CHAPTER 3: AFFECTED ENVIRONMENT

INTRODUCTION

This "Affected Environment" chapter describes the resources of Glen Canyon National Recreation Area (Glen Canyon) that could be affected by the implementation of any of the proposed off-road vehicle (ORV) management alternatives as described in chapter 2 of this Off-road Vehicle Management Plan / Draft Environmental Impact Statement (plan/DEIS). The resources described here correspond to those identified in chapter 1 as impact topics. The affected environment descriptions serve as the baseline against which the National Park Service (NPS) will evaluate the anticipated impacts of proposed management actions. This evaluation is the focus of "Chapter 4: Environmental Consequences."

This chapter describes the resources of Glen Canyon in two sections. The first section presents an overview of the general project setting, including landscape, location, and management zoning of Glen Canyon. The second section describes the general resources evaluated and identified in chapter 1 as impact topics, including geology and soils, vegetation, wildlife and wildlife habitat, special-status species, soundscapes, visitor use and experience, cultural resources, socioeconomics, health and safety, paleontological resources, and wilderness.

GENERAL PROJECT SETTING

Glen Canyon, located in the Colorado Plateau physiographic province, extends more than 200 miles from the Green River in southern Utah downstream to Lees Ferry in Arizona. It is a desert region of rock, arid shrublands, grasslands, and low-growing pinyon/juniper woodlands. As shown in the vicinity map (refer to figure 1 in chapter 1), Glen Canyon is bordered by Canyonlands National Park to the northeast; the Red Rock Plateau to the east; the Henry Mountains to the north; Grand Staircase–Escalante National Monument (Grand Staircase–Escalante), Dixie National Forest, and Capitol Reef National Park to the northwest and west; and the Navajo Indian Reservation to the south. Glen Canyon surrounds Lake Powell.

Glen Canyon extends more than 200 miles from the Green River in Southern Utah downstream to Lees Ferry in Arizona.

Congress authorized the construction of the Glen Canyon Dam in the Colorado River Storage Project Act of 1956 (PL 84-485). The primary purposes of the project were to prevent flooding on the Colorado River, create a reservoir to meet downstream water requirements, and generate hydroelectric power. Incidental to construction activities, the city of Page, Arizona, was established about 2 miles from the dam site to provide housing and other services for workers. Page now serves as the largest gateway community to Glen Canyon.

Lake Powell was formed by the inundation of the Colorado River following the construction of the Glen Canyon Dam between 1960 and 1963. The 186-mile-long Lake Powell formed along the courses of the Colorado River and three tributaries: the Escalante, San Juan, and Dirty Devil Rivers. Lake Powell is the second-largest reservoir by volume in North America, and the largest reservoir in North America by surface acreage, length, and shoreline length. The lake includes parts of Arizona and Utah, and is within the jurisdiction of several agencies. These include the Park Service, the Bureau of Reclamation, and the Bureau of Land Management (BLM); the Navajo Nation; the states of Utah and Arizona; one Arizona county (Coconino); and four Utah counties (Garfield, Kane, San Juan, and Wayne).

The Bureau of Reclamation manages the Glen Canyon Dam. It was designed to accommodate lake levels ranging from 3,490 feet to 3,700 feet above sea level. As the water level changes, the surface of Lake Powell varies in area from 52,000 acres to 163,000 acres and the shoreline fluctuates from 990 miles to 1,960 miles in length. Usually, the lake surface is about 160,000 acres, which represents approximately 13% of Glen Canyon. Annual fluctuations in

lake levels typically are about 25 vertical feet. The lake level rises in the spring as water from snowmelt runoff and spring storms collects behind the dam. It then declines throughout the rest of the year, particularly during summer and early fall as water is released for electrical power generation and irrigation.

Approximately 13% of Glen Canyon is inundated by Lake Powell. The other 87% of Glen Canyon consists of upland desert incised by deep canyons, dry washes, and steep cliffs, as well as talus, and clay or slickrock badlands. Much of the lake's shoreline consists of steep slopes and cliff walls. Elevations in Glen Canyon vary from approximately 3,600 feet (at low lake levels) to over 7,500 feet above sea level.

Glen Canyon was established in 1972 "to provide for public outdoor recreation use and enjoyment of Lake Powell and adjacent lands, and to preserve and protect the scenic, scientific, and historic features contributing to public enjoyment of the area" (PL 92-593). The primary management objective of Glen Canyon, as established in the General Management Plan (GMP), is "to manage the recreation area so that it provides maximal recreational enjoyment to the American public and their guests" (NPS 1979). NPS is responsible for managing all federal lands and waters within Glen Canyon boundaries (NPS 1987a).

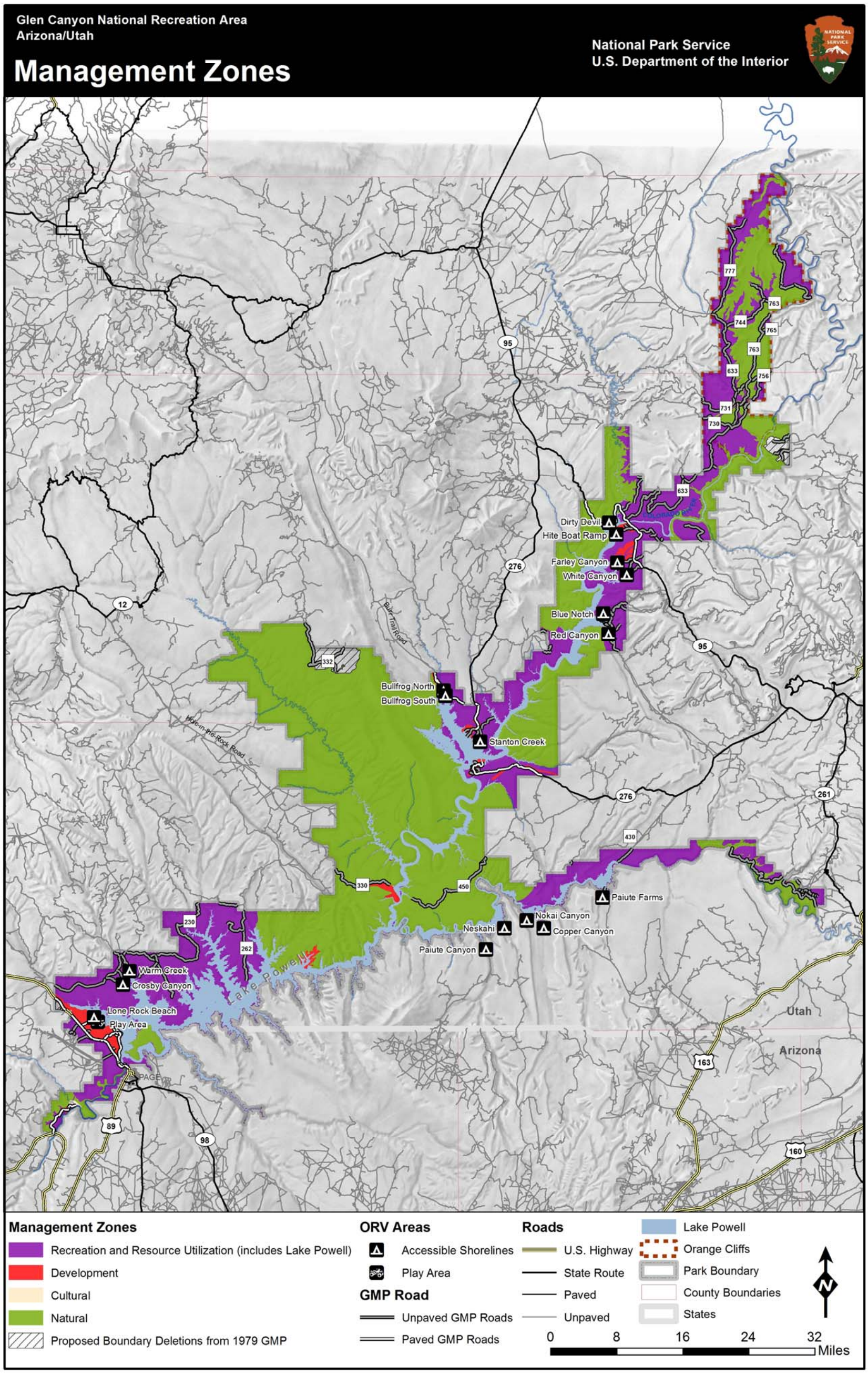
The area of analysis is broad. Natural topographical features generally contain the accessible shoreline areas, and therefore these shoreline areas are limited in extent and easily described in terms of resource conditions. The designated road system (GMP roads [paved and unpaved]), however, opens vast expanses of Glen Canyon to potential illegal ORV impacts, and the resources that may be subjected to impacts from illegal cross-country travel are extensive.

As lake levels drop and the shoreline recedes from the original designated ORV area, ORV users are authorized to continue traveling a natural course toward the lakeshore from the end of the access route. This natural course is considered a normal extension of the original ORV area access route. As Lake Powell has dropped in elevation, users have continued on a natural course past the high water terminus of the original road to reach the new lakeshore, a practice often referred to as "chasing the water." This allows for the establishment of a temporary social road. NPS has instituted temporary closures of ORV areas where the practice of chasing the water has resulted in damage to resources or has exceeded acceptable parameters, or where it has become evident that the natural topographic features of the area cannot contain off-road use.

MANAGEMENT ZONING

The 1979 Glen Canyon GMP specifies the long-term allocation of the approximately 1,246,000 acres of land and water resources in Glen Canyon through four management zones (figure 11). Additions to Glen Canyon not shown in figure 11 are in the four management zones as designated in the 1979 GMP (NPS 1979). Figure 11 shows the four management zones, as well as Glen Canyon boundary deletions, which are boundary adjustments documented in the 1979 GMP.

The Recreation and Resource Utilization Zone (557,890 acres, or 45% of Glen Canyon) consists of areas possessing somewhat less scenic value, greater susceptibility to human activities, potential or actual mineral resources, or value for utility rights-of-way or development. The Recreation and Resource Utilization Zone includes the entire surface (up to 163,000 acres) of Lake Powell. The remaining area in this zone (almost 400,000 acres) consists of dry land and includes about half of the lake shoreline. NPS manages the zone to maintain natural processes and enhance fish and game populations. Consumption of renewable and nonrenewable resources is subject to the protection of recreational values.



Note: NPS Route 450 corridor (Hole-in-the-Rock Trail) is managed as a "Cultural Zone" per the 1979 GMP; scale of this map prohibits this depiction.

FIGURE 11: MANAGEMENT ZONES

The Development Zone (19,270 acres, or less than 2% of Glen Canyon) is managed to provide visitor services and maintain facilities. This zone includes the permanent structures and operations necessary to support recreation activities and allows a wide range of recreational use. It includes the areas around Lees Ferry; the complex that includes the Glen Canyon Dam, Carl Hayden Visitor Center, and Wahweap Marina; and the developments at Halls Crossing, Bullfrog, Hite, Dangling Rope, Antelope Point, Llewellyn Gulch, and Hans Flat in the Orange Cliffs area.

The Cultural Zone (25 acres, or less than 1% of Glen Canyon) is managed for the preservation and interpretation of cultural, historic, and archeological resources, including restoration where deemed appropriate. This zone is composed of several areas located primarily along Wilson Mesa and the Escalante River.

The Natural Zone (668,670 acres, or 54% of Glen Canyon) includes Glen Canyon's outstanding scenic resources, relatively undisturbed areas isolated and remote from the activities of man, or areas bordering on places with established land-use practices complementary to those of the Natural Zone. NPS manages the Natural Zone to maintain isolated, natural processes. Consumption of renewable resources is subject to the protection of the recreational values of the area. The majority of the Natural Zone is proposed as wilderness.

The lakeside boundary of the Natural Zone is concurrent with the fluctuating water levels of Lake Powell except at Antelope Island. The zoning acreage under the GMP was established at the 3,700-foot contour of Lake Powell. As such, as the lake level has declined, there has been a corresponding increase in the total acreage of the Natural Zone. NPS treats the Natural Zone for Antelope Island differently because below the 3,620-foot contour, Antelope ceases to be an island. In this situation the Natural Zone is concurrent with the top of the south side of the channel between Antelope Island and Castle Rock. When lower than the 3,620-foot contour, the Natural Zone remains at this channel (NPS 1979).

Full pool on Lake Powell is considered 3,700 feet above sea level. The 1979 GMP established this elevation, which is the elevation considered as full pool by the U.S. Army Corps of Engineers for jurisdiction over permitting purposes. Glen Canyon Dam can accommodate a pool of 3,711 feet, beyond which the dam is overtopped. The 1988 Environmental Assessment and Management / Development Concept Plans for Lake Powell's Accessible Shorelines (EA/DCP) references a pool elevation of both 3,700 feet and 3,711 feet (NPS 1988). For the purposes of analysis in this plan/DEIS, however, 3,700 feet is the full pool mark (NPS 1979).

The GMP provides examples of allowed recreational activities for each management zone. The intent was to ensure that current and future public uses of Glen Canyon were evaluated and managed to preserve the integrity of the management zones, as well as the unique characteristics for which certain land and water resources were set aside (NPS 1979).

Motorized recreation was recognized as a permitted activity for the Recreation and Resource Utilization Zone and the Development Zone. The recreational description of these two zones includes scenic touring by conventional motor vehicles and boat as acceptable activities. Activities such as riding trail bikes and dune buggies are also recognized as acceptable activities in designated use areas. All the ORV areas at Glen Canyon are located in either the Recreation and Resource Utilization Zone or the Development Zone (NPS 1979). Although the Hole-in-the-Rock Road is in the Recreation and Resource Utilization Zone, the corridor is narrow and is surrounded by proposed wilderness.

Under the GMP, the use of motorized equipment is prohibited in the Natural Zone. Such uses would be inappropriate given the characteristics of these areas. The GMP describes the Natural Zone as possessing Glen Canyon's outstanding scenic resources and relatively undisturbed areas, isolated and remote from human activities (NPS 1979).

GEOLOGY AND SOILS

GEOLOGY

The geology of Glen Canyon represents a spectacular example of exposed Colorado Plateau rocks (Sprinkle et al. 2000) and is characterized by relatively flat-lying Mesozoic and Paleozoic sedimentary rocks. This area of high-standing crustal blocks is largely pristine due to a lack of rock deformation over the last 300 million years. The area stands in stark contrast to the highly deformed Southern Rocky Mountains region to the northeast and the Basin and Range regions to the west and south.

The bedrock units of Glen Canyon range in age from 300 million years (Late Pennsylvanian) to 85 million years (Late Cretaceous). Vigorous downcutting of the Colorado and San Juan River systems has exposed more than 8,500 feet of sedimentary rock strata. The strata contain a visible record of marine, marginal marine, coastal, and alluvial plain, vast desert, and small oasis conditions over a vast period.

Glen Canyon consists primarily of sedimentary strata of the Triassic and Jurassic ages. The majority of Glen Canyon is of the Moenkopi and Chinle Formations of the Triassic, and the Glen Canyon Group of the Jurassic. The Moenkopi, of Lower and Middle Jurassic age, is exposed most noticeably in the Hite area and the Orange Cliffs. The Moenkopi is distinguishable by its maroon to reddish brown sandstones, mudstones, shales, and lighter-colored carbonate layers.

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Above the Moenkopi is the Chinle Formation, composed of brilliantly colored limestone, claystone, siltstone, sandstone, and arkose and conglomerate beds, many of which contain petrified wood and coal seams. In Glen Canyon, the Chinle exposure is largely confined to the Orange Cliffs, Red and White Canyons, the Rincon, and in sections of the San Juan River. The Chinle exposure is also very widespread in the Circle Cliffs–Escalante Canyons area and in the Purple Hills. The Chinle erodes to form slopes between the underlying Moenkopi and the overlying Glen Canyon Group (described below). When dry, it is structurally weak, and such weakness increases when wet, with the potential of forming large landslide blocks in areas.

Above the Chinle is the block-forming Wingate sandstone, the lowest formation of the Glen Canyon Group. The Wingate consists of massive sandstone with large sweeping tangential crossbeds. The orange-red vertical cliffs of the Wingate can be up to 330 feet high, and are the formation for which the Orange Cliffs are named. The Wingate is usually capped by the Kayenta Formation, which often forms small ledges and step-like benches between the Wingate and the overlying Navajo Sandstone. The Kayenta is an orange to reddish sandstone interbedded with siltstone and rare lenses of limestone. The weathered sections can appear pale red with a purplish cast.

The Navajo Sandstone is the uppermost formation of the Glen Canyon Group and is prominent throughout Glen Canyon. Where it is exposed in its entirety, the tan to light reddish brown Navajo sandstone can form massive, near-vertical cliffs reaching 600 to 1,500 feet high. Where the younger rocks were removed the sandstone erodes into the characteristic domes and knobs dissected by deep ravines.

The Chinle Formation, along with the Tropic Shale and Dakota Formations, is especially vulnerable to disturbance. These formations contain high amounts of bentonitic clays, which will swell when wet, slide easily, and appear to flow, resulting in an undermining of overlying materials. Compaction or scarring of the surface can cause accelerated sheet and gully erosion, which is further aggravated by the absence of vegetation.

Gully Erosion at Glen Canyon

In the uplake portions of Glen Canyon, upper Jurassic formation rocks dominate the landscape at the Bullfrog area, where rocks are typically thinly bedded siltstones and mudstones with occasional thin beds of white sandstone. Holocene gravels, dunes, and soils are scattered in the area. The rocks in the Hite Boat Ramp area are older than the rocks at Bullfrog, with geology at Hite being dominated by rocks of Permian and early Triassic age (NPS 2008e).

There are 36 miles of unpaved GMP road corridors on erosion-susceptible rock units in the Orange Cliffs and Smoky Mountain / Nipple Bench area. These deposits are highly unsuitable to all types of development, as noted in the GMP (NPS 1979).

SOILS

Soils in Glen Canyon are integral to maintaining the physical, biological, and chemical integrity of the ecosystem. Wind and water action, both current and historic, have been and continue to be the dominant shaping forces in this region of canyons and plateaus. Unless soil deposits are protected from these natural forces they are subject to constant movement and erosion. The area receives little precipitation and contains scarce vascular vegetation cover. Soil and associated biological crusts provide three key functions in this water- and nutrient-limited environment: water absorption, resulting in decreased runoff; carbon and nitrogen fixation, providing mineral nutrients for vegetation growth; and porous material for physical support of soil structure and vegetation (Belnap 1993). Although wide swathes of Glen Canyon consist of bare rock, steep canyon walls, or bare rock with minimal soil cover, there are many areas that contain or have the potential to contain biological crusts and small areas of deeper alluvial soils. If such soils are disturbed, compacted, or eroded, the ecology of the entire ecosystem suffers a loss of productivity, diversity, and integrity.

Soils of Glen Canyon

Approximately one-third (400,000 acres) of Glen Canyon is exposed bare rock and the disintegrated shale and sandstone that make up canyon walls and plateau edges (NRCS 2010). The weathering of rock in flat areas such as plateaus and mesas, along with introduced windblown sand, may create a thin, noncontinuous soil mantle over the rock. This thin cover often has pockets of deeper soils in indented or sheltered areas, which frequently shift due to wind and erosion. These thin, shifting, constantly disturbed soils cover most of the remaining area. Because much of the soil in Glen Canyon is transported by water and wind, most of the deeper soils are present in protected areas such as dry streambeds, alluvial zones, former and existing canyons, and cliff bases. Deeper, more established soils make up a fraction of the Glen Canyon National Recreation Area (1,850 acres) (NRCS 2010).

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Soils in Glen Canyon are generally sandy, with most upland areas containing variants of sandy loam, loamy sand, and sand. There are also areas of high clay content, known as clay barrens, and areas with high mineral concentrations (NRCS 2010). Clay and silt loams may be found in alluvial areas or the shoreline area of Lake Powell where soil deposits are left behind by retreating waters. In sections of the accessible shoreline areas of Glen Canyon where soils are occasionally inundated, flooding creates anaerobic conditions and limits the development of biological crusts or vegetation. Shoreline areas and dry washes that are rarely covered in water may support increased vegetation because of deeper, more fertile alluvial or windborne soil deposits, protection from erosive forces, and/or increased moisture availability. Alluvial soil deposits and associated vegetation commonly occur at the edge of the high water line, especially in protected stream beds or canyons. Upland areas that contain sandy soils or sand mixed with clay and minerals may form either biological or physical crusts. The majority of the soils in ORV areas are shallow and subject to frequent shifting due to wind and water. Deeper, established soils are found in accessible shoreline areas (particularly in canyons), or at the base of rock outcrops or cliffs (above the high water line and/or protected from water run-off). These areas may contain biological crusts and vegetation, and are subject to less wind and water erosion because these processes fix the soil in place.

Biological crusts (or biotic crusts) are a key component of the ecosystem formed on the thin soils of Glen Canyon and across the Colorado Plateau region, where up to 70% of living ground cover may consist of biological crusts (Belnap 1994). Biological crusts are composed of a community of specialized organisms including cyanobacteria, green algae, lichens, mosses, microfungi, and other bacteria, and appear as dark, sponge-like-textured pinnacles of soil (Belnap and Lange 2001). The soil is stabilized when filaments of cyanobacteria and microfungi extend into the upper few millimeters of soil and secrete a gel-like substance that binds the soil particles together to form a cohesive matrix (Belnap and Gardner 1993; Belnap 1993). Once formed, biological crusts are an important foundation of the desert ecosystem and serve to retain soil moisture, reduce water and wind erosion, fix atmospheric nitrogen, and contribute to soil organic matter (Neff et al. 2005). The composition of species associated with biological soil crusts varies from site to site but the diversity of organisms in a crust is often greater than that of the vascular plants present in the area (Belnap and Lange 2001; Rosentreter et al. 2007). As such, these crusts are increasingly recognized for having a major influence on terrestrial ecosystems by stabilizing the soils, reducing runoff, increasing water absorption, and forming a base for the growth of lichens and bryophytes (Belnap et al. 2001).

Bathtub Ring on Far Shore

Soils in Glen Canyon may form biological crusts in areas free from historic or current nonnatural disturbance, with shallow soil and limited water and wind erosion. Biological crust cover generally increases in areas with low vascular plant cover, at lower elevation, and with more loosely embedded rocks, shallower soils, and fine soil texture (Belnap and Lange 2001). Soil chemistry also influences crust formation and composition with calcareous and gypsiferous soils supporting a high coverage of species-rich crust (McCune and Antos 1982). Biological crust formation is limited because over one-third of Glen Canyon consists of bare rock, and one-third has thin, shifting soils, with wide swathes containing high concentrations of minerals. Biological crusts are also unlikely to form in areas with high salt concentrations (Belnap and Lange 2001). Additionally, areas of Glen Canyon in the “bathtub ring” of Glen Canyon (the land around Lake Powell bleached by high water), or in dry streambeds and canyons, are subject to inundation during high water events. Flooded soils create anaerobic conditions, which inhibit the development of biological crusts due to the intolerance of lichen for low-oxygen or no-oxygen conditions (Winward 1980).

Nonbiotic crusts, known as physical crusts, also commonly occur in Glen Canyon. These crusts are primarily formed by raindrop impact, which breaks down the soil and fixes small-diameter silt and clay particles to the surface, creating strong, dense, soil layers ranging in thickness from 1 millimeter to 3 centimeters. The crusts have low infiltration rates, which limits drainage, resulting in increased water runoff and soil erosion, and in reduced germination and emergence rates of vascular plants (Belnap and Lange 2001). Aerial images of Glen Canyon show large areas of physical crusts, often indicated by white expanses of salts, lime, and silica, which are deposited at the surface during evaporation. Physical soil crusts are commonly formed in soils with low organic matter and low silt and clay content (Lemos and Lutz 1957; Belnap and Lange 2001). The formation of such crusts is reduced by livestock grazing management, soil surface protection, and increased soil organic matter (Belnap and Lange 2001; Neff et al. 2005). When left undisturbed, physical crusts pool water and may become a foundation for biological crusts (Belnap et al. 2001). Impermeable soils are also formed through trampling by livestock or through wheeled vehicle passage, which compact and shear the soil, resulting in more surface runoff along with the destruction of soil pores and structure (Adams et al. 1982; Payne et al. 1983). Because the compaction associated with livestock or vehicles destroys soil structure, these impermeable soils generally do not form the basis for biological crusts (Belnap and Lange 2001).

Soils in the Project Area

Lone Rock Beach

Lone Rock Beach is located in a highly disturbed area with heavy impacts caused by visitors traveling off designated trails, ORV traffic, and camping. In areas that are occasionally or seasonally inundated during high water levels, soil disturbance and compaction leads to increased erosion and runoff. Biological crusts are uncommon due to existing disturbance levels, and trails and associated compaction related to foot traffic and off-road use are omnipresent. Although some patches of vegetation, including four-wing saltbush (*Atriplex canescens*) and Russian thistle (*Salsola pestifer*), exist on older portions of the beach, soils are primarily thin and sandy with little vascular vegetation cover. Shoreline soils may contain deposits of fine clay or loam, with anaerobic conditions and occasional inundation, both of which limit plant growth. Soils found in this area are of the Pagina–Farb–rock outcrop association and rock outcrop–Needle association, which are generally shallow, fine, and sandy soils, derived from sandstone and deposited by the wind. Such soils are easily disturbed. There are also areas of exposed rock and sandy deposits, indicating that wind is a strong shaping force in the soils in the vicinity, and many of the soils are therefore transient and shallow.

Lone Rock Beach Play Area

This area is highly disturbed by off-road use, leading to erosion and compaction. Minimal biological or physical soil crusts and very little, if any, vascular vegetation cover exist in this area due to the physical disturbance from tire passes. ORV traffic results in increased soil loss due to disturbance from these vehicles, which loosens and kicks up soil, and subsequent wind action, which transports it away from the area. Soils found in this area are of the Pagina–Farb–rock outcrop association and rock outcrop–Needle association, which are generally shallow, fine, and sandy soils derived from sandstone and deposited by the wind. Such soils are easily disturbed. There are also areas of exposed rock and sandy deposits, indicating that wind is a strong shaping force in the soils in the vicinity, and many of the soils are therefore transient and shallow.

Ferry Swale

The Ferry Swale area is increasingly subject to off-road use along user-created routes, leading to soils erosion and compaction in descrete portions of the wider Ferry Swale area. Minimal biological or physical soil crusts and very little, if any, vascular vegetation cover exist in these portions of Ferry Swale due to the physical disturbance from tire passes. Soils in Ferry Swale include easily disturbed Farb-Pagina type soils. Other soil types include Juanalo,

Needle-Sheppard, and Pagina-Denazar. There are also areas of exposed rock and sandy deposits, indicating that wind is a strong shaping force of the soils in the vicinity.

Paved and Unpaved GMP Roads

Soils along these roads in the Uplake Area consist primarily of alluvial or colluvial soils derived from water and wind erosion of the surrounding bedrock. Soils along paved and unpaved GMP roads generally are not experiencing ongoing disturbances because paved and unpaved GMP roads are maintained for motor vehicle use. Soils in the vicinity of these roads may be disturbed by off-road vehicle travel. These soils include the Monue, Bluecheif, Moenkopi, and Moffat series.

The Monue series soils consist of very deep, well-drained, moderately rapidly permeable soils on alluvial terraces and eolian deposits on structural benches. These soils form from the erosion of sandstone. Soils are loamy fine sand. Slopes range from 1% to 12%. These soils are typically deeper than 60 inches, but may have bedrock at depths of 40 to 60 inches. Soils are typically used for rangeland.

The Bluechief series consists of moderately deep, well-drained, moderately to rapidly permeable soils that are formed in sandy eolian deposits and alluvium derived from sandstone. These soils are located on benches and fan terraces. Soils are fine sandy loam. Slopes range from 1% to 15%. Soil depths are typically 30 to 40 inches, but bedrock can occur at 20 inches. Soils in this series are typically used for rangeland, wildlife habitat, and recreation.

The Moenkopi series consists of very shallow and shallow, well-drained, moderately to rapidly permeable soils that formed in alluvium and residuum from sandstone and shale. Moenkopi soils are on mesas, hill slopes on structural benches, and plateaus. Soils are loamy sand. Slopes are 1% to 30%. Soil depths are typically 9 to 12 inches, but can range from 4 to 20 inches. Soils in this series are typically used for livestock grazing and wildlife habitat.

The Moffat series consists of very deep, well-drained, moderately rapidly permeable soils that formed in eolian and alluvial sediments. These soils are on plains, plains on structural benches, and alluvial fans and have slopes ranging from 1% to 25%. Soils are gravelly fine sand. Soil depths are typically 40 to 60 inches. Soils are typically used for rangeland.

Accessible Shoreline Areas

Areas where vehicles access shorelines may contain sensitive soils, particularly because roads and routes often lead through canyons and old or existing streambeds. Under the right conditions, these areas may contain better established soils with higher levels of organic components and more vegetation cover, or biological crusts (see detailed discussion of each shoreline area). Most soils found in these areas are poorly developed, shallow soils that erode easily and regenerate slowly. These areas may develop biological crusts where there are shallow slopes and minimal vascular vegetation cover. Many areas contain high percentages of rocky outcroppings with soil deposits on the slopes and at the bases of the outcroppings that are shallow, frequently shifted by the wind, and primarily sandy. Shoreline areas that are below the high water line of the reservoir already experience disturbance due to fluctuating water levels. However, further erosion, runoff, and compaction from off-road use may result in decreased water quality along with increased soil loss.

Neskahi, Dirty Devil, Copper Canyon, Farley Canyon, Paiute Canyon, and Stanton Creek: These accessible shoreline areas all contain Torriorthents–rock outcrop association soils. This association consists of nearly half rock outcrops, with most of the remainder made up of Torriorthents or similar soils. Better-established, deeper Myton soils are found in drainages, particularly at Farley Canyon. Torriorthents soils are sandy and gravelly talus derived from sandstone and shale, and are of variable depth. These soils are transported by wind or water and form a thin mantle over the rock. In areas of shallow slopes and sparse vegetation cover, these soils may form biological crusts.

Paiute Farms and Nokai Canyon: These accessible shorelines contain rock outcrop soil associations similar to those of other shorelines in the immediate vicinity, such as Copper Canyon. The Moenkopi Formation, in which these sites are situated, is described as thin-bedded. Rapid erosion at Paiute Farms has created a relatively level surface shallowly dissected by gullies and washes that drain northward into the former San Juan River channel (Fairley 1985; NPS 1986).

Stanton Creek: Soils in this area are rock outcrop–Needle association. Soils are derived from windblown sandstone, and rock outcrops cover the majority of the area. Soils are shallow, with rare areas of deeper soils where they were deposited by water or are protected from scouring winds. The topography of the areas limits the formation of biological crusts to gently sloping or flat areas. In areas of rock outcrop, the potential for erosion is minimal. In areas with soil cover where there is no vegetation or biological crust to fix the soil in place, there is frequent erosion due to wind, and water, and soils shift frequently. In areas where biological crusts have formed, or sand sagebrush grows, fixing the soil in place, there is less potential for wind or water erosion. Any physical disturbance to the area (tire tracks, foot traffic), may break down the biological crust or disrupt the root system of vegetation, increasing erosion potential.

Red Canyon and Blue Notch: These areas contain mostly Torriorthents–rock outcrop association soils, which are shallow, sandy soils generally located on slopes, with almost half consisting of rock outcrops. Because of the steeper topography generally found in these areas, biological crust formation would be less likely, except in areas of gentle slopes. The slopes on which these soils are found may be too steep for any ORV. Increased vehicle use is possible in those limited areas that do contain deeper, better established soils, because most access roads run through canyons, where protection from the wind and shallow slopes may allow for soil collection and subsequent vegetation stabilization. Physical disturbance to these better established soils, especially disruption to stabilizing biological crusts or to the root system of vegetation (blackbrush and shadscale) may increase erosion. Canyon areas are prone to flash floods or periods of fast moving water, and loose soil in the path of this water would be carried away.

Bullfrog South, Bullfrog North, Warm Creek, and Crosby Canyon: These areas contain a mixture of deeper, better-established, and loamy Pagina soils, and shallow, shifting, sandy Torriorthents–rock outcrop. As with many shoreline areas around Glen Canyon, rock outcroppings make up about a third of the surface area, with shallow soils prevalent and deeper soils occurring on flatter plateaus and structural benches. The deeper soils present in these areas are somewhat rare and may contain better established vegetation. In areas of shallow clay or loamy soil, biological crust formation is likely due to their ability to retain moisture for a longer period following a rainfall event. Biological crusts in these areas are susceptible to erosion due to physical disturbance (tire tracks, foot traffic), because a breakdown of the crust allows the underlying soil to be carried away by wind or water. Shallow, shifting Torriorthents soils are subject to frequent wind and water erosion, which would be accelerated by physical disturbances to these areas.

White Canyon: The soils in White Canyon are shallow, sandy, and shifting soils found in rock-outcrop-Needle association and Torriorthents–rock outcrop association. Nearly half of the area consists of exposed rock outcroppings. Soils are shallow with rare areas of deeper soils where they were deposited by water or are protected from scouring winds. The topography of the areas limits the formation of biological crusts to gently sloping or flat areas. In areas of rock outcrop, the potential for erosion is minimal. In areas with soil cover where there is no vegetation or biological crust to fix the soil in place, there is frequent erosion due to wind and water, and soils shift frequently. In areas where biological crusts have formed or with vegetation cover fixing the soil in place, there is less potential for wind or water erosion. Any physical disturbance to these areas (tire tracks, foot traffic), may break down the biological crust or disrupt the root system of vegetation, increasing the erosion potential.

Hite Boat Ramp: Although the Hite Boat Ramp area itself is located upon rock outcropping, soils in the Hite area include those from the Moenkopi series. The Moenkopi series consists of very shallow and shallow, well-drained, moderately to rapidly permeable soils that formed in alluvium and residuum from sandstone and shale. Moenkopi

soils occur on mesas, hill slopes on structural benches, and plateaus. Soils are loamy sand. Slopes are 1% to 30%. Soil depths are typically 9 to 12 inches, but can range from 4 to 20 inches. Soils in this series are typically used for livestock grazing and wildlife habitat.

Figure 12 shows soils in the project area.

VEGETATION

The vegetation of Glen Canyon is highly diverse and typical of the Colorado Plateau Region, consisting of a variety of arid and semiarid plant communities.

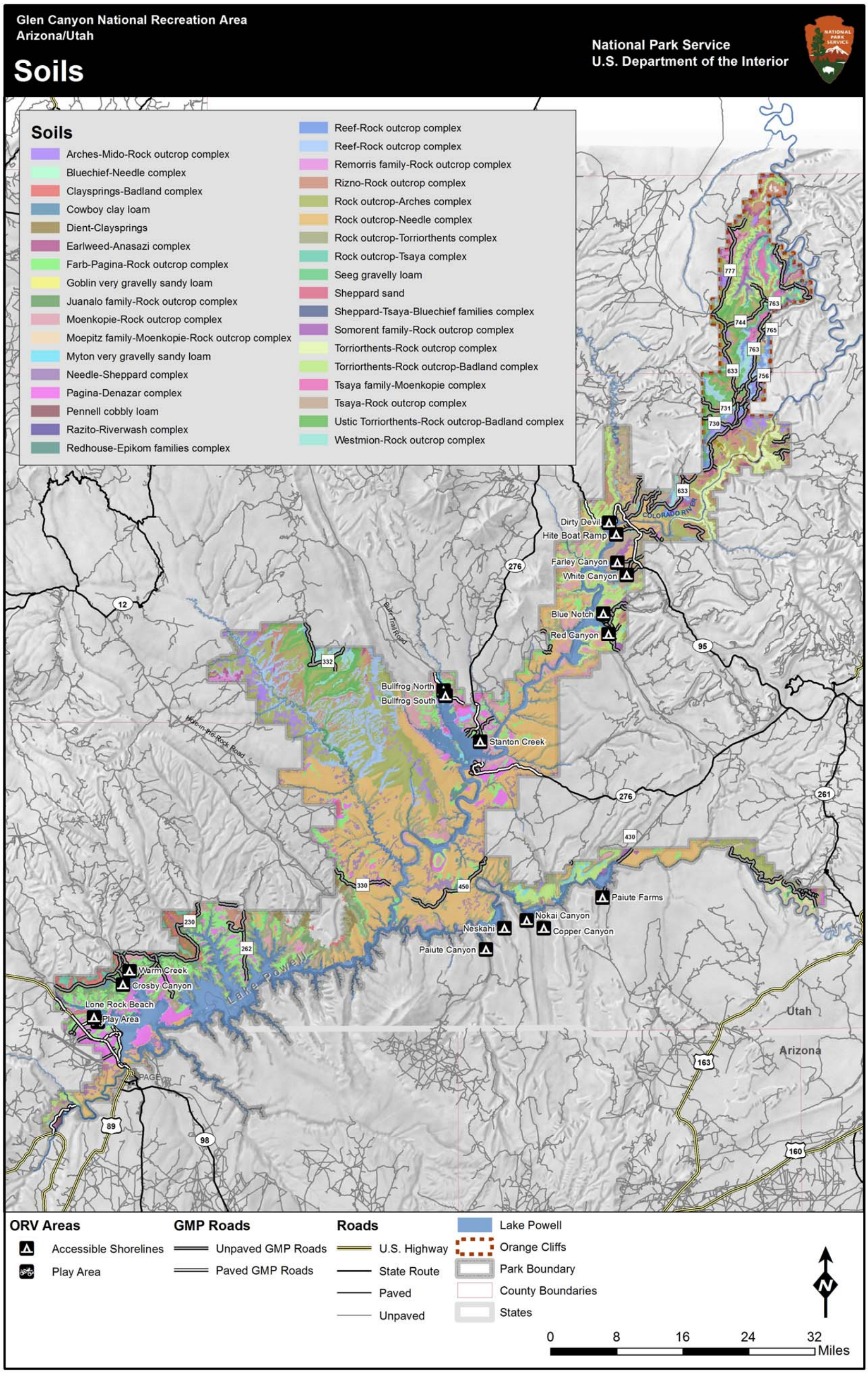
Glen Canyon lies in the Colorado Plateau Floristic Region. This region is roughly centered on the "four corners" region of the southwestern United States, occupying Arizona, Colorado, New Mexico, and Utah. The vegetation of Glen Canyon is highly diverse and typical of the Colorado Plateau Region, consisting of a variety of arid and semiarid plant communities. Generally, the majority of Glen Canyon below 5,000 feet above sea level is dominated by blackbrush shrubland on shallow rocky soils. Typically, surrounding these areas shadscale, a mixture of shadscale and blackbrush, sand sagebrush, and Cutler-Mormon-tea (*Ephedra cutleri*) can be found. Sandy soils support a mosaic of shrubland and grassland types. Clay barrens are common and generally vegetated by ephemeral annual forbs or dwarf shrubland that is dominated by species of saltbush (*Atriplex* spp.), including mat saltbush (*A. corrugata*) and four-wing saltbush. In areas along streams, Fremont cottonwood (*Populus fremontii*) can be frequently found. Areas above 5,000 feet above sea level are dominated by pinyon/juniper woodlands composed of stands of pinyon pine (*Pinus edulis*) and Utah juniper (*Juniperus osteosperma*), interspersed with meadows dominated by big sagebrush (*Artemisia tridentata*) (figure 13).

Glen Canyon exhibits a tremendous diversity in vegetation types. Over 850 species of vascular plants were identified in Glen Canyon, including more than 30 Colorado Plateau–endemic plant species (Hill and Ayers 2009). Of these, 10 species are considered rare by the states of Utah and Arizona and three species are federally listed. The "Special-status Species" section of chapter 3 includes discussion in greater detail. The majority of Glen Canyon below 5,000 feet is considered shrubland and grasslands, with areas above 5,000 feet being recognized as woodlands.

Shrubland areas affected by off-road use include upland arid and semiarid, northern desert shrublands, upland dwarf shrublands, and riparian shrublands. In addition to shrublands, Glen Canyon is home to two woodland vegetation communities: upland and riparian. Additionally, Glen Canyon has springs and hanging gardens, a number of nonnative species, and relict plant communities.

Vegetation at the Warm Creek Area

Classification of the vegetation communities of Glen Canyon has been undertaken by Tuhy and MacMahon (1988), and by Spence (1995; Spence 2002 unpublished). Differences in vegetation associations and plant communities are due to local variations in environmental conditions: geologic formations, which affect soil types and water availability, elevation, and slope aspect affect the conditions available for distinct plant communities. The following sections describe the principal vegetative communities in Glen Canyon.



Note: Due to the extent of the map, not all soil types are displayed (more than 50 soils types occur within Glen Canyon's boundaries). Only soil types within the geographic scope of the plan are displayed.

FIGURE 12: SOILS IN THE PROJECT AREA, GLEN CANYON NATIONAL RECREATION AREA

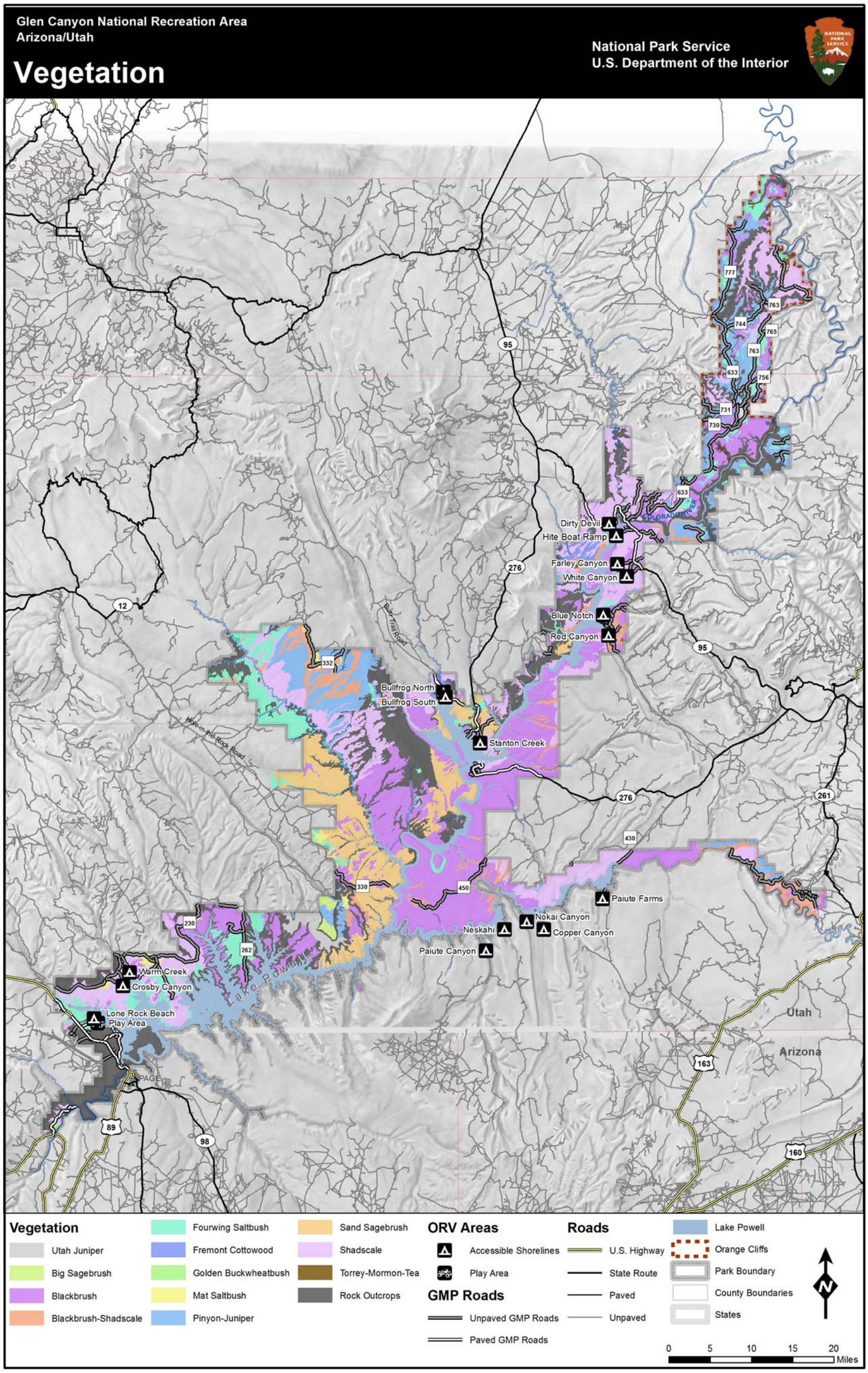


FIGURE 13: VEGETATION OF GLEN CANYON NATIONAL RECREATION AREA

UPLAND SHRUBLAND

Upland arid and semiarid, northern desert shrublands and upland dwarf shrublands form the dominant vegetation in Glen Canyon. A variety of shrub species have adapted to the arid hot summer and cold winter climate of the region. Differences in species composition between shrublands are primarily related to soil characteristics, aspect, and elevation.

Blackbrush is the dominant shrub species over extensive areas in upland shrublands. Blackbrush grows on nonsaline, sandy or stony loams of old pediment slopes and terraces with caliche layers. Blackbrush sites with shallow soils are often found with well-developed biological soil crusts, which are highly susceptible to surface disturbance. In accessible shorelines where blackbrush is present include White Canyon, Blue Notch, Hite Boat Ramp, Red Canyon, and Warm Creek.

Shadscale is another relatively abundant evergreen shrub found throughout Glen Canyon. Shadscale stands often cover sites with finer-textured, relatively saline soils. This community covers less of Glen Canyon than blackbrush because the shale and siltstone formations that favor shadscale are less common in the area compared to the sandstone-derived soils that support blackbrush and sand shrub vegetation (see discussion of sand shrub communities in Vegetation in Accessible Shoreline Areas below). Shadscale is often found in association with galleta and Indian ricegrass in shallow sandy clay loams, but where the clay content is high it coexists with mat saltbush. Accessible shorelines where shadscale is found include Dirty Devil, White Canyon, Farley Canyon, Bullfrog South, Stanton Creek, Crosby Canyon, and Warm Creek.

RIPARIAN SHRUBLANDS

In Glen Canyon two types of riparian shrublands occur, one associated with permanent water or a shallow water table and the second associated with ephemeral or intermittent streams. Along permanent streams, coyote willow (*Salix exigua*) and seepwillow (*Baccharis salicina*) are dominant, with understories that typically include horsetail (*Equisetum hyemale*), wiregrass (*Juncus balticus*), or species of bulrush (*Scirpus* spp.). Along the original Colorado River corridor, stands of arrowweed (*Tessaria sericea*) are common, with some patches still found below Glen Canyon Dam and in side canyons off Lake Powell.

Vegetation at the Alstrom Point Area

A facultative riparian species-rich shrubland can develop along intermittent or ephemeral stream channels. Dominant species include Apache plume (*Fallugia paradoxa*), cliffrose (*Purshia stansburiana*), and various species of rabbitbrush (*Chrysothamnus nauseosus* and *C. viscidiflorus*). The understory of these stands is typically composed of upland species found in the adjacent upland vegetation.

Many riparian shrublands in Glen Canyon have been invaded by nonnative species, primarily tamarisk (*Tamarix ramosissima*), Russian olive (*Elaeagnus angustifolia*), Ravenna grass (*Saccharum ravennae*), camelthorn (*Alhagi maurorum*), and Russian knapweed (*Acroptilon repens*). In many areas, tamarisk has become the dominant species. These areas then become susceptible to fire, which increases the dominance of tamarisk because it is a fire-adapted species.

UPLAND WOODLANDS

Upland woodland has vegetation dominated by trees, typically open canopy, with cover of 20% to 60% that supports various kinds of conifer woodlands, dominated by species of *Pinus* and *Juniperus*. These woodlands are widespread in the western and southwestern portions of United States and extend into Mexico. They tend to develop where precipitation is about 12 inches or more, although they can be found in drier regions, typically in areas where underlying rock holds water.

The pinyon/juniper alliance is the principal woodland community in Glen Canyon, consisting of the small pinyon pine and Utah juniper trees. These woodlands typically occur above 5,000 feet above sea level, up to elevations of 7,500 feet. They are highly variable depending on soil type, aspect, slope, and elevation. Many examples of the pinyon/juniper alliance are fairly open, with a sparse shrub understory. In a few areas, including the Orange Cliffs and Navajo Point, very dense stands of large old-growth pinyon/juniper exist. In these cases there is very little understory other than a few low shrubs and forbs (NPS 1993).

In addition, the pinyon/juniper alliance has a variety of associated shrub species typically found in nearby meadows, including big sagebrush, Utah serviceberry (*Amelanchier utahensis*), mountain mahogany (*Cercocarpus intricatus*), blackbrush, singleleaf ash (*Fraxinus anomala*), and roundleaf buffaloberry (*Shepherdia rotundifolia*).

Grazing is the most prevalent disturbance in pinyon/juniper woodlands, but recreation, including off-road driving, can also impact these areas. Disturbed stands often have high concentrations of cheatgrass (*Bromus tectorum*) and other nonnative annuals in their understory, and markedly reduced species diversity.

RIPARIAN WOODLANDS

Stands of Fremont cottonwood occur throughout Glen Canyon along streams and sometimes in association with springs. There is typically a series of stands of this species of differing ages related to flooding, ranging from young dense congregations of saplings along recent stream channels to older, larger trees on high terraces. They are classified as woodlands rather than forests because most examples are rather open, with fairly low canopy cover. Fremont cottonwood is a critically important component in both breeding and migratory habitat for many bird species, with the majority found along the Escalante River. Stands of cottonwood also occur in alliance with Goodding willow (*Salix gooddingii*), or more rarely, box elder (*Acer negundo*).

On upper stream terraces and in somewhat drier sites, Fremont cottonwood is the sole tree species present, typically with a dense understory of upland shrubs, especially of rabbitbrush. Locations with cottonwood stands are attractive to recreationists because the trees provide cover and are associated with water. Heavy use of these areas can lead to soil compaction and erosion, the exposure of root systems, the trampling of understory vegetation, and direct damage to the trees from wood collection and other activities. Flooding is also a common disturbance in riparian woodlands stands.

A number of riparian woodlands in Glen Canyon have been invaded by nonnative species, primarily tamarisk (*Tamarix ramosissima*), sweet clover (*Melilotus* spp.), Russian olive, alfalfa (*Medicago sativa*), Russian thistle, rip gut brome (*Bromus diandrus*), Japanese brome (*Bromus japonicus*), and cheatgrass.

Springs and Hanging Gardens

Spring- and seep-supported plant communities are rare in the Colorado Plateau physiographic province, but occur with enough frequency in Glen Canyon that explorer John Wesley Powell named the area Glen Canyon due to the abundance of these glens, or hanging gardens. There are approximately 50 acres of hanging gardens (spring-fed colonies of plants found clinging to vertical cliff walls) in Glen Canyon. The springs are derived from a local aquifer primarily supplied by winter precipitation. The water supply moves through a porous sandstone unit until it

reaches a less permeable layer of rock, such as the Kayenta Formation. At this point, the water begins to flow laterally, seeping out of the stone and flowing over the cliff face. This water source provides suitable habitat for a rich array of plants to grow directly from the cliff face. Hanging gardens support a rich variety of water-loving plant species, such as ferns, lilies, sedges, and orchids. About 35 species of Colorado Plateau–endemic plants are associated with hanging gardens and related spring communities. These gardens are also hot spots of biodiversity, supporting many species of plants and associated terrestrial invertebrates, aquatic invertebrates, birds, mammals, and amphibians. Hanging gardens are very fragile and are easily damaged by cattle grazing, recreation, and other impacts that can damage the vegetation or soils on which these gardens depend. Existing off-road use and potential future off-road use would not impact the springs or hanging gardens.

Many other types of springs also occur in Glen Canyon, including limnocrenes, slope springs, gushettes, wetland springs, and mound springs. Biodiversity varies across these spring types, but overall tends to be lower than in hanging gardens.

Relict Plant Communities

A relict plant community is a community that once had a wider distribution but now only occurs in a localized area. There are two kinds of relict plant communities in Glen Canyon. One consists of patches of vegetation with species that do not typically occur in the region or at the elevations in Glen Canyon; these are ecological relicts. The second type consists of intact, ungrazed vegetation that retains pre-European settlement conditions. Tuhy and MacMahon (1988) identified these latter known and potential ungrazed native (relict) vegetation areas in Glen Canyon. These are locations where natural biological and physical processes occur unhindered by direct human influence. They are important because they serve as sanctuaries for individual species and plant communities, and have value for applied science as a baseline against which to compare the impacts of human intervention on the natural environment.

Of the 21 areas identified as in relict or near-relict condition, more than half were assessed by Tuhy and MacMahon as being candidates to become part of the Colorado Plateau regionwide network of relict areas. Most of these areas are found on upland benches and are inaccessible due to topography. Only one relict area, on the Grand Bench, is accessible by ORVs.

Ecological relicts include patches of California sawgrass (*Cladium californicum*) at springs and in hanging gardens, stands of bigtooth maple (*Acer grandidentatum*) in canyons off the Escalante Arm, and stands of Douglas fir (*Pseudotsuga menziesii*) associated with shaded alcoves (Spence 1994).

Nonnative Species

Nonnative plants are exotic plants introduced from other parts of the world. Nonnative, invasive species are nonnative species that are able to spread and invade into natural areas. The spread of invasive plants is regarded as one of the most serious ecological threats facing our nation, second only to outright habitat destruction. Invasive plants can outcompete native species, disrupt food chains, and change nutrient cycles.

NPS has identified 83 nonnative plant species in Glen Canyon. Of these known nonnative species, nine are controlled because of the threat they pose to native plants and plant habitats: Russian knapweed, African mustard (*Brassica tournefortii*), Russian olive, camelthorn, tamarisk (salt cedar), giant reed (*Arundo donax*), Uruguayan pampas grass (*Cortaderia selloana*), perennial peppergrass (*Lepidium latifolium*), and Ravenna grass. The remaining nonnative plant species are not prone to being invasive and are not a threat, or they are too abundant and too difficult to control, such as Russian thistle and cheatgrass.

VEGETATION IN ACCESSIBLE SHORELINE AREAS

Vegetation in accessible shorelines is minimal and sparse. In the 13 accessible shoreline areas, as well as Nokai Canyon, Lone Rock Beach and the Lone Rock Beach Play Area, vegetation is minimal and primarily consists of blackbrush and shadscale. These accessible shorelines are typified by lower elevations and low to moderate sand slopes. Sand shrub communities typically include sand sagebrush, four-wing saltbush, Vanclevea (*Vanclevea stylosa*), Torrey-Mormon-tea, and plains beavertail (*Opuntia erinacea*). Grasses include Indian ricegrass (*Achnatherum hymenoides*) and dropseeds (*Sporobolus* spp.). A variety of forbs occur, including globemallow (*Sphaeralcea grossulariifolia*), bird's beak (*Cordylanthus wrightii*), pallid evening-primrose (*Oenothera pallida*), annual sunflower (*Helianthus petiolaris*), and numerous additional annual species. Biological soil crusts are typically common on sandy soils in these communities, especially under and around the shrubs.

Vegetation in Paiute Farms is typical of a desert shrub community, with the primary vegetation types being four-wing saltbush, Mormon tea (*Ephedra torreyana*), prickly-pear cacti (*Opuntia* spp.), rabbitbrush, and Russian thistle (NPS 1986). ORVs are also used in locations dominated by rock outcrops (Spence n.d.). Some slopes and heavily used accessible shorelines are completely denuded of vegetation, except for partial areas inhabited by sagebrush. Some species, such as snakeweed (*Gutierrezia microcephala*), dicoria (*Dicoria brandegeei*), and ragweed (*Ambrosia acanthicarpa*), that have taken advantage of ORV activity because they have adapted to various soil disturbances.

VEGETATION ALONG PAVED AND UNPAVED GMP ROADS

Vegetation along both unpaved and paved GMP roads throughout Glen Canyon is typically minimal and sparse and is characteristically similar to the vegetation found within the region of Glen Canyon where the roads exist. Typical vegetation found along roads throughout Glen Canyon includes shadscale, blackbrush and rock outcrops, as well as the presence of pinyon-juniper and four-wing saltbrush in the northern, southwestern and Ferry Swale portion of Glen Canyon and mat saltbush sand sagebrush along NPS Roads 330, 332, and 230.

VEGETATION IN FERRY SWALE

Vegetation in the Ferry Swale area is slightly different than vegetation throughout the remainder of Glen Canyon in that the majority of Ferry Swale is composed of rock outcrops. Rock outcrops dominate the landscape in the southwest and northwest portion of Ferry Swale. Some shadscale and golden buckwheat bush exist intermittently in the southwest portion, while the western, eastern, and central portion of Ferry Swale consists primarily of shadscale and fourwing saltbrush as well as some smaller areas of mat saltbrush.

WILDLIFE AND WILDLIFE HABITAT

The highly diverse vegetation of Glen Canyon creates important habitat for a diverse range of vertebrate animals.

Glen Canyon supports a complex and fragile ecosystem, with plants and wildlife that have developed unique adaptations to the arid conditions of their environments. Typical of the Colorado Plateau, the highly diverse vegetation of Glen Canyon creates important habitat for a diverse range of vertebrate animals, including mammals, fish, reptiles and amphibians, and birds (NPS 2007d). Within the boundaries of Glen Canyon, approximately 438 vertebrate species have been documented, including 64 species of mammals (NPS 2007b), 25 species of fish (NPS n.d.d), 31 species of reptiles (Drost et al. 2008), 6 species of amphibians (NPS n.d.e), and 316 species of birds (Spence, LaRue, and Grahame 2011). In addition, an unknown but potentially large number of arthropod species could be found in Glen Canyon. This section describes vertebrate wildlife that could be affected by off-road use. Fish species are not discussed because impacts to water quality in Glen Canyon from the alternatives proposed in the plan/DEIS would not be substantial. Therefore, it is expected that there would not be a substantial indirect impact to fish or its habitat, including species of special concern.

MAMMALS

Adaptations such as temperature control and water conservation help mammals survive the heat of the Colorado Plateau desert. Small mammals are more common than larger mammals in a desert environment because of their lower energy requirements, rates of heat loss, and food and water needs. Of the 64 mammal species documented in Glen Canyon, bats, rodents, and other small mammals are the most commonly observed. Deer mice, pocket mice, and several other species of mice are common small mammals in Glen Canyon. Ord's kangaroo rat is ecologically important because of its seed-caching behavior. The kangaroo rat will husk and cache seeds of Indian ricegrass and other grasses, sometimes forgetting caches (NPS 2008d) thus increasing seed dissemination.

Other herbivores include desert cottontail, black-tailed jackrabbit, squirrels, chipmunks, and four species of woodrat. Woodrats prefer to build their middens on rocky slopes in scrublands and pinyon/juniper woodlands. Some middens were dated to over 50,000 years old, and show a record of the plant and animal communities that once existed in the woodrat's range (NPS 2008d).

There are 17 bat species known to be found in Glen Canyon (NPS n.d.b), including two rare species: the spotted bat (*Euderma maculatum*) and Townsend's big-eared bat (*Plecotus townsendii*). The largest bat likely to be seen at Glen Canyon is the pallid bat, which is commonly seen at dusk. Some bats, such as the big brown bat, may only be seen during migration. Other bat species known to be present in Glen Canyon include Yuma myotis (*Myotis yumanensis*), little brown myotis, fringed myotis (*Myotis thysanodes*), western pipistrelle, hoary bat, silver-haired bat, Allen's big-eared bat, big free-tailed bat (*Nyctinomops macrotis*), and Brazilian free-tailed bat (Bogan and Ramotnik 1995; NPS 2008d, n.d.b). Bats are able to lower their body temperature, metabolism, and breathing during the day to conserve energy as they roost alone or in colonies on the towering cliffs and canyon walls. Disturbing roosting bats or bats in torpor, which is similar to hibernation, may compromise their energy reserves and reduce their chances of survival (NPS 2008d). In 1994, baseline surveys for mammals in four riparian areas in Glen Canyon were conducted. The most abundant bat species observed during the surveys were Yuma myotis and pallid bat; both species are tolerant of arid environments, although Yuma myotis is closely tied to permanent sources of water (Bogan and Ramotnik 1995). Table 5 indicates which bat species were observed at the four riparian areas.

Predators in the area include bobcat, mountain lion, and coyote. These mammals avoid humans, but their scat and tracks in the area reveal their presence (NPS 2008d). Red, kit, and gray foxes are also present in the area, and can be found in various open and semiopen habitats, including grassland, savanna, shrubland, and woodland (NatureServe 2009; NPS n.d.b). Smaller predators and omnivores include ringtail, raccoon, American badger, long-tailed weasel, and skunks. A single sighting of black bear was recorded at Trachyte Creek (NPS n.d.b). In recent years river otters have colonized Lake Powell from source populations in the Escalante River and Green River (NPS 2008d).

Larger mammals like the mule deer are found locally in Glen Canyon but are seldom seen. Pronghorn antelopes exist on adjacent public lands, and may occasionally wander into Glen Canyon. Elk and bison are known from surrounding public lands and occasionally individuals wander into Glen Canyon. In 1941, bison were reintroduced from Yellowstone National Park to the Henry Mountains northwest of Glen Canyon. They are one of the few remaining genetically pure bison herds (NPS 2008d).

Mammal species generally more vulnerable to ORV activity include burrowing species such as kangaroo rats and other rodents that nest in open sandy sites and whose burrows are easily crushed (Spence n.d.). In addition to ORVs crushing habitat, engine noise can deafen a kangaroo rat and virtually eliminate its defensive hearing (Radle 2007). Bighorn sheep are also known to be intolerant of noise and ORV activities, and can abandon areas where such activity is common (Keller and Bender 2007).

TABLE 5: BAT SPECIES OBSERVED AT FOUR RIPARIAN AREAS IN GLEN CANYON NATIONAL RECREATION AREA

State	County	Area(s)	Species	Number Observed
Utah	San Juan	Lake Powell, north bank San Juan River, Wilson Creek	Yuma myotis	1
			Townsend's big-eared bat	1
Utah	Kane	Last Chance Creek	Pallid bat	4
			Allen's big-eared bat	1
			California myotis	2
			Yuma myotis	1
			Western pipistrelle	2
			Pale Townsend's big-eared bat	1
Utah	San Juan	East bank Lake Powell, Ribbon Canyon	Pallid bat	1
			Fringed myotis	1
			Yuma myotis	2
			Mexican free-tailed bat	1
Utah	Kane	East bank Escalante River, Cow Canyon	Big brown bat	1
			Yuma myotis	3
			Western pipistrelle	1
			Mexican free-tailed bat	1

Source: Bogan and Ramotnik 1995.

REPTILES AND AMPHIBIANS

Reptiles have adapted to survive in hot, arid climates, and spend the hottest parts of the day in the shade in order to regulate their body temperature. Habitat preferences vary by species, although reptiles will escape the heat and predators in shady areas under bushes and tree trunks and in crevices in areas with vegetation. Therefore, many reptiles are more active in the early morning, twilight, or night to avoid these threats. Lizards can be commonly seen during the day, but most snakes are more likely to be seen at night (NPS 2008c).

Recent (–2007) systematic surveys have documented the presence of 31 species of reptiles and amphibians in Glen Canyon, and one extirpated species (Drost et al. 2008). Lizards are common to the Colorado Plateau and Glen Canyon, including the desert spiny lizard, eastern fence lizard, common side-blotched lizard, sagebrush lizard, eastern collared lizard, Great Basin collared lizard, western whiptail and ornate tree lizard (NPS 2008c; NPS n.d.c). The ornate tree lizard has been found in riparian areas, with a preference for slickrock walls and boulders (NPS 2008c). Rare, special-status lizards include the desert night lizard (*Xantusia vigilis*) and western banded gecko (*Coleonyx variegatus*) (NPS n.d.c). The chuckwalla (*Sauromalus obesus*) is the largest lizard found in Glen Canyon. This species was historically found along the Colorado River in Glen Canyon as far north as Hite, but likely has a smaller distribution due to the destruction of much of its habitat by the creation of Lake Powell (NPS 2008c). The "Special-status Species" section of this chapter includes further discussion of the desert night lizard and chuckwalla.

Common snakes in Glen Canyon include the terrestrial garter snake in riparian zones, as well as gopher snake, striped whipsnake, and the common kingsnake (NPS 2008c; n.d.c). The common kingsnake is generally active in

the morning and late afternoon, but tends to be nocturnal in hot weather. The night snake is nocturnal is and active at dawn and dusk. At least four western rattlesnake subspecies are present, including the midget faded rattlesnake, the Grand Canyon rattlesnake, the Hopi rattlesnake, and the Great Basin rattlesnake (NPS 2008c). Rare snakes include the glossy snake (*Arizona elegans*), which is listed as a species of special concern in Arizona, and western ground snake (NPS n.d.c). Rattlesnakes are the only venomous snakes in Glen Canyon and, like most reptiles, avoid detection if possible (NPS 2008c).

Like all desert dwellers, amphibians have adapted to the hot, arid environment of the Colorado Plateau. In general, amphibians are most active during the warmer months of the year (May to October) and may become more active in the early morning, twilight, or night during those months to conserve energy and moisture. The canyon treefrog is common around the shores and side canyons of Lake Powell and can be found clinging to sandstone walls near water during the day. Canyon treefrogs are widely distributed throughout the Colorado Plateau and prefer intermittent or permanent streams with rocky bottoms. The northern leopard frog (*Rana pipiens*), once common along the Colorado River through Glen Canyon, is now irregularly distributed across the Colorado Plateau and requires a permanent water source, preferably with well-developed wetland vegetation. The northern leopard frog is disappearing from much of its historic range in North America. It inhabits eight side canyons off Lake Powell. The Great Basin spadefoot toad is common throughout Glen Canyon, especially along ephemeral sandy washes. Two species of true toads have also been documented: the Woodhouse's and the red-spotted. These species are most common along streams in side canyons, but can be found crossing the desert as they move between canyons and waterholes (NPS 2008a). The exotic bullfrog has recently colonized the Hite area along the Colorado River in 1998 (Drost et al. 2008). Based on personal observation by John Spence, chief scientist at Glen Canyon, for years there have been persistent reports of bullfrogs throughout Cataract Canyon by river runners.

Although tiger salamanders are known to occur in Glen Canyon, none were observed in a 2003 inventory of amphibians and reptiles of Glen Canyon. This species is found in the Colorado Plateau and historically along the San Juan River and in Navajo country. Tiger salamanders require permanent or semipermanent water for breeding. Adults are commonly underground, but can be seen migrating between breeding sites during rains or found around pools and under objects in wetter side canyons off Lake Powell (NPS 2008a).

Reptiles and amphibians, most of which occur throughout Glen Canyon and in ORV areas, are highly vulnerable to the impacts of ORV activity. ORVs could impact reptiles by running over and killing individuals; collapsing burrows, thereby reducing access to subterranean prey as well as escape and thermoregulatory locations; or altering the habitat by changing the plant community, thereby affecting the availability of prey, escape locations, and shady locations (Munger and Ames 1998). Amphibians can often be impacted by ORV activity in riparian zones, either through chemical contamination of breeding pools or through direct crushing of adults and tadpoles (Maxell and Hokit 1999). In addition, ORV noise has been shown to damage hearing sensitivity and predator detection in fringe-toed lizards, and cause behavioral changes in spadefoot toads that put the animal at risk (Brattstrom and Bondello 1983; Schubert and Smith 2000). See the "Wildlife and Wildlife Habitat" section in chapter 4 for more detailed regarding the impacts of off-road use on reptiles and amphibians.

BIRDS

There are 307 native and 9 nonnative bird species reported from Glen Canyon and immediately adjacent developed areas, including the City of Page. This diversity of species was unknown prior to the construction of the dam, golf courses, and sewage treatment ponds, and can be largely attributed to the colonization of Lake Powell by aquatic and migratory birds. Shorebirds, waterfowl, and other water-associated bird species frequently use Lake Powell for resting and foraging during migration and overwintering, representing 101 of the 316 bird species found in Glen Canyon (Spence, LaRue, and Grahame 2011). Species commonly observed along the shoreline and on the lake include loons, grebes, cormorants, herons, egrets, coots, ducks, gulls, terns, and shorebirds (Spence 1998; Spence and Bobowski 2003).

Desert shrubland and grassland communities and adjacent rocky slopes host a variety of wintering, migrant, and resident bird species including the northern mockingbird, lesser nighthawk, Say's phoebe, mourning dove, rock wren, horned lark, white-crowned sparrow, lark sparrow, and black-throated sparrow. Permanent residents of these areas include the common raven, loggerhead shrike, canyon wren, and house finch (NPS 2007a).

The diversity of small rodents, songbirds, fish, and reptiles, combined with the proximity of nesting cliffs, explains the large number and diversity of raptors and owls in the area. Permanent and summer resident species include red-tailed hawk, Cooper's hawk, great horned owl, turkey vulture, prairie falcon, and the special-status species peregrine falcon (*Falco peregrinus*), golden eagle (*Aquila chrysaetos*), and osprey (*Pandion haliaetus*) (NPS 2007a; NPS n.d.a). Peregrine falcons, delisted from the endangered species list in 1999, are common around Lake Powell and along the major rivers, occupying 80 to 90% of known nests in the area each year (NPS 2008b). Peregrine falcons nest on Lone Rock and occasionally forage over the ORV area (Spence n.d.). The Lone Rock Beach Play Area includes potential habitat for burrowing owl (*Athene cunicularia*), which is a sparse summer resident of deep sandy slopes and rock outcrops in the Wahweap area and a species of special concern in Arizona and Utah (NPS n.d.a; Spence n.d.).

In winter, the summer resident species are augmented by bald eagle (*Haliaeetus leucocephalus*), northern harrier, and merlin (NPS n.d.a). Winter residents generally arrive around Lake Powell in October and November and are found in the area through January and February. Bald eagles prefer wide, shallow bays and side canyons including Wahweap, Warm Creek, Halls Creek Bay, and Bullfrog Bay and are rarely seen below the Glen Canyon Dam in the winter. This avoidance of the downstream area is most likely due to human disturbance through recreational activities. High water dam releases may also force birds off the Colorado River (NPS 2007c).

Riparian zones are critically important for birds. Many species nest and forage in these areas, and a majority of bird species use riparian corridors at some point in the year, particularly during migration. Summer residents include Bullock's oriole, ash-throated flycatcher, blue-gray gnatcatcher, yellow warbler, lesser goldfinch, black-chinned hummingbird, yellow-breasted chat, and black-headed grosbeak. Permanent year-round residents include house finch, Bewick's wren, great-tailed grackle, and many upland species that forage in riparian zones (NPS 2007b, n.d.a).

Several bird species are sensitive to human disturbance, with the potential for the disruption of courtship activities, overexposure of eggs or young to weather, and premature fledging of juveniles. Repeated disturbance can eventually lead to nest abandonment. Ground-nesting species are at greatest risk from ORV activity, due to nest abandonment and direct mortality from nests and young being crushed (Switalski and Jones 2010). These species are most common in the upland desert shrub communities, where lark sparrows, horned larks, burrowing owls, and lesser nighthawks build nests on the ground or use rodent burrows. Loggerhead shrikes and black-throated sparrows build nests in low shrubs (Cornell Lab of Ornithology n.d.; NatureServe 2010), and thus they are also susceptible to disturbance from ORV activity.

SPECIAL-STATUS SPECIES

For the purposes of this plan/DEIS, "special-status species" are defined as species listed by the U.S. Fish and Wildlife Service (USFWS) as endangered, threatened, candidate, or candidate with conservation agreements; by the states of Arizona or Utah as sensitive species; or by Glen Canyon as species of concern. The terms "threatened" and "endangered" as defined by the 1973 Endangered Species Act describe species that are likely to become or are now in danger of extinction throughout all or a significant portion of their ranges. "Candidate" species are those species for which sufficient information on biological vulnerability and threats is available to

"Special-status species" are defined as species listed by the USFWS as endangered, threatened, candidate, or candidate with conservation agreements; by the states of Arizona or Utah as sensitive species; or by Glen Canyon as species of concern.

support issuance of a proposed rule to list, but for which the rule issuance has not occurred. "Conservation agreements" refer to conservation measures for species that are proposed for listing, are candidates for listing, or are likely to become candidates in the near future.

Species are placed on the Utah state-listed sensitive species list if they are federally listed or if they are state "wildlife species of concern." Wildlife species of concern are species for which credible scientific evidence exists to substantiate a threat to continued population viability. Arizona lists "wildlife species of concern" for species whose occurrence in Arizona is or may be in jeopardy. Rare plants are listed in Arizona under one of five categories (highly safeguarded, salvage restricted, export restricted, salvage assessed, and harvest restricted).

Glen Canyon "species of concern" are species that may be on state lists or species that are rare in Glen Canyon even though they may be common in nearby locations.

Not all special-status species will be present in the project area. The Park Service received a letter from the USFWS dated October 5, 2007 (see "Appendix A: Consultation and Coordination") that included a list of species that may be found in the Coconino County portion of the project area, along with the location of information for all special-status species in the five-county region. These lists were reviewed by NPS biologists and narrowed down to a list of special-status species that could be found within the boundaries of Glen Canyon. This list was narrowed further to those species that could be expected to exist in one of the specific locations, including the ORV areas and adjacent to GMP roads, that could be affected by the actions proposed in the various alternatives presented under this plan/DEIS. These species are listed in table 6.

TABLE 6: SPECIAL-STATUS SPECIES AT GLEN CANYON NATIONAL RECREATION AREA

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Mammals				
Townsend's big-eared bat	*Corynorhinus townsendii*	State species of concern	Both	
Spotted bat	*Euderma maculatum*	State species of concern	Both	
Western red bat	*Lasiurus blossevillii*	State species of concern	Both	
Western small-footed myotis	*Myotis ciliolabrum*	State species of concern	Both	
Fringed myotis	*Myotis thysanodes*	State species of concern	Both	
Long-legged myotis	*Myotis volans*	State species of concern	Both	
Yuma myotis	*Myotis yumanensis*	State species of concern	Both	
Big free-tailed bat	*Nyctinomops macrotis*	State species of concern	Both	
Desert bighorn sheep*	*Ovis canadensis nelsoni*	State species of concern	Both	Parkwide
Silky pocket mouse	*Perognathus flavus*	State species of concern	UT	

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Kit fox*	*Vulpes macrotis*	State species of concern	UT	Parkwide
Reptiles				
Glossy snake*	*Arizona elegans*	State species of concern	AZ	Only one sighting near Wahweap; Warm Creek to Grand Bench region
Western banded gecko	*Coleonyx variegatus*	State species of concern	AZ	
Glen Canyon chuckwalla*	*Sauromalus obesus*	State species of concern	Both	Potential occurrence in vegetation complexes below 4500 feet elevation
Desert night lizard*	*Xantusia vigilis*	State species of concern	UT	Parkwide; Garfield and San Juan counties for one subspecies
Amphibians				
Northern leopard frog	*Rana pipiens*	State species of concern	Both	
Birds				
Southwestern willow flycatcher*	*Empidonax traillii extimus*	Federally endangered	—	Riparian areas; riparian forest vegetation along permanent water; Hite Boat Ramp area; Orange Cliffs region
California condor*	*Gymnogyps californianus*	Federally endangered	—	Parkwide
Brown pelican*	*Pelecanus occidentalis*	Federally endangered	—	Lakes and rivers parkwide
Mexican spotted owl*	*Strix occidentalis lucida*	Federally threatened	—	Parkwide including Orange Cliffs region; widespread but scattered
Yellow-billed cuckoo*	*Coccyzus americanus*	Federal candidate species	—	Riparian areas; desert riparian woodlands
Golden eagle*	*Aquila chrysaetos*	State species of concern	Both	Parkwide
Burrowing owl*	*Athene cunicularia*	State species of concern	Both	Parkwide
Peregrine falcon	*Falco peregrinus*	State species of concern	Both	
Pinyon jay*	*Gymnorhinus cyanocephalus*	State species of concern	Both	Pinyon-juniper vegetation complex; may occur in Orange Cliffs region

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Bald eagle*	*Haliaeetus leucocephalus*	State species of concern	Both	Lake Powell; Hite Boat Ramp area; and Orange Cliffs region
Belted kingfisher	*Megaceryle alcyon*	State species of concern	AZ	
Long-billed curlew*	*Numenius americanus*	State species of concern	Both	Lake Powell
Virginia's warbler	*Oreothlypis virginiae*	State species of concern	UT	
Lucy's warbler	*Oreothlypis luciae*	State species of concern	Both	
Osprey	*Pandion haliaetus*	State species of concern	Both	
American white pelican*	*Pelecanus erythrorhynchos*	State species of concern	UT	Lake Powell
Bell's vireo	*Vireo bellii*	State species of concern	Both	
Gray vireo*	*Vireo vicinior*	State species of concern	Both	Pinyon-juniper vegetation complex; may potentially occur in Orange Cliffs region
Great blue heron*	*Ardea herodias*	Glen Canyon species of concern	—	Lake Powell
Dusky flycatcher	*Empidonax oberholseri*	Glen Canyon species of concern	—	
Orange-crowned warbler	*Oreothlypis celata*	Glen Canyon species of concern	—	
Plants				
Brady pincushion cactus*	*Pediocactus bradyi*	Federally endangered	—	Kaibab limestone
Navajo sedge*	*Carex specuicola*	Federally threatened	—	One occurrence in park in Slickhorn Canyon
Jones' cycladenia*	*Cycladenia humilis* var. *jonesii*	Federally threatened	—	Chinle, Cutler, and Summerville formations; found in Escalante and Orange Cliffs regions
American spikenard	*Aralia racemosa*	State species of concern	Both	
Harrison's milkvetch	*Astragalus harrisonii*	State species of concern	UT	

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Copper Canyon milkvetch*	*Astragalus cutleri*	State species of concern	UT	Found adjacent to roads in Copper Canyon and Clay Hills Crossing areas; use Wilson Mesa region
Ferron's milkvetch	*Astragalus musiniensis*	State species of concern	UT	
Atwood's camissonia	*Camissonia atwoodii*	State species of concern	UT	
California sawgrass	*Cladium californicum*	State species of concern	UT	
Higgins biscuitroot	*Cymopterus higginsii*	State species of concern	UT	
Hole-in-the-Rock prairie clover	*Dalea flavescens* var. *epica*	State species of concern	Both	
Zion shooting star	*Dodecatheon pulchellum* var. *zionense*	State species of concern	UT	
Kachina daisy*	*Erigeron kachinensis*	State species of concern	UT	Hanging gardens habitat along canyon edges; may potentially occur in Orange Cliffs region
Alcove daisy	*Erigeron zothecinus*	State species of concern	UT	
Paria spurge*	*Euphorbia nephradenia*	State species of concern	UT	Tropic Shale and Entrada formations; no recorded evidence in park
Cataract gilia*	*Gilia imperialis*	State species of concern	UT	Warm Cliffs to Grand Bench region; in Tropic Shale, Carmel and Straight Cliffs formations
Tropic goldeneye*	*Heliomeris soliceps*	State species of concern	UT	Tropic Shale formation; in Warm Cliffs to Grand Bench region
Satintail grass	*Imperata brevifolia*	State species of concern	UT	
Western hophornbeam*	*Ostrya knowltonii*	State species of concern	Both	Clearwater Canyon in Orange Cliffs region
Alcove rock daisy*	*Perityle specuicola*	State species of concern	UT	Hanging gardens habitat along canyon edges; Orange Cliffs region
Howell's phacelia*	*Phacelia howelliana*	State species of concern	Both	Tropic Shale formation; no recorded evidence

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Nipple phacelia*	*Phacelia mammillarensis*	State species of concern	Both	Warm Cliffs to Grand Bench region
Alcove bog-orchid	*Platanthera zothecina*	State species of concern	Both	
Mojave indigo-bush	*Psorothamnus arborescens* var. *pubescens*	State species of concern	Both	
Whiting's indigo-bush*	*Psorothamnus thompsoniae* var. *whitingii*	State species of concern	Both	Wilson Mesa region
New Mexico raspberry*	*Rubus neomexicanus*	State species of concern	UT	Clearwater Canyon; Orange Cliffs region
Jane's globemallow*	*Sphaeralcea janeae*	State species of concern	UT	White Rim Sandstone formation; Orange Cliffs region
Rocky Mountain maple	*Acer glabrum*	Glen Canyon species of concern	—	
Bigtooth maple	*Acer grandidentatum*	Glen Canyon species of concern	—	
Desert mountain lilac*	*Ceanothus vestitus* var. *franklinii*	Glen Canyon species of concern	—	Wilson Mesa and Orange Cliffs regions
Red-osier dogwood	*Cornus sericea*	Glen Canyon species of concern	—	
Utah brittle-fern	*Cystopteris utahensis*	Glen Canyon species of concern	—	
Cotton top	*Echinocactus polycephalus*	Glen Canyon species of concern	—	
Ross's spurge	*Euphorbia aaron-rossii*	Glen Canyon species of concern	—	
Rice cutgrass	*Leersia oryzoides*	Glen Canyon species of concern	—	
American bugleweed	*Lycopus americanus*	Glen Canyon species of concern	—	
Dunebroom	*Parryella filifolia*	Glen Canyon species of concern	—	
Tompkins phacelia*	*Phacelia pulchella* var. *sabulonum*	Glen Canyon species of concern	—	Tropic Shale and Straight Cliffs formation; Warm Creek to Grand Bench region
Floating pondweed	*Potamogeton natans*	Glen Canyon species of concern	—	
Hoptree	*Ptelea trifoliata*	Glen Canyon species of concern	—	
Douglas fir*	*Pseudotsuga menziesii*	Glen Canyon species of concern	—	Orange Cliffs region

Common Name	Scientific Name	Status	State (UT, AZ, or both)	Potential Occurrence within Glen Canyon
Smooth sumac	*Rhus glabra*	Glen Canyon species of concern	—	
Blue-eyed grass	*Sisyrinchium demissum*	Glen Canyon species of concern	—	

Source: Spence 2012a; Sweatland pers. comm. 2010a.

*Species carried forward for analysis in chapter 4, including all federally listed species and state-listed species with the potential to be affected by the ORV Management Plan alternatives (Spence pers. comm. 2012b).

— = Species not listed in either Utah or Arizona.

SPECIES-SPECIFIC INFORMATION

There are several federally listed species and species of concern found in Glen Canyon (table 6); however, it is not likely that all the sensitive species in the area would be affected by the use and management of ORVs under the proposed alternatives.

Based on consultation with the USFWS, as well as conversations and research provided by John Spence, Glen Canyon ecologist/botanist, the following are special-status species carried forward for analysis in chapter 4, which includes all federally listed species at Glen Canyon, as well as state-listed species with the potential to be affected by the actions proposed under this plan/DEIS (Spence pers. comm. 2012b; Sweatland pers. comm. 2010a).

Mammals

Desert Bighorn Sheep (*Ovis canadensis nelsoni*) — Species of Concern (Arizona and Utah)

Desert bighorn sheep are medium-sized bovids with muscular bodies and thick necks (USFWS 2011). This species has adapted well to the desert environment and prefers rocky cliffs away from human activity (Singer et al. 2000). They are primarily diurnal (active chiefly in the daytime), but may be active at any time of the day or night (USFWS 2011). Desert bighorn sheep inhabit desert mountain ledges and grassy basins from elevations of 90 to 4,500 feet above sea level (27 to 1,371 meters) (AZGFD 2009). Areas of gentle terrain, such as valley floors, are important linkages between adjacent mountainous regions, thereby providing temporary access to resources (e.g., forage, water, lambing habitat) in neighboring areas, and allowing gene flow to occur between subpopulations (USFWS 2011). In the wild, grasses are important to the bighorn sheep. They also feed heavily on jojoba, and pincushion and saguaro cactus provide moisture (AZGFD 2009).

Bighorn sheep have large home ranges that allow them to move in response to variations in predation pressure and changes in resource availability. Rams and ewes tend to loosely segregate during much of the year, coming together primarily during the mating season (USFWS 2011), which typically peaks from September through November (AZGFD 2009). As parturition (labor) approaches, ewes seek secluded sites with shelter, unobstructed views, and steep terrain, which aids in predator evasion, whereas rams may be found in less steep or rugged terrain. Lambs are generally born between February and April, although some lambing may occur as late as August (USFWS 2011).

Unregulated hunting, habitat destruction and fragmentation, grazing, and disease decimated or eliminated bighorn sheep populations across the west in the 1800s (NPS 2008d). Glen Canyon supports one of the last relict desert bighorn sheep herds in Utah. The most critical areas for the sheep include the Red, White, and Gypsum Canyons branching off the northeastern portion of Lake Powell, as well as the Waterpocket Fold east of the Escalante River. These areas have been identified as possible lambing grounds (Singer et al. 2000).

Kit Fox (*Vulpes macrotis*) — Species of Concern (Utah)

The kit fox is the smallest member of the canid family in North America, reaching 15 to 20 inches (38 to 51 centimeters) in length, with a tail 9 to 12 inches (23 to 30.5 centimeters) long. They stand 11 to 12 inches (28 to 30.5 centimeters) high, and adults weigh approximately 3 to 4 pounds. The kit fox is generally pale grey or tan in color with a slightly darker back. This species is highly specialized and adapted to desert and semiarid areas of western North America. In Utah, kit foxes live in cold desert regions at elevations below 5,500 feet (1,676 meters). They can be found in the Great Basin area as well as in the southwestern and southeastern parts of the state, and generally inhabit sparsely vegetated flat areas in the desert (Utah DNR n.d.a). Shadscale, greasewood (*Sarcobatus vermiculatus*), and sagebrush are characteristic of kit fox habitat (NatureServe 2009; Utah DNR n.d.a). Kit foxes are nocturnal and emerge from their dens at sundown to hunt in thick vegetation. As opportunistic omnivores, their diet primarily consists of black-tailed jackrabbits, cottontails, and kangaroo rats (Utah DNR n.d.a).

Kit foxes live in dens dug in the desert soil and tend to select sites in barren areas with silty, clay soil that are higher than the surrounding terrain. They generally breed from late December to February, producing a liter of 4 to 5 pups in March and early April. The pups do not leave their den until they are at least a month old, and generally begin to hunt when they are about five months old. Recreational activities, such as off-road use, often disturb den sites, caving in den openings or leading to den abandonment. Habitat loss, fragmentation, and disturbance are the greatest threats to kit foxes (Utah DNR n.d.a). The resulting loss and fragmentation of habitat, and human disturbance to kit fox denning areas by recreational activities, especially off-road use, may pose a substantial threat to kit fox populations (Meaney, Reed-Eckert, and Beauvais 2006).

Reptiles

Glossy Snake (*Arizona elegans*) — Species of Concern (Arizona)

This medium-sized snake is tan or gray in color with dark-edged, tan or golden-brown blotches and reaches 42 inches (107 centimeters) in length. This species is found in Arizona across the northeastern plateaus, the southwestern and western deserts, and the southwestern valleys. It occurs at elevations ranging from sea level along the Colorado River to approximately 6,000 feet (1,830 meters) above sea level. Glossy snakes inhabit biotic communities ranging from Arizona's desert shrublands, through semidesert grassland, and into plains and Colorado Plateau grassland. They are typically found in flat, open, shrubby areas with sandy soil. This species is nocturnal and spends the majority of its time burrowing underground. Mating occurs in spring with a clutch of up to 23 eggs laid in the summer, which generally begin to hatch in August (Brennan 2008).

As described in the "Wildlife and Wildlife Habitat" section of this chapter, snakes are known to favor roads and trails as thermoregulation sites, which put them at risk of death due to being crushed by vehicles (Rosen and Lowe 1994; Rudolph 2000).

Glen Canyon Chuckwalla (*Sauromalus obesus*) — Species of Concern (Arizona and Utah)

Also known as the common chuckwalla, this species of lizard has a flattened body shape and lacks a mid-dorsal crest. The chuckwalla is the second largest lizard in the United States (SDNHM n.d.), and the largest lizard found in Glen Canyon (NPS 2011b), with males reaching up to 18 inches (46 centimeters) in total length. This species is distributed throughout the deserts of southern California, southern Nevada, southwestern Utah, and western Arizona in the United States and Sonora and Baja California in Mexico (SDNHM n.d.). It is found in desert communities of creosote/bursage, blackbrush, and salt desert scrub at elevations up to 4,500 feet (1,372 meters) (SDNHM n.d.; Utah DNR 2011). The Glen Canyon chuckwalla is herbivorous and browses on leaves, buds, flowers, and fruit. It is restricted to habitat with large rocks and boulders on rocky hillsides, outcrops, or lava beds, which provide cover and basking locales. Mating for this species occurs between April and July, with a clutch of as many as 16 eggs laid between June and August with eggs hatching in the late warm season (SDNHM n.d.). The

chuckwalla was historically found along the Colorado River in Glen Canyon as far north as Hite, but likely has a smaller distribution due to the destruction of much of its habitat by the creation of Lake Powell (NPS 2011b).

Major threats to this species include excessive collecting and habitat degradation. As described above, the damming of the Colorado River has substantially reduced or eliminated historical populations in the Glen Canyon area as a reduction of their habitat (Hammerson 2007). Additionally, off-road use can impact the chuckwalla and other lizards through direct mortality, disturbance, and habitat loss and fragmentation (Switalski and Jones 2010). This species is primarily found in the vicinity of Glen Canyon, Kane County; however, its distribution reaches Moab along the river. Much of this species' habitat in Glen Canyon was eliminated by the construction of the Glen Canyon Dam (Utah DNR 2011).

Desert Night Lizard (*Xantusia vigilis*) — Species of Concern (Utah)

The desert night lizard is a slim species averaging 1.0 to 1.8 inches (2.6 to 4.5 centimeters) in length. Its body is grey, olive, or dark brown with fine black speckles and smooth, granular scales (USGS 2003). This species is found in arid and semiarid rocky areas. Its typical habitat is characterized by concealing, protective vegetation, such as yuccas and agaves, as well as rock crevices, dead brush, and other debris. Two subspecies of the desert night lizard exist in Utah, the common night lizard (*Xantusia vigilis vigilis*) and the Utah night lizard (*X. v. utahensis*). The common night lizard is found on the Beaver Dam Slope in southwestern Washington County, whereas the endemic Utah night lizard is found exclusively in Garfield and San Juan Counties in southeastern Utah (Utah DNR 2011).

Habitat modification is one of the primary threats to the desert night lizard, and the specialized habitat requirements and life history characteristics of this species make it vulnerable to habitat disturbance. In particular, roads act as barriers to dispersal and increase mortality for this species (Utah DNR 2011).

Birds

Southwestern Willow Flycatcher (*Empidonax traillii extimus*) — Federally Endangered

The southwestern willow flycatcher is approximately 5.75 inches (15 centimeters) long, and weighs about 0.42 ounces (12 grams). This small migratory species occupies thickets, scrubby and brushy areas, open second growth, swamps, and open woodland from near sea level to over 8,500 feet (2,600 meters) elevation; however, it is primarily found in lower-elevation riparian habitats. The southwestern willow flycatcher breeds in dense growths of trees and shrubs in riparian ecosystems in the arid southwestern United States, and possibly extreme northwestern Mexico. The birds typically arrive on breeding grounds between early May and early June, with the breeding season lasting approximately from mid-June to mid-July (USFWS 2002a). The southwestern willow flycatcher formerly bred in Glen Canyon, but currently there are no confirmed nesting or breeding pairs in the area (NPS n.d.a). Two confirmed identifications of the willow flycatcher were made on the Colorado River below the Glen Canyon Dam, and a pair was observed courting in 1997 on the Escalante River. In addition, individuals have been recorded during migration at Clay Hills Crossing and upstream along the San Juan River (Spence, LaRue, and Grahame 2011). This species may occur in the Hite Boat Ramp area and Orange Cliffs region.

Threats to this species include loss and modification of breeding habitat. Destruction and modification of riparian habitats have been caused mainly by the reduction or removal of surface and subsurface water due to diversion and groundwater pumping, changes in flood and fire regimes due to dams and stream channelization, vegetation clearing, and changes in soil and water chemistry due to the disruption of natural hydrologic cycles (USFWS 2002a). In addition, reductions in the density and diversity of bird communities, including willow flycatchers, have been associated with livestock grazing and recreational activities (Riffell et al. 1996; Taylor 1986).

California Condor (*Gymnogyps californianus*) — Federally Endangered (Experimental Population)

Listed as endangered in 1967, California condors are among the largest flying birds in the world. Adults weigh approximately 22 pounds (10 kilograms) and have a wingspan of up to 9.5 feet (2.9 meters). This species requires suitable habitat for nesting, roosting, and foraging. Nest sites are located in cliff cavities, large rock outcrops, or large trees. A single egg is normally laid between late January and early April, and hatches after approximately 56 days. Roosting sites are often near feeding sites on cliffs or large trees, and foraging generally occurs in grasslands, in chaparral areas, or in oak savannahs (USFWS 1996). California condors are a rare local permanent resident in Glen Canyon. The captive-reared birds were released on the nearby Vermilion Cliffs beginning in 1996 and have on several occasions spent time in Glen Canyon. Most occurrences of this species have been below the dam at Navajo Bridge, Marble Canyon, south of Lees Ferry (Spence, LaRue, and Grahame 2011).

The California condor remains one of the world's rarest and most endangered vertebrate species. Despite intensive conservation efforts in the 1980s, the wild California condor population declined steadily until the last free-flying individual was captured in 1987. Following several years of successful captive breeding, condors were first released back to the wild in early 1992. Primary threats to this species include shooting, lead poisoning, and collisions with human-made objects (USFWS 1996). In addition, as described in the "Wildlife and Wildlife Habitat" section of this chapter, many raptors are intolerant of noise and human-associated disturbances (Richardson and Miller 1997).

Brown Pelican (*Pelecanus occidentalis*) — Federally Endangered

Listed as endangered in 1970, brown pelicans are the smallest members of the seven pelican species worldwide and inhabit the Atlantic, Pacific, and Gulf Coasts of North and South America. Adults measure up to 54 inches (137 centimeters) long, weigh 8 to 10 pounds, and have a wingspan between 6-1/2 and 7-1/2 feet. Pelicans eat primarily fish (e.g., herring and minnows) and require up to four pounds of fish a day. Pelicans generally fly over water at great heights, diving steeply into the water when they spot fish. Depending on the height of the dive, they may submerge completely or only partly into the water and come up with a mouthful of fish (USFWS 2008). Brown pelicans usually forage in shallow waters within 12 miles (20 kilometers) of nesting islands during the breeding season, and up to 47 miles (75 kilometers) from the nearest land during nonbreeding season (Shields 2002).

Brown pelicans nest in large colonies on the ground, in bushes, or in the tops of trees. Peak egg-laying usually occurs in March through May (USFWS 2008). The young are able to fly and begin to fend for themselves by 11–12 weeks of age. The brown pelican is a long-lived species; the oldest individual on record died at 43 years of age (Shields 2002). Brown pelicans are not known to breed within Glen Canyon. Within Glen Canyon, this species is considered a rare local transient with three known records: one on the Colorado River below the dam in June 1992, one on Lake Powell 0.5 mile above the dam in July 1987, and an extraordinary record of six in Hall's Creek Bay in October 1994 (Spence, LaRue, and Grahame 2011).

Despite its longevity and popularity, the brown pelican nearly disappeared from North America between the late 1950s and early 1970s. Extensive scientific investigations revealed the culprit to be human-made organochlorine pesticides (i.e., endrin and dichlorodiphenyltrichloroethane (DDT)) entering the marine food web. Reproduction soon improved and pelican numbers began to rise following the ban on the use of DDT in the United States in 1972 and a reduction in the use of endrin during the 1970s. Known threats to this species include habitat degradation, disturbance at roost and nest sites, pesticides and other contaminants/toxins, shooting and trapping, oil pollution, and collisions with stationary/moving structures or objects (e.g., aircraft, power transmission lines, vehicles) (Shields 2002).

Mexican Spotted Owl (*Strix occidentalis lucida*) — Federally Threatened


Mexican Spotted Owl

Listed as a threatened species in 1993, the Mexican spotted owl is mottled in appearance with irregular brown and white spots on its head, abdomen, and back. Although the spotted owl is often considered a medium-sized owl, it ranks among the largest owls in North America (USFWS 1995). This species is frequently associated with mature mixed-conifer, pine/oak, and riparian forests. It is also found in canyon habitat dominated by vertical-walled rocky cliffs in complex watersheds, including tributary side canyons. Owls are typically found in areas with some type of water source, such as perennial streams, creeks, reservoir emissions, small pools, springs, or ephemeral water (69 FR 53182–53183). They nest in tree cavities, broken-topped trees, and platforms, such as old raptor or squirrel nests (Cornell Lab of Ornithology n.d.). In Glen Canyon, the Mexican spotted owl is a rare permanent resident found in canyons containing deeply fissured cliffs (NPS n.d.a). Surveys conducted between 1992 and 1998 found this species in the canyon heads off the Big Ridge, Easter Canyon, several Escalante River tributaries, Millard Canyon, and in Miller's Canyon (NPS n.d.a). Breeding for the spotted owl has been confirmed in Glen Canyon (NPS 2007a) but breeding is often sporadic and nesting does not occur every year. In Arizona, it has been reported that eggs usually hatch in early May, with fledging generally occurring in early to mid-June (USFWS 1995). In 2004, designated critical habitat was established in Arizona, Colorado, New Mexico, and Utah, and identified in areas within Glen Canyon, including the Orange Cliffs region (USFWS 2004).

The primary threat to this species is habitat alteration. The danger of catastrophic wildfire was also cited as a potential threat for additional habitat loss (69 FR 53183). Additionally, both motorized and nonmotorized vehicles have the potential to degrade or destroy spotted owl habitat, particularly meadow and shrub habitats vital to the species' prey. Noise produced by vehicles and vehicle riders can also disturb spotted owls at important nesting and roosting sites (USFWS 1995).

Yellow-billed Cuckoo (*Coccyzus americanus*) — Federal Candidate Species

This medium-sized bird averages 12 inches (30 centimeters) in length with a slender, long-tailed profile and a fairly stout and slightly down-curved bill. Plumage is grayish brown above and white below (74 FR 57823). The yellow-billed cuckoo prefers open woodland with clearings and low, dense, scrubby vegetation; in Utah and Arizona, this species prefers desert riparian woodlands composed of cottonwood, willows, and dense mesquite (*Prosopis* spp.). Nests are typically placed in willows, and cottonwoods are used extensively for foraging (Hughes 1999). In addition, dense understory foliage is an important foraging habitat for this bird (74 FR 57823). Nesting occurs on horizontal branches or vertical forks of small trees and large shrubs, averaging 3 to 19 feet (1 to 6 meters) above ground (Hughes 1999). In Glen Canyon, the yellow-billed cuckoo is a rare, restricted transient in dense riverside tamarisk thickets. Specifically, the species has been recorded at Colorado River RM-14, Lees Ferry, and Clay Hills Crossing. Breeding may occur at Clay Hills Crossing on the San Juan River (NPS n.d.a; Spence, LaRue, and Grahame 2011).

Large declines in the distribution and abundance of the yellow-billed cuckoo have occurred as a result of pesticide use and the destruction of preferred riparian habitat (Hughes 1999). Threats to the yellow-billed cuckoo include habitat loss, overgrazing, and pesticide application. The principal causes of riparian habitat losses are conversion to agricultural and other uses, dams and river flow management, stream channelization and stabilization, and livestock grazing (74 FR 57823). Additionally, as described in the "Wildlife and Wildlife Habitat" section of this chapter, repeated noise disturbance from ORV activity can result in nest abandonment (Switalski and Jones 2010). As described above, yellow-billed cuckoos are known to use shrubs for nesting, which are particularly susceptible to damage by ORV passage because vehicles strip the protective bark and break branches and stems (Sowl and Poetter 2004).

Golden Eagle (*Aquila chrysaetos*) — Species of Concern (Arizona and Utah)

This large raptor averages 32 inches (81 centimeters) in length and has a wingspan of 6.5 feet (2 meters) (Gough et al. 1998). Its plumage is almost entirely brown, with a golden wash on the back of the head and neck. This species is generally found in open country and barren areas in hilly or mountainous regions. Preferred habitat includes cliff, desert, grassland/herbaceous, savanna, and woodland areas. Golden eagles nest on the rock ledges of cliffs or in large trees. In Utah, nesting typically occurs from late February to early March (NatureServe 2009). Breeding for this species has been confirmed in Glen Canyon (NPS 2007a).

The golden eagle is considered an uncommon, permanent resident throughout Glen Canyon. Habitat is widespread and nesting has been documented from several areas of Glen Canyon. Since 1990, one-day-a-month winter aerial surveys around Lake Powell have located between 3 and 25 individuals per survey. The golden eagle became particularly scarce the winter of 1997–1998, but recovered the following winter, with the highest count recorded of 25 birds. In the winter of 2000, the second-highest count, of 23 birds, was detected (NPS n.d.a). The golden eagle may occasionally forage over the Lone Rock Beach Play Area, because there is a territory on Castle Rock (Spence n.d.). Primary threats to this species include habitat alteration and loss. In addition, some populations of golden eagles are still threatened by illegal killing, poisoning, and egg-collecting (RSPB 2009). It is unlikely that off-road use would have substantial impacts on raptors (including the golden eagle) in this particular area because there are extensive areas around Lone Rock Beach that are off limits (Spence n.d.). However, as described in the "Wildlife and Wildlife Habitat" section of this chapter, many raptors are intolerant of noise and human-associated disturbances (Richardson and Miller 1997); therefore, the potential for some impacts still exists.

Burrowing Owl (*Athene cunicularia*) — Species of Concern (Arizona and Utah)

The burrowing owl averages a weight of 5.3 ounces (150 grams) and a length of 7.5 to 9.8 inches (19 to 25 centimeters), with a wingspan of 21.7 inches (55 centimeters). This species generally inhabits dry, open areas with no trees and short grass (Cornell Lab of Ornithology n.d.). In Glen Canyon, the burrowing owl is considered uncommon and is known to exist in desert scrub habitats, including blackbrush, shadscale, and sagebrush (NPS 2007a). The burrowing owl is considered diurnal because it can often be seen foraging during the day. It hunts by walking, hopping, or running along the ground, or by flying from a perch (Cornell Lab of Ornithology n.d.). Burrowing owls eat mainly terrestrial invertebrates, but also consume a variety of small vertebrates, including small mammals, birds, reptiles, and amphibians (Utah DNR n.d.b).

Breeding is confirmed in Glen Canyon, where this species is considered a summer resident (NPS 2007a; Spence, LaRue, and Grahame 2011). Mating begins in early spring, and egg laying typically occurs between mid-March and early May (Poulin et al. 2011). As its name indicates, this owl nests in a mammal burrow, usually that of a prairie dog, ground squirrel, badger, or armadillo (Cornell Lab of Ornithology n.d.; Utah DNR n.d.b). If a mammal burrow is not available the owl will sometimes excavate its own nest burrow. Three to 11 (usually 5 to 9) eggs are incubated by the female parent for 27 to 30 days (Utah DNR n.d.b).

The burrowing owl is federally protected by the Migratory Bird Treaty Act in the United States, Canada, and Mexico, and is considered by the USFWS to be a bird of conservation concern at the national level (Burrowing Owl Conservation Network n.d.). It was once distributed broadly throughout western North America, but has been declining in numbers throughout all historic ranges over the last 30 years. The greatest threat to burrowing owls is habitat destruction and degradation, caused primarily by land development and agricultural activity (Burrowing Owl Conservation Network n.d.; Poulin et al. 2011). Other sources of disturbance and mortality include pesticides and other contaminants/toxins, and noise disturbances at nest and roost sites (Poulin et al. 2011). Collision with vehicles is also considered a major source of mortality (Cornell Lab of Ornithology n.d.).

Pinyon jay (*Gymnorhinus cyanocephalus*) — Species of Concern (Arizona and Utah)

The pinyon jay occurs throughout much of the western United States, and is a common bird of the pinyon-juniper forests of Utah. Pinyon jays are often found in loose flocks that consist of multiple breeding pairs and the offspring of those pairs from previous nesting seasons. Each flock has an established home range, but may become somewhat nomadic and move long distances when food is scarce (Utah DNR n.d.b).

The pinyon jay is a common widespread permanent resident in pinyon-juniper woodland of Glen Canyon and may occur in the Orange Cliffs region. It is most frequently seen in more open stands as in Hans, Waterhole, and Andy Miller Flats and the bench at the base of the Kaiparowits Plateau. It was not observed in the dense woodlands on the summit of the Kaiparowits Plateau during the series of trips there until May 2000. The only breeding records are a raucous group of about 40 juveniles on the southwest rim of the Kaiparowits Plateau on May 24, 2000, and a flock with begging juveniles at Hans Flat on July 13, 1999 (NPS n.d.a).

The primary threats to pinyon jay population viability are loss and degradation of habitat, livestock grazing, and fire suppression. Specifically, widespread die-off of pinyon pine in the southwestern United States, together with large-scale thinning of pinyon-juniper woodlands in an attempt to reduce fuel loads are known current threats (Wiggins 2005).

Bald Eagle (*Haliaeetus leucocephalus*) — Species of Concern (Arizona and Utah)

This large bird of prey weighs 6.6 to 14 pounds (3 to 6.3 kilograms), has a total length of 30 to 37.8 inches (71 to 96 centimeters), and a wingspan of 66 to 96 inches (168 to 244 centimeters). Quality of foraging areas for this raptor is defined by diversity, abundance, and vulnerability of the prey base, structure of aquatic habitat, such as the presence of shallow water, and absence of human development and disturbance (Buehler 2000). The bald eagle typically breeds in forested areas adjacent to large bodies of water where fish and waterfowl prey are available (Buehler 2000). Wintering areas are commonly associated with open water as well, though other habitats may be used if food resources, such as rabbit or deer carrion, are available (Utah DNR n.d.c). Often, areas with considerable shoreline development or human activity have nests located farther from the shoreline than nest sites in less developed areas (Buehler 2000).

Within Glen Canyon, the bald eagle is considered a common and widespread winter resident along the Lake Powell shoreline, primarily distributed along the open bays (NPS n.d.a). Bald eagles prefer wide, shallow bays and side canyons including Wahweap, Warm Creek, Halls Creek Bay, and Bullfrog Bay and are rarely seen below the Glen Canyon Dam in the winter. The Park Service has monitored wintering bald eagle populations in Glen Canyon since 1991 (NPS 2007c). The highest count of 50 bald eagles was recorded in January 2003; the count ranged from seven to 28 between 1991 and 2002 (NPS n.d.a, 2007c). Birds start arriving around Lake Powell in October and November and are found through January and February. The species is occasionally seen along the Colorado River where heavy recreational use likely limits its occurrence (NPS n.d.a). Bald eagles may occur in the Hite Boat Ramp area and Orange Cliffs region.

The bald eagle was listed as endangered under the Endangered Species Act in most of the lower 48 states until 1994 when its status was changed to threatened. In 2007, the USFWS removed the bald eagle from the Endangered Species List throughout its range. However, the species is classified as a Critically Imperiled S1 species by the Utah Natural Heritage Program due to its extreme rarity and vulnerability to extirpation as a breeding bird within the state. Similarly, protective management actions continue in Arizona, which are coordinated by the Southwestern Bald Eagle Management Committee, and implemented through the Arizona Game and Fish Department (AZGFD n.d.). Additionally, the bald eagle retains federal protection under the Bald and Golden Eagle Protection Act, the Migratory Bird Treaty Act, and Utah State Code (Utah DNR 2011). Despite the continuing recovery of populations in recent decades, fewer than ten nesting pairs were known in Utah in 2005 (Utah DNR n.d.c). In general, bald eagles avoid areas with nearby human activity and development (Utah DNR n.d.c). Primary threats to this species

include degradation of breeding and wintering habitat, disturbance at nest and roost sites, collisions with stationary/moving structures or objects, and pesticides and other contaminants/toxics (Buehler 2000).

Long-billed Curlew (*Numenius americanus*) — Species of Concern (Arizona and Utah)

This aquatic bird reaches a height of 18 to 26 inches (45 to 66 centimeters), with a wingspan of 36 to 40 inches (91 to 101 centimeters). Its long, thin, down-curved bill can be more than 8 inches (20 centimeters) in length (TPWD 2009). Mating season for this species is typically from mid-April through September (TPWD 2009), and one clutch of four eggs on average is laid per season (Dugger and Dugger 2002). Nests are built on the ground in flat, open areas with clumps of grass, and are vulnerable to predation and human disturbance (TPWD 2009; Utah DNR 2011). During the breeding season, this species prefers prairies and pastures with short grass, and seeks seashores, lakes, rivers, mudflats, and salt marshes after breeding (TPWD 2009). In general, long-billed curlews rely on grassland and wetland habitats to survive (Utah DNR 2011). In Glen Canyon, this species is considered an uncommon, restricted migrant and is found along the Lake Powell shoreline and at sewage treatment settling ponds. Spring passage is from mid-April to mid-May, and fall passage is from late June to early September. Between 1974 and 2000, bird records from the greater Grand Canyon region reveal that the peak number of long-billed curlew reported in Glen Canyon was 20 in Warm Creek Bay in 1999 and five additional birds (recorded the same day) in the Wahweap area (NPS n.d.a; Spence, LaRue, and Grahame 2011).

Primary threats to this bird include loss of breeding habitat and habitat modification. Specifically, habitat fragmentation has provided predators with travel corridors, which increases predation on ground-nesting birds (Utah DNR 2011). Additionally, as described in the "Wildlife and Wildlife Habitat" section of this chapter, ground-nesting birds are at greatest risk from ORV activity, due to nest abandonment and direct mortality from nests and young being crushed (Switalski and Jones 2010).

American White Pelican (*Pelecanus erythrorhynchos*) — Species of Concern (Utah)

This large waterbird is 50 to 65 inches (127 to 165 centimeters) long and has an enormous bill with an extensible pouch (Evans and Knopf 2004). The American white pelican is a diurnal and nocturnal forager; however, capture rates are higher during day (Utah DNR n.d.d). It forages mainly on fish in shallow wetlands. Unlike the brown pelican, the white pelican dips its head under water to scoop up fish (rather than diving). Several pelicans may fish cooperatively, moving into a circle to concentrate fish, and then dipping their heads under simultaneously to catch fish (Cornell Lab of Ornithology n.d.).

White pelicans are most commonly seen at foraging and adjacent loafing sites, where they are tolerant of human observers if not approached too closely. At breeding colonies, by contrast, they are shy and, if approached, prone to desert or to leave eggs and young exposed to predators (Evans and Knopf 2004). However, in Utah, the only breeding colonies of the American white pelican are located in the northern portions of the state, specifically within the Utah Lake/Great Salt Lake ecological complex (i.e., Gunnison Island) (Utah DNR 2011).

This species is considered an uncommon restricted migrant on Lake Powell. Groups up to 300 have been noted within Glen Canyon. This pelican is sparse in winter; four have been recorded: one at Bullfrog in 1995, one in Wahweap Bay in 1994, one below Glen Canyon Dam in 1995, and one at Wahweap/Page Sewage Treatment Plan in 2000. Fall migrants have been seen as late as December when eight were seen at Antelope Island in 1998 (Spence, LaRue, and Grahame 2011).

Overall, American white pelicans are highly sensitive to human intrusions into breeding colony, which cause desertions, especially during courtship and early incubation. Loud and close passes by motor boats and low flying airplanes can cause upflights from colony. Also, feeding and loafing flocks are dispersed by approach of motor boats. Historically, pelicans were shot for sport or trophies; shooting was reported in the 1970s and 1980s as the

greatest single source of mortality observed from band returns. Other threats to the American white pelican include pesticides and other contaminants, as well as habitat degradation (Evans and Knopf 2004).

Gray vireo (Vireo vicinior) — Species of Concern (Arizona and Utah)

The species breeds on arid slopes dominated by mature pinyon-juniper or juniper woodlands in southwestern Utah (Utah DNR n.d.b). It is an uncommon widespread summer resident and probable breeder in open pinyon-juniper woodland covered slopes generally at the lower elevational limits of the woodland. There are no breeding records. A key component within these areas appears to be the presence of a deciduous shrub or small tree, typically Utah serviceberry (*Amelanchier utahensis*) and/or singleleaf ash (*Fraxinus anomala*). The majority of the birds in Glen Canyon are found along Fiftymile Bench at the base of the Kaiparowits Plateau and along the Chinle, Moenkopi, and Cutler formation slopes and canyons of the Andy Miller Flat and Waterhole Flat area (NPS n.d.a). The species may also occur in the Orange Cliffs region.

Habitat loss through fragmentation and clearing of pinyon-juniper woodlands, cowbird brood parasitism, and predation are threats to this species. Disturbances such as grazing and off-road activities may have a negative impact on populations (Winter and Hargrove 2004).

Great Blue Heron (*Ardea herodias*) — Glen Canyon Species of Concern

The great blue heron is one of the most widespread and adaptable wading birds in North America. It stands about 63 inches (160 centimeters) tall, 38 to 54 inches (97 to 137 centimeters) in length, with a mass of 4.6 to 5.5 pounds (2.1 to 2.5 kilograms). During the breeding season, this species forages in wetlands, water bodies and water courses, but can also be found occasionally in upland areas. Although the heron is primarily a fish eater, wading along the shoreline of oceans, marshes, lakes, and rivers, it also stalks upland areas for rodents and other animals, especially in winter. Nesting occurs in trees, bushes, on the ground and on artificial structures, usually near water (Vennesland and Butler 2011).

In Utah, the great blue heron is the most commonly encountered heron, found statewide along shorelines of lakes and rivers, as well as in marshes. During March and April, nests are built colonially in the tops of trees growing along water's edge. Typically four eggs are laid each year (Utah DNR n.d.e). The great blue heron is considered an uncommon widespread migrant and winter resident on Lake Powell and along the San Juan and Colorado Rivers from July through March. It is less common the remainder of the year. While it bred formerly in Glen Canyon, the only recent nesting attempts have been in 1998–2005 when one to four pairs began nesting at Lee's Ferry and (in 1998 only) unsuccessfully as a single attempt 243 feet (74 meters) above the river on a ledge at Colorado River RM-13.0, and every year since at least 1992 (and probably earlier) in upper Hall's Creek Bay. Attempts to breed in Hall's Creek Bay are often unsuccessful because of rapid lake rises in May–June drowning nests and recreational disturbances (NPS n.d.a). Recently, sporadic breeding of heron was documented during a summer 2013 survey that confirmed the presence of two colonies and 21 nests along the Colorado River below the Glen Canyon Dam (Nealon 2013).

Breeding colonies are vulnerable to disturbance and habitat loss, and climate change and increasing predator populations may bring new challenges.

Plants

Brady Pincushion Cactus (*Pediocactus bradyi*) — Federally Endangered

Listed as endangered in 1979, the Brady pincushion cactus is a small, semiglobose cactus that occupies areas with a substrate of Kaibab limestone chips over Moenkopi shale and sandstone soil (NatureServe 2009; USFWS 1985). The vegetation where this small cactus grows is generally open and sparse, characterized by low shrubs, grasses,

and annuals (USFWS 1985). Associated plants include shadscale, snakeweed (*Gutierrezia sarothrae*), and Mormon tea (NatureServe 2009). Brady pincushion cactus is known from a geographical area of about 17,000 acres in Coconino County, Arizona. It grows on the benches and terraces in the Colorado Plateau near Marble Canyon (USFWS 1985).

This cactus is protected by the Convention on International Trade in Endangered Species and by the Arizona Native Plant Law (USFWS 1985). The limited distribution and small number of populations make this species vulnerable to extinction. ORV traffic, pesticide application, illegal collecting, and herbivory by native animals are known current threats (USFWS 2002b).

Navajo Sedge (*Carex specuicola*) — Federally Threatened

Listed as threatened in 1985, Navajo sedge is a perennial herb known to exist in the project area (NPS 2009b; USFWS 1987). This slender plant reaches approximately 10 to 18 inches (25 to 45 centimeters) in height, and has pale green leaves clustered near the plant's base. Flowering and fruit set occur from spring through summer, but most reproduction appears to be vegetative (USFWS 1987). Navajo sedge occupies silty soils of shady seep/spring pockets on Navajo Sandstone at 5,710 to 5,984 feet (1,740 to 1,834 meters) elevation in the Navajo Nation, and on Cedar Mesa sandstone at 3,772 feet (1,150 meters) in Glen Canyon (NPS 2009b; USFWS 1987). It coexists with other hanging garden and wetland/riparian species such as monkey flower (*Mimulus eastwoodiae*), helleborine (*Epipactis gigantea*), water bentgrass (*Agrostis semiverticillata*), and common reed (*Phragmites communis*) (USDA 2011). In Glen Canyon, the single population is known from hanging garden habitats in Slickhorn Canyon along the San Juan River. Populations are also known from side canyons of the Arizona portion of the Navajo Nation. Designated critical habitat has been established on the Navajo Nation outside Glen Canyon (NPS 2009b).

Water is vital to the survival of Navajo sedge; therefore, any change in the water table level will have an effect on the populations in Glen Canyon (USFWS 1987). Populations occupying low-lying, accessible habitat are vulnerable to domestic livestock grazing. ORVs could also negatively impact Navajo sedge habitat (USDA 2011). However, the single population in Glen Canyon, which is in a hanging garden in Slickhorn Canyon, would not be affected by off-road use.

Jones' Cycladenia (*Cycladenia humilis* var. *jonesii*) — Federally Threatened

Listed as threatened in 1986, this herbaceous perennial grows 4 to 6 inches (10 to 15 centimeters) tall. It generally occurs between 4,390 to 6,000 feet (1,338 to 1,829 meters) in elevation in plant communities of mixed juniper, desert scrub, or wild buckwheat / Mormon tea. Jones' cycladenia is rhizomatous (having a long underground stem system that cannot be seen above ground), and produces pink or rose-colored, trumpet-shaped showers from mid-April to early June (USFWS 2008). It grows only on alluvium of gypsiferous and saline soils on the Chinle, Cutler, and Summerville Formations. This species has recently been found to be widespread in suitable habitat (Last 2009) on the Colorado Plateau. In Glen Canyon, populations are known to exist in the Purple Hills, in Moody Canyons, Orange Cliffs region, and along the Escalante River in Garfield County, Utah. The Park Service conducts annual monitoring of Jones' cycladenia in Glen Canyon (NPS 2009b).

Jones' cycladenia is vulnerable to human-caused threats because of the relatively small number of populations and because the arid climate and harsh soils make this ecosystem a fragile one, slow to recover from surface disturbance (USFWS 2000). Threats include off-road use; oil, gas, and mineral exploration; and livestock grazing. Although these threats have been managed to reduce human-caused impacts, they remain an ongoing and long-term concern (USFWS 2008).

Copper Canyon Milkvetch (*Astragalus cutleri*) — Species of Concern (Utah)

This short-lived perennial forb often flowers as an annual and averages 4 to 14 inches (10 to 35 centimeters) in height. Its stems are few to several, erect to spreading, and form bushy clumps from a branched root crown (AZGFD 2004; Roth 2001). The flowering and fruiting period for this plant is from mid-April to early June (Roth 2001). Copper Canyon milkvetch inhabits warm desert shrub communities from approximately 3,803 feet (1,160 meters) in elevation (AZGFD 2004). It grows in selenium-rich clays and alkaline soils with level to moderate slopes (Roth 2001) on the Shinarump and Chinle Formations (Roth 2009). This extremely rare species is restricted to a few locations in San Juan County, Utah, and is known from only two locations inside Glen Canyon, Clay Hills Crossing and Copper Creek. Copper Canyon milkvetch is not currently monitored in Glen Canyon (NPS 2009b).

Burros were blamed for the disappearance of the species from the Copper Canyon area from 2000 to 2003. *Astragalus* species are generally considered toxic to livestock but can become addictive once grazed. Other threats include competition with annual invasive plant species such as *Bromus rubens*, *Schismus arabicus*, and *Erodium cicutarium*, which are all abundant in the Copper Canyon area (Roth 2009). In addition, Copper Canyon milkvetch has been previously affected by ORV activity in Glen Canyon near Clay Hills Crossing (Sweatland pers. comm. 2010a).

Kachina daisy (*Erigeron kachinensis*) — Species of Concern (Utah)

This perennial herb with lax stems reaches up to 20 centimeters high and produces flowers with white or pinkish rays surrounding a yellow disk bloom from late April to August (NatureServe 2009). The typical habitat for the Kachina daisy are low elevation seeps and hanging gardens to high elevation mesic sandstone outcrops in aspen and ponderosa pine communities (NatureServe 2009). This plan is endemic to the Colorado Plateau in Garfield and San Juan Counties in Utah, and in Montrose County, Colorado (UNPS 2009). Potential threats to this species include mining, energy development, and water projects, which could affect water supplies to its habitat (NatureServe 2009). Based on Glen Canyon staff observation, this species is found within Glen Canyon in hanging gardens habitat along canyon edges and potentially in the Orange Cliffs region.

Paria Spurge (*Euphorbia nephradenia*) — Species of Concern (Utah)

This annual herb reaches 4 to 9.8 inches (10 to 25 centimeters) in length and produces small flowers inside yellow-green, cup-shaped structures. Its flowers bloom between June and August (NatureServe 2009). Typical habitat for Paria spurge includes desert shrubland and grassland communities between 3,800 and 4,800 feet (1,158 and 1,463 meters) in elevation. This plant mainly grows on dark clay hills, blow sand, and stabilized dunes from Tropic Shale and Entrada Formations. This species is endemic to the Colorado Plateau in Emery, Garfield, Kane, and Wayne Counties in Utah, and in Colorado (UNPS 2009). In general, potential threats to this species include mineral exploration and human-related activities including road construction (NatureServe 2009).

Cataract Gilia (*Gilia imperialis*) — Species of Concern (Utah)

This annual herb has intricately branched clusters of flowers and can reach over 9.8 inches (25 centimeters) in height. This species is distinguished from *G. latifolia* by a later phenology, lasting from June to October, and by several morphological traits and distribution. Habitat type includes shadscale and other mixed desert shrub communities, especially in wash bottoms and at the bases of ledges (UNPS 2009). Cataract gilia is endemic to Utah and can be found growing mainly on Tropic, Carmel, and Straight Cliffs Formations near roads (NPS 2009b; Sweatland pers. comm. 2010a) at 3,800 to 5,200 feet (1,160 to 1,585 meters) in elevation (NPS 2009b; UNPS 2009). Known from only three locations, this species is considered uncommon in Glen Canyon and is found on clayey soils (NPS 2009b).

Tropic Goldeneye (*Heliomeris soliceps)* — Species of Concern (Utah)

Tropic goldeneye is an annual herb with a deep taproot that averages 6 to 16 inches (15 to 40 centimeters) in height. Its long stems contain yellow flowers that bloom from May through June. Preferred habitat for this species includes mat saltbush communities on gumbo clay knolls at 4,593 to 4,823 feet (1,400 to 1,470 meters) in elevation (NatureServe 2009). Endemic to Kane County, Utah, tropic goldeneye is restricted to Tropic Shale Formations and is considered rare in Glen Canyon (NatureServe 2009; NPS 2009b). Based on Glen Canyon staff observation, this species is threatened by ORV activity.

Western hophornbeam (*Ostrya knowltonii*) — Species of Concern (Arizona and Utah)

Western hophornbeam is a small tree 10 to 40 feet (3 to 12 meters) tall with a 6 to 18 inch (15.2 to 45.7 centimeter) diameter. The trunk is usually short and divided into a number of slender, crooked branches to form a round-topped crown. It is found in southeastern Utah, northern Arizona, southeastern New Mexico (in the Guadalupe and Sacramento mountains in Eddy County), and northern Trans-Pecos Texas. It is not a common tree and its occurrence is sporadic even in these areas (Tesky 1994). In Arizona, this species has been reported in Coconino and Yavapai Counties; in Utah, it has been reported in Garfield, Grand, Kane, and San Juan Counties (NatureServe 2009). Based on Glen Canyon staff observation, this species is found within Clearwater Canyon and potentially the Orange Cliffs region. This species is threatened in unprotected areas by water diversion and development (NatureServe 2009).

Alcove rock-daisy (*Perityle specuicola*) — Species of Concern (Utah)

The alcove rock-daisy is a woody-based perennial herb reaching approximately 20 to 27 inches (50 to 70 centimeters) long. The leaves are tiny and inconspicuous and the flower heads have disk flowers that are yellow. The species flowers from July to September (NatureServe 2009). The species is endemic to Garfield, Grand, and San Juan Counties, Utah. Its habitat consists of desert shrub and hanging garden communities in narrow, protected canyons, alcoves, and at cliff bases in Navajo Sandstone and the Cedar Mesa Formation (UNPS 2009). Based on Glen Canyon staff observation, this species is found within Glen Canyon in hanging gardens habitat along canyon edges and may occur in the Orange Cliffs region. Overall threats to this species include recreational activities; camping and road construction may also be threats (NatureServe 2009).

Howell's Phacelia (*Phacelia howelliana*) — Species of Concern (Arizona and Utah)

Howell's phacelia is an annual herb reaching approximately 9 inches (23 centimeters) in height, with blue-purple flowers growing on one side of the flowering stalks in curved clusters (NatureServe 2009; UNPS 2009). The flowering period for this plant is April to June. This species is endemic to the Colorado Plateau and is found in Grand, Kane, San Juan, and Wayne Counties in Utah, as well as in Arizona (UNPS 2009). Howell's phacelia is associated with Tropic Shale Formations (Sweatland pers. comm. 2010a) and is restricted to clay and basalt hills (NPS 2009b). Howell's phacelia inhabits salt and warm desert shrub and pinyon/juniper communities at 3,700 and 5,000 feet in elevation (UNPS 2009). Potential threats to this species include industrial development and other changes in land use (NatureServe 2009). Based on Glen Canyon staff observation, this species is also threatened by ORV activity.

Nipple Phacelia (*Phacelia mammillarensis)* — Species of Concern (Arizona and Utah)

Nipple phacelia is an annual herb with pale blue to white flowers, and is endemic to the Tropic Shale and Kaiparowits Formations east of Glen Canyon City, Utah. This plant is one of very few that is capable of surviving on the colluvial soils of the region (NatureServe 2009). In Glen Canyon, this species is considered occasional and is widely scattered in desert shrubland habitats, specifically in Kane County (NPS 2009b). Since 1979, primary threats to Nipple phacelia include the use of ORVs and potential industrial development (NatureServe 2009).

Whiting's Indigo-bush (*Psorothamnus thompsoniae* var. *whitingii*) — Species of Concern (Arizona and Utah)

Whiting's indigo-bush is an armed shrub ranging from 9.8 to 31.5 inches (25 to 80 centimeters) in height. Its leaflets are linear to narrowly elliptic or oblong, with flowers containing indigo or purple-pink petals (UNPS 2009). This species is endemic to the Navajo Basin and is found only in San Juan County, Utah, and Coconino County, Arizona (NatureServe 2009; UNPS 2009). Whiting's indigo-bush can be found in sandy soils at 3,800 to 5,000 feet in elevation from late May to June (UNPS 2009). In Glen Canyon, this rare species inhabits desert shrub communities and bottomlands, specifically at Clay Hills Crossing (NPS 2009b).

New Mexico raspberry (*Rubus neomexicanus*) — Species of Concern (Utah)

The New Mexico raspberry is a small shrub, approximately 3 to 6 feet (1 to 2 meters) tall, with small white flowers found singly or in pairs. Its fruit is a red berry, approximately 0.6 inch (15 millimeters) thick (Latimer 2005). The species distribution is Utah, New Mexico, Arizona, and northern Mexico (Latimer 2005). In Arizona, it is found in Coconino and Yavapai counties, at 5,000 to 9,000 feet in moist canyons (Latimer 2005). Based on Glen Canyon staff observation, this species is found within Glen Canyon in Clearwater Canyon in the Orange Cliffs region. According to Glen Canyon's strategic plan, New Mexico raspberry is likely to be stable (NPS 2007e).

Jane's globemallow (*Sphaeralcea janeae*) — Species of Concern (Utah)

Jane's globemallow is a perennial herb, approximately 12 to 35 inches (30 to 90 centimeters) tall, and produces a cluster of orange flowers from May to June (NatureServe 2009). The species is endemic to San Juan and Wayne Counties, Utah (UNPS 2009). Its habitat consists of warm, salt, and mixed communities on the Shinarump and Moenkopi formations and White Rim and Organ Rock members of the Cutler Formation (NatureServe 2009). Based on Glen Canyon staff observation, this species is found within Glen Canyon in the White Rim Sandstone formation in the Orange Cliffs region. Overall threats to this species include mining activities (NatureServe 2009).

Desert mountain lilac (*Ceanothus vestitus* var. *franklinii*) — Glen Canyon Species of Concern

This variety of *Ceanothus* is shorter than var. *vestitus* (8 to 20 inches [20 to 50 centimeters] versus 39 to 79 inches [100 to 200 centimeters]), is more intricately branched, and usually has blue rather than white flowers. The species is endemic to Utah and is found in Grand, San Juan, and possibly Garfield Counties. Its habitat consists of pinyon-juniper, blackbrush, skunkbrush, and serviceberry communities at 5,400 to 6,200 feet elevation (UNPS 2009). Based on Glen Canyon staff observation, this species is found within Glen Canyon in the Wilson Mesa and Orange Cliffs regions.

Tompkin's phacelia (*Phacelia pulchella* var. *sabulonum*) — Glen Canyon Species of Concern

Tompkin's phacelia is a rare annual forb/herb (USDA n.d.) endemic to Utah, and is restricted to the Tropic and Straight Cliff Shale Formations (NatureServe 2009; NPS 2009b). Most of the known locations for this species are in eastern Kane County, where it is common on gravelly benches and sandy wash bottoms in shadscale and greasewood communities (NatureServe 2009). Based on the observation of Glen Canyon staff, threats to this species include ORV activity.

Douglas fir (*Pseudotsuga menziesii*) — Glen Canyon Species of Concern

Douglas fir is a medium-sized evergreen tree with a short pyramidal symmetrical crown at the top of a clear straight trunk. The average size of this tree in Utah is 130 feet (40 meters) tall, and 36 inches (91 centimeters) in diameter (Utah State University 2013). Relict Douglas-fir stands, which prefer cooler, moist climates, exist in north-facing shaded alcoves associated with springs (NPS 2013b). Based on Glen Canyon staff observation, this species is found

within Glen Canyon in the Orange Cliffs region. Threats to this species include disease, grazing pressure, and development.

CRITICAL HABITAT

Provisions of the Endangered Species Act require the consideration of both species populations and designated critical habitat for species listed or proposed for listing. "Critical habitat" is defined as a specific geographic area that is essential for the conservation of an endangered or threatened species and that is designated as such in the recovery plan for that species, or in subsequent legislation.

Glen Canyon supports designated critical habitat for Mexican spotted owl and four endangered fish species: the Colorado pikeminnow (*Ptychocheilus lucius*), razorback sucker (*Xyrauchen texanus*), bonytail chub (*Gila elegans*), and humpback chub (*Gila cypha*). As described in chapter 1, it is not expected that off-road use would adversely impact these fish species, because none occur in the designated ORV areas within the scope of this plan/DEIS. Therefore, Colorado pikeminnow, razorback sucker, bonytail chub, and humpback chub are not analyzed in chapter 4.

Glen Canyon supports designated critical habitat for Mexican spotted owl.

Critical habitat units for the Mexican spotted owl are designated in portions of Apache, Cochise, Coconino, Graham, and Pima Counties in Arizona; Carbon, Emery, Garfield, Grand, Iron, Kane, San Juan, Washington, and Wayne Counties in Utah; and several counties in New Mexico and Colorado. Glen Canyon lies in Unit CP-13, which is in Wayne, Garfield, Kane, and San Juan Counties, Utah. It is primarily in the Waterpocket Fold landform extending to Lake Powell. Canyons and steep-sloped, mixed-conifer habitats are included in this unit, as well as foraging and dispersal habitat. Unit CP-12 designates critical habitat adjacent to Glen Canyon in the vicinity of the Kaiparowits Plateau and the Cockscomb, in Kane and Garfield Counties. Additionally, Unit CP-14 lies adjacent to Glen Canyon in Wayne, Garfield, San Juan, and Grand Counties and designates critical habitat in the Orange Cliffs region. In addition, this unit includes the Dark Canyon primitive and wilderness areas of the BLM and U.S. Forest Service, respectively (69 FR 53214). Also included in this unit is a significant area in Canyonlands National Park, which is considered one of the major population centers of the Mexican spotted owl on the Colorado Plateau (NPS 2004a). In determining which areas to designate as critical habitat for a species, the USFWS considers those physical and biological attributes that are essential to species conservation (i.e., constituent elements). The owl's primary constituent elements, which exist in mixed conifer, pine/oak, and riparian forest types, that provide for one or more of the owl's habitat needs for nesting, roosting, foraging, and dispersing are in areas defined by the following:

1. **Primary constituent elements related to forest structure**:
    a. A range of tree species, including mixed-conifer, pine/oak, and riparian forest types, composed of different tree sizes reflecting different ages of trees, 30% to 45% of which are large trees with a trunk diameter of 12 inches (0.3 meters) or more when measured at 4.5 feet (1.4 meters) from the ground;
    b. A shade canopy created by the tree branches covering 40% or more of the ground; and
    c. Large dead trees (snags) with a trunk diameter of at least 12 inches (0.3 meters) when measured at 4.5 feet (1.4 meters) from the ground.
2. **Primary constituent elements related to maintenance of adequate prey species**:
    a. High volumes of fallen trees and other woody debris;
    b. A wide range of tree and plant species, including hardwoods; and
    c. Adequate levels of residual plant cover to maintain fruits, seeds, and allow plant regeneration.

3. **Primary constituent elements related to canyon habitat include one or more of the following**:
    a. Presence of water (often providing cooler and often higher humidity than the surrounding areas);
    b. Clumps or stringers of mixed-conifer, pine/oak, pinyon/juniper, and/or riparian vegetation;
    c. Canyon wall containing crevices, ledges, or caves; and
    d. High percent of ground litter and woody debris. (69 FR 53211)

SOUNDSCAPES

The natural soundscape encompasses all the natural sounds that occur in parks, including the physical capacity for transmitting those natural sounds and the interrelationships between park natural sounds of different frequencies and volumes.

According to NPS *Management Policies 2006* and Director's Order 47: Sound Preservation and Noise Management, an important component of the Park Service mission is the preservation of natural soundscapes associated with national park units (NPS 2000, 2006a). Natural soundscapes exist in the absence of human-caused sound. The natural soundscape is the aggregate of all the natural sounds that occur in parks (such as waves on the shoreline, birds calling, wind blowing, or the sound of thunder), together with the physical capacity for transmitting natural sounds. Natural sounds are intrinsic elements of the environment and part of "the scenery and the natural and historic objects and the wild life" protected by the NPS Organic Act. They are vital to the visitor experience of many parks and provide valuable indicators of the health of various ecosystems. Natural sounds are necessary for ecological functioning and occur within and beyond the range of sounds that humans can perceive. Many mammals, insects, and birds decipher sounds to find desirable habitat and mates, avoid predators and protect young, establish territories, and to meet other survival needs.

The Glen Canyon soundscape is composed of both a natural and human-caused components. Human-caused sounds at Glen Canyon largely are attributable to motor engines and include all types of watercraft, conventional and nonconventional motor vehicles, aircraft, and electronic devices such as radios and horns. As discussed in chapter 1, soundscapes was identified as an impact topic for further analysis in this plan/DEIS because of the potential for noise from motor vehicles travelling off-road to interfere with non-motorized recreation or disturb wildlife. Human sounds are not unexpected or necessarily inappropriate at the developed areas, but are part of the overall soundscape in an area where water activities, picnicking, camping, sightseeing, and other recreational uses occur.

SOUNDSCAPE TERMINOLOGY

Whereas sound may be described as an auditory sensation characterized by variations in pressure that move through air or water, noise is generally defined as an unwanted or intrusive sound (NPS 2010b). For example, sounds are described as noise if they interfere with an activity or disturb the person or organism hearing them.

Sound is measured in a logarithmic unit called a decibel (dB). Sound pressures described in decibels are called sound pressure levels and are often defined in terms of frequency-weighted scales (A, B, C or D). The A-weighted decibel scale is commonly used to describe noise levels because it reflects the frequency range to which the human ear is most sensitive (1,000–5,000 Hertz) (Caltrans 2009). Sound levels measured using an A-weighted decibel scale are generally expressed as "dBA." Throughout this section, all noise levels are expressed in A-weighted decibels. Several examples of sound pressure levels in the A-weighted scale (dBA) measured in national parks are listed in table 7.

TABLE 7: SOUND PRESSURE LEVELS MEASURED IN NATIONAL PARKS

Sound	dBA
Threshold of Human Hearing	0
Haleakala National Park: Volcano Crater	10
Canyonlands National Park: Leaves Rustling	20
Zion National Park: Crickets (5 meters)	40
Whitman Mission: Conversational Speech (5 meters)	60
Yellowstone National Park: Snowcoach (30 meters)	80
Arches National Park: Thunder	100
Yukon–Charley Rivers National Park: Military Jet (100 meters above ground level [AGL])	120

Source: NPS 2010b.

Definitions of terms that are commonly used in this "Soundscapes" section are provided below.

Acoustic Zone: Areas of like vegetation, topography, elevation, and climate are considered acoustic zones, based on the assumption that similar animals, plants, physical processes, and other sources of natural sounds occur in similar areas with similar attributes.

Audibility: Audibility is the ability of animals with normal hearing (including humans) to hear a given sound. The main factors that affect audibility are the hearing ability of the animal, other simultaneous interfering sounds or stimuli, and the frequency content and amplitude of the sound.

Existing Ambient Sound Level (L_{50}): This term refers to the sound level of all sounds in a given area, and includes all natural sounds as well as all mechanical, electrical, and other human-caused sounds. The existing ambient sound level will be characterized by the L_{50} exceedance level (i.e., the median).

Natural Ambient Sound Level (L_{nat}): The sound level of all natural sounds in a given area, excluding all mechanical, electrical and other human-caused sounds, is considered the natural ambient sound level. The L_{nat} will be characterized by the L_{50} exceedance value calculated during the times when no human-caused sounds are audible.

Equivalent Sound Level (L_{eq}): This term refers to the logarithmic average (i.e., on an energy basis) of sound pressure levels over a specific time period. "Energy averaged" sound levels are generally much higher than arithmetic averages because they are logarithmic values. Typically, L_{eq} values are calculated for a specific period (e.g., 1-hour and 12-hour periods); L_{eq} values are computed from all the 1-second L_{eq} values for the specific period. L_{eq} must be used carefully in quantifying sound levels because occasional loud sound events may heavily influence/increase the L_{eq} value, even though sound levels for that period of time are typically lower.

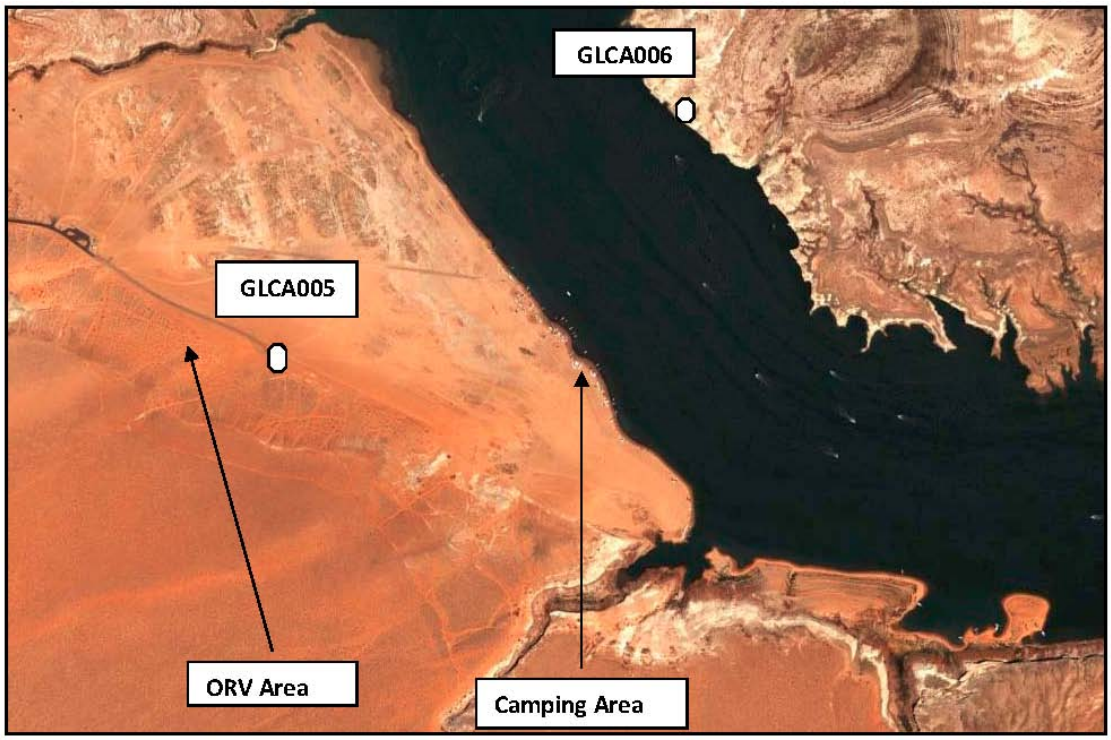
L_x (Exceedance Percentile): This metric represents the sound pressure level (L), in decibels, exceeded x% of the time for the specified measurement period. For instance, L_{90} is the sound pressure level exceeded 90% of the time.

Noise-free Interval (NFI): NFI refers to the length of the interval between noise events during which only natural sounds are audible.

EXISTING SOUND LEVELS

2007 Glen Canyon Off-road Vehicle Sound Study

In 2007, the Park Service conducted a sound monitoring project to collect acoustic data in the Lone Rock Beach area on Lake Powell, as referenced above, in order to characterize and describe ORV sounds in that area to understand how ORVs may impact the natural soundscape of Glen Canyon. Sound levels were recorded by acoustic monitors deployed at Lone Rock Beach Play Area on the west side of the bay (designated GLCA005) as well as on the east side of Lone Rock Beach (GLCA006), as shown in figure 14. Continuous sound monitoring was conducted at GLCA005 from August 16 to August 21, 2007, and from August 29 to September 3, 2007. Continuous sound monitoring was conducted at GLCA006 from August 17 to August 20, 2007, and from August 30 to September 2, 2007.



Note: ORV Area is the Lone Rock Beach Play Area.
Source: Ambrose and Florian 2008.

FIGURE 14: LONE ROCK BEACH ACOUSTIC MONITORING SITES

This study found that sound levels at the Lone Rock Beach Play Area regularly exceeded 75 dBA at 50 feet from the sound source, and occasionally exceeded 90 dBA at 50 feet (Ambrose and Florian 2008). At this location, human-caused sounds were audible, on average, 90.5% of the time, and it was noted that ORV sounds were the loudest and most common sounds at the site. Specifically, ORVs and other vehicles were audible 54.7% of the day (ORVs alone were audible 31.7% of the day), whereas watercraft (boats and personal watercraft) were audible 21.8% of the day (Ambrose and Florian 2008). Average sound levels at the site ranged between 24 and 45 dBA, with the major contributor being ORV sounds.

On the east side of Lone Rock Bay, watercraft (boats and personal watercraft) were the loudest and most common sounds. Such sources were audible, on average, 57.2% of the day, whereas ORVs and other vehicles were audible 32.1% of the time (Ambrose and Florian 2008). Average sound levels at this site ranged between 26 and 51 dBA, with the main contributor being watercraft sounds (Ambrose and Florian 2008).

The loudest events at monitoring sites GLCA005 and GLCA006 were calculated, using measured data, for a standard reference distance of 50 feet and presented in the ORV study report (Ambrose and Florian 2008). The loudest events at GLCA005 were most frequently attributed to ORVs (up to 101.6 dBA at 50 feet). In contrast, the loudest events at GLCA006 were attributed to motor boats (up to 102.8 dBA at 50 feet), which is logical given the proximity of GLCA006 to Lake Powell. This study also found that, of the ORVs used in Glen Canyon and recorded during the measurement period, those with modified or performance exhaust systems tended to be two to four times louder than ORVs with stock exhausts.

2010 Glen Canyon National Recreation Area and Rainbow Bridge National Monument Acoustic Inventory

An acoustic study was conducted at Glen Canyon and Rainbow Bridge National Monument (Rainbow Bridge) in 2010 to determine sound levels and sound sources in the primary land cover groups in summer and winter during daytime and nighttime (Ambrose and Florian 2011). The objective of the study was to collect and analyze acoustic data in the primary land cover types of Glen Canyon and Rainbow Bridge sufficient to develop an acoustic baseline for frontcountry and backcountry areas.

The acoustic study measured sound levels and sources at seven locations, three frontcountry sites and four backcountry sites, including areas of high visitor use and low visitor use. The study also used data collected as part of two other acoustic studies related to Glen Canyon, the 2007 ORV study at the Lone Rock Bay area (as discussed above) and an airport study related to the Cal Black Memorial Airport, increasing the number of locations to 11.

Areas with like vegetation, land cover, topography, elevation, and climate are generally considered acoustic zones because they often exhibit similar acoustical characteristics, including sound sources (birds, insects, mammals), sound levels, and propagation and attenuation properties. Measurement locations were selected to represent four land cover groups in Glen Canyon and Rainbow Bridge: cliff/canyon; desert shrubland/grassland; pinyon/juniper; and developed. Lake areas were not specifically addressed, although several monitors were close to water. Two levels of human use were considered, low and high. Low-use areas included isolated lakeside camping areas, low-use motorboat areas, trails, and other areas with regular human use but relatively low numbers; high-use areas were busy, developed areas such as marinas, visitor centers, and high-density camping areas. The 11 acoustic measurement locations, as well as their primary land cover type and level of human use, are listed in table 8 and mapped in figure 15.

TABLE 8: ACOUSTIC MEASUREMENT LOCATIONS

Site Number	Site Name	Latitude	Longitude	Elevation (meters)/(feet)	Primary Land Cover(s)	Visitor Use Level*
GLCA006	Lone Rock Bay East	37.01984	111.5285	1,111/3,645	Rock / sand / lake	High*
GLCA007	Wahweap Marina	36.9941	111.48994	1,129/3,704	Developed / desert shrub	High
GLCA008	Rainbow Bridge	37.07777	110.96253	1,155/3,789	Canyon / rock / shrub	High*
GLCA009	Iceberg Canyon	37.30342	110.73644	1,130/3,707	Canyon / rock / lake	High*
GLCA010	Warm Creek Rd	37.10004	111.50516	1,226/4,022	Desert shrub / bare soil	Medium
GLCA011	Sewing Machine Rd	37.92109	110.3122	1,490/4,888	Desert shrub / bare soil	Low
GLCA012	Hans Flat	38.22666	110.15087	1,999/6,558	Pinyon / juniper / bare soil	Low
GLCA016	Lake Canyon	37.43071	110.65193	1,109/3,638	Canyon / riparian	Low
GLCA017	Moki Canyon	37.47441	110.58277	1,137/3,730	Canyon / desert shrub	Low
GLCA018	Forgotten Canyon	37.54443	110.58262	1,132/3,713	Canyon / desert shrub	Low
GLCA019	Hansen Creek	37.56828	110.68369	1,128/3,700	Rock / desert shrub	Low

Source: Ambrose and Florian 2011.
*Visitor use in these areas varied by season.

A total of 13,617 hours of acoustical data were collected for the Glen Canyon and Rainbow Bridge acoustic inventory; in addition, 354 hours of data collected as part of the ORV study in 2007 (Ambrose and Florian 2008) and 4,230 hours of data from the Cal Black Memorial Airport study in 2010 (Ambrose and Florian 2011, 2013) were analyzed. Sound levels (L_{nat} and L_{50}) for summer and winter seasons and day and night periods for 11 measurement locations in Glen Canyon and Rainbow Bridge are shown in tables 9 and 10. Backcountry area sound levels were very low, often as low as the acoustic systems could measure, whereas sound levels in developed and high visitor use areas were notably higher and reflect almost continuous human-caused sounds in those areas.

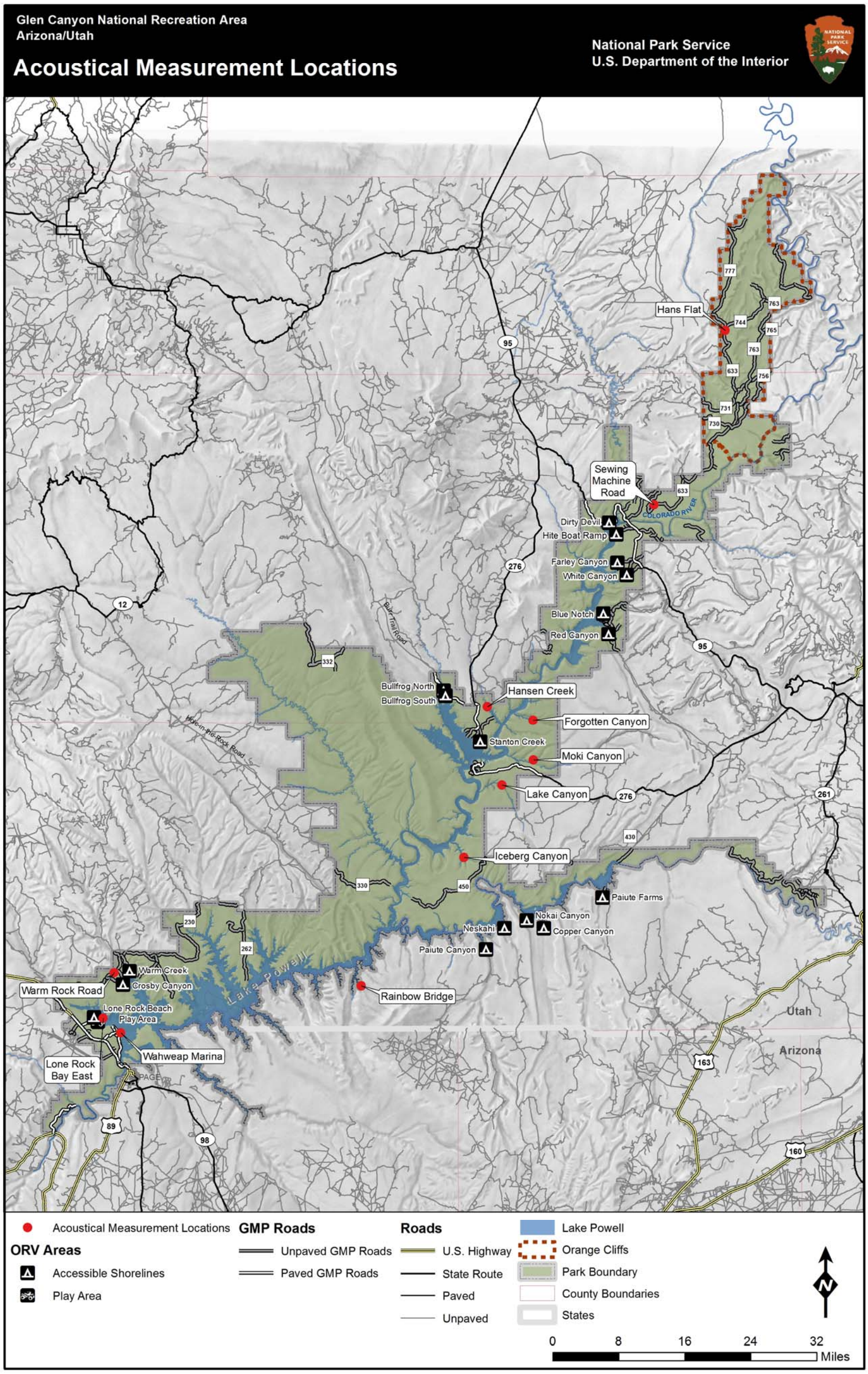


FIGURE 15: ACOUSTICAL MEASUREMENT LOCATIONS

TABLE 9: NATURAL AMBIENT SOUND LEVELS (L_{NAT}), DAY AND NIGHT, SUMMER AND WINTER, 2010

Site Number	Site Name	Summer		Winter	
		Day	Night	Day	Night
GLCA006*	Lone Rock Bay East	41.4*	31.4*	19.8	19.6
GLCA007*	Wahweap Marina	35.9*	31.9*	28.2*	24.6*
GLCA008	Rainbow Bridge	18.7	24.9	20.9	21.1
GLCA009*	Iceberg Canyon	25.0*	22.1	14.8	14.1
GLCA010	Warm Creek Road	18.4	18.6	15.8	14.5
GLCA011	Sewing Machine Rd.	20.8	23.7	15	14.2
GLCA012	Hans Flat	23.0	16.0	17.0	14.0
GLCA016	Lake Canyon	20.7	40.3	ND	ND
GLCA017	Moki Canyon	19.4	18.6	ND	ND
GLCA018	Forgotten Canyon	19.2	23.5	ND	ND
GLCA019	Hansen Creek	20.9	39.4	ND	ND

Source: Ambrose and Florian 2011, 2013.

*Human-caused sounds were audible > 75% of the time. In these situations where human-caused sounds are audible >75% of the time, L_{nat} computations are less reliable.

ND = no data available.

TABLE 10: EXISTING AMBIENT SOUND LEVELS (L_{50}), DAY AND NIGHT, SUMMER AND WINTER, 2010

Site Number	Site Name	Summer		Winter	
		Day	Night	Day	Night
GLCA006	Lone Rock Bay East	51.3	35.6	26.8	22.3
GLCA007	Wahweap Marina	46.4	36.4	39.5	28.1
GLCA008	Rainbow Bridge	22.8	32.2	21.5	21.3
GLCA009	Iceberg Canyon	35.8	26.9	19.2	14.1
GLCA010	Warm Creek Road	23.0	20.6	19.5	14.6
GLCA011	Sewing Machine Road	22.5	27.0	15.3	14.1
GLCA012	Hans Flat	24.6	16.2	18.5	14.0
GLCA016	Lake Canyon	23.6	42.4	ND	ND
GLCA017	Moki Canyon	21.9	19.2	ND	ND
GLCA018	Forgotten Canyon	20.5	25.1	ND	ND
GLCA019	Hansen Creek	24.5	20.2	ND	ND

Source: Ambrose and Florian 2011, 2013.

ND = no data available.

In developed, high-density areas such as Wahweap Marina, human-caused sounds were audible nearly 100% of the time during both summer and winter seasons, daytime and nighttime. Human-caused sounds were audible over 90% of the time during summer daytime hours in high-use lake areas (e.g., Iceberg Canyon), and were less audible in these areas during summer nighttime and winter periods. Aircraft sounds were common throughout Glen Canyon and Rainbow Bridge, most often high-altitude commercial jet aircraft.[5] In developed areas and high visitor use areas, watercraft sounds, vehicle sounds, and other ground-based, human-caused sounds often masked aircraft sounds. (Note that no winter data were available at four locations: GLCA016, Lake Canyon; GLCA017, Moki Canyon; GLCA018, Forgotten Canyon; and GLCA019, Hansen Creek). Table 11 exhibits common sound sources and the percentage of time each was audible for high-use and low-use areas. Classification (high versus low use) of location varied by seasonal use, as shown in table 12.

TABLE 11: COMMON SOUND SOURCES AND PERCENTAGE OF TIME AUDIBLE IN DEVELOPED / HIGH-USE AREAS AND BACKCOUNTRY / LOW-USE AREAS, SUMMER AND WINTER SEASONS

Sound Source	Developed / High-use Areas		Backcountry / Low-use Areas	
	Summer Mean (%)	Winter Mean (%)	Summer Mean (%)	Winter Mean (%)
Jet Aircraft	11.6	18.1	19.1	27.9
Propeller Aircraft	2.5	3.3	2.4	2.6
Helicopter Aircraft	0.0	0.2	0.0	0.0
Vehicles	26.5	41.4	1.8	0.8
Watercraft	35.3	7.7	3.9	0
Trains	0.0	0.0	0.0	0.0
Motors	11.8	21	6.0	4.0
Grounds Care	0.0	0.8	0.0	0.0
People	20.1	8.0	1.7	0.1
Domestic Animals	1.3	0.7	0.0	0.0
Building Sounds	7.6	15.7	0.0	0.0
Construction Sounds	0.0	0.4	0.0	0.0
Other Human Sounds	0.0	0.0	0.0	0.0
Unknown Human Sounds	0.0	0.0	0.1	0.1
Wind	15.5	15.6	40.5	29.4
Water	25.7	33.5	8.9	33.6
Mammals	0.4	0.4	1.3	0.0
Birds	12.2	22.5	27.8	5.4
Amphibians	1.0	0.0	0.0	0.0
Insects	27.7	0.8	66.4	0.4
Animal Sounds	0.7	0	1.4	0.4
Other Natural Sounds	0.0	0.0	0.1	0.0

Source: Ambrose and Florian 2011.

[5] Except at Rainbow Bridge during summer months, where air tour aircraft were common.

TABLE 12: CLASSIFICATION (HIGH USE OR LOW USE) OF MEASUREMENT LOCATION BY SEASON

Developed / High-use Areas			
Summer		**Winter**	
GLCA006	Lone Rock Bay East	GLCA006	Lone Rock Bay East
GLCA007	Wahweap Marina	GLCA007	Wahweap Marina
GLCA008	Rainbow Bridge		
GLCA009	Iceberg Canyon		
Backcountry / Low-use Areas			
Summer		**Winter**	
GLCA010	Warm Creek Road	GLCA008	Rainbow Bridge
GLCA011	Sewing Machine Road	GLCA009	Iceberg Canyon
GLCA012	Hans Flat	GLCA010	Warm Creek Road
GLCA016	Lake Canyon	GLCA011	Sewing Machine Road
GLCA017	Moki Canyon	GLCA012	Hans Flat
GLCA018	Forgotten Canyon		
GLCA019	Hansen Creek		

Source: Ambrose and Florian 2011.

Twenty-one hours of continuous audio data were analyzed to determine NFI metrics, including the percentage of time non-natural sounds were audible, the percentage of time natural sounds were audible, mean maximum NFI, and mean NFI.[6] NFI analysis results indicate that NFI periods were essentially nonexistent in the high-density developed areas, such as Wahweap Marina. In low-density developed areas, such as Rainbow Bridge, NFI periods were similar to medium- and low-use areas, with human-caused sounds present but much less so than in high-density developed areas. Table 13 presents the NFI metrics for day and night periods in low-use backcountry areas.

TABLE 13: NOISE-FREE INTERVAL METRICS (MEAN), DAY AND NIGHT PERIODS, IN LOW-USE BACKCOUNTRY AREAS

Period of Day	Nonnatural Sounds (%)	Natural Sounds Only (%)	Mean Max. NFI (minutes)	Mean NFI (minutes)
Day	29.1	71.0	16.8	7.3
Night	22.0	78.0	19.2	7.4

Source: Ambrose and Florian 2011.

As a recreation area, Glen Canyon's noise metrics (including sound levels and the audibility of human sounds) are greatly affected by the number of visitors in a given area and the type of activity that the visitors partake in. Visitors to the lake area use various types of watercraft, including kayaks, houseboats, and speedboats, some of which are

[6] Continuous audio data were not available for 2007 measurement locations (GLCA006, Lone Rock Bay East, and GLCA007, Wahweap Marina). Human-caused sounds were audible nearly 100% of the time at these two locations.

extremely loud. In such high-use areas, existing sound levels in the summer average about eight times as loud[7] as in low-use areas (50 dBA versus 20 dBA). Similarly, the percentage of time that human-generated sounds were audible in high-use areas was roughly four times higher than in low-use areas.

The study notes that visitor use of Glen Canyon backcountry areas appears to be relatively less than in backcountry areas of nearby national parks (e.g., Grand Canyon National Park, Zion National Park). Given the low number of backcountry visitors, opportunities to experience natural sounds, remoteness, and solitude at Glen Canyon are high. Visitor use at the lake is also relatively low during winter, as evidenced by low sound level measurements of about 14 dBA near the lake in winter months (as low as could be measured by the equipment).

The highest level of visitor activity in Glen Canyon occurs during the summer at Lake Powell, with watercraft as the primary sound source (watercraft sounds frequently mask the aircraft sounds that are also common on the lake). High-altitude commercial jet aircraft are the most common source of sound in areas away from the lake (i.e., more than 3 miles [5 kilometers] from the lake). The primary reason for visitation at Rainbow Bridge is the naturally occurring bridge formation. Lake levels have been low in recent years, resulting in an approximately one-half mile (1 kilometer) distance between the dock and bridge. Given the distance of the separation and the no-wake boat speed rules, watercraft were not a common sound source at the monument (2.1%). The most common sound sources at the monument included people talking and walking, high-altitude commercial jets, and air tour aircraft.

There were few and short periods of natural sound only in the developed and high use areas of Glen Canyon and Rainbow Bridge (mean NFI was 1.04 minutes), such as the marinas and some lake areas during summer months. Mean noise-free periods in low-use backcountry areas and lake areas in winter, however, were longer than in nearby parks. The mean daytime NFI was 7.3 minutes and the mean nighttime NFI was 7.4 minutes in these areas of Glen Canyon and Rainbow Bridge, compared to a mean NFI of 3.2 minutes for four backcountry sites in Grand Canyon National Park (Ambrose and Florian 2005). High-altitude commercial jets were the main sound source responsible for shortening these NFI periods.

VISITOR USE AND EXPERIENCE

In 1972, Glen Canyon was established “to provide for public use and enjoyment and to preserve the area’s scientific, historic, and scenic features.” The unique area encompassed in the recreation area stretches for hundreds of miles from Lees Ferry in Arizona to southern Utah. The clear deep blue water of Lake Powell set against the red and orange sandstone cliffs has creates a scenic landscape that has contributed to drawing over 3 million visitors each year from all over the world to recreate at Glen Canyon. Visitation to Glen Canyon has fluctuated in the past several years, averaging about 1.9 million visitors annually during the past seven years (2003–2009), with a recent peak of 2.2 million visitors in 2011 (figure 16). However, between 1992 and 2002, Glen Canyon experienced an average of 2.7 million visitors annually (NPS 2011d).

[7] Since sound is measured using a logarithmic scale, increasing sound levels are not linear. An increase of 10 dBA is generally perceived by humans as twice as loud; an increase of 20 dBA is perceived as four times as loud, an increase of 30 dBA is perceived as eight times as loud, etc.

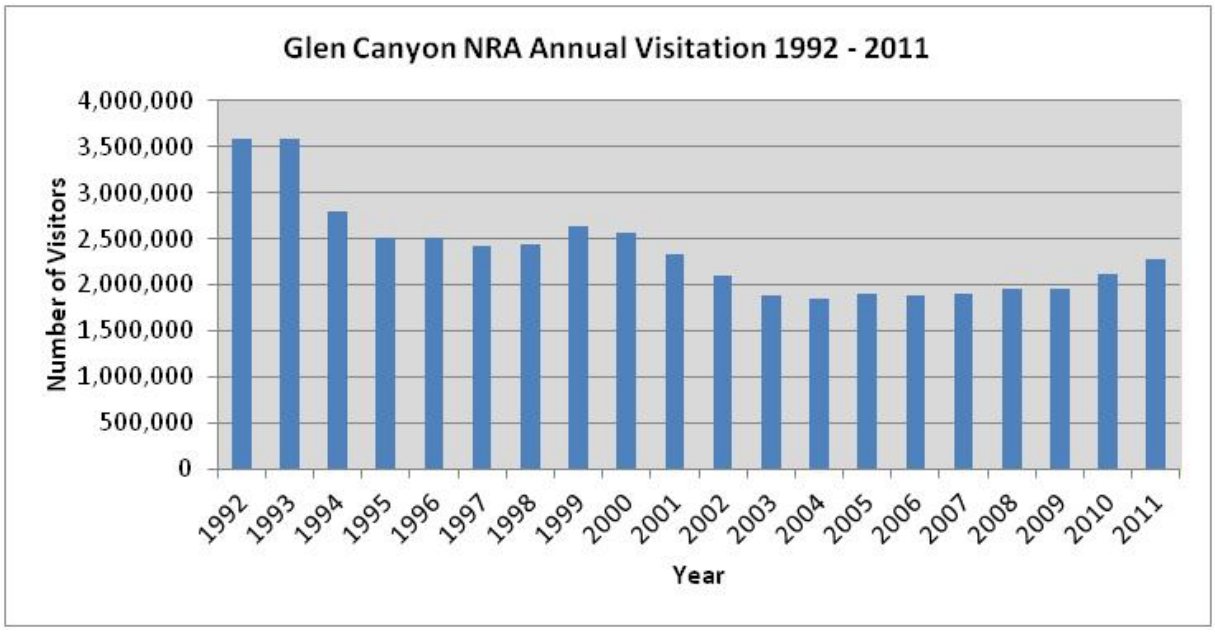


FIGURE 16: ANNUAL VISITATION 1992–2011

The recreational features of Glen Canyon include Lake Powell, its 96 major side canyons, and the related natural, cultural, and geologic resources.

Glen Canyon includes more than 1.25 million acres of opportunities for water-based and backcountry recreation. The recreational features of Glen Canyon include Lake Powell, its 96 major side canyons, and the related natural, cultural, and geologic resources. With 160,000 surface acres and 1,960 miles of shoreline, Lake Powell is a premier global destination for water-based recreation enthusiasts. A variety of recreational opportunities exist on and around the lake, including powerboating, waterskiing, fishing, riding tour boats, sailing, kayaking, and using houseboats and personal watercraft. The lake occupies only about 13% of Glen Canyon. The remaining 87% of Glen Canyon offers backcountry experiences in a desert setting that is extraordinarily rugged and beautiful. Opportunities exist for hiking and backpacking in the surrounding canyon areas, most of which are only accessible by visitors arriving via 4-wheel-drive vehicles or watercraft. Visitors can enjoy camping opportunities ranging from remote and undeveloped campsites to fully developed campgrounds. Other recreational opportunities offered at Glen Canyon include sightseeing, photography, and scenic auto touring. Visitors can experience archeologically and culturally significant sites throughout Glen Canyon. A 2007 visitor survey analyzed visitor use during the spring and summer seasons. According to the 2007 visitor survey, the most common activities in Glen Canyon included sightseeing (54% [spring] / 58% [summer]), visiting the visitor center / ranger stations (35% / 32%), motorized boating (32% / 53%). Swimming/diving was an additional common activity during the summer season, at 59% of all visitors surveyed. Visitors stated that sightseeing and motorized boating were the most important reasons for visiting Glen Canyon (NPS 2007f).

RECREATIONAL AREA ROAD SYSTEM

Planning for the Glen Canyon system began soon after Congress established Glen Canyon National Recreation Area in 1972. During the development of the 1979 Glen Canyon GMP, the issue of road access and circulation was thoroughly reviewed.

As a result of the GMP planning effort, 86.3 miles of unpaved roads were closed. Most of the roads that were closed were primitive unimproved tracks associated with early mineral prospecting, sheep and cattle grazing, or social exploration and were not in public use at the time of GMP planning. A few roads were closed to protect proposed wilderness areas or to preserve the integrity of the Natural Zone of Glen Canyon.

The GMP left open approximately 365 miles of unpaved roads and approximately 75 miles of paved roads to allow for public use and circulation through Glen Canyon (NPS 1979). The roads designated through the GMP (paved and unpaved GMP roads) are the only roads in Glen Canyon authorized for public travel.

Glen Canyon has undertaken several extensive road inventories since the development of the GMP. A road inventory was conducted in 1984 in response to the unauthorized expansion of Glen Canyon's designated road network. This inventory resulted in two actions: the first was a decision to physically close all unauthorized Glen Canyon roads. Authorized Glen Canyon roads were deemed to be only those roads illustrated in the GMP (NPS 1989 memorandum). All other roads were closed; closure generally was accomplished by placing orange Carsonite stakes on all unauthorized roads, or by placing obstructions such as boulders on the road. The second action was the development of a specific three-digit road numbering system for Glen Canyon National Recreation Area. This road numbering system remains in place today.

Another extensive road inventory took place in 2006. The inventory was required under NPS facility asset management program, which required that parks account for the condition of all facilities, including roads and trails. The inventory specifically found that the majority of roads in the Orange Cliffs and Hite areas were in very poor condition; were located in rough and occasionally impassable terrain; were subject to infrequent, if any, maintenance; and possessed no improvements (culverts, signs, gates, ditches, etc.). The inventory found that roads had been blocked off by natural events (slides, washouts, etc.), had deteriorated due to disuse to the point that they could no longer be located, and/or their alignment and location had been altered due to changes in the terrain and mistakes in original road alignment mapping efforts.

These findings are typical of inventories and site visits to unpaved GMP roads in Glen Canyon, especially in the Hite and Orange Cliffs region. The desert landscape of Glen Canyon is a dynamic, ever-changing environment. Primitive and infrequently maintained roads tend to be unstable. Natural events may block or obliterate a road and the road is rapidly reclaimed by nature. County road crews may alter the road alignment around a new obstacle to make the road passable.

Based on road inventories and site visits conducted as part of this EIS planning process, NPS updated the road network maps that are a part of this plan.

OFF-ROAD VEHICLE RECREATION TRENDS

The term "off-road vehicle" applies to a wide range of vehicle types. Under federal regulations, any vehicle driven off a road or parking area onto natural terrain is defined as an ORV (see the "Terminology" section in chapter 1). Nationwide the popularity of off-road use has been increasing for decades. From 1982 to 2000/2001, driving motor vehicles off-road became one of the fastest-growing activities in the country, growing in number of participants by more than 100% during this time period (Cordell et al. 2004). The most recent data, compiled from the National Survey on Recreation and the Environment, reported that nearly one in four Americans age 16 and older participated in ORV recreation (Cordell et al. 2005). This figure represented a 42% growth in off-road use from 1999/2000 to 2003/2004 (Cordell et al. 2005).

Arizona and Utah have experienced rapid growth in ORVs. In Arizona, the number of ATVs titled or registered with the state's motor vehicle division increased 347% from 1998 (51,453 vehicles) to 2006 (230,000 vehicles) (McVay and Racki 2008).The number of ATVs registered in Utah increased 233% between 1998 and 2008 (Burr et al. 2008).

The largest community in the planning area is Page, Arizona, with a population of 6,800 people. The four Utah counties that encompass Glen Canyon have a total population only of 27,875. The entire Glen Canyon is buffered by large federal and Tribal holdings. The BLM alone administers more than 9.3 million acres that surround Glen Canyon. The BLM administers over 9.3 million acres of federal holdings adjoining Glen Canyon and provides numerous riding opportunities for the off-road recreationist. In Utah, between the Richfield and Monticello Field Offices, the BLM allows ATV use on 7,000 miles of roads and routes, and cross-country travel across 10,700 acres of federal lands (figure 17).

OFF-ROAD USE AT GLEN CANYON

Few major roads lead to the interior of Glen Canyon. To the north, two state highways (State Routes 276 and 95) transect Glen Canyon, whereas U.S. Highways 89 at Page and 163 at Mexican Hat provide access to the southern portions of Glen Canyon. Most of Glen Canyon's interior roads are in fair to poor condition; are seldom maintained; are subject to rapid degradation due to passing storms; and often require high-clearance, 4-wheel-drive vehicles for safe passage. Although these are the conditions often sought by ORV recreationists, in most instances one must first travel across miles of BLM-administered roads before reaching the boundary of Glen Canyon. These factors (the geographic isolation and the difficult access conditions) have resulted in limited interest in and use of Glen Canyon for off-road use. Glen Canyon has previously allowed off-road use at several accessible shoreline areas, but they are limited in size. Lone Rock Beach, one of the largest and the most popular of the off-road areas, is approximately 400 acres. Many of the areas are only 100 to 200 acres, depending on lake levels.

Deriving an accurate estimate of the use of these areas is difficult because the locations are remote, isolated, and undeveloped, and are dispersed across a large area. The available data suggests a total estimated annual historic use that may have been as high as 40,000 vehicles, but this use was concentrated in three areas: Lone Rock Beach, Stanton Creek, and Bullfrog North and South.

Visitation has historically been very low at the other accessible shoreline areas. The Farley, Dirty Devil, and Crosby Canyon areas may have received several thousand annual visitors when lake levels were higher, but present conditions have resulted in lighter visitation to these areas.

RECREATIONAL OPPORTUNITIES IN GLEN CANYON

The regions in Glen Canyon[8] are Warm Creek–Grand Bench, Escalante, Wilson Mesa, Hite, and Orange Cliffs (figure 18) and Ferry Swale–Vermilion Cliffs in Arizona. Each region offers unique recreational opportunities, ranging from boating and camping to hiking and sightseeing. Several areas allow off-road use. The previously designated accessible shorelines areas in Glen Canyon are intended to provide public motor vehicle access to the Lake Powell shoreline for the purposes of recreational use in a primitive setting. Glen Canyon's 1979 GMP identified 20 such ORV locations (NPS 1979). In 1988 Glen Canyon developed a management plan that revised this to 12 accessible shoreline areas (NPS 1988).

[8] Five of these regions (Warm Creek–Grand Bench, Escalante, Wilson Mesa, Hite, and Orange Cliffs) were created by the project's interdisciplinary team (IDT) during the planning process to describe the Glen Canyon road system, and are based on topography and the road network.

Ferry Swale–Vermilion Cliffs Region

General Description

Located just west of Page, Arizona, is the Ferry Swale–Vermilion Cliffs region (figure 19). The area extends west along U.S. Highway 89 to the top of the Vermilion Cliffs and is crossed by a network of primitive roads that are used for recreation, access to grazing leases, and the maintenance of utilities. The area is recognizable by the 3,000-foot escarpment of the Vermilion Cliffs, which dominates the horizon to the west of Page. The area is characterized by blows and deposits and shallow, undeveloped soils over Navajo Sandstone. The primary vegetation is blackbrush interspersed with various grasses and other low-growing shrubs. The BLM administers a section of the Vermilion Cliffs National Monument area as wilderness.

Off-road use is growing in the Ferry Swale area. The area is popular with local residents from Page and is easily accessed directly from U.S. Highway 89. The BLM and Glen Canyon coordinate activities in this area, including the development of ORV staging areas, shared law enforcement resources, and the placement of informational kiosks to explain ORV-related rules and regulations.

Roads and Off-Road Use

Three unpaved GMP roads enter the area from U.S. Highway 89, crossing through a small section of Glen Canyon before entering the abutting lands administered by the BLM. These roads have not been designated with NPS road numbers.

These roads cross blackbrush-dominated areas of deep sand and slickrock. The roads are lightly traveled but remain popular with a subset of locals from Page. Over the years, new routes extending from existing GMP roads have been established by users. Some of these routes connect Glen Canyon to existing BLM routes and roads while others do not.

On the south side of the Colorado River are Page, Arizona, and the Glen Canyon headquarters. Paved GMP roads in this area include U.S. Highway 89, which spans the Colorado River into Page. State Route 117 enters Glen Canyon from U.S. Highway 89 at the southernmost point of Glen Canyon.

Other roads that provide access to Page, and thus to the Ferry Swale–Vermilion Cliffs area, include State Route 98 and Coppermine Road.

Warm Creek to Grand Bench Region

General Description

The Warm Creek area (figure 20) stretches from Big Water, Utah, along the southern tip of the Kaiparowits Plateau, and up to the Hole-in-the-Rock Road and the Escalante region to the north. The Wahweap area is the most easily accessible section of Glen Canyon and includes a marina, boat launches, and a restaurant/lodge. The Glen Canyon Dam area, located 5 miles south of Wahweap, includes the Carl Hayden Visitor Center.

The Lone Rock Beach Play Area is located on the western shore of Lake Powell, approximately 2 miles northwest of Wahweap. The play area is the only location in Glen Canyon where off-highway vehicles (OHVs) and street-legal ATVs (in addition to conventional motor vehicles) are allowed to be operated off-road. The area is intended as a location where motor vehicle operators can challenge themselves, develop riding skills, operate at high speeds, perform jumps and hill climbs, and so on. Adjacent to the north of the play area is Lone Rock Beach, which includes recreational activities such as swimming, fishing, boating, off-road use, and camping.

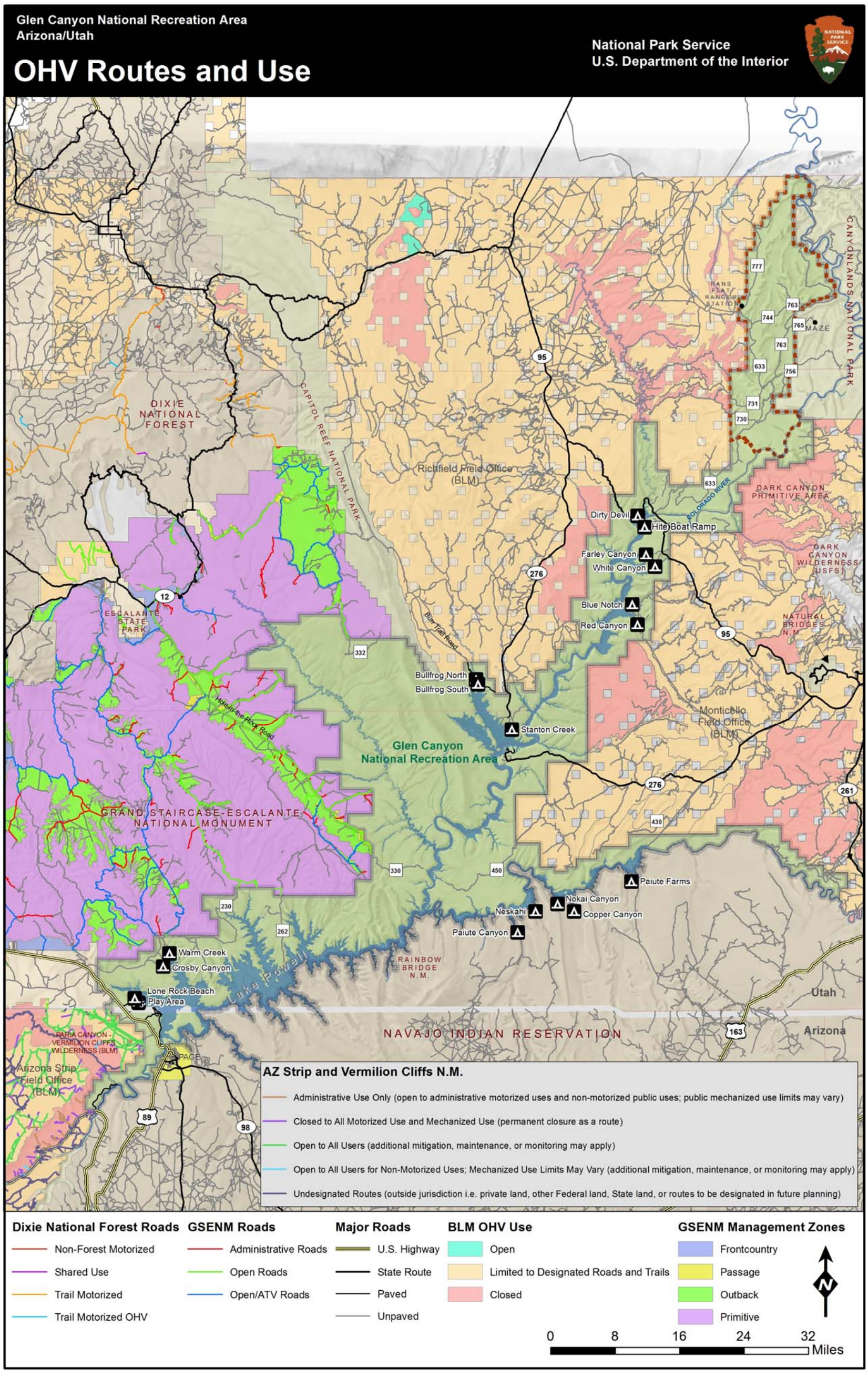


FIGURE 17: OHV USE IN ADJACENT BLM LANDS

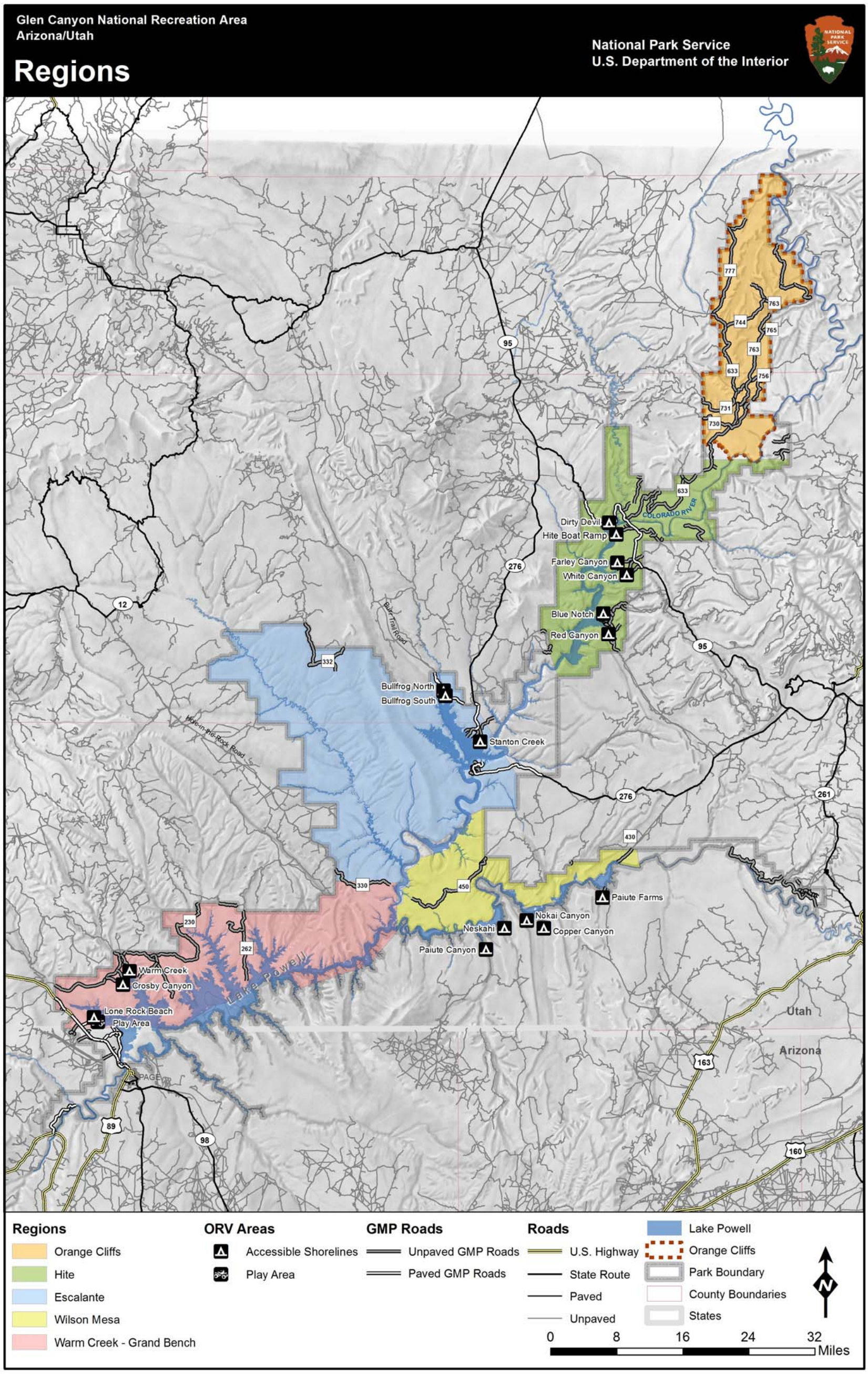


FIGURE 18: GLEN CANYON RECREATION AREA REGIONS

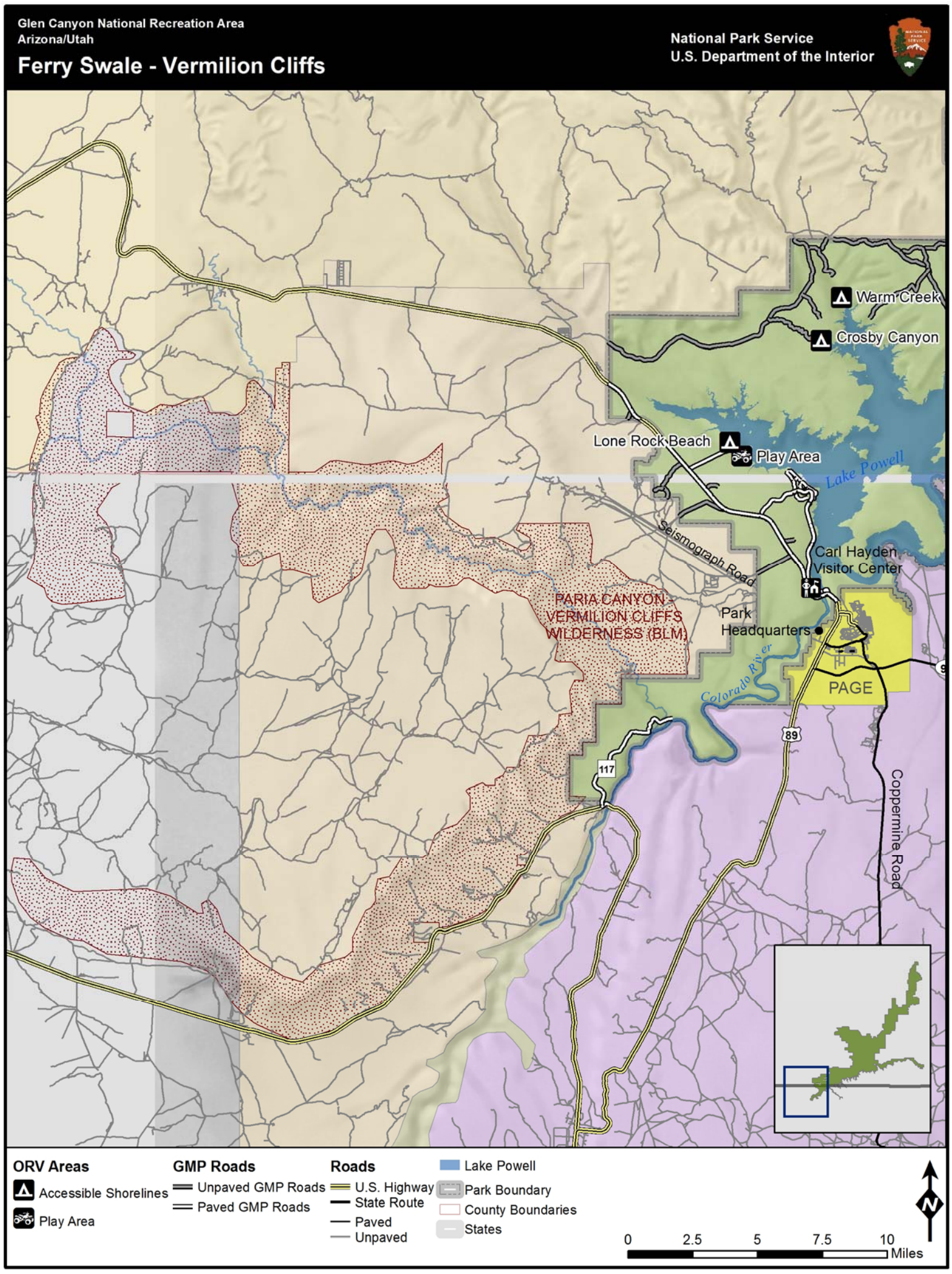


FIGURE 19: FERRY SWALE–VERMILION CLIFFS REGION

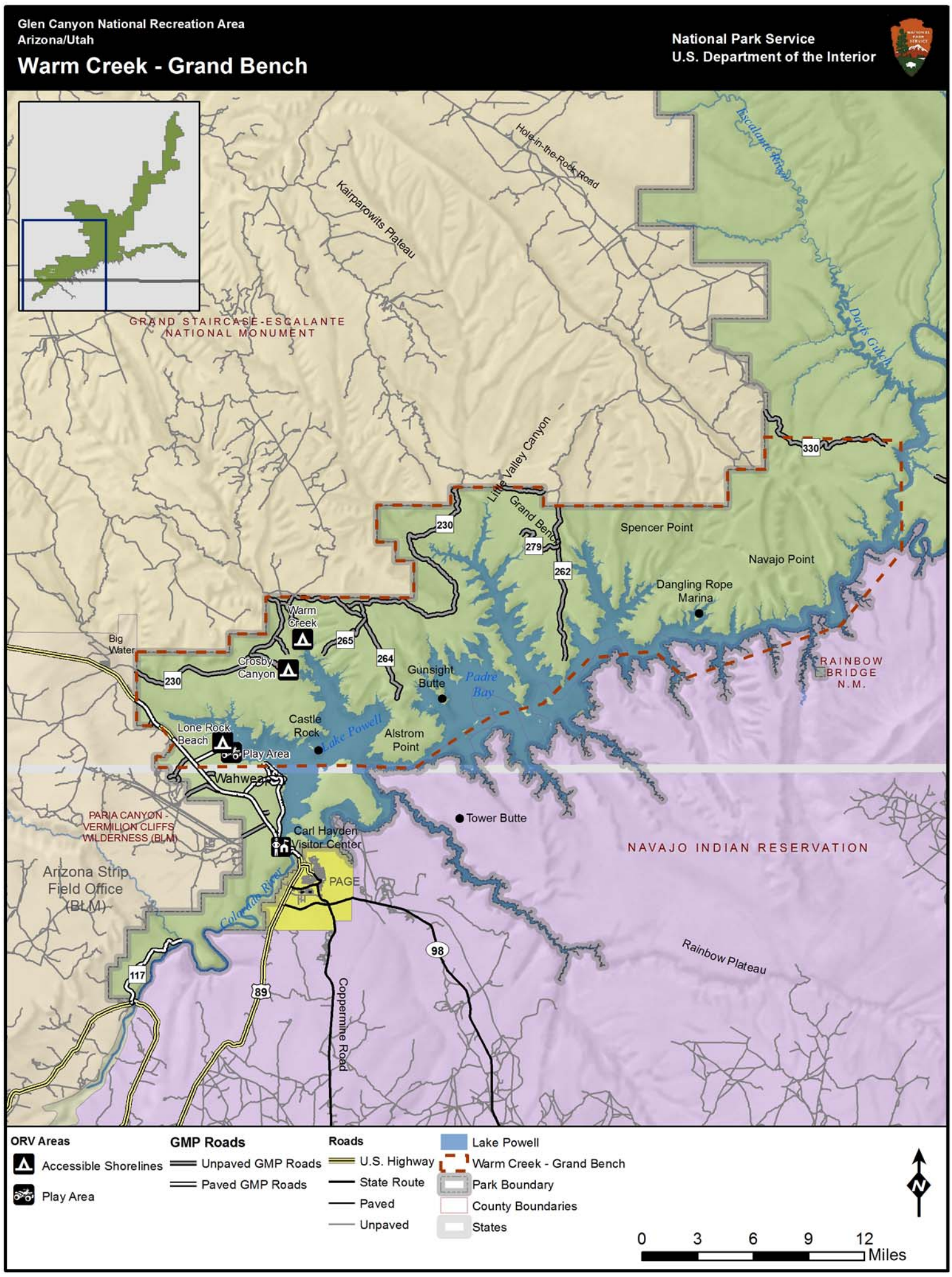


FIGURE 20: WARM CREEK TO GRAND BENCH REGION

Further upstream is the Padre Bay area, which offers extraordinary views of Lake Powell. Alstrom Point, accessed by NPS 264, is a high mesa (500 feet above Lake Powell) providing expansive views of Lake Powell and Padre Bay and formations including Gunsight Butte, Castle Rock, and Tower Butte. The area is a destination for day users, sightseers, photographers, and the occasional overnight camping party. The Grand Bench, accessed by NPS 262, is extremely remote and difficult to access due to the degraded roadbed crossing at Little Valley Canyon. Dangling Rope Marina, accessible only by water, is located north of Grand Bench.

The viewshed of the Warm Creek area includes some of the most dramatic aesthetic features of Glen Canyon. The most visible feature in this region is the Kaiparowits Plateau, a giant upland rising abruptly from the Escalante and Colorado River drainages. With an elevation of approximately 7,500 feet, its southernmost tip at Navajo and Spencer Points provides a dramatic panorama of the entire canyon country and Lake Powell. Southwest of the plateau, the Warm Creek area is characterized by the sharply defined high cliff faces alternating with talus slopes and benches of shale and mudstone within Grand Staircase–Escalante. These forms give rise to numerous high mesas, plateaus, and buttes.

South of Lake Powell is the Rainbow Plateau. The Rainbow Bridge National Monument is located 49 miles upstream of the Glen Canyon Dam and has a courtesy dock. Rainbow Bridge is the largest natural bridge in the world. Carved by water from a fin of red Navajo Sandstone, the bridge is 290 feet tall and 270 feet across and is considered sacred in tribal culture as a symbol of the deities responsible for creating clouds, rainbows, and rain.

Roads and Off-road Use

Warm Creek Road (NPS 230), an unpaved GMP road, connects with several roads that lead into Grand Staircase–Escalante and locations north, including the town of Escalante, Utah. These roads include Tibbett Canyon (BLM 325), Smoky Hollow (BLM 330) (figure 21), Smoky Mountain (BLM 300), and Croton (BLM 340) roads.

FIGURE 21: SMOKY HOLLOW

The proximity to Page, Arizona, makes the area popular with local ATV owners and tourists who are interested in the relatively easy access the Warm Creek Road provides to the Glen Canyon and Grand Staircase–Escalante backcountry. The Warm Creek Road is well maintained and passable by 2-wheel-drive vehicle during most of the year, although driving conditions can degrade rapidly following heavy rains. The unpaved GMP road to Grand Bench (NPS 262) in particular is extremely difficult to traverse, as are often some of the roads diverging from Warm Creek and leading into Grand Staircase–Escalante.

NPS has experienced some illegal off-road driving in this area, particularly along the section of Warm Creek Road that crosses flat areas of Tropic Shale just beyond Big Water. A section of state land between the Glen Canyon boundary and the town of Big Water is a hot spot for local off-road enthusiasts, and is crisscrossed with the tracks of ATVs and other vehicles. The impacts associated with this off-road activity have spilled into Glen Canyon via the Warm Creek Road.

Alstrom Point is accessible via unpaved GMP road NPS 264. The area is a popular destination for day users, sightseers, photographers, and the occasional overnight camping party. The point provides panoramic and expansive views of Lake Powell and the surrounding region, and drivers have left the main roadway to seek the most advantageous view, resulting in a spiderweb of unauthorized roads and minor resource impacts.

Additional unpaved GMP roads in this area include NPS 330, NPS 279, NPS 262, and NPS 265. Only one paved GMP road is located in this area: the upper portion of U.S. Highway 89 once it exits the Ferry Swale area.

Alstrom Point

Accessible Shoreline Areas

Lone Rock Beach: Lone Rock Beach (figure 22), Glen Canyon's principal ORV area, is located on the western shore of Lake Powell, 2 miles south of Big Water, Utah, and 12 miles north of Page, Arizona, at the Utah/Arizona border. Also approximately 2 miles northwest of Wahweap, Lone Rock Beach includes recreational activities such as swimming, fishing, boating, and camping. There is limited hard-surfaced road, with the majority of access to Lake Powell on sandy roads or beach. Lone Rock Beach is the primary access to Lake Powell for the nonboating public.

Accessible by U.S. Highway 89 and Lone Rock Road, beyond the entrance station is a recreation vehicle dump station, parking area, and rest area. Along the shoreline is a primitive camping area. Further inland and to the south is the Lone Rock Beach Play Area, separated from the camping area by a post and cable fence. Restrooms and outdoor showers are available just outside the play area.

Lone Rock Beach (figure 22) is the most popular of the off-road use areas in Glen Canyon. According to NPS visitation statistics, in 2007 there were 12,445 overnight camping groups on the beach, and nearly 23,000 motor vehicles entering Lone Rock Beach. Entrance records indicate that a small percentage of visitors recreate using ATVs at Lone Rock. Since 2003, the number of ATVs recorded entering Lone Rock has ranged from 1,065 (2004) to 498 (2007).

FIGURE 22: LONE ROCK BEACH

Crosby Canyon and Warm Creek: Crosby Canyon and Warm Creek are two accessible shoreline areas that provide access to Warm Creek Bay. Both are located close to Page, Arizona, and offer a more primitive setting compared to nearby Lone Rock Beach. Neither shoreline contains any facilities and both sites have been closed since 2003, when lake elevations dropped drastically during a prolonged drought, to control illegal off-road driving beyond the designated areas.

Access to Crosby Canyon is by NPS 231 off the Warm Creek Road (NPS 230). The Crosby Canyon Road is an infrequently graded, 4-wheel-drive road that follows the drainage bottom. The area is subject to flash flooding. Warm Creek is accessed by an unmarked and active ephemeral desert wash channeling through the Dakota, Morrison, and Entrada Formations.

Crosby Canyon (figure 23) had received a moderate amount of use before closing in 2003. Originally there were two main camping areas along the road. Evidence of these sites exists in the form of old fire rings and trash. Currently, some illegal use occurs as individuals drive past a road closure sign and down along the lakeshore. A prominent vehicle track is visible and extends for miles below the high water mark and along the lakeshore. There is limited evidence of illegal off-road use beyond this track.

Warm Creek has always experienced minimal use, and therefore has been lightly impacted by activity. At higher lake elevations, a campsite was available on a small knoll surrounded by steep cliffs. Currently, two barbed-wire livestock fences across the wash bottom preclude access to the site and there is little evidence of recent visitor use of the area.

Based on measurements taken during an October 2008 site visit, lake elevations would need to recover to approximately 3,670 feet before the natural topographic conditions and lakeshore would result in a confined use area for both Crosby Canyon and Warm Creek.

FIGURE 23: CROSBY CANYON

Escalante Region

General Description

Extending north from the Kaiparowits Plateau to the Purple Hills and the southern end of the Waterpocket Fold (part of Capitol Reef National Park) is the Escalante region (figure 24). The Escalante River and its tributaries have incised, deep, narrow canyons in the apricot-hued sandstones. The Escalante River is the core of this proposed wilderness area. The Escalante and its tributaries offer unparalleled hiking opportunities, and the side canyons offer some of the most beautiful scenery in the southwest. High above the river, the windswept slickrock and sand benches offer grand vistas and unbroken solitude.

Halls Crossing, located in the southeastern part of the Escalante region, includes a marina, campground, and boat launch. The John Atlantic Burr Ferry serves as a continuation of State Route 276 from Halls Crossing to Bullfrog Bay. The Bullfrog visitor center, which includes a medical clinic, is located on Utah State Route 276 just past the entrance station. Bullfrog also includes a restaurant/lodge, campsites, and marina. The Bullfrog Creek area includes two accessible shoreline areas — Bullfrog North and Bullfrog South — located off the Burr Trail north of the developed area. Past visitor use had been very high, but since 2003 these shoreline sites have been closed to vehicles due to low lake levels; therefore, public access and use is difficult

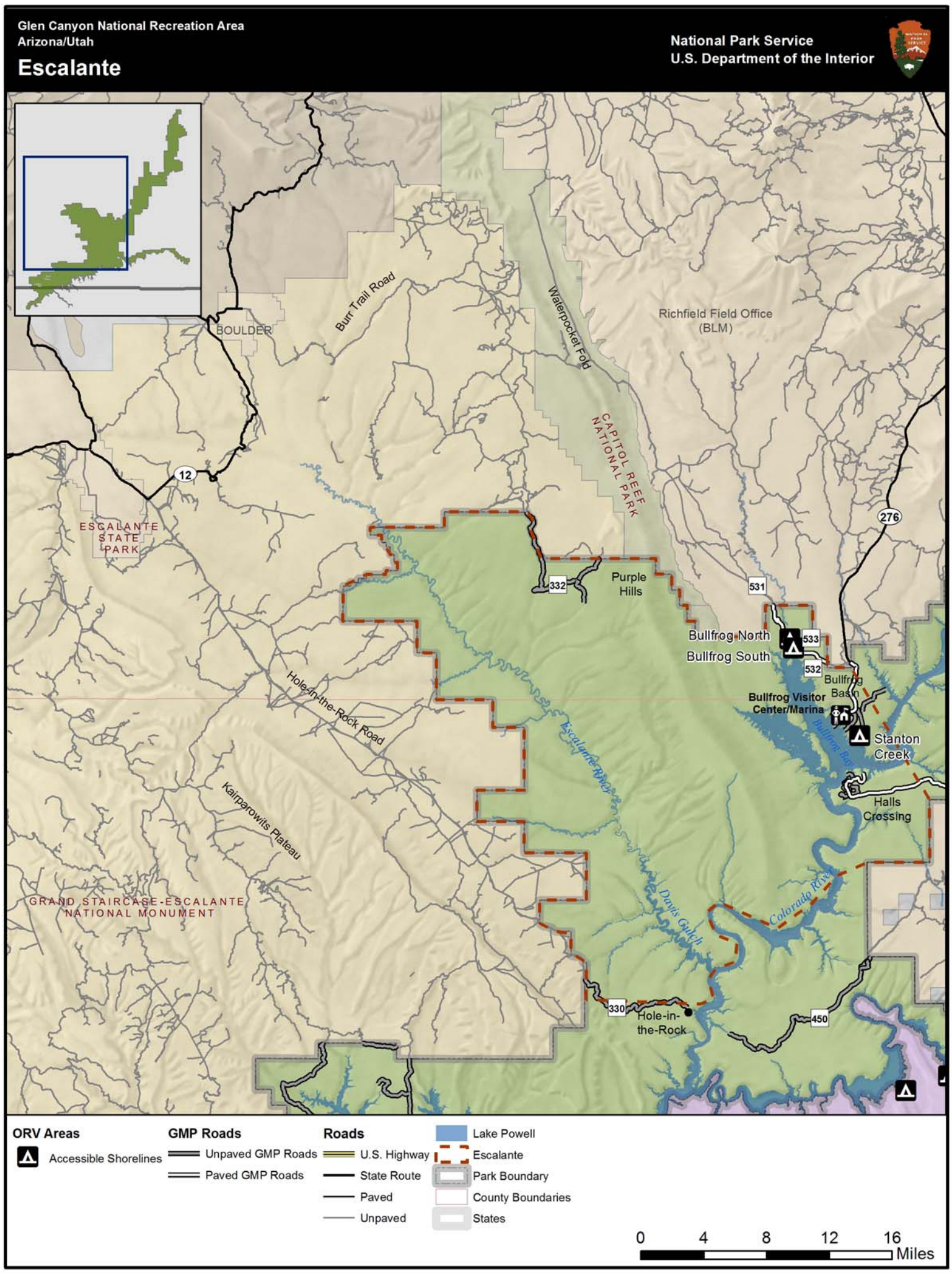


FIGURE 24: ESCALANTE REGION

Roads and Off-road Use

The unpaved Hole-in-the-Rock Road (NPS 330) is the primary artery into the Escalante region. The Hole-in-the-Rock Road is a popular scenic and historical driving route for local residents, tourists, and those hiking the Escalante River area. The road is a historically and culturally significant route through the Escalante region. Listed on the National Register of Historic Places (National Register), Hole-in-the-Rock is the location where, in 1880, Latter-day Saints settlers used pickaxes, shovels, and blasting powder to work their way down to the Colorado River through the only known natural breach in the 2,000-foot vertical cliff. The road generally is increasingly difficult to drive as it approaches Glen Canyon. The road deteriorates for the last 5 miles past the Davis Gulch crossing and generally is passable to 4-wheel-drive, high-clearance vehicles only from this point to the road terminus.

The Burr Trail is a 68-mile route winding through federally owned lands from the town of Boulder, Utah, down through Grand Staircase–Escalante into Capital Reef National Park and then across BLM administered land to the Bullfrog visitor use area in Glen Canyon. The road is paved on its upper end and graded dirt on the lower end. The condition of the graded section is subject to deterioration, and a high-clearance vehicle may be required. During inclement weather the Burr Trail may be impassable even to 4-wheel-drive vehicles.

The 7.7-mile segment of the Burr Trail in Glen Canyon is designated as the Notom–Bullfrog Road (NPS 531) and is a paved GMP road to the crossing at Bullfrog Creek, where it becomes a graded dirt road (unpaved GMP road). The Burr Trail is the only established Revised Statute (RS) 2477 right-of-way in Glen Canyon (U.S. v. Garfield County, 122 F. Supp. 2d 1201—Dist. Court, D. Utah 2000).

In the far northern section of the Escalante region is Moody Canyon Road (NPS 332), a 12-mile road located in the Purple Hills. The road enters Glen Canyon from the Burr Trail to the north and crosses 12 miles of natural soils before terminating at the Glen Canyon boundary. The road is isolated and seldom used but offers access to hunters and hikers and is categorized as an unpaved GMP road.

State Route 276 enters Glen Canyon in the Bullfrog area, continuing into Glen Canyon as a paved GMP road to the Bullfrog Visitor Center/Marina. Four small (approximately a quarter of a mile) unpaved GMP roads continue from the Visitor Center/Marina, continuing to the Stanton Creek accessible shoreline locations. State Route 276 enters Glen Canyon again west from Carl Black Memorial Airport where it becomes a 7-mile paved GMP road to the Hails Crossing section of Glen Canyon. Small unpaved roads stem from this unpaved GMP road, providing access to the water.

Accessible Shoreline Areas

Bullfrog Creek: Three accessible shoreline areas in the Bullfrog developed area have been popular vehicle-accessible campsites in the past. In 2002, 9,680 vehicles entered the Bullfrog North and South campsites. These areas have been closed since 2003 due to low lake levels. The gentle topography in this area has magnified the impact of low lake levels as vast areas of soft and deep sand are exposed, and the distance required to reach the lakeshore has been increased. This situation is noticeable particularly at the Bullfrog South site. Because of these conditions, public access, public use, and NPS operational duties (such as servicing toilets and conducting routine patrols) has become difficult, resulting in the closure of these areas. Based on geographic information system (GIS) analysis, lake elevations may need to recover to as high as 3,670 feet before the Bullfrog sites reasonably could be reopened to public use.

Stanton Creek: Stanton Creek is accessed from Utah State Route 276 close to Bullfrog Marina. Due to the closure of the Bullfrog North and South sites and the relatively easy access to Stanton Creek, Stanton Creek has become a popular accessible shoreline area. At Stanton Creek, vehicle counts ranged from 5,716 in 2002 to 3,953 in 2007. The area is managed for both day and overnight use for recreation opportunities of semi-isolation where shoreline

campsites have been used as boat anchorage. Camping use zones exist in the western portion of the site. Toilets and trash containers are maintained in the area.

Wilson Mesa Region

General Description

Wilson Mesa is a large, prominent topographic feature located on the south shore of Lake Powell opposite Hole-in-the-Rock and the Escalante River (figure 25). The primary route on Wilson Mesa is the Hole-in-the-Rock Trail Road (NPS 450), also referred to as Cottonwood Canyon Road. Cottonwood Canyon Road is the only road that traverses Wilson Mesa and it is isolated, is extremely difficult to negotiate the terrain, and requires a high-clearance, 4-wheel-drive vehicle. There are numerous obstacles and steep ascents and descents in sections of the road, including the sections up Grey Mesa and Iceberg Canyon. Driving the road is popular with a small subset of 4-wheel-drive enthusiasts, but the area remains infrequently visited due to its isolation and difficult driving conditions.

Roads and Off-road Use

Cottonwood Canyon Road (unpaved GMP road NPS 450) is the continuation of the Hole-in-the-Rock Road from the Escalante region. The road is accessed from State Route 276 at the Cal Black Memorial Airport, approximately 10 miles east of Halls Crossing and 75 miles west of Blanding, Utah. It can also be accessed farther west from State Route 276. The road travels southwest for a distance of approximately 30 miles from the Cal Black Memorial Airport to its terminus at Cottonwood Canyon. Only the last 11.8 road miles are in Glen Canyon; the remaining road miles cross BLM-administered lands.

Unpaved GMP road NPS 430 traverses Glen Canyon in this region for approximately 2.5 miles, continuing from BLM-administered land to the confluence of the San Juan River with Lake Powell. A prominent feature on Wilson Mesa is the Rincon. Located between Long and Iceberg Canyons, the Rincon is the remnant of a former channel of the Colorado River. Aleson Arch, a 100-foot-long span, is on the landform between Iceberg Canyon and the Rincon.

Accessible Shoreline Areas

Paiute Farms: Paiute Farms is the site of an abandoned marina development on the Navajo Nation. The marina was developed by Utah Navajo Industries in the 1980s but all structures were removed after a severe flash flood damaged many of the facilities in 1989. Many of the unpaved service roads on the marina site can be driven on. The area is located primarily in Moenkopi and Chinle Formations and is extensively overgrown with tamarisk. Both formations are composed of thin-bed mudstone and siltstone, varying in color from purple to grey for the Chinle, and red to pale brown for the Moenkopi. Access to the area is provided by Paiute Farms Road which runs along the Paiute Farms Wash on the Navajo Nation. The marina site is still frequented by residents of nearby communities and it is the access point to a prominent waterfall on the San Juan River just downstream from the Clay Hills Crossing raft take-out area.

Nokai and Copper Canyon: Nokai is an accessible shoreline located where the Nokai Wash intersects with Zahn Bay on the San Juan arm of Lake Powell. Copper Canyon is located just upstream on the San Juan Arm. Access to these areas is poor along primitive 4-wheel-drive roads leading from State Route 163, making visitation low. The areas are located primarily in the Moenkopi and Chinle Formations and can be described as canyon country with steep Wingate escarpments forming physical barriers around the areas. These steep sandstone cliffs limit vehicle access to 4-wheel-drive vehicles. Only a limited area is available for camping at each site and these areas are utilized primarily by local residents from nearby communities of the Ojeto Chapter on the Navajo Nation. No facilities are present at Copper Canyon or Nokai.

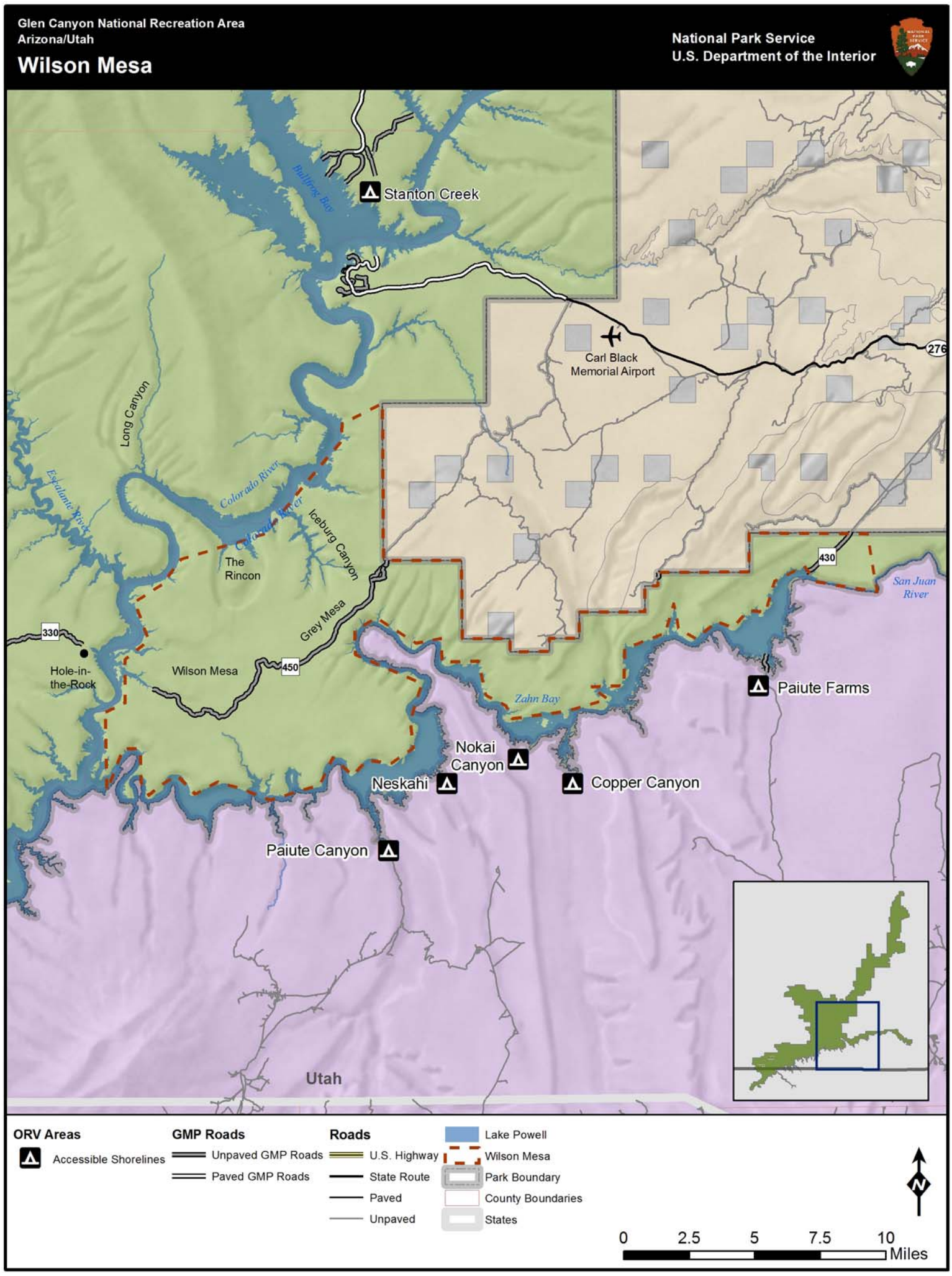


FIGURE 25: WILSON MESA REGION

Paiute Canyon and Neskahi: These areas are located downriver from Nokai on the San Juan Arm. The areas are similarly characterized primarily by Moenkopi and Chinle Formations, and the Shinarump Formation at the Neskahi site, making the area relatively unstable. Sloughing occurs and is observable in the form of mounded peninsulas and islands that jut into the river. The area can be described as canyon country with steep Wingate escarpments forming physical barriers around the areas. These steep sandstone cliffs limit vehicle access to 4-wheel-drive vehicles which travel on rugged roads across the Navajo Mountain Chapter of the Navajo Nation. Paiute Canyon (figure 26) is accessible via a 5-mile, primitive, 4-wheel-drive road off the Wetherill Trail, itself located approximately 50 road miles from State Route 98. Only a very small area is available for vehicle camping and the areas are used primary by nearby residents. Although there is evidence of recent use, it appears that the use is extremely limited. The Neskahi site is not directly accessible by road and provides no opportunities for vehicle access. It appears the area is accessed by cross-country travel along the shoreline at low water levels.

FIGURE 26: PAIUTE CANYON

Hite Region

General Description

The uplake area around Hite, Utah, begins on the east side of Lake Powell, extending roughly from Good Hope Bay north to the Orange Cliffs boundary at Clearwater Canyon. The Hite region is located at the northernmost part of Lake Powell (figure 27). The region is best accessed by State Route 95, also known as Bicentennial Highway, from both the north and south. The State Route 95 steel arch bridge provides the only road crossing of the Colorado River for 300 miles between the Glen Canyon Dam west of Page, Arizona (139 miles away by boat), and U.S. Highway 191 at Moab, Utah. State Route 95 also crosses the Dirty Devil River at the northern tip of Lake Powell.

Hite offers a stunning example of the geologic record that is a signature feature of southern Utah's canyon country. The views from the Hite overlook off State Route 95 are particularly dramatic, with distant views of the towers and buttes of the Orange Cliffs Special Management Unit (Orange Cliffs Unit) and sweeping views of the white, undulating Cedar Mesa Sandstone and its contact with the deep red, multilayered Organ Rock Formation. Looking north, Hite is characterized by an impressive, white Cedar Mesa Sandstone bench that outcrops at lake level and extends upriver past the mouth of the Dirty Devil River, the steel arch bridge across State Route 95, and up the inner gorge of the Colorado River. Looking southeast across the river from the overlook offers a fine example of the Organ Rock cliffs and talus slopes with views of the Hite developed area, which includes launch facilities, primitive camping, a small store, and a ranger station. Looking southwest from the State Route 95 entrance to the Hite developed area, the deep red rock layer of the Organ Rock Formation frames a dramatic view of the Henry Mountains and a row of massive Navajo Sandstone fins perched atop the Kayenta Formation and sheer, deep-orange-colored Wingate cliffs. Heading east toward Natural Bridges National Monument, the Cedar Mesa Sandstone and the White Canyon complex is the dominant feature at road grade, whereas towering on the southwest side of State Route 95 is the Red Rock Plateau.

Roads and Off-road Use

Red Canyon and Blue Notch Roads lead to small, accessible shoreline areas on Good Hope Bay. Red Canyon Road (NPS 650) begins at State Route 276 and heads northwest across BLM-administered lands into Glen Canyon. The road travels approximately 22 miles across BLM lands before entering Glen Canyon. The segment of the road in Glen Canyon is known to be subject to flash flooding and the road is in extremely poor condition. Blue Notch Road (NPS 651) travels from Utah State Route 95 west to Good Hope Bay. The road crosses BLM lands for approximately 10 miles before entering Glen Canyon. Blue Notch is an intermittently maintained, 4-wheel-drive road that can range from poor to fair condition. The road traverses slopes composed of clay soils and can be extremely hazardous when wet. Travel becomes increasingly difficult once the road enters Glen Canyon due to the numerous wash crossings. Good Hope Bay is one of the largest bays in Lake Powell, featuring fishing and plenty of room for water sports.

Three short roads lead to White and Farley Canyons, two accessible shoreline areas; all three are unpaved GMP roads. The Farley Canyon Road (NPS 630) is a maintained gravel road in fair condition. Farley Canyon is one of the few accessible shoreline areas that is used for boat launching, and is a short drive (3 miles) from Utah State Route 95. Two roads lead into White Canyon, NPS 656 and 657. Both roads travel approximately 3.25 miles over natural surfaces and are in fair condition. Travel can become difficult below the high water mark at 3,700 feet elevation due to dense stands of tamarisk and deep silt. Currently there is no access to Lake Powell from the White Canyon roads. The White Canyon accessible shoreline area lies at the base of the steep Moenkopi Cliffs along the Lake Powell shoreline and is closed to vehicular traffic. White Canyon is a colorful, two-level canyon that lends itself to exceptional hiking adventures, especially in the section known as the Black Hole. Its eastside tributaries also have many enchanting stretches of narrows.

Brown's Rim Road (NPS 632) off Utah State Route 95 runs east from Hite toward the Dark Canyon area. The road can be traveled east across BLM and U.S. Forest Service lands, or back in a loop to a junction with State Route 95. This unpaved road travel is approximately 5 miles long, is in fair condition, and is occasionally maintained by the county. NPS 633 connects State Route 95 to Clearwater Canyon. One additional unpaved GMP road enters Glen Canyon from the southern boundary, in the Dark Canyon area.

One paved GMP road is located in this area. State Route 95 enters Glen Canyon just north of White Canyon. The road leads across NPS 632 near the Hite Marina and continues up and across the Dirty Devil River, passes the Dirty Devil accessible shoreline area, and north out of the Glen Canyon boundary into BLM administered lands. The road is approximately 15 to 20 miles long.

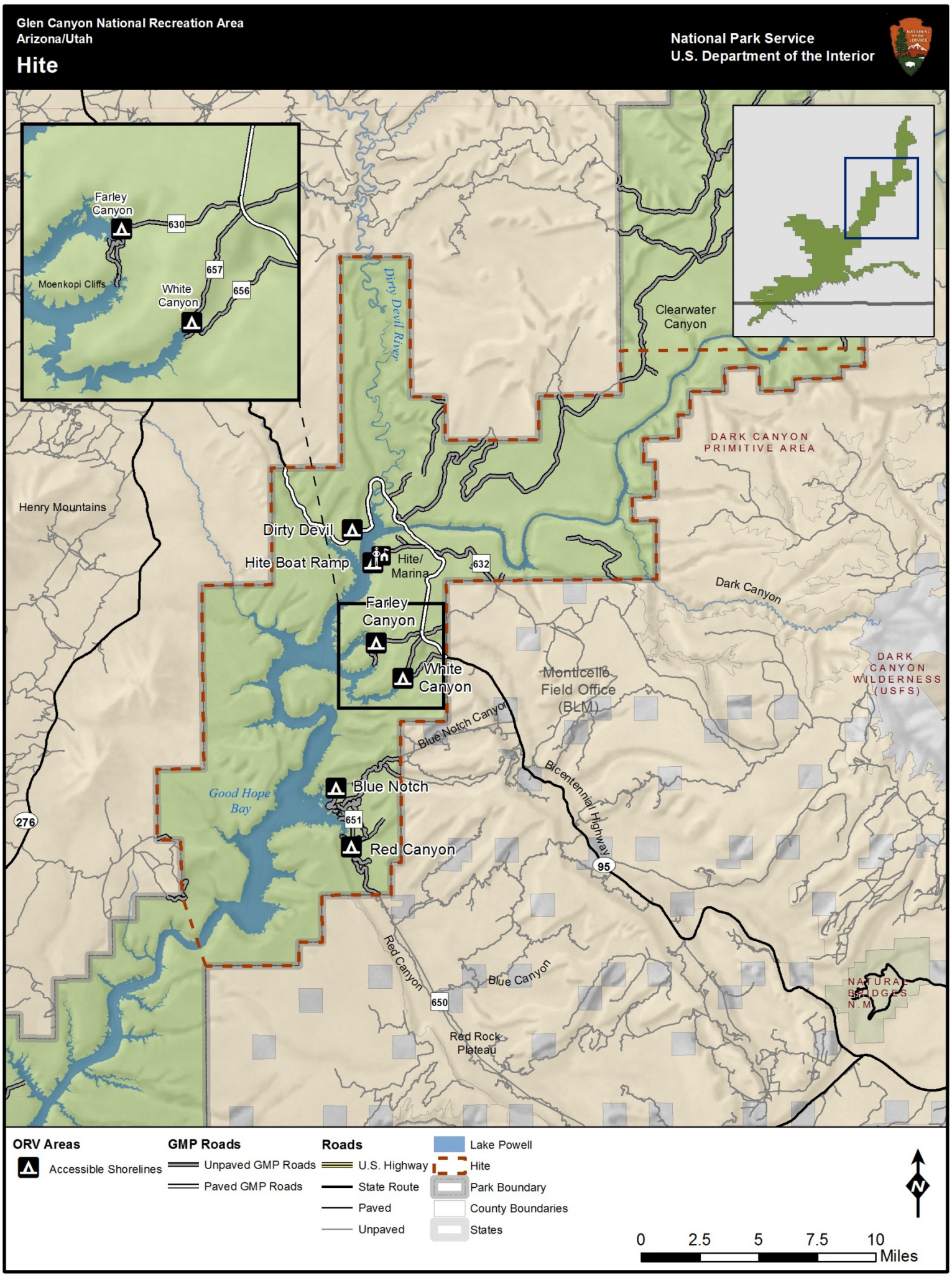


FIGURE 27: HITE REGION

The Hite Marina is located at the uppermost part of the lake, 139 miles upstream from the Glen Canyon Dam. The paved launch ramp can be used at higher lake levels and there are no on-water services; all marina facilities were moved down lake during the extended drought period in the early 2000s. When the lake is at or above 3,606 feet, smaller boats can launch from an old road bed just down lake from the paved launch ramp. Hite also has a campground, overnight lodging, and a gas station / convenience store.

Accessible Shoreline Areas

Dirty Devil: The Dirty Devil accessible shoreline area is a small area between Utah State Route 95 and the lakeshore on the Dirty Devil arm near the Hite developed area. The site includes three isolated areas divided by canyons formerly filled with the waters of Lake Powell. The northern area is the largest and lacks shoreline access. This area is accessed by 4-wheel-drive vehicles for camping. The center area is smaller, and historically provided shoreline access where boats could launch; it once was used as a swimming beach. The southern portion is the smallest and served as a boat ramp and received heavy camping pressure. The area provides a dispersed primitive camping experience with visitor facilities, including toilets and trash containers, to protect resources and provide for appropriate visitor experience.

The Dirty Devil shoreline was a popular camping location when Lake Powell was at full pool. Due to low water levels, the Dirty Devil area no longer provides access to Lake Powell, although the site remains open to camping. Based on measurements recorded during an October 2008 site visit, lake elevations would need to recover to a minimum of 3,650 feet before lake access would be possible.

The Dirty Devil area is located at the base of steep cliffs, capped by the Wingate formation and underlain by exposed strata of the Chinle, Moenkopi, and White Rim Formations. The shoreline area consists of broad exposures, ridges, and low hills of exposed Cedar Mesa slickrock overlain in the northern portion by limited aeolian gravel-bearing caps. The southern portion is characterized by the weathered colluvial covering from the steep cliffs above, where these deposits have filled the Cedar Mesa canyons.

Hite Boat Ramp: Hite is located just off of paved GMP road State Highway 95, approximately 50 miles southwest of Hanksville, Utah. The Hite Boat Ramp accessible shoreline is a remote area adjacent to the confluence of the Colorado and the Dirty Devil Rivers, 8 miles from State Highway 632. The Hite developed area includes a small ranger station, gas station, boat storage, sanitary dump/potable water station, fish clearing station, and primitive RV and shoreline camping. Boat launching is available at north and south boat ramps, which are currently open, however four-wheel drive vehicles are recommended. The north ramp is concrete and the south ramp is gravel (NPS n.d.h).

In 2005, there were 59,405 visitors to the Hite region (DCP 2008e). Similar to Dirty Devil, Hite Boat Ramp was a popular visitation location when Lake Powell was at full pool, however Hite Boat Ramp continues to provide access to the lake. Prior to the 2001 drought, uplake visitation, including Hite Boat Ramp, showed steady increases. From 2000 to 2005, the annual visitation dropped from 147,694 to 59,405 (DCP 2008e).

Blue Notch and Red Canyon: Blue Notch and Red Canyon are located in San Juan County along Good Hope Bay, off Lake Powell. Blue Notch is located approximately 10 miles west of State Highway 95 on NPS 651, and is accessible by an intermittently maintained, primitive, 4-wheel-drive road. Red Canyon is approximately 20 miles from State Highway 276 on NPS 650, a seldom-maintained, primitive road located along a canyon bottom that is subject to flash flooding.

Because of their isolation and difficult access routes, visitation to both areas has remained low. A limited number of Glen Canyon visitors use the Blue Notch area because access to this site is more practical than to Red Canyon. Blue Notch can be used during low water. An October 2008 site visit found little evidence of litter or other problems related to overuse. When the main road approached the high water mark, social trails were evident as area users drove to locations along the lake's edge that are not designated ORV routes or areas. Beyond these social trails

toward the lakeshore, evidence of illegal off-road use such as hill climbs or exploration routes was limited to a few instances.

Reliable counts of visitation to the Red Canyon area are difficult to obtain, but aerial inspection during the summer of 2009 did not reveal any use of the area. No facilities are available at either shoreline area.

Farley Canyon: Farley Canyon is accessed off State Highway 95 by NPS 630, a maintained gravel road. A large, gravel-surface parking lot with two vault toilets and a wayside panel are located along the road just above the 3,700-foot lake elevation. Measurements taken during a site visit in October 2008 found the main, well-traveled road continuing approximately 325 yards beyond the parking area to 3,650 feet in elevation before ending. At this point, the road becomes several prohibited social trails. The location where the roadbed terminated provided evidence of heavy use in the past, based on the presence of old fire rings and litter.

Farley Canyon remains a popular camping and fishing location. There is evidence of moderate levels of ongoing use of the area, including unauthorized off-road use. Illegal tracks lead cross-country in what is an apparent attempt by some individuals to reach the old White Canyon shoreline site. Visitation records from the late 1980s report up to 250 vehicles present on a Memorial Day weekend. At lower lake elevations, the topography confines the size of the use area and a smaller number of users can be present at one time. The lake elevation was 3,624 feet at the time of the October 2008 site visit. The topography restricted the useable lakeside area to a few cars.

White Canyon: The White Canyon drainage cuts through the deep-red Moenkopi and banded Cutter Formations. The accessible shoreline area lies at the base of the steep Moenkopi Cliffs along the Lake Powell shoreline. White Canyon proper is a narrow drainage that is cut into the Cedar Mesa portion of the Cutter Formation. The canyon walls are steep (up to 300 feet) within a few miles of the Lake Powell shoreline.

Access to White Canyon is by NPS 656 and 657 off Utah State Route 95. Due to the level, open terrain in the eastern portion of the White Canyon area, the 1988 Accessible Shoreline EA/DCP (NPS 1988) closed roads to vehicular travel to protect resources. At lake elevations below 3,650 feet, there is no access to Lake Powell. The high water area from 3,650 feet to 3,700 feet in elevation is dominated by a dense stand of tamarisk and deep silt, requiring a 4-wheel-drive vehicle for passage. A deeply incised channel prevents vehicles from proceeding down the wash and accessing the lakeshore.

A number of old fire rings identify the previous use area. Site visits conducted in 2008 and 2009 found limited evidence of use or illegal off-road use. On-site signs are used to convey user restrictions and distribute site-specific information. There are no facilities at the site.

Orange Cliffs Region

General Description

The Orange Cliffs Unit extends from Clearwater Canyon to the northernmost boundary of Glen Canyon (figure 28). The Colorado River is located in the southern part of the region. The Green River is located east of the region, just outside Glen Canyon. These rivers offer a variety of water sport opportunities: rafting, motorized boating, row boating, etc. At the south end of the Orange Cliffs region is the famous Cataract Canyon on the Colorado River. East of Cataract Canyon, bordering Glen Canyon, is the BLM Dark Canyon Primitive Area.

Orange Cliffs

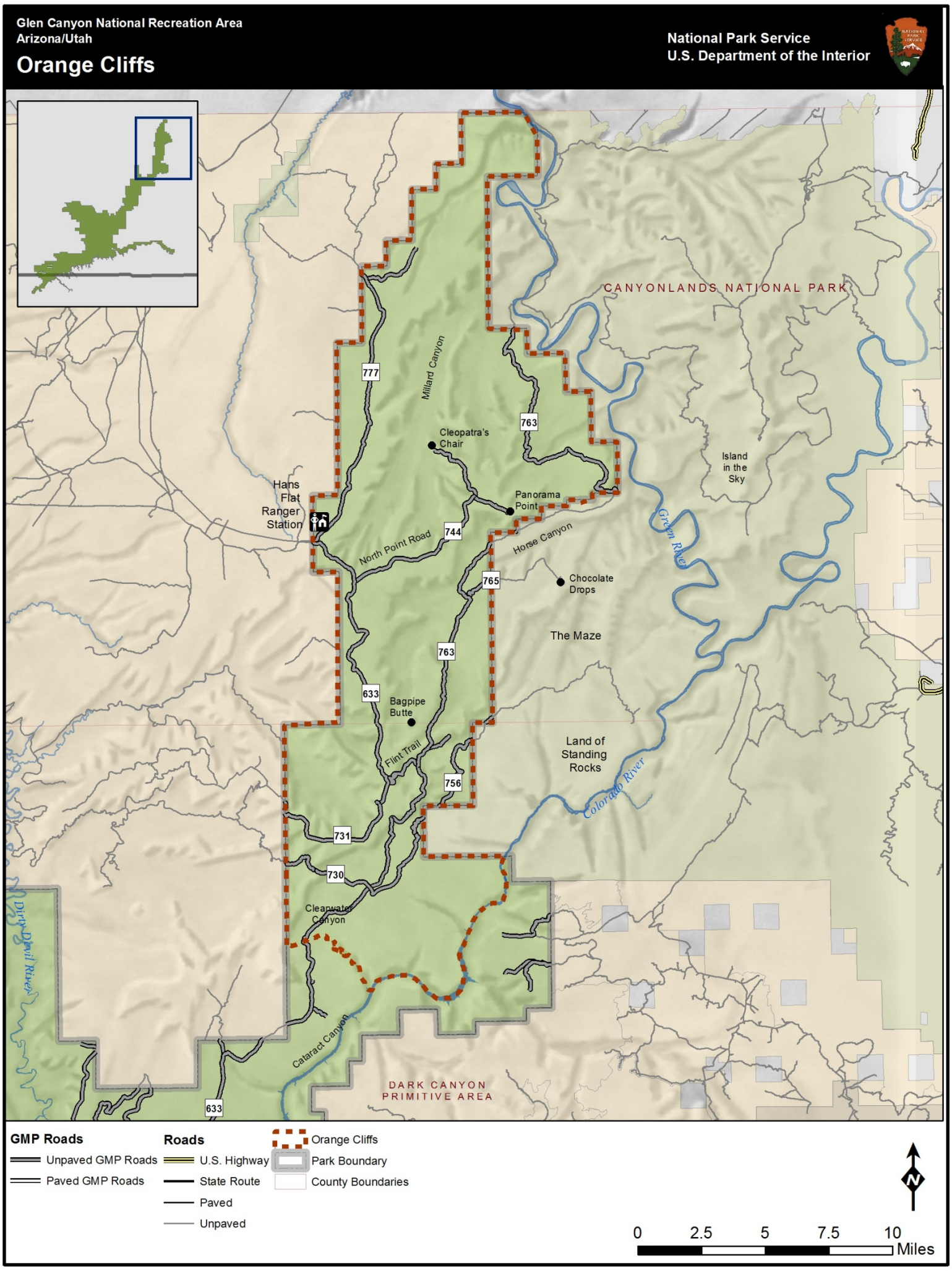


FIGURE 28: ORANGE CLIFFS REGION

The Orange Cliffs contains a scenic row of Wingate Sandstone cliffs, from the top of which one can view the vast and spectacular panoramas of Canyonlands National Park. The canyon of the Green and Colorado Rivers, the Maze, Horse Canyon, the Land of Standing Rocks, the Needles, Island in the Sky, and the cliffs far to the east of the Colorado River are visible. The foreground view of Millard Canyon is stunning, with the sandstone cliff face plunging abruptly downward over 1,000 feet and the canyon receding from sight to the north for 7 miles in a nearly straight line. This region also affords scenic views of various landforms, including Cleopatra's Chair, Bagpipe Butte, and the Chocolate Drops.

For the visitor, the beauty of the landscape is complemented by the area's isolation and solitude. Orange Cliffs is one of the least-visited areas in Glen Canyon; approximately 2,500 visitors pass through the Hans Flat Ranger Station in a year. Access to the area is provided by two main roads, the Flint Trail and the North Point Road. The Flint Trail (NPS 633) extends from Utah State Route 95 at Hite to the Hans Flat Ranger Station, located on the west side of the Orange Cliffs region. Hans Flat and the Orange Cliffs also can be accessed from the west by a 46-mile drive down a graded dirt road from State Route 24. Just east of Hans Flat is the North Point Road (NPS 744), which leads to two scenic views: Cleopatra's Chair and Panorama Point.

Roads and Off-road Use

Numerous unpaved GMP roads in the Orange Cliffs lead to scenic viewpoints and designated camping locations. The majority of the roads are in poor condition, and only the Flint Trail may be maintained more than once a year. Many of the roads are unimproved and subject to washouts, cross natural soils and bare slickrock, and require high-clearance, 4-wheel-drive vehicles for safe passage. Speed of travel is limited by natural conditions at the time of the visit, and may be no more than 5 to 10 miles per hour (mph) for extensive periods of travel time. The roads are often difficult to negotiate and can be even more difficult to follow as the movement of desert sands and rockslides obscure or even block routes.

The Flint Trail is the most commonly used road in the Orange Cliffs, and is sometimes signed as the "Orange Cliffs Road" (figure 29). This 55-mile-long road is the easiest road to negotiate. The road receives occasional grading and has some good sections. The road traverses slopes of clay soils that can be extremely hazardous when wet. The most well-known section of the Flint Trail is the drop off, the section of steep road and hairpin turns that leads from Gordon Flats down to the Maze area. The Flint Trail can be closed in winter months due to adverse driving conditions.

FIGURE 29: ORANGE CLIFFS ROAD

There are no paved GMP roads in the Orange Cliffs region.

Accessible Shoreline Areas

Because the Orange Cliffs region does not contain any segments of Lake Powell, there are no accessible shoreline areas in Orange Cliffs.

CULTURAL RESOURCES

Cultural resources are aspects of a cultural system that are valued by or significantly representative of cultural groups or that contains significant information about those groups. These resources are typically tangible entities but may include cultural practices. Tangible cultural resources are categorized for NPS management purposes as archeological resources, historic and prehistoric structures, cultural landscapes, ethnographic resources, and museum collections. Section 106 of the National Historic Preservation Act of 1966 (NHPA) (16 USC 470 et seq.) specifically directs each federal agency to consider the effects of their undertakings on tangible cultural resources that fit the definition of historic properties.

The commitment of the Park Service to the preservation of cultural resources is further articulated in the Glen Canyon National Recreation Area Resource Management Plan, Cultural Component (NPS 1987b), Glen Canyon National Recreation Area Archaeological Resources Protection Plan (NPS 1996b), and the Ruins Projection Plan, Glen Canyon National Recreation Area (NPS 2004b). The first document outlines policies and procedures for the implementation of Glen Canyon's cultural resource management program, the second identifies a protection strategy for archeological sites, and the third document tightly focuses on the steps deemed necessary to arrest the deterioration of the Glen Canyon archeological resource base.

More than 2,500 cultural resource sites have been recorded in Glen Canyon.

More than 2,500 cultural resource sites have been recorded in Glen Canyon, the majority of which are from the prehistoric time period (NPS 2004b). However, only about 2% of Glen Canyon has been intensively surveyed or tested for cultural resources (NPS 2004b). As would be expected, the developed areas such as Hite, Halls Crossing, and Bullfrog have received the most attention. Most of the surveys have been in these areas. A partial listing of past archeological investigations in Glen Canyon at 20 shoreline areas that were accessible by automobile (including the 12 shorelines that are currently accessible) is included in the Accessible Shoreline DCP/EA (NPS 1988).

For the purposes of this plan/DEIS, cultural resources have been divided into five types, including archeological resources, historic and prehistoric structures, cultural landscapes, ethnographic resources, and museum collections. Historic and prehistoric structures, cultural landscapes, and museum collections have been dismissed as a topic for evaluation (see chapter 1); archeological resources and ethnographic resources are described below.

ARCHEOLOGICAL RESOURCES

Archeological resources consist of "any material or physical evidence of past human life or activities which are of archeological interest, including the record of the effects of human activities on the environment. They are capable of revealing scientific or humanistic information through archeological research" (NPS 1998). Archeological resources include both prehistoric and historic time periods and can be found in both terrestrial and underwater settings. Sporadic archeological investigation of the canyonlands of the Colorado Plateau began in 1869 with John Wesley Powell's exploration of the Colorado River (Jennings 1966). Interest in the area continued throughout the 1920s and 1930s, with continuing study underwritten by the American Museum of Natural History and the Peabody Museum (NPS 2004b).

Systematic archeological investigation of the area that would become the Glen Canyon National Recreation Area began in the late 1950s. This project, which lasted eight years, was in response to the construction of the Glen Canyon Dam across the Colorado River in Arizona (Jennings 1966). The scope of the archeological survey work included the main stem of the Colorado River and its tributaries between the towns of Hite, Utah, and Page, Arizona (Jennings 1966). This work is summarized in a series of reports published by the University of Utah and in reports and bulletins prepared by the Museum of Northern Arizona (NPS 2004b). It is estimated that this effort resulted in the identification of about 2,000 archeological sites (Geib 1996; Jennings 1966). Subsequent large-scale surveys of Glen Canyon were conducted by Northern Arizona University (NAU) in the 1980s (Geib 1996). This work resulted in the identification of 489 archeological sites, 20 of which were subjected to limited testing (Geib 1996, 12). Numerous management- and project-related archeological surveys and excavations have been conducted at Glen Canyon since the 1960s (NPS 2004b, 4-7).

These combined studies have resulted in the identification of over 2,500 sites (Baker pers. comm. 2012a). Summary data provided by NPS indicate that 1,937 sites have been classified as prehistoric Native American in origin (Baker pers. comm. 2012b). Cliff dwellings, granaries, open habitation sites, lithic and ceramic scatters, and rock art panels are examples of prehistoric sites located within the boundaries of Glen Canyon (NPS 1996b; Geib 1996; Jennings 1966).

A total of 129 historic sites have been inventoried in Glen Canyon.

A total of 129 historic sites have been inventoried in Glen Canyon, including Anglo-American mining–related resources, ferry/ford sites, sites associated with Latter-day Saints colonization, the remains of protohistoric/historic Numic-speaking peoples like the Paiutes, and Navajo camp sites and residential structures (Baker pers. comm. 2012b; Geib 1996; Jennings 1966). Glen Canyon has stewardship of seven National Register–listed archeological sites (Baker pers. comm. 2012a) (table 14). A further 874 sites have been determined to be eligible for the National Register by Glen Canyon in consultation with the Utah State Historic Preservation Office (SHPO). A small subset of 72 sites has been recommended as eligible for the National Register and SHPO has not yet been consulted, whereas 1,214 sites are unevaluated. Baker (pers. comm. 2012b) indicates that many of the unknown and unevaluated sites in the Glen Canyon inventory were identified prior to the construction of the dam and filling of Lake Powell.

TABLE 14: NATIONAL REGISTER OF HISTORIC PLACES LISTED PROPERTIES

Name	National Register Information System Number	Remark
Charles H. Spencer (Hulk)	089001593	Paddle wheel steam boat ca. 1911
Davis Gulch Pictograph Panel	075000166	Ancestral Puebloan pictograph site ca. 1050-1240 AD
Defiance House	078000347	Ancestral Puebloan dwelling ca. 1250-1285 AD
Hole-in-the-Rock	075000165	Dug-out road constructed by The Church of Jesus Christ of Latter-day Saints pioneers ca. 1880
Hole-in-the Rock Trail	082004792	Trail utilized by Latter-day Saints pioneers in settlement of the San Juan basin ca. 1879-1880
Lee's Ferry Historic District	076000374	Contains several historically significant archeological sites associated with Non-Native American settlement of the southwestern United States ca. 1776-1930
Lonely Dell Ranch Historic District	078000277	Latter-day Saints pioneer subsistence farm/ranch ca. 1873-1909

ASMIS = Archeological Sites Management Information System.

Culture History

In order to understand the significance of cultural resources it is necessary to place them in their historical contexts. This task is usually one of the first undertaken by archeologists when studying a region. The history of archeological inquiry into the Glen Canyon region reaches back to the late 1860s and early 1870s and continues to the present day; consequently, a rich vein of chronological information exists about the early Native American occupation of Glen Canyon. This information is given below in summary form.

The cultural history of the Colorado Plateau, including Glen Canyon, is based in part on the pioneering work of A.V. Kidder and many subsequent archeologists, including such luminaries as Julian Steward and Jesse Jennings (Geib 1996; Jennings 1966). Kidder systematized the chronology of the ancestral Puebloan people of the region based on work conducted at the Pecos ruins in New Mexico during the first decades of the 20th century. Kidder's temporal sequence, with modifications, is still used by southwestern archeologists today (Geib 1996; Jennings 1966). Our understanding of the cultural chronology of the Glen Canyon region has benefited from the advent of chronometric dating in the 1950s. Radiocarbon dating of carbonized plant remains and perishable items has had a major impact on our understanding of preceramic Archaic chronology and lifeways in the region (Geib 1996).

The human occupation of the Glen Canyon region began many millennia prior to the development of agriculture by the ancestral Puebloans. The archeological evidence suggests that the region was first occupied during the late Pleistocene period by dispersed, mobile groups of hunter-gatherers. Subsistence focused on the pursuit of large game, including many now-extinct forms of megafauna (Geib 1996). This period is generally known as the Paleo-Indian. The beginning date for the period is a matter of dispute (Meltzer 2009). However, it is conservatively estimated that Native Americans have occupied the Colorado Plateau for at least 10,000 years (Geib 1996). Evidence of Paleo-Indian presence in Glen Canyon is limited to surface finds of fluted, lanceolate projectile points assigned to the Clovis and Folsom clusters (NPS 2004b; Geib 1996). The Paleo-Indian occupation of Glen Canyon is generally believed to date from about 11,000 to 9,000 before the present (BP). The terminal date coincides with the end of the Pleistocene, when climate change brought about the disappearance of many genera of big game animals and a reordering of biotic communities on a continental scale (Meltzer 2009). Geib (1996) suggests that the Paleo-Indian big game–hunting lifeway probably did not persist in Glen Canyon past 9,000 BP.

The Archaic period in the Glen Canyon region lasted from about 9000 BP to 2400 BP (Geib 1996). The archeological evidence indicates that Native Americans developed broad-based hunting and gathering strategies that took advantage of small game and plant resources early in this period (NPS 1987b). Archaic-period open habitation sites, rock shelters, and lithic scatters are among the most frequently identified archeological resources in Glen Canyon. Hunting and gathering remained the basis of the Native American subsistence economy throughout the Archaic period. The introduction of agriculture in about 2400 BP marks the end of the Archaic period in the Glen Canyon region (Geib 1996).

The archeological testing of 74 sites in the Glen Canyon region produced a robust assemblage of 180 radiocarbon dates, sufficient to divide the Archaic period into a series of seven subperiods: Initial Archaic (ca. 9000 to 8000 BP), Early Archaic (8000 to 6300 BP), Early-Middle Transition (6300 to 5600 BP), Middle Archaic (6300 to 4400 BP), Middle-Late Transition (4400 to 3800 BP), Late Archaic (3800 to 2900 BP), and Terminal Archaic (2900 to 2400 BP) (Geib 1996) (table 15). Given the limitations of surface survey it is often difficult to assign specific sites to one of the subperiods based on diagnostic artifacts, which are often lacking. The careful reader will also notice little change in the suite of temporally diagnostic artifacts across several of the divisions.

TABLE 15: GLEN CANYON REGIONAL ARCHAIC CHRONOLOGY

Archaic Period Subdivisions	14 Carbon Years BP*	Calibrated Years BC*	Diagnostic Projective Points—Examples	Diagnostic Perishable Artifacts
Terminal Archaic	2400–2900	400–1045	Gypsum points; Elko points	Split-twig figurines, plain-weave sandals
Late Archaic	2900–3800	1045–2200	Gypsum points; Elko eared; McKean lanceolate	Split-twig figurines, plain-weave sandals
Middle-Late Transition	3800–4400	2200–2980	San Rafael side-notched; McKean lanceolate	Split-twig figurines, plain-weave sandals
Middle Archaic	4400–5600	2980–4400	Sudden side-notched; Hawken side-notched	Plain-weave sandals
Early-Middle Transition	5600–6300	4400–5260	Sudden side-notched; Hawken side notched	Plain-weave sandals
Early Archaic	6300–8000	5260–6840	Elko corner side-notched; northern side-notched	Open-twined sandals replaced by plain-weave sandals
Initial Archaic	8000–9000	6840–8030	Pinto; Elko corner side-notched	Open-twined sandals, fine warp-faced sandals

Source: Geib 1996.

* "BP" refers to uncalibrated radiocarbon dates before present ("present" by accepted convention is AD 1950); "cal AD" and "cal BC" denote calibrated calendar ages according to standard Western usage.

Nevertheless, Geib's fine-grained chronological model allows for inferences to be made about changing population densities, settlement patterns, and subsistence systems across a substantial portion of the region's prehistoric past (Geib 1996). For example, there is evidence to suggest that Native American population density increased during the Early and Late Archaic subperiods, although it seems to have suffered a hiatus during the Middle Archaic. Geib (1996) reflects at length on the apparent reduction in population density and site visibility during the Middle Archaic, suggesting that changes in settlement patterns may account for the pattern rather than out-migration from Glen Canyon.

The period from 400 BC to AD 500 goes by a variety of names, including the Early Agriculture, Preformative, and Basket Maker II periods (NPS 1987b, 2004b; Geib 1996; Jennings 1966). As such, it represents the first in the sequence of ancestral Puebloan cultures believed to have experimented with increased sedentism and agriculture. It is likely that Native American people used both mobile hunter-gatherer and nascent sedentary agriculturalist lifeways during this period (NPS 1987b).

The Formative period (AD 500 to AD 1300) includes two of the Colorado Plateau's best-known Native American archeological complexes: Fremont and Anasazi. Both of these complexes occupied Glen Canyon and are regarded as Ancestral Puebloans (NPS 1987b). This period was characterized by sedentary and semi-sedentary settlement patterns; craft specialization, including pottery production; and agriculture (NPS 1987b). Archeologists believe that the Fremont occupation of Glen Canyon occurred between AD 400 and 1000 (Smiley et al. 2010). The Ancestral Puebloans resided in Glen Canyon during the Pueblo II and III stages, from AD 1050 to 1300. Interestingly, Smiley et al. (2010) point out that sites associated with the Fremont culture are limited to the Escalante River Basin, whereas Anasazi sites are widespread in Glen Canyon. The temporal and spatial aspects of settlement during this period continue to be a major archeological research domain in Glen Canyon (Geib 1996).

The Pueblo II (ca. AD 1000 to 1170) occupation has been well documented in Glen Canyon (NPS 1987b; Jennings 1966). It appears that southwestern Native American populations increased in size during this stage, resulting in the

use of the canyonlands. Sites of this age in Glen Canyon frequently consist of small, one to three living rooms and storage structures. Large sites with many living rooms, storage structures, and kivas are absent from the resource base.

Pueblo III (AD 1150 to 1300) represents the final temporal division associated with the Ancestral Puebloan occupation of Glen Canyon (Jennings 1966). Sites belonging to this stage are typically larger, with more cultural features and higher artifact densities. Three large, highly visible architectural sites, Defiance House (State Site No. 42SA00598), Three-roof Ruin (State Site No. 42KA00207), and Widow's Ledge (State Site No. 42SA00633) date to this period (NPS 1987b).

Information concerning the late prehistoric (ca. AD 1300 to 1500) inhabitants of Glen Canyon is scanty, possibly reflecting the lack of diagnostic artifacts assigned to the period, and/or decreasing use of the area by native peoples (NPS 1987b). Scattered evidence of late prehistoric and protohistoric occupations are limited to lithic and ceramic scatters characterized by Ute and Paiute pottery and desert corner-notched points. Other types of resources include brush shelters and rock-art panels. Protohistoric and historic Native American archeological sites are affiliated with the Navajo and Southern Paiute Tribes (Smiley et al. 2010). The Numic-speaking Southern Paiute and Ute and Athapaskan-speaking Navajo occupied different ecozones on a seasonal basis in semipermanent base camps often located near springs. Tributary stream gravel beds provided sources of material for stone tools throughout the prehistoric and protohistoric periods.

Archeologists and anthropologists believe that the Southern Paiute and Ute Tribes spread across the Great Basin, southern Nevada, and Utah about 1,000 years ago during a period of population movement known as the Numic expansion (Grayson 2011). These Native American people were encountered by early Spanish and American explorers in the Glen Canyon portion of the Colorado River basin (Sucec 1996). Western scholars using linguistic analysis suggest that the Athapaskan Navajo may have entered the San Juan River basin including the Glen Canyon area sometime later perhaps only a few hundred years ago (Grayson 2011). The Navajo Nation, however, assert their ancestors had been in the region for a much longer time (Sucec pers. comm. 2013). By the time the Spanish arrived in the region, the Ancestral Puebloan peoples had moved south from the canyonlands and San Juan Basin to the mesas of Arizona (Sucec 1996). Contemporary Puebloan tribal leaders regard the Glen Canyon as containing physical and spiritual places important to their cultural heritage and way of life (Sucec 1996).

Both Paiute and Navajo archeological sites have been identified in Glen Canyon but remain to be systematically investigated (Smiley et al. 2010: 15). Obtaining base-line data on sites directly associated with these two Native American tribal groups is regarded as a high priority within the boundaries of the Glen Canyon National Recreation Area. Data gaps include site structure, artifact assemblage composition, and site location to name a few. Questions at the intra-site level of analysis involve co-occurrence of Paiute and Navajo sites with those of earlier inhabitants of the region and other aspects their settlement system and subsistence economy (Smiley et al. 2010).

Archeologists use the exploration of the Franciscan friars Domingues and Escalante in 1776 as a convenient event marking the end of the Protohistoric period and the beginning of the Historic period. Archeological, architectural, and archival research conducted during the Glen Canyon Dam Project resulted in the documentation of 270 historic sites in the flood pool and surrounding uplands (NPS 1987b; Jennings 1966). Archeological resources relating to Euroamerican pioneer, mining, and ranching activities have been identified within the boundaries of Glen Canyon. Prominent among these is the Lees Ferry and Lonely Dell Ranch National Historic District.

Archeological Site Location and Site Density

The ecological zonation of Glen Canyon has structured archeological enquiry since the 1950s (Geib 1996). Three ecozones have been significant in the Native American occupation of the region. Following Geib (1996), these ecozones are defined as follows:

1. **Lowlands**. This zone consists of the hot, arid canyons of the Colorado River and its tributaries below 4,500 feet. Water from the rivers, intermittent streams, seeps, and springs made this a focal point of settlement, particularly after the Late Archaic period when agriculture began to be practiced by Native Americans occupying the Glen Canyon region. Geib (1996) notes that alcoves and overhangs provided abundant shelter and nearby river gravel bars were a source of lithic raw material.
2. **Midlands**. This zone captures the arid benchlands and low plateaus situated between canyon rims from 4,500 to 5,500 feet above sea level. The midlands consist of slickrock barrens, dune fields, and scale-covered flats (Geib 1996). The grass-covered flatlands provided good antelope habitat. This zone would have provided numerous resources for Native American hunter-gatherers and was exploited during all phases of the Prehistoric period (Geib 1996; Jennings 1966).
3. **Highlands.** Located above 5,500 feet in elevation, the uplands of Glen Canyon are cool and covered with pinyon/juniper woodlands (Geib 1996). Interestingly, archeological survey evidence generated during the Glen Canyon Dam Project and subsequent archeological endeavors have documented numerous Ancestral Puebloan sites in the uplands (Jennings 1966; Smiley et al. 2010). How these ancient people were able to exploit the uplands for agriculture was a focal point of investigation during the 1950s and 1960s (Jennings 1966).

Geib's (1996) tripartite division of Glen Canyon into three ecozones reflects variation in terrain and lifezones critical to prehistoric Native American populations. The Glen Canyon grazing allotment study included parcels assigned to all three environmental divisions. Consequently, baseline information on the number of sites per ecozone in the grazing areas of Glen Canyon was summarized (table 16) (Vance 2010). These data indicate prehistoric use of all three ecological zones, with a marked preference for the better-watered lowland ecological settings, which feature arable terraces, diverse plant communities, and long growing seasons (Vance 2010).

TABLE 16: PREVIOUSLY IDENTIFIED GRAZING LAND SITES BY ECOZONE

Ecozone	Acreage	Percentage of Total Acreage	Site Numbers	Percent of Total Sites
Lowlands	453,895.70	54.75	629	43.86
Midlands	256,734.15	30.97	411	28.66
Highlands	118,351.44	22.72	394	27.48
Total	828,981.29	NA	1,434	100.00

Source: Vance 2010.

NA = not applicable.

Probably the best data on site density for Glen Canyon was generated by surveys conducted by NAU between 1984 and 1989 (Smiley et al. 2010). This is because the survey methods used were intensive in nature and consistently applied by the consulting archeologists. Values range from one site per 2.8 acres at the Rainbow Bridge National Monument to one site per 127.7 acres in the Bullfrog/Henry Mountains region of Glen Canyon (Smiley et al. 2010). The NAU survey of 28,974 acres produced an average site density of one site per 37.4 acres; the range of variation in site density values generated by the NAU surveys is presented in table 17.

TABLE 17: NAU SITE INVENTORY 1984–1987 SITE DENSITY VALUES

Region	Number of Acres Surveyed	Number of Sites Documented	Site Density (sites/acre)
Lees Ferry	1,114	25	1/44.5
Lower Glen Canyon Benches	2570	58	1/44.3
Rainbow Bridge	70	25	1/2.8
Cow Canyon	1,080	45	1/24.0
25-mile Wash	990	47	1/21.0
Bowns Canyon	600	55	1/10.9
San Juan Arm	2,320	40	1/58.0
Bullfrog/Henry Mountains	3,450	27	1/127.7
Orange Cliffs	2,625	76	1/34.5
Clearwater Canyon	2,075	62	1/33.4
North Point	1,130	26	1/43.4
The Spur	950	20	1/47.5
Total*	18,974	506	1/37.4

Source: Smiley et al. 2010.

*Final column shows average.

Archeological Sites in the Study Area

The data presented in the sections below is drawn from a number of sources including published reports, personal communications, GIS analyses, and the Glen Canyon archeological site data base. Analysis of this data has revealed that 223 archeological sites are located within the study areas and surrounding buffers (table 18). A total of 70 of these sites have either been recommended eligible for the Nation Register by archeologists that meet the Secretary of the Interior's Standards and Guidelines or have received a consensus determination of eligibility finding based on Section 106 consultation between the NPS and the appropriate SHPO/Tribal Historic Preservation Offices (THPOs). The records indicate that an additional 82 sites have been evaluated as not eligible. While a further 70 sites are listed as having not been evaluated for inclusion in the National Register. Additional summary data for each ORV area is presented in subsequent sections.

TABLE 18: NATIONAL REGISTER STATUS OF ARCHEOLOGICAL SITES IN ORV AREAS

National Register Eligibility Status				
	Eligible	Not Eligible	Not Evaluated	Total
Lone Rock Beach and Play Area				
Lone Rock Beach Study Area	0	0	0	0
Lone Rock Beach Buffer	0	16	3	19
Lone Rock Beach Play Area Study Area	0	3	0	3
Lone Rock Beach Play Area Buffer	0	2	1	3
Subtotal Lone Rock Beach and Play Area	**0**	**21**	**4**	**25**

National Register Eligibility Status				
	Eligible	**Not Eligible**	**Not Evaluated**	**Total**
Accessible Shoreline Areas				
Stanton Creek Study Area	0	2	0	2
Stanton Creek Buffer	3	2	1	6
Farley Canyon Study Area	0	2	0	2
Farley Canyon Buffer	0	0	3	3
Dirty Devil Study Area	0	0	0	0
Dirty Devil Buffer	0	0	1	1
Bullfrog North and South Study Area	1	1	0	2
Bullfrog North and South Buffer	5	6	8	19
White Canyon Study Area	0	0	0	0
White Canyon Buffer	0	0	0	0
Blue Notch Study Area	2	0	0	2
Blue Notch Buffer	0	0	0	0
Crosby Canyon Study Area	0	0	0	0
Crosby Canyon Buffer	4	0	3	7
Paiute Canyon Study Area	0	0	0	0
Paiute Canyon Buffer	1	1	1	3
Neskahi Study Area	0	0	0	0
Neskahi Buffer	0	0	0	0
Nokai Study Area	3	0	1	4
Nokai Buffer	0	0	1	1
Copper Canyon Study Area	0	0	0	0
Copper Canyon Buffer	1	0	11	12
Paiute Farms Study Area	0	0	1	1
Paiute Farms Buffer	0	1	8	9
Red Canyon Study Area	0	0	0	0
Red Canyon Buffer	0	0	0	0
Warm Creek Study Area	0	0	2	2
Warm Creek Buffer	0	0	0	0
Hite Boat Ramp Study Area	0	0	0	0
Hite Boat Ramp Buffer	5	3	0	8
Subtotal Accessible Shoreline Study Area	**6**	**5**	**4**	**15**
Subtotal Accessible Shoreline Buffer	**19**	**13**	**37**	**69**
Unpaved GMP Roads Study Area	**35**	**35**	**23**	**93**
Paved GMP Roads Study Area	**4**	**6**	**0**	**10**
Ferry Swale ORV routes Study Area	**6**	**2**	**3**	**11**
Total	***70***	***82***	***70***	***223***

Lone Rock Beach: A total of three archeological surveys have been conducted within the 0.5-mile buffer that surrounds the Lone Rock Beach study area resulting in the identification of 19 archeological sites (Liestman 1986; Tipps 1987) (see table 18). All of these sites are located in the buffer area. None of these sites are eligible for the National Register.

Lone Rock Beach Play Area: In general, the three archeological surveys conducted in the Lone Rock Beach study area and buffer also captured the Lone Rock Beach Play Area. Consequently, there is some overlap in the archeological inventories especially with regard to the buffers. A total of three archeological sites are located within the study area of this ORV area (see table 18). None of these sites are eligible for the National Register. The 0.5-mile buffer surrounding the study area contains three archeological sites. None of these sites are eligible for the National Register.

Accessible Shoreline Areas

Glen Canyon has prepared a definition for the accessible shoreline study areas (Baker pers. comm. 2012b). The definition consists of two variables: (1) a 35° gradient is used as the restricting limit for off-road use below the 1988 maximum flood pool of 3,700 feet in designated ORV areas; and (2) a 0.5-mile buffer around each study area is proposed to address indirect impacts (Baker pers. comm. 2012a)

Acting on this information, NAU prepared archeological survey designs for the accessible shoreline areas (Bryce 2010; Caldwell 2011). The research designs include information on archeological sites inventoried in the vicinity of the shoreline study area. For the purposes of the research designs the buffer was expanded from 0.5 mile to 1.0 mile. Archeological survey teams from NAU have completed the accessible shoreline areas fieldwork. The results have been published in two letter reports (Vance and Downum 2012, 2013). The NAU findings were used for the analysis. Although the NAU used a 1.0-mile buffer in their study, Glen Canyon has indicated that a 0.5-mile buffer is adequate for estimating potential indirect impacts on archeological resources (Baker pers. comm. 2012a). This is consistent with the Accessible Shoreline Cultural Considerations draft document (Baker 2010).

The Glen Canyon archeological database indicates that a total of 83 sites are located within the accessible shoreline study area and surrounding buffers. The National Register status of these sites includes 25 determined to be eligible, 17 believed to be not eligible, and 41 that have not been evaluated. Summaries about the archeological sites found within the study area and buffer for each accessible shoreline area are presented below.

Stanton Creek: Archeological surveys conducted within the vicinity of Stanton Creek resulted in the identification of six archeological sites in the 0.5-mile buffer and two archeological sites in the study area (Caldwell 2011; Vance and Downum 2012; and Vance and Downum 2013) (see table 18). Sites GCNRA-014 and GCNRA-015 located in the study area are recommended not eligible for the National Register. However, there are three sites within the boundaries of the buffer that are either recommended eligible for the National Register or have been determined eligible for the National Register (Sites GCNRA-003, GCNRA-004, and GLCA01037/42KA03375) (see table 18). A total of two sites in the buffer are listed as not eligible for the National Register, while a third site is noted as unevaluated.

Farley Canyon: Archeological surveys conducted in the vicinity of the Farley Canyon have resulted in the identification of three archeological sites within the 0.5-mile buffer and two archeological sites in the study area (Caldwell 2011; Vance and Downum 2012; Vance and Downum 2013) (see table 18). Sites GCNRA-006 and GCNRA-007 located within the study area are recommended as not eligible for the National Register (Vance and Downum 2012). The three sites in the buffer area have not been evaluated.

Dirty Devil: One archeological survey has been conducted in the vicinity of the Dirty Devil study area (Vance and Downum 2012). No archeological sites were recorded or revisited during the NAU survey (Vance and Downum

2012). However, one previously identified site is located within the buffer surrounding the study area (Caldwell 2011). This site has not been evaluated for the National Register.

Bullfrog North and South: Archeological surveys conducted in the vicinity of Bullfrog North and South resulted in the identification of 19 archeological sites in the 0.5-mile buffer and 2 archeological sites in the study area (Caldwell 2011: 17; Vance and Downum 2012; Vance and Downum 2013) (see table 18). Site GCNRA-002 located within the study area is recommended eligible for the National Register (Vance and Downum 2013). A second site, GCNRA-020 is also located in the study area. This site has been recommended as not eligible for the National Register. In addition, five previously recorded National Register eligible sites are situated in the surrounding buffer. These remaining 14 sites situated in the buffer are either not eligible or have not been evaluated (see table 18).

White Canyon: An archeological survey conducted in the vicinity of White Canyon did not record any archeological sites (Vance and Downum 2013) (see table: 18). No previously identified sites have been recorded in the buffer or study area (Caldwell 2011).

Blue Notch: Archeological surveys conducted in the vicinity of Blue Notch identified a total of two archeological sites in the study area (Caldwell 2011, Vance and Downum 2012; Vance and Downum 2013) (see table 18). Sites GCNRA-005 and GCNRA-017 located in the study area are recommended eligible for the National Register.

Crosby Canyon: Archeological surveys conducted in the vicinity of Crosby Canyon identified a total of seven archeological sites in the 0.5-mile buffer (Caldwell 2011, Vance and Downum 2012; Vance and Downum 2013) (see table 18). Sites GCNRA-018, GCNRA-019, GLCA00983/42KA03219 and GLCA00987/42KA03223 located within the 0.5-mile buffer are either recommended eligible for the National Register or have been determined to be eligible for the National Register. A total of three unevaluated sites are also located within the buffer.

Paiute Canyon: Archeological surveys conducted in the vicinity of Paiute Canyon resulted in the identification of three archeological sites in the 0.5-mile buffer (Caldwell 2011; Vance and Downum 2013a: Table 3) (see Table 18). Site GLCA02040 is reported to be drowned by the flood pool of Lake Powell. This site has not been evaluated for the National Register. Site GCNRA-008 was identified during the NAU shoreline survey and has been evaluated as eligible for the National Register. A second archeological deposit, Site GCNRA-009 has been evaluated as not eligible for the National Register. No sites were identified within the study area of the Paiute Canyon accessible shoreline.

Neskahi: An archeological survey conducted in the vicinity of Neskahi did not record any archeological sites (Vance and Downum 2013: Table 3) (see table: 18). No previously identified sites have been recorded in the buffer or study area (Caldwell 2011).

Nokai Canyon: Archeological surveys conducted in the vicinity of Nokai Canyon resulted in the identification of one archeological site in the 0.5-mile buffer and four sites in the study area (Caldwell 2011, Vance and Downum 2012, 2013) (see table 18). Sites GCNRA010, GCNRA011, and GCNRA012 located in the study area are recommended eligible for the National Register. Site GLCA02014/42NA06810 also located in the study area has not been evaluated and is described as having been destroyed (Caldwell 2011). Finally, the buffer contains one site that has not been evaluated for the National Register.

Copper Canyon: Archeological surveys conducted in the vicinity of Copper Canyon resulted in the identification of 12 archeological site within the 0.5-mile buffer (Caldwell 2011, Vance and Downum 2012; Vance and Downum 2013) (see table 18). A total of 11 sites are listed as unevaluated for the National Register. Site 42SA20912 was re-located during the recent NAU Copper Canyon survey (Vance and Downum 2013: Table 3). This site has been recommended as eligible for the National Register.

Paiute Farms: Archeological surveys conducted in the vicinity of Paiute Farms resulted in the identification of nine sites in the 0.5-mile buffer and one site in the study area (Caldwell 2011; Vance and Downum 2012; Vance and Downum 2013) (see table 18). Site GLCA02009/NA06802 located in the study area is described as unevaluated for the National Register. NAU recorded Site GCNRA-013 is in the buffer (Vance and Downum 2013: Table 3). This site is recommended as not eligible for the National Register. The remaining eight sites situated in the buffer are described as unevaluated.

Red Canyon: No previous archeological surveys have been conducted in the vicinity of the Red Canyon study area (Bryce 2010). No previously identified sites have been recorded in the buffer or study area (see table 18). This accessible shoreline was not included in the recent archeological surveys conducted by NAU (Vance and Downum 2012; Vance and Downum 2013) as funding was not available for this survey.

Warm Creek: One previous archeological survey has been conducted in the Warm Creek study area (Bryce 2010; Caldwell 2011). This accessible shoreline was not included in the recent archeological surveys conducted by NAU (Vance and Downum 2012; Vance and Downum 2013). However, based on the available ASMIS data, it appears that two archeological sites are located in the Warm Creek study area (see table 18). These two sites, GLCA00635/42LA00251 and GLCA00636/42KA00252, have not been evaluated for the National Register.

Hite Boat Ramp: One previous archeological survey has been conducted in the Hite vicinity (Baker 2004). Data from this accessible shoreline was not included in the Caldwell (2011) design document. Based on examination of the data from the Baker (2004) report, it appears that eight archeological sites are located in the 0.5-mile buffer that surrounds the study area (Baker 2004) (see table 18). Sites 42SA3954, 42SA3955, and Sites 42SA24694-24697 have been determined eligible for listing in the National Register (Baker 2004). The remaining three sites have been determined not eligible for the National Register.

Unpaved GMP Roads

The unpaved GMP roads are described as consisting mainly of old jeep trails leading to scenic viewpoints and camping locations. Many of the roads are unimproved, cross natural soils and bare slickrock, are subject to washouts, and require high-clearance, 4-wheel-drive vehicles for safe passage. Speed of travel is limited by natural conditions at the time of the visit, and may be no more than 5 to 10 mph for extensive periods of travel time. The roads are often difficult to negotiate and can be even more difficult to follow as the movement of desert sands and rockslides obscure or even block routes.

Analysis of the archeological data pertaining to these roads revealed a total of 93 previously recorded archeological sites within the study area for each road (see table 18). To ensure that sites immediately adjacent to these tracks were included in the study, a 60-meter buffer measured from the centerline of the road for a total of 120-meters was included in the study area. A total of 35 sites determined to be eligible for the National Register are included in these linear corridors. An additional 58 sites are either not eligible or have not been evaluated.

Paved GMP Roads

Glen Canyon has approximately 72 miles of paved road to facilitate visitor access to the recreation areas main recreational and educational facilities. The study area of the paved roads is the same as for the unpaved roads described in the preceding section. A total of four previously identified archeological sites located within the study area have been determined eligible for the National Register (see table 18). Evaluation of an additional six sites found within the study area yielded findings of not eligible for the National Register.

Ferry Swale

This analysis was limited to the ORV routes that fall within the Ferry Swale portion of Glen Canyon. The study area for Ferry Swale is the same as that described above for the paved and unpaved GMP roads. It consists of a 60-meter buffer drawn from the center line of the road for a total width of 120 meters. A total of 11.9 miles of previously established ORV routes have been inventoried for archeological sites (Baker and Burrillo 2013). The survey and GIS analysis indicate that a total of 11 archeological sites are located in the study area (see table 18). Sites AZ C:02:067, AZ C:03:032, and GLCA02272/42NA25984 have been evaluated and determined eligible for the National Register. In addition, sites FS-1, FS-4, and FS-5 have been recommended eligible for the National Register. These latter three sites are identified by temporary site numbers reflecting the draft status of the Baker and Burrillo (2013) report. The National Register status of the remaining sites is listed as either not eligible or unevaluated.

ETHNOGRAPHIC RESOURCES

NPS defines "ethnographic resources" as "objects and places, including sites, structures, landscapes, and natural resources, with traditional cultural meaning and value to associated peoples" (NPS 2006a). Research and consultation with associated people identifies and explains the places and things they find culturally meaningful. Associated peoples include those that are the contemporary neighbors to the Glen Canyon National Recreation Area and ethnic or occupational communities that have been associated with the area for two or more generations (40 years), and whose interests in the resources began before the area was established (NPS 2006a).

Ethnographic resources eligible for the National Register are called "traditional cultural properties" or TCPs. TCPs are defined by NPS as "a property associated with cultural practices, beliefs, the sense of purpose, or existence of a living community that is rooted in that community's history or is important in maintaining its cultural identity and development as an ethnically distinctive people" (NPS 2006a). This class of cultural resource was specifically addressed in the 1992 amendments to the NHPA. Contemporary communities are often, but not necessarily Native American groups.

Ethnographic resources eligible for the National Register are called "traditional cultural properties."

There are seven tribes associated with Glen Canyon / Rainbow Bridge: Hopi Tribe; Kaibab Paiute Tribe; Navajo Nation (inclusive of the Coppermine Chapter; Gap/Bodaway Chapter; Ts'ah Biikin Chapter; Kaibeto Chapter; LeChee Chapter; Oljato Chapter; and Shonto Chapter); Paiute Indian Tribe of Utah (inclusive of the Kanosh Band; Koosharem Band; and Shivwits Band); Pueblo of Zuni; San Juan Southern Paiute; and Ute Mountain Ute (inclusive of the White Mesa Ute). In addition, Glen Canyon consults with members of The Church of Jesus Christ of Latter-day Saints on matters involving cultural resources that are associated with the settlement history of the Latter-day Saints Church in Glen Canyon National Recreation Area.

Archeological sites made by indigenous peoples are regarded as ethnographic resources. American Indian archeological sites known and likely to occur within the study area include Paleoindian, Archaic, Ancestral Puebloan, Paiute and Ute sites, as well as Navajo sites. The Pueblo of Zuni and the Hopi Tribe both passed resolutions declaring their relationships with the people who lived during the Paleoindian and Archaic periods. Paleoindian and Archaic period sites, therefore, become ethnographic resources. The Hopi Tribe also claims association with any Ancestral Puebloan and Fremont sites. The Pueblo of Zuni claims association with Fremont period sites. Therefore, the sites are ethnographic resources because of the significance of those sites within the cultural traditions and histories of the Hopi Tribe and Pueblo of Zuni. Any archeological sites associated with Navajo inhabitance of the area are also ethnographic resources. Any Numic or Paiute or Ute sites would similarly be regarded as ethnographic resources by contemporary Paiute and Ute tribes and bands.

Ethnographic resources that are archeological sites have been documented in association with the accessible lakeshores and within the play area of Lone Rock Beach. Ethnographic resources that are archeological resources

have not been documented for the areas proposed for ORV routes and for Ferry Swale. Consultation with tribes and SHPO are ongoing over these resources.

Ethnographic Resources that are or have the Potential to be Traditional Cultural Properties: Four historic properties potentially eligible to the National Register as TCPs lie adjacent to, but are not within, the study area. They include (1) Rainbow Bridge within Rainbow Bridge National Monument; (2) the Colorado River inclusive of what is now Lake Powell; (3) an archeological site associated within the Wahweap governmental housing complex near the Lakeshore Drive Access Road; and (4) a location in association with the Halls Crossing Access Road. Rainbow Bridge is considered significant to the histories and on-going traditions of five tribes associated with Glen Canyon/ Rainbow Bridge. These tribes include the Kaibab Paiute Tribe, San Juan Southern Paiute Tribe, Navajo Nation, Hopi Tribe, and Ute Mountain Ute that includes the White Mesa Ute Band. The Colorado River within the jurisdiction of Glen Canyon, and adjacent to various accessible lakeshores, is regarded as a TCP by the Kaibab Paiute Tribe, the Navajo Nation, the Hopi Tribe, and the Pueblo of Zuni. The Colorado River has been and remains a significant place within the histories traditions and cultures of these tribes. The archeological site that is a potential TCP to the Navajo Nation lies within the government housing complex, but outside of the study area. The location in association with Halls Crossing Access Road is a potential TCP to the Navajo Nation Hopi Tribe, the San Juan Southern Paiute, and the White Mesa Ute of the Ute Mountain Ute Tribe but is outside the study area.

One potential TCP is located within the study area. The Hole-in-the-Rock Road/Trail corridor is significant to members of The Church of Jesus Christ of Latter-day Saints as a location associated with their pioneer history, and it continues to be important in the development as an ethnically distinctive group maintenance of their on-going communal identity and in their development as an ethnically distinctive group. The significance of the corridor is documented in the 2011 Programmatic Environmental Assessment for Organized Group Activities along Hole-in-the-Rock Road (NPS 2011c).

The Hole-in-the-Rock Road traverses portions of Garfield and Kane counties and is approximately 61 miles long (USDOI-BLM 2011). This historic trail falls within Glen Canyon and the Grand Staircase-Escalante National Monument. This cultural resource is managed by Glen Canyon as part of its unpaved GMP road system. Sites located along the trail are recognized as significant by members of The Church of Jesus Christ of Latter-day Saints for its association with the 1879–1880 San Juan Mission expedition. It was during this period that Latter-day Saints pioneers mounted a series of expeditions for the purpose of colonizing areas south and east of the Colorado River.

The site of the engineered wagon passage is known as the Hole-in-the-Rock. Over the decades, members of The Church of Jesus Christ of Latter-day Saints have conducted re-enactments of the events leading to the crossing of the Colorado River by passing through the Hole-in-the-Rock. These reenactments include camping along the historic trail in Glen Canyon and the Grand Staircase-Escalante National Monument. An EA was conducted by the BLM which manages the Grand Staircase-Escalante National Monument to address the issuance of permits for group activities along the Hole-in-the-Rock corridor (USDOI-BLM 2011). The EA resulted in a Finding of No Significant Impact (FONSI) for issuance of organized group permits for day time use of the Hole-in-the-Rock and nearby Dance Hall Rock sites, as well as overnight camping in the Grand Staircase-Escalante National Monument and Glen Canyon (DOI-BLM-UT-0300-2010-0008-EA).

SOCIOECONOMICS

This section describes current social and economic conditions that could potentially be affected by the proposed alternatives. The social and economic conditions of a region are characterized by its demographic composition, the structure and size of its economy, and the types and levels of services and social qualities and factors available to its citizens. Glen Canyon provides recreational opportunities, quality of life, and other amenities to both visitors and residents in the region.

Glen Canyon provides recreational opportunities, quality of life, and other amenities to both visitors and residents in the region.

SOCIOECONOMIC AREA OF CONSIDERATION

Glen Canyon lies in five counties: Coconino County, Arizona, and Garfield, Kane, San Juan, and Wayne counties, Utah. A labor analysis conducted through the U.S. Census Bureau's "LED on the Map" tool revealed that the labor market for this region should include additional counties where residents live and commute to jobs in the counties that encompass the Glen Canyon National Recreation Area. Each county was assessed through the "LED on the Map" tool (U.S. Census 2008).

Counties that account for at least 60% of the workforce in the counties encompassing Glen Canyon were included: Coconino County, Arizona, and Kane, San Juan, and Wayne counties in Utah. However, in Garfield County, Utah, only 30.3% of the jobs were held by Garfield County residents. Some members of the Garfield County workforce also reside in Washington County (11.3%), Iron County (11.3%), and Sevier County, Utah (11.0%). When combined with Garfield County, these three counties accounted for approximately 63.9% of the labor force in Garfield County. Therefore, Sevier, Washington, and Iron counties are also included in this socioeconomic study area because these counties could be affected by socioeconomic events in the counties encompassing Glen Canyon.

The communities adjacent to Glen Canyon are primarily rural. Although formerly dependent on natural resource and extractive industries, the communities adjacent to Glen Canyon have long since diversified their economies. Tourism, service, and trade sectors have grown in the economy, supporting job creation, the local tax base, and overall economic growth in the region.

The towns through which most tourists travel on the way to Glen Canyon include the following:

- Page, Arizona, on Highway 98
- Kanab and Big Water, Utah, on Highway 89
- Escalante and Boulder, Utah, on Highway 12
- Hanksville, Utah, on Highway 276
- Bluff and Blanding, Utah, on Highway 191
- Mexican Hat, Utah, on Highway 163

These are gateway communities into Glen Canyon, and will be further described in the sections below.

DEMOGRAPHICS

Glen Canyon lies in a sparsely populated region predominantly encompassing the southeastern region of Utah and a small portion of far north-central Arizona. The closest large cities are Flagstaff, Arizona (in Coconino County), with a population of 60,222 in 2008 (U.S. Census 2010a), approximately 135 miles south of Glen Canyon; and St. George, Utah (in Washington County), with a population of 72,718 in 2008 (U.S. Census 2010a), approximately 110 miles east of Glen Canyon.

The nearest major population centers are Phoenix, Mesa, and Scottsdale, Arizona, with a combined population of more than 4 million (U.S. Census 2008), approximately 225 miles south of Glen Canyon; and Salt Lake City–Ogden–Clearfield, Utah, with a population of over 1.6 million (U.S. Census 2008), approximately 185 miles northwest of Glen Canyon.

Demographic information in the study area states and counties are summarized in table 19 and are described in more detail in the sections that follow. Additionally, as described in chapter 1, the proposed action would not have disproportionate health or environmental impacts on minority or low-income populations or communities as defined in the Environmental Protection Agency's Environmental Justice Guidance (EPA 1998). Therefore, environmental justice was dismissed as an impact topic and is not being carried forward in this analysis.

ARIZONA

The Arizona portion of Glen Canyon is in Coconino County, Arizona. Coconino County encompasses 18,617 square miles and, by land area, is the largest county in Arizona. Flagstaff, about 135 miles south of Glen Canyon Dam and Lake Powell, is the county seat and the largest city in Coconino County.

In 2000, the population of Coconino County was 116,320 people, and in 2008 it grew to 128,558, reflecting a 10.5% increase. Over the same period, the population of Arizona expanded by 25.8%. As of 2008, only 2.0% of Arizona's total population of 6,500,180 people resided in Coconino County (U.S. Census 2010c). Coconino County is quite rural in nature, with 6.9 people per square mile. By contrast, the population density in Arizona overall was 57 people per square mile. In 2010, 63.4% of Coconino County's population was identified as white. American Indians and Alaskan Natives constituted 28.2% of the population. The remaining 8.4% of the population identified other ethnic backgrounds (U.S. Census 2010d).

In Coconino County, per capita personal income was $31,855 (2007$). This figure is about 2% below Arizona's 2007 per capita personal income of $32,833 (BEA 2010a).

Trends: Arizona was the second-fastest-growing state in the United States from 2000 to 2008, with a population growth of 26% during this period (U.S. Census 2010e). For the period 2006 to 2008, the state population grew by 3.7%, giving Arizona the third-largest percent growth of any state for that period (U.S. Census 2010e). Coconino County had the ninth-fastest-growing population of any of Arizona's 15 counties for the period 2000 to 2008, growing 10.5% (U.S. Census 2010c). For the period 2006 to 2008, the Coconino County population grew 2.1%, giving it the tenth-largest percent growth of any Arizona county for that period (U.S. Census 2010c).

TABLE 19: DEMOGRAPHIC CHARACTERISTICS FOR THE STUDY AREA

Demographic Characteristics	Utah	Garfield County	Iron County	Kane County	San Juan County	Sevier County	Washington County	Wayne County	Arizona	Coconino County
Population est. in 2008[a]	2,727,343	4,658	44,540	6,577	15,055	20,014	137,589	2,589	6,499,377	128,558
Percent of State 2008 Population	-	0.2%	1.6%	0.2%	0.6%	0.7%	5.0%	0.1%	-	2.0%
Population in 2000[a]	2,244,314	4,748	33,992	6,079	14,373	18,868	91,254	2,529	5,166,697	
Percent Change 2000 to 2008[a]	21.5%	–1.9%	31.0%	8.2%	4.8%	6.1%	50.8%	2.4%	25.8%	10.5%
Race / Ethnicity Composition 2000[b]										
White	89.2%	96.2%	93.1%	96.8%	40.6%	95.9%	93.7%	97.8%	75.5%	63.4%
American Indian or Alaskan Native	1.3%	1.3%	1.9%	0.9%	56.6%	1.7%	1.0%	0.7%	4.9%	28.2%
Other Backgrounds	9.5%	2.5%	5.0%	2.3%	2.8%	2.4%	5.4%	1.5%	19.6%	8.4%
Hispanic or Latino	9.0%	1.9%	4.0%	3.0%	3.1%	2.5%	5.0%	1.5%	25.3%	10.9%
Per Capita Personal Income in 2007[c, d]	$29,831	$24,167	$21,103	$29,663	$17,170	$23,081	$24,014	$23,610	$32,833	$31,855
Land Area (square miles)[e]	82,168.1	5,174.5	8,543.1	3,992.2	7,820.7	4,947.9	6,286.4	2,460.5	113,642.2	18,619.1
Persons per Square Mile in 2008	33	1	5	2	2	4	22	1	57	7

[a] U.S. Census 2010c.

[b] U.S. Census 2010d.

[c] BEA 2010a, 2010b.

[d] Personal income figures are reported in 2007 dollars, adjusted with the GDP deflators (OMB 2010).

[e] U.S. Census 2000.

Arizona Gateway Communities: The gateway community to Glen Canyon in the state of Arizona is the City of Page. This city was established in 1957 to provide housing for workers during the construction of Glen Canyon Dam and has evolved into a gateway community for Glen Canyon. The 2008 U.S. Census population estimate for Page was 6,928, whereas the 2000 population estimate was 6,819, reflecting population growth of only 1.5% during this time period (U.S. Census 2010a).

The per capita income in Page was $22,703 (2009$) for the period 2005 to 2009, below the Arizona average of $25,203 (U.S. Census 2010g). Tourism and power generation are the largest sources of revenue in Page. The largest employers are Lake Powell Resorts and Marinas, the Navajo Generating Station, and the Page Unified School District (Cobb pers. comm. 2011).

The City of Page is adjacent to the Navajo Indian Reservation, the largest American Indian reservation by land area in the United States. The Navajo people represent the largest segment of the population in the Glen Canyon area. Their reservation adjacent to Page contains more than 16 million acres (25,000 square miles) and extends into both Utah and New Mexico. The Navajo Indian Reservation and its off-reservation trust land were home to 181,269 people in 2000 (U.S. Census 2010f).

UTAH

The Utah portion of the study area includes seven counties: Garfield, Iron, Kane, San Juan, Sevier, Wayne, and Washington. These areas are sparsely populated, all having population densities of five or fewer people per square mile. Washington County, which includes the city of St. George, is the only exception, at 22 people per square mile in 2008 (U.S. Census 2000, 2010c). These counties are surrounded by federal lands, including several popular national park system units, as well as lands administered by the BLM and the U.S. Forest Service.

The seven-county Utah region had a 2008 population of 231,022. Iron, Kane, San Juan, Sevier, Wayne, and Washington counties recorded population growth between 2000 and 2008, whereas Garfield recorded a decline. Iron and Washington counties had a higher population growth rate than any of the other counties, with Washington County growing by over 50% from 2000 to 2008 (U.S. Census 2010c).

In San Juan County, which includes part of the Navajo Indian Reservation, nearly 56.6% of the population is American Indian or Alaskan Native, and 40.6% is reported to be white. The other six counties were predominantly white, reporting at least 93% of all residents as white (U.S. Census 2010d).

The highest per capita income in the Utah region was Kane County, at $29,663. The lowest was San Juan County, at $17,170. The Utah state average per capita income in 2007 was $29,831 (BEA 2010b). All per capita income figures are reported in 2007 dollars.

The largest population center located in the Utah portion of the study area is St. George, Utah, in Washington County, with a population of 72,718 in 2008. The next-largest population center is Cedar City, Utah, in Iron County, with a population of 28,667 in 2008 (U.S. Census 2010b). Communities that are close to the Utah portion of Glen Canyon include Big Water, Blanding, Boulder, Escalante, Hanksville, Kanab, Mexican Hat, and Monticello, many of which are considered gateway communities.

Trends: Utah was the third-fastest-growing state in the United States from 2000 to 2008, with a population increase of 21.5% (U.S. Census 2010e). Washington County was the fastest-growing of all counties in the study area for the period 2000 to 2008, with a percent population change of more than 50% (U.S. Census 2010c).

Utah projects continued population growth through 2060, up to 6.8 million citizens, more than double the current population. Population growth is projected to slow down, with the annual projected growth rate decreasing from 2.7% in 2010 to 1.3% by 2060 (Utah Governor's Office of Planning and Budget 2008). Population growth across the state has been slowing as a result of the economic downturn. As such, it is possible that the population projection figures overestimate the future population growth in Utah.

Utah Gateway Communities: The town of Hanksville (Wayne County), the city of Blanding and towns of Bluff and Mexican Hat (San Juan County), the towns of Escalante and Boulder (Garfield County), and the towns of Big Water and Kanab (Kane County are Utah gateway communities to Glen Canyon. Hanksville, Blanding, Bluff and Mexican Hat are gateways to uplake destinations, including Glen Canyon's Bullfrog, Halls Crossing, and Hite developed areas. Escalante, Boulder, Kanab, and Big Water serve as gateways to the Escalante region and southwestern sections of Glen Canyon. For the location of these areas, see the vicinity map (figure 1 in chapter 1). Some of these gateway communities are described in this section.

The economy of Hanksville has depended and still depends on mining and ranching. Visitation to Lake Powell and other federal lands is important to the small town of Hanksville (Wine pers. comm. 2011). The town, with an estimated population of 204 in 2008 (U.S. Census 2010b), has some lodging, restaurants, and a small store. Hanksville is 45 road miles north of Hite, 68 miles north of Bullfrog, and 70 miles north of Halls Crossing.

Blanding, with a population of 3,290 in 2008 (U.S. Census 2010b), depends economically on tourism and government institutions, including the state-operated Utah State University Eastern. Additionally, a uranium manufacturing plant and a gallium manufacturing plant are major employers in the area, along with the Four Corners Regional Health Care Center, which is the healthcare provider for southeastern Utah (Webb pers. comm. 2011). Because Blanding is located near Lake Powell and many other natural attractions (for example, Natural Bridges and Hovenweep National Monuments, Goosenecks and Edge of the Cedars State Parks, and Monument Valley Navajo Tribal Park), it has a range of lodging, restaurants, and other visitor-oriented business establishments. At least two ATV tour companies operate in Blanding. Blanding, along with Monticello, is host to the annual San Juan ATV Safari, a three-day ATV trail ride that is a popular event. Blanding is also host to the Arch Canyon Jeep Jamboree, an event sponsored by Jeep-Chrysler. Bluff, located 26 miles south of Blanding, had a population of 320 in 2000. Mexican Hat, population of 88, is located southwest of Bluff.

The population of Escalante in 2008 was 763 (U.S. Census 2010b). Escalante provides visitor services to tourists and recreationists seeking access to the BLM-administered Grand Staircase–Escalante National Monument and the Escalante region of Glen Canyon. Escalante provides access to the Hole-in-the-Rock Road, a significant cultural and recreational resource in Grand Staircase–Escalante and Glen Canyon. Escalante also serves as an access point to a number of backcountry roads that cross Grand Staircase–Escalante into Glen Canyon. Escalante is home to an outdoor sporting goods store, several backcountry recreation outfitters, a number of small inns and lodges, two hotels, and other services. An ATV rental business operates out of Escalante. Boulder, Utah is located 29 miles northeast of Escalante, with a population of 180.

Big Water, Utah, is a small community whose population was 406 in 2008 (U.S. Census 2010b). It is located approximately 18 miles north of Page, Arizona. Originally called Glen Canyon City, the town housed workers who constructed Glen Canyon Dam. Big Water is home to several boat storage businesses that serve Lake Powell visitors. Big Water provides access to a network of backcountry roads that transect Grand Staircase–Escalante and Glen Canyon and connect with the town of Escalante to the north. Kanab, located approximately 57 miles west of Big Water, is home to 3,564 residents in 2000.

EMPLOYMENT

Government is a major employer in the study area, accounting for at least 15% of employment in all counties except Washington County. Government employment in Washington County accounted for 11% of the total. It is notable that Washington County is the farthest county from Glen Canyon and is also the most urban in nature. Of all the counties in the study area, San Juan County had the highest proportion of government employment, at 27%. Most of the government employment in the study area is associated with state and local governments, generally with the proportion of employment by local governments higher than that of state governments. With the exception of Washington County, for which retail trade is the largest category of employment, all the counties in the study area have a higher proportion of government employment than their respective states; in 2009, government employment in Utah was 14.3%, and in Arizona it was 14.1%.

Industries related to tourism include accommodation and food services; retail trade; and arts, entertainment, and recreation. These industries were very important in Garfield County (36.4% of total employment) and in Wayne County (24.5% of total employment). Notably, four of the gateway communities are found in these counties, which suggest that visitor spending associated with Glen Canyon is important to the counties' economies. Accommodation and food services accounted for at least 7% of total employment in all study area counties. Employment in arts, entertainment, and recreation in the Utah counties, with the exception of San Juan and Sevier Counties, was comparable with the Utah state total of 2%. Employment in this industry in San Juan and Sevier Counties was approximately 1% of total employment. However, Coconino County in Arizona had a slightly higher proportion of its employment in arts, entertainment, and recreation than did the state: 3.8% in the county compared to 2% in the state. Retail trade was an important source of employment throughout the study area, with at least 8% of employment in retail sectors in all counties. Of all the study area counties, Sevier County had the highest proportion of retail trade (15.0%).

Healthcare employment data was not available for all counties; however, healthcare is also an important employing industry, generally accounting for 8% to 12% of all employment for counties that report these data.

The size of other industries varied across the study area. Farm employment accounted for approximately 9% of total employment in Garfield County, 12.9% in Wayne County, and 11.2% in San Juan County, but was not otherwise an important employer in other counties in the study area. Mining was an important industry in San Juan and Sevier Counties, both accounting for approximately 6% and 5% of total employment, respectively. Most other industries represented less than 5% of the counties' respective total employment.

Employment by industry in the study area for the year 2009 is summarized in table 20. Note that the percentages in a column may not add up to 100% due to missing data for some industry.

TABLE 20: EMPLOYMENT BY INDUSTRY IN THE STUDY AREA (2009)

Industry	Utah	Garfield County	Iron County	Kane County	San Juan County	Sevier County	Washington County	Wayne County	Arizona	Coconino County
Total Employment	1,622,518	3,394	23,087	4,395	6,376	11,191	68,930	1,672	3,217,666	82,367
Accommodation and Food Services	6.16%	25.87%	7.23%	20.59%	10.76%	8.40%	9.04%	13.64%	7.43%	13.84%
Administrative and Waste Services	5.22%	ND	4.92%	1.96%	2.71%	2.19%	4.52%	ND	7.74%	3.04%
Arts, Entertainment, and Recreation	2.13%	2.36%	2.46%	1.82%	1.13%	0.72%	2.33%	2.51%	2.13%	3.77%
Construction	6.15%	3.42%	7.28%	5.16%	4.81%	5.17%	8.88%	8.07%	5.63%	4.61%
Educational Services	2.83%	ND	1.26%	ND	ND	ND	1.19%	ND	1.90%	1.25%
Farm Employment	1.16%	8.78%	2.84%	3.07%	11.17%	6.09%	0.79%	12.86%	0.84%	1.99%
Finance and Insurance	6.88%	ND	5.83%	3.53%	2.62%	3.03%	6.30%	ND	6.00%	2.61%
Forestry, Fishing, and Related Activities	0.20%	ND	ND	ND	ND	ND	ND	ND	0.47%	0.31%
Healthcare and Social Assistance	8.31%	ND	8.26%	ND	ND	ND	12.11%	ND	10.23%	10.80%
Information	2.16%	ND	0.87%	0.57%	0.19%	0.87%	ND	ND	1.52%	0.92%
Management of Companies and Enterprises	1.31%	0.00%	0.39%	0.00%	ND	0.26%	0.49%	0.00%	0.92%	0.15%
Manufacturing	7.36%	2.06%	6.80%	3.44%	3.20%	3.48%	3.62%	1.32%	5.06%	5.13%
Mining	0.92%	ND	ND	ND	5.93%	5.43%	0.59%	ND	0.60%	0.42%
Other Services, Except Public Administration	5.12%	3.42%	5.52%	14.72%	4.75%	5.42%	5.53%	4.13%	5.05%	4.86%
Professional, Scientific, and Technical Services	6.59%	2.03%	4.47%	2.50%	ND	3.65%	5.23%	ND	6.44%	4.67%
Real Estate and Rental and Leasing	5.66%	ND	6.25%	5.03%	2.35%	3.48%	6.88%	1.91%	5.98%	5.80%

Industry	Utah	Garfield County	Iron County	Kane County	San Juan County	Sevier County	Washington County	Wayne County	Arizona	Coconino County
Retail Trade	10.89%	8.13%	11.62%	10.81%	7.59%	14.97%	12.85%	8.37%	11.24%	10.99%
Transportation and Warehousing	3.22%	ND	2.07%	ND	1.73%	9.36%	4.77%	ND	2.79%	2.60%
Utilities	0.28%	ND	0.42%	ND	ND	ND	0.19%	ND	0.40%	0.14%
Wholesale Trade	3.18%	1.41%	1.56%	1.02%	ND	ND	2.09%	1.73%	3.52%	1.43%
Government and Government Enterprises	14.29%	17.91%	18.84%	17.04%	26.76%	15.48%	11.00%	17.58%	14.10%	20.67%
Federal, Civilian	2.24%	5.22%	1.51%	2.34%	2.60%	1.84%	0.80%	6.04%	1.77%	3.70%
Military	1.05%	0.59%	0.87%	0.66%	1.04%	0.79%	0.88%	0.66%	1.07%	0.35%
State Government	4.07%	2.15%	7.77%	1.46%	6.09%	2.92%	1.79%	1.32%	2.67%	7.06%
Local Government	6.93%	9.96%	8.69%	12.58%	17.03%	9.93%	7.53%	9.57%	8.59%	9.56%

Source: BEA 2011.

ND = No data available.

UNEMPLOYMENT

Table 21 summarizes unemployment rates in the study area, Utah, Arizona, and the United States, for the years 2000, 2008, and 2010. Arizona's unemployment rate rose by 6.0% from 2000 to 2010, whereas Utah's unemployment rate rose 4.3% over the same period of time. In 2008, unemployment rates in Garfield, San Juan, and Sevier Counties were lower than their respective 2000 rates, but unemployment rates increased for all counties in the study area over the 10-year period from 2008 to 2010.

TABLE 21: UNEMPLOYMENT RATES (PERCENT OF LABOR FORCE)

Area	2000	2008	2010
Arizona	4.0%	5.5%	10.0%
Coconino County	4.5%	5.1%	8.9%
Utah	3.4%	3.4%	7.7%
Garfield County	6.8%	5.9%	10.3%
Kane County	3.8%	4.0%	8.2%
Iron County	3.3%	4.2%	9.6%
San Juan County	8.0%	6.0%	13.3%
Sevier County	3.9%	3.8%	8.3%
Washington County	3.5%	4.6%	10.1%
Wayne County	4.6%	5.3%	9.3%
United States	4.0%	5.8%	9.6%

Source: BLS 2010a, 2010b, 2010c.

The rise in the unemployment rate in the study area follows the same general trend as that of the nation between the years 2000 and 2010.

ECONOMIC CONTRIBUTIONS TO LOCAL ECONOMIES

Visitors to Glen Canyon and the surrounding public lands contribute to local economies by spending money at local and regional businesses on lodging, gasoline, food, permits and fees, and souvenirs. These expenditures create jobs and income that, in turn, create secondary economic impacts. This section analyzes general tourism and travel spending in the study area, visitor spending and NPS payroll associated with Glen Canyon, and the economic contribution of ORV/ATV activities.

ECONOMIC CONTRIBUTIONS OF TRAVEL AND TOURISM ACTIVITIES

Travel and tourism visitor spending in the eight-county region is provided in table 22. Coconino County accounts for nearly half of all travel- and tourism-related visitor spending in the study area. Washington County accounts for almost 27% of visitor spending on the region, followed by Garfield and Iron counties, with 7.8% and 7.5% respectively.

TABLE 22: 2006 DIRECT TRAVEL AND TOURISM IMPACTS—VISITOR SPENDING IN THE STUDY AREA

County	Direct Visitor Spending	Percentage of Total Study Area Visitor Spending
Arizona		
Coconino	$870,000,000	44.8%
Utah		
Garfield	$151,544,908	7.8%
Iron	$146,191,632	7.5%
Kane	$99,127,314	5.1%
San Juan	$71,242,554	3.7%
Sevier	$60,070,251	3.1%
Washington	$513,894,657	26.5%
Wayne	$28,866,267	1.5%
Total	$1,940,937,583	100%

Sources: Dean Runyan Associates 2009; Utah Office of Tourism 2006.
Note: All monetary values in this table are in 2008 U.S. dollars.

ECONOMIC CONTRIBUTIONS OF GLEN CANYON NATIONAL RECREATION AREA

Glen Canyon contributes to local economies in several ways. First, it provides jobs to Glen Canyon employees, including seasonal, term, and permanent full-time or part-time positions. Glen Canyon employees spend their income and wages in the local economies, which support jobs, income, and gross regional product in the area. In 2010, Glen Canyon employed 182 employees, who supported an additional 27 jobs in the local economy, for a total of 209 jobs.[9] This payroll spending contributes to the value added,[10] or the region's gross regional product, by an estimated $12.5 million (Stynes 2011). These payroll benefits are summarized in table 23. Glen Canyon may also support the local economy if local vendors are used, through contracted construction services or purchases of supplies and materials, for example, although these figures are not assessed in this "Socioeconomics" section.

[9] The local economy or local regions are defined as a 50-mile radius around the recreation area, which is the primary impact region around most parks. Economic multipliers are based on regions or areas defined as groupings of counties to approximate a 50-mile radius of the recreation area (Stynes 2011).

[10] Value added, also known as gross regional product, is defined as gross output (sales or receipts and other operating income, plus inventory change) minus intermediate inputs (consumption of goods and services purchased from other industries or imported). Value added consists of compensation of employees, taxes on production and imports less subsidies (formerly indirect business taxes and nontax payments), and gross operating surplus.

TABLE 23: 2010 GLEN CANYON NATIONAL RECREATION AREA PAYROLL SPENDING IMPACTS

NPS Payroll and Impacts	NPS	Total (NPS and Supporting Jobs and Income)
Jobs	182	209
Labor Income (Payroll and Benefits)	$10,721,000	$11,615,000
Total Value Added (Gross Regional Product)	NA	$12,528,000

Source: Stynes 2011.

Note: All monetary values in this table are in 2010 U.S. dollars.

NA = not applicable.

Second, Glen Canyon attracts a large number of visitors, many from outside the region. These visitors consume from local businesses, such as restaurants, hotels, and retail outlets, during their visits in communities surrounding Glen Canyon, contributing to local economies. The economic contribution of the visitor spending is a function of how many visitors arrive and how much money they spend while visiting. Visitor spending benefits for Glen Canyon have been estimated by Stynes (2011) and Cui, Mahoney, and Herbowicz (2013) and are summarized in table 24.

TABLE 24: TOTAL VISITOR SPENDING AND IMPACTS

Impact	Total Amount (2009)	Total Amount (2011)
Spending by All Visitors	$181,609,000	$233,895,000
Labor Income Generated	$68,395,000	$88,152,000
Gross Regional Product	$100,298,000	$138,044,000
Jobs Supported in Local Economy	2,278	2,755

Source: Stynes 2011; Cui, Mahoney, and Herbowicz 2013.

Note: Monetary values in this table are in 2009 U.S. dollars and 2011 U.S. dollars.

Glen Canyon had a total of 2,124,467 recreational visits in 2010, and in 2009, visitation was slightly less, at 1,960,345 (NPS Public Use Statistics Office 2010; Stynes 2011). Recreation visits for 2011 are 2,270,817, approximately 150,000 more than in 2010 (Cui, Mahoney, and Herbowicz 2013). Overnight stays in 2009 were 1,580,992, or approximately 80% of recreational visits. Total spending associated with Glen Canyon visitation in 2011 was estimated to be $233,895,000, all of which was spent by nonlocal visitors. The total labor income generated by this spending was over $88,152,000, and the gross regional product was $138,044,000. This economic activity supported 2,755 jobs in the local economy (Cui, Mahoney, and Herbowicz 2013).

In 2006, total visitor spending in the eight counties was estimated to be $1.9 billion. Visitor spending for Glen Canyon was estimated to be $152,205,000 in 2009 (Stynes 2011), which represents approximately 7.3% of total visitor spending in the study area in 2009 dollars.[11]

Total employment in the seven-county study area (see "Employment") in 2009 was 201,412, while employment in the five-county regions in which Glen Canyon lies was 98,204. Employment associated with Glen Canyon in 2010 was estimated to be 209 for employment and 2,278 for visitor spending, for a total of 2,487 jobs. This employment

[11] $1.9 billion is in 2006 dollars. This amount, when converted to 2009 dollars, is $2.1 billion. This allows for the comparison of 2009 visitor spending, which is in 2009 dollars, with the total visitor spending of all eight counties, which is in 2006 dollars.

from 2010 represents approximately 1.2% and 2.5% of the 2009 employment that existed in the seven-county and five-county areas, respectively.

ECONOMIC CONTRIBUTIONS OF OFF-ROAD VEHICLE RECREATION

A number of economic surveys have documented the investments that ORV/ATV owners make to purchase vehicles and related equipment, and to maintain and operate them (Otto 2008; Stynes 2000; Reed and Haas 1989; the Louis Berger Group 2009; Keith et al. 2008). Additional expenditures occur when ORV owners take trips away from home. Communities bordering public ORV areas benefit economically from these trip-related expenditures.

Stynes (2000) has estimated the spending and economic impacts that occur from ORV/ATV trips on Michigan's public trail system. He reported that in 1998/1999, ORV/ATV users spent $264 per party per trip en route and at their destination. Spending on lodging, restaurants, and food accounted for the three largest expenditures at the destination. A similar study in Minnesota reported that direct residential ATV-related expenditures totaled approximately $642 million in 2005. This includes money spent on ATV trips, with groceries constituting the largest share of the cost per trip, and does not include the price of vehicle purchase. Approximately 41% of this total ($260.3 million) was spent at the destination area in the state, and 48.6% ($311.8 million) was spent at home and en route to the destination (Schneider and Schoenecker 2006).

A study documenting the economic contribution of ORV/ATV recreation in the state of Colorado found that, statewide, ORV/ATV users spent approximately $541 million on trip expenditures (spending between $120 and $620 per trip), and $241 million on vehicle-related expenditures such as vehicle purchases, maintenance, and equipment, in the 2007/2008 season (figures are in 2007 dollars; The Louis Berger Group, Inc., 2009). This generated over 10,000 jobs, and $294 million in labor income, for the state of Colorado during that period of time.

An internal U.S. Forest Service memorandum highlighted how developing ATV recreation opportunities can affect adjacent communities (Reid 2004). The Paiute ATV Trail is a 275-mile loop trail located in south-central Utah. Established in 1990, it has grown into a popular destination for ATV riders, and in 2004 attracted over 72,000 users. According to the memorandum, in 2003 the trail brought in over $7 million in revenues to local economies. Five new ATV rental and outfitter businesses have been established and numerous side businesses, including an 80-unit campground that caters to users of the Paiute Trail, have been opened since the inception of the Paiute ATV Trail.

Arizona has documented the economic importance of ORV recreation to state and local economies. Arizona State Parks reported that ORV/ATV use contributed in excess of $4 billion in annual economic activity through direct expenditures for vehicles, equipment, and other costs related to ORV/ATV trips (Arizona 2003). All the figures from Arizona (2003) are expressed here in inflation-adjusted 2007 dollars (OMB 2010). According to the study, which only included expenditures made by Arizona residents, total ORV/ATV expenditures in Coconino County included $122.3 million for vehicles and equipment, and $119.5 million in trip-related expenditures. Of the $119.5 million in trip-related expenditures, $86 million (72%) came from other Arizona residents traveling to Coconino County. ORV/ATV recreation expenditures in the county, including trip-related, vehicle, and equipment expenditures, supported 2,580 jobs and $58 million in income for county residents, and contributed $11.8 million in state tax revenues. Using an economic multiplier, the study concluded that ORV/ATV recreation in Coconino County resulted in a total economic impact (i.e., total sales or revenues) of $289.8 million.

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A Utah study for the Governor's Public Lands Policy Coordination Office indicates that the number of registered ORV/ATV owners in Utah has risen 233% over the past decade to more than 170,000 in 2006 (Keith et al. 2008). ORV/ATV visitation in the four Utah counties in which Glen Canyon is located accounted for a total of 111,500 trips during a 12-month period in 2006 and 2007. Kane County had the largest number: over 49,000 trips. Trip expenditures were used to estimate the economic impacts on local economies. The authors indicate that ORV/ATV expenditures are a very small part of the regional economies, never exceeding more than 1.5% of total employment, income, value added, or economic output (sales). As part of the study, the authors projected the change in ORV/ATV trips by county associated with proposed changes in BLM policies. The results generally indicate that there would be decreases in ORV/ATV trips in eastern and southeastern Utah and increases in trips in northern and western Utah. The estimated decrease in trips for the four Utah counties range from 2.7% in Kane County to a 17.0% decrease in trips to Wayne County. The change in trips does not exceed 0.1% for any economic measure within any of these counties (Keith et al. 2008).

HEALTH AND SAFETY

The protection and safety of human life takes precedence over all other management actions in NPS.

The protection and safety of human life takes precedence over all other management actions in the Park Service. Under Section 8.2.5 of NPS *Management Policies 2006* (NPS 2006a), the Park Service recognizes that both recreational activities and Glen Canyon resources that attract visitors can pose a significant risk to visitors. Visitors assume the risk and responsibility for their own safety when visiting areas that are managed and maintained as natural, cultural, or recreational environments. According to a Utah State University study, the vast majority of ORV trips involve ATVs. Off-highway motorcycles are a distant second, and other 4-wheel-drive vehicles that are not street-legal, dune buggies, and sand rails represent an even smaller percent of Utah's off-road use (Burr et al. 2008).

Public health and safety facilities in the area are located at Bullfrog, Halls Crossing, and Hite. The uplake district ranger's office at Bullfrog coordinates law enforcement and emergency response, fire protection, and visitor information for all three developed areas. Rangers are assigned to Bullfrog, Halls Crossing, and Hite subdistricts. Jurisdiction for handling public safety issues (i.e., law enforcement) is managed by NPS rangers, although other law enforcement entities may also respond. The Bullfrog medical clinic provides emergency care through a staff of physician's assistants and ranger staff. The skill level of clinic staff varies from first responders to emergency medical technicians and paramedics (NPS 2006b). A permanent helipad is located at Bullfrog for emergency events (NPS 2009c).

ALL-TERRAIN VEHICLE–RELATED INJURIES AND FATALITIES

NPS is concerned with safety issues connected with on- and off-road motor vehicle use. ATVs have been the subject of inquiries and actions by the Consumer Product Safety Commission due to their injury and accident record. The Consumer Product Safety Commission reports that the number of deaths and injuries associated with ATV use has increased since 1982. Nationwide, a total of 11,688 ATV-related deaths occurred between 1982 and 2011 (CPSC 2013). From 1982 to 2011, in the state of Arizona 252 deaths occurred resulting from an ATV-related injury, and 207 deaths occurred in Utah. California is ranked as the state with the highest amount of fatalities, with 628 ATV-related deaths reported between 1982 and 2011. Arizona is ranked as the 19th state in reported ATV-

related fatalities, and Utah is ranked 24th (CPSC 2013). Table 25 shows ATV-related fatality numbers for Arizona and Utah.

TABLE 25: REPORTED ALL-TERRAIN VEHICLE–RELATED FATALITIES IN ARIZONA AND UTAH (JANUARY 1, 1982–DECEMBER 31, 2011)

	Reported Deaths 1982–2007	Reported Deaths 2008–2011	Total Reported Deaths 1982–2011
Arizona	210	42	252
Utah	159	48	207
Total	369	90	459

Source: CPSC 2013.

Note: Includes ATVs with three, four, or an unknown number of wheels.

According to the report, an estimated 25% of the reported fatalities during the same period were people under the age of 16 years, and 10% were under 12 years of age (CPSC 2013).

Table 26 shows estimates of ATV-related injuries treated in hospital emergency departments between 2000 and 2011. Since 2008, there has been a decrease in emergency-treated injuries of all ages. However, data showed that there was a significant increase in ATV-related injuries from 2000 to 2007.

TABLE 26: ANNUAL ESTIMATES OF ALL-TERRAIN VEHICLE–RELATED EMERGENCY DEPARTMENT–TREATED INJURIES (JANUARY 1, 2001–DECEMBER 31, 2011)

Year	Estimated Number of Injuries: All Ages	Estimated Number of Injuries: Younger than 16 years	Percentage of Total: Ages Younger than 16 years
2011	107,500	29,000	27
2010	115,000	28,300	25
2009	131,900	32,400	25
2008	135,100	37,700	28
2007	150,900	40,000	27
2006	146,600	39,300	27
2005	136,700	40,400	30
2004	136,100	44,700	33
2003	125,500	38,600	31
2002	113,900	37,100	33
2001	110,100	34,300	31
2000	92,200	32,000	35

Source: CPSC 2013.

Note: Includes ATVs with three, four, or an unknown number of wheels.

According to a news release from Utah State Parks, an average of 12 people die every year and 4,000 more are treated in emergency rooms for injuries suffered in ATV accidents. In 2002, the release noted, nearly 1,600 children were among those injured in accidents (Utah State Parks 2004). The release noted that many accidents were due to user failure to follow manufacturer instructions regarding the safe use of their vehicles.

OFF-ROAD VEHICLE–RELATED ACCIDENTS AND INJURIES AT GLEN CANYON

A review of incident reports from Glen Canyon reveals a low accident / personal injury rate related to ORV operation. Since 2000, 17 incident reports involving personal injury have been filed at Glen Canyon. Three of these incidents involved Glen Canyon staff; two incidents involved property damage to NPS vehicles and two incidents involved damage to personal property after an argument and an attempt to tow another vehicle from the sand; the remainder involved ATV accidents by recreationists at Lone Rock Beach, Lone Rock Beach Play Area, and in the Halls Crossing area (Sweatland pers. comm. 2010b; Carey pers. comm. 2013).

COMPLIANCE WITH GLEN CANYON RECREATION AREA RULES AND REGULATIONS

Compliance with Glen Canyon use rules and regulations is an important consideration for Glen Canyon management. These rules exist to protect resources and visitors alike from the harm that can be caused by inappropriate user behavior.

A review of available social research reveals that noncompliance is a finding common to many ORV user surveys. For example, in a 2006 survey of Montana ORV owners, Montana Fish, Wildlife, and Parks reported that 58% of survey respondents stated that they did not follow ORV user guidelines and traveled off established routes to retrieve game (Lewis and Paige 2006). In a study to test the effectiveness of a voluntary ORV compliance and education program in Colorado, two-thirds of adult ORV riders were found to occasionally ride off trail, even when they knew that this behavior was not "correct." An estimated 15% to 20% of ORV users "frequently" break the rules and often go off trail (Frueh and Monoghan and Associates 2001).

On-the-ground observations of ORV operators in other areas have noted compliance problems. Resource managers at California's Red Rock Canyon State Park found that illegal off-trail riding is a regularly occurring problem impacting routinely monitored archeological sites. They reported that ORV tracks in a riparian zone signposted as closed by the Glen Canyon were observed on every single visit by Glen Canyon staff (Sampson 2007).

In a study to develop an ORV monitoring program on the Dixie National Forest in Utah, researchers described as a "surprising finding" the number of occurrences of ORV encroachment and impacts on signposted hiking/bicycling/horse trails where off-road use clearly was prohibited. They further described "evidence that ORV users had taken extensive measures to access nonmotorized trails," including moving boulders, chainsawing trees, and otherwise purposely creating new trails around ORV traffic barriers (Divine and Foti 2004).

Similar ORV-user compliance problems were noted in a USFWS 2007 Federal Register notice on a proposed threatened and endangered species petition (72 FR 24260–24261). The USFWS cited a study by the BLM that had identified high levels of noncompliance with a voluntary route closure system. The USFWS stated that the BLM reported that 50% of noncompliance ORV intrusion points occurred at or near red Carsonite posts designed to discourage travel beyond the posts.

Tire Tracks Near "No Motor Vehicles"

In Glen Canyon, ATV users have been observed riding around "Road Closed" and "No ORV" signs. The presence of illegal off-road tracks, by both ATV and conventional 4-wheel-drive vehicles, are routinely observed during ranger patrols. A search of incident reports maintained by Glen Canyon reveals that from 2003 through October 2008, there were 224 off-road incidents reported by law enforcement staff. Not all incidents lead to citations, or even contact with the responsible individual(s). Incidents range from observations of off-road damage to a previously undisturbed area, to issuing citations for illegal off-road use, to incidents that lead to the impoundment of the offender's vehicle. Of the 224 cases, 75 resulted in NPS law enforcement personnel issuing at least one citation. A similar file search yielded a total of nine personal injury incidents (unspecified) in which there was an injury to an individual during the same period.

PALEONTOLOGICAL RESOURCES

Glen Canyon has a nearly complete record of Mesozoic rocks, with many geologic formations containing abundant and significant fossils.

Glen Canyon has a nearly complete record of Mesozoic rocks, with many geologic formations containing abundant and significant fossils. Paleontological resources at Glen Canyon are known from the Honaker Trail Formation (marine invertebrates), Halgaito Formation (bones), Cedar Mesa Sandstone (tetrapod tracks), Moenkopi Formation (tetrapod tracks), Chinle Formation (petrified wood, plant debris, bones, and dinosaur tracks), Wingate Sandstone (tracks), Kayenta Formation (tracks), Navajo Sandstone (trace fossils, bones, and wood), Page Sandstone (wood), Entrada Sandstone (tracks), Morrison Formation (a dinosaur track, bone fragments, and termite nests), Dakota Formation (coal and bivalves), Tropic Shale (marine invertebrates, fish, turtles, and marine reptiles), Straight Cliffs Formation (coal), and Quaternary deposits (plant matter, pollen, spores, bones, hair, dung, packrat middens, and tracks in alcoves) (Santucci et al. 2009).

Fossils have not yet been documented from the following rock units in Glen Canyon: Paradox Formation, Organ Rock Formation, De Chelly Sandstone, White Rim Sandstone, Carmel Formation, and Summerville Formation / Romana Sandstone. However, these formations are known to preserve fossils elsewhere, and future field investigations in Glen Canyon may recover fossils from one or more of them (Santucci et al. 2009).

PROTECTION OF FOSSIL RESOURCES

Intentional theft and vandalism through unauthorized collecting of fossils has been reported at Glen Canyon. The majority of these impacts have occurred with the collection of vertebrate tracks from the Orange Cliffs area and the collection of petrified wood from the Chinle Formation throughout the Glen Canyon National Recreation Area, especially along the shores of Lake Powell. Motorized vehicle access facilitates such unauthorized collection in more remote areas of Glen Canyon.

Protection of fossil resources involves active enforcement of laws and regulations, including the Paleontological Resources Protection Act of 2009 (PL 111-011) and periodic monitoring of known resources for assessment of existing and potential impact from erosion and other natural causes such as inundation by Lake Powell. The following recommendations, adopted with modifications from Santucci (1998), establish the basis for fossil protection in Glen Canyon National Recreation Area.

- Review Glen Canyon National Recreation Area records over the past decade related to paleontological theft or vandalism.

- Provide paleontological resource protection training for staff working in Glen Canyon National Recreation Area with fossiliferous exposures.

- Establish interagency cooperative efforts to protect fossils on public lands in the immediate area (e.g., other NPS parks, BLM, U.S. Army Corps of Engineers, Utah State and Institutional Trust Lands Administration).

- Offer public education for local and regional audiences on the importance of fossils on public lands and the need to manage these resources responsibly.

- Engage paleontologists and other field-oriented scientists (e.g., archeologists, geologists, biologists) in recognition and observation of fossils.

- Establish reciprocal training for field-based scientific activity that can benefit all disciplines. For example, training paleontologists to recognize rare and endangered species of immediate concern to the Glen Canyon National Recreation Area will help in conservation of those species and plotting their occurrence. Likewise, training field biologists to look for fossils or to locate fossils known or expected in their field areas will facilitate discovery and enhance management initiatives.

- Establish protocols and strategies for the proper permitting of paleontological research, including required mitigation needs, planning such as National Environmental Policy Act (NEPA) requirements, and appropriate curation procedures.

PALEONTOLOGICAL RESOURCES AT OFF-ROAD VEHICLE–ACCESSIBLE SHORELINES

A paleontological resources assessment was conducted by Clites (2011) that describes the sensitivity of several accessible shoreline areas in Glen Canyon. The resources assessment found that Lone Rock Beach and Lone Rock Beach Play Area contains no known paleontological sites. Fossils of plant material, mammal bones, and animal dung of many different types (including mammoth, shrub ox, mountain lion, and bison) may be present. No significant Pleistocene-age fossils are known to exist there. By contrast, abundant and widespread significant fossils are present in the Neskahi and Paiute Canyon area, such as petrified logs in the Neskahi Wash. Copper Canyon and Nokai Canyon cut through the Monitor Butte and Shinarump Conglomerate Members of the Chinle Formation, which contain extensive fossiliferous lacustrine deposits, abundant petrified logs, and a variety of invertebrate, leaf, and trace fossils. The primitive campground at Stanton Creek is set in the Carmel Formation. The campground road traverses aeolian and alluvial deposits with some significant but sporadic sites. The Farley Canyon campground is located on alluvial deposits, whereas the access road to this site is located on a bench formed by the Organ Rock Formation, occasionally passing through Quaternary deposits. The Organ Rock formation represents terrestrial conditions where Permian reptiles dominated the landscape and may contain reptile or reptile-related fossils. It is known to contain plant fossils and vertebrates. These include root casts in petrified soil horizons, ferns, and pteriodosperms, and conifer, fish, amphibian and reptile fossils. Common fossils may be abundant in the Quaternary deposits, but significant fossils are rare. Hite Boat Ramp and Dirty Devil campground are located amid

the Organ Rock Formation, which has yet to produce fossils within Glen Canyon boundaries. Paiute Farms is located in the Moenkopi Formation, which contains locally common tracks and traces.

The following sections have been condensed from the Glen Canyon National Recreation Area Paleontology Inventory Report (Santucci et al. 2009).

Hermosa Group: Honaker Trail Formation (Middle-Late Pennsylvanian)

The Honaker Trail Formation is composed of sandstone, limestone, and shale. At Glen Canyon, it is 100 to 1,300 feet (30 to 400 meters) thick, 550 feet (170 meters) on average, and is composed of gray to tan limestone with minor sandstone. Only the upper part of the formation is exposed, and only in northern Glen Canyon and the San Juan Arm. Honaker Trail Formation fossils include plants, algae, fusulinid foraminifera, other foraminifera, bryozoans, gastropods, crinoids, conodonts, and pellets. Fossils of the upper Honaker Trail Formation include algae, sponges, corals, bryozoans, brachiopods, bivalves, cephalopods, gastropods, trilobites and other arthropods, crinoids, and trace fossils (Santucci et al. 2009).

Cutler Group: Halgaito Formation / Rico Formation / Elephant Canyon Formation (Late Pennsylvanian–Early Permian)

The Halgaito / Rico / Elephant Canyon interval was deposited during the Late Pennsylvanian and Early Permian, sometime between 305 and 280 million years ago (Ma). Rocks include a mix of continental to nearshore sandstone, siltstone and conglomerate, and marine limestone. At Glen Canyon, this interval is 0 to 500 feet (0 to 150 meters) thick, 250 feet (75 meters) on average, and is composed of yellowish-tan to brown limestone and silty sandstone. Like the Honaker Trail Formation, it is only present in northern Glen Canyon and on the San Juan Arm (Santucci et al. 2009).

A vertebral "sail back" from the unusual temnospondyl amphibian *Platyhystrix* (an extinct early amphibian) was collected from the Halgaito Formation at the extreme eastern end of the San Juan Arm. Isolated bones and fragments are reported from aeolian sandstones, channel limestones, and conglomerates of the Halgaito Formation elsewhere in Glen Canyon. Fossils from sharks, crossopterygian fish (lobe-fins), early ray-finned fish, amphibians, early tetrapods, early diapsid reptiles (the group including lizards, snakes, and crocodilians), and pelycosaur synapsids (mammal-like reptiles) have also been collected from this unit. Fossils reported from the Halgaito Formation in general include seed ferns, lycopods, the tree-like horsetail *Calamites*, foraminifera, bivalves, gastropods, crinoids, echinoids, sharks, palaeoniscid and phyllodont fish, lungfish, crossopterygians, temnospondyl and aistopod (limbless) amphibians, anthracosaurs (reptile-like tetrapods), early diapsid reptiles, and several types of pelycosaurs, such as *Edaphosaurus*. Bones are largely limited to stream channels. Fossils reported from the Rico Formation include foraminifera, brachiopods, bivalves, gastropods, and crinoids. Fossils reported from the Elephant Canyon Formation include wood fragments, algal mats, foraminifera, corals, bryozoans, brachiopods, bivalves, gastropods, cephalopods, trilobites, echinoderms, invertebrate burrows, and palaeoniscid fish (Santucci et al. 2009).

Cutler Group: Cedar Mesa Sandstone (Early Permian)

The Cedar Mesa Sandstone is a marginal marine aeolian unit. At Glen Canyon, it is 700 to 1,400 feet (210 to 425 meters) thick, 1,100 feet (335 meters) on average, and is composed of yellowish-tan, brown, and red sandstone with minor siltstone and limestone. The Cedar Mesa Sandstone was deposited during the Early Permian, sometime between 299 and 280 Ma. It forms slickrock in northern Glen Canyon and on the San Juan Arm. Fossils are not common in the Cedar Mesa formation, but this formation has yielded critically important plant fossils that provide details of terrestrial plant species that existed here prior to the catastrophic extinction event at the end of the Permian period.

Three published track sites have been found in the Cedar Mesa Sandstone at Glen Canyon, with two more sites just outside its boundaries. The Dirty Devil site, now submerged, appears to preserve a predation event, with a larger animal catching a smaller animal. The other track sites are not as potentially dramatic. Synapsids (the group including pelycosaurs, other mammal relatives, and true mammals) were the primary track makers, leaving tracks similar to *Anomalopus* and *Chelichnus* (Santucci et al. 2009). This formation is exposed in the area of the Hite Boat Ramp.

MOENKOPI FORMATION (EARLY-MIDDLE TRIASSIC)

The Moenkopi formation contains the earliest record of Triassic flora and fauna of the southern Colorado Plateau. The fossil record represents the recovery stage following the catastrophic end-Permian extinction event that nearly extinguished all life on earth. Reptilian ancestors to dinosaurs and all other reptiles are contained in the Moenkopi formation. There is some evidence that the oldest dinosaurs in the world occur in this formation. The Moenkopi Formation is a heterogeneous unit present in several western states. In central and southeastern Utah, it was deposited on a coastal plain affected by two major marine transgressions and other smaller changes in sea level. At the northeast end of Glen Canyon, the Moenkopi Formation represents a fairly stable shelf. At Glen Canyon, it is 270 to 500 feet (80 to 150 meters) thick, 390 feet (120 meters) on average, and is composed of reddish-brown, yellow-gray, pale-green, and white beds of siltstone, sandstone, claystone, limestone, and conglomerate. This formation is exposed around the Hite Boat Ramp, on the eastern shores of Lake Powell in the San Juan Arm, and in the Escalante canyons of the northwestern part of Glen Canyon. The Moenkopi Formation dates to the Early and early-Middle Triassic, between approximately 250 and 240 Ma. It has been divided into several members, depending on location. In southeastern Utah, it was only divided relatively recently, aside from the Sinbad Limestone. At Glen Canyon the members that may be used are, from oldest to youngest, the Hoskinnini and rough equivalent Black Dragon, Sinbad Limestone, Torrey, and Moody Canyon Members (Santucci et al. 2009).

Fossils are not currently well known in the Black Dragon Member, but trace fossils are known. Fossil organisms of the Sinbad Limestone include stromatolites, algae, sponges, bivalves, gastropods, scaphopods, ammonites, ostracodes, crinoids, echinoids, conodonts, and trace fossils. The dominant fossils are microgastropods, which may have been opportunist species spreading after the Permian–Triassic extinction event.

Until recently, fossils from the Torrey Member have been uncommon, with only rushes, bivalves, ostracodes, fish scales, a labyrinthodont amphibian skull, and amphibian tracks reported. However, more extensive finds, particularly tracks and traces from invertebrates and vertebrates, have now been reported from the Torrey Member and equivalents at Glen Canyon. The depositional setting of these areas is interpreted as a broad flat coastal delta plain influenced by both tidal and fluvial processes. Tracks have been found as sandstone casts in mudstone. To date, reptile tracks are dominant, with horsetail molds, invertebrate trace fossils (such as those of millipedes and horseshoe crabs), fish fin marks, and fish bones also found. The Moody Canyon Member is similar to the Torrey Member, and has a similar trace fossil assemblage, at least in central and northern Utah (Santucci et al. 2009).

At least five track sites have been found in Moenkopi Formation rocks at Glen Canyon (Gillette and Newcomb 2009), at least some from the Torrey Member. Two have been published and include horseshoe crab tracks, swim traces, and lizard-like tracks; the horseshoe crab tracks are most abundant.

CHINLE FORMATION (LATE TRIASSIC)

The Late Triassic-age Chinle Formation (or Group) is an important fossiliferous unit of the southern Colorado Plateau. It is a heterogeneous terrestrial unit largely deposited in various fluvial and lacustrine settings, and is divisible into several members depending on location. In the Glen Canyon, these include from oldest to youngest the Shinarump, Monitor Butte, Moss Back, Petrified Forest, Owl Rock, and Church Rock Members, but these are often lumped together. At Glen Canyon, the Chinle Formation is 480 to 1,195 feet (145 to 365 meters) thick, 750 feet (230 meters) on average, and is composed of red, orange, purple, green, and dark-brown beds of sandstone,

mudstone, siltstone, claystone, limestone, and conglomerate. Its colorful, slope-forming beds are best exposed along Lake Powell. The Chinle Formation is particularly known for petrified wood and other plant fossils, and such fossils have been reported from Glen Canyon. Its exact age is uncertain, but its base predates 219 Ma, and its top predates the Triassic/Jurassic boundary (201.6 Ma) because this division is known to be in the overlying Wingate Sandstone (Santucci et al. 2009).

The most common fossils of the Shinarump Member are plants. Fossils from the Chinle Formation at Glen Canyon include petrified wood and carbonaceous debris, gastropods, crayfish burrows, bones, coprolites, and dinosaur tracks. At least three track sites have been found in Chinle Formation rocks at Glen Canyon (Gillette and Newcomb 2009). Two sites have been described from Four Mile Canyon and Mike's Mesa. The Four Mile Canyon site has prints of dinosaur-like *Atreipus*, and lizard-like *Rhynchosauroides* tracks. The tracks were removed in 1992 and are in NPS collections. The Mike's Mesa site has tridactyl (three-toed) tracks. Isolated reports of bones have come from several locations and stratigraphic levels, including the Lees Ferry area; the Rincon area; and bones, including those of fish, from the Church Rock / Rock Point Member at an unspecified location. Petrified wood has been reported from many localities. Dubiel reported conchostracans while working in and near Glen Canyon on lower Chinle Formation rocks of the White Canyon / Red Canyon area (Santucci et al. 2009).

Glen Canyon Group: Wingate Sandstone (Late Triassic–Early Jurassic)

The Wingate Sandstone is an aeolian sandstone unit that spans the Triassic/Jurassic boundary. Limestone lenses are also present. At Glen Canyon, it is 100 to 400 feet (30 to 120 meters) thick, 250 feet (75 meters) on average, and is composed of cliff-forming brown sandstone. The best exposures are in the northern part of Glen Canyon. Trace fossils have been collected from the Wingate Sandstone at Glen Canyon. At least five track sites have been found (Gillette and Newcomb 2009). Three sites have been described from Glen Canyon and the immediate vicinity, from Lees Ferry, the Rincon, and North Wash (outside Glen Canyon).

In general, fossils are uncommon in the Wingate Sandstone, although tracks are known from multiple levels in Utah, Arizona, and Colorado. Track makers include invertebrates, mammal-like animals, nondinosaurian reptiles, and theropod, prosauropod, and possible sauropod ("brontosaur") dinosaurs. Mammal-like tracks are often found nearly alone and are confined to dunes. There appear to be distinct Late Triassic and Early Jurassic assemblages, with mammal-like tracks limited to the Late Triassic and prosauropod tracks appearing in the Early Jurassic. Aside from these trace fossils, petrified wood and a phytosaur skull are also known (Santucci et al. 2009).

Glen Canyon Group: Kayenta Formation (Early Jurassic)

The Kayenta Formation is mostly made up of fine to coarse sandstone with some small amounts of interbedded shale and siltstone, and rare limestone and conglomerate. At Glen Canyon, it is 250 to 330 feet (75 to 100 meters) thick, 310 feet (95 meters) on average, and is composed of pale-red to dark-orange sandstone with minor siltstone and shale. It is exposed in the Good Hope Bay area, between the Rincon and a few miles south of the Escalante / Colorado River junction, and in the western San Juan Arm. The age of the Kayenta Formation is now thought to be early- to middle-Early Jurassic, between approximately 197 and 190 Ma. The Kayenta Formation was formed by shifting, freshwater, braided and meandering streams; floodplain deposits are also known.

At Glen Canyon, dinosaur tracks have been found at multiple sites in the Kayenta Formation. Six sites have been described from Glen Canyon and its immediate vicinity, from Explorer's Canyon, Long Canyon, Mike's Mesa, Slick Rock Canyon (two sites), and at neighboring Rainbow Bridge National Monument. At least 29 track sites were found in the Kayenta-Navajo transition (Gillette and Newcomb 2009). These sites were later determined to be located within carbonate beds within the Navajo Formation.

Kayenta Formation vertebrate trace fossils include coprolites and tracks of small (*Grallator*) and large (*Eubrontes*) theropods. Lesser-known theropod track taxa include *Hopiichnus* and *Kayentopus*. Kayenta Formation fossils that

are not vertebrates or vertebrate traces include algal limestone, petrified wood (which is locally abundant in the silty facies), invertebrate trails and burrows, unionid bivalves, freshwater gastropods, and ostracodes (Santucci et al. 2009).

GLEN CANYON GROUP: NAVAJO SANDSTONE (EARLY-MIDDLE JURASSIC)

The Navajo Sandstone Formation is the uppermost part of the Glen Canyon Group. Although the dating of Glen Canyon Group units has proven difficult to establish, the bulk of the Navajo Sandstone probably dates to the middle and late Early Jurassic, between approximately 190 and 175 Ma.

Several reports of fossils in the Navajo Sandstone have been made from Glen Canyon or its immediate vicinity. Ten track sites ranging from single track site to multiple track ways have been reported. *Eubrontes* prosauropods (*Otozoum*), small theropods (*Grallator* or *Grallator*-like), large biped (*Eubrontes*-like), both small and large tridactyl tracks, ornithopod tracks similar to *Anomoepus*, and mammal-like reptile tracks (*Brasilichnium*). As with the Kayenta Formation, additional track sites have been exposed by the recent water level drop of Lake Powell, and at least 39 track sites are known in all (Gillette and Newcomb 2009). An undescribed reptile skeleton was found in a lacustrine limestone bed in the Navajo Nation section of Glen Canyon. Traces of termite mounds were reported, and wood has also been reported (NPS 1999a). Two crocodylomorph skeletal specimens have been collected from north-central Arizona near the Utah border at West Canyon, which runs into and is partially in Glen Canyon. These specimens largely consist of scutes and feet. Finally, tree fossils are known from a possible oasis near Page, Arizona, at the southern tip of Glen Canyon (Santucci et al. 2009). At least two vertebrate tracksites, including one with multiple trackways, are now known from the Page Sandstone within Glen Canyon.

SAN RAFAEL GROUP: PAGE SANDSTONE (MIDDLE JURASSIC)

The Page Sandstone is another aeolian sandstone, very similar to the Navajo Sandstone. It is sometimes considered to be the uppermost part of the Navajo Sandstone, as the Page Member. At Glen Canyon, it is mapped with the Navajo Sandstone, because the two are difficult to distinguish. At Glen Canyon, Page Sandstone is 0 to 300 feet (0 to 90 meters) thick, 40 feet (12 meters) on average, and is composed of tan to reddish-brown sandstone. It dates to the Middle Jurassic, with internal ash units of 167.7 ± 0.5 Ma to 166.3 ± 0.4 Ma. The Carmel–Page sequence includes two transgressive/regressive cycles. The various tongues of the Page Sandstone represent aeolian and beach sand and sandy, muddy, or limy marginal marine locations, deposited against the Carmel–Twin Creek Seaway represented by the Carmel Formation. This seaway ran through Glen Canyon during the Middle Jurassic. The lower Carmel Formation is more prominent to the west, and the Page is more prominent to the east.

Fossils are extremely rare in the Page Sandstone; however, wood is reported from the Page Sandstone at Glen Canyon (NPS 1999a). Otherwise, to date there have been reports only of echinoderm fragments and a single possible theropod footprint from Grand Staircase–Escalante (Santucci et al. 2009). At least two vertebrate track sites, including one with multiple track ways, are now known from the Page Sandstone in Glen Canyon.

SAN RAFAEL GROUP: ENTRADA SANDSTONE (MIDDLE JURASSIC)

The Entrada Sandstone is dominated by red sandstone, with some silt. It is divided into multiple members depending on location. It lacks age-diagnostic fossils and is regarded as late Middle Jurassic in age, approximately 165 Ma. The Entrada Sandstone represents a semiarid to arid dune field that was hot and sparsely vegetated. It is 120 to 850 feet (35 to 260 meters) thick at Glen Canyon, 350 feet (105 meters) on average, and is composed of reddish-orange to white sandstone with minor siltstone and shale. It is particularly prominent in the Bullfrog area, and to the south along the western shore of Lake Powell.

At Glen Canyon, some theropod tracks from Lake Powell have been reassigned to the Entrada Sandstone from the Navajo Sandstone. Trace fossils are the best-known fossils from the Entrada Sandstone in general. Types of trace fossils include rare root traces, insect burrows, vertebrate burrows, traces of sand-swimming vertebrates, and theropod and sauropod dinosaur tracks. Tracks are common in some areas, and megatrack sites with large theropod tracks are known from upper beds that grade into the overlying Summerville Formation. This level may not be present at Glen Canyon because the Entrada Sandstone and Summerville Formation are separated by an unconformity (Santucci et al. 2009).

MORRISON FORMATION (LATE JURASSIC)

The Morrison Formation is a heterogeneous unit dated to the middle Late Jurassic, 155 to 148 Ma. Several members have been named; at Glen Canyon, the Tidwell and overlying Salt Wash Members are present, and the overlying Brushy Basin Member may be present in the vicinity. At Glen Canyon, Morrison Formation rocks are 0 to 710 feet (0 to 215 meters) thick, 350 feet (105 meters) thick on average, and include tan sandstone and maroon to gray-green shale. It is present in the Lake Powell area, particularly along the western shoreline.

The Morrison Formation is famous for its fossils, particularly its large dinosaurs. Such familiar genera as *Allosaurus*, *Apatosaurus* ("*Brontosaurus*"), *Brachiosaurus*, *Diplodocus*, and *Stegosaurus* are best known from skeletons found in Morrison Formation rocks. To date, only a few Morrison Formation fossils have been reported from Glen Canyon. The most notable is a handprint of a small sauropod dinosaur found near Bullfrog, the first sauropod track with skin impressions. This specimen was found in the Tidwell Member, so could also be referred to the Summerville Formation. Dinosaur bone fragments are also known. Termite nests preserved as cylindrical concretions 8 inches (20 centimeters) across and 12 to 16 inches (30 to 40 centimeters) tall are known from an unspecified location in Glen Canyon.

The potential for diverse fossils exists, because the Morrison Formation has one of the best terrestrial fossil records of the Mesozoic. Fungal or photosynthetic organisms and traces represented in the Morrison Formation include fungi (both body and traces), algae (including stromatolite structures), charophyte algae, bryophytes, horsetails, ferns, pteridosperms, cycads, bennettitales, ginkgoes, czekanowskiales, and conifers, along with spores and pollen of the following: rhodophytes, bryophytes, lycopsids, ferns, cycads, bennettitales, conifers, gnetales, and unknown plants. Also found were a variety of plant debris, root casts, wood, and seeds. Invertebrates represented by body fossils include sponges, gastropods, unionid bivalves, conchostracans, ostracodes, and crayfish. Many other invertebrates are known from traces, including numerous insect groups not yet known from body fossils. Invertebrate trace fossils have been assigned to anthozoans (corals and anemones), brachiopods, gastropods, bivalves, nematodes, annelids, horseshoe crabs, mayflies, orthopterans (grasshoppers, crickets, and locusts), caddisflies, hemipterans (aphids, cicadas, and allies), flies, beetles, hymenopterans (ants, bees, and wasps), termites, decapods, and echinoderms.

Vertebrates known from body fossils in the Morrison Formation include several varieties of early ray-finned fish like bowfins, lungfish, frogs, salamanders, turtles, sphenodonts, lizards, possible snakes, the lizard-like aquatic reptile *Cteniogenys*, terrestrial crocodylomorphs, *Goniopholis* (closely related to the ancestry of modern crocodilians) and other extinct crocodylomorphs, long-tailed and short-tailed pterosaurs, multiple large (such as *Allosaurus*, *Ceratosaurus*, and *Torvosaurus*) and small (such as *Ornitholestes*) theropods, diverse sauropods (generalized, stocky like *Camarasaurus*, elongate like *Diplodocus*, or long-limbed and long-necked like *Brachiosaurus*), plated dinosaurs like *Stegosaurus*, armored dinosaurs, bipedal herbivorous dinosaurs (such as *Camptosaurus* and *Dryosaurus*), and triconodont, docodont, multituberculate, and symmetrodont mammals. Tracks are known from most of these groups as well, as well as coprolites of herbivorous dinosaurs and mammal burrows. Finally, eggshells from the Morrison Formation have been assigned to turtles, crocodile relatives, and dinosaurs (Santucci et al. 2009).

DAKOTA FORMATION (LATE CRETACEOUS)

The Dakota Formation (also Sandstone or Group) is a heterogeneous rock unit with outcrops as far from Utah as Minnesota. The Dakota Formation present at Glen Canyon is 20 to 170 feet (5 to 50 meters) thick, 75 feet (20 meters) on average, and is found between Wahweap and Fiftymile Mountain. It is divided into three informal units. At the base, there is a conglomeratic unit. This is overlain by a heterogeneous middle unit of sandstone, mudstone, claystone, and coal, which is capped by an upper sandstone unit. In the Glen Canyon, the deposition of the Dakota Formation took place during the early Late Cretaceous, around 94.7 Ma, although it is known to be older elsewhere. The Dakota Formation leads into the overlying Tropic Shale without a break in deposition at Glen Canyon.

The fossils of the Dakota Formation are diverse, befitting a formation including rocks from a variety of depositional settings present over a wide geographic range. At Glen Canyon, there are coal beds in the middle unit and bivalves in the upper sandstone, which was deposited under brackish to marine conditions. The best-known terrestrial fossils from the Dakota Formation are plant fossils (particularly angiosperm leaves) and vertebrate tracks.

Dakota Formation outcrops of the neighboring Kaiparowits Plateau and the rest of Grand Staircase–Escalante have yielded diverse fossils, and provide a model for what might be found at Glen Canyon. These include palynomorphs, petrified wood, coal, algae, foraminifera, gastropods, bivalves, ostracodes, ammonites, invertebrate traces, sharks, rays, ray-finned fish, lungfish, amphibians, turtles, lizards, several types of crocodilians and crocodile relatives, small theropods such as dromaeosaurids and troodontids, tyrannosaurids, armored dinosaurs, hypsilophodonts (small bipedal herbivorous dinosaurs), hadrosaurids (duckbills), mammals, and footprint sites. The mammal fossils are significant, and include multituberculates, marsupials, and a nonmarsupial therian. Most fossils there were found in floodplain settings of the middle unit, with some from lacustrine rocks, and algae, foraminifera, gastropods, bivalves, ostracodes, and burrows from the upper part (Santucci et al. 2009).

TROPIC SHALE (LATE CRETACEOUS)

The Tropic Shale crops out at the southeastern end of Fiftymile Mountain in Glen Canyon. It is 500 feet (150 meters) thick on average in Glen Canyon, and is composed of dark, slope-forming marine shale. It may grade into sandier beds near its upper boundary in southern Utah, and there is no depositional gap between it and the overlying Straight Cliffs Formation. It represents a transgression and regression over a broad coastal plain. Because the marine transgression reached different areas at different times (e.g., the Western Interior Seaway), deposition occurred over a range of time during the early Late Cretaceous, between approximately 94 and 90.5 Ma.

Most fossils in the Tropic Shale are marine specimens. Several fossiliferous localities at Glen Canyon have been described in publications. All sites are from the extreme southwest of Glen Canyon near Big Water and include plesiosaur *Trinacromerum bentonianum,* turtles (both *Desmatochelys* and *Naomichelys*), ammonites, bivalves, fish, *Brachauchenius lucasi*, *Eopolycotylus rankini*, and polycotylid plesiosaur (Santucci et al. 2009).

STRAIGHT CLIFFS FORMATION (LATE CRETACEOUS)

The Straight Cliffs Formation is a heterogeneous unit deposited in multiple settings. At Glen Canyon, the Straight Cliffs Formation averages 1,500 feet (455 meters) thick and is composed of sandstone, siltstone, shale, and coal, found stratigraphically above the Tropic Shale. Beach and coastal plain sandstones intertongue with marine shales. Like the Tropic Shale, it crops out near Fiftymile Mountain. The Straight Cliffs Formation of south-central Utah is divisible into four members. From oldest to youngest, these are the Tibbet Canyon Member, the Smoky Hollow Member, the John Henry Member, and the Drip Tank Member. Straight Cliffs Formation rocks are known for their mammal fossils (Gillette and Newcomb 2009).

So far, only coal is known from the Straight Cliffs Formation at Glen Canyon, but fossils are well known from the various members at Grand Staircase–Escalante, and provide a guide for what might be present at Glen Canyon. Fossils from the Tibbet Canyon Member include marine invertebrates, sharks, rays, gars, crocodilians, and marsupials. Fossils from the Smoky Hollow Member include dicotyledonous leaf compressions (possibly in this unit) at Alvey Wash; sharks, rays, and ray-finned fish such as bowfins and gars; the unusual amphibian *Albanerpeton*, frogs, turtles, lizards, and several types of crocodilians and crocodile relatives; small theropods (such as dromaeosaurids and troodontids), tyrannosaurids, armored dinosaurs, hypsilophodonts, and hadrosaurids; and symmetrodont, marsupial, and possible eutherian mammals. Fossils in the John Henry Member include coal; palynomorphs; bivalves and ammonites; footprints; sharks, rays, and ray-finned fish like bowfin and gars; *Albanerpeton*, frogs, turtles, lizards, and several types of crocodilians and crocodile relatives; dromaeosaurids, armored dinosaurs, and hadrosaurids; and multituberculate, symmetrodont, and marsupial mammals. Finally, fossils in the Drip Tank Member include turtle and crocodilian fragments (Santucci et al. 2009).

Quaternary Rocks and Sediments (Pleistocene-Holocene)

Quaternary sedimentary rocks and deposits at Glen Canyon include fragments of igneous rocks, metamorphic rocks, sandstone, limestone, dolomite, quartzite, siltstone, and shale, and are 0 to more than 200 feet (0 to more than 60 meters) thick. They include alluvial deposits left by rivers, aeolian deposits, mass-wasting deposits (like landslides and talus), colluvium on moderate slopes, and residuum from weathered, in-place bedrock. Typical Quaternary fossils include isolated bones of large mammals (such as sloths, proboscideans, equids, bison, and camelids) and fossil material useful for paleoecological and paleoclimatological studies (such as pollen and packrat middens). Both types are common at or within approximately 60 miles (approximately 100 kilometers) of Glen Canyon.

Alcove sites are of great importance at Glen Canyon. These sites are commonly found at the boundary of the Kayenta Formation and Navajo Sandstone. The best-known Quaternary site from Glen Canyon is a large cave that contained 10,600 cubic feet (300 cubic meters) of fossil dung (Santucci et al. 2009). The cave contains diverse fossil resources, including fungal spores in droppings; pollen, charcoal, wood, seeds and plant fragments, and insects; dung assigned to packrats (*Neotoma*), cottontail rabbits (*Sylvilagus*), Shasta ground sloths (*Nothrotheriops shastensis*), mammoths (*Mammuthus*), horses (*Equus*), shrub oxen (*Euceratherium collinum*), bighorn sheep (*Ovis canadensis*), and mountain goats (*Oreamnos harringtoni*); hair from shrews, packrats (*Neotoma*), deer mice (*Peromyscus*), olive-backed mice (*Perognathus*), Abert's squirrel (*Sciurus aberti*), small-footed bats (*Myotis*), coyotes (*Canis latrans*), bear (*Ursus*), ground and mylodont sloths (*Glossotherium* and *Nothrotheriops*), mammoths, horses, bison (*Bison*), bighorn sheep, and deer (*Odocoileus*); bones from toads (*Scaphiopus*), snakes (*Crotalus* and *Pituophis*), grouse-sized birds, marmots (*Marmota*), ground squirrels (*Spermophilus*), pocket gophers (*Thomomys*), voles (*Microtus*), packrats, rabbits (*Brachylagus*), and the extinct shrub ox *Euceratherium* (a tooth); and packrat middens covering the last 12,000 years (Santucci et al. 2009).

Nine other alcove sites have been described from Glen Canyon. Fossil materials range from oak twigs to mammoth bones and dung. Mammoth bones are also known from other locations in Glen Canyon at the southern end and the northeastern tip (Santucci et al. 2009).

Although less spectacular than the cave fossils, microfossils, plant matter, and freshwater invertebrates, such as Pleistocene bivalves and Holocene plant debris, can be found in Quaternary fluvial sediments (Santucci et al. 2009).

WILDERNESS

NPS manages significant Glen Canyon acreages for wildness characteristics.

NPS manages significant Glen Canyon acreages for wildness characteristics. PL 92-593, which established Glen Canyon National Recreation Area, required a wilderness review in accordance with subsections 3(c) and 3(d) of the 1964 Wilderness Act (Section 9, PL 92-593). NPS completed this study and in 1980 submitted to the Secretary of the Interior a proposed wilderness recommendation that identified 588,855 acres as suitable for addition to the National Wilderness Preservation System. An additional 48,955 acres (4% of the total Glen Canyon acreage) that contained federal oil and gas leases were proposed as potential wilderness additions (NPS 1980).

The proposed wilderness areas are largely congruent with the Natural Zone, as shown previously in this chapter in "Figure 11: Management Zones." However, because the proposed wilderness excluded (1) suitable state lands and state mineral rights, (2) federal oil/gas leases (zoned as potential wilderness additions), and (3) boundary additions, it makes up only 588,855 acres, or 47% of Glen Canyon, compared to 681,918 acres of the Natural Zone. Potential wilderness additions totaling 48,955 acres are to become wilderness once the nonconforming conditions or uses are terminated. Like the Natural Zone, the lakeside boundary of the proposed wilderness is coincident with the fluctuating surface of Lake Powell (except at Antelope Island). In the Glen Canyon GMP (NPS 1979), the 3,700 foot contour was identified as the lakeside boundary of the proposed wilderness. However, as the water surface fluctuates when it is lower than this contour, there would be more proposed wilderness acreage with a corresponding decrease in non-wilderness acreage. Conversely, the opposite would occur when the fluctuating water surface is higher than this contour (NPS 1979).

The proposed wilderness identified nine roadless areas exceeding the Wilderness Act minimum requirement of 5,000 acres. These roadless areas range in size from 6,900 acres to 906,920 acres. The largest area includes the vast portion of Glen Canyon that encompasses the lands of the Escalante Region across to Wilson Mesa and along the San Juan Arm to Mexican Hat. The proposed wilderness noted that the "largest and most scenically outstanding" of the roadless areas is located in the Orange Cliffs, and includes "such beautiful canyons between the cliffs and the Green River as Millard, Horsethief, Deadhorse, and Horse" (NPS 1980).

The preservation of wilderness character in proposed wilderness areas traversed by roads is a management challenge. In proposed wilderness areas, the public use of motor vehicles is prohibited (NPS 2006a, Section 6.4.3.3). However, roads open to conventional motor vehicles exist where Hole-in-the-Rock Road crosses the Escalante Region; where Hole-in-the-Rock Road crosses Wilson Mesa; and in the Orange Cliffs Special Management Unit, where a network of unpaved GMP roads cross through proposed wilderness areas (see "Figure 11: Management Zones").

The Canyonlands National Park and Orange Cliffs Unit of Glen Canyon National Recreation Area Backcountry Management Plan (NPS 1995) describes backcountry management objectives specifically for the Orange Cliffs unit. This backcountry plan only briefly addresses proposed wilderness in Orange Cliffs, but states that Glen Canyon lands zoned as "natural" will continue to be managed as wilderness until Congress acts on the proposed wilderness areas (NPS 1995). Lands zoned as "natural," which are managed as wilderness, are depicted in "Figure 11: Management Zones."