WRD RESOURCE ROOM

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BIG BEND NATIONAL PARK
WATER RESOURCES SCOPING REPORT

Water Resources Division

and

Big Bend National Park

Technical Report NPS/NRWRD/NRTR-92/08

WATER RESOURCES DIVISION

National Park Service - Department of the Interior
Fort Collins - Denver - Washington

United States Department of the Interior • National Park Service

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BIG BEND NATIONAL PARK

WATER RESOURCES SCOPING REPORT

National Park Service
Water Resources Division
Fort Collins, CO 80201

and

Big Bend National Park
Big Bend National Park, TX 79834

Technical Report NPS/NRWRD/NRTR-92/08

March, 1992

United States Department of the Interior
National Park Service
Washington, D.C.

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CONTENTS

EXECUTIVE SUMMARY / v

INTRODUCTION / 1

Figure 1. Big Bend Park Map / 2

WATER RESOURCES MANAGEMENT PLAN / 3

WATER RESOURCES PLANNING ISSUES / 4

1- Water Supply / 4
a. Present & Future Water Supply Needs & Options / 5
b. Evaluation of Water Rights / 8
c. Oak Spring Water Distribution & Consumption / 10
d. Water Conservation & Drought Contingency Planning / 11

2- Transboundary Water Resources / 14
a. Rio Grande Historic Flows / 14
b. Rio Grande Water Quality & River Use / 15
c. Impacts of Trespass Livestock / 18
d. External Groundwater Withdrawal & Pollution Potential / 19

3- Floodplain Assessment & Management / 19
a. Castolon / 19
b. Boquillas (Rio Grande Village) / 20

4- Resource Monitoring of Springs and Seeps / 20

5- Fisheries & Aquatic Biological Resources / 21

6- Riparian Zone Classification, Protection & Management / 22

7- Water Resources Issues Related to Park Development & Operations / 23
a. Wastewater Treatment Issues / 24
b. Landfill Issues / 24
c. Proposed Road Improvements & Aggregate Removal / 24
d. Hazardous Materials Management / 25

RECOMMENDATIONS / 26

LITERATURE CITED / 28

PREPARERS & ACKNOWLEDGEMENTS / 31

EXECUTIVE SUMMARY

Big Bend National Park (BIBE), located in western Texas along the Rio Grande border with Mexico, preserves a representative portion of the desert, montane, and riverine environments found in the northern Chihuahuan Desert. Water plays a particularly important role in these harsh environments, strongly influencing the surficial geology, the distribution of biological communities, and even the patterns of human settlement.

The Rio Grande (Rio Bravo del Norte), which forms the southern boundary of the park, is the region's predominant surface water feature. Other surface water features include ephemeral streams, more than 200 springs, and locally important features such as seeps, tinajas, and man-made water holes, stock tanks, etc. The groundwater hydrology of the park is exceedingly complex, but important, as it provides the majority of the potable water necessary for park operations.

The purposes of the Big Bend National Park Water Resources Scoping Report are: 1) to identify and discuss water resources-related issues and management concerns; 2) to provide a summary of the existing hydrological information pertaining to these issues; and 3) provide park management with a recommendation regarding the need for the development of a Water Resources Management Plan (WRMP).

Water-related issues addressed within this report include:

- the provision of an adequate and safe water supply;
- an assessment of transboundary water resource issues;
- an analysis of floodplain delineation and management needs;
- an evaluation of fisheries and aquatic biological resource issues;
- a review of spring and seep monitoring efforts;
- a discussion of riparian zone classification & management needs; and,
- an overview of water resources-related aspects of park development and operational activities.

Because of the relatively complex nature of the unresolved water resources issues and the importance of water in the desert environment, this scoping report recommends the development of a Water Resources Management Plan.

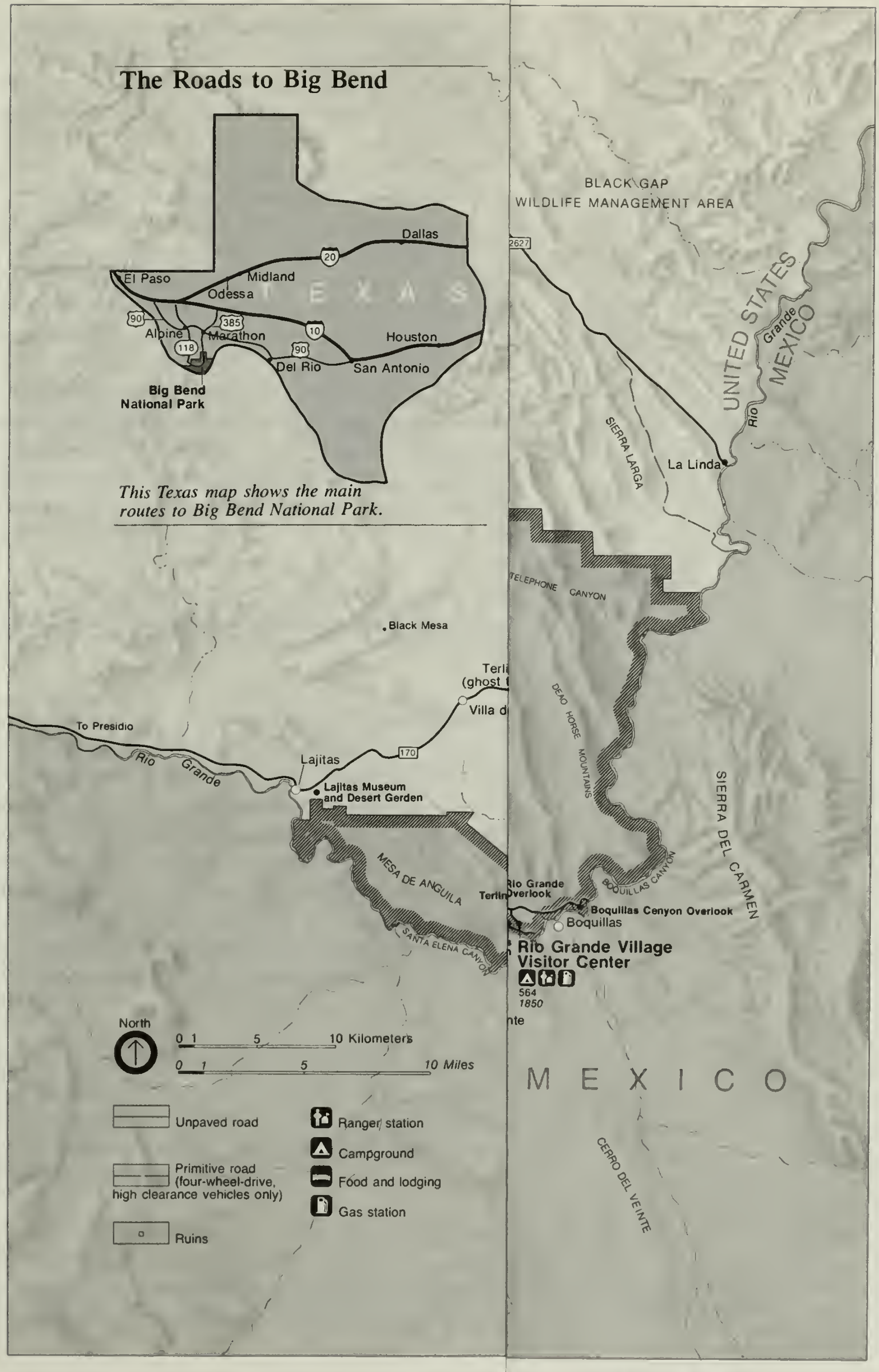
INTRODUCTION

Big Bend National Park is located along the southern border of western Texas where the Rio Grande forms a large bow that sweeps southward into the Mexican states of Chihuahua and Coahuila (Figure 1). Established in 1944, Big Bend is the thirteenth largest unit of the National Park System and the sixth largest unit located in the continental United States. The park is representative of the northern half of the Chihuahuan Desert, where daily temperatures may be extreme and water is generally in limited supply. In the central portion of the park, however, the desert gives way to the Chisos Mountains, which rise several thousand feet above the surrounding plain creating a montane environment which has been described as a "relict green island in a desert sea." Similarly, along the southern boundary of the park, the Rio Grande supports a green oasis arcing in a narrow band along the river's length, supporting riverine and riparian habitats not commonly found in the desert environment.

The Rio Grande (Rio Bravo del Norte), which forms the southern boundary of the park, is the region's predominant surface water feature. From its headwaters in southern Colorado, the Rio Grande flows south through New Mexico, turning southeast near the New Mexico-Texas border. Most of the Rio Grande's initial flow is derived from runoff in the mountainous regions of southwestern Colorado and northwestern New Mexico. By the time it enters Texas, however, the Rio Grande resembles a small stream having lost most of its flow to mainstream reservoirs, agricultural water diversions, and evaporation. In many years, the Rio Grande remains dry from southeast of El Paso to Fort Hancock, TX. Southeast of Fort Hancock, groundwater surfaces to form a salty stream. The Rio Grande remains small for the next 185 miles until the confluence with the Rio Conchos (near Presidio, TX), whose inflow in recent years (1932 - 1985) has provided approximately 85% of the flow in the Rio Grande through Big Bend National Park (Saunders 1987).

This ribbon of riverine and riparian environments provides a stark contrast to the adjacent desert. The river provides access to water supply and popular recreational activities including river-rafting and fishing. The associated riparian environments provide important habitat for wildlife and a migratory route for birds (Wauer 1977). Three canyons, Santa Elena, Mariscal, and Boquillas also bisect the limestone mesas along this segment of the Rio Grande, creating some of the most outstanding scenic features within the park. In 1978, Congress established the Rio Grande Wild and Scenic River along a 191.2 mile stretch of the river from the Terrell/Val Verde county line in Texas to the Chihuahua/Coahuila state line in Mexico. The upper 69 miles of the Rio Grande Wild and Scenic River fall within BIBE. Thus, the stretch of the Rio Grande flowing through BIBE and the Rio Grande Wild and Scenic River comprises approximately 13% of the entire United States/Mexico boundary.

Except for the Rio Grande, the surface waters of BIBE consist largely of creeks originated by small headwater streams (or springs), and locally important springs,



BIG BEND
PARK MAP

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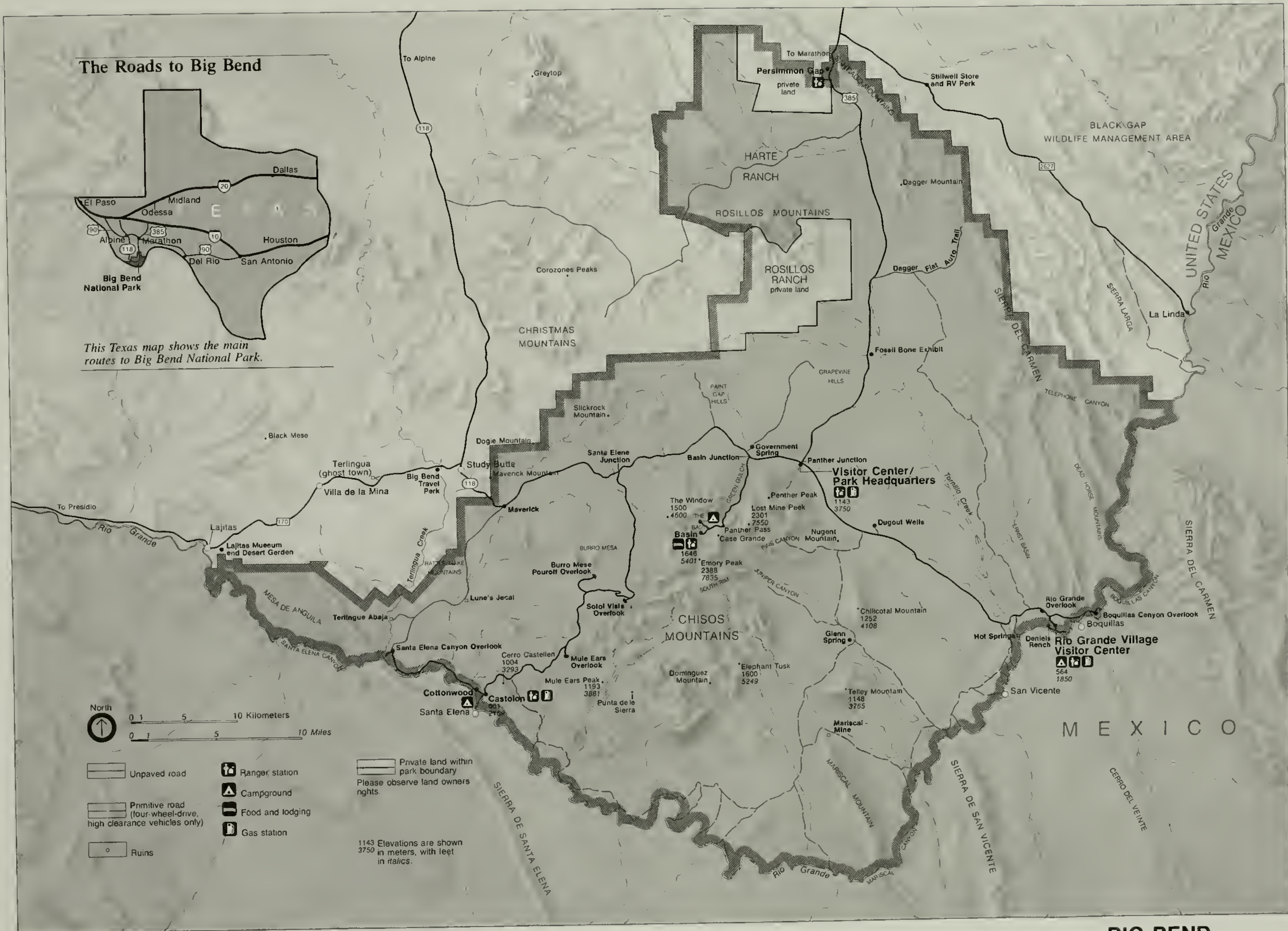

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seeps, and tinajas. These streams generally flow only ephemerally or locally over their stream beds, usually losing their water to evaporation and percolation. However, they often form broad arroyos that carry flood waters following infrequent heavy rains. The major exception to this is Terlingua Creek, which due to groundwater discharges, remains a perennial stream that enters the Rio Grande below Santa Elena Canyon. The hydrogeology of the park is exceedingly complex, and because of the importance of groundwater as a water supply, has been the subject of numerous studies. Baker et al. (in press) investigated the hydrogeology of Oak Spring, sole source water supply for the highly developed Chisos Basin. Wilson and Shroeder (1984) have further summarized a series of theses (Archer (1982), Abbott (1983), Gibson (1983), Cross (1984), Lopez Sepulvada (1984) and Monti (1984)), investigating the hydrogeology and groundwater supply for the Panther Junction area, the park's administrative headquarters, and for the Rio Grande Village vicinity, a major visitor use area.

The park staff has also mapped over 300 additional water sources within the boundaries of BIBE (Mike Fleming, Big Bend National Park, personal communication). These include over 200 springs, as well as numerous seeps, tinajas, man-made water holes, stock tanks, etc. The importance of these water sources in providing local plant and wildlife habitat and as water supplies can not be overstated in this harsh desert environment.

WATER RESOURCES MANAGEMENT PLAN

Whether in support of natural systems or providing for visitor use, water is often a significant resource in units of the National Park System. Consistent with its fundamental purpose, the National Park Service (NPS) seeks to perpetuate surface and ground waters as integral components of park aquatic and terrestrial ecosystems, by carefully managing the consumptive use of water and striving to maintain the high quality of surface and ground waters in accordance with all applicable federal, state, and local laws and regulations. In addition, the NPS assures compliance with all floodplain management and wetland protection requirements and obtains and uses water for the preservation, management, development, and use of the National Park System in accordance with legal authority and with due consideration of the needs of other water users.

Planning is an essential step in addressing a park's water resources issues, and a WRMP is often prepared in parks where water resources are sufficiently important, complex, or controversial. The WRMP structures and uses information about the park's hydrologic resources to assist management in evaluating the range of alternatives concerning water resources issues.

There are three major sections in a WRMP. First, the plan provides the necessary background with respect to the park and water resources issues, concerns, and needs which have led to the preparation of a WRMP. In particular, this section provides information on laws, regulations, and policies applicable to the park, and land status and uses adjacent to the park. This section also sets forth the objectives concerning use and management of water in the park and lists the specific water resources issues that have been identified for evaluation in the plan. The second section of the plan provides sufficient information to characterize the hydrologic setting of the park and to describe the current condition and status of park water resources. Depending upon the hydrologic resources of the park and the water resource issues to be addressed, the description of the hydrologic environment section should summarize published information, and perform, where necessary, an analysis of available unpublished data, including information relating to the physiography, climate, and geology; surface water resources; groundwater resources; aquatic and riparian resources and habitats; water uses within the park; and water rights. The final section of the plan presents the action program of the planning effort. This section includes specific project statements which describe day-to-day operational activities and special projects necessary to address the water resources issues facing the park. These activities and projects may consist of management, monitoring, interpretation, law enforcement specifically directed toward water resources protection, program administration, research, management studies, and mitigation/treatment action. Guidance for the development of a WRMP may be found in "Instructions for the Preparation of Water Resources Management Plans" (National Park Service, 1991a).

WATER RESOURCES PLANNING ISSUES AT BIG BEND NATIONAL PARK

Water Resources Division (WRD) and BIBE personnel held an initial scoping session in the park on July 18-20, 1990. Its purpose was to identify water resources issues and concerns of park management. Subsequent discussions have been held with additional NPS personnel, state officials, and water resource professionals in order to further define potential issues and concerns.

Specific water resources issues identified for consideration in the WRMP include:

1) Water Supply

The provision of an adequate and safe water supply is a primary management concern in BIBE. The location of the park in the Chihuahuan Desert often complicates the provision of a safe and adequate drinking water supply. Historically, settlement in this water-scarce environment was limited to areas where water was attainable. From the perspective of current needs and standards, however, these historic water sources are sometimes inadequate.

a. Present and Future Water Supply Needs and Options

Six existing or planned sites within BIBE require potable water supplies. These sites include:

Chisos Basin

Oak Spring historically provided an adequate and high quality water supply to the Chisos Basin of BIBE. Flow from Oak Spring is thought to vary significantly, but a continuous record of spring discharge has only been available since the installation of a V-notch weir gaging station in December 1986. The June 1990 "scoping visit" occurred following a period of prolonged drought. On June 18, 1990 the discharge at Oak Spring was only 19.9 gallons per minute (gpm), the lowest historic spring flow recorded since the gaging station was placed in operation. Fortunately, heavy rains occurred from July through September 1990, and again during the summer of 1991, replenishing the local aquifers and dramatically increasing Oak Springs discharge to greater than 100 gpm.

A spring flow of less than 20 gpm is considered marginal for meeting the present water supply requirements in the Chisos Basin. While a limited additional water supply could be supplied from Cattail Falls, such a diversion would likely cause a serious disruption of sensitive biological communities along Cottonwood Creek, potentially damaging or destroying park natural resources.

As it is unlikely that a supplemental water supply for the Chisos Basin could be developed, the need for the preparation of an emergency drought contingency plan and operational procedures is evident (see section 1.d.).

Panther Junction

Panther Junction is the main administrative, visitor center, and employee housing area supporting BIBE. The exact number of wells which have been drilled in the general area is unknown, but ranges from perhaps 15 to 20. Several of the older production wells were replaced in the early 1980s and a number of observation wells were also drilled. The quantity of water produced in the vicinity remains adequate for supporting the present park headquarters, visitor center, maintenance yard, employee housing area, and gas station requirements. Any substantial expansion of facilities at Panther Junction would likely require additional water supply. However, an evaluation by Texas A&M indicates that the amount of groundwater available for development in the Panther Junction vicinity is several-fold the amount presently utilized (Wilson and Schroeder 1984). Future water development expansion would likely be most successful in the Lone Mountain area, though a program of test well drilling and aquifer delineation would be required.

Castolon

The development of an adequate drinking water supply has long been an issue at Castolon. Ten wells are known to have been drilled or dug in the area. Two wells drilled in the 1970's to explore for "deep" water were dry and abandoned. In the 1980s, two shallow alluvial wells were drilled which provide the present potable water supply. These wells provide water of marginal quality and quantity. Irrigation water at Castolon is currently provided by an additional well adjacent to the Rio Grande.

A single well provides potable water for the new maintenance yard and several NPS residences located about one mile north of the historic Castolon site. Again, yield and water quality are marginal, and the water is currently treated to reduce the iron content, processed through a problem-prone electrodialysis reversal system, and chemically disinfected (John Lowe, Big Bend National Park, personal communication).

It is desirable that the park locate and develop a new groundwater source of good quality in the general area to meet present and future needs. A single water supply system for the campground, the store, housing, and the maintenance area would be desirable. While a cursory review of the geology of the area does not indicate the presence of formations favorable for aquifers, a more intensive investigation is warranted, possibly requiring test well drilling.

If other adequate well sources can not be located, which is a fairly high probability, additional water will need to be acquired from new wells drilled into the alluvium along the Rio Grande. Such wells would probably require large diameters and perhaps other completion methods to enhance production. These wells may also require extensive water quality monitoring and possibly advanced treatment, because of the large variety of contaminants potentially contained in the Rio Grande (see section 2.b). Future considerations may include the development of dual water systems with reverse osmosis or other advanced treatment technologies applied to drinking water but not to water utilized for other purposes.

Boquillas/Rio Grande Village

Four springs are located on the eastern side of the Boquillas area, in close proximity to the Rio Grande. Studies have indicated that these springs are structurally controlled with linear openings. Spring 1 is the northernmost opening and issues at the highest elevation. Water issuing from this spring provides prime habitat for the Big Bend Gambusia (*Gambusia gaigei*), an endangered fish species.

Other fish, which prey upon the Big Bend Gambusia are located in waters of the other openings which are connected to the Rio Grande by surface water flow. In order to enhance the prime habitat for this endangered species, and to isolate them from predators, the NPS has constructed a refugium near Spring 1 which has isolated a population of the Big Bend Gambusia. The maintenance of sufficient water quantity and quality in this refugium is a high management priority. Thus, it is imperative that future groundwater uses and general development (e.g. wells, drinking water supplies, etc.) not affect the quantity or quality of water available to this endangered species.

Problems have been encountered with the engineered system supporting this refugium including lack of warm water because of pump and/or power failure. Also, the system requires daily inspection and frequent maintenance. In the early 1980s, an additional well was drilled to a deeper depth in the hopes that water might flow naturally to the surface in order to provide additional water without pumping. Unfortunately, the static water level in the new well was below ground surface and pumping from the original well continues.

Potable water for Boquillas/Rio Grande Village is obtained by partial diversion from Spring 4. Discharge from Spring 4 provides water for an important marsh ecosystem adjacent to the Rio Grande. A monitoring program was devised in 1988 to evaluate any possible deleterious effects of the partial diversion from Spring 4 on this ecosystem. Preliminary analysis of the limited data indicates that no discernable damage to the natural ecosystem has occurred. It is, however, an important management priority to maintain the natural ecosystem of this marsh community. Thus, any increased diversion from this spring for potable water supply in order to support future development would be discouraged. Should additional diversion be considered, prudence would dictate that it be preceded by the a thorough analysis of the aquifer yield and the implementation of an improved monitoring system.

Irrigation water for the Rio Grande Village area is acquired by direct intake pumps from the Rio Grande at the western edge of the site and from two wells located in the alluvium adjacent to the river. A problem encountered with the direct intake pumps is the high sediment load in the Rio Grande at this location. To prevent sediment buildup within the irrigation ditch network, water is pumped to settlement ponds prior to use. Once a portion of the suspended sediment is allowed to settle out, the water is released by gravity flow for irrigation.

Operations and maintenance costs of the irrigation system are high because pumps must be removed during periods of high water (pump house flooding has occurred as recently as October 1990 and October 1991), the high suspended sediment load of the river water causes excessive wear on the pumps, and the settlement ponds require periodic dredging. Also, the buildup of accumulated dredged sediments has been extensive enough to alter the natural terrain of the settlement pond area. The need for additional sediment ponds and an evaluation of the costs/benefits and options for the irrigation operation is warranted.

A partial list of options that could be considered as part of a WRMP include:

1) construction of a pit/holding pond adjacent to the Rio Grande where water could percolate through the alluvium into the pit allowing for partial filtration;

2) reduction of the intake pumping rate which may reduce the overall amount of sediment pumped;

3) disposal of dredged sediment by trucking to designated sites; and

4) other engineering options.

It must be noted that the direct water intake from the Rio Grande is an existing water right, and any change would have to be reviewed and approved by the State of Texas. Thus, a water rights determination by the Water Rights Branch of the WRD should be undertaken as part of any evaluation of alternatives for change of the intake system, amount of water diverted, or change in water use.

Persimmon Gap Entrance Station

At least two wells were drilled at this site a decade or so ago, but yields are barely adequate to meet present requirements. Additionally, water quality problems have been reported. Presently, potable water is being trucked from Panther Junction to the Persimmon Gap Entrance Station.

A field inspection of the area and review of recent geologic work need to be accomplished in order to evaluate options for providing a permanent potable water supply. A recent expansion of the park boundary (Harte Ranch addition) may also allow for drilling at sites not previously available to the NPS. In addition, a privately owned groundwater well a few miles north of the site is reported to have good yield and adequate water quality. The option of purchasing water from the private owner for truck delivery or piping to the park could be explored.

Proposed West (Maverick) Entrance Station

The construction of a new visitor contact point and employee residences is being planned at the junction of Park Road 13 (extension of State Route 118) and the old Maverick Road, approximately two miles east of Study Butte. The potential for providing potable groundwater at this site has not yet been evaluated, but water supply problems may be anticipated due to difficulties in acquiring adequate groundwater in the vicinity of Study Butte. However, park personnel report that a recent private well drilled near Study Butte is rumored to be producing a good yield. A study to evaluate the groundwater supply potential at the proposed West (Maverick) Entrance Station site needs to be conducted, and the option of purchasing for truck delivery or piping of privately owned water from outside the park needs to be evaluated.

b. Evaluation of Water Rights

An examination of NPS dockets for BIBE reveals that five water rights exist for BIBE. Three of these are appropriative water rights and two are riparian water rights. These water rights are described below:

Water Right #1 - Wedin Ditch

The NPS is successor-in-interest to the Wedin water right in the amount of 7.0 cubic feet per second (cfs), not to exceed 780 acre-feet of water annually from the Rio Grande. Water is used for irrigation on approximately 312 acres of land in the Rio Grande Village area. The water right (permit no. 927) has a priority date of October 5, 1925. This water right was adjudicated on August 13, 1976, for the amounts indicated above in Cause No. 245154, In Re: The Adjudication of water rights in the Upper Rio Grande and Tributaries of the Rio Grande Basin, in a final Decree of the 201st District Court of Travis County, Texas.

At the request of the NPS, the Texas Water Commission on July 5, 1989, amended Certificate of Adjudication No. 23-987 and authorized the National Park Service:

> a) To divert and use not to exceed 530 acre-feet of water per annum from the Rio Grande for municipal purposes in the Castolon and Rio Grande Village areas of Big Bend National Park in Brewster County, Texas.
>
> b) To divert and use not to exceed 1000 acre-feet of water per annum from the Rio Grande to irrigate 227 acres of land within the Castolon and Rio Grande Village areas of Big Bend National Park (campgrounds and peripheral areas) owned and operated by the National Park Service in Brewster County, approximately 100 miles south of Alpine, Texas.

Water Right #2 - Chisos Basin Water System

This is a riparian water right (No. 38185) which allows for the diversion of water from Cottonwood Creek through infiltration pipes in the stream bed below Cattail Falls and from Oak Spring by means of a collection box placed over the spring. At the present time, water is not being diverted from Cottonwood Creek; however, a substantial portion of Oak Spring flow is collected, stored in storage tanks, and pumped to the Chisos Basin for municipal purposes. In Texas, a spring originating from percolating water is the absolute property of the landowner, unless the spring is the source of a stream that flows off of that landowners land. The owner of a spring is further favored by a statutory presumption that underground water is percolating water. Both Oak Spring and Cattail Falls are presumed to consist of percolating waters, form the source of no streams that flow off of National Park Service land, and are therefore the absolute property of the National Park Service.

Water Right #3 - Wedin Spring

This riparian water right (No. 5820) consists of Springs No. 1 and No. 4 located in the Rio Grande Village Area, a short distance from the Rio Grande. The primary source is Spring No. 4 which fills a 400,000 gallon storage tank and serves municipal and irrigation purposes. Water from Spring No. 1 is pumped to a small pond which provides habitat for the Big Bend Gambusia, an endangered species. Another population of the Big Bend Gambusia live in a nearby pond, supported by the outflow of Spring No. 4. Both populations require warm water from the springs for their survival during cold weather.

Water Right #4 - Castolon Irrigation Project

The NPS is successor-in-interest to Water Permit No. 125 which allows for the diversion of 3.5 cfs from the Rio Grande, not to exceed 750 acre-feet annually. This appropriative water right has a priority of March 31, 1916, and has a point of diversion in the vicinity of the Castolon Ranger Station. It is used for municipal and irrigation purposes.

This water right was adjudicated on August 13, 1976, for the amounts indicated above in Cause No. 245154, In Re: The Adjudication of water rights in the Upper Rio Grande and Tributaries of the Rio Grande Basin, in a final Decree of the 201st District Court of Travis County, Texas.

As previously noted, the Texas Water Commission, at the request of the NPS, amended Certificate of Adjudication No. 23-987 on July 5, 1989, authorizing the NPS:

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b) To divert and use not to exceed 1000 acre-feet of water per annum from the Rio Grande to irrigate 227 acres of land within the Castolon and Rio Grande Village areas of the Big Bend National Park (campgrounds and peripheral areas) owned and operated by the National Park Service in Brewster County, approximately 100 miles south of Alpine, Texas.

Water Right #5 - Four Wells: Panther Junction Area

Water for visitor and administrative uses in the Panther Junction area is supplied by several wells located in the vicinity. Texas does not require a permit for the use of groundwater taken from wells. However, as a matter of comity, the NPS reports the total amount of water pumped annually (approximately 16 acre-feet) from the Panther Junction wells to the Texas Water Commission. Copies of these annual reports are filed in the water rights dockets.

Based upon the current status of the water rights and the relatively good condition of the water rights dockets, no further work relating to water rights is currently necessary as part of the water resources management planning activities.

c. Oak Spring Water Distribution & Consumption

A substantial portion of the flow from Oak Spring is captured by a horizontal pipe and conveyed through a trough/weir system which allows for the quantification of spring discharge. After passing over the measurement weir, water falls into a concrete box where two pipes set at different elevations allow two flow path options. The lower, "first call" pipe leads to nearby storage tanks by gravity flow. Upon call, water from the storage tanks is pumped over a distance of 2.5 miles and lifted approximately 1500 feet to an "upper" storage tank located in the Chisos Basin. From here, the water is distributed to the various visitor facilities, concessionaire activities, and NPS residential users within the Basin. During periods when springflow substantially exceeds the capacity of the "first call" intake pipe, or when demand is low and storage tank requirements have been met, water rises in the weir box until outflow through the upper pipe to the Oak Creek channel occurs.

It is believed that potable water flow is measured only by an in-line meter at the pumphouse, and in the distribution line that services the concessionaire and the NPS residences. An appropriate flow metering system needs to be designed and installed to monitor both water consumption and potential water loss due to leakage in the existing pipeline and distribution system. In addition, measurements of the outflows to Oak Creek, when they occur, should be made.

Flow metering of the inflow pipe in the proximity of the "upper" storage tank would be useful in ascertaining possible substantial leakage and need for repairs in the 35 year-old pipeline leading from the Oak Spring storage tanks to the "upper" storage tanks. Under the present monitoring system, substantial undetected leakage may be occurring, contributing to potential water shortages.
Water meters placed at additional locations throughout the distribution system would allow for a more accurate quantification of water use at the various visitor facilities (e.g., campground and dump station), concessionaire activities (e.g., restaurant, motel units), the Basin Visitor Center, and new NPS residences. Such information would be helpful in detecting leaks in the distribution system and essential in the development of an adequate and equitable emergency drought contingency plan.

d. Water Conservation & Drought Contingency Planning

Because of its location in the Chihuahuan Desert, water conservation and emergency drought management are continuing management concerns at BIBE. During a period of extended drought in 1990, the WRD was requested to provide park management with a recommended program of water conservation activities and an emergency drought contingency plan which could be implemented during periods of prolonged drought and declining water supply.

The recommended water conservation/drought contingency program consists of five phases, the appropriate phase dependent upon the severity of the current drought/water supply condition (Memorandum to the Superintendent, Big Bend National Park, dated August 3, 1990). The five phases include:

Phase I: Routine Conservation Practice

1) Encourage a parkwide voluntary water conservation program and provide park residents with an information fact-sheet on residential water conservation.

2) Install/calibrate water meters at key locations that would allow for the routine audit of water use and possible waterline leakage.

3) Conduct an audit of flow rate at individual National Park Service spigots, shower heads and toilets. Install/retrofit devices so that consumption is reduced to 1.5 gallons/flush for toilets, 2 gpm for showers and 1.5 gpm for personal use spigots. Install automatic shut-off faucets in all public restroom facilities.

4) Evaluate the need for contracting a leak detection survey. This activity is especially recommended for sections of distribution systems that are old, suspected of leaking, or located in potential water supply shortage areas.

5) Phase-out lawn areas, promote the use of native vegetation for landscaping activities, and require the use of drip irrigation systems where watering is essential.

6) Develop concession contract and/or concession cooperation to implement:

a) installation/retrofitting (as appropriate) of low volume toilets (1.5 gallons/flush), reduced-flow showerheads (2 gpm), and reduced-flow bathroom sink aerators (1.5 gpm) in lodging units and automatic shut-off faucets in restaurant and public restrooms. These measures are reasonably inexpensive and could reduce concessions water use by approximately 20%, resulting in a significant cost savings in water usage charges.

b) development of a training session for restaurant/kitchen employees to discuss possible water conservation measures in food preparation, dishwashing, and food service operation.

c) utilize "off-site" laundry/linen services.

d) cooperate in the implementation of a water conservation public awareness program that would include placards on restaurant tables (i.e. serving water only upon request), hanging "water conservation reminder" placards in bathrooms and showers, etc.

Phase II: Initial Drought Condition (below average rainfall over a four month or greater period/no significant decrease in spring flow/well level)

1) Activate a standing "Drought Advisory Committee" with the responsibility of conducting a monthly assessment of water usage, water conservation measures, and water supply status, and for providing the superintendent with a monthly situation report and recommendations for appropriate management actions.

2) Posting of water shortage emergency restriction notices and providing increased public awareness through park publications and visitor contact at entry stations and visitor centers.

3) Request voluntary reductions of residential shower and laundry use.

4) Prohibition on the washing of all government, concession, and private vehicles and trailers.

5) Case-by-case evaluation by the "drought advisory committee" for:

a) mandatory restrictions on lawn, garden, and landscape watering;

b) increased water conservation measures in food service operations;

c) closing of trailer dump stations;

d) prohibition of visitor trailer water hookups;

Phase III: Moderate Drought Condition (declining water supply/spring flow below pre-determined level)

1) Adopt appropriate Phase I & II water use restrictions and recommendations.

2) Close camper service laundries and showers.

3) Case-by-case evaluation of "Drought Advisory Committee" for:

a) turning-off exterior spigots in the campground thereby requiring that water be hauled from the restrooms;

b) mandatory use restrictions on water for food service operations, including limiting dishwashing operations;

c) limiting use of toilets and/or showers in lodging units.

4) Prepare water hauling contingency plan evaluating prospective needs, costs, alternative suppliers and contract requirements.

Phase IV: Severe Drought Condition (water demand surpasses water supply recharge)

1) Adopt appropriate Phase I, II, & III water use restrictions and recommendations.

2) Institute weekly drought status meetings attended by the "drought advisory committee", division chiefs, and concessions representatives.

3) Implement, as deemed necessary, emergency water hauling.

4) Secure & turn-off water to all lodging units bathrooms (necessitating the use of public restrooms).

5) Institute water rationing for food service operations, possibly requiring use of pre-packaged foods.

Phase V: Emergency Water Supply Condition (Water storage below minimum needed to assure adequate visitor safety and fire protection)

1) Close all visitor services in the affected area requiring water supply. If visitation is deemed safe and appropriate, contract for the use of portable toilets. If visitation is not deemed safe and appropriate, close area to visitation. Haul water, if necessary, for essential park operations.

This recommended water conservation/drought contingency program should be reviewed as part of a WRMP, and if found acceptable, implemented as park management policy.

2) Transboundary Water Resources

a. Rio Grande Historic Flows

While it flows unimpeded through relatively undisturbed lands in BIBE, the effects of upstream impoundments, channelization, diversions, and irrigation has profoundly altered natural flow patterns, subsequently affecting natural conditions, water quality, and potential recreational use in BIBE.

Saunders (1987) analyzed period-of-record streamflow records for seven gaging stations of the Rio Grande drainage from above the confluence with the Rio Conchos to below BIBE in order to determine historic seasonal and annual variations in flow rates and volumes. This analysis included streamflow records from four gaging stations on the mainstem (River Miles 963.7, 949.8, 862.4 and 657.5) and from three tributaries (Rio Conchos, Alamito Creek, and Terlingua Creek) just before their confluence with the Rio Grande. A minimum of 25 years of record (1961-1986) was available for all seven gaging stations, though records for the earliest station (Rio Grande above Rio Conchos (RM 963.7)) date back to 1889.

Saunders' (1987) analysis of streamflow records from 1961-1985 showed that, on an average, the mainstem Rio Grande (above the Rio Conchos) contributed less than 6% of the flow of the Rio Grande near Castolon. More than 86% of the flow of the Rio Grande at this point is attributed to inflow from the Rio Conchos, with Alamito Creek and Terlingua Creek together contributing an average 8% of the flow. The flow pattern appears to have been altered significantly in 1986 when the streamflow in the Rio Grande above the Rio Conchos increased 500 percent from 1985, probably because of releases from the Elephant Butte Reservoir in New Mexico brought about by three successive record years for runoff in the Upper Rio Grande basin (Saunders 1987).

Since the recreational use potential and water quality of the Rio Grande in BIBE are influenced, to some extent, by both the source of the water and flow patterns dependent upon upstream uses, information on flow volumes, flow patterns, source water, and upstream releases should be readily available to park managers. It is strongly recommended that the development of a WRMP include an updating of the streamflow database (1987-present) for all seven gaging sites analyzed by Saunders (1987), and provide recommendations concerning the maintenance, methods of evaluation, and use of these data in NPS management planning including river use, backcountry, flood warning, and facility siting activities.

b. Rio Grande Water Quality & River Use

The suitability of the Rio Grande for water supply, fisheries and wildlife habitat, and recreational river use is dependent upon streamflow and water quality. While water quality has been intensively studied in the more developed areas of the Rio Grande basin, fewer studies (Mendieta 1974, Warshaw 1975, and others noted below) have been conducted in the river segment from below El Paso to the southeastern boundary of BIBE. Additionally, water quality information pertaining to the Rio Conchos is extremely limited. The studies that have been completed in this river segment, while preliminary in nature, do provide at least an overview of existing water quality and identify some significant probable water quality concerns.

From his assessment of US Geological Survey water quality data for the Rio Grande at Foster Ranch (RM 657.5), downstream from BIBE, Saunders (1987) characterized the Rio Grande water quality as being moderately high in total dissolved solids, especially sodium and sulfate ions, with calcium and chloride present to a lesser extent. This probably indicates that groundwater via mineralized springs has an influence on the water quality, as well as a possible impact from upstream agriculture.

Roberts (1989) monitored Rio Grande physico-chemical water quality monthly during 1988 at seven sites from above the confluence of the Rio Conchos (near Presidio, TX) to Horse Canyon (below BIBE). While the data collected provides useful background information for a number of constituents, neither the parameters selected nor frequency of monitoring were sufficient to adequately link water quality with upstream land-use activity.

Irwin (1989) conducted a survey of contaminants and toxic chemicals in fish and wildlife along the Rio Grande in the vicinity of Castolon in BIBE. The study measured residues of 67 chemical contaminants including organochorines, PCB's, heavy metals, aliphatic hydrocarbons, and polycyclic aromatic hydrocarbons (PAH's), many of which can be related to urban, agricultural, mining, or industrial activities.

DDE, a breakdown product of DDT, was found in concentrations exceeding predator concern levels in aquatic insect samples and several small birds from the Rio Grande area (Irwin, 1989). This is an issue since eggshell thinning, an effect of DDE, has been a probable cause of the declining Peregrine Falcon (*Falco peregrinus*) populations along the Rio Grande. The DDE-contaminated aquatic insects which emerge from the river constitute a portion of the food base for a number of small bird species which are prey for the Peregrine Falcon. Thus, DDT/DDE contamination is probably affecting this endangered species.

Until recently, DDT was applied to agricultural crops in the Rio Conchos watershed of Mexico. Thus, inflows from the Rio Conchos and other Mexican sources are suspected as being the most likely sources of recent DDE contamination in the Rio Grande. The use of DDT on agricultural crops has only recently been outlawed in Mexico (Howard Ness, National Park Service, Mexican Affairs Branch, Office of International Affairs, personal communication). The potential persists in the near term, however, for continued illegal use along both sides of the border. While, it is expected that concentrations of DDT and its breakdown products will eventually decrease through natural breakdown processes, these breakdown processes may occur more slowly in the arid environments of the Big Bend area than in other parts of the United States. (Roy Irwin, U.S. Fish & Wildlife Service, personal communication).

Irwin (1989) also found mercury to be slightly elevated in most fish and wildlife samples, but not at concentrations high enough to be alarming. He further reported elevated PAH concentrations in several sediment and fish tissue samples in the Castolon area. The presence of PAH's at this remote site is somewhat problematic, as these petroleum-related contaminants are most often associated with urban or industrial influences. While the source of PAH's in BIBE is unknown, it is possible that the contaminants originate in the urbanized corridor around El Paso/Juarez and Presidio/Ojinaga or are generated locally via improper disposal of motor oil, river fording by automobiles, or oil spills from unidentified upstream sources.

Another potential issue is the possible water resources-related effects of a proposed forestry development project in the Sierra Madre Occidental located in the Rio Conchos watershed of Mexico. This World Bank sponsored project proposes to extract 226 million board feet of lumber from approximately 19.5 million acres along the upper and western slopes of the Sierra Madre Mountain range. While selective logging, when combined with measures to preserve streamside riparian vegetation can be conducted with minimal impacts to water quality, poorly managed timber sales may alter local runoff patterns, increase erosion and sedimentation, and result in the degradation of water quality. Because of the influence of the Rio Conchos on the lower Rio Grande, the NPS's Office of Mexican Affairs has been monitoring this project and is developing a strong working relationship with the Government of Mexico and the World Bank in order to encourage that forestry management practices be conducted in a manner that will not result in significant downstream degradation of the Rio Conchos and Rio Grande (Howard Ness, Mexican Affairs Branch, Office of International Affairs, National Park Service, personal communication).

In a recent icthyofauna and aquatic habitats survey, Bestgen and Platania (1988) found considerable evidence of extreme organic (i.e., sewage) pollution in the Rio Grande downstream of the Rio Conchos. They noted a foul smell, thick deposits of black, anoxic silt in low velocity areas, and the presence of a foamy scum in backwater areas. In addition, Bestgen and Platania (1988) reported significantly lower fish densities and reduced fish species diversity than were found at this site in 1977 (Hubbs et al. 1977). These highly degraded conditions were found only in the Rio Grande, and not in tributaries or in the Rio Grande upstream of the Rio Conchos.

While most of the existing water quality studies are preliminary, taken together, they indicate that water quality degradation has probably occurred in the Rio Grande within BIBE and that these problems continue to exist. These issues appear to be complex and may involve contamination from sewage, agricultural, industrial, and urban sources.

As part of planning activities in support of WRMP development, existing water quality information should be reviewed, and its availability through the Environmental Protection Agency's (EPA's) STORET system should be verified. Existing data not already in the STORET system should be added. Discussions should also be held with the International Boundary and Water Commission, the U.S. EPA, Secretaria de Desarrollo Urbano y Ecologia (SEDUE), the Texas Water Commission, the States of Chihuahua and Coahuila, and other appropriate entities to ascertain the availability of existing land-use, point source discharge, and potential nonpoint source pollution information for both the Rio Grande watershed below El Paso and the Rio Conchos watershed. This information may then be utilized to assess future monitoring and study needs.

A particular concern is the suitability of the Rio Grande or its shallow alluvial water as a water supply. The WRMP should evaluate the adequacy of the existing drinking water quality monitoring program and recommend any enhancements necessary to meet the EPA's expanded regulations for drinking water contaminants, or otherwise deemed appropriate, due to the suspected presence of DDE, PAH's, and other potential contaminants.

Additionally, river rafting is popular along the Rio Grande and contact recreation occurs both in the river and at hot springs along the river's edge. Little information is available regarding the possible presence of pathogenic waterborne organisms in these waters. However, hot springs in other locations, have sometimes been found to contain *Naegleria fowleri*, a pathogenic protozoan, suspected in several fatalities nationwide. This and other non-fatal pathogens (Giardia, Cryptosporidium, viruses, etc.) could occur in the Rio Grande and other water bodies resulting in gastro-intestinal problems or dermal irritation.

It is recommended that public health issues be more fully addressed in the pending River Use Management Plan. The river use planning team may wish to distribute a follow-up survey where river users could report incidences of gastro-intestinal problems or dermal irritation (persistent itch, rash, etc.) following river trips. In addition, the plan should evaluate requiring outfitters and private users to carry all their potable water because of the presence of chemical contaminants in the Rio Grande which may not be treated by simple purification methods.

The WRMP should also propose alternatives for developing and promoting a strategy to locate and control sources of water quality contamination entering the Rio Grande upstream of BIBE. Since the Rio Conchos would play an important role in any such strategy, it is likely that extensive international cooperation and coordination will be necessary. Thus, the NPS's newly established Office of Mexican Affairs Branch (Office of International Affairs) will play an important role in this process.

c. Impacts of Trespass Livestock

The frequent occurrence and probable natural resource damage inflicted by trespass livestock, including cattle, horses, and burros, have long been a management concern at BIBE. The trespass livestock, generally originating from Mexico, are frequently found in the riparian zone along the Rio Grande (primarily in the vicinity of low water river crossings), and near springs and seeps further into the park.

Although riparian habitats comprise only a small proportion of the park, they play a crucial role in providing important plant and wildlife habitat. Adverse impacts from grazing livestock on soils, vegetation, and water quality in the riparian zone have been well documented (Kauffman and Krueger 1984, Platts and Raleigh 1984). These impacts include damage to, or destruction of sensitive riparian vegetation, increased erosion from soil compaction and streambank trampling, and an increase in sediment loading, nutrients, and fecal coliform bacteria in the adjacent springs and streams.

The degree of impact to the natural resources is generally correlated to livestock numbers, the amount of time they remain in the riparian zone, their dispersion patterns, and recent weather conditions. During a period of drought, the impact to riparian vegetation may be exceptionally severe, while the most significant water quality degradation will often follow a large rainfall event when sediments and fecal material are washed into the receiving stream.

The control and elimination of trespass livestock in BIBE are more a manpower and political consideration than it is a water resources issue. While no quantitative studies have been completed to assess resource damage in the park, it may be assumed that the amount of resource damage is directly proportional to the amount of trespass activity.

Methodologies for standardized, quantitative riparian zone condition assessment have been developed by the USDA Forest Service (USDA Forest Service 1989) and the Bureau of Land Management (Gebhardt et al. 1990) and are currently being field-tested. If necessary, similar condition assessments could be undertaken in BIBE in order to assess the impact of trespass grazing activity on the riparian zone. However, the costs associated with such a study would be significant, and the trespass livestock issue at BIBE appears to be more one of defining alternatives to limit the problem, rather than one of documenting resource damage (see also Section 6).

d. External Groundwater Withdrawals and Potential Pollution

A geohydrologic investigation is needed for the general area to delineate groundwater regimes which originate outside the park and contribute water to the park. Areas of potential groundwater overdraft and/or pollution need to be identified, as well as areas within the park susceptible to such impacts. Potential impacts to the park could possibly include loss of spring flow and/or degradation of water quality in wells and springs.

A project statement for such a study should be developed in the WRMP. Information gained would provide park management with the information needed to identify susceptible areas (if any), and to develop long-term management strategies for their protection.

3) Floodplain Assessment & Management

BIBE is located in an area that experiences sudden, violent runoff events in response to periods of short duration, intensive rainfall. All tributaries to the Rio Grande that exist in the park should be considered capable of producing flash flood events. Obviously, those tributaries with the largest watershed areas are the most dangerous, but even streams with small drainage areas may produce life threatening floods. The Rio Grande itself is less prone to flash flooding than are the local tributaries. Flow in the river can rise rapidly when tributaries are flooding but flow of sufficient magnitude to cause overbank flooding will rarely, if ever, occur as a flash flood. Therefore, floodplain management activities within BIBE should emphasize 1) detection, warning, and contingency action planning for sites prone to Rio Grande flooding; and 2) minimal and selective use of areas subject to tributary flooding.

There are two visitor use areas within the park that are particularly prone to flooding, Castolon and Boquillas (Rio Grande Village).

a. Castolon

Flooding in the Castolon area can be caused by the Rio Grande and Terlingua Creek. Sites of concern in the vicinity of Castolon include the following:

(1) The Alvino House and other historical structures which are part of the National Historic Register District, and are located on the Rio Grande floodplain below the Castolon Ranger Station;

(2) Cottonwood Campground which located on the alluvium along the Rio Grande;

(3) Santa Elena Crossing Parking Area;

(4) areas near the mouth of Terlingua Creek which have been developed to provide for public parking for access to Terlingua Creek and the Santa Elena Canyon Overlook;

(5) trail and day use areas leading from the parking lot described above, across Terlingua Creek, and connecting with a trail proceeding to the Santa Elena Canyon overlook;

(6) the boat/raft take-out point and parking areas adjacent to the Rio Grande approximately one mile below the confluence with Terlingua Creek; and,

(7) primitive camping areas along Terlingua Creek.

The safety during a flash flood of those rafting from Lajitas through Santa Elena Canyon is also a concern.

b. Boquillas (Rio Grande Village)

A two mile stretch, along the north bank of the Rio Grande in the vicinity of Boquillas, contains historical sites, major NPS campgrounds, a water pumping site, and concessionaire facilities. Most are probably located within the 100-year floodplain, with a few structures possibly subject to loss from bank erosion.

In addition, this river stretch contains several important springs which support the Big Bend Gambusia, an endangered species. A natural resources implication of the flooding of these springs by the Rio Grande would be the potential introduction of predators which could lead to a possible elimination of the Big Bend Gambusia.

In addition to the flooding of the Rio Grande proper, the Boquillas area may be subject to flooding from an unnamed wash to the north. This stream is believed to be subject to periodic flash-flooding, though the stream gradient in the vicinity of Boquillas is low and the channel poorly defined. It is felt, however, that a wide area, including the NPS housing area, maintenance yard, and sewage disposal pond may lie within the floodplain of this stream. The completion of floodplain mapping and assessment, as well as a flood/erosion mitigation plan are necessary for these areas.

In addition to the two above areas, the historic Hot Springs road and parking area, located approximately 1.5 river miles upstream of Boquillas should be inspected for flood hazard study requirements.

4) Resource Monitoring of Springs and Seeps

In 1976, an initial inventory and survey identified approximately 180 water sources in BIBE including springs, seeps, tinajas, and stock tanks. Follow-up surveys in 1986 and 1990 further refined the inventory so that today over 300 water sources have been located and surveyed, including more than 200 springs (Mike Fleming, Big Bend National Park, personal communication).

Because of the park's location in a desert environment, these water sources constitute an extremely important natural resource. They provide critical wildlife water supply, support endangered species habitat, and are utilized for visitor water supply. There is, however, a general feeling that available free water is being reduced at many of these sites because of the encroachment of tamarisk (*Tamarix spp.*) and other vegetation (National Park Service, 1988a).

Because of the importance of these water sources and the general lack of long-term trend information, the continuation of the five year cyclic inventory and survey program is encouraged. It is recommended, however, that a WRMP review similar inventory studies, evaluate the results from the 1976, 1986, and 1990 Big Bend surveys, and develop the proper statistical framework that will allow for the optimal analysis of long-term trends for both flow quantities and water quality.

In addition, a WRMP should propose management alternatives relevant to the existence and continued maintenance of historical man-made water sources (wells, windmills, stock tanks, etc.) within backcountry areas of the park.

5) Fisheries & Aquatic Biological Resources

The fisheries and aquatic biological resources of the Rio Grande have undoubtedly been affected in the vicinity of BIBE by upstream dams, diversions, land-use, and channelization projects. Carl Hubbs (1940) reported on fish specimens collected from the vicinity of the park in the late 1930's. Even at this time, Hubbs stated that "poisonous run-off from mercury and silver mines in the region are reported to have killed vast numbers of fish in the Rio Grande from Presidio to Glenn Springs." (Hubbs 1940).

Clark Hubbs et al. (1977) conducted the first thorough fisheries inventory in the Rio Grande between El Paso and the confluence with the Pecos River. This study found the fish communities to be divided into three faunal assemblages: 1) the saline Rio Grande fauna made up of widely distributed and salt tolerant species (upstream of the Rio Conchos); 2) the Rio Conchos-Rio Grande fauna composed primarily of south Texas and Mexican species (Rio Grande between the confluence of the Rio Conchos and the Pecos River); and 3) the tributary creek fauna that depend on tributary creeks for part or all of their life stages (Chihuahuan species plus derivatives). The last two assemblages included a number of endangered species.

Bestgen and Platania (1988) provided a more recent fisheries inventory of the Rio Grande from El Paso to the boundary of BIBE, while Platania (1991) extended this survey from Boquillas to San Ygnacio. Platania is presently completing an additional survey which will provide a current fisheries inventory for the Rio Grande within BIBE (Dr. S. Platania, University of New Mexico, personal communication).

A comparison of these recent inventories with the earlier survey of Hubbs et al. (1977) indicate that the icthyofauna of the Rio Grande upstream of the Rio Conchos has changed little since 1977 (Bestgen and Platania 1988). The fish community remains composed largely of species that are resistant to the effects of reduced flows, high salinity, and temperature extremes. Below the confluence of the Rio Conchos, however, Rio Grande fish species diversity have decreased markedly since 1977, possibly due to a decline in water quality (Bestgen and Platania 1988). Of particular concern, is the report of Bestgen and Platania (1988) of large amounts of black, anoxic silts located in pools within the Rio Grande below the confluence of the Rio Conchos. Anoxic silts frequently typify heavy organic loading, the source of which is presently unknown.

A limited amount of limnological and aquatic biological information is also available for the other water resources of BIBE. Lind and Bane (1975, 1979) and Bane and Lind (1978) conducted limnological surveys of several aquatic ecosystems of BIBE. The surveys provided baseline chemical and biological data on water sources primarily around Rio Grande Village including the Rio Grande and the springs and ponds which support the endangered Big Bend Gambusia. In addition, chemical and biological information was also provided for Hot Springs, Boquillas Canyon Warm Springs, Cattail Falls, Ernst Tinaja, Boot Springs, and Lower Tornillo Creek.

Four fisheries/aquatic biological-related issues need to be addressed as part of BIBE's WRMP. These include: 1) providing adequate protection for the survival of the Big Bend Gambusia; 2) refining the reasons for, and downstream implications of, the reported degradation of fish community structure/species diversity in the Rio Grande below the Rio Conchos; 3) determining the effects of runoff events from intermittent streams which may result in fish kills (especially carp) after extended dry periods (Mike Fleming, Big Bend National Park, personal communication), and 4) evaluating any potential public health issues associated with eating fish caught in the Rio Grande within BIBE and the Rio Grande Wild & Scenic River.

6) Riparian Zone Classification, Protection, & Management

Ditton et al. (1977) identified 64 major riparian areas along the Rio Grande between Lajitas and La Linda. Of these, 8 are accessible by paved road, 18 by primitive road, and the remaining 38 accessible only by river. The extent of these riparian communities varies considerably, ranging from several feet to more than a half mile in width. In several cases, similar riparian environments can be found in adjacent arroyos and streams where enough surface water or shallow groundwater exists to support riparian vegetation.

These riparian environments constitute important wildlife habitat and provide a popular recreational resource in BIBE. Boeer and Schmidly (1977) collected or observed 30 species of terrestrial mammals in the riparian habitats in Big Bend National Park, and Wauer (1977) reported that these habitats support an important migratory corridor for birds.

Changes to riparian environments frequently occur as a response to flood events, but can be influenced by man-induced activities such as cattle grazing (see section 3.c.) and visitor use. Site descriptions from earlier studies seem to indicate that significant vegetative change has occurred in riparian zones adjacent to the Johnson Ranch and at the mouth of Santa Elena Canyon between the early 1940s and mid-1970s (Boeer and Schmidly 1977). However, the park has had no systematic program to monitor changes occurring within the riparian zone.

Visitor use within Big Bend's riparian zone includes developed facilities (Rio Grande Village, Cottonwood Campground, and the Santa Elena Canyon trailhead parking area and take-out boat ramp), camping at primitive campsites with road access, backcountry use (nonvehicular), and boating use, including popular float trips.

Ditton et al. (1977) analyzed visitor use patterns, biological conditions, and selected recreational impacts (including litter, trampling, tree cutting, and human waste) on the riparian zone of the Rio Grande in BIBE in 1975. This study found that, while recreational impact was not significantly related to the biological health of the area, one in every four sites was heavily impacted, decreasing the aesthetic appeal of backcountry use. Trespass livestock impacts (including trampling and waste) were also assessed and found to be fairly constant along the river. The impacts of trespass livestock tend to mask impacts caused by visitor use. Thus, until the trespass livestock issue is resolved, it will not be possible to fully evaluate and address impacts related to visitor use.

At present, a two-phased river use study is underway at BIBE which will assess the sociological and physical/biological characteristics associated with use of the Rio Grande corridor (Dr. Keith Yarborough, Big Bend National Park, personal communication). An important component of this plan will be to define what constitutes an acceptable "carrying capacity" for visitor use. This assessment will be based largely upon the resilience of the riparian zone biota and physical environments. Methods including riparian zone classification and monitoring should be evaluated in order to quantify recreational use, visitor impact, and the effects of trespass livestock. Data from this study will then be used to develop a River Use Management Plan.

7) Water Resources Issues Related to Park Development & Operations

A mission of the NPS to provide for visitor use often requires the development, operation, and maintenance of visitor use facilities within national parks. These may include the development of roads, visitor centers, camping facilities, etc., as well as the provision of adequate water supply, sanitary facilities, and trash collection. Since these activities may, at times, affect water resources, it is the responsibility of the National Park Service to assure that any potential effects upon water resources are minimized and that compliance is achieved with all applicable federal, state, and local laws and regulations.

a. Wastewater Treatment Issues

Wastewater treatment is provided at BIBE via a number of different systems. An evaporative sewage lagoon is located in the Chisos Basin, which, during periods of high visitation, is permitted (TX0094684) to periodically discharge effluent into an intermittent stream (Oak Creek to Rough Run to Terlingua Creek) (Roberts, 1989). An evaporative sewage lagoon is also utilized at Rio Grande Village. At Panther Junction, sewage is treated, and the effluent is recycled through an irrigation system. The overflow is released into an open-bottomed pit edged with concrete, where it is allowed to percolate into the substrate. The solid waste from these systems is initially stored on-site in concrete drying pans and eventually taken to a solid waste disposal site located within the park. Septic tanks are utilized for wastewater management at both Castolon and Persimmon Gap.

A concern was expressed that contaminated water from the Chisos Basin lagoon system could be leaking and, in time, could contaminate Oak Spring, the Chisos Basin's only water supply. Baker et al. (in press) completed a hydrogeologic investigation of the Basin/Oak Spring Area in order to investigate this issue. Test drilling near the two sewage lagoons indicated that no significant leakage is occurring from the lagoons. It was further reported that most of the groundwater from Oak Spring originates from precipitation in the Oak Springs area west of the Chisos Basin, though a smaller component may be derived from precipitation in the Chisos Basin (Baker et al. in press). While continued vigilance is warranted, further investigations pertaining to the Chisos Basin sewage lagoons do not appear necessary at this time.

b. Landfill Issues

Two landfills have historically been operated in BIBE. A landfill currently operated in the vicinity of Grapevine Hills, receives both domestic trash and sludge from the sewage lagoons at Chisos Basin and Rio Grande Village. In addition, the NPS formerly operated a second landfill site in the vicinity of the Paint Gap Hills.

Both landfill sites are located in remote areas within the Tornillo Creek drainage. Groundwater flow at both sites is towards Tornillo Creek and away from all existing or potential well fields, so the potential contamination of drinking water supplies appears highly unlikely. Nevertheless, landfill closure or the implementation of significantly more stringent monitoring requirements is being required by the State of Texas in 1992.

In order to address this issue, the park is currently developing a Solid Waste Management Plan which will evaluate alternatives for solid waste handling in light of new NPS and State of Texas requirements.

c. Road Improvements & Aggregate Removal

BIBE contains 161.8 miles of paved and 256.9 miles of unpaved roads. The NPS, in cooperation with the Federal Highway Administration, is responsible for providing these roads, and for maintaining them in a safe condition. In recent years, road improvements, as well as routine road rehabilitation and maintenance operations, have required significant quantities of borrow material (sand and gravel). These borrow materials have been extracted from sites on private lands near the park (Rough Run) and from public land inside the park (Tornillo and Nine Point Draw Creeks). The need for borrow material will continue into the foreseeable future as additional road improvement projects are implemented, and as maintenance and rehabilitation work continues. NPS Special Directive 91-6 requires that park managers first look outside the park for sand, gravel, and other borrow material needs. Superintendents are instructed to utilize new in-park borrow pits only if it has been determined, based upon written analysis, that economic factors make it totally impractical to import sand or gravel and if acceptable sources are identified in the park resource management plan. (National Park Service, 1988b).

The most common sources of borrow material in the vicinity of BIBE include terrace and streambed deposits along many of the region's streams and floodplain deposits along the Rio Grande itself. While a number of potential borrow material sources are available both inside and outside the park, the location of several in-park sites within a recommended wilderness area presently favors material sources from outside of the park.

In all cases, however, should the use of *in-stream* sites within the park be considered, NPS Special Directive 91-06 requires that appropriate scientific studies be conducted to assure that:

(1) upstream and downstream channel stability will not be affected;

(2) water quality and aquatic and terrestrial habitats will not be adversely impacted;

(3) extraction pits can be designed to resemble natural features and function in a manner that does not encourage morphologic or vegetative changes;

(4) the extraction site will refill with mineral materials similar in characteristics to the removed borrow; and

(5) replenishment will occur in a reasonable timeframe (National Park Service, 1991b).

d. Hazardous Materials Management

BIBE has previously conducted two park-wide inventories for the presence of potentially hazardous materials. With the exception of pesticides, gasoline, oil, coolants/antifreeze, paint, and solvents used in the operation and maintenance activities, no known sources of additional hazardous materials currently exist within the park (Mike Fleming, Big Bend National Park, personal communication).

Present park policy restricts the maintenance of government vehicles to the main maintenance facility at Panther Junction. Waste materials such as oil and solvents generated from this facility are temporarily stored in a holding tank, where they are periodically collected for recycling by an independent contractor. Similar materials generated by park employees in the maintenance of private vehicles are also collected for recycling at this facility. The disposal of coolants/antifreeze currently presents a problem as the park lacks a proper recycling machine. At this time, these fluids are not changed in government vehicles until absolutely necessary. The residual fluids are then passed through a primitive cloth filter and reused in the vehicles to the maximum extent possible (Dan Muntean, Big Bend National Park, personal communication). This procedure, while demonstrating an awareness of hazardous materials disposal issues, is acceptable only in the short-term and the importance of obtaining and utilizing commercially available recycling machinery can not be over emphasized.

Fuel is stored at the Panther Junction maintenance yard in underground storage tanks. These tanks were recently repaired and the long-term plan calls for replacement of the existing system with above-ground fuel storage facility. In the interim, periodic testing of government-owned underground storage tanks has been initiated.

In addition, the concessionaire operates two public gas stations, one at Panther Junction and a second at Rio Grande Village. No information is available concerning hazardous materials storage facilities or disposal at these sites.

A WRMP should review all hazardous materials handling procedures, locate all underground storage tanks utilized by the park and concessionaire, and assure that adequate periodic testing procedures are implemented on all government and non-government underground storage tanks located within the park.

RECOMMENDATIONS

It is the recommendation of the WRD that a WRMP be developed for BIBE. While the park has been very successful in the past in implementing a long list of important water resources-related studies, the importance of water in the desert environment, combined with the relatively complex nature of the unresolved water resources issues, warrants the development of an integrated water resources management strategy. It is felt that the development of a WRMP would provide BIBE with a blueprint to address key water resources issues over the next 5-10 years and be integral to the development of a comprehensive water resources management program for the park.

Predominant issues to be addressed in a WRMP would include:

(1) an assessment of water supply and projected needs (visitor use and endangered species protection), design of a water use monitoring program, implementation of a conservation/drought management plan, and an evaluation of drinking water quality monitoring requirements;

(2) development of a strategy to address complex, persistent transboundary water resources-related issues;

(3) coordination with the WRD for the completion of needed floodplain delineation studies for Rio Grande Village and areas prone to flooding in the vicinity of Castolon; and,

(4) an evaluation of continuing inventory, monitoring, research, and management alternatives relating to springs and seeps, man-made water sources, fisheries and aquatic biological resource issues, and riparian zone classification, protection, and management.

In addition, the WRMP could, where appropriate, address water resources-related aspects of the River Use Management Plan, Backcountry Management Plan, and Solid Waste Management Plan.

Because of staff constraints both within the park and the WRD, it is recommended that the WRMP be developed under either a cooperative agreement with an appropriate university or in-house utilizing a temporary position (NTE 16 months) for a GS-1315-9 hydrologist. In either case, experience has shown that the development of a WRMP for an area as complex as BIBE will require approximately 2 years and cost approximately $62,000.

It is further recommended that this Water Resources Scoping Report be utilized as an interim guidance document for water resources-related issues until the completion of a WRMP. Components of the scoping report may be used in the development of management strategies and project statements relating to water resources issues requiring immediate management attention. The long-term development of a Water Resources Management Plan, however, provides the advantage of allowing park management to address water resources-related issues programmatically, rather than on a project-by-project basis.

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

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