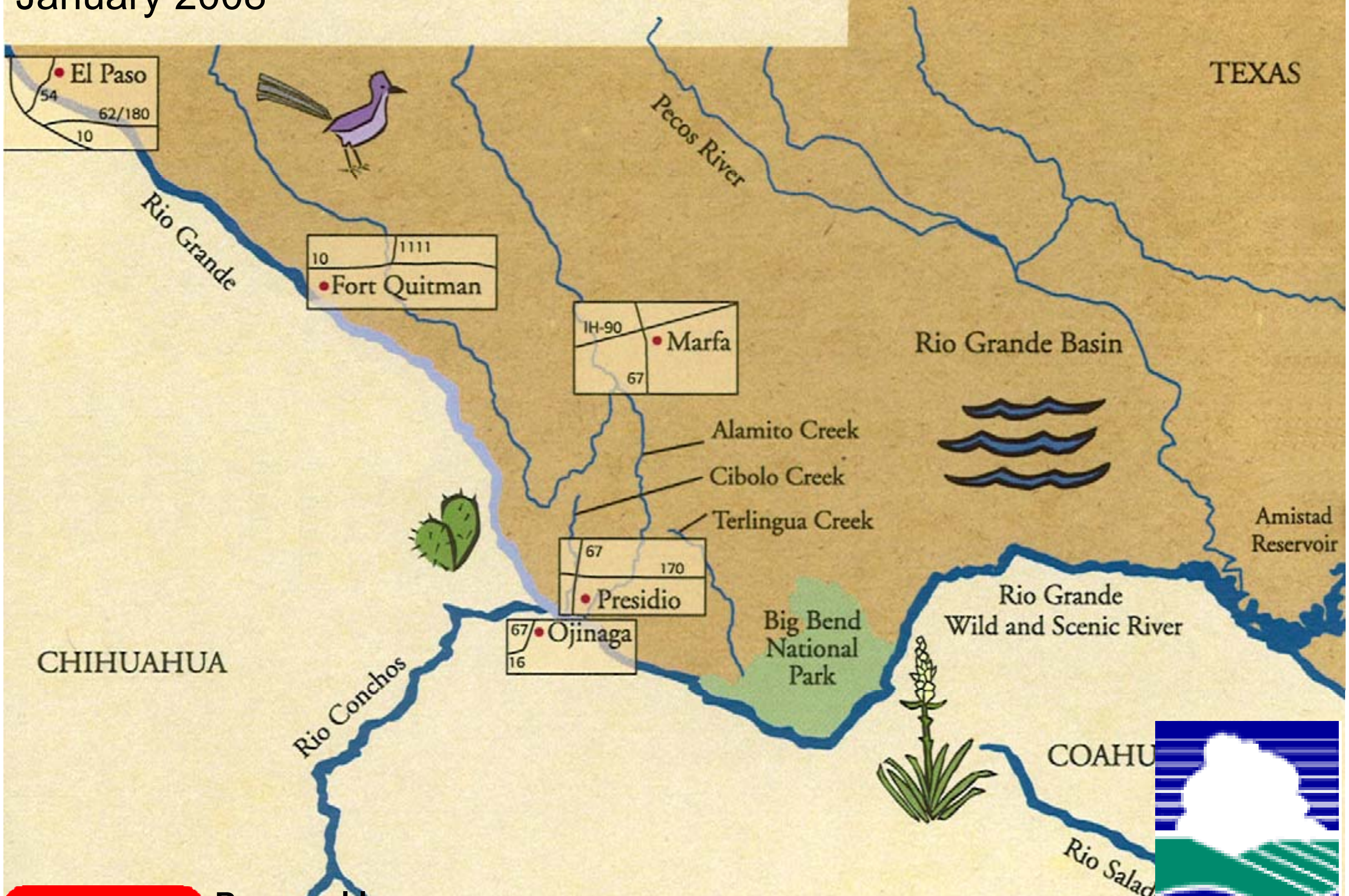
Forgotten Reach of the Rio Grande, Fort Quitman To Presidio, Texas

Section 729

January 2008



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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

TCEQ

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CHAPTER 1 – OVERVIEW

The Forgotten Reach of the Rio Grande, Fort Quitman to Presidio, Texas, 729 Study (the study) is being conducted in response to concerns by the Texas Commission on Environmental Quality (TCEQ) and the Texas Water Development Board (TWDB) related to floodplain and riverine function, environmental resources, water quality, agriculture, and watershed hydrology. The study presents an opportunity for local, state, and Federal agencies to work together to develop solutions to manage the varied resources of the Forgotten Reach of the Rio Grande. The study will produce mapping of the area, report on the existing environmental and hydrologic conditions, and offer possible solutions regarding these issues for the greater public interest. This report is not an implementation document, but an analysis of present and potential conditions.

The most notable feature of concern in the study area is the progressive replacement of native floodplain vegetation by the invasive shrub saltcedar (Tamarisk spp.). It is clear that saltcedar has gained a competitive advantage over more desirable species largely as a result of profound alterations in the hydrologic regime following construction of Elephant Butte Reservoir. Despite its present role in capturing water and sediment, concentrating salinity and impacting land use, the “saltcedar problem” is viewed by the present study as a symptom of the overall decline of the Rio Grande’s basic riverine functions.

The overall goal, beginning with the present study, is to ultimately restore the Forgotten Reach of the Rio Grande to a healthy and hydrologically functioning ecosystem, of which the control of saltcedar is only a part.

This report recommends an experimental approach in which local, monitored projects are implemented. Lessons learned in one sub-reach can be applied to new project areas and eventually form a set of long-term improvements throughout the Forgotten River. This report also recommends a systematic watershed approach that addresses hydrology, sediment, salinity and vegetation. Further, any such projects should include meaningful participation of, and cooperation between, all stakeholders, private and public, and the United States and Mexican governments.

It should be noted that the official name of the river reach between Fort Quitman and Presidio, Texas, is the Rio Grande Boundary Preservation Project. The joint project with Mexico was authorized by the 1972 “Treaty to Resolve Pending Boundary Differences and Maintain the Rio Grande and Colorado River as the International Boundary,” Treaties and International Acts Series 7313;23 UST 371.

1.1 Study Authority and Reconnaissance Study

Section 729 of the Water Resources Development Act (WRDA) of 1986, as amended, provided the U.S. Army Corps of Engineers (Corps) with the authority to address management issues in the Forgotten Reach of the Rio Grande Basin, Texas. Under this authority, the Corps prepared an expedited reconnaissance report in accordance with Section 905(b) of WRDA 1986. The study reviewed and assessed past and current activities and resource trends within the Forgotten Reach. The purpose of the reconnaissance study was to determine if a Federal interest existed for investing public resources in a more detailed feasibility study of the watershed. Issue areas investigated included land use, topography, geology, sedimentation, hydrology, flooding, water supply, biological habitat, cultural resources, regulatory issues, and physical change.

The reconnaissance study phase was completed in May 2005, resulting in the identification of Federal interest in further cost-shared feasibility level studies. In addition, the reconnaissance study identified other alternatives including multi-purpose opportunities that could be developed within existing policy. The reconnaissance study recommended that the "Forgotten Reach of the Rio Grande Basin, Fort Quitman to Presidio, Texas, study proceed into the feasibility phase to develop comprehensive watershed management recommendations for the Forgotten Reach of the Rio Grande."

Sponsor involvement workshops were held during the reconnaissance study where concerns were identified by the sponsor. Their concerns include:

- Improve riverine ecosystem function;
- Stabilize river geomorphology;
- Improve water conveyance;
- Reduce nutrient loading to improve water quality;
- Increase biodiversity of the riverine ecosystem;
- Improve international boundary delineation and improve security of the border with Mexico;
- Reduce the loss of lands for agriculture and ranching within the study area.

1.2 Feasibility Study

The purpose of the feasibility phase of the Forgotten Reach study is to develop various alternatives to address ecosystem degradation within the Forgotten Reach of the Rio Grande. Currently, there is no long-term plan for sustainable management of this reach of the Rio Grande. A plan must be developed in order to preserve and enhance ecosystem resources that are complimentary to overall watershed management.

The feasibility study will generate a report describing the existing conditions in the study reach and offer possible alternatives to the sponsor. Aspects of this report may include the recommendation of specific projects for detailed implementation studies and will serve as a framework for future watershed management decisions by the sponsor and other local, state, and Federal agencies. A range of watershed management alternatives will be formulated that address ecosystem restoration, groundwater recharge, and erosion control. The formulation of alternatives will be based upon the assessment of historic, existing, and future without-project conditions, technical evaluations, and the planning objectives. Alternatives may include watershed-wide management practices and policies to be implemented by local, state, Federal and international agencies as well as specific projects for potential participation by the Corps and other agencies.

As a study, the associated report is not intended to be a decision document. The primary goal is to develop the study from a regional perspective in which the sponsor, the TCEQ, can identify and “spin off” projects under other authorities to address flood damage reduction, erosion control, sedimentation, and ecosystem restoration. The projects considered in this report are not limited to Corps authorities. However, the only projects that can be spun off for implementation by the Corps are those that fall under existing Corps authorities. Other projects may be identified that can be implemented by other Federal or state or local agencies that do not fall under Corps authorities. The end result of this study is an existing conditions and recommendations report to the TCEQ and a map book showing the Forgotten Reach and its characteristics such as sediment cones, tributaries, vegetation, river channel, etc.

Major tasks and activities for the study include:

- Define and evaluate existing conditions in the Forgotten Reach of the Rio Grande Basin. This was accomplished through limited hydrologic and geomorphologic studies and environmental studies;
- Attempt to identify pilot projects, both structural and non-structural, which address environmental restoration and water quality improvements.

1.3 Local Sponsor's Support

During the reconnaissance phase of this study, the TCEQ, with funding from TWDB, participated in various coordination activities. They expressed an interest and willingness to participate in the cost-shared feasibility study with the goals of developing an existing conditions and possible alternatives report and identifying potential water quality and environmental restoration opportunities.

1.4 Watershed Planning Goals, Methods, Objectives and Constraints

1.4.1 Planning Goals

The overall goal of the Forgotten Reach of the Rio Grande, Fort Quitman to Presidio, Texas 729 study is to develop an existing conditions and possible alternatives report for the sponsor. The report may include recommendations of specific projects for detailed implementation studies and will serve as a framework for future watershed management decisions by the sponsor and other local, state, and Federal agencies.

1.4.2 Planning Methods

The methods used to compile this report include structured, rational, system-wide approachs to problem solving. Planning was conducted in a collaborative manner with the TCEQ and Environmental Defense, as well as other interested stakeholders. The planning process used by the project delivery team for this study was modified from that normally used by the Corps for studies that serve as decision documents. The process included the following steps:

1. Problems were identified;
2. Future goals were established;
3. Existing hydraulic, hydrologic, geomorphological, and environmental conditions were determined through field work and available data;
4. Various alternatives to address identified problems were formulated;
5. Effects of alternatives were evaluated individually and in combination;
6. Plans using various alternatives were compared individually and in combination;
7. Recommendations were made by the project delivery team.

Due to the difficulty of accessing large portions of the study area, the University of Texas Center for Space Research (UTCSR) was contracted to gather the necessary data to determine existing conditions using remote sensing procedures (See Appendix B).

1.4.3 Planning Objectives

Key planning objectives of the feasibility study were developed in coordination with the project delivery team, the local sponsor, and participating stakeholders and include the following:

- Increase the ability to manage the watershed holistically, by understanding the potential impacts of actions on a regional and watershed perspective;
- Formulate possible future ecosystem restoration efforts by evaluating the hydrology and sediment movement within the Forgotten Reach of the Rio Grande basin and its tributaries;
- Restore channel capacity;
- Increase water delivery capacity downstream of the Forgotten Reach;
- Revitalize agricultural and eco-tourism economies;
- Encourage eco-tourism and recreational opportunities;
- Restore the Forgotten Reach of the Rio Grande to a healthy and functioning riparian ecosystem by restoring a cottonwood, willow, mesquite system;
- Reduce the presence of exotic/invasive species;
- Revegetation with native plant species;
- Reestablish the ecology throughout the Forgotten River system;
- Identify data gaps (ex. lack of weather stations within the study area's watersheds);
- Educate the public on watershed-related issues;
- Identify / evaluate flood risk.

1.4.4 Planning Constraints

Planning constraints are restrictions that may limit the planning process. General types of constraints that were encountered in this study were resources and legal and policy restraints (those defined by law, governmental policy, and guidance).

Examples of constraints encountered include:

- The Rio Grande is highly regulated upstream of the Forgotten Reach
- Reduced magnitude of water flows in the Rio Grande caused by;
    - Attenuation and evapotranspiration by exotic invasive plant species (ex. saltcedar);
    - Infiltration;
- Decreased level of sediment transport;
- Ambiguity in ownership of water that flows through the Forgotten Reach;
- Large size of the study area;
- Two percent of lands on the U.S. side in public ownership;
    - Would need a Non-Governmental Organization or governmental agency to act as the sponsor for Corps projects (ex. Soil and Water Conservation Districts, World Wildlife Fund (WWF), Environmental Defense (ED), Rio Grande Restoration (RGR), and Rio Grande Institute (RGI);
- Difficult access to the river, floodplains and tributaries on both sides of the river;
- Mexican Sovereignty over half of the river;
    - Would need support from the Mexican government for any projects regarding ecosystem restoration;
- Border security;
- Impaired water quality;
- Displacement of native vegetation by saltcedar;
- Sediment aggradation caused by precipitation/runoff in the tributary watersheds.

1.5 Existing Studies

Many studies have been conducted pertaining to water and related land resources within the study area. These studies have examined themes including environmental resources, water supply, groundwater recharge, flooding and erosion, geology, cultural resources, and history. The studies and reports cited in the references section of this document contribute to the investigative body of work from which conclusions and recommendations are made.

CHAPTER 2 – STUDY AREA DESCRIPTION

2.1 Study Area Definition

The Rio Grande in the study reach follows a sinuous channel for a distance of 198.8 miles between a point about 13 miles downstream from Fort Quitman, Hudspeth County, and a point near Haciendita Ranch, about six miles upstream from Presidio, Presidio County (Figure 1). The straight line distance through the reach is 117 miles. The study area was primarily limited to the U.S. side of the Rio Grande and its tributaries in the Forgotten Reach, although some study was given to environmental conditions and tributaries on the Mexican side of the International Border.

The study area is contained within a 1.86 mile buffer extending to either side of the river from the main channel centerline of the Forgotten Reach of the Rio Grande from Fort Quitman to Presidio, Texas. Areas within the buffer zone determined to exceed the river channel base elevation level by 30.28 feet or more were eliminated from the study area. This latter parameter was established after discussion with UTCSR so that steep canyon walls would be eliminated from photo interpretation.

The Forgotten Reach of the Rio Grande is located near the northeastern edge of the Mexican Highlands section of the Basin and Range Physiographic province. The canyon segments have steep to mildly sloping walls. The soils in the Rio Grande floodplain in Hudspeth County are of the Harkey-Glendale association of deep, nearly level, calcareous, loamy soil. The soils are used for irrigated cropland, pastures, and orchards. Prior to the advent of intensive irrigation and to construction of the Rio Grande Project, the Rio Grande below El Paso generally experienced biannual seasonal peak flows. (More information regarding the Bureau of Reclamation's Rio Grande Project can be found in Chapter 5.) Presently, surging spring runoffs from snowmelt in the upper Rio Grande Basin, Rio Chama Basin, Sangre De Cristo Mountains Basin, Jemez Basin, and the flash flood swells in summer months have been impounded, impeded, and controlled. One-hundred-and-one arroyos provide flash flood runoff to the Rio Grande in the Forgotten Reach. Fifty-seven arroyos originate in the bordering mountains on the U.S. side and forty four originate on the Mexican side. The Arroyos deliver large quantities of heavy sediments into the river channel, and because of the flat river gradients, much of the sediment deposits into the channel.

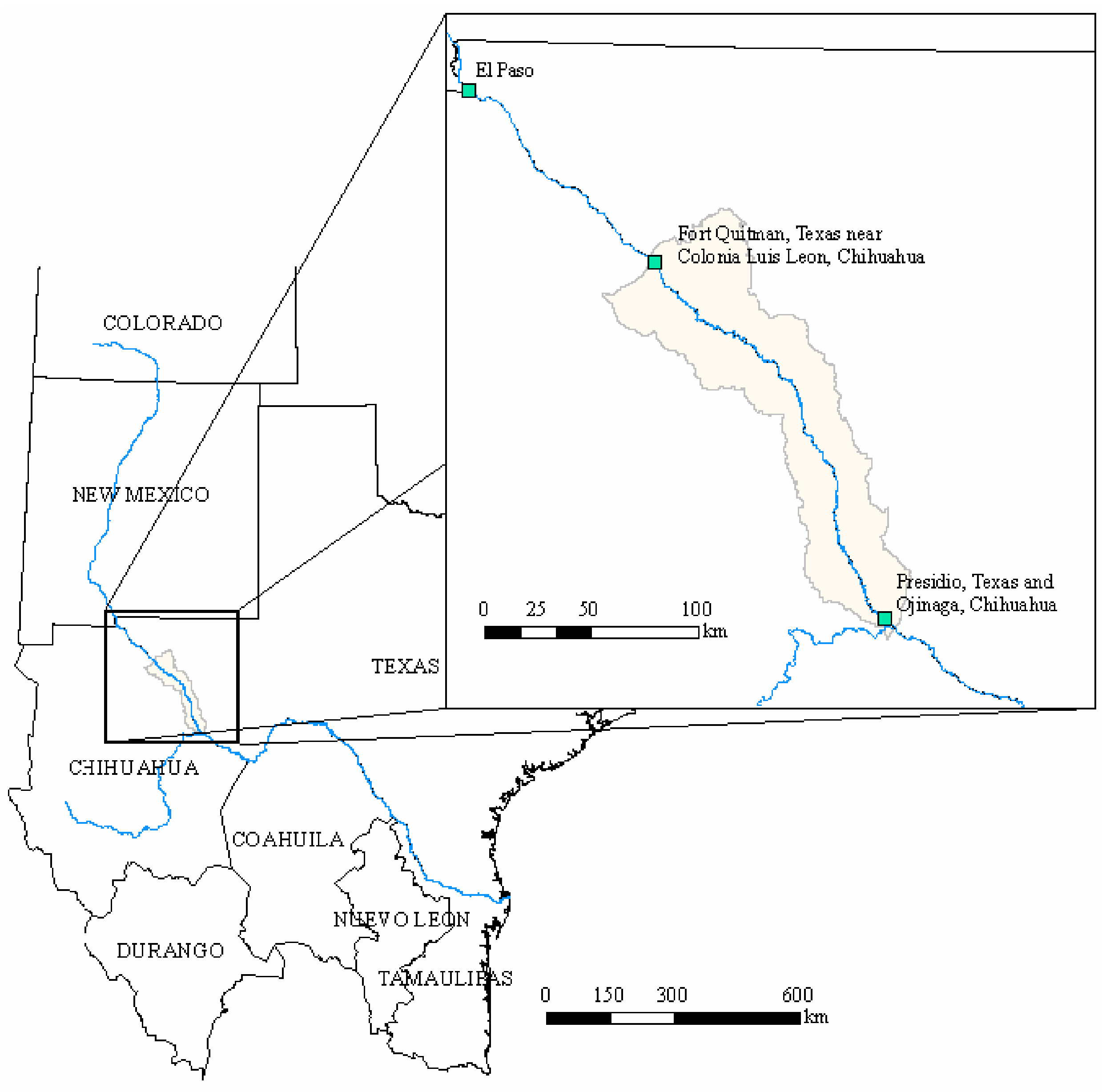

Figure 1 - Map showing area of the Forgotten River.

2.2 History and Population

During the Civil War, the post was intermittently garrisoned by Confederate and Union detachments and quickly fell into disrepair. Over the next decade companies and detachments of black soldiers of the Ninth Cavalry and the Twenty-fifth U.S. Infantry guarded the mails and served as scouts. The post was abandoned in 1882, partly because it was not on a railroad line. Fort Hancock (originally Fort Rice) was established in 1882 nearby. Today only a cemetery remains near the site of Fort Quitman.

Presidio is located on the Rio Grande in southern Presidio County, Texas. The surrounding area is the oldest continuously cultivated area in the U.S. Farmers have lived in the area of present-day Presidio since 1500 B.C. By 1400 A.D., the area's Native Americans lived in small, close-knit settlements, which the Spaniards later called pueblos.

The handful of Anglo-American settlers who came to the region was assimilated into the Hispanic population, and their descendants are primarily Spanish speaking today.

In 1930, the Kansas City, Mexico and Orient Railway reached Presidio, and the town incorporated. The population grew from 96 in 1925 to 1,671 in 1988, but the number of businesses declined from 70 in 1933 to 22 in 1988. At the end of 1988, Presidio experienced a population boom due in part to previously undocumented aliens enrolled in the amnesty program. The population in 1990 was 3,422. Population reached 4,877 by 1998, and is expected to top 10,000 by the year 2013 at present growth rates (Texas State Historical Association).

2.2.1 Climate

Historical climate data was derived from the National Weather Service (NWS) El Paso station and data collection sites operated by the TWDB. Data from these sources indicate that precipitation, primarily in the form of brief but heavy local thunderstorms, averages 9 to 11 inches per year for the upper end of the study area and between 14 to 22 inches at the lower end of the study area (TWDB 2007; NWS 2007), with approximately 55% of this annual amount occurring during the months of July, August, and September. August is historically the wettest month and April the driest. Annual extremes include 1884, when a high of 18.29 inches of precipitation fell at the El Paso station, and in 1891, when only 2.22 inches fell at the same station; all months except for July have experienced zero precipitation (NWS 2007). Rainfall events vary from a number of intense storms per month to periods of no rainfall. Occasionally, the rainfall during a single month can exceed the average annual rainfall at that station. For the period 1879 through 2003, temperatures in the study area averaged 100 degrees Fahrenheit or higher for 14 days a year; however, in 1994, there were 62 days with temperatures higher than 100 degrees Fahrenheit. June and July are the hottest months, averaging maximum temperatures of approximately 95 degrees Fahrenheit. January is the coldest month with monthly lows of 33 degrees Fahrenheit. Prevailing winds are generally out of the west during February through May, shift to the east-southeast during June and July, transition to the south in August and September, and originate from the north-northeast during October through January.

Pan evaporation rates average approximately 56 inches per year (TWDB 2007). These high evaporation rates are the result of the low relative humidity (which is often as low as ten percent during summer afternoons and occasionally as low as five percent) and high temperatures.

2.2.2 Physiography and Geology

The study area is located near the northeastern edge of the Mexican Highlands section of the Basin and Range Physiographic province. The region has a long history of extensive tectonic activity. A great deal of tertiary block faulting led to the formation of much of the present basin and range topography. In general, the study area is composed of a number of southeast trending fault-block mountains with intervening basins and their sedimentary fills.

The canyon segments have steep to mildly sloping walls. The valley reaches display numerous but discontinuous areas of floodplain with some low depositional terrace remnants, tributary arroyo mouths and alluvial fans, intervening dissected pediment and bolson fill deposits (both of which are abandoned erosion surfaces of the ancient Rio Grande), and isolated sand dune deposits.

Bolsons are basins or structurally deep depressions partially filled with sediments from the surrounding highlands. In most cases, bolsons are formed by down-faulted blocks, while up-lifted or tilted blocks on either side separate the basins from one another.

Stratigraphically, the area contains sedimentary deposits or rocks of Permian to Holocene Age and igneous rocks of Tertiary Age. In general, the mountains are composed of Permian or Cretaceous shale, sandstone, and limestone and early Tertiary volcanic tuffs, ignimbrites, rhyolites, trachytes, andesites, and basalts. The mid-Tertiary and later basin fills consist principally of gravels, conglomerates, and other sediments that are the basic materials of most of the pediments, terraces, and older alluvial fans. In some places, close to the river, these basic materials are inter-bedded or overlain by the more recent Rio Grande sediments. Recent deposits of the Pleistocene and Holocene are composed primarily of floodplain sediments deposited within the last centuries: the lowest river and arroyo terraces, sand dunes, and a very thin veneer of sand or gravel on some of the older and higher surfaces.

The Forgotten Reach valley width is typically 1,000 feet or less, but periodically widens, with some areas as wide as 9,000 feet (see Map Book) (Fullerton and Batts 2003). In contrast, the river also flows through several narrow canyons no more than 200 feet wide between Mayfield Canyon and Goat Canyon below Indian Hot Springs, and 2.5 river miles above the Hudspeth County line (UTCSR 2006).

2.2.3 Soils

The soils in the Rio Grande floodplain in Hudspeth County are of the Harkey-Glendale association of deep, nearly level, calcareous, loamy soil. The soils are used for irrigated cropland, pastures, and orchards.

In Presidio County, the Glendale-Anthony-Toyah association of deep, nearly level, light to dark colored, calcareous soils is used for rangeland and wildlife. Some areas along the Rio Grande are used for irrigated cropland.

Where these alluvial soils are heavy (clay-rich) they are often highly impregnated with soluble salts. This is especially true where irrigation practices coupled with an aggraded river channel have resulted in a high water table with poor drainage conditions.

In the tributary watershed area, the Reeves and Anthony series soils (gravelly) are found above the floodplain or overflow areas, on the pediment and terraces slopes and flats, and within most of the arroyos and their fans.

The Reeves series soils have light brown to ashy gray, calcareous, low organic content and surface soils underlain by light brown, yellow, or buff calcareous subsoil, which may consist primarily of igneous rock gravel, caliché, or both. The texture of the Reeves soils varies from fine sand to clay with much included gravel. The Anthony series soils are light brown to grayish brown, friable, calcareous, generally well drained surface soils and subsoils, which at a depth of several feet may rest on loose, rounded gravel.

Land use in the Forgotten Reach of the Rio Grande is mainly limited to farming and ranching. Ownership on the U.S. side of the International Border with Mexico is 98% private, with approximately 2% owned by the state of Texas. Access to the study area is limited.

2.2.4 Watershed Stakeholders

The Rio Grande Compact is an interstate agreement to apportion equitably the water of the Rio Grande among Colorado, New Mexico, and Texas. The preliminary compact of February 12, 1929, provided for stream-gaging stations, for construction of a reservoir in Colorado, and for equitable dividing of the water of the river pending the signing of a permanent compact. The compact was signed in Santa Fe, New Mexico, on March 18, 1938, approved by the state legislatures, and approved by Congress on May 31, 1939. The compact provided for Colorado and New Mexico to deliver water in accord with a formula based upon the flow of the Rio Grande and its tributaries at designated gauging stations above the state lines. The Rio Grande Compact Commission was then established. This commission consists of one representative from each state: the state engineers of Colorado and New Mexico, who serve ex officio, and the Texas governor's appointee. The President of the United States appoints the Chairman of the Rio Grande Compact Commission, but the Federal appointee does not vote on commission business.

Apportionment of water of the Rio Grande between the U.S. and Mexico is determined by various agreements and treaties made between 1904 and 1944. The first attempt at apportionment of the waters was the Compromise of 1904, which apportioned the waters above and below the Texas-New Mexico state line. In the International Convention of 1906, the U.S. promised to deliver 60,000 acre-feet of water annually for irrigation in the Juarez Valley, peak period of delivery falling in April, May, and June. In return, Mexico waived all claims for any purpose to the waters of the river between the head of the Acequia Madre, known as the Old Mexican Canal, above the city of Juarez, Mexico and Fort Quitman, Texas. The 1944 treaty dealt with the Rio Grande between Fort Quitman and the Gulf of Mexico. The following order of preference in joint use of the international waters was set up: (1) domestic and municipal uses, (2) agriculture and stock raising, (3) electric power, (4) other industrial uses, (5) navigation, (6) fishing and hunting, and (7) any other beneficial use to be determined by the International Boundary and Water Commission (IBWC). Under Article IV of the 1944 treaty, Mexico received all of the waters of the San Juan and Alamo rivers; one-half of the flow in the main channel of the Rio Grande below the lowest major international storage dam; two-thirds of the flow in the main channel from the Conchos, San Diego, San Rodrigo Escondido, and Salado rivers and Las Vacas Arroyo, provided that the U.S. receive from these same six streams not less than 350,000 acre-feet annually as an average in five-year cycles, and one-half of all other flows not otherwise allotted and occurring in the main channel of the Rio Grande.

Also under Article IV, the U.S. was given all of the waters of the Pecos and Devils rivers, Goodenough Spring, and Alamito, Terlingua, San Felipe, and Pinto creeks. The quantity of water allotted to the U.S. not only took care of existing needs but also permitted expansion of irrigated areas. The 1944 treaty remains in effect today.

Local governments manifesting a stake in the study area include county governments, resource conservation and development agencies, and soil and water conservation districts.

State agencies with an interest in the Forgotten River study include TCEQ, TWDB, Texas Parks and Wildlife Department (TPWD), and the Texas Department of Agriculture (TDA). Federal agencies with jurisdiction in the watershed include IBWC, U.S. Border Patrol (a division of the Department of Homeland Security), U.S. Fish and Wildlife Service (USFW), Bureau of Reclamation (BOR), and the Natural Resource Conservation Service (NRCS).

In the past, the Mexican government has indicated interest in sharing information regarding hydrology, geomorphology, and ecology as well as working with the U.S. in future restoration projects. There is also evidence of interest from the many private land owners and communal farmers in Mexican lands adjacent to the study area.

Private parties own large portions of the river and floodplain and have agricultural, recreational, and other economic interests in the resources of the watershed. A number of landowners are actively participating in “the La Junta Project”, a newly-initiated program to control saltcedar by the release of the Saltcedar leaf beetle (D*iorhabda elongata*). The University of Texas-El Paso owns substantial tracts, which they use for scientific study. Other universities, such as University of Texas, Sul Ross State

University and Texas A&M University have evidenced their interest in the management of the area. Non-governmental agencies, such as ED, WWF, RGR, and RGI have shown a willingness to assist in studies and work on projects within the Forgotten Reach of the Rio Grande.

As part of the study's public involvement process, public workshops were held in Marfa, Sierra Blanca, and Presidio, Texas, in 2007. The workshops provided an opportunity for attendees to learn about the study and the planning process and to highlight issues they felt to be important. The attendees were asked to review provided poster boards demonstrating the issues within the Forgotten Reach of the Rio Grande Basin and to provide opinions concerning rehabilitation of the study area. The issues ranged from invasive species to surface water use and they covered large areas of the watershed. This information has been incorporated into the various analyses conducted under this study.

The information gathered from the public meetings was delivered to the study sponsor. Technical comments received from attendees were used by the project delivery team to refine this report.

CHAPTER 3 – GEOMORPHOLOGY AND SEDIMENT CONES

Geomorphology is the study of the configuration and evolution of landforms. Landforms evolve in response to both natural and anthropogenic (caused or produced by humans) processes. Of particular interest for this study is the fluvial geomorphology; the landform processes associated with the movement of water and sediment associated with rivers and streams. The following will describe some of the prominent natural and anthropogenic processes, and how they are recognized to have changed, to aid in understanding the current condition of the landforms within the Forgotten Reach and to serve as an informed basis from which alternatives and recommendations can be developed.

3.1 Hydrology

The following three stream gages are currently active in the project reach:

Gage Name	Location	Established	Link
08 3705 00 Fort Quitman	Fort Quitman	1923	**http://www.ibwc.state.gov/wad/histflo1.htm**
08 3712 00 Candelaria	Candelaria	1976	**http://www.ibwc.state.gov/wad/histflo1.htm**
08 3715 Rio Grande above Rio Conchos	North of Presidio	1900	**http://www.ibwc.state.gov/wad/histflo1.htm**

Figure 2 - Fort Quitman IBWC gage in the rectified channel at the upper end of the Forgotten Reach looking downstream.

Figure 3 - Candelaria IBWC Gage upstream of Capote Creek and Candelaria, Texas, January 2007. Note aggradation from influence of San Antonio Diversion Dam (Mexican) just downstream and San Antonio arroyo confluence just upstream.

The first ditch for irrigation in the study area is reported to have been at Ruidosa in 1872. Other small ditches were constructed in the next decades. By 1900, farming had been extended northward to Pilares. Examination of aerial photographs made in 1928 show that roughly 50% of the floodplain from the Rio Conchos to Candelaria was under cultivation, but upstream there was very little agricultural activity. On the U.S. side, the irrigated area increased to a peak of 10,000 acres during 1928-1930 and then declined.

Prior to the advent of intensive irrigation and the construction of the Rio Grande Project (most importantly Elephant Butte and Caballo Dams and Reservoirs, but also Percha Dam, Leasburg Dam, Mesilla Dam, American Dam, International Dam, and Riverside Dam), the Rio Grande below El Paso generally experienced biannual seasonal flows. From April through June, snowmelt runoff from southern Colorado and northern New Mexico typically delivered a majority of the annual flow. In the summer monsoon months of July to September, flash floods from tributary arroyos provided substantial flows into the main river channel. During the 1800s and early 1900s, the river was indeed considered navigable for 100-150 ton keelboats from a point approximately 147 miles below El Paso (Kelley 1986). Before Elephant Butte Dam construction, El Paso and Juarez farmers witnessed huge annual flows above one million acre feet in 1891, 1897, 1903, 1905, 1906, 1907, 1911, 1912, and 1914 and only trickles of less than 100,000 acre-feet during 1894-96, 1899, and 1902 (IBWC 1978). Consequently, farming communities affected by these unreliable flow conditions clamored for the U.S. government to dam and control the river.

Since the construction of the Elephant Butte Dam in 1915, the character of the Rio Grande has been dramatically altered. However, irrigation withdrawals in the El Paso/Juarez valley were sufficiently extensive prior to 1915 that the magnitude and duration of the annual snowmelt flood had decreased by more than half between El Paso and the Rio Conchos, "Schmidt et al. 2003". The magnitude of the 2-year recurrence flood, decreased from 7380 feet/second prior to 1915 to 4308 feet/second post-dam between El Paso/Juarez and the Rio Conchos (Table 1). In those years, when the annual peak flow at El Paso/Juarez was less than 3531 cubic feet/second (cfs), no snowmelt flood peak reached the Rio Conchos. In years of greater snowmelt runoff, the magnitude of the peak flow at the Rio Conchos was never more than 90% of that measured at El Paso/Juarez and typically occurred 7-10 days after the peak had passed El Paso/Juarez. The only times when stream flows at Presidio were significantly larger than at El Paso/Juarez were in the late summer and early fall when flood flows were triggered by rainfall in the downstream tributaries of the basin.

Table 1 - Magnitude of flows of different recurrences at El Paso and upstream of the Rio Conchos.

Discharge in cubic feet per second, of the annual maximum mean daily discharge, for the indicated period at the indicated location

Prior to 1915	**1.25 year**	**2 year**	**5 year**	**10 year**
At El Paso	3460	7380	13347	17090
Above Rio Conchos	1836	4308	8616	16652

1915 – present	**1.25 year**	**2 year**	**5 year**	**10 year**
At El Paso	1130	1801	3531	4378
Above Rio Conchos	530	1201	2472	3496

Presently, spring runoff from snowmelt in the upper Rio Grande Basin and the flash flood swells in summer months have been impounded, impeded, and controlled. The energy within the Rio Grande, ex., peak flows, and the ability to transport sediment, has been significantly reduced. The river between El Paso and Presidio is now an aggrading reach of stream whose bed is substantially higher than prior to dam construction upstream (Schmidt et al. 2003) The impacts of Caballo Dam and downstream diversion dams have compounded the shift from a seasonally meandering wild river to a regulated irrigation project generally confined within constructed levees. Effects of these upstream impacts have had consequences, usually adverse, in the Forgotten Reach. Over the years, the U.S. Department of Agriculture's Soil Conservation Service (now know as the Natural Resources Conservation Service or NRCS) constructed 12 flood and sediment detention dams on tributary arroyos to the Rio Grande between Caballo Dam and the head of the study reach. These structures regulate flows from 533 square miles of the 1,650-square-mile watershed between Caballo Dam and the study area and serve to reduce sediment contributions from these arroyos and temper peak flows. Today, the biannual peak flows in spring and summer have been replaced by a low, steady flow regime tied to the irrigation season. Typically, annual irrigation releases begin in February and last through October (Landis 2001).

The volume of flows through the Forgotten Reach of the Rio Grande post 1915 is approximately one quarter of the annual volume of flows recorded prior to the construction of Elephant Butte Dam (Landis 2001) and prior to the 1906 treaty between the U.S. and Mexico. The 1906 treaty specified annual delivery from the Rio Grande of up to 60,000 acre feet of water to Mexico that is diverted through the Acequia Madre canal immediately below El Paso.

There are 101 arroyos that provide flash flood runoff into Rio Grande in the Forgotten Reach, which head in the bordering mountains on the U.S. (57) and Mexican (44) sides and which deliver large quantities of heavy sediments into the river channel. Because of its flatter gradient, much of the sediment deposits into the channel. These deposits have caused the channel cross section to progressively decrease in size. In some places, such as upstream of Indian Hot Springs on the Rancho Consuelo, the channel is now only three feet or less in width and one foot or less in depth. Nearly 30 years ago, the channel was, in some places, barely discernable due to aggradation and saltcedar growth (IBWC 1978).

Recently, a photojournalist who boated the entire Forgotten Reach stated how often he followed what he thought was the main channel only to reach a dead end thicket of saltcedar, thus having to work back upstream to the "true channel" (Nat Stone, pers. comm. 2007). Fifty-six of these arroyos showed evidence of depositional activity at their confluence with the main stem, based on photogrammetric interpretation by UTCSR in 2006. This activity varied from small but significant depositions that affect existing vegetation to major depositions that have visibly modified the channel compared to previous years' photography (*e.g.*, Green River confluence [Figure 5] and San Antonio Arroyo confluence). Unfortunately, obtaining ground truth for many of the 56 sites evidencing some level of depositional activity through photogrammetric interpretation was not possible by Corps personnel due to private lands access issues.

Figure 4 - Confluence of the Green River with the Rio Grande (42 river miles downstream of Indian Hot Springs, Texas). Note the sediment plug. Photo February 2007.

Figure 5 - Upstream view of the Rio Grande and Green River confluence showing relative elevation of sediment plug and abrupt change in gradient of the Rio Grande; looking upstream. Photo February 2007.

Data assimilation and photogrammetry by UTCSR indicates 54 levee structures within the project study reach (see map book for locations), only three of which are clearly owned by the IBWC. The remainder appear to be levees built over time by various entities to protect agricultural lands and to influence the course of the river. Most of these non-IBWC levees bear little relationship to the current location of the channel or floodplain. Nearly all are overgrown by trees and brush. Additionally, the UTCSR geospatial database shows 13 drains owned by the IBWC, and one rip rap grade control structure.

Flows

Table 2 – 1915 through 2007. Extreme drought years as recorded at the Fort Quitman stream gage. Each of these years had at least a single month in which the gage reported zero flows.

Calendar Years where Fort Quitman gage recorded zero flows for any single month

1955	1956	1957	1958	1959	1964	1965	1977	1978	1987

Table 3 – 1915-2007. Years with high flows (greater than 2000 cfs) as recorded at the Fort Quitman gage.

Years with high flows (greater than 2000 cfs) as recorded at the Fort Quitman gage.

Year Recorded	Estimated Flows (cfs)
1925	2000
1929	2000
1937	2000
1938	2000
1941	6000
1942	5000
1944	2000
1945	2000
1946	3000
1953	4000
1960	3000
1966	2000
1986	2000
1995	2000

Soon after they enter the river from tributaries, flood peaks are dissipated by overbanking and floodplain and channel bank storage. Examples of attenuation can be seen on aerial imagery where wide expanses of saltcedar occur, e.g., upstream of Indian Hot Springs. This phenomenon is reflected by the records of flood peaks at the Presidio gage near the downstream end of the reach above Rio Conchos. The records show that during the period of 1951-1976, floods exceeding 500 cfs occurred only about once a year on the average and peaks over 2,000 cfs only about once every 15 years on the average (IBWC 1978). However, from a total annual volume perspective, almost 93% of the flows recorded at Ft. Quitman arrive at the Presidio gage. Apparently, the in-stream losses due to evapotranspiration and seepage are nearly offset by the summer rains that fall below Ft. Quitman. The annual hydrograph for the three gages in the Forgotten Reach indeed indicate that in some years, the reach is actually a gaining river (Landis 2001).

The timing of peak flow months has shifted by an average of three months later in the season as a result of storing and releasing water for irrigation purposes. Prior to 1915, the average monthly volume of water in El Paso averaged nearly 220,000 acre-feet in the month of May. After the completion of Elephant Butte Dam, the peak month shifted to July, with a maximum average volume of 63,700 acre-feet for the last 60 years. Similarly, the peak flow at Presidio prior to 1915 occurred in July with an average of just under 160,000 acre-feet, and during the last 60-year period, the peak month has been October with an average volume of 17,700 acre feet, a reduction in peak flow of almost 90% (Landis 2001). Thus, the peak period of spring runoff flow has been delayed by three months for the Forgotten River, and markedly diminished in quantity. The figure below depicts these changes in maximum average monthly volume, but not the temporal delay associated with them.

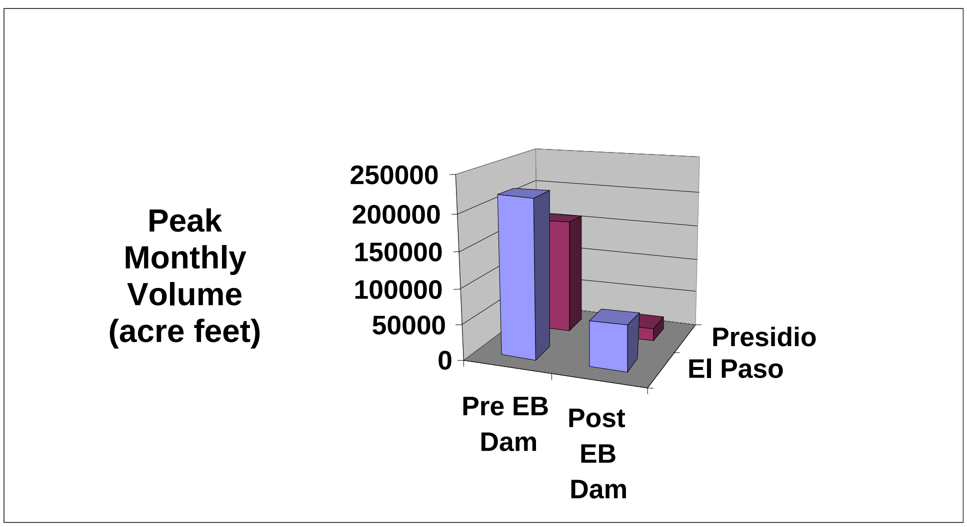

Figure 6 - Average Peak Monthly Volumes at El Paso and Presidio (Pre- and Post-Elephant Butte Construction).

Similarly, prior to 1915, the annual average amount of water reaching Presidio equaled 573,700 acre-feet. Since the completion of the Elephant Butte Dam, the total annual volume of water has been reduced by 77% to 131,800 acre feet. This change in flow patterns through the Forgotten River has critically reduced the river's capacity for sediment transport. Additionally, the resulting river system now experiences a higher proportion of arroyo contributions into the total flow through the Forgotten River. These monsoonal flood events deliver huge amounts of sediment into the main river channel, a river now lacking the velocity and quantity of flow to effectively transport these loads. Consequently, enormous sediment bars reside at the mouths of the arroyos which previously were transported by the river for dispersion in downstream floodplains. Today, there are sections of the Forgotten River which are aggraded, having a river bed higher than the surrounding floodplain (Landis 2001).

Extensive sheet erosion and gullying often results from high velocity flood waters flowing over the steep gradient mountain fronts and heavy bank erosion occurs in arroyos. Much of the arroyo sediments are deposited in arroyo deltas in the Rio Grande floodplain and channel. The average annual sediment deposition in the Rio Grande channel is estimated to be in the order of about 300,000 cubic yards per year, and on the floodplain in the order of 500,000 cubic yards per year. The arroyo flows include silts, sands, and gravels, the larger particles being deposited near the arroyo mouths.

3.2 River Channel Geomorphology and Cross Section Changes

The U.S. and Mexico under Convention of February 1, 1933, stabilized the international river boundary in the El Paso-Juarez Valley and provided flood protection to this area by rectifying a reach of 155 miles of the formerly meandering Rio Grande and shortening it to a distance of 86 miles. This action had considerable effects upon the geomorphology and hydrology and hydraulics occurring in the Forgotten Reach.

The Rio Grande in the study reach follows a sinuous channel a distance of 198.8 miles between a point about 13 miles downstream from Fort Quitman, Hudspeth County , and a point near Haciendita Ranch, about six miles upstream from Presidio, Presidio County The straight line distance through the reach is 117 miles.

Upland plains have slopes of about 60-200 feet per mile to the Rio Grande floodplain. In contrast, the Rio Grande has an average gradient of 4.5 feet per mile through the study reach (Fullerton and Batts 2003).

Elephant Butte Reservoir has controlled the snowmelt floods which prior thereto flushed sediment through the channel in the study reach. However, tributaries to the Rio Grande below Fort Quitman have continually deposited sediment into the study reach and, absent spring runoff flows, progressive aggradation of the channel has resulted.

Since construction of Elephant Butte Dam, the Rio Grande channel form has changed from wide and moderately deep to a shallower channel with a marked decrease in cross-sectional area (IBWC 1978). The decrease in cross-sectional area has become more pronounced since 1950, incident to decreasing flows. This was apparent from a comparison done by IBWC geomorphologists of photographs taken some 40 to 60 years ago and in 1977 (IBWC 1978 – However, due to photograph age, they are unavailable to be included here). Because of the decreased channel size, the frequency of overbank flooding due to arroyo floods has increased. The decrease in channel cross sections is further demonstrated by surveys made from time to time of the Rio Grande channel in the upper, middle, and lower parts of the study reach. The first cross-section surveys were made in 1935-36 and continued through 1977. The data show the channel was progressively decreasing in size throughout the study reach. The data indicated that for the upper segment of the study area, cross-sectional area in 1977 was 22% smaller on average of what it was in 1935; in the middle segment, 17% of the 1935 area; and in the lower segment, 8% of the 1935 area. This data demonstrated that, even in 1977, it was only a matter of time until there was no identifiable channel, a condition that has ultimately occurred (IBWC 1978).

Figure 7 – A narrow, single-thread channel, almost ditch-like in appearance and function, has been vegetatively reinforced by the root system of the saltcedar which line it. This phenomenon is repeated at intervals along the entire Forgotten Reach.

Figure 8 - A myriad of small channels as a result of sediment aggradation and saltcedar establishment characterize much of the Forgotten Reach. Areas like these comprise thousands of acres and are responsible for attenuation of flows. (USGS, 1996)

Figure 9 - Below Candelaria, the Forgotten Reach has a narrow, defined channel (foreground) at low flows, but transforms into a myriad of channels through an aggraded floodway at high flows, Photo taken looking upstream January 2007.

Figure 10 - An avulsion out of a vegetatively reinforced and aggraded channel into an adjacent Bermuda grass pasture upstream of Indian Hot Springs demonstrates the tentative nature of the channel through the Forgotten Reach. Photo taken January 2007.

Channel location changes occurred at 25 places during the flood of 1942 and spill at Elephant Butte Dam (IBWC 1978). Changes were mainly cutting new channels across 25 bends. In the following years, with much reduced flows and cumulative deposition of sediments in the channel and encroachment of saltcedar, changes began to occur in the channel location. During the years 1967-75, the river at eleven places spread out to flow in a number of small distributary channels, no one of which could be identified as the main channel. In 1978, there were seven additional locations identified where the channel has lost its identity (IBWC 1978).

As recently as 2003, Fullerton and Batts characterized the Fort Quitman to Candelaria reach as having a sinuosity of 1.5 with a predominately sand bed; a floodplain varying between 0 and 3,000 feet, but typically about 100 feet wide; a channel width varying from 50-100 feet, and a 2-year discharge flow peak (50% exceedance) of approximately 2,500 cfs (but which varies from 3,800 cfs at Fort Quitman to 1,000 cfs at Presidio).

3.3 Sedimentation Observations within the Forgotten Reach

3.3.1 Limitations

The following discussion is based on extremely limited information, primarily consisting of infrared aerial photography viewed within a GIS environment to which a number of “sediment cones” (arroyo confluences) were located, along with qualitative notes at each cone (based on interpretation of three sets of aerial photography) (UTCSR, 2006). It is important to note that this discussion comes about without the benefit of any field work, and is almost entirely based on interpretation of the 2005 photography available, coupled with a general understanding of river mechanics and sediment transport, since little quantitative information was available. As such, any conclusions drawn must be limited, and should be verified, as well as supplemented with further studies, prior to proceeding with any project alternative development.

3.3.2 Qualitative Geomorphic Response

The geomorphic responses of river systems can often be understood in terms of energy. The particles of soil (sediment) that make up the boundaries of the river channels and pass through the system respond to the energy of the fluid (water) interacting with them. Larger particles require more energy to mobilize and stay in motion, while smaller sizes may remain suspended in the water column with considerably less energy. In this way, channels form and change, banks erode, bars and floodplains build.

Of particular interest in the current study is the discontinuity of hydraulic conditions typical of confluences. The cessation of the bank line confinement of a tributary channel at the confluence allows the flow field to widen, dispersing energy. A ‘fan’ or ‘delta’ deposit at the confluence is typical of this phenomenon. This effect is often elevated by flow escaping an unvegetated, reasonably-defined channel and encountering obstructions within overbanks (ex., increased vegetation) that further reduce flow energy. The degree that this type of feature develops is dependant on many individual site factors, such as local geometry, distance of tributary ‘mouth’ from mainstem channel, floodplain vegetation, etc., as well as the amount of energy within the mainstem to redistribute the sediment deposition.

Another useful concept for understanding river systems is response to regime change. This concept is captured succinctly by Lane's Relationship:

$$Q_S D \propto QS$$

where; Q_S is sediment discharge

D is sediment size (diameter)

Q is water discharge

S is stream slope

The right side of this proportionality could be considered as the available energy from the amount and slope of the flowing water. The left side could be considered as a response to the right side terms, though responses can occur on both sides of the proportionality.

From this proportionality it is seen that, for example, a decrease in water discharge (Q) (without any slope change, S) would lead to a decrease in sediment discharge (transport through the system, Q_S) and/or sediment size (D). Thus, sediment typically delivered by tributary arroyos to the mainstem Rio Grande, which historically had higher flows (IBWC, 1978, Teasley, 2005) and consequently more energy to move the sediment through the reach, would be expected to exhibit more deposition, at least for larger sizes, under the current reduced-flow regime. Thus, the mainstem active channel flow area would be expected to decrease, via the width narrowing, the bed aggrading, coarsening, etc. at the macro scale.

These responses do not necessarily occur uniformly throughout the system but, rather, could be associated with where localized imbalances occur, with the expected responses described above typically diminishing in proportion to the distance from the local unbalancing stimuli (ex., arroyo confluence).

This forms the primary basis for understanding the sediment cones identified within the GIS product, which are almost all in close proximity to tributary confluences, as seen in the individual cone notes. The most plausible explanation for the increased prominence of these depositional zones is primarily as a result of the decrease in the water discharge (and, consequently, energy) of the mainstem Rio Grande in the Forgotten Reach in historic terms, resulting from water supply infrastructure operations upstream (ex., Elephant Butte dam), while the inflowing sediment load has remained essentially the same.

To be clear, sediment deposits at tributary confluences are the norm – increasing and diminishing over time in response to the (delivering) arroyo’s and (transporting) river’s hydrology and associated hydraulic energy. The energy regime and, thus, quasi-equilibrium condition, under which the Forgotten Reach historically formed has been disturbed by the hydrologic impacts of the infrastructure, and the sediment cone behavior is simply part of the river’s response to this perturbation.

3.3.3 GIS Assessment of Sediment Cones

A GIS database prepared by the UTCSR was used in evaluating sediment dynamics. The database included 56 arroyo confluences (described as sediment cones) identified visually for three time periods: 2005, 2004 and the mid-1990s. The sediment cones were differentiated by use of a Feature Identification (FID) number. These cone / confluence features are also shown on the accompanying Map Book, and discussed further in Appendix B. The shapefile's "Notes" for each FID point included supplemental information, including an 'activity level' designation of "Low", "Medium" or "High" indicating the sediment deposition. The identified sediment cones were viewed within ArcMap against underlying recent (2005) infrared aerial photography (see Appendix A)."

Overall, the activity designations for the 56 sediment cones were skewed towards the “High” end, with approximately 54% categorized as such (Figure 10). Of the 56 sediment cones, approximately 43% are associated with tributaries flowing in from the U.S. side of the river, with the remaining roughly 57% joining the Rio Grande from the Mexico side. Assessed by origin country, the Mexican tributaries showed a significantly higher proportion designated as “High” activity level (~61%) vs. the U.S. (~39%). Conversely, the Mexican tributaries had a lower percentage designated as “Low” (~10%) than the U.S. tributaries (~17%). Those designated as “Medium” for the U.S. and Mexico were ~44% and ~29%, respectively. (See Figures 13 and 14 below) These differences could potentially be related to topography, surface geology, (recent) hydrology, etc., or could reflect more systematic influences such as differences in land-use practices and watershed management by the two countries.

The sediment cones marked along the study reach appear visually to be randomly distributed for the most part, with the exception of a ‘cluster’ (Feature Identification Numbers [FID] 3-14, 54, 55 on pages 7 and 8 of the Map Book) at about 20% downstream from the top of the reach (see Figure 13). The cluster identified above may be related to a visually obvious topographic feature that dissects it – what appears based on the ‘shadowing’ to be a series (one of which is quite prominent, defined near FID 8) of steep ridges/cliffs that run roughly perpendicular to the general river trend in this area (fault lines?).

Conclusion - The flow regime of the Rio Grande within the Forgotten Reach has changed markedly in response to regulation from water resource infrastructure, primarily for irrigation. The volume of water reaching and passing through the Forgotten Reach has decreased significantly. In addition, the magnitude of peak flows has been clearly reduced. And, finally, the seasonal arrival of peak volumes has shifted meaningfully.

The change in river flows, and consequent hydraulic energy, has resulted in a changed sediment transport regime and fluvial geomorphology. The river channel has demonstrably changed in response to this change in flow regime. Channel capacities have decreased through aggradation and channel narrowing, and deposition has also altered the floodplain. Tributary sediment contributions have become more significant in comparison to the current mainstem carrying capacity. While some potential localized influences were noted (e.g., ‘ridge’ topography), no quantitative hydraulic parameters were available. Changes to the tributary watershed conditions were also not examined. Further studies are needed to more fully understand the channel morphology and its interaction with the ecology.

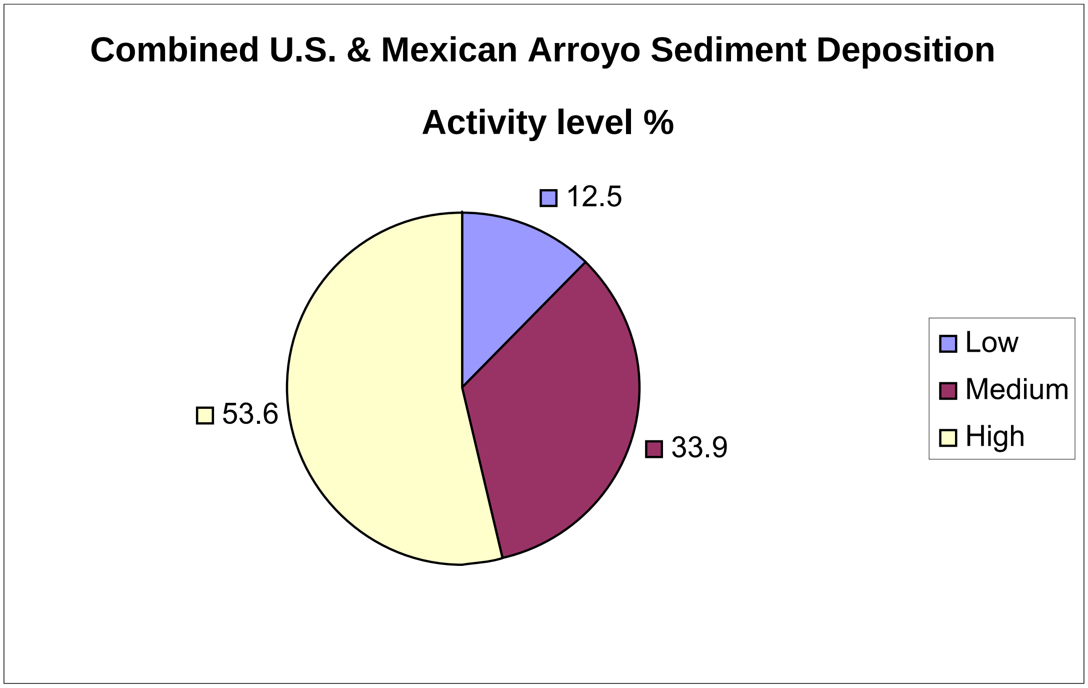

Figure 11 – Combined U.S. and Mexico Arroyo Sediment Deposition by Activity level.

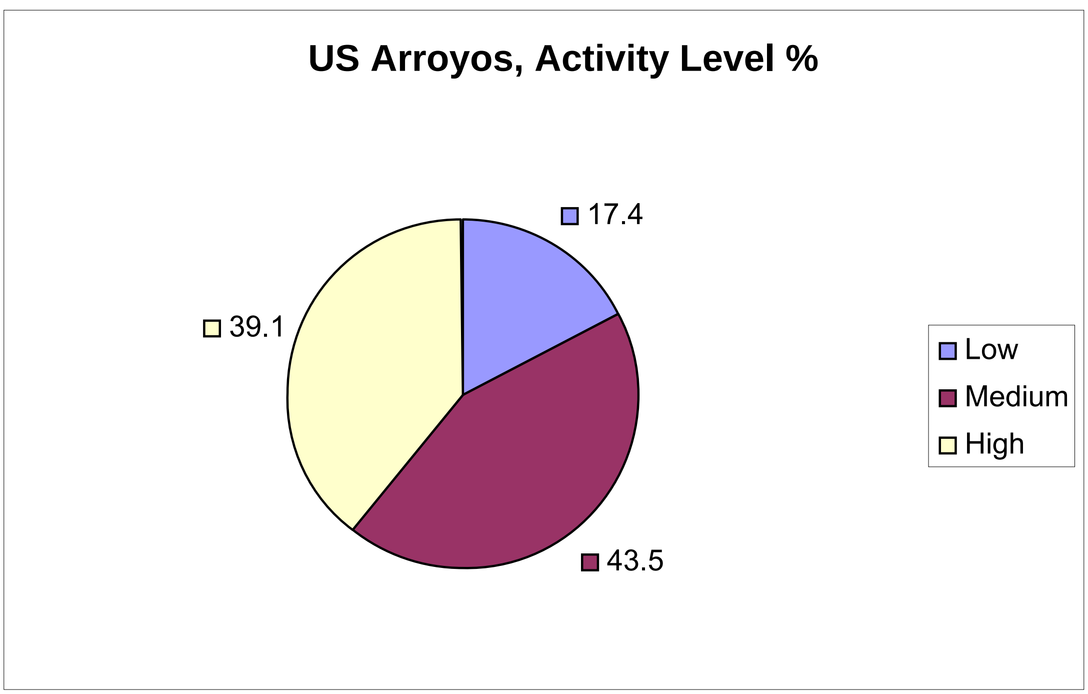

Figure 12 - Distribution by activity level, U.S.

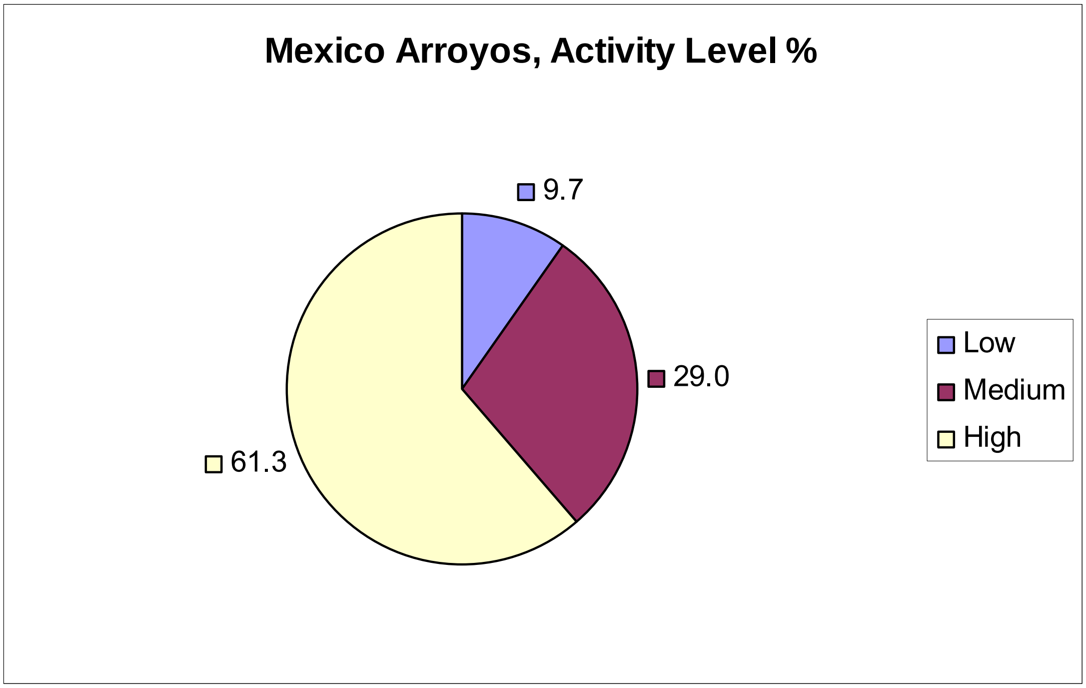

Figure 13 - Distribution by activity level, Mexico.

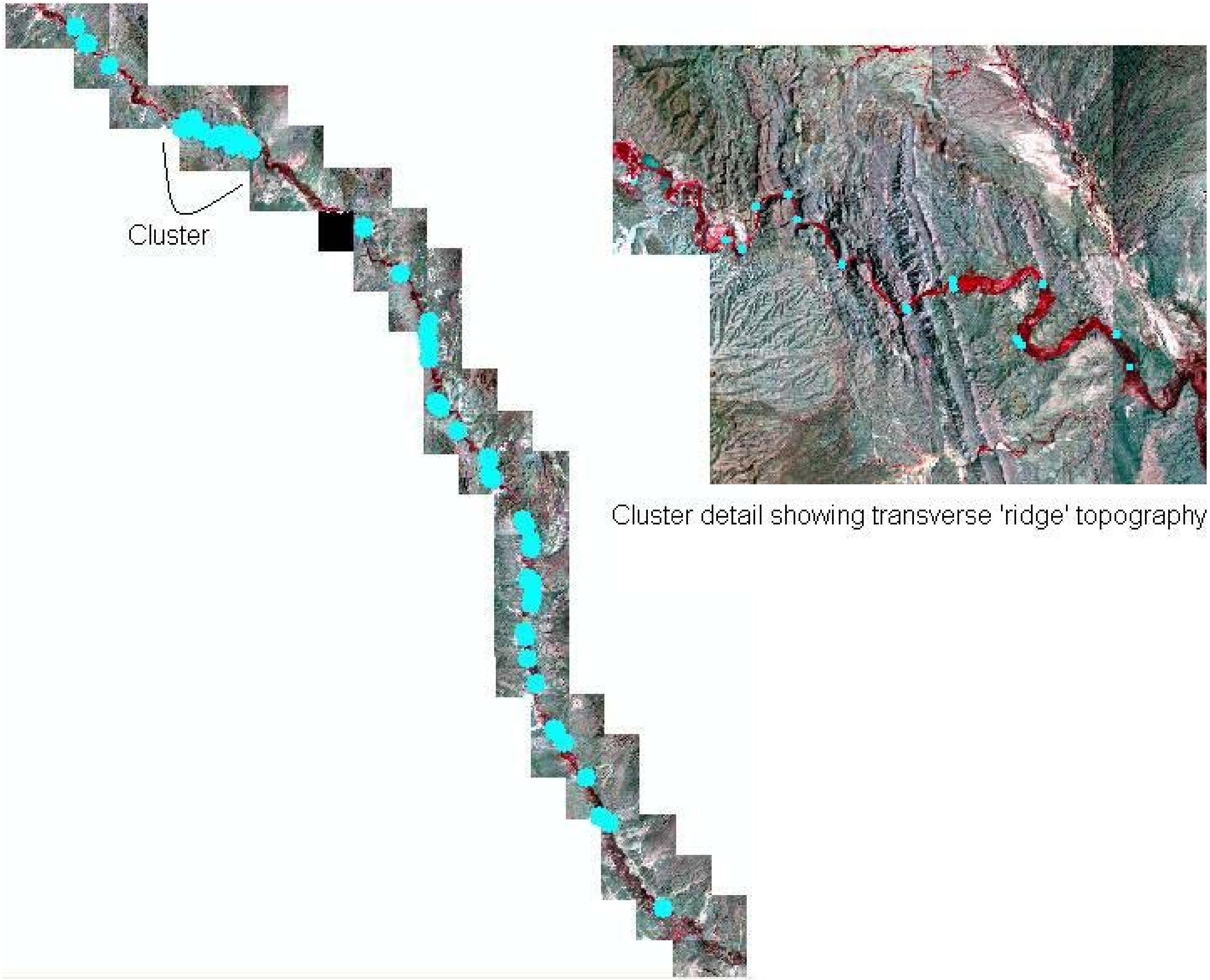

Figure 14 - Spatial distribution of "sediment cones" over study area.

CHAPTER 4 – ENVIRONMENTAL RESOURCES

Forgotten Reach of the Rio Grande – Fort Quitman to Rio Conchos Confluence – Existing Ecological Conditions, July 2007.

The Rio Grande (or Rio Bravo as it is known in Mexico) throughout its course has been declared an Endangered River four times since 1993 by American Rivers, a national non-profit conservation organization. More recently (2007), the Rio Grande was listed as one of the most endangered rivers globally, by the World Wildlife Fund. The Forgotten Reach of the Rio Grande, the subject of this report, is a term first coined by Steve Harris of Rio Grande Restoration, a non-profit entity. The term refers to an approximately 200 mile reach of the Rio Grande/Rio Bravo from El Paso to Presidio, Texas/Ojinaga, Mexico, where the river is now devoid of large, high energy spring runoffs due to the highly regulated Rio Grande Bureau of Reclamation's Rio Grande Project, below Elephant Butte.

UTCSR conducted a geospatial map compilation with available data during 2006-2007. Conclusions from these data are made throughout this document and a summary of their geospatial findings is presented in appendix A.

The geo-database includes the following:

- National Wetland Inventory maps of the project reach;
- Impaired stream segments from TCEQ 303(d) list (This list describes the status of the state's waters, as required by Sections 305(b) and 303(d) of the federal Clean Water Act. It summarizes the status of the state's surface waters, including concerns for public health, fitness for use by aquatic species and other wildlife, and specific pollutants and their possible sources.);
- Arroyo Confluences that exhibit sediment plugs, as visual inspection of one and two meter aerial imagery acquired during the mid 1990s, 2004, and 2005;
- Pumping sites and Diversion Dams from USGS topographic maps and IBWC data;
- Groundwater depth monitoring wells from the Texas Water Development Board Ground database reports;
- Land ownership data from the original Texas Land Survey and Railroad Commission of Texas;
- Vegetation mapping from 2002 LandSat 7 Enhanced Thematic Mapper Plus;
- Structures and channelization infrastructure from IBWC datasets;

- NRCS STATSGO soils from the USDA NRCS State Soil Geographic (STATSGO) database for Texas.

Corps personnel conducted a literature search of studies done in the project study area and assembled relevant information into this report. Corps personnel also reconnoitered the Forgotten Reach on two separate occasions subject to private land access, and ground-truthed the photo interpretation conducted by UTCSR.

4.1 Water Quality

The study reach is in Texas Water Quality Segment 2307 (TCEQ Basin 23, Segment 07). Water quality of the Forgotten Reach was deemed of interest during this study because of concerns relative to public health, fish and macroinvertebrate health, and quality of irrigation water. Water quality measurements taken from 1970-76 reflect the flows at Fort Quitman to be high in total dissolved solids, sodium and chlorides, which reflect drainage and return flows from irrigated areas. Portions of the water passing the Fort Quitman station are evaporated and transpired and are replaced in part with fresher flows from arroyos which have dissolved solids on the order of 500-700 parts per million (ppm) (IBWC 1978). Thus, concentrations at Upper Presidio are less than that at Fort Quitman. Miyamoto et al, (1995) examined the flow weighted annual salinity of the river from 1969 through 1989. An estimated 444,225 tons of salt entered the Forgotten Reach at Fort Quitman annually over this 20 year period. Other data collected by the Texas Clean Rivers Program indicate that concentrations of chlorides, total dissolved solids (TDS), and sulfates generally decrease in salt content as the Rio Grande courses from Fort Quitman to Presidio (Landis 2001).

Below is the most recent draft TCEQ 2004 303(d) Federal Clean Water Act list of impaired streams in the project study reach. The entire Forgotten Reach of the Rio Grande from Fort Quitman to Presidio is classified as an impaired stream for one parameter or another.

Table 4 - Impaired Status, TCEQ Segment ID 2307, Rio Grande below Riverside Diversion Dam to the convergence with the Rio Conchos.

Area	Parameter	Point Source	Non-Point Source	Category	Rank
25 miles upstream of segment boundary	Chloride	Y	Y	5b	S
25 miles upstream of segment boundary	Total dissolved solids	Y	Y	5b	S
Arroyo Diablo to one mile downstream of Neely Canyon	Chloride	Y	Y	5b	S
Arroyo Diablo to one mile downstream of Neely Canyon	Total dissolved solids	Y	Y	5b	S
Guadalupe Bridge to Arroyo Diablo	Bacteria	Y	Y	5c	D
Guadalupe Bridge to Arroyo Diablo	Total dissolved solids	Y	Y	5b	S
Guadalupe Bridge to Arroyo Diablo	Chloride	Y	Y	5b	S
Remainder of segment	Chloride	Y	Y	5b	S
Remainder of segment	Total dissolved solids	Y	Y	5b	S

Key:

Category 5: The water body does not meet applicable water quality standards or is threatened for one or more designated uses by one or more pollutants.

Category 5b - A review of the water quality standards for this water body will be conducted before a Total Maximum Daily Load (TMDL) is scheduled.

Category 5c - Additional data and information will be collected before a TMDL is scheduled.

Rank: For water bodies in Category 5b, a ranking of "S" has been assigned to indicate that a standards review will be conducted before a TMDL is scheduled. For water bodies in Category 5c, a ranking of "D" has been assigned to indicate that additional data and information will be collected before a TMDL is scheduled. For Categories 5b and 5c, TCEQ will develop a separate prioritized schedule for standards review or the collection of additional data and information. These activities will be conducted at the same time that TMDLs are being developed for the parameters in Category 5a. The Surface Water Quality Standards Advisory Work Group (SWQSAWG), EPA, and TCEQ are considering comments received during the comment period that ended March 1, 2006 on revisions to current Texas surface water quality standards. The last SWQSAWG meeting was September 6, 2007, in Austin. More information can be found at http://www.tceq.state.tx.us/permitting/water_quality/stakeholders/swqsawg.html

The photograph taken below at the confluence of the Rio Conchos and the Rio Grande near Haciendita, Texas, above Presidio visually depicts the water quality issues in the Rio Grande, where the difference in the water clarity is visible as the rivers merge.

Figure 15 - Confluence of the Rio Grande (to the right) and Rio Conchos (to the left) in Presidio County, Texas. Photo taken January 2007.

4.2 Groundwater

Groundwater along the study area occurs in alluvial deposits. Recharge to the alluvial deposits in the valley occurs from seepage of the Rio Grande, from surface water applied for irrigation, and by subsurface discharge of the bolsons to the valley alluvium. The discharges from groundwater in the valley alluvium occur as flows into the Rio Grande, as evapotranspiration by trees, shrubs and other vegetation, and, to a slight extent, by pumping of wells for irrigation. A few wells in the valleys, near the northerly Presidio County line, have yields up to 2,100 gallons per minute (gpm). Yields of other existing irrigation wells range from 300 to 1200 gpm. The volume and quality of water from these wells vary greatly (IBWC 1978).

Water levels in the valleys are shallow, normally varying from the land surface to a depth of about 15 feet. There is a direct relationship between the river stage and the groundwater adjacent to the river channel. During periods of high flow or flooding, the groundwater levels rise and approach the land level and exceed the land level in some cases where the river channel bottom elevation is about the same or above that of the adjacent land. During dry periods with little or no flow in the river, drainage and evapotranspiration lower water levels by about five feet. Cross sections taken across the floodplain and river channel, show that in some locations the channel bottom is perched at a higher elevation than the adjacent lands. This perching results in sustained water logging of the surface soils.

Movement of groundwater is downstream along the course of the river. Generally, the hydraulic gradient is very flat, restricting movement of the groundwater. Irregularly deposited clays, silts and fine sands impose further restrictions upon the movement of groundwater down gradient. This combination of poor movement of groundwater and evaporation and transpiration results in concentration of salt in the soil. In the immediate vicinity of the channel and adjacent floodplain, salinity ranges from 3,000 to 16,200 ppm total dissolved solids. Generally, nearer the margins of the floodplain, the salinity is less, ranging from 1,500 to 3,000 ppm total dissolved solids. In alluvial wash fan and floodplain deposits at the mouths of major canyons and arroyos, total dissolved solids usually range from 500 to 2,000 ppm. Local exceptions to these general conditions are not uncommon (IBWC 1978).

Currently, based on data compiled by UTCSR (2006), there are 121 groundwater monitoring wells in the project reach. Each well has an assigned Texas Water Development Board well number and each is individually owned. Records of changes in groundwater levels relative to surface elevations at these wells can be found at: http://www.twdb.state.tx.us/publications/reports/GroundWaterReports/GWDatabaseReports/GWdatabaserpt.htm

4.3 Vegetation

William Whiting led a stage coach route survey up the Rio Grande to El Paso, Texas, in 1849. His journal contains descriptions of large groves of cottonwoods, willows, mesquites, and extensive areas of grass along the Rio Grande floodplain. Animals specifically mentioned were white pelicans and mule deer (Bieber 1937). In 1859, Emory reported heavy growths of cottonwood and willow intermixed with mesquite and seep willow along what is now the study area.

Because of the spatial and temporal variability built into the geomorphic processes of channel meandering, channel narrowing, and flood deposition and the plant reproduction dependent upon them, a continuous ribbon of cottonwoods and willows did not likely occur along the Forgotten Reach (Stotz et al. 2000). Rather, patchy distributions were common in early accounts, with occasional untimbered stretches. Grasses such as sacaton and phragmites and possibly vine mesquite were noted by some travelers of the Rio Grande, and Fosberg (1940) documented many wetland plants of the Mesilla Valley, including duckweed (Lemma minor) and pondweed (*Potamogeton* spp.), as well as emergents like cattails (*Typha angustifolia*), rushes (*Juncus balticus*), a variety of sedges (*Cyperus, Eleocharis*, and *Scirpus* spp.) and horsetails (*Equisetum hyemale*).

Travelers and settlers likely played a role in a significant change in the vegetation along the river by introducing exotic plants. In 1930, Fosberg (1940:581) collected 23 species of introduced plants in the Mesilla Valley north of the study area. The more common exotic species were tamarisk or saltcedar, Russian thistle (*Salsola kali*), thistles (*Sonchus* spp.), and an introduced reed (*Arundo donax*) (Stotz et al. 2000). The most impacting of these was saltcedar, a phreatophyte, “a plant with roots in the water table, which can consume large quantities of water”, introduced as an ornamental and for erosion control. In small numbers, it was present in the Albuquerque area in 1908. It was planted along the banks of the Rio Puerco, a tributary of the Rio Grande, by the Middle Rio Grande Conservancy District in 1926 and occurred in the Presidio Valley by 1935 (Everitt 1998). As dam building, flow regulation, and channelization occurred, saltcedar became more and more dominant; Everitt (1998) argues that saltcedar was not responsible for changes in river hydrology, but that it simply responded to such changes that were already underway. In both the Middle Rio Grande and Presidio valleys, extensive spreading of saltcedar occurred after significant flood events in 1929 and 1942, respectively (Crawford 1993; Everitt 1998). As Everitt explains, such floods dispersed saltcedar seeds widely across the floodplain to areas previously not colonized and also opened new habitats via scouring and channel migration.

Everitt (1998) concluded that there is no evidence that saltcedar actively displaced native species along the Rio Grande in the El Paso and Presidio valleys. However, its prodigious production of airborne seeds, long seed production and germination periods, and rapid growth allowed it to compete favorably with native trees in colonizing newly stabilized sandy or silty surfaces (Graf 1994). Regardless of whether saltcedar has played an active role in replacing native vegetation, it has come to dominate many areas along the Rio Grande where it plays an important role in the ongoing process of channel aggradation and narrowing. From Fort Quitman through the Presidio Valley, saltcedar now occupies some patches of land once covered by cottonwood woodland and tornillo thickets. Ohmart (2002, as referenced in Fullerton and Batts 2003) estimated that only about 60 acres of cottonwood-willow remain below El Paso, with soil salinity being a limiting factor that has affected species composition.

Saltcedar was not in abundance or considered a dominant species in riparian habitats along the Rio Grande until about or shortly after 1942. The spill from Elephant Butte Reservoir in 1942 which inundated the floodplain appears to have scattered seeds and formed optimum germination conditions for saltcedar.

Upstream reservoirs have regulated and reduced downstream flows, which in turn, have enabled encroachment of saltcedars into the river channel. The afore-described deteriorated channel conditions, and the resultant overflows and ponding of highly saline waters, evaporate and leave the soil encrusted with salt accumulations which reduce soil productivity. Most native species cannot tolerate these high salt conditions, but saltcedar thrives in these conditions. Impoundments, fires and salt accumulations have aided the spread and dominance of saltcedar within the study area at the expense of native species (Ohmart et al. 1977).

The floodplain within the study area on the U.S. side had a total area of 18,100 acres in 1977. Of this, approximately 60 acres were in cottonwood and willow.

To define the expansion of the denser vegetation areas, principally saltcedar, such areas were delineated on 1947, 1967, and 1974 aerial photographs. The results listed in the Table 5 show that saltcedar area doubled between 1947 and 1974, and at that point saltcedar occupied about 46% of the entire floodplain. The data also illustrates the progress of saltcedar encroachment in the study reach from 1947-74.

Table 5 - Saltcedar Occupied Area (acres) in floodplain, Fort Quitman to Haciendita, Texas (IBWC 1978).

Year	United States	Mexico	Total
1947	5,800	4,600	10,400
1967	8,700	4,900	13,600
1974	12,900	7,300	20,200

Figure 16 - Large old-growth saltcedar trees on the Green River Valley Ranch, exceeding 20" Diameter Breast Height; February 2007.

Engel-Wilson and Ohmart (1978) classified plant communities along the Forgotten Reach into four dominant community types:

- Saltcedar; a community dominated by dense stands of saltcedar with little or no understory except for small patches of grass and seep willow where the saltcedar canopy was not continuous;
- Cottonwood-willow with substantial saltcedar but contain enough cottonwoods and southwestern black willows to have considerable impact on wildlife habitat;
- Screwbean mesquite-wolfberry community with screwbean mesquite, honey mesquite and wolfberry as the dominant plants, a rare community type found on the floodplain outside of the band of saltcedars which occurred along the river, characterized by screwbean mesquite trees scattered through a shrubby understory of Torrey wolfberry and honey mesquite;
- Thorny shrub, which is a complex mixture of a variety of desert shrubs. They also classified structural type, based on distribution and density of foliage at various heights above ground level.

Type I vegetation – Trees over 30 feet tall with the foliage distributed somewhat evenly among the layers. This type is rare in the study area.

Type II vegetation – This designation captures most of the saltcedar, is characterized by trees up to 30 feet tall and virtually no green vegetation above five feet and 80% of the foliage is at ten feet or more.

Type III vegetation – Composed of trees mostly 10 to 20 feet with most of the foliage concentrated below 15 feet, including a well-developed bottom layer.

Type IV vegetation – some trees 15 feet and above, but most of the foliage is below ten feet with the greatest amount in the lower levels.

Type V vegetation – few trees over ten feet but most of the foliage is below five feet. Type VI is the shortest structural type. Most of the foliage is in the shrub and forbs/grass levels below five feet, sometimes with an occasional tree over ten feet tall.

Type VI vegetation – Most of the thorny shrub in the study area.

Table 6 illustrates vegetation types present in the study area in 1977. Appendix C catalogs the plant species found by Engel-Wilson and Ohmart in 1977.

Table 6 - Areas of vegetation types on the U.S. side, study area, Forgotten Reach, Rio Grande, Fort Quitman to Rio Conchos Confluence, 1977.

Vegetation Type	Acres
Saltcedar II and III	4,757
Saltcedar IV	2,352
Saltcedar VI	588
Cleared Farmland	2,975
Cottonwood	5
Bare Ground	956
River Channel	445
Thorny Shrub	14,063
TOTAL	**26,141**

Poor grazing management of domestic livestock over time has likely contributed to a shift from primary grasses to sparse woody shrubs and annual grasses. This existing vegetation does little to slow surface waters during torrential rains, and, consequently, large sediment loads are transported into the study reach to compound the problem of river channel changes. Species that were likely present include: mesa dropseed, sand dropseed, saltgrass, sacaton, sideoats grama, six weeks grama, black grama, blue grama, cowpen daisy, desert baileya, desert seep weed, dock, grounsel, jimmyweed, mountain pepperweed, rocket mustard, sand verbena, spectacle fruit, tansy mustard, tree tobacco, trailing allionia and wild buckwheat.

Based on LandSat 7 Enhanced Thematic Mapper Plus data collected in 2002, the following acreages (Table 7) of vegetation types occur as estimated by UTCSR from their compiled geospatial database. Since the location of the channel and thus the boundary are often un-detectable (for the reasons stated above) from satellite imagery, the acreage given is for both the Mexican and U.S. sides, within 1.86 miles of the channel unless an elevation rise of 32.8 feet or more was encountered. High or moderate probability saltcedar monoculture or mixed stands totaled 37,761 acres on both sides.

Table 7 - Acreage of vegetation types within the study area as photo interpreted by UTCSR from 2002 LandSat data.

Vegetation Type	Acreage
Saltcedar	13,575
Saltcedar in water or wet soils	2,519
Saltcedar (mowed or short) or mixed with bare soil	1,421
Saltcedar/mesquite	20,246
Vegetation in water or shadow	792
Other dense scrub/shrub	11,891
Other sparse scrub/shrub	32,526
Row crop/herbaceous	2,906
Fallow fields, senescent vegetation	6,676
Developed or very sparsely vegetated	2.930
TOTAL	**95,482**

An indication of the difficulty of maintaining restoration plantings without an investment in periodic inspection and maintenance is given by the current status of the Cecil's Pond revegetation project of 1985. This revegetation effort was undertaken to partially mitigate for wildlife habitat losses incurred in construction and clearing activities on the Boundary Preservation Project of 1980 (Anderson and Ohmart 1986). A visit to the site by a Corps biologist and a Corps contractor on February 16, 2007, revealed poor survival of cottonwood and black willow plantings. Uncontrolled livestock grazing, drought, and channel incision and entrenchment appeared to be the main causes of planting failures observed, as less than 20 willows and ten cottonwoods were found to have survived on the 12 acre site, despite a planting effort of over 1,000 trees in 1985. Salinity of soil and surface and groundwater may have also contributed to the demise of plants.

Figure 17 - The Rio Grande near Cecil's Pond Mitigation site - entrenched and displaying poor water quality, upstream of Haciendita, Texas looking downstream.

Figure 18 - A Corps' contractor examines the few remnants of over a thousand Cottonwoods and Willows that were planted in 1985 at Cecil's Pond Mitigation Site - Note the artificial snag placed in 1985 and still standing on the far left; 2007.

Currently, some ranchers mow salt cedar saplings and seedlings in their Bermuda grass pastures in the spring when/if soils have dried out from the previous monsoon. Old tire casings are put over farm tractor tires to protect the tractor tires from being impaled and flattened by salt cedar sprouts and stubs. This mowing process tends to encourage further sprouting of salt cedar saplings, but allows the Bermuda grass a somewhat competitive advantage. Few if any ranchers follow up this treatment with either foliar or basal stem herbicide treatment. Hudspeth County Soil and Water Conservation District has released the Chinese leaf beetle (*Diorhabda elongata* [Crete variety]) 50 miles south of Ft. Hancock. Likewise, a major effort to introduce leaf beetles above Candelaria occurred in the spring of 2007 (Mark Muegge, Ph.D., pers. comm.). It is possible that this project could change the density of live stems of both old and young stands. It is questionable whether any geomorphic benefit would accrue in the salt-cedar armored sections without removal of dead boles and roots.

The La Junta Project, a major introduction of leaf beetles above Candelaria was initiated in June 2007. The La Junta Saltcedar Project is joint restoration initiative by the Rio Grande Institute and the Chihuahuan Desert Resource Conservation and Development Area carried out in collaboration with local ranchers and the USDA/ARS Laboratories in Temple with support from local landowners, the USDA/NRCS Grazing Lands Conservation Initiative and the World Wildlife fund. The beetle releases have been coordinated with IBWC and Comision Internacional de Limites y Aguas (CILA) in conformity with the Bi-National River Ecology Workgroup and pertinent International Minutes.

It is possible that the La Junta Project's releases of the bio-control agent could change the density of live stems in both old and young stands. It is, however, uncertain whether any geomorphic benefit would accrue in the vegetatively reinforced sections without change in flow regimes. Monitoring in Fall 2007 indicated that the beetle had become established; further monitoring will determine whether it is able to overwinter successfully, resist predation and spread to adjacent areas.

Figure 19 - A Bermuda grass pasture being colonized with Saltcedar in southern Hudspeth County, Texas; January 2007.

4.4 Wetlands

IBWC (1978) estimated 1,764 acres of inland saline flats that were wetlands on the U.S. side, 93% of which were occasionally flooded agricultural fields and saltcedar and mesquite covered flats. A few small wetlands were relatively permanent. There were two small cattail marshes, one-half mile downstream from Panales Arroyo near Ruidosa, and one-half mile southwest from Candelaria. Both are borrow pits which were formed during the construction of private levees.

Ephemeral ponding of water occurs in the study area during wet years where the river is perched or where water is trapped behind old levees and prevents drainage of these ponded areas. High ambient temperatures and low relative humidities likely promoted rapid evaporation of the ephemeral ponds so that over the years these low areas become highly saline. Rooted aquatic vegetation never became established due to the ephemeral nature of surface water.

The UTCSR geospatial database calculated, based on National Wetland Inventory Maps (May 1984), a sum of 14,266 acres of wetlands in the project area. The

Palustrine scrub-shrub needle-leaved deciduous (PSS2J), intermittently flooded, which indicates saltcedar, occupies 6,205 acres, according to the UTCSR database.

4.5 Wildlife

The spread of saltcedar may have had significant impacts on animal communities. Along the river above Presidio, Engel-Wilson and Ohmart (1978) found that the distributions of many different groups of vertebrates were affected by the presence of saltcedar. In their study of the project reach in 1978, they found that Cottonwood-willow Type I had the greatest density of birds, but Thorny Shrub VI had the greatest diversity. Cottonwood-willow and screwbean mesquite-wolfberry were preferred by twice as many bird species as any other community during the summer breeding and nesting season. Saltcedar had a fairly high bird density during the summer, but this was primarily due to the large number of nesting White Winged Doves (*Zenaida asiatica*). Yellow Breasted Chats (*Ictera virens*), various hummingbird species, and Summer Tanagers (*Piranga rubra*) also used saltcedar. The screwbean mesquite-wolfberry community had high bird densities and a fairly high diversity. Gambel's quail (*Callipepla gambelii*) was found primarily in cottonwood willow communities in the floodplain. Mule deer (*Odocoileus hemionus*) and peccaries (*Tayassu tajacu*) rarely entered saltcedar or cottonwood-willow except to obtain water from the river. Beavers (*Castor canadensis*) were noted to be dependent upon cottonwood-willow for food and dam-building materials, although some saltcedar was used in at least one of the three dams located in the study area. White-footed mice (*Peromyscus spp.)* were the most frequently found rodent in saltcedar, but the lowest rodent densities overall occurred in saltcedar and thorny shrub. House mice (*Mus musculus*), hispid cotton rats (*Sigmodon hispidus)*, and western harvest mice (*Reithrodontomys megalotis*), deer mice (*Peromyscus maniculatus*), cactus mice (*Peromyscus eremicus)*, and white-footed mice (*Peromyscus spp.)* were found in the moister, riparian cottonwood-willow community. Texas toads (*Bufo speciosus*) were the most common toad found on the floodplain, although red-spotted toads (*Bufo punctatus*), great plains narrow-mouthed toads (*Gastrophryne olivacea*) and Couch's spadefoot toads (*Scaphiopus couchii*) also occurred. Reptiles were most abundantly found in thorny shrub VI, and almost no reptiles occurred in saltcedar; however, it was observed that reptiles will move into a saltcedar area if the canopy is open and grassy openings are present.

Appendix C lists the faunal species within the study area as recorded during Ohmart et al.'s reconnaissance study of 1992 (Ohmart et al 1993).

4.5.1 Ichthyofauna

Twelve species of fish representing eight families were identified by Engel-Wilson and Ohmart (1978) from samples taken at 20 locations throughout the study area and in the channelized portions above and below the study area. Five species (red shiner [*Notropis lutrensis*], common carp [*Cyprinus carpio*], gizzard shad [*Dorosoma cepedianum*], mosquito fish [*Gambusia affinis*], and green sunfish [*Lepomis cyanellus*]) constituted 96% of the sampled population, with the red shiner comprising 49% of the total. The five species of game fish (channel catfish [Ictalurus punctatus], blue catfish [*Ictalurus furcatus*], green sunfish [*Lepomis cyanellus*], longear sunfish [*Lepomis megalotis*], and white bass [*Morone chrysops*]) comprised 11% of the population. Bullhead minnow (*Pimephales vigilax*), river carpsucker (*Carpiodes carpio*) and yellow bullhead (*Ictalurus natalis*) and speckled chub (*Macrhybopsis aestivalis*) were also found in the project study reach by Bestgen and Platania (1988). Fish density in the Rio Grande above the Rio Conchos was found to be 283 fish per 328 square feet. Salinity and conductivity values were found to rise dramatically downstream of Acala and Fort Hancock in Hudspeth County, upstream of Fort Quitman, where most diverted water returned to the Rio Grande, carrying a large ambient load of dissolved solids (Bestgen and Platania 1988).

Two tributaries of the Rio Grande in the project area (Capote Creek, which is an intermittent spring-fed freshwater stream, and Indian Hot Springs, where warm saline spring water drains into the river) were sampled extensively. Hubbs (1977) thought that these areas were likely to have endemic or rare fishes; however, he found no endemic or rare fishes at these sites or anywhere else in the study area.

4.5.2 Mollusks and Crustaceans

Metcalf (1978) identified ten species of aquatic snails, four species of bivalve mollusks, an aquatic crustacean, and one species of terrestrial crustacean in the river and in the contiguous floodplain of the study area. He also found nine xeric land snails, which are widespread throughout the southwestern U.S. and into northern Mexico.

The species richness of aquatic invertebrates in the Rio Grande was low throughout the study reach (Metcalf, 1978). A single two-mile stretch of river directly upstream from Haciendita supported a rather diverse fauna, however. This stretch has relatively permanent water, as before stated, due to return flows from lands in Mexico irrigated with Rio Conchos water. The aquatic fauna here appears to be similar to that found in the area under pre-settlement conditions. Of the ten species of mollusks taken in this two-mile stretch, four species (*Anodenta imbecillis, A. musculium transversum, A. antillorbis sonorensis*, and *A. micromenetus dilatatus*) were found only in this reach. Only a few opportunistic species occur in the rest of the river such as *Physa virgata* and (in some places) *Lymaaea bulimoides*. Much of the channel was dry and contained no live aquatic invertebrates at all. No mollusks or crayfish were found in oxbow pools or intermittently flooded fields or flats. The springs in the valley contained a relatively diverse molluscan fauna including one species (*Lymnaea parva*) which was found only in springs away from the river and is common elsewhere in the country (Metcalf 1978).

4.5.3 Federally or State Listed Species

The Bald Eagle (Federally delisted June 2007) has been sighted over the study area during its migration, but it is not believed that this species utilizes the area to the extent that any work done under a construction alternative would adversely impact it.

Certain species possibly occurring within the habitats of the study reach are of particular concern to Federal and state officials due to pressures from human activities. Included among these species are the following (TPWD 2007):

Table 8 - Federal or state listed species that may occur in the Forgotten Reach of the Rio Grande, Texas.

Species Common Name	Scientific Name	Status	County
American peregrine falcon	*Falco peregrinus anatum*	SE	Hudspeth Presidio
Northern aplomado falcon	*Falco femoralis septentrionalis*	FE SE	Hudspeth Presidio
Common black-hawk	*Buteogallus anthracinus*	SE	Presidio
Gray hawk	*Asturnina nitida*	ST	Presidio
Southwestern willow flycatcher	*Empidonax traillii extimus*	FE SE	Presidio
Western Yellow-billed cuckoo	*Coccyzus americanus occidentalis*	FC	Presidio Hudspeth
Zone-tailed hawk	*Buteo albonotatus*	ST	Presidio
Gray wolf	*Canis lupus*	FE SE	Hudspeth Presidio
Greater long-nosed bat	*Leptonycteris nivalis*	FE SE	Presidio
Chihuahua shiner	*Notropis Chihuahua*	SE	Hudspeth
Bluntnose shiner	*Notropis simus*	ST	Hudspeth Presidio
Blue Sucker	*Cycleptus elongatas*	ST	Presidio

Species Common Name	**Scientific Name**	**Status**	**County**
Conchos pupfish	*Cyprinodon eximius*	ST	Presidio
Rio Grande silvery minnow	*Hybognathus amarus*	FE SE	Hudspeth Presidio
Mexican stoneroller	*Campostoma ornatum*	ST	Presidio
Chihuahuan Desert lyre snake	*Trimorphodon vilkinsonii*	ST	Hudspeth Presidio
Chihuahuan mud turtle	*Kinosternon hirtipes murrayi*	ST	Presidio

FE=Federally Endangered
SE=State Endangered
ST=State Threatened
FC=Federal Candidate

Potential projects with a Federal or state nexus would have to consider effects of a proposed action on the above species.

CHAPTER 5 – PROBLEMS AND OPPORTUNITIES

5.1 Problems

Historically, the Forgotten Reach of the Rio Grande was subject to higher spring time flows than at present, from snowmelt runoff. It continues to receive intermittent tributary flows from isolated thunderstorms throughout the Forgotten Reach's adjacent watersheds during the monsoon season. Changes to the natural hydrologic regime from construction of irrigation and flood damage reduction structures upstream of the Forgotten Reach have dramatically changed the river's flow regime and the vegetation communities within the study area.

The Bureau of Reclamation's Rio Grande Project furnishes a full irrigation water supply for about 178,000 acres of land and electric power for communities and industries upstream of the Forgotten Reach. Drainage water from project lands provides a supplemental supply for about 18,000 acres in Hudspeth County, Texas. Project lands occupy the river bottom land of the Rio Grande Valley in south-central New Mexico and west Texas. About 57% of the lands receiving water are in New Mexico; 43% are in Texas. Water is also provided to Mexico to irrigate about 25,000 acres in the Juarez Valley.

Physical features of the project include Elephant Butte and Caballo Dams, six diversion dams, 139 miles of canals, 457 miles of laterals, 465 miles of drains, and a hydroelectric power plant. The project is operated as two divisions: The Water and Land Division, and the Power and Storage Division.

Invasive species removal and control needs to be managed to minimize the negative impacts to both the terrestrial and aquatic habitats within the study area and to maximize the river's water quality and availability. Native plant communities can be reintroduced, but in order to do so, actions would have to be taken to satisfy the species' requirements for germination and establishment within the current flow constraints.

The Rio Grande throughout its course has been declared an Endangered River five times since 1993 by the American Rivers and the World Wildlife Fund. The TCEQ, Environmental Defense, and the Corps partnered in 2005-2007 to conduct a study of the Forgotten Reach of the Rio Grande from Fort Quitman to Presidio, Texas. As a part of the study, the UTCSR created a substantial geospatial database of ecological, water quality, and socioeconomic attributes, which is a part of this report (Appendix A).

Prior to the advent of intensive irrigation in the El Paso/Juarez Valley, and since the construction of Elephant Butte Dam in 1915, the character of the Rio Grande has dramatically altered from a bimodal snowmelt runoff and monsoon driven hydrologic system to a system regulated and characterized by consistent flow regimes tied to the irrigation season, and which is largely unable to move sediment. The reach is now an aggrading reach whose bed is substantially higher than prior to dam construction upstream (Schmidt et al. 2003).

These changes in river hydrology largely facilitated the invasion of saltcedar throughout the reach (U.S. and Mexico sides), with an estimated 16,000 acres of saltcedar in monotypic stands currently existing in the floodplain and terraces of the reach, and another 20,000 acres of saltcedar mixed with other shrubs and trees (UTCSR 2006). The consequences of this noxious shrub invasion is increased salinization of soils and water, substantial loss of habitat quality for many faunal species, displacement of native flora, increased surface and groundwater loss due to evapotranspiration losses by saltcedar, and loss of agricultural productivity. Seventeen faunal or fish species are federally or state listed in the study area and the entire reach is declared an impaired stream by TCEQ for total dissolved solids, bacteria, and chloride salts.

5.2 Opportunities

A TCEQ partnership with Environmental Defense is working to identify ecosystem restoration projects within the Forgotten Reach. Environmental Defense has created a booklet entitled "The Forgotten River Chronicles" to educate the public on the rich history of this area and on the ecosystem restoration opportunities within the Forgotten River. More recently, the La Junta Project has created a public-private partnership between NRCS, the Chihuahuan Desert RCD, Rio Grande Institute and ranchers in the Ruidosa-Candelaria reach, creating wide community awareness and media attention. Through these and other outreach programs, the citizens in the area are discovering the potential for preserving floodplains.

Recent initiatives to resolve the Rio Grande's pressing water supply issues may offer additional opportunities to support river restoration activities in the study area:

- The IBWC's Canalization Project draft EIS analyzes river channel and riparian enhancements in the reach immediately upstream of the Forgotten River;

- The Bureau of Reclamation is in process of implementing the first revision to the Rio Grande Project Operating Agreement in over 20 years;
- The Region M (Lower Rio Grande, Texas) Regional Water Plan references the desirability of opening channels in the Forgotten River as a means of enhancing its water supply;
- The Region E (Far West Texas) Regional Water Plan discusses the potential for an off-channel storage reservoir, near Fort Hancock which might be used to regulate inflows to the Forgotten Reach;
- The federal Water Resources Development Act of 2007 authorizes up to $50 million for "Rio Grande Ecosystem Management" throughout the river basin.

Opportunities now exist to improve local floodplains as a mosaic of wetland and riparian habitat, as well as to increase the river's channel capacity to ensure that more water reaches downstream water users. Such uses are consistent with the ecosystem restoration missions that Federal agencies, such as the Corps, participate in.

CHAPTER 6 – RECOMMENDATIONS

6.1 Recommendations

All of the Rio Grande's environmental problems identified in this report are inter-related. It is not possible to successfully address the most prominent issue, invasive saltcedar, without simultaneously attending to channel aggradation, sediment transport, soil and water salinity and water management issues. While much information is available with which to guide the implementation of projects, several significant data gaps remain to be filled.

In a reach almost 200 miles in length, the inherent uncertainties and high cost of a full-scale, holistic approach to these issues probably renders wholesale river restoration infeasible at the present time. This report recommends initiating an experimental approach, in which local, welldesigned, and monitored projects are employed. Lessons learned in one sub-reach may then be applied to new project areas, which may eventually inform a set of long-term improvements throughout the Forgotten River. Worthwhile projects, such as the La Junta Saltcedar Control Project, are already underway. These should be continued, expanded when possible and additional components added, toward an ultimate goal of evolving an effective ecosystem management program.

For any suite of projects to have a meaningful impact on the study area, a systematic watershed approach, conceived at both local and landscape scales, will be needed. With the reach serving as an international boundary, this will necessarily involve coordination and cooperation between the two nations. With its location below a large irrigation project, cooperation and buy-in from national, international, and state regulatory and action agencies, land owners, local governments, environmental groups, and upstream water users will also be necessary.

6.1.1 General Recommendations:

It would be beneficial to begin future projects within the Forgotten Reach with the following general recommendations:

Leadership, Coordination and Information Sharing – Project proponents should have a mechanism for coordinating activities. This might come from the designation of a lead agency or from a less formal network of stakeholders, meeting regularly.

Outreach – Local land owners and agencies should be fully informed of current and future project developments. Elected representatives, especially those involved in appropriations processes, should be kept aware of the latest developments and the desirability of action to restore the Forgotten River. To date, Environmental Defense has done a commendable job in performing this function, and The Rio Grande Institute has conducted outreach tasks for agency stakeholders in Mexico.

Baseline Data Collection – The aerial mapping undertaken for this report by UTCSR has identified the scope of invasive species and sediment issues. If possible, the accompanying geographical database should be housed and maintained to permit additional new data. Further aerial data-gathering, incorporated into the existing database, would enable analysis of trends. Paso del Norte Watershed Council's recently constructed hydrologic database might be suitable to house both the original CSR data and subsequently collected data. Similar to the CSR effort, a further reach-wide data gathering effort is needed to characterize arroyo discharges of stream flow and sediment, salinity, and sediment storage and changes in vegetation and channel morphology. Additionally, several weather stations should be installed at strategic points within the watershed to enable elaboration of more accurate water, salinity, and sediment budgets for the reach. NOAA, USGS, or other agency programs may offer resources to assist in placing weather stations within the study area.

Planning – Individual projects will benefit from the formulation of plans. which address the entire suite of desired ecological outcomes, from vegetation, sediment, and salinity management to groundwater depth and direction, wildlife habitat, and river channel functions. Projects would benefit from the development of methods for quantifying environmental water-flow needs so that restoration hydrologic requirements can be met. Adequate resources should be devoted to monitoring the effects of project activities, so that an adaptive management approach can be implemented. A reach-wide planning effort which would logically follow a successful pilot project will benefit from continued investigation of sediment, salinity, and water budgets. We recommend the addition of these, along with land ownership data, to the existing GIS database.

Construction of a water budget model is recommended as a planning tool, as well as a precursor to the activities that follow. A water budget is a method of accounting for the balance of water inputs and outputs of a system, that is, where the water goes. A water budget would facilitate quantification of the various inputs and outputs to the Forgotten Reach system, such as:

- Base inflow;
- Seasonal runoff;
- Precipitation;
- Evapotranspiration;
- Tributary surface inflow;
- Groundwater infiltration;
- Groundwater extraction;
- Irrigation diversion.

This would, in turn, allow various ‘what if’ scenario simulations to estimate response of the system or features to changes in the inputs/outputs.

6.1.2 Construction of a Conceptual Model of Rio Grande Channel Forms

A critical first step to both individual project and reach-wide planning is to improve understanding of the fluvial, and associated ecological, processes at work in the study area. We recommend creation and testing of a conceptual model of the various typical channel types which occur in the Forgotten Reach, both functioning and impaired.

This would consist of sub-dividing the study reach into sub-reaches with similar channel/floodplain morphology and ecologic characteristics, and subsequent ‘target’ ecosystem objectives from which to develop alternative arrays.

For example, the faulted area associated with the cluster of sediment cones described earlier in this report (See Section 3.3.3) appears to represent a unique set of channel conditions associated with geologic influences.

Large alluvial, channel-connected floodplain areas were frequently encountered within the study area. These saltcedar “filter” areas typically have saltcedar overstories with baccharis species in the mid-story, and grass / sedge communities in the herbaceous strata with a high groundwater table.

These saltcedar filters depict a unique channel (or, perhaps more appropriately, non-channel) sub-reach. The approaches to these filters could comprise a discrete sub-reach and the typical incised, narrow channel downstream of the saltcedar filters, yet another sub-reach (though it would conceivably be possible to group these three into one sub-reach because the characteristics would seem to be related to each other).

From field observations and aerial photographic indicators, it seems that high groundwater conditions in the vicinity of the filters are a major component. It is not clear at this time, however, whether this is more of a cause or effect. On the one hand, it is possible that reduced conveyance within the channel could be inducing transfer of surface flows to the groundwater table and the significant moisture presence in soils near the ground surface observed. On the other hand, it is conceivable that high water tables impose a limit on the ability of the river channel to deepen and achieve higher conveyance capacity. Under this latter hypothesis, any conveyance area adjustment created through incision by the channel would be occupied by essentially static water corresponding to the groundwater table and, thus, would not yield an effective conveyance increase.

Another sub-reach might be those areas with pronounced vegetative reinforcement of the channel banks however; it is possible that this biologic characteristic could extend over several sub-reaches.

Finally, though there may not be as much discussion within this report of them, some sub-reaches may, in fact, be functioning productively. Inclusion of one or more of these sub-reach categories would go a long way in providing a model of ecosystem function with which to form 'target' ecosystem objectives.

6.2 Pilot Projects

Experimental pilot projects will seek to determine what combination of treatments and / or structures will restore sustainable hydrological and ecological processes within the Forgotten Reach to pre-1915 conditions.

6.2.1 Project Components

Vegetation Management – Non-native saltcedar apparently continues to spread in the study area. While a goal of complete eradication of this species is unrealistic, the science of saltcedar control is rapidly developing in response to the large-scale invasion of this species in river basins throughout the West. A number of alternative land treatments are available for application to this problem. Two types of treatment can be scaled to large areas like the Forgotten River, which contains nearly 38,000 acres of saltcedar: aerial herbicide treatment and bio-control. Broadly applied herbicide potentially impacts desirable vegetation, such as pasture, and sprayed areas may also require extensive re-treatment. Biological control using a natural predator, the saltcedar leaf beetle, may offer an effective, reasonable cost method for saltcedar control in the study area. In native habitats, herbivory helps prevent saltcedar population from dominating the riparian zone, as it does in the study area. At present insufficient stocks of the Crete sub-species have been propagated at the Agricultural Research Service station at Big Spring, Texas, to support a large-scale release in the Forgotten River. When available, additional releases should be considered, with the goal of retarding the spread of saltcedar and/or reducing its dominance.   Some projects, which may prescribe removal of vegetation in the river channel, may elect to employ selective mechanical removal of saltcedar. Sites which have little or no presence of desirable native species suggest that, in some projects, employment of active re-vegetation strategies should also be considered.

Sediment Management –Tributary arroyos within the study area continue to introduce large volumes of sediment into the channel. A cursory view of present channel geometries suggests that there is potential to engineer in-channel enhancements that might increase the river's capacity to transport sediment. Similarly, the construction of retention structures in large sediment-producing arroyos adjacent to a project area offer a further strategy for enhancing equilibrium in the river's sediment budget. Corps' authorities and expertise may be available to assist in the design and construction of the sediment management components of projects.

Channel Improvements – Channel training experiments at project sites should be designed to test the potential for utilizing the river's current hydrology to enhance water and sediment conveyance. The goal of such project features would be to discover viable strategies for creating new channel forms that are at once diverse, efficient, and self-sustaining.

Groundwater and Wetlands – The role of shallow groundwater in the increasing dominance of saltcedar in the study area deserves additional investigation and monitoring. Projects should include installations of groundwater monitoring wells to track the effects of channel improvement components. Regional groundwater mapping, utilizing project data and other monitoring well data, is also a very useful objective. Paradoxically, locally elevated high water tables are at once an economic nuisance and an ecological amenity. If channel improvements are designed to reduce inundation of pastures and farm fields, draining of productive wetlands may also occur. As this effect is probably inevitable, mitigation wetlands should be included in project design. A constructed wetland, as proposed by World Wildlife Fund in an area above Fort Quitman, could potentially create multiple benefits: cleaning saline and nutrient laden waters and serving as a "mitigation bank" for ponds impacted by downstream projects. Other locations along the Forgotten River stretch may also be suitable for creating backwater wetlands.

Water Management and Improved Stream Flows – Diminished stream flows are at once the most important organizing principle of the Rio Grande's current condition and its most difficult management problem. If a reliable flood pulse could be provided, great progress might be made in restoring a functioning river. Absent the greatly increased degree of management control that would be required, the potential for restoration is dramatically lower. However, some future potential for attaining the necessary water management control does exist. Two general opportunities for improvement should be vigorously explored; both involve an effort to control the timing of the 200,000 acre-feet of water (on an annual average) passing Fort Quitman. One possibility is to improve Rio Grande Project water management through acquisition (by lease or purchase from one of the irrigation districts), aggregation by storage, and eventual timed release of project water. While the present institutional barriers to this approach are substantial, potential changes in the reservoir operating agreement, coupled with emerging state programs for providing environmental flows may create opportunities to which project proponents should be alert. A second potential project is a possible "conservation dam" project, which might be located at a site above Fort Quitman. Separately, or in tandem, it is at least remotely possible that water managers may eventually be able to capture, store, and release water to work sediment and maintain channels in the Forgotten River. It should be noted that occasional monsoon-season flood events originating below Elephant Butte may continue to adventitiously provide these benefits.

Research – As the condition of natural rivers continue to decline, the value society places on maintaining and restoring river ecosystems continues to grow. Viewed in this light, the "Forgotten" Rio Grande might have great value as a laboratory for the art and science of rehabilitating perturbed rivers. Just as Sul Ross State University is an enthusiastic participant in the La Junta Project, so might other educational institutions with restoration ecology, environmental engineering, and natural resource management programs seize some of the many opportunities for research within the study area. It is possible that the study topics recommended in this section to inform project design and implementation could also benefit by student involvement in research. Certainly, there is more to be learned about the functioning of rivers, knowledge that, if gained, could enhance scientific management of ecosystems and economies in the "forgotten" Rio Grande and beyond.

Monitoring and Adaptive Management – As project treatments are applied, their outcomes should be monitored and follow-up actions designed, based upon knowledge gained. Standardized monitoring protocols to evaluate existing conditions, as well as to provide data demonstrating the effectiveness of long-term restoration goals, have been developed by various governmental and non-governmental agencies.

6.2.2 Design of Pilot Projects

The following narrative describes possible engineering features that could be used to achieve ecosystem restoration objectives associated with hydraulic and sedimentation behavior. These engineering features would accompany vegetation treatments which utilize some combination of biological control agents and mechanical removal of saltcedar, as well as revegetation with native grasses, shrubs, and trees where appropriate. It is important to note that these are developed from very limited observation of site conditions. More rigorous analysis and design would be necessary to achieve success. Here we illustrate some of the types of engineered facilities that might be incorporated to meet the sponsor's and other stakeholders' objectives.

Completed Pilot Projects would almost certainly involve partnership among a number of entities who would provide various project components such as land access, engineering design, construction, and vegetative treatments and monitoring.

Of course, no project would proceed without the concurrence and cooperation of the private land owner in the planning for such a project. Considering that the present condition of the lands in the study area are a result of past agency practices, the suggested activities may have limited initial appeal. However, the deteriorating condition of so much of the ranchland in the Forgotten River may provide sufficient incentive for ranchers to commit to participation in what are necessarily long term demonstrations.

Potential Feature Array for Channel improvements (undetermined site)

A new channel could be designed for one of these sites based on stable channel geometric parameters. This would entail review of available historic channel geometry and sedimentation information. Development of a flow-duration curve (Discharge vs. %

time exceeded) and a representative sediment transport rating curve would allow determination of an ‘effective discharge’ (A representative flow that through its combination of both magnitude and frequency moves the most sediment). In turn, this would facilitate the determination of channel geometry parameters (width, depth, slope combinations) to be fit within the adjacent topographic constraints.

The channel would be dredged of its fill to an elevation approximating the elevation of the upstream river bed (above the filter) and the fill removed from the site. An experimental approach would also point to construction of a sediment detention structure on a proximate upstream arroyo that has been determined to have high sediment transport activity, to evaluate the effect of reducing (or passing) local sediment contributions on the sustainable conveyance capacity of the constructed channel. The entire channel complex would be re-surveyed after each significant flow event and changes analyzed.

In harmony with the channel training experiment, the most proximate downstream vegetatively reinforced channel segment could be engineered to harmonize with the expected response to channel training. In this section, vegetation would be treated at various designed distances lateral to the channel and the response of the channel monitored after significant flow events.

<u>Potential Feature Array for IBWC Mitigation site (Cecil’s Pond)</u> – This potential pilot project could be located on the periphery of the alluvial fan formed by the upstream left-bank arroyo (FID 35). If the restoration objectives included reducing sediment deposition in the mainstem river channel adjacent to this pilot project site, a detention structure on the upstream arroyo would be worth considering. However, this reach is reportedly incised. Assuming the restoration objectives include raising the local groundwater table (e.g., to increase the pond surface area, depth, etc.), a low-head grade-control feature constructed in the river could have enough local influence to achieve this objective. This type of feature would effectively raise the channel bed for some distance upstream of itself, which would increase the width/depth ratio of the river, and increase the frequency of overbank flows (due to decreased channel capacity). It could also add some hydraulic diversity, with a pool/riffle effect. Careful design would be required for such a structure to reduce fish migration issues if this is a concern, in addition to assuring survivability during high flows. Alternatively, a portion of the overly-high overbank could be mechanically lowered by excavation, enhancing the hydrologic connectivity of the river with the floodplain. Either of these approaches could be combined with modification of the channel geometry to achieve desirable aquatic hydrodynamic conditions (e.g., wide, shallow channel form, increased sinuosity, etc.). If

freshwater flow-through circulation was desired within the pond (e.g., to increase dissolved oxygen content, reduce temperature), a small distribution channel and return could be created to divert a portion of river flow. This would presumably require some 'hardening' to preclude capture by, or abandonment of, the active river channel. A 'backwater channel' could also be created in the vicinity within the overbank to create low-velocity aquatic habitat, incorporating bankline plantings to moderate water temperatures and enhance stability. Creation of a low-velocity deposition zone in the overbank upstream of the pond could help reduce deposition within the pond during high-flows, thereby reducing maintenance. This could be achieved by planting a dense 'screen' of, for example, willow cuttings which would increase local hydraulic roughness, reducing velocity and sediment transport capacity. Modern planting techniques reportedly have the potential to achieve much higher survival results than those used at the site originally. A much more intensive monitoring effort than undertaken by the original project would also be required.

Conclusion – The preceding conceptual approaches are offered to illustrate an array of features potentially available to help achieve desired biological functions at the site. The combination of prudent data collection, careful design and implementation, and watchful monitoring would almost certainly yield insight for application to other sites within the study area. Estimating the cost of such projects is difficult, as details may vary widely according to the ultimate design of features, size, and condition of the site(s) selected and the requirements of various cooperators.

Future restoration efforts within the Forgotten Reach must necessarily address both sides of the Rio Grande. It is acknowledged that for these restoration efforts to be successful, these activities would necessitate close collaboration between various private land owners, non-governmental agencies, and U.S. Federal, state, and local governments, as well as those of the Mexican governments. The IBWC would act as the coordinating agency between the U.S. and Mexico.

CHAPTER 7 – REFERENCES

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CHAPTER 8 – APPENDICES

Appendix A – Observation Notes on Sediment Cones

- FID 0 (US) shows up upstream of the tributary confluence. This could simply be due to the GIS resolution. Not clear on the meaning of the note “The flow has been assisted, not natural.” Braided tributary appearance. “Low” activity designation.
- FID 1 (Mexico) “High” activity designation - Tributary much more confined than FID 0’s braided planform. ‘Pushing’ mainstem planform.
- FID 48 (US) “High” activity designation - Tributary much more confined than FID 0’s braided planform. Not indicating mainstem planform influence.
- FID 2 (Mexico) “High” activity designation -. Appears (visually) to be large flow contributor, based on channel width (as compared with mainstem). Additionally, the mainstem appears to widen downstream of this tributary, and the mainstem’s abrupt angles suggest this tributary exhibits considerable influence on the mainstem’s alignment. More confined tributary planform like previous.
- {Major Mexico tributary between FID 2 and FID 3 appears to exhibit considerable influence on mainstem alignment.}
- FID 3 (Mexico) “Medium” activity designation - More confined planform.
- FID 4 (Mexico) “High” activity designation - Appears (graphically) to influence mainstem alignment considerably. Notes support this.
- FID 5 (US) “Medium” activity designation - Deposition area located (per GIS) away from mainstem channel. Very narrow tributary channel(s).
- FID 55 (US) “High” activity designation - Tributary channel <u>very</u> straight alignment appears (visually) to be very deep canyon. Notes indicate long term deposition trend (older deposits vegetated). Could be exhibiting base-level lowering planform impacts (outside of mainstem bend).
- FID 6 (Mexico) “Medium” activity designation - There is no apparent tributary associated with this marker (appears visually to be a ridge/rib). Curious.
- FID 7 (Mexico) “High” activity designation - Apparent large flow contributor with well-developed fan. Wide tributary channel (compared to mainstem). Perennial?
- FID 8 (Mexico) “Low” activity designation - Ill-defined channel planform, braided.
- FID 10 (US) “Low” activity designation - Apparent small (relatively) drainage area.
- FID 9 (Mexico) “Low” activity designation - Very small drainage area. Appears to be associated with old mainstem channel ‘scar’ (avulsion?). Visually apparent fan, located far from mainstem active channel. Little impact to mainstem anticipated.
- FID 11 (US) “Medium” activity designation - Classic fan deposits with numerous apparent flow paths. Appears (visually) to potentially be a big contributor – mainstem channel located on opposite edge of vegetated meander band, drains visually dissimilar landforms.

- FID 54 (Mexico) “Medium” activity designation - Tributary appears to have ‘captured’ a smaller adjacent tributary. Does not appear to be capable of much impact on mainstem.
- FID 12 (Mexico) “Medium” activity designation - Mainstem meander pattern becomes noticeably more sinuous downstream of this tributary. Drains a fairly large area with apparently steep upland.
- FID 13 (US) “Low” activity designation - No apparent significant tributary drainage associated with this point. Appears to be a mainstem channel scar/secondary flow path.
- FID 14 (Mexico) “Medium” activity designation - This one, too, appears to be a mainstem channel scar, though there is a right-bank (Mexico) tributary coming in adjacent to it.
- {Significant (perennial?) tributary comes in on right-bank (Mexico) between FID 14 and FID 15.}
- {Mainstem appears very anastomosed in this stretch, as well. Lots of scars, oxbows, etc.}
- FID 15 (US) “High” activity designation - Very large braided tributary (FID 16 also part of this terminus) system. Appears to be exhibiting significant influence on mainstem channel alignment (significant sinuosity increase in mainstem adjacent to/downstream of this point). This area appears quite active.
- FID 16 (US) “Medium” activity designation - Oxbow/cutoff on mainstem. Appears associated with large braided tributary (see FID 15). In fact, this location appears to coincide with primary tributary flowpath.
- FID 17 (US) “Medium” activity designation - Oxbow/cutoff on mainstem. No defined tributary associated with this point – could be associated with nearby center-pivot irrigation (return flow?), but more probably tied to above large braided tributary, historically.
- {Mainstem channel vegetated meander band becomes noticeably narrow downstream of the large tributary described above.}
- {Upstream of FID 18, the mainstem channel meander band becomes considerably wider and exhibits extensive channel scarring. Apparent high groundwater level, with visibility open water in old scars, oxbows. This GW level could be associated with extensive agricultural development adjacent to the floodway in this area.}
- FID 18 (US?) “Med’ activity designation - No tributary associated with this point. The mainstem floodway is decidedly narrow for a short reach in this area – ‘bottleneck’.
- {The mainstem channel becomes extremely difficult to distinguish, with lots of scarring, between FID 18 and FID 49. Very wide vegetated meander band.}

- FID 49 (US) “Low” activity designation - Fairly large drainage-area, likely low gradient tributary enters. Old fan visible seems to exhibit impact on mainstem alignment.
- FID 19 (Mexico) “High” activity designation - Presumably (photography cuts off) small drainage area tributary apparently causing a localized meander.
- FID 20 (Mexico) “High” activity designation - Another localized meander, very similar in appearance to FID 19, but the arroyo fan shape does not support the kind of concentrated deposition expected by this feature. Could be formed by old mainstem channel scar.
- {Large left-bank tributary (perennial?) enters on U.S. side between FID 20 and FID 21. Exhibits strong influence on mainstem planform.}
- FID 21 (Mexico) “High” activity designation - Right-bank tributary enters just upstream and a depositional feature appears visible in the mainstem where it enters. But the above noted large left-bank tributary seems to exhibit much more influence on this reach of the mainstem. Could be some combination of the two.
- FID 22 (Mexico) “High” activity designation - Pronounced localized mainstem meander. Left-bank tributary enters in this area, but appears to join the mainstem too far downstream of this feature to have caused it (recently anyway). There is another, presumably man-made feature that seems to be related to this meander. Visually, it could be a roadway or, perhaps an irrigation canal. If it’s a roadway, the arroyo crossing could have become plugged and laterally shifted the flowpath during an event. If the latter, this meander could have resulted from a breach of the canal. Curious.
- FID 47 (Mexico) “High” activity designation - Larger right-bank tributary enters from Mexico side in this area (about this point and FID 23 define the fan). This one appears to be the more secondary flowpath (compared with FID 23) but, together, this tributary appears to be shifting the mainstem alignment significantly.
- FID 23 (Mexico) “High” activity designation - The apparent primary flowpath of this braided tributary. Probable high sediment contributor.
- FID 24 (Mexico) “Medium” activity designation - Right-bank tributary enters where mainstem has “button-hooked” up-valley.
- FID 26 (US) “Medium” activity designation - Apparently, an abandoned historic primary tributary channel. Presumably functions as a secondary channel during high flows.
- FID 25 (US) “High” activity designation - The presumed main flowpath of this left-bank tributary. Multiple middle bars (vegetated?) seen in mainstem channel at this outlet.

- FID 27 (?) “High” activity designation - Visually, appears to be the convergence point of a number of mainstem channel braids. There does not appear to be a tributary associated with this point. The mainstem channel is visibly braided/anastomosed upstream of this point, and tortuously sinuous downstream.
- FID 28 (Mexico?) “High” activity designation - This appears to be associated with a ‘cut-off’ of a pronounced meander bend, and a significant braided tributary entering from the south (Mexico).
- {The mainstem channel changes from tortuously sinuous to conspicuously straight (man-made?) between FID 28 and FID 50.}
- FID 50 (Mexico) “High” activity designation - Apparent relatively small tributary.
- FID 51 (Mexico) “High” activity designation - At downstream of significant low-sinuosity (straight) mainstem segment. Apparently influencing mainstem alignment.
- FID 29 (Mexico) “High” activity designation - Significant drainage-area, braided (multi-path) tributary enters from Mexican side.
- FID 30 (US) “High” activity designation - This appears to be the confluence of a significant (perennial?) tributary.
- FID 31 (?) “High” activity designation - No tributary associated with this sediment feature. Appears graphically to be a point bar/meander formation.
- FID 33 (Mexico) “Medium” activity designation - Right-bank tributary enters here, but this point also appears to be an unusual apparent alternative flow path exit for FID 32.
- Increased sinuosity on mainstem.
- FID 32 (Mexico) “Medium” activity designation - Notes state “Obvious vegetation disturbance. This point is marked in the ‘fan’ of the tributary, away from the mainstem channel. Not sure the relationship to sedimentation.
- FID 34 (US) “Medium” activity designation - Left-bank tributary enters, with visually obvious alternating bars within the mainstem downstream of the confluence.
- FID 35 (US) “High” activity designation - Tributary confluence.
- FID 36 (US) “Medium” activity designation - Small, left-bank tributary that does not appear to make it to the mainstem. The drainage of this tributary is extremely small – minimal influence on mainstem morphology would be expected from this one. Notes state “Pretty thin sediment deposition” (not surprisingly based on drainage area) <u>or</u> this deposition could be from flow escape from mainstem.
- Mainstem meanders become tortuous, sometimes heading apparently up-valley.
- Mainstem exhibits some exceedingly straight reaches.

- FID 37 (Mexico) “High” activity designation - Tributary enters on river right – entry path makes a significant down-valley deviation before entering the mainstem (probable mainstem planform change in the past – there appears to be a faint channel ‘scar’ within the floodplain). Point or middle bar appears (atypically) on the mainstem at this confluence).
- FID 38 (US) “Medium” activity designation - A large, braided tributary enters from river left. The confluence is a broad ‘fan’ with numerous secondary flow paths. Depositional area marked where the primary flow path enters the dense mainstem floodplain vegetation.
- FID 52 (Mexico) “Low” activity designation - Another tributary enters on river right – with a similar entry path down-valley deviation before entering the mainstem (probable mainstem planform change in the past – there appears another channel ‘scar’ within the floodplain), similar to FID 37.
- The mainstem meander belt has become significantly wider, crossing to the other side of the valley vegetation numerous times.
- FID 39 (Mexico?) “High” activity designation - This point is located near an apparent outlet of the right bank tributary, but it is not clear from the photography if this (excavated?) path is associated with the arroyo or a river-bend ‘cut-off’.
- FID 40 (Mexico) “High” activity designation - A right bank tributary enters in this vicinity, and one of two visible flow paths (secondary) enters the mainstem here. A tell-tale deposition fan shows its influence on the mainstem planform.
- FID 41 (Mexico) “High” activity designation - A right bank tributary enters in this vicinity, and one of two visible flow paths (primary) enters the mainstem here. A more significant deposition fan is seen here on the mainstem.
- FID 42 (US) “High” activity designation - Left-bank tributary enters here. The tributary appears to have a substantially wide active channel. Deposition is marked right at the confluence, past the apparently narrowed (by vegetation) arroyo channel. There is another mainstem point bar upstream from here, apparently an abandoned (secondary?) arroyo flow path.
- FID 43 (Mexico) “High” activity designation - A right-bank tributary crosses the floodplain vegetation, in a surprisingly straight (levee-confined?) manner, and enters the mainstem here. The RG channel shows a number of point/middle bars immediately downstream from this point. The apparent confinement of the tributary entrance, with associated increase in maintained energy, probably results in higher sediment delivery at this point.

- FID 44 (US) “High” activity designation - Left bank tributary enters the mainstem, which has meandered up-valley, here with attendant mainstem deposition features (middle/point bars) visible.
- Large water body appears on river right of the mainstem. The adjacent flow path features indicate this area is quite saturated.
- FID 45 (Mexico) “Medium” activity designation - Right bank tributary enters here; apparently contributing significant sediment based on the visual indications in the mainstem and, perhaps, a fair amount of water (the mainstem channel width appears noticeably wider downstream).
- FID 46 (US) “Medium” activity designation - The left bank tributary here appears to have changed its primary delivery point numerous times, based on the photography. There appears a substantial ‘delta’ at this point, delineated on either side by visible flow paths, as well as an historic confluence upstream some distance on the mainstem.
- FID 53 (US) “High” activity designation - Left bank tributary enters here, and a point bar appears to be building/enlarging downstream of the confluence.
- The mainstem becomes severely confined downstream of FID 53 to the point where a major tributary enters from the Mexican side. This latter tributary results in at least a four-fold increase in the visible mainstem channel width.

Appendix B – The University Of Texas Center For Space Research Summary Information

The Center for Space Research (CSR) presents a brief narrative describing our map compilation procedures, with references to more detailed technical information included in the project deliverables. We include a table summarizing feature counts and acreages, as appropriate. The summary information concludes with a brief section on project findings.

Map Compilation Procedures

Subtask B1: Project Area Definition

CSR delineated the study area for the Forgotten River Watershed Management project. The boundary file consists of a 3-km buffer surrounding the main channel centerline of the Forgotten Reach of the Rio Grande from Fort Quitman in Hudspeth County to Presidio, Texas. CSR used a Euclidean allocation process and other ArcGIS Spatial Analyst functions to eliminate areas within the buffer zone that exceeded the river channel base elevation level by 32.8 feet.

More information about this dataset may be found in the readme.txt file in the Project_Area directory and the metadata that accompany the dataset. All CSR-generated metadata are compliant with Federal Geographic Data Committee (FGDC) standards.

Subtask B2: Scanning of National Wetlands Inventory (NWI) Mylar Sheets

CSR scanned and geo-referenced seven National Wetlands Inventory (NWI) 1:100,000 and 1:24,000 scale Mylar sheets. The NWI maps were geo-referenced to the USGS Digital Raster Graphics (DRG) topographic maps. CSR created FGDC-compliant metadata for the raster GeoTIFF files. Some areas in the 1:100k scale NWI maps did not aligned well with the comparison datasets after geo-referencing. A shapefile called ref_errors.shp includes circles denoting areas of misalignment in the study region only.

After geo-referencing, each NWI map was subset within the study area. CSR reclassified the subsets into bi-level (two class) images to prepare the data for vectorization. Polygons were selected from an auto-generated line vector, edited if necessary, and placed in a polygon shapefile. Additional polygon and point vectors were created manually. The majority of the line features were selected from polygon features and placed in the line vector because the river (line feature) often formed the boundary for many polygon features. Features that consisted of less than 20 pixels were converted to points and placed into a point shapefile. Only features falling within the defined project area were vectorized. Each feature was attributed with its corresponding NWI code or codes (CODE_1 and CODE_2), the locational error status (REF_ERROR), and the source map name and scale (SOURCE). There are 81 NWI point features, 1,285 NWI line features, and 941 NWI polygon features.

A detailed account of the Subtask B2 procedures may be found in the PDF document called Procedures_MylarScans.pdf.

Subtask B4: Geospatial Data Search and Retrieval for the U.S. side of the Rio Grande

a. Impaired river segments

CSR extracted four impaired Rio Grande line segments from the TCEQ Stream Segments 2004 dataset. The impaired river attributes were assigned to this shapefile from the DRAFT 2004 Texas 303(d) List (May 13, 2005). The attribute field descriptions are listed in this document under Explanation of Column Headings. The vector line work used for the shapefile was constructed from the 24k scale National Hydrography Dataset.

More information about the impaired river segments dataset may be found in the readme.txt file in the Impaired_River directory and the FGDC-compliant metadata that accompany the dataset.

b. Arroyo confluences

CSR identified 56 point features representing arroyo confluences, also referred to as sediment cones, from the visual inspection of 1- and 2-meter aerial imagery acquired during three different time periods: 2005, 2004, and the mid-1990s. Each sediment cone point in the shapefile was collected in the center and at the furthest reach of deposition activity. CSR assigned each point a level of sediment deposition activity. The three levels are low, medium, and high. The "Note" section in the shapefile's attribute table further describes the arroyo confluences such as size of affected area or direction the main channel was pushed.

More information about this dataset may be found in the readme.txt file in the Arroyos directory and the FGDC-compliant metadata that accompany the dataset.

c. Pumping sites and diversion dams

CSR located three pumping stations in the study area. Two were digitized from the early 1970s 24k scale topographic Digital Raster Graphics (DRGs). The third pumping site, located in Mexico, was determined by visual inspection of 1- and 2-meter aerial imagery acquired during three different time periods: 2005, 2004, and the mid-1990s.

The remaining 14 points in the shapefile represent locations of diversion dams. CSR determined these locations from a scanned document called Distances along Rio Grande.pdf provided by the IBWC. As stated at the top of the document, these feature locations were established from the international boundary maps approved by the commission in minute no. 253, September 23, 1976.

More information about the pumping sites and diversion dam's dataset may be found in the readme.txt file in the Pump_Sites_Diver_Dams directory and the FGDC-compliant metadata that accompany the dataset.

d. Groundwater depth monitoring wells

CSR extracted 121 groundwater monitoring wells from the Texas Water Development Board (TWDB) Groundwater Database Reports. A text file called Well Data Table was used to compile the well ID, latitude, longitude, coordinate accuracy information, and reporting agency from each of the three counties that fall in the study area: Hudspeth, Jeff Davis, and Presidio. The well data from each county were then merged into one shapefile. The TWDB Well Data Table contains many more attribute fields, and the other Groundwater Database Reports have additional information about each well. These text files may be linked to the shapefile by state_well_number. The TWDB groundwater metadata are found in the Ground-Water Data System Dictionary.

More information about this dataset may be found in the readme.txt file in the Groundwater_Wells directory and the FGDC-compliant metadata that accompany the dataset.

e. Land ownership

The primary land ownership dataset represents land ownership polygons that intersect the Forgotten Reach study area. The secondary land ownership dataset includes the land ownership polygons that intersect the 3-km buffer study area but do not fall on the defined study area. CSR extracted the majority of the land ownership polygons in both shapefiles from the Original Texas Land Survey (OTLS) digital data published by the Railroad Commission of Texas (RRC). One polygon in the primary shapefile was extracted from the Texas Parks and Wildlife (TPWD) state parks dataset. Mexico land ownership status information was not available to CSR. The non-US polygons cover the Mexican side of the study area and were constructed from the Forgotten River project area shapefiles. CSR did not locate any U.S. Federal lands in the Forgotten River study area.

In the primary area of interest, there are 314 polygon features representing the boundaries of privately owned land, eight polygon features for state owned land, and one polygon feature for non-US land. There are 248 polygon features representing privately owned land, three polygon features representing state owned land, and one polygon feature representing non-US land in the secondary area of interest.

More information about these datasets may be found in the readme.txt file in the Land_Ownership directory and the FGDC-compliant metadata that accompany each dataset.

f. Land cover

NLCD 1992

CSR assessed the accuracy of the U.S. Geological Survey 1992 National Land Cover Database (NLCD) within the Forgotten River study area to determine the reliability of the dataset. The accuracy assessment method used by CSR was chosen as a reasonable and rapid way to test the NLCD. The method was designed to test the product's currency and suitability for mapping primarily cropland, rangeland, woody vegetation, and wetlands at the present time. Aerial imagery collected during the 2004/2005 time frame was used as the main source of reference data. CSR performed the accuracy assessment on the 1992 NLCD image pixels that fell in the defined study area only. A stratified random sample of 20 points per class was generated. These 240 points were assigned class values from the NLCD within a 3x3 window size using a majority threshold value of 3. All 240 points were labeled (referenced) with 1 of 12 NLCD classes based on the visual inspection and photo-interpretation of 1- and 2-meter aerial imagery that were typically viewed at a map scale of 1:4000.

The overall classification accuracy was 32.50%, which means that 78 of 240 CSR reference points matched the 1992 NLCD. While this number is a concise measurement, it is more useful to evaluate the level of accuracy for each class in order to understand each category's performance or error contribution. By constructing an error matrix of the classified data against the reference data, producer's and user's accuracy percentages were calculated for each class. CSR discovered that none of the

1992 NLCD classes are very reliable for the Forgotten Reach study area. Each one has a different level or degree of accuracy. In general, the most useful classes for the project goals are a combined Forest class, the Shrubland class, and possibly the Row Crop and Pasture/Hay classes in the southern part of the study area only.

CSR determined that the NLCD 1992 dataset is an unreliable representation of land cover for the Forgotten Reach study and, consequently, did not calculate cover type acreages. A detailed account of the NLCD 1992 Accuracy Assessment procedures may be found in the PDF document called NLCD92_Accuracy_Assessment.pdf in the NLCD_1992 subdirectory of the Land_Cover directory.

Vegetation mapping

CSR produced two vegetation cover maps derived from LandSat 7 Enhanced Thematic Mapper Plus (ETM+) data collected on November 9 and 16, 2002. The first product shows the distribution of eleven land cover types: four saltcedar classes, five other vegetation classes that include agricultural areas, one developed class, and one water class. The second product maps the probability of saltcedar occurrence within the study area. The vegetation mapping data are distributed in raster (ERDAS Imagine) and vector (ESRI shapefile) data formats. Other preliminary datasets that contain the "fuzzy classifications" used to create the final products are included in the data deliverables.

CSR performed image classification using eCognition 4.0 by Definiens, an object oriented classification software. An alternate classification of data collected by the TM sensor in late fall 2003 was attempted using the SubPixel Classifier Add-on module in ERDAS Imagine. However, results were unsatisfactory, and further efforts were abandoned. The object oriented approach yielded more satisfactory results. Source satellite data included six 30-m multispectral channels and one 15-m panchromatic channel of two ETM+ datasets collected on November 9 and 16, 2002, and archived in the CSR LandSat image archive. To inform the image classification procedure, CSR staff, accompanied and assisted by TCEQ Watermasters, collected 37 GPS points and 61 polygon samples at accessible locations within the study area. As an additional input, CSR also calculated standard Normalized Difference Vegetation Index (NDVI) data using the visible red and the near infrared channels of the two LandSat source datasets.

The classification was performed separately on the two source datasets. The northern ETM+ dataset is dated November 16, 2002; the southern dataset was collected on November 9 of the same year. Nearly a third of the project area was imaged on both dates as there is considerable spatial overlap. Both datasets were subset and masked using the project area boundary file. The eCognition classification procedure begins with a segmentation process that creates image objects of similar adjacent pixels based upon user-specified parameters. We used the same parameters and weights for both datasets:

- Scale parameter = 10; Shape parameter = 0.1; Color = 0.9; Smoothness = 0.5; and Compactness = 0.5.
- NDVI weight = 2; ETM+ Channels 1,3,4,7 and 8 (pan) = 1; and ETM+ Channels 2 and 5 = 0.

In the northern dataset, the segmentation process yielded 11,040 objects. In the south, the process generated a total of 14,729 objects.

The classification in eCognition was an iterative process. After segmentation, the analyst chose several samples representing possible variations of the desired classes before running an initial classification. Next the analyst improved the classification by identifying an appropriate class for unclassified objects, placing incorrectly classified samples in the correct class, and by adding new samples. The process also identified gaps in the classification scheme. Table 7 shows the initial sample counts per seven land cover classes collected in the northern region of the study area. Table 8 shows classes and samples collected for the final version of the classification.

Table 9 - Initial iteration of Forgotten River North classes and samples.

ID	Class name	Sample count	Pixel count
1	Saltcedar	6	684
2	Saltcedar mowed	2	292
3	Saltcedar/mesquite	1	68
4	Other scrub/shrub	6	992
5	Water	4	516
6	Herbaceous	3	436
7	Sparse vegetation	1	1096
Totals		**23**	**4084**

Table 10 - Final iteration of Forgotten River North classes and samples.

ID	Class name	Sample count	Pixel count
1	Saltcedar	6	684
2	Saltcedar mowed	1	248
3	Saltcedar/mesquite	1	220
4	Other scrub/shrub	22	2869
5	Water	4	516
6	Herbaceous	5	484
7	Sparse vegetation	5	1260
8	Saltcedar and bare soil	1	176
9	Veg in shadow or water	2	371
10	Saltcedar submerged	1	392
Totals		**48**	**7220**

Tables 11 and 12 show classes identified and samples collected for the southern region of the Forgotten Reach

Table 11 - Initial iteration of Forgotten River South classes and samples.

ID	Class name	Sample count	Pixel count
1	Fallow/Senescent	3	448
2	Sparse shrub	3	345
3	Water	3	545
4	Herbaceous	3	244
5	Dense other shrub	2	531
6	Developed	3	876
7	Saltcedar/mesquite	3	264
8	Saltcedar submerged	2	216
9	Saltcedar	3	316
10	Shadowed vegetation	1	80
Totals		**26**	**3865**

Table 12 - Final iteration of Forgotten River South classes and samples.

ID	Class name	Sample count	Pixel count
1	Fallow/Senescent	8	1228
2	Sparse shrub	19	3077
3	Water	7	1321
4	Herbaceous	5	340
5	Dense other shrub	3	867
6	Developed	5	1052
7	Saltcedar/mesquite	7	952
8	Saltcedar submerged	5	352
9	Saltcedar	6	1260
10	Shadowed vegetation	1	80
11	Bare soil	4	332
Totals		**70**	**10861**

CSR also mapped vegetation density based on NDVI ratio values per segmentation object. The dense vegetation criteria was a segment NDVI ratio value greater than 0.2. All segments with lower values were labeled as sparse vegetation. A similar procedure was applied to the southern and northern regions. CSR used the vegetation density maps to improve the final classification map.

In ArcMap, CSR unioned north and south project area mask shapefiles to demarcate image overlap areas. The non-overlap area of the northern segment of the Forgotten Reach was used to subset the northern area classification. CSR performed the following procedures using ERDAS Imagine 8.7 software:

- Subset the non-overlap area of the northern segment of the classification;
- Recoded to nine common land cover classes in preparation for mosaicing;
- Mosaiced the northern and southern region maps;

- Hand-edited the overlap seam and some misclassified areas;
- Filled a small number of data gaps;
- Followed a similar process to mosaic vegetation density maps;
- Constructed a model to recode classes based on vegetation density map;
- Ran model to create final 11 classes;
- Recoded from 11 land cover classes to four saltcedar probability classes;
- Reprojected from UTM Zone 13 North WGS84 to UTM Zone 13 North NAD83 projection using a rigorous transformation;
- Updated attribute tables;
- Exported attribute tables, which were converted to a comma-delimited format in a text editor.

CSR used ArcGIS Spatial Analyst, ArcMap, and ArcCatalog to:

- Convert Imagine format classifications from Raster to Vector, creating generalized and raster versions of shapefiles;
- Join comma-delimited attribute tables to shapefiles;
- Export new shapefiles;
- Delete null background;
- Recalculate area fields;
- Create layer files for display;
- Generate FGDC-compliant metadata.

CSR also referenced the 2004 National Agricultural Imagery Program (NAIP) photography and other ancillary data in ArcMap during sample selection and image classification.

More information about the vegetation and land cover datasets may be found in the readme.txt file in the Vegetation_Map subdirectory of the Land_Cover directory and the FGDC-compliant metadata that accompany each dataset.

g. Structures/channelization infrastructure

CSR constructed three shapefiles of structures/channelization infrastructure including levees, drains, canals, channels, barrow pits, and one grade control structure. These data were compiled from various sources, such as IBWC GIS datasets, a scanned document from the IBWC, DRGs, and aerial imagery. There are 53 levees and one canal in the line dataset. CSR identified 13 drains, one grade control structure, one rip-rap structure, two canal headings, and two end points of channel rectification for the point shapefile. Polygon features include 129 channels and three barrow pits.

More information about these datasets may be found in the readme.txt file in the Channelization_Infrastructure directory and the FGDC-compliant metadata that accompany each dataset.

h. NRCS STATSGO Soils

CSR extracted seven soil polygons from the Natural Resources Conservation Service (NRCS) State Soil Geographic (STATSGO) database for Texas. In addition to the dBase table attached to the shapefile, there are ten dBase tables that contain STATSGO attributes for the study area. These tables may be added to the shapefile table as desired. A description of each table may be found in the STATSGO metadata.

More information about the soils dataset may be found in the readme.txt file in the STATSGO_Soils directory and the FGDC-compliant metadata that accompany the dataset.

Other

CSR obtained GIS datasets from the IBWC that do not specifically fall into the Forgotten Reach study task list. With the exception of the four gauging station point features, the data features are clustered in the northernmost and southernmost ends of the study area where channel rectification exists. There are very few descriptive attributes for most of the IBWC data.

In Presidio County, there are 3,745 line features of 1-foot contour data around the levees, 12 polygon features represent the main channel in 1940, three polygon features of the Rio Grande channel in 1967, and ten polygon features of the Rio Grande channel in 1996. Major geologic or geomorphic surfaces comprise 15 polygon features.

In Hudspeth County, there are 2,683 line features of 1-foot contour data around the levees in the north portion and 4,390 line features of 1-foot contour data around the levees in the south portion. Major geologic or geomorphic surfaces are represented by three polygon features.

More information about these IBWC datasets may be found in the readme.txt file in the directory called Other and the FGDC-compliant metadata that accompany each dataset.

Subtask B5: Geospatial Data Exploration and Integration for Areas on the Mexican side of the Rio Grande

CSR compiled several geospatial datasets from source data obtained from the IBWC. The IBWC shared shapefiles of hydrologic and channelization infrastructure features and one document stating approximate location information of diversion dams, cities, and crossings among other topographic elements. Some features are located on the Mexican side of the study area. These data fall under tasks B4c and B4g. Under task B4c, one pumping site and one diversion dam are located on the Mexican side. For task B4g, one drain and two canal headings are located on the border, and many small channels fall on the Mexican side near the northern and southern portions of the study area.

CSR downloaded 1:50,000 scale digital elevation model (DEM) data free of charge from the Instituto Naćional de Estadistica Geografica e Informatica (National Institute of Geographic and Computer Science) (INEGI) website. The ten DEMs, in BIL (band interleaved by line) format, are separated into directories by quad name. CSR translated information about these data available on the INEGI website from Spanish to English.

There are two 1:50,000 scale vector datasets available for purchase from INEGI that are called:

1. Datos topograficos vectoriales;
2. Toponimos, also referred to as Toponimicos.

For the Forgotten River vector data quads with metadata available online, CSR translated the HTML sites from Spanish to English. CSR used an INEGI online service to investigate product availability for the Forgotten River project area. The Datos topograficos vectoriales and Toponimos datasets are available for all ten quads that intersect the study area. The Forgotten River project area vector data availability was also confirmed by an INEGI sales representative via email.

More information about the Mexican datasets may be found in the PDF document called Data_for_Mexican_side_of_ForgottenRiver.pdf.

Summary Information about Mapped Features

Table 11 summarizes basic information about the number of features mapped within the designated Forgotten River study area. Feature counts are noted where appropriate or feasible. CSR calculated total length in miles for linear features. Total acreages were calculated for polygon features. Measurements are approximate. Acreages estimated from the intersection of features collected at different map scales are only as reliable as the coarsest scale used. The counts for land ownership type reflect the number of individual polygon features that intersect the study area and generalized buffer and not necessarily the number of land owners. Data for the Mexican side of the study area are sparse. Most environmental features collected and enumerated are located on the U.S. side of the international boundary with Mexico.

Table 13 - Summary of mapped features.

Subtask Number	Summarized Feature	Feature Count	Total Length [miles]	Total Area [acres]	Feature Type
B2	National Wetlands Inventory	70	----	----	Point Locations
		----	301	----	Linear segments
		856	----	14,266	Individual areas
B4a	Impaired River Segments	2	214	----	----
B4b	Arroyo confluences	56	----	----	----
B4c	Diversion Dams	14	----	----	----
B4d	Groundwater depth monitoring wells	121	----	----	----
B4e	Land ownership, primary [within study area]	314	----	44,583	Private
		8	----	1,144	State
		1	----	46,730	non-US [Mexican]

Subtask Number	Summarized Feature	Feature Count	Total Length [miles]	Total Area [acres]	Feature Type
B4e	Land ownership, secondary [outside study area but inside the 1.86 mile buffer]	248	----	136,043	Private
		3	----	2,726	State
		1	----	142,764	non-US [Mexican]
B4f	Land cover	----	----	5,493	Saltcedar
		----	----	1,019	Saltcedar in water or wet soils
		----	----	575	Saltcedar [mowed or short] or mixed with bare soil
		----	----	8,193	Saltcedar / Mesquite mix
		----	----	321	Vegetation in water or shadow
		----	----	4,812	Other dense scrub / shrub
		----	----	13,163	Other sparse scrub / shrub
		----	----	1,176	Row crop / herbaceous
		----	----	2,702	Fallow fields / senescent vegetation
		----	----	1,186	Developed or very sparsely vegetated
		----	----	135	Water

Subtask Number	Summarized Feature	Feature Count	Total Length [miles]	Total Area [acres]	Feature Type
B4f	Saltcedar occurrence probability	----	----	6,513	High probability monoculture
		----	----	8,768	High probability mixed with other vegetation
		----	----	5,133	Moderate probability
		----	----	18,361	Low probability of occurrence
B4g	Structures / channelization infrastructure	129	----	1,351	Channels
		----	48	----	Levees
		----	0.32	----	Canal
		3	----	1	Barrow Pits
		13	----	----	Drains
		1		----	Grade control structures
		1		----	Rip-Rap structure
		2		----	Canal Heading
		2		----	End points of channel rectification

Subtask Number	Summarized Feature	Feature Count	Total Length [miles]	Total Area [acres]	Feature Type
B4h	NRCS STATSGO soils [within project area] *NOTE: Area calculations are approximate because of layer scale differences*	----	----	42,653	Del Norte – Canutio – Nickel [TX085]
		----	----	1,877	Harkey – Glendale – Gila [TX217]
		----	----	1,148	Rock outcrop – Brewster – Volco [TX077]
		3	----	45,678	Total
B4h	NRCS STATSGO soils [outside study area but within the 1.86 mile buffer] *NOTE: Area calculations are approximate because of layer scale differences*	----	----	124,494	Del Norte – Canutio – Nickel [TX085]
		----	----	10,162	Harkey – Glendale – Gila [TX217]
		----	----	2,275	Rock outcrop – Brewster – Volco [TX077]
		----	----	626	Del Norte – Canutio – Nickel [TX085]
		----	----	557	Harkey – Glendale – Gila [TX217]
		5	----	138,114	Total
Other	Gauging stations	4	----	----	----

Project Findings

The study area as defined for subtask B1 is 94,383 acres in size. The area covered by the 3-km buffer, 372,435 acres, is nearly four times greater in size. At its narrowest locations, between Mayfield Canyon and Goat Canyon downstream from Indian Hot Springs and 2.5 km north of the intersection of the Hudspeth, Jeff Davis, and Presidio County lines, the study area is less than 328 feet wide. The study area is widest in the floodplain north of the International Bridge linking Ojinaga in Chihuahua State, Mexico and Presidio, Texas. The width rarely exceeds 3.10 miles. CSR noted during field reconnaissance that the project area delineation effectively excluded higher ocotillo-dominated altitudes.

Most of the environmental features mapped within the Forgotten River segment of the Rio Grande from Fort Quitman to Presidio, Texas are located on the U.S. side of the international boundary with Mexico. CSR identified a primary source for Mexican data, and collected a number of no-cost public domain datasets. CSR also obtained cost estimates and contact information that can be used to request environmental GIS data from the Instituto Nacional de Estadistica Geografica e Informatica (INEGI) (National Institute of Geographic and Computer Science).

National Wetlands Inventory data for the Forgotten River segment of the Rio Grande are provisional. Draft maps compiled in the mid-1980s were never finalized, and few locations were verified in the field. NWI designations may no longer be valid for areas that have experienced significant change. Only two quadrangles near Presidio are available at the preferred 1:24,000 map scale and as Mylar separate sheets. Most of the area was mapped at a scale of 1:100,000 upon enlarged base topographic maps of 1:250,000 scale, as the U.S. Geological Survey had not completed mapping at the larger scale at the time of the NWI project. As Mylar separates are not available for most of the project area, CSR conducted the vectorization process under less than ideal circumstances. Consequently, the exact location, extent and area of NWI features may be imprecise in relation to NAIP photography. CSR noted nine locations where geo-referencing of NWI data was problematic.

NWI data were collected as point, linear, and polygon features. Twenty-six (26) different NWI codes are assigned to 70 point features. Two codes occur most frequently, 13 times each. These are the Palustrine Scrub-Shrub Needle-Leaved Deciduous Intermittently Flooded (PSS2J) code, indicating saltcedar, or saltcedar, presence, and the Palustrine Unconsolidated Shore Temporarily Flooded Excavated (PUSAx) code. Ten NWI codes occur one time only. Slightly more than one third of the linear features, 121 miles of a total 301 miles, are coded as Riverine Intermittent Streambed Semi-permanently Flooded Excavated (R4SBFx). The remaining linear features include 13 NWI code designations, of which four occur once. Among the 856 polygon features, the PSS2J code occurs most frequently (333 times) and occupies the greatest area (6,205 acres), nearly half of the mapped wetland area. Another 44 wetland codes were used with 13 unique assignments. The impact of saltcedar invasion in the mid-1980s is evident in the NWI dataset.

Under Section 303(d) of the Federal Clean Water Act, the TCEQ has assigned impaired status to the entire Forgotten Reach of the Rio Grande. Less than a mile of the lower reach, near and south of the confluence with the Rio Conchos, coincides with TCEQ Segment 2306, which is cited for bacteria and chronic toxicity in water to aquatic organisms. Most of the river in the study area is part of TCEQ Segment 2307. Chloride and total dissolved solids exceed Federal standards in this segment. TCEQ will spatially define impaired segments in future versions of the TCEQ Stream Segments GIS dataset. The 2006 dataset is expected for release in 2007.

The arroyo confluences mapped along the Forgotten Reach are more accurately described as sediment cones. About half of the sediment deposition points were present in the mid-90s imagery but not in the 2004 or 2005 imagery. Two locations were highly active in all three time periods. Another nine locations exhibited high activity in the mid 1990s but not later. Another 20 locations were highly active in 2004. Of these, 18 remained at the same activity level in 2005, and another location joined the group. Twelve locations were of medium activity level in the mid 1990s. A different set of seven locations displayed medium activity in 2004 and 2005. Only five locations showed the lowest level of activity in the mid 1990s. A different location was slightly active in 2004, and was joined by a second location in 2005. All active arroyo confluences occur in areas where the river is not channelized.

CSR identified two pumping stations in the northern Forgotten Reach. TCEQ Watermasters confirmed that these have been idle for many years and are owned by private individuals. CSR identified a third pumping station in Chihuahua State northwest of Ojinaga through visual inspection of recent aerial photography. The Mexican pumping station may be a part of the Paradero Diversion Dam irrigation canal system. Local farmers and communities built the fourteen identified diversion dams. They are not associated with specific land owners. Many of the dams are no longer used, and could be considered historical features. According to the TCEQ Watermasters, no one has water rights in the middle and upper reaches of the Forgotten River. During fieldwork, however, the TCEQ Watermasters located an illegally irrigated alfalfa field of approximately 20 acres in the middle of the study area. The location is evident in recent NAIP photography.

CSR identified three land ownership types in the Forgotten River study area. Slightly more than 50% of the land is Mexican. Of the remaining parcels, most (48.2% of total area and 97.6% of Texas lands) are in private ownership. The state of Texas owns approximately 1.2% of the lands within the study area, or 2.4% of the property on the U.S. side of the river. The greatest area of the state-owned parcels belongs to the Ocotillo Unit of Las Palomas Wildlife Management Area.

According to the TCEQ Watermasters, irrigated areas in the Forgotten Reach are limited to a seven-mile stretch north of Presidio. In and very near Presidio, La Junta Farm owners are the primary irrigators. La Junta Farms and another area owner, Frank Armendariz, grow alfalfa as their main crop. The Presidio Valley Farms used to farm alongside La Junta Farms, growing cotton, but abandoned their lands within the last four years. CSR noted tumbleweed and other shrubs on Presidio Valley Farm fields in October 2006. North of Presidio, farmers restrict irrigation to small alfalfa fields that rarely exceed ten acres in size. Shrub had invaded all other abandoned agricultural fields. Such abandoned sites are numerous. Information about irrigated lands in Texas was not available in a GIS format. Information about agricultural activities in the Mexican side of the study area may be available from INEGI.

As stated in the section on map compilation procedures, CSR determined that the 1992 National Land Cover Dataset is not a reliable predictor of the primary land cover of interest in the Forgotten Reach study area. CSR mapped the distribution of likely concentrations of saltcedar (Saltcedar ssp.) and other vegetation types within the study area. During a four day field survey, CSR staff learned that agricultural activities in the U.S. side of the study area have diminished in recent years, and consequently, it was not possible to collect sufficient samples for cropland, active grazing, and fallow fields. Saltcedar stands dominated the samples of submerged vegetation collected along the riparian corridor. We estimate that 16.8% of the study area, 6513 acres, has a high probability of saltcedar dominance, and possible monoculture. Another 22.6% of the study area, 8768 acres exhibits concentrations of saltcedar mixed with other vegetation, primarily mesquite. Saltcedar may be interspersed among another 13.2% of the area, although its spectral signature was not dominant. The final classification shows that nearly half of the study area, 47.7%, has a low probability of saltcedar occurrence. However, these areas are rarely adjacent to the Rio Grande. The vegetation maps tell the story of a river channel that is choked by the invasive tree.

Structures and channelization infrastructure are located in two distinct areas on the U.S. side of the Forgotten River segment of the Rio Grande. One area is near Presidio, Texas, in Presidio County in the southernmost part of the study area. The other area is located at the northernmost section of the Forgotten Reach in Hudspeth County. The channelization structure in Hudspeth County is the lower segment of levees demarking channel rectification that extends far to the north towards El Paso. Four short levee segments intersect the structure south of Fort Quitman. CSR identified 36 segments of relict channels that snake around the rectified course. Another 96 segments representing relict channels are found in Presidio County. Most are in the wide floodplain on the Mexican side of the river. IBWC maintains two levee structures along the Rio Grande north of Presidio. Seven smaller levee segments are on the U.S. side of the river alongside the rectified channel, although most do not connect with the channel.

All mapped drains, grade control and rip-rap structures, and barrow pits are also near the rectified channel north of Presidio. Few structures are located between the rectified channels. CSR identified one canal approximately 2.8 miles southeast of the end point of the northern rectified channel segment. Another 25 levees of varying length are scattered along the natural course of the Forgotten River. Most are still visible on the landscape although it is not known if the structures are maintained by landowners.

Appendix C – Species Found within the Forgotten Reach

Grasses

Arizona cottontop	*Digitaria californica* (Benth.) Henr.
Black grama	*Bouteloua eriopoda* (Torr.) Torr.
Blue grama	*Bouteloua gracilis (Willd.* ex. H.B.K.) Lag. *ex* Griffiths
Bufflegrass	*Pennisetum ciliare* (L.) Link
Burrograss	*Scleropogon brevifolius* Phil.
Bush muhly	*Muhlenbergia porteri* Scribn.
Chino grama	*Bouteloua breviseta* Vasey
Common reed	*Phragmites australis* (Cav.) Trin.
Ear muhly	*Muhlenbergia arenacea* (Buckl.) Hitchc.
Fluffgrass	*Erioneuron pulchellum* (H.B.K.) Tateoka
Giant reed	*Arundo donax* L.
Green sprangletop	*Leptochloa dubia* (H.B.K.) Nees
Hairy grama	*Bouteloua hirsuta* Lag.
Johnson grass	*Sorghum halepense* (L.) Pers.
Mesa dropseed	*Sporobolus flexuosus* (Thurb.) Rydb.
Nealley grama	*Bouteloua uniflora* Vasey
Red grama	*Bouteloua trifida* Thurb.
Saltgrass	*Distichlis spicata* (L.) Green
Sand dropseed	*Sporobolus cryptandrus* (Torr.) Gray
Sideoats grama	*Bouteloua curtipendula* (Michx.) Torr.
Sixweeks grama	*Bouteloua barbata* Lag.
Slim tridens	*Tridens muticus* (Torr.) Nash
Spike pappusgrass	*Enneapogon desvauxii* (Beauv.)
Tanglehead	*Heteropogon contortus* (L.) Beauv.
Tobosa	*Hilaria mutica* (Buckl.) Benth.
Whiplash pappusgrass	*Pappaphorum vaginatum* Buckl.

Forbs

Buckwheat	*Eriogonum* spp.
Common cattail	*Typha latifolia* L.
Cowpen daisy	*Verbesina encelioides* (Cav.) Gray
Desert baileya	*Baileya multiradiata* Harv. and Gray
Desert holly	*Pereiza nana* Gray
Desert seepweed	*Suaeda suffrutescens* Wats
Dock	*Rumex* spp.
Drymary	*Drymaria* spp.
Fleabane	*Erigeron* spp.
Groundsel	*Senecio* spp.

Gypsum weed	*Datura* spp.
Jimmyweed	*Isocoma wrightii* (Gray) Rydb.
Mallow	Malvaceae
Mesa greggia	*Nerisyrenia camporum* (Gray) Greene
Mountain pepperweed	*Lepidium montanum* Nutt.
Prairie gentian	*Eustoma* spp.
Purslane	*Portulaca* spp.
Rocket mustard	*Sisymbrium irio* L.
Russian thistle	*Salsola kail* L.
Sand verbena	*Abronia* spp.
Snakeweed	*Xanthocephalum* spp.
Spectaclefruit	*Wislizenia refracta* Engelm.
Spectaclepod	*Dithyraea wislizenii* Engelm.
Stalked rhombopod	*Cleomella longipes* Torr.
Tansy mustard	*Descurainia pinnata* (Walt.) Britt.
Tree tobacco	*Nicotiana glauca* Grah.
Trailing allionia	*Allionia incarnata* L.
Twinevine	*Sarcostemma* spp.
Woolly paperflower	*Psilostrophe tagentina* (Nutt.) Greene

Shrubs and Trees

Agarito	*Berberis trifoliolata* Moric.
Allthorn	*Koeberlinia spinosa* Zucc.
Bee-brush	*Aloysia gratissima* (Gill & Hook.) Troncoso
Brasil	*Condalia hookeri* M.C. Johnst.
Buckthorn	*Rhamnus* spp.
Candelilla	*Hymenoclea mongryra* T. & G.
Catclaw acacia	*Acacia greggii* Gray
Cholla, pricklypear	*Opuntia* spp.
Creosote bush	*Larrea tridentata* (DC) Cov.
Desert willow	*Chilopsis linearis* (Cav.) Sweet
Echinocactus	*Echinocactus* spp.,
Echinocereus	*Echinocereus* spp.
Four-wing saltbush	*Atriplex canescens* (Pursh.) Nutt.
Hackberry	*Celtis pallida* Torr.
Hierba del gato	*Croton dioicus* Cav.
Honey mesquite	*Prosopis glandulosa* Torr.
Javelina brush	Microrhamnus ericoides Gray
Leatherstem	*Jatropha dioica* Cerv.
Lechuguilla	*Agave lechuguilla* Torr.
Longleaf ephedra	*Ephedra trifurca* Torr.

Lotebush	*Ziziphus obtusifolia* (T. & G.) Gray
Narrowleaf forestiera	*Forestiera angustifolia* Torr.
Ocotillo	*Fouquieria splendens* Engelm.
Quail bush	*Atriplex lentiformis* (Torr.) Wats.
Retama	*Parkinsonia aculeata* L.
Rio Grande cottonwood	*Populus wislizenii* (Wats.) Sarg.
Rosemary mint	*Poliomintha* spp.
Saltcedar	*Tamarix chinensis* Loureiro
Screwbean mesquite	*Prosopis pubescens* Benth.
Seepwillow	*Baccharis salicifolia* (R. & P.) Pers. (*B. glutinosa* (R. & P.) Pers.)
Soaptree yucca	*Yucca elata* Engelm.
Southwestern black willow	*Salix gooddingii* Ball
Spanish dagger	*Yucca torreyi* Shafer
Texas virgin bower	*Clematis drummondii* (T. & G.)
Torrey wolfberry	*Lycium torreyi* Gray
Whitethorn acacia	*Acacia constricta* Gray

Source of nomenclature Gould (1975) , Lehr (1978), and Lehr and Pinkava (1980, 1982).

AVIAN SPECIES LIST

Common Name	Scientific Name
American Avocet	*Recurvirostra americana*
American Bittern	*Botaurus lentiginosus*
American Coot	*Fulica americana*
American Kestrel	*Falco sparverius*
American Pipit	*Anthus rubescens*
American Robin	*Turdus migratorius*
American Wigeon	*Anas americana*
Ash-throated Flycatcher	*Myiarchus cinerascens*
Barn Swallow	*Hirundo rustica*
Bell's Vireo	*Vireo bellii*
Belted Kingfisher	*Ceryle alcyon*
Bewick's Wren	*Thryomanes bewickii*
Black Phoebe	*Sayornis nigricans*
Black Vulture	*Coragyps atratus*
Black-chinned Hummingbird	*Archilochus alexandri*
Black-crowned Night-Heron	*Nycticorax nycticorax*
Black-tailed Gnatcatcher	*Polioptila melanura*
Black-throated Sparrow	*Amphispiza bilineata*
Blue Grosbeak	*Guiraca caerulea*
Blue-gray Gnatcatcher	*Polioptila caerulea*
Blue-winged Teal	*Anas discors*
Boat-tailed Grackle	*Quiscalus major*
Brewer's Blackbird	*Euphagus cyanocephalus*
Brewer's Sparrow	*Spizella breweri*
Brown Creeper	*Certhia americana*
Brown-headed Cowbird	*Molothrus ater*
Bufflehead	*Bucephala albeola*
Burrowing Owl	*Athene cunicularia*
Bushtit	*Psaltriparus minimum*
Cactus Wren	*Campylorhynchus brunneicapillus*
Canada Goose	*Branta canadensis*
Canyon Towhee	*Pipilo fuscus*
Canyon Wren	*Catherpes mexicanus*
Cassin's Sparrow	*Aimophila cassini*
Cattle Egret	*Bubulcus ibis*
Cave Swallow	*Hirundo rustica*
Cedar Waxwing	*Bombycilla cedrorum*
Chihuahuan Raven	*Corvus cryptoleucus*
Chipping Sparrow	*Spizella passerina*
Cinnamon Teal	*Anas cyanoptera*
Clay-colored Sparrow	*Spizella pallida*
Cliff Swallow	*Hirundo pyrrhonota*

Common Ground-Dove	*Columbina passerina*
Common Merganser	*Mergus merganser*
Common Poorwill	*Phalaenoptilus nuttallii*
Common Raven	*Corvus corax*
Common Snipe	*Gallinago gallinago*
Common Yellowthroat	*Geothlypis trichas*
Cooper's Hawk	*Accipiter cooperii*
Cordilleran Flycatcher	*Empidonax occidentalis*
Crissal Thrasher	*Toxostoma crissale*
Curve-billed Thrasher	*Toxostoma curvirostre*
Dark-eyed Junco	*Junco hyemalis*
Eared Grebe	*Podiceps nigricollis*
Eastern Phoebe	*Sayornis phoebe*
Ferruginous Hawk	*Buteo regalis*
Fox Sparrow	*Passerella iliaca*
Gadwall	*Anas strepera*
Gambel's Quail	*Callipepla gambelii*
Gila Woodpecker	*Melanerpes uropygialis*
Golden Eagle	*Aquila chrysaetos*
Golden-crowned Kinglet	*Regulus satrapa*
Great Blue Heron	*Ardea herodias*
Great Egret	*Casmerodius albus*
Great Horned Owl	*Bubo virginianus*
Great-tailed Grackle	*Quiscalus mexicanus*
Greater Roadrunner	*Geococcyzus californianus*
Greater Yellowlegs	*Tringa melanoleuca*
Green-backed Heron	*Butorides striatus*
Green-tailed Towhee	*Pipilo chlorurus*
Green-winged Teal	*Anas crecca*
Harris' Hawk	*Parabuteo unicinctus*
Hermit Thrush	*Catharus guttatus*
Hooded Merganser	*Lophodytes cucullatus*
House Finch	*Carpodacus mexicanus*
House Sparrow	*Passer domesticus*
House Wren	*Troglodytes aedon*
Inca Dove	*Columbina inca*
Indigo Bunting	*Passerina cyanea*
Killdeer	*Charadrius vociferus*
Ladder-backed Woodpecker	*Picoides scalaris*
Lark Bunting	*Calamospiza melanocorys*
Lark Sparrow	*Chondestes grammacus*
Lazuli Bunting	*Passerina amoena*

Least Flycatcher	*Empidonax minimus*
Least Sandpiper	*Calidris minutilla*
Lesser Goldfinch	*Carduelis psaltria*
Lesser Nighthawk	*Chordeiles acutipennis*
Lincoln's Sparrow	*Melospiza lincolnii*
Loggerhead Shrike	*Lanius ludovicianus*
Lucy's Warbler	*Vermivora luciae*
MacGillivray's Warbler	*Opornis tolmiei*
Mallard	*Anas platyrhynchos*
Marsh Wren	*Cistothorus palustris*
Mourning Dove	*Zenaida macroura*
Nashville Warbler	*Vermivora ruficapilla*
Northern Cardinal	*Cardinalis cardinalis*
Northern Flicker	*Colaptes auratus*
Northern Harrier	*Circus cyanea*
Northern Mockingbird	*Mimus polyglottos*
Northern Oriole	*Icterus galbula*
Northern Pintail	*Anas actus*
Northern Rough-winged Swallow	*Stelgidopterix serripennis*
Northern Shoveler	*Anas clypeata*
Orange-crowned Warbler	*Vermivora celata*
Orchard Oriole	*Icterus spurius*
Osprey	*Pandion haliaetus*
Painted Bunting	*Passerina ciris*
Phainopepla	*Phainopepla nitens*
Pied-billed Grebe	*Podilymbus podiceps*
Prairie Falcon	*Falco mexicanus*
Pyrrhuloxia	*Cardinalis sinuatus*
Red-naped Sapsucker	*Sphyrapicus nuchalis*
Red-tailed Hawk	*Buteo jamaicensis*
ed-winged Blackbird	*Agelaius phoeniceus*
Ring-necked Duck	*Aythya collaris*
Rock Dove	*Columba livia*
Rock Wren	*Salpinctes obsoletus*
Rough-legged Hawk	*Buteo lagopus*
Ruby-crowned Kinglet	*Regulus calendula*
Ruddy Duck	*Oxyura jamiacensis*
Rufous-capped Warbler	*Basileuterus rufifrons*
Rufous-sided Towhee	*Pipilo erythrophthalamus*
Sage Sparrow	*Amphispiza belli*
Savannah Sparrow	*Passerculus sandwichensis*
Say's Phoebe	*Sayornis saya*

Scaled Quail	*Callipepla squamata*
Scissor-tailed Flycatcher	*Tyrannus forficatus*
Scott's Oriole	*Icterus parisorum*
Sharp-shinned Hawk	*Accipiter striatus*
Short-eared Owl	*Asio flammeus*
Snowy Egret	*Egretta thula*
Song Sparrow	*Melospiza melodia*
Sora	*Porzana carolina*
Spotted Sandpiper	*Actitis macularia*
Summer Tanager	*Piranga rubra*
Swainson's Hawk	*Buteo swainsoni*
Swamp Sparrow	*Melospiza georgiana*
Tree Swallow	*Tachycineta bicolor*
Turkey Vulture	*Cathartes aura*
Varied Bunting	*Passerina versicolor*
Verdin	*Auriparus flaviceps*
Vermilion Flycatcher	*Pyrocephalus rubinus*
Vesper Sparrow	*Poocetes gramineus*
Violet-green Swallow	*Tachycineta thalassina*
Virginia Warbler	*Vermivora virginiae*
Western Kingbird	*Tyrannus verticalis*
Western Meadowlark	*Sturnella neglecta*
Western Tanager	*Piranga ludoviciana*
White-crowned Sparrow	*Zonotrichia leucophrys*
White-tailed Hawk	*Buteo albicaudatus*
White-throated Sparrow	*Zonotrichia albicollis*
White-winged Dove	*Zenaida asiatica*
Wild Turkey	*Melaagris gallopavo*
Willow Flycatcher	*Empidonax traillii*
Wilson's Phalarope	*Phalaropus tricolor*
Winter Wren	*Troglodytes troglodytes*
Wood Duck	*Aix sponsa*
Yellow Warbler	*Dendroica petechia*
Yellow-bellied Sapsucker	*Sphryrapicus varius*
Yellow-billed Cuckoo	*Coccyzus americanus*
Yellow-breasted Chat	*Icteria virens*
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*
Yellow-rumped Warbler	*Dendroica coronata*

MAMMAL SPECIES LIST

Common Name	Scientific Name
Badger	*Taxidea taxus*
Beaver	*Castor canadensis*
Black-tailed jackrabbit	*Lepus californicus*
Bobcat	*Felis rufus*
Braziiian freetail bat	*Tadarida brazilienus*
Cactus mouse	*Peromyscus eremicus*
Coati	*Nasua nasua*
Collared peccary	*Dicotyles tajacu*
Coyote	*Canis latrans*
Deer mouse	*Peromyscus maniculatus*
Desert cottontail	*Syvilagus audubonii*
Desert pocket mouse	*Perognathus penicillatus*
Fulvous harvest mouse	*Reithrodontomys fulvescens*
Gray fox	*Urocyon cinereoargenteus*
Hispid cotton rat	*Sigmodon hispidus*
Hog-nosed skunk	*Conepatus mesoleucus*
House mouse	*Mus musculus*
Kit fox	*Vulpes macrotis*
Merriam kangaroo rat	*Dipodomys merriami*
Merriam's pocket mouse	*Perognathus merriami*
Mule deer	*Odocoileus hemionus*
Nutria	*Myocastor coypus*
Ord kangaroo rat	*Dipodomys ordii*
Ringtail cat	*Bassariscus astutus*
Rock pocket mouse	*Perognathus intermedius*
Rock squirrel	*Spermophilus variegatus*
Silky pocket mouse	*Perognathus flavus*
Southern grasshopper mouse	*Onychomys torridus*
Southern plains woodrat	*Neotoma micropus*
Spotted ground squirrel	*Spermophilus spilosoma*
Striped skunk	*Mephitis mephitis*
Texas antelope squirrel	*Ammospermophilus interpres*
Western harvest mouse	*Reithrodontomys megalotis*
White-ankled mouse	*Peromyscus pectoralis*
White-footed mouse	*Peromyscus leucopus*
Yellow-faced pocket gopher	*Pappogeomys castanops*

Source for mammal nomenclature, Schmidly (1977).

AMPHIBIAN SPECIES LIST

Common Name	Scientific Name
Bullfrog	*Rana catesbeiana*
Couch's spadefoot	*Scaphiopus couchi*
Great Plains narrow-mouthed toad	*Gastrophryny olivacea*
Great Plains toad	*Bufo cognatus*
Red-spotted toad	*Bufo punctatus*
Rio Grande leopard frog	*Rana berlandieri*
Texas toad	*Bufo speciosus*
Western spadefoot	*Scaphiopus hammondi*

Source for nomenclature was Conant and Collins (1991).

REPTILE SPECIES LIST

Common Name	Scientific Name
Lizards	
Checkered whiptail	*Cnemidophorus tesselatus*
Chihuahua whiptail	*Cnemidophorus exsanguis*
Collared lizard	*Crotaphytus collaris*
Crevice spiny lizard	*Sceloporus poinsetti poinsetti*
Desert grassland whiptail	*Cnemidophorus uniparens*
Desert side-blotched lizard	*Uta stansburiana stejnergeri*
Greater earless lizard	*Holbrookia texana texana*
Little striped whiptail	*Cnemidophorus inornatus*
Marbled whiptail	*Cnemidophorus tigris marmoratus*
New Mexican whiptail	*Cnemidophorus neomexicanus*
Round-tailed horned lizard	*Phrynosoma modestum*
Southern prairie lizard	*Sceloporus undulatus consobrinus*
Texas horned lizard	*Phrynosoma coronatum*
Trans-Pecos striped whiptail	*Cnemidophorus inornatus heptagrammus*
Tree lizard	*Urosaurus ornatus*
Snakes	
Big Bend patch-nosed snake	*Salvadora hexalepis deserticola*
Black-tailed rattlesnake	*Crotalus molossus molossus*
Bull snake	*Pituophis melanoleucus sayi*
Central Texas whip snake	*Masticophis taeniatus girardi*
Checkered gartersnake	*Thamnophis marcianus marcianus*
Great Plains rat snake	*Elaphe guttata emoryi*
Kansas glossy snake	*Arizona elegans elegans*
Mexican black-headed snake	*Tantilla planiceps atriceps*
Plains black-headed snake	*Tantilla nigriceps*
Texas blind snake	*Leptotyphlops dulcis*
Western black-necked snake	*Thamnophis cyrtopsis cyrtopsis*
Western coachwhip	*Masticophis flagellum testaceus*
Western diamondback rattlesnake	*Crotalus atrox*
Western ground snake	*Sonora semiannulata*
Turtles	
Texas spiny softshell	*Apalone spiniferus emoryi*
Yellow mud turtle	*Kinosternon flavescens*

Source for nomenclature was Conant and Collins (1991).

Appendix D – La Junta Project Saltcedar Biological Control in Forgotten Reach of Rio Grande: Vegetation Canopy Cover and Frequency within 100m diameter Bird Point Count Plots

Table 14 - Plant species found in plots of native versus saltcedar riparian woodlands on the Rio Grande near Candelaria, Texas on 24-26 July 2007.a.

Native Woodland Plot RGN01 (30.14036017° N, -98.68452037° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bermuda grass	41.70	open air	28.50	open air	48.50
quailbush	17.00	western honey mesquite	18.00	quailbush	33.00
bare ground	9.50	quailbush	17.50	western honey mesquite	20.00
saltcedar	8.50	small-head sneezeweed	15.00	saltcedar	15.00
western honey mesquite	8.00	curly dock	15.00		
curly dock	5.00	saltcedar	15.00	**Tree Layer (5.0–10.0)**	
willow baccharis	3.55	willow baccharis	7.00	open air	94.00
small-head sneezeweed	2.75	climbing-milkweed	2.00	saltcedar	5.50
climbing-milkweed	2.40	seepwillow	1.00	western honey mesquite	1.00
butterfly-weed	2.00	butterfly-weed	1.00		
torrey wolfberry	2.00				
seepwillow	1.00				
blueweed	1.00				
frogfruit	1.00				
blackweed or slim aster	0.50				
narrow-leaf globe-mallow	0.50				
dock	0.10				

Native Woodland Plot RGN02 (30.14412136° N, -98.68496528° W)

Percent Cover (mean of three subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bermuda grass	38.20	Rio Grande cottonwood	39.00	open air	66.00
willow baccharis	23.00	willow baccharis	31.30	Rio Grande cottonwood	45.00
saltcedar	17.45	saltcedar	30.50	willow baccharis	10.00
bare ground	13.50	open air	22.67	saltcedar	6.50
hairyseed paspalum	12.00	seepwillow	7.33		
dead wood	4.50	horseweed	3.00	Tree Layer (5.0–10.0)	
aster	4.00	hairyseed paspalum	3.00	open air	50.00
seepwillow	3.33	western honey mesquite	3.00	Rio Grande cottonwood	50.00
quailbush	2.00	fourwing saltbush	2.00		
Rio Grande cottonwood	2.00	Ipomoea	1.00	Tree Layer (10.0–25.0)	
climbing-milkweed	1.80	narrow-leaf globe-mallow	1.00	open air	75.00
horseweed	1.50	climbing-milkweed	0.10	Rio Grande cottonwood	25.00
western honey mesquite	1.50				
annual horsetail	1.00				
fourwing saltbush	1.00				
small-head sneezeweed	1.00				
Ipomoea	1.00				

narrow-leaf globe-mallow	1.00				
torrey wolfberry	0.75				
blackweed or slim aster	0.50				
ground-cherry	0.50				
Silver-leaf nightshade	0.30				

End of Native Woodland Plot RGN02 (30.14412136° N, -98.68496528° W)

Native Woodland Plot RGN03 (30.15341201° N, -98.68663196° W)

Percent Cover (mean of three subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bermuda grass	69.11	western honey mesquite	52.00	open air	76.00
western honey mesquite	17.00	open air	44.06	western honey mesquite	23.33
bare ground	15.50	burrobush	6.00	burrobush	2.00
Bird-of-Paradise	2.00	Bird-of-Paradise	2.00		
burrobush	1.05	Texas virgin's bower	1.55		
catclaw acacia	1.00	torrey wolfberry	0.50		
Texas virgin's bower	1.00	climbing-milkweed	0.10		
eastern gammagrass	1.00	vine mesquite	0.10		
whitebrush	0.50	showy chloris	0.01		
torrey wolfberry	0.50				
western mugwort	0.10				
showy chloris	0.10				
climbing-milkweed	0.10				
vine mesquite	0.10				
ground-cherry	0.10				
plains bristle grass	0.10				
silver-leaf nightshade	0.10				
common purslane	0.08				
jimson-weed	0.06				

amaranth	0.05				
red sprangletop	0.05				
bushy knotweed	0.05				
white tridens	0.05				
cocklebur	0.05				
horseweed	0.01				
caltrop	0.01				

End of Native Woodland Plot RGN03 (30.15341201° N, -98.68663196° W)

Native Woodland Plot RGN04 (30.15522834° N, -98.68592887° W)

Percent Cover (mean of three subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bermuda grass	57.15	western honey mesquite	65.63	open air	62.33
western honey mesquite	37.33	open air	23.33	western honey mesquite	30.67
whitebrush	2.50	saltcedar	8.00	saltcedar	10.50
torrey wolfberry	2.00	whitebrush	4.00		
saltcedar	2.00	torrey wolfberry	4.00	**Tree Layer (5.0–10.0)**	
fourwing saltbush	1.00	balsam gourd	0.50	open air	97.00
balsam gourd	0.50	Thurber willow	0.50	saltcedar	3.00
Thurber willow	0.50	silver-leaf nightshade	0.10		
ground-cherry	0.10				
plains bristle grass	0.10				
silver-leaf nightshade	0.10				
cowpen daisy	0.10				
coarse vervain	0.10				
burrobush	0.05				

Native Woodland Plot RGN05 (30.15714354° N, -98.68547047° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)	
bermuda grass	32.50
bare ground	17.30
fourwing saltbush	15.00
jimmyweed	11.40
western honey mesquite	5.50
caric sedge	5.00
plains bristle grass	5.00
dead wood	4.50
switch grass	3.00
saltcedar	3.00
showy chloris	2.51
desert seepweed	2.03
torrey wolfberry	1.50
stalked rhombopod	1.00
climbing-milkweed	1.00
screwbean	1.00
surface water	1.00
cocklebur	1.00
silver-leaf nightshade	0.45
yerba mansa	0.10
blackweed or slim aster	0.10

Shrub Layer (0.5–2.0)	
open air	56.00
torrey wolfberry	38.50
western honey mesquite	15.00
fourwing saltbush	13.00
jimmyweed	11.00
saltcedar	7.00
dead wood	2.00
screwbean	1.00

Tree Layer (2.0–5.0)	
open air	80.00
torrey wolfberry	64.00
western honey mesquite	22.50
saltcedar	5.50

strawberry cactus	0.10			
annual buckwheat	0.10			
sicklepod rushpea	0.10			
common purslane	0.10			
southern crab grass	0.05			

End of Native Woodland Plot RGN05 (30.15714354° N, -98.68547047° W)

Native Woodland Plot RGN06 (30.15853936° N, - 98.6869927° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)	
bush muhly	47.45
western honey mesquite	15.50
plains bristle grass	13.50
bare ground	10.00
fourwing saltbush	4.50
cowpen daisy	3.00
desert seepweed	1.50
lotebush	1.50
showy chloris	1.00
croton	1.00
strawberry cactus	1.00
climbing-milkweed	1.00
tree cholla	1.00
trailing allionia	0.28
common purslane	0.25
Spanish dagger	0.10
silver-leaf nightshade	0.08
bushy knotweed	0.05

Shrub Layer (0.5–2.0)	
western honey mesquite	48.50
open air	32.50
dead wood	15.00
fourwing saltbush	8.00
lotebush	4.00
cowpen daisy	2.50
plains bristle grass	2.00

Tree Layer (2.0–5.0)	
western honey mesquite	54.50
open air	43.00
lotebush	2.50

Native Woodland Plot RGN07 (30.15669043° N, -98.68777128° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)	
gypgrass	23.45
bare ground	20.33
western honey mesquite	13.50
quailbush	9.00
torrey wolfberry	8.50
plains bristle grass	8.25
screwbean	4.50
Bermuda grass	4.00
willow baccharis	2.63
narrow-leaf globe-mallow	2.00
small-head sneezeweed	1.75
desert seepweed	1.50
inland saltgrass	1.00
butterfly-weed	1.00
alkali heliotrope	1.00
saltcedar	1.00
lotebush	1.00
unknown herb	0.63
silver-leaf nightshade	0.40
seepwillow	0.25
annual horsetail	0.15

Shrub Layer (0.5–2.0)	
open air	45.25
western honey mesquite	21.50
quailbush	10.50
torrey wolfberry	9.50
screwbean	7.75
lotebush	4.00
saltcedar	1.75
willow baccharis	0.75
small-head sneezeweed	0.75
seepwillow	0.50

Tree Layer (2.0–5.0)	
open air	75.00
screwbean	14.50
western honey mesquite	9.50
saltcedar	1.00
lotebush	1.00

End of Native Woodland Plot RGN07 (30.15669043° N, -98.68777128° W)

Native Woodland Plot RGN08 (30.15475854° N, -98.68809777° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	45.15	open air	74.00	open air	88.50
desert seepweed	21.10	western honey mesquite	22.00	western honey mesquite	11.00
western honey mesquite	9.50	quailbush	2.50	saltcedar	1.00
jimmyweed	9.00	torrey wolfberry	2.50		
plains bristle grass	9.00	desert seepweed	2.50		
alkali heliotrope	3.00	saltcedar	1.00		
quailbush	2.50	showy chloris	0.75		
showy chloris	2.50	butterfly-weed	0.50		
mountain pepperweed	2.50				
torrey wolfberry	2.25				
sicklepod rushpea	1.50				
sixweeks grama	1.00				
butterfly-weed	1.00				
saltcedar	1.00				
gypgrass	0.80				
blackweed or slim aster	0.10				
bush muhly	0.10				
common purslane	0.10				

Native Woodland Plot RGN09 (30.06533047° N, -98.69433806° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	67.95	open air	69.00	open air	69.50
quailbush	13.00	western honey mesquite	23.50	western honey mesquite	29.00
western honey mesquite	8.50	quailbush	12.00	quailbush	3.00
cowpen daisy	5.00	plains bristle grass	1.50		
plains bristle grass	4.50	torrey wolfberry	1.00		
sixweeks grama	4.00	cowpen daisy	0.50		
dead wood	3.00				
strawberry cactus	2.00				
gypgrass	2.00				
desert baileya	1.00				
torrey wolfberry	1.00				
ground-cherry	0.50				
silver-leaf nightshade	0.50				
narrow-leaf globe-mallow	0.50				
creosotebush	0.30				
Gregg keelpod	0.20				
sicklepod rushpea	0.10				

Native Woodland Plot RGN10 (30.06456779° N, -98.69642025° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	28.15	open air	52.50	open air	89.00
western honey mesquite	23.10	western honey mesquite	25.75	western honey mesquite	10.00
dead wood	20.00	catclaw acacia	10.00	quailbush	2.00
plains bristle grass	14.50	fourwing saltbush	10.00		
fourwing saltbush	8.00	quailbush	5.00		
cowpen daisy	6.25	torrey wolfberry	4.00		
quailbush	5.75	pencil cactus	4.00		
pencil cactus	4.00	dead wood	3.00		
Russian thistle	2.50	cowpen daisy	2.50		
catclaw acacia	2.00				
torrey wolfberry	2.00				
tahoka daisy	1.30				
narrow-leaf globe-mallow	1.05				
showy chloris	1.00				
desert baileya	0.10				
silver-leaf nightshade	0.10				
desert seepweed	0.10				

Saltcedar Woodland Plot RGSC01 (30.1280063° N, -98.67881748° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)	
vine mesquite	64.15
bermuda grass	37.00
saltcedar	21.00
sixweeks grama	15.00
bare ground	7.50
blackweed or slim aster	5.03
seepwillow	4.00
frogfruit	1.50
quailbush	1.00
dead wood	1.00
small-head sneezeweed	1.00
screwbean	1.00
dock	1.00
common purslane	0.80

Shrub Layer (0.5–2.0)	
saltcedar	67.00
open air	30.00
dead wood	27.00
seepwillow	5.00
quailbush	3.00
screwbean	1.00

Tree Layer (2.0–5.0)	
open air	64.00
saltcedar	35.00
seepwillow	2.00

Saltcedar Woodland Plot RGSC02 (30.12840476° N, -98.68102069° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
blackweed or slim aster	75.41	open air	44.00	open air	66.75
saltcedar	11.50	saltcedar	43.50	saltcedar	30.00
bare ground	8.50	dead wood	8.00	dead wood	5.00
dead wood	5.00	blackweed or slim aster	3.00	quailbush	0.75
quailbush	1.50	quailbush	3.00		
dollar weed	0.33			Tree Layer (5.0–10.0)	
small-head sneezeweed	0.22			open air	98.00
dock	0.22			dead wood	2.00

Saltcedar Woodland Plot RGSC03 (30.12893412° N, -98.68318582° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)	
blackweed or slim aster	65.73
bare ground	15.25
saltcedar	9.00
bermuda grass	8.00
quailbush	4.00
willow baccharis	3.00
western honey mesquite	2.00
switch grass	0.50
small-head sneezeweed	0.10
sicklepod rushpea	0.10
vine mesquite	0.10
screwbean	0.10
dock	0.10
aster	0.05

Shrub Layer (0.5–2.0)	
open air	63.00
saltcedar	20.00
quailbush	8.00
willow baccharis	8.00
western honey mesquite	5.50
dead wood	3.00
screwbean	1.00

Tree Layer (2.0–5.0)	
open air	56.50
saltcedar	36.50
western honey mesquite	10.00
dead wood	2.00
quailbush	1.00
willow baccharis	1.00

Tree Layer (5.0–10.0)	
open air	86.00
saltcedar	13.00
willow baccharis	1.00

Saltcedar Woodland Plot RGSC04 (30.12619278° N, -98.68747161° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
blackweed or slim aster	29.75	saltcedar	31.50	saltcedar	50.00
bermuda grass	26.00	open air	25.50	open air	33.75
small-head sneezeweed	26.00	blackweed or slim aster	10.00	quailbush	8.50
saltcedar	11.00	dead wood	10.00	dead wood	6.50
quailbush	4.00	small-head sneezeweed	10.00	western honey mesquite	2.00
western honey mesquite	1.50	quailbush	8.50	climbing-milkweed	0.50
huisache daisy	1.00	western honey mesquite	4.00		
bare ground	1.00	climbing-milkweed	1.00		
climbing-milkweed	1.00				

Saltcedar Woodland Plot RGSC05 (30.12812759° N, -98.68836993° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
Bermuda grass	39.25	open air	43.00	saltcedar	56.50
blackweed or slim aster	25.25	saltcedar	32.50	open air	31.00
saltcedar	12.00	dead wood	10.00	dead wood	10.00
small-head sneezeweed	10.50	quailbush	6.50	western honey mesquite	10.00
dock	6.00	blackweed or slim aster	5.50	willow baccharis	3.00
bare ground	5.00	western honey mesquite	4.50	quailbush	2.00
quailbush	2.00	small-head sneezeweed	3.00		
western honey mesquite	1.50	willow baccharis	1.50		
dollar weed	1.00				
willow baccharis	0.75				
sicklepod rushpea	0.50				

Saltcedar Woodland Plot RGSC06 (30.12968703° N, -98.68983472° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
blackweed or slim aster	75.00	saltcedar	62.00	saltcedar	74.75
saltcedar	17.50	open air	25.00	open air	20.00
bare ground	3.00	dead wood	8.50	dead wood	10.00
small-head sneezeweed	2.00	quailbush	2.50	quailbush	0.50
quailbush	1.50	blackweed or slim aster	1.00		
Roosevelt weed	1.00	Roosevelt weed	1.00	**Tree Layer (5.0–10.0)**	
seepwillow	1.00	seepwillow	1.00	open air	98.50
				saltcedar	1.50

Saltcedar Woodland Plot RGSC07 (30.12683783° N, -98.69012626° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	41.35	open air	47.50	saltcedar	52.00
saltcedar	33.50	saltcedar	32.95	open air	42.50
quailbush	12.50	quailbush	17.00	dead wood	5.00
blackweed or slim aster	9.50	dead wood	3.00	quailbush	3.00
small-head sneezeweed	3.00	small-head sneezeweed	2.00		
climbing-milkweed	0.10	climbing-milkweed	0.10		
bermuda grass	0.08				
vine mesquite	0.05				

Saltcedar Woodland Plot RGSC08 (30.12493592° N, -98.68928434° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	49.33	saltcedar	90.50	saltcedar	96.50
saltcedar	32.00	dead wood	10.00	open air	3.50
□ermuda grass	16.50	open air	3.50		
seepwillow	1.00	seepwillow	1.00	**Tree Layer (5.0–10.0)**	
willow baccharis	1.00	climbing-milkweed	1.00	open air	80.00
horseweed	1.00			saltcedar	20.00
quailbush	0.10				
climbing-milkweed	0.10				
goldenrod	0.05				

Saltcedar Woodland Plot RGSC09 (30.12366311° N, -98.69128547° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bare ground	39.00	saltcedar	50.00	open air	55.50
bermuda grass	35.35	open air	46.50	saltcedar	40.50
saltcedar	21.50	quailbush	3.00	quailbush	3.00
quailbush	1.50	dead wood	2.00	dead wood	3.00
seepwillow	1.00	climbing-milkweed	2.00	climbing-milkweed	2.00
climbing-milkweed	1.00				
ground-cherry	1.00			Tree Layer (5.0–10.0)	
dock	1.00			open air	98.00
willow baccharis	0.10			saltcedar	2.00
horseweed	0.10				
small-head sneezeweed	0.10				
hairyseed paspalum	0.10				

Saltcedar Woodland Plot RGSC10 (30.12245556° N, -98.69319215° W)

Percent Cover (mean of two subplots) of Plant Species and Physical Structures by Plant Community Height Layer (in meters)

Herbaceous Layer (0.0–0.5)		Shrub Layer (0.5–2.0)		Tree Layer (2.0–5.0)	
bermuda grass	42.20	saltcedar	78.50	saltcedar	85.50
saltcedar	38.70	quailbush	11.00	open air	10.00
bare ground	7.50	open air	7.50	quailbush	8.00
quailbush	5.00	climbing-milkweed	2.00	climbing-milkweed	1.50
climbing-milkweed	3.50	seepwillow	1.00		
horseweed	1.00	dead wood	1.00	Tree Layer (5.0–10.0)	
unknown herb	1.00			open air	93.50
seepwillow	0.75			saltcedar	6.50
willow baccharis	0.75				
switch grass	0.10				
western honey mesquite	0.10				

[a]Data averaged from two to three 7 m radius subplots within bird point count plot (50 m radius). Geooordinates are taken at center of bird point count plot from which subplots are displaced by 25 m. Percent cover visually estimated over total area of subplots (including physical structures). See Table 2 for list of scientific names of plants and vegetation type.

Table 15 - Common names and vegetation types of plant species found in bird survey plots near Candelaria, Texas in 2007.

Common Name	Plant Species	Plant Group	Plant Subgroup
alkali heliotrope	*Heliotropium curassavicum*	Broadleaf Annuals	
amaranth	*Amaranthus* sp.	Broadleaf Annuals	
annual buckwheat	*Eriogonum* sp. prob*. anuum*	Broadleaf Annuals	
annual horsetail	*Laennecia coulteri*	Broadleaf Annuals	
aster	*Aster* sp.	Broadleaf Annuals	
balsam gourd	*Ibervillea lindheimeri*	Vines	
bermuda grass	*Cynodon dactylon*	Perennial Grasses	Rhizomatous & Stoloniferous
Bird-of-Paradise	*Caesalpinia gilliesii*	Shrubs	
blackweed or slim aster	*Aster subulatus*	Broadleaf Annuals	
blueweed	*Helianthus ciliarus*	Broadleaf Perrenials	
burrobush	*Hymenoclea monogyra*	Shrubs	
bush muhly	*Muhlenbergia porteri*	Perennial Grasses	Rhizomatous & Stoloniferous
bushy knotweed	*Polygonum ramosissimum*	Broadleaf Annuals	
butterfly-weed	*Gaura* sp.	Broadleaf Annuals	
caltrop	*Kallstroemia californica*	Broadleaf Annuals	

Common Name	Plant Species	Plant Group	Plant Subgroup
caric sedge	*Carex* sp.	Sedges & Rushes	
catclaw acacia	*Acacia greggii*	Shrubs	
climbing-milkweed	*Funastrum cynanchoides*	Vines	
coarse vervain	*Verbena* sp. prob*. xutha*	Broadleaf Annuals	
cocklebur	*Xanthium strumarium* var. *canadense*	Broadleaf Annuals	
common purslane	*Portulaca oleracea*	Broadleaf Annuals	
common sunflower	*Helianthus annuus*	Broadleaf Annuals	
cowpen daisy	*Verbesina encelioides*	Broadleaf Annuals	
creosotebush	*Larrea tridentata*	Shrubs	
croton	*Croton* sp.	Broadleaf Perrenials	
curly dock	*Rumex crispus*	Broadleaf Perrenials	
desert baileya	*Baileya multiradiata*	Broadleaf Annuals	
desert seepweed	*Suaeda suffrutescens*	Subshrubs	
dock	*Rumex* sp.	Broadleaf Annuals	
dollar weed	*Malvella leprosa*	Broadleaf Perrenials	
eastern gammagrass	*Tripsacum dactyloides*	Perennial Grasses	Bunch Grasses
fourwing saltbush	*Atriplex canescens*	Shrubs	

Common Name	Plant Species	Plant Group	Plant Subgroup
frogfruit	*Lippia nodiflora*	Broadleaf Perrenials	
goldenrod	*Solidago* sp.	Broadleaf Perrenials	
Gregg keelpod	*Synthlipis greggii*	Broadleaf Annuals	
ground-cherry	*Physalis* sp.	Broadleaf Perrenials	
gypgrass	*Sporobolus nealleyi*	Perennial Grasses	Rhizomatous & Stoloniferous
hairyseed paspalum	*Paspalum pubiflorum* var. *pubiflorum*	Perennial Grasses	Rhizomatous & Stoloniferous
horseweed	*Conyza canadensis*	Broadleaf Annuals	
huisache daisy	*Amblyolepis setigera*	Broadleaf Annuals	
inland saltgrass	*Distichlis spicata* var. *stricta*	Perennial Grasses	Rhizomatous & Stoloniferous
Ipomoea	*Ipomoea* sp.	Broadleaf Perrenials	
jimmyweed	*Isocoma pluriflora*	Subshrubs	
jimson-weed	*Datura wrightii*	Broadleaf Perrenials	
lotebush	*Ziziphus obtusifolia*	Shrubs	
mountain pepperweed	*Lepidium montanum* var. *angustifolium*	Broadleaf Perrenials	
narrow-leaf globe-mallow	*Sphaeralcea angustifolia*	Broadleaf Perrenials	
pencil cactus	*Opuntia leptocaulis*	Shrubs	
plains bristle grass	*Setaria leucopila*	Perennial Grasses	Bunch Grasses

Common Name	Plant Species	Plant Group	Plant Subgroup
quailbush	*Atriplex lentiformis*	Shrubs	
red sprangletop	*Leptochloa mucronata*	Annual Grasses	
Rio Grande cottonwood	*Populus deltoides sub*sp. *wislizeni*	Trees	
Roosevelt weed	*Baccharis neglecta*	Shrubs	
Russian thistle	*Salsola tragus*	Broadleaf Annuals	
saltcedar	*Saltcedar ramosissima*	Trees	
screwbean	*Prosopis pubescens*	Trees	
seepwillow	*Baccharis salicifolia*	Shrubs	
showy chloris	*Chloris virgata*	Annual Grasses	
sicklepod rushpea	*Hoffmanseggia glauca*	Broadleaf Perrenials	
silver-leaf nightshade	*Solanum eleagnifolium*	Broadleaf Perrenials	
sixweeks grama	*Bouteloua barbata*	Annual Grasses	
small-head sneezeweed	*Helenium microcephalum*	Broadleaf Annuals	
solanum	*Solanum* sp.	Broadleaf Annuals	
southern crab grass	*Digitaria ciliaris*	Annual Grasses	
Spanish dagger	*Yucca torreyi*	Shrubs	
goldenrod	*Solidago* sp.	Broadleaf Perrenials	
strawberry cactus	*Echinocerus enneacanthus*	Subshrubs	
switch grass	*Panicum virgatum*	Perennial Grasses	Bunch Grasses
tahoka daisy	*Machaeranthera tanacetifolia*	Broadleaf Annuals	

Common Name	Plant Species	Plant Group	Plant Subgroup
Texas virgin's bower	*Clematis drummondii*	Vines	
Thurber willow	*Salix thurberi*	Trees	
torrey wolfberry	*Lycium torreyi*	Shrubs	
trailing allionia	*Allionia incarnata*	Broadleaf Perrenials	
tree cholla	*Opuntia imbricata* var. *imbricata*	Shrubs	
vine mesquite	*Panicum obtusum*	Perennial Grasses	Rhizomatous & Stoloniferous
western honey mesquite	*Prosopis glandulosa* var. *torreyana*	Trees	
western mugwort	*Artemesia ludoviciana*	Broadleaf Perrenials	
white tridens	*Tridens albescens*	Perennial Grasses	Bunch Grasses
whitebrush	*Aloysia gratissima*	Shrubs	
willow baccharis	*Baccharis salicina*	Shrubs	
yerba mansa	*Anemopsis californica*	Broadleaf Perrenials	

End of Table 13

Appendix E – Bird Monitoring at Saltcedar Beetle Release Sites, Rio Grande, Candelaria, Presidio County Texas, 2007

Table 16 - Counts of bird species found in point count plots of native versus saltcedar riparian woodlands on the Rio Grande near Candelaria, Texas in 2007.a

Native Woodland Plot RGN01 (30.14036017° N, -98.68452037° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	1	3	2
Painted Bunting	1	0	3
Yellow-breasted Chat	2	1	1
Bell's Vireo	1	1	1
Bewick's Wren	1	1	1
Bushtit	0	3	0
Black-chinned Hummingbird	1	0	1
Gambel's Quail	0	0	2
Great-tailed Grackle	0	0	2
Northern Cardinal	0	2	0
Cassin's Sparrow	0	0	1
Eurasian Collared-Dove	0	0	1
Ladder-backed Woodpecker	0	1	0

Native Woodland Plot RGN02 (30.14412136° N, -98.68496528° W)

	Count per Sample Period		
Bird Species	21–22 May	12–13 June	26–27 June
White-winged Dove	2	4	4
Bushtit	0	5	1
Summer Tanager	1	2	1
Yellow-breasted Chat	1	1	2
Common Yellowthroat	0	0	1
Empidonax sp.	0	1	0
Indigo Bunting	0	0	1
Ladder-backed Woodpecker	0	1	0
Painted Bunting	1	0	0

Native Woodland Plot RGN03 (30.15341201° N, -98.68663196° W)

Bird Species	Count per Sample Period 21–22 May	12–13 June	26–27 June
Lesser Goldfinch	8	0	0
Yellow-breasted Chat	0	2	2
Blue Grosbeak	2	0	1
Bullock's Oriole	0	2	1
Northern Cardinal	0	2	0
Summer Tanager	0	2	0
Bell's Vireo	0	1	0
Black-chinned Hummingbird	1	0	0
Curved-billed Thrasher	1	0	0
Northern Mockingbird	0	1	0

Native Woodland Plot RGN04 (30.15522834° N, -98.68592887° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Bushtit	0	5	1
Yellow-breasted Chat	2	2	2
White-winged Dove	0	1	1
Bell's Vireo	0	0	1
Bewick's Wren	0	0	1
Brown-headed Cowbird	0	0	1
Bullock's Oriole	0	0	1
Lesser Goldfinch	1	0	0
Painted Bunting	0	0	1
Pyrrhuloxia	0	0	1
Vermilion Flycatcher	1	0	0

Native Woodland Plot RGN05 (30.15714354º N, -98.68547047° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	5	0	0
Bell’s Vireo	0	2	1
Ash-throated Flycatcher	0	0	1
Black-chinned Hummingbird	1	0	0
Black-tailed Gnatcatcher	0	1	0
Curve-billed Thrasher	0	1	0
Gambel’s Quail	0	1	0
Northern Mockingbird	1	0	0
Pyrrhuloxia	1	0	0
Summer Tanager	0	0	1

Native Woodland Plot RGN06 (30.15853936° N, -98.68699270° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Bell's Vireo	1	2	3
Blue Grosbeak	1	0	2
Northern Cardinal	1	1	1
Black-chinned Hummingbird	0	0	1
Cassin's Sparrow	0	0	1
Gambel's Quail	0	1	0
Greater Roadrunner	0	0	1
Summer Tanager	0	0	1

Native Woodland Plot RGN07 (30.15669043° N, -98.68777128° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	13	9	4
Yellow-breasted Chat	2	3	2
Lucy’s Warbler	2	2	2
Vermilion Flycatcher	2	2	0
Bewick’s Wren	0	2	1
Black Phoebe	0	1	2
Northern Mockingbird	2	0	0
Verdin	0	0	2
Black-tailed Gnatcatcher	0	1	0
Brown-headed Cowbird	0	0	1
Mourning Dove	0	1	0

Native Woodland Plot RGN08 (30.15475854° N, -98.68809777° W)

Bird Species	Count per Sample Period 21–22 May	12–13 June	26–27 June
Lucy's Warbler	4	0	2
Northern Mockingbird	2	2	2
House Finch	0	3	2
White-winged Dove	0	2	3
Bewick's Wren	0	2	1
Ash-throated Flycatcher	2	0	0
Black-tailed Gnatcatcher	0	0	2
Blue Grosbeak	1	0	1
Gambel's Quail	0	2	0
Painted Bunting	0	1	1
Summer Tanager	0	2	0
Yellow-breasted Chat	1	1	0
Bell's Vireo	0	0	1
Bullock's Oriole	0	0	1
Empidonax sp.	0	0	1
Ladder-backed Woodpecker	1	0	0
Vermilion Flycatcher	0	0	1

Native Woodland Plot RGN09 (30.06533047° N, -98.69433806° W)

Bird Species	Count per Sample Period 21–22 May	12–13 June	26–27 June
Gambel’s Quail	3	0	3
Bushtit	0	5	0
Brown-headed Cowbird	0	1	1
Bell’s Vireo	0	1	0
Bewick’s Wren	0	1	0
Northern Mockingbird	1	0	0
Verdin	0	0	1
White-winged Dove	1	0	0

Native Woodland Plot RGN10 (30.06456779° N, -98.69642025° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	10	2	2
Blue Grosbeak	1	2	1
Bewick's Wren	1	2	0
Common Yellowthroat	0	0	3
Lucy's Warbler	0	2	1
Bell's Vireo	2	0	0
Brown-headed Cowbird	0	1	1
Gambel's Quail	2	0	0
Yellow-breasted Chat	0	0	2
Mourning Dove	1	0	0
Northern Cardinal	1	0	0
Summer Tanager	0	1	0
Western Kingbird	0	1	0

Saltcedar Woodland Plot RGSC01 (30.12800630° N, -98.67881748° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Empidonax sp.	0	2	0

Saltcedar Woodland Plot RGSC02 (30.12840476° N, -98.68102069° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Gambel's Quail	0	2	4
Blue Grosbeak	0	2	2
White-winged Dove	0	0	2
Bewick's Wren	1	0	0
Greater Roadrunner	0	0	1
Northern Cardinal	0	1	0

Saltcedar Woodland Plot RGSC03 (30.12893412° N, -98.68318582° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Yellow-breasted Chat	3	1	2
Turkey Vulture	0	0	3
White-winged Dove	2	1	0
Painted Bunting	0	2	0
Rock Wren	0	0	2

Saltcedar Woodland Plot RGSC04 (30.12619278° N, -98.68747161° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Bushtit	0	3	0
White-winged Dove	1	1	1
Black-tailed Gnatcatcher	2	0	0
Gambel's Quail	0	1	1
Northern Cardinal	0	0	2
Yellow-breasted Chat	1	1	0
Bewick's Wren	0	1	0
Blue Grosbeak	0	0	1
Great-tailed Grackle	0	1	0
Northern Mockingbird	1	0	0
Vermilion Flycatcher	1	0	0

Saltcedar Woodland Plot RGSC05 (30.12812759° N, -98.68836993° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Yellow-breasted Chat	1	2	2
Red-winged Blackbird	0	1	2
Blue Grosbeak	0	0	2
Northern Cardinal	1	1	0
Bell's Vireo	0	0	1
Ladder-backed Woodpecker	0	1	0
White-winged Dove	0	1	0

Saltcedar Woodland Plot RGSC06 (30.12968703° N, -98.68983472° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Gambel's Quail	0	8	0
Yellow-breasted Chat	1	0	1
Bushtit	0	0	1
House Finch	0	1	0
Ladder-backed Woodpecker	0	1	0
Mourning Dove	1	0	0
Painted Bunting	1	0	0
Red-winged Blackbird	0	1	0

Saltcedar Woodland Plot RGSC07 (30.12683783° N, -98.69012626° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	2	0	4
Bewick's Wren	0	1	2
Northern Mockingbird	2	1	0
Yellow-breasted Chat	0	1	2
Bushtit	2	0	0
Lucy's Warbler	0	1	1
Mourning Dove	0	0	2
Painted Bunting	1	0	1
Blue Grosbeak	0	0	1
Gambel's Quail	1	0	0
Ladder-backed Woodpecker	1	0	0

Saltcedar Woodland Plot RGSC08 (30.12493592° N, -98.68928434° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
Bewick's Wren	1	2	2
White-winged Dove	1	2	2
Yellow-breasted Chat	1	1	3
House Finch	0	3	0
Gambel's Quail	0	2	0
Northern Cardinal	1	0	1
Northern Mockingbird	0	2	0
Painted Bunting	0	1	1
Summer Tanager	0	2	0

Saltcedar Woodland Plot RGSC09 (30.12366311° N, -98.69128547° W)

Bird Species	Count per Sample Period		
	21–22 May	12–13 June	26–27 June
White-winged Dove	2	0	4
Bewick's Wren	0	1	2
Northern Mockingbird	2	1	0
Yellow-breasted Chat	0	1	2
Bushtit	2	0	0
Lucy's Warbler	0	1	1
Mourning Dove	0	0	2
Painted Bunting	1	0	1
Blue Grosbeak	0	0	1
Gambel's Quail	1	0	0
Ladder-backed Woodpecker	1	0	0

Saltcedar Woodland Plot RGSC 10 (30.12245556° N, -98.69319215° W)

Bird Species	Count per Sample Period 21–22 May	12–13 June	26–27 June
White-winged Dove	2	2	2
Yellow-breasted Chat	2	0	2
Bewick's Wren	1	2	0
Blue Grosbeak	0	2	1
Common Yellowthroat	0	0	3
Lucy's Warbler	0	2	1
Brown-headed Cowbird	0	1	1
Summer Tanager	0	1	0
Western Kingbird	0	1	0

[a]Data from bird point count plots of 50 m radius censused for five minutes. Geocoordinates are taken at center of bird point count plot.