

14 August 95

Shared Water Resources Overview Paper No. NPS-03

Study Areas: Rio Grande - Rio Conchos to Amistad Subarea
Rio Grande - Below Amistad to Falcon Reservoir Subarea
Rio Grande - Lower Rio Grande Valley Below Falcon Reservoir
to Gulf of Mexico Subarea

Bureau: National Park Service (NPS)

I) Rio Grande - Rio Conchos to Amistad Subarea

The NPS administers three units of the National Park system located within the Rio Grande - Rio Conchos to Amistad subarea, **Big Bend National Park, Rio Grande Wild & Scenic River, and Amistad National Recreation Area**. Since both Big Bend National Park and the Rio Grande Wild & Scenic River are administered by the Superintendent, Big Bend National Park, they will be addressed as a single unit for this analysis.

Big Bend National Park/Rio Grande Wild & Scenic River (Texas)

Introduction

Big Bend National Park is located along the southern border of western Texas where the Rio Grande forms a large bend that sweeps southward as the boundary with the Mexican states of Chihuahua and Coahuila. Established in 1944, the Big Bend National Park is representative of the northern half of the Chihuahuan Desert, where water is generally in limited supply. In the central portion of the Park, the desert gives way to the Chisos Mountains, which rise several thousand feet above the surrounding desert plain creating a montane environment. Along the southern boundary of the Park, the Rio Grande supports a narrow band of riverine and riparian habitats not commonly found in the desert environment.

In 1978, Congress established the Rio Grande Wild and Scenic River along a 196 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 Big Bend National Park. The remaining 127 miles of the Rio Grande Wild and Scenic River is also administered by the National Park Service. Thus, the Superintendent of Big Bend National Park administers over 244 miles along the Rio Grande, approximately 13% of the international boundary between Mexico and the United States.

Water Resources

The Rio Grande (Rio Bravo del Norte), which forms the southern boundary of the Park, is the Park'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, saline groundwater arises from springs which again establishes surface flow in the Rio Grande. 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. 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.

Except for the Rio Grande, the surface waters of Big Bend National Park consist largely of creeks originated by small headwater streams (or springs), and locally important springs, seeps, and tinajas. Except during flash floods, most of these streams generally flow only ephemerally or locally over their stream beds, usually losing their water to evaporation and percolation. 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 park staff has also mapped over 300 additional water sources within the boundary of the Park including over 200 springs, as well as numerous seeps, tinajas, man-made water holes, stock tanks, etc. These water sources provide locally important habitat and water supplies. The complex geohydrology of the park is an important resource, as groundwater is the sole source domestic water supply for the highly developed Chisos Basin and other park visitor use areas.

Water Issues

1) Water Supply

The provision of an adequate and safe water supply is a primary management concern in the Park. Potable water, irrigation supply, and aquatic habitat for the endangered Big Bend Gambusia (*Gambusia gaigei*) fish are operational concerns.

2) Transboundary Water Resources

Rio Grande Historic Flows. While it flows unimpeded through relatively undisturbed lands within the Park, 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. An 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.

As additional agricultural lands are developed in Mexico, there is a concern that eventually Mexico may develop additional storage projects and divert the Rio Conchos as efficiently as the United States has diverted the Rio Grande. The long term effects of current altered flow patterns upon natural systems as well as future impoundments in the Rio Conchos basin are important management concerns of the Park.

Rio Grande Water Quality & River Use. While water quality has been intensively studied in the more developed areas of the Rio Grande basin, fewer studies have been conducted in the river segment from below El Paso to the southeastern boundary of Big Bend National Park. Additionally, water quality information pertaining to the Rio Conchos is extremely limited; however, preliminary studies do provide at least an overview of existing water quality and identify some potentially significant water quality concerns.

Chemical contaminants related to urban, agricultural, mining, or industrial activities, are present and potentially affecting fish and wildlife in the area. Elevated total dissolved solids indicate groundwater via mineralized springs may also have an influence on water quality of the Rio Grande.

A recent aquatic habitats survey found considerable evidence of extreme organic (i.e. sewage) pollution in the Rio Grande downstream of the Rio Conchos. Significantly lower fish densities and reduced fish species diversity were associated. 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.

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. Poorly managed timber sales could 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.

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. However, hot springs in other locations, have sometimes been found to contain a potentially fatal pathogenic protozoan and other non-fatal pathogens (Giardia, Cryptosporidium, viruses, etc.), posing a potential threat to visitor safety and health.

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 the Park. 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. Adverse impacts associated with trespass livestock 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 Rio Grande and adjacent springs and streams. 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.

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.

3) Fisheries & Aquatic Biological Resources

The fisheries and aquatic biological resources of the Rio Grande have undoubtedly been affected in the vicinity of Big Bend National Park by upstream and downstream dams, diversions, land-use, and channelization projects.

A comparison of recent inventories with a survey conducted in 1977 indicate that the ichthyofauna of the Rio Grande upstream of the Rio Conchos has changed little since 1977. 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. Of particular concern, is the report 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.

4) Flooding

Because of the number of dams on the Rio Conchos and their propensity to discharge water during periods of heavy rainfall, resultant periodic flood events in the Rio Grande are probably more pronounced and of longer duration than in the past.

5) Other Water Resource Issues

Other concerns less affected by transboundary issues include floodplain assessment and management, resource monitoring of springs and seeps, park development and operations, as well as riparian zone classification, protection, and management.

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BIBLIOGRAPHY

Abbott, C.L. 1983. Bedrock aquifer geometry in the Panther Junction Area of Big Bend National Park, Texas. Master's Thesis. Texas A&M University, College Station, TX. 113 pp.

Archer, J.A. 1982. A hydrogeologic evaluation of the alluvial fans in northern Big Bend National Park, Texas, Using Geophysical Methods. Master's Thesis. Texas A&M University, College Station, TX. 106 pp.

Ashworth, J.B. and P.L. Nordstrom. 1989. Public Supply Ground-water Use in Western Texas. Tex. Water Dev. Brd. Report 311.

Bane, C.A. and O.T. Lind. 1978. The benthic invertebrate standing crop and diversity of a small desert stream in the Big Bend National Park, Texas. *The Southwestern Naturalist* 23(2):215-226.

Baker, E.T. Jr., P.M. Buszka, and D.G. Woodward. 1993. Hydrogeology, geochemistry, and quality of water of the Basin and Oak Springs Areas of the Chisos Mountains, Big Bend National Park, TX. U.S. Geological Survey Water Resources Investigations Report 93-4112. Austin, TX. 76 pp.

Bestgen, K.R. and S.P. Platania. 1988. The ichthyofauna and aquatic habitats of the Rio Grande from the New Mexico-Texas border to Big Bend National Park. Report to the U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, NM. 55 pp.

Boer, W.J. and D.J. Schmidly. 1977. Terrestrial mammals of the riparian corridor in Big Bend National Park. In: *Symposium on the Importance, Preservation, and Management of the Riparian Habitat*. July 9, 1977, Tucson, AZ. pp. 212-217.

Chesser, K.C. 1976. A Study of the Geothermal Areas of the Big Bend: The Geological and Chemical Aspects of Thermal Springs Along the Rio Grande. Final Technical Report NSF, SOS EPP 76-07669, 37 pp.

Christensen, P.K. 1981. Hydrologic Reconnaissance of the Rosillos Mountains, Brewster County, Texas. Water Res. Rep. 81-3, SW Region, 19 pp.

Cross, B.D. 1984. Application of remote sensing to the groundwater hydrology study of Big Bend National Park, Texas. Master's Thesis. Texas A&M University, College Station, TX. 80 pp.

Ditton, R.B., D.J. Schmidly, W.J. Boer, and A.R. Graefe. 1977. A survey and analysis of recreational and livestock impact on the riparian zone of the Rio Grande in Big Bend National Park. In: *Proceedings of a Symposium on River Recreation Management and Research*. USDA Forest Service, Minneapolis, MN. pp. 256-266.

Dorfman, M. and R.O. Kehle, 1974. Potential Geothermal Resources of Texas. Bur. of Eco. Geo. Circ. 74-4, 33 pp.

Fallin, J.A., 1988. Hydrology of the U.S.G.S. 7 1/2 Degree Terlingua Quadrangle Map Area, Texas. Janus Press, 113 pp.

Gibson, J.L. 1983. Groundwater hydrology of the Panther Junction Area of Big Bend National Park, Texas. Master's Thesis. Texas A&M University, College Station, TX. 110 pp.

Henry, C.D. 1979. Geologic Setting and Geochemistry of Thermal Water and Geochemical Assessment, Trans-Pecos, Texas. Bur of Eco. Geo., Rep. # 96. 48 pp.

Hubbs, C.L. 1940. Fishes from the Big Bend Region of Texas. Texas Academy of Science Transactions

Hubbs, C., R.R. Miller, R.J. Edwards, K.W. Thompson, E. Marsh, G.P. Garrett, G.L. Powell, D.J. Morris, and R.W. Zerr. 1977. Fishes inhabiting the Rio Grande, Texas and Mexico, between El Paso and the Pecos confluence. In: Importance, Preservation, and Management of Riparian Habitat - A Symposium. July 9, 1977. USDA Forest Service General Technical Report RM-43 pp. 91-97.

International Boundary and Water Commission, 1940. 1940 Diversion and Irrigation Census, Brewster, Co. along the Rio Grande. 122 pp.

International Boundary Waters Commission. 1994. Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and its Tributaries along the Boundary Portion Between the United States and Mexico. 246 pp.

Irwin, R.J. 1989. Toxic chemicals in fish and wildlife at Big Bend National Park, Texas. Contaminants Report, Fish and Wildlife Service, U.S. Department of the Interior, Fort Worth Field Office, Fort Worth, TX. 36 pp.

Kaiser, R.A., S.E. Alexander and J.P. Hammitt. 1993. A Study of the Adequacy of Texas Water Quality Standards for Protecting the Water and Water-Related Resources of the Nine Units of the National Park System in Texas. Report to the NPS Water Resources Division, Fort Collins, CO. 145 pp.

Kauffman, J.B. and W.C. Krueger. 1984. Livestock impacts on riparian ecosystems and streamside management implications -- a review. J. Range Management 37:430-438.

Kiersch, George A., Et. Al. 1952. Structural Localization of Ground Water in Limestones-- "Big Bend District". Bur. of Eco. Geo. 47(8) pp. 794-806.

Leggat, E. R., Et. Al., 1968. Results of Water Resources Investigation of Big Bend National Park, Phase II. USGS Report to the National Park Service. 16 pp.

Leggat, E. R., 1969. A Report on the Progress of the Investigation of the Water Resources of Big Bend National Park, Brewster County, Texas through 1969. USGS Report to the National Park Service. 9 pp.

Lind, O.T. and C.A. Bane. 1975. A limnological survey of aquatic resources of the Rio Grande Valley in Big Bend National Park between Hot Springs and Boquillas Canyon. Report to Southwest Regional Office, National Park Service (Contract No. PX700-3-0502), Santa Fe, NM. 100 pp. + app.

Lind, O.T. and C.A. Bane. 1979. Aquatic ecosystems of Big Bend National Park: biological and chemical indicators of water quality. In: Proceedings of the Second Conference on Scientific Research in the National Parks. Vol 2:7-29. National Park Service, Washington, DC.

Lopez Sepulvada, H.J. 1984. Environmental and geochemical investigation of groundwater in Big Bend National Park, Texas. Master's Thesis. Texas A&M University, College Station, TX. 107 pp.

Mendieta, H.B. 1974. Reconnaissance of the chemical quality of surface waters of the Rio Grande Basin, Texas. Texas Water Development Board Report No. 180. Austin, TX.

Monti, J. 1984. Seismic mapping of alluvial fans and sub-fan bedrock in Big Bend National Park, Texas.

Master's Thesis. Texas A&M University, College Station, TX 52 pp.

Moore, G. 1980. Aquifer Test of Geothermal Spring #4, Rio Grande Village, Big Bend National Park. Water Res. Rep. #80-8 SW Region, 26 pp.

National Park Service. 1995. Resources management plan for Big Bend National Park. Big Bend National Park, TX. 253 pp.

National Park Service. 1992. Big Bend National Park Water Resources Scoping Report. Water Resources Division, National Park Service, Fort Collins, CO. Technical Report NPS/NRWRD/NRTR-92/08. 31 pp.

Platania, S.P. 1991. The ichthyofauna of the Rio Grande drainage, Texas and Mexico, from Boquillas to San Ygnacio. Report to Region 2. US Fish and Wildlife Service, Arlington, TX.

Rawson, J. 1964. Quality of Water from Test Wells in the Castolon Area, Big Bend National Park, Brewster County, Texas. Typewritten Report. 12 pp.

Roberts, J.L. 1988. Systematic Population Survey of the Micro Organisms from Ernst Tinaja, Big Bend National Park, Texas. Typewritten Report on file in the Off. of Sci. and Res. Mgmt. Big Bend National Park, Texas, 8 pp.

Roberts, J.L. 1989. An environmental evaluation of the Rio Grande water quality in the Big Bend Area. Master's Thesis. Sul Ross State University, Alpine, TX. 100 pp.

Roberts, J.L. 1989. Survey of Constituents in the Rio Grande from above the Rio Conchos Confluence to Horse Canyon, Black Gap Wildlife Management Area. Typewritten Report on File with the Office of Sci and Res. Mgmt., Big Bend National Park, Texas. 370 pp.

Saunders, G.P. 1987. Analysis of streamflow of the Rio Grande: Big Bend National Park, Texas. Interim Research Report No.2. Submitted to Office of Resource Management, Big Bend National Park, TX. 24 pp. + app. and map.

Twichell, T. 1966. Results of Phase I, Water Resources Investigations, Big Bend National Park, USGS Report to the NPS Western Service Center, San Francisco, CA. U.S.G.S.

Warshaw, S. 1975. Water quality segment report for segment no. 2306 Rio Grande. Report No. WQS-9. Texas Water Quality Board, Austin, TX. 24 pp.

Wauer, R.H. 1977. Significance of Rio Grande riparian systems upon avifauna. In: Symposium on Importance, Preservation, and Management of the Riparian Habitat. July 9, 1977. Tucson, AZ 165-174.

Wilson, M.P. and M.C. Schroeder. 1984. Groundwater investigation in an area of Big Bend National Park. Final Contract Report (National Park Service Contract CX70290018). Department of Geology, Texas A&M University, College Station, TX.

Amistad National Recreation Area (Texas)

Introduction

Amistad National Recreation Area is located in south central Texas on the Rio Grande/Rio Bravo del Norte along international border with Mexico. The Amistad Reservoir was created in 1969 when the governments of the United States and Mexico cooperatively dammed the Rio Grande River two miles upstream from Del Rio, Texas. The National Recreation Area covers approximately 65,000 acres, making it the third largest international reservoir in the world.

Water Resources

The reservoir is fed by the Rio Grande, Pecos and Devils rivers and extends approximately 74 miles along the Rio Grande, 14 miles up the Pecos River and 25 miles up the Devils River. At its conservation pool elevation of 1,117 feet above sea level, the reservoir has a maximum surface area of 88,200 acres and an average shoreline of 850 miles.

The conservation pool level may rise to 1,125 feet during flood stage, with an estimated 100-year flood level of 1,140 feet. The International Boundary Water Commission is responsible for operating the dam and maintaining the water level. During occasional deep drawdowns, recreational use of the reservoir may be adversely affected, primarily by dry docking boat ramps. At the maximum drawdown elevation of 930 feet, the water will only extend for about 10 miles up the Rio Grande and be 30 feet deep at the dam. The Amistad project flooded two narrow hydroelectric reservoirs on Devils River. Devils Lake, at Rough Canyon, will reappear if the water level of Amistad Reservoir drops below 1,040 feet. Lake Walk, downstream from Rough Canyon, will be exposed if the reservoir falls to 1,000 feet. The condition of both submerged dams is unknown.

Water Issues

1) Potential Contamination from Agricultural Runoff

Extensive agricultural activity occurs upstream of the reservoir in both the United States and Mexico. There is a concern that the reservoir may serve as a "sink" for persistent chemicals which could ultimately affect the aquatic biological resources and higher food chain organisms. While this issue was identified in the 1985 General Management Plan for Amistad National Recreation Area, no studies of the presences of toxic substances has yet been completed. However, the Texas Natural Resources Conservation Commission, in conjunction with the Government of Mexico, the US Environmental Protection Agency and other organizations are currently planning to conduct some reconnaissance sampling in and above the Amistad reservoir as part of the second phase of a Binational Study regarding the presence of toxic substances in the Rio Grande/Rio Bravo and its tributaries (IBWC, 1994).

2) Sedimentation and Eutrophication of Amistad Reservoir

Sedimentation occurs in the upper canyon reaches, being most pronounced on the Rio Grande and moderate on the Pecos and Devils rivers. Each time the dam pool elevation drops, silt is flushed farther downstream. While the National Recreation Area does not currently have a precise estimate of

sedimentation rates, the siltation at the junction of the Pecos/Rio Grande appears to have been occurring at a rate greater than that originally anticipated by the International Boundary Waters Commission (IBWC). Presently, siltation on the Rio Grande extends for about 2 miles downstream and one mile upstream from the Pecos. Sedimentation is extreme with Tamarisk becoming established in a large numbers of areas that were previously river channel. The IBWC estimates sediment thickness of up to 85 feet deep in some areas.

The International Boundary and Water Commission conducts a sedimentation study every 10 years and the Texas Water Commission collects and analyzes water quality samples on a regular basis. As of 1994, results of past and present studies had been requested. A project to compile existing information and study long term sedimentation and eutrophication (AMIS-N-041.000) has been proposed in the National Recreation Area's Resources Management Plan, though as of 1995, the project has not been funded.

3) Other Water Resource Issues

Other water resource issues less affected by transboundary issues include mitigation of Georgia cane (*Arundo donax*) blockages on the Pecos and Rio Grande rivers, investigation of potential impacts from a proposed toxic waste dump in Dryden, Texas, mitigation of human waste disposal problems associated with backcountry camping, and protection and monitoring of an endangered shorebird -least tern (*Sterna antillarum*).

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BIBLIOGRAPHY

Ditton and Schmidly. 1977. A User-Resource Analysis of Amistad Recreation Area. Texas A&M University.

International Boundary Waters Commission. 1994. Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and its Tributaries along the Boundary Portion Between the United States and Mexico. 246 pp.

Texas Water Commission. 1992. Regional Assessment of Water Quality in the Rio Grande Basin. Austin, TX. 207 pp. + app.

Texas Parks and Wildlife Department. 1982. Performance Report: Stateside Fishery Management Recommendations: Existing Reservoir and Stream Management Recommendations, Amistad Lake.

USDI National Park Service. 1985. Draft General Management Plan, Development Concept Plan, and Environmental Assessment. Amistad National Recreational Recreation Area. 207 pp.

II) Rio Grande -- Below Amistad to Falcon Reservoir Subarea

The NPS does not administer any units in the Rio Grande -- below Amistad to Falcon Reservoir Subarea

III) Lower Rio Grande Valley -- Below Falcon Reservoir to Gulf of Mexico Subarea

The NPS administers two units of the National Park system located within the Rio Grande - Below Falcon Reservoir to the Gulf of Mexico subarea, **Padre Island National Seashore and Palo Alto Battlefield National Historic Site.**

Padre Island National Seashore, Texas

Introduction

Padre Island National Seashore consists is a 68 mile long, 0.5 - 3 mile wide barrier island which extends to within 40 mi of the international boundary. The National Seashore contains approximately 133,919 acres of land and water. It is bordered on the east by the Gulf of Mexico and is separated from the Texas mainland to the west by the Laguna Madre.

The National Seashore was established in 1962 to preserve a portion of the diminishing undeveloped seashore of the United States. Padre Island is the longest undeveloped barrier island in the United States. The National Seashore encompasses tens of thousands of pristine wetlands, 29 islands including 19 rookery islands, and 68 miles of undeveloped sandy beaches.

Water Resources

Approximately 53,550 acres of Padre Island National Seashore are made up of marine, estuarine, and/or wetland communities. Laguna Madre is a shallow, hypersaline water body that has been reasonably well studied. Less information is known about the water quality condition of adjacent Gulf of Mexico waters, though the shoreline is heavily impacted by the wash-up of marine debris from shrimping, oil and gas and shipping activities.

Wetland communities include salt marshes, ephemeral ponds, and wind tidal flats. The salt marshes, located in the interior of the island, are characterized by halophytic plants, brackish water with little exchange of fresh and salt water, and low elevation. The ephemeral ponds are usually inundated year round and contain unique fish and plankton communities. The wind tidal flats is one of the most prominent features of the National Seashore and is characterized by flat, periodically inundated areas with a thin surface layer of blue-green algae. The tidal flats are habitat for a large number of benthic invertebrates, which provide an important food source for hundreds of bird species.

Historical data indicate the near surface groundwater of Padre Island is a 30 feet thick lens of freshwater, overlying saltwater. The groundwater is recharged by precipitation events and saltwater wave surges. Although the hydrology of the area has not been completely assessed, it has been theorized that the groundwater flows in an easterly orientation from the Laguna Madre to the Gulf of Mexico. Twelve groundwater monitoring wells provide monthly data to assess water quality and to model flow.

Water Resource Issues

Potential Transboundary Issues

Two water quality threats that could be related to activities within Mexico are transportation of oil and hazardous materials within the Gulf of Mexico and Laguna Madre and deposition of marine debris along the Gulf beaches. Neither threat is specifically linked to Mexico, but could be related due to close proximity of the National Seashore to Mexico.

Gulf currents change direction biannually; marine debris is swept northward during the summer, southward during the winter. Therefore, debris originating in Mexico could be washing up along the National Seashore. Most of the debris (onion sacks, rubber gloves, milk cartons, light bulbs, tar balls) is associated with the shrimping season. An ongoing monitoring program (PAIS-N-023.000) is attempting to qualify and quantify the types and amounts of marine debris as well as study long-term trends in ocean pollution.

Over 24,000 oil tankers regularly travel within the Gulf of Mexico in close proximity to the National Seashore. Barges also travel the Gulf Intracoastal Waterway on the western boundary of Laguna Madre. Oil spills resulting in the release of hydrocarbons pose a significant threat to park groundwater and wetland resources. In the past the National Seashore has experienced oil spill events which have inundated areas along both the Gulf of Mexico and Laguna Madre. Mexico is now considering opening up the lower Laguna Madre south of the international boundary to barge traffic, thus allowing transport of hazardous materials from Mexico along the National Seashore's western side. A related threat is the periodical maintenance of the waterway by dredging and disposal of the spoil materials.

Other Water Resource Issues

Other threats include visitor use and internal oil and gas development.

BIBLIOGRAPHY

Amdurer, M. 1978. Geochemistry, hydrology, and mineralogy of the Laguna Madre flats, south Texas. University of Texas, Austin.

Baker, B.B. Jr. 1949. Compilation of salinity data for the Laguna Madre. Texas Game Fish Commission, Austin, TX.

Boylan, D.M. 1986. The hydrogeologic resource of North Padre Island. Baylor University, Waco.

Breuer, J.P. 1961. Biological survey of waters of the Laguna Madre of Cameron and Willacy counties and adjacent waters. Rep. no. M-9-R-3, Job no. E-4. Texas Parks and Wildlife Department, Austin.

Britton, J.C. and B. Morton. 1989. Shore ecology of the Gulf of Mexico. University of Texas Press, Austin.

Caudle, C.S. 1992. Population dynamics of the fish fauna found in three earthen ponds on North Padre Island, Texas. Southwest Texas State University, San Marcos.

Conover, L.T. 1963. The ecology, seasonal periodicity and distribution of benthic plants in some Texas lagoons. University of Rhode Island, Rhode Island.

Duke, J.H. 1990. Lower Laguna Madre hydrology. Texas Water Development Board, Austin.

Geyer, R.A. 1975. Naturally occurring hydrocarbon seeps in the Gulf of Mexico and the Caribbean Sea, Unpubl. report. Texas A&M University, College Station.

Gudramovics, R. 1981. A geochemical and hydrological investigation of a modern coastal marine sabkha. Michigan State University, Michigan.

Hill G.W. and L.E. Garrison. 1975. Map showing drift patterns along the Texas coast, 1974-75. Rep. no. MF 839. National Park Service, Padre Island National Seashore, Texas.

Hill, G.W., C.A. Pyle, and L.E. Garrison. 1976. Map showing summer drift patterns of surface waters over the south-central Texas continental shelf. U.S. Geological Survey open file report 76-834.

Kocurek, G., M. Townsley, E. Yeh, K. Havholm, and M.L. Sweet. 1991. Dune and dune field development on Padre Island, Texas with implications for interdune deposition and water table controlled accumulation, Unpubl. Report. University of Texas, Austin.

Lockwood, A.a.N.I. 1962. Sediment and salinity control for conservation of habitat and fishery in the upper Laguna Madre, Texas. Texas Game Fish Commission, Austin.

Miller, J. 1995. Personal communication about hazardous material transport in Laguna Madre. Padre Island National Seashore.

Myers, B.N. 1964. Preliminary investigations of potential water supply on Padre Island, Texas. Unpubl. Rep.

National Park Service. Annual Reports of Marine Debris Monitoring Program 1989-1993.

National Park Service. 1992. Marine Debris Monitoring on Padre Island National Seashore.

National Park Service. 1993. Marine Debris Investigation, Padre Island National Seashore, December 1993.

Nemir, C.E. 1983. Laguna Madre Estuary: A study of the influence of freshwater inflows. Report no. LP-182. Texas Department of Water Resources, Austin.

Oxley, F.M. 1992. A fungal survey of three ponds on North Padre Island. Southwest Texas State University, San Marcos.

Peart, L.W. 1987. Accumulation and sources of beach debris on Padre Island National Seashore. Corpus Christi University, Corpus Christi.

Sadd, J.L., E.R. Gundlach, W. Ernst, and G.I. Scott. 1980. Distribution, size, and oil content of tar mats and the extent of buried oil along the south Texas shoreline. Report no. RPI/R/80/4/28-15. NOAA, Boulder, Colorado.

Scalan, R.S. and J.K. Winters. 1980. Quantification and organic geochemical characterization of petroleum-like materials found on an undisturbed beach of Padre Island National Seashore. National Park Service, Santa Fe, New Mexico.

Sissom, S.L., R.D. Koehn, D. Lenke. 1990. A baseline study of three ponds within the Padre Island National Seashore. National Park Service, Padre Island, National Seashore, Texas.

Sweet, W.E. Jr. 1971. Water circulation study in the Gulf of Mexico. Unpubl. Report. Texas A&M University, College Station.

Texas Department of Water Resources. 1983. Laguna Madre Estuary: A study of the influence of freshwater inflows. Report LP-182. Austin.

Tolbert, J.N. 1987. The sources, pathways, and sinks of chromium, manganese, iron, cobalt, nickel, and copper in near surface sabkha sediments: Laguna Madre flats. Michigan State University, Ann Arbor, Michigan.

Tunnell, J.W. 1988. Bibliography on tides, tidal-flats, and tidal boundaries in the Laguna Madre of Texas, In-house report. Corpus Christi State University, Corpus Christi.

Tunnell, J.W., Jr. and Q.R. Dokken. 1979. An annotated bibliography of recent environmental studies pertaining to the marine and estuarine areas of the central and south Texas coast. Report No. NA79RAC00136. U.S. Dept of Commerce, Washington, D.C.

USDI National Park Service. 1983. General Management Plan. Padre Island National Seashore.

USDI National Park Service. 1994. Resource Management Plan. Padre Island National Seashore.

Ward, G.H. Jr. 1980. Intensive inflow study, Laguna Madre Texas. Texas Department of Water Resources, Austin.

Warshaw, S. 1975. Water quality segment report for segment no. 2491, Laguna Madre. Report no. WQS-14. Texas Water Quality Board, Austin.

White, W.A., T.R. Calnan, R.A. Morton, R.A. Kimble, T.G. Littleton, et al. 1989. Submerged lands of Texas, Kingsville area: sediments, geochemistry, benthic macroinvertebrates, and associated wetlands. Bureau of Economic Geology, Austin.

Whitledge, T.E. and W.M. Pulich Jr. 1991. Brown Tide Symposium Workshop. Report no. TR-91-002. University of Texas, Port Aransas, Texas.

Palo Alto Battlefield National Historical Park, Texas

Introduction

Palo Alto Battlefield National Historic Site was established in 1978 to preserve and interpret the Mexican-American War and its causes and consequences from the perspectives of both Mexico and the United States. The authorized boundary of 3,400 acres contains no federally owned land; all land is currently in private ownership.

The Park is located in Cameron County, Texas, due north of Brownsville. The site shares no international borders with Mexico. The Rio Grande River meanders about 8 miles to the west and south of the site.

Water Resources

The Park currently has a very limited natural resource database; consequently, little information exists regarding the quantity and quality of water resources.

There are a number of emergent and open water seasonal or semipermanent palustrine systems. In addition, much of the battlefield lies on a remnant floodplain and resacas to the north, west, and south hold water at least part of the year.

Water Issues

1) Transboundary Water Resources

With little information regarding water resources, potential transboundary water issues are poorly defined. It is possible that impacts to the Rio Grande River and adjacent groundwater could impact park resources.

2) Other Water Resource Issues

The biggest water resource concern is the lack of information. Several studies are proposed; although as of 19954, none were funded. A proposal to conduct a natural resource issues overview (PAAL-N-100.300) is the first step to define and prioritize wetland and floodplain issues. A proposal to conduct ground water assessment and monitoring (PAAL-N-100.400) would initiate a monitoring program of groundwater quantity and quality. A proposal to develop a historical database of floods (PAAL-N-130.000) would record the frequency, extent, and impact of periodic flooding and other weather related occurrences.

BIBLIOGRAPHY

Farmer, M. 1992. A natural resource survey of Palo Alto National Battlefield.

Richard, N. and A. Richardson. 1993. Biological inventory, natural history, and human impact of Palo Alto National Battlefield.

USDI National Park Service. 1994. Resource Management Plan for Palo Alto Battlefield National

Historic Site.

USDI National Park Service, Southwest Region. 1982. Study of Palo Alto Battlefield National Historic Site, Texas.