CANYONLANDS NATIONAL PARK, ARCHES NATIONAL PARK, AND NATURAL BRIDGES NATIONAL MONUMENT

WATER RESOURCES SCOPING REPORT

Kevin Berghoff and David Vana-Miller

Technical Report NPS/NRWRS/NRTR-97/94

WATER RESOURCES DIVISION

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for

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NATURAL BRIDGES NATIONAL MONUMENT

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EXECUTIVE SUMMARY

Canyonlands and Arches National Parks and Natural Bridges National Monument, collectively called the Southeast Utah Group Parks, are located in the high desert of the Colorado Plateau in southeast Utah. All three park units were established due to the unique scenic, scientific, and archeological features found within their boundaries. Due to the and environment of the Colorado Plateau, water resources are a critical concern of National Park Service (NPS) management.

The Group Parks are located in the Upper Colorado River Basin as designated by the Colorado River Compact of 1922. The operation of all reservoirs and apportionment of all water throughout the upper basin is dictated in accordance with the "Law of the River." Legislation and operating criteria for the water storage facilities in the upper basin have significantly altered the flow regime of the Colorado and Green rivers through Canyonlands National Park. Subsequent effects of altered flow regime include impacts on water quality, endemic fish habitat, adjacent riparian/wetland areas and associated biota.

The purpose of this scoping report is to describe the existing condition of the watershed, identify specific water resource issues of concern to park management, and provide recommendations on future actions. Initial meetings with the Group Parks Resource Management staff identified the following issues to address in this report:

- Water quality
- Seeps and springs
- Culinary water
- Threatened and endangered fish (Canyonlands)
- Salt Creek (Canyonlands)
- Water rights
- Mining (Canyonlands, Arches)

Water resource issues affecting the Southeast Utah Group Parks are far reaching with activity impacting park resources often originating far beyond the park boundaries in the headwater areas of the Colorado and Green river basins. The complexity of the issues facing the Group Parks warrants the development of a comprehensive water resource management plan. Since so many federal and non-governmental organizations have a significant interest in the upper basin, input from water resource professionals outside of the NPS will be crucial for successful implementation of a water resource management plan.

INTRODUCTION

Water is an important resource for areas administered by the National Park Service (NPS) and is of critical concern for those parks located in the arid environments of the southwestern United States. Its scarce nature makes even small sources of water, such as seeps and springs or ephemeral streams, potentially crucial to maintaining the riparian and aquatic habitat that supports the local desert flora and fauna.

This Water Resources Scoping Report identifies a number of water related concerns for Canyonlands National Park, Arches National Park, and Natural Bridges National Monument. Existing resource status is discussed and a number of water resource issues identified as key concerns by park management, are considered. These three parks share a common Resource Management Division and are collectively known as the Southeast Utah Group. Information generated from this scoping report can be incorporated into the parks' resource management plan and will provide necessary information for a comprehensive water resources management plan.

PARK LOCATIONS AND DESCRIPTIONS

All three parks are located in southeast Utah in the Canyon Lands Section of the Colorado Plateau Physiographic Province. Figure 1 shows the location of the Southeast Utah Group Parks in relation to the surrounding states.

Canyonlands National Park (Figure 2) is the largest of the three, encompassing 337,570 acres. The confluence of the Green and Colorado rivers is located in the heart of Canyonlands. Enabling legislation for the park (PL85-590), established in 1964, states that the purpose of the park is to preserve an area "... possessing superlative scenic, scientific, and archeological features for the inspiration and benefit of the public" (NPS, 1985). Canyonlands is further divided into four management subunits based on the boundaries created by the rivers. The Island in the Sky District lies on the plateau area between the Green and Colorado rivers and covers approximately 132,437 acres. The Maze District (76,285 acres) includes the Horseshoe Canyon Detached Unit of Canyonlands and is located to the west and adjacent to the two rivers. The Needles District (128,848 acres) is located east and adjacent to the Colorado River. The River District occupies a narrow corridor along the two rivers and was established specifically to manage river activities.

Arches National Park (Figure 3) was originally established as a national monument in 1929 by Presidential Proclamation. The purpose was to "... protect extraordinary examples of wind erosion in the form of gigantic arches, natural bridges, `windows', spires, balanced rocks and other unique wind-worn sandstone formations the preservation of which is desirable because of their educational and scenic value." Arches went through a number of boundary changes and was designated as a national park in 1971 (PL92-155). The park currently covers 73,379 acres (NPS, 1989).

Southeast Utah Group

Canyonlands, Arches, & Natural Bridges

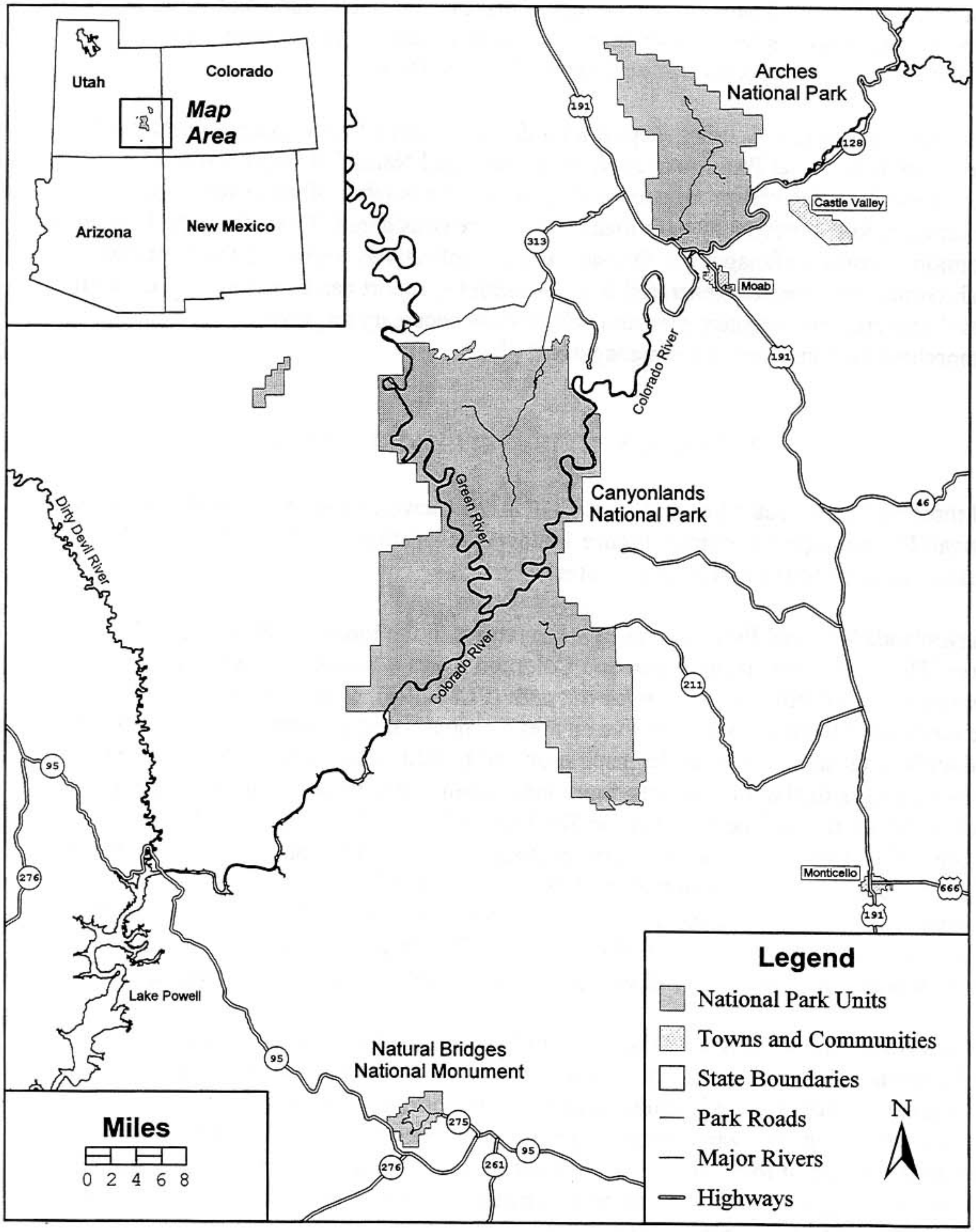

Figure 1. Location of Canyonlands, Arches and Natural Bridges in relation to the surrounding area and major hydrography (modified from Long and Smith, 1996)

Canyonlands National Park

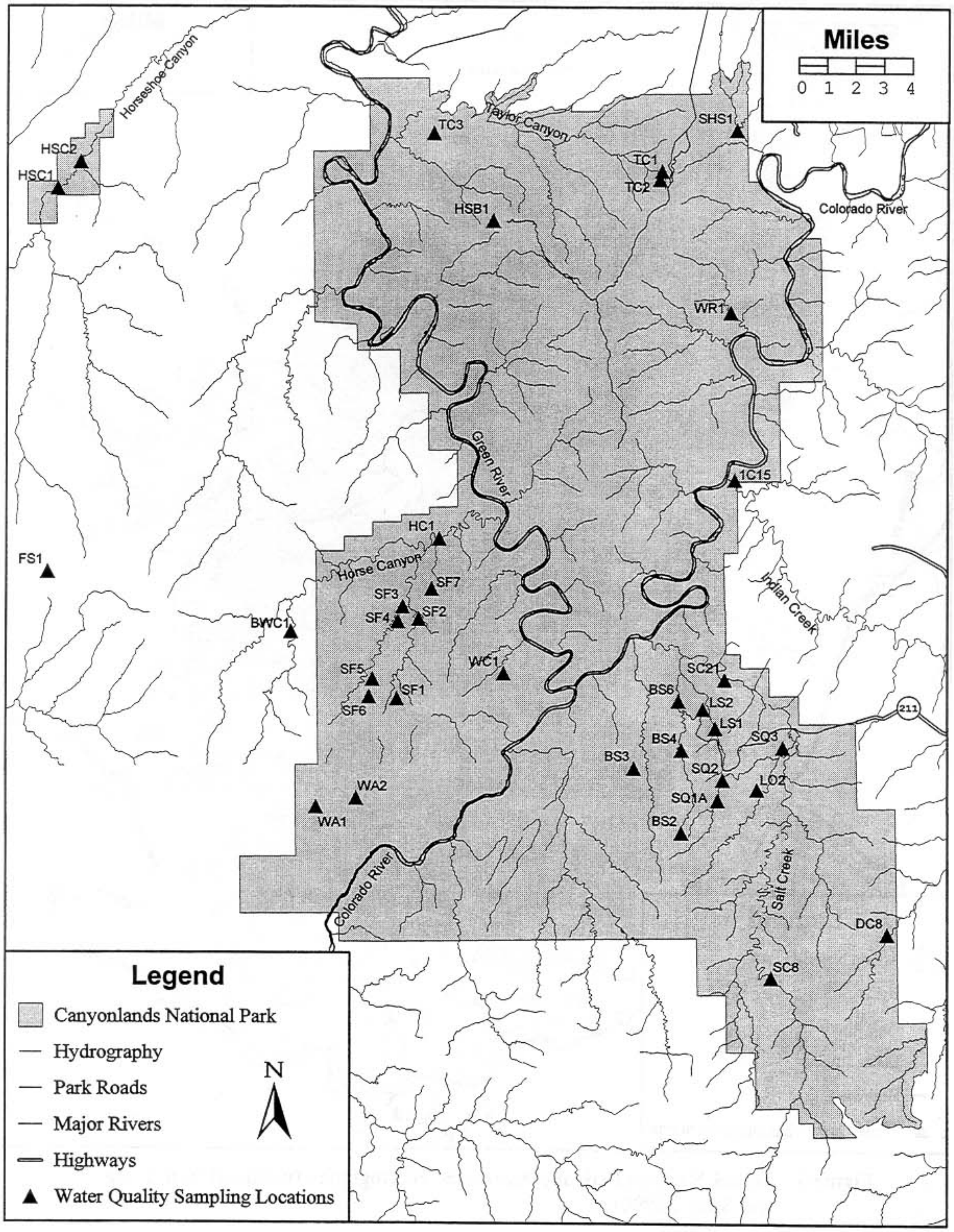

Figure 2. Canyonlands National Park and Associated Hydrography (modified from Long and Smith, 1996)

Arches National Park

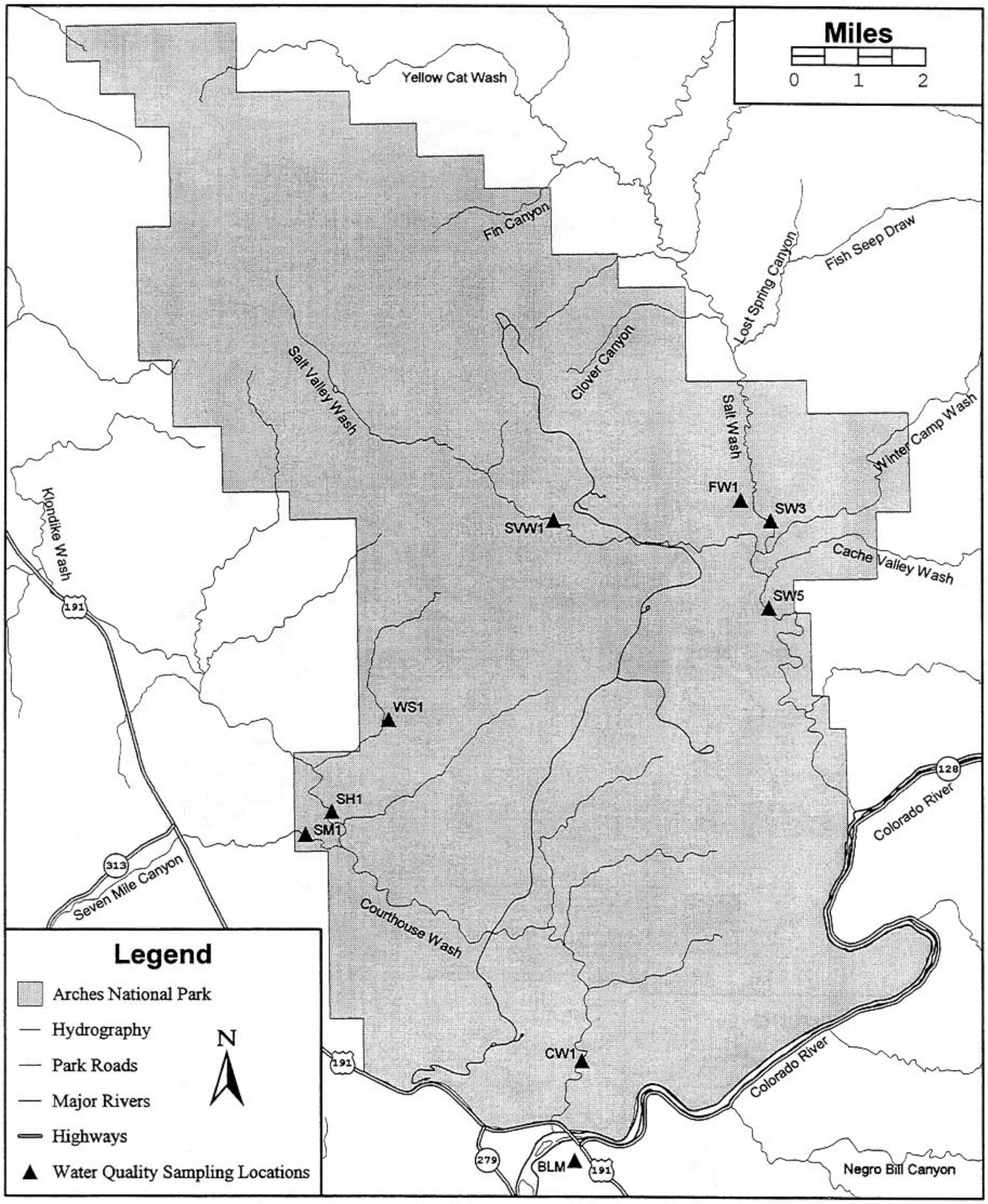

Figure 3. Arches National Park and Associated Hydrography (modified from Long and Smith, 1996)

Natural Bridges National Monument

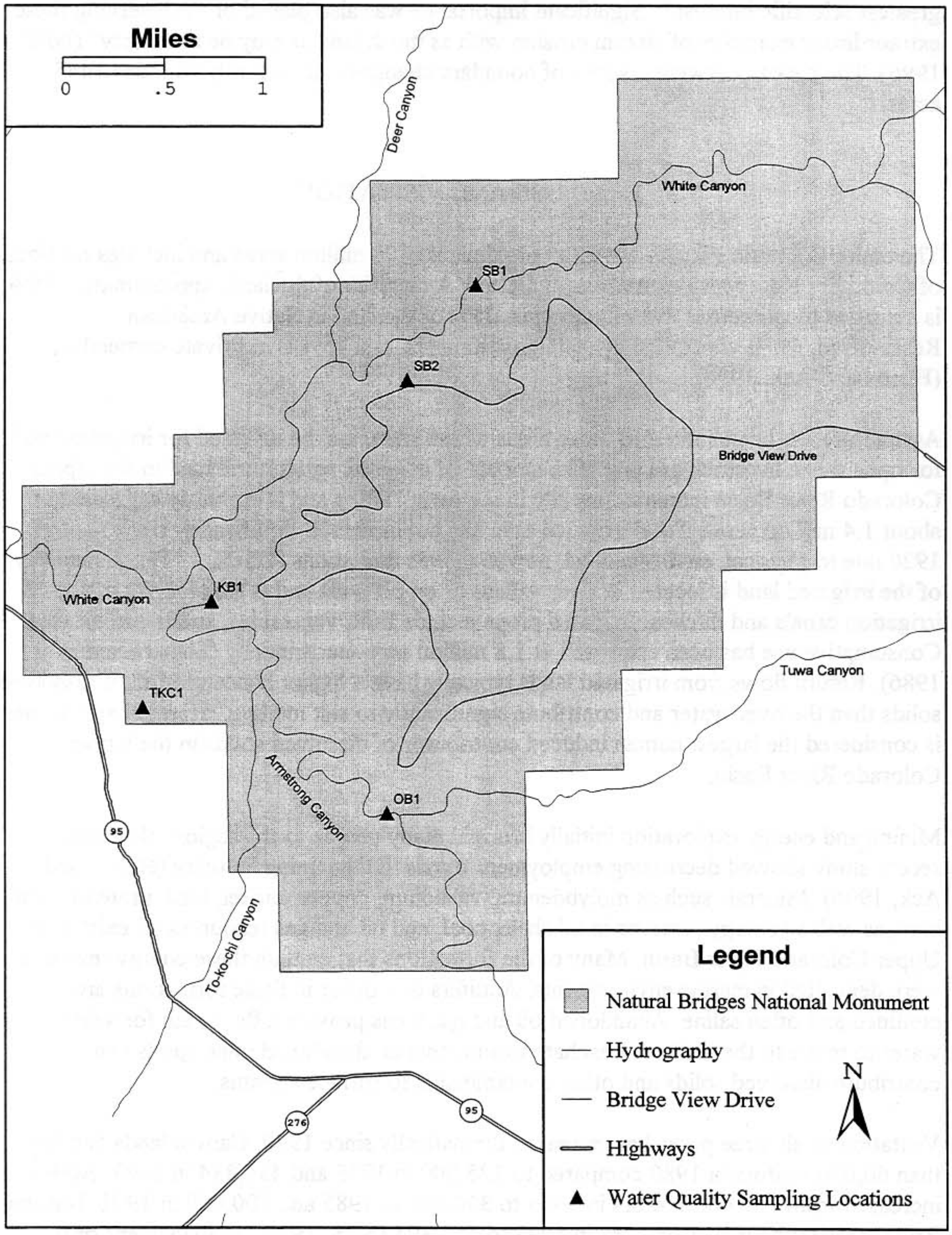

Figure 4. Natural Bridges National Monument and Associated Hydrography
(modified from Long and Smith, 1996)

Natural Bridges National Monument (Figure 4) is Utah's oldest NPS unit and was established in 1908 by Presidential Proclamation (No. 804, 35 Stat. 2183). This park was created to protect the natural bridges contained within its' boundaries considered "...of greatest scientific interest." Significant importance was also placed on "...reserving these extraordinary examples of stream erosion with as much land as may be necessary" (NPS, 1996). The park underwent a series of boundary changes and currently contains 7445 acres.

LAND USE AND VISITATION

The entire Colorado Plateau covers approximately 108 million acres and includes portions of Colorado, New Mexico, Arizona and Utah. A majority of the land, approximately 55%, is managed by numerous federal agencies, 24% of the land is Native American Reservation, 6% is controlled by state governments, and 15% is in private ownership (Hecox and Ack, 1996).

Agriculture has been limited to those areas where water can be diverted for irrigation and for open range livestock grazing. The amount of irrigated agricultural land in the Upper Colorado River Basin increased rapidly in the early 1900's and is currently estimated at about 1.4 million acres. Total irrigated area has not increased significantly since about 1920 due to physical, environmental, and economic limitations (USDI, 1995). A majority of the irrigated land is located in river valleys or on plateaus and is supplied by various irrigation canals and ditches. Irrigated crops include fruit, vegetables, and livestock feed. Consumptive use has been estimated at 1.8 million acre-feet annually (Liebermann et al., 1986). Return flows from irrigated lands typically have a higher concentration of dissolved solids than the river water and contribute significantly to salt loading. Irrigated agriculture is considered the largest human induced contributor of dissolved solids in the Upper Colorado River Basin.

Mining and energy exploration initially brought many people to the region, although a recent study showed decreasing employment trends in the mining industry (Hecox and Ack, 1996). Minerals such as molybdenum, vanadium, copper, nickel, lead, uranium, and zinc, as well as energy reserves in oil shale, coal, and oil and gas resources all exist in the Upper Colorado River Basin. Many of the formations that contain these energy resources were deposited in marine environments. Aquifers that occur in these formations are confined and often saline. Abandoned oil and gas wells provide a flow path for saline water to move to the surface. Leachate from active or abandoned mine spoils can contribute dissolved solids and other contaminants to surface streams.

Visitation to all three parks has increased dramatically since 1980. Canyonlands had less than 60,000 visitors in 1980 compared to 125,000 in 1985 and 434,834 in 1993. Arches increased from 150,000 visitors in 1965 to 350,000 in 1985 and 700,000 in 1991. Natural Bridges visitation increased 12% in 1993 to 152,304 (NPS, 1994). Management of the Southeast Utah Parks has had difficulty keeping pace with the rapid rise in visitation.

NPS units on the Colorado Plateau increased staffing by 48% between 1981-1994. During the same period, budgets for NPS Plateau Parks increased 31%. In 1993, 15% of park visits were to the Plateau Parks, while only 4.2% of the total NPS expenditures went to those parks (Hecox and Ack, 1996).

LEGISLATION AFFECTING THE COLORADO RIVER SYSTEM

The waters of the Colorado River have been one of the most legislated and fought over water resources in the United States. Apportionment of Colorado River water among basin states, instream *flows,* and operation of all reservoirs in the Colorado River Basin is dictated by a complex series of interstate compacts, international treaties, statutes, and regulations collectively known as the "Law of the River." The Colorado River Compact of 1922 divided the Colorado River into the Upper and Lower basins at Lees Ferry, Arizona, approximately 200 miles below Canyonlands. It was established that the Upper Basin was obligated to deliver 75 million acre-feet (maf) of water, averaged over a 10 year period, to the Lower Basin states. None of the existing treaties and compacts specifically address the total amount of water available. They only authorize the Upper Basin to consumptively use 7.5 maf of water per year (on average), provided it is available and delivery requirements to Lees Ferry are met. The Water Treaty of 1944 guaranteed 1.5 maf of water annually to Mexico; the obligation for delivery being "...equally borne by the Upper Basin and the Lower Basin" during times of insufficient *flow.* Initially, representatives from the seven basin states assumed they were dividing an average annual *flow* of 16.4 maf measured at Lees Ferry (MacDonnell et al., 1995). Subsequent research based on tree ring dendochronology has indicated the mean annual flow of the Colorado River is actually substantially less, approximately 13.5 maf (Stockton and Jacoby, 1976). The Upper Colorado River Basin Compact of 1948 divided the water apportioned to the Upper Basin among the five states with drainages above Lees Ferry. The annual amount of water use was allocated as follows: 50,000 acre-feet to Arizona, and of the <u>remaining</u> portion, 51.75% to Colorado, 11.25% to New Mexico, 23% to Utah, and 14% to Wyoming. The Colorado River Storage Project Act of 1956 had a major affect on the *flow* regime of the entire Upper Basin by authorizing construction of Glen Canyon Dam, Flaming Gorge Dam, Navajo Dam, and the Aspinall Unit Dams consisting of Blue Mesa, Morrow Point and Crystal Reservoirs (Liebermann et al., 1986).

In addition to these legislative acts, an Annual Operating Plan (AOP) is developed each year to coordinate the operation of all the reservoirs on the Colorado River system. Development of the AOP is based on projected hydrologic and climatic conditions and is generated in accordance with the "Law of the River." The AOP is developed in consultation with various federal and state agencies, environmental organizations, and the general public through the Colorado River Management Work Group (USDI, 1996). All of these laws and operating criteria have a direct effect on the *flow* regime of the rivers through Canyonlands National Park.

WATERSHED DESCRIPTION

GEOLOGY, TOPOGRAPHY AND SOILS

The area consists of numerous red rock canyons carved into layer cakes of sedimentary rock formations that have been deformed by a variety of uplifting and erosional processes. The geologic strata exposed in the three NPS units range from the Paradox Formation (Pennsylvanian Period) to the Mancos Shale Formation (Cretaceous Period). These formations consist of many intermixed layers of marine, fresh water and eolian deposition that are collectively several thousand feet thick. Regionally, these depositional layers are nearly horizontal with a slight dip to the north.

In Arches National Park, the central features are the spectacular rock arches formed in the Entrada sandstone. The 2000 arches located in the park represent one of the highest concentrations of these formations in the world. A number of major sedimentary formations exposed in the park originate from the Pennsylvanian Period to the Cretaceous Period. Geologic strata consist of formations including: Paradox, Honaker Trail, Cutler Group (includes Cedar Mesa, Organ Rock and White Rim), Moenkopi, Chinle, Glen Canyon Group (includes Wmgate, Kayenta and Navajo sandstones), Entrada, Morrison, Cedar Mountain, Dakota Sandstone and Mancos Shale. A major structural feature of the park is the collapsed salt anticline of the Paradox Formation located in Salt Valley. The crystalline salts of this formation are of marine origin and have accumulated to great depths through the process of precipitation and evaporation of stagnant seawater. Subsequent rock overburden as well as regional uplifting and mountain building activities caused a plastic deformation in the Paradox Formation, resulting in the salt layers "flowing" to the southwest. As the uplifting and erosional processes entrenched the rivers and streams of the surrounding plateaus, groundwater dissolved the more soluble salts. This resulted in a collapse of the underground salt anticlinal structure forming the Salt Valley in Arches, along with numerous other salt valleys around the Paradox Basin area (Barnes, 1978). Sediments and evaporites from the Paradox Formation have a significant effect on water quality. The majority of the geologic surface expressions within Arches consists of the Navajo and Entrada sandstones. The Chinle, Wingate, and Kayenta formations create vertical 800 foot cliffs along the Colorado River at the south boundary of the park.

The primary features of Canyonlands National Park are the immense canyons that have been cut into the Colorado Plateau by the Green and Colorado rivers. The park is characterized by the horizontal sedimentary formations typical of the Plateau region. The Colorado and Green rivers cross the park generally from north to south, progressively cutting into older geologic formations (McKnight, 1940). The great canyons of the Colorado Plateau were created by the downcutting action of the rivers during the period that the surrounding Plateau region uplifted. Underlying geologic formations include: Paradox, Honaker Trail, Lower Cutler, Organ Rock Shale, White Rim, Moenkopi, Chinle and Glen Canyon Group.

The topography of Natural Bridges National Monument consists of a high plateau with two main deeply incised canyons, White and Armstrong, which join in the western region of the park. The key features of the park are the massive natural bridges that were a result of stream erosion (different from arches that are formed by a combination of wind erosion, groundwater and frost action). The principle geologic formation of the park is the Cedar Mesa sandstone, a member of the Cutler Formation, which ranges between 500 and 1000 feet thick.

The area encompassing the Southeast Utah Group Parks is an erosional landscape with over a quarter of the area being exposed bedrock. The soils vary widely on the Colorado Plateau and resemble the parent material from which they are derived. Vegetation boundaries are usually abrupt, corresponding to sharp changes in substrate or available soil moisture. Soils located in the lower elevations and canyon floors are typically hot and dry and are poorly developed, while those at higher elevations are cool and moist. Soils found in recent eolian deposits, derived from sandstone, range from sandy loam to sand. Those derived from the shale parent material range from clay loam to clay. Deeper soils are found in the mountains and valley alluvial fills, while shallow soils and exposed sandstone are found on rims, benches, and slopes associated with anticlines and synclines (Lammars, 1991).

Precipitation runoff and erodability of soils have increased over much of the surrounding watersheds due to overgrazing of domestic livestock. Excessive removal of plant and litter cover has lead to increased erosion, causing the down cutting of numerous stream channels and loss of the A-horizon from some soils profiles. When these alterations are combined with the introduction of several exotic species, changes in species composition, overall productivity, and hydrology can be expected to remain for a period extending into the geologic time scale.

CLIMATE

Elevations at the parks range from a low of 3720 feet at the Colorado River near Cataract Canyon to a maximum of 6987 feet on Cedar Mesa. The climate of the area is arid, characterized by hot, dry summers and cold winters. Average precipitation varies from approximately 8 inches in Arches, 8.6 inches in Canyonlands to 13.2 inches in Natural Bridges. Temperature varies widely with elevation and latitude with extremes ranging from -16 °F to 111 °F. Mean annual temperature varies from 56 in Arches, 53 °F in Canyonlands to 50 °F in Natural Bridges. Precipitation in the higher elevations of the Plateau can occur as snowfall from November through March (NPS, 1994). Summer precipitation consists almost exclusively of brief, intense thunderstorms which can present a substantial hazard in the form of flash floods. Potential evapotranspiration is approximately 50 inches annually and greatly exceeds total precipitation amounts.

VEGETATION

Vegetation in the Southeast Utah Group Parks varies depending on elevation, precipitation and soil type. There are a number of plant communities in the parks including pinyon pine juniper, blackbrush, shadscale, saltbush-snakeweed, sagebrush, grassland, riparian, and hanging garden.

The riparian vegetation community consists of Fremont cottonwood, yellow willow, box elder, phragmites, and horsetail. The hanging garden communities are typically characterized by water dependent plants that are unique to a desert environment. These include maidenhair fern, monkey flower, death cams, and alcove bog-orchid.

Water resources in the form of riparian areas, seeps and springs, and hanging gardens form critical habitat for fish, amphibians, aquatic insects as well as other terrestrial and avian fauna. These locations are often the only source of surface water for large areas in the arid high desert of the plateau. Invasion of exotic plant species such as tamarisk, Russian olive, cheatgrass, and Russian knapweed has significantly altered the natural vegetation in these riparian areas. The impacts of introduced exotic plants have placed large portions of these ecosystems at risk (NPS, 1994).

SURFACE WATER HYDROLOGY

Arches and Canyonlands National Parks and Natural Bridges National Monument are centrally located on the Colorado Plateau (Figure 1) in the Upper Colorado River Basin as designated by the Colorado River Compact of 1922. The major drainages of the Plateau Province are the Colorado and Green rivers which originate in the mountains to the north and east beyond the perimeter of the Colorado Plateau. Flow records show a great deal of monthly and annual variability. Local intermittent tributary streams can quickly become raging torrents during summer thunderstorms. Seasonal hydrographs for the Green and Colorado rivers display a typical snowmelt runoff peak, with a majority of the discharge occurring in May and June.

The U.S. Geological Survey (USGS) collects daily streamflow and water quality data at long-term monitoring stations on both the Green and Colorado rivers. Both of these stations are located upstream from Canyonlands. (Station information is included in Table 1.) The Colorado River has no major tributaries between the Cisco station and Canyonlands, while the San Rafael River joins the Green between the Green River station and the park.

Table 1. USGS long term monitoring stations upstream from Canyonlands National Park. Parameters collected include: Discharge, various water chemistry and suspended sediment.

USGS #	Station Name	Distance Upstream from Confluence	Period of Record
09180500	Colorado River near Cisco, Utah	97 miles	1895 - present (discharge) 1928 - present (water quality)
09315000	Green River at Green River, Utah	118 miles	1894 -1899, 1904 - present (discharge) 1928 - present (water quality)

Colorado River

The headwaters of the Colorado River begin at 14,000 feet in the high peaks of Rocky Mountain National Park in Colorado. The Colorado River flows 420 miles through the Upper Basin to its confluence with the Green River in the heart of Canyonlands National Park. The average river gradient above the confluence is 24 feet per mile. Mean discharge from 1914-1995, computed from records at the USGS gaging station near Cisco, Utah, is 7393 cubic feet per second (cfs). Extreme flows for the period of record are a maximum of 76,800 cfs on June 19, 1917 and a minimum of 558 cfs on July 21, 1934 (USGS, 1995).

Water resource development projects in the Upper Colorado River Basin have significantly affected the flow regime of the river in Canyonlands. Although there is only one reservoir on the Colorado River mainstem upstream from the park (Lake Granby near Rocky Mountain National Park), flow is regulated by numerous reservoirs on most of the upstream tributaries. Beginning in the early to mid-1900's, reservoirs were constructed primarily for water storage, irrigation, and flood control. Availability of water in a region characterized by an arid environment and seasonal streamflow, was important for agricultural development and resulted in the construction of over 80 reservoirs in the Upper Colorado River Basin having a storage capacity greater than 5000 acre-feet (Liebermann et al., 1986). Major effects of reservoirs on the Colorado River system include the evaporative losses associated with water impoundment and the disruption of the normal temperature and flow regimes of the river. Flow regulation from reservoirs tends to decrease the seasonal variability of streamflow, resulting in decreased peak flow and flood frequency, and increased base flow discharge.

Blue Mesa Reservoir on the Gunnison River was completed in 1966 and is the largest impoundment upstream from Canyonlands on the Colorado River drainage. A plot of the annual maximum discharge at the Cisco gaging station for 1914 to 1993, shows a substantial decrease in the mean annual peak discharge when comparing the pre- and post-1966 record (Figure 5). In addition, flow duration curves for the same periods show the effects of decreased peak flows and increased base flows (Figure 6). Alterations in the flow regime have been shown to have a significant affect on channel morphology and width leading to encroachment of exotic vegetation and reduction of fish habitat (Andrews, 1986; Gellis et al., 1991; Pemberton, 1976; Williams and Wolman, 1984).

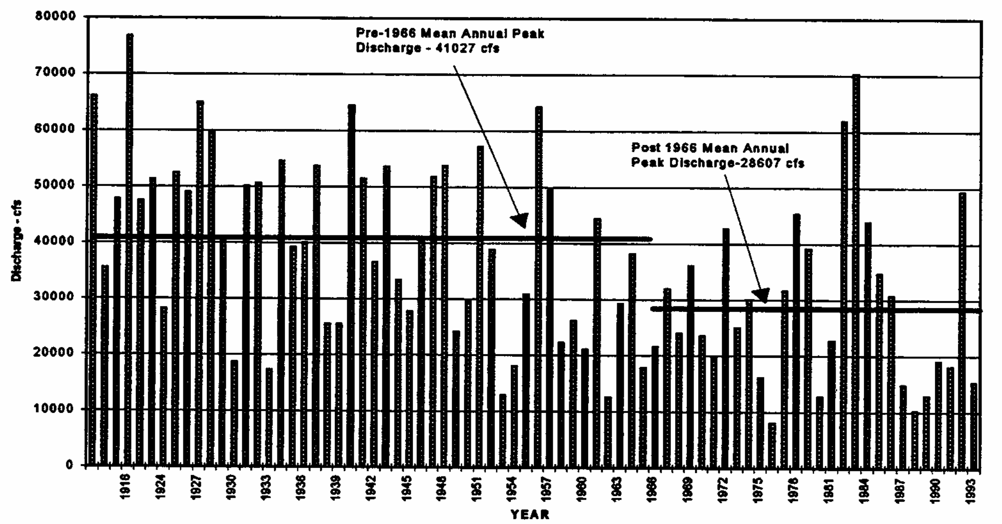

Figure 5. Annual peak discharge at the Colorado River at Cisco, Utah, station

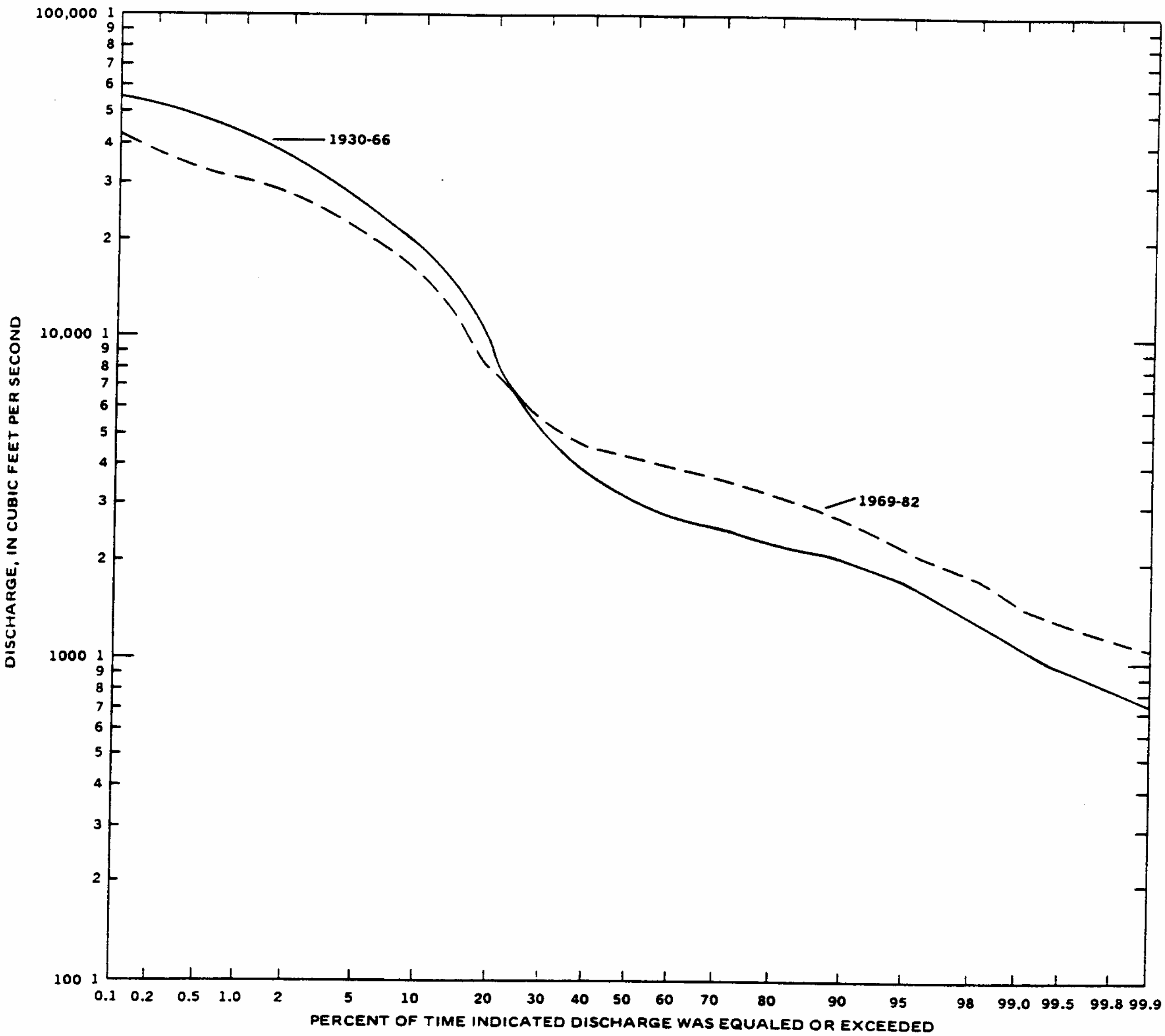

Figure 6. Pre- and post-1966 flow duration curves for the Colorado River near Cisco, Utah, from 1930-1982 (from Thompson, 1984a)

From 1930-1982, the USGS collected suspended sediment data at the Cisco gaging station. Analysis of these data show two significant changes in the relationship between suspended sediment and river discharge (Thompson, 1984a). The first change occurred in the early 1940's and coincides with a change in sampling equipment, and the second change occurred in 1966 and coincides with the closure of Blue Mesa Reservoir. The 1930-1982 suspended sediment data record was divided into three data sets based on the changes observed. Table 2 lists the descriptive statistics before the equipment change (1930-1945), after the equipment change, and before (1946-1967) and after (1968-1982) the construction of Blue Mesa Reservoir.

Although the shift observed after the change in sampling equipment appears substantial, it *likely does not reflect a* true alteration in suspended sediment load. Thompson (1984a) determined the 1946-1967 record more accurately represents the pre-reservoir suspended sediment load conditions. Comparison between these data and the 1968-1982 record likely represents the actual change that did occur.

Table 2. Suspended sediment load in millions of tons at the Colorado River near Cisco, Utah, gaging station

	Pre-Equip.	Post-Equip	
		Pre-Dam	Post-Dam
	1930-1945	1946-1967	1968-1982
Mean	17.64	9.44	7.59
Minimum	2.72	3.46	2.04
Maximum	35.7	21.54	14.55
Std. Deviation	10.166	5.067	4.01
% Change		46%	20%

In addition to the effects of water impoundments, large volumes of water are exported out of the Upper Colorado River Basin to the Arkansas, Missouri, South Platte, Rio Grande, and Great basins (USDI, 1995). These transmountain diversions have been substantial, exporting over 700,000 acre-feet annually (Liebermann et al., 1986). Transbasin exports from the Colorado River Basin are primarily from the headwater areas, removing relatively pure water with low dissolved solids concentrations. This removes the dilution effect of the pure headwaters flow and results in increased dissolved solids concentration downstream.

Green River

The Green River starts in the Wind River Mountains in Wyoming and flows south 730 miles to the Colorado River confluence. The Green River drains approximately 70% more area than the Colorado River but produces approximately 25% less discharge (USDI, 1995). Mean discharge from 1906-1995 at the USGS gaging station at Green River, Utah, was 6191 cfs. Extremes for the period of record were a maximum of 68,100 cfs on June 27, 1917 and a minimum of 255 cfs on November 26, 1931.

Flow is regulated on the Green River mainly by Flaming Gorge Reservoir located 412 miles upstream from the Colorado River confluence and also by numerous other reservoirs on most of the tributaries. Inspection of the flow record at the Green River, Utah, gaging station reveal similar flow alterations as those observed on the Colorado River. Flow regulation for hydropower generation has resulted in an increase in the mean base flow discharge (Flo Engineering, 1995). The mean annual peak discharge showed a decrease (Figure 7) when comparing the pre- and post-1962 record (when Flaming Gorge Dam was completed). Flow duration curves for the pre- and post-1962 flow record show decreased peak flows and increased base flows (Figure 8; Thompson, 1984b).

The 1930-1982 suspended sediment record also shows trends similar to the Colorado River. A double mass curve of the data shows the same change in the early 1940's corresponding to the change in sampling equipment. In addition, a second change occurs in 1963 and corresponds with the closure of Flaming Gorge Reservoir. Thompson (1984b) shows mean annual suspended sediment load decreasing by 35% after completion of Flaming Gorge Dam. Actual decrease would most likely be less if the change in sampling equipment is taken into account.

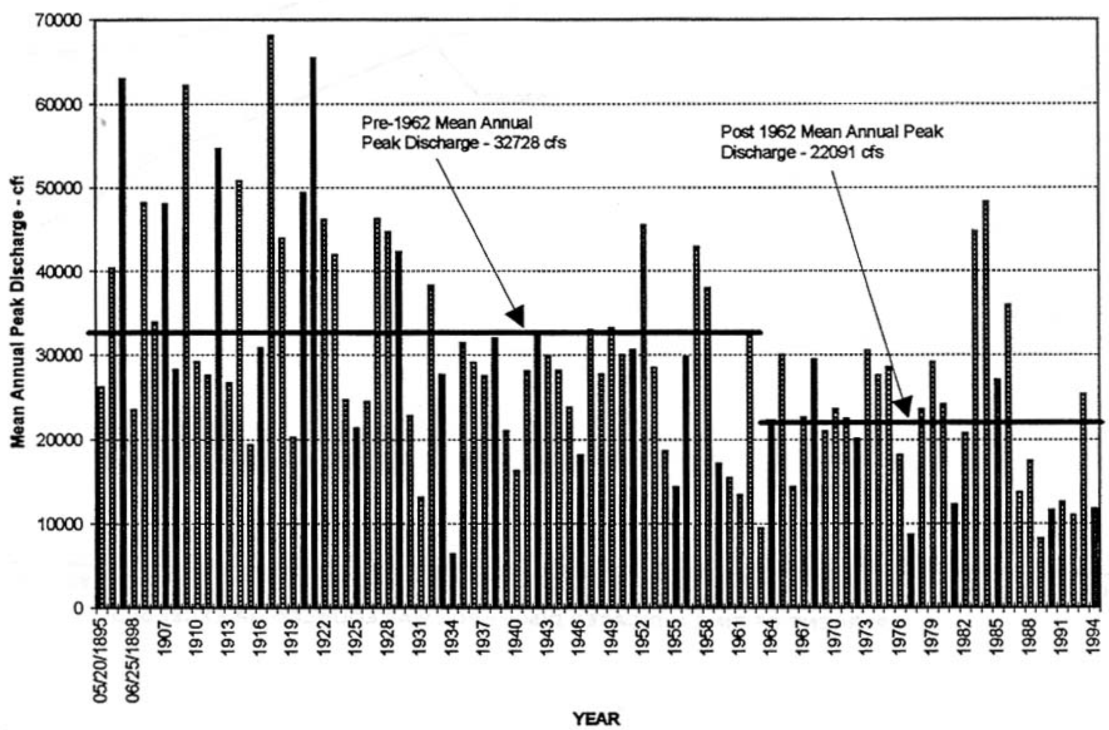

Figure 7. Annual peak discharge at the Green River at Green River, Utah, gaging station

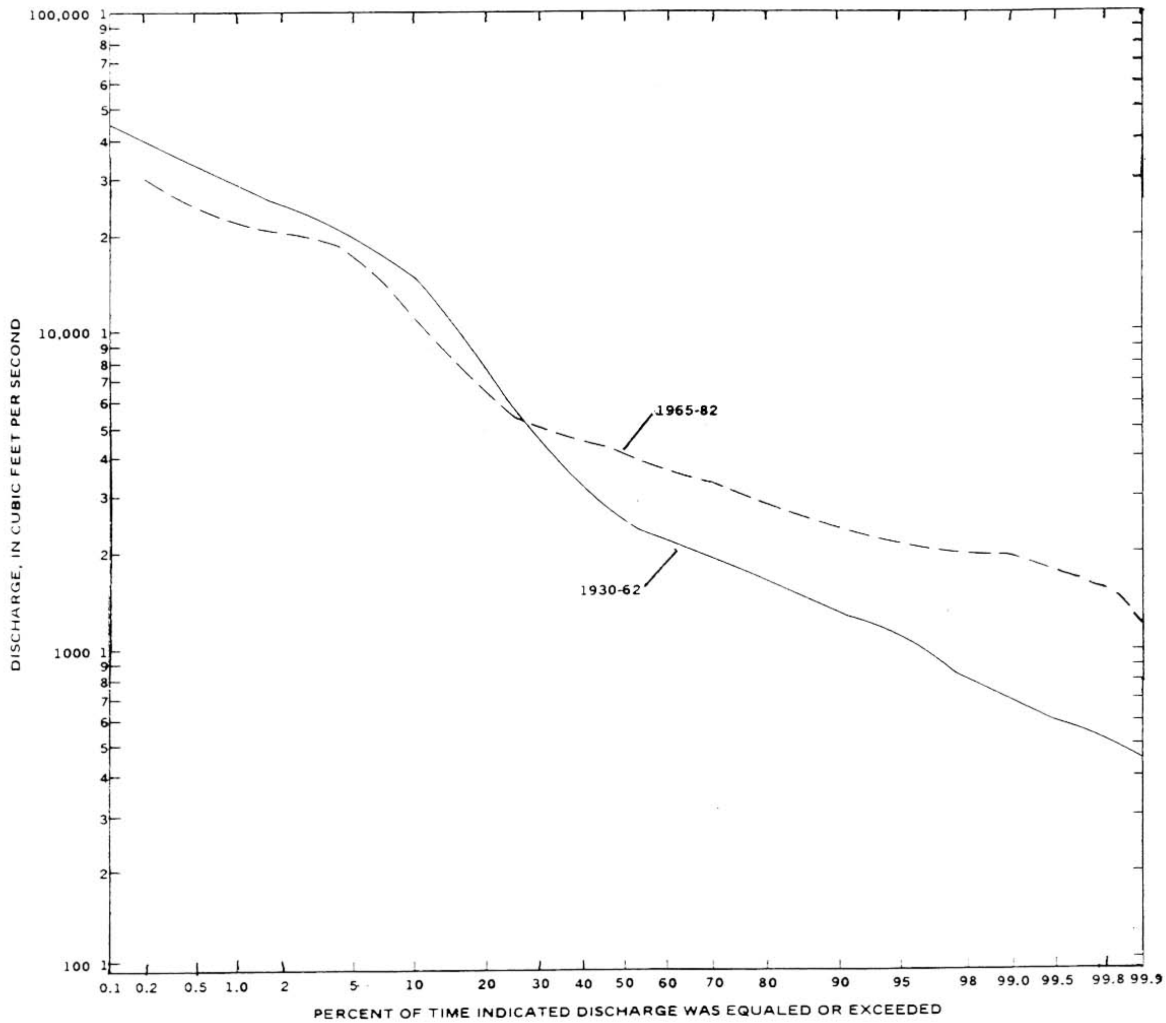

Figure 8. Pre- and post-1963 flow duration curves for the Green River at Green River, Utah, station for 1930-1982 (from Thompson, 1984b)

Seeps and Springs

Despite the arid environment of the Group Parks, there are a large number of seeps, springs and potholes within NPS boundaries. A previous study identified the Navajo, Wingate, and White Rim sandstones as water bearing formations based on the presence of seeps and springs at the base of these formations (Huntoon, 1977). Many of these springs produce a small quantity of water and are ephemeral in nature. Despite this fact, they collectively represent the largest volume of backcountry surface water available (except for the Green and Colorado rivers) and are critical for wildlife, vegetation, and other aquatic biota.

Ephemeral Channels

The Colorado Plateau is dissected by a maze of canyons and channels leading to the main drainage of the Green and Colorado rivers. Although these canyons were the result of fluvial processes, a large majority of them do not contain perennial water. Ephemeral channels are not actually considered a surface water resource, yet they often support riparian vegetation and are major sources of sediment input to the major river systems. During summer thunderstorms, these channels carry dramatic flash floods and debris flows. It is important to consider the destructive power of flash floods when considering development activities in associated floodplains.

GROUNDWATER HYDROLOGY

Huntoon (1977) identifies three water bearing aquifers in the northern Canyonlands area based on the presence of springs that discharge from the base of the Navajo, Wingate and White Rim sandstones. Groundwater may also occur in perched aquifers and alluvial material in washes and canyon bottoms. Seeps and springs associated with the Navajo and Wingate formations are often found along bedding planes and fractured joints with flow amounting to a few gallons per minute or less. The White Rim sandstone has an almost continuous series of small seeps at some locations along its lower contact. These are also small discharge springs that individually amount to a few gallons per minute. While these aquifers may lack the ability to produce water in sufficient quantity and quality for human consumption, they represent an important source of water for vegetation and wildlife.

WATER QUALITY

Water quality in the Upper Colorado River Basin is affected by local geology and upstream human impacts. Salinity is one of the major and most pervasive water quality problems in the entire Colorado River Basin. Nearly half (47%) of the salinity load in the Colorado River is from natural sources such as saline springs, erosion of geologic formation, and soils with a high degree of soluble minerals and surface runoff. The naturally high salt levels of the Green and Colorado rivers have been increased by water developments in a number of ways. Net evaporative losses from reservoirs tend to increase the dissolved solids concentration of the released water. In addition, when the reservoir is drawn down, water in bank storage may have a high concentration of dissolved solids if it has been in contact with soluble minerals that are typical for soils in the Upper Basin. Transbasin exports of water from the headwaters area remove the dilution effect of water, low in dissolved solids, and result in increased dissolved solids downstream. Irrigated agriculture is the second largest use of water in the Colorado River Basin and is also the second greatest contributor of salinity to the system (37%). Surface runoff from irrigated areas contribute approximately 3.4 tons of salt annually to the river system (USDI,1995). Concern over the affects of elevated levels of salinity to agricultural and municipal water industries led the Colorado River Basin states and the Federal Government to adopt numeric salinity standards to limit further increases in salt loading (PL 92-500; Federal Water Pollution Control Act of 1972).

Many of the geologic formations in the region were deposited in marine environments and therefore have a naturally high concentration of dissolved solids. Energy resource development for coal, oil and gas, and oil shale can contribute to the salt loading problem. Fossil fuels are generally located in association with marine shales and extraction of these resources results in increased dissolving of soluble minerals. Increased salinity can be caused by leaching of spoils material, discharge of saline groundwater, and increased erosion from surface disturbances. Total dissolved solids from mining spoils leachate have been recorded as high as 3900 mg/l in northwestern Colorado (Parker and Norris, 1983). In addition to fossil fuel extraction, there has been a substantial amount of uranium mining in areas surrounding NPS lands on the Colorado Plateau. Surface runoff and pollution from uranium mines can result in elevated levels of heavy metals, radionuclides and other toxic elements.

The concentration of dissolved solids typically increases in a downstream direction. The mean annual dissolved solids concentrations increase from less than 100 mg/l in the headwaters area to greater than 500 mg/1 at the bottom of the Upper Colorado River Basin. All major tributaries that have high concentrations of dissolved solids are downstream from extensive areas of irrigated agricultural land (Liebermann et al., 1986).

In the early 1980's, the Department of Energy identified a possible site for a nuclear waste repository within a mile of the Canyonlands National Park boundary. Park management expressed concerns over the potential impacts to water quality at springs near the proposed site. In response, the Southeast Utah Group Parks have initiated a water quality monitoring program at varying levels of effort at a number of seep and spring sites since 1983. In 1992, the NPS Water Resources Division (WRD) assisted the Group Parks by analyzing the existing data and providing recommendations regarding the revision of the monitoring plan (Long and Smith, 1996). The monitoring plan was revised from approximately 50 sites annually to 10 - 15 sites sampled two to three times per year.

Results from these analyses show median values for most water quality parameters to be within normal levels for typical small springs on the Colorado Plateau. The data displayed a wide range and large degree of variability, possibly due to ambient conditions and sampling errors. Analyses were performed for several trace elements with most of the results being reported as values below the lab detection limit. Several different spring types were identified based on location and physical characteristics. Many parameters such as pH, dissolved oxygen, and phosphorus remain relatively consistent among the different spring types. Other parameters such as water temperature, filterable residue or ionic content, nitrogen, turbidity, and bacteria were highly variable among the different spring types.

Although concerns were raised by Long and Smith (1996) regarding quality control factors, some trends were visible. Elevated levels of copper and iron were observed at many of the springs at least once. There were 30 springs at Canyonlands, 7 at Arches, and 3 at Natural Bridges that showed concentrations of copper in excess of the state standard at least once, and sometimes several times. The Environmental Protection Agency (EPA) has listed copper as one of 129 priority pollutants (Irwin, Pers. comm., 1996). Since elevated levels of copper are considered toxic to many aquatic species, concentrations of this element should be observed closely in future monitoring.

There are a number of potential sources of selenium in the Upper Colorado River Basin from natural and anthropogenic origins. Mancos shale and soils derived from this parent material are naturally high in selenium, containing levels as high as 1100 µg/kg (Stephens et al., 1992). Surface irrigation flow and shallow groundwater flow through the Mancos shale mobilize the soluble selenium and transport it to the rivers and adjacent wetland/riparian areas. Median concentrations in drainwater discharged to Stewart Lake in the middle Green River Basin have been detected as high as 140 mg/l, greatly exceeding the Utah state standard of 5 µg/1. Studies have shown that selenium bioaccumulates through the food chain, with elevated levels found in fish (Hamilton and Waddell, 1994) and waterfowl (Stephens, 1994). There is concern that agricultural activities are increasing contaminants to levels that are detrimental to aquatic biota. Currently, there are several agencies, including the U.S. Fish and Wildlife Service, Bureau of Reclamation, and U.S. Geological Survey, conducting studies on selenium levels that impair reproduction and larval survival of razorback suckers.

AQUATIC BIOLOGY

Aquatic Invertebrates

The parks have a variety of other natural water sources. There are potholes, pools fed from seeplines in canyon alcoves, pools fed by below ground percolation, plunge pools, springs that gush from rock walls and streams that flow continuously. Currently, little information exists on the aquatic invertebrate and plant/algae populations of these water resources. This is somewhat surprising considering the opportunities for biological discovery. For example, springs tend toward a uniform temperature, usually the mean annual air temperature of the region (Hynes, 1970). Therefore, springs provide uniform conditions in areas that are subject to seasonal changes. In these spring environments, relictual species may have survived and many crenobionts (species confined to springs) can occur far outside their normal geographical range (Hynes, 1970).

The madicolous habitat consists of thin sheets of water flowing over rock faces (Hynes, 1970). In these parks, this habitat is referred to as "hanging gardens." This unique habitat can provide for some unusual species and associated biological adaptations. For example, the Diptera are usually the most numerous madicoles, and in contrast to the truly stream-dwelling families of insects, they are all air-breathing (Hynes, 1970).

Recently, some attempts have been made to rectify this paucity of information on aquatic invertebrates. Researchers from Brigham Young University are attempting to quantify aquatic invertebrates in selected habitats of the Colorado and Green rivers in Canyonlands. Preliminary results indicate significant differences in densities of nematodes, copepods, and rotifers for both sites and habitats, suggesting that artificial substrates may provide one of the most easily monitored databases. These substrates, if placed appropriately, can be monitored every few months over the year to generate information on the water quality. In addition, Dr. Lawrence Stevens and staff of the Grand Canyon Monitoring and Science Center are studying the benthic ecology of the Green and Colorado rivers in Canyonlands. The group of species sampled appears representative of large, low-gradient Colorado Plateau streams. Quantification of density and standing crop will reveal how comparable these assemblages are with regulated reaches of the Colorado River downstream.

Fish

The present Colorado River drainage was established when two separate river systems forged a connection by cutting through the present Grand Canyon several million years ago in the Pliocene (McKee et al., 1967). Except for mainstream species, there has always been a sharp autistic separation between Upper and Lower Basin fishes (above and below the Grand Canyon). The Colorado River Basin probably lacked direct connections with any other major drainage for millions of years. This resulted in long isolation of the fish fauna. Except for species inhabiting headwater streams such as trout, sculpins, speckled dace, and mountain suckers, which can be transferred between drainage basins by stream capture, the majority of the native species of the Colorado River Basin are endemic, that is, they have been so long isolated from their nearest relatives they have evolved into species now restricted to the Colorado basin. The Colorado basin fish fauna exhibit the highest degree of endemism of any major drainage in North America (Behnke and Benson, 1980). The minnows (Cyprinidae) and suckers (Catostomidae) comprise about 70% of the freshwater fish species native to the Colorado River Basin. Miller (1958) claimed 87% of the 23 species of minnows and suckers known to be native to the basin at that time were endemic to the basin. Of the over 35 species of freshwater fishes native to the Colorado River Basin, 14 are native to the Upper Basin (Table 3). Almost 42 introduced fishes are presently reported in the upper Colorado River.

Prior to human induced alterations, the Colorado River system was characterized by tremendous fluctuations in flow and turbidity. Miller (1961) cites flows recorded in the Colorado River at Yuma, Arizona, ranging from 18 cfs in 1934 to 250,000 cfs in 1916. The drainage basin lacked large natural lakes, so the native fishes never adapted evolutionary specializations for lacustrine environments. For millions of years, the unique environment of the Colorado River with its great diversity and torrential flows through canyon areas, directed the evolutionary pathways followed by the native fishes. It molded the bizarre morphologies of the razorback sucker, the humpback and bonytail chubs, and produced the largest of all North American minnows, the squawfish. Behnke and Benson (1980) provide a good overview of distribution, life history, causes of decline for these unique, and in one case (razorback sucker) monotypic species.

The construction of mainstream dams, forming large lakes, regulating flow regimes, precipitating out the silt load and releasing cold, clear water, created new environments for which the native mainstream fishes were ill adapted (Mlnckley et al., 1991; Modde et al., 1995; Tyus, 1991; Holden and Wick, 1982; Seethaler, 1978; Vanicek, 1967). In addition, predation and competition from nonnative fishes (Behnke and Benson, 1980) and toxic metal contamination (Stephens et al., 1992) have contributed to the decline of these species. These factors have impaired the ability of these species to recruit throughout their ranges (McAda and Wydoski, 1980; Tyus, 1992). Consequently, it is not surprising that the Colorado River squawfish, humpback chub, bonytail chub, and razorback sucker are federally-listed endangered species. In addition, two other native species, the flannelmouth sucker and roundtail chub, are candidate species for potential future inclusion on the Federal Threatened and Endangered Species List.

Table 3. Common and scientific names of the native fishes of the Upper Colorado River Basin (modified from Behnke and Benson 1980)

Family		Family	
Common	*Scientific*	*Common*	*Scientific*
Salmonidae (trout)		Catostomidae (suckers)	
Colorado River cutthroat trout	*Onchoryncus clarki pleuriticus*	Razorback sucker	*Xyrauchen texanus*
Rocky Mountain whitefish	*Prosopium williamsoni*	Flannelmouth sucker	*Catostomus latipinnis*
		Bluehead mountain sucker	*Catostomus discobolus*
		Mountain sucker	*Catostomus platyrhynchus*
Cyprinidae (minnows)		Cottidae (sculpins)	
Colorado River squawfish	*Ptychocheilus lucius*	Mottled sculpin	*Cottus bairdi*
Humpback chub	*Gila cypha*	Paiute sculpin	*Coitus beldingi*
Bonytail chub	*Gila elegans*		
Roundtail chub	*Gila robusta*		
Speckled dace	*Rhinichthys osculus yarrowi*		
Kendall Warm Springs dace	*Rhinichthys osculus thermalis*		

Research on the status of the four endangered fish species in the Upper Colorado River Basin has been conducted by the U.S. Fish and Wildlife Service, Utah Division of Wildlife Resources, Bureau of Reclamation, and National Park Service. The Colorado and Green rivers through Canyonlands National Park contain significant habitat for these endangered species (Valdez, 1990; Valdez and Williams, 1993).

Given the limited information available, it appears that recruitment of these species is likely associated with high-flow events, most notably with the availability of flooded bottomlands (Modde et al., 1995). Riverside wetlands provide important and perhaps critical habitat for young fish. Water development projects (dams, levees, and other flood-control structures) often prevent the rivers from overflowing their banks and flooding the bottomlands. These wetlands can be provided by removing barriers to historic bottomlands and by providing sufficient flow to inundate bottomlands in a manner that approximates the natural hydrograph.

The U.S. Fish and Wildlife Service has been in consultation with other federal agencies in the Upper Colorado River Basin under provisions of the Endangered Species Act of 1973 as amended, and has issued over 100 Biological Opinions pursuant to Section 7 of the Act (Tyus, 1991). In general, the U.S. Fish and Wildlife Service has determined that water depletion and dam operations would likely jeopardize the continued existence of some listed fishes. An interagency program has been established in the Upper Colorado River Basin in an effort to recover listed fishes without violating existing state and federal water agreements. This program oversees recovery activities in the upper Colorado River, provides funds for evaluating habitat requirements of the fishes, and seeks ways to obtain water needed by the fishes (Tyus, 1991).

WATER RESOURCE ISSUES

All the NPS units on the Colorado Plateau are located in the arid environment of the high desert. Water is such a scarce resource that even intermittent and ephemeral sources can be critical for sustaining the natural floral and faunal ecosystems of the Group Parks. Impacts to water quality, riparian habitat and aquatic biota are key concerns of the Southeast Utah Group.

The use of certain water resources within Canyonlands for recreation is also considered important. The Green and Colorado rivers form the heart of Canyonlands and represent a major drainage for the southwestern United States. Recreational boating in the form of kayaking and rafting, are very popular and have established themselves as a significant aspect of the local tourist economy.

Water quality issues were identified as the number one priority during the initial meeting with the Southeast Utah Group staff. Since water quality is a component of most of the issues identified, it will be addressed under each relevant topic.

HIGH PRIORITY ISSUES

Seeps and Springs

The seeps and springs represent one of the few riparian and aquatic habitats away from the main river drainages. Visitation was identified as the primary threat to non-river water sources in the Southeast Utah Group Parks. The impacts to water quality due to the effects of sunscreen, insect repellent, body oil and salts, in backcountry water sources frequently used for bathing and swimming, are unknown. Although the current Backcountry Management Plan (NPS, 1995) prohibits "swimming, bathing and immersing human bodies in water sources..." a detailed study may be necessary to develop a basis for these restrictions. The increased impact due to human visitation may drive away wildlife that depend on the springs as a water source. Trampling of surrounding vegetation and soils, and increased sedimentation are also concerns that may impact water quality and benthic aquatic organisms existing in the seeps and springs.

Salt Valley Wash is a tributary of Salt Wash (in Arches) and was formed as a result of collapsed salt anticlines in the Paradox Formation. Salt Valley Spring is a perennial water source located in the headwaters of the wash and has been developed in the past for stock watering. The spring has been at risk of completely drying up due to invasion of tamarisk *(Tamarix ramosissima).* The NPS has been involved in a tamarisk eradication project at the spring in an attempt to control this exotic species. This effort has involved routinely cutting down the tamarisk and applying the herbicide Garlon 4 to inhibit resprouting. Removal of the tamarisk would reduce evapotranspiration and rejuvenate the spring by increasing discharge back to natural levels. In the past, this area has been considered for antelope re-introduction if a sufficient water source could be found. Arches staff involved with the project have expressed concern over the effects of exposure to the herbicide and the impacts to surface and groundwater quality.

Trespass cattle also affect springs in Arches and Canyonlands. Impacts include trampled soil and vegetation, increased sedimentation, and elevated levels of fecal contamination. In addition, a full biotic assessment is needed to determine if rare or threatened and endangered vegetation and aquatic species are present at the seep and spring sites. In 1996, Natural Bridges will complete the last segment of fencing that will effectively exclude cattle from the water resources of the monument.

Culinary Water

NPS units on the Colorado Plateau have become a major destination for millions of tourists annually. Average visitation to Plateau Parks has increased 94% between 1981 and 1994. The South East Utah Group Parks are even outpacing the average Plateau visitation increase. For example, Canyonlands experienced a growth of 160% in visitor days between 1981 and 1993 (Hecox and Ack, 1996).

Accompanying the increased visitation is an increased need to provide visitor services. All districts administered by Canyonlands have experienced significant increases in visitation which at times overtaxes the existing culinary water systems. Currently, water is trucked into the Maze and Island Districts, limiting the amount of potable water available. Previous studies to determine groundwater availability indicate poor water quality and excessive aquifer depth in the northern regions of Canyonlands (Huntoon, 1977). In some areas, perched aquifers discharge directly to local springs. Some of the underlying strata (i.e., sandstones) are considered water bearing formations, but hydraulic conductivity of these consolidated rock formations is generally quite low and results in low well yields, although in some areas of localized fracturing and faulting, well yields may increase significantly (USGS, 1984). One previous study noted two wells that are relatively close to existing developments at Hans Flat (Hand, 1979). Discharge from these wells appear quite low but may be increased by development work and augmented by storage options. Water quality is also a concern. Dissolved solids are routinely greater than 1000 mg/l where the top of the Navajo Sandstone is more than 500 feet below the surface (Blanchard, 1987). A water treatment process, such as a reverse osmosis system, may be necessary to deal with high levels of dissolved solids. A detailed engineering and economic feasibility study would be necessary to determine the potential for local groundwater development.

The Needles District of Canyonlands contains an abandoned landfill that was reportedly in use from 1966-1987 (Figure 9). A preliminary assessment was done on the site, and it determined that potential contaminants may include: paints and thinners, batteries, pesticides, aerosol cans, human waste, oils, construction debris and household waste (Mesa State College, 1996). It is unknown at this time whether leachate from this landfill is a potential threat to the well currently being used for domestic water. Impact to the culinary water system should be determined and a site remediation plan designed. Also, there are numerous abandoned wells in the general area of the Needles Ranger Station (Figure 9). If a decision is made to terminate the use of these wells, they should be officially abandoned and properly sealed. Unplugged wells can be a conduit for contaminants to move between aquifers. This is especially a concern if the abandoned wells intercept groundwater flow carrying leachate from the abandoned landfill, possibly transmitting contaminants to the aquifer used for the domestic water supply.

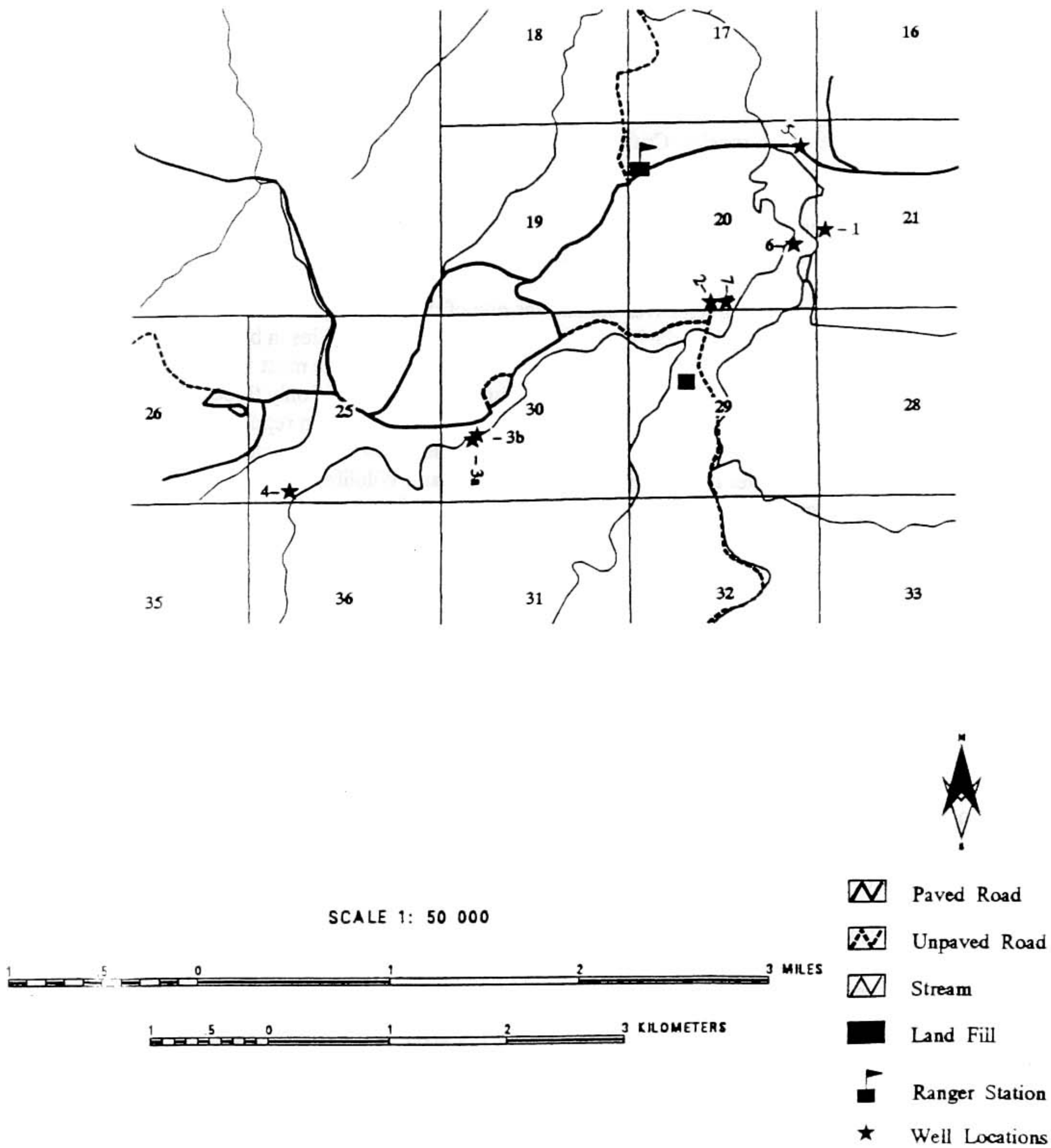

Figure 9. Well and landfill locations in the Needles District of Canyonlands National Park (from Mesa State College, 1996)

Threatened and Endangered Fish

The Colorado River in Arches and Canyonlands, and the Green River in Canyonlands were designated by the U.S. Fish and Wildlife Service as critical habitat for the four federally endangered fish species. Critical habitat is a regulatory term describing the areas of land, water, and air space containing the physical and biological features essential for the survival and recovery of threatened and endangered species. Section 7 of the Endangered Species Act requires federal agencies to ensure that their actions are not likely to jeopardize the survival of a listed species or adversely modify its critical habitat.

The lower 50 miles of the Green River constitutes one of the most important nursery areas for Colorado River squawfish in the basin, due to relatively high densities in backwater habitats. Similarly, the Colorado River in Cataract Canyon contains the most recently discovered reproducing population of humpback chub. It is also one of only three areas in the Upper Colorado River Basin where bonytail chub have recently been reported (Valdez and Williams, 1993). In 1996, more than 170 razorback sucker larvae were documented from the lower Green River near Canyonlands (U.S. Fish and Wildlife, 1996). This confirms that spawning is occurring in this stretch of river and suggests the presence of another population of razorback sucker in the lower Green.

Flow regime and channel geomorphology have changed dramatically over time. Flow in the Green River has been regulated by various water development projects and the Flaming Gorge Dam since 1963. The mean annual peak discharge at the Green River gaging station at Green River, Utah, (USGS station 09315000) has decreased 33% from 32,728 cfs to 22,091 cfs between the pre- and post-1963 streamflow data. While the pre- and post-1963 mean annual flow data remain relatively unchanged at 5800 cfs and 5600 cfs, the mean base flow (represented by flow records from September 1 to March 1) for the same period of record increased 64% from 2150 cfs to 3380 cfs (Flo Engineering, 1995). Riparian vegetation has been shown to be sensitive to changes in maximum and minimum flows, but substantial changes in riparian areas can occur without changing mean annual flow (Auble et al., 1994). This flow alteration likely reflects the operation of Flaming Gorge Dam for storage and hydropower generation. Reservoirs will typically act as sediment traps, blocking all sediment transport downstream. However, on the Green River below Flaming Gorge Dam, the decrease in sediment transport at the Green River gage far exceeds the amount of sediment trapped by the reservoir. Flaming Gorge Reservoir is located in the upper reaches of Green River Basin where a majority of the basin runoff is generated, while the principle area of sediment contribution is farther downstream. The results of the study by Andrews (1986) indicate the decrease in sediment transport at the lower end of the Green River Basin is primarily due to a decrease in the magnitude of the river flows and not necessarily a decrease in available sediment.

The reduction in magnitude and frequency of peak discharges and the decrease in sediment transport have resulted in significant changes to channel morphology. The result of these changes has been extensive vegetation encroachment, stabilization and bank attachment of sandbars within the active river channel, and narrowing of the river channel. Comparison of historic photos in specific reaches on the Green River in Canyonlands clearly show some large sandbars have become so densely vegetated that inundation results in sediment deposition and vertical development of the bars (Flo Engineering, 1995). Eventually, this process results in the loss of side channels which are considered key spawning habitat for some of the native fish species. Erosional processes on unregulated rivers have been observed that do not occur on regulated rivers (Cluer, 1996). These processes may be significant due to their impacts on aquatic biota and habitat in the river channels.

Flaming Gorge Reservoir, as well as all other reservoirs in the Upper and Lower Colorado River basins, is operated in accordance with the "Law of the River." The 1997 Annual Operating Plan for the Colorado River Reservoirs states, "All operations will be undertaken subject to the primary water storage and delivery requirements established by the "Law of the River"... including enhancement of fish and wildlife, and other environmental factors." Flaming Gorge has been operated under the criteria specified in the Biological Opinion on the Operation of Flaming Gorge since 1992.

The 1996 water year is the final year of a five year study plan called for in the Biological Opinion initiated to determine river flows necessary to maintain native endangered fish populations. The Bureau of Reclamation and the Western Area Power Administration are expected to release a revised Biological Opinion in 1997 which may modify specific constraints regarding flow releases for the entire annual cycle. It will be necessary for the NPS to stay current regarding decisions made on operating criteria for Flaming Gorge Dam. Releases from Flaming Gorge will determine future changes in channel geomorphology as far downstream as Canyonlands National Park.

Effective management practices have not been developed for native Colorado River fishes, nor have endangered fishes been recovered. To do so would require many years of research and management work. However, the Interagency Recovery Program is assisting the development and testing of management practices for the fishes. This was made possible by funds provided by a coalition of federal, state, and private agencies, and interests wishing to recover listed endangered fishes and at the same time, allow for some water development. It is the cooperation of various agencies that are charged with protection of the fishes and management of the water upon which they depend, that will permit the development and testing of management procedures and practices for recovery of listed fishes; presumably to the benefit of the entire fish fauna.

Salt Creek

Salt Creek is a very popular spot located in the southern area of Canyonlands Needles District. Other than the Colorado and Green rivers, Salt Creek is the only other perennial stream in the park. This makes Salt Creek a significant riparian resource that forms important habitat for aquatic and terrestrial wildlife. A four-wheel drive road runs in the bottom of the wash and accesses popular backcountry hiking areas in the upper reaches of Salt Creek. Several archeological sites accessible from the wash make it a culturally important area as well.

The Salt Creek area has experienced a dramatic increase in visitation in the form of four-wheel drive vehicles. Salt Creek Road is located directly through the wash and causes a substantial impact to the riparian habitat. Impacts to aquatic and terrestrial wildlife are unknown. The riparian area along Salt Creek has not been fully assessed regarding the presence of rare or threatened and endangered vegetation. Determinations should be made specifying whether areas in Salt Creek meet the criteria for designated wetlands.

Due to the increased adverse impacts observed on Salt Creek Road, the current Backcountry Management Plan has limited access to this area. Four-wheel drive roads are remaining open to vehicle traffic, but travel on Salt Creek Road will be allowed by permit only. It is hoped that the effort to limit traffic will serve as a starting point to resource protection in this area. In addition, the Backcountry Management Plan states that a monitoring program will evaluate the effectiveness of this restriction.

MEDIUM PRIORITY ISSUES

Water Rights

A system of allocating water for beneficial use was developed because of the arid climate and limited available water in the western United States. This system is known as the prior appropriation doctrine and is the primary philosophy regarding allocating water resources in the west. The concept of "first in time, first in right" applies in western water rights, meaning the date of appropriation determines the users priority to use water. If there is insufficient water to meet all needs, the senior appropriators (those with earlier appropriation dates) will obtain all of their allocated water before junior appropriators (those with later appropriation dates) obtain any of theirs. The prior appropriation system of water rights is under the jurisdiction of the individual states in the western United States (Getches, 1984).

In addition to the prior appropriation doctrine, water allocation and use in the western United States is governed by the Federal reserve water rights doctrine (also known as the Winters Doctrine). This doctrine asserts that the U.S. reserves, by implication, the right to enough of the unappropriated water on or adjacent to the reserved lands to fulfill the purpose of the reservation (Newberry, 1995). Reserve water rights institute a priority date back to when the reservation was established and are not subject to state water law except when properly joined in a general adjudication. This concept of federal primacy over state control of water is of great concern to states' water rights holders. Federal reserve rights are often unused and unquantified. Water users with state rights established after the creation date of the reservation have a lower priority than that of the reservation. If the federal government asserts its water rights claim after a stream has been fully appropriated under the state system, junior rights filed under the state system may subsequently go unfilled (Getches, 1984). This could potentially disrupt a state's water rights system and displace any junior water users, yet it can also have the effect of protecting instream flows, thus protecting existing downstream users from new diversions. The National Park

Service has used both the federal reserve and prior appropriation doctrine to protect water rights interests of National Park units (Newberry, 1995).

Water allocation in the Upper Colorado River Basin is dictated by states' rights, federal reserve rights, and the "Law of the River." The McCarran Amendment (1952, 66 stat. 560) grants a limited waiver of Sovereign Immunity to allow the United States to be joined as a defendant in suits involving the adjudication of water rights. This amendment requires the United States to assert its claim to water rights when general adjudication is occurring in the pertinent river system. Failure to assert a claim to water rights in such a proceedings may result in forfeiture of these rights. Portions of the Colorado River drainage system through Utah are currently undergoing water rights adjudication, and the federal government is expected to be a part of this adjudication procedure sometime in the future. The Southeast Utah Group Parks are a part of this system by nature of their location in the heart of the Upper Basin. Water rights issues that were identified during initial meetings with park staff are discussed below.

In the Horseshoe Canyon detached unit of Canyonlands, active grazing allotments exist adjacent to park boundaries. There is currently a water right conflict over stock watering at a nearby spring. The NPS Water Rights Branch and the Department of Interior Solicitors Office is currently investigating this situation.

The Lost Spring Canyon is a tributary of Salt Wash in Arches National Park. This spring is located in a designated Wilderness Study Area (WSA) outside of park boundaries, but consideration has been given to include the WSA into the NPS system. In the past, the Lost Spring has been developed for cattle stock watering and may have an existing water right associated with it. This claim should be investigated for validity or status regarding forfeiture or abandonment.

In initial meetings with Arches staff; concern was expressed over a spring located within park boundaries in the upper reaches of Courthouse Wash. This spring has been used for stock watering in the past. A staff member referred to a letter written by a previous Arches superintendent, which gave a local rancher permission to use the spring for stock watering. The administrative files were searched, but a copy of the letter has not been found. Questions were raised over whether a water right was established by the local rancher due to abandonment or forfeiture by the Park Service. Arches currently has a good relationship with the local rancher but occasionally has trespass cattle in the area.

In December of 1996, Utah and the Department of Interior reached a final agreement on water rights at Zion National Park. This agreement is paving the way for future negotiations of NPS units in Utah. A water rights assessment of the Southeast Utah Group Parks is appropriate at this time to take advantage of the `settlement momentum' initiated by the Zion decision. This will ensure that the NPS will pursue water rights filings where appropriate and adjudicate existing water rights if necessary.

Mining

Much of Moab's history and early growth center around the boom and bust cycle of the mining industry. Extensive mining activity has occurred in the recent past concentrating primarily on uranium, oil and gas exploration, and oil shale extraction.

The Atlas Moab Mill and associated uranium tailings pile are located approximately 3 miles northwest of Moab on the west bank of the Colorado River (Figure 10). Arches National Park Headquarters and Visitor Center are located approximately 1.5 miles northeast of the tailings pile. The Atlas Mill is no longer in operation and is currently being dismantled. As required by the Nuclear Regulatory Commission (NRC), the 10.5 million ton, 130 acre uranium mill tailings pile will be reclaimed by the Atlas Corporation. The criteria specified by the NRC for reclaiming uranium tailings provides flexibility on a site specific basis to determine optimum disposal. The current reclamation proposal preferred by the Atlas Corporation and recommended by the draft environmental impact statement (DEIS) specifies reclaiming the tailings for permanent disposal at its current location (USNRC, 1996). This process would involve reducing the sideslopes of the pile to 30% and capping the pile with an earth and rock system to minimize radon outgassing, rainwater infiltration, movement of tailings leachate into the groundwater and adjacent Colorado River, and natural and flood-induced surface erosion of the tailings pile. A rejected alternative plan required transporting the spoils pile to a remote site away from Moab and the Colorado River. The DEIS final recommendation appears to be based on the high cost of transporting the tailings to the alternative location. The Atlas Corporation has publicly stated that if forced to transport the spoils pile from its present location, the company will declare bankruptcy and walk away from the situation (ENR, 1984).

The proper reclamation of the Atlas tailings pile is of critical concern to the National Park Service. The DEIS acknowledges the potential impacts to downstream resources but considers the impacts insignificant. A catastrophic failure of the tailings pile adjacent to the river would result in contaminated sediments deposited all along the downstream channel margins through the river section of Canyonlands. The subsequent chronic effects of elevated levels of radionuclides, heavy metals, and other toxic contaminants can only be detrimental, especially to the recovery efforts of the threatened and endangered fishes. Water samples collected by the Utah Department of Environmental Quality in 1995, showed elevated levels of total and dissolved manganese, ammonia as nitrogen, and molybdenum. When comparing samples collected above and below the tailings pile, the Department found concentrations below the pile exceeded state water quality standards (UDEQ, 1996).

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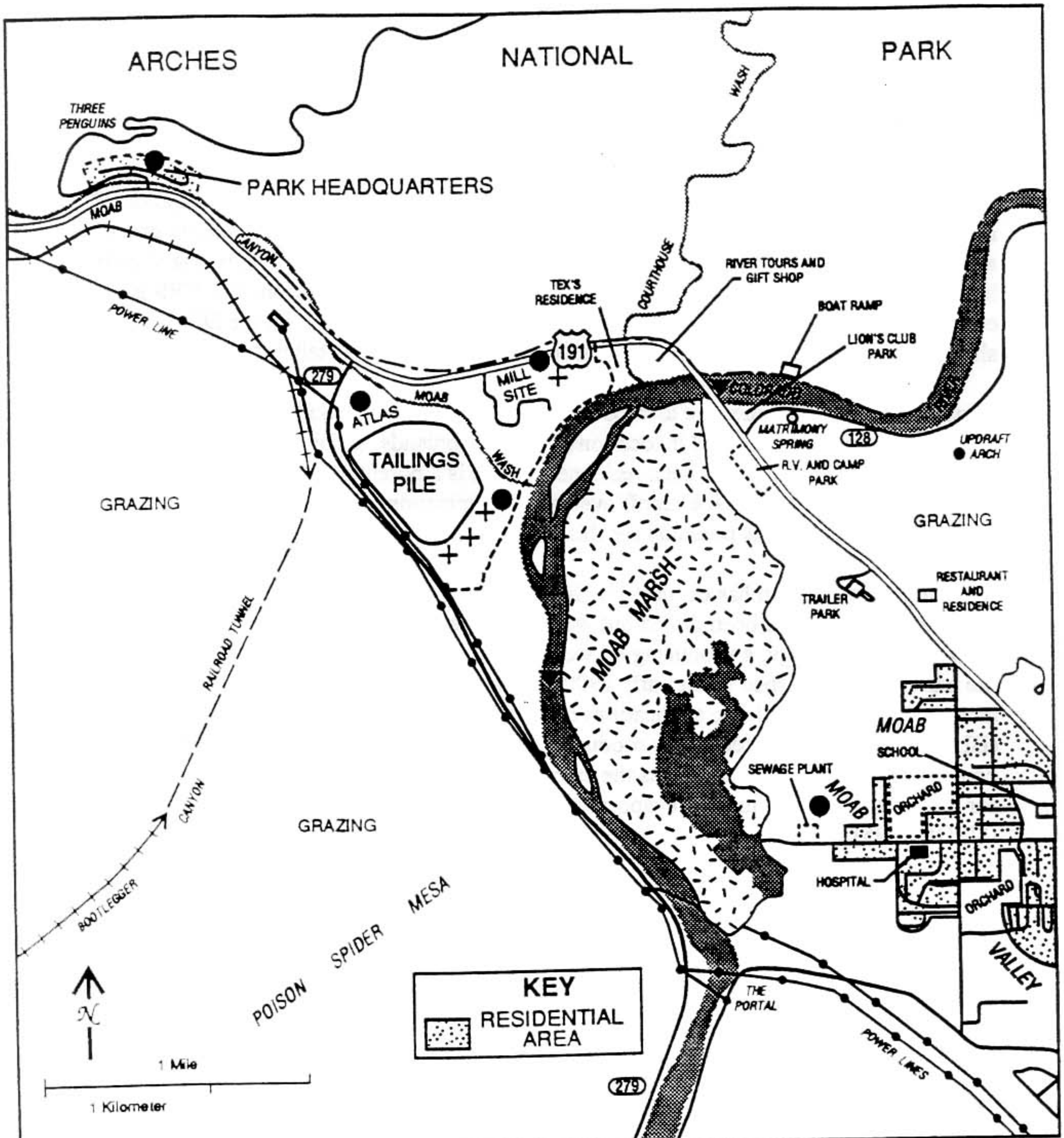

● RADON AND PARTICULATE MONITORING STATIONS, SOIL SAMPLES

+ GROUNDWATER MONITORING WELLS

▼ SURFACE WATER

Figure 10. Location of the Atlas Corporation Mill and tailings pile in relation to Moab and Arches National Park (from USNRC, 1996)

Another concern is the potential for o f site groundwater contamination. The Atlas tailings pile has been in place since 1956. Possible hydraulic connection to the alluvial aquifer and rainfall infiltration to the pile over an extended period of time, may have altered the groundwater flow direction. Radial flow away from the pile could carry contaminants in many directions including toward Arches (UDEQ, 1996). While analysis of a water sample taken from the Arches culinary well on January 18, 1996, did not show any indication of radionuclide contamination, well samples taken during the summer of 1996 show gross alpha levels near the maximum threshold (Rogers, pers. comm., 1996). Sampling should be continued to periodically monitor the well for possible contamination. The NPS is currently waiting for the U.S. Fish and Wildlife Service final opinion on the DEIS and should be kept current of any decisions made regarding the Atlas tailings pile reclamation.

Abandoned uranium mines are located in the headwaters area of Salt Wash and Seven Mile anyon near Arches and in locations near Canyonlands. Spoils from these abandoned mines have never been reclaimed. There is a potential for mine drainage to enter the parks during surface runoff events. Contamination from mine waste has not been documented, but there is potential for this to occur.

Oil and gas exploration has occurred in the Salt Valley area near Arches. Numerous exploratory wells have been drilled but were never developed due to economic reasons. Using new technology, a producing oil well located approximately 10 miles southwest of the park, was established in the early 1990's. This successful operation has resulted in an increase of oil and gas lease applications on surrounding Bureau of Land Management (BLM) lands. Saline water is a by product of oil and gas production with active wells commonly producing several times the amount of saline water as oil. Disposal techniques for excess saline water include evaporation, injection and discharge to local streams (USDI, 1995).

RECOMMENDATIONS

The complexity of the water resource issues facing the Southeast Utah Group Parks justifies the development of a comprehensive Water Resource Management Plan. The emphasis of this scoping report has been to identify issues that will be explored in greater detail in the management plan. These issues were identified during initial meetings with the Resource Management staff and personal contacts with park rangers at Arches and Natural Bridges. It will be important to solicit input from water resource professionals affiliated with other local federal and non-governmental organizations concerned with regional water resource issues. This may be accomplished through an issues scoping workshop at the beginning of the water resource management planning process, an event designed to bring together a group of people with specialized knowledge of water resource issues of concern to the Southeast Utah Group Parks.

The water resource issues affecting the Southeast Utah Group Parks are complex and far reaching. Impacts to water resources of the Group Parks quite often originate far beyond the park boundaries in the upper Green and Colorado river basins. Activities of private and federal entities can affect the aquatic resources and associated biota all along both river systems. The dual, and sometimes contradictory, mandate of the NPS to "...provide for their (visitors) enjoyment..." while leaving the natural resources "...unimpaired for future generations" has become difficult under the explosive growth in visitation the Colorado Plateau parks have experienced in the last 10 to 15 years. The NPS is continually placed in a controversial arena when attempting to initiate restrictions in popular areas. The management decision to implement restrictions on the Salt Creek Road (Needles District, Canyonlands) as specified by the Canyonlands Backcountry Management Plan is being legally challenged due to conflicting opinions and uses of this area. Creative management and careful monitoring of the natural resources will be necessary to maintain the parks in a relatively pristine state.

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As the nation's principal conservation agency, the Department of the Interior has the responsibility for most of our nationally owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to ensure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

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