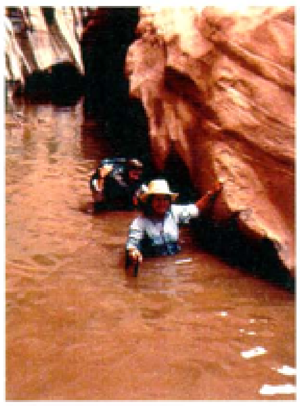
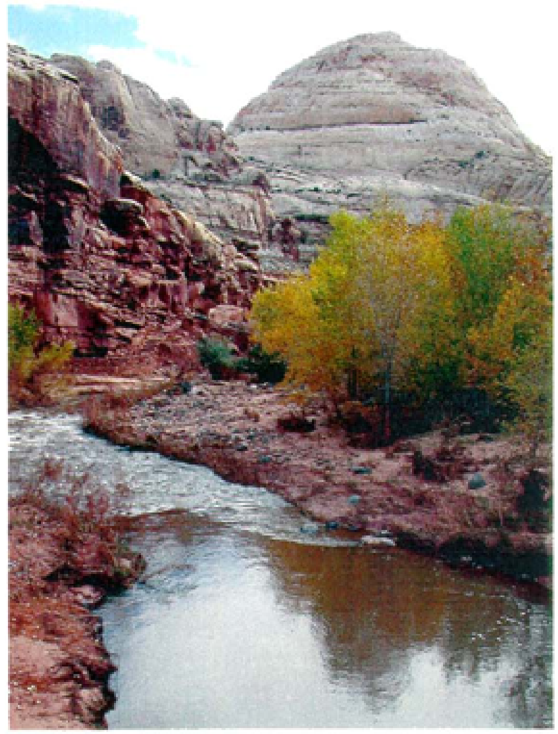
Capitol Reef National Park
Utah

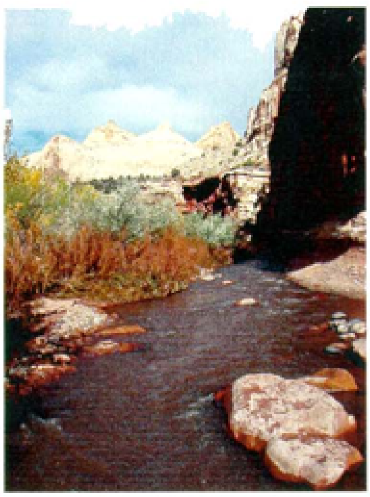
National Park Service
U.S. Department of the Interior

Capitol Reef National park
Utah

Water Resources Management Plan







WATER RESOURCES MANAGEMENT PLAN

CAPITOL REEF NATIONAL PARK
UTAH

June 2004

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ACKNOWLEDGEMENTS

The persons and their affiliations listed below provided important data, essential reports, ideas, and valuable interviews to support the authors in the preparation of this plan. We especially appreciate their contributions of time and information.

Army Corps of Engineers: Shawn Zinszer, Bountiful, UT.

Booz, Allen and Hamilton: Dave Walls (contractor for BLM, Richfield), Salt Lake City

Bureau of Land Management: Walt Fertig, Kanab; Greg Christensen, Escalante, Lori Armstrong, Richfield; Phil Zieg, Richfield; Frank Erikson, Richfield; Justin Seastrand, Richfield; Gary Hall, Hanksville; Heidi Hadley, Salt Lake City.

Capitol Reef National Park: Keith Durfey, Bob Cox, LaMont Chappell, Jeff Pace, Ron Wilson, Lee Kreutzer, Al Hendricks, and Riley Mitchell.

Colorado State University: Jill Baron, Boris Kondratieff, Tyler Scheid.

U.S. Environmenal Protection Agency: Region VIII office, Denver, CO.

Farm Service Agency: Paul Pace, Loa.

U.S. Forest Service, Dixie National Forest: Joanne Stenten, Teasdale; Kurt Robins, Teasdale; and Dan Range, Escalante.

U.S. Forest Service, Fishlake National Forest: Jim Whelan, Richfield; Dale Dieter, Richfield; Frank Fay, Richfield; Rob Hamilton, Loa.

Fremont Irrigation Co.: Dean Chappell and John Brinkerhoff, Loa.

Millenium Science & Engineering: Steve Bauer, Boise; John Christensen, Salt Lake City.

National Park Service, Water Resources Division: Jeff Albright, Paula Cutillo, Bill Jackson, Larry Martin, Pete Penoyer, Gary Rosenlieb, Dean Tucker, Joel Wagner.

National Park Service, Geologic Resources Division: Deanna Greco.

National Park Service, Northern Colorado Plateau Network, *et al*.: Aneth Wight, Moab; Ron Hiebert, Flagstaff; Nancy Skinner, Flagstaff; John Reber, Denver.

National Weather Service: Kevin Berghoff, Portland, OR.

Natural Resources Conservation Service: John Huntamer, Richfield; Tom Jarman, Richfield; Victor Parslow, Richfield.

Purdue University: John MacDonald.

U.S. Geological Survey: Greg Auble and Michael Scott, USGS-BRD Fort Collins; Jane Belnap, USGS-BRD, Moab; Paul von Guerard and Kirby Wynn, USGS, Grand Junction.

Utah Association of Conservation Districts: David R. Pace, Richfield.

Utah Department of Natural Resources: Kirk Forbush, Richfield; Terry Monroe, Richfield; Mark Page, Price.

Utah Division of Water Quality: Arne Hultquist, Salt Lake City; Richard Denton, Salt Lake City; William Moellmer, Salt Lake City.

Utah Division of Wildlife Resources: Chuck Chamberlin, Cedar City; Dale Hepworth, Cedar City

Utah Department of Transportation: Ross Christensen, Richfield; Daryl Friant, Richfield; Larry Gay, Richfield.

Utah State University: Mark Vinson, Logan.

Finally, we are grateful to Al Hendricks, Superintendent of CARE, John Reber of the Intermountain Regional Office and Mark Flora, Kevin Noon, Pete Penoyer, Dean Tucker, Joel Wagner, and Don Weeks of the NPS Water Resources Division for their valuable reviews of the draft plan and technical suggestions.

EXECUTIVE SUMMARY

Description of the Water Resources Management Plan: Chapter 1 defines a Water Resources Management Plan, describing how it complements the park's General Management and Resource Management Plans, but with focus on water resources and issues related to water resources.

Description of the Park: Chapter 2 describes how Capitol Reef National Park was established, first as a national monument in 1937, then as a park in 1971, eventually growing to 241,904 acres. Maps and text define the park's location and describe its division into three administrative districts: the Fremont River, Cathedral and Waterpocket districts. The chapter notes the park's emphasis on wilderness preservation and resource protection while ensuring a variety of park uses.

Objectives of the Plan: Chapter 3 elaborates how a park's water resources management plan can be used to: identify programs, plans and studies; promote efforts to reduce erosion; identify the needs for wetlands work; recognize the concerns and regulations relating to floodplain management; identify needs to acquire and/or maintain water rights; suggest how to gather water quality and quantity data; propose water resource applied research valuable to the park; review park inventory and monitoring needs; suggest cooperative programs; summarize the legal aspects of water; generally promote water conservation; and help ensure that park operations do not adversely impact water resources.

Water Resources Legislation and Regulations: Chapter 4 summarizes legislation and memoranda of agreements or understandings which influence the management of water resources, including federal acts, executive orders, state legislation, and planning legislation, such as the Clean Water Act and legislation on wetlands.

Land Use Overview: Chapter 5 briefly describes land use in and around the park, noting that the land use activities or features include: agriculture; irrigation, ditches and small impoundments; grazing; logging; wildfires; fire management; livestock trailing; horseback riding; various recreational activities; dumps; occasional spills; roads; trails; mines; and exploration for minerals, oil, gas, or other extractives.

Soil, Water, and Geology : An overview of the soil, water, hydrology, and geology of the park appears in Chapter 6, with presentations of graphical data on the park's climate and descriptions of the common soils. The geology is described, defining the basic stratigraphy, structure, and hydrologic characteristics of water-bearing formations. The major water-bearing formation is the Navajo Sandstone, yet the park derives its water supply from a lens within the Moenkopi Formation. The Waterpocket Fold and other major physical features are reviewed, especially as related to ground water. Ground water is discussed in terms of volume, movement, storage, and availability. The chapter also summarizes mining history in the area.

Surface Waters: The Fremont River Basin and its principal tributaries are discussed in Chapter 6, describing streams, tinajas, springs, seeps, hanging gardens, and other features common to the park. The river and its key tributaries are defined in terms of watershed size, discharge, floods, dams, and location of stream gages. Tables of data are presented to describe streamflows, and maps are provided on floodplains, watersheds, streams, and reservoirs. The chapter provides graphs of peak flows for the river at the Bicknell and Caineville gaging stations, above and below the park.

Springs, Tinajas, and Other Special Features: Chapter 6 also reviews the special role and value of springs and seeps found in the park and nearby, discussing spring discharges and reviewing how springs are fed by ground water in the sandstone layers. The chapter reviews how tinajas are key resources for desert plants, vertebrates, and invertebrate species, for cattle, and occasionally for humans, and notes how the park's hanging gardens contain rare and endemic species. A review of research describes what has been learned about the ecology of tinajas, springs, and hanging gardens in the park. Section 8.5 describes the need for wetland and hydrologic studies, and notes that ground-water drawdown by well pumping could diminish springs, and that more studies could define this issue. The section also points out the need to map and characterize the park's hanging gardens, and to complete a survey of tinajas.

Small Impoundments: Chapter 6 describes small impoundments scattered around the park, left from earlier days of extensive grazing. These features continue to provide water for livestock and wildlife; however, they create habitat for exotics such as tamarisk, so the park favors removal of these small dams. Section 8.3 of the plan details the park's goal to inventory the impoundments, describe them in terms of exotic plant species, and plan a removal program, among other actions.

Water Quality: Chapter 6 details water quality for the Fremont River, and provides some information on water quality for Pleasant and Oak creeks. Although waters of the park generally are of good quality, impacts result from human activities related to roads, campsites, grazing, wastewater discharges, and irrigation return flows. The Fremont River experiences periods of high turbidity. Phosphorus, temperature, and fecal coliform counts also have been elevated at times.

Water Quality Monitoring: The report's Chapter 6 and Section 8.6 provide a review of about two decades of water quality monitoring in the park and nearby, providing data on chemical, biological, and physical water quality parameters and summarizing the water quality impacts. The section summarizes the studies, reports, data, and interpretations from past years and provides specifics on what has been learned, presented in maps, tables of data, and text. The chapter summarizes some information from other agencies, especially the Forest Service. The data show that the Fremont River and Oak Creek sometimes suffer impacts from fecal inputs from cattle, erosion from logging and recreation, and various agricultural practices. Pollution on the river recently has led to development of an interagency Water Quality Management Plan for the river, with the park participating on the steering committee for that planning group. The park recognizes the need to continue assessment of its waters with the intent to improve the quality of the water. Section 8.8 analyzes the water quality designation for the river.

Flora and Fauna : The last section of Chapter 6 describes the vegetation most relevant to riparian zones and streams, noting that from 50 to 80% of wildlife species require that some part of their life cycle be spent near or in water, and that nine of the park's 34 plant communities are associated with riparian or wetland areas -- including some unusual and rare plant communities such as the hanging garden ecosystems. The chapter also summarizes the fish species and other aquatic organisms in the park. A number of scientists have assessed macroinvertebrate populations in waters of the park, and their work is summarized.

Water and Sewage Infrastructure: Chapter 7 describes water use at the park, noting that during 1992-2002 the annual water use ranged from 2.7 million gallons in 2002 to 4.4 million gallons in 1998. The chapter reviews the history of water supply in the park and describes the wells and other structures that have been used. The chapter discusses the sewage treatment facility for the campground, and summarizes information on the sewage disposal at the picnic area, Ripple Rock Nature Center, the group campground, Hold House, and the Visitor center/residential area.

Irrigation and Ditches: As discussed in Chapter 7, historic irrigation is a cultural activity, and the park cultivates approximately 66 acres of orchard and pasture. The park draws 8 cubic feet per second (cfs) of flow from the Fremont River, plus 0.9 cfs diversion on Sulphur Creek, as well as a 1 cfs diversion at Pleasant Creek. Privately owned Sandy Ranch maintains an irrigation canal of 10,298 ft passing through the park to their property, adjacent to the park's eastern border, with a right-of-way to maintain the canal.

Infrastructure Issues: Section 8.1 notes how the visitor center and residential area sewage system has distribution lines that are old and may need attention. The park also is interested in a concrete diversion structure for the Fremont River diversion, since a concrete structure would require low maintenance. The park's sluice channel near the Fremont River is used to remove sediment from diverted water prior to irrigating the orchards. Section 8.1 discusses flushing the sluice channel back to the Fremont River. Lastly, the Peekaboo Trailer in the southern portion of the park needs a drinking water source, probably a well.

Water Rights: Section 8.2 provides a general overview of water rights with details on various issues regarding water rights. A table and appendix table provide information on water right numbers, priority date, discharges, source, and points of diversion for water rights owned by the park. Water rights data also are provided on Oak and Pleasant creeks and other locations in the park. The proposed Caineville Wash Dam project near the town of Caineville would divert water from the Fremont River, and is discussed from a water rights perspective. The section describes a ground-water study to estimate the effects of ground-water pumping on water resources within the park.

River Oxbow Restoration: The Fremont River oxbow was created by the construction of Utah Highway 24 across a meander of the river in 1964, cutting off an old river oxbow. Section 8.4 describes recent meetings between the Utah Department of Transportation and the park and the mutual desire to rehabilitate the oxbow. The section describes various restoration possibilities and studies that will be needed. The options range from culverts, to one bridge, to two bridges.

Wetlands Issues: The park would like to inventory and map its wetlands, as described in Section 8.5. Riparian areas attract cattle, wildlife, and birds, as well as recreationists, horseback riders, campers, and other people; therefore, these areas are susceptible to impacts.

Wild and Scenic Considerations: A number of agencies and organizations are interested in a possible Wild and Scenic River Act (WSRA) designation for the Fremont River Gorge area. Section 8.7 of the report reviews the options for such designation, weighing the pros and cons, listing the criteria, and reviewing highlights of the legislation, to provide information to allow the park to consider exploration of this topic, if desired.

Halls Creek Water Quality: A main concern at Halls Creek is recreational impacts, where growing numbers of hikers in Halls Creek Narrows are likely impacting the creek. This issue is reviewed, and a detailed discussion of possible monitoring is given in Section 8.9.

Oak and Pleasant Ceeks: Section 8.10 discusses how these two creeks have a number of impacts, from cattle grazing and trailing, diversions, logging upstream, wildfires, recreation, roads, trails, old mines, a highway (with possible spills), and other disturbances. Water quality data are presented and the need for monitoring is spelled out. Details on grazing and other land uses are provided.

Hydrogeology: Section 8.11 describes how understanding the extent of ground water within the park, its availability, and its vulnerability to outside extraction is critical for several reasons including: 1) maintenance of a ground-water culinary supply, 2) protecting water for wildlife at springs, and 3) maintenance of riparian areas around springs.

Mining and Minerals: Section 8.12 of the plan summarizes how mining has occurred in the park and adjacent to the park on Bureau of Land Management (BLM), Forest Service, state, or private lands, and has left some scars that still require remediation. These lands also are re-appraised from time to time for mining, oil and gas drilling, tar sand development, and other extractive activities, so future impacts upstream from the park are still possible. Details are provided on uranium mines in the park. The section notes how coal mining in the broader general area poses a potential impact of possible future concern. Section 8.14 discusses how some old mining sites in the park are still eroding and in need of rehabilitation.

Exotic Plant Impacts: The two species of greatest concern in Capitol Reef National Park are tamarisk (*Tamarix ramosissima*) and Russian-olive (*Elaeagunus angustifolia*), as discussed in Section 8.13. These riparian species compete for water and nutrients and can impact native plant communities. The section discusses the goal to control these undesirable plants.

Watershed Restoration Work: Erosion is occurring in the southwestern area of the park where the BLM conducted erosion control work in the 1950s-60s. They originally removed piñon and juniper trees to improve rangelands. Section 8.14 discusses this problem and the need for restoration of the area.

Project Statements: The report provides project statements on topics discussed. These are, by number:

9.1. Restoration of Impoundments within Capitol Reef National Park;

9.2. Riparian and Aquatic Habitat Inventory and Assessment at Capitol Reef National Park;
9.3. Inventory of Tinajas North of Burr Trail in Capital Reef National Park;
9.4. Inventory of Springs in the Southern Area of the Park;
9.5. Determine Impacts of Nutrient, Sediment, and Toxic Inputs on the Fremont River;
9.6. Evaluate Recreation Impacts on Halls Creek in Capitol Reef National Park;

9.7. Hydrology Study of the Fremont River Oxbow;
9.8. Hydrogeological Study of Capitol Reef National Park;

9.9. Control of Exotics Species in Riparian Areas;
9.10. Delineation of Wetlands in Capitol Reef National Park;

9.11. Design of Abandoned Mining Road Restoration Project in the Park;

9.12. Design for Restoration of Disturbed Piñon-Juniper Watersheds in the Park; and

9.13. Restoration and Protection of Ackland Springs.

CAPITOL REEF NATIONAL PARK'S WATER RESOURCES MANAGEMENT PLAN AND NEPA

The National Environmental Policy Act (NEPA) mandates that federal agencies prepare a study of the impacts of major federal actions having a significant effect on the human environment and alternatives to those actions. The adoption of formal plans may be considered a major federal action requiring NEPA analysis if such plans contain decisions affecting resource use, examine options, commit resources or preclude future choices. Lacking these elements, this Water Resources Management Plan (WRMP) has no measurable impacts on the human environment and is categorically excluded from further NEPA analysis.

According to Director's Order (DO) #12 Handbook (Section 3.4), water resources management plans normally will be covered by one or more of the following Categorical Exclusions:

- *3.4.B (1) Changes or amendments to an approved plan when such changes have no potential for environmental impact.*
- *3.4.B (4) Plans, including priorities, justifications, and strategies, for non-manipulative research, monitoring, inventorying, and information gathering.*
- *3.4.B (7) Adoption or approval of academic or research surveys, studies, reports and similar documents that do not contain and will not result in NPS recommendations.*
- *3.4.E (2) Restoration of non-controversial native species into suitable habitats within their historic range.*
- *3.4.E (4) Removal of non-historic materials and structures in order to restore natural conditions when the removal has no potential for environmental impacts, including impacts to cultural landscapes or archeological resources.*
- *3.4.E (6) Non-destructive data collection, inventory, study, research, and monitoring activities.*
- *3.4.E (7) Designation of environmental study areas and research natural areas, including those closed temporarily or permanently to the public, unless the potential for environmental (including socioeconomic) impact exists.*

These Categorical Exclusions require that formal records be completed (Section 3.2, D0-12 Handbook) and placed in park files. It is the responsibility of the park to complete the documentation for the applicable Categorical Exclusion(s) when the Water Resources Management Plan is approved and published.

1. INTRODUCTION

1.1 Purpose of Plan

This Water Resources Management Plan describes the water resources of Capitol Reef National Park and the issues affecting them. The plan provides detailed descriptions of 1) the park hydrological environment, 2) management issues developed in a water resources scoping session, and in interviews with park personnel, other government agency personnel and knowledgeable local people, and 3) recommendations to management in the form of project statements. Often a Water Resources Management Plan is preceded by a scoping session and development of a scoping report. The process has been streamlined in this instance. Information wrought from 1) the scoping meeting held October 29, 2002 at Capitol Reef National Park, 2) the park's Resource Management Plan (National Park Service, 1993), 3) a hydrological assessment completed in 1989 (Christiana and Rasmussen, 1989), and 4) description of park water resources (Christiana and Rasmussen, 1991) form the basis for discussion of water resource management issues. Identified are a number of concerns including water quality in the Fremont River, restoration of natural water resources, inventory and assessment of park water resources, water rights both external and internal to park which affect park resources, visitor impacts to aquatic environments, hydrogeological study of the park, eradication of exotic plant species, and review of stream classifications for the Fremont River, among others.

Water is scarce and thus highly manipulated on the Colorado Plateau. Yet, five perennial streams flow through Capitol Reef National Park. These are critically important for their associated flora and fauna, but all are diverted for irrigation or impacted in some other manner. Other water sources including intermittent and ephemeral drainages, springs, hanging gardens, and waterpockets, also referred to as tinajas, capture what little precipitation falls in this desert environment. Fold into this mix, the human component which is dependent on available water, and the park experiences impacts to its water sources ranging from water pollution to scarcity, from watershed degradation to manipulation, and from flooding to construction of dams for water retention.

Diversions from the Fremont River, and Sulphur, Pleasant and Oak creeks impact park water resources. Lower flows result in sedimentation, elimination of floodplain wetlands, and creation of habitat suitable for invasive species such as tamarisk or saltcedar (*Tamarix ramosissima*) and Russian-olive (*Eleaganus angustifolia*). Diversions at the headwaters of Polk, Bulberry and Deep creeks prevent natural flow of water to the park, even interupting seasonal flow patterns.

Impoundments on most of the ephemeral drainages in the park reduce contribution to flow in larger drainages and invite establishment of exotics as noted above. These impoundments served as watering holes for livestock. Since livestock grazing has been reduced from 19 allotments when the park was established to two allotments now, these impoundments are less used. Restoration of these sites would reduce exotic species, ensure re-establishment of a natural landscape, and increase flows to larger drainages.

Since large portions of the park's watersheds lie outside of park boundaries, a large range of influences related to land development and resource use have the potential to impact park waters, for example, impacts from grazing. These land and resource use impacts are reviewed in Section 5 on Land Use.

Nutrient loading and fecal contamination from livestock grazing and recreation in and outside the park contributes to contamination in the Fremont River. Upstream of the park, the Fremont River has been placed on the 303(d) list for not complying with total phosphorus and dissolved oxygen criteria associated with State of Utah stream standards. The Fremont River Water Quality Management Plan (Millennium, 2002) discussed grazing practices and recreational use which raise total phosphorus levels and lead to decreased dissolved oxygen levels. Downstream of the park, the Fremont River is 303(d) listed for total dissolved solids. Millennium Science & Engineering, Inc. (2002) implicated spring discharges from the Caineville Wash as the greatest source of high salt levels. Although the Fremont River within the park is not a 303(d) listed water, the river experiences intense swings in turbidity, fecal coliform contamination, and high total phosphorus and temperatures (National Park Service, 1994).

Also, visitor use translates into greater consumptive use of treated water, with impacts to springs, creeks, riparian areas, and tinajas. Greater highway use along Utah State Highway 24 increases the potential for spills and the discharge of material to the Fremont River.

Another issue involves State Highway 24 (U-24), which parallels and crosses the Fremont River within the park. One engineering feat reduced the number of bridged crossings, by re-channeling the river and cutting across a river meander. Re-channeling the river to one side of the road shortened its length and steepened its gradient. The river now cuts through sandstone, creating a waterfall below which a large pool exists. The waterfall prevents natural migration of fish upstream and invites visitors to swim in an unsafe environment. Also the old meander no longer supports a hydric environment and the accompanying threatened species, Ute ladies' tresses (*Spiranthes diluvialis*). Restoration of the meander and removal of impoundment features throughout the park could improve riparian habitat and reduce the number of exotics.

These are only some of the water resource issues that face Capitol Reef National Park, the sum total of which lead to a degraded natural environment with less than optimal functioning conditions. Based on the complexity of the issues, the multitude of the public and private interests and the desire to preserve the park's water resources, development of a Water Resources Management Plan is a necessity.

National Park Service (NPS) policy requires that a unit of the national park system develop and implement a land and water use management plan called a General Management Plan. The park's 1982 General Management Plan underwent revision with a Final Environmental Impact Statement for the General Management Plan, Development Concept Plan, and Statement for Management (National Park Service, 1989a). National Park Service policy also requires that a unit of the national park system develop a Resources Management Plan. The present document (National Park Service, 1993) serves as a strategic planning document in effective management and preservation of park resources including plants, wildlife, water, paleontological and cultural resources.

This Water Resources Management Plan serves as an implementation plan to complement the General Management Plan and the Resources Management Plan. It is similar to the Resources Management Plan, but focuses on water resources and related issues. Project statements developed in this plan will be integrated into the Resources Management Plan.

2. PARK PURPOSES AND SIGNIFIGANCE

Capitol Reef National Park was established by Public Law 92-207 on December 18, 1971. Originally designated a national monument in 1937 by presidential proclamation (Presidential Proclamation 3249), the park's size was increased twice, once in 1958 and then again in 1969, to its present 241,904 acres. The proclamations of 1937, 1958, and 1969 point to its dramatic geologic and scientific values (National Park Service, 2001a). However, the 1971 act creating the park only generally describes the reasons for park establishment, and these are to: "…administer, protect and develop the park subject to provision of the National Park Service Organic Act (16 U.S.C. Sec. 1 *et seq.*).

The park is located in south-central Utah, in the heart of the state's canyon country. The Waterpocket Fold, consisting of many layers of sedimentary rock that formed over hundreds of millions of years, results from the flexing and bending of these layers during an extensive regional mountain–building episode. The park includes the Fruita Historic District as well as nearly 100 miles of the Waterpocket Fold (Figure 1). The park is divided into three administrative districts, primarily to establish areas of responsibility for patrol rangers:

- The Fremont River District (central portion of the park);
- The Cathedral District (northern portion of park) encompassing areas called the Hartnet and Cathedral Valley; and
- The Waterpocket District (southern portion of the park) encompassing a major portion of the Waterpocket Fold.

The purposes of Capitol Reef National Park are found in its enabling legislation and include:

- Conserving and protecting such geologic wonders as the Waterpocket Fold, Cathedral Valley, narrow canyons, evidence of ancient sand dune deposits, and objects of geologic and scientific interest; and
- Protecting from unauthorized appropriation, injury, destruction, or removal of all park features.

The essence of Capitol Reef's significance stems from several factors or features. They include the Waterpocket Fold, the largest exposed monocline in North America; numerous other geologic features; clean air and striking views; diverse habitats supporting a diversity of plant and animal life; significant archeological resources; and contribution to the regional economy (National Park Service, 2001a).

3. OBJECTIVES OF THE WATER RESOURCES MANAGEMENT PLAN

The park has developed a list of water resource objectives. These objectives, listed below, are based on a park scoping meeting held October 29, 2002 and from meetings with personnel from the State of Utah, Bureau of Land Management (BLM), Forest Service, Natural Resource Conservation Service, Utah Association of Conservancy Districts, the irrigation districts, and the Water Resources Division of the National Park Service (NPS).

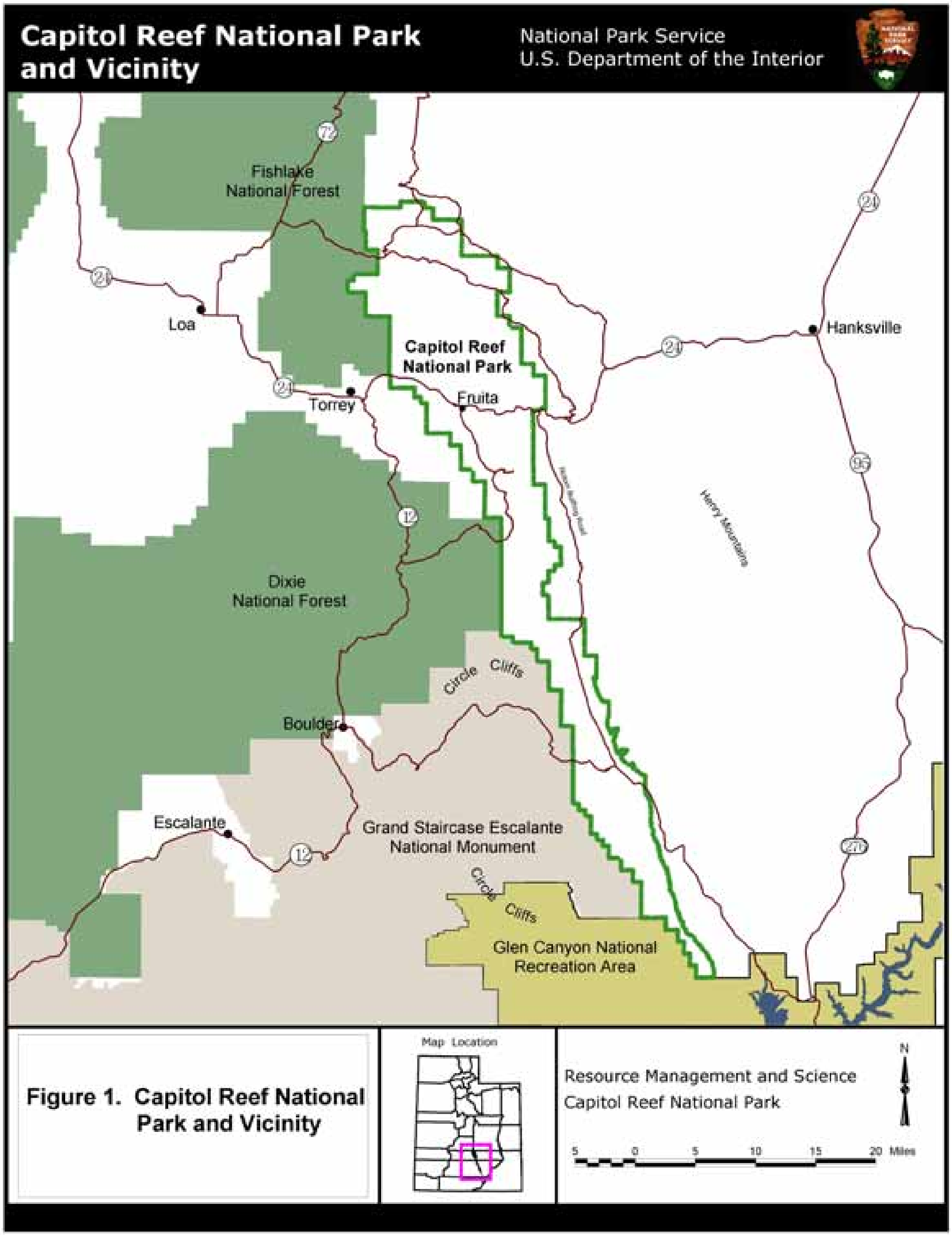


Figure 1. Park vicinity map.

Water Quality and Quantity

- Ensure that water resources, especially at seeps and springs, are available to wildlife, aquatic organisms, and plants in quantities and of a quality that promote the existence and well being of these organisms.
- Recognize opportunities to develop programs, plans and studies that integrate the efforts of the Fremont Watershed Steering and Technical Advisory committees.
- Recognize importance of healthy watersheds, and in doing so promote efforts to reduce unnatural erosion and sediment production inside and outside park boundaries.
- Recognize importance of wetlands, and initiate wetland delineation studies as required by Section 404 of the Clean Water Act and Executive Order 11990 with guidance from Director's Order #77-1.
- Recognize the concerns and regulations relating to floodplain management and development of any kind within those zones.
- Investigate, acquire, quantify, and/or maintain water rights for Capitol Reef National Park.

Inventory and Monitoring

- Continue to gather, compile and analyze water quality and quantity data in Capitol Reef National Park in order to determine level of impairment and trends.
- Encourage partnerships between local, state and federal agencies in monitoring water quality and biota.
- Gather and analyze information on the structure and function of organisms which inhabit springs, tinajas, riparian areas and seeps, and implement studies which determine the effects of increased visitor use in these areas.
- Participate in the active development of reclamation plans or studies which assess impacts of past or present grazing and development activities, such as road development, vegetation manipulation and impoundment development.
- Participate in the remediation of the Fremont River oxbow.

Park Operations

- Through educational programs promote and maintain riparian or aquatic habitats for wildlife, fish, plants, and other aquatic organisms.
- Ensure that special uses of park water resources adhere and correspond to enabling legislation and management statements and plans of the parks.
- Promote water conservation through both the National Park Service actions, and cooperation with local businesses and communities, and state and federal agencies.
- Ensure that park operations including orchard management, irrigation, waste disposal and water extraction do not adversely impact park water resources and water dependent environments.

4. FEDERAL, STATE, AND LOCAL WATER RESOURCES LEGISLATION AND REGULATIONS

4.1 Federal Legislation Influencing Water Resources Management

Legislation and memoranda of agreements or understandings which influence the management of water resources include:

The **National Park Service Organic Act of 1916** directs the Service to preserve park resources for future generations while allowing for public enjoyment. In 1916 Congress created the National Park Service:

> "to promote and regulate the use of the Federal areas known as national parks, monuments, and reservations... by such means and measures as to conform to the fundamental purpose of said parks, monuments, and reservations, which purpose is to conserve the scenery and the natural and historic objects and the wildlife therein and to provide for the enjoyment of the same in such a manner and by such means as will leave them unimpaired for the enjoyment of future generations."

The General Authorities Act of 1970 reinforced this act -- all parklands are united by a common preservation purpose, regardless of title or designation. Hence, federal law protects all water resources in the national park system equally, and it is the fundamental duty of the National Park Service to protect those resources unless otherwise indicated by Congress.

Congress amended the Authorities Act of 1970 in the **Redwood National Park Act (1970)** directing that the management of the National Parks:

> "... shall not be exercised in the derogation of the values and purposes for which these various areas have established, except as may have been or shall be directly and specifically provided by Congress."

Thus, by amending the general Authorities Act of 1970, this act reasserted system wide the high standard of protection prescribed by Congress in the Organic Act.

National Parks Omnibus Management Act of 1998 recognized the ever increasing societal pressures being placed upon America's unique natural and cultural resources contained in the national park system; this act attempts to improve the ability of the National Park Service to provide state-of-the-art management, protection, and interpretation of and research on the resources of the national park system by:

- assuring that management of units of the national park system is enhanced by the availability and utilization of a broad program of the highest quality science and information;
- authorizing the establishment of cooperative agreements with colleges and universities and the establishment of cooperative study units to conduct multi-disciplinary research and develop integrated information products on the resources of the national park system;
- undertaking a program of inventory and monitoring of national park system resources to establish baseline information and to provide information on the long-term trends in the condition of national park system resources; and
- taking such measures as are necessary to assure the full and proper utilization of the results of scientific study for park management decisions. In each case in which an action undertaken by the National Park Service may cause a significant adverse effect on a park resource, the administrative record shall reflect the manner in which unit resource studies have been considered. The trend in the condition of resources of the national park system shall be a significant factor in the annual performance.

The **Wilderness Act of 1964** established the National Wilderness Preservation System, composed of federal lands designated as wilderness areas. A wilderness, in contrast with those areas where man and his own works dominate the landscape, is … an area where the earth and its community of life are untrammeled by man… an area of undeveloped federal land retaining its primeval character and influence… which is protected and managed so as to preserve its natural conditions that:

- appear to have been affected primarily by the forces of nature, with the imprint of man's work substantially unnoticeable;
- provide outstanding opportunities for solitude or a primitive and unconfined type of recreation; and,
- has at least 5,000 acres of land or are of sufficient size as to make practicable their preservation and use in an unimpaired condition.

Except as provided by law, there are no permanent roads within any wilderness area. Except as needed for administrative purposes, there are to be no temporary roads or use of motorized vehicles or motorized equipment, no landing of aircraft, no other form of mechanical transport, and no structure or installation within any wilderness area.

There are no areas within the park managed as wilderness under this act.

The Fish and Wildlife Coordination Act of 1965 requires federal agencies to consult with the U.S. Fish and Wildlife Service or the National Marine Fisheries Service and with parallel state agencies whenever water resource development plans result in alteration of a body of water. The Secretary of the Interior is authorized to assist and cooperate with federal agencies to "provide that wildlife conservation shall receive equal consideration and be coordinated with other features of water-resource development programs."

The **Land and Water Conservation Fund Act of 1965** makes available funds "to assist the States and federal agencies in meeting present and future outdoor recreation demands and needs of the American people." These funds are available to purchase land and have been used to buy land administered by the NPS.

The **National Environmental Policy Act (NEPA) (1969)** requires that any major federal action which may significantly affect the environment including the human environment be reviewed via the NEPA process. Any actions proposed within this document will be evaluated with regards to the NEPA process. Major federal actions could include activities related to remediation of abandoned mine or oil and gas sites, management of the floodplains where facilities or campsites are located, alteration to wetlands, and construction of dams.

The **Federal Water Pollution Control Act (1972) (the Clean Water Act)** was passed in 1972. Having undergone two major revisions in 1977 and 1987, the Act is up for renewal. The Act had set goals for fishable and swimmable waters by 1983 and no further discharge of pollutants into the nation's waterways by 1985. To an extent, these goals have been attained via two main programs. A major grant program offered funds to construct municipal sewage treatment facilities. A second program limited the amounts of pollutants that could be discharged. The National Pollutant Discharge Elimination System (NPDES), a permit system for point-source dischargers, reflects the programs "effluent limitation" approach. The Environmental Protection Agency has set limits for pollutants that may be released based on available technology and cost of treatment for various industrial categories.

The Act also recognizes state primacy in managing and regulating the nation's water quality. The states implement water quality protection, as promulgated by the Act, through water quality standards. Standards are set for designated uses for individual stream segments. Uses recognized by the State of Utah include the following general categories: domestic supply, recreation, aquatic organisms and other wildlife, and agriculture. Identified standards include physical, chemical, and biological characteristics that when applied to a segment will insure protection of the designated uses on that segment.

One of three levels of protection is afforded any particular stream segment. As the absolute foundation, designated uses are protected. Degradation of water quality cannot extend beyond a level detrimental to the designated use or uses. A second tier of protection is afforded those segments where water quality exceeds that which is needed to support swimming and fishing. Only limited degradation can occur in these waters, and only after an anti-degradation review that prohibits substantial impacts to water quality. Social and economic aspects of the impacts are considered in evaluating the activity which may impact the stream segments. The last tier of protection calls for no degradation of the stream segment once it has been designated as such. The High Quality - Category 1 or Outstanding Waters designation in the State of Utah safeguards the state's highest quality waters.

The Clean Water Act with the 1987 amendments introduced new initiatives with emphasis on non-point source pollution control programs, toxics controls, and management of coastal and near-coastal waters. In addition, the Act, in Section 404, protects wetlands as these have been interpreted to be waters of the United States. With regards to this plan, the Act induces the Park to take part in triennial reviews, to continue with monitoring programs, to analyze available data, and to interact with the State of Utah Water Quality Division. The State of Utah recognizes that some stretches of water do not meet state standards (Utah Department of Environmental Quality, 2000); these waters are placed on the 303(d) list, and sited for which parameter the designated use is impaired. These segments must undergo a total maximum daily load review to seek remedies. Two sections of the Fremont River, above and below the park were identified. A Water Quality Management Plan was developed to manage the pollution problems on the Fremont (Millennium Science & Engineering, Inc., 2002).

The **Safe Drinking Water Act (1974 and Amendments 1986)** applies to developed public drinking water supplies. It sets minimum national standards and requires regular testing of drinking water for bacterial contamination, metals, volatile organics, and nitrates. At the bequest of the supplier, some testing can be waived. Individual park units deemed by the Public Health Management Guideline (NPS, 1993a) must assure "that water supply systems are properly operated and maintained...".

At Capitol Reef National Park, tests for total coliform and residual chlorine where applicable, occur on a schedule developed and required by the State of Utah for systems serving the public. Bacteriological testing occurs bi-weekly. The park tests its waters for organics and metals on a periodic basis.

The **Endangered Species Act (1973)** requires that all entities using federal funding must consult the Secretary of Interior on activities that potentially impact endangered flora and fauna (Section 6). It requires agencies to protect endangered and threatened species as well as designated critical habitats.

Federally listed species within Capitol Reef National Park may include Ute ladies' tresses (*Spiranthes diluvialis*) and the southwestern willow flycatcher (*Empidonax traillii extimus*). The orchid was known to inhabit the Fremont Gorge within the park and the oxbow near State Hwy 24. The bird has not been documented as nesting in the park. However, its habitat includes a variety of dense understory and/or midstory shrubs in broad riparian floodplains (Sferra *et al.*, 1995), habitats that occur in the park. These communities can include dense monotypic or mixed stands of willows, and in some cases dense stands of tamarisk or saltcedar (*Tamarix ramosissima*), all present within the park.

The **Mining in the Parks Act (1976)** requires claim holders to register all active claims, provide a detailed plan of operation for park manager approval, and purchase substantial performance bond that covers all reclamation costs. The law also prohibits new claims in any national park or monument. The act states that all claims had to be recorded with the Bureau of Reclamation by Sept. 28, 1977, or be declared null and void. A total of 189 claims were recorded with the Bureau before the September deadline. All but three of these were declared invalid, then in 1986 both the Rainy Day Mines #2 and #3 were nullified. One valid claim remains in the park.

The **National Wild & Scenic Rivers Act (1968)** was enacted on October 2, 1968, and under the Act, selected rivers can be preserved in a free-flowing condition and protected for future generations. Rivers can qualify for the National System by act of Congress or by the Secretary of Interior designation if the river has first been designated into a valid state river protective system by state law and if the appropriate governor has applied for a Wild & Scenic River designation for the river. Rivers so designated by a state must be administered permanently as wild, scenic or recreational rivers by an agency or political subdivision of the state concerned, determined by the Secretary of the Interior as meeting the criteria established in the Act, and approved by the Secretary for inclusion in the System.

National Invasive Species Act of 1996. The Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 was re-authorized through this 1996 act. Under the 1990 act, the Great Lakes became the first area where ballast water regulations were imposed. The 1996 act extends the ballast management program to the national level and enhances other national monitoring, management and control programs.

National Park Service Management Policies and Guidelines

The National Park Service Management Policies (National Park Service, 2001c) provide broad policy guidance for the management of units of the national park system. Topics include park planning, land protection, natural and cultural resource management, wilderness preservation and management, interpretation and education, special uses of the parks, park facilities design, and concessions management.

With respect to water resources, it is the policy of the National Park Service to determine the quality of park surface and ground-water resources and avoid, whenever possible, the pollution of park waters by human activities occurring within and outside of parks. In particular the National Park Service will work with appropriate governmental bodies to obtain the highest possible standards available under the Clean Water Act for protection of park waters; take all necessary actions to maintain or restore the quality of surface and ground waters within the parks consistent with the Clean Water Act and all applicable laws and regulations; and, enter into agreements with other agencies and governing bodies, as appropriate, to secure their cooperation in maintaining or restoring the quality of park water resources.

The National Park Service will also manage watersheds as complete hydrologic systems, and will minimize human disturbance to the natural upland processes that deliver water, sediment and woody debris to streams. The National Park Service will manage streams to protect stream processes that create habitat features such as floodplains, riparian systems, woody debris accumulations, terraces, gravel bars, riffles and pools.

The National Park Service will achieve the protection of watershed and stream features primarily by avoiding impacts to watershed and riparian vegetation and by allowing natural fluvial processes to proceed unimpeded. When conflicts between infrastructure (such as bridges) and stream processes are unavoidable, park managers will first consider relocating or redesigning facilities, rather than manipulating streams. Where stream manipulation is unavoidable, managers will use techniques that are visually non-obtrusive and that protect natural processes to the greatest extent practicable.

Recommended procedures for implementing service-wide policy are described in the National Park Service guideline series. The guidelines most directly pertaining to actions affecting water resources include:

Director's Order #2: Park Planning;
Director's Order #12: Conservation Planning, Environmental Impact
    Analysis, and Decision-making;
Director's Order #77: Natural Resources Management
Director's Order #77-1: Wetland Protection;
Director's Order #77-2: Floodplain Management;
Director's Order #83: Public Health; and
NPS-75: Natural Resource Inventory and Monitoring.

4.2. Executive Orders Influencing Water Resources Management

Invasive Species (E.O.13112) signed in 1999, this E.O. complements and builds upon existing federal authority to aid in the prevention and control of invasive species.

The objective of **Executive Order 11988 Flood Plain Management (1977)** is "… to avoid to the extent possible the long- and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative." For non-repetitive actions, the E.O. states that all proposed facilities must be located outside the limits of the 100-year floodplain. If there were no practicable alternative to construction within the floodplain, adverse impacts would be minimized during the design of the project. National Park Service guidance pertaining to this E.O. can be found in Director's Order #77-2, Floodplain Management (National Park Service, 2003). It is National Park Service policy to recognize and manage for the preservation of floodplain values, minimize potentially hazardous conditions associated with flooding, and adhere to all federally mandated laws and regulations related to the management of activities in flood-prone areas. Particularly, it is the policy of the National Park Service to:

- restore and preserve natural floodplain values;
- avoid to the extent possible, the long- and short-term environmental impacts associated with the occupancy and modification of floodplains, and avoid direct and indirect support of floodplain development wherever there is a practicable alternative;
- minimize risk to life and property by design or modification of actions in floodplains, utilizing non-structural methods when possible, where its is not otherwise practical to place structures and human activities outside of the floodplain; and,
- require structures and facilities located in a floodplain to have a design consistent with the intent of the Standards and Criteria of the National Flood Insurance Program (44 CFR 60).

Capitol Reef National Park conducted a floodplain study (Berghoff, 1995a) and defined several actions to alleviate flood hazards.

Executive Order 11990 (1977), entitled “Protection of Wetlands”, requires all federal agencies to “minimize the destruction, loss or degradation of wetlands, and preserve and enhance the natural and beneficial values of wetlands.” Unless no practical alternatives exist, federal agencies must avoid activities in wetlands that have the potential for adversely affecting the integrity of the ecosystem. National Park Service guidance for compliance with E.O. 11990 can be found in Director’s Order #77-1 and Procedural Manual #77-1, “Wetlands Protection” (National Park Service, 1998). Particularly, it is the policy of the National Park Service to:

- avoid to the extent possible the long- and short-term adverse impacts associated with the destruction or modification of wetlands;
- preserve and enhance the natural and beneficial values of wetlands;
- avoid direct or indirect support of new construction in wetlands wherever there is a practicable alternative;
- adopt a goal of no net loss of wetlands and strive to achieve a longer-term goal of net gain of wetlands servicewide;
- conduct or obtain park-wide wetland inventories to help assure proper planning with respect to management and protection of wetland resources;
- use “Classification of Wetlands and Deepwater Habitats of the United States “ (Cowardin *et al.*, 1979) as the standard for defining, classifying and inventorying wetlands;
- employ a sequence of first avoiding adverse wetland impacts to the extent practicable; second, minimizing impacts that could not be avoided; and lastly, compensating for remaining unavoidable adverse wetland impacts at a minimum 1:1 ratio via restoration of degraded wetlands;
- prepare a Statement of Findings to document compliance with Director’s Order #77-1 when the preferred alternative addressed in an environmental assessment or environmental impact statement will result in adverse impacts on wetlands; and,
- restore natural wetland characteristics or functions that have been degraded or lost due to previous or ongoing human activities, to the extent appropriate and practicable.

4.3. State Water Resources Legislation Influencing Water Resources Management

State of Utah Water Quality Standards (1997)

Utah's Water Quality Standards recognizes that:

> ... the pollution of the waters of this state constitute a menace to public health and welfare, creates public nuisances, is harmful to wildlife, fish and aquatic life .... it is hereby declared to be the public policy of this state to conserve the waters of the state and to protect, maintain, and improve the quality thereof for public water supplies, for the propagation of wildlife, fish and aquatic life, and for domestic, agricultural, industrial, recreational, and other legitimate beneficial uses...

The standards developed by the State of Utah as they pertain to waters within Capitol Reef National Park are presented in Table 1 which provides designated use classifications for stream segments.

Table 1. Designated use classification for the Fremont River and tributaries.

Designated Use Classifications for Capitol Reef National Park		
Water Bodies	**Stream Segments Classification [a]**	**Designation**
Tributaries in North District which flow into Fremont R. east of park	Fremont River and tributaries from the confluence with Muddy Creek to Capitol Reef	2B 3C 4
Fremont River and its tributaries in the park	Fremont River and tributaries through Capitol Reef to headwaters	1C 2B 3A 4
Pleasant Creek and its tributaries in the park	Pleasant Creek and tributaries from east boundary of Capitol Reef to headwaters	1C 2B 3A
Tributaries in park which flow to Pleasant Creek east of park	Pleasant Creek and tributaries from confluence with Fremont River to east Boundary of Capitol Reef	2B 3C
Halls Creek	All tributaries to Lake Powell except as listed separately	2B 3B 4
Moody Creek and other small tributaries in southwestern margin of park	Escalante River and tributaries from Lake Powell to confluence with Boulder Creek	2B 3C

[a]1C - Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Department of Health ; 2B - Protected for secondary contact recreation such as boating, wading, or similar uses; 3A – Protected for cold water species of game fish and other coldwater aquatic life, including necessary aquatic organisms in their food chain; 3B- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain; 3C- Protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain; 4 - Protected for agricultural use including irrigation of crops and live stock watering.

The degree to which actual water quality meets these standards is discussed in National Park Service (1994) and in the water quality section (6.6) of this plan. In Capitol Reef National Park, waters are protected for domestic purposes with prior treatment, for secondary contact such as wading and boating, for cold and warm water species of game fish and other warm water aquatic life in specific stream segments, and for agricultural uses. A 1C designation for a drinking water source (treatment required) denotes a maximum total coliform count per 100 ml (30-day geometric mean) of 5000, and a maximum fecal coliform count per 100 ml (30-day geometric mean) of 2000. A 2B designation for recreational use restricts maximum total coliform count per 100 ml (30-day geometric mean) to 5000, and a maximum fecal coliform count per 100 ml (30-day geometric mean) to 200. The 4 designation for agricultural use restricts total dissolved solids to 1200 mg/L, the 3A designation requires that the maximum temperature not exceed 20^{o}C and total phosphorus as P not exceed 0.05 mg/L, and the 3B designation requires that the maximum temperature can exceed 27^{o}C.

State of Utah Safe Drinking Water Act (Title 19, Chapter 4) (1981)
The Utah Safe Drinking Water Act of the Utah Code enables the Utah Drinking Water Board to enact rules pertaining to public water systems. Utah, by agreement with the Environmental Protection Agency, administers the Federal Safe Drinking Water Act. The Utah Safe Drinking Water regulations apply to the parks. The act states that the owner or operator is responsible for providing a safe and reliable supply of water to its customers. The delivered water must meet all applicable maximum contaminant levels. Owners and operators must monitor water in accordance with R309-4, and meet water quality standards presented in R309-103. Records of this monitoring effort must be kept, and the operator or owner must notify the public if the owner cannot meet the standards or if there is an emergency according to R309-104.

The park has maintenance personnel who are trained and qualified to operate the drinking water systems and conduct the appropriate monitoring according to Utah regulations. The park also developed a drinking water source protection plan (Martin, 1998) which relates that no contaminant sources are delineated within the protection zones of the park's drinking water well.

State of Utah Stream Channel Alteration Act (73-3-29 of the Utah Code) (1971) which is administered by the Utah Division of Water Rights requires a permit to change the course, current, or cross section of a stream channel. Any disturbance which alters the bed or banks of a stream requires such a permit.

State of Utah Administrative Rules for Large Underground Wastewater Disposal Systems and Individual Wastewater Disposal Systems (R 317-501 and 317-513 of the Utah Administrative Code) governs the wastewater disposal in the State of Utah. The state delegated administration of these regulations to local health departments. Parks must adhere to these regulations.

4.4. Local Planning Regulations

Regulations pertaining to water resources at the county level for Emery, Wayne, Garfield, and Sevier are few. Those regulations that affect septic system placement, stormwater management, and construction on private lands near park boundaries could impact water resources in the park.

5. LAND USE IN THE PARK AND ITS ENVIRONS

The lands adjacent to Capitol Reef National Park and in the park support multiple land and resource uses that affect streamflow or water quality, including:

- agriculture and irrigation along the Fremont River;
- orchard irrigation in the park;
- grazing on Forest Service, state, and park lands;
- canals and ditches above as well as in the park, for irrigation water;
- logging and silviculture on nearby National Forests;
- wildfires and fire management in the National Forest and park;
- livestock trailing through the park;
- recreation in the park as well as upstream in the National Forest, including off-road vehicles, hiking, camping, horseback riding, hunting, and fishing;
- potential land exchanges between the State of Utah and federal or private entities;
- dumps and sometimes spills;
- roads, trails, and highways (with possible spills);
- old mines, and exploration for minerals, oil, gas, or other extractives on State of Utah or Forest Service lands (Millennium, 2002; National Park Service, 2001a).

Grazing affects watersheds in the Fremont basin, especially in the upper reaches, and cattle drives impact the riparian areas of some of the creeks and sections of the river within the park and National Forests. Herds first came into the area in the late 1800s, extending into the early 1900s, and the sheep and cattle of that era left long-lasting scars on the landscape. By the early 1930s, the range in and around the Capitol Reef area was severely damaged by grazing. Thousands of cattle and sheep impacted Oak, Pleasant, and Halls creeks and other watersheds, and riparian areas were affected, especially since animals were not properly rotated or managed. The grazing eliminated cottonwoods along the Fremont River at one time (Frye, 1998). Sections 8.9 and 8.10 describe these cattle effects.

Cattle trailing is legislated into the park for perpetuity as an official historic activity or cultural feature, and several ranchers drive cattle up or down Oak and Pleasant creeks, in the Cathedral Valley area, and along U-24. Trailing in Oak and Pleasant creeks as well as other areas of the park is detailed in Section 8.10.4.

Logging and forestry upstream from the park can contribute sediment and other pollutants to streams. Section 8.10.5 looks at the topics of forestry and fires, especially activities in the headwaters of Oak and Pleasant creeks.

Recreation in the park and upstream in the two National Forests, Dixie and Fishlake, produces waste and contaminants, and second homes or other human presence in the National Forest can affect the park downstream. All-terrain vehicles (ATVs) in the National Forest sometimes trespass in the park, causing erosion and turbidity, as discussed in Section 8.14 on abandoned roads. State Highway 24, in the heart of the park, affects riparian areas, floodplains, and wetlands with road runoff and presents a threat of spills from trucks (Millennium, 2002; Range, D. Dixie NF and Hamilton, R, Fishlake NF, pers. comm., 2003).

Land exchange at the boundaries of the park could possibly cause the ground-water elevation in certain geological formations to decrease. A briefing report submitted to the Water Resources Division of the National Park Service presented several of the park's concerns regarding Wayne County's proposal to exchange land (Hansen, B., NPS-WRD, pers. comm., 2002). Approximately six miles of the eastern park boundary, now shared with the BLM, may become private if the federal land near Notom is exchanged with the state, and subsequently sold to private individuals. This topic is reviewed in Section 8.11.

As reviewed in Sections 8.9 (Halls Creek), 8.12 (mining), and 8.14 (abandoned roads), no major mining is active in the park or adjacent watersheds; however, erosion from abandoned mining roads is still an issue. Oil and gas exploration can occur on nearby non-park lands, and impacts from these activities is a concern for the future. Section 8.12 on mining and minerals reviews the potential impacts of oil and gas in the area. Tar sands also have been recognized as a potential source of oil on lands adjacent to the park; therefore, tar sand development could affect the Halls Creek drainage in the future, as described in Section 8.9 on Halls Creek.

Wildfires and prescribed fires in the National Forests impact watersheds, potentially releasing sediment or nutrients into streams. The increased surface runoff from burned areas can cause streambank erosion downstream and impact riparian areas, degrading water quality. Section 8.10 (Oak and Pleasant creeks) summarizes prescribed burns in the adjacent National Forest and describes water quality monitoring of fire areas.

Water quality problems as discussed in Sections 6.6 and 8.6 were identified by the State and portions of the Fremont River were placed on the 303(d) list of waters that were impaired for designated uses. The State of Utah, the Natural Resource Conservation Service, the Utah Association of Conservation Districts, the local soil district, and others worked together to prepare a water quality management plan for the Fremont River Basin in 2000-2001, to encourage better land use. Actions proposed in the plan included: 1) improvement of livestock distribution to reduce cattle impacts 2) protection of riparian vegetation; 3) maintenance of roads properly; 4) improvement of fish hatchery management; 5) improvement of irrigation management, and 6) protection of channels (Millennium, 2002).

6. EXISTING WATER RESOURCE CONDITIONS

6.1. Climate

Capitol Reef National Park has a semi-arid to arid climate with mild, dry winters and warm to hot summers. Elevations ranging from 3880 ft (1183 m) at the southern boundary to 8960 ft (2731 m) in the northwestern portion of the park indicates that climate is highly variable.

Data from the Western Region Climate Center (<www.wrcc.dri.edu>) show for the period of record (1967 to 2001) that temperatures at park headquarters ranged from an average maximum high of 91^{o}F (33^{o}C) in July to an average minimum low of 18^{o}F (-7.8^{o}C) in January (Figures 2 and 3). Temperature at the higher elevations may reveal lower maximums and minimums. Annual average total precipitation is 7.56 in (192 mm) and an annual average of 15.5 in (394 mm) falls as snow (Figures 4 and 5).

The arid environment of the Capitol Reef encourages strong winds, particularly during the spring months when cool air masses mix with warming of the earth’s surface. Another climatic phenomenon associated with the Colorado Plateau is the influx of monsoon air from the south, which typically results in a summer rainy season from July through September, when approximately half of the annual precipitation falls.

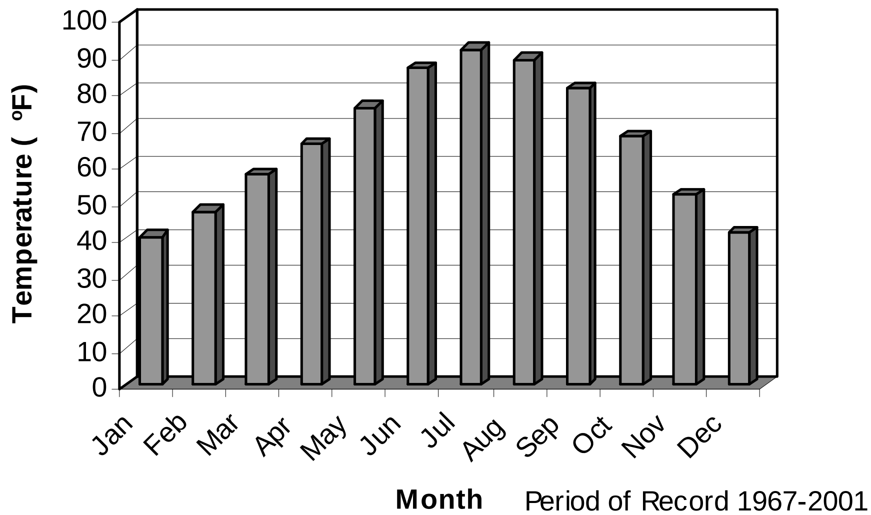


Figure 2. Mean maximum temperature at Capitol Reef headquarters.

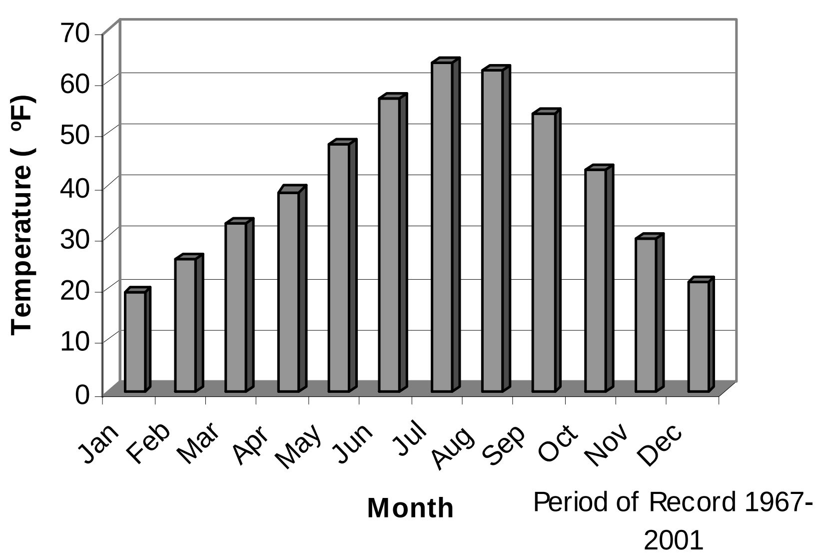


Figure 3. Mean minimum temperature at Capitol Reef headquarters.

Figure 4. Mean monthly total precipitation at Capitol Reef National Park headquarters.

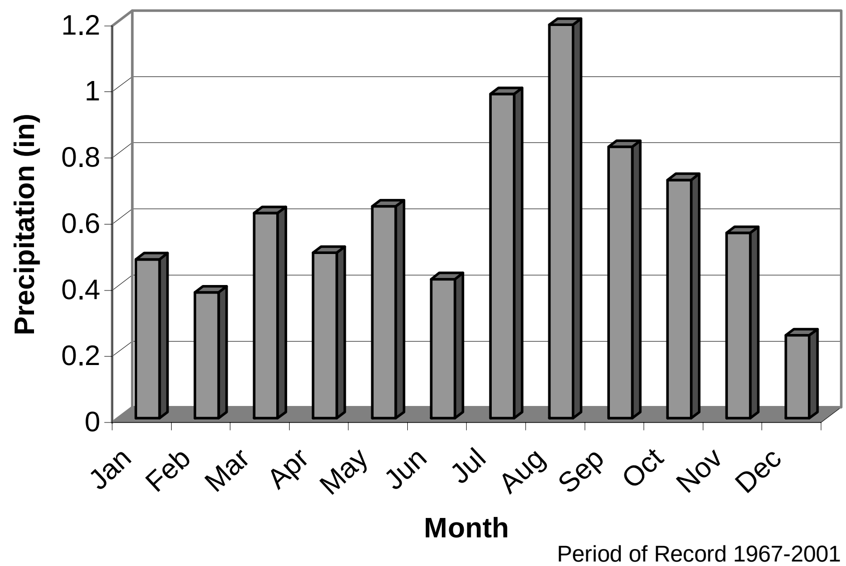
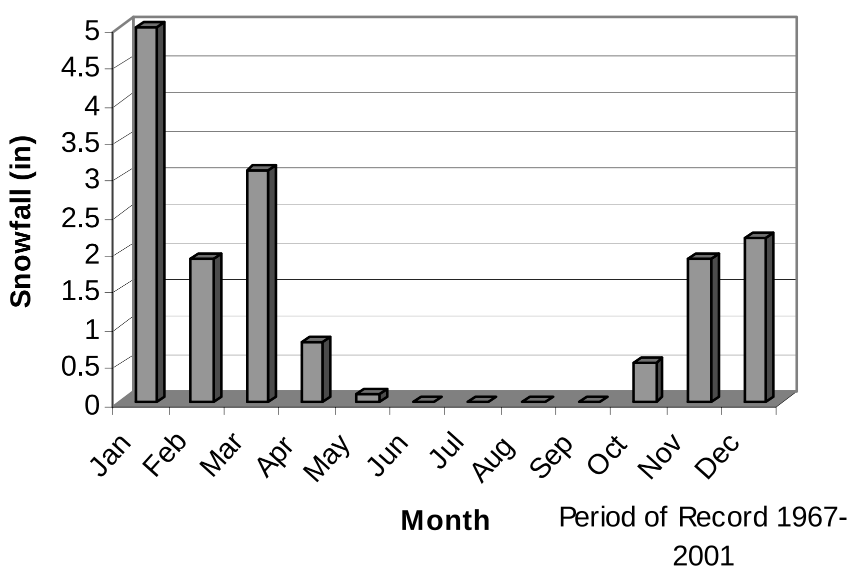


Figure 5. Mean annual total snow at Capitol Reef headquarters.



6.2. Soils

The Natural Resource Conservation Service completed a soil survey report and soils map for Capitol Reef National Park (US Department of Agriculture, 1991). With bare rock surfaces being a compelling aspect of the park, soils are less noticeable except in Fruita, along creeks, in between sandstone formations, and in the Cathedral District of the park. The soils generally consist of shallow, friable eolian and alluvial deposits. Soil pattern within the area includes deep and moderately deep soils derived from sandstone formations, shallow to deep soils that overlie shales, shallow rocky soils, and deep sand along the numerous desert washes. The soils are well drained and have medium to fine textures (National Park Service, 1974).

Soils located in the lower elevations are typically hot and dry with poor development, while those at higher elevations are cool and moist. Soils found in eolian deposits, derived from sandstone, range from sandy loam to sand. Those derived from shale parent material range from clay loam to clay. Deeper soils are found in the valley alluvial fills, whereas shallow soils and exposed sandstone are found on rims, benches, and slopes associated with monoclines.

Since erosion rates are high, little or no soil development occurs in many places. Overgrazing by livestock has led to an increase in precipitation runoff and erosion of soils. Vast changes in plant cover and composition have been the result, as have the downcutting of streams and the loss of the A-horizon from the soil profile (Barth and McCullogh, 1988).

Deep alluvial soils have become established in wide stream valleys in which the creeks flow through the soft, erodible substrate such as the Entrada Sandstone, Moenkopi, or Chinle Formation (National Park Service, 1987).

6.3. Geology

6.3.1. Stratigraphy

Capitol Reef National Park lies along an eastward dipping monocline, called the Waterpocket Fold, which trends north-south for approximately 160 km (100 mi) (Harris and Tuttle, 1992). This geologic feature was one of the main reasons for the establishment of Capitol Reef National Monument in 1937 (Figure 6). The so-called Reef refers to the barrier prohibiting pioneers' easy migration west, much like an ocean reef which prevents sea-farers from reaching land. The Capitol refers to the dome-like features of the Navajo Sandstone likened to our federal government's Capitol in Washington, D.C. (Harris and Tuttle, 1992; Billingsley *et al.*, 1987).

The geology of the Capitol Reef area was first described by Gilbert in 1887 and C.E. Dutton in 1880. Later geologic investigations included specific studies on oil and gas resources (Gilluly and Reeside, 1928), coal and uranium (Gregory and Moore, 1931; Smith *et al.*, 1963), and general studies on the establishment of Capitol Reef National Monument (Gregory and Anderson, 1939) and the Henry Mountains Region (Hunt *et al.*, 1953).

Figure 6. Photograph of the Waterpocket Fold

While older rocks dating to Precambrian times appear deep in the Grand Canyon, only the top strata found at the Grand Canyon present themselves as the very bottom strata in Capitol Reef (Fillmore, 2000) (see Table 2 for stratigraphy and Figure 7 for a general geology map). Times of deposition starting with the arid Permian Period (286-245 million years before present (mybp)) laid down the White Rim Sandstone, an eolian formation, and its marine counterpart, the Kaibab Limestone. These depositional materials were derived from the uplift of the Uncompahgre highlands, a late Paleozoic tectonic event (Fillmore, 2000). Both of these formations are found in the Fremont Gorge, the Goosenecks of Sulphur Creek, and Pleasant Creek.

Prior to the Triassic Period (245-208 mybp), the ocean environment receded, and the top layers of the Kaibab eroded, leaving an unconformity. During the Triassic Period, rivers coursing from the Uncompahgre highlands dumped loads of sediment in the park area resulting in the establishment of the Moenkopi Formation, readily seen west of park headquarters and along the flanks of the Waterpocket Fold and Miner's Mountain. This formation reveals well-preserved ripple marks (Christiana and Rasmussen, 1991). The Chinle, another Triassic Formation, is dominated by shale and siltstone, and appears as a band along the Waterpocket Fold above the Moenkopi Formation. Three strata, collectively called the Glen Canyon Group, formed during the Jurassic Period (208-144 mybp); they include the Wingate Sandstone, the Kayenta Formation, and the Navajo Sandstone. The Wingate, an eolian formation, stands red and sentinel above the park headquarters and is a main feature of the Waterpocket Fold. The Kayenta Formation, which is relatively indistinguishable from the underlying Wingate is a fluvial deposit. The Navajo Sandstone, represents an extensive dune system. The prominent domes, spires, and ridges of the Navajo Sandstone instigated the name "Capitol Reef".

Table 2. Stratigraphy and hydrologic characteristics of water-bearing formations in Capitol Reef National Park.

Age	Formation	Geologic Events	Hydrologic Characteristics
QUATERNARY	Unconsolidated rocks, alluvium, colluvium	Mass wasting, stream erosion, canyon cutting, glacial climate.	Contain water only beneath stream channels. Water generally high in dissolved solids, though can be fresh in the mountains, Low to high permeability.
TERTIARY	Basalt flows, minor intrusives	Extrusive and intrusive activity, uplift and deep fluvial erosion	Unknown, however, cinder cones and basalt probably are good recharge medium, Probably not saturated.
CRETACEOUS	Mesaverde Formation	Waterpocket Fold formed during Laramide orogeny	Low permeability. Yields an estimated 10 gpm to a slightly saline spring. Might produce more water to wells that penetrate fully saturated sections, but probably saline.
	Mancos Shale: Masuk Member	Sandy shales deposited in oscillating sea	Very low permeability. Shale inhibits drainage of water from overlying consolidated rocks. Unleached debris from this member, where present in alluvium, contributes to the salinity of ground water in the alluvium.
	Emery Sandstone Member		Caps South Caineville Mesa. Very low permeability. Yields small amounts of saline water to springs and seeps.

	Blue Gate Member		Very low permeability. Debris from this member, where present in alluvium, contributes to the salinity of ground water in alluvium.
	Ferron Sandstone		At edge of Caineville Monocline. Generally low permeability. Yields small amounts of slightly saline water to springs.
	Tunuk Member		At edge of Caineville Monocline and in bottom of North Blue Flat. Low permeability.
	Dakota Sandstone	Non-marine, then shore deposits in transgressing sea.	Very low to low permeability. May be a source of water locally, but thinness and discontinuity indicate it is not an important aquifer in the study area.
JURASSIC	Morrison Formation: Brushy Basin Shale Member	Bray-green and maroon clays, dinosaur bones in floodplain deposits.	Contains variegated beds of bentonite, preventing deep infiltration. Very low permeability. Barren surfaces contribute much to sediment to surface runoff during thunderstorms; sediment seals surface of otherwise permeable alluvium and reduces permeability when mixed with alluvium.
	Morrison Formation: Salt Wash Sandstone Member	Conglomerates, siltstones; contains uranium	Yields perched water under artesian pressure at well (D-287)36bbb-1. Low permeability, but potential aquifer where fully saturated. Water is mainly sodium sulfate type.
	Summerville Formation	Sand dunes; shales on tidal flats and in shallow lakes.	Very low permeability. May supply water to a few seeps, but would be saline and of calcium sulfate type.
	Curtis Formation	Green shales, tidal-flat deposits.	Caps bluffs of Entrada Sandstone. Generally low permeability. Any water in aquifer is probably saline.
	Entrada Sandstone	Reddish brown sandstone, shallow water deposits.	Yields water to wells in adjacent areas, Hanksville. Overall permeability is low. Source of small amount of slightly to moderately saline water in the Burr and San Rafael deserts.
JURASSIC	Carmel Formation	Shales, limestone, gypsum deposited by advancing and retreating seas.	Yields water where fractured or included limestone is cavernous. Water is generally saline. Very low to locally very high permeability.
TRIASSIC	Navajo Sandstone	Accumulation of white, well rounded sand grains in cross-bedded dunes; cliff former.	Major aquifer. Massive sandstone. Water saline where deeply buried. Large yields obtained where fully saturated, thick and under confined conditions.
	Kayenta Formation	Fluvial, interbedded red shale and sandstone; slope former.	Contains siltstone beds that separate Navajo from Wingate aquifers. Very low to low permeability. Leakage through formation where it is sandy or fractured. Springs or seeps occur near the contact with the Navajo in the bottoms of canyons.
	Wingate Sandstone	Bright red sandstone, cross-bedded dunes; cliff former.	Potentially a source of water to supplement that from Navajo. Probably has lower intergranular permeability than Navajo, but probably equal to it in fracture permeability. Yields small quantities of fresh to moderately saline water to a few springs where rocks are jointed. Due to low permeability, the Wingate, where buried, probably is more saline that Navajo.

	Chinle Formation: Shinarump Member	Conglomerate; contains uranium.	Generally low permeability. Mainly sandstone in this locality. Thin and discontinuous. Most of formation is too fine-grained to accept much recharge; enhances runoff and contributes much to sediment in water. May contribute small amounts of water to seeps.
	Moenkopi Formation: Upper Unit	Brownish red shales, gypsum, sandstones in tidal-flat deposits; "ripple rock".	Very low to low permeability. Sandstone units yield small quantities of fresh to moderately saline water.
	Sinbad Limestone Member		Low permeability in most areas; where the limestone is near the surface or has been strongly fractured, ground water circulation probably has caused cavernous development and enhanced permeability.
	Lower Unit		Similar to upper part of the Moenkopi Formation.
	Kaibab Limestone	Dolomitic limestone, siltstone	Very low to moderate permeability. Undisturbed formation probably has low permeability; where fractured by folding or faulting, secondary permeability may be moderate.
	Cutler Formation: White Rim Sandstone	Marine Sandstone	Very low to moderate permeability. No direct data available, but formation estimated to have characteristics similar to Navajo, including effects of fracturing. Where deeply buried, water probably slightly saline, but in and near outcrops, as in central part of Capitol Reef, water may be fresh.

(compiled and adapted from Christiana and Rasmussen, 1991; Harris and Tuttle, 1992; Hood and Danielson, 1979, 1981)

Also during the Jurassic Period, deposition of the Carmel Formation capped the Navajo particularly in the area of the Golden Throne near Capitol Gorge, and is exposed on the eastern flank of the Waterpocket Fold. This marine formation consists of different layers of limestone, mudstone, sandstone, and gypsum salts. After the seas retreated, wind-blown sand was deposited forming the Entrada Sandstone. This easily eroded formation exists in Cathedral Valley. The white Curtis Formation, found along the northeast and east sides of the fold, forms steep cliffs in the South Desert. A marine formation, the Curtis, was followed by accumulation of tidal and mud flat material known as the Summerville Formation. Cedar Mesa Campground area is representative of this formation. These last four strata comprise the San Rafael Group. Lastly, the Morrison Formation, representing ancient deposits from rivers and lakes, supported an environment ripe for the proliferation of dinosaurs. This formation is found east and northeast of the Waterpocket Fold and is also known for its uranium deposits as is the Chinle Formation.

During the Cretaceous Period (144 to 66 mybp), sand bars from subsequent encroachment and subsidence of an invading sea formed. These sand bars now comprise the Dakota Sandstone found in the park's Waterpocket District. Atop the Dakota Sandstone, the Mancos Shale is comprised of five members. Mostly exposed in a broad band east of the Fold, the Mancos Shale's dull, gray, color is attributed to the deep water, marine deposition of its sediments. Other Cretaceous age sedimentary layers cap the Mancos on nearby mesas, these layers include the Mesaverde Group and represent the youngest sedimentary rocks in the park.

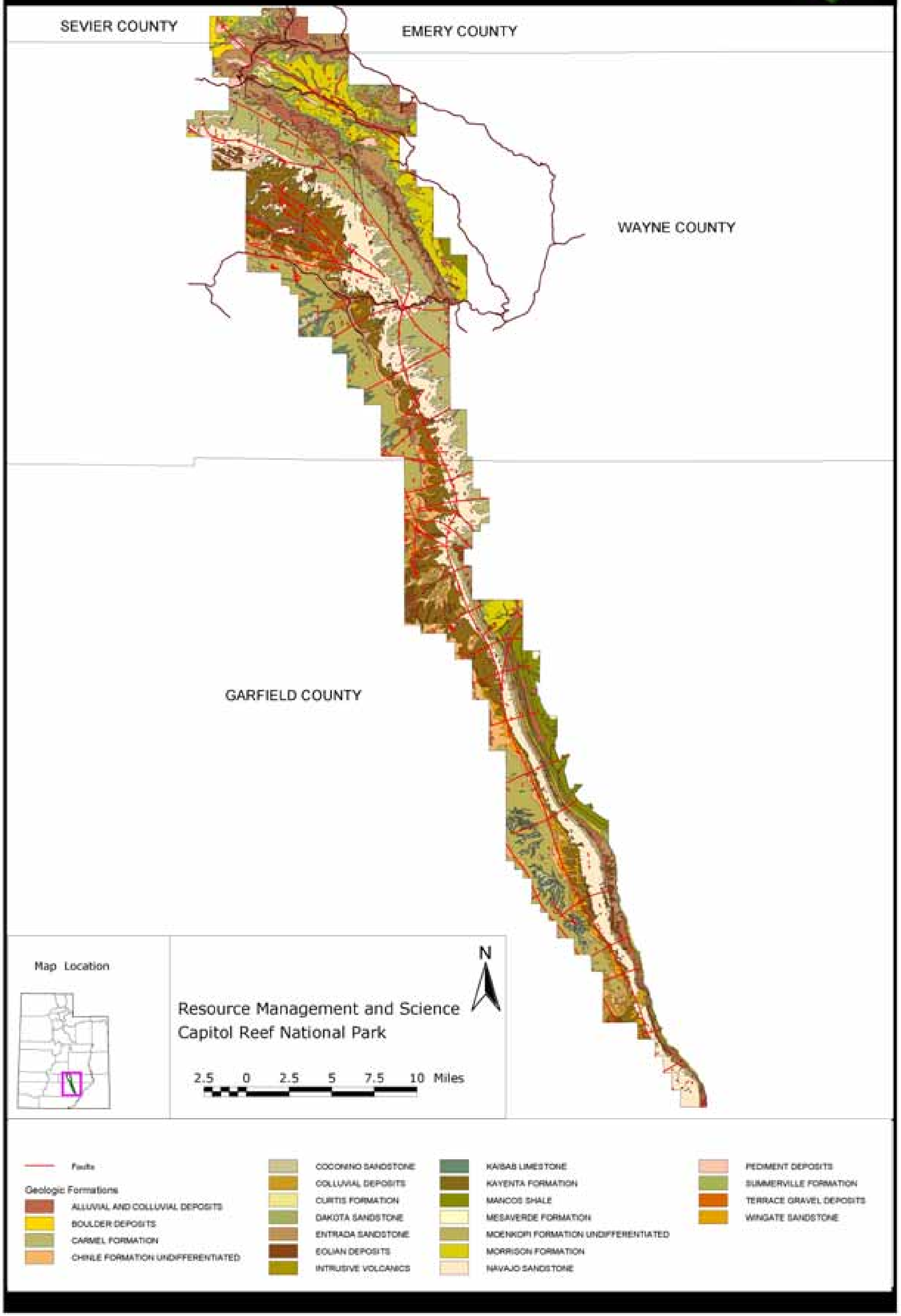


Figure 7. Generalized Geologic Map of Capitol Reef National Park

National Park Service
U.S. Department of the Interior

At the end of the Cretaceous, the Western Interior Sea receded from the region, and tectonic activity in the Sevier orogenic belt ceased. Where compressional stress transferred eastward, uplifts occurred in the previously flat sedimentary basin of the region. The Laramide orogeny is marked by the formation of the modern Rocky Mountains and mild upwarps such as the Waterpocket Fold (Fillmore, 2000). Biological and geological events occurring during the Tertiary Period (66 to 1.6 mybp) have molded the modern landscape. Stretching of the earth's crust followed the compression, uplifting, and fracturing that accompanied the Laramide orogeny. Magma began to rise and pushed into weakened crustal zones (Harris and Tuttle, 1992). The magma also intruded into sedimentary layers which were later uplifted and eroded. Dikes and sills in the park's Cathedral District mark this activity. Some magma reached the surface of the earth as basaltic lava, particularly on the present day Aquarius and Fishlake plateaus. Much later during Pleistocene times, glacial activity scoured the lava cap and moved the basaltic rock miles resulting in the rounded boulders which litter the exposed surface of the park's sedimentary rock.

Regional uplift beginning in either the Cretaceous or early Tertiary periods resulted in a 12,000-foot rise of the Colorado Plateau, which reaches elevations of 11,000 feet (mean sea level). Uplifting and exposure brings erosion, and today's land surface is abraded by wind and water. The Pleistocene and Holocene (Recent) epochs comprise the Quaternary Period (1.6 mybp to present). This is the time when the Fremont River developed a course across the fold, and new drainages including Halls and Sandy creeks began to flow parallel to the monocline.

These creeks, rivers, and slopes associated with the fold provide for deposition of alluvial and colluvial sand and gravels. The alluvial material, associated with streams and creeks, may reach thicknesses ranging from 10 to 40 feet (3 to 12 m). The alluvial sand and gravels and the Navajo Sandstone prove to be some of the most important water sources in Capitol Reef National Park as presented in Section 6.4.

6.3.2. Structure

Several important structural features are found in the area around and including Capitol Reef National Park. They include the Waterpocket Fold, the Teasdale and Fruita anticlines, and the Teasdale Thousand Lake faults (Smith *et al.*, 1963).

The Waterpocket Fold, formed during the early Tertiary Period, is one of the major features of the Colorado Plateau, and as with all monoclines reveals several characteristics including a single direction of dip and a great length to width ratio.

The Teasdale anticline trends northwestward and parallels the Teasdale fault. It plunges northwestward and southeastward with dips ranging from 10^o to 50^o. The Fruita anticline, approximately 10 km (6 mi) long, is a doubly-plunging asymmetrical anticline along the Waterpocket Fold.

The Teasdale fault is a high-angle to vertical normal fault, and trending northwestward, extends approximately 40 km (25 mi). The Thousand Lake fault, along the west side of Capitol Reef, is also a high-angle fault that trends generally northward. Total vertical displacement is approximately 800 m (2500 ft) (Smith *et al.*,1963).

Another structural feature critical to water resources in the park are joints, particularly within the massive sandstone units where steep-sided ravines are eroded along them. Passage through the Navajo Sandstone within the park is almost impossible as a result of dissection along the joints. These joints allow for infiltration of precipitation and recharge of the local and regional aquifers.

6.3.3. Mining Activities

The history of mining in the Capitol Reef area falls into four periods: (1) an early, generally unsuccessful search for gold or other metals; (2) the uranium boom of the 1950s; (3) some limited mining of other types in the area; and (4) more recent oil and gas exploration and interest in coal strip mining for power production. When the monument was first proposed in the early 1930s, there had been a few, but mostly unsuccessful attempts to mine in the Waterpocket Fold. Some gold, oil, copper, uranium, and other minerals occur in the area, but were not found in the quantities to make the mining worthwhile at that time (Smith *et al.*, 1963; Frye, 1998).

Uranium and radium mining came to the Capitol Reef area by the early 1900s. Then in the early 1950s, when Capitol Reef National Monument was still open to mining, the Atomic Energy Commission offered price supports and encouragement to uranium miners, and thousands of would-be prospectors descended on the area in search of this commodity. Over 10,000 claims were filed on lands near the National Monument of the time, later to be incorporated within the expanded National Park boundary. Prospecting was especially active during the 1953-55 period, but the situation changed significantly in 1976 with the passage of the Mining in the Parks Act. The act gives NPS officials tighter control over mining in parks and prohibits new claims in parks and monuments, and in national recreation areas (Smith *et al.*, 1963; Frye, 1998).

Petroleum deposits are generally associated with the geologic formations found in and near the park, and although oil exploration began in this area of Utah as early as the 1920s, success has been limited. During the 1950s, oil exploration test holes were drilled in the Circle Cliffs area on BLM lands just west of the southern end of the park. Today, the BLM and Forest Service issue oil and gas leases on lands near the park boundary, and given the current, renewed focus on energy development in the U.S., oil development adjacent to the park is a strong likelihood. Tar sands are another potential source of oil that occasionally has gained interest. Large deposits of oil-bearing sandstones occur in the Circle Cliffs area. In 1984, a proposal for a tar sand project evolved, including the preparation of a BLM Draft Environmental Impact Statement (EIS) for the project (Christiana and Rasmussen, 1989; Bureau of Land Management, 1984; Bureau of Land Management, Richfield District, 1988).

Two fairly large coal fields exist near the park. The southern end of the Emery coal field lies approximately five miles north of the park boundary, and at the present time this field is supplying coal to power plants. The Henry Mountains coal field lies between the park's eastern edge and the Henry Mountains, within sight and sound of the Waterpocket District of Capitol Reef. Situated close to the park's boundary, this coal field contains over 200 million tons of coal available for strip-mining.

6.4 Hydrogeology

6.4.1. Aquifer Types

Studies of ground water within Capitol Reef remain limited even with the relatively recent development of a new drinking water well for the park, a well head protection study (Martin, 1998), and a study of impacts related to potential ground water development in the Notom area (Cutillo, 2002). Most historical studies relate to development of ground-water resources. Marine (1962) discussed the water supply potential at Capitol Reef National Monument. Hood and Danielson (1979), Hood (1980), Hood and Danielson (1981), and Blanchard (1986a) discussed prospects for development of the Navajo Sandstone ground water in areas including Capitol Reef National Park. Weigel (1987) provided a compilation of hydraulic conductivity, transmissivity, and porosity values for the Mesozoic formations near the park. Bjorklund (1969) discussed ground-water resources in the Upper Fremont River Valley. Regional studies deal with modeling of ground-water flow in areas surrounding the Colorado River (Weiss, 1987). Generally, these latter two studies indicate that in the area of Capitol Reef ground water flows from west to east towards the Colorado River.

Storage of ground water within Capitol Reef occurs within three types of geologic units: sedimentary bedrock formations, unconsolidated deposits, and basalt flows that overlie bedrock and unconsolidated deposits (Christiana and Rasmussen, 1991) (see Table 2).

- Major sedimentary aquifers include the Entrada, Navajo, Wingate, and White Rim (formally thought to be the Coconino Sandstone) sandstones (Marine, 1962).
- Alluvial and eolian deposits, colluvium, terrace gravels, and pediment deposits comprise the unconsolidated deposits supporting aquifers. Principal alluvial aquifers within Capitol Reef include areas along 1) the Fremont River in Fruita, 2) Pleasant Creek in the vicinity of Sleeping Rainbow Ranch, 3) Sulphur Creek, and 4) Hall's Creek.
- Basalt flows in the Thousand Lake and Boulder mountains are highly fractured and serve as a ground-water source. Basalt flows also occur along the edges of valley floors near Bicknell Bottoms, Torrey, and at the base of Thousand Lake Mountain.

6.4.2. Hydrologic Characteristics of Ground Water

Few data are available regarding hydrologic characteristics of the various aquifers within the park. A new drinking water well was drilled in 1993 in the Fruita area, near the mouth of the Fremont River Gorge. This well supplies the park headquarters, residential area, and campground with potable water. Martin (1993) estimated the hydraulic conductivity at 160 ft/d (49 m/d) and the transmissivity at 6000 gpd/ft (155 m^3pd/m) for the sandstone lens which the well intersects. This 5-foot thick bed ranges from 68 to 73 feet (20-20m) below ground and is within the Moenkopi Formation. No hydraulic gradient, direction of ground-water flow, or effective porosity was calculated since no other wells had been drilled in the area (Martin, 1993). However, Martin (1993) offered that the direction of ground-water flow is towards the northeast and that the effective porosity is 25% based on textbook estimates. Due to proposed drilling and development of deep wells in the Notom area, Cutillo (2002) used Martin's estimates to model potential impacts to ground-water resources along the eastern boundary of the park. She mentioned the lack of other wells in Capitol Reef from which to calculate transmissivity, hydraulic conductivity, and storativity.

Other studies of hydrologic properties are presented in Weigel (1987) and these are provided in Table 3. These figures represent field and laboratory methods. Hydraulic conductivity, a measure of the ability of a medium to transmit a liquid, is scale - dependent resulting in different estimates. Values obtained in the laboratory are an estimate of the rock matrix hydraulic conductivity, while field methods estimate hydraulic conductivity of the regional aquifer. Weigel's work focused on an area near Capitol Reef, but did not include any wells in Capitol Reef.

Hydraulic conductivities range from very low values of (9.1×10^{-6} m/day) in the Dakota Sandstone to 0.67 m/day in the Navajo Sandstone. These numbers are based on laboratory methods. Transmissivity, the ability of a rock formation to transmit water, ranges from 0.073 m^2/day in the Curtis Formation to 3049 m^2/day in the Navajo Sandstone using specific capacity calculations. Transmissivity, using aquifer tests, ranges from 488 to 793 m^2/day in the Navajo Sandstone. Weigel (1987) also provided effective porosities, which are measures of the volume of interconnected pores available for movement of fluid per unit volume of material, exclusive of large fractures. Laboratory estimates range from 4% in the Dakota Sandstone to 26% in the Navajo Sandstone and 31% in the Wingate Sandstone.

A hydrogeological report for Sandy Ranch (Campbell, 1975) discussed the potential of developing a drinking water well in the Navajo Sandstone. The report also mentions three wells: the Weaver well, the Caineville well, 20 miles north of Sandy Ranch, and the Colt well. The potentiometric surface was measured at 5055 feet (1541 m) in the Weaver well. The Caineville well produced an impressive 3 cfs (cubic feet per second; 0.08 m^3/s) with a potentiometric surface of 5080 feet (1548 m). Cutillo (2002) presented data for seven wells in the Notom area. The well logs indicated that water is drawn from the Navajo Sandstone at 1000-1800 feet (305 – 549 m) below ground surface.

6.4.3. Recharge

Recharge in Capitol Reef National Park occurs principally from infiltration of precipitation. Direct recharge from precipitation at the park's lower elevations is minimal, but important, considering the lack of annual precipitation. However, at higher altitudes on Boulder and Thousand Lake mountains where precipitation is higher, recharge may be considerable. These relatively flat-surfaced areas capture water which infiltrates to lower strata. Few perennial streams mark the mountain surfaces and thus drainage of water is expected to be subsurface. Additional sources of recharge to regional aquifers are incidental and in the form of infiltration from ditches, canals, and irrigated pasture.

No data are available to derive the distribution of recharge to the park and adjacent basins.

Recharge to sedimentary units occurs where the mantle of colluvium and streambed alluvium maintains a saturated zone in contact with the underlying bedrock. Streamflow is a direct source of recharge where the streams cross outcrops of permeable rock and the ground-water level is below the streambed. Recharge to the Navajo Sandstone in the vicinity of Capitol Reef is along the Waterpocket Fold, and ranges from 6.2 to 8.6 million m^3/yr. This value included recharge directly from precipitation in the area of the

Table 3. Hydrologic properties of aquifers in the Capitol Reef area.

Formation	Location T R S quad	Method	Hydraulic Conductivity (m/day)	Hydraulic Conductivity (Horiz. m/day)	Hydraulic Conductivity (Vert. m/day)	Anistropy Ratio	Transmissivity (m2/day)	Effective Porosity (%)
Blue Gate	28 9 29 bdb-1	SC					1829	
Blue Gate	28 9 30 dad-1	SC					1738	
Brushy Basin	30 11 5 adb-1	SC					104	
Mesaverde	27 9 27 abb	Lab		0.2				
Dakota	32 8 18 bda	Lab		9.1E-06				3.7
Dakota	25 4 8 da	DST	0.0037					
Morrison	30 11 5 cbb	Lab		0.43				
Morrison	29 7 23 caa	Lab		3.7				
Salt Wash Member	32 8 18 aca	Lab		0.0011				3.7
Salt Wash Member	29 7 36 ddb	Lab		0.017				6.4
Salt Wash Member	28 11 18 aac	Lab		0.052				13.4
Carmel	28 8 33 cdd-1	DST	0.012					
Carmel	26 9 22 bcb	Lab		8.2E-04				
Carmel	27 7 7 bcc-1	SC					61	
Curtis	26 9 22 dbc	SC					0.073	
Entrada	26 9 22 cba	Lab		0.034				
Entrada	33 9 32 aab	Lab		0.26				
Entrada	28 11 15 bdc-1	SC					128	
Entrada	28 11 16 cba-1	SC					9	
Entrada	28 11 16 dad-1	SC					16	
Entrada	28 11 21 abd-1	SC					12	
Entrada	28 11 28 bdd-2	SC					37	
Entrada	29 11 36 daa-1	SC					143	
Entrada	29 11 1 bbc-1	SC					162	
Entrada	35 3 8 aba-1	SC					0.40	
Entrada	35 3 29 bbd-1	SC					0.10	
Entrada	35 11 16 cdd-1	SC					125	
Navajo	28 7 27 cdb-1	AQ					793	
Navajo	28 8 29 cdc-1	AQ					488	
Navajo	28 8 29 dcb-1	AQ					488	
Navajo	28 8 33 cdd-1	AQ					488	
Navajo	28 8 33 bbb-1	AQ					518	
Navajo	28 8 29 dcb-1	SC					1250	
Navajo	28 8 29 dcb-1	SC					823	
Navajo	28 8 33 bbb-1	SC					396	
Navajo	28 8 33 bbb-1	SC					610	

Table 3 (continued). Hydrologic properties of aquifers in the Capitol Reef area.

Formation	Location T R S quad	Method	Hydraulic Conductivity (m/day)	Hydraulic Conductivity (Horiz. m/day)	Hydraulic Conductivity (Vert. m/day)	Anistropy Ratio	Transmissivity (m2/day)	Effective Porosity (%)
Navajo	29 4 25 dcb-1	SC					396	
Navajo	29 4 26 dac-1	SC					3049	
Navajo	31 7 36 dad-1	SC					122	
Navajo	33 4 35 cbb-1	SC					2348	
Navajo	33 4 36 abb-1	SC					73	
Navajo	28 8 33 cdd-1	DST	0.23					
Navajo	28 8 33 cdd-1	DST	0.55					
Navajo	26 9 21 aab	Lab		0.67				
Navajo	28 7 27 cdb-1	Lab		0.24	0.16	1.5		20.5
Navajo	28 7 27 cdb-1	Lab		0.13	0.16	0.79		20.7
Navajo	28 8 33 bbb-1	Lab		0.052	0.020	2.5		22.3
Navajo	28 8 33 bbb-1	Lab		0.14	0.037	3.9		20.4
Navajo	28 8 33 bbb-1	Lab		0.0046	0.011	0.43		22.5
Navajo	28 8 33 bbb-1	Lab		0.10	0.052	1.9		20.4
Navajo	28 8 33 bbb-1	Lab		0.12	0.076	1.5		22.5
Navajo	28 8 33 bbb-1	Lab		0.14	0.13	1.0		22.3
Navajo	31 7 28 ddb	Lab		0.0026	0.0064	0.38		
Navajo	34 8 15 bcc	Lab		0.82	0.28	3.0		17.4
Navajo	34 8 16 dad	Lab		6.7E-04	3.35E-04	2.0		16.1
Navajo	35 4 1 da	Lab		0.13	0.076	1.7		25.6
Navajo	35 4 1 da	Lab		0.27	0.140	1.9		14.2
Chinle	26 9 9 bcd	Lab		0.017				
Kayenta	26 9 16 dbd	Lab		0.082				
Kayenta	35 9 29 ccb	Lab		0.104				
Shinarump Member	30 6 9 aaa	Lab		0.23				
Wingate	36 7 7 aba	Lab		0.040	0.013	3.0		20.4
Wingate	34 8 16 dca	Lab		0.015	0.0034	4.4		24.1
Wingate	34 5 12 dbc-1	Lab		0.43	0.091	4.7		31.4
Wingate	30 6 35 cdd	Lab		0.104				
Wingate	26 9 16 cbd	Lab		0.055				
Moenkopi	31 9 22 aca-1	DST	6.7E-04					
Moenkopi	29 5 34 ddb-1	SC					9	
Sinbad Limestone	29 11 17 bd	DST	0.023					
Sinbad Limestone	29 5 19 cba-1	SC					0.305	
Sinbad Limestone	29 5 32 bad-1	SC					82	

AQ=aquifer test; DST=drill stem test; SC=specific capacity; Lab=Laboratory
Source: Weigel, 1987; Christiana and Rasmussen, 1991

outcrop and recharge from perennial and ephemeral streams that flow through the outcrops of Navajo Sandstone, but does not include possible recharge from leakage between formations (Hood and Danielson, 1981).

6.4.4. Discharge

Ground-water discharge occurs as flows from springs and seeps, withdrawals from wells for irrigation and drinking water, and from evapotranspiration. Springs and seeps occur along the contact between formations, at the termini of basalt flows, along water courses, and where structural features such as dikes emerge. Discharge at springs is variable and responds to climatic conditions.Ground-water development has occurred in the Torrey and Fruita area. The newest ground-water well at the park was developed in 1993 with the completion of the culinary well in the Fremont River Gorge. New houses in the Torrey area predict a number of new wells and discharge of ground water at these sites. Domestic wells in Torrey revealed that ground-water elevations respond to changes in precipitation and other factors. An upward trend in the water level in a Torrey well revealed a response to initiation and cessation of irrigation (Christiana and Rasmussen, 1991).

Evaporation of ground water may be significant in agricultural areas in Torrey and Fruita and in densely vegetated riparian areas in the park.

6.4.5. Movement and Storage

Few data are available to construct a complete potentiometric map for all principal aquifers in the area. Hood and Danielson (1981) and Weiss (1987) constructed a map of the approximate potentiometric surface of the Navajo Sandstone. Weiss (1991) modeled the potentiometric surface of upper and middle Paleozoic rocks in southeastern Utah. These efforts revealed that ground water moves from the Thousand Lake Mountain and Waterpocket Fold areas eastward toward the Dirty Devil River and southward along the axis of the Henry Mountain structural basin toward Lake Powell. The potentiometric surface of the Wingate is assumed to be similar to that of the Navajo Sandstone due to their similar aerial extent and structural distortion (Hood and Danielson, 1981).

Hood and Danielson (1981) provided estimated volumes of ground water in storage in the Navajo, Wingate, and Cutler sandstones in the Lower Dirty Devil River Basin of which Capitol Reef is only a small portion (Table 4). Total storage within these three formations has been estimated at 1.306 billion ft^3 (37 million m^3) in the Torrey area and 27.5 million ft^3 (0.78 million m^3) in the Fruita area.

Christiana and Rasmussen (1991) attempted to characterize ground-water hydrology in the vicinity in Fruita. They established seven piezometers to measure change in ground water levels. They were located near the irrigation settling ponds, behind the visitor center, near the group campground, behind Pendleton-Gifford house, in the Pendleton pasture, and in the Mott and Cook orchards. Only two measurements were taken (March 22, 1990 and September 12, 1990). The ground-water elevation increased at all wells over time with the water level in the well near the campground rising more than 6 feet (2 m). Christiana and Rasmussen (1991) offered no explanation; however, the increase in ground-water elevation may have occurred from cessation of irrigation or recharge from infiltration of rain.

Table 4. Ground-water storage in various formations near Capitol Reef National Park. Based on estimates from Hood and Danielson (1981).

Formation	Average Thickness –ft (m)	Area – mi^2 (km^2)	Est. Effective Porosity	Volume – $ft^3 \times 10^9$ ($m^3 \times 10^9$)
Navajo Sandstone	804 (245)	2587 (6700)	20	8686 (246)*
Wingate Sandstone	394 (120)	2200 (5700)	20	4837 (137)
Cutler Sandstone	689 (210)	2703 (7000)	20	10,381 (294)
Total				23,905 (677)

*Navajo Sandstone within the area estimated to be 75% saturated.

6.5. Surface Water Hydrology

6.5.1. Overview of the Fremont River Drainage Basin

Five perennial rivers or streams, in addition to numerous intermittent and ephemeral drainages, course through the park providing water for aquatic organisms, wildlife, waterfowl, humans, and livestock. Surface water in the park provides for aquatic and riparian habitat, irrigation water for the orchards and pastures in the Fremont River District, and culinary water for the park.

Other important surface water features for which Capitol Reef is known are waterpockets or tinajas (Figure 8), springs, seeps, and hanging gardens. The Wingate and Navajo sandstones form the basis for small watersheds funneling snowmelt and stormwater runoff into the waterpockets. These waters are critical to wildlife and visitors alike. They support their own flora and fauna. Also, springs are key park water resources for wildlife and are common. In addition, Capitol Reef supports hanging gardens owning their own unique flora. These hanging gardens are driven by ground- water sources.

The Fremont River originates outside the park on Thousand Lake Mountain, traverses basaltic flows, and is captured in three reservoirs (Fish Lake, Johnson Valley Reservoir and Mill Meadow Reservoir). These reservoirs release irrigation water on demand to Rabbit Valley, which is privately owned land surrounding the towns of Loa, Lyman and Bicknell. Water diversions occur along this stretch of the Fremont River. Bicknell Bottoms, approximately 2 miles (3.2 km) south of the town Bicknell, was a shallow lake at one time, but has since filled. The area is marked by numerous springs recharging the Fremont River. Water diversions associated with the Torrey and Garkane canals, located near the town of Torrey, reduce flows during irrigation season. Below State Highway 12 (U-12), the Fremont River enters a scenic canyon with pristine riparian habitat known as the Fremont River Gorge. It exits this gorge within park boundaries. In Fruita, water is diverted for irrigation of park orchards and pastures. Park managers view the river as the "life blood" of the park. Millennium Science & Engineering (2002) presents a complete description of the Fremont River setting upstream and downstream of the park.

The Fremont Watershed (HUC 14070003) encompasses 4921 km^2 (1900 mi^2) and originates on Boulder and Thousand Lake mountains draining south and east through Bicknell Bottoms, Capitol Reef National Park, through Caineville and Hanksville to its confluence with the Dirty Devil River (Figure 9). HUC refers to hydrological unit code,

Figure 8. Views of some tinajas in Capitol Reef National Park.

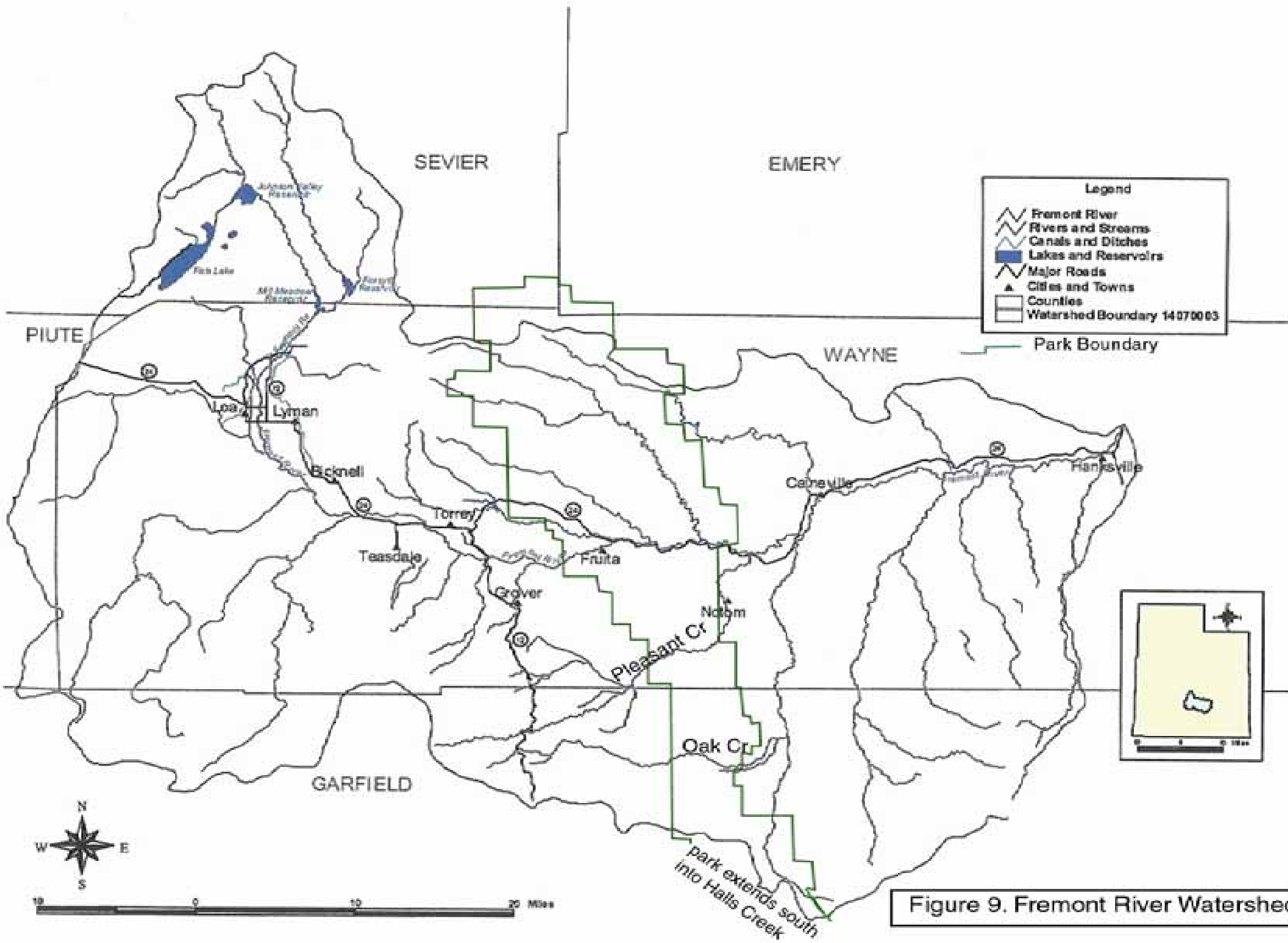


Figure 9. Fremont River Watershed

and it is comprised of an eight-digit number that indicates the hydrologic region (first two digits), hydrologic sub-region (second two digits), accounting unit (third two digits), and cataloging unit (fourth two digits). Within the park, six sub-watersheds exist (Figure 10); they include:

- The Deep Creek, Polk Creek, and Bulberry Creek watershed flanking the northeastern boundary of the park.
- The Sulphur Creek watershed draining Thousand Lake Mountain.
- The Fremont River flowing predominantly east through the park.
- The Pleasant Creek watershed draining Boulder Mountain to the southwest.
- The Oak Creek watershed dammed at its headwaters.
- The Halls Creek watershed which flows south and parallels the Waterpocket Fold in the southern portion of the park.

The Fremont River and Sulphur, Pleasant, Oak and Halls creeks are perennial systems. Deep, Polk, and Bulberry creeks are intermittent for a majority of their length. Table 5 provides morphometric information regarding these main flowing water sources.

Table 5. Morphometric characteristics of sub-watersheds in Capitol Reef National Park.

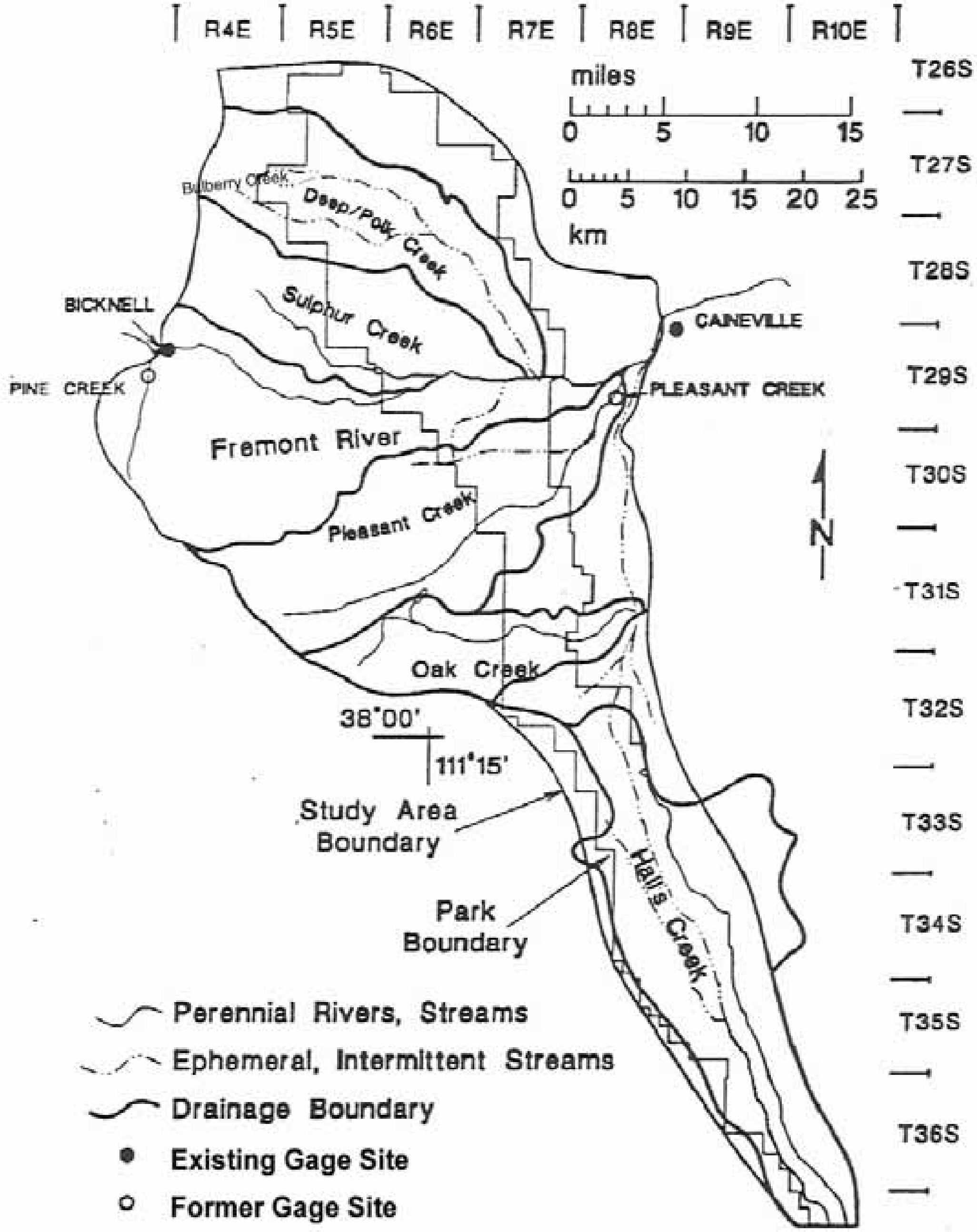
Watercourse	Drainage Area mi^2 (km^2)	Stream Length mi (km)	Length within park mi (km)	Relief w/in park ft (m)	Gradient w/in park (%)
Fremont River	872 (2248)	40 (61)	13 (21)	1198 (365)	1.73
Sulphur Creek	60 (145)	21 (33)	6 (10)	778 (237)	2.27
Pleasant Creek	120 (310)	34 (54)	7 (11)	919 (280)	2.48
Oak Creek	58 (150)	24 (39)	6 (9)	528 (161)	1.86
Halls Creek	100 (260)	40 (65)	35(56)	1762 (537)	0.82
Deep Creek	135 (350)	35(56)	33 (53)	3251 (991)	1.86
Polk Creek	*	15(24)	12 (19)	1365 (416)	2.19
Bulberry Creek	*	4.4(7)	4.4(7)	2160(658)	9.3

* Included within Deep Creek drainage
** Information provided by Aneth Wight, NPS, Moab, Utah and Christiana and Rasmussen, 1991, and wrought from Capitol Reef Hiking Map & Guide and the Fishlake National Forest map.

Streams originating on Boulder and Thousand Lake mountains have reliefs ranging from 4920 ft (1500 m) to 5900 ft (1800 m). Gradients for entire stream lengths range from 0.8 % in Halls Creek to 4.4 % in Sulphur Creek (gradients in Table 5 refer to reaches within the park only). The Fremont River's gradient changes as it transitions from a gentle grade through Bicknell Bottoms west of the park (0.3%) to a steeper grade (0.9% to 2.4%) within the Fremont River Gorge, and then back to a gentle grade east of the park (0.7%) (Christiana and Rasmussen, 1991).

The U.S. Geological Survey (USGS) has operated stream gages on the Fremont River and Sulphur and Pleasant creeks. These gages and their periods of record are presented in Table 6. Stream gages operating presently are the Fremont near Bicknell (#09330000) and the Fremont near Caineville (#09330230).

Mean annual discharge for the period of record at the Bicknell site ranged from a low of 70.6 cubic feet per second (cfs) in 1940 to 118 cfs in 1910. For the Caineville site mean


R4E
R5E
R6E
R7E
R8E
R9E
R10E
T26S
T27S
T28S
T29S
T30S
T31S
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T33S
T34S
T35S
T36S
miles
0 5 10 15
0 5 10 15 20 25
km
Bulberry Creek
Deep/Polk Creek
Sulphur Creek
BICKNELL
PINE CREEK
CAINEVILLE
PLEASANT CREEK
Fremont River
Pleasant Creek
Oak Creek
38°00'
111°15'
Study Area Boundary
Park Boundary
Halls Creek
N
Perennial Rivers, Streams
Ephemeral, Intermittent Streams
Drainage Boundary
Existing Gage Site
Former Gage Site

Figure 11. Mean annual discharge at the Bicknell and Caineville stream gages on the Fremont River, Utah.

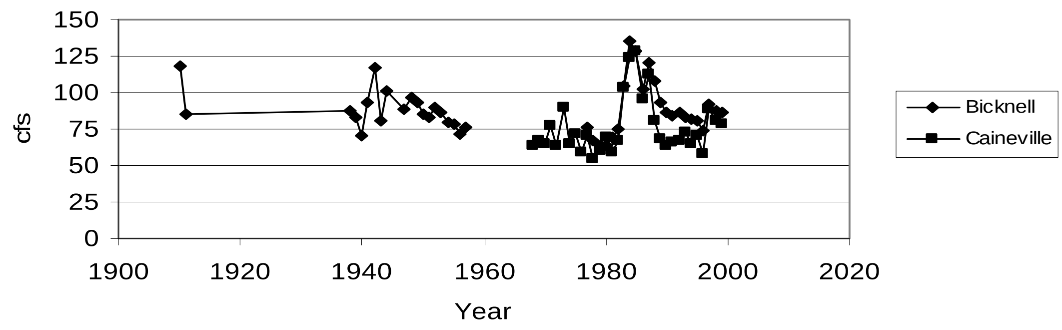


Figure 12. Mean monthly discharge at Bicknell and Caineville stream gages on the Fremont River, Utah.

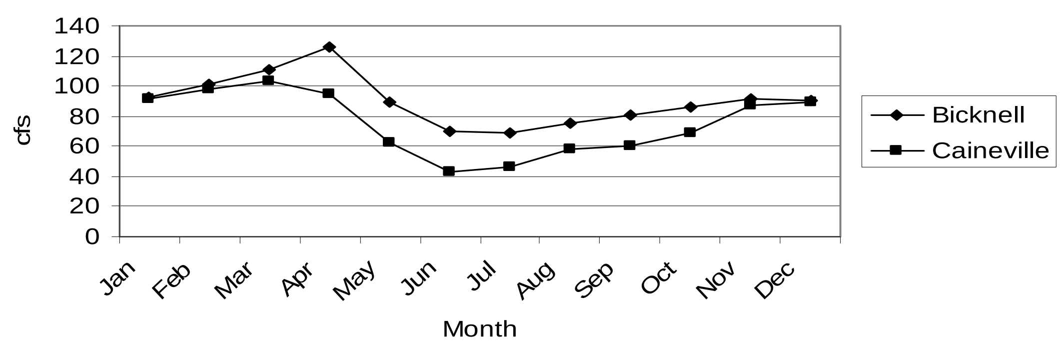
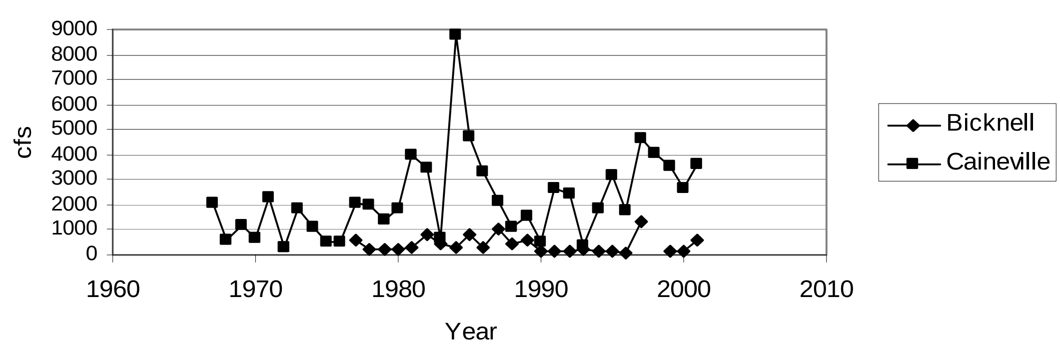


Figure 13. Annual peak discharge at Bicknell and Caineville gages on the Fremont River, Utah.



annual flow ranged from a low of 55.0 in 1981 to 124 cfs in 1984 (Figure 11). Several years of high flows occurred during the 1980s. Mean monthly discharge for the Bicknell site revealed a high in April of 126 cfs to a low of 68.6 cfs in July. For the Caineville gage mean monthly discharge ranged from 103 cfs in March to 42.9 cfs in June (Figure 12). Highest flows occurring in the spring reflect snowmelt runoff and the rapid decline corresponds to diversions for irrigation, evapotranspiration and low precipitation during summer months.

Maximum annual peak discharge for the Bicknell gage ranged from 106 cfs in 1996 to 1360 cfs on March 21, 1997 (period of record 1977-2001). These flows are affected by regulation and diversion. For the Caineville gage maximum annual peak discharge ranged from 330 cfs on July 26, 1972 to 8800 cfs on July 24, 1984 (period of record 1967-2001) (Figure 13).

Table 6. U.S. Geological Survey information regarding stream gages on waters flowing through Capitol Reef National Park (<www.usgs.gov>).

Name/Station No./Location/Elevation	Period of Record	Range of Annual Peak Discharge during Period of Record (cfs)
Fremont River near Bicknell Station No. 09330000 Latitude 38°18'25" Longitude 111°31'03" NAD27 Drainage Area 751.00 mi^2 Elevation 6920.00 ft above sea level NGVD29	1909-1912 1938-1957 1977-present	106 cfs in 1996 to 1360 cfs in 1997 (gage height = 7.02 ft) Discharge was affected by regulation or diversion. In 1998 stage height was 7.59 with no corresponding flow measurement.
Fremont River near Caineville Station No. 09330230 Latitude 38°16'45" Longitude 111°03'54" NAD27 Drainage Area 1208.00 mi^2 Elevation 4760.00 ft above sea level NGVD 29	1967-present	330 cfs in 1972 to 8800 cfs in 1984
Fremont River near Hanksville Station No. 09330400 Latitude 38°22'00" Longitude 110°45'00" NAD27 Drainage Area 1900.00 mi^2 Elevation 4300.00 ft above sea level NGVD29	1959-1973	1330 cfs in 1967 to 15,300 cfs in 1973
Pleasant Creek at Notom Station No. 09330200 Latitude 38°14'00" Longitude 111°07'00" NAD27 Drainage Area 80.60mi^2 Elevation 5230.00 ft above sea level NGVD29	1959-1973	20 cfs in 1959 to 2040 cfs 1965
Sulphur Creek near Fruita Station No. 09330120 Latitude 38°18'00" Longitude 111°16'00" NAD27 Drainage Area 56.7 mi^2 Elevation 5550.00 ft above sea level NGVD29	1959-1974	78 cfs in 1962 to 2600 cfs on 1961

Christiana and Rasmussen (1991) determined that the Fremont River was a losing system from the U-12 crossing through the Fremont River Gorge with a net loss of 5.6cfs to 8.5 cfs (0.16 m^3/s – 0.24 m^3/s). In the Fruita Valley, net ground-water accretions ranged from 3.9 cfs to 14.1 cfs (0.11 m^3/s – 0.40 m^3/s) accounting for water diversions and tributary inflows. Between the U-24 Hickman Trail Bridge and the east park boundary, net losses equaled 1.1 cfs to 5.3 cfs (0.03 m^3/s –0.15 m^3/s). They also determined that salt load increased from 484 grams per second (g/s) to 749 g/s between the U-12 crossing and the east boundary of the park.

6.5.2. Proposals to Dam the Fremont River Drainage

Proposals for dams on the Fremont River go back to at least the 1940s --both upstream and downstream from the park. In 1963, irrigators proposed construction of a 100-foot (30 m) high earthen dam, the Aldridge Dam, to impound 17,000 acre-feet of water and inundate about 660 acres near the abandoned ranch community of Aldridge, about 5.5 miles (8.8 km) downstream from the monument boundary. The project was cancelled due to concerns over rapid siltation of the reservoir.

In the early 1970s the Intermountain Power Project proposed to construct a dam near Caineville to supply water to a coal-fired power plant. The plant would use Water Right Number 95-697 owned by the Intermountain Consumers Power Association for 50,000 acre-feet with a priority date of 1971. No assessment was made regarding the effects of the dam on the park's water rights. The dam and power plant projects were cancelled due to air quality concerns related to coal burning.

In 1986 the Wayne County Water Conservancy District (WCWCD) proposed a 100-foot (30 m) high, 6000-feet (1829 m) long dam south of Torrey, upstream from the park, with a 35,000 acre-foot reservoir, for power production. Vegetation studies and other research were done for this proposal by the park but no assessment was made regarding the effects of the dam on the park's water rights (Hardy et al, 1989; Welsh, 1988). In 1992 the Federal Energy Regulatory Commission (FERC) cancelled the project due to opposition by the National Park Service, the Bureau of Land Management, and environmental organizations (Frye, 1998; Welsh, 1988).

Dams continued as an issue in the 1990s. The NPS collected data to quantify instream flow characteristics for perennial streams within the park in anticipation of dam proposals and to quantify the stream flow necessary to maintain a healthy riparian vegetation community along the river (Hammack and Cluer, 2000). A Caineville Wash Dam proposal, initiated in 1993, proposed a dam on Caineville Wash, immediately above the town of Caineville, approximately one mile upstream of the Fremont River. The dam was to be built in the "Caineville Reef", a hogback of the upturned Ferron Sandstone Member of the Mancos Formation. In 2002, Capitol Reef National Park voiced its concern over a renewed Wayne County proposal for construction of a dam at Caineville Wash, also linked to a possible exchange of State Land with the BLM along the eastern border of the park. Section 8.2 describes this project in terms of water rights.

The Town of Hanksville, downstream from the park, has senior water rights for irrigation, so the issue of dams will likely continue (Scoping Meeting Notes, October 29, 2002). Water users upstream from the park could benefit from downstream dams, since it would offer flexibility in how the downstream appropriations can be met (e.g., storing water in a dam in the spring rather than needing to supply as much during the summer). Naturally, any such dam proposals have major implications for instream flows inside the park. Additional discussion of dams and water rights appears in Section 8.2.

6.5.3 The Fremont River Floodplain

Hunt (1953), in a classic study of the geology of the Henry Mountains, illustrated the result of a catastrophic flood in the Fremont River in 1897. This event initiated a cycle of channel erosion which continued through 1979 (Graf, 1980) and probably continues today. Much of Capitol Reef is subject to flash flooding, particularly during summer months. The Fremont River and Sulphur Creek are particularly susceptible to sudden thunderstorms occurring during the summer monsoon. In 1945, two major flash floods occurred in Fruita resulting from 1.45 inches (3.68 cm) of rain within 20 minutes (Gilbert and McKoy, 1997). A 1937 flood near the campground and picnic areas and a 1985 flood in the same area point to the number of historical flood events occurring in the park (Berghoff, 1995a).

Grand Wash, which is typically dry and is a tributary to the Fremont River, experienced a flash flood on July 24, 1992. McInerney and Schmidt (1993) noted that a single thunderstorm cell produced heavy rainfall on the northeast aspects of Boulder and Miners mountains. These aspects produced runoff which flowed into Grand Wash and then the Fremont River. Although the visitor center reported 0.19 inches (0.48 cm) of rain, the size of the flood indicated a much larger volume of precipitation. A visitor's video tape captured water levels ranging from 4-6 feet (1.2-1.8 m) above normal to 20 feet (6.1 m) in narrow sections of the wash. No one was injured; however, hikers were stranded in Grand Wash for up to six hours and 50 cars were stranded on U-24. This incident proves that with even marginally favorable meteorological conditions, dangerous flash flooding can occur.

Berghoff (1995a) performed a floodplain study in the Fruita area to comply with the NPS floodplain guidelines (National Park Service, Draft 2003) and for general management planning. The report assessed risks and defined means to alleviate flood hazards. Survey data were collected at several stream cross sections. Watershed area and mean basin elevation were determined from GIS coverages. The 100- and 500-year and the estimated maximum flood (Q_{me}) were modeled. Table 7 provides the physical characteristics of the two basins and estimated flood discharges.

Table 7. Physical characteristics of the 2 basins and estimated flood discharges for the Fremont River and Sulphur Creek.

	Basin Area – mi^2 (km^2)	Mean Elevation ft (m)	Flood 100-year cfs (cms)	Flood 500-year cfs (cms)	Q (max) cfs (cms)
Fremont River	872 (2248)	8625 (2629)	9000 (255)	15,000 (425)	70,000 (1982)
Sulphur Creek	56 (145)	7211 (2198)	4800 (136)	8100 (229)	19,000 (538)

Adapted from Berghoff (1995a)

Figures 14a,b,c show the aerial extent of the 100- and 500-year Q_{me} for Sulphur Creek and the Fremont River. For Sulphur Creek, the 100-year flood reaches an elevation of 5495 feet (1674.9 m) directly behind the park offices closest to the channel. The 500-year flood reaches an elevation of 5497 feet (1675.5 m) in the administration area. The Q_{me} reaches an elevation ranging from 5498 to 5503 feet (1675.7 to 1677 m) and would

Figure 14a. Delineation of Fremont River floodplain in the Fruita District.

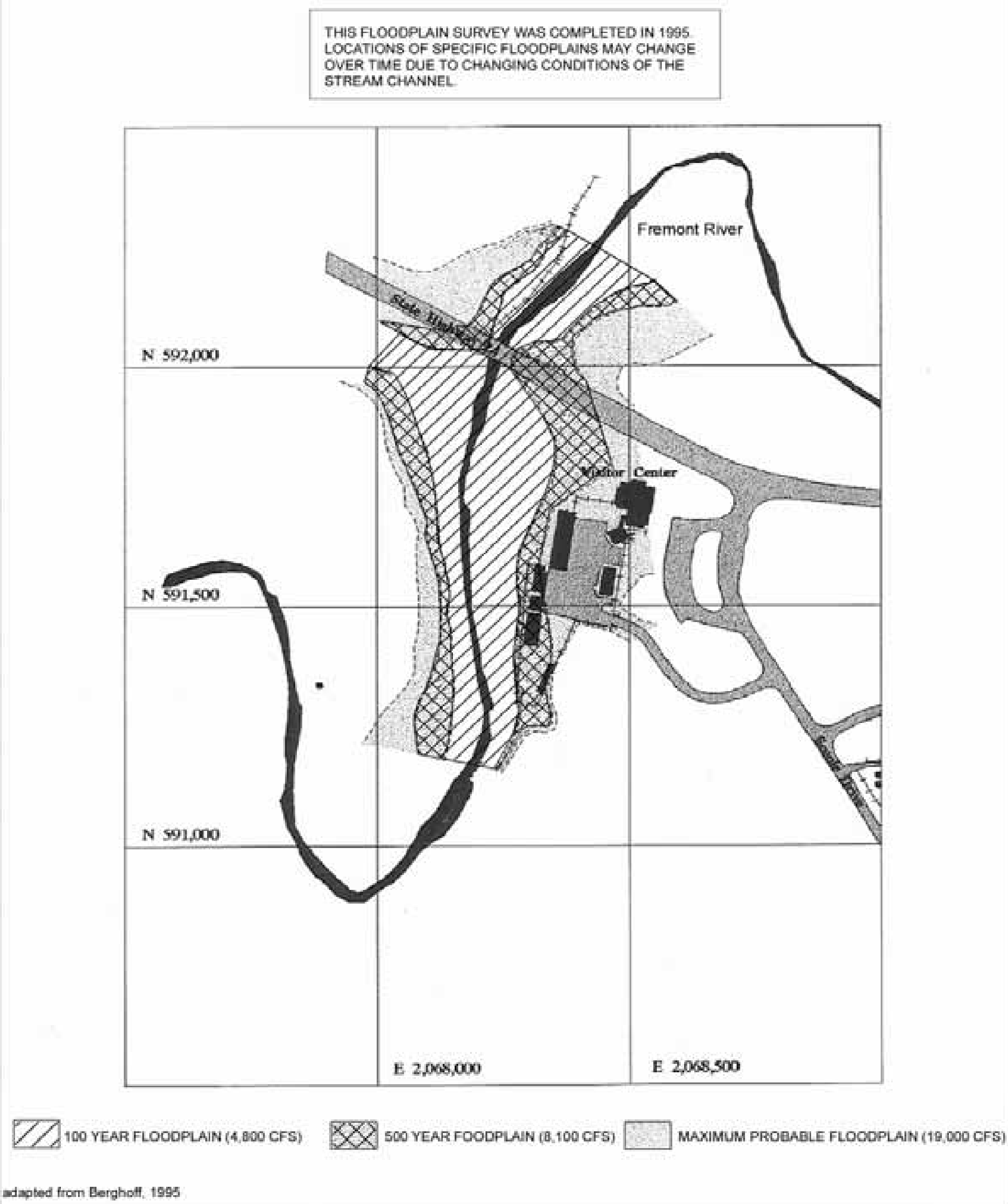


Figure 14a. Floodplain delineation near Fremont R.

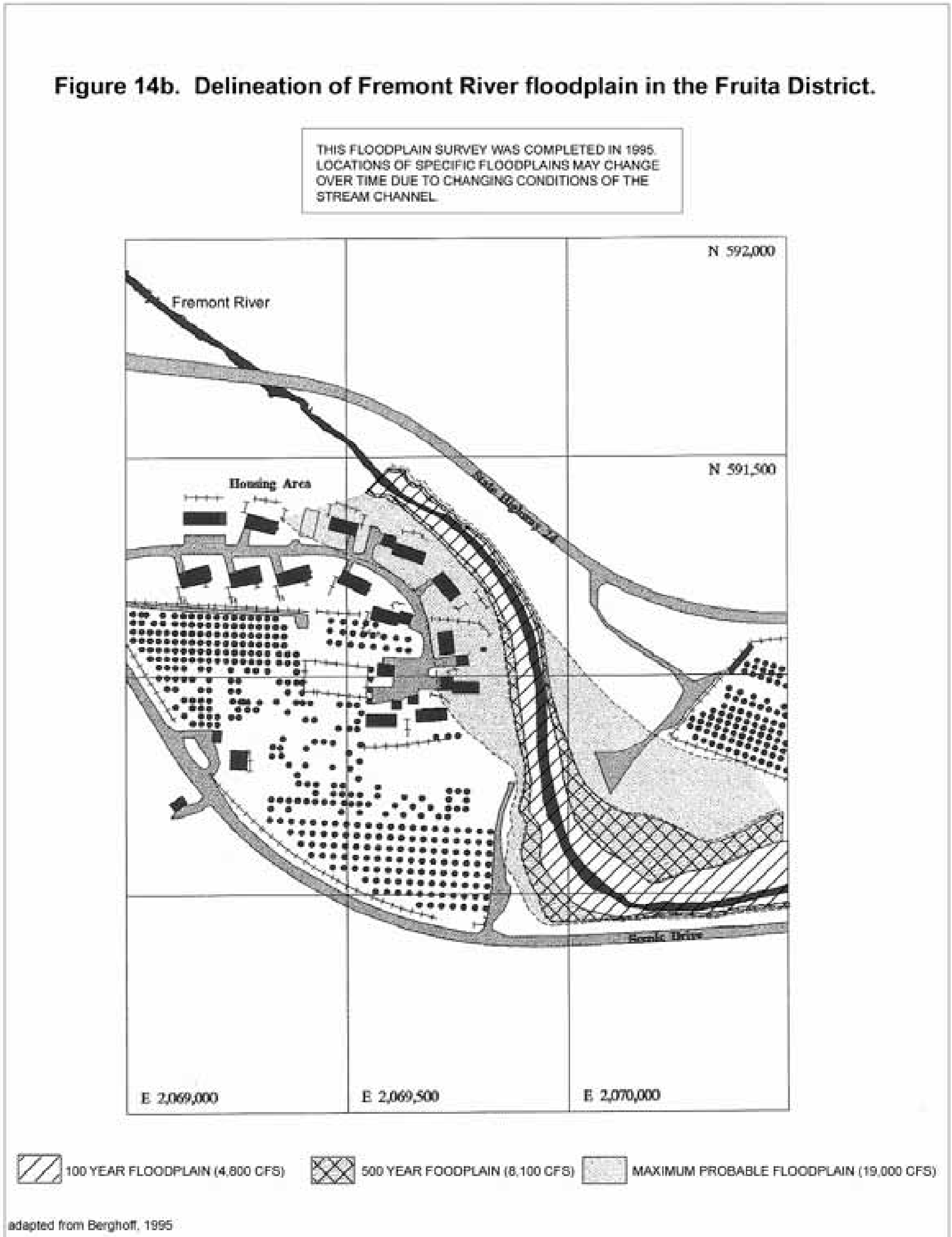


Figure 14b. Floodplain delineation near Fremont R.

Figure 14c. Delineation of Fremont River floodplain in the Fruita District.

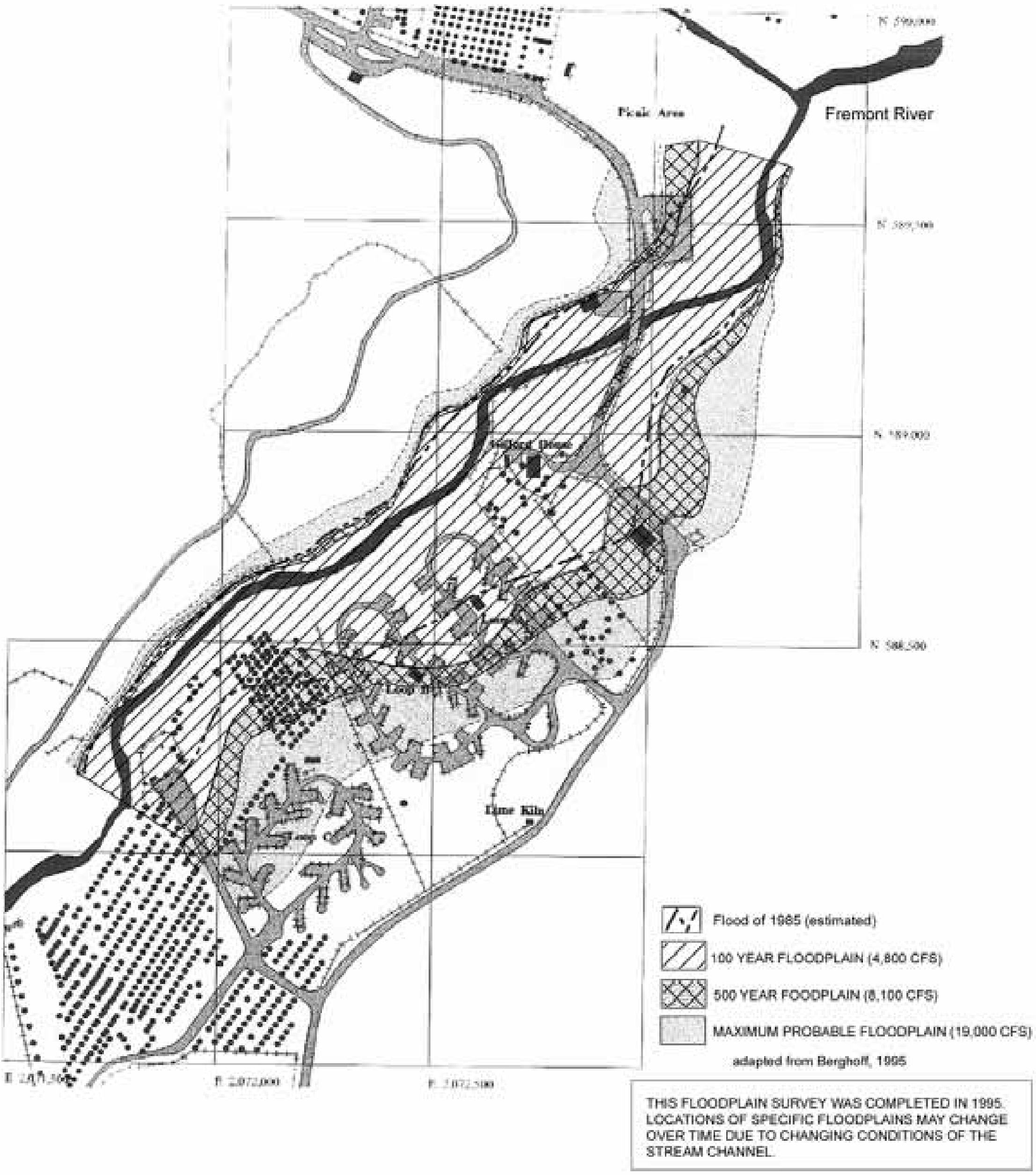


Figure 14c. Floodplain delineation near Fremont R.

impact all the administration area. For the residential area associated with Sulphur Creek, the floodwater surface elevation for the 100-year flood rises to an elevation ranging from 5454 to 5461 feet (1662-1664 m). The 500-year flood reaches elevations ranging from 5456 to 5463 feet (1663-1665 m). The Q_{me} elevation would encroach into the residence area reaching elevations ranging from 5463 to 5470 feet (1665-1667 m).

Table 8 shows the floodwater surface elevations along the Fremont River for specific floodplains. The changing nature of the floodplain can lead to changes in the estimated flood elevations. However, based on these estimations, Berghoff (1995a) determined that a 100-year flood would have a significant effect along the Fremont River from the campground to the picnic area.

Table 8. Floodwater surface elevations above mean sea level for the 100-year, 500-year, and Q_{me} flood.

	100-year cfs (cms)	500-year cfs (cms)	Q_{me} cfs (cms)
Campground A & B Loops	5433-5429 (1656-1655)	5434-5430 (1656-1655)	5441-5437 (1658-1657)
Gifford House	5426 (1654)	5428 (1654)	5436 (1657)
Water Treatment Plant	5422 (1653)	5424 (1653)	5432 (1655)
Picnic Area	5415 (1650)	5417 (1651)	5427 (1654)

Storage of potentially hazardous material near the administration area and overnight occupancy in the campground were the main issues with respect to anticipated floods. The hazardous material has been removed. The chief ranger is on the calling list for a network of the National Weather Service, federal and local agencies that have a flood warning system for the Fremont River Valley. The ranger is notified and mobilizes to evacuate the campground and residence area if necessary. The system has worked successfully.

6.5.4. Other Streams

Sulphur Creek is a perennial stream which drains Thousand Lake Mountain to the northwest of the park. Below Torrey, seepage from adjacent irrigated pastures account for much of the flow in the creek. Upstream from its confluence with the Fremont River in Fruita, Sulphur Creek flows through the Goosenecks. This scenic gorge is one of the few places in the area where the Kaibab Limestone and the White Rim Sandstone are exposed (Harris and Tuttle, 1992). Maximum annual peak flows ranged from 78 cfs on March 23, 1962 to 2600 cfs on September 17, 1961 (Table 6, period of record 1959-1974).

Both Oak and Pleasant creeks originate on Boulder Mountain southwest of the park. Discharges in both these creeks are altered as a result of reservoirs west of the park boundary. Oak Creek supports a reservoir at its headwaters, and Pleasant Creek is captured by Lower Bowns Reservoir and released into Oak Creek (Figure 15). Oak Creek drains about 58.5 mi^2 (150 km^2) and is approximately 24 miles (39 km) long, with about 6 miles (9 km) of the creek passing through the park. Pleasant Creek is larger, draining approximately 120 mi^2 (310 km^2) and is about 34 miles (54 km) long, with about 7 miles (11 km) of the creek passing through the park. The headwaters of these creeks contain good soils, vegetative cover, and fairly stable watersheds that supply perennial

Figure 15. Pleasant and Oak creek irrigation ditches on Dixie National Forest, Boulder Mountain.

flows downstream into the park. Remaining flows traverse the park, and flows are diverted at the Notom Ranch.

From 1959 to 1973, the U.S. Geological Survey maintained a stream gage on Pleasant Creek at Notom. Annual peak discharge ranged from 20 cfs on August 25, 1959 to 2040 cfs on July 16, 1965 (Table 6). No stream gage information is available for Oak Creek, whose flows are maintained by releases from Oak Creek Reservoir on Boulder Mountain and Lower Bowns Reservoir. East of the park much of the creek is diverted for irrigation at the Sandy Ranch.

Halls Creek flows from north to south within the park's Waterpocket Fold for a distance of about 35 miles (56 km) in length and is the only stream of significance in the park flowing south (Figure 10). The creek flows perennially above ground for its last 12 miles (19 km) in the park, and the southern end of this perennial stretch includes three miles through a spectacular sandstone canyon known as Halls Creek Narrows. The Narrows lies a few miles north of the boundary separating Capitol Reef National Park and Glen Canyon National Recreation Area. Once the creek leaves Halls Creek Narrows it flows through dense riparian vegetation for about a mile just before passing into Glen Canyon National Recreation Area, then continues through more riparian vegetation until it reaches Lake Powell (National Park Service, 1993).

Halls Creek is geologically distinct from other streams in the park. The stream follows along the strike direction of the Waterpocket Fold, with the Narrows cutting through Navajo Sandstone on its route south to the Colorado River (Figures 7 and 10). Ground-water flow parallels the Waterpocket Fold and moves southward as well. Viewing a geologic cross-section of the Halls Creek area, the highest elevation of the Navajo Sandstone to the west protrudes about 1,000 feet (305 m) above the creek and slopes toward the east. The Navajo Sandstone is the major aquifer in the Halls Creek area. Ground-water quality in the Halls Creek area primarily reflects the water's movement through the Navajo Sandstone formations (Huntoon,1978; Harris and Tuttle,1992).

Polk, Bulberry, and Deep creek headwaters are located on Thousand Lake Mountain. Polk Creek is an intermittent system with discharge emanating from the Upper South Desert Spring, where volcanic dikes force water to the surface. Christiana and Rasmussen (1991) reported the discharge as 0.1 cfs on March 17, 1990. Deep Creek appears to be an intermittent stream (Figure 10), and may exhibit perennial flows if it were not for irrigation diversions (the Baker Ditch) which captures water from this creek.

6.5.5. Wetlands

For the purpose of implementing Executive Order 11990, any area that is classified as wetland habitat according to the U.S. Fish & Wildlife Service's (USFWS) wetland classification system is subject to the NPS Director's Order #77-1 (National Park Service, Water Resources Division, 1998). According to Cowardin *et al.* (1979) wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes; (2) the substrate is predominantly undrained hydric soil; and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year.

All tinajas, hanging gardens, creek channels, springs, impoundments, and riparian areas within Capitol Reef are considered wetlands according to NPS Directors Order #77-1 (National Park Service, Water Resources Division, 1998). For example, creek beds (any channel with side slopes and a bottom that conveys water at least once a year) are delineated as riverine wetlands from the top of bank to the opposite top of bank, and along the entire length. Tinajas that hold water for more than five percent of the growing season are palustrine wetlands. Riparian areas, containing willows on alluvial sediments, are likely riverine wetlands. The dominant vegetation in hanging gardens and springs is hydrophytic and, with the presence of permanent or intermittent flow, they can be classified as palustrine wetlands.

Executive Order (E.O.) 11990 directs the NPS: 1) to provide leadership and to take action to minimize the destruction, loss, or degradation of wetlands; 2) to preserve and enhance the natural and beneficial values of wetlands; and 3) to avoid direct or indirect support of new construction in wetlands unless no practicable alternatives exist. In carrying out the park's purpose in a manner consistent with E.O. 11990 and the "no net loss of wetlands" goal, the park adopted a "no net loss" policy and can conduct wetland inventories to assure proper planning with respect to management and protection of its wetlands. Proposed new developments within Capitol Reef should, in order of priority, 1) avoid impacts to wetlands, 2) minimize impacts that cannot be avoided, and 3) compensate for remaining unavoidable adverse wetlands impacts via restoration of degraded wetlands. Any actions that have a potential to adversely impact wetlands will be addressed in an Environmental Assessment (EA) or an Environmental Impact Statement (EIS). The park will need to delineate wetlands according to the definition provided above and the Superintendent of Capitol Reef National Park will oversee a Statement of Findings regarding the proposed action. For example, Section 8.4 discusses the restoration of the Fremont Oxbow. This proposed project requires a wetland delineation, and a Statement of Findings must be issued.

Areas of Capitol Reef National Park that support wetlands are particularly important for plant and wildlife habitat support, attenuation of floods, stabilization of streambanks, retention of sediment, provision for food to the aquatic fauna, biogeochemical cycling, water storage, and discharge and recharge to the ground water. Especially important for the park is wetland habitat associated with streams and rivers. Ute ladies' tresses orchid (*Spiranthes diluvialis*) was present in the riparian areas of the Fremont River Gorge and in the Fremont River oxbow. It has not been seen since 1995. Recently introduced desert bighorn sheep (*Ovis canadensis*) in the Pleasant Creek area depend on this water resource and its associated wetland features.

The following sections describe types of wetlands found with the park and refer to them by their common names; however, when delineating these wetlands, they should be classified according to Cowardin *et al.* (1979) as shown in parentheses.

Riparian Areas (Riverine and Palustrine Wetlands)
Riparian ecosystems comprise less than one percent of the park's watershed total area, yet these sites are by far the most diverse. Wildlife seek vegetation, water, or associated organisms in riparian areas, and aquatic systems serve as a refuge for unique animal species and as a nursery for native fishes inhabiting areas downstream. The floral and

faunal communities adjacent to permanent park water sources are productive and diverse (National Park Service, 1989a; Van Pelt *et al.*, 1991; Heil *et al.*,1993; National Park Service, 2001a, 2001b; Grand Staircase-Escalante BLM online, 2003).

The Fremont River and its perennial tributaries, namely Sulphur, Oak, Pleasant and Halls creeks, in the park contain excellent examples of riparian ecosystems (Figure 10). The Fremont River Gorge contains one of the best examples of intact riparian vegetation in the states of Utah and Colorado, according to The Nature Conservancy (TNC). Of the 34 plant communities identified in the park, nine are associated with riparian or wetland areas (Heil *et al.*, 1993). The trees observed include Fremont cottonwood *Populus fremontii*), box-elder (*Acer negundo*), river birch *Betula occidentalis*), alder (*Alnus tenuifolia*), and sandbar willow (*Salix exigua*) among others (Van Pelt *et al.*, 1991).

Both Oak and Pleasant creeks, within the parks, support native riparian vegetation including sandbar willow, silver buffaloberry (*Shepherdia argentea*), river birch, thinleaf alder, Fremont cottonwood, Russian olive (*Eleagnus angustifolius*), and tamarisk (*Tamarix ramosissima*). Exotics are a problem in some areas of the two watersheds, as discussed in Section 8.13 on that topic (Borthwick and Henderson, 1991; Christiana and Rasmussen, 1991). Sulphur Creek, since it winds through exposed bedrock, has little soil to support a dense riparian cover. Instead it supports patches of vegetation, including some exotics. As the creek approaches the visitor center, it begins to support more riparian vegetation, particularly around the residential and picnic areas. Here, Fremont cottonwood and willow dominate. Halls Creek flows through riparian vegetation for a mile prior to crossing into Glen Canyon National Recreation Area, and the creek continues through riparian vegetation until reaching Lake Powell (National Park Service, 2001b). A portion of Halls Creek through which visitors hike is called the Narrows. The riparian woodland along this section of Halls Creek includes box-elder, single-leaf ash *(Fraxinus anomala*), Fremont cottonwood, gambel oak *(Quercus gambelii),* and willow species *(Salix spp).* The riparian floodplain communities include Emory's baccharis *(Baccharis emoryi),* Baltic rush *(Juncus balticus),* and sandbar willow, with some scattered tamarisk.

For natural riparian and aquatic systems to be diverse and productive, they need to maintain their "properly functioning condition." A properly functioning stream requires good natural riparian vegetation and vegetative debris in the channel area to dissipate stream energy, control erosion, filter sediment, capture bedload, aid floodplain development, and enhance ground-water movement. A properly functioning stream will develop the ponding and channel characteristics to provide the water depth, duration, and temperatures needed to support greater biodiversity in the stream and its riparian area (Prichard, 1998, 1999). Protection of a stream and its riparian area can provide these values.

Springs (Palustrine Wetlands)

Springs are surface water features in that they produce enough water to form a small rivulet. Seeps support smaller discharges with no resulting channel formation. Both features provide a unique and necessary resource in a desert environment. In the park, they are usually found at the contact between two formations of different permeability (Chimney Rock and Ackland springs), along alluvial aquifers (Dewey Gifford and Sleeping Rainbow springs), and at the termini of basaltic flows (numerous springs in Bicknell Bottoms, Pine Creek and Birch springs), and where structural features such as dikes emerge (Ringwater Spring) (Christiana and Rasmussen, 1991).

The Waterpocket Fold is a major recharge zone for water entering the Navajo Sandstone, and some major springs and seeps from the Navajo and Entrada sandstones. The Navajo Sandstone is the shallowest formation supplying good well water in the area, and the Entrada Sandstone is a major source of freshwater northeast of Notom. Some smaller springs also issue from the Moenkopi Formation. Where jointing occurs, for example in the Wingate Sandstone, a formation can yield small quantities of fresh to moderately saline water to springs (Cutillo, 2002; Hood and Danielson, 1981; Marine, 1962; Huntoon,1978). The springs in the park area range in size from ephemeral, surface trickles to gushers in the Bicknell Bottoms area emitting large discharges into the river. Springs in the backcountry are critical for livestock, wildlife, birds, amphibians, bats, and the transplanted desert bighorn sheep. Some springs have been vital to pioneers or ranchers, for example, the Sleeping Rainbow Ranch spring near Pleasant Creek (National Park Service, 2001b).

At least 13 springs have been documented and have had discharges measured within the park (Christiana and Rasmussen, 1991; Table 9). Additionally, they serve as areas moist enough to support mesic vegetation. The park believes more springs exist and need identification, since these water resource features are important to wildlife. Several springs in the Bicknell Bottoms area west of the park emit large enough discharges to recharge the Fremont River after diversions of irrigation water in Rabbit Valley.

Seeps generally emit smaller flows than springs and are less obvious; nonetheless, seeps can play a critical role for wildlife in a desert habitat. Verification of the location of seeps is important as well. Mapping of geologic formations from which springs or seeps issue should aid in understanding the hydraulic gradient of ground water and other functional characteristics of springs and seeps (Cutillo, 2002).

Rock Pools –Tinajas (Palustrine Wetlands)

Tinajas (Spanish for jars or vats) or waterpockets or rock pools are depressions eroded out of bedrock by the action of water, wind, or other physical or chemical weathering processes (pothole is another term sometimes applied to smaller tinajas). Some tinajas store water for months and may be perennial in some years, but most are small and ephemeral. The tinajas of Capitol Reef offer some of the best examples on the Colorado Plateau, and the park contains thousands of tinajas in all sizes. Tinajas, like springs and seeps, are key resources for desert plants, vertebrates, and invertebrate species, and provide essential water for cattle and occasionally humans. Tinajas are most likely critical water sources for the desert bighorn sheep transplanted into the park in 1996-97 (Spence and Henderson, 1993; National Park Service, 1991, 1993, and 2001b; Berghoff, 1995b).

In order to better understand tinajas in the park, biological and physical parameters of tinajas and associated wetlands were measured by park staff from autumn of 1993 to spring of 1994. Data collected included sampling location, date, time, water depth, volume, faunal species, water pH, conductance, chemical composition, and other parameters. Berghoff (1995b) summarized a survey of tinaja wetlands in the Waterpocket fold and recognized over 400 sites south of the Burr Trail. He noted that many of the pools were temporary and small, but collectively they account for the greatest and most widespread source of surface water in the area (Figure 16)

Scientists have studied the ecology of tinajas in Capitol Reef National Park. Haefner and Lindahl (1988, 1991) described the mechanisms of community organization in tinaja

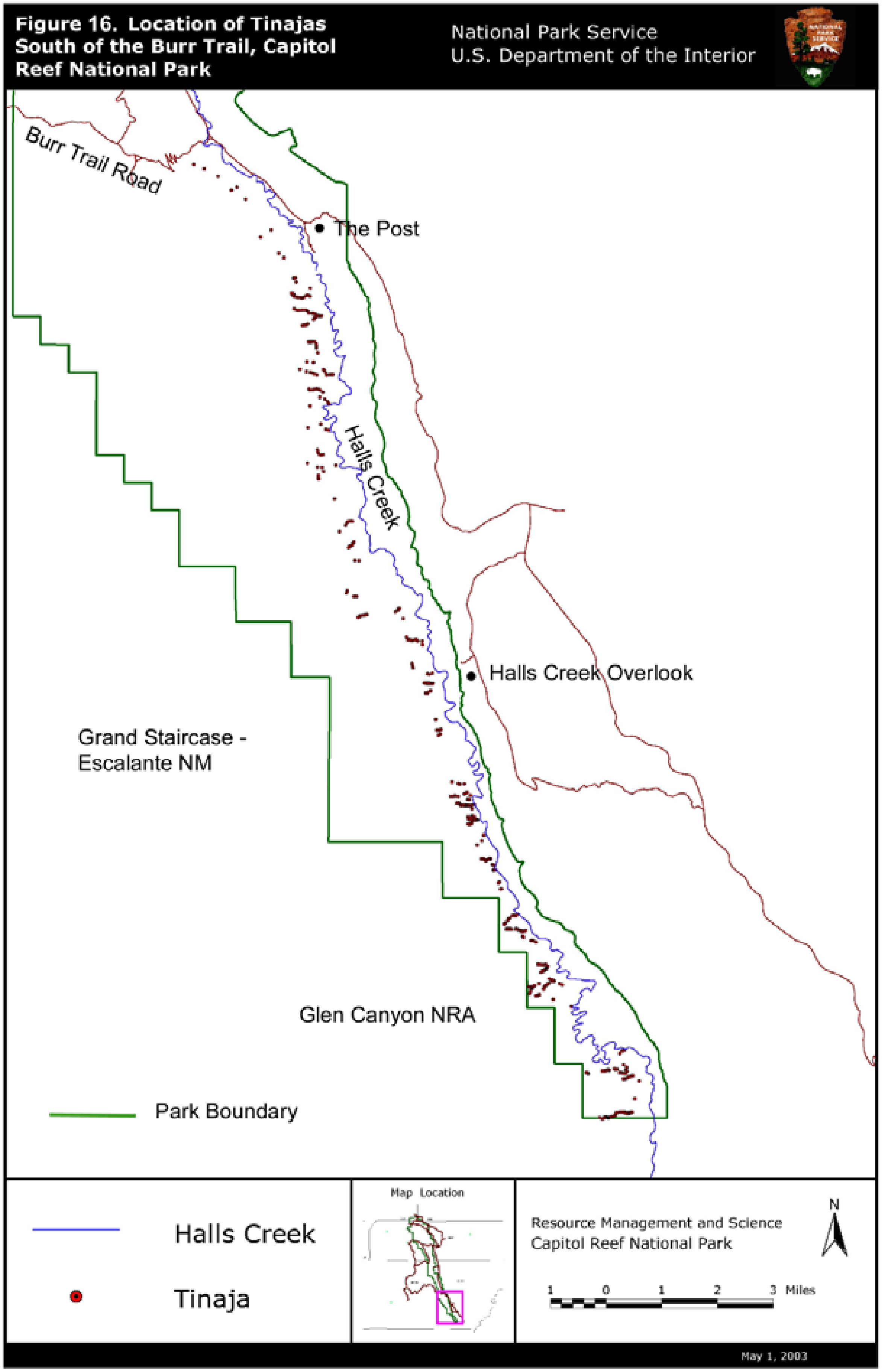


Figure 16. Location of Tinajas South of the Burr Trail, Capitol Reef National Park
National Park Service
U.S. Department of the Interior
Burr Trail Road
The Post
Halls Creek
Halls Creek Overlook
Grand Staircase - Escalante NM
Glen Canyon NRA
Park Boundary
Halls Creek
Tinaja
Map Location
Resource Management and Science
Capitol Reef National Park
N
1 0 1 2 3 Miles
May 1, 2003

habitats and the effects of livestock grazing on these systems. Spence and Henderson (1993) determined that the tinajas of Capitol Reef supported more vegetative species than the park's hanging gardens, and species included riparian obligates like common reed (*Phragmites australis*), cattail (*Typha latifolia*), and species of rush (*Juncus sp.*) and willow (*Salix sp*). Lafrancois (1994, 1995) studied the ecology of desert rock pools in the park. He documented more macroinvertebrate species than in past studies. Baron *et al.* (1998) also reviewed the chemical and biological characteristics of desert rock pools in the park. They found that neither flooding or drying, nor the presence or absence of surrounding vegetation, had a great effect on the chemical composition.

Table 9. Spring discharges in Capitol Reef National Park and Bicknell Bottoms. Springs other than those associated with Bicknell Bottoms were measured during July 1989 (from Christiana and Rasmussen, 1991).

Spring	Location[1]	Discharge (cfs)
Bicknell Bottoms*		
Pine Creek	(D-29-3)14bcb-S1	17.6
Dab Kell	(D-28-3)34baa-S1	4.4
Bullard	(D-29-3)14abc-S1	3.2
Hugh King	(D-29-3)11cca-S1	1.6
Fremont River District		
Dewey Gifford	(D-29-6)23bbb-S1	0.2
Sleeping Rainbow	(D-30-7)20dca-S1	0.007
Chimney Canyon	(D-28-6)32bbb-S1	**
Cathedral District		
Birch	(D-26-5)15aaa-S1	0.2
Ring Water	(D-27-6)31aba-S1	0.07
Ackland	(D-27-6)23cba-S1	0.02
Mud	(D-27-4)36cbb-S1	0.01
South Desert	(D-27-5)10cbd-S1	**
Camper's	(D-27-7)17bdb-S1	Dry
Bull Spring	Unavailable	***
Lone Pine Spring	Unavailable	**
Waterpocket District		
Bitter Creek	(D-33-8)27bbb-S1	0.05
Swap Canyon	(D-33-8)36dab-S1	0.01
Bert's Spring	(D-36-9)10dcb-S1	0.004
Dove Spring	(D-36-9)10acc-S1	0.004

* measured in 1966; **too small to measure; *** no data

[1] The system of numbering wells and springs in Utah is based on the cadastral land-survey system of the U.S. Government. The number, in addition to designating the well or spring, locates its position to the nearest 10-acre tract in the land net. By this system, the State is divided into four quadrants by the Salt Lake Base Line and Meridian, and these quadrants are designated by the uppercase letters A, B, C, and D, thus: A, for the northeast quadrant; B, for the northwest quadrant; C, for the southwest quadrant; and D, for the southeast quadrant. Numbers designating township and range, respectively, follow the quadrant letter, and the three are enclosed in parentheses. The number after the parentheses designates the section, and the lowercase letters give the location within the section. The first letter indicates the quarter section (usually a 160-acre tract), and the second letter indicates the 40-acre tract, and third letter indicates the 10-acre tract. The numbers that follow the letters indicate the serial number of the well or spring within the 10-acre tract. When the serial number is preceded by an "S" the number indicates a spring; if the spring is located to the nearest 40-acre tract, a suffixed "S" is used without a serial number.

Hanging Gardens (Palustrine Wetlands)
Hanging gardens form along cliffs of sandstone formations with a sequence of sedimentary strata of varied permeability. Seeping water is the core requirement for hanging garden development. Precipitation percolates into sandstone, follows along an impervious stratum, and seeps out laterally at the cliff. A hanging garden develops at this drip- or spring-line on the cliffside. Then the growth of plants plus chemical and mechanical weathering helps develop the garden; an overhang develops; and the plant acids, roots, and moisture continue to expand the hanging garden (Welsh and Toft, 1972).

Capitol Reef supports examples of hanging gardens, which often contain rare and endemic species, and, as such, serve as sites for research. Fowler *et al.* (1995) surveyed the level of endemism among vascular plant taxa in Capitol Reef and other Colorado Plateau parks. They found only five hanging gardens. At two of the gardens they found one taxa (*Mimulus eastwoodiae*), which is endemic to the Colorado Plateau and also endemic to hanging gardens in general. All found in the Waterpocket District, the names of the gardens at Capitol Reef are: Sidewall, Beaver Dam, Horseshoe, Fort, and Meander.

May *et al.* (1995) also described the general geomorphology of hanging gardens and provided a description of sapping processes leading to hanging garden development on the Colorado Plateau. They are ground-water driven systems, whereby the seep is the necessary condition for hanging garden development. Other important controlling features are a lack of fluvial processes that you find in spring systems and protection from sun and wind. Seeps are horizontal exit lines of water where water moving through an aquifer intercepts an impermeable layer or aquitard. Through chemical and mechanical weathering, loosened material falls away from the rock face producing a protective overhang. Colluvial material falls downslope, and the hanging garden develops therein.

May *et al.* (1995) noted that the monoclinal structure of the Waterpocket Fold precludes the geomorphology necessary for hanging garden development. The Navajo Sandstone dips too steeply to allow for recharge of the interstitial spaces in the rock. Water entering the sandstone quickly moves down through joints and fractures. They further noted that the scarcity of hanging gardens at the park makes those that have developed a rare and important resource. Fowler *et al.* (1995) suggested that monitoring the limited populations of hanging garden flora was important.

Small Impoundments (Palustrine Wetlands)
Prior to the establishment of the park, lands that are now in the park and other surrounding areas were utilized as range for livestock. Since water is scarce in the desert environment, numerous impoundments were created in the South Desert (Cathedral District) and along the eastern edge of the Waterpocket Fold. Almost every drainage coursing down from the fold in the Waterpocket District supports an impoundment. Bitter Creek Reservoir, constructed in the 1950s, is the largest impoundment in the park. It supports high bird densities, amphibians, tadpole shrimp, bison, and other wildlife. These features continue to provide water for livestock and wildlife, yet they reduce flows to drainage downstream and create habitat for the establishment of exotics such as tamarisk; therefore, the park favors the remediation of these sites. The exact number of impoundments in the park has not been inventoried;

some impoundments are small and not obvious in aerial photographs. The park has been seeking funding to restore some of these sites.

The only documentation of water impoundments and water sources are the personal observations of Ken Kehrer, Chief Ranger. He observed ten locations for water availability and use during the grazing season. Sites observed include:

- Ackland Spring;
- Bull Spring;
- South Desert Spring;
- Lake Creek at Cathedral Cabin;
- Lake Creek near park boundary on Caineville Wash Road;
- Polk Creek at Deep Creek junction;
- Polk Creek near Blackburn Farm (Upper South Desert);
- Polk Creek opposite Blue Notch Reservoir;
- South Desert Reservoir; and
- Blue Notch Reservoir.

Photographs of the sites are available, but few data regarding the sites have been found. In addition to this list, a general inventory of the impoundments in the park is necessary.

Section 8.3. of this plan looks at the issue of these impoundments, and Project Statement #9.1 in this report proposes an inventory and mapping of these structures.

6.6. Water Quality

6.6.1. Introduction

Capitol Reef National Park's original focus on water quality stemmed from efforts to develop a suitable drinking water source for residents and visitors. That effort successfully resulted in a drinking water well established near the old diversion on the Fremont River at the mouth of the gorge. An abundance of water quality data has been collected from the Fremont River watershed with greatest concentration on the Fremont River. Most recently, the U.S. Geological Survey under contract with the National Park Service developed a water quality database for the park. The database reveals over 36,000 observations retrieved from the U.S. Geological Survey's NWIS database, the Environmental Protection Agency's STORET database, and from the park's own database. An earlier retrieval from STORET by the NPS Water Resources Division served as the baseline water quality data inventory and analysis for the park (National Park Service, Water Resources Division, 1994). The results of this STORET retrieval for water quality data revealed 12,938 observations for 211 separate water quality parameters collected by two federal and state agencies at 99 water quality stations. Twenty-three sites yielded information within the park. Ten stations within and near the park yielded long-term records consisting of multiple observations for important parameters. Table 10 shows the assigned name from the NPS Water Resources Division effort and the actual site IDs that may be related to the STORET and NWIS databases. Clearly, several sampling efforts and duplicate IDs occur for at least two of the sites.

6.6.2. General Water Quality

Although the NPS Water Resources Division report (National Park Service, Water Resources Division, 1994) states that waters of the park generally appear to be of good quality, there are indications of impacts from human activities related to roads, campsites, grazing, wastewater discharges, and irrigation return flows. The Fremont River experiences periods of high turbidity which causes problems with irrigation, and prior to 1994, caused problems with drinking water treatment.

The report compared water quality data mostly pre-dating 1985 to the Environmental Protection Agency standards and State of Utah Standards. During that time period exceedences occurred for turbidity, sulfates (drinking water), pH, cyanide, copper, lead, zinc, and total and fecal coliform bacteria. Except for turbidity, the exceedences represented a low percentage of total observations. More recently, total phosphorus levels, high temperatures, and fecal coliform bacteria are of concern on the Fremont River in the park (Millennium, 2002).

Table 10. Assigned station number and site name from Water Resources Division report (1994) for ten sites with long-term data, and related STORET and NWIS site ids.

Station ID	Site Name	Site IDs	Period of Record for all site IDs associated with Site Name	Within Park Boundaries
CARE 0040	Capitol Reef Fremont River	381701111122	4/2/79-10/18/89	Yes
CARE 0049	(D-29-7)15DBS-1 (stream)	Unknown	9/12/77-6/16/83	Yes
CARE 0053	Fremont River at Hickman Bridge Trailhead	495436	6/20/78-10/13/92*	Yes
CARE 0035	Fremont River at west boundary of Capitol Reef NP	495446	6/30/88-11/4/92	No
CARE 0037	Fremont River at U-12 Crossing and Above Fish Creek	495438 38160711224	6/29/1988-11/5/92	No
CARE 0041	Pleasant Creek near Caineville, Utah	495483 09330210	4/22/69-9/9/76	No
CARE 0043	Fremont River near Caineville, Utah	495432 09330230 38194511005	3/14/67-8/20/91	No
CARE 0059	Fremont River at U-24 Crossing 3 mi. SW of Caineville	495401	6/21/80-5/11/82	No
CARE 0063	Fremont River near Teasdale at U-24 Crossing	495437	1/27/81-6/21/89	No
CARE 0066	Fremont River near Bicknell, Utah	495438	5/25/76-8/20/91	No

* State of Utah, Department of Environmental Quality continues to monitor this site.

The Fremont River transitions from a calcium-bicarbonate type in its upper reaches to a calcium-sulfate type as it passes through agricultural lands and the park. The same can be said for Oak and Pleasant creeks. Sulphur Creek, aptly named, carries high sediment loads with associated high levels of sulfates and is a calcium-sulfate type water (Christiana and Rasmussen, 1991). Appendix B provides copies of water quality data analyses from the Horizon Report for these perennial streams.

Section 4.3., Table 1, presents the designated use classification for the Fremont River and tributaries. In 2000, the Utah Division of Water Quality (2000a) recognized impairment of protected designated uses on the Fremont River . They placed the Fremont River from its headwaters to Bicknell west of the park on the 303(d) list for total phosphorus and dissolved oxygen. These constituents exceed standards or guidelines for a coldwater fishery. The river also is listed for total dissolved solids from the eastern park boundary downstream to its confluence with Muddy Creek. This constituent exceeds standards for agricultural use. Millennium Science and Engineering (2002) provided total maximum daily loads for the Fremont River on the two stretches of the river that were listed. The plan calls for instituting best management practices such as moving corrals from river's edge in the Upper Fremont and controlling flows from artesians (i.e., capping the springs in some manner) in the lower Fremont. The report states that realizing substantive results from these practices may take a long time.

6.6.3. Results of Previous Studies on the Fremont River and its Tributaries

In an early assessment of water resources in the park, Envirosphere (1981) described a program to assess water quality. The Envirosphere effort was conducted to identify sources of water quality problems both inside and outside the boundaries of the park and to design a water quality monitoring program to track these problems and assure protection of the water resources. They concluded that 1) existing water quality data for the park were virtually absent; 2) agricultural irrigation was the primary activity affecting park waters; 3) gross beta radiation (53 pCi/L $\pm$ 17 pCi/L) in the Fremont River was above State of Utah warning limits for public water supplies (50 pCi/L established by the state at the time); and 4) water quality and fish tissue samples indicated no significant water quality problems.

Christiana and Rasmussen (1991) analyzed the park's water quality based on review of existing databases and by sampling selected streams, springs, seeps, and tinajas in May 1989 and September 1990. This study is the only comprehensive survey of water resources conducted in the park to date, and their work summarized not only the status of water quality, but also provided an overview of ground-water sources, surface water flows, water use, water budgets, and water rights. Their investigations noted that total dissolved solids almost doubled between Bicknell and Caineville (mean total dissolved solids: 311 to 569 mg/L). Pesticides were found to be below the detection limit of 1 μg/L for those organic compounds screened in samples from 5 Fremont River sites, the Fruita ground-water sites, and Sulphur and Sand creeks. Turbidity increased with distance downstream from a median level of 7 nephlometric turbidity units (NTU) near Bicknell to 25 NTU at the Gifford House in the park. Levels peaked at the beginning of snowmelt, declined during late spring and summer, and remained variable during irrigation season (April through October). Fecal coliform counts peaked during the summer and generally increased downstream. Measured levels ranged from <1 to 600 colony forming units/100 ml (CFU/100 ml) at the Gifford House, and in Sulphur Creek from <1 to 2600 CFU/100ml.

In the late 1980s, the park developed a proposal to monitor water quality. Their effort stemmed from trying to understand why the Fremont River produced high turbidity levels during portions of the year (Borthwick and Henderson, 1991). The program included sampling the Fremont River within and upstream of the park, and tributaries such as Pine, Pleasant, and Sulphur creeks (Figure 17). Park personnel measured temperature, specific conductance, turbidity, fecal coliform bacteria, and in later years pH, dissolved

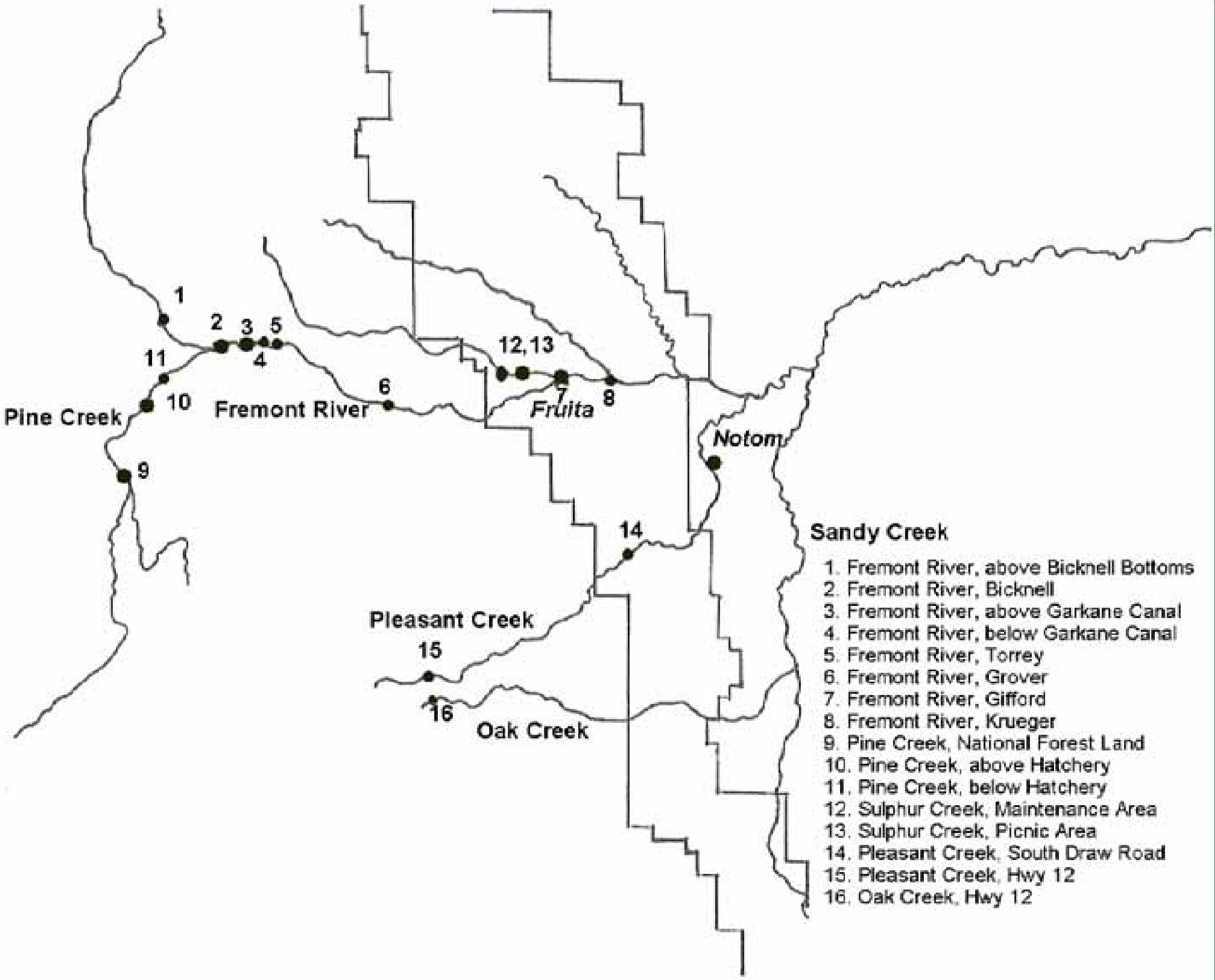


Figure 17. Sampling sites for 1988 through 1994 water quality monitoring effort.

oxygen, various forms of phosphorus, total ammonia as nitrogen, nitrate-nitrogen, sulfates, and settleable solids. A Hach kit was used to measure nutrients. Discharge was not measured at any of the sites and thus water quality parameters were not weighted for changes in streamflow.

The proposal was implemented for several years and resulted in reports by Borthwick (National Park Service, 1990)[2] and Berghoff (National Park Service, 1994). A summary of the 1988-1989 data for the Fremont River (National Park Service, 1990) revealed that temperature, turbidity, conductivity, and fecal coliform all showed an increase from upstream sites to downstream sites. Turbidity was lowest during the irrigation season (April 1 to October 31) and least variable between sites. Turbidity typically increased downstream and with increased discharge. Turbidity spikes unrelated to precipitation events occurred during the irrigation season resulting in high variability during this period. Specific conductance (measured as microSiemens/centimeter -µS/cm) remained the highest during the summer months. Temperature increased during the summer months and at times exceeded the state standard of 20^{o}C for a coldwater fishery. Numbers of fecal coliform bacteria also increased through the summer months. The study suggested that turbidity spikes unrelated to discharge events were human-induced.

A summary (National Park Service,1994) of the 1991 monitoring effort included results of nutrient analyses as well as basic parameters. Again, specific conductance and turbidity (measured as NTU) increased significantly from upstream to downstream on the Fremont River. The author used geometric means to compare sites. The specific conductance geometric means were significantly different between the above Bicknell Bottoms site, which was farthest upstream, and the Krueger site, which was farthest downstream (494.8 and 642.0 µS/cm, respectively, $p<0.05$). Geometric means for turbidity differed significantly between the above Bicknell Bottoms to the Krueger site (1.98 to 33.90 NTU, $p<0.05$). Variable conductivity and turbidity levels and turbidity peaks during the irrigation season were attributed to changes in discharges and agricultural return flows suspected to carry fertilizers and soil. Comparison between proximate sites outside of the park revealed significant differences in turbidity levels. However, no significant difference occurred between sites in the park (Gifford and Krueger) and the closest upstream site (Grover, which is outside the park). The Fremont River Gorge, which experiences no agricultural use, is situated between the Grover site and the Gifford site. The lack of significant change between the Grover site and the Gifford site and the occurrence of change between all other upstream sites along the Fremont River suggested an impact on the river due to irrigation and grazing practices.

Other sites revealed a range of specific conductance and turbidity levels. For example, the geometric mean above the Eagan Fish Hatchery on Pine Creek was 140 µS/cm while below it was 227 µS/cm. Sulphur Creek at the picnic area revealed a comparatively high specific conductance geometric mean of 1619 µS/cm. Geometric means for turbidity were 8.77, 0.76, and 20.90, respectively, for the above sites.

Nutrient results were highly variable and laboratory techniques for phosphates and nitrates changed in September 1991. Samples prior to September were not filtered and

[2] The first study results (National Park Service,1990) predate the proposal (Borthwick and Henderson, 1991) , since the park had already begun to monitor water quality before they received funds from the proposal to fully implement a monitoring program.

afterwards were filtered in the field. Un-ionized ammonia levels at all sites, except for one on Pleasant Creek, did not exceed state standards which are based on relative water temperature and pH. Nitrate-nitrogen levels ranged from a low of 0.064 mg/L at the Grover site to a high of 0.788 mg/L at the Bicknell site on the Fremont River. The lowest levels occurred during the summer months. On the Fremont River, geometric mean sulfate levels ranged from 119 mg/L at Bicknell to 178.8 mg/L above Bicknell Bottoms. Sulphur Creek revealed high sulfate levels ranging from 510-1600 mg/L. The creek flows through the Moenkopi Formation, which contains gypsum, a highly soluble sulfate-bearing material. The change in methodology for analyzing phosphorus revealed a marked drop from highs near 0.94 mg/L (January to August) to 0.05 mg/L (September to December). Essentially the park measured a form of total phosphorus from January to August and total dissolved phosphorus from September to December. They used a Hach kit and colorimeter to analyze the samples, and most likely measured orthophosphate; the methodology section of the report does not state specifically which species of phosphorus they measured other than to say phosphorus as PO_4.

During the summer of the 1991 sampling effort, temperature at several Fremont River sites exceeded the 20^{o}C maximum state criterion. Lack of vegetative cover apparently related to streamside grazing can contribute to increased water temperatures. Dissolved oxygen decreases with increased temperature, and the 1991 study revealed occasions where dissolved oxygen did not meet the requirements for a coldwater fishery.

Lastly, the 1991 study revealed counts of fecal coliform bacteria exceeding the 200 CFU/100ml state standard on most sites on the Fremont River and in Sulphur Creek. The author suspected that high counts in Sulphur Creek may be attributed to a failing absorption field behind the residences.

The concern that upstream irrigation practices dictate turbidity levels within the park has yet to be confirmed, a point discussed further in water quality issue section 8.6 of this plan. Also, the State of Utah has continued monitoring of the Fremont River at Hickman Bridge, a site that the park used to monitor. Their efforts continue to show exceedences of the state recommended level of 0.05 mg/l total phosphorus. Other than the screening performed by Christiana and Rasmussen (1991), only one site – Fremont River at U-12 crossing and above Fish Creek (STORET # 495438) - outside the park was subjected to pesticide analyses. No exceedences occurred (National Park Service, Water Resources Division, 1994). No other substantive studies have been conducted to determine the level of contamination occurring in the river. Since the Fremont River served as a culinary source for the park, water was sampled for nitrates, volatile organics, and metals. At no time did the water reveal elevated levels of these contaminants. However, applications of fertilizers and pesticides do occur upstream and inside the park, and the park needs to know their effect on water quality. These in-park studies reveal water quality issues related to land use practices and natural events on the Fremont River.

Recently, the U.S. Geological Survey compiled a water quality database for use in selecting water quality vital signs as part of the Northern Colorado Plateau Network of parks. The data include information from 1975 to the present. A cursory review of the data corroborated earlier findings and concerns. Exceedences of state standards for the Fremont River inside the park included temperature, pH, dissolved oxygen, total phosphorus, total suspended solids, manganese, zinc, and total and fecal coliform. High sulfates and turbidity were documented in the database as well. No pesticide data were found. Sulphur Creek also revealed exceedences for temperature, dissolved oxygen, pH and fecal coliform. Pleasant Creek at the Sleeping Rainbow Ranch revealed exceedences for fecal coliform, total phosphorus, and aluminum. Oak and Halls creeks have few data which encourages monitoring in these drainages, especially for fecal coliform (or E.coli) in Halls Creek, where water quality impacts from hikers has a high potential. Although most exceedences mentioned are small percentages of the total observations, they warrant further investigation.

Water quality of the Fremont River was also monitored through biological assessments and development of biotic indices. Mangum (1993) sampled macroinvertebrates in the Fremont River at Hickman Bridge, the park campground, and U-24 at the "oxbow" from 1985 through1992 and calculated the Biotic Condition Index (BCI) and Diversity Index (DAT) for the sites. These indices showed indications of organic enrichment, sedimentation, a riparian habitat mostly in "poor" condition (sometimes "fair"), and a "stressed ecosystem." All the park sites observed were rated "poor" to "fair" for the indices. At the U-24 "oxbow," the BCI indicated "extreme stress conditions" (Mangum, 1993). He noted impacts from grazing and poor quality of return flows.

Other more recent assessments revealed a predominance of mayflies (Ephemeroptera), which are less pollution tolerant (Kirby and McAllister, 1999, 2000). Fish inventories (Winget, 1975; Hardy, 1989a; Hepworth *et al.*,1993; Kirby and McAllister, 1999, 2000) suggested that the Fremont River immediately above and within the park support mostly non-game fishes that can tolerate temperatures which exceed the criterion for coldwater fish.

6.6.4 Specific Water Quality Studies on Oak and Pleasant Creeks

In the Oak and Pleasant creek watersheds, from 1988 to 1991, the park or associates conducted bacterial and sediment studies; these studies found high bacterial counts in stream reaches accessible to livestock (National Park Service, 1993). Barth and McCullough (1988) sampled Oak and Pleasant creeks during 1985-86 to evaluate the effects of cattle drives in the two drainages. They found that after cattle drives Oak Creek exhibited substantially higher levels of coliforms and sediment than did Pleasant Creek. The "numerous cattle crossings" observed in Oak Creek meant cattle had direct access to the riparian area. Pleasant Creek contained more taxa of benthic macroinvertebrates, which they assumed may have reflected the basic difference between the two streams' ecology more than the temporary effect of the cattle drives. They considered Pleasant Creek to be a "high quality aquatic habitat."

Buckhouse and Gifford (1976), who studied grazing in piñon-juniper rangelands in southeast Utah to correlate grazing and water quality, confirmed that grazing can produce bacterial pollution. However, they learned that the public health hazard of livestock grazing in open range on gentle slopes is minimal if the waste does not wash directly into the channels. Other researchers have observed that a few cattle with direct access to a stream's channel can significantly raise fecal coliform contamination; but if the cattle are denied direct access to riparian areas *per se* the grazing will have only minor effects on a stream's water quality (Kunkle, 1970).

Christiana and Rasmussen (1991), reviewed water quality on Oak and Pleasant creeks to compare dissolved solids, chemistry and bacteria. They found that mean total dissolved solids (TDS) of Pleasant Creek increased from 152 mg/L at the Scenic Drive to 750 mg/L after being used for irrigation near Notom. Likewise, the TDS in Oak Creek increased from 111 mg/L at the east park boundary to 780 mg/L below Sandy Ranch. However, they noted that the change reflects the geochemistry of the basins as well, since the creeks originate in volcanic rocks on Boulder Mountain, but flow into calcium-sulfate type rock toward the lower ends of the watersheds. Water quality of both Oak and Pleasant creeks generally degrades in the downstream direction.

By the 1990s, park staff had sampled water quality on Pleasant Creek and Oak Creek and found that the two creeks contained comparable levels or readings of nutrients, conductivity, turbidity, and dissolved oxygen. Oak Creek, however, displayed higher nitrate levels than at Pleasant Creek. They observed on both streams that the levels of all these constituents indicated poorer water quality in the downstream direction (National Park Service, 1994).

Brammer (1997) and colleagues from Purdue University (working under Prof. J. MacDonald) compared the two creeks and found that Pleasant Creek supports a rich and diverse aquatic insect fauna and is “pristine,” in contrast to Oak Creek, judged “severely impacted by cattle.” These conclusions were based on macroinvertebrate diversity, riparian vegetation condition, streambank erosion, and siltation. This was the first inventory of benthic macroinvertebrates in Pleasant Creek, and the Purdue investigators found the stream to be an excellent candidate for a “reference stream.” They found no evidence that driving cattle up and down the canyon twice a year had a significant effect on the macroinvertebrate community. Presumably, the stream’s macroinvertebrates are resilient and recover from the temporary effect of the cattle drives. Kirby and McAllister (2000) surveyed fish and macroinvertebrates in Pleasant Creek inside the park boundary and summarized the species and taxa observed.

6.6.5. Tinaja Water Quality

Baron *et al.* (1998) reviewed the chemical and biological characteristics of desert rock pools in the park. Mid-April temperatures ranged from 22-25^{o}C. The rock pool waters were dilute (<200 μS/cm) and near neutral, and ratios of calcium:silica (>20) and calcium:sulfate (>8) differed from those in ground water (<5 and <2 respectively). These specific conductance and ratio figures indicated that water in the tinajas comes primarily from surface water, not ground water. Phosphorus was not measured above detection limits. Nitrates were low while ammonium was present in higher concentrations. Berghoff (1995b) conducted a survey of tinaja wetlands in the Waterpocket Fold and found the median specific conductance for 409 tinajas was 39 μS/cm and the median pH was 7.8 in 46 tinajas.

6.6.6. Other Agencies’ Water Quality Monitoring Efforts

Other agencies with federal lands adjacent to the park have had or have water quality monitoring programs. The Bureau of Land Management, Richfield District, cooperatively monitored water quality with the State of Utah. Presently, they monitor only on a case-by-case basis since the Bureau does not have the funding to allow sample collection on a monthly basis (Zieg, P., BLM, Richfield Office, pers. comm., 2003). All of the Bureau’s water quality data have been uploaded to STORET.

The Fishlake National Forest, adjacent to the park to the NW, is conducting a watershed analysis to be completed in 2003. The analysis develops a disturbance matrix, a tool which can anticipate water quality issues within watersheds. This National Forest has few data from the field (Deiter, D. Fishlake National Forest, Richfield, UT Office, 2002). Yet, they do cooperative sampling with the state. Only Sevenmile, UM Creek and North Fork Box creeks are sampled cooperatively. The Dixie National Forest, Teasdale District, has monitored Pleasant Creek above Tantalus Creek for water quality and macroinvertebrates since 1992. Samples were not collected every year and are not cooperatively sampled with the state now. Some samples from Pleasant Creek revealed exceedences for cadmium, total phosphorus, chromium and total suspended solids (Range, 1998c). More recently, data taken in 1999 on Pleasant Creek revealed total phosphorus levels in exceedence of the state criterion for all three sampling efforts (Utah Division of Water Quality, 2000c).

The Dixie National Forest controls erosion during and after timber operations by water bars, stream buffer strips, and other measures. The Forest monitors the effectiveness of their best management practices (BMPs) for erosion protection, with a minimum of 10 percent of timber sale units selected at random for evaluation. In some examples where roads were not adequately waterbarred, erosion and sediment resulted, but generally the BMPs have been successful (Range, 1998c).

The National Forest has monitored sites in the headwaters of Oak Creek and Pleasant Creek within a baseline cooperative program with the State Department of Environmental Quality. They have measured chemistry, bacteria, or benthic macroinvertebrates at least sporadically since the 1970s at some sites. State water quality measurements include common cations/anions, nutrients, metals, pH, and conductance. Exceedences (i.e., values above the acceptable state standard) for phosphorus and sediment have occurred, but generally the water quality has been good in the headwater areas of the two creeks (Kendall, 1998 and 1999). Note that somewhat elevated levels of phosphorus appear in some natural springs in the general Fremont basin, presumably a result of natural geologic influences (Zieg, P., BLM, Hamilton, R., Forest Service, and Pace, D., Utah Assc. of Conservation Districts, pers. comm., 2003).

The National Forest has monitored benthic macroinvertebrates in Pleasant and Oak creek headwaters at least sporadically and in some periods regularly, and the taxa basically have indicated good water quality, based on a biotic condition indiex (BCI; Dixie NF, 1976; Staats, 1993 and 1995; Mangum, 1997; Range, 1997c; Kendall, 1998 and 1999).

The Dixie National Forest (Eastern Zone) hydrologist has monitored the effects of grazing, timbering, prescribed burns, wildfires, and recreation on water quality without observing sustained or significant impacts. Some riparian areas have heavy grazing pressure, which produces sediment. Logging roads also produce sediment. Following fires, erosion rate increases can affect water quality, but in general, fires have not produced a sustained water quality problem. The Forest emphasizes buffer strips along riparian areas as their principal technique for trapping and holding sediment to protect water quality. At times, cattle have had excessive access to the stream channels, degrading water quality, but generally water quality has been good in the two creeks. An evaluation of campground and recreation impacts in the 1970s used stream bacteria as an indicator, and the bacteria did not indicate a problem of recreational impacts on water quality in the two creeks (Range, D., Dixie NF, pers. comm., 2003; Dixie NF,1994 and

1976; Range, 1996; Range, 1977a; Range 1997b; Kendall, 1998 and 1999; Envirodata, 1994).

6.7. Vegetation

According to Heil *et al.* (1993) 759 vascular plant species representing 352 genera and 86 families exist within the park. Capitol Reef supports at least 36 taxa that are listed as threatened, endangered, candidate species, species no longer candidates for listing, or species of concern. This indicates that the park supports one of the greatest concentrations of rare taxa in the region. The variety of taxa results from the wide range of habitats in the park. Distribution is governed by environmental factors such as water availability, temperature extremes, and soil limitations. Heil *et al.* (1993) identified 34 plant communities nine of which are associated with riparian or wetland areas. Unusual and rare plant communities found near water include the:

- dogwood-spruce riparian woodland at high elevations;
- hanging gardens and the waterpockets;
- hornbeam-box elder-oak woodland at low elevations.

Welsh (1988) described the Fremont River riparian vegetation within the park and noted that within the gorge, river birch (*Betula occidentalis*), thin-leaf alder (*Alnus tenuifolia*), and sandbar willow (*Salix exigua*) dominate the river banks. Box-elder (*Acer negundo*) dominates in shady areas farther downstream, and some tamarisk (*Tamarix ramosissima*) is also present. Fremont cottonwood (*Populus fremontii*), Russian-olive (*Eleagnus angustifolius*), and tamarisk dominate the river past Fruita. The latter two species are exotics, and the park is seeking funding to control or eradicate them.

One species associated with riparian areas, the Ute ladies'-tresses is federally listed as threatened. This species could occur in the Fremont River Gorge since it is adapted to disturbance regimes such as flooding. Welsh (1988) did not find this species during his review of the riparian vegetation associated the Fremont River Gorge. However, Heil *et al.* (1993) does list it as a species that occurs along the Fremont River below the gorge within Capitol Reef.

The Nature Conservancy and the National Park Service sponsored and completed a comprehensive survey of potential natural areas of the park (Van Pelt *et al.*,1991). They determined that the Fremont River Gorge riparian area was one of the best examples of intact riparian vegetation in the states of Utah and Colorado. The park Resource Management Plan (National Park Service, 1993) recommends formally recognizing this and four other areas within the park as Research Natural Areas.

Wetlands support vegetation adapted to saturated soil conditions, and they do exist within the park. They are found along streams, around tinajas, and particularly in an oxbow adjacent to the waterfall at U-24. This latter wetland was formed when road construction blocked the natural river channel, and a new channel with a waterfall was established. The abandoned channel has filled with sediment leaving some uplands interspersed among areas of riparian vegetation. The Utah Department of Transportation and the park are interested in the restoration of the stream channel to its original meander, and in doing so would enhance habitat for the Ute ladies-tresses that occur there.

Hanging gardens also support vegetation adapted to saturated conditions, and several species are encountered including alcove columbine (*Aquilegia* sp.), an endemic sedge (*Carex* sp.), helliborine (*Epipactis* sp.), and the maidenhair fern (*Adiantum capillus-veneris*) (Clark, T., Capitol Reef National Park, pers. comm., 2003). Eastwood monkeyflower (*Mimulus eastwoodiae*) is present in at least one hanging garden (Fowler *et al.*, 1995) and is considered endemic to the Colorado Plateau hanging gardens. Park records for rare plant locations indicate that alcove bog-orchid (*Habenaria zothecina*) is present in Halls and Pleasant creeks.

6.7.1 Invasive Plant Species

The park also supports many exotic species, two of which (tamarisk and Russian-olive) are a serious problem for the park. Tamarisk (also called saltcedar) (*Tamarix ramosissima*) is a fire-adapted species with long tap roots that allow the tree to intercept deep water tables and interfere with natural aquatic systems. Tamarisk disrupts the structure and stability of native plant communities and degrades native wildlife habitat by outcompeting and replacing native plant species, monopolizing limited sources of moisture, and increasing the frequency, intensity and effect of fires and floods. Although it provides some shelter, the foliage and flowers of tamarisk provide little food value for native wildlife species that depend on nutrient-rich native plant resources. Tamarisk spreads vegetatively, by adventitious roots or submerged stems, and sexually. Each flower can produce thousands of tiny (1/25-inch diameter) seeds that are contained in a small capsule usually adorned with a tuft of hair that aids in wind dispersal. Seeds can also be dispersed by water. Seedlings require extended periods of soil saturation for establishment (www.nps.gov/plants/alien/fact /tama1.htm).

Tamarisk is a relatively long-lived plant that can tolerate a wide range of environmental conditions, particularly inundation and drought, once established (Stevens and Waring, 1988). It can replace or displace native woody species, such as cottonwood and willow, which occupy similar habitats, especially when timing and amount of peak water discharge, salinity, temperature, and substrate texture have been altered by human activities. Stands of tamarisk generally have lower wildlife values compared to stands of native vegetation, although tamarisk can be important to some bird species as nesting habitat. Tamarisk is a facultative phreatophyte, meaning that it can draw water from underground sources but once established it can survive without access to ground water. It consumes large quantities of water, possibly more than woody native plant species that occupy similar habitats. Tamarisk is tolerant of highly saline habitats, and it concentrates salts in its leaves. Over time, as leaf litter accumulates under tamarisk plants, the surface soil can become highly saline, thus impeding future colonization by many native plant species (http://tncweeds.ucdavis.edu/esadocs/documnts/ tamaram.html).

The Russian-olive is a small thorny tree that appears to be colonizing the Fremont River corridor and, like tamarisk, outcompeting native species such as willows and perhaps the Fremont cottonwood. Russian-olive interferes with natural plant succession and nutrient cycling, and taxes water reserves. Since Russian-olive is capable of fixing nitrogen in its roots, it can grow on bare, mineral substrates and dominate riparian vegetation where an overstory of cottonwoods has died. Although Russian-olive provides a source of edible fruits for birds, ecologists have found that bird species richness is actually higher in riparian areas dominated by native vegetation. Establishment and reproduction of Russian-olive is primarily by seed, although some vegetative propagation also occurs. The fruit of Russian-olive is a small cherry-like drupe that is readily eaten and disseminated by many species of birds (< www.nps.gov/plants/alien/fact/elan1.htm). These two plant species have invaded other areas in the park, particularly around created impoundments and smaller drainages

6.8. Fauna

6.8.1. Fish and Fishery

Fish, aquatic macroinvertebrates, and amphibians are important wildlife associated with either streams, springs, or tinajas in Capitol Reef National Park. As the Fremont River flows from west to east through the park, it undergoes a rapid transition from a coldwater stream to a warmwater desert stream. Fish populations have adapted to this transition in environments. Fish species found in the park include those from downstream Colorado River associations and from more coldwater upstream sources (Hepworth *et al.*, 1993). The cyprinids (minnows) and the catostomids (suckers) have historically comprised the park fish communities. Four cyprinid species, the speckled dace (*Rhinichtys osculus),* Utah chub (*Gila atraria*), leatherside chub (*Gila copei*) and redside shiner (*Richardsonius balteatus*), and two catostomid species, the flannelmouth sucker (*Catostomus latipinnis*) and the bluehead sucker (*Catostomus discobolus*) have been documented in the Fremont River. Also, a native cottid, the mottled sculpin (*Cottus bairdi*) has been found in the Fremont River in the park. Rainbow (*Onchoryhnchus gairdneri*) and brown trout (*Salmo trutta*) inhabit the Fremont River as did the Colorado River cutthroat (*Onchorynchus clarki pleuriticus*), which has since been extirpated (Hepworth *et al.*, 1993). Four of the above fish species are introduced: brown trout, rainbow trout, redside shiner, and the Utah chub (Schwarzbach, 2000).

McAda *et al.* (1978) found the roundtail chub (*Gila robusta*) in the Fremont River; however, the chub's presence has not been confirmed subsequently. Mottled sculpin exist in the Fremont; Borthwick (1991) documented their presence when 42 dead sculpin were found after a rotenone spill affected the Fremont River in 1991. Kirby and McAllister (1999, 2000, 2001) documented mottled sculpin in their fish and macroinvertebrate surveys. Federally threatened or endangered fish species have not been recently documented in the park; however, the State of Utah lists the roundtail chub and both suckers as threatened in the upper Colorado River basin.

Pleasant Creek downstream of the park supports bluehead sucker, flannelmouth sucker, and speckled dace (Schwarzbach, 2000), and within the park in Pleasant Creek Kirby and McAllister (1999) documented flannelmouth suckers and redside shiners. They also found speckled dace in Sulphur Creek. Lastly, Baron *et al.* (1998) documented the fathead minnow (*Pimephales promelas*), an introduced species, in the Miahana tinaja that terminates close to Halls Creek, a stream in which this species is common. Two other fishes have been recorded in the lower reaches of Halls Creek, the black bullhead (*Ictalurus melas*) and the bluegill (*Lepomis machrochirus*). Most likely, they migrate upstream from Lake Powell (Capitol Reef National Park website: www.nps.gov/care).

Several factors affect the health of the park fishery, and these include: 1) an artificial waterfall (created by U-24 road construction) which may create a barrier to fish migration, 2) upstream agriculture resulting in lowered flows, increased turbidity and temperature, 3) livestock grazing contributing to streambank instability and water quality degradation, 4) introductions of non-native fish species, 5) nutrient loading from upstream aquaculture, and 6) fish kills from accidental rotenone spills. In the 1980s, construction of a reservoir upstream of the park threatened natural resources in the Fremont River Gorge. Yet, a study of the potential impacts to the fisheries from the proposed Fremont River Water Power Project (Hardy *et al.*, 1989) suggested that stabilization of the fisheries habitat would occur with construction of the dam. The reservoir and dam would provide better habitat downstream as a result of improved water quality conditions. Since the 1980s, preference for the dam has waned somewhat, but the idea resurfaces periodically, and the potential impact to fisheries and other resource issues may need to be reviewed again in the future. Section 6.5.2 discusses the history of dam proposals on the Fremont River.

6.8.2. Aquatic Macroinvertebrates

Several investigators including the State of Utah have assessed macroinvertebrate populations in water sources at the park. Early investigators Woodbury and Musser (1963) established stations to examine different aquatic environments. Reichert (1977) documented the initiation of an aquatic invertebrate monitoring program in 1977. Bauman (1989) listed macroinvertebrates for the Fremont River. The Forest Service (1991) studied three stations in 1988 for macroinvertebrates. They found taxa typically associated with systems high in sediment. Magnum (1993) reviewed samples taken and results for macroinvertebrates in the Fremont River. Other efforts include MacDonald's (1992a, 1992b) work in Pleasant and Sulphur creeks, Winget's (1975) very early work on the Fremont River, Brammer (1998) on Pleasant Creek, and Kirby and McAllister's work on Pleasant and Sulphur creeks and the Fremont River (2000). MacDonald's studies of aquatic flies resulted in the assigning of the type locality of two species to Capitol Reef National Park. The species are *Hemerodromia burdicki chelata* and *Neoplasta concave* (letter from J.F. MacDonald to D. Worthington, June 15, 1999). Most recently Brammer and MacDonald (2003) found a diverse fauna in Pleasant Creek with over 133 taxa that suggests few impacts from humans or cattle.

According to Kirby and McAllister (1999, 2000), the mayfly *Ephemeralla* sp. was one of the most common and abundant species in the Fremont River. In 1999, another mayfly (Family Baetidae, probably *Fallceon*), the caddisfly *Ceratopschye* and the stonefly *Isoperla* were also common. In 2000, other common mayflies included *Tricorythodes* sp. and probably *Fallceon* sp. Both *Isoperla* and another stonefly, *Pteronarcys* sp. were common upstream of the Fremont River and Sulphur Creek confluence. *Ephemeralla* sp., *Ceratopschye* sp., *Isoperla* sp. dominated Pleasant Creek and a baetid mayfly and a midge larvae dominated samples in Sulphur Creek below U-24. The presence of mayflies, caddisflies and stoneflies indicate relatively good water quality. Since 1991, when a rotenone spill killed large numbers of macroinvertebrates and fish, the macroinvertebrates have re-colonized the waters.

Haefner and Lindahl (1988, 1991) described the mechanisms of community organization in rock pool (tinajas) habitats and the effects of livestock grazing on these systems. Lafrancois (1995) found 53 taxa of macroinvertebrates in 20 rock pools of southern Capitol Reef. He determined that no distinct biological communities exist within the park rock pools, and that volume and temperature did not affect species richness or individual species abundances. However, *Notonecta kirby* and *Rhantus gutticolis* were abundant in pools surrounded by wetlands, and moreover, species richness was significantly greater at pools surrounded by wetlands. Finally, the biggest determinants of species abundance were flooding of pools and evaporation as the season progressed. Baron *et* *al.* (1998) determined that neither flooding nor drying affected the composition of the biological communities in the pools and that the pool fauna appears to be resilient to climatic variability.

Other agencies, including the Forest Service and the Bureau of Land Management, have assessed macroinvertebrates on their respective federal lands over the years. Any macroinvertebrate work conducted by the BLM has been uploaded to STORET. The Forest Plan for the Fishlake National Forest monitoring schedule is to sample macroinvertebrates in five streams/year. This goal has been generally met. Sampling location is driven by interest in key watersheds, for baseline data, or from specific project activities. The best long-term aquatic macroinvertebrate data sets in the Loa Ranger District of the Fishlake National Forest are on Sevenmile and UM creeks. The Forest Service uses the Biotic Condition Index developed by Winget and Mangum (1979) to provide a quantitative measure of aquatic health due to overall watershed condition, land management and natural disturbances. A rating over 90 is considered excellent and below 72 is poor. Index values peaked in the late 1980s and have since trended downward on these creeks (Whelan, J., Utah Div. of Wildlife Resources, pers. comm., 2002); a closer review of the data is warranted.

6.8.3. Amphibians and Reptiles

Surface water sources provide important habitat for several amphibian species in the park. The park website (www.nps.gov/care) lists at least 10 amphibians that occur in the park or its vicinity. The spadefoot toad (*Scaphiophus intermontanus*), the red spotted toad (*Bufo punctatus*), the Rocky Mountain toad (*B. woodhousei*), and the canyon tree frog (*Hyla arenicolor*) are present in the tinajas of Capitol Reef. Other amphibians documented in the park are the leopard frog (*Rana pipens*), the tiger salamander (*Eustoma tigrinum*) and the Great Basin skink (*Eumeces skiltonia*). The western spadefoot toad (*Scaphiosus intermontanus*), the boreal chorus frog (*Pseudacaris triseriata*) and the boreal toad (*Bufo boreas*) have been documented near the park.

One snake found in the park, which may seek habitats associated with water, is the striped whip snake (*Masticophus taeniatus*). It is one of the most common snakes at Capitol Reef; and has been observed in Fruita, along the Fremont River and in the Cathedral and Waterpocket districts. Lizards may frequent areas with water, but typically they are associated with drier habitats. One lizard, the desert spiny lizard (*Sceloporus magister*) has been documented on the east side of the park from the southern boundary north to the Fremont River. It frequents riparian zones that support trees (www.nps.gov/care).

6.8.4. Other Wildlife

From 50 to 80% of wildlife species require that some part of their life cycle be spent near or in water. While the park does support rodents including beaver, voles, mice, and bats requiring riparian, aquatic, or wetland habitat, none are threatened or endangered. The southwestern willow flycatcher, a federally listed endangered bird species, has been sighted in the park on several occasions. However, no records of its nesting in the park has been documented. This bird, obligate to riparian and wetland habitat, occupies densely vegetated areas along flowing water.

The recent and successful reintroduction of desert bighorn sheep near Pleasant Creek within the park warrants maintenance of this water source for these mammals. Water is one of their critical needs.

7. WATER-RELATED INFRASTRUCTURE AND WATER RIGHTS

7.1. Drinking Water

Efforts to supply an adequate and potable drinking water source for the park have marked the park's history. Since the Fremont River water was deemed non-potable, and since a well had not been completed, the search for an adequate supply continued through the 1990s. The search earnestly began with a study by Marine (1962) that determined a water supply of 50 gallons per minute (gpm) (190 Lpm) would be sufficient to meet park needs. He noted that the Coconino Sandstone (now recognized as the White Rim Sandstone; Fillmore, R., Western State College, pers. comm., 2002) seemed capable of yielding this quantity. Prior to this effort, culinary water was either obtained from the Fremont River, chlorinated and boiled, or trucked from Bicknell (Frye, 1998). The trucked water was stored in a 1000-gallon (3.8 m^3) cistern.

Use of the Fremont River as a culinary source for headquarters, the campground, and residents continued through the early 1990s. Beginning in 1963 with the construction of a treatment facility, water was pumped from the river and treated by sand and anthracite coal filtration. During periods of high turbidity, the park ceased pumping and treating water, and depended on water stored in the cistern. To secure a more stable water supply, in 1985 the park drilled a deep well beside the treatment plant. Three holes were completed at depths ranging from 1050 ft (320 m) to 1706 ft (520 m). A strong sulfide odor emanated from the wells. Also, an aquifer test (National Park Service, 1989b) revealed a well yield of less than 3 gpm (11 Lpm) and the wells were deemed not sufficient to supply the treatment plant. Use of the wells was discontinued in 1987 (Christiana and Rasmussen, 1991; Inglis, 1989; Jackson, 1993). The wells were plugged with sand and capped. The park will want to determine if old records confirm that abandoned water wells from the 1980s were plugged and capped according to state recommended guidelines for safety and aquifer protection. If no such records are available, the park can request technical assistance from the NPS Water Resources Division to inspect the capping, and to determine if any follow-up capping or plugging would be advisable.

Another well was completed in May 1993 and placed on-line in April 1994. Completion of a pipeline to the distribution line and a solar pumping system was completed in November, 1994. This well, located approximately 0.5 mi (0.8 km) southwest of Fruita, intercepts a sandstone lens within the Moenkopi Formation between 68 to 73 ft (20 – 22 m) and is 78 ft (24 m) deep. The well produces 2-50 gpm (7.6-189 Lpm) depending on the strength of the sun (Martin, 1998). The solar panels are effective, but the park anticipates obtaining a propane generator backup system.

The drinking water produced from the well drilled in 1993 is harder than that of the Fremont River. Total dissolved solids equal 720 mg/L versus Fremont River levels of 450 mg/L. A memorandum (Memo from Chief of Water Operations Branch to Norm Henderson, Chief of Natural Resources, Capitol Reef National Park, July 12, 1993) stated that no better quality of water may be available from another ground-water source, and that the park should consider alternative treatments and use of either the well or the river as drinking water sources. The memo suggested using a centralized reverse osmosis unit or mixing the two water sources.

Specific information and driller's logs for the various wells drilled near the existing treatment plant are found in Christiana and Rasmussen (1991) and Martin (1998). In addition Christiana and Rasmussen (1991) discussed the treatment plant operation for Fremont River water. Since the completion of the 1993 drinking water well, treatment of water consists of chlorination and storage in a buried 100,000 gallon concrete reservoir. Table 11 presents information regarding the current drinking water well for Capitol Reef National Park.

Water use at the park is variable depending on season and can range from 76,000 gallons per month in the winter to more than 420,000 gallons per month in the summer (Martin, 1998). Since total annual visitation has remained close to 700,000, this new well apparently meets the demand. However, if the park headquarters expand, the capacity would not meet fire protection requirements. From 1992-2002, annual water use ranged from 2.7 million gallons (10.2 million liters) in 2002 to 4.4 million gallons (16.7 million liters) in 1998.

Martin (1998) completed a drinking water source protection plan for the park. He noted that the protection zones for this well are entirely within the boundaries of the park, and that there are no developed zones within several miles to the north and south of the well. East of the well, campgrounds and picnic areas with associated bathrooms and septic systems exist. The nearest leach field is approximately 0.5 mi (0.8 km) east of the well beyond the delineated protection zone. These potential contaminant sources are

Table 11. Fremont River Gorge drinking water well information.

Fremont River Gorge Well	
Activation Date	April 1994
Pumping rate	50 gpm (3.1 lps)
Pumping Capacity	125 gpm (7.9 lps)
Water Right	0.032 cfs (0.9 lps)
Treatment	Chlorination
Reservoir Storage Capacity	100,000 gal (378.5 m^3)
Water Use (Mean Annual gallons, 1993-1997)	3,265,616 gal (12,360 m^3)
Chemical & Biological Testing	Chlorine – every day at pump Total Coliform – twice/month Inorganics-metals – every 3 years Nitrate – every year VOC's – every 6 years Radionuclides – every 4 years
Service Area	Headquarters, Residences, Campground, Picnic Areas

hydrologically isolated from the confined aquifer by 100 ft (30 m) or more of vertical separation by low permeability Moenkopi and Chinle formations.

The water distribution system is old and dates to “Mission 66” in the 1960s.[3] Some clay pipe, which should be cleaned and inspected, serves as a portion of the system. However, the lines from the storage tank to the campground are new.

The finished drinking water is tested for residual chlorine daily at the pump, and total coliform twice monthly. Park personnel perform routine monitoring according to state requirements - inorganics and metals every 3 years, VOC’s every 6 years, radionuclides every 4 years, and nitrates every year. The park is exempt from sampling for asbestos, nitrite, and pesticides. Central Utah Public Health in Richfield conducts the test for total coliform bacteria. American West Analytical Lab or Chemtech Ford Lab completes the inorganics/organics testing. Radioactivity has not been detected in the water.

Since the water is hard, the park has considered a softener at the treatment plant, but acknowledges their cost and high maintenance. Individual residences had softeners, but they were removed.

A new well was drilled at Sleeping Rainbow Ranch in 2001. This well pumps 25 gpm (95 Lpm) from the aquifer at 180-220 feet (55-67 m). Since the park is still seeking a change in point of diversion, the well is not connected yet. The application is in the process of being approved. This well replaces a spring-fed system where water was stored in a cistern. The Sleeping Rainbow Ranch will be used as an educational facility for Utah Valley State College.

The park has no other interest in developing water except at the Peekaboo trailer in the southern portion of the park. A water tank exists there, but no water source has been developed. This site is used by park personnel and researchers.

The Post, in the southern portion of park, supports an old and shallow well with a non-functioning hand pump. The park has no records on this well and is not aware of its history and capabilities.

7.2. Sewage Treatment

Several absorption fields occur within Fruita. These include the following:

- Picnic area;
- Ripple Rock Nature Center;
- Group Campground;
- Hold House;
- Visitor center/Residential area.

The latter field is located south of Sulphur Creek and north of the residences. Odors do emanate from this area, and Sulphur Creek, downstream of the site measures high for some nutrients (Scoping Meeting Notes, Oct. 29, 2002).

The park recently upgraded the sewage treatment facility for the campground and now operates a two-celled sewage lagoon. This system exceeds the campgrounds needs at

[3] Mission 66 was a National Park Service program operating from 1956-66 to fund and develop infrastructure projects in the parks, such as visitor centers, housing, and water systems.

this time (Scoping Meeting Notes, October 29, 2002). The previous absorption field for the campground had various problems, and required replacement.

The Sleeping Rainbow Ranch septic system was replaced and park personnel are interested in upgrading the Peekaboo trailer system.

7.3. Irrigation and Canals

Historic irrigation is a cultural activity included in the park's mission. The park cultivates approximately 66 acres (27 ha) of orchard and pasture, a decrease of 46 acres since 1940 (Gilbert and McCoy, 1997). Due to improvements in measurement and irrigation infrastructure, mean annual diversions for irrigation amount to approximately 1621 acre-feet (70.62 million ft^3 or 2.0 million m^3), which is 892 acre-feet (38.84 million ft^3 or 1.1 million m^3) less than previous years (Christiana and Rasmussen, 1991). In 1975, the park added a settling pond for the Fremont River diversion and converted some open ditches to pipelines. In 1982, the park added a sprinkler system to the Jorgensen Pasture, and in 1987 a sluice channel was added to reduce silt in the irrigation system (Gilbert and McCoy, 1997). Christiana and Rasmussen (1991) estimated consumptive use at approximately 198.6 acre-feet (8.651 million ft^3 or 245,000 m^3) per year, and they further estimated a decrease in salt load of 50 grams/second if irrigation efficiency was improved by 30%.

The park draws 8 cfs (0.23 m^3/s) from the Fremont River as measured by an in-line meter. Parshall flumes measure the 0.9 cfs (0.03 m^3/s) diversion on Sulphur Creek, as well as the 1 cfs (o.03 m^3/s) diversion at Pleasant Creek. These diversions are used to irrigate the park orchards, fields, the picnic area, the Gifford House and the residential area, and are all used during the irrigation season. The water right period extends from April 1 through November 30. Flood irrigation serves the orchards and is recognized as a historic use. The picnic area, residences, Jorgensen pasture, and Gifford House use a form of sprinkler irrigation.

Diversion of water from Fremont River enters a sluice channel and pond for settling of large and fine materials prior to water entering the irrigation system. The sluice channel is backwashed and waters flow into the Fremont. The park is concerned with issues of point source discharges. Any time the park flushes the settling ponds, water laden with sediment is discharged to the Fremont River. These kinds of point discharges are regulated through the Utah Pollutant Discharge Elimination System (UPDES). The Utah Division of Water Quality issues discharge permits (<www.deq.state.ut.us/>). Section 8.1.2 discusses this issue further.

The diversion point on the Fremont is a rock structure and must be maintained annually. The park would like to reduce stream impacts and anticipates a more permanent rock or concrete structure. The Sulphur Creek diversion has a concrete structure, but occasionally rock material is moved to assist with diversion.

Return flow from irrigation occurs from the low point in each orchard and field and from the Fremont River sluice channel. The irrigation infrastructure from the Fremont River is dated around the 1970s and consists of a cement-asbestos pipe which becomes brittle over time.

The Sandy Ranch maintains an irrigation canal, 10,298 ft (3139 m) of which passes through the park to their property adjacent to the park's eastern border. The canal, constructed in 1924, draws water from Oak Creek. Sandy Ranch possesses a right-of-way through the park to operate and maintain the canal. Sandy Ranch will install an underground pipe for approximately 4,069 ft (1240 m) through previously undisturbed land and through the original ditch.

The park developed an environmental assessment to analyze impacts related to the proposal to develop an underground pipe. They determined that the preferred alternative, to install a pipeline, would reduce the resource damage caused by frequent washouts and subsequent maintenance activities. Water loss would also be reduced. Improvement to these kinds of infrastructure help in the long-term to maintain water quality and reduce resource damage.

7.4. Water Rights

The National Park Service maintains state appropriative and federal reserved water rights in Capitol Reef National Park. The State of Utah, Division of Water Rights, regulates the use of surface and ground water in Utah and issues permits for state appropriative rights.

State appropriative rights are based on the Doctrine of Prior Appropriation which states that a party who applies water to a state-recognized beneficial use (including domestic, irrigation, livestock watering, municipal, and industrial uses) has a right that is superior to those who commence their use at a later date. The right is statutory and can be bought or sold. The water's point of diversion, place of use, and purpose of use can be changed without losing priority, provided there is no injury to the water rights of others (Christiana and Rasmussen, 1989 and 1991 and Water Laws of Utah, 73-1-10). The right is a fixed allocation and if the water is not used for a period of consecutive years it may be lost through action by the state (forfeiture) or intent by the right holder (abandonment). Conflicts or disputes over the use of water can be resolved by the Utah Division of Water Rights through an administrative hearing process. During shortages, right holders with junior priority dates do not receive water until the allocations of senior right-holders have been satisfied. At this time only the Utah Division of Wildlife can obtain an instream flow water right (Monroe, T. Utah DNR, pers. comm., 2003); however, at Zion National Park and Hovenweep, Rainbow Bridge, and Cedar Breaks National Monuments, the State of Utah and the NPS have agreements that grant the National Park Service instream flows (Hansen, W.R., Water Resources Div., NPS, pers. comm., 2003; Zion NP, 1996).

State appropriative water rights based on "Diligence Claims" are rights based upon the claim that the water was put to use prior to the time state law required applications for water right appropriations. The priority date for the Diligence Claim is based on the date of the first documented use of the water.

Federal reserved water rights may be obtained by the NPS for the minimum amount of water necessary for the park unit to carry out its primary legislated purposes. Federal reserved water rights have a priority date as of the date the land upon which the use occurs was reserved and are junior to pre-existing water rights.

Section 8.2 of this report reviews the water rights issues and also provides a basic overview of water rights in the park and presents tables and maps of the points of diversion as well as discussions of the issues of concern.

8. WATER RESOURCE ISSUES

This plan describes the hydrological setting of Capitol Reef National Park, but more importantly, presents a series of management actions or project statements intended to deal with some of the identified water resource issues. Not all of the issues will result in project statements, but are presented here to ensure that they are recognized as areas of concern. The principal issues, as identified by park staff, include:

- Water resource infrastructure;
- Water rights;
- Restoration of water impoundments;
- Road improvements and restoration of Fremont River oxbow;
- Wetland inventories and assessments;
- Fremont River: impacts from nutrients, sediments, and toxic contaminants;
- Wild and scenic considerations for the Fremont River gorge;
- Review of water quality use designations on the Fremont River;
- Halls Creek issues;
- Water resource issues of Pleasant and Oak creeks;

- Hydrogeology - what does the park know;
- Mining, oil and gas exploration, and tar sands operations and their Impacts on water;
- Exotics along riparian corridors;
- Abandoned roads;
- Restoration of disturbed pinon-juniper watersheds in the park; and
- Maintenance of contacts with other agencies.

8.1. Water Resource Infrastructure

Improvements to park water resource infrastructure have occurred with the greatest success having been the completion of a drinking water well in 1993. Other improvements, including piping of irrigation, provide for greater efficiency and a reduction in salt loading to the Fremont River.

8.1.1. Drinking Water and Sewage Treatment at Headquarters

Since the installation of a new drinking water well, little concern has arisen regarding the system, except for the hardness of the water. The NPS Water Operations Branch advised either a reverse osmosis system or maintaining the same level of treatment already occurring (Memo, Chief of Water Operations Branch, July 12, 1993).

The park views any future issue with the drinking water storage tank capacity as a low priority, unless a new visitor center and housing area are developed. In the event of a new visitor center and housing area, greater capacity would be required for fire protection. The park's main concern with the drinking water is an aging distribution system, and the park maintains that this must be dealt with at a later date.

The sewage treatment system for the visitor center and residential areas also warrants review for its distribution lines. They are old and composed of a cement/asbestos pipe which becomes brittle with time. The septic system for the residential area may not adequately treat sewage, and the park has a valid concern that leachate could reach nearby Sulphur Creek.
Expansion of the new sewage lagoon is unlikely, since the current capacity may be adequate for connection to the residences, group campground, and headquarters.

None of these issues warrants a project statement at this time; however, the park acknowledges problems with the drinking water and sewage treatment distribution systems. At some point a study of water flow and soils in the Sulphur Creek area near the leach field could be warranted.

8.1.2. Irrigation System and Sluice Channel

The park diverts 8 cfs (0.23 m^3/s) from the Fremont River at the mouth of the gorge. The rock diversion must be maintained on an annual basis and requires the use of heavy equipment in the river. Such disturbance causes further siltation downstream as well as continued disturbance at the site. The park is interested in a concrete diversion structure that requires low maintenance. Even this structure may need to be coupled with stream work. Other instream structures, such as Rosgen's "W" weir (Rosgen, 1996), can provide diversion capabilities without having to maintain the structure each year. Since the channel is fairly narrow and the diversion placed just below a steep gradient, this particular structure may not be adequate.

Since the Fremont River frequently experiences high turbidity, the diverted irrigation water can also carry high total suspended solids. This suspended material creates higher maintenance in the open ditch systems and is a problem for pipelines. The park developed a sluice channel in 1987 to settle out the large debris. On occasion the park jettisons some of the water in the sluice channel back to the Fremont River. The park questions whether this constitutes a discharge requiring a permit. Facilities that produce, treat, dispose of, or otherwise discharge wastewater may need permits from the Utah Division of Water Quality. The park can apply for a surface water discharge permit. This permit authorizes discharging of wastewater to surface waters, including storm drains. Utah Pollutant Discharge Elimination System (UPDES) permits are required for all industrial, municipal and federal facilities, except those on Indian lands.

Other sluice channels in the park include 1) one on Oak Creek, which serves Sandy Ranch, 2) two on Pleasant Creek – Notom and Sleeping Rainbow Ranch which are not functional now, and 3) Sulphur Creek, which is rarely used. Since the Fremont River sluice channel is a high priority water quality issue for the park and for downstream river functions, technical assistance from the NPS Water Resources Division to review the need and apply for the discharge permit is needed.

8.1.3. Peekaboo Drinking Water Development

The Peekaboo Trailer in the southern portion of the park is without a drinking water source. The park contemplates development of a drinking water source if there were funds to support an employee there. The park may actually find better water quality there associated with the Navajo Sandstone aquifer.

8.2. Water Rights

8.2.1. Introduction

This plan's Section 7.4 provides a general overview of water rights; this section presents details on various issues regarding water rights.

8.2.2. Adjudications

The State Engineer periodically may carry out an adjudication of water rights in any river basin in the state. During the adjudication all parties claiming rights to water in the basin must submit permit applications. The State Engineer determines the validity of each claim, recommends the valid claims to the court, and the court adjudicates (makes legal) the final water rights.   The NPS is obliged by the McCarran Amendment (66 Stat 560, 43 USC 666) to take part in state water rights adjudications.

In 1935 the State of Utah adjudicated water rights of the Fremont River Basin in the vicinity of the town of Fruita, the historic center of Capitol Reef National Park. The Bates Decree granted 8 cubic feet per second (cfs) of primary water rights from the Fremont River and its tributaries to seven residents of Fruita for irrigation of orchards. In the same decree the Hanksville Canal and Caineville Irrigation Companies downstream of the park were granted 22 cfs of primary water rights from the Fremont River and its tributaries. The NPS has since acquired the Fruita water rights beginning in 1937 with the purchase of private lands.

In 1981 the United States received a summons to submit claims for Capitol Reef National Park in the General Water Rights Adjudication “Civil No. 435” for the drainage area of the Colorado River in Kane, Garfield, Wayne, Piute, Emery, Sevier, and Sanpete Counties, Utah. The Department of Justice representing the National Park Service submitted claims for Capitol Reef National Park for state appropriative rights and federal reserved rights in the adjudication. State appropriative water rights were claimed for domestic uses, livestock watering directly on streams, and irrigation. Federal reserved water rights were claimed for the water necessary to fulfill the primary purposes of the park. The federal reserved water right has not been quantified (Christiana and Rasmussen, 1989, 1991; Harte, J., NPS-WRD, pers. comm., 2003). The National Park Service claimed 3.62 cfs of water rights for more than 50 livestock permit holders to water livestock on various streams, springs, and waterpockets throughout the park (Frye, 1998). The final adjudication of “Civil No. 435” is pending. In addition, the National Park Service and the State Engineer are discussing a water rights agreement similar to those already in place for Zion, Cedar Breaks, Hovenweep, and Rainbow Bridge that would protect the water and water-related resources of the park into the future (Zion National Park, 1996).

8.2.3. Water Rights Permits Inside Capitol Reef National Park

As of June 26, 2002 the State of Utah, Division of Water Rights, database included water rights permits held by the NPS, other state and federal agencies, corporations, and private individuals with approximately 115 Points of Diversion within Capitol Reef National Park. The National Park Service permits are associated with points of diversion on the Fremont River, Sulphur Creek, Pleasant Creek, Miner’s Mountain Draw, an unnamed spring, and an underground water well. The National Park Service’s water rights within the park are summarized in Table 12. Points of diversion for all water rights are summarized in Appendix Table A and illustrated in the map of Figure 18.

Water rights with points of diversion inside park boundaries that are not owned by the NPS include:

(1) Four water rights totaling 25.2 cfs and one temporary water right for 12 acre feet in the names of private individuals on Pleasant Creek near Notom;
(2) One water right for 70 cfs or 50,000 acre feet in the name of the Intermountain Consumers Power Association with 22 points of diversion near the east park boundary, north of the Fremont River, inside the boundaries of the park;
(3) Seven water rights in the name of the State of Utah School & Institutional Trust Lands Administration for on-stream livestock watering throughout the park;
(4) Two water rights totaling 50 cfs and 5 water rights totaling 15.22 cfs in the names of the Tercero Corporation and Tercero Corporation (Warren II) on Oak Creek and Pleasant Creek;
(5) One water right in the name of the U.S. Forest Service for on-stream livestock watering in Deep Creek;
(6) 60 water rights in the name of the Bureau of Land Management for on-stream livestock watering throughout the park; and

Figure 18. Points of diversion in and external to Capitol Reef National Park.

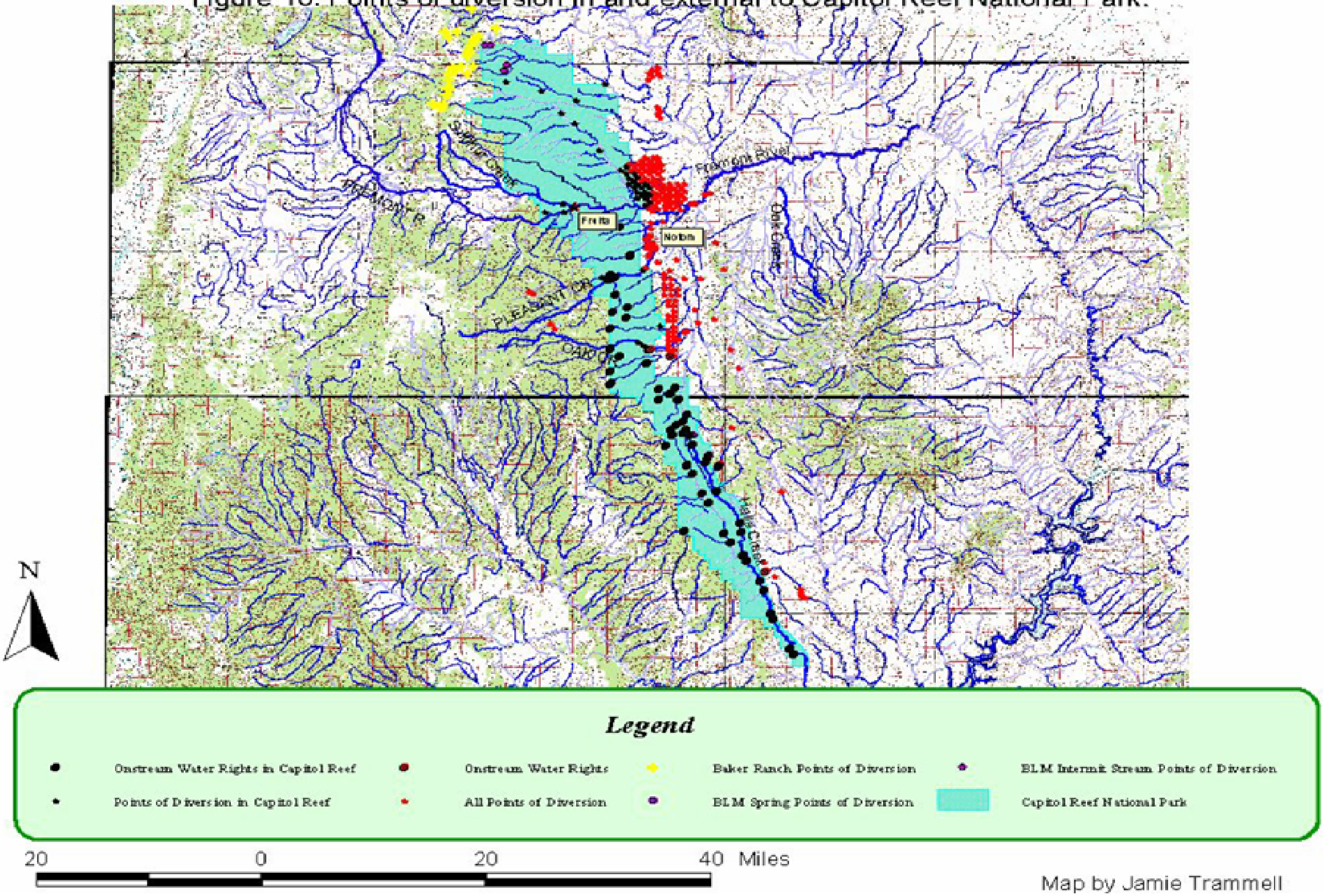


Table 12. Water right number (WRNUM), priority date, discharge (cubic feet per second), source, and points of diversion (POD) for water rights owned by Capitol Reef National Park (Utah Division of Water Rights, 2002).

WRNUM	Priority Date	Discharge (cfs)	Source	POD
95-1	0/0/1882	0.925	Pleasant Creek	S160 W1065 from NE Sec 30, T30S, R7E
95-2	0/0/1882	0.1	Miner's Mountain Draw No.4	N710 E580 from W4 Sec 29, T30S, R7E
95-3	0/0/1882	0.1	Miner's Mountain Draw No. 3	N1070 E790 from W4 Sec 29, T30S, R7E
95-4	0/0/1882	0.1	Miner's Mountain Draw No. 2	S955 E1440 from NW Sec 29, T30S, R7E
96-5	0/0/1882	0.237	Unnamed Spring	N500 W660 from SE Sec 20, T30S, R7E
95-6	0/0/1881	On stream	Pleasant Creek	From SENW Sec 29, T30S, R7E
95-7	0/0/1881	On stream	Pleasant Creek	From SESE Sec 20, T30S, R7E
95-8	0/0/1881	On stream	Miner's Mountain Draw	From SWSW Sec 20, T30S, R7E
95-544	07/15/1935	0.0557	Fremont River	N406 E504 from SW Sec 14, T29S, R6E
95-747	0/0/1902	1.0	Sulphur Creek	S350 E950 from W4 Sec 15, T29S, R6E
95-4683	0/0/1883	8.0	Fremont River	Section 22, T29S, R6E
a19741 (95-544 and a19741 are a shared right)	02/15/1996	0.0557	Underground Water Well	S1812 W2514 from NE Sec 22, T29S, R6E

(7) One water right for 100 cfs in the name of the Wayne County Water Conservancy District on the Fremont River near Fruita (Appendix A with data from the Utah Division of Water Rights, 2002).

The State of Utah School and Institutional Trust Lands Administration lands within the park and associated water rights have since been acquired by the park. Livestock grazing is being phased out at Capitol Reef National park and as the associated water rights within the park are no longer needed the current owner should work with the State Engineer to formally abandon those water rights permits.

8.2.4. Water Rights Permits Outside of Capitol Reef National Park

The Bates Decree of 1935 decreed water rights on the Fremont River. The Fremont River has its headwaters on Thousand Lakes Mountain in the Fishlake National Forest, west of the park, and flows through several small agricultural communities, where water is diverted for irrigation before it flows east through Capitol Reef National Park and downstream to its confluence with the Muddy River, near Hanksville. Water is stored in reservoirs upstream of the park and released throughout the irrigation season of April 1 to September 30. During the irrigation season the minimum flow through the park is defined by the downstream primary rights. The NPS owns 8 cfs of primary water rights which are diverted for irrigation in the Fruita area. There are 23.75 cfs of primary water rights downstream of the park owned by the Hanksville Canal Company (11.5 cfs), the Caineville Irrigation Company (12 cfs), and Forest Simms (0.25 cfs). By decree, when water in the Fremont River is naturally available the minimum flow through the park should be 23.75 cfs during the irrigation season.

The Baker Ranch, located north of the park, maintains diversion ditches that run from south to north along the east side of Thousand Lakes Mountain upstream of the west park boundary in the Fishlake National Forest. The ditch intercepts the headwater flow of numerous small streams including Deep Creek and Polk Creek and conveys the water north to the ranch. Baker Ranch water rights pre-date the establishment of Capitol Reef National Park and are therefore senior to the park. Capitol Reef National Park would like to re-establish flows into the park in streams whose headwater flows are now intercepted by the Baker Ditch.

The Intermountain Consumers Power Association (ICPA) holds one water right for 70 cfs or 50,000 acre feet with 78 points of diversion at proposed underground water well sites located outside of the park near the east border; this is the same water right for the ICPA referred to in Section 8.2.3 above, noting the 22 points of diversion inside the park . The water would be used to supply a steam generation power plant. The water right application was protested by the National Park Service and has not been approved by the State at this time. It is possible that the source and point of diversion for the water right could be changed from ground water to surface water storage in a reservoir. The NPS will continue to monitor the application.

Pleasant Creek and Oak Creek arise on the east slope of Boulder Mountain, in the Dixie National Forest, flow east through the park and then north into the Fremont River near State Highway 24, downstream of the park. Pleasant Creek and Oak Creek are connected by a reservoir and ditch system that includes Oak Creek Reservoir and Lower Bowns Reservoir on the east slope of Boulder Mountain. Pleasant Creek and Oak Creek are diverted into Lower Bowns Reservoir from November 1 to April 1, then 7.2 cfs is diverted from Lower Bowns Reservoir into Pleasant Creek. When the Pleasant Creek stream flow falls below 7.2 cfs, 1.0 cfs is diverted from Oak Creek to Pleasant Creek (State decree). These adjustments continue until November 1, when all the water is diverted into Lower Bowns Reservoir (Range, D., Dixie NF, pers. comm., 2002). The Sandy Ranch, located downstream of the park on Oak Creek, owns water rights on Pleasant Creek and Oak Creek [(Tercero Corporation and Tercero Corporation (Warren II)] and maintains flow in Oak Creek through the park via a radio-controlled headgate at Lower Bowns Reservoir.

At least six dams have been proposed for the Fremont River upstream and downstream of the park including the Torrey, Garkane, Hickman, Aldrich, Caineville #2, and Caineville Reef dams (Monroe, T., State of Utah, pers. comm., 2002). Another proposal would construct a dam immediately upstream of the Fremont River on Caineville Wash (the Caineville Wash Dam) and divert water from the Fremont River to the reservoir (Figure 9). Each proposal has associated water rights and environmental issues.

The park is concerned about the potential effects of the Caineville Wash Dam proposal, initiated in 1993, to construct a dam on Caineville Wash immediately above the town of Caineville, approximately one mile upstream of the Fremont River in the "Caineville Reef" --a hogback of upturned Ferron Sandstone Member of the Mancos Formation. Water was to be brought to the reservoir via a 72" pipeline from a diversion on the Fremont River located downstream of Capitol Reef National Park. Three reservoir sizes were being studied; 35,000, 50,000 and 75,000 acre-feet (Utah Division of Water Resources, 1993). The stored water was to be used to irrigate newly developed agricultural lands located along the Fremont River corridor. The proposal included a plan to pump water from the reservoir upstream to the Notom area. In conjunction with the dam proposal, Wayne County has requested the Bureau of Land Management identify lands suitable for trade with state lands. The state lands could then be sold into private ownership and developed for private homes or commercial uses. The county has identified approximately six sections of BLM land located along the east boundary of the park near the town of Notom. The park is concerned that private or commercial development, including ground-water wells, in these sections may impact water resources in the park. Preliminary studies of the effects of ground-water withdrawals near the east border of the park have been completed by the National Park Service, Water Resources Division (Cutillo, 2002). Other information about the history of dams in the area appears in Section 6.5.2 on the Fremont River.

8.2.5. Issues and Recommendations

Baker Ranch maintains diversion ditches that intercept the headwater flow of numerous small streams that would otherwise flow east from the Fishlake National Forest into the park, including Deep Creek and Polk Creek. The park would like to remove the diversions and re-establish flows into the park for the benefit of plant and animal species, since diversion of the water that would naturally flow into these streams no doubt has some impact on these species. At this time, the extent of such impacts is not understood. Nonetheless, the Baker Ranch water rights are senior to the park and therefore as long as the Baker Ranch is putting the water to beneficial use it is under no obligation to remove the diversions. The National Park Service could approach Baker Ranch and discuss their interest in negotiating an agreement for future removal of some or all of the diversions.

As discussed above, the proposed Caineville Wash Dam project would divert water from the Fremont River for irrigation near the east boundary of the park and downstream to Hanksville. Currently the needs of senior water rights owners downstream of the park require that at least 23.75 cfs flow through the park when it is naturally available. If the Caineville Wash Dam were constructed it could be possible for senior Fremont River water rights owners downstream of the park to store their water in the reservoir and then during the irrigation season divert their water from the reservoir instead of the Fremont River. The consequences could be that in some years water in the Fremont River that was not needed by senior downstream water right owners could become available for users upstream of the park resulting in lower flows through the park during the irrigation season. A related land exchange inquiry initiated by Wayne County could result in development of ground water for domestic or irrigation use. The park should take an active roll in the permitting process of the Caineville Wash Dam and associated land exchange. If necessary, the park also should initiate ground water and other studies to determine the possible effects on its resources.

The current practice of the Wayne County Water Conservancy District is to encourage Fremont River water users upstream of the park to divert water prior to April 1 during years of above normal precipitation. This practice reduces the magnitude of spring runoff flows in the Fremont River and helps to decrease streambank erosion and destabilization of U-24; however, the effective discharges necessary to maintain a dynamic channel and natural processes are also reduced. Measures to protect the magnitude and duration of these runoff events would be necessary to assure the continuation of natural channel processes and the health of the riparian resources in the Fremont River corridor (Hammack and Cluer, 2000). An agreement with the state and water district to end this practice would be appropriate.

Livestock grazing in the park is being phased out over time. Some allotments have been retired; however, the water rights may still be in the name of the BLM or other parties. The National Park Service should research the ownership of water rights in the park and, if necessary, the current owner should file Change of Ownership Applications with the State Engineer or abandon the unused water rights.

Diversions upstream of the park on Sulphur Creek with rights junior to the park have at times impacted the park's ability to divert water from the stream. The park has worked with the State Engineer to rectify this problem, and will continue to monitor stream flow to assure that the park's water rights are fulfilled.

8.2.6. Water Rights-Related Studies

From 1993 through 1998 various studies were conducted to quantify the stream flow needs to maintain a healthy riparian vegetation community [conducted by the U.S. Geological Survey, Biological Resources Division (BRD)] and to maintain geomorphic channel processes [conducted by the National Park Service's Water Rights Branch (WRB), Water Resources Division, on the Fremont River]. The results of the USGS study are in a recent draft report (Auble et al, 2003), and the results of the geomorphic study have been summarized and recommendations made (Hammack and Cluer, 2000). The recommendations include:

(1) obtain watershed protection zones around the park;

(2) obtain assurances from the State that no new water storage projects will be approved that would adversely affect surface flows;
(3) obtain assurances from the State that changes in water management practices or policies will not adversely affect surface flows;
(4) obtain agreements with the State and water district to end the practice of premature water diversion during wet springs; and
(5) work with the state highway department to improve State Highway 24 road bank to withstand higher flows (Hammack and Cluer, 2000).

In 2002, the National Park Service's Water Rights Branch prepared a preliminary ground-water study of the park in the area approximately between the town of Fruita and the town of Notom. The study was designed to estimate the effects of ground-water pumping on water resources within the Capitol Reef National Park. The study was performed in-house using published references and standard drawdown equations. The results of the study suggest that pumping ground water in quantities necessary for domestic or irrigation purposes in the vicinity of the east border of the park near the town of Notom could result in a cone of depression extending within the park and including park water resources (Cutillo, 2002).

8.3. Restoration of Water Impoundments

As discussed in Section 6.5.5., by using small dirt dams, drainages were dammed in and around the park an attempt to reduce erosion and store water. The park indicates the need to remove numerous impoundments in the Cathedral and Waterpocket districts of the park (Scoping Meeting Notes, October 29, 2002). These impoundments, possibly numbering in the hundreds (note that the Waterpocket District network of impoundments is referred to as the "bombing runs"), dam even the smallest drainage. Photographs of the sites are available, but little data regarding the sites has been found; therefore, a general inventory of the impoundments in the park is needed.

With only two existing grazing permittees, 1141 AUMs (animal month units) in the Hartnet (Cathedral District) and 400 AUMs in the Waterpocket District, the need for such a network of impoundments is minimized. Also the park questions the efficacy of these impoundments as sediment traps.

Further, the impoundments reduce and at many times eliminate the flow of water immediately downstream of the dams. Ultimately, water that may have flowed to larger drainages downstream does not, and these lower drainages are dry. Additionally, the impoundments are suitable sites for establishment of exotics like saltcedar and Russian-olive. The park continues to eradicate these species, and by remediating these sites, the park intends to reduce the establishment and spread of exotic plant species.

These impoundments do serve other wildlife species and can provide water to horseback riders where they are permitted. However, these impoundments are not natural landscape features and impede natural water flow processes. They can in some cases reduce movement of sediment down drainage. The silt detained behind the small earthen dams builds up and provides an excellent site for growth of exotics.

Bitter Creek Reservoir, constructed in the 1950s on an upper section of Halls Creek, is the largest impoundment in the park. Located in the Waterpocket District, it supports high bird densities, amphibians, tadpole shrimp, bison, and other wildlife. This particular feature, as large as it is, remains an important component of the landscape and most likely does not warrant removal.

Several concrete check dams in Capitol Gorge represent features associated with the Capitol Gorge Road. These features will be surveyed as part of a cultural landscape inventory and may be included on a list of classified structures. They are not to be removed since they comprise historical features of the landscape (Kreuzter, L. Capitol Reef National Park, 2003).

Remediation of the small impoundments includes 1) inventory and mapping of the impoundments in the Cathedral and Waterpocket districts, 2) data collection regarding presence of exotic plant species, drainage characteristics, and size, 4) systematic inventory of cultural resources at each impoundment, 5) development of a decision matrix guiding which are priority impoundments, 6) wetland classification and delineation where necessary, and 7) removal of impoundment features.

An impoundment remediation project is discussed in project statement #9.1 in Section 9.

8.4. Road Improvements and Restoration of the Fremont River Oxbow

8.4.1. Introduction

The Fremont River oxbow was created by the construction of State Highway 24 (U-24) across a meander of the river in 1964, cutting off an old river oxbow. Rather than constructing the highway to follow the old meander, the road was routed through an area of sandstone cliff that was blasted. Now an excavated channel carries the Fremont River parallel to the road alignment. The river cascades over a 20-foot (6.1 m) tall waterfall and flows into the original channel (Figure 19).

This section of the highway is approximately 6 mi (10 km) east of the visitor center. Over the years, the river has eroded the bottom of the re-aligned channel, thus causing the channel to become more incised and the waterfall to move upstream. The original channel was slightly altered with shallow road fills during private ownership most likely between 1964 and 1969. During periods of high flows, flood waters overtop the re-aligned channel and flow into the oxbow. Ponding has occurred in the downstream end of the abandoned meander. The park notes that following the river diversion, the oxbow supported a pond which provided habitat for the Ute ladies'-tresses (*Spiranthes diluvialis*), a federally threatened species, and other riparian and wetland species. Since that time the oxbow has become increasingly desiccated, perhaps as a result of drainage work required to maintain stability of the roadbed conducted approximately 15 years ago.

The park's Resource Management Plan (National Park Service, 1993) contended that a hydric environment existed in the abandoned meander as result of springs. Further, the 5-acre wetland, at the time the plan was prepared, supported Ute ladies'-tresses. Beaver, muskrat, and leopard frogs utilized the resource year-round. Drying conditions in the meander appear to have caused the disappearance of the Ute ladies'-tresses since 1995. The recent lack of water in the meander suggests that instead of springs serving as the source of water, the Fremont River provides ground water which previously maintained a high water table in the meander.

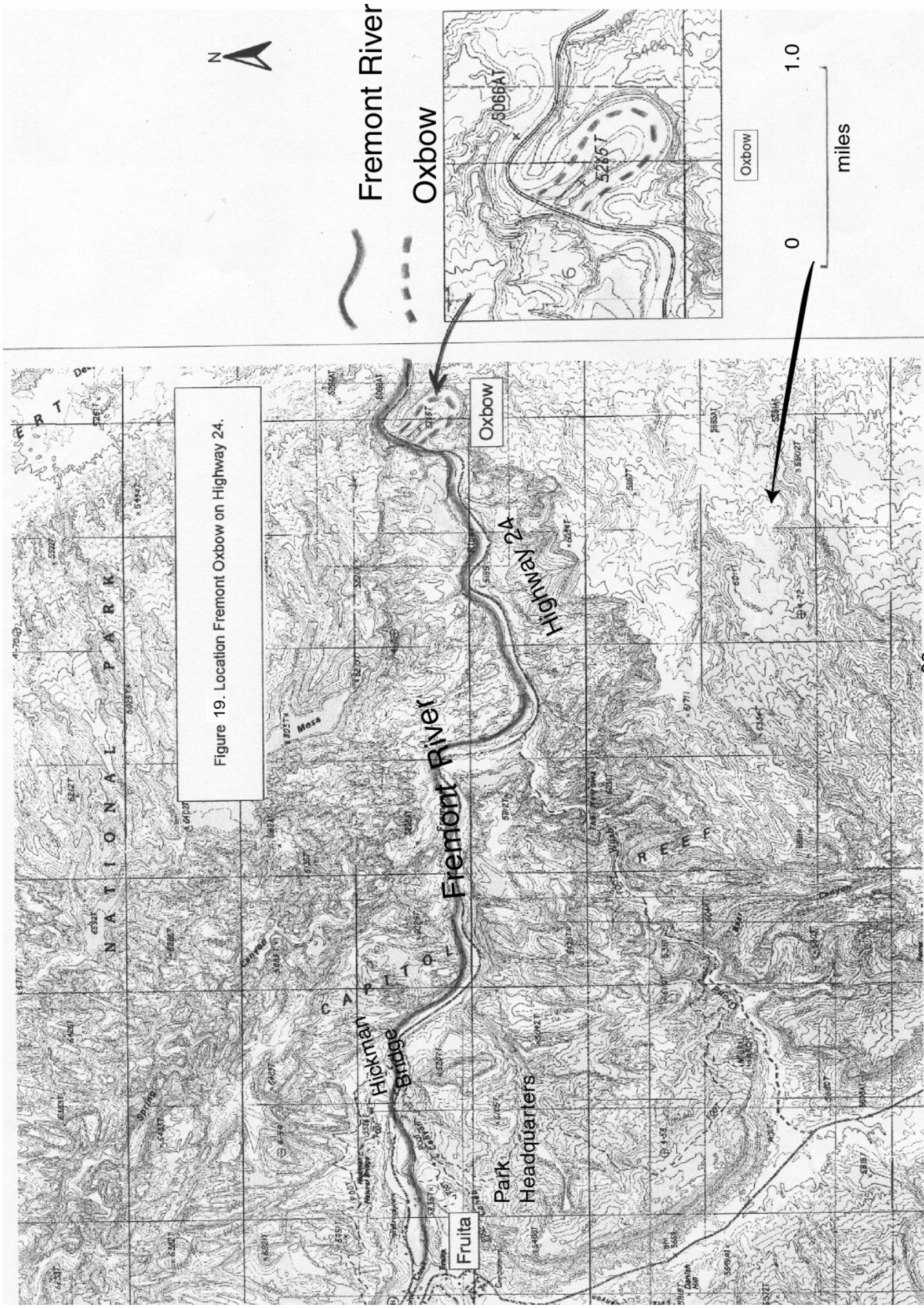


Figure 19. Location of Fremont River oxbow

Fillmore (2000) discussed the gradient prior to the construction of U-24. The original gradient was 35 ft/mile (6.6 m/km), and now although the drop is the same, it occurs over a shorter distance of 0.16 mi (0.25 km), resulting in a waterfall. The abrupt drop brings about a concomitant drop in the ground water level in the area, most likely no longer providing sub-surface water to the meander.

8.4.2. Purpose of Restoring the Fremont River Oxbow

The park identified significant environmental and safety concerns resulting from the present Fremont River course over the waterfall (Scoping Meeting Notes, October 29, 2002; National Park Service, 2002b). The riparian and wetland systems are non-functional as a result of further desiccation in the oxbow. A federally threatened species has not been seen since 1995. The National Park Service is mandated to protect wetlands from degradation and to restore natural wetland functions and values where they have been disturbed by human activity per the NPS Director's Order # 77-1 (National Park Service, Water Resources Division, 1998). Additionally, Hepworth *et al.* (1993) mentioned upstream fish migration limitations due to physical barriers such as the waterfall, or changes in environmental conditions such as elevation and temperature. The park also remains concerned about the physical barrier that the waterfall creates.

The existing waterfall is a safety hazard. The park has a posted sign which states no jumping into the pond below the waterfall, yet the park has responded to numerous injuries from this activity. Water quality concerns related to high fecal coliform counts may also present a problem. Traffic congestion occurs at the parking pullout. The parking area is not striped and large recreational vehicles must back out into adjacent traffic when departing.

8.4.3. Park and Utah Department of Transportation Concerns

Recent meetings between the Utah Department of Transportation and Capitol Reef National Park (Federal Highway Administration, 2003) identified several issues which relate to the project and these include:

- Degree of oxbow restoration
- Effects of a new water source on the existing oxbow vegetation
- Flow monitoring and regulation
- Restorative streambed actions in the oxbow
- Debris and sediment load
- Removal of waterfall
- Roadway geometrics
- Water quality
- Effects of recharging the oxbow on downstream water users
- Disposal of fill material
- Traffic control
- Project proponent and funding mechanisms.

The Federal Highway Administration (2003) deemed full restoration of the river to its original meander as the "best" project, yet this option requires assuring short- and long-term stream channel stability in the oxbow. Discussion of the effects of a new water source on existing vegetation recognized that vegetation would have to acclimate to a new water regime through flow regulation or a new channel must be established;

otherwise, vegetation could be swept downstream. If installed, a flow regulator would need to be maintained by the park or the transportation department. These entities would respond to high water events by regulating flows in order to avoid blow-outs of the re-established channel.

Since the Fremont River is prone to flash floods, boulders and vegetation including trees are swept into the stream. These can block culverts or inlet structures and must be removed. Bridging as opposed to culverting the channel may avoid such debris jams.

Returning the Fremont River to its old channel would render the waterfall harmless and thus remove this particular danger to visitors. The visitors do enjoy this feature and would be reluctant to see its removal (Scoping Meeting Notes, October 29, 2002). Highway safety would increase and problems with traffic congestion ameliorated.

In the long-term, water quality may improve as the river has more distance to travel allowing for silt to drop out and for vegetation and stream channel dynamics to abate flooding conditions. Rivers of a certain gradient normally meander as a means of carrying load and to dissipate energy. The short-term water quality may be adversely affected with increased sediment load. The construction effort must include best management efforts to reduce water-quality pollution. Quantity of water may be reduced as the new stream channel becomes saturated. Delivery of downstream water is guided by water rights ownership and must be dealt with correctly.

If bridges are used, a disposal site for existing roadbed material is needed. If culverts are used for drainage, several types and means of installation can be considered.

The National Park Service will continue to lead the project, and funding may come from several sources including National Park Funds, Utah State Funds and Federal Highway funding. This project could serve as a prototype for restoring river environments.

Project statement # 9.7 of this plan focuses on the oxbow issue, proposing a hydrogeological study of how to move the Fremont River back to its original channel. Restoration of the oxbow also will require several coordinated studies, since the Federal Highway Administration (2003) has identified six alternative drainage crossings. They range from culvert with and without flow regulators to one bridge and two bridges with and without flow regulators.

The park will need to conduct a wetland delineation and NEPA review with production of a Statement of Findings as required by NPS Director's Order #77-1. The Army Corps of Engineers, which regulates discharge of fill material, will also require a wetland delineation, determination of the ordinary high water mark in the existing channel, and a cultural study to meet 106 requirements. The park or transportation department will have to apply for a Nationwide #27 permit from the Corps unless the Corps deems that an individual permit is required. Additionally, a threatened and endangered species survey with Section 7 consultation must be conducted.

8.4.4 Other Road Issues

State Highway 24 parallels portions of the Fremont River particularly east of Fruita. The Utah Department of Transportation related the need to stabilize some of the river's streambanks in anticipation of floods and in response to past floods. Efforts to do this usually result in discharge of fill material into waters of the United States. As soon as an environmental assessment is completed and all necessary permits received, they will proceed with stabilization including rip-rap of banks. Only temporary impacts to water quality are anticipated. This type of work may have to occur from time to time, and each time the Utah Department of Transportation must conform to park environmental assessment needs. This process assures that impacts to water quality are minimized. Utah Department of Transportation also occasionally sprays herbicides along the roadway (Christensen, R., UDOT, pers. comm., 2003). Impacts to water quality are unknown, but suspected to be minimal.

8.5. Wetlands Inventories and Assessments

8.5.1. Introduction

Section 6.5.5 notes that all tinajas, hanging gardens, creek channels, springs, impoundments, and riparian areas within Capitol Reef are wetlands according to NPS Director's Order #77-1 (National Park Service, Water Resources Division, 1998). The National Wetland Inventory maps produced by the U.S. Fish and Wildlife Service, which serve as the baseline inventory for wetlands of the United States and use the classification developed by Cowardin *et al.* (1979), have not been produced for this area. Thus, the park has little information regarding its wetland boundaries, including riparian areas, creek channels, impoundments, hanging gardens and springs. The only work related to wetlands occurred in and around the park's tinajas south of the Burr Trail (Berghoff, 1995b; Lafrancois, 1994; Lafrancois, 1995; Baron *et al.*, 1998).

Section 404 of the Clean Water Act notes that any discharge to waters of the United States requires a permit; wetlands are considered special aquatic sites and waters of the United States. In addition, Executive Order 11990 states there shall be no net loss of wetlands. To that end, the National Park Service is responsible for ensuring that no discharge to wetlands occurs without the proper permit. More importantly and as discussed in Section 6.5.5, Capitol Reef National Park must acknowledge the presence of wetlands as defined by the National Park Service's Procedural Manual #77-1 (National Park Service, Water Resources Division, 1998).

The park must also ensure that their disturbance either does not occur, is minimized, or is mitigated if required as a part of a permitting/compliance process. First, the National Park Service procedures for compliance with Executive Order 11990 require a Statement of Finding for proposed action with adverse impacts on wetlands [as defined by Cowardin et al (1979)] (National Park Service, Water Resources Division,1998), and secondly, Section 404 of the Federal Water Pollution Control Act (the Clean Water Act 33 U.S.C. 1251, et.seq.) requires a permit for excavation and discharge of fill to jurisdictional wetlands and other waters.

Some areas may not meet the technical criteria for classification as wetlands, but still provide some of the same functions, or may provide buffers against wetland impacts. For example, the ground water in an arid environment might not be within the specified distance to the ground surface, with little if any hydrophytic vegetation present, but the area still provides good cover for wildlife and waterfowl. The parks must recognize these important habitats as well. A means of protecting wetlands and related areas includes delineating the wetland and adding a buffer from the boundary to ensure no impacts to that wetland complex. Physical barriers formed by vegetation buffers slow surface flow rates, and flow rates are generally slower for sheet flow versus channelized flow. Vegetated buffers of 33 to 164 feet (10 to 50 m) are adequate for reduction of sediment introduction to water systems. To maintain species diversity buffers from 33 to 295 feet (10 to 90 m) are recommended (Castelle *et al.*, 1994). The park should be most cognizant of any road construction, sewage disposal system, or other developments placed near wetlands. In effect, a delineation and development of a buffer zone around the wetland or along the wetland is the first step in ensuring the protection of these wetlands.

At least two projects provided in this plan, the restoration of the Fremont River oxbow and the restoration of small impoundments, require following the NPS Director's Order Procedural Manual # 77-1 (National Park Service, Water Resources Division,1998). If the Fremont River were to be moved back to the abandoned meander, the park needs to delineate the present wetlands and the extent to which wetlands may be disturbed as a result of the Fremont River restoration. Likewise, human-made impoundments may also support wetlands; remediation of these sites warrant wetland delineations in their vicinity. Also, the Utah Department of Transportation needs to stabilize sections of the Fremont River along U-24. Having an advanced wetland identification along the highway as it passes through the park may facilitate conducting the proper environmental assessments prior to any streambank stabilization. Project statement # 9.10 presents a project for inventorying the park's wetlands.

8.5.2 Impacts on Wetlands

Wetland identification park-wide is also warranted. The water sources of the park, and thus associated wetland areas, receive use by recreationists in the park. From camping near tinajas to walking along riparian areas, wetlands incur impacts which reduce functions such as water storage, retention of sediment and water purification.

8.5.3 Impacts on the Riparian Areas and Riverine and Palustrine Wetlands

Riparian areas naturally attract cattle, wildlife, and birds, as well as recreationists, miners, horseback riders, campers, and other people, so these areas are especially susceptible to impacts. Grazing has damaged park riparian habitats over the decades. Starting in the 1800s, some riparian and meadow areas in the headwaters above the park continue to experience grazing pressure. The Dixie National Forest monitors water quality and erosion periodically, and attempts to adjust grazing levels to minimize the effects, as this plan describes in Section 8.10 on Oak Creek and Pleasant Creek issues. Also, some of these headwater areas contain sites that are "marginally stable," i.e., have evidence of past landslides, so are more subject to impacts by land use (Frye, 1998; Range, 1997a; EnviroData, 1994; National Park Service,1983).

Municipal, industrial, and agricultural activities upstream as well as activities in the park sometimes pollute riparian zones of the river or its tributaries. Water depletion from irrigation can concentrate pollutants, and reduced flows in the river have resulted in the deposition of sediment along the banks and elimination of some wetlands and riparian habitat, with risk to unique species. Diversions dewater some streams at times (National Park Service, 1993). Aquatic, fishery, and vegetative resources are dependent on the condition and functioning of channels and on the quality of associated riparian habitats. Degraded riparian areas do not provide shading, good substrate, and other factors that aquatic organisms require.

Recreation in the park and upstream in the two National Forests can affect streams and riparian areas with litter, human waste, or contaminants. Camping, second homes, fishing, and other human presence in the National Forest can contribute organic contaminants or eventually affect park riparian areas downstream. All-terrain vehicles (ATVs) and horses can gouge hillslopes and streambanks, producing sediment and turbidity. Roads, highways, and trails are key sources of sediment, including erosion from abandoned mining roads from the 1950s-60s, many upstream from the park. ATVs can aggravate erosion on abandoned roads. Utah State Highway 24 affects riparian areas and floodplains by road runoff and presents a threat of toxic spills from fuel trucks or other vehicles (Millennium, 2002; Range, D. Dixie NF and Hamilton, R, Fishlake NF, pers. comm., 2003).

The impact of dams upstream as well as the human impacts described above have helped introduce exotic plants into the park's riparian areas, especially Russian-olive and tamarisk. Dominance by exotic plants in some cases degrades the habitats for birds and wildlife and greatly reduces the overall biodiversity of riparian areas (National Park Service, 2001a). The problem of exotic plants is reviewed in Section 8.13.

8.5.4. Spring and Seep Issues (Palustrine Wetlands)

Although an enormous number of seeps, springs, and perennial waterpockets (tinajas) exist in the park they are only partially catalogued. Information is limited on exact spring locations, and little is known about spring discharge volumes or how the discharges relate to storm events, annual precipitation, and overall climate patterns (see Table 9; Christiana and Rasmussen, 1989 and 1991; National Park Service, 1989a).

Ground water drawdown by well pumping could diminish springs. Cutillo (2002) modeled well pumping effects on water table drawdown and found that on the eastern boundary of the park one irrigation well pumping at 3.23×10^5 gallons per day (i.e., 0.5 cfs or 0.01 m^3/s) would decrease the hydraulic head at the eastern park boundary by 48 to 67 ft (14 to 20 m) over a 10-year period. This drawdown impact could extend out 5 miles around the well, according to Cutillo's assessments. More studies of this type could help explain ground water in the area, and better assess the potential impact if well development is proposed near the park boundary.

8.5.5. Impacts on Hanging Gardens in the Park (Palustrine Wetlands)

The park needs to map and characterize hanging gardens in order to provide a base to monitor status, changes, or disturbances. Ground water movement in the park is not well understood, and how infiltration and seepage function to support hanging gardens is a question for research. What is the source of water for the hanging gardens in Halls Creek, for example, and could the source be disturbed; if so, how should it be protected? What is the role of joints or fractures in water capture and movement? Ground-water depletion by stream diversions or well pumping could affect the gardens, and human traffic is a potential problem at some accessible hanging gardens. A monitoring program could track the status and changes of hanging garden conditions.

8.5.6. Impacts on Tinajas and their Functions (Palustrine Wetlands)

Tinajas support species-rich assemblages of obligate riparian species and non-riparian species from surrounding areas; however, tinajas are subject to flooding and drought that can destroy their vegetation (Spence and Henderson, 1993). Tinajas have been carved in bedrock by the action of falling water and the abrasive action of fine and coarse sediment whirling in turbulent water, so many are still actively eroding as flash floods take place or as natural weather cycles occur (Harris and Tuttle,1992). Comprehending these natural effects is necessary background for interpreting human-caused impacts. Floods and droughts may result from natural causes. Non-natural causes include upstream watershed disturbances, diversion influences, or local impacts, which can cause drying or siltation of tinajas. The connection between watershed impacts and tinajas is not well defined.

Grazing and livestock trailing affect tinajas. In earlier times, grazing impacts were common, but effects occurring now relate to temporary livestock drives and trespass cattle. Cattle are attracted to tinajas for shade and water, at least to accessible ones. Research in Cottonwood and Willow drainage tinajas demonstrated that cattle raise fecal coliform bacteria significantly and lower pH levels. Cattle affect vegetative cover, so that more weeds, less diversity, and less cover exist at cattle-impacted tinajas. Strong floristic differences result from grazing effects (Spence and Henderson, 1993; National Park Service, 1991). Haefner and Lindahl (1991) researched the effects of grazing on the ecology of tinajas and their fauna, studying the toxic effects of ammonia on *Baetis spp* and chironimids. They concluded that cattle affect nutrients and oxygen, thereby impacting a tinaja's ecosystem.

Road use, water diversions, logging, and other human actions can add sediment, spread exotic seeds, or add chemicals to streams, and it is possible that certain tinajas are affected by these upstream activities. Invasive vegetation is a problem at some springs and seeps and can be a potential disruption at tinajas. Not enough information is available to say if this problem is a growing one at tinajas in the park (National Park Service, 1993 and 2001b).

Wildlife use tinajas for water and shade and affect the vegetative cover, plant composition, water quality, and aquatic ecosystem. Berghoff (1995b) observed signs of large and small mammals at the tinajas he surveyed, but speculated that wildlife use must be in fact higher, given that rock pools rarely show tracks to reveal the story.

Tromping, wading, waste disposal, and other human actions impact water quality, vegetative covers, flora-fauna diversity, and tinaja ecology. In the park's tinaja surveys of the early 1990s, it was estimated that about seven percent of the tinajas had evidence of human use, the more accessible sites naturally being most affected (Berghoff, 1995b). After nearly a decade of growing visitation, the impacts most likely are higher.

8.5.7. Some Basic Information and Research Needs

The park lacks basic information on its wetland areas. Riparian zones along the Fremont River were inventoried a few years ago, and some of the riverine wetland areas upstream from the park were assessed in conjunction with a dam proposal in the late1980s (Hammack and Cluer, 2000; Welsh, 1988). In general, inventory work is needed to determine the extent of wetlands and to understand their location, areas, flora/fauna species composition, and "proper functioning condition" of the channels. Halls Creek is a high priority area for riparian evaluation in view of its growing human impacts.

Additional research is needed to understand how stream discharges and floods affect the composition of riparian vegetation. In the late 1990s, the NPS Water Resources Division carried out studies to define the relationships of streamflow to plant distribution and plant species along the river (Hammack and Cluer, 2000). Hydraulic modeling was used in conjunction with vegetation research by the USGS-Biological Research Division (BRD) to document riparian vegetation distributions in the reaches studied, and a draft report is underway. The draft report will relate plant species distributions along the river to flow duration curves, to show how the pattern of vegetation is related to the flow regime. The work will illustrate how this relationship can be used to estimate the vegetative changes that might be associated with alternative flow regimes resulting from changes in upstream water management practices, for example, changes in the withdrawal of water for irrigation upstream (Auble, G., USGS, pers. comm. and draft materials, 2003).

The park needs to conduct assessments of invasive aquatic and plant species, including research to define water interactions of exotic versus native species (for example, what flooding patterns favor reproduction of invasive riparian species?). This would provide information to help develop a program for the control of exotic species (National Park Service, 2001a).

The park's tinaja survey of the early 1990s covered the area south of Burr Trail, but not areas to the north (Figure 16). A survey could extend northward following the basic protocol of the southern survey, to assess pool size, slope, water volume, pH, nutrients, color, conductance, other water quality aspects, the flora, plant diversity, identification of exotic plant problems or new plants, the macroinvertebrates, amphibians, evidence of people, wildlife, or cattle impacts, and likelihood of accessibility of recreationists (Scoping Meeting Notes, October. 29, 2002). Wildlife use could be assessed, including the bighorn sheep transplanted into the park in 1996-1997. Repeat surveys on tinajas and hanging gardens would be valuable in the area south of Burr Trail as well, for two reasons: 1) this is an important area for recreation, likely to receive growing impacts; and 2) follow-up of the earlier surveys would determine if conditions have changed since the early 1990s.

This plan includes Project Statement # 9.2 that proposes inventorying and assessing riparian and aquatic habitats and Project Statement # 9.3 that proposes additional tinaja surveys. Project Statement # 9.4 discusses an inventory of springs in the southern portion of the park. In addition, Project Statements # 9.8 and 9.10 describes the need for understanding the hydrogeology of the park and delineating the park wetlands, respectively.

8.6. Fremont River: Impacts from Nutrients, Sediments, and Toxic Contaminants

8.6.1. Water Quality Issues

Fecal inputs from cattle, soil compaction, erosion from logging and recreation, and various agricultural practices can all contribute to poor water quality in the Fremont River. These impacts were discussed extensively in Sections 5 and 6.6.2. Numerous water quality studies have been completed on the Fremont and its tributaries and the State of Utah continues to monitor the Fremont River at the Hickman Bridge within the park (Envirosphere, 1981; Christiana and Rasmussen, 1991; National Park Service, 1991 and1994: Millennium, 2002). These studies discussed concerns with temperature, turbidity, dissolved oxygen, and total phosphorus levels. From a water quality standpoint, the State of Utah recognized that portions of the Fremont River did not support some of the designated beneficial uses (see Table 1for designated use classification of the Fremont River and tributaries). As such, the Utah Division of Water Quality in 2000 placed two segments of the Fremont on the 303(d) list. The list is so named since it refers to Section 303(d) of the Clean Water Act, which establishes the Total Maximum Daily Load (TMDL) program. This program's aim is to protect public health and the health of impaired aquatic systems by attaining beneficial uses.

The Utah Division of Water Quality designated the upper Fremont from its headwaters to near the town of Bicknell as partially supporting the beneficial use of a coldwater fishery due to low dissolved oxygen and high total phosphorus levels. High phosphorus levels lead to increased algal production. Upon decomposition of the algae, consumption of oxygen takes place, thus lowering the overall dissolved oxygen levels. The lower Fremont River, from the eastern boundary of Capitol Reef to its confluence with the Muddy River only partially supports the beneficial use of agriculture due to high total dissolved solids (Millennium, 2002). High dissolved solids in irrigation water interfere with crop growth. To remedy the water quality problems, the Fremont River Watershed Steering Committee with the assistance of Millennium Science & Engineering developed a Water Quality Management Plan for the Fremont River (Millennium, 2002). Notably, the plan lacks discussion of the Fremont River within the park. This segment of the river was not placed on the 303(d) list. Yet, this section reveals total phosphorus levels greater than the state recommended level of 0.05 mg/L at Hickman Bridge. The Millennium report showed that levels of total phosphorus at Hickman Bridge on the Fremont River (STORET #495436) exceeded the state recommended level in 73% of the 15 samples measured, and that dissolved oxygen levels were outside the range of the state standard in 5% of 22 samples measured. Their report did not elaborate on whether the exceedences for dissolved oxygen are below or above the range of the state standard.

The park has participated on occasion with the Fremont River Technical Advisory and Steering committees which assisted with the development of the TMDL, but has not sought the same kind of assessment for the reach within the park, since legally there was no mandate. However, there is reason for the park to be concerned with the Fremont's water quality. The Fremont River as it flows through the park is designated as a coldwater fishery, yet this reach of the Fremont is transitional between the warmer waters of the Fremont River downstream near Caineville and Hanksville and the coldwater fishery that can support trout upstream in the Bicknell area. Temperature, turbidity and dissolved oxygen levels have not always met the coldwater fishery status of this reach (National Park Service, 1991 and1994). Although the water quality of the Fremont River within the park has been assessed, it is still not known whether turbidity is solely related to irrigation diversion activities, whether the waters really constitute a coldwater fishery, or what is causing the high total phosphorus levels.

Additionally, the park applies pesticides to its orchards. Return flows from irrigation may carry these contaminants into the Fremont River. Since the Fremont River served as a culinary source for the park, water was sampled for nitrates, volatile organics, and metals. At no time did the water reveal elevated levels of these contaminants. Yet, no substantive studies have been conducted to determine the level of pesticide contamination occurring in the river. Presence of contaminants in the Fremont River that may relate to park pesticide application should be known and the park should maintain a nutrient management plan for the orchards if appropriate.

8.6.2. Future Efforts

Considering that temperatures have exceeded the state criteria for a coldwater fishery, and that nutrient levels and turbidity levels are more than occasionally high, the park considers water quality matters to be important, and needs to continue assessment of its waters with the intent of seeking improvement to the quality of the water. An effort through the Northern Colorado Plateau Network of parks will give rise to an integrated inventory and monitoring program for park vital signs. With regards to water quality, each park will have the ability to access funding for monitoring. Development of the water quality vital signs is occurring. The outcome of that process parallels development of this water resources management plan, and water quality monitoring needs defined in Project Statement # 9.5 tie in with the network water quality monitoring efforts. The water quality monitoring effort will include the Fremont River and other tributaries such as Oak, Pleasant and Halls creeks.

8.7. Wild and Scenic River Considerations for the Fremont River Gorge

8.7.1. Introduction

Below the town of Torrey, the Fremont River exits the valley and enters a scenic canyon in BLM lands, and continues into the park into the canyon known as the Fremont River Gorge. A number of organizations have reviewed or offered opinions on possible Wild and Scenic River Act (WSRA) designation for this scenic gorge area:

- The BLM and NPS have proposed the gorge area for inclusion in the Wild and Scenic Rivers System;
- Capitol Reef National Park has considered the gorge area for recognition as a “Research Natural Area;”
- The Nature Conservancy has proposed the Fremont River Gorge for inclusion in the Utah Natural Areas Inventory;
- Utah Rivers Council group has defined the gorge as eligible for WSRA designation; and
- American Rivers considers the gorge as both wild and scenic (National Park Service, 1993; Borthwick and Henderson, 1991; American Rivers, 1988; BLM, online information, 2003).

Wild and Scenic Rivers Act designation is thought to be a tool that might help keep the river flowing more wild and natural in the gorge area. This section provides an overview of the wild and scenic river concept, with focus on the Fremont River Gorge area.

8.7.2. Wild and Scenic: Definitions and Background

As described in this report’s Section 4.1., the National Wild & Scenic Rivers Act (Public Law 90-542; 16 U.S.C. 1271-1287), 1968, allows designation of a river into a state river protective system. Rivers so designated by a state must be administered permanently as wild, scenic or recreational rivers by an agency or political subdivision of the state concerned. To be eligible for designation, a river must be free-flowing and contain an "outstandingly remarkable value" --usually scenic, recreational, geologic, or some other resource feature, and the adjacent land area also must possess some of these "remarkable values" (Baldwin, 2001; Forest Service and BLM online information – US Dept. of Agriculture, 2003; Bureau of Land Management,1995). "Wild and Scenic Rivers" by definition fall into three categories:

- A "Wild River:" Rivers or sections of rivers that are free of impoundments and generally inaccessible except by trail, with watersheds or shorelines essentially primitive and the waters unpolluted;
- A "Scenic River:" Rivers or sections of rivers that are free of impoundments, with shorelines or watersheds still largely primitive and shorelines largely undeveloped --but accessible in places by roads;
- A "Recreational River:" Rivers or sections of rivers that are readily accessible by road or railroad, perhaps with some shoreline development, and may have undergone some impoundment or diversion in the past.

"Free-flowing" refers to a river or section of a river without impoundments, diversions, straightening, rip-rapping or other engineering. The presence of dams above and/or below a free-flowing river segment or less than ideal water quality does not disqualify the segment as a potential addition to the National System.

The water quality criteria for WSRA designation are flexible (excerpts):

> (1) "Wild:" … meets or exceeds Federal criteria … for primary contact recreation (swimming).
> (2) "Scenic:" …rivers… will not be precluded from scenic or recreational classification because of poor water … provided a water quality improvement plan exists or is being developed in compliance with applicable Federal and State laws.
> (3) "Recreational:" rivers … will not be precluded from scenic or recreational classification because of poor water quality at the time of their study provided a water quality improvement plan exists or is being developed in compliance with applicable Federal and State laws."(USDA, 2003).

Wild and Scenic Rivers Act designation appeals to constituents seeking to restrict federally-assisted water resource development projects that might adversely affect wild, scenic, or recreational values. The law "protects these listed wild and scenic rivers from water projects and from additional discharges, and it prohibits the development of public or private hydroelectric power plants on these rivers and restrains certain other types of development" (Baldwin, 2001; Texas Center for Policy Studies, 2003; Forest Service and BLM online information; Bureau of Land Management, 1995).

8.7.3. Proposals Under Consideration for Wild and Scenic Designation

The BLM has taken the lead in pursuing a Wild and Scenic designation for the Fremont Gorge. A Wild and Scenic Rivers Act designation also would extend the Fremont Gorge Wilderness Study Area. BLM has affirmed, "The Fremont River is eligible for inclusion as a component of the National Wild and Scenic Rivers System because of its outstanding recreational values… scenery in the Fremont gorge is spectacular." They also have noted that the gorge contains pristine riparian habitat, recreational, scenic, and scientific values, and that these values are enhanced by their proximity to an area endorsed by the NPS for wilderness. They have pointed out that the BLM segment of the gorge is "wild, roadless, and lacks evidence of man-made intrusions." In their view a WSRA designation in tandem with Capitol Reef National Park's wilderness designation would provide “remarkable solitude,” and even more so if the park also would participate in the Wild and Scenic Rivers System.

The Forest Service supports the BLM proposal for a Wild and Scenic Rivers Act designation for the Fremont River Gorge, and together NPS, BLM, and Forest Service have an agreement to work on the WSRA proposal (Zieg, P., BLM, pers. comm., 2003; National Park Service, 1993; and Borthwick and Henderson, 1991). The Utah Rivers Council group defined the gorge as eligible for WSRA designation, and the park has recommended both the Fremont River and Pleasant Creek for inclusion on the National Rivers Inventory (BLM and Forest Service online information; Zieg, P., BLM, pers. comm., 2003). The Utah Departments of Water Resources and Natural Resources and possibly the State Institutional Trust Lands Administration would need to play a role in any WSRA proposals (Monroe, T., Utah Dept. of Nat. Res., pers. comm., 2003).

8.7.4. The Arguments for Wild and Scenic Designation for the Gorge

Proponents believe that a Wild and Scenic Rivers Act designation could perhaps help maintain a more natural flow in the Fremont River Gorge and protect riparian ecosystems by restricting projects that would artificially manage the flow.

From a “free flowing” perspective, it is important to note that research on the river within the park has determined that the Fremont River has the potential to maintain the dynamic fluctuations of the river during late summer thunderstorm events and during early spring snowmelt floods prior to the irrigation season, even with the dams that now exist upstream (Hammack and Cluer, 2000). Natural riparian ecosystems need a natural regime of flooding, scouring, and sedimentation to remain natural. The research pointed out that additional upstream diversions or damming in the Fremont River could possibly impact the river’s dynamic function and thereby harm its natural ecosystems (Hammack and Cluer, 2000). From a park perspective, natural flows would be desirable.

A dam can affect channel characteristics, since a reservoir removes sediment from a stream; the energy normally required to carry the sediment then is available for eroding streambanks downstream from the dam. A dam therefore can impact fish habitat by changing channel substrate, water temperature, and nutrient levels (Christiana and Rasmussen, 1989). Research in arid areas of the southwestern U.S. has demonstrated that dams affect the habitat downstream in ways unfavorable to natural cottonwood regeneration. Asplund and Gooch (1988) found that cottonwoods and associated riparian ecosystems in Arizona desert canyons depended on hydrological fluctuations, and that excessive, unnatural scouring below dams reduces cottonwood reproduction. Dams reduce meanders and other natural stream characteristics that are essential for cottonwood populations. While dams inhibit native vegetation, they also tend to encourage exotic vegetation (Fenner et al, 1985; Everitt, 1995).

Since better land management practices are intended for the Fremont River Basin under the water quality management plan for the basin (Millennium, 2002), then the Fremont River Gorge appears to meet the water quality criterion for a “scenic” or “recreational” river as defined above.

8.7.5. Some Arguments Against the Wild and Scenic Designation for the Gorge

Some may consider the Fremont River Gorge as not a “natural enough” segment to be a good candidate for a Wild and Scenic nomination, given the pollution, existing flow manipulations upstream, and other human impacts now affecting the gorge. The river and its tributaries above the gorge are subject to contamination and water depletion by municipal, agricultural, and other users. Manipulated flows have caused: deposition of sediment along riverbanks; the elimination of some floodplain wetlands; the destruction of habitat for some unique species; and the creation of habitats attractive to exotic plants such as Russian olive and tamarisk.

Additionally, the Fremont Irrigation Company is entitled to divert the entire river during the irrigation season (Brinkerhoff, J., Fremont Irrigation Co., pers. comm., 2003); however, this does not dry the river in the gorge, given the large springs and other tributaries that feed the river downstream from the irrigation company’s outtake.

As detailed in Section 6.6 of this report, the water quality of the river is poor in places upstream from the gorge. A water quality management plan and total maximum daily load (TMDL) procedure has been completed for the basin (Scoping Meeting Notes, October 29, 2002; Millennium, 2002; Pace, P., TMDL committee, pers. comm., 2003).

8.7.6. Possible Dam or Diversion Projects

A Wild and Scenic designation for the gorge attracts some parties because it could help restrain water projects on the river upstream, to help protect the gorge’s free flow. Proposals for dams on the Fremont River go back to at least the 1940s --both upstream and downstream from the park. The proposals for dams are described further in Section 6.5.2 on the river and also in Section 8.2 on water rights.

To understand potential dam impacts, the park first needs to understand what stream flows are needed to maintain a healthy riparian vegetation community and to maintain desirable geomorphic channel processes. Therefore, the NPS Water Resources Division initiated a data collection program in 1993-98 to quantify the instream flow characteristics and requirements of the perennial streams within the park (also in response to the pending adjudication of the Dirty Devil River Division, which is the area downstream from the park). These data can help define the potential impacts of dams.

8.7.7 Concluding Remarks and Recommendations

In close cooperation with the Bureau of Land Management (the lead), Forest Service, and State of Utah, the park may wish to explore the pros and cons of a Wild and Scenic River Act designation for the Fremont River Gorge reach of the river. Any exploration of the wild and scenic question as regards the gorge also could be in cooperation with The Nature Conservancy and other conservation groups that have interest in the topic.

The concept of “free-flowing” stream is inherent in the wild and scenic river discussion, as defined above. For this reason, more basic research is needed on the river’s hydrology upstream from and in the Fremont River Gorge, to understand potential water use or water diversion effects on the gorge. Analysis of the various flow scenarios and their effect on the Fremont River's hydrograph and flow duration curves should be combined with the observations and analyses of sediment transport and riparian vegetation, to provide insight into future resource impacts from basin water development (Hammack and Cluer, 2000).

The water quality planning conducted for the Fremont River offers a chance for improved water quality in the Fremont River Gorge in the future. It is therefore also logical that the park continue to work with other agencies and organizations to promote best management practices (BMPs) in the Fremont River basin, to improve water quality. Should the park wish to work with BLM and others to explore wild and scenic river designation for the gorge, this could be complementary to the effort to promote BMPs for the Fremont Basin.

8.8. Review of Water Quality Use Designations on the Fremont River

States adopt water quality standards to protect public health or welfare, enhance the quality of water, and serve the purposes of the Clean Water Act (33 U.S.C. 1251, *et seq*.) as defined in sections 101(a)(2) and 303(c) of the Act. Each state adopts designated uses specified in their water quality standards for each water body or segment whether or not they are being obtained (40 CFR131.3(f))(Utah Dept. of Environmental Quality, 1997; Utah Division of Water Quality, 2000a; Utah Division of Water Quality, 2000b; Utah Board of Water Resources, 2000).

The State of Utah Division of Water Quality splits the Fremont River into two segments with respect to use designations. Table 1 in Section 4.3 presents the designated use classification for the Fremont River and tributaries. The table shows that from the eastern boundary of the park upstream to the headwaters of the Fremont River, a coldwater fishery use designation prevails. Also the waters are recognized for domestic purposes with prior treatment, secondary contact such as boating and wading, and agricultural use. Downstream of Capitol Reef to its confluence with Muddy Creek, the use designations for the Fremont River include support of non-game fish, secondary contact, and agricultural use. The State of Utah listed only a portion of the upper section of the Fremont River as a 303(d) water, and did not include the segment in Capitol Reef in that listing although the segment is part of river section with the same use designation.

Classifying the Fremont River within the park as either a coldwater or warmwater fishery is difficult, since geological and ecological transitions occur from the headwaters of the Fremont to its lower reaches in the park. The geology changes from volcanic rocks to sandstone near Bicknell, and between Bicknell and Teasdale, a north-south fault brings Mesozoic sedimentary strata to the surface (Millennium, 2002). Coupled with various land uses and plant cover types, the sedimentary strata can contribute to natural siltation in the river.

Also, recognizable changes in the river relate to gradient changes, streambed and load, and accordingly the riparian vegetation. Between Bicknell Bottoms and the State Highway 12 crossing, the Fremont is a slow moving system (0.3% gradient) with some marshland areas at the river's margin. Cattle do graze along this section, and the streambed consists of silts, sands, and some gravels and boulders. The Fremont River enters a gorge below the crossing where a marked change in gradient occurs (up to 2.4%). Plant associations including alder/dogwood, box-elder/dogwood, river birch/dogwood, piñon, and Douglas fir parallel the river (Van Pelt *et al.*, 1991). The streambed consists of boulders and gravel. At the mouth of the gorge, just upstream of the Fruita, the river slows and the gradient changes (0.7-0.9%). After flowing past the

Fruita orchards, the river's margin supports Fremont cottonwoods, Russian-olive, and some tamarisk. The understory consists of grasses and forbs. The streambed through this section is sandy and silty with some gravel and boulders. From the headwaters through the park, the elevation ranges from approximately 8843 ft (2695 m) to 5120 ft (1561 m).

Changes in riparian vegetation along the river can contribute to changes in water quality parameters such as temperature and dissolved oxygen. These changes in vegetation types can also be accelerated when grazing occurs and streamside vegetation disappears. As a result, water temperature rises and dissolved oxygen levels lower.

The temperature and dissolved oxygen data suggest that the river at least below the Fremont River Gorge may not meet a coldwater fishery use designation. Within the park, river temperatures have exceeded 68^{o}F (20^{o}C) (Borthwick, 1991; National Park Service, 1994). Utah Division of Water Quality documented dissolved oxygen below the state criterion at Hickman Bridge on the Fremont River (STORET # 495436) and total phosphorus in exceedence of the state criterion at the same site (Millennium, 2002).

Rarely are game fish such as brown trout encountered within park, but native non-game species are (Hepworth *et al.*, 1993; Kirby and McAllister, 1999; 2000). Prior to 1985, the Fremont River between Bicknell and the Garkane Diversion at the west end of Torrey was a critically valued, Class II blue ribbon quality stream. From the Garkane power plant to Fruita, the river was a Class III high priority valued stream . In 1987 the Utah Division of Wildlife Resources re-evaluated these waters and downgraded them to Class IV, which recognizes streams of poor quality with a limited sport fishery (National Park Service,1991). Hepworth *et al.* (1993) recognized that the mottled sculpin, a coldwater fish, does not usually venture below the confluence with Sulphur Creek, and that the Colorado River cutthroat trout was extirpated from the Fremont River near the park. Given the lack of abundant coldwater fish within the park and the apparent water quality exceedences, the park may be interested in pursuing improvement to water quality.

The issue is that the use designation does not suit the waters within Capitol Reef National Park. Temperatures may exceed the state criteria for a coldwater fishery, and total phosphorus levels and fecal coliform levels may also exceed state criteria. The park has the opportunity to witness changes in water quality upstream of the park as a result of a mandated Water Quality Management Plan developed by Millennium (2002) and the Fremont River Steering Committee. Several best management practices, such as moving corrals from the rivers edge will be implemented. Improvements to water quality may take some time, however. In the meantime, the park can continue to participate in the Fremont River Steering Committee meetings to oversee the projects and also initiate a comparable water quality management plan for the section of the Fremont (from Bicknell through the park to the park's eastern boundary) that was not listed as impaired. Depending on the outcome of water quality improvements, the park may also wish to review the use designation for the segment of the river within the park. The process however is rigorous, and requires a use attainability analysis in which the public participates and the Environmental Protection Agency accepts or rejects the proposed change. Project Statement # 9.5 proposes a review of the river's water quality and its use designation.

8.9. Halls Creek Issues

8.9.1. Introduction

Halls Creek, with a total length of about 35 miles, is the only stream that exits the park to the south (Figure 10). The creek flows perennially above ground for its last 12 miles before emptying into Lake Powell, within the Glen Canyon National Recreation Area. The perennial reach includes 3 miles within the spectacular sandstone canyon known as the Halls Creek Narrows, in the southen end of Capitol Reef National Park. Since Halls Creek is the only perennial stream in the southern tip of the park, its riparian zone takes on special significance for plant and animal communities in a larger area.

8.9.2. Impacts and Potential Issues

Various water resource issues and impacts occur in the Halls Creek drainage. Several problems appear to threaten the stream and its riparian areas. Noxious plants are encroaching, with salt cedar, Russian-olive, and other exotics invading the riparian zone and some of the small impoundments. Exotic plants around old stock ponds increase the evapotranspiration rate. Ground-water withdrawal by wells occurs at several sites in the drainage, which is probably affecting springs. Hundreds of small stock impoundments or check dams remain in washes in the upper Halls Creek's drainage, left from earlier cattle operations. These ponds detain water (and let it evaporate) that otherwise could nourish the creek and its riparian zone. The impoundment issue is covered in Section 8.3 and is also the subject of Project Statement # 9.1.

Perhaps Halls Creek's issue of greatest concern is recreational impacts. Hikers are attracted to the Narrows because of the challenging, scenic hike along the creek, and growing numbers of hikers in Halls Creek Narrows are most likely impacting the creek and its riparian ecosystem and its water quality. Hikers walk through water within the confining walls during most of their time in the Narrows, stirring up the streambed and sediment. No restrooms or water supplies are maintained in the area, posing a risk of contamination. Hiker disturbance in the channel may increase turbidity, bacteria, and change the water chemistry of the creek, affecting the aquatic habitat. The park has gathered little data on the visitor impacts (National Park Service, 1993). This plan includes Project Statement # 9.6 which proposes to investigate the recreational impact.

In the past, the Halls Creek watershed sustained heavy grazing impacts. A Bureau of Land Management range survey in 1963-64 described the area including the headwaters of Halls Creek as "badly depleted… with heavy use… much Russian thistle… and dramatic erosion". In 1964, the BLM significantly reduced the numbers of animals, advised on fencing, re-evaluated all of the allotments in the area, and mandated firm guidelines for the grazing season (Frye, 1998).

Cattle grazing is authorized by the enabling legislation of the park, and grazing continues in the upper reaches of the Halls Creek drainage, but under more managed conditions than in the past. Grazing can raise creek nutrient levels, especially nitrates. The potential also exists for cattle to contribute fecal coliforms and other bacteria or viruses to the surface waters, and sediment and turbidity can rise in areas where cattle access streams. Such nonpoint source pollution may flow into the Narrows as a result of upstream cattle grazing (National Park Service, 2001a; Frye, 1998; Capitol Reef National Park Staff, pers. comm., 2003).

A basic issue at Halls Creek is the lack of streamflow information; the creek is ungaged and essentially no stream measurements have been made. At least reasonable approximations of streamflow are needed to interpret water quality data. Ground-water information is likewise lacking. Although hydrogeologists have studied ground water in parts of the park, they have collected little information on ground water in the Halls Creek area. The stream “loses” (goes underground) at places upstream, re-emerges in other stretches, then becomes a perennial surface stream for its last 12 miles (Huntoon, 1978). A study and understanding of these flow characteristics and the creek’s sources of water would be valuable. In summary, baseline water resource data on surface and ground water are lacking for Halls Creek.

For decades tar sands in the upper watershed have been recognized as a potential source of oil (as described further in Section 8.12.4 of this report). At some point in the future, tar sand development could pose a potential impact on the Halls Creek drainage.

8.9.3. Information Needs and Project Ideas

WATER RESOURCE AND AQUATIC DATA NEEDS: During the past few years, park staff began to recognize the need for basic information on the water resources of Halls Creek and prepared a proposal on this topic (Capitol Reef project # CARE-N-015.004). Essentially no water resource data exist for the creek, and park managers therefore are unable to interpret human, development, or land-use impacts. Routine information on the native fishes, amphibians, and aquatic invertebrates is needed since turbidity, nutrients, or other chemicals can affect them. Information on streamflow and water quality in the Halls Creek drainage also could help interpret Halls Creek’s effects on Lake Powell downstream.

A two-year study of water resource and aquatic information would assess present conditions and collect basic background information for designing appropriate periodic monitoring for the creek. Flow data and water quality samples could be gathered along the 12 mile length of Halls Creek. The study could be in cooperation with the Utah Division of Water Quality, who could provide essential laboratory analyses for major water quality constituents, appropriate quality control, technical advice, assistance in interpretation, and suggestions on stream gaging. Capitol Reef National Park natural resource staff could help determine sampling sites and assist with global positioning system (GPS) work.

EVALUATION OF VISITOR IMPACTS: A study to evaluate the impacts from visitation would complement the baseline aquatic ecology and physical water resource assessments described above. This plan includes a Project Statement # 9.6 on this topic.

ADDITIONAL CHEMICAL BACKGROUND FOR TAR SAND BACKGROUND: In view of the potential for tar sand development and its possible effect on Halls Creek drainage, certain supplementary water quality parameters should be included with the more basic quality analyses described above. A few additional special sampling sites may be needed at places where tar sand effects could occur someday (e.g., a pipeline route). The special parameters would be indicators of oil effects (e.g. chlorides, phenols, surfactants, some organic suites, and specific conductance). At least a “snapshot” of water quality in a few sites would be good basic background should the tar sand issue arise again.

REMOVAL OF OLD IMPOUNDMENTS: As discussed above, small stock ponds (impoundments placed in washes a few decades ago) exist up and down Halls Creek. Removal of these ponds would allow the artificially stored water to continue its travel down to Halls Creek, instead of evaporating in place. A project for removing of these structures, including the Halls Creek basin, appears in Project Statement # 9.1.

8.10. Impacts to Pleasant and Oak Creeks

8.10.1. Introduction

Oak and Pleasant creeks originate in the National Forest, above 8,000 ft (2400 m) in elevation, where the headwaters consist of good soils, vegetative cover, and fairly stable watersheds that supply perennial flows downstream into the park (Figure 10). Oak Creek drains about 58 mi^2 (150 km^2) and Pleasant Creek is larger, draining approximately 120 mi^2 (310 km^2) .

Douglas fir, aspen, and blue spruce grow in the upper elevations of the two watersheds, above about 8,500 ft (2591 m). From about 8,500 down to about 7,000 ft (2491 to 2133 m), the watersheds support a ponderosa pine type forest. From roughly 7,000 ft down to about 4,500-5,000 ft (2133 to 1372 m) the cover is predominantly piñon-juniper type, while lower than about 4,500-5,000 (1372-1524 m) ft the sagebrush, rabbitbrush, cactus, and other more arid species dominate (Smith *et al.*, 1963, Christiana and Rasmussen, 1991).

Capitol Reef National Park manages only the bottom third of these two watersheds, while the upstream two-thirds essentially lie in the Dixie National Forest. Therefore, the flow patterns, water quality, sediment yields, and other characteristics of the two creeks are influenced by the upstream activities outside National Park Service management, so that park managers' influence on these upstream activities depends on cooperation with the Forest Service.

Pleasant Creek and Oak Creek watersheds support multiple land and resource uses, and those activities and their possible impacts that affect streamflow or water quality include:

- Cattle grazing and trailing; horseback riding;
- Diversions of water for irrigation, above as well as in the park;
- Logging and forestry above the park;
- Wildfires and fire management, mainly in the National Forest;
- Recreation, including all-terrain vehicle use, hiking, camping, hunting, and fishing, and their associated wastes, trash, and spills (some only in the National Forest);
- Roads, trails, old mines, a highway (with possible spills), and other disturbances that can yield sediment or pollutants (mainly in the National Forest);
- Exploration or development for minerals, oil, gas, or other extractives on State of Utah or Forest Service lands where claims and leases are possible (Millennium, 2002; National Park Service, 2001b).

8.10.2. Floods and Erosion in Oak Creek and Pleasant Creek Watersheds

Stream discharge data for the two creeks are sparse or old. Pleasant Creek at its lower extreme near Caineville was gaged from 1969-1972, and the Water Resources Division of the National Park Service collected some flow data at a site on Pleasant Creek for a short period in 1995 (Christiana and Rasmussen, 1991; Hammack and Cluer, 2000). Oak Creek basically is lacking information on stream discharge in the park.

Natural flash floods erode channels, initiate gullies, and create arroyos, and the tributary streams around the Waterpocket Fold have mostly downcut their channels. Some arroyo networks have cut upward into their tributaries to where the drainage area is too small to provide sufficient overland flow for continued cutting. It is not clear how grazing, logging, mining, and irrigation affects the stability of stream channels or stimulates the cutting of channels and arroyos, since some of the cutting is natural. In the past, overgrazing no doubt caused accelerated erosion, but climate change and major event storms also caused natural erosion. Hunt *et al.* (1953) concluded that cycles of arroyo cutting occur in the Fremont River basin in response to climate and large floods; for example, a great flood in 1897 started a cycle of arroyo cutting. Research has shown that arroyo cutting occurred prior to European settlement, also indicating that erosion is partly natural (Graf, 1980, 1983; Hunt *et al.*, 1953).

Flooding can be impressive in these creeks. Flow data were collected on Pleasant Creek for a period in the 1990s; however, the hydrologists suspended measurements in November 1995 due to difficulties maintaining a stable, long-term collection site; storms destroyed the gaging sites (Hammack and Cluer, 2000). Summer flash floods frequently wash out portions of the Bowns irrigation canal in Oak Creek, resulting in erosion, debris, and disruptions (National Park Service, 2002).

8.10.3. Diversions in the Watersheds

Stream diversions impact Oak Creek and Pleasant creeks, changing the flow regimes and volumes in the streams to produce sediment or to drain certain riparian zones. A water system supplying the Bowns Canal originates at the Oak Creek (Upper Bowns) Reservoir, flows through ditches in the National Forest into a common ditch with water coming from a Pleasant Creek diversion, empties into Lower Bowns Reservoir, and then flows into Oak Creek (Figure 15). This system also is discussed in Section 7.3 on irrigation and in Section 8.2 on water rights issues. The 1969 park expansion encompassed the land through which the various ditches and pipes pass.

Summer flash floods carry sediment and debris along the irrigation canal and cause channel erosion and turbidity. Canal repairs also produce erosion when tractors disturb the canal banks. Because of these sediment and erosion impacts and repair costs, the canal managers plan to pipe underground some 3,575 ft (1090 m) of the existing overland canal. The piping should help eliminate flash flood washouts of the ditch and reduce erosion and sediment impacts (National Park Service, 2002).

8.10.4. Grazing and Trailing Impacts and the Streams

Cattle grazing and trailing above and in the park affects Oak and Pleasant creeks at times by increasing nutrient loads, turbidity, and bacteria in water and influencing stream ecosystems and riparian zones. Cattle damage was heaviest in watersheds in the Capitol Reef area during the 1900 to 1950 period, when significant overgrazing, erosion, and exotic plant introductions occurred. Since that time, watershed and riparian conditions have improved, especially as the park continues to buy out grazing allotments. Grazing continues upstream in the headwaters of Oak and Pleasant creeks in the Dixie National Forest and other lands, and trespass cattle or strays left from trailing appear in the park at times.

The Teasdale Ranger District of the Dixie National Forest maintains allotments for about 1700 cattle in the Oak Creek and Pleasant creek watersheds, above the park, as summarized in Table 13a.

The continuation of cattle trailing along historically used routes through the park, including Oak and Pleasant creeks, has been permitted under the terms of the legislation that established the park. Table 13b summarizes these drives for the two creeks and other areas in the park.

The Taylor Ranch spring drives along Oak Creek start to the west of the Notom-Bullfrog Road, about 2 miles south of Sandy Ranch, then follow the creek up towards Lower Bowns Reservoir. The Sandy Ranch cattle follow a similar route in the spring. In the fall, the Taylor Ranch cattle are driven from the National Forest, mostly along Oak Creek, but sometimes down along the ridge between North and South Coleman Canyons. The Pleasant Creek trailing begins near the Notom-Bullfrog Road at the Notom Bench area and follows uphill into the National Forest. Trucks transport some of the Pleasant Creek cattle uphill to the National Forest in the spring, but most of these cattle are driven down the trail in the fall (Durfey, K., Capitol Reef National Park, pers. comm., 2003).

Table 13a. Cattle allotments in the Oak and Pleasant creek divisions in the Dixie National Forest, upstream from the park.

Oak Cr watershed allotment	Trailing June1 & Oct 15	1078 head	~4851 AUMs
Pleasant Cr watershed allotment	Trailing June 1 & Oct 15	611 head	~2750 AUMs

(Information from K. Robins, Dixie NF, 2003; AUM = animal unit month)

Table 13b. Cattle trailing in the park, including Oak and Pleasant creeks.

Route	**Cattle Owner**	**Dates**	**General Location Notes**	**Numbers of Cattle**
Along Oak Creek	Sandy Ranch	June 1-10 Oct 15-20 3 days to go up 1-2.5 down	Boulder Mt area grazing	1078 head both ranches in spring ~ 2000 in fall with calves
	Taylor Ranch			
Along Pleasant Creek	Elvin Taft	June 1-10 Oct 15-20 3 days to go up 1-2.5 down	Truck the cattle up in the spring; trail them down in the fall	115 head in spring
	Wood Bros			200 head in fall
Along the Highway	Harnet, Pace Ranch (#1 CARE Allotment)	Down only in the fall	From Torrey to just NE of oxbow in CARE	~200 head

Bitter Creek divide area	Sandy Ranch (#3 CARE Allotment) and Taylor	April 15 about 2 days	Bitter Creek divide by SE boundary to Sandy Ranch	238 head (Sandy) 87 head (Taylor)
NW corner of park	Castle Valley Ranch	June 7 (~1 week) Nov 1	From Baker Ranch spring and fall trailing	~150 head spring/fall 408 head also some years for rotation (Solomon Basin)
Cathedral Valley trailing	Albrecht Ranch	June 1 (3 days) Nov 1 (3 days)	By Lake Creek along road to Hanksville	250 head, with calves in spring
	Jeffrey Ranch	Apr 1 Nov 3-4	Truck in fall; trail in spring; east end of allotment	100 head in spring

Table data based on interview with Keith Durfey, Jan-April, 2003. Note that a spring calf ~ 100-125 lbs and a fall calf is ~ 500 lbs. CARE = Capitol Reef National Park.

8.10.5. Other Impacts: Recreation, Logging, Fires, and Mining

Logging in the National Forest is a potential source of sediment and nutrient in the streams, and removal of forest cover can accelerate runoff. Timber salvage sales have taken place along U-12 above the park in Oak and Pleasant creeks, for example, the 1971-96 sales where mistletoe infestation caused ponderosa pine die-off.

Recreation, including hiking, hunting, camping, and fishing is growing in the National Forest and the park and can impact streams with litter, wastes, trampling, and four-wheeling effects. Three campgrounds and picnic areas are located in the watersheds: two along U-12 and one at Lower Bowns Reservoir (Figure 15). Roads and trails often are principal contributors of sediment. All-terrain vehicle (ATVs) use is increasing in the headwaters of Oak and Pleasant creeks; ATVs can erode and impact riparian areas or initiate gullies (Millennium, 2002). Horseback riding/camping is similar to cattle in terms of bacterial contributions, streambank erosion, or vegetative cover destruction.

Miners established claims in the headwaters of Oak and Pleasant creeks in the boom days of the 1950s, but no major mining is presently active in the watersheds. Oil and gas exploration can occur near the park boundary, and impacts upstream from the park are possible if lands are leased and developed (National Park Service, 2001a). Section 8.12 provides further discussion on the potential impacts of oil and gas. The park largely relies on other agencies to track petroleum developments; however, it would be valuable for the park to have background data on chemical water quality in Oak and Pleasant creeks, for baseline prior to any development. At this time, water chemical data on the streams inside the park are sparse or old.

Prescribed fires and wildfires in the National Forests potentially can cause erosion, and also increase sediment, debris, and nutrients in streams. Once a wildfire destroys vegetation and bakes soil surfaces, infiltration of rain or snow decreases, causing an increase in surface runoff. The increased surface runoff --during storms or spring snowmelt-- can cause streambank erosion downstream, impacting riparian vegetation and contributing sediment and nutrients to the stream. All of this can degrade water quality. For these reasons, the Forest Service considers it important to monitor the effects of fires on streamflow, riparian zones, and water quality. Table 14 summarizes the principal prescribed burns of the 1990s upstream of the park in the Dixie National Forest.

Exotic plants also affect the two creeks at some sites, as discussed in Section 8.13 on this topic. Power lines crossing Oak Creek potentially could affect watersheds as well. The dirt roads under power lines are often steep, with potential for erosion and sediment yield. Herbicides may be applied for brush control in certain areas, presenting the potential for contamination where powerlines cross riparian areas.

8.10.6. Some Water Resource and Water Quality Observations

The first evaluations of water resources in Oak Creek and Pleasant Creek watersheds inside the park occurred over 20 years ago, when the Envirosphere (1981) gathered a "snapshot" of water quality, sampling at the lower end of Pleasant Creek by Sleeping Rainbow Ranch and the lower end of Oak Creek at Notom Road. They found "no significant water quality problems," however they did recommend a sampling program.

Table 14. Prescribed burns in Oak Creek and Pleasant Creek watersheds during recent years or planned.

Oak Cr burn 1997	To regenerate aspen	~1500 acres planned; 800 treated	In the spruce-fir
Indian Trail Bench burn	To break up P-J and improve range	~500 acres	In the P-J
Dry Bench burn 1996-97 (above Coleman Canyon)	To break up the P-J sagebrush type	~500 acres	In the P-J sagebrush type
Larb Hollow burn (upper Pleasant Cr)	To reduce fuel loads	~1400 acres	In the P-J sagebrush type
Wide Hollow proposal	To reduce fuel loads, increase forage for deer-elk	Above Garver (planning phase)	Up to the sub-alpine fir level and aspen areas
Park Ridge	To reduce fuel loads	~1500 acres	Ponderosa pine type area

(table information from pers. com., K. Robins, Teasdale District, Dixie NF, 2003)

By the mid-1980s, grazing in and around the park became a contentious issue, and the park conducted or contracted a suite of studies to quantify the effects of livestock on park resources, including water. Three of these studies looked at the effects of livestock on water quality.

Water quality impacts occur in both creeks. In the Oak and Pleasant creek watersheds, studies have found high bacterial counts in stream reaches accessible to livestock . Also, after a cattle drive Oak Creek especially has exhibited substantially higher levels of coliforms and sediment (Barth and McCullough,1988). Purdue University scientists compared the two creeks and found that Pleasant Creek supports a rich and diverse aquatic insect fauna and is "pristine," in contrast to Oak Creek, judged "severely impacted by cattle" (Brammer,1997).

The Forest monitors for erosion during logging, and in some examples sediment has resulted, but generally the best management practices have been successful (Range, 1997b), although slightly elevated levels of phosphorus and sediment have occurred at times (Kendall, 1998 and1999). Stream bacterial measurements have not indicated a problem of recreational impacts on water quality in the two creeks (Range, D., Dixie NF, pers. comm., 2003; Dixie NF, 1976 and 1994; Range, 1996; Range, 1997a; Range 1997c).

Section 6.6 of this report, on water quality, provides further details on the principal water quality monitoring projects in Oak and Pleasant creek watersheds carried out by the National Park, the Forest Service, and university scientists.

8.10.7. Data Needs, Possible Research, Possible Projects

The park needs basic water quality monitoring for Pleasant and Oak creeks. Water chemistry data and other water quality information inside the park are sparse, old, or inadequate to serve as baseline information at this time. New activities or developments in the National Forest headwaters of the two creeks are possible, and baseline information is needed prior to developments. Recreation inside the park likely will grow, so it will be valuable to have water quality data to monitor the effects of this activity within the park. The various data will show if mitigation is needed to protect park waters. The Northern Colorado Plateau Network and Vital Signs program presently are designing monitoring guidelines, which likely will include a monitoring site on at least Pleasant Creek (Cudlip, L., pers. observ., 2003).

Stream discharge information is exceptionally limited for the two creeks, so it is not known how stream channels are changed by diversions or what discharges occur during flash floods. Information on floodplains or wetland areas also is limited.

Water diversions in Oak and Pleasant creeks continue to affect the flow and sediment conditions. Monitoring could show if management actions should be taken to protect against the impact of diversions. A study of these effects could evaluate sediment loads and streamflow fluctuations.

About 10 years ago, the park proposed a “videography,” or low level photography of some streams in the park, to inventory the conditions of riparian areas, channels, erosion, wetland areas, and vegetation along the streams. This type of inventory or low-level color-IR photography could provide valuable information and tie into the riparian and wetland inventories proposed in Project Statements # 9.2 and # 9.10 of this plan.

8.11. Hydrogeology: What does the Park Know?

Scientists have studied the hydrogeology of the Colorado Plateau intensely with particular emphasis on assessing water sources, oil and gas sources, coal, and tar sand sources. However, review of ground water within the park has been limited, and researchers have only been compelled to understand ground water when development of a local water source has been of interest. The Fremont River had been the key drinking water source for the park until 1993, when a well was finally completed in a sandstone lens of the Moenkopi Formation. Prior to that time, Marine (1962) used knowledge of the park geology to assume water availability within various formations. Martin (1993) provided more detailed hydrogeological information surrounding the Capitol Reef water supply well.

The regional hydrogeology studies including Bjorkland (1969), Hood and Danielson (1979, 1981), Hood (1980), Blanchard (1986a, 1986b), Weigel (1987), and Weiss (1987, 1991) reviewed ground water availability, conditions, characteristics, and flow, but they were not specific to Capitol Reef. These studies identified various geological formations as providing potential water sources (see Table 2). The most notable formation as a source of water is the Navajo Sandstone. The Wingate Sandstone and locally the Entrada can also supply water. That the park finally pulled their culinary water from a lens within the Moenkopi, a formation which generally does not provide a good source of drinking water, points to the inadequacy of regional studies in predicting or even understanding local hydrogeology.

Only recently has hydrogeological modeling of projected drawdowns related to proposed wells been completed (Cutillo, 2002). Cutillo conducted a modeling effort based on published references and standard drawdown equations. Cutillo determined that proposed wells completed east of park could impact ground water within the park. She concluded from her model that after 10 years of pumping at 0.05 cfs (22.4 gpm), one irrigation well may produce 48 ft (15 m) of drawdown at the park boundary. The 5-ft (1.5-m) drawdown contour captures the Capitol Reef water supply well. Pumping water for households (100 houses at 100 gpd each for a total of 6.94 gpm) would create less of a drawdown – 1.5 ft (0.45 m) at the park boundary and cause 0.5 feet (0.02m) of drawdown in the park's well after 10 years. Cutillo presented other scenarios based on a sensitivity analysis.

Cutillo's study responded to proposed land exchanges and the potential threat of water development on the eastern side of the park near Notom. Her study indicates that few sources of information for estimates of transmissivity and water storage potential for various geological formations. Would other existing or potential drinking water sources, i.e., Sleeping Rainbow Ranch or Peekaboo, incur impacts if water development were to occur outside of the park?

Personnel with the Utah Division of Water Rights noted that any water development via wells requiring appropriation of more than 4 ac-ft/year would be highly scrutinized (Monroe, T. Utah Dept. of Nat. Resources, pers. comm., 2003). Cutillo's study uses irrigation scenarios that would exceed this 4 ac-ft level, however her modeling of domestic water use does not exceed that 4 ac-ft level, and could more readily be approved. The Division of Water Rights also approves water rights for greater amounts than 4 ac-ft with a fixed-time application. These types of rights may be issued for 10 years, for example, and then reviewed upon re-application.

Understanding the extent of ground water within the park, its availability and vulnerability to outside extraction is critical for several reasons including maintenance of 1) a ground-water culinary supply to visitors and park personnel, 2) water for wildlife at springs and tinajas, and 3) maintenance of riparian areas around springs and tinajas.

More knowledge of the area's hydrogeology, recharge patterns, and the ground-water sources of springs would be useful baseline information for scientists, park managers, and cooperators. Geologists and others have studied the ground water of the Capitol Reef area for years, exploring for possible well sites for ranchers or for general knowledge. However, much less effort has gone into the study of springs and seeps. Springs are critical to wildlife but usually not as important to agriculture or ranching, compared to wells. A hydrogeology study is needed to understand the flow of water through formations into permanent tinajas and hanging gardens. Not much is known about flow rates, any ground-water inputs, surface recharge processes, and other aspects of tinajas, to understand what allows a permanent pool. Ground-water studies of tinajas therefore could be part of a larger package to evaluate ground-water development. Study of ground-water geochemistry and surface-water chemistry could be useful, since geochemical tracing or prospecting provides a tool to understand water movement.

Project Statement # 9.8 addresses the need for understanding the park 's hydrogeology.

8.12. Mining, Oil and Gas Exploration, and Tar Sands Operations, and Impacts on Water Quality

8.12.1. Introduction

Capitol Reef National Park has a history of mining in the park (Table 15) and nearby, and although mining or other extractive activities generally have not occurred near the park for many years, the area still has the potential for development. Section 6.3.3. of this report reviews the history of mining in the park.

Mining can occur upstream or adjacent to the park on Bureau of Land Management, Forest Service, State of Utah, or private lands, and these lands are re-appraised from time to time for mining, oil and gas drilling, tar sand development, and other extractive activities. Petroleum deposits are associated with the geologic formations found in and near the park; therefore, oil and gas exploration and development will continue to have potential to impact park water resources. Minerals found in the park area include uranium, vanadium, copper, manganese, gypsum, building stone, and sand and gravel, but many of these are not profitable to extract at this time. [4]

Table 15. Location and status of principal mines in Capitol Reef National Park.

Mine	Location	Adits	Shafts	Total
1. Oyler (6 closed)	T29S, R6E, s26	5	1	6
2. Rainy Day (12 closed)	T34S, R8E, s33; T35N, R8E, s3,4	12	0	12
3. Solitude	T33S, R8E, s29	1	0	1
4. Floral Reef	T30S, R7E, s33	1	0	1
5. Double Ladder	T31S, R7E, s7	1	0	1
6. Oak Creek	T31S, R7E, s30	1	0	1
7. Sinkhole (explosives mitigated)	T27S, R5E, s1	1	0	1
8. Ferris Nipple	T30S, R6E, s1	1	0	1
9. Terry	T34S, R8E, s4	1	1	2
10. Duchess	T35S, R8E, s25	0	1	1

Uranium-containing rock [5] is widespread in the Capitol Reef area. Uranium or abnormal radioactivity occurs in several stratigraphic units, but especially in the Chinle Formation, Shinarump Member in Sections 10 and 11 of T.29.S.R.4.E (Figure 7). Most mines in the park are in the Chinle formation, although the Morrison is a bigger player elsewhere in the broader Colorado Plateau (Burghardt, 1996). The Shinarump member is

[4] Note that "claims" are for federally owned locatable minerals under General Mining Law of 1872 (gold, silver, lead, copper, etc.), "leases" are used to appropriate coal, oil/gas, etc., "sales" are used to appropriate common variety minerals, e.g., sand, gravel and building stone.

[5] Uranium does not occur naturally in its elemental form, hence is not a "mineral."

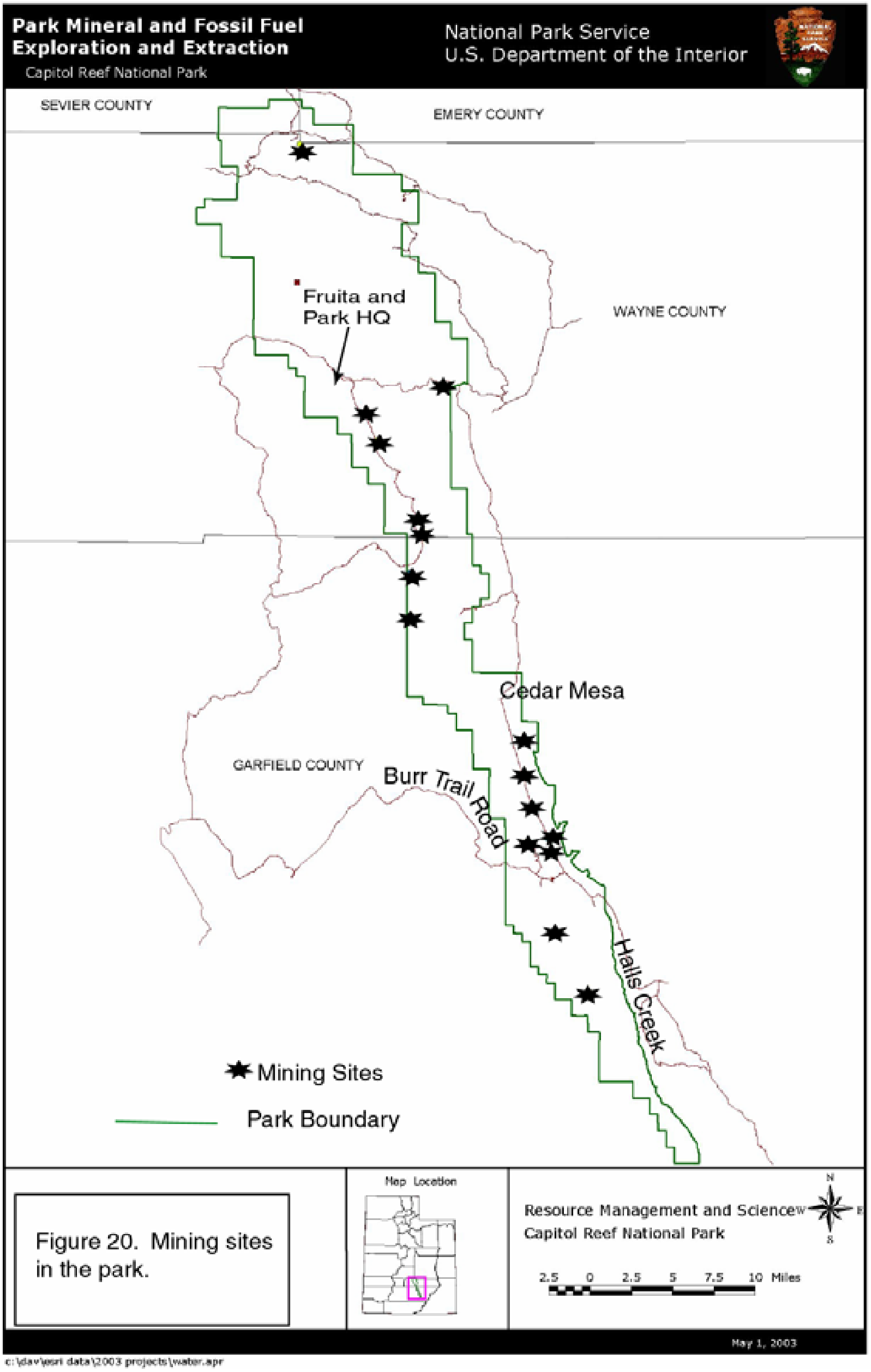


Figure 20. Mining sites in the park.

discontinuous from about 2.5 (4 km) miles northwest of Fruita southeastward along the Waterpocket Fold to Oak Creek and north along Coleman Canyons (Figures 7, 10, and 20).

The Oyler Mine, claimed in 1901, sits at the head of Grand Wash, about 2 miles south of Fruita; it was mined for radium (Table 15). This mine was active during 1901-1937, then reworked in the1950s-60s. It has about 300 ft (91 m) of underground workings, accessed by five portals. In 1967, the NPS attained this mine and fenced off the portals; however, vandalism and human trespass were constant problems and the fences used also largely precluded bats. In 1993, the fences were replaced with heavy steel gates, thereby restoring the valuable bat habitat and successfully precluding human trespass The Rainy Day Mine (Table 15) is situated 4 miles south of the Burr Trail in the Circle Cliffs area (Figure 20), impacting about 100 acres. The Rainy Day was one of the largest mines in the area during the 1950s, probably with the richest deposit. Perhaps 8,000 tons of ore were removed, leaving some of the bigger scars in the park. Rainy Day had great production, drawing from about a mile of underground workings to produce the largest spoil piles around. While the Rainy Day Mine is not as heavily visited as Oyler Mine, it is easily within a one-day round trip hike of the Burr Trail. The Rainy Day mine has extensive underground workings, potential radiation exposure, and an anticipated increase in visitation as development in the south end of the park continues. The mine's twelve openings were backfilled in 1994 to protect visitors and to close off the site. The Duchess mine is more directly in the Waterpocket Fold, and the park anticipates developing Duchess as an interpretive site once its portal is closed. These two mines were excavated into the Shinarump Member of the Chinle Formation (Smith et al, 1963; Frye, 1998).

8.12.2. Mining Issues

Runoff and seepage from abandoned mines and mine wastes inside the park or nearby present a potential threat to park water quality. Abandoned mining roads continue to erode in areas of the park. The Geologic Resources Division (GRD) of the National Park Service has cooperated with the park since the late 1980s on issues related to abandoned mines, questions of restoration, water pollution control, and monitoring. Park stream monitoring in general could help to understand any upstream mining impacts. Monitoring also can be useful to evaluate restoration's effectiveness (Burghardt, J., NPS, pers. comm., 2003; Smith et al, 1963; Frye, 1998; Christiana and Rasmussen, 1991).

Water pollution from abandoned mines poses a potential problem. The GRD has assisted the park by sampling rock in some of the abandoned uranium mines' waste rock dumps and in ephemeral stream beds around several mines in the park. The objectives of the GRD sampling were: a) to determine the analytical concentrations of uranium, uranium decay products, and heavy metals in waste rock piles, surface waters, and downstream sediments through both composite and individual samples; b) to determine the nature and extent of uranium and heavy metal potential migration from sampled waste rock piles into surface waters; c) to determine soil and opportunistic surface waters' pH, soil metal leachability characteristics, soil types (in accordance with USGS soil particulate sizes), and water quality parameters; and d) to evaluate risk impacts to human health and targeted ecological receptors from soils and surface waters.

In their September 2002 sampling, the Geologic Resources Division, Water Resources Division, and Intermountain Region Environmental Management Division of the National Park Service worked with staff from the US Environmental Protection Agency and the

State of Utah to assist the park in sampling waters and soils in the Rainy Day and Duchess mine areas, as well as upstream and downstream from the mines. They searched for any radioactive "hot spots." An ephemeral cattle pond containing frogs was sampled at Rainy Day Mine. Water inside the Rainy Day Mine 1 is now inaccessible due to backfill of the mine portals in 1994, so was not sampled. Water also was sampled inside Duchess mine, which sits on a perched water table and is flooded. A historic mining camp one mile downstream from Duchess Mine was purportedly supported by a spring, but the spring was not running at the time of the sampling event, so no water sample was taken from this location. Sediments from the spoil piles and nearby drainages also were sampled but did not reveal a radioactive contamination problem. [6]

After sampling water from abandoned mining sites in the park, the Geologic Resources Division of the National Park Service summarized the following observations:

- The main wash-outs of spoil material already have occurred since these mines were abandoned about 50 years ago; the remaining piles are stabilized, in fact, armored by a caliche crust that has formed over time. Should the park attempt to move or encapsulate these piles, this caliche crust would be breached and contaminants most likely would re-mobilized into the environment; therefore, it is best to simply leave remote piles in place.
- If this area had not been mined, values in the drainages where the mines are found most likely would exceed "background" levels of contaminants in any event, since the miners obviously targeted mineralized hot spots.
- Levels of contaminants in the ephemeral stream sediments sampled typically dropped to background levels within about 200 meters down-gradient of mine spoil piles, so are not a widespread concern. Note that 10 background samples were taken at the Rainy Day and Duchess sites to show natural variability, in order to draw statistically valid interpretations of the sample data.
- The park should continue to close hazardous mine openings so as to prevent human entry underground. It is good to post sites with a radiation warning sign, prohibiting camping and water use in the area (Burghardt, J., GRD-NPS, pers. comm., 2003).

While the Mining in the Parks Act now protects the park itself, the nearby presence of State of Utah, private, or other lands raises a concern that mining can still occur in a critical location upstream from the park. For example, Pleasant Creek flows through Section 36 (T30S, R6E), which is State of Utah land immediately on the edge of the park. The Pleasant Creek drainage had claims in the past, including 1950s uranium claims, so mining is possible in these areas, albeit unlikely due to weak mineralization and depressed market demand for uraninum.

Other mining activities around the park have included minor-scale copper and lead claims in the early 1900s at Miners Mountain, where tunnels were driven. Limestone quarries have occurred in Grand Wash and Sulphur Creek in the park. In 1970, a controversial flagstone mining operation took place in Section 16 (T29S, R6E) near the Visitor Center, when the section was still State of Utah land.

[6] Note: most of the AML sites are dry, and Geologic Resources Division studies at Capitol Reef and Canyonlands were designed to predict leachability of mine wastes, which is most likely the biggest potential problem. However, based on samples analyzed so far, the GRD or EPA colleagues agreed that leachability is not a major concern.

8.12.3. Oil and Gas

Oil or gas exploration, operations, and production can impact water resources. Oil and gas development can seriously contaminate aquifers and watercourses in or above

the park. Petroleum deposits are generally associated with the geologic formations found in as well as near the park, and although oil exploration began in this area of Utah in the early 1920s, success has been limited. However, newer technologies are now available (e.g., horizontal or directional drilling), and these techniques increase the potential for petroleum development at some point in the future in or near the park. One current oil lease is present within the park boundaries. Many oil leases exist in the park area, mostly in State of Utah land inholdings, but most of these leases have expired.

In some parts of the park, abandoned oil and gas exploration wells have been capped or plugged, however some have caved in. The effect of such abandoned sites on surface or ground waters is basically unknown and not studied**.** The park would like to document those that exist and determine if proper abandonment of the wells is required. This should be done in coordination with petroluem engineers and geologists in the Geological Resources Division.

Oil and gas operations essentially occur in five phases:

- Investigation --with surveys in the field;
- Exploration --with wildcat well drilling, access road construction, use of camps;
- Development --with pipelines, storage tanks, wells, roads, buildings;
- Production --with waste disposal, continued well development; and
- Abandonment --with or without reclamation and well closure, including plugging and capping.

The potential water resource impacts from these five phases includes:

- Erosion, soil compaction, and vegetation loss by roads, other works;
- Surface water pollution by oil, brine, sediment, spills, drilling fluids, fuels;
- Ground water contamination by leaks of various fluids and brine (Vaculik, 1987).

Oil and gas activities adjacent to the park are a concern. During the 1950s, oil exploration test holes were drilled in the Circle Cliffs area in BLM lands just west of the southern end of the park (Figure 1) and around the Pleasant Creek watershed at the western boundary of the park. The area south of Notom was explored as well, but without any significant development (Frye, 1998). Today, the BLM and Forest Service issue oil and gas leases on lands near the park boundary. If leases are developed adjacent to the park, the impacts listed above are possible, and park managers are aware of these potential issues (National Park Service, 1993).

8.12.4. Tar Sands and Halls Creek

Tar sands are another potential source of oil, and large deposits of oil-bearing sandstones occur in the Circle Cliffs area, a few miles southwest of the park. Circle Cliffs is considered a “giant” deposit containing about 1.3 billion barrels of oil (Christiana and Rasmussen, 1989). During the 1960s to 1980s, investors continued to investigate the potential of tar sands development in the area, and in 1984 a proposal for a tar sand project evolved, including the preparation of a BLM Draft Environmental Impact Statement for the project. However, this proposal failed to evolve into operations. The 1984 proposal featured a steep pipeline flowing into the Halls Creek area, so in view of this past proposal, the primary concern of eventual tar sand development would be potential impacts on the Halls Creek drainage. The economics of tar sand development is not sufficiently attractive at this time, but oil prices heavily depend on international affairs. Economics could change one day and revise interest in tar sands (Christiana and Rasmussen,1989; Frye,1998).

8.12.5. Coal in the Park Area

Coal field development probably has the greatest potential to impact air, water, visibility, sound, aesthetics, and other resources in the general park area. Coal extraction to supply a power plant near the park would demand massive volumes of water, requiring damming of the river or very heavy ground-water extractions, or both, threatening park water resources.

In the 1970s, the Intermountain Power Project proposed a coal-burning power plant some 10 miles east of the park, but Clean Air Act requests prevented this project in such close proximity to the park (Frye, 1998). In the 1980s, the BLM also reviewed a proposal to mine in this area (see further description of this in Section 6.3.3).

8.12.6. Recommendations

BASELINE INFORMATION: In light of possible mineral and other extractive development in the future, the park needs baseline water quality information for streams that are potentially threatened. A number of tributaries need at least a periodic assessment of their water quality, and from a minerals or oil perspective, monitoring of Halls, Pleasant, and Oak creeks would be valuable.

MONITORING: At mining sites where restoration work occurs monitoring could assess the effectiveness of the restoration. A design for minerals development monitoring could be incorporated in the Vital Signs project to develop a park natural resources monitoring design.

Assessment or follow-up monitoring may be needed at some abandoned mines and oil exploration wells, for example at mining sites with elevated radioactivity or at oil exploration areas in need of reclamation. Monitoring could determine if radioactive waters, other pollutants, or sediment are affecting streams, springs, or other water features.

CRITICAL LIAISON: Continued close cooperation with the Bureau of Land Management, Forest Service, and State of Utah will be important regarding possible oil, gas, or tar sands development. Information may appear in environmental assessments, planning work, monitoring designs, or other activities that these agencies may have underway or planned.

8.13. Exotics Species along Riparian Corridors

Throughout the western United States, several exotic plant species dominate riparian areas. The two species of greatest concern in Capitol Reef National Park are tamarisk (*Tamarix ramosissima*) and Russian-olive (*Elaeagunus angustifolia*). The intent of the park is to maintain natural functioning riparian systems with their native flora. Tamarisk and Russian-olive outcompete native vegetation, consume large quantities of water, create saline soils in the case of tamarisk, and generally reduce habitat suitability for wildlife. Maintenance of the native riparian community requires active management of invasive species. The Russian-olive is of particular concern in the park, since eradication of tamarisk has been underway for some time. The Russian-olive now represents another threat to natural plant communities and efforts to eradicate it are required.

Tamarisk is a relatively long-lived plant that can tolerate a wide range of environmental conditions, particularly inundation and drought, once established (Stevens and Waring, 1988). It can replace or displace native woody species, such as cottonwood and willow, which occupy similar habitats, especially when timing and amount of peak water discharge, salinity, temperature, and substrate texture have been altered by human activities (www.tncweeds.ucdavis.edu/esadocs/documnts/tamaram.html).

The Russian-olive is a small thorny tree that appears to be colonizing the Fremont River corridor and, like tamarisk, outcompeting native species such as willows and perhaps the Fremont cottonwood. Russian-olive interferes with natural plant succession and nutrient cycling, and taxes water reserves (www.nps.gov/plants/alien/fact/elan1.htm).

Efforts to eradicate these species must take into account concerns regarding methods, particularly if they include use of herbicides. Garlon 4 appears to be the most effective means of controlling tamarisk after they have been mechanically removed. Other parks, using repeated applications, have sprayed Garlon 4 on the remaining stumps. If spraying occurs near water sources and for these two species it does, care must be taken to avoid contamination of the water sources. The chemical name for Garlon 4 is [(3,5,6-trichloro-2-pyridinyl) Oxy]acetic acid and has limited solubility in water and does not degrade easily. It is similar to 2,4-D and referred to as triclopyr (Hultquist, A., Utah Dept. of Environmental Quality, pers. comm., 1998). The CAS # for triclopyr is 55335-06-3.

Effective mechanical means of eliminating Russian-olive include mowing hedges with a brush type mower, followed by removal of cut material. Herbivorous animals are not known to feed on it and few insects seem to utilize or bother it. Canker disease is occasionally a problem but not enough to be useful as a control agent (< www.nps.gov/plants/alien/ fact/elan1.htm >).

Since colonization by these species is rapid in suitable areas, it is also important for the park to understand occurrences on adjacent lands. The Teasdale District of the USDA Forest Service is a weed free district, a status which the Forest Service wishes to maintain, yet they do see some tamarisk and Russian-olive leading to and in drainages of the park. The Loa District does not have a noxious weed problem, but does see some tamarisk and Russian-olive evasion. They do not see it as a problem.

To address the desire to control tamarisk and Russian-olive, the park needs to obtain any mapping that adjacent agencies have collected. The park would complement their own mapping effort with this information. Areas of concentration would include Sulphur Creek, Halls Creek, Fremont River and, Spring Creek Canyon, and other major riparian areas including impoundment areas. The park has mapped Russian-olive and tamarisk along the Fremont River. Project Statement # 9.9 of this plan is a proposal to inventory and control these two species.

8.14. Abandoned Roads

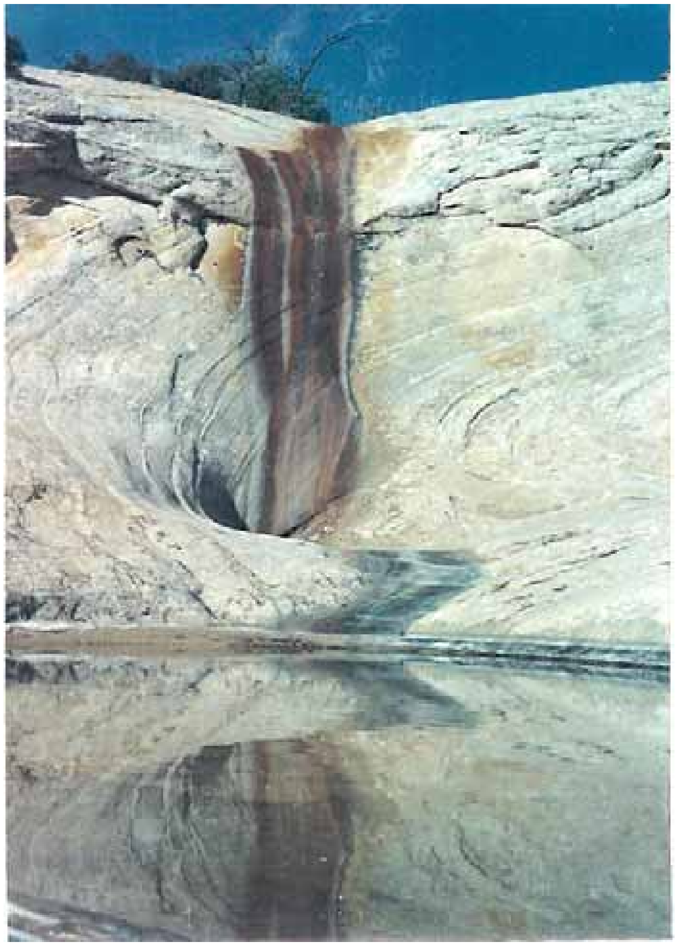
Uranium mining existed in the Capitol Reef National Park area as far back as the early 1900s. During the 1950s boom, when Capitol Reef was a National Monument and still legally open to mining, over 10,000 claims were filed. The abandoned mining roads from a half century ago are still an issue in parts of the park, especially along the park's western boundary. Erosion heals very slowly in arid lands. The old roads collect overland flow from intense thunderstorms to make gullies, produce sediment, and destroy vegetation. A gully can drain ground water, which endangers springs or seeps. Trespassing all-terrain vehicles also stimulate erosion by tracking on the old roads and spoil piles and by cutting tread marks into slopes. Erosion of exposed soils by wind and water depletes nutrients, harms soil microbiota, and invites encroachment of invasive plants. This report offers project statement #9.11. for a project to rehabilitate areas in the park affected by old mining roads.

8.15. Restoration of Disturbed Piñon-Juniper Watersheds in the Park

Overgrazing many decades ago decreased the grass cover and encouraged an increase of piñon-juniper tree density. Over-dense piñon-juniper woodlands take up root space and inhibit grass and shrub re-growth; then accelerated erosion occurs in the bare soils between the trees. In the 1950 and 1960s the Bureau of Land Management conducted erosion control work along the southwestern boundary of the park by removing piñon and juniper trees by tractors and chaining, installing infiltration terraces and check dams, and seeding the area with grasses and forbs. Some of these old areas are now within the park. Their watershed treatments were partially successful, but in places the planted/seeded shrubs and grasses failed, allowing the piñon-juniper stands to return, and in some cases, hillside contours failed and the contours became diversions to concentrate runoff and initiate gullies. Either the BLM was not able to adequately maintain the work or the seeding was simply attempted in a difficult droughty period. Some larger arroyos have formed in the area, and flashfloods now present a hazard. For the most part the erosion problem has gone untreated. Further intervention will be needed to reverse the erosion. This plan includes project statement # 9.12 for a project on watershed restoration in the areas affected.

8.16. Maintenance of Contacts with other Agencies

From a water resources perspective, cooperation with nearby agencies is vital in order to conduct park management. The Fremont River flows into the park from Bureau of Land Management areas, and park tributary streams nearly all originate in Forest Service lands. Other agencies take the lead or have programs on water resource topics important to the park; for example, BLM has the lead on investigating Wild and Scenic River designation for the Fremont River; the State of Utah coordinates water rights and also is the main cooperator on water quality monitoring; the Forest Service monitors creeks flowing into the park and allocates grazing for cattle that trail in and out of the park; many agencies are involved in water quality concerns and watershed management in the Fremont River watershed upstream from the park. The key agencies in the area and contacts made in the preparation of this plan appear in Section 11.



9. PROJECT STATEMENTS

Project Statement 9.1. Restoration of Impoundments within Capitol Reef National Park

PMIS Number: 100804

Background

In the past, hundreds of created impoundments on small drainages in the park have stored water for livestock and wildlife. In addition, these drainages were dammed in an attempt to reduce erosion. These impoundments dam even the smallest drainage. With only 2 permittees, 1141 AUMs (animal unit months) in the Hartnet (Cathedral District) and 400 AUMs in the Waterpocket District, the need for such a network is minimized. Also the efficacy of these impoundments as sediment traps is questionable. Removal of these impoundments in the Cathedral and Waterpocket districts of the park is desirable.

These impoundments do serve other wildlife species and can provide water to horseback riders where they are permitted. However, these impoundments are not natural landscape features and impede flow. They can in some cases reduce movement of sediment downstream; however, the silt detained behind the small earthen dams has aggraded and only provides an excellent site for growth of exotic plant species.

Further, the impoundments reduce and at many times eliminate the flow of water immediately downstream of the dams. Ultimately, water that may have flowed downstream in larger drainages does not, and consequently the lower drainages are dry. Additionally, the impoundments are suitable sites for establishment of exotics like saltcedar and Russian-olive. The park continues to eradicate these species, and by remediating these sites, the park intends to reduce the establishment and spread of exotic plant species.

Bitter Creek Reservoir, constructed in the 1950s, is the largest impoundment in the park. Located in the Waterpocket District, it supports high bird densities, amphibians, tadpole shrimp, bison, and other wildlife.

Several check dams in Capitol Gorge represent features associated with the Capitol Gorge Road. These features will be surveyed as part of a cultural landscape inventory. They are not to be removed since they comprise historical features of the landscape.

Remediation of these impoundments includes 1) inventory and mapping of the impoundments in the Cathedral and Waterpocket districts, 2) data collection regarding presence of exotic plant species, drainage characteristics, and size, 3) systematic inventory of cultural resources at each impoundment, 4) development of a decision matrix guiding which are priority impoundments, 5) development of an Environmental Assessment, and 6) report documenting how impoundments will be removed including deposition and/or use of excavated material.

Description of Recommended Project or Activity

The park requests:

- Inventory of the impoundments using aerial photography and digital orthophoto quadrangles (DOQ), The park has the DOQs, but would have to obtain the aerial photography, the latter of which can be used for inventory of wetlands, riparian areas, tinajas, and other water sources. The first level of inventory will require aerial photo interpretation to identify impoundments. The second level of inventory will require site visits and geographical positioning system (GPS) surveying of the impoundments, documenting size, presence of exotics, and other features.
- Design of a systematic program to assess and select impoundments for restoration based on presence of 1) exotic plant species, 2) cultural resources, and 3) drainage characteristics and size. During field visits, presence of plant species, drainage characteristics and presence of cultural resources will be documented and entered into a GIS database along with the location coordinates.
- Preparation of an Environmental Assessment.

- Documentation of how impoundments will be removed including 1) quantities of materials removed and location and or use of excavated material, 2) labor and equipment requirements and costs to complete work, and 3) revegetation and labor costs to remediate sites.

Relation to other Project Statements: This project would relate generally to the project statements on wetland delineation (#9.10), riparian inventory (#9.2), and exotic plants (#9.9), but is not dependent on those projects. This work could be done in the park by park personnel, but some aspects could be contracted.

Proposed Budget

Biological Technicians, 2 for 1 season	$15,000
Cultural Resource Technician, 2 for 1 season	$15,000
GIS Personnel	$ 6,000
Aerial photography, 1:24000 Color IR	$10,500
Environmental Assessment	$25,000
Impoundment Removal Plan and Cost Estimate Report	$15,000
TOTAL	$86,500

Project Statement 9.2. Riparian and Aquatic Habitat Inventory and Assessment at Capitol Reef National Park

PMIS Number: 100805

Background

According to The Nature Conservancy, the Fremont River Gorge, on the western edge of the park, contains some of the finest examples of intact riparian vegetation in the states of Utah and Colorado. Several of the river's tributaries also contain excellent examples of riparian ecosystems, including Sulphur, Oak, Pleasant, and Halls creeks, which are the four perennial tributaries of the park. Although riparian habitats along the watercourses of Capitol Reef National Park represent less than one percent of the park's surface area, these habitats are critical for wildlife, containing the greatest diversity of flora and fauna in the area. Many protected plant species occur in riparian areas (Frye, 1998; National Park Service, 1993; BLM online, 2003; Van Pelt *et al.*, 1991; Heil *et al.*,1993; Auble *et al.*, 2003).

Riparian zones in an arid park attract wildlife, birds, cattle, and visitors, so are naturally more susceptible to impacts. For example, heavy cattle grazing eliminated most cottonwoods along the Fremont River at one time. In addition, land use upstream from the park affects streamflows and water quality, impacting park riparian zones with pollutants, sediment, or artificial fluctuations of flow, especially along the larger streams.

Unfortunately, information on the park's riparian ecosystems is limited and fragmented, and little data exist for most of the habitats. The lack of information makes it difficult or impossible to assess impacts or to develop mitigation to protect riparian areas. A synoptic survey, followed by periodic monitoring to observe impacts, changes, and trends, would identify the need for any protective actions.

Description of Recommended Project or Activity

The park proposes a project to survey and inventory the riparian areas within Capitol Reef National Park. The project would:

- Define the extent, distribution, and characteristics of riparian zones within the park, with focus first on high priority stream reaches, especially areas subject to impacts. A contractor would work with park natural resource specialists to select the areas of focus.[7]

- Place the field data into a database and GIS format to quantify the riparian areas on a reach-by-reach basis by channel condition, geomorphic type, the vegetative cover, and proper functioning condition; and

- Enter the data into software designed to facilitate follow-up monitoring to evaluate trends or identify impacts on the riparian habitats.

A contract field crew would work with park natural resource staff. Park staff also would supply aerial photographs, database information, maps, advice on vegetative lists, some suggestions on reach selection, advice on logistics/access information, help on selection of priorities, linkages with the park's GIS and GPS databases, and other cooperation. Aerial photography (color IR at a scale of 1:24,000) would show the main riparian areas and serve as the base to plan and prioritize the work. [8]

The project would use the following procedure:

- Field inventories would be conducted along riparian reaches (a "reach" being a stretch of similar riparian habitat along a stream, selected from the air photos originally and adjusted in the field). A reach could be several hundred meters long, but generally only 15-25 meters wide, given the topography in the area. Within a reach the crew would gather individual measurement point observations plus more details at one of the points, as described below. The number of points would depend on habitat variability and size of the reach.

- At each of the measurement points along a reach, the field crew would: (1) take a GPS reading; (2) measure the riparian area width (to GPS or optical distance measurement accuracy); and (3) check off a riparian checklist of the principal vegetative community type observed. [9]

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[7] The project could be contracted entirely or park staff (or seasonals) could provide part of the necessary staffing and expertise. The project proposed here also could proceed in tandem with the wetland and the spring/seep inventories proposed for the park.

[8] Cost of aerial photos recommended for several projects proposed for the park, including this one, could be shared among projects.

[9]The basic vegetative communities can be based on: work done in the Fremont River Gorge by Van Pelt *et al.* (1991) for The Nature Conservancy; on the vegetation surveys by Heil *et al.* (1993) in the park; on observations along the river by USGS-BRD; on the riparian surveys in the Dixie National Forest upstream; and from park information on the NP-Flora database; or on a modified approach reflecting two or more of these projects. Heil *et al.* (1993) surveyed the vegetation of the park and identified 34 plant community

- At one measurement point within each reach (one that typifies the reach) more details would be gathered to: (1) check off all the vegetative species observed within a fixed radius around the point (using a prepared checklist to facilitate this work); (2) make a depth-width measurement estimate of the cross-section (tape and hand level accuracy); (3) assign a "proper functioning conditioning" estimate of "functional; functional at risk; non-functional" to the channel (Prichard, 1998); (4) assign a Rosgen geomorphologic description A-G to the channel (Rosgen, 1996); (5) generally describe the geomorphic condition (agrading, degrading, meanders, etc); (6) note any impacts (e.g., erosion, sediment, exotics, etc); (7) describe the general soil type and geologic substratum; (8) photograph the vegetation, the channel, and any impacts observed in the reach; and (9) set a marker to facilitate follow-up visits.

- Use pre-designed data formats and checklists to facilitate entry of field data so the contractor could work in conjunction with park staff to enter the data into park databases, including GIS.

The project would produce a summary report of species and communities found, an overview of the hydrologic conditions, and provide ArcView-based maps of the vegetative communities and their areas.

Literature Cited

Auble, G.T., M.L. Scott, and J.M. Friedman. 2003. (draft) Wetland and Riparian Vegetation in Relation to a Transverse Hydrologic Gradient along the Fremont River, Utah. Draft by United States Geological Survey, BRD, Fort Collins, Colorado. 28 pp.

Dixie NF. 1994. Dixie National Forest level II riparian inventory: Pleasant Creek. Internal summary report. Escalante, UT. 52 pp + appendix data.

Frye, Bradford J. 1998. From barrier to crossroads: An administrative history of Capitol Reef National Park, Utah. Cultural Resources Selections. Intermountain Region, National Park Service. Vols. I & II. 638 pp.

Heil, K.D., J.M. Porter, R. Fleming, and W.H. Romme. 1993. Vascular flora and vegetation of Capitol Reef National Park, Utah. Technical Report NPS/NAUCARE/NRTR-93/01. Cooperative Park Studies of NAU. Flagstaff. 82 pp.

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types, where a community was defined as a more or less unique and repeated assemblage of plant species occupying sites characterized by a more or less unique combination of elevation and soil texture conditions. They named the natural riparian/wetlands communities: 1. cottonwood-rabbitbrush; 2. waterpocket; 3. cottonwood-willow; 4. alder-birch; 5. dogwood-spruce; 6. hanging garden; 7. hornbeam-box elder-oak; and 8. perennial wetlands (van Pelt et al, 1991; Dixie NF, 1994; pers. com., M. Scott, USGS-BRD, 2003; Heil et al, 1993). Auble et al, 2003 also sampled vegetation along the Fremont River and have a plant list.

National Park Service. 1993. Final resources management plan, Capitol Reef National Park. Torrey, UT. 17pp + ca. 100 pp attachments.

Prichard, Don. 1998. Riparian area management: a user guide to assessing proper functioning condition and the supporting science for lotic areas. Tech Ref 1737-15. Bureau of Land Management. Denver. 126 pp.

Rosgen, Dave. 1996. Applied river morphology. Wildland Hydrology. Pagosa Springs, CO. 377pp.

Van Pelt, N.S., C.D. Schelz, J.S. Tuhy, and J.R. Spence. 1991. Community site descriptions and unit analyses, BRCA, CARE, CEBR, and ZION. (extracts from) Coop agreement with The Nature Conservancy to survey relict plant communities in the Colorado Plateau. NPS. Rocky Mt Regional Office. Lakewood, CO. 154 pp.

Relation to other Project Statements: This project would relate generally to the project statements on wetland delineation (#9.10) and the inventory of springs (#9.4) and tinajas (#9.3), but is not dependent on those projects. All the projects would be complementary. Some of this work could be done in the park by park personnel, but more likely contracting would be needed.

Proposed Budget

Field survey and mapping: 50 days X 2 techs @ $150/day	$ 15,000
Senior coordination: 15 days at @ $280/day	$ 4,200
Data analysis/entry into GIS & maps $150/10 days + $280/5 days	$ 2,900
Report, map, interpretation preparation 20 days @ $280/day	$ 5,600
Software, disks, other computer supplies	$ 800
Vehicles mileage 4000 miles @ .35/mile	$ 1,400
Per diem	$ 3,000
Misc. field/office supplies, telephones	$ 1,500
Maintenance, updating, or servicing of GPS unit for the park	$ 1,500
Aerial photos, digital photo memory cards, batteries	$ 1,500
Subtotal	$ 37,400
Overhead @ 15%	$ 5,610
TOTAL	$ 43,010

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection
Assistance on GIS for entering field data into ArcView format

Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.3. Inventory of Tinajas North of Burr Trail in Capitol Reef National Park

PMIS Number: 100806

<u>Background</u>

Tinajas are depressions in the bedrock along streams or arroyos that catch and hold water. They range from small ephemeral pools (or potholes) to larger, perennial ponds. Capitol Reef National Park contains hundreds of tinajas eroded out of the park's Navajo Sandstone formations. Water is of course a critical and limited resource in a desert, and the tinajas collectively represent the greatest and most widespread source of surface water in the park, and are therefore a vital resource for the wildlife, vegetation, and aquatic life (Berghoff, 1995b; Spence and Henderson, 1993; Harris and Tuttle, 1992). In view of the ecological importance of tinajas, the park must protect and manage this unique resource.

Park managers lack the basic information needed to manage tinajas in much of the park. In the early 1990s, park resource managers surveyed the tinajas in the southern third of the park and produced a valuable map and report describing these resources. Much also has been learned about tinajas as special ecosystems, and their importance has been illuminated by scientific studies in the park (Haefner and Lindahl,1988; Lafrancois, 1995). However, little is known about tinajas in the northern two-thirds of the park, and this is a major knowledge gap for managers. The type of survey conducted for the southern third of the park could be duplicated in the north, and would be a valuable and feasible project.

The park would like to learn about:

- the extent and location of all tinajas;
- the water chemistry of the pools (as indicator of geochemistry as well as detection of any pollution);
- the vegetation associations and species (including any new information on species or identification of any threatened and endangered species);
- the amphibians, macroinvertebrates, or other smaller fauna found;
- tinajas' use by mammals and birds;
- geologic or soil characteristics around tinajas; and
- evidence of impacts.

<u>Description of Recommended Project or Activity</u>

The park proposes to conduct a survey of tinajas in the northern two-thirds of Capitol Reef National Park, along the eastern slopes of the Waterpocket Fold area of the park. The proposed survey would essentially duplicate the successful techniques employed in the southern part of the park several years ago.

A field crew would survey each stream and arroyo upstream from their lower (east) ends, conducting the following measurements and observations:

- Mark each tinaja on the appropriate U.S. Geological Survey 7.5 minute topographic map and record the UTM coordinates (or tinajas circumference if larger) with a Global Positioning System unit, confirming that the UTM and map readings correspond.
- Photograph each tinaja to illustrate the size, shape, depth, and surroundings.
- Measure the length, width, depth (current depth plus apparent maximum possible), and make a sketch map.
- Record the percent of the surrounding slopes and degree of shading.
- Sample the water for pH, specific conductivity, and color.
- Observe any signs of impacts and use.
- Describe accessibility and the distance to trailheads or other features.
- Check off vegetative species found on a checklist.
- Collect a sample of the macroinvetebrates (for identification later); record any tadpoles or other amphibians seen.

The project would produce a GIS map of the tinajas accompanied by a directory of the tinajas, plus a final report. The directory would list each tinaja surveyed by watershed/sub-watershed, with details on the above bulleted items plus additional calculations on the volume of the maximum water pool. The final report would summarize the findings of the study, discuss the items bulleted above, with interpretation of such factors as:

- Size, shape, shading and other physical features and the correlation with the flora and fauna;
- Discussion of any impacts observed and the relationship to animals, distance to trailheads, or other explanations of the impacts;
- Discussion of the vegetation associations and fauna observed and their relation to the tinajas' physical features (continue with the system Berghoff (1995) used in the park's earlier work); and
- Summary and discussion of the water quality as related to the geology, physical features, impacts, or other factors.

Literature Cited

Auble, G.T., M.L. Scott, and J.M. Friedman. 2003. (draft) Wetland and Riparian Vegetation in Relation to a Transverse Hydrologic Gradient along the Fremont River, Utah. Draft by United States Geological Survey, BRD, Fort Collins, Colorado. 28 pp. (provides list of vegetation).

Berghoff, Kevin. 1995. Resource Management and Science Division, Capitol Reef National Park. Capitol Reef National Park tinaja wetland survey - summary report. 1995(t) Apr120 p.

Harris, Ann G., and Esther Tuttle. 1992. Capitol Reef National Park. pp 56-67 In Geology of national parks: Fourth Ed. Kendall/Hunt Publ. Co. Dubuque, Iowa. 652 pp.

Haefner, James W. and Lindahl, Alice M. 1988. The ecology of small pools in Capitol Reef National Park, Utah: Final report for phase 1. (Utah State University, Department of Biology, Logan, UT). 1988 Sep 15; USDI/NPS Contract No. PX-1350-7-0259. 70 p.

Lafrancois, Toben. 1995. Biology and ecology of rock pools in Capitol Reef National Park, Utah. MS Thesis, Colorado State University. Fort Collins. 64 pp.

Spence, John R. and Norman R. Henderson. 1993. Tinaja and hanging garden vegetation of Capitol Reef National Park, southern Utah, USA. Jour of Arid Environments 1993(24):21-36.

Relation to other Project Statements: This project would relate generally to the project statements on spring inventory (#9.4) and riparian inventory (#9.2), but is not dependent on those projects. It would also relate to the wetland inventory and assessment project (#9.10). Some of this work could be done in the park by park personnel, but probably some contracting would be needed.

Proposed Budget

Field survey and mapping: 75 days of (2) field techs @ $150/day each	$ 22,500
Senior field oversight 25 days at @ $280/day	$ 7,000[10]
Tech data analysis/entry 10 days @ $150/day	$ 1,500
Senior data oversight 5 days @ $280/day (park in-kind contribution)	$ (NPS)
Report and map preparation 10 days @ $280/day	$ 2,800
Software, disks, other computer supplies	$ 800
Vehicles mileage 6000 miles @ .35/mile	$ 2,100
Per diem	$ 5,000
Misc field/office supplies, telephones	$ 1,500
Maintenance, updating, or servicing of GPS unit for the park	$ 2,000
Aerial photos, digital photo memory cards, batteries	$ 3,500
Macroinvertebrate analyses	$ 4,500
Subtotal	$53,200
Overhead @ 15%	$ 7,980
TOTAL	$61,180

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection

[10] Park natural resource staff also would play some supervisory role as well.

Assistance on GIS for entering field data into ArcView format
Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.4. Inventory of Springs in the Southern Area of the Park

PMIS Number: 100807

Background

The sandstone formations under Capitol Reef National Park are remarkable in their ability to absorb precipitation, percolate it along a stratum, and feed it into springs. For this reason, Capitol Reef National Park has many more springs and seeps than one might expect in a desert. These water features are essential elements to consider in the management of wildlife, water resources, and backcountry recreation and to plan the protection of riparian or wetland areas. In an arid park with few perennial streams, wildlife depend on springs and seeps for their survival, and also visit riparian or wetland areas around springs or seeps to seek nutrition, nesting, or shade. The vegetation of these small wet areas comprises an important segment of the natural ecology of the park; in fact, some species of plants and animals exist only in these special sites or along streams. Hikers are attracted to springs for the bird and wildlife viewing or in cases for backcountry water supply (National Park Service,1993; Huntoon, 1978; Smith et al, 1963).

Despite the special importance of springs and seeps, park managers have a limited knowledge of the location and characteristics of these water features. Some larger springs appear on maps or in other documents or may be listed in water rights records; however, the information is incomplete and sometimes approximate, and many smaller springs are not included. Little descriptive information is available about flow rates, chemistry, surrounding vegetation, or other characteristics of the springs and seeps. The park therefore needs a map plus descriptions of its springs and seeps. Characterizing springs in terms of their geologic setting, geochemistry, and flows also would help the park better understand ground-water movement.[11]

Description of Recommended Project or Activity

The park proposes to prepare a map plus descriptive manual of the springs and seeps in Capitol Reef National Park. The manual, organized by watershed and sub-watershed, would provide details on the information list below:

- site number (and name, if one exists) of the spring or seep;
- coordinates and UTM numbers for the site;
- a description of how to access the site;
- a description of the size and configuration of the spring or seep;

[11] Note that either this project or the ones proposed to inventory riparian areas or wetland areas in the park could also survey the few hanging gardens found in the park (mainly the Halls Creek area).

- a description of the geology (sandstone name, other geologic notes) in which the spring/seep is found;
- a description of any aquatic organisms observed (principally macroinvertebrates and amphibians);
- an estimation of the likely permanence of the flow (based on aquatic flora/fauna or other evidence);
- a general photograph of the area, plus photographs of any evident impacts;
- a summary of the spring/seep's general chemistry;
- an instantaneous measurement of flow and a rough estimate of likely maximum flow;
- a list of the major vascular plants around the spring/seep; and
- remarks on the evidence of birds, wildlife, or livestock use;
- remarks on the evidence of any impacts;
- any notes on history associated with the spring or water rights claims.

The project would carry out the following steps:

DESIGN AND PLAN:

- Analyze the spring inventory protocols of the Northern Colorado Plateau Network effort, and other protocols in the arid Southwest and West with ongoing or recent spring inventory and monitoring programs (this includes Big Bend NP, Glen Canyon NRA, and possibly Grand Canyon NP, and Mojave NP). Develop a Capitol Reef protocol that is as consistent and interchangeable as possible with these other parks, taking advantage of their software, written protocols, materials, or experiences wherever feasible.
- Assemble and review existing maps, geographic information databases, references, history notes, water rights lists, earlier surveys, aerial photographs, or other information on springs and seeps in the park and immediate surrounding area, using the 1:24,000 color IR aerial photographs also proposed for park riparian and wetlands surveys.
- Compare the maps, photos, and data to identify the location of as many of these water features as possible and plot them temporarily on a field working map.
- Coordinate with the natural resource staff (e.g., the range conservationist) and other staff who know the area well; interview local long-term residents to add other springs/seeps to the master working map or help interpret air photos.
- Working with the park natural resources staff, prioritize site visits and access procedures.
- Arrange for analysis of the chemical samples with a university or the State DEQ laboratory for analyses of parameters indicative of basic water quality and geology (Ca, Mg, Na, K, sulfate, carbonate/bicarbonate, phosphate, and chloride, plus on-site measurements of pH, conductivity, and temperature, with the final suite to be arranged with the laboratory). Some larger springs would be analyzed for metals.
- Agree with park natural resource staff on procedures for entering the field survey information into the park's GIS system for mapping (using park software to transfer the GPS to ArcView format).

FIELD DATA COLLECTION AND REPORTING:

- In the field, visit each spring or seep with global positioning system/compass, air photos, maps, sampling bottles, gear to estimate flows, flora/fauna/bird checklists, aquatic fauna sampling gear, digital camera, pH/conductivity meters, field forms, and other measurement tools to collect the information in the “information list” set of bullets above. Information would be digitized in the field where possible but otherwise compiled weekly into digital form.
- Produce a final report to show the spring/seep sites on a GIS-ArcView map (as part of the park’s GIS system). Produce an accompanying manual to list and discuss the items in the “information list” set of bullets above.

The basic budget needs are for a survey team (probably 2 persons); some GIS specialist’s time, GPS equipment, travel, digital cameral, analysis of water samples, and access to GIS for downloading in the park. A member of the field survey crew or a cooperator will need expertise in identification to the lowest taxa of macroinvertebrates and amphibians and a member will need ability to identify the vascular plants (Heil et al, 1993; Auble *et al.*, 2003).

Literature Cited

Auble, G.T., M.L. Scott, and J.M. Friedman. 2003. (draft) Wetland and Riparian Vegetation in Relation to a Transverse Hydrologic Gradient along the Fremont River, Utah. Draft by United States Geological Survey, BRD, Fort Collins, Colorado. 28 pp.

Heil, K.D., J.M. Porter, R. Fleming, and W.H. Romme. 1993. Vascular flora and vegetation of Capitol Reef National Park, Utah. Technical Report NPS/NAUCARE/NRTR-93/01. Cooperative Park Studies of NAU. Flagstaff. 82 pp.

Huntoon, Peter Wesley, 1978. Ground water test drilling sites in the Hartnet, Fremont River, and Hall Creek areas. University of Wyoming, Wyoming Water Resources Research Institute, Laramie, WY. Capitol Reef National Park, Utah. 17 pp.

National Park Service. 1993. Final resources management plan, Capitol Reef National Park. Torrey, UT. 17pp + ca. 100 pp attachments.

Smith, J.F. Jr, L.C. Huff, E.N. Hinrichs, and R.G. Luedke. 1963. Geology of the Capitol Reef area, Wayne and Garfield Counties, Utah. U.S. Geological Survey Professional Paper 363. Washington. 102 pp.

Relation to other Project Statements: This project relates to the project statement on hydrogeological study of the park (#9.8), and this project might logically precede the hydrogeological study and provide useful background information. Some of this work could be done in the park by park personnel, but probably contracting would be needed. This project also relates to the wetlands inventory (#9.10).

Proposed Budget

Field survey and mapping: 75 days X 2 techs @ $150/day	$ 22,500
Senior coordination: 25 days at @ $280/day	$ 7,000
Data analysis/entry into GIS & maps $150/10 days + $280/5 days	$ 2,900
Park's in-kind oversight 5 days	$ (NPS)
Report and map preparation 15 days @ $280/day	$ 4,200
Software, disks, other computer supplies	$ 1,800
Vehicles mileage 6000 miles @ .35/mile	$ 2,100
Per diem	$ 6,000
Misc field/office supplies, telephones	$ 2,500
Maintenance, updating, or servicing of GPS unit for the park	$ 2,500
Aerial photos, digital photo memory cards, batteries	$ 2,000
Chemical analyses 100 X $250	$ 8,500[12]
Macroinvertebrate analyses	$ 5,500
Subtotal	$ 67,500
Overhead @ 15%	$ 10,125
TOTAL	$ 77,625

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection
Assistance on GIS for entering field data into ArcView format
Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.5. Determine Impacts of Nutrient, Sediment, and Toxic Contaminant Inputs into the Fremont River

PMIS Number: 100808

Background

The Fremont River is the largest perennial stream in Capitol Reef National Park. Mean annual discharge at upstream and downstream gages ranges between 60 and 130 cubic feet per second (cfs). These flows have supported the fruit orchards that make the Fremont River District so intriguing, and the wildlife and flora important to the functioning of a vital riparian ecosystem. The park has also derived its drinking water from the Fremont River. Attaining and maintaining good water quality in the Fremont River ensures that the above benefits of the Fremont are achieved and that the spirit of the Clean Water Act is attained.

[12] May be able to obtain some State of Utah cooperation to reduce this cost.

The Utah Department of Environmental Quality assigns designated beneficial uses to the waters in the State of Utah (see table below). The Fremont River's designated uses within the park are for domestic purposes, agriculture, secondary recreational contact and as a cold water fishery (Utah Department of Environmental Quality, 1997). As a

Designated use classification for the Fremont River and tributaries.

Designated Use Classifications for Capitol Reef National Park		
Water Bodies	**Stream Segments Classification [a]**	**Designation**
Tributaries in North District which flow into Fremont R. east of park	Fremont River and tributaries from the confluence with Muddy Creek to Capitol Reef	2B 3C 4
Fremont River and its tributaries in the park	Fremont River and tributaries through Capitol Reef to headwaters	1C 2B 3A 4
Pleasant Creek and its tributaries in the park	Pleasant Creek and tributaries from east boundary of Capitol Reef to headwaters	1C 2B 3A
Tributaries in park which flow to Pleasant Creek east of park	Pleasant Creek and tributaries from confluence with Fremont River to east Boundary of Capitol Reef	2B 3C
Halls Creek	All tributaries to Lake Powell except as listed separately	2B 3B 4
Moody Creek and other small tributaries in southwestern margin of park	Escalante River and tributaries from Lake Powell to confluence with Boulder Creek	2B 3C

[a]1C - Protected for domestic purposes with prior treatment by treatment processes as required by the Utah Department of Health ; 2B - Protected for secondary contact recreation such as boating, wading, or similar uses; 3A – Protected for cold water species of game fish and other cold water aquatic life, including necessary aquatic organisms in their food chain; 3B- Protected for warm water species of game fish and other warm water aquatic life, including the necessary aquatic organisms in their food chain; 3C- Protected for non-game fish and other aquatic life, including the necessary aquatic organisms in their food chain; 4 - Protected for agricultural use including irrigation of crops and live stock watering.

cold water fishery, the water temperature should not be above 68^{o}F (20^{o}C), nor should the average dissolved oxygen level fall below the range of 5 to 9.5 mg/L based on a 7 day average. The State of Utah also has guidelines for total phosphorus, with anything above 0.05 mg/L being an indicator of polluted conditions. Another guideline suggests that total suspended solids greater than 35 mg/L are a problem for cold water aquatic life.

From a geological and ecological standpoint, natural transitions occur between the headwaters of the river to the lower elevations of park. Recognizable changes in the river relate to gradient changes, streambed and sediment load, and accordingly the riparian vegetation. The application of use designations to segments does not always correspond with the natural transitions. As such, the Fremont River Gorge in the park may naturally have different water quality than that which is near the eastern boundary of the park.

Although a tremendous amount of water quality work has occurred within the Fremont River drainage (Envirosphere, 1981; National Park Service, 1990 and 1994), not much is known about background water quality, because land uses such as agriculture have always been a complicating factor. The park understands there are problems, but does not understand the extent and to what degree the park can play a role in rectifying issues. The Fremont River upstream and downstream of the park has been listed as a 303(d) water for dissolved oxygen, total phosphorus, and total dissolved solids. The listing stems from requirements of the Clean Water Act and the Environmental Protection Agency's Water Planning and Management Regulations (40 CFS Part 130) that require states to report water bodies which do not meet water quality standards for their designated beneficial uses. A total maximum daily load (TMDL) program developed by the Fremont River Advisory and Technical groups has been established for the listed waters. Although the section of the Fremont River within the park was not listed, the park has observed that it does not meet some water quality standards.

Within the park, the Fremont River temperatures have exceeded 68^{o}F (20^{o}C) (National Park Service, 1990 and 1994; National Park Service, Water Resources Division, 1994). Utah Division of Water Quality documented dissolved oxygen below the state criterion at Hickman Bridge on the Fremont River (STORET # 495436), and total phosphorus in exceedence of the state criterion at the same site (Millennium, 2002). Rarely are game fish such as brown trout encountered within the park, but native non-game species are. The temperature and dissolved oxygen data suggest that the river at least below the Fremont River Gorge may be impaired and warrant remedy or recognition that it is a sediment-laden system prone to flooding and occasional periods of higher temperatures and phosphorus.

The U.S. Geological Survey (USGS, 2003) developed a water quality database for 16 parks within the Northern Colorado Plateau Network, and Capitol Reef was included in this grouping. A cursory review of the database corroborated exceedences, although these exceedences of state standards, except for total phosphorus, may have been infrequent occurrences.

Assessment of pesticides has occurred within the park on the Fremont River, but all organics reviewed were below detection limits (Christiana and Rasmussen, 1991). Only one site -- the Fremont River at U-12 crossing and above Fish Creek (STORET # 495438), outside the park-- was subjected to pesticide analyses. No exceedences occurred (National Park Service, Water Resources Division,1994).

Funding from the Northern Colorado Plateau Network (NCPN) Vital Signs effort includes water quality monitoring as one of its tasks. Money has been allocated to the NCPN from the National Park Service, Water Resources Division for water quality sampling. A network workshop in April, 2003 identified several streams in Capitol Reef National Park that warrant sampling. Among them was the Fremont River. At that meeting, the Division of Water Quality offered to analyze samples for national parks in the State of Utah if the parks would collect the samples.

Additional water quality sampling and a retrospective analysis of the Fremont River water quality and its tributaries would enable the park to make clear decisions on how 1) to participate in the Fremont River Watershed Advisory and Technical groups' efforts, 2) to proceed with triennial reviews, 3) to manage their land better with respect to water quality, 4) to comprehend and use to its benefit the beneficial use designation applied to the Fremont River within the park, and 5) to participate in a long-term and effective water quality monitoring effort.

Description of Recommended Project or Activity

The park requests:

- A retrospective analysis of the Fremont River water quality data (both chemical and biological);
- A review of the present use designation of the Fremont River;
- Initiation of a total maximum daily load calculation for the Fremont River from below Bicknell through the park;
- Development of best management practices within the park and upstream of the park;
- Funding from the Northern Colorado Plateau Network Water Quality Monitoring effort to monitor at least 3 sites within the park – Fremont River, Sulphur Creek and Pleasant Creek – based on recommendations from the NCPN Water Quality Monitoring Phase II and III reports.

Available to the park and to assisting personnel are initial water quality data analyses prepared by the U.S. Geological Survey (2003). The Fremont River Watershed Technical Advisory Committee and the Fremont River Watershed Steering Committee developed the TMDL process for the Fremont River and should be consulted regarding this effort. Once the sites and parameters have been selected in accordance with the NCPN Vital Signs program, a hydrological technician can collect samples for the water quality monitoring, and the park can maintain a cooperative agreement with the State of Utah to analyze the samples.

Literature Cited

Envirosphere Company. 1981. Final report: National Park Service - Rocky Mountain Regional Office water quality studies at Capitol Reef National Park and Dinosaur National Monument. 74 pp.

Millennium Science and Engineering, Inc. 2002. Fremont River Watershed water quality management plan. 2319 S. Foothill Dr., Suite 180, Salt Lake City, UT. 84109. 141 pp.

National Park Service. 1990. Water quality of the Fremont River from Bicknell Bottoms through Capitol Reef National Park, 1988-1989. Resource Management Division.

National Park Service. 1994. Water quality of the Fremont River and selected tributaries from Bicknell Bottoms through Capitol Reef National Park. Resource Management Division, Capitol Reef National Park.

National Park Service, Water Resources Division. 1994. Baseline water quality data - inventory and analysis: Capitol Reef National Park. 1994 Oct; Technical Report NPS/NRWRD/NRTR-94/32. Fort Collins. 400 p.

Utah Department of Environmental Quality. 1997. Standards of quality for waters of the state. R317-2 Utah Admin Code. Division of Water Quality, DEQ. Salt Lake City. 49 pp.

U.S. Geological Survey. 2003 (unpublished). National Park Service Northern Colorado Plateau Network Inventory & Monitoring Program Summary Document Vital Signs Workshop Water Quality Vital Signs. Water Resources Division, Colorado District, Grand Junction, CO. 127pp.

Relation to other Project Statements: This project stands by itself as a project that warrants funding. Cooperation with the State of Utah is envisioned. The Hydrological Technician can be shared with other projects such as surveying riparian areas, tinajas, and springs (#9.2, #9.3, #9.4).

Proposed Budget

Hydrologist – Contractor, Retrospective Analysis and Review of Use Designation	$ 35,000
Hydrologist – Contractor, Total Max. Daily Load Evaluation	$ 25,000
Hydrologist and Biologist – Contractor, Best Management Practices Development	$ 15,000
Hydrological Technician – water quality monitoring	$ 10,000
TOTAL	$ 85,000

Project Statement 9.6. Evaluate Recreation Impacts to Halls Creek in Capitol Reef National Park

PMIS Number: 46366

Background

In 1996 and 1997, some outdoor magazine articles highlighted Halls Creek Narrows in Capitol Reef National Park as an interesting destination point, inspiring increased visitation to the area. In addition, the county road leading south to Halls Creek (Figure 10) has recently been improved, improving access to the area. A growing number of hikers in the Halls Creek Narrows appear to be impacting the creek's channel, water quality, and riparian habitat.

A typical trip for park visitors to Halls Creek is a two-night stay, with one day spent hiking through the incised canyon known as the Narrows. Hikers walk through the water within the confining walls during most of their time in the Narrows, stirring up the streambed and its sediment. The area provides no restrooms or water supplies, so sanitation is a concern; potentially water-borne pathogens or parasites from contamination could be posing a health risk. In places, the foot traffic tramples riparian vegetation or disturbs streambanks, inciting erosion and turbidity. It appears that the impacts may even extend downstream and affect water quality in Lake Powell in Glen Canyon National Recreation Area. In summary, human activity in a stream has the potential to increase sediment, contribute bacteria and pathogens, affect water chemistry, and impact the aquatic ecology, fisheries, aesthetics, and sanitation (Scoping Meeting Notes, Oct. 29, 2002; National Park Service, 1993).

The park has anecdotal data on human impacts on the Narrows, but the seriousness of the problem is not well defined. Lacking concrete data, the park cannot develop guidelines on visitation, issue permits, restrict certain activities, or develop regulations or policies to protect the area and its resources (National Park Service, 1993 and 2001).

Description of Recommended Project or Activity

Capitol Reef National Park proposes to study the impacts of hikers on the stream and riparian area of Halls Creek Narrows, in the southern end of the park. A study for two recreation seasons would provide specific scientific data on the extent of recreational impacts and provide information that the park could use to control the situation, for example, to possibly establish a permit system for regulating use patterns (National Park Service, 1993). The study also could dovetail into and complement baseline studies of hydrology and aquatic ecology recommended for Halls Creek (Camp, 1978).

Park natural resources staff would most likely need to work in conjunction with an outside contractor or university personnel to set up a study as defined below.

SAMPLING SITE GENERAL DESCRIPTIONS:

- Establish about eight measurement/sampling sites at approximately 600-800 meter intervals along the Narrows. Use GPS to position and map each site in the field[13]. The measurement/sampling sites would follow from upstream to downstream, to show local and possibly cumulative effects in the downstream direction. Two of the measurement/sampling sites (for "control") would be sited upstream from where the Narrows impacts can begin, with one site below. Establish a marker at each site.
- Describe each measurement site and channel in terms of: cross-sectional width, depth and shape; the type of substrate; vegetation patterns (where applicable); shading patterns; and visible impacts. These factors would be described three times per season, at the beginning, mid-point, and end.
- Establish a photo point so each measurement/sampling site and its cross-section could be photographed to track visible erosion, sedimentation, or other changes (for the 3 times per season). Photographs on site would record the vegetative, substrate, or streambank status and changes.
- Survey the vascular vegetative species at the beginning and at the end of each year, to reveal the changes in the vegetation during the season or during the 2 years.

WATER MEASUREMENTS AND SAMPLING

- Collect physical, chemical and bacteriological samples at the measurement/sampling site every 10-12 days to provide 8-10 samples for each site per year of study (i.e., enough points for graphical and statistical comparisons or trend analysis).
- Physical sampling would include: pH, specific conductance, temperature, and turbidity (with portable instruments) and dissolved oxygen (either instrument or portable titration).
- Sample water at half the sites, preserving for analysis of: common cations/ions, basic metals, common nutrients, hardness, and alkalinity [note: the State of Utah Division of WQ would be a likely cooperator, to analyze standard suites of parameters]. Half the sites would provide a picture of chemistry.

[13] To map certain sites in the narrow canyon, a physical or optical ground distance measurement will be needed over to the closest point where the GPS unit receives a signal.

- Collect bacteriological samples (American Public Health Association, 1998) at 5-6 sites and place the samples on media or on ice for transport back to the park laboratory (for analysis in the evening).[14]
- Select a few samples during the mid- to late- season for special analysis to assess if the bacteria are human derived (Zion NP has worked with a university for such determinations, or they are commercially available). A few samples also would be analyzed microscopically for presence of parasites (Giardia, etc).
- For all analyses, establish proper quality assurance/quality control (duplicate samples, spikes, other tests), working with the contract laboratories as needed.
- Estimate the creek's flow by setting up a simple staff gage established at one station near the upper end and one at the lower, to be able to observe the staff reading during each visit, for a flow estimate.[15] Field notes also would indicate the weather conditions (e.g., if any storm runoff, if a dry period, etc).
- Twice each season, sample the benthic macroinvertebrates at three sites (one above, one midway, lower part of the Narrows) to observe numbers of taxa and diversity.

OTHER OBSERVATIONS

- Evaluate the numbers of visitors and their distribution patterns by field observations, a registration tablet on the trail, and interviews with a few visitors (interviews would help interpret the visitor use patterns). Evident trash or waste patterns or obvious impacts could be noted in the field for possible interpretation later.

INTERPRETATIONS

- Compare the data from above the Narrows vs within, from sites upstream vs downstream, for above vs below certain reaches, and for changes as the season progresses. Two years' data should allow a bare minimum year-to-year comparison as well.
- Summarize the chemical information to help interpret impacts (e.g., turbidity, sediment, nitrate, and chloride are useful indicators of pollution or disturbance).
- Compare the bacteriological information to evaluate the human influences and waste impacts.
- Use the photographs and notes to help evaluate any obvious impacts on the stream channel and vegetation.
- Use the macroinvertebrates as indicators of the aquatic environment, also comparing to sediment, substrate, and other factors.
- Prepare a publishable report with maps and a graphical and statistical summary, providing written interpretations of the impacts of human activities on Halls Creek. The interpretations must focus on practical implications for park managers. The NPS Water Resources Division would review the manuscript for approval before final payment. An abbreviated version of the report would be developed in conjunction with the park staff for distribution to other parks in *Park Science.*

[14] Portable incubator, filter, pump, petri dishes, etc would be set up at Fruita to analyze for bacteria.
[15] Measurement of the cross-section plus simple field discharge observations on several occasions would establish an adequate stage-discharge relationship of the cross-section to allow at least flow estimates from staff gage readings.

Personnel and Budget[16]

The field aspects of the project either could rely primarily on two biological technicians for 2 years during the main recreation season (either park, university, or contractor, but most likely a combination of these). Analyses could be with the State of Utah or a university. A more senior water resource person would coordinate, design, interpret, and write the report. Service of the park's GIS Specialist would be needed for about 2 weeks to assist in global positioning system (GPS) mapping of the field sites and to bring the data into a geographic information system (GIS) format for reporting and records. Other costs would include: instruments (for pH, etc), equipment (e.g., bacteria incubator), supplies, shipping, travel, and laboratory analyses.

Literature Cited

American Public Health Association. 1998. Standard methods for the examination of water and wastewater. (20th Ed.) APHA. 1220 pp.

Camp, Pamela A. 1978. Ecological reconnaissance of Halls Creek. Report to Capitol Reef National Park from Department of Botany, Utah State University. Logan. 27 pp and appendices.

National Park Service. 1993. Final resources management plan, Capitol Reef National Park. Torrey, UT. 17pp + ca. 100 pp attachments.

National Park Service. 2001. . Project statement: Water resources management plan. PS# CARE-N-015.005. Capitol Reef National Park. 9pp.

National Park Service. 2002. Project statement: Water resources management plan. PS# CARE-N-015.005. Capitol Reef NP. 9pp.

Capitol Reef National Park. 2002. Scoping meeting with park resources staff to review water issues, October, 2002, Torrey, UT.

Relation to other Project Statements: This project would relate generally to the project statement on riparian inventory (#9.2), but is not dependent on that project. Some of this work could be done in the park by park personnel, but contracting would be needed for much of the work.

[16] Draft budget notes only at this point, pending park staff suggestions. For example, could the park provide in-kind support for this project, or would outside staffing be needed for basically the entire work?

Proposed Budget

Survey: 120 days field/lab (2 techs X 30 days X 2 years) @ $150/day	$18,000
Senior field work 20 days/yr X 2 years = 20 at @ $280/day	$11,200
Tech data analysis/entry 8 days @ $150/day	$ 1,200
Senior data oversight and planning/design 4 days @ $280/day	$ 1,120
Field sampling equipment (Hydrolab or similar instruments)	$ 9,500
Software, disks, other computer supplies	$ 2,000
Vehicles mileage 6000 miles @ .35/mile	$ 2,100
Per diem costs	$ 3,000
Misc lab, field/office supplies, telephones	$ 1,500
Maintenance, updating, or servicing of GPS unit for the park	$ 1,000
Aerial photos, other photos, maps	$ 800
Field laboratory equipment (coliforms, etc)	$ 4,500
Chemical analyses	$ 4,500[17]
Special analyses for coliform identification	$ 2,000
Digital camera, memory cards, rechargeable batteries, etc	$ 600
Report copies, photograph, printing costs	$ 600
Subtotal	$63,620
Overhead @ 15%	$ 9,543
TOTAL	$73,163

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection
Assistance on GIS for entering field data into ArcView format
Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.7. Hydrology Study of the Fremont River Oxbow

PMIS Number: 100809

Background

The Fremont River oxbow was created as a result of constructing State Highway 24 across a meander of the river in 1964. Rather than constructing the highway to follow the old meander, the road was routed through an area of sandstone cliff that was blasted. Now an excavated channel carries the Fremont River parallel to the road alignment. The river cascades over a 20-foot (6.1-m) tall waterfall and flows into the original channel.

This section of the highway is located approximately 6 mi (10 km) east of the visitor center. Over the years, the river has eroded the bottom of the re-aligned channel and initiated head cutting, thus causing the channel to become more incised and the waterfall to move upstream. The original channel was slightly altered with shallow road

[17] This cost could be cut if the State of Utah is able to assist with some analyses

fills during private ownership most likely between 1964 and 1969. During periods of high flows, flood waters overtop the re-aligned channel and flow into the oxbow. Ponding has occurred in the downstream end of the abandoned meander. The park notes that following the river diversion, the oxbow supported a pond which provided habitat for the Ute ladies'-tresses (*Spiranthes diluvialis*), a federally threatened species, and other riparian and wetland species. Since that time the oxbow has become increasingly desiccated, perhaps as a result of drainage work required to maintain stability of the roadbed, conducted approximately 15 years ago.

The park identified significant environmental and safety concerns resulting from the present Fremont River course over the waterfall (Scoping meeting, October 29, 2002; National Park Service, 2002). The riparian and wetland systems, not to mention the lotic system, is non-functional as a result of the further desiccation in the oxbow. A federally threatened species (*Spiranthes diluvialis*) has not been seen since 1995. The National Park Service is mandated to protect wetlands from degradation and to restore natural wetland functions and values where they have been disturbed by human activity (National Park Service Organic Act (16 U.S.C. Sec. 1 *et seq.* [1988], Aug. 25,1916, ch. 408, 39 Stat. 535). The waterfall creates a potential physical barrier to the upstream migration of fish. Hepworth *et al.* (1993) mentioned upstream fish migration limitations due to physical barriers such as the waterfall, or changes in environmental conditions such as elevation and temperature.

The park also recognizes the safety hazard associated with the existing waterfall. They have a posted sign stating no jumping into the pond below the waterfall, yet the park has responded to numerous injuries from this activity. Water quality concerns related to high fecal coliform counts may also present a problem. Traffic congestion occurs at the parking pullout, the parking area is not striped, and large recreational vehicles must back out into adjacent traffic when departing.

Description of Recommended Project or Activity

Presently, the Utah Department of Transportation and Capitol Reef National Park and interested returning the channel to the oxbow. In order to do this, several studies are required. In particular, the data requirements of an adequate hydrology study should include the following historic and existing information:

Hydrology

- Bankfull flow peaks
- Bankfull flow duration
- System flashiness
- Mean annual, typical wet and dry year hydrographs.

Geomorphology

- Reference reach channel geometry and pattern dimensions
- Channel slope upstream, through and below the restoration reach
- Particle size distribution of bedload and materials located in the restoration reach

A wetland delineation, which meets NPS Director's Order # 77-1 and the Corps of Engineers requirements must be conducted. The wetland inventory is described in project statement #9.10. Similarly a vegetation study is required. This information provides for the planned configuration of the restoration reach and addresses questions relating to potential vegetation encroachment, increased exotic establishment, or potential erosion of constructed streambanks.

Since the idea is not to release water in the oxbow without defining a channel, the study must also describe the floodplain characteristics of the restoration reach. These include measurement of the present gradient and presence of a pre-existing channel. The study must describe the dimension, pattern, and profile of the restoration reach based on review of the river's hydrological data. The study will also identify the source of rock and woody materials for bank stabilization. This latter item needs to be coordinated with the Utah Department of Transportation since they will also need to determine a materials source for the road re-alignment.

This river restoration project is large and requires very careful review of the river's hydrology and proposed channel geometry. If not correctly assessed, designed, and implemented, the result may impede flow of water to downstream water rights owners, may increase or decrease the amount of sediment moving through the system, or may cause vegetative debris to flow downstream. If correctly assessed, designed and constructed, the restoration of the Fremont River oxbow can provide more riparian habitat, reduce flooding downstream, provide water purification through associated wetlands, increase alluvial storage of water for late season release, increase ground water recharge, and provide the opportunity for the restoration of the Ute ladies'-tresses.

Literature Cited

Hepworth, D. K.; Ottenbacher, M. J., and Archer, D. L., Utah Department of Natural Resources, Division of Wildlife Resources. 1993. An evaluation of native fishes of the Fremont River in or near Capitol Reef National Park. Publication No. 93-5. 17 p.

National Park Service. 2002. Project statement: Water resources management plan.

PS# CARE-N-015.005. Capitol Reef NP. 9pp.

Relation to other Project Statements: This project would relate somewhat to the project statements on wetland delineation (#9.10), riparian inventory (#9.2), and exotic plants (9.9), but is not dependent on those projects. The project would depend on cooperation with the State of Utah and the Army Corps of Engineers.

Proposed Budget

Hydrologist – Field Work (10 days @ $85/hr)	$ 6,800
Hydrological Technician – Field Work (10 days @ $12/hr)	$ 960
Hydrologist – Report Development	$ 6,800

Hydrologist Technician - Report Development	$ 960
GIS	$ 5,000
Equipment Use	$ 1,000
Travel	$ 2,000
Office Materials	$ 500
TOTAL	$25,200

Project Statement 9.8. Hydrogeology Study of Capitol Reef National Park

PMIS Number: 100810

Background

The regional hydrogeology studies including Bjorkland (1969), Hood and Danielson (1979, 1981), Hood (1980), Blanchard (1986a, 1986b), Weigel (1987), and Weiss (1987, 1991) review ground water availability, conditions, characteristics, and flow, but they are not specific to Capitol Reef. These studies identified various geological formations as providing potential water sources. The most notable formation as a source of water is the Navajo Sandstone, but the Wingate Sandstone and locally the Entrada can also supply water. That the park finally pulled their culinary water from a lens within the Moenkopi, a formation which generally does not provide a good source of drinking water, points to the inadequacy of regional studies in predicting or even understanding local hydrogeology.

Ground-water data including location and hydrologic characteristics are already available (Table 3., Section 6.4.2, Water Resources Management Plan). However, these sites may not be close enough to the park to provide adequate information.

Only recently has hydrogeological modeling of projected drawdowns related to proposed wells been completed (Cutillo, 2002). Cutillo determined that proposed wells completed east of park could impact ground water within the park. Cutillo presented other scenarios based on a sensitivity analysis.
This type of study coupled with other field efforts would allow park management the ability to address issues of impact from proposed development outside the park and within the park. Specifically, the park needs to understand how water flows through sandstone formations in the park and to comprehend percolation rates, ground-water recharge and ground-water discharge in relationship to their drinking water well, as well as to park natural resources such as tinajas, springs, and hanging gardens. Assessment of the park's hydrogeology is requested.

Description of Recommended Project or Activity

The park proposes that a contractor provide the expertise to study and report on the hydrogeology of the park. The assistance would take the form of:

- Reviewing regional ground-water data;
- Reviewing data regarding spring and well water quality for sites in and adjacent the park. Coupled with the spring inventory project statement, professionals will have locations of springs located in the park;
- Determining if more information is required to calculate transmissivity and hydraulic conductivity;

- Designing a monitoring network of wells and springs including existing and new wells that will provide water level and water quality information;
- Developing a potentiometric surface for Capitol Reef based on existing information and new wells if required; and
- Discussing how ground water influences spring discharge and determining if there are ground water connections to tinajas within the park.

The design of a monitoring network for the ground water in the park may be coupled with the inventory and monitoring program for the Northern Colorado Plateau Network of parks. Only two wells within the park are functional; others such as one located at the Post may only work after repair. An oil and gas well is located in the Cathedral District. Approximately seven known springs occur in the park (an inventory is required to locate others). Since so few wells and springs are available to model the potentiometric surface of the ground water within the park, more wells may need to be completed. However, they are very expensive ($10,000 or more per well), and impacts from construction are notable.

Literature Cited

Bjorklund, L. J., 1969. Reconnaissance of the ground-water resources of the upper Fremont River Valley, Wayne County, Utah. U.S. Geological Survey and Utah Department of Natural Resources, Division of Water Rights. State of Utah, Department of Natural Resources Technical Publication No. 22. 54 p.

Blanchard, P.J. 1986. Ground water conditions in the Lake Powell area, Utah: State of Utah, Dept. of Natural Resources, Technical Publication No. 84, 64pp.

Blanchard, P.J. 1986. Ground water conditions in the Kaiparowits Plateau area, Utah and Arizona, with emphasis on the Navajo Sandstone: State of Utah, Dept. of Natural Resources, Technical Publication No. 84, 64pp.

Hood, J.W. 1980. The Navajo Sandstone: A Regional Aquifer, in Picard, M. D., Ed. Henry Mountains Symposium, Utah Geological Assoc., Pub. 8, Salt Lake City.

Hood, J.W. and T.W. Danielson. 1979. Aquifer tests of the Navajo Sandstone near Caineville, Wayne County, Utah: State of Utah: Dept. of Natural Resources Technical Publication No. 66, 69 pp.

Hood, J.W. and T.W. Danielson. 1981. Bedrock aquifers in the lower Dirty Devil Basin area, Utah, with special emphasis on the Navajo Sandstone. State of Utah Dept. of Natural Resources Technical Publication No. 66, 69 pp.

Weigel, J.F. 1987. Selected hydrological and physical properties of Mesozoic formations in the Upper Colorado River Basin in AZ, CO, UT and WY excluding the San Juan River Basin. USGS Water Resources Investigation 86-4170.

Weiss, Emanuel. 1987. United States Geological Survey, Denver, Colorado. Ground-water flow in the Navajo Sandstone in parts of Emery, Grand, Carbon, Wayne, Garfield, and Kane counties, southeast Utah.; Water-Resources Investigations Report 86-4012. 41 p.

Weiss, Emanuel. 1991. Regional ground-water flow in upper and middle Paleozoic rocks in southeastern Utah and adjacent parts of Arizona, Colorado, and New Mexico. U.S. Geological Survey Water-Resources Investigations Report 90-4079. Denver. 57 pp.

Relation to other Project Statements: This project would relate generally to the project statement on spring inventory (#9.4), but is not dependent on that project. Some of this work could be done by the NPS Water Resources Division, but probably some sub-contracting would be needed.

Proposed Budget

Hydrogeologist	$50,000
Hydrological Technician	$10,000
TOTAL	$60,000

Project Statement 9.9. Control of Exotics Species in Riparian Areas

PMIS Number: 59999

Background

The intent of the park is to maintain natural functioning riparian systems with intact native flora. The park supports over 759 species of vascular plants of which 36 taxa are threatened, endangered, or sensitive. Over 34 plant communities exist within the park, and result from the variety in topography and substrate. Maintenance of the community types and rare species requires active management of invasive species.

The two invasive species of concern along the park's riparian systems are tamarisk and Russian-olive. They both compete effectively for habitat to the detriment of native shrub species such as willow. They also diminish the value of wildlife habitat in that monocultures of at least tamarisk can border an entire drainage. Plant biodiversity is at risk leading to a loss of biodiversity in the fauna that inhabit riparian areas. Also, these two plants are very effective in using large quantities of water. Tamarisk has the ability to render soils underneath more saline due to its a ability to concentrate salts in its leaves. The leaves drop and salt accumulates at the soil surface (The Nature Conservancy website for invasives, 2003; National Park Service website for alien plants, 2003).

The Russian-olive is of particular concern in the park, since eradication of tamarisk has been underway for sometime. The Russian-olive now represents another threat to natural plant communities and efforts to eradicate it are required. Effective mechanical means of eliminating Russian-olive include mowing hedges with a brush type mower, followed by removal of cut material.

Removal of tamarisk and Russian-olive is desirable and achievable given a planned approach. Efforts to eradicate these species must take into account concerns regarding methods, particularly if they include use of herbicides. Garlon 4 appears to be the most effective means of controlling tamarisk after they have been mechanically removed. Other parks, using repeated applications, have sprayed Garlon 4 on the remaining stumps. If spraying occurs near water sources and for these two species it does, care must be taken to avoid contamination of the water sources.

Description of Recommended Project or Activity

The park would proceed with their own mapping effort, and areas of concentration would include Fremont River and Sulphur Creek, Spring Creek Canyon, and other major riparian areas including impoundment areas. The park has mapped Russian-olive and tamarisk along the Fremont River. This point coverage will be converted to polygons based on density percentage categories. The exotic populations in other drainages including Sulphur Creek and Spring Creek Canyon would be mapped to the extent that the Fremont River has been mapped. The park would also update the Fremont River inventory since it was completed in 1997. The park would also obtain any mapping that the Bureau of Land Management or the Forest Service has. To date these agencies note the presence of these species, but have not mapped them.

The mapping effort would include using a GPS to locate the boundaries of the invasives. The park would prioritize populations regarding their need for eradication. Once mapped and prioritized, the park would hire teams that work the Southern Colorado Plateau in a two-year effort to control these two invasive species.

Literature Cited

U. of California – Davis. 2003 website. The Nature Conservancy, Invasives on the Web. < http://tncweeds.ucdavis.edu/esadocs/tamaramo.html >

National Park Service. 2003 website. Alien plants gone wild. www.nps.gov/plants/alien/fact/elan1.htm

Relation to other Project Statements: This project would relate generally to the project statements on restoration of impoundments (#9.1), wetland delineation (#9.10) and riparian inventory (#9.2), but is not dependent on those projects. Cooperation with other agencies in the area would be envisioned.

Proposed Budget

Biological Technicians, 2 for 1 season	$15,000
GIS Specialist	$ 6,000
Eradication Team	$50,000
TOTAL	$71,000

Project Statement 9.10. Delineation of Wetlands in Capitol Reef National Park

PMIS Number: 100811

Background

Wetlands are present in Capitol Reef National Park. They include areas along rivers, streams, and creeks, tinajas and hanging gardens. These areas are particularly important for support of wildlife, stabilization of streambanks, retention of sediment, flood attenuation, provision of food to the aquatic fauna, biogeochemical cycling, and discharge and recharge to the ground water. The park has very little to no information about its wetland resources, and since they provide desirable ecosystem functions and maintenance of native plant and animal populations, the park would like to investigate their presence in the park. Some wetland areas along streams provide habitat for Ute ladies'-tresses. This orchid species has not been seen in the park since approximately 1995. A wetland inventory could confirm its existence. Studies of the tinajas (Berghoff, 1995; LaFrancois, 1995; Baron, 1998) south of the Burr trail advanced the parks knowledge regarding plant and macroinvertebrate species, not to mention information regarding water chemistry and physical factors. Continued work around these types of water sources would enhance the park's information base about their water resources and associated habitats.

NPS Director's Order # 77-1 requires NPS managers to follow a set of wetland protection procedures for all wetlands. Parks must avoid, minimize and mitigate impacts to wetlands. In addition, if park actions impact wetlands, the park superintendent must develop a Statement of Findings regarding the impacts. Also, since Section 404 of the Federal Water Pollution Control Act (the Clean Water Act 33 U.S.C. 1251, et.seq.) restricts excavation and discharge of fill to jurisdictional wetlands, Capitol Reef National Park must acknowledge the presence of wetlands and ensure that either their disturbance does not occur, is minimized, or mitigated if required as a part of a permitting process with the Army Corps of Engineers.

Several areas are of particular interest to the park from a regulatory standpoint and from an inventory and monitoring basis. From a regulatory standpoint the issues are:

1) The Fremont River oxbow (described in Section 8.4) supports wetlands. If the Fremont River were to be moved back to the abandoned meander, the park needs to determine the presence of wetlands and the extent to which wetlands may be disturbed as a result of the Fremont River restoration.
2) Likewise, human-made impoundments may also support wetlands; remediation of these sites warrant wetland delineations in their vicinity.
3) Also, the Utah Department of Transportation occasionally needs to stabilize sections of the Fremont River along Utah Highway 24. Having an advanced wetland identification along the highway as it passes through the park would facilitate conducting the proper environmental assessments and wetland compliance prior to any streambank stabilization.

From an inventory and monitoring standpoint the areas of interest are:

1) Inventory and delineation of wetlands along perennial streams including the Fremont River, and Oak, Pleasant, Halls, and Sulphur creeks.
2) Inventory and delineation of wetlands along intermittent or ephemeral drainages including Deep, Bulberry, Polk creeks, and their tributaries.
3) Inventory and delineation of wetlands along additional intermittent and ephemeral drainages including but not limited to Spring Canyon, Muley Twist Canyon, and other washes that warrant review.
4) Inventory of delineation of wetlands surrounding tinajas, springs, and hanging gardens.

Information regarding those areas marked for inventory relates to visitor impacts, assessing current conditions of these wetlands, and addition to the natural resource knowledge base of the park.

The park may be initially interested in delineating those wetlands that could warrant regulatory actions. These are a priority. Secondarily, the park needs to develop a database of existing wetlands.

These two efforts can be coupled first by interpreting aerial photographs for the presence of wetlands. The National Wetland Inventory project has mapped and classified wetlands nationwide. Exceptions do occur and these include the counties encompassing the park. The park would purchase aerial photography at a scale necessary to view perceived wetland and riparian areas along rivers, streams and around tinajas. The aerial photos would then be interpreted for wetlands according to the Cowardin *et al.* (1979) classification. In addition to delineating those wetlands requiring regulatory review, the park would proceed with field verification and delineation of wetlands along perennial systems, intermittent and ephemeral systems, and along tinajas and springs. The wetland delineations would be completed according to NPS Director's Order Procedural Manual #77-1 (National Park Service, Water Resources Division, 1998). Delineations of wetlands associated with tinajas, springs, and riparian areas could be associated with an over all assessment of riparian areas, tinajas and springs as described in project statements #9.2, #9.3 and #9.4.

Delineations require mapping of the boundary and recording soil, hydrology and vegetation data. The park has a GPS unit and can utilize this to obtain boundaries and record data.

Description of Recommended Project or Activity

The park proposes that a qualified contractor conduct a wetland delineation within the park according to a prioritization scheme. The delineation will be conducted according to NPS Director's Order Procedural Manual #77-1. A geographical positioning system (GPS) unit will be used to locate the boundary of the wetlands and to record soil, vegetation, and hydrology information. Data will be downloaded to a geographic information system (GIS) file, and corrected. A buffer may be established in the GIS zone where the wetland is of particular importance. Management may refer to this map regarding proposed activities within the delineated wetlands or buffer zones.

As a preface to the delineation, color infrared aerial photography (preferably at a scale of 1:24,000) will be obtained through flying. This medium will allow the park to identify wetland areas and prioritize their delineation, in the same manner that the US Fish and Wildlife Service used in development of their National Wetland Inventory maps. The aerial photos will be useful in other inventory projects including riparian and aquatic assessment.

When conducting the delineation, other information can be obtained such as the presence of amphibians, reptiles, and mammals, as well as extent of impact. Any data sheet prepared for the work should include the basic requirements for a delineation, but also include places for recording of other information. Additionally, riparian and aquatic inventories could proceed in tandem (see project statements #9.2, #9.3, and #9.4).

Literature Cited

Baron, Jill S., T. LaFrancois, and B.C. Kondratieff. 1998. Chemical and biological characteristics of desert rock pools in intermittent streams of Capitol Reef National Park, Utah. Great Basin Naturalist 58(3):250-264.

Berghoff, Kevin. 1995. Resource Management and Science Division, Capitol Reef National Park. Capitol Reef National Park tinaja wetland survey - summary report.

Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetlands and Deepwater Habitats of the United States. US Fish and Wildlife Service Report FWS/OBS-79/31.

Lafrancois, T. 1995. Biology and ecology of rock pools in Capitol Reef National Park, Utah. MS Thesis, Colorado State University. Fort Collins. 64 pp.

National Park Service, Water Resources Division. 1998. (Joel Wagner, Ed.). National Park Service procedural manual 77-1: Wetland protection. Tech. Rpt. NPS/NRWRD/NRTR-98/203. Oct. 1998. Fort Collins, CO. 32 pp.

Relation to other Project Statements: This project would relate generally to the project statements on riparian, tinaja and springs inventories, the Halls Creek survey, and exotic species removal (#9.2, #9.3, #9.4, #9.6, #9.9), but is not dependent on those projects. Some of this work could be done in the park by park personnel, but probably contracting would be needed. Cooperation with the BLM is envisioned.

Proposed Budget

Biological Technicians – 2 for 2 seasons	$37,000
Project Supervisor – Professional Wetland Scientist (3 months)	$25,000
GIS services	$10,000
Aerial photography 1:24000, Color IR	$10,500
TOTAL	$82,500

Project Statement 9.11. Design of an Abandoned Mining Road Restoration Project for Capitol Reef National Park

PMIS Number: 100812

Background

Uranium mining existed in the Capitol Reef National Park area in the early 1900s, but became most active during the 1950s when Capitol Reef was a National Monument and still legally open to mining. The Atomic Energy Commission and government offered price supports and encouragement to uranium miners; consequently, thousands of prospectors flooded the area. Over 10,000 claims were filed, some in areas that now fall within the park's boundary.

Abandoned mining roads from a half century ago are still an issue in parts of the park, especially along the park's western boundary near Bureau of Land Management and Forest Service lands. Surface disturbances on the landscape are so slow to heal in arid climates, and some of the abandoned roads are still eroding. Old roads collect overland flow from intense thunderstorms to make gullies that then carve their way upstream; these headward-eroding gullies yield sediment and destroy vegetation in their path. A gully also serves as a ditch to drain ground water, thereby endangering nearby springs, seeps, or other areas of value to wildlife.

Recreationists on all-terrain vehicles, ATVs (aka as off-road or off-highway vehicles: ORVs or OHVs) can trespass onto abandoned roads in the park, especially since little fencing exists along the park boundary. In addition, the boundary is not well marked, since much of the southern part of the park's boundary is yet to be surveyed. All-terrain vehicles can stimulate erosion by tracking on spoil piles and by cutting tread marks into slopes; tire tracks focus runoff. All-terrain vehicles can destroy sensitive arid vegetation and expose the soils; erosion of exposed soils by wind and water depletes nutrients, harms soil microbiota, and invites encroachment of invasive plants. All-terrain vehicles also can transport exotic seeds into an area.

Description of Recommended Project or Activity

The park proposes a project to restore eroding watersheds impacted by abandoned mining roads. Development of a project design and work plan is the necessary first phase of any restoration project; a design would provide: (1) the plans and technical details for project implementation; (2) a budget; (3) the elements the park would need to prepare an effective "request for proposals" for the project; and (4) the environmental assessment (EA) needed for such a project. A proposal to complete the design, planning, and EA phase is covered in this proposal. The following implementation phase of a project would carry out surface reshaping, erosion control measures, seeding, and other actions to rehabilitate the eroding watersheds.

In brief terms, the project's design phase (proposed here) would:

- Identify and map the specific sites where erosion or other impacts associated with abandoned roads are occurring, calculate the acreages, and rate the sites by severity, suitability for treatment, and accessibility.
- For the sites identified, design a restoration project with the specifications for earth movement, planting, seeding, staffing, supply/equipment, travel/transport, logistics, and other details, including the budget.
- Prepare an environmental assessment for the project proposed.

- Identify park staff roles and partnership opportunities.

More specifically, the project design work proposed here would conduct the following tasks[18].

PREPARATION

- Locate and interpret old aerial photographs, other photographs, reports, maps, and files to document the history and progression of the watershed erosion.
- Interview park natural resources staff and locals to help identify locations of the abandoned mining road sites or areas affected by erosion and/or all-terrain vehicles (ATVs).
- Analyze recent aerial photographs of the park and surrounding area (color-IR, 1:24,000) to confirm the extent and location of the eroding roads, consulting with park staff and/or locals on interpretation.
- Work with the park staff to assemble basic natural resource information relevant to erosion control in the area, including lists of vegetation and soils maps (Moench and Fusaro, 2002; Toy *et al.*, 2002).
- Prepare a preliminary working map of the eroding areas to be surveyed on the ground, and prepare field note forms, check lists, and GPS software programming to facilitate the field work.
- Review past, present, or planned erosion control projects of this type by the Bureau of Land Management, Forest Service, or the State of Utah in the area, to study their design features and costs (e.g., seeding rates, plants, tractor types, juniper removal processes, etc).

VISUAL INTERPRETATIONS IN THE FIELD

- Rate the severity of the erosion (extent of gullies, signs of recent soil movement) at each eroding site or area.
- Rate each eroding site in terms of its risk to water, vegetative cover, wildlife habitat, or other resources. High priority areas would be those: contributing sediment; actively eroding; frequented by recreationists; likely to worsen; affecting a spring or seep area (needed by wildlife); threatening a cultural feature, and/or visible to a road or trail.

FIELD SURVEYING AND MAPPING IN THE FIELD

- With GPS and hand survey equipment (distance to within 10 feet), map the areas of erosion and their slopes (hand instrument) and sketch the acres of treatment needed. Record soil types + slopes (= an erodibility index), aspects, and existing vegetative cover/cover losses. Record native vegetation species found in each affected area (background information for planning seeding or planting).
- Measure approximate volumes of gullies to fill, eroding road fills to contour, or other tractor work needed. Estimate the needs for water-barring or other shaping at each site.
- Evaluate options for local materials (brush, rock, junipers, etc) suitable for erosion checks, mulching, or runoff diversions.

CALCULATIONS AND DESIGN

- Place the mapping information into ArcView format in cooperation with park staff and record the field data in Word and Excel.
- Use the field information to rate each site for potential for seeding/planting.
- For each site, summarize: the approximate volumes of soil to be moved for any reshaping and calculate the tractor-days required for water-barring, runoff-spreaders, and gully shaping. Summarize by site: the tractor-days for disking, raking, drilling, or piling; the acres of seeding required and pounds of seed needed; the appropriate seed mixtures/species needed (and source); acres of soil disking or raking; quantification of mulch, fertilizer, or other supplies needed; a summary of labor and professional needs.
- Develop a plan of logistics/scheduling for a project, to account for equipment access, collection of materials, and sequence of actions; develop a plan for the earth work and seeding by appropriate season.
- Cost out all factors noted above with local figures.
- Define the skill, labor, or equipment inputs that the park staff could bring to a project.

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[18] Note that the park also has a proposal for an erosion control project in piñon-juniper areas treated for rangeland improvement prior to the area being a National Park. The project proposed here logically could share work, activities, equipment, and materials with the piñon-juniper project.

ENVIRONMENTAL ASSESSMENT

- Collect the necessary data and write an environmental assessment (EA) using DO-12 for format and guidance, completing the standard NEPA sub-sections on soils, water, wildlife, archaeology, history, T&E species, geology, park management aspects, etc and contacting the state and federal agencies to attain needed lists, permit applications, and other information (in conjunction with park resource staff).

FINAL REPORTING AND PLAN

- Prepare a final project plan with maps, tables, drawings, text, and interpretations in a form that a contractor could follow for project implementation. Prepare a draft "request for proposal" that the park staff and NPS can adapt for advertising.

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Toy, T.J., G.R. Foster, and K.G. Renard. 2002. Soil erosion: processes, prediction, measurement, and control. John Wiley. 338 pp.

Relation to other Project Statements: This project would relate generally to the project statement on restoration of disturbed watersheds (#9.12) and could be complementary. Some of this work could be done in the park by park personnel, but probably contracting would be needed. Cooperation with the BLM is envisioned.

Proposed Budget [19]

Field survey and mapping: 60 days of (2) field techs @ $150/day		$ 9,000	
Senior field oversight 15 days at @ $280/day	$ 4,200		
Tech data analysis/entry 10 days @ $150/day		$ 1,500	
Senior data oversight 5 days @ $280/day		$ 1,400	
Report preparation 10 days @ $280/day		$ 2,800	
Software, disks, other computer supplies		$ 1,200	
Vehicles mileage 4000 miles @ .35/mile		$ 1,400	
Per diem			$ 3,000
Misc field/office supplies, telephones			$ 1,500
Maintenance, updating, or servicing of GPS unit for the park	$ 2,000		
Aerial photos, data purchase			$ 2,500
Subtotal		$30,500	
Overhead @ 15%		$ 4,575	
TOTAL			$35,075

[19] Includes cost for the EA

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection
Assistance on GIS for entering field data into ArcView format
Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.12. Design Restoration of Disturbed Piñon-Juniper Watersheds in Capitol Reef National Park

PMIS Number: 100813

Background

Erosion is a problem in piñon-juniper areas in the southwestern part of Capitol Reef National Park by the boundary between the park and the Bureau of Land Management (BLM) Grand Staircase-Escalante National Monument. Overgrazing many decades ago decreased the grass cover, which encouraged an increase of piñon-juniper tree density. The over-dense piñon-junipers in such cases take up root space and inhibit grass and shrub re-growth; then accelerated erosion occurs in the bare soils between the trees. Such erosion is arid areas often is not able to heal itself, and human intervention is necessary to bring the vegetative cover back into its original balance. Thinning the trees and seeding can promote the return of the grass and brush cover.

In the 1950s-60s the Bureau of Land Management conducted erosion control work in the area, removing piñon and juniper trees by tractors and chaining, installing infiltration terraces and check dams, and seeding the area with grasses and forbs. Their goal was to control erosion and sediment and also to protect Lake Powell from sediment, and simultaneously to improve the rangeland. The concept of piñon-juniper thinning plus seeding or planting is valid, as demonstrated by research at Bandelier National Monument, in the Cíbola National Forest of New Mexico, and in other places in the Southwest (W. Fertig and G. Christensen, Bureau of Land Management staff, Utah, pers. comm., 2003; Cíbola NF, pers. comm., 2000; and C. Allen, Bandelier NM/USGS, pers. comm., 2001).

The 1950s-60s Bureau of Land Management watershed treatments were partially successful, but in places the planted/seeded shrubs and grasses failed, allowing the piñon-juniper stands to return. In some cases, hillside contours failed and the contours became diversions to concentrate runoff and initiate gullies. Possibly BLM did not maintain the work, or perhaps the work was simply attempted in a droughty period when seeding was too difficult. In any event, some larger arroyos have formed in the area, and flashfloods now present a hazard. In places exotic grasses also have encroached. Gullies can drain ground water and therefore have the potential to endanger springs or seeps important to wildlife.

Some hand sawing has been done to remove the excess piñon-junipers in areas in the park, but for the most part the erosion problem has gone untreated and continues. Further intervention will be needed to reverse the erosion. The nearby Bureau of Land Management staff plan to treat similar eroding sites, near the park, so it would be practical for the park to cooperate with the Bureau of Land Management staff wherever possible on the watershed restoration efforts (Bureau of Land Management, pers. comm., 2003).

Description of Recommended Project or Activity

The park proposes a project to restore eroding park piñon-juniper lands suffering from the historic effects of overgrazing in the early 1900s and degraded watershed treatment projects dating from the 1950s-60s. Development of a project design and a work plan is the essential first phase of any watershed restoration. The follow-up implementation phase of a project then would carry out the surface reshaping, runoff spreading, piñon-juniper thinning, brush-mulching, seeding/planting, and/or other actions needed to rehabilitate the eroding watersheds.

In brief terms, the project's design phase (proposed here) would:

- Identify and map the sites where the erosion and other impacts are occurring and prioritize these problem sites by severity.
- Design a restoration project for the eroding areas, recommending the specifications, schedules, and guidelines for piñon-juniper thinning, brush

mulching, earth work, seeding, supplies/equipment, logistics/access, and other elements, including costs.
- Assemble and write an environmental assessment for the implementation project proposed.
- Identify park staff roles, cooperation, and partnership opportunities.
- Provide the park staff with the text elements to advertise a Request for Proposals.

In more detail, the project design work (proposed here) would include the following tasks[20].

PRE-FIELD PREPARATION

- Locate and interpret photographs, reports, maps, and files to document the background and progression of the erosion problem, especially from aerial photographs from the 1950s-1960s on.
- Analyze recent aerial photographs of the park and surrounding area (color 1:24,000) to assess the extent and location of the erosion, consulting with park staff and/or locals for photo interpretation.[21]
- Collect natural resource background materials, including soil maps and lists of vegetation (needed for vegetative prescriptions) (Moench and Fusaro, 2002; Toy *et al.*, 2002).
- Review past, present, or proposed comparable projects in the area by the Bureau of Land Management, Forest Service, or State of Utah, to take advantage of past design features and experience (e.g., seeding mixtures, plant species, tractor sizes, juniper removal procedures, brush mulching techniques, contouring designs, contract arrangements, etc).
- Prepare a working map of areas and sites to be surveyed, mapped, and analyzed in the field. Design the field note forms, check lists, and GPS software programming to facilitate the field data collection.

FIELD EROSION OBSERVATIONS AND INTERPRETATIONS

- Rate the severity of the erosion at each site by: size/numbers of gullies; extent of sheet erosion; slides or other mass wasting.
- Prioritize each eroding site in terms of the evident risk to soils, vegetative cover, wildlife habitat, ground water, or other resources. “Highest priority” erosion areas will have one or more of these factors: yielding sediment; still actively eroding; frequented by recreationists; appears likely to worsen; possibly affecting a spring or seep area (needed by wildlife); threatening a cultural feature; and/or visible to a trail.

FIELD SURVEY AND MAPPING

- Using GPS plus hand-level type survey equipment, map the individual sites for acres of erosion or disturbance, defining each problem site for: soil type; slope; aspect; and gully details. Evaluate the sites for piñon-juniper (P-J), sage, and/or other vegetative cover, assess the cover density of the P-J to determine thinning needed. Assess the site’s potential for seeding/planting. Record the native vegetation found in each area (background information to help plan seeding or planting).
- Measure approximate size of gullies and areas of eroding road fills or other sediment producers in need of tractor reshaping or filling before seeding, and estimate the tractor hours required per site (field hand optical distance measurements and hand inclinometer accuracy adequate, tied to the GPS readings).
- Evaluate options for local materials (P-J brush, other brush, rock, etc) available for erosion checks or mulching.

CALCULATIONS AND DESIGN

- Place the field mapping information into geographic information system format (cooperating with park staff); place field data into Word or Excel.
- For each site, calculate: volumes of soil to be moved in reshaping surfaces (e.g., where old contours exist); tractor-days required for water-barring or other runoff diversions, surface or gully shaping; tractor-days needed for disking, raking, drilling, or other pre-seeding treatment; person-day needs for chainsawing or other thinning and labor needed for brush-handling; acres of seeding required and pounds of seed needed; seed mixtures/species to be used; acres of soil disking or raking; needs for

[20] Note that the park also has a proposal for erosion control work on abandoned mining roads. The project proposed here could possibly link with the abandoned road project if both projects materialize.
[21] The purchase of the photographs could be shared with other projects.

brush piling; quantification of mulch, fertilizer, or other supplies; a summary of labor and professional needs in terms of skills.

- Develop a plan of logistics and access for a project, to account for equipment access routes, collection/delivery of materials; scheduling of earth work, tree thinning, seeding, or other work by season and sequence.
- Cost out all factors with local figures for materials, equipment, labor, etc.
- Define the skill, labor, material, supplies, and other inputs the park staff could bring to a restoration project.

ENVIRONMENTAL ASSESSMENT

- Collect the necessary information and prepare an environmental assessment (EA) following the NPS/Intermountain Region format, including the usual NEPA sections on soils, water, wildlife, archaeology, history, T&E species, geology, park management aspects, etc; contact the state and federal agencies for lists and background; determine any permitting requirements; contact NPS Region compliance officer to follow current procedures.

FINAL REPORTING

- Prepare a final project plan of work and report with maps, tables, design drawings, text, and interpretations in a form that a contractor could follow for project implementation. Prepare a draft "request for proposals."

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Toy, T.J., G.R. Foster, and K.G. Renard. 2002. Soil erosion: processes, prediction, measurement, and control. John Wiley. 338 pp. Abstract: overview of rill, gully, and other erosion processes. Reviews principles of erosion control. Discusses concepts of erodibility.

Relation to other Project Statements: This project would relate generally to the project statement on mining road restoration (#9.11) but is not dependent on that project. Some of this work could be done in the park by park personnel, but probably contracting would be needed. Cooperation with the BLM is envisioned.

<u>Proposed Budget[22]</u>

Survey: 50 days of (2 field techs X 35 days) @ $150/day		$ 7,500	
Senior field work 12 days at @ $280/day		$ 3,360	
Tech data analysis/entry 8 days @ $150/day	$ 1,200		
Senior data oversight 5 days @ $280/day		$ 1,400	
Plan preparation 10 days @ $280/day		$ 2,800	
Software, disks, other computer supplies		$ 1,000	
Vehicles mileage 4000 miles @ .35/mile		$ 1,400	
Per diem costs		$ 2,000	
Misc. field/office supplies, telephones		$ 1,500	
Maintenance, updating, or servicing of GPS unit for the park	$ 2,000		
Aerial photos, data purchase			$ 2,500

[22] Includes cost for the EA

Subtotal	$26,660	
Overhead @ 15%	4,000	
TOTAL		$30,660

Park staff needed for following in-kind contributions

Assistance on GPS programming for field data collection
Assistance on GIS for entering field data into ArcView format
Assistance on aerial photograph and map interpretations
Review of field information and draft reports

Project Statement 9.13. Restoration and Protection of Ackland Springs

PMIS Number: 101128

Background

Ackland Springs is located on the Hartnet Wash about 5 miles west of the park entrance near Hartnet Road in the Cathedral District of the park (Section 23, T 27 S, R. 6 E SLBM). Actually consisting of two springs, the first is undeveloped (except for some small, old concrete pools constructed in the wash) and situated on the on the edge of the wash along the road. Water flows from the edge of the wash, and remains at the surface for approximately 300 yards. Riparian vegetation, including grasses, sedges, and willows grow along the wash through this area.

The second spring is located on the east side of the road, approximately 200 yards from the first. Developed by the BLM in 1956, the spring flows into an underground storage tank, and then is piped via gravity feed to a cattle trough. The spring and storage tank are within a fenced enclosure; the trough is unfenced, and is utilized by cattle and other wildlife (including bats and toads).
Ackland Springs lies within the Hartnet Grazing allotment. 1141 AUMs (animal unit months) are permitted in the allotment during the winter months of each year. Although the developed spring in protected by fencing, virtually all of that water is subsurface until it is piped into the trough; there is no riparian vegetation associated with the spring. The undeveloped spring is not fenced, and is heavily impacted by cattle. Although livestock grazing in this area will eventually be phased out, cattle trailing through the area is likely to continue. Indeed, during the spring and summer when cattle are not in the area, the vegetation is thick and healthy, but is heavily grazed when cattle pass through the area, regardless of whether they remain to graze throughout the winter.

Because there is little other water in the area, cattle on the allotment use the springs area often, and linger in the area for long periods. The area is further impacted because the road crosses the wash twice within the riparian area created by the undeveloped spring.

The rocky terrain surrounding the undeveloped spring is rugged, making it difficult to fence the area to exclude cattle. Furthermore, because Hartnet Road passes through the area, cattle guards would be needed to allow vehicles to pass through the area. Additionally, flashfloods are frequent in the area, making the design of an effective enclosure even more difficult. Ultimately, the park wishes to design an enclosure that would allow cattle to access the developed trough, but exclude them from the riparian area created by the undeveloped spring.

Ackland Springs is one of only a few springs in the park; the presence of a significant amount of riparian vegetation makes the area even more unique, particularly given its presence in the otherwise relatively arid Cathedral District. It is a significant water source.

Description of Recommended Project or Activity

Conduct an inventory of the plant species (and associated animal species) in the riparian area, and design an enclosure to exclude cattle from Ackland Springs while allowing the developed water source to function as a livestock water source. The project would involve fencing, installation of cattle guards, and possibly, reworking and relocating the livestock watering facility to another nearby location. This work could be done in the park by park personnel, but some aspects could be contracted.

Relation to other Project Statements: This project would relate generally to the project statements on wetland delineation (#9.10) and riparian inventory (#9.2).

Proposed Budget

Fencing crew for one month		$5,000
Fencing materials	$3,000	
Cattle Guard Installation	$8,000	
Spring Modification		$2,000
TOTAL		$18,000

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APPENDIX A. Water rights within Capitol Reef Nationa Park [with Points of Diversion (POD)] as listed in the Utah Division of Water Rights Internet database as of 05-21-2002. Last update: 06-11-02 Capitol Reef, State of Utah listed water rights permits within park boundary as of May 21,2002 to JUNE26, 2002[23]

WRNUM	NAME	DATE	FLOW cfs	FLOW af	SOURCE	POD	Comment
95-12	17 named owners incl., Strikwerda, Durfey, Howard.	0/0/1882	6.3	384	Pleasant Creek	S1140 W490 frN4 Sec 23, T30S, R7E	Same as 95-18 and 95-17
95-18	Davis, Ross T. and Elaine (Trustees)	0/0/1882	6.3		Pleasant Creek	S1140 W490 frN4 Sec 23, T30S, R7E	
95-9	Durfey, Durfey, and Roderick	0/0/1882	6.3		Pleasant Creek	S1440 W490 frN4 Sec 23, T30S, R7E	
95-17	Durfey, Joseph Golden and Esther	0/0/1882	6.3		Pleasant Creek	S1140 W490 frN4 Sec 23, T30S, R7E	Same as 95-18
t26400	Durfey, Keith A. and Kay Frances C.	3/5/2002		12	Pleasant Creek	S1429 E1945 frNW Sec 12, T30S, R7E	Portion of 95-9 for road constr.
95-4683	Fruita Residents- CARE	0/01/1883	8.0		Fremont River	S1740 W2260 frNE Sec 22, T29S, R6E	
95-697	Intermountain Consumers Power Association	7/8/1971	70	50000	Underground Water Well	N2350 W900 frSE Sec 28 T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N500 E2350 frSW Sec 28, T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S1400 W900 frNE Sec 33, T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S1400 W2400 frNe Sec 34, T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1900 E1000 frSW Sec 34, T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1900 W600 frSE Sec 34 T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N200 W2400 frSE Sec 34, T28S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S300 W2200 frNE Sec 11, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S2100 W550 frNE Sec 11, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S2100 E1300 frNW Sec 11, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1750 W2200 frSE Sec 11, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S200 W350 frNE Sec 14, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S2150 W2200 frNE Sec14, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1550 W350 frSE Sec 14, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S1650 W600 frNE Sec 3, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S1650 E1000 frNW Sec 3, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1900 W2350 frSE Sec 3, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S300 W550 frNE Sec 10, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1800 W550 frSE Sec 10, T29S, R7E	

[23] Table prepared by James Harte, Water Rights Branch, Water Resources Division, NPS, Fort Collins.

WRNUM	NAME	DATE	FLOW cfs	FLOW af	SOURCE	POD	Comment
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	S1700 W2200 frNE Sec 2, T29S, R7E	
95-697	Int. Cons. Power.Assoc.	7/8/1971	70	50000	Underground Water Well	N1900 E1300 frSW Sec 2, T29S, R7E	
95-697	Intermountain Consumers Power Association	7/8/1971	70	50000	Underground Water Well	N1900 W400 frSE Sec 2, T29S, R7E	
95-7	Lurton J. Knee - USA NPS CARE	0/0/1881			Pleasant Creek	on stream fr SESE Sec 20, T30S, R7E	
95-8	Lurton J. Knee - USA NPS CARE	0/0/1881			Miner's Mountain Draw	on stream fr SWSW Sec 20, T30S, R7E	
95-1	Lurton J. Knee - USA NPS CARE	0/0/1882	0.925		Pleasant Creek	S160 W1065 frNE Sec 30, T30S, R7E	
95-2	Lurton J. Knee - USA NPS CARE	0/0/1882	0.1		Miner's Mtn Draw No. 4	N710 E580 frW4, Sec 29, T30S, R7E	
95-5	Lurton J. Knee - USA NPS CARE	0/0/1882	0.237		Unnamed Spring	N500 W660 frSE Sec 20, T30S, R7E	
97-1047	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Muley Twist Canyon Stream	on stream fr NENW Sec 16, T34S, R8E	
97-1057	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Muley Twist Canyon Stream	on stream fr NWNW Sec 2, T35S, R8E	
97-1059	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Hall's Creek	on stream fr NWNE Sec 16, T36S, R9E	
97-1065	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Halls Creek	on stream fr NENW Sec 2, T37S, R9E	to NESE Sec 2, T37S, R9E
97-1076	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Hall's Creek	on stream fr NWNE Sec 36, T34S, R8E	
97-1094	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Hall's Creek	on stream fr NWNE Sec 32, T35S, R9E	
97-524	State of Utah School & Institutional Trust Lands Admin	0/0/1888			Muley Twist Canyon Stream	on stream fr NWNW Sec 32, T33S, R8E	
a11599	Tercero Corporation	12/22/1980		3325	Pleasant Creek & Oak Creek	N860 W1620 frE4 Sec 28, T31S, R7E	Change to 95-444

WRNUM	NAME	DATE	FLOW cfs	FLOW af	SOURCE	POD	Comment
95-4104	Tercero Corporation	3/6/1987	50	9000	Oak Creek and Dogwater Creek	4 points of diversion	
95-444	Tercero Corporation (Warren II)	7/14/1961		3325	Pleasant Creek & Oak Creek	N860 W1620 frE4 Sec 28, T31S, R7E	This is a Point of Rediversion
94-4025	Tercero Corporation (Warren II)	3/28/1984	7		Oak Creek	S400 E200 frW4 Sec 27, T31S, R7E	
95-32	Tercero Corporation (Warren II)	11/28/2013	2.74		Oak Creek	N850 W1620 frE4 Sec 28, T31S, R7E	
95-33	Tercero Corporation (Warren II)	11/28/2028	2.74		Unnamed Trib. of Oak Creek	N310 W660 frS4 Sec 27, T31S, R7E	
95-34	Tercero Corporation (Warren II)	11/28/2028	2.74		Unnamed Trib of Oak Creek	S1000 W145 frN4 Sec 34, T31S, R7E	
95-4536	US Forest Service	0/0/1876			Deep Creek	on stream fr/to SENE Sec 25, T27S, R4E	Not on DW POD CARE List
95-107	USA BLM	6/20/1951	0.001		Red Seep Spring	on spring in NENW Sec 23, T32S, R7E	
95-399	USA BLM	5/17/1956	0.00183		Aukland Spring	S2991 E2002 frNW Sec 23, T27S, R6E	
95-580	USA BLM	1/14/1965		2.2	Unnamed Wash	N41 E1405 frSW Sec 35, T27S, R6E	
95-586	USA BLM	3/25/1965	0.00223		South Desert Spring	S1019 E1079 frW4 Sec10, T27S, R5E	
95-588	USA BLM	3/25/1965	0.0007		Bull Spring	N169 E556 frSW Sec 27, T27S, R6E	
95-590	USA BLM	3/25/1965		3.14	Unnamed Wash	S1051 W3693 frE4 Sec 17, T27S, R6E	
95-591	USA BLM	3/25/1965		2.8	Unnamed Wash	S4462 E2301 frNW Sec 18, T28S, R7E	
95-102	USA BLM	0/0/02	0.1		Unnamed Trib to Bitter Creek	on reservoir in NWSE Sec 6, T33S, R8E	
95-104	USA BLM	0/0/02	0.011		Unnamed Trib to Sandy Creek	on spring in SWSW Sec 30, T32S, R8E	
95-105	USA BLM	0/0/02	0.5		Unnamed Trib to Sand Wash	on reservoir SWSE Sec 24, T32S, R7E	
95-106	USA BLM	0/0/02	0.2		Unnamed Trib to Red Cyn Cr	on reservoir NESW Sec 24, T32S, R7E	
95-109	USA BLM	0/0/02	0.2		Unnamed Trib to Sandy Creek	on reservoir in NESE Sec 18, T32S, R8E	
95-1610	USA BLM	0/0/03	0.02		Oak Creek	on stream fr NWNE Sec 34, T31S, R7E	Enters park in SESE Sec 27
95-2894	USA BLM	0/0/1876			Unnamed Intermittent Stream	on stream fr NWNW Sec 28, T29S, R7E	
95-103	USA BLM	0/0/1881	0.004		Divide Canyon Spring	on spring SESE Sec 31, T32S, R8E	
95-110	USA BLM	0/0/1881	0.002		Coleman Seep Spring	on spring in SESE Sec 13, T32S, R7E	
95-111	USA BLM	0/0/1881	0.003		South Coleman Spring	on spring in SENW Sec 3, T32S, R7E	

WRNUM	NAME	DATE	FLOW cfs	FLOW af	SOURCE	POD	Comment
95-119	USA BLM	0/0/1881			Sandy Creek	on stream fr SESE Sec 1, T33S, R7E	
95-124	USA BLM	0/0/1881			Red Canyon Creek	on stream fr SESE Sec 27, T32S, R7E	to SWSE Sec 18, T32S, R8E
95-126	USA BLM	0/0/1881			South Coleman Canyon Creek	on stream fr NWSW Sec 18, T32S, R7E	
95-127	USA BLM	0/0/1881			North Coleman Canyon Creek	on stream fr SWNW Sec 7, T32S, R7E	to SESE Sec 34, T31S, R7E
95-130	USA BLM	0/0/1881			Birch Creek	on stream fr SWSE Sec 31, T31S, R7E	
95-131	USA BLM	0/0/1881			Bear Canyon Wash	on stream fr SWNW Sec 31, T31S, R7E	Not on DW POD CARE List
95-132	USA BLM	0/0/1881			Oak Creek	on stream fr SWSW Sec 30, T31S, R7E	Not on DW POD CARE List
95-139	USA BLM	0/0/1881			Sheets Gulch Stream	on stream fr SWSW Sec 18, T31 S, R7E	
95-140	USA BLM	0/0/1881			Five Mile Wash	on stream fr NWSE Sec 8, T31S, R7E	
95-141	USA BLM	0/0/1881			Cottonwood Wash	on stream fr NWSW Sec 5, T31S, R7E	
95-148	USA BLM	0/0/1881			Pleasant Creek	on stream fr/toSWNW Sec 29, T30S, R7E	
95-149	USA BLM	0/0/1881			Pleasant Creek	on stream fr NENE Sec 29, T30S, R7E	
95-150	USA BLM	0/0/1881			South Draw	on stream fr SWNE Sec 7, T31S, R7E	
95-151	USA BLM	0/0/1881			South Draw Stream	on stream fr SESE Sec 32, T30S, R7E	
95-155	USA BLM	0/0/1881			Bitter Creek	on stream fr SWNE Sec 12, T33S, R7E	to NWSE Sec 31, T32S, R8E
95-156	USA BLM	0/0/1881			Divide Canyon Creek	on stream fr/to NWNW Sec 30, T32S, R8E	
95-168	USA BLM	0/0/1881			Capitol Wash	on stream fr NWSW Sec 10, T30S, R7E	
95-170	USA BLM	0/0/1881			Water Pocket Creek	on stream fr SESW Sec 10, T30S, R7E	
97-956	USA BLM	0/0/1881			Muley Twist Canyon Creek	on stream NWNE Sec 13, T33S, R7E	
97-1009	USA BLM	0/0/1888			Wash	on stream fr NWNE Sec 17, T33S, R8E	
97-1010	USA BLM	0/0/1888			Wash	on reservoir in SESE Sec 20, T33S, R8E	
97-214	USA BLM	0/0/1888			Halls Creek	on stream fr SENE Sec 7, T33S, R8E	to SWSE Sec 25, T34S, R8E
97-215	USA BLM	0/0/1888			Hall's Creek	on stream fr NENE Sec 1, T35S, R8E	
97-217	USA BLM	0/0/1888	0.011		Bitter Spring #1	on spring in NENE Sec 28, T33S, R8E	
97-219	USA BLM	0/0/1888			Deep Canyon Creek	on stream fr SWSE Sec 7, T33S, R8E	to SENW Sec 15, T34S, R8E
97-231	USA BLM	0/0/1888			Bitter Spring Creek	on stream fr/to SENE Sec 28, T33S, R8E	

WRNUM	NAME	DATE	FLOW cfs	FLOW af	SOURCE	POD	Comment
97-232	USA BLM	0/0/1888			Bitter Creek	on stream fr/to NENE Sec 34, T33S, R8E	
97-233	USA BLM	0/0/1888			Bitter Creek	on stream fr NENE Sec 34, T33S, R8E	to SWNW Sec 3, T34S, R8E
97-235	USA BLM	0/0/1888			Swap Canyon Stream	on stream fr/to SWSE Sec 10, T34S, R8E	
97-246	USA BLM	0/0/1888			Clay Canyon Stream	on stream fr NENE Sec 29, T35S, R9E	Outside of Park bndy?
97-835	USA BLM	0/0/1888			Bitter Spring Creek	on stream fr SENE Sec 28, T33S, R8E	
97-836	USA BLM	0/0/1888			Muley Twist Canyon Creek	on stream fr SENE Sec 13, T35S, R8E	
97-848	USA BLM	0/0/1888			Muley Tanks Wash	on stream fr NWNW Sec 19, T35S, R9E	
97-849	USA BLM	0/0/1888			Halls Creek	on stream fr NENW Sec 4, T36S, R9E	to SWSE Sec 9, T36S, R9E
97-850	USA BLM	0/0/1888			Hall's Creek	on stream fr NENE Sec 21, T36S, R9E	
97-851	USA BLM	0/0/1888			Hall's Creek	on stream fr NWSW Sec 1, T37S, R9E	
97-876	USA BLM	0/0/1888	0.022		Onion Flats Seep	on spring in NWNW Sec 24, T33S, R7E	
97-938	USA BLM	0/0/1888			Onion Flats Wash	on stream fr NWNW Sec 24, T33S, R7E	
97-953	USA BLM	0/0/1888			No. Fork Silver Falls Creek	on stream fr SWSE Sec 31, T34S, R8E	
97-956	USA BLM	0/0/1888			Muley Twist Canyon Creek	on stream fr/to NENE Sec 31, T33S, R8E	
97-957	USA BLM	0/0/1888			Muley Twist Canyon Creek	on stream fr NENW Sec 5, T34S, R8E	
97-958	USA BLM	0/0/1888			Muley Twist Canyon Creek	on stream fr NENE Sec 21, T34S, R8E	
97-959	USA BLM	0/0/1888			Muley Twist Canyon Creek	on stream fr NENE Sec 11, T35S, R8E	
95-544	USA NPS CARE	7/15/1935	0.0557		Fremont River	N406 E504 frSW Sec 14, T29S, R6E	CARE, also #a19741
a19741	USA NPS CARE	2/15/1996	0.0557		Underground Water Well	S1812 W2514 frNE Sec 22, T29S, R6E	CARE, also 95-544
95-6	USA NPS CARE	0/0/1881			Pleasant Creek	on stream fr SENW Sec 29, T30S, R7E	
95-3	USA NPS CARE	0/0/1882	0.1		Miner's Mountain Draw No. 3	N1070 E790 frW4 Sec 29, T30S, R7E	
95-4	USA NPS CARE	0/0/1882	0.1		Miner's Mountain Draw No. 2	S955 E1440 frNW Sec 29, T30S, R7E	
95-747	USA NPS CARE	0/0/1902	1		Sulphur Creek	S350 E950 frW4 Sec 15, T29S, R6E	CARE
95-434	Wayne County Water Conservancy District	11/29/1960	100	50000	Fremont River	S1850 E2640 frNW Sec 22, T29S, R6E	1 of 6 Points of REDIVERSION

Station Inventory for Station: CARE0053

NPS Station ID: CARE0053 | LAT/LON: 38.288616/-111.234449 | Agency: 21UTAH | Date Created: 03/24/79
Location: FREMONT R AT HICKMAN BRIDGE TRAILHEAD | FIPS State/County: 49055 UTAH/WAYNE
Station Type: /TYPA/AMBNT/STREAM | STORET Station ID(s): 495436
RMI-Indexes:
RMI-Miles:
HUC: 14070003 | Depth of Water: 0 | Aquifer:
Major Basin: COLORADO RIVER BASIN | Elevation: 0 | Water Body Id:
Minor Basin: UPPER COLORADO-DIRTY DEVIL R | ECO Region:
RF1 Index: 14070003007 | RF1 Mile Point: 9.770 | Distance from RF1: 0.00 | On/Off RF1: ON
RF3 Index: 14070003048400.00 | RF3 Mile Point: 0.12 | Distance from RF3: 0.02 | On/Off RF3:
Description:

Parameter Inventory for Station: CARE0053

Parameter	Period of Record	Obs	Median	Mean	Maximum	Minimum	Variance	Std. Dev.	10th	25th	75th	90th
00010 TEMPERATURE, WATER (DEGREES CENTIGRADE)	06/20/78-10/13/92	25	11.5	10.724	21.9	0.	34.501	5.874	0.78	6.55	14.65	18.64
00061 FLOW, STREAM, INSTANTANEOUS CFS	06/20/78-10/13/92	12	64.	55.583	81.	20.	499.356	22.346	20.	33.5	71.5	80.1
00076 TURBIDITY,HACH TURBIDIMETER (FORMAZIN TURB UNIT)	06/20/78-08/28/92	23	38.	86.604	1000.	1.2	41061.25	202.636	5.16	13.	79.	125.
00094p SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	10/18/78-10/13/92	24	647.5	649.333	850.	515.	9876.928	99.383	529.5	547.	724.25	795.
00095 SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	06/20/78-08/28/92	23	660.	657.609	870.	519.	10481.249	102.378	547.	560.	721.	840.8
00300p OXYGEN, DISSOLVED MG/L	10/18/78-10/13/92	24	9.05	8.925	10.8	6.6	1.245	1.116	7.4	8.05	9.825	10.6
00310 BOD, 5 DAY, 20 DEG C MG/L	06/20/78-10/18/78	2	1.55	1.55	1.9	1.2	0.245	0.495	**	**	**	**
00335 COD, .025N K2CR207 MG/L	10/18/78-09/14/87	17##	7.5	12.559	26.	5.	52.996	7.28	5.	7.25	18.	26.
00400p PH (STANDARD UNITS)	06/20/78-10/13/92	25	8.4	8.332	8.8	7.3	0.101	0.317	7.86	8.2	8.5	8.64
00400p CONVERTED PH (STANDARD UNITS)	06/20/78-10/13/92	25	8.4	8.17	8.8	7.3	0.128	0.358	7.86	8.2	8.5	8.64
00400p MICRO EQUIVALENTS/LITER OF H+ COMPUTED FROM PH	06/20/78-10/13/92	25	0.004	0.007	0.05	0.002	0.	0.01	0.002	0.003	0.006	0.014
00403 PH, LAB, STANDARD UNITS SU	06/20/78-08/28/92	8	8.1	8.137	8.5	7.8	0.043	0.207	**	**	**	**
00403 CONVERTED PH, LAB, STANDARD UNITS	06/20/78-08/28/92	8	8.1	8.096	8.5	7.8	0.045	0.211	**	**	**	**
00403 MICRO EQUIVALENTS/LITER OF H+ COMPUTED FROM PH	06/20/78-08/28/92	8	0.008	0.008	0.016	0.003	0.	0.004	**	**	**	**
00405 CARBON DIOXIDE (MG/L AS CO2)	06/20/78-08/28/92	22	2.	1.909	4.	0.	0.658	0.811	1.	1.75	2.	3.
00410 ALKALINITY, TOTAL (MG/L AS CACO3)	06/20/78-08/28/92	23	148.	149.391	174.	133.	116.794	10.807	134.4	141.	157.	167.
00440 BICARBONATE ION (MG/L AS HCO3)	06/20/78-08/28/92	23	180.	180.522	212.	156.	184.806	13.594	162.8	172.	189.	201.6
00445 CARBONATE ION (MG/L AS CO3)	06/20/78-08/28/92	23	0.	0.696	8.	0.	3.858	1.964	0.	0.	0.	4.
00515 RESIDUE, TOTAL FILTRABLE (DRIED AT 105C),MG/L	06/20/78-10/10/84	12	125.5	268.083	1020.	55.	97585.538	312.387	58.9	80.5	319.75	949.8
00530 RESIDUE, TOTAL NONFILTRABLE (MG/L)	05/05/81-10/13/92	18	106.	237.722	1020.	7.	82070.801	286.48	12.4	63.	369.5	809.4
00610 NITROGEN, AMMONIA, TOTAL (MG/L AS N)	10/16/79-10/13/92	22##	0.05	0.087	0.7	0.	0.02	0.14	0.025	0.044	0.1	0.1
00613 NITRITE NITROGEN, DISSOLVED (MG/L AS N)	06/20/78-09/14/87	7##	0.025	0.02	0.05	0.005	0.	0.017	**	**	**	**
00615 NITRITE NITROGEN, TOTAL (MG/L AS N)	10/28/80-09/14/87	5##	0.025	0.017	0.025	0.005	0.	0.011	**	**	**	**
00618 NITRATE NITROGEN, DISSOLVED (MG/L AS N)	06/20/78-09/14/87	8	0.23	0.284	0.8	0.1	0.053	0.231	**	**	**	**
00620 NITRATE NITROGEN, TOTAL (MG/L AS N)	10/28/80-09/14/87	5	0.22	0.302	0.8	0.1	0.081	0.284	**	**	**	**
00625p NITROGEN, KJELDAHL, TOTAL, (MG/L AS N)	06/20/78-10/13/92	24	0.35	0.48	1.3	0.05	0.125	0.353	0.075	0.21	0.685	1.12
00630 NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	06/20/78-11/20/91	16	0.525	0.519	1.67	0.	0.189	0.435	0.056	0.15	0.788	1.166
00631 NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	04/04/91-10/13/92	6	0.2	0.302	0.7	0.04	0.082	0.287	**	**	**	**
00665p PHOSPHORUS, TOTAL (MG/L AS P)	06/20/78-10/13/92	24	0.08	0.113	0.6	0.02	0.016	0.126	0.025	0.041	0.128	0.27
00666 PHOSPHORUS, DISSOLVED (MG/L AS P)	04/04/91-10/13/92	6	0.029	0.024	0.043	0.005	0.	0.016	**	**	**	**
00671 PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	06/20/78-09/14/87	8##	0.015	0.095	0.6	0.003	0.042	0.205	**	**	**	**
00680 CARBON, TOTAL ORGANIC (MG/L AS C)	06/20/78-09/14/87	16	3.25	5.519	18.	1.3	25.059	5.006	1.37	2.325	7.05	15.97
00900p HARDNESS, TOTAL (MG/L AS CACO3)	06/20/78-10/13/92	24	318.	314.917	430.	236.	2679.123	51.76	253.	270.	342.25	398.
00915p CALCIUM, DISSOLVED (MG/L AS CA)	06/20/78-10/13/92	24	80.	81.263	120.	52.	251.602	15.862	63.5	69.25	87.75	107.5
00925p MAGNESIUM, DISSOLVED (MG/L AS MG)	06/20/78-10/13/92	24	27.8	27.067	34.	19.	19.098	4.37	21.	23.25	30.75	33.
00930 SODIUM, DISSOLVED (MG/L AS NA)	06/20/78-08/28/92	23	20.	20.609	30.	15.	14.431	3.799	16.	17.	23.	26.2
00935 POTASSIUM, DISSOLVED (MG/L AS K)	06/20/78-08/28/92	23	6.	5.53	9.6	4.	1.929	1.389	4.	4.	6.	7.06
00940 CHLORIDE,TOTAL IN WATER MG/L	06/20/78-09/14/87	18	17.	16.722	22.	12.	5.036	2.244	12.9	16.	18.	20.2

** - Less than 9 observations ## - Computed with 50% or more of the total observations as values that were half the detection limit p - Has a corresponding time series plot

APPENDIX B. Water quality data.

Parameter Inventory for Station: CARE0053

Parameter	Period of Record	Obs	Median	Mean	Maximum	Minimum	Variance	Std. Dev.	10th	25th	75th	90th
00941 CHLORIDE, DISSOLVED IN WATER MG/L	10/16/79-08/28/92	19	17.	16.579	20.	12.	3.702	1.924	13.	16.	18.	19.
00946 SULFATE, DISSOLVED (MG/L AS SO4)	06/20/78-08/28/92	22	170.5	174.725	285.	0.05	4514.155	67.187	106.7	133.5	217.5	274.4
00950 FLUORIDE, DISSOLVED (MG/L AS F)	06/20/78-10/29/82	8	0.205	0.198	0.26	0.05	0.004	0.067	**	**	**	**
00955 SILICA, DISSOLVED (MG/L AS SIO2)	06/20/78-10/29/82	7	30.	31.	35.	27.	9.333	3.055	**	**	**	**
01002 ARSENIC, TOTAL (UG/L AS AS)	06/20/78-08/01/91	19	5.	4.789	7.	2.	2.37	1.539	2.5	4.	6.	7.
01007 BARIUM, TOTAL (UG/L AS BA)	10/28/80-08/01/91	17##	0.025	9.729	70.	0.025	400.992	20.025	0.025	0.025	12.53	46.
01020 BORON, DISSOLVED (UG/L AS B)	06/20/78-10/29/82	8	117.5	118.125	145.	90.	313.839	17.716	**	**	**	**
01027 CADMIUM, TOTAL (UG/L AS CD)	10/28/80-08/01/91	17##	0.5	0.5	0.5	0.5	0.	0.	0.5	0.5	0.5	0.5
01032 CHROMIUM, HEXAVALENT (UG/L AS CR)	10/28/80-10/29/82	5##	2.5	2.5	2.5	2.5	0.	0.	**	**	**	**
01034 CHROMIUM, TOTAL (UG/L AS CR)	10/28/80-08/01/91	17##	2.5	2.5	2.5	2.5	0.	0.	2.5	2.5	2.5	2.5
01040 COPPER, DISSOLVED (UG/L AS CU)	10/13/92-10/13/92	1##	10.	10.	10.	10.	0.	0.	**	**	**	**
01042 COPPER, TOTAL (UG/L AS CU)	10/18/78-08/01/91	18##	5.	8.333	40.	5.	67.647	8.225	5.	5.	10.	13.
01051 LEAD, TOTAL (UG/L AS PB)	10/28/80-08/01/91	17##	2.5	4.853	35.	2.5	61.305	7.83	2.5	2.5	3.75	11.
01055 MANGANESE, TOTAL (UG/L AS MN)	06/20/78-08/01/91	19	70.	97.842	315.	15.	6433.474	80.209	29.	45.	120.	260.
01067 NICKEL, TOTAL (UG/L AS NI)	10/28/80-10/29/82	11##	5.	7.727	20.	5.	36.818	6.068	5.	5.	5.	20.
01077 SILVER, TOTAL (UG/L AS AG)	10/28/80-08/01/91	17##	1.	1.	1.	1.	0.	0.	1.	1.	1.	1.
01092 ZINC, TOTAL (UG/L AS ZN)	06/20/78-08/01/91	19	20.	24.842	90.	5.	510.474	22.594	5.	10.	25.	60.
01147 SELENIUM, TOTAL (UG/L AS SE)	10/28/80-08/01/91	17##	0.5	0.647	2.5	0.25	0.5	0.707	0.25	0.25	0.5	2.5
01167 SELENIUM, ACID SOLUBLE, WATER, WHOLE UG/L	11/20/91-08/28/92	3##	2.5	3.333	5.	2.5	2.083	1.443	**	**	**	**
01501 ALPHA, TOTAL	01/27/81-05/11/82	7	7.	8.714	21.	4.	34.238	5.851	**	**	**	**
03501 BETA, TOTAL	01/27/81-05/11/82	7	7.	8.714	21.	4.	34.238	5.851	**	**	**	**
07000 TRITIUM (1H3),TOTAL (PICOCURIES/LITER)	01/27/81-05/11/82	7	12.	30.571	151.	0.	2892.286	53.78	**	**	**	**
09501 RADIUM 226, TOTAL	01/27/81-05/11/82	7##	250.	214.286	250.	0.	8928.571	94.491	**	**	**	**
11501 RADIUM 228, TOTAL	07/07/81-05/11/82	6##	0.5	0.583	1.	0.5	0.042	0.204	**	**	**	**
31506 COLIFORM,TOT,MPN, CONFIRMED TEST, TUBE CONFIG.	06/20/78-10/18/78	2	235.	235.	430.	40.	76050.	275.772	**	**	**	**
31506 LOG COLIFORM,TOT,MPN, CONFIRMED TEST, TUBE CONFIG.	06/20/78-10/18/78	2	2.118	2.118	2.633	1.602	0.532	0.729	**	**	**	**
31506 GM COLIFORM,TOT,MPN, CONFIRMED TEST, TUBE CONFIG.		GEOMETRIC MEAN =		131.149								
31614 FECAL COLIFORM,MPN,TUBE CONFIGURATION	06/20/78-10/18/78	2	3965.	3965.	7500.	430.	24992450.	4999.245	**	**	**	**
31614 LOG FECAL COLIFORM,MPN,TUBE CONFIGURATION	06/20/78-10/18/78	2	3.254	3.254	3.875	2.633	0.771	0.878	**	**	**	**
31614 GM FECAL COLIFORM,MPN,TUBE CONFIGURATION		GEOMETRIC MEAN =		1795.828								
70300 RESIDUE,TOTAL FILTRABLE (DRIED AT 180C),MG/L	06/20/78-08/28/92	23	462.	463.217	620.	370.	5807.178	76.205	380.8	394.	516.	601.6
71830 HYDROXIDE ION (MG/L AS OH)	06/20/78-08/28/92	23	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
71886 PHOSPHORUS, TOTAL, AS PO4 - MG/L	10/28/80-10/10/84	4##	0.035	0.169	0.6	0.005	0.083	0.289	**	**	**	**
71900 MERCURY, TOTAL (UG/L AS HG)	10/28/80-08/01/91	17##	0.05	0.085	0.4	0.05	0.007	0.084	0.05	0.05	0.1	0.16
74010 IRON, TOTAL (MG/L AS FE)	06/20/78-08/01/91	19	0.64	0.895	3.54	0.13	0.648	0.805	0.22	0.4	1.3	1.93
82702 AS DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	2.5	2.5	2.5	2.5	0.	0.	**	**	**	**
82703 BA DECNT FLD ACID WTR MG/L	11/20/91-08/28/92	3	70.	896.667	2600.	20.	2176633.333	1475.342	**	**	**	**
82705 CD DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	0.5	0.5	0.5	0.5	0.	0.	**	**	**	**
82706 CR DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	2.5	2.5	2.5	2.5	0.	0.	**	**	**	**
82708 CU DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	10.	10.	10.	10.	0.	0.	**	**	**	**
82710 FE DECNT FLD ACID WTR MG/L	11/20/91-08/28/92	3	0.36	0.79	2.	0.01	1.129	1.062	**	**	**	**
82711 PB DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	2.5	3.333	5.	2.5	2.083	1.443	**	**	**	**
82712 MN DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3	46.	792.	2300.	30.	1705612.	1305.991	**	**	**	**
82713 HG DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	0.1	0.233	0.5	0.1	0.053	0.231	**	**	**	**
82716 AG DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	1.	1.	1.	1.	0.	0.	**	**	**	**
82719 ZN DECNT FLD ACID WTR UG/L	11/20/91-08/28/92	3##	10.	17.667	33.	10.	176.333	13.279	**	**	**	**

** - Less than 9 observations ## - Computed with 50% or more of the total observations as values that were half the detection limit p - Has a corresponding time series plot

EPA Water Quality Criteria Analysis for Station: CARE0053

Parameter	Std. Type	Std. Value	Total Obs	Exceed Standard	Prop. Exceeding	7/01-10/14 Obs	7/01-10/14 Exceed	7/01-10/14 Prop.	10/15-4/09 Obs	10/15-4/09 Exceed	10/15-4/09 Prop.	4/10-6/30 Obs	4/10-6/30 Exceed	4/10-6/30 Prop.	n/a Obs	n/a Exceed	n/a Prop.
00076 TURBIDITY, HACH TURBIDIMETER	Other-Hi Lim.	50.	23	10	0.43	7	2	0.29	13	7	0.54	3	1	0.33			
00300 OXYGEN, DISSOLVED	Fresh Acute	4.	24	0	0.00	8	0	0.00	14	0	0.00	2	0	0.00			
00400 PH	Other-Hi Lim.	9.	25	0	0.00	8	0	0.00	14	0	0.00	3	0	0.00			
	Other-Lo Lim.	6.5	25	0	0.00	8	0	0.00	14	0	0.00	3	0	0.00			
00403 PH, LAB	Other-Hi Lim.	9.	8	0	0.00	3	0	0.00	4	0	0.00	1	0	0.00			
	Other-Lo Lim.	6.5	8	0	0.00	3	0	0.00	4	0	0.00	1	0	0.00			
00613 NITRITE NITROGEN, DISSOLVED AS N	Drinking Water	1.	7	0	0.00	3	0	0.00	3	0	0.00	1	0	0.00			

& - Below detection limit observations, for which half the detection limit exceeded the edit criterion, were excluded from the criterion comparison for this parameter

EPA Water Quality Criteria Analysis for Station: CARE0053

Parameter		Std. Type	Std. Value	Total Obs	Exceed Standard	Prop. Exceeding	7/01-10/14 Obs	7/01-10/14 Exceed	7/01-10/14 Prop.	10/15- 4/09 Obs	10/15- 4/09 Exceed	10/15- 4/09 Prop.	4/10- 6/30 Obs	4/10- 6/30 Exceed	4/10- 6/30 Prop.
00615	NITRITE NITROGEN, TOTAL AS N	Drinking Water	1.	5	0	0.00	2	0	0.00	3	0	0.00			
00618	NITRATE NITROGEN, DISSOLVED AS N	Drinking Water	10.	8	0	0.00	3	0	0.00	4	0	0.00	1	0	0.00
00620	NITRATE NITROGEN, TOTAL AS N	Drinking Water	10.	5	0	0.00	2	0	0.00	3	0	0.00			
00630	NITRITE PLUS NITRATE, TOTAL 1 DET.	Drinking Water	10.	16	0	0.00	2	0	0.00	11	0	0.00	3	0	0.00
00631	NITRATE PLUS NITRATE, DISS. 1 DET.	Drinking Water	10.	6	0	0.00	3	0	0.00	3	0	0.00			
00940	CHLORIDE,TOTAL IN WATER	Fresh Acute	860.	18	0	0.00	5	0	0.00	10	0	0.00	3	0	0.00
00941	CHLORIDE, DISSOLVED IN WATER	Fresh Acute	860.	19	0	0.00	5	0	0.00	12	0	0.00	2	0	0.00
00946	SULFATE, DISSOLVED (AS SO4)	Drinking Water	400.	22	0	0.00	6	0	0.00	13	0	0.00	3	0	0.00
01002	ARSENIC, TOTAL	Fresh Acute	360.	19	0	0.00	6	0	0.00	10	0	0.00	3	0	0.00
		Drinking Water	50.	19	0	0.00	6	0	0.00	10	0	0.00	3	0	0.00
01007	BARIUM, TOTAL	Drinking Water	2000.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
01027	CADMIUM, TOTAL	Fresh Acute	3.9	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
		Drinking Water	5.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
01032	CHROMIUM, HEXAVALENT	Fresh Acute	16.	5	0	0.00				5	0	0.00			
		Drinking Water	100.	5	0	0.00				5	0	0.00			
01034	CHROMIUM, TOTAL	Drinking Water	100.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
01040	COPPER, DISSOLVED	Fresh Acute	18.	1	0	0.00	1	0	0.00						
		Drinking Water	1300.	1	0	0.00	1	0	0.00						
01042	COPPER, TOTAL	Fresh Acute	18.	18	1	0.06	6	0	0.00	10	1	0.10	2	0	0.00
		Drinking Water	1300.	18	0	0.00	6	0	0.00	10	0	0.00	2	0	0.00
01051	LEAD, TOTAL	Fresh Acute	82.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
		Drinking Water	5.	17	4	0.24	6	1	0.17	9	3	0.33	2	0	0.00
01067	NICKEL, TOTAL	Fresh Acute	1400.	11	0	0.00	2	0	0.00	7	0	0.00	2	0	0.00
		Drinking Water	100.	11	0	0.00	2	0	0.00	7	0	0.00	2	0	0.00
01077	SILVER, TOTAL	Fresh Acute	4.1	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
		Drinking Water	50.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
01092	ZINC, TOTAL	Fresh Acute	120.	19	0	0.00	6	0	0.00	10	0	0.00	3	0	0.00
01147	SELENIUM, TOTAL	Fresh Acute	20.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
		Drinking Water	50.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
01167	SELENIUM, ACID SOLUBLE, WATER, WHOLE	Fresh Acute	20.	3	0	0.00	1	0	0.00	2	0	0.00			
		Drinking Water	50.	3	0	0.00	1	0	0.00	2	0	0.00			
31506	COLIFORM, TOTAL, MPN, CONF. TEST, TUBE C	Other-Hi Lim.	1000.	2	0	0.00				1	0	0.00	1	0	0.00
31614	FECAL COLIFORM, MPN, TUBE CONFIGURATION	Other-Hi Lim.	200.	2	2	1.00				1	1	1.00	1	1	1.00
71900	MERCURY, TOTAL	Fresh Acute	2.4	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00
		Drinking Water	2.	17	0	0.00	6	0	0.00	9	0	0.00	2	0	0.00

& - Below detection limit observations, for which half the detection limit exceeded the edit criterion, were excluded from the criterion comparison for this parameter

(continued Appendix B)

Station Inventory for Station: CARE0052

NPS Station ID: CARE0052 LAT/LON: 38.287227/-111.249448 Agency: 112WRD Date Created: 02/20/76
Location: SULPHUR CREEK AT MOUTH AT FRUITA, UTAH FIPS State/County: 49055 UTAH/WAYNE
Station Type: /TYPA/AMBNT/STREAM STORET Station ID(s): 381714111145801
RMI-Indexes:
RMI-Miles:
HUC: 14070003 Depth of Water: 0 Aquifer:
Major Basin: Elevation: 0 Water Body Id:
Minor Basin: ECO Region:
RF1 Index: 14070003 RF1 Mile Point: 0.000 Distance from RF1: 0.00 On/Off RF1:
RF3 Index: 14070003001100.22 RF3 Mile Point: 0.55 Distance from RF3: 0.01 On/Off RF3:
Description:

Parameter Inventory for Station: CARE0052

Parameter		Period of Record	Obs	Median	Mean	Maximum	Minimum	Variance	Std. Dev.	10th	25th
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	08/28/75-09/09/76	5	19.	17.8	23.	7.5	38.075	6.17	**	**
00061	FLOW, STREAM, INSTANTANEOUS CFS	08/28/75-09/09/76	5	2.	2.6	5.	1.	3.3	1.817	**	**
00095	SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	08/28/75-09/09/76	5	1740.	1744.	2030.	1470.	57280.	239.332	**	**
00400	PH (STANDARD UNITS)	08/28/75-09/09/76	5	7.9	7.92	8.1	7.8	0.017	0.13	**	**
00400	CONVERTED PH (STANDARD UNITS)	08/28/75-09/09/76	5	7.9	7.905	8.1	7.8	0.017	0.131	**	**
00400	MICRO EQUIVALENTS/LITER OF H+ COMPUTED FROM PH	08/28/75-09/09/76	5	0.013	0.012	0.016	0.008	0.	0.004	**	**
00405	CARBON DIOXIDE (MG/L AS CO2)	08/28/75-09/09/76	5	4.6	4.24	5.6	3.	1.228	1.108	**	**
00410	ALKALINITY, TOTAL (MG/L AS CACO3)	08/28/75-09/09/76	5	182.	176.4	195.	148.	403.3	20.082	**	**
00440	BICARBONATE ION (MG/L AS HCO3)	08/28/75-09/09/76	5	222.	215.	238.	180.	607.	24.637	**	**
00445	CARBONATE ION (MG/L AS CO3)	08/28/75-09/09/76	5	0.	0.	0.	0.	0.	0.	**	**
00631	NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	08/28/75-09/09/76	5	0.3	0.34	0.6	0.1	0.043	0.207	**	**
00660	PHOSPHATE, ORTHO (MG/L AS PO4)	08/28/75-09/09/76	5	0.06	0.716	3.4	0.	2.252	1.501	**	**
00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	08/28/75-08/10/76	3	0.01	0.012	0.02	0.005	0.	0.008	**	**
00900	HARDNESS, TOTAL (MG/L AS CACO3)	08/28/75-09/09/76	5	970.	960.	1100.	750.	22450.	149.833	**	**
00902	HARDNESS, NON-CARBONATE (MG/L AS CACO3)	08/28/75-09/09/76	5	780.	800.	990.	570.	32600.	180.555	**	**
00915	CALCIUM, DISSOLVED (MG/L AS CA)	08/28/75-09/09/76	5	250.	256.	330.	190.	3080.	55.498	**	**
00925	MAGNESIUM, DISSOLVED (MG/L AS MG)	08/28/75-09/09/76	5	79.	80.8	98.	66.	135.7	11.649	**	**
00930	SODIUM, DISSOLVED (MG/L AS NA)	08/28/75-09/09/76	5	41.	40.4	48.	34.	31.3	5.595	**	**
00931	SODIUM ADSORPTION RATIO	08/28/75-09/09/76	5	0.6	0.58	0.6	0.5	0.002	0.045	**	**
00932	SODIUM, PERCENT	08/28/75-09/09/76	5	8.	8.	9.	7.	0.5	0.707	**	**
00935	POTASSIUM, DISSOLVED (MG/L AS K)	08/28/75-09/09/76	5	19.	19.4	25.	15.	17.3	4.159	**	**
00940	CHLORIDE,TOTAL IN WATER MG/L	08/28/75-09/09/76	5	31.	32.2	38.	28.	15.2	3.899	**	**
00945	SULFATE, TOTAL (MG/L AS SO4)	08/28/75-09/09/76	5	810.	814.	1000.	600.	30030.	173.292	**	**
00950	FLUORIDE, DISSOLVED (MG/L AS F)	08/28/75-09/09/76	5	0.4	0.44	0.5	0.4	0.003	0.055	**	**
00955	SILICA, DISSOLVED (MG/L AS SI02)	08/28/75-09/09/76	5	24.	24.	26.	21.	3.5	1.871	**	**
01000	ARSENIC, DISSOLVED (UG/L AS AS)	11/17/75-09/09/76	3	2.	2.167	4.	0.5	3.083	1.756	**	**
01005	BARIUM, DISSOLVED (UG/L AS BA)	11/17/75-08/10/76	2##	50.	50.	50.	50.	0.	0.	**	**
01020	BORON, DISSOLVED (UG/L AS B)	08/28/75-09/09/76	5	260.	248.	330.	190.	3170.	56.303	**	**
01035	COBALT, DISSOLVED (UG/L AS CO)	11/17/75-08/10/76	2##	0.	0.	0.	0.	0.	0.	**	**
01046	IRON, DISSOLVED (UG/L AS FE)	11/17/75-09/09/76	4	45.	47.5	80.	20.	758.333	27.538	**	**
01049	LEAD, DISSOLVED (UG/L AS PB)	11/17/75-08/10/76	2	2.5	2.5	3.	2.	0.5	0.707	**	**
01056	MANGANESE, DISSOLVED (UG/L AS MN)	11/17/75-09/09/76	4	35.	28.75	40.	5.	272.917	16.52	**	**
01060	MOLYBDENUM, DISSOLVED (UG/L AS MO)	11/17/75-08/10/76	2	1.	1.	1.	1.	0.	0.	**	**
01080	STRONTIUM, DISSOLVED (UG/L AS SR)	08/28/75-08/10/76	3	3100.	3366.667	3900.	3100.	213333.333	461.88	**	**
01090	ZINC, DISSOLVED (UG/L AS ZN)	11/17/75-09/09/76	3##	10.	6.667	10.	0.	33.333	5.774	**	**
01106	ALUMINUM, DISSOLVED (UG/L AS AL)	11/17/75-08/10/76	2	15.	15.	20.	10.	50.	7.071	**	**
01130	LITHIUM, DISSOLVED (UG/L AS LI)	11/17/75-08/10/76	2	55.	55.	60.	50.	50.	7.071	**	**
01145	SELENIUM, DISSOLVED (UG/L AS SE)	11/17/75-09/09/76	3	1.	1.	1.	1.	0.	0.	**	**

** - Less than 9 observations ## - Computed with 50% or more of the total observations as values that were half the detection limit p - Has a corresponding time series plot

(Appendix B continued)

Parameter Inventory for Station: CARE0052

Parameter	Period of Record	Obs	Median	Mean	Maximum	Minimum	Variance	Std. Dev.	10th	25th
70301 SOLIDS, DISSOLVED-SUM OF CONSTITUENTS (MG/L)	08/28/75-09/09/76	5	1380.	1378.	1630.	1070.	57070.	238.893	**	**
70302 SOLIDS, DISSOLVED-TONS PER DAY	08/28/75-09/09/76	5	6.71	9.274	16.5	3.47	38.711	6.222	**	**
70303 SOLIDS, DISSOLVED-TONS PER ACRE-FT	08/28/75-09/09/76	5	1.88	1.876	2.22	1.46	0.105	0.324	**	**
71890 MERCURY, DISSOLVED (UG/L AS HG)	11/17/75-09/09/76	3##	0.25	0.25	0.25	0.25	0.	0.	**	**

** - Less than 9 observations   ## - Computed with 50% or more of the total observations as values that were half the detection limit   p - Has a corresponding time series plot

EPA Water Quality Criteria Analysis for Station: CARE0052

Parameter	Std. Type	Std. Value	Total Obs	Exceed Standard	Prop. Exceeding	7/01-10/14 Obs	7/01-10/14 Exceed	7/01-10/14 Prop.	10/15-4/09 Obs	10/15-4/09 Exceed	10/15-4/09 Prop.	4/10-6/30 Obs	4/10-6/30 Exceed	4/10-6/30 Prop.
00400 PH	Other-Hi Lim.	9.	5	0	0.00	3	0	0.00	1	0	0.00	1	0	0.00
	Other-Lo Lim.	6.5	5	0	0.00	3	0	0.00	1	0	0.00	1	0	0.00
00631 NITRATE PLUS NITRATE, DISS. 1 DET.	Drinking Water	10.	5	0	0.00	3	0	0.00	1	0	0.00	1	0	0.00
00940 CHLORIDE,TOTAL IN WATER	Fresh Acute	860.	5	0	0.00	3	0	0.00	1	0	0.00	1	0	0.00
00945 SULFATE, TOTAL (AS SO4)	Drinking Water	400.	5	5	1.00	3	3	1.00	1	1	1.00	1	1	1.00
01000 ARSENIC, DISSOLVED	Fresh Acute	360.	3	0	0.00	2	0	0.00	1	0	0.00			
	Drinking Water	50.	3	0	0.00	2	0	0.00	1	0	0.00			
01005 BARIUM, DISSOLVED	Drinking Water	2000.	2	0	0.00	1	0	0.00	1	0	0.00			
01049 LEAD, DISSOLVED	Fresh Acute	82.	2	0	0.00	1	0	0.00	1	0	0.00			
	Drinking Water	5.	2	0	0.00	1	0	0.00	1	0	0.00			
01090 ZINC, DISSOLVED	Fresh Acute	120.	3	0	0.00	2	0	0.00	1	0	0.00			
01145 SELENIUM, DISSOLVED	Fresh Acute	20.	3	0	0.00	2	0	0.00	1	0	0.00			
	Drinking Water	50.	3	0	0.00	2	0	0.00	1	0	0.00			
71890 MERCURY, DISSOLVED	Fresh Acute	2.4	3	0	0.00	2	0	0.00	1	0	0.00			
	Drinking Water	2.	3	0	0.00	2	0	0.00	1	0	0.00			

& - Below detection limit observations, for which half the detection limit exceeded the edit criterion, were excluded from the criterion comparison for this parameter

(continued Appendix B)

Station Inventory for Station: CARE0027

NPS Station ID: CARE0027 LAT/LON: 38.179726/-111.179726 Agency: 112WRD Date Created: / /
Location: PLEASANT CREEK AT PLEASANT CREEK RANCH FIPS State/County: 49055 UTAH/WAYNE
Station Type: /TYPA/AMBNT/STREAM STORET Station ID(s): 381047111104701
RMI-Indexes:
RMI-Miles:
HUC: 14070003 Depth of Water: 0 Aquifer:
Major Basin: Elevation: 0 Water Body Id:
Minor Basin: ECO Region:
RF1 Index: 14070003 RF1 Mile Point: 0.000 Distance from RF1: 0.00 On/Off RF1:
RF3 Index: 14070003002300.27 RF3 Mile Point: 0.26 Distance from RF3: 0.04 On/Off RF3:
Description:

Parameter Inventory for Station: CARE0027

Parameter		Period of Record	Obs	Median	Mean	Maximum	Minimum	Variance	Std. Dev.	10th	25th
00010	TEMPERATURE, WATER (DEGREES CENTIGRADE)	07/24/75-05/25/76	3	16.	17.167	19.5	16.	4.083	2.021	**	**
00061	FLOW, STREAM, INSTANTANEOUS CFS	07/24/75-05/25/76	3	5.	6.667	10.	5.	8.333	2.887	**	**
00095	SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	07/24/75-05/25/76	3	216.	224.	251.	205.	577.	24.021	**	**
00400	PH (STANDARD UNITS)	07/24/75-05/25/76	3	8.3	8.267	8.4	8.1	0.023	0.153	**	**
00400	CONVERTED PH (STANDARD UNITS)	07/24/75-05/25/76	3	8.3	8.248	8.4	8.1	0.024	0.154	**	**
00400	MICRO EQUIVALENTS/LITER OF H+ COMPUTED FROM PH	07/24/75-05/25/76	3	0.005	0.006	0.008	0.004	0.	0.002	**	**
00405	CARBON DIOXIDE (MG/L AS CO2)	07/24/75-05/25/76	3	0.8	1.	1.4	0.8	0.12	0.346	**	**
00410	ALKALINITY, TOTAL (MG/L AS CACO3)	07/24/75-05/25/76	3	89.	92.	101.	86.	63.	7.937	**	**
00440	BICARBONATE ION (MG/L AS HCO3)	07/24/75-05/25/76	3	109.	112.333	123.	105.	89.333	9.452	**	**
00445	CARBONATE ION (MG/L AS CO3)	07/24/75-05/25/76	3	0.	0.	0.	0.	0.	0.	**	**
00631	NITRITE PLUS NITRATE, DISS. 1 DET. (MG/L AS N)	07/24/75-05/25/76	3	0.02	0.03	0.05	0.02	0.	0.017	**	**
00660	PHOSPHATE, ORTHO (MG/L AS PO4)	07/24/75-05/25/76	3	0.06	0.07	0.09	0.06	0.	0.017	**	**
00671	PHOSPHORUS, DISSOLVED ORTHOPHOSPHATE (MG/L AS P)	07/24/75-08/27/75	2	0.025	0.025	0.03	0.02	0.	0.007	**	**
00900	HARDNESS, TOTAL (MG/L AS CACO3)	07/24/75-05/25/76	3	100.	105.	120.	95.	175.	13.229	**	**
00902	HARDNESS, NON-CARBONATE (MG/L AS CACO3)	07/24/75-05/25/76	3	11.	14.333	23.	9.	57.333	7.572	**	**
00915	CALCIUM, DISSOLVED (MG/L AS CA)	07/24/75-05/25/76	3	25.	25.667	28.	24.	4.333	2.082	**	**
00925	MAGNESIUM, DISSOLVED (MG/L AS MG)	07/24/75-05/25/76	3	9.8	10.233	13.	7.9	6.643	2.577	**	**
00930	SODIUM, DISSOLVED (MG/L AS NA)	07/24/75-05/25/76	3	4.2	4.067	4.5	3.5	0.263	0.513	**	**
00931	SODIUM ADSORPTION RATIO	07/24/75-05/25/76	3	0.2	0.2	0.2	0.2	0.	0.	**	**
00932	SODIUM, PERCENT	07/24/75-05/25/76	3	7.	7.333	8.	7.	0.333	0.577	**	**
00935	POTASSIUM, DISSOLVED (MG/L AS K)	07/24/75-05/25/76	3	1.8	1.767	1.8	1.7	0.003	0.058	**	**
00940	CHLORIDE,TOTAL IN WATER MG/L	07/24/75-05/25/76	3	2.	2.	3.	1.	1.	1.	**	**
00945	SULFATE, TOTAL (MG/L AS SO4)	07/24/75-05/25/76	3	19.	22.667	31.	18.	52.333	7.234	**	**
00950	FLUORIDE, DISSOLVED (MG/L AS F)	07/24/75-05/25/76	3	0.1	0.1	0.1	0.1	0.	0.	**	**
00955	SILICA, DISSOLVED (MG/L AS SIO2)	07/24/75-05/25/76	3	24.	23.	25.	20.	7.	2.646	**	**
01020	BORON, DISSOLVED (UG/L AS B)	07/24/75-05/25/76	3##	10.	16.667	30.	10.	133.333	11.547	**	**
01046	IRON, DISSOLVED (UG/L AS FE)	05/25/76-05/25/76	1	40.	40.	40.	40.	0.	0.	**	**
01056	MANGANESE, DISSOLVED (UG/L AS MN)	05/25/76-05/25/76	1##	5.	5.	5.	5.	0.	0.	**	**
01080	STRONTIUM, DISSOLVED (UG/L AS SR)	08/27/75-08/27/75	1	210.	210.	210.	210.	0.	0.	**	**
01145	SELENIUM, DISSOLVED (UG/L AS SE)	07/24/75-07/24/75	1##	0.5	0.5	0.5	0.5	0.	0.	**	**
70301	SOLIDS, DISSOLVED-SUM OF CONSTITUENTS (MG/L)	07/24/75-05/25/76	3	139.	145.	162.	134.	223.	14.933	**	**
70302	SOLIDS, DISSOLVED-TONS PER DAY	07/24/75-05/25/76	3	1.88	2.687	4.37	1.81	2.126	1.458	**	**
70303	SOLIDS, DISSOLVED-TONS PER ACRE-FT	07/24/75-05/25/76	3	0.19	0.197	0.22	0.18	0.	0.021	**	**

** - Less than 9 observations ## - Computed with 50% or more of the total observations as values that were half the detection limit p - Has a corresponding time series plot

(continued Appendix B)

EPA Water Quality Criteria Analysis for Station: CARE0027

Parameter	Std. Type	Std. Value	Total Obs	Exceed Standard	Prop. Exceeding	7/01-10/14 Obs	7/01-10/14 Exceed	7/01-10/14 Prop.	10/15- 4/09 Obs	10/15- 4/09 Exceed	10/15- 4/09 Prop.	4/10- 6/30 Obs	4/10- 6/30 Exceed	4/10- 6/30 Prop.
00400 PH	Other-Hi Lim.	9.	3	0	0.00	2	0	0.00				1	0	0.00
	Other-Lo Lim.	6.5	3	0	0.00	2	0	0.00				1	0	0.00
00631 NITRATE PLUS NITRATE, DISS. 1 DET.	Drinking Water	10.	3	0	0.00	2	0	0.00				1	0	0.00
00940 CHLORIDE,TOTAL IN WATER	Fresh Acute	860.	3	0	0.00	2	0	0.00				1	0	0.00
00945 SULFATE, TOTAL (AS SO4)	Drinking Water	400.	3	0	0.00	2	0	0.00				1	0	0.00
01145 SELENIUM, DISSOLVED	Fresh Acute	20.	1	0	0.00	1	0	0.00						
	Drinking Water	50.	1	0	0.00	1	0	0.00						

& - Below detection limit observations, for which half the detection limit exceeded the edit criterion, were excluded from the criterion comparison for this parameter

(continued Appendix B)