The Resacas

In the Vicinity of the City of Brownsville, Texas
Interim Ecosystem Restoration Feasibility Study and Environmental Assessment

US Army Corps of Engineers ®
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and
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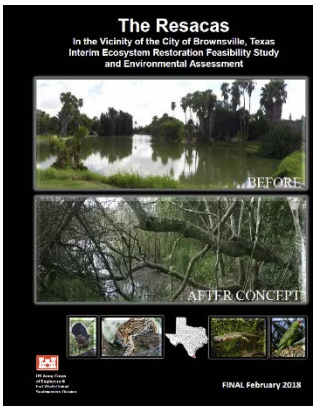

SYNOPSIS

The Resacas, In the Vicinity of the City of Brownsville, Texas, Interim Ecosystem Restoration Feasibility Study and Environmental Assessment

***Purpose of Study**. The purpose of the study was to determine if ecosystem restoration of a portion of one percent of remaining unique resaca habitat, which has been otherwise destroyed in the lower Rio Grand Valley delta, would be feasible for the investment of the Federal government and the City of Brownsville, Texas. The City of Brownsville is located at the southern tip of Cameron County, Texas. There are three resaca within the City of Brownsville: Resaca de la Guerra, Resaca del Rancho Viejo, and Town Resaca.*

***Goals of the Restoration**. The objectives were to 1) identify potential restoration measures and alternatives to restore the resaca ecosystems, and 2) identify a National Ecosystem Restoration (NER) plan that was in the federal interest. These objectives included evaluation of environmental impacts of the proposed restoration. The objectives would be achieved by the plan recommended for implementation.*

***Study Sponsors**. The federal sponsor was the U.S. Army Corps of Engineers (USACE), represented by the Galveston District. The non-federal sponsor was the City of Brownsville, Texas.*

***Study Findings**. A National Ecosystem Restoration plan was identified as the recommended plan and ecosystem restoration was found to be justified. The plan would restore about 845 acres of aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo. The total restoration acreages would consist of about 625 acres of terrestrial riparian habitat restoration, by clearing invasive species and replanting native species of plants, and about 220 acres of aquatic habitat restoration, through the removal of sediment, expanding aquatic areas, shaping banks, and by planting aquatic and emergent vegetation along 33 miles of shoreline. After implementation, a management plan would continue with monitoring and management of invasive species. The recommended plan identified cost effective restoration measures on 763 acres of city and private lands; about 28 acres of state Texas Parks and Wildlife Department (TPWD) lands, and 54 acres of federal U.S. Fish and Wildlife Service (USFWS) lands. The USACE could not cost share in the implementation on the USFWS lands. That implementation would be further coordinated with the USFWS and the non-federal sponsor during the USACE preconstruction engineering and design phase subsequent to approval of this feasibility phase report.*

Resaca Terminology. The "resaca" are former channels of the Rio Grande located in Cameron County, Texas, and Tamaulipas, Mexico, formed by major flooding. The word resaca is unique to the Rio Grande lower valley. The term identifies both the entire former channels (Resaca) and individual pockets of habitat along the former channel (resaca). Loss of aquatic and terrestrial ecological connectivity along each of the Resacas has disrupted flora and fauna migration among resacas and to the surrounding high quality managed habitat east and west of the project area. The connectivity has been lost due to agriculture and urbanization. The one percent of the remaining resaca habitat consists of vegetation communities that are extremely rare and at a high risk of extinction.

Connectivity Terminology. Connectivity spans many concepts that are dependent on species, opportunities for linkage to broader areas, and the purpose of species movement, such as migration, dispersion of populations, or home range activities. For this study, the USACE adopted the strategy that has been successfully used by the USFWS and the TPWD to create habitat connectivity in urban areas of the lower Rio Grande Valley. That strategy is the restoration of "stepping stone" habitats to provide a series of nearby patches of habitat that can are used as refuge habitat for dispersing wildlife. This strategy has been applied to the ocelot and jaguarundi recovery plans and has been a key tool in the recovery of these species. The stepping stone habitats are essential for many wildlife species such as smaller mammals, birds, reptiles, and amphibians to move across an urban landscape. The proposed restoration plan would create a corridor of stepping stone habitats that would link to high quality resource agency managed lands east and west of Brownsville. Connectivity in this ecosystem is not dependent on a continuous riparian buffer that might exist along Midwestern or eastern streams.

Habitat Terminology. The place or environment where a plant or animal naturally or normally lives and grows.

Ecosystem Terminology. The complex community of organisms and its environment functioning as an ecological unit. An ecosystem encompasses the interrelationships between living organisms (plants and animals) and the nonliving environment (rock, soil, water, air, temperature, sunlight, elements, compounds).

Scope of Study. Sixty-six resacas were identified and evaluated for potential restoration. All of the areas identified had highly degraded aquatic and/or riparian habitat. The areas ranged in size from less than one to over 50 acres, with an average of 18 acres. The result of the restoration evaluation was the identification of a plan to restore 44 resacas along the Resaca de la Guerra and Resaca del Rancho Viejo. The restoration of Town Resaca was not recommended for restoration at this time. While its restoration would be ecologically beneficial, the biological output of that effort would be less cost effective than restoration efforts along the other two Resacas.

Cause of Habitat Damage and Destruction. Dam age to the resacas has been the direct result of the past 150 years of expansion of agriculture and urbanization. While these are the direct impacts, the implementation of flood risk management projects by the U.S. and Mexico on and throughout the Rio Grande basin resulted in the virtual elimination of major floods in the lower Rio Grande valley delta. The reduced risk of flooding enabled the urbanization and agricultural expansion in the delta. Those projects also included agricultural water supply, which further enabled agricultural to benefit from the rich delta soils. The end result was the loss of 99 percent of the historic resaca habitat.

General Study Guidance. This study was conducted in accordance with Engineering Regulation (ER) 1105-2-100, Planning, PLANNING GUIDANCE NOTEBOOK, April 22. This study was also conducted in accordance with the National Environmental Policy Act (NEPA) of 1969 (PL 91-190), (40 Code of Federal Regulations (CFR) 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)), the Council on Environmental Quality (CEQ), and the U.S. Army Corps of Engineers (USACE) implementing regulation ER 200-2-2, and the procedures for implementing the NEPA regulations. An environmental assessment is seamlessly integrated into this report.

Problems to be Resolved. Three **problems** were identified regarding the resaca habitat forecast:

1. **No New Resaca Habitat Will Be Created**.
The first problem identified was that it is unlikely new resacas will be formed. The management of water in the Rio Grande (and the Pecos River) Basins has effectively eliminated the potential for a major flood to cut a new course to the Gulf in the lower Rio Grande Valley. It is less likely that the Rio Grande would create a new course through the study area, the City of Brownsville, due to levees and other infrastructure. The forecast is for the eventual loss of the resaca habitat due to succession, urbanization, and agriculture.
2. **Loss of Connectivity**. The loss of resaca habitat due to urbanization has segmented the habitat and disrupted ecological connectivity along and among the three resacas, and more significantly has severed connectivity with high quality native thornscrub and resaca habitats of the surrounding ecosystem for most species. The forecast is for the Brownsville Resacas to be further segmented and remain disconnected from the surrounding ecosystem.
3. **Invasive Species**. Invasive (and non-native) species, both aquatic and terrestrial flora and fauna, exist in and around the resaca habitat. These species have significantly reduced the quality of habitat and because they tend to out-compete native species, the forecast is continued expansion of invasive species and a corresponding decline in the quality and quantity of resaca habitat.

Objectives of Restoration. Three **objectives** were identified for restoration of the resaca habitat:

1. **Cost Effective Restoration Prioritization of Existing Resaca Habitat**. The objective is to restore impacted resaca aquatic and riparian complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. Alternatives would be formulated to prioritize cost effective restoration efforts to optimize the fiscal resources.
2. **Restore Connectivity**. The objective is to restore connectivity within the Brownsville resacas and to the high quality thornscrub and resaca habitats of the surrounding ecosystem. Alternatives would be formulated to meet this objective. This objective is responsive to the USACE goal to formulate ecosystem restoration in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems, wherever those restoration features improve the value and function of the overall ecosystem.
3. **Invasive Species Management**. The reduction or elimination of invasive and non-native species would be an objective of all alternatives. The objective would be approached through an initial plan for removal, initial monitoring after construction, and long term monitoring and maintenance. Cost effectiveness would guide the selection of methodologies.

Restoration Measures. Eight restoration measures were identified for the formulation of alternatives. The measures were "applied" in the Resaca Reference Condition Model to each of the sixty-six potential restoration areas as needed to restore those areas to or near reference site conditions over a 75-year period of analysis. These were the eight management measures:

- Dredging (removing sediment from the resacas and excavating to restore aquatic habitat)
- Riparian Soil Supplementation with Dredged Material (nutrient enrichment of the riparian area)
- Planting Riparian Species (replanting native species appropriate for the natural habitat)
- Bank Slope Restoration (restoring flatter bank slopes represented in reference sites)
- Bank Stabilization (stabilizing banks to reduce sediment from runoff and to benefit species movement from the aquatic habitat to the terrestrial habitat)
- Plant Aquatic and Emergent Vegetation (replanting native species to benefit aquatic fishes and amphibian species life cycles)
- Water Control Structure/Flow Management (water management to mimic the water budget of natural resacas)
- Invasive Plant Species Management (removal and perpetual management of non-native and invasive species)

Evaluation Methodology. The evaluation of alter natives involved two equally important and complementary assessments:

1) Habitat restoration, and

2) Connectivity restoration:
   a) Within Resacas,
   b) Among Resacas, and
   c) Across Resacas to the surrounding ecosystems.

Data Acquisition. Ecological data was developed from field investigations and was aided by a Resaca Reference Condition Model. The model was developed in cooperation with the USFWS, the TPWD, the National Parks Service, the Brownsville Public Utilities Board, and university biologists. The model was used to quantify and assess existing and future habitat conditions, with and without the alternatives. The data was collected from the sixty-six damaged resacas and compared to high quality resaca habitat in the Resaca de la Palma State Park, The Nature Conservancy Southmost Preserve, and Camp Lula Sams – the reference site conditions.

Models. The ecological forecasts were evaluated for cost effectiveness and incremental analysis using the USACE Institute of Water Resources (IWR) Planning Suite 2.0.6.1 tool (IWR Plan). The cost effectiveness and incremental analysis provides an economic ranking of restoration opportunities based on the existing habitat and how closely that habitat can be efficiently restored to reference conditions. However, that economic analysis model was not designed for or capable of evaluating the connectivity component that was a primary object of the study. Therefore, the IWR Plan tool alone could not identify the best ecosystem restoration plan. The IWR Plan tool was used to evaluate millions of potential combinations of ecosystem measures applied at each of the sixty-six restoration areas and further millions of combinations of the best restoration areas. That assessment provided a cost effect ranking of ecosystem restoration within the study area identified as alternatives, numbed 1, 2, 4, 5, 6, and 7. These were the "best buy" plans based on efficiency. The connectivity assessment was then used to identify the National Ecosystem Restoration (NER) plan from the IWR Plan ranking.

Connectivity Forecasts. The connectivity forecasts were based on professional opinion of the USACE and resource agency subject matter experts. The USACE, including the Engineering Development and Research Center (ERDC), and the USFWS, The Nature Conservancy, and TPWD, and other subject matter experts evaluated and compared the project alternatives and provided the connectivity assessment. Alternative 5 was assessed to be most efficient plan that would meet the connectivity objective.

The Recommended Plan. Alternative 5 was identified as the NER plan because it would benefit the larger ecosystem surrounding the Brownsville region at the lowest incremental cost. Through that identification, the USACE tenant to increase the net quantity and/or quality of preferred ecosystem resources through the formulation of ecosystem restoration in a systems context would be met. The NER plan would improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating functioning systems for the Brownsville Resacas. More importantly, the NER plan would add significant improvement to the value and function of the overall ecosystem in the Brownsville region by connecting high quality habitat in the surrounding ecosystem. The City of Brownsville, USFWS, TPWD, and TNC support the recommended plan.

Potential for Negative Environmental Impacts. The alternatives, including the no action plan, were evaluated in the integrated feasibility study. No significant impacts to the human environment were identified from the implementation of the recommended plan. The plan would restore aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo. Terrestrial riparian habitat would be cleared of invasive species of plants and native species would be replanted. An implementation plan would restore aquatic habitat through the removal of sediment by widening some resacas (excavating), by shaping banks, and by planting emergent vegetation. After implementation, a management plan would continue with monitoring and with management and control of invasive species. As an ecosystem restoration project, the recommended plan (Alternative 5) is intended to have long-term beneficial impacts to the Brownsville resaca and surrounding areas. The restoration would cause no long-term adverse environmental impacts. There would be no adverse impacts to habitat for threatened or endangered species as the impacts to all wetlands and waters of the U.S in a 404(b)(1) analysis was evaluated. The TCEQ provided a water quality certification on 26 July 2017. Adverse impacts to cultural resources, either buried or in the cultural landscape would be identified and appropriate mitigation would be completed prior to project construction. The restoration would not entail significant irretrievable or irreversible commitments of resources.

NEPA Documentation. Taking into account the environmental findings, the USACE Galveston District Commander determined an Environmental Impact Statement (EIS) would not be necessary. A Draft Finding of No Significant Impact (FONSI) was prepared for the recommended plan.

Recommendation. The Galveston District Commander recommended implementation of the National Ecosystem Restoration plan, identified as Alternative 5 in the Interim Ecosystem Restoration Feasibility Study and Environmental Assessment, The Resacas in the Vicinity of the City of Brownsville, Texas, Feb. 2018, with such modifications thereof as in the discretion of the Commander, Headquarters, U.S. Army Corps of Engineers (HQUSACE), may be advisable, to restore aquatic and terrestrial complexes within two resacas: Resaca de la Guerra and Resaca del Rancho Viejo through the restoration of 44 “stepping stone” areas. About 845 acres of aquatic and riparian habitat would be restored. Terrestrial riparian habitat would be restored by removing

invasive plants and replanting native species on about 625 acres. Aquatic habitat would be restored by removing sediment, shaping banks, and planting aquatic and emergent vegetation along the shaped banks on about 218 acres. Restored shoreline would total about 33 miles. The sediment removed from the resacas would be placed in restored riparian areas to mimic the nutrient supplementation of former systems natural processes. Hydrologic reliability of the system would be assured through the implementation of in-channel water control measures, modifying an existing local system.

Project Costs. The total project first cost is estimated to be $202,492,000 at October 2017 prices, with a federal share of $138,238,000 (by the USACE and the USFWS) and a local sponsor share of $64,255,000. The federal project first cost would be shared between two federal agencies with the USACE share estimated at $119,332,000 and the USFWS share estimated at $18,907,000. The local sponsor would cost share the project first cost of the restoration of resaca measures on lands acquired for the project, including lands held by the TPWD (28.21 acres), but excluding the cost of restoration measures on lands held by the USFWS (54 acres). Annual operation, maintenance, repair, rehabilitation, and replacement costs for the total project would be the responsibility of the non-federal sponsor, and are estimated to be about $624,000 at October 2017 prices and Federal discount rate of 2.75 percent.

Assurance Monitoring. Monitoring, and if necessary adaptive management, would occur for up to 10 years to assure successful establishment of the project before the project would be turned over to the non-federal sponsor for operation and maintenance. Monitoring efforts would be conducted by BPUB and USACE personnel.

USFWS Coordination for Implementation. Initial co-ordination to outline the joint agency implementation during the feasibility phase was positive and detailed coordination would continue during the USACE preconstruction engineering and design. Failure to come to an agreement on implementation, or conflicting USFWS priorities would potentially result in the USACE implementing a slightly smaller plan or refinements to the recommended plan. The final array of alternatives was coordinated with the public and resource agencies. Adoption of a smaller alternative would not require additional NEPA documentation or review.

INTRODUCTION

This study was conducted in accordance with *Engineering Regulation (ER) 1105-2-100, Planning, PLANNING GUIDANCE NOTEBOOK, April 22, 2000* and is organized in the framework of the ER. Chapters 1 through 6 have been prepared to match the U.S. Army Corps of Engineers (USACE) six-step planning process. The six-step process originated in the *1983 Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (also known as Principles and Guidelines or P&G). Table I-1 lists the six-step process. The P&G were established for civil works planning studies, generally for the assessment of water resources problems and the potential to implement solutions to those problems.

Table I-1: Six-step Planning Process

Chapter	Step	The Six Step Process
1	**1**	Identify problems and opportunities
2	**2**	Inventory and forecasting conditions
3	**3**	Formulate alternative plans
4	**4**	Evaluate alternative plans
5	**5**	Compare alternative plans
6	**6**	Select a plan

This study was also conducted in accordance with the National Environmental Policy Act (NEPA) of 1969 (PL 91-190), (40 Code of Federal Regulations (CFR) 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)), the Council on Environmental Quality (CEQ), and the U.S. Army Corps of Engineers (USACE) implementing regulation ER 200-2-2, and the procedures for implementing the NEPA regulations. An environmental assessment is seamlessly integrated into this report. This document serves as an integrated USACE feasibility report and NEPA document.

Authorization

Authority is provided by the House Committee on Transportation and Infrastructure Resolution, 10 Nov., 1999,

> *"Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, that the Secretary of the Army is requested to review that report of the Chief of Engineers on Louisiana and Texas Intracoastal Waterway, Corpus Christi, Texas to the Rio Grande, published as House Document No. 402, 77th Congress, 1st Session, and other pertinent reports to determine the feasibility of providing improvements to the Resacas in the vicinity of the City of Brownsville, Texas, in the interest of flood control,*

> *watershed management, environmental restoration and protection, water quality, and other allied purposes."*

Section 206 of the Water Resources Development Act (WRDA) of 1996 (Pl. L. 104-303), as amended, also referred to as Section 206 under the Continuing Authorities Program provides authority for the USACE to participate in planning, engineering and design, and construction of projects to restore degraded aquatic system structure, function, and dynamic processes to a less degraded, more natural condition when the restoration would improve the environment, is in the public interest, and is cost-effective, as described in the USACE Planning Guidance Notebook. The guidance utilized for a Section 206 study was generally applied to the study conducted under the Committee Resolution.

Purpose of Action

The USACE and the City of Brownsville (Brownsville), Texas, would restore the unique, rare, and endangered resaca habitat at a landscape level within the study area. Specifically, the study is to identify degraded areas for potential habitat restoration facilitating the creation of improved habitat and wildlife connectivity corridors within and across Brownsville. See Figure I-1 for the location and study area.

The resaca resource significance assessment, in accordance with regulations implementing the NEPA, is discussed later in this report. The conclusion is the resaca habitat meets the definition of "significant" as determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition. Pictures, scientific descriptions, and lists of species provide technical insight into the resacas, but a visceral understanding may be gained by the description of E. Dan Klepper, writing for the Texas Parks and Wildlife magazine in October 2008 about the Resaca de la Palma State Park.

> *"Resacas, with their marshy habitats composting in remnant floodwaters, are important components of the Rio Grande's Tamaulipan thorn scrub and are invariably the source of both its dampness and decay. These ancient river channels provide conduits for floodplains to negotiate periodic and natural inundations. The resulting resacas form arterial, snake-like patterns across the landscape. Before the advent of dams along the Rio Grande, resacas performed nature's own flood control and assisted wildlife that depended on their peculiar environs to survive and thrive.*
>
> *Nature, in fact, loves a resaca. It is the womb from which all manner of bugs and beasts are born. Its water harbors shore,*

song and sea birds; the nimble branchwork above it gives rise to nests, eggs and wings; and its mud coddles and then recycles frogs, turtles, and insects. Quietly watching a resaca in scrub shadow grants witness to a semitropical world in full swing – green jays chatter and feed, dragonflies strafe the water's edge, bobcats drink, then scatter.

But once daylight lags, darkness comes quickly to a resaca's thorn scrub, and night is its inhabitants' milieu. Great horned owls haunt the canopy, ocelots stalk prey, Mexican treefrogs squeak like bed springs, indigo snakes thread the resaca cattails, and Rio Grande lesser sirens (a type of salamander) surface the mud with a click-click-click of odd, amphibian song. Fireflies ignite and beacon a crazy course through an impenetrable morass so remarkably dense that humans are no more hamstrung by it in darkness than they are by the light of day."

The purpose of the action would restore one or more of the three resacas that cross the urban landscape of Brownsville, to simulate the quality of habitat, diversity of plant and animal species, and ecological connectivity found in the Resaca de la Palma State Park and other reference resacas.

Scope

The scope of the study is to identify potential restoration measures and alternatives to restore the resaca ecosystems, identify a National Ecosystem Restoration (NER) plan in the federal interest, and evaluate the environmental impacts of the proposed restoration.

The scope of the study area is the three resacas in the vicinity of Brownsville:

- Resaca de la Guerra,
- Resaca del Rancho Viejo, and
- Town Resaca

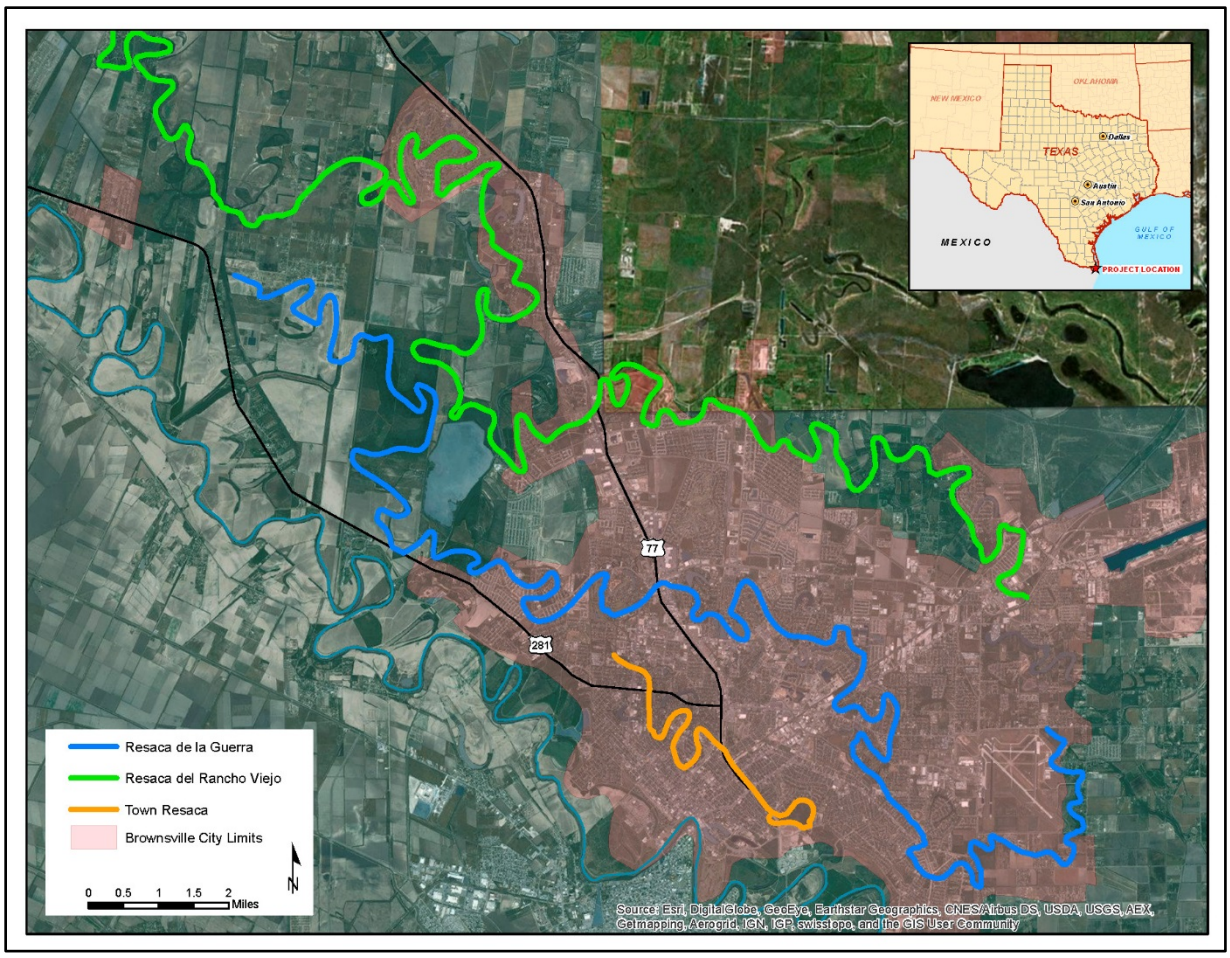

Figure I-1:Resacas de la Guerra, del Rancho Viejo, and Town Resaca

Study Area

The City of Brownsville is located at the southern tip of Cameron County, Texas (Figure I-3). The study area includes three separate resaca systems: Resaca de la Guerra transecting the middle portion of the city, Resaca del Rancho Viejo stretching west to east across the northern portion of Brownsville, and the Town Resaca system located at the southwestern portion of the city. The study area encompasses the parts of the resaca systems from the edge of the western Brownsville city limit to the eastern city limit boundary, inclusive of Cameron County inholdings.

At the beginning of an ecosystem restoration feasibility study, a project delivery team has an initial conceptualization of the physical conditions in an area and the causes of the ecosystem losses that have occurred over time. That understanding is achieved from observations by the team members interpreted through their collective experiences of other projects and their general knowledge.

Study Documentation

As the study progresses through the six planning steps and knowledge is gained, the team's understanding of the issues improves. As that understanding improves, it is necessary to readdress the plan formulation steps already taken, so that less informed decisions are validated or revised.

That process and the plan formulation statements that guide the study are intended to assure that the formulation process identifies a reasonably optimal solution. This iterative planning process is an effective systematic procedure. However, documenting the iterations, which may include numerous step loops, can be difficult. Fortunately, for the reader the feasibility report is not a diary or chronology of day-to-day effort and decisions. The information is summarized and is generally presented as if the six planning steps had been conducted in sequence without iterations.

At times, the reader may be provided with advance information that offers a look ahead in the report for the purpose of providing a clear understanding of the process. An example is an overview of the recommended plan later in this introduction. The plan is not identified until Chapter 6. At times, the advance information may point out a formulation revision.

The USACE Goal of Ecosystem Restoration

Ecosystem restoration is one of the primary missions of the USACE. The goal is to increase the net quantity and/or quality of preferred ecosystem resources. Ecosystem restoration projects are to be formulated in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating functioning systems wherever those restoration features improve the value and function of the overall ecosystem. The purpose is to restore significant ecosystem function, structure, and dynamic processes that have been degraded. Protection may be included to prevent future degradation of an ecosystem's structure and functions.

Legislative Interests

Federal Senators John Cornyn and Ted Cruz, and Representative Filemón Bartolomé Vela Jr. (District 34) serve Brownsville.

Sponsors

The federal sponsor is the USACE, represented by the Galveston District (CESWG). The non-federal sponsor is the City of Brownsville, Texas. About 54 acres of restoration would be on U.S. Fish and Wildlife Service (USFWS) lands. The USACE could not implement that effort. That restoration is discussed in Chapter 6.

The City of Brownsville

The City of Brownsville has a population of about 183,000 and covers about 146 square miles (about 93,500 acres). Urbanization along the resacas has resulted in the replacement of many native plant species with non-native ornamental and invasive species. Urban landscaping adjacent to the resacas has converted native thornscrub habitat to turf grass and non-native and invasive ornamentals, shrubs, and trees. The resaca habitat is about 3.7 percent of the land use in the City.

Before construction of the International Falcon Dam and Reservoir and other lakes on the Rio Grande, the entire lower valley was subject to flooding during times of high river flow. The purpose for building these reservoirs was to reduce flooding in the Rio Grande River floodplain.

Resacas are former channels of the Rio Grande located in Cameron County, Texas, and Tamaulipas, Mexico, formed by major flooding. The word “Resaca” is unique to the Rio Grande lower valley. The term identifies both the entire former channels and individual pockets of habitat along the former channel. Figure I-2 provides a view of the former resacas in the vicinity of the City of Brownsville, Texas and the remaining resacas in Mexico. Loss of connectivity along each of the resaca has disrupted flora and fauna migration between these resacas and to the surrounding high quality managed habitat east and west of the project area.

Without Rio Grande flooding, the resacas would have dried out except for rainfall runoff. The habitat value would have been essentially lost over time even without the losses due to industrialization (agriculture and urbanization). However, with urbanization, a series of locally implemented water diversion and irrigation canals were developed to manage water levels in the resacas. Water is added when needed and storm water runoff is diverted among the resacas to reduce economic damages of flooding. The resacas are variously used for irrigation, raw water supply conveyance, stormwater drainage, and recreation. They also provide a scarce aesthetic value in this highly urbanized subtropical landscape.

Over time, public awareness of the ecological significance and value of the resacas has increased and Brownsville has taken significant steps to preserve and restore the habitat. Brownsville has large scale plans for restoration, however, the scope of the restoration effort needed, and the urgency to preserve and restore the habitat before it is lost, prompted the City to approach the USACE as a partner for the restoration effort.

Ecosystem Value

One of the questions often asked about ecosystem habitat destruction is, “So what?” While environmentalists view the question as naive, many in the public do not have the environmental background to recognize the function and value of natural habitat, neither do they recognize the impacts of loss of habitat to humans. The following is a brief explanation of why habitat destruction is of great concern and why there is a critical need to protect and restore habitat.

First some simple definitions.

- **Habitat:** The place or environment where a plant or animal naturally or normally lives and grows.
- **Ecosystem:** The complex community of organisms and its environment functioning as an ecological unit. An ecosystem encompasses the interrelationships between living organisms (plants and animals) and the nonliving environment (rock, soil, water, air, temperature, sunlight, elements, compounds).
- **What’s the Difference:** A habitat is a place where an organism (animal, plant, human) lives, but an ecosystem is a group of organisms plus the entire surrounding environment. One analogy has suggested that an ecosystem is the neighborhood and the habitat is the address.

Ecosystems are the natural habitats composed of the physical, chemical, and biological systems that support the plants, animals, fungi, and microbes (microorganisms that include bacteria, protozoa, fungi, algae, amoebas, and slime molds). Habitats are the places where these organisms live. Therefore, the result of degradation or loss of habitat caused by natural or human-caused activities is that fewer (or no) species can live there. The loss of habitat degrades the surrounding ecosystem and in turn impacts the human population, not just in the nearby ecosystem, but potentially in distant ecosystems.

Numerous agencies and organizations are desperately trying to preserve and restore ecosystems around the planet, including the Brownsville Resacas and the surrounding upland components of habitat. The question remains, “So what?” and a reasonable second question is, “Why is the USACE involved?” The USACE may participate in this study because legislation has provided the agency with authority to

restore significant ecosystem function, structure, and dynamic processes that have been degraded. Through various legislation, ecosystem restoration has become one of the primary missions of the USACE. Specifically, under the authority provided by Section 206 of the Water Resources Development Act of 1996, the USACE may plan, design, and build projects to restore aquatic ecosystems for fish and wildlife. Still, the question remains for the lost resacas habitat, “So what?”

For some of those concerned about habitat destruction, the primary focus is compassion for other species that share this planet. For others, the primary focus stems from an understanding that humans are part of the broader ecological functions, and we depend on the natural systems for our own survival. However, the fundamental issue for the USACE is that natural systems create the air we breathe, break down our wastes, provide our food, purify our drinking water, control the climate, control disease, and ultimately supply all the materials we require for living. When habitat is impacted or destroyed in one area, the quantity and quality of the benefits of those systems are reduced or lost and there are negative consequences to humans.

The consequences may be immediate and apparent or they may be slowly incurred through transferred health or economic costs to other natural resources; or they may be less tangible but significant social or cultural losses. An example of immediate consequences would be erosion and flash flooding that might result from clear cutting of timber. Transferred costs might consist of increased water treatment costs resulting from the destruction of wetlands. An example of social and cultural consequences would be the loss of native plants, animals, or waters significant to traditional native culture. These consequences would lead to transferred economic costs because of diminished recreation opportunities and spending that would leave the county or state. Whatever the consequences are, they will be borne by humans as well as the affected plants and animals.

The benefits of ecosystems are called “services,” and are categorized in many different ways. Four frequently used categories are:

1. Provisioning (such as the production of food and water);
2. Regulating (such as the control of climate and disease);
3. Supporting (such as nutrient cycles and crop pollination); and
4. Cultural (such as spiritual and recreational benefits).

Habitat destruction anywhere will result in consequences in one or more of these services. The challenges for the evaluation of these impacts and the recommendation of restoration efforts are numerous. The ecosystems are complex an assessment of them relies primarily on professional experience and judgment aided by technology.

These ecosystem service categories are high-level layers and this study will only evaluate relatively low-level layers of habitat restoration and ecological connectivity, but it is necessary to understand the concepts and to recognize that restoration and connectivity (defined below) improves these ecosystem services. That is the answer to “So what?” at the highest level.

The limitations of federal and local budgets require the prioritization of not only which ecosystem restoration projects should be implemented, but the prioritization of ecosystem restoration versus other federal and local needs.

The following summary presents an overview of the need and priority for restoration of the resacas in the vicinity of Brownsville.

This summary presents two central issues: One, the loss of nearly all of the Resaca habitat; and two, the loss of connectivity provided by that habitat.

Here is the definition of connectivity:

> *Connectivity spans many concepts that are dependent on species, opportunities for linkage to broader areas, and the purpose of species movement, such as migration, dispersion of populations, or home range activities. Due to the urban nature of the lower Rio Grande Valley, the USFWS and the Texas Parks and Wildlife Department (TPWD) strategy on creating habitat connectivity is through the restoration of “stepping stone” habitats. The stepping stone concept provides a series of nearby patches of habitat that can be used as refuge habitat for dispersing wildlife such as the ocelot and jaguarundi. The ocelot and jaguarundi species recovery plans specify this strategy as a key tool in the recovery of these species. These habitats also provide essential habitat for other wildlife species such as smaller mammals, birds, reptiles, and amphibians. The proposed restoration plan creates a corridor of stepping stone habitats linking high quality resource agency managed lands east of Brownsville to those in the west. Connectivity is not dependent on a continuous riparian buffer, that might exist along Midwestern or eastern streams.*

Need For Action

Resacas are former channels of the Rio Grande located in Cameron County, Texas, and Tamaulipas, Mexico. Figure I-2 shows the general area. The word “Resaca” is unique to the Rio Grande lower valley. The term identifies both the entire former channels and individual pockets of habitat along the former channel. Figure I-2 shows the courses of some former resacas that can be identified in the vicinity of the City of Brownsville, Texas and the remaining resacas in Mexico.

The former resacas contributed significantly to a regional ecosystem encompassing about 7,000 square miles in the lower Rio Grande delta. The delta covers an area about 100 miles (roughly) west to east and about 130 miles (roughly) north to south.

Natural succession in each of the resacas would have tended to reduce the habitat quality. Depending on local rainfall, runoff, and subsequent Rio Grande flooding, some of the existing resacas would have declined and essentially ceased to exist. However, others would have reached a somewhat stable condition. The stable resacas would have looked like the images in Figure I-4.

Most importantly for the historic ecosystem, new resacas would have been formed when large flood events occurred in the lower Rio Grande. As the habitat quantity and quality would shift across the floodplain, wildlife would have followed. The historic resaca habitat would have connected all of the surrounding upland habitat. The extent of upland connection just six miles beyond the resaca habitat would have consisted of about 2,300 square miles. At ten miles beyond the resacas habitat the upland connection would have consisted of 3,900 square miles (2.5 million acres).

Figure I-2: A View of the Lower Rio Grande Valley Resacas

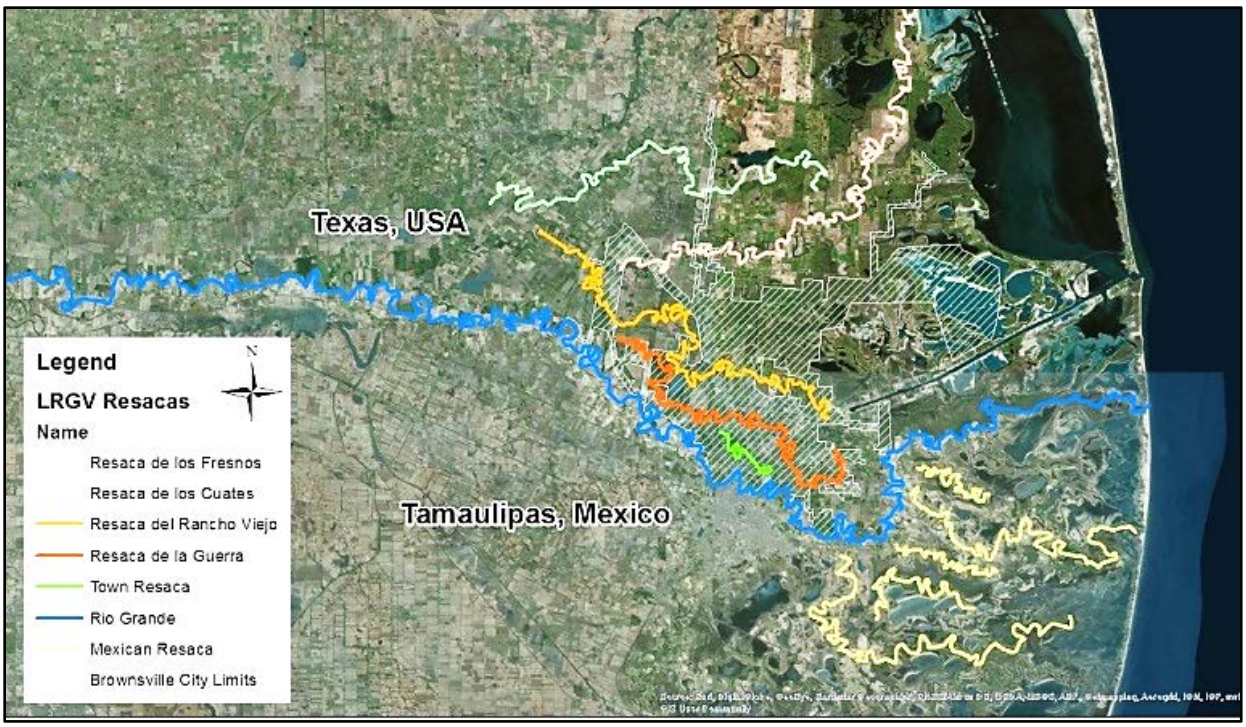

Figure I-3: Map of the Brownsville, Texas area. (Map courtesy of DurangoTexas.com)

Before major flooding in the lower Rio Grande Valley was managed by the two nearest upstream reservoirs (Amistad Dam and Reservoir and Falcon Dam and International Reservoir) and roughly twenty large management structures upstream on the Rio Grande, plus five large management reservoirs on the Pecos River tributary, major floods would erode new Rio Grande channels to the Gulf. The old channels would be isolated and cut off from normal Rio Grande flow. The Rio Grande would stabilize miles away from the former abandoned course. The former channels would become isolated, narrow bodies of shallow water with depths between 4 to 6 feet. While hydraulically isolated from the normal Rio Grande flow, the old channels (resacas) would be inundated by Rio Grande floods, and the resacas would also receive local rainfall runoff. This natural water budget supported an evolving and unique ecosystem along the many resacas.

The creation of resacas is somewhat similar to the creation of riverine meanders created by erosion and accretion but the changes in the Rio Grande floodplain would create tens of miles of new channel in a period of days. That new channel would develop a new aquatic and riparian habitat. The old channel (resaca) would adjust to the change in conditions.

Ecosystems everywhere change over time due to changing conditions. One term used to describe the change that occurs in a natural environment is succession. Until significant anthropogenic changes started in the 1870s, resaca habitat looked similar to the images below (Figure I-4).

Figure I-4: View of how Resacas once appeared

The resacas provided an abundance of habitat that provided ecological connections (corridors) through the 7,000 square mile flood plain ecosystem and to the surrounding upland. The historic habitat acreage is difficult to estimate because of the large area in Mexico and the U.S. and the significant impact of agriculture. The time and cost of a geomorphological investigation would be prohibitive. But, by using the current acreage per resaca, adjusted for urbanization, and the distribution of known historic resaca, a ratio to the overall floodplain can be used to make a conservative estimate. Using this approach, there may have been about 70,000 acres of resaca habitat before the 1800s.

When irrigation practices were introduced in the 1870s that shifting and self-perpetuating system began to be lost. The native riparian resaca communities are predominantly comprised of three dense, thornscrub vegetation associations: Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony-Snake Eyes Shrubland. These vegetation associations are found exclusively in the Lower Rio Grande Valley and are considered critically imperiled with extinction or elimination (Diamond, 1993). The loss of native thornscrub vegetation, including resaca habitats, to cultivated agriculture uses has resulted in the loss of 95 percent of thorn-scrub habitat in the LRGV and 99 percent of riparian resaca habitats (Jahrsdoerfer and Leslie, 1988).

As regional and national populations increased in the U.S. and Mexico, the urban areas of Brownsville, Texas, and Matamoras, Mexico, expanded. Agriculture expanded within the fertile Rio Grande valley in both countries to meet demands. Damage to the resacas has been the direct result of over 100 years of agricultural expansion and urbanization. While these are the direct impacts, the implementation of flood risk management projects by the U.S. and Mexico on and throughout the Rio Grande Basin resulted in the virtual elimination of major floods in the lower Rio Grande Valley delta. The reduced risk of flooding enabled the urbanization and agricultural expansion in the delta. Those projects also included agricultural water supply, which further enabled agricultural to benefit from the rich delta soils. The end result was the loss of 99 percent of the historic resaca habitat, including the virtual elimination of resaca habitat in Mexico.

The outlook is grim for the remaining resaca habitat if federal support isn't forthcoming. Without that support, the forecast scenario is for the essential loss of the ecosystem function, processes, and value of the resacas. The outlook is summarized below:

- Without major Rio Grande flooding, there will never be a new resaca formed. The remaining one percent of the unique habitat will never be increased and the quality will decline and be lost.
- If the remaining resacas are not preserved and restored, they will be lost either to agriculture or urbanization, or through the natural succession process of aging.
- The aquatic component will eventually be lost as sediment fills the channels.
- Even before the water volume is completely lost, the shallow intermittent pools will not support aquatic ecosystem processes.
- The loss of the aquatic processes will diminish the adjoining riparian ecosystem.
- Invasive plant species already exist throughout the Resacas in Brownsville, Texas. These species will tend to out compete the native species, further diminishing the quality of the habitat.

The image of agricultural fields in Mexico, Figure I-5, shows one of the areas where resaca were, but can no longer be identified.

Figure I-5: Agricultural Areas Where Resacas Once Were In Mexico

The image below (Figure I-6) simulates a resaca that has aged and been impacted by clearing and an invasive monoculture that provides some aquatic habitat but minimal riparian habitat.

Figure I-6: Image of a Resaca Suffering from Habitat Destruction

The image below (Figure I-7) is along a former resaca developed as a city park. Urbanization for residential and commercial development, and the necessary transportation and other infrastructure, has eliminated other segments of the natural resaca habitat.

Figure I-7: A View of an Urbanized Resaca

The three resacas evaluated in the vicinity of Brownsville consist of about 3,500 acres of habitat. The connectivity has been lost due to urbanization. This habitat has also become ecologically disconnected from the surrounding ecosystem for most species due largely to agricultural practices. The habitat consists of vegetation communities that are extremely rare and at a high risk of extinction.

At one time, these resacas were connected to the surrounding ecosystem and provided transportation corridors to the Rio Grande, among resacas, and to nearby upland habitat. This beneficial connection was a significant ecological component of the lower Rio Grande ecosystem. The low-lying Rio Grande delta encompassed about 4.5 million acres. An estimated 70,000 acres of resaca habitat provided connections throughout the delta and to millions of acres of surrounding Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland. The USFWS recognizes the vegetation communities that evolved around the scarce remaining resaca habitat in Brownsville as nationally significant.

For 150 years the resaca ecosystem has been continuously impacted by agriculture and urbanization. The condition of the remaining habitat reflects two ecological problems:

1. Segmentation is the result of overall industrialization, which includes urbanization (roadways, developments, utility lines, etc.) and agricultural development. Segmentation disrupts hydrologic flows, which has adversely affected habitat quality and quantity,
2. Loss of connectivity along each of the target resaca has disrupted flora and fauna migration between these resacas and to the surrounding high quality managed habitat east and west of the project area, also due to loss of quality and quantity.

The remaining resacas habitat is isolated from high quality habitat in the area. The areas are the native thorn-scrub and resaca habitats at the Resaca de la Palma State Park (1,200 acres), the Nature Conservancy's Southmost Preserve (1,034 acres), the Audubon Society's Sabal Palm Sanctuary (527 acres), and Camp Lula Sams (86 acres).

The remnant resaca habitat within the study area provides an excellent opportunity for restoration. Restoration of the target resacas would provide an equally valuable opportunity to connect as wildlife corridors this habitat to the surrounding high value habitat managed by various agencies and interests.

Figure I-8 shows how the restored resacas of the recommended plan (shown in red) would provide connections across the City of Brownsville among the existing, managed, high quality areas.

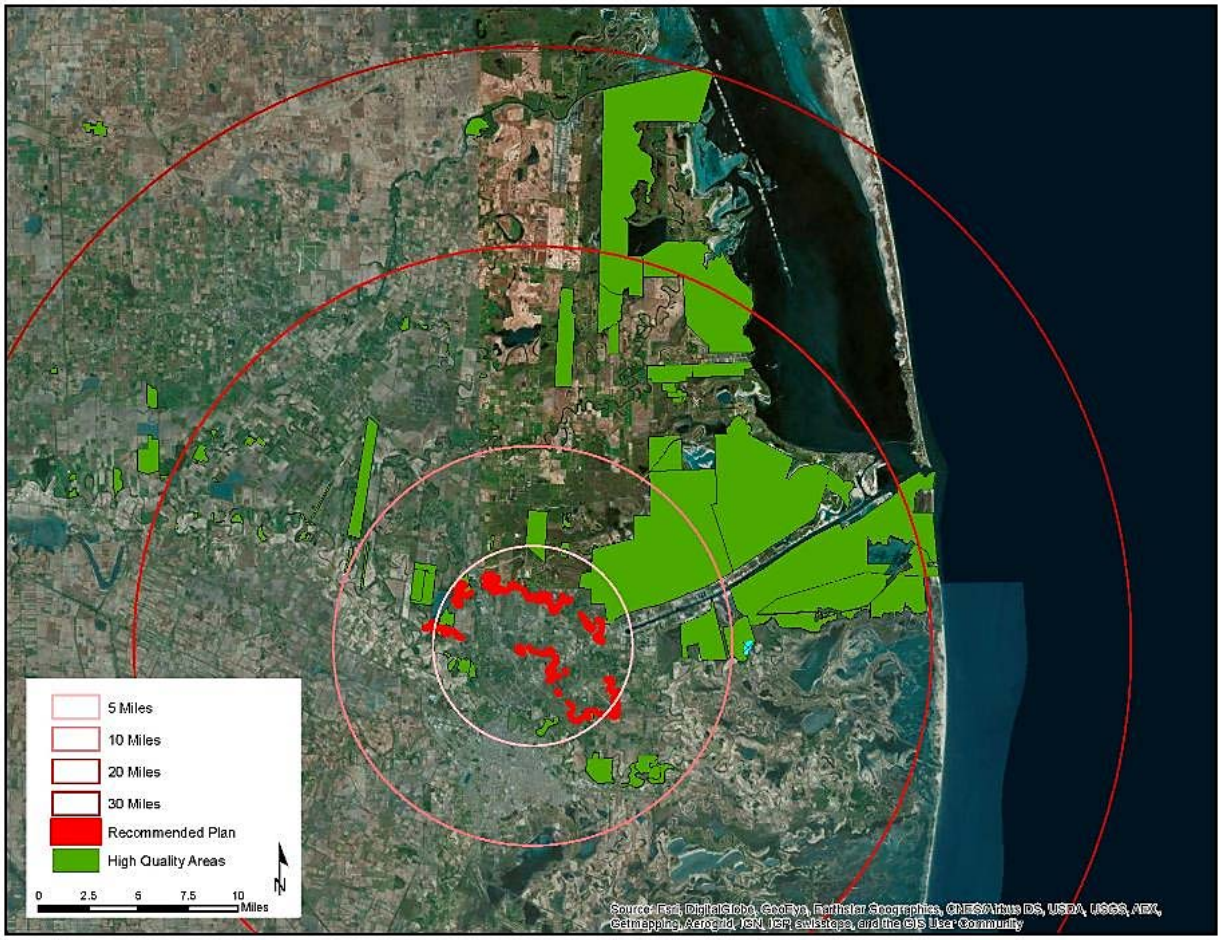

Figure I-8: A View of the Restored Resacas of the Recommended Plan

The feasibility study and implementation would be an interim response to the study authority. The resource is nationally significant and consists of vegetation communities that are extremely rare and at a high risk of extinction. The destruction

of 95 percent of thorn-scrub habitat in the Lower Rio Grande Valley and 99 percent of riparian resaca habitats shows the severe impact to this ecosystem.

There are about 3,500 acres of remaining resaca habitat in the study area described by the authorization – the vicinity of Brownsville, Texas. The recommended plan would restore about 24 percent of that habitat. By identifying this feasibility study as an interim response to the authorization, an opportunity would be preserved to restore additional resaca habitat in the future. The significance of the resaca habitat and its value to the surrounding ecosystem are of national importance. Preserving the opportunity to restore additional habitat in the future is supported by the USACE Environmental Operating Principles and Campaign Plan goals.

The principles are:

1. Foster sustainability as a way of life throughout the organization.

2. Proactively consider environmental consequences of all Corps activities and act accordingly.

3. Create mutually supporting economic and environmentally sustainable solutions.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.

5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

6. Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.

7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

The preserved study opportunity would apply to the second principle by considering and acting to maintain and existing authority to allow additional restoration or rare and endangered resaca habitat in the future. The opportunity would apply to the third principle by maintaining the ability to address additional economic and environmental prospects. The fourth principle would apply by maintaining the ability of the USACE to act on its responsibility to avoid impacts to humans and protect and restore natural environments. The scientific knowledge to be gained from implementation of the recommended plan would apply to the sixth principle by providing an opportunity to leverage that knowledge and collaborate with other resource agencies in the study and implementation of additional restoration of resaca habitat. The local sponsor and resource agencies appreciate the opportunity of federal assistance and the USACE commitment to economic and environmentally sustainable solutions. Those interests see the opportunity for the USACE to conduct an additional resaca restoration study in the future as a beneficial decision.

The applicable Campaign Plan goal is Goal 2 – Deliver Integrated Water Resource Solutions. The goal has four objectives

1. Deliver Quality Water Resource Solutions and Services

2. Deliver the Civil Works Program and innovative solutions

3. Develop the Civil Works Program to meet the future needs of the Nation

4. Manage the life-cycle of water resources infrastructure systems to consistently deliver reliable and sustainable performance

The preserved study opportunity would apply to the Campaign Plan goal's objectives one and three by maintaining the ability to initiate a restoration study in the timeliest manner in the future.

Previous Studies and Constructed Projects

Resaca restoration and preservation efforts have been limited to the last 15 to 20 years and only a fraction of high quality resaca habitats remain. The TPWD, the Nature Conservancy (TNC), the USFWS, the National Park Service (NPS), the Environmental Protection Agency (EPA) and the City of Brownsville have ongoing or completed resaca restoration projects. This study is an opportunity to provide connectivity to these other areas. The USACE has worked with local technical experts from the TPWD, TNC, and the USFWS to identify management measures that have either been successfully applied to resacas restoration efforts or are suitable to address specific habitat degradation in the project study resacas.

The USFWS, the TPWD, and TNC have been acquiring Tamaulipan thornscrub habitats due to the rarity of those ecosystems and their connection to highly endangered fish and wildlife resources. Some of these conservation efforts have incorporated the aquatic component of these habitats. These areas include Resaca de la Palma State Park, Laguna Atascosa National Wildlife Refuge, Resaca de la Palma National Battlefield, and TNC Southmost Preserve.

Resaca restoration has occurred relatively recently so information on restoration success is documented primarily on agency or non-government agency websites rather than via peer reviewed journal articles. There is however, a wealth of information regarding restoration success of Tamaulipan thornscrub vegetation habitat, which is typically connected to resacas habitat.

The restoration of the Resaca de la Palma State Park incorporated measures such as piping, pumps, levees, and water control structures to restore water connectivity creating an environment that allowed for a significant positive response by the aquatic emergent and riparian vegetation (Klepper, 2008). The results at TNC Southmost Preserve were similar. The success of the restoration is represented by the emergence of these two sites as premier birding areas in the LRGV. The state park and preserve were used as reference sites for the habitat modeling efforts for this feasibility study.

Although not specifically resaca focused, the USFWS has been restoring Tamaulipan thornscrub habitat for the last three-and-a-half decades. Although numerous lessons were learned early on in the development of restoration methodologies, the USFWS and TNC have had great success in the revegetation of fallow farmlands and areas with suboptimal habitats throughout the LRGV (Vora, 1989, Vora, 1992, Ewing and Best, 2004). By planting resacas-specific vegetation areas of refuges have been created and conservation easements lands have been restored.

The Brownsville Public Utility Board (BPUB) has completed construction of an ecosystem restoration project on Town Resaca adjacent to the old Brownsville Cemetery. This restoration was focused on improving water quality within the resaca through riparian planting, water quality filter strips, and erosion armoring.

The early success of these restoration efforts proves that the restoration measures planned for this project (hydrologic manipulation, invasive control, targeted vegetation planting, etc.) would result in project success. In particular, the USFWS work on revegetation of resacas/Tamaulipan habitat (Ewing and Best, 2004) includes many technical details likely to be included in the vegetation restoration plan developed for this project.

Resource Significance

Resource significance is determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition in the study area. In compliance with the Council of Environmental Quality (CEQ) NEPA regulations (40 Code of Federal Regulations (CFR) 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)), guidance for the USACE ecosystem restoration projects require the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). “Significant” is defined as “likely to have a material bearing on the decision-making process” (Apogee Research, Inc., 1996). The P&G defines these significance criteria as:

- Institutional Recognition: The importance of the resource or attribute is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups.
- Public Recognition: The resource or attribute is considered important by some segment of the general public.
- Technical Recognition: The importance of the resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

The area is home to plant and animal species found nowhere else in the United States. The presence of rare communities combined with the areas' rich diversity of bird and butterfly species make this area one of the state's most popular nature tourism destinations.

Diverse plant and animal species and many rare species are found in the resaca ecosystems of the reference resaca. That diversity of plant and animal species would be achieved by restoration of the Brownsville resacas. The amalgamated ecosystem of aquatic and riparian habitats provides greater environmental outputs than would be possible as separate habitats. Over millions of years, this ecosystem has become a unique assemblage of plants and animals found nowhere else on earth.

The variety of resaca species supports a large ecotourism industry in the Lower Rio Grande Valley. Bird watchers from around the world travel to observe species found nowhere else in the U.S. Unique birds include the plain chachalaca, white-tailed kite, gray hawk, Harris's hawk, white-tailed hawk, common ground dove, white-tipped dove, northern beardless-tyrannulet, great kiskadee, tropical kingbird, green jay, long-billed thrasher, tropical parula, Altamira oriole, and Audubon's oriole. The invertebrate community of the resacas is equally diverse with species that include the Tamaulipan agapema (a moth) found nowhere else. Amphibian and reptile species include the black-spotted newt, south Texas siren, indigo snake, black-striped snake, northern cat-eyed snake, and the Texas scarlet snake. Other unique species include the red-crowned parrot *(Amazona viridigenalis)*, black-spotted newt (*Notophthalmus meridionalis*), South Texas siren *(Siren sp 1),* Brownsville common yellowthroat *(Geothlypis trichas insperata)*, and Tamaulipan agapema *(Agapema galbina)* utilize urban resacas. All resident species are discussed in greater detail in Chapter 2.

The proposed restoration measures reflect the structure and function of high quality reference resacas. Each of the proposed restoration measures would benefit native plants and animals of the resaca ecosystem. Dredging and excavating of resacas and construction of water control structures would create the foundation for restoration because water drives the diversity of the ecosystem. Dredging and water control has been successfully implemented at the Resaca de la Palma State Park and TNC Southmost Preserve. Dredging would mimic the sediment flushing function in the resacas by physically removing accumulated sediments down to the clay layer of the resaca bed.

The dredging would increase the water depth and storage capacity of the resaca, thereby increasing the volume of the aquatic habitat. The greater volume would provide ancillary water quality benefits by mediating water temperatures and dissolved oxygen concentrations.

Restoring the resaca bank slopes and vegetation would support the life processes and transitioning of amphibian species from egg to adult. The restored banks would promote the growth of aquatic and emergent plant vegetation that would provide cover for small fishes and amphibians, and would aid in reducing sedimentation of the resacas. Bank slope restoration would alter the existing steep bank to a varied 1:10 to 1:15 grade. It would also inhibit vermiculated sailfin catfish spawning – the vermiculated sailfin catfish is an invasive species. The relaxed slope would allow the dissipation of erosive energies to be spread over a greater area, reducing bank erosion and sedimentation of the resacas.

Resaca shorelines and wetlands would be planted with hydrophilic (water loving) vegetation making these areas highly productive environments for many species of fish, reptiles, amphibians, birds, invertebrates, and mammals. The aquatic habitat and emergent vegetation would provide cover for the state-listed Coues' rice rat.

The removal and control of invasive plants would be the first step in reestablishing native terrestrial plants. The resaca nutrient cycling function has been lost due to the flood control projects implemented along the Rio Grande.

Riparian soil supplementation would be the next step after removal of invasive species. Dredged material from the resacas would be used to supplement the soils of riparian habitats. The soil supplementation would restore nutrients to the riparian soils leached out over the extended period of flood control. The nutrient enrichment would promote establishment and growth of native vegetation communities. In addition, the restored vegetation communities would benefit native invertebrate, amphibian, avian, and mammalian communities dependent on healthy resaca environments.

A grassland seed mix would be sown in the riparian area. The mix would include early successional native plant species. The grass establishment would minimize erosion until native planted species would become established. Replanting of assorted native vegetation communities, consistent with the aquatic, emergent, and riparian planting measures would begin the establishment of habitat that would support fish and wildlife. Planting would include the reestablishment of site-specific, native plant species associated with Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland vegetation associations.

The two most important needs of the resaca ecosystem are restoration of the habitat to recover loss of segmentation and connectivity, both aquatic and terrestrial; and restoration of the ecological connections, both among restoration areas and to the surrounding ecosystem. All of the proposed measures would combine to meet these needs. The connections would support invertebrates, fishes, amphibians, reptiles, avian, and mammalian species that rely on this rare ecosystem for all or portions of their life cycles. Following are a few of the animal species of interest that are found in the resaca ecosystem.


Black Spotted Newt


Red-crowned Parrot


Rose-throated Becard


Ocelot


Jaguarundi


Tropical Parula

Projects Planned or Under Construction

The USACE, Galveston District (SWG), and the City of Brownsville are in the Pre-construction Engineering and Design (PED) phase of a Section 206 (Aquatic Ecosystem Restoration) project on the Town Resaca at a location identified as the Resaca Boulevard Resaca. The 206 study was used as a “test” study for this current

Brownsville Resaca study. The identification of restoration measures, the development of a habitat quality model, and the plan formulation were processes initiated during the Section 206 study. Lessons learned were incorporated into this feasibility study.

The USFWS, the TPWD, and TNC continue to identify Tamaulipan thornscrub habitats as high priority ecosystems and continue to preserve, conserve, and restore this habitat throughout LRGV. However, the resacas (the aquatic component of the Tamaulipan thornscrub habitats) are underrepresented in these restoration efforts.

Decision

The USACE and the City of Brownsville must consider and decide on a viable alternative meeting the project goal of restoring aquatic and terrestrial complexes for one or more of three resacas. The resacas are:

- Resaca de la Guerra,
- Resaca del Rancho Viejo, and
- Town Resaca

If this evaluation identifies a cost effective and sustainable plan meeting the study objectives and constraints, the plan would be recommended for implementation as the National Ecosystem Restoration plan.

The Recommended Plan

The 66 individual segmented resaca areas were identified and evaluated for potential restoration. All of the areas identified were highly degraded. The result of the restoration evaluation was the identification of a NER plan to restore 44 areas. The plan (Alternative 5) would restore aquatic and terrestrial complexes as self-regulating functioning systems in Resaca de la Guerra and Resaca del Rancho Viejo. The restoration of Town Resaca would not be recommended for restoration at this time. While its restoration would be implementable and beneficial, the ecological output of that effort would be less cost effective than restoration efforts in the other two resacas.

In total, the plan would restore 845 acres of aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo. For the recommended plan, about 625 acres of terrestrial riparian habitat would be cleared of invasive species of plants, and native species would be replanted. An **implementation plan** would restore about 218 acres of aquatic habitat through the removal of sediment, by shaping banks, and by planting aquatic and emergent vegetation along 33 miles of shoreline. After implementation, a **management plan** would continue with monitoring and management of invasive species. The recommended plan identified

cost effective restoration measures on 763 acres of city and private lands; 28 acres of TPWD lands, and 54 acres of USFW lands.

Plan Formulation Methodology and Connectivity Assessment

Plan formulation would use cost effectiveness and incremental cost analysis for quantifiable benefits based on an ecological model and qualitative benefits associated with connectivity. The connectivity benefits are an important ecological concept in fragmented habitats such as the urban and agricultural landscapes of the Brownsville study area. Travel corridors connecting isolated patches are critical for the dispersal and survival of species.

The connectivity of the resacas would be considered at two scales. At the first scale, the proposed restoration measures ensure linear connectivity of aquatic habitats along each of the resacas. This would provide direct connectivity for fish and amphibian species that require water for their dispersal. The existing riparian habitat is degraded and provides virtually no connectivity. Restoration measures would provide high quality habitat areas spaced from 20 feet to approximately 5,000 feet. These areas would provide connectivity through a stepping stone approach, which is the method of developing travel corridors utilized by the USFWS and TPWD for the conservation of the ocelot and jaguarundi (USFWS, 2013; USFWS, 2016b).

The stepping stone approach would benefit floral and faunal species differently because of their disparate habitat requirements (Brooker et al., 1999). The ocelot and jaguarundi travel across gaps of inhospitable habitat beyond the 5,000-foot maximum habitat gap in the proposed alternatives, while a tree frog may require habitat gaps 20 to 30 feet because of their arboreal nature and the safety provided by the tree canopy. Habitat connectivity is more important to specialist species and these conditions are even more important for resaca habitats because the high species richness is comprised of many habitat specialists that evolved with the resaca ecosystem.

Although less dependent on connectivity, habitat patches in the fragmented urban landscape provide urban reserves for plant conservation, restoring the highly imperiled vegetation communities within the study area (Kendal et al., 2017).

Direct linear connectivity for aquatic species would be achieved by the dredging and excavation of restoration areas. This measure would ensure direct aquatic connection for fish, amphibian, and reptile species such as the Rio Grande perch, the red-eared sunfish, the black-spotted newt, and the south Texas siren. The newt and the siren, are especially significant because they are known to inhabit urban portions of the resacas. Restoration of the amphibian populations would be dependent on the direct connectivity of aquatic habitats.

The second scale of connectivity is the lateral connectivity between the aquatic and riparian resaca ecosystems, and surrounding upland communities. The resacas are the aquatic component of the Tamaulipan thornscrub ecosystem. The restoration of the upland and aquatic components of this ecosystem provides exponentially greater habitat benefits. This is because the width of the habitat corridor is wider, resulting in a more buffered travel corridor. The upland species are provided a water source with continuous habitat across the resaca/upland interface. High quality upland areas adjacent to the resacas within the study area are managed by natural resource agencies and the NGO and are thereby protected from development. (Prugh, L. et al., 2008); (Tischendorf, L., and Wissell, C., 1997); (Rail, J., Darveau,M et al., 1997); (Ruefenacht, B. and R. Knight. 2017. Ruefenacht, B. and R. Knight. 2017).

The stepping stone strategy for increasing connectivity is not limited to the ocelot and jaguarundi. This strategy is frequently used by ecologists when dealing with highly fragmented systems such as the agricultural and urban environments of the resacas (Saura, S et al., 2014.); (Saura, S and L Rubio, 2010.); (Bierwagen, B, 2007.); (Baum, K et al., 2004.); (Sondgerath, D and B Schroder, 2002.). Stepping stone habitats create long-distance dispersal opportunities for species, and facilitate range expansion through the stepping stone network. The full value of the stepping stones is realized over time and across generations as the species extend their reach across the landscape.

Another consideration in the stepping stone strategy is the size of the habitat patches. It is better to have one large patch than several smaller patches. The resaca study utilizes the many small stepping stones approach which has been shown to increase species diversity (Tscharntke, T et al., 2002.); (Whittaker, R, 1998.); (Burkey, T, 1989.); (Quinn, J., and Harrison, S., 1988.). Through the use of the many small stepping stones approach, the Brownsville resaca study would increase connectivity between the east and west sides of the city and would increase the species diversity for the resaca habitats within the city.

One primary goal of the proposed study was to maximize ecological connectivity between existing high quality resaca habitats. By using the many stepping stone approach, the study would restore degraded habitat, minimize physical gaps between riparian habitats across the study area, and provide a pathway through which species could navigate the urban landscape. Without proactive restoration measures, the ability of fish and wildlife resources to disperse east to west across the study area would be greatly diminished, if not completely eliminated.

In addition, the proposed restoration would increase the number of restored habitats along the resacas which would increase the probability of wildlife, specifically avian species, to cross between Resaca de la Guerra and Resaca del Rancho Viejo. Therefore, the proposed project would increase connectivity by decreasing habitat gaps and using the resacas as stepping stone habitats linearly along two resacas as well as between them.

The cost effectiveness and incremental analysis provides an economic ranking based on habitat to be restored. However, that analysis (a computer model) is not capable of evaluating the connectivity component of the plan formulation. The connectivity assessment was based on professional opinion of the USACE and resource agency subject matter experts.

The USACE formulates, designs, and constructs projects for specific missions and authorities including ecosystem restoration and recreation. Investment decisions are based on established methodology that shows the benefit of a project in advancing a specific mission area. There is not an accepted method for quantifying how a USACE project may advance other national priorities and often the full “value to the nation” of a project is unaccounted. In addition to the NER benefit, which captures the effects of the recommended plan on the Environmental Quality (EQ) account, three other accounts are identified in ER 1105-2-100, were considered during the formulation process: National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE). Brief explanations follow of the four accounts.

1. National Economic Development (NED): This account displays changes in the economic value of the national output of goods and services

2. National Ecosystem Restoration (NER) or Environmental Quality (EQ): This account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and negative aspects of ecosystem restoration plans. Example: habitat units.

3. Regional Economic Development (RED): This account displays changes in the distribution of regional economic activity (e.g. income and employment). Examples of RED effects could be, but are not necessarily limited to: employment, business income, and local tax revenues.

4. Other Social Effects (OSE): This account displays non-monetary effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. Example: changes in population at risk.

Next Step

The USACE planning process follows a six-step process defined in the Principles and Guidelines (P&G) for Water and Related Land Resources adopted by the Water Resources Council. Guidance is provided in ER 1105-2-100. The first six chapters present the six planning steps:

- Chapter 1 - Identify Problems And Opportunities
- Chapter 2 - Inventory And Forecasting Conditions
- Chapter 3 - Formulate Alternative Plans
- Chapter 4 - Evaluate Alternative Plans
- Chapter 5 - Compare Alternative Plans
- Chapter 6 - Select A Plan

Chapter 1 describes the first step in the planning process, the identification of problems and opportunities that would exist in a future forecast set of conditions expected to exist in the absence of a federally constructed ecosystem restoration project. The forecast is based on a foundation of historic and current conditions that are used to anticipate trends and changes over a future period called the period of analysis.

The purpose of forecasting future conditions is to identify the best project suited for the future. The problems and opportunities are presented in Chapter 1, as well as discussion of the objectives and constraints and the period of analysis.

The problems, opportunities, objectives, and constraints are the plan formulation foundation for the entire study. The problem statements are supported by the information presented in Chapter 2.

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CHAPTER 1: IDENTIFY PROBLEMS AND OPPORTUNITIES

INTRODUCTION

The first step in the planning process was to identify problems and opportunities. Problems are undesirable, negative conditions that the study will assess. Opportunities are desirable conditions that could be achieved in the future. The "conditions" to be considered are those forecast to exist during a future period of analysis. The problems are forecast for conditions expected to exist in the absence of a federally constructed ecosystem restoration project. The opportunities are forecast for conditions expected to exist in the presence of a federally constructed ecosystem restoration project. For this project there is just one forecast condition assuming no project is constructed as a result of this study. Each potential ecosystem restoration alternative would produce different desirable results, therefore, there is a different forecast condition for each alternative. The desirable results are measured by comparing the future with-project (FWP) conditions to the future without-project conditions (FWOP). The forecast is made over a period of analysis, typically 50 years for a civil works project with the period beginning after the end of construction. However, this ecosystem restoration project would have a long construction schedule and a long maturation and establishment period for the emergent and riparian plants. Therefore, a 75-year period of analysis was established. The explanation of the longer period of analysis follows.

Period of Analysis. The period of analysis was examined to determine the appropriate conditions for evaluation of the alternatives to be considered. The period of analysis begins after the construction period is finished and the implemented project begins to realize the desirable conditions (often called benefits). The period of analysis is typically 50 years and that is generally sufficient to allow comparison of the cost of implementation to the benefits. However, as the feasibility study progressed and the scope of the potential project became clearer in terms of the large number of real estate interests to be acquired and the relatively large local sponsor's cost share, a 50-year period of analysis was reexamined. The sponsor considered the effort required to obtain the necessary real estate interests and their annual fiscal capability. Through coordination with the District, a 16-year construction period was determined to be the appropriate implementation plan. The construction period was reviewed by the Cost Engineering Mandatory Center of Expertise (Cost MCX), considered to be reasonable, and was utilized in the cost and schedule risk assessment to develop appropriate contingencies. The Cost MCX noted that because of the large number of real estate acquisitions and the estimated sponsor funding of more than ten million dollars per year that estimating a shorter construction schedule would likely increase the risk estimate, which would be reflected in higher cost and schedule contingencies (personal communications,

September 2017, James Neubauer, Cost ATR Coordinator, Cost MCX). Further coordination with the Cost MCX concluded that consideration of the sponsor's budget was appropriate in determining an optimum construction schedule.

A 16-year construction period in itself would not be an issue for a project such as flood control or navigation. With those types of structural projects, benefits (or the estimated annual benefits) would begin to accrue almost immediately after completion of construction. However, for an ecosystem restoration project, benefits do not all begin immediately and when phased over 16 years there is an obvious lag before the overall project can begin to function, let alone become well established. Even for the first restored areas, plants need time to become established. Fish and wildlife would utilize the habitat as it improves.

The implementation scenario would restore areas from upstream to downstream, in adjacent groups, over the 16-year construction period. Restoration efforts (dredging, planting, etc.) generally would be completed for a group of areas annually. The first group restored would still be starting to provide environmental output at the end of about five years (overall about 10 percent of the eventual output), and in that period, four more groups of areas would have been restored and would be starting to produce benefits. One reason for the upstream to downstream plan is recognition of the potential for downstream sediment transport during construction activities, such as dredging or bank shaping. If sediment is transported to downstream resacas, it would be dredged as part of subsequent work. Controlling sediment would be an inherent component of the construction requirements, but there is a risk of transport and the upstream to downstream implementation negates any significant impacts.

Assuming that the first year of construction may be 2021 and the end of construction would be 2037. The start of the period of analysis was assigned to be 2038 (one year later). If the period of analysis would be constrained to the typical 50-years, the forecast conditions would not reflect a representative view of the output of restoration areas as they became established. That would negatively skew the cost effectiveness evaluation and potentially lead to falsely identifying the "best" long-term restoration project. Therefore, the period of analysis was extended from 50-years to 75-years (2038 to 2113). By the end of a 75-year period of analysis, the restoration area groups are forecast to provide between 80 and 100 percent of their habitat value. That was considered to be an acceptable period that would lead to identification of a best long-term plan.

Conditions Summary

Since the early 1870s, there has been a loss of 95 percent of Thornscrub habitat in the lower Rio Grande Valley (LRGV) and 99 percent of riparian resaca habitats (Jahrsdorfer, S.E. and Leslie, Jr, D.M., no date)

The agricultural history and rapid urbanization of the area has resulted in the loss of 99 percent of resaca dependent habitats in Texas.

Functioning resacas and the native vegetation associated with them have essentially been eliminated from the Mexican side of the Rio Grande River.

The vegetation communities associated with the resacas are globally imperiled with extinction according to the rankings from NatureServe (NatureServe. 2017). The three vegetation associations of the resacas have evolved specifically with the dynamics of the resacas and the Rio Grande and are found nowhere else on earth.

NatureServe's G1: critically imperiled species or communities that are in a very high risk of extinction due to extreme rarity, very steep declines, or other factors include Texas Ebony Resaca Forest.

The G2 ranking: imperiled species or communities at high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or factors include: Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland

Invasive plant species are present in the riparian habitat and the sailfin catfish is present in the aquatic habitat.

PROBLEMS AND OPPORTUNITIES

The problems and opportunities are based on the forecast resource conditions presented in Chapter 2.

Problems

The problems (P) apply to the three resaca within the vicinity of the City of Brownsville and the period of analysis from 2038 and 2113.

P1: No New Resaca Habitat Will Be Created

The first problem identified the unlikelihood new resacas will be formed. The management of water in the Rio Grande and Pecos River Basins has effectively eliminated the potential for a major flood to cut a new course to the Gulf in the lower Rio Grande Valley. It is less likely that the Rio Grande would create a new course

through the study area, the City of Brownsville, due to levees and other infrastructure, such as water control structures. A consequence (secondary problem) of not flooding is the lack of periodic nutrient distribution across the Rio Grande floodplain. It is unlikely the resaca habitat will receive the nutrient loaded sediment that was historically distributed with major flood events creating the highly fertile, lower valley floodplain.

An additional consequence of the absence of flooding is the lack of higher velocity flow in the resacas that would tend to scour sediment and erode banks thereby creating “young” bank habitat and adding large woody vegetation in the aquatic habitat.

If no new resacas will be formed, it is likely that a portion of the remaining one percent of the historic resaca habitat will be lost to agriculture or urbanization; and it is certain that the remaining habitat will decline through secession and the impacts of invasive species. The cumulative impacts to the historic resaca habitat in the lower Rio Grande Valley have been a catastrophic loss. Every acre lost in the future is leading to the extinction of the unique habitat.

P2: Loss of Connectivity

The loss of resaca habitat due to urbanization has segmented the habitat and disrupted ecological connectivity along and among the three resacas, and more significantly has severed connectivity with high quality native thornscrub and resaca habitats of the surrounding ecosystem for most species.

P3: Invasive and Non-Native Species Expansion

Invasive species, both aquatic and terrestrial flora and fauna, exist in and around the resaca habitat. These invasive and non-native species have significantly reduced the quality of habitat and because they tend to out-compete native species, the forecast condition is for continued expansion of invasive species and a corresponding decline in the quality and quantity of resaca habitat.

Opportunities

The opportunities (Op) are restatements of the problem conditions as desirable forecasts. The opportunities apply to the three resacas within the vicinity of the City of Brownsville and apply to the period of analysis between 2038 and 2113.

Restoration measures are not discussed until Chapter 3, but the opportunity statements were composed with the understanding that the restoration methods proposed in this report have been used on numerous sites throughout the LRGV over the last three-and-a-half decades. The USFWS, the TPWD, the NPS, and TNC have successfully propagated native plant species representative of the resaca habitats and reestablished native vegetation on National Wildlife Refuges, State Parks and Wildlife Management Areas, conservation easements, and ecological preserves.

Op1: Restore Function of Resaca Complexes

Because there is not an opportunity for new resacas to be formed, the realistic opportunity would be to restore the function of the aquatic and terrestrial complexes to mimic (ER 1105-2-100) newly formed resaca areas with bare banks and no invasive riparian vegetation. Through management these areas would be developed more quickly to achieve the high quality function of reference resacas. (ER 1105-2-100 Restored-ecosystems should mimic, as closely as possible, conditions, which would occur in the area in the absence of human changes to the landscape and hydrology.)

The human changes to the landscape and hydrology are reflected in the urbanization and agricultural impacts that have caused the loss of 99 percent of the historic resaca habitat and have essentially precluded the creation of a new resacas. The human changes within the City of Brownsville limit the scope of the restoration. Altering the residential, commercial, or infrastructure improvements to provide a continuous reach of restoration along a resaca is both socially and economically impractical in this urban landscape. ***However***, that limitation in scope does not preclude the identification of effective ecosystem restoration efforts. The long term accumulation of sediment can be removed. Restoration planting of emergent vegetation and riparian grasses can minimize future sedimentation. Invasive plan species can be removed and replaced with native species. Connectivity can be restored by providing “stepping stones” of high quality aquatic and terrestrial resaca habitat.

Op2: Restore Connectivity

The restored resaca would provide ecological connectivity for a variety of species, along the resaca, among the resacas, to high quality thorn-scrub, and managed resaca habitats of the surrounding ecosystem. The restored areas would not be the only habitat along or among the resacas, but would be preserved and protected stepping stone properties through the urban landscape. Ideally, a continuous corridor or buffer would be restored along one or both sides of the resacas and connect the resacas to the surrounding ecosystem. The reality is that existing urbanization and infrastructure precludes that possibility of a continuous corridor. A

continuous corridor is not necessary for the restoration of an effective corridor. The stepping-stones would create the necessary connections to the existing resaca habitat and the surrounding high quality thornscrub and resaca habitats to enable wildlife to travel through the urban environment.

Op3: Reduce Invasive Species

The restored resaca would reduce the viability of the aquatic invasive species, and clearing of terrestrial invasive and non-native vegetation, and an active management plan would facilitate optimal performance of the restoration plan.

OBJECTIVES

Like Problems and Opportunities, Objective statements (Ob) provide a qualitative or quantitative metric used to evaluate the measures and alternatives that will be identified to achieve the desirable conditions described by the opportunity statements.

Ob1: Cost Effective Restoration Prioritization

Restore impacted resaca aquatic and riparian complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. Alternatives would be formulated to prioritize cost effective restoration efforts to optimize the fiscal resources.

Ob2: Connectivity

The objective is to restore connectivity within the Brownsville resacas and to the high quality thornscrub and resaca habitats of the surrounding ecosystem. Alternatives would be formulated to meet this objective. This objective is responsive to the USACE goal to formulate ecosystem restoration in a systems context to improve the potential for long-term survival of aquatic, wetland, and terrestrial complexes as self-regulating, functioning systems, wherever those restoration features improve the value and function of the overall ecosystem.

Ob3: Invasive and Non-Native Species Management

The reduction or elimination of aquatic invasive species, particularly the sailfin catfish, and invasive and non-native riparian plant species would be the objective of all alternatives. The objective would be approached through an initial plan for removal, initial monitoring after construction, and long term monitoring and maintenance. Cost effectiveness would guide the selection of methodologies. Once identified, the same cost effective methodologies would be applied to all alternatives. Measures to address invasive and non-native terrestrial species were determined to be a prerequisite for measures to address Ob1 (restoration).

CONSTRAINTS

Constraints are characterized as *universal constraints* that would apply to similar categories of studies and *study specific constraints* that are relatively unique for an individual study. Alternatives are formulated to achieve the objectives and avoid the constraints. Universal constraints (not listed below) include all of the applicable laws, policy, guidance, and other federal government requirements. This report is an integrated feasibility report (for plan formulation) and NEPA document (for environmental compliance). The following two **plan formulation constraints** were used to avoid undesirable results and comply with policy. The subsequent lists of **environmental compliance constraints** outline the laws, policy, and principles considered in conducting the environmental assessment, and considered for plan formulation.

Plan Formulation Constraints

Study specific constraints (listed below) identify things that alternative plans should avoid in order to reduce or eliminate undesirable results that might be associated with an otherwise well-intentioned solution. Two specific plan formulation constraints were identified.

1. The Federal Aviation Administration (FAA) identified a potential increased risk of bird strikes if restoration areas in proximity to the Brownsville Airport included emergent vegetation planting (Figure 1–1). Through coordination with the FAA, a 1,000-foot buffer to each side of the two runways was recommended. The buffer is a constraint for emergent vegetation planting in compliance with FAA Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants on or Near Airports. Other restoration measures (such as riparian planting) would not be restricted. The buffer area is shown in white. The buffer intersections with the resacas considered (and included in the recommended plan) are shown in red. No emergent vegetation planting would be included in the intersection of the buffer and the resacas for plans considered or recommended by this feasibility study. Communication with the FAA is contained in Appendix D-4.

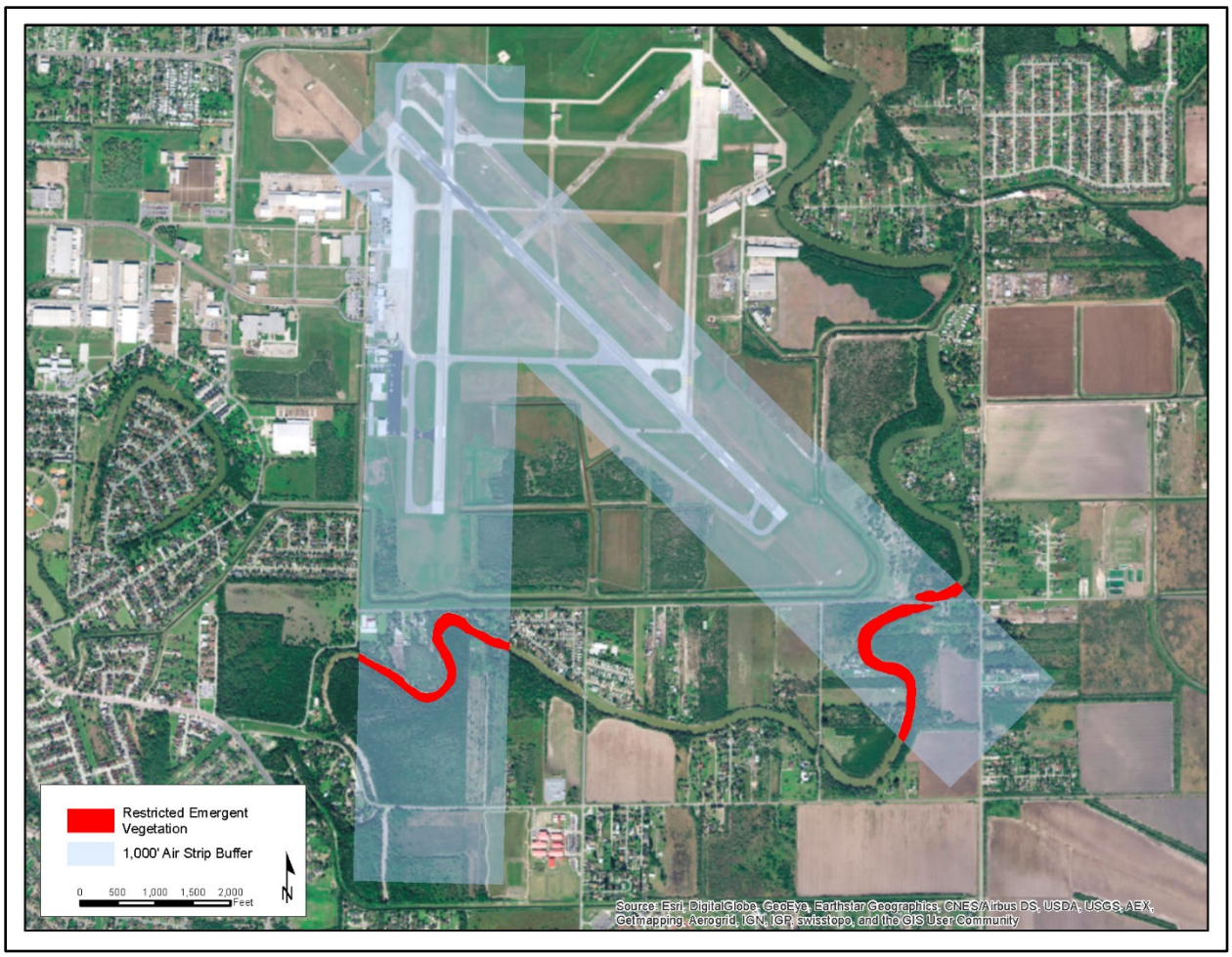

Figure 1–1: Aerial view of Restricted Emergent Vegetation Planting Areas

2. A policy constraint was identified during plan formulation related to USFWS lands along the resacas. The policy is based in fiscal law and policy and relates to the concept of augmentation where funds appropriated by Congress for one agency may not be used to augment the budget of another agency. For this study, the issue involves tracts of land that had been identified as impacted habitat and suitable for significant habitat value uplift through restoration, which were subsequently found to be held by the USFWS. Both the USACE and the USFWS are responsible for ecosystem restoration and therefore USACE restoration efforts on the USFWS lands would be prohibited under the policy. When the USFWS ownership was identified, the constraint was applied with the following effects on the recommended plan. The recommended plan lands held by the USFWS would be identified and presented separately, including identification of associated restoration measures and costs. Coordination was initiated with the USFWS to determine the agency's interest and capability to fund jointly the recommended plan. Initial coordination consisted of a letter from the USACE to the USFWS to identify the lands, measures, and costs. The USFWS

determined the recommended plan is compatible with their management plans for these lands and they are interested in potential participation. That response letter from the USFWS to the USACE is sufficient to allow completion of this USACE ecosystem restoration feasibility study. Subsequent analysis and coordination are appropriate during the preconstruction engineering and design phase. If at any time the USFWS determines that the recommended plan is not compatible with their management plan, or timely funding is unlikely, the USACE would recommend the next most efficient "best buy" plan (a smaller plan without the USFWS lands), with such modifications as were deemed appropriate at the time. The next most efficient plan (a smaller plan) was also coordinated during public review in 2017, and therefore no subsequent review of the integrated Environmental Assessment would be anticipated.

The USFWS lands account for 54 acres of the plan eventually identified as the recommended plan with a total of 845 acres of restoration.

There are also about 28 acres of TPWD lands on which components of the recommended plan would be implemented. These lands are not related to the policy constraint.

Environmental Compliance Constraints

Constraints considered in preparation of the integrated Environmental Assessment include the following list of legislation, executive orders, plans, and agreements. The constraints are described in Appendix A – Environmental Resources with a discussion of how they were assessed and considered in the plan formulation. The assessment of these constraints is presented in Chapter 5.

The following list of environmental compliance laws and regulations were identified for consideration of the proposed action.

1) The environmental compliance constraints that require evaluation of a proposed action by the USACE include:
    - Clean Water Act of 1972
        - Section 401 State Water Quality
        - Section 404b1 Wetlands and Waters of the United States
        - Section 402 (p) National Pollutant Discharge Elimination System (NPDES)
    - Clean Air Act of 1967 (as amended)
    - Endangered Species Act of 1973
    - Executive Order 13112 Invasive Species
    - Executive Order 11988 Floodplain Management

- Migratory Bird Treaty Act, Migratory Bird Conservation Act, and Executive Order 13186 Migratory Birds
- Executive Order 12898 Environmental Justice
- Executive Order 13045 Protection of Children
- Farmland Protection Act of 1981
- Rivers and Harbors Act, Section 122 OF 1970
- Executive Order 11990 Protection of Wetlands
- Federal Water Project Recreational Act of 1965
- Water Resources Development Act of 1986
- Water Resources Development Act of 1990
- Wild and Scenic Rivers Act of 1968

Compliance is discussed in Chapter 5

2) The environmental compliance constraints requiring consultation with other agencies include:
   - Advisory Circular 150/5200-33A Hazardous Wildlife Attractants on or Near Airports
   - Texas Commission on Environmental Quality (TCEQ) Section 401 Water quality certification
   - TCEQ Texas Coastal Management Program (CMP)
   - National Historic Preservation Act of 1966
   - U.S. Fish and Wildlife Coordination Acts of 1956 and 1958

Consultation is documented in Appendix D.

3) The environmental constraints requiring the proposed action to adhere to the Council on Environmental Quality (CEQ) principles include:
   -
   - National Environmental Policy Act of 1969Relationship between Short-Term Use and Long-Term Productivity
   - Relationship to Land Use Plans
   - Irreversible and Irretrievable Commitment of Resources
   - Indirect Effects
   - Cumulative Impacts

Adherence to these principles is discussed in Chapter 6.

4) Engineering Regulation 1105-2-100 identifies other resources necessary to consider in project planning:
   - Life
   - Health
   - Safety
   - Long term productivity
   - Energy requirements
   - Energy conservation

Chapter 5 addresses compliance with ER 1105-2-100.

That concludes the identification of the problems, opportunities, objectives, and constraints.

An informal policy was identified during the study that relates to how construction schedules are developed. The policy, sometimes referred to as an “optimal funding stream” policy, directs the development of a capability construction schedule that assumes full federal funding would be available. The intent of a capability schedule is to identify how quickly construction could be completed, and therefore, how quickly the benefits of a project could begin to be realized. By applying the policy, a capability schedule would not anticipate the traditional delays and limitations of federal funding that are often experienced by projects during construction. However, the policy recognizes that to avoid inimical impacts of a fallacious construction plan, the capability schedule must be based in the realities of the sponsor’s fiscal ability and the rigorous requirements of their items of local cooperation. Ignoring the sponsor’s capabilities would guarantee immediate failure to meet the construction schedule and would add time and costs to update that schedule.

In accordance with Engineer Circular Bulletin (ECB) No. 2007-17, dated 10 September 2007, "Cost risk analysis methods will be used for the development of contingency for the Civil Works Total Project Cost estimate. It is the process of identifying and measuring the cost and schedule impact of project uncertainties on the estimated total project cost. When considerable uncertainties are identified, cost risk analysis can establish the areas of high cost uncertainty and the probability that the estimated project cost will or will not be exceeded. This gives the management team an effective additional tool to assist in the decision making process associated with project planning and design." The optimal funding stream policy adds risk to the schedule and cost estimate, but those risks are acceptable to the USACE and are considered to be offset for the value of the information gained.

For this study, the sponsor’s fiscal ability and the roughly 700 parcel real estate actions that would be required were considered to be key concerns for determining a realistic and achievable construction schedule. The study team sought the advice of the Civil Works Cost Engineering and Agency Technical Review Mandatory Center

of Expertise (MCX) with Technical Expertise (TCX) duties, located at the Walla Walla District Cost Engineering Branch. The MCX subject matter experts considered the recommended plan restoration measures, the sponsor's fiscal capabilities, and the prerequisite real estate actions necessary for the initiation of construction. These parameters and others were considered in development of the cost and schedule risk analysis (CSRA). The USACE mandates the application of a CSRA to enforce improvements in establishing the cost and schedule risk and resulting contingencies that are used within the calculation of the total project cost. The CSRA is part of the greater emphasis to produce quality schedule and cost estimates.

A "shorter than capability" construction schedule was discussed with MCX technical experts. The impact to contingencies resulting from a CSRA based on a shorter than capability schedule would, in the professional opinion of the MCX, significantly increase contingencies and the estimated total project cost by proposing an unrealistic and unachievable schedule. The capability schedule was retained.

Note that the term "total project cost" (a financial cost) is not used elsewhere in the report. The total project cost includes Federal and non-federal costs for lands and damages, all construction features, preconstruction engineering and design, supervision and administration, and all other non-construction features along with the appropriate contingencies and escalation associated with each of these activities, including real estate and appropriate credit provisions of Section 104 of the WRDA of 1986 and Section 215 of Public Law 90-483. The total project cost includes inflation through project completion (accomplished by escalation to mid-point of construction per ER 1110-2-1302). The total project cost is reflected in the project partnership agreement between the USACE and the local sponsor and is used in the authorizing language for construction. The total project cost is inherently larger than the project first cost. For this project the total project cost is about 25 percent higher due to the additional financial costs, escalation, and inflation.

Note that the term "project first cost" (an economic cost) is used in subsequent chapters as required by ER 1105-2-100.

The construction schedule developed for the recommended plan assumed an optimal funding stream for the federal budget and a capability construction schedule for the local sponsor.

NEXT STEP

Chapter 2 presents the second step of the planning process, the development of forecast without-project conditions. The second step begins with the identification of relevant resources, then an inventory of those resources, and finally the forecast conditions expected to occur during the period of analysis.

The categories below were considered to provide a broad view of resources that would be potentially affected by the proposed restoration alternatives. This resource outline will be consistently presented in the remaining chapters that assess alternative conditions.

Environmental Resources

- Air Quality
- Sustainability, greening and climate change
- Geologic Resources
- Water Resources
- Biological Resources
- Cultural and Historic Resources
- Land Use
- State parks, conservation areas, and other areas of recreational, ecological, scenic, or aesthetic importance
- Floodplains
- Socioeconomics
- Minority and low-income populations (Environmental Justice)
- Visual Aesthetics
- Noise
- Hazardous, Toxic, and Radioactive Waste (HTRW)

A Resaca Reference Condition Model (RRCM) was developed in cooperation with the USFWS, the TPWD, the NPS, the BPUB, and university biologists, to quantify and assess existing and future biological resource conditions. The table below shows an example of the evaluation data for only three of the Town Resaca areas. The base data was accumulated for all of the 66 restoration areas considered across the three resacas. Notes below the table describe each column heading and the calculations involved.

Example Evaluation Data for Three Town Resacas Areas and Explanation of Column Titles

Restoration Area	Existing Resaca Depth (feet)	FWOP Resaca Depth (feet)	Existing RRCI	FWOP Annualized RRCI	Acres	Existing Habitat Units	FWOP Habitat Units
3	3	0	0.46	0.33	0.69	0.32	0.23
4	3	0	0.46	0.33	1.83	0.84	0.61
5	3	0	0.46	0.33	5.53	2.54	1.85

Where:

- The restoration area was an assigned number.
- Existing resaca depth is the observed water depth.
- The future without project (FWOP) Resaca Depth is the depth of water forecast by the end of the period of analysis due to sedimentation.
- The existing RRCI is the existing Resaca Reference Condition Index (RRCI) that is a value between zero (no Resaca habitat) and one (highest quality resaca habitat).
- The FWOP annualized RRCI is the average index over the period of analysis.
- The acres column is the area within the aquatic and riparian perimeter of the site.
- The existing habitat units is the product of the existing RRCI and the acres.
- The FWOP habitat units is the product of the FWOP annualized RRCI and the acres.

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CHAPTER 2: INVENTORY AND FORECASTING CONDITIONS

Introduction

In the first step (Chapter 1), problems and opportunities were identified. The objective of the second step is to establish a frame of reference, or baseline, to evaluate the project's ecosystem restoration measures.

Chapter 2 presents the second step where information was gathered about historic and existing conditions. These inventories were used to forecast the potential future conditions if no action is taken to address resacas degradation.

Conditions existing at the time of the study are collectively called the existing conditions. The existing condition helps form the baseline for determining the future without project conditions (FWOP). The FWOP conditions are synonymous with the no action plan as required under the NEPA. The no action plan is the most likely condition expected to occur in the future in the absence of the proposed federal action. The FWOP conditions were forecast for the study period of analysis (75 years beginning in 2038). The FWOP conditions also help identify the measures appropriate for those forecast future conditions. Designing a measure for existing conditions might result in a measure not functioning well in the future. The FWOP conditions establish the baseline for measuring impacts and benefits of alternative plans.

Relevant Resources Found in the Planning Area. The existing conditions are discussed for each resource category, and then the forecast is presented. These resource categories consist of:

- Air quality
- Sustainability, greening and climate change
- Geologic resources
- Water resources
- Biological resources
- Cultural and historic resources
- Land use
- State parks, conservation areas, areas of recreational, ecological, scenic, or aesthetic importance
- Floodplains
- Socioeconomics
- Minority and low-income populations (Environmental Justice)
- Visual Aesthetics
- Noise

- Hazardous, Toxic, and Radioactive Waste (HTRW)

Air Quality

Existing Condition

Under the Clean Air Act (CAA) of 1990, the EPA identified and set limits on the amount of particular harmful pollutants can be in the air. The EPA has regulated air pollutants that are called criteria air pollutants. The EPA developed two types of air quality standards: primary standards protecting human health, and secondary standards preventing environmental and property damage. If an area is designated as nonattainment (designated areas), states must develop a State Implementation Plan (SIP) detailing the path to attain and maintain the National Ambient Air Quality Standards (NAAQS).

The study area is located in Cameron County, Texas, which is currently in attainment, or unclassified status for all NAAQS criteria pollutants as established and monitored by the EPA (TCEQ, 2017). Therefore, a SIP was not required to document air quality attainment.

Future Without Project Condition

Population growth and economic development is anticipated to increase the amount of emissions of criteria air pollutants emitted into the atmosphere. Emissions drifting into the U.S. from Mexico would likely increase air issues in the planning area. The forecast assumptions are that all regulated criteria air pollutants would be monitored and if exceedances occur, measures would be implemented to address the exceedance.

Sustainability, greening and climate change

Existing Condition

Brownsville has a subtropical climate with a maritime influence from the Gulf of Mexico. The mean annual temperature is 74.6 degrees F with an average high temperature of 92.6 degrees F in August and an average low temperature of 68.7 degrees F in January. The region experiences occasional freezes; however, low temperatures do not persist. Average rainfall for Brownsville is 27.37 inches with most of the precipitation from tropical storms during the hurricane season. Tropical storm events, which can fluctuate, affect annual precipitation. Tropical storms and hurricanes have become more intense during the past 20 years. Although warming oceans provide these storms with more potential energy, scientists are not sure whether the recent intensification reflects a long-term trend **Invalid source specified.**.

Future Without Project Condition

Temperatures in Texas are expected to increase by 4 degrees F by 2050 due to greenhouse gas emissions to the atmosphere. The intensity of tropical storm activity and resulting precipitation is expected to increase; however, these pulsed periods of high precipitation are expected to be followed by increasingly extended periods of drought (EPA, 2016).

Model results show future changes in precipitation resulting from climate change is highly variable and has a high level of uncertainty **Invalid source specified.**. In the future, storms are likely to become more severe, deserts may expand, and summers are likely to become increasingly hot and dry, creating problems for agriculture and possibly human health.

While noting the intensification of tropical systems over the past two decades, and the fact that warming oceans provide these storm with more potential energy, scientists remain unsure if recent intensification indicates a long-term trend. Nevertheless, hurricane wind speeds and rainfall rates are likely to increase as the climate warms.

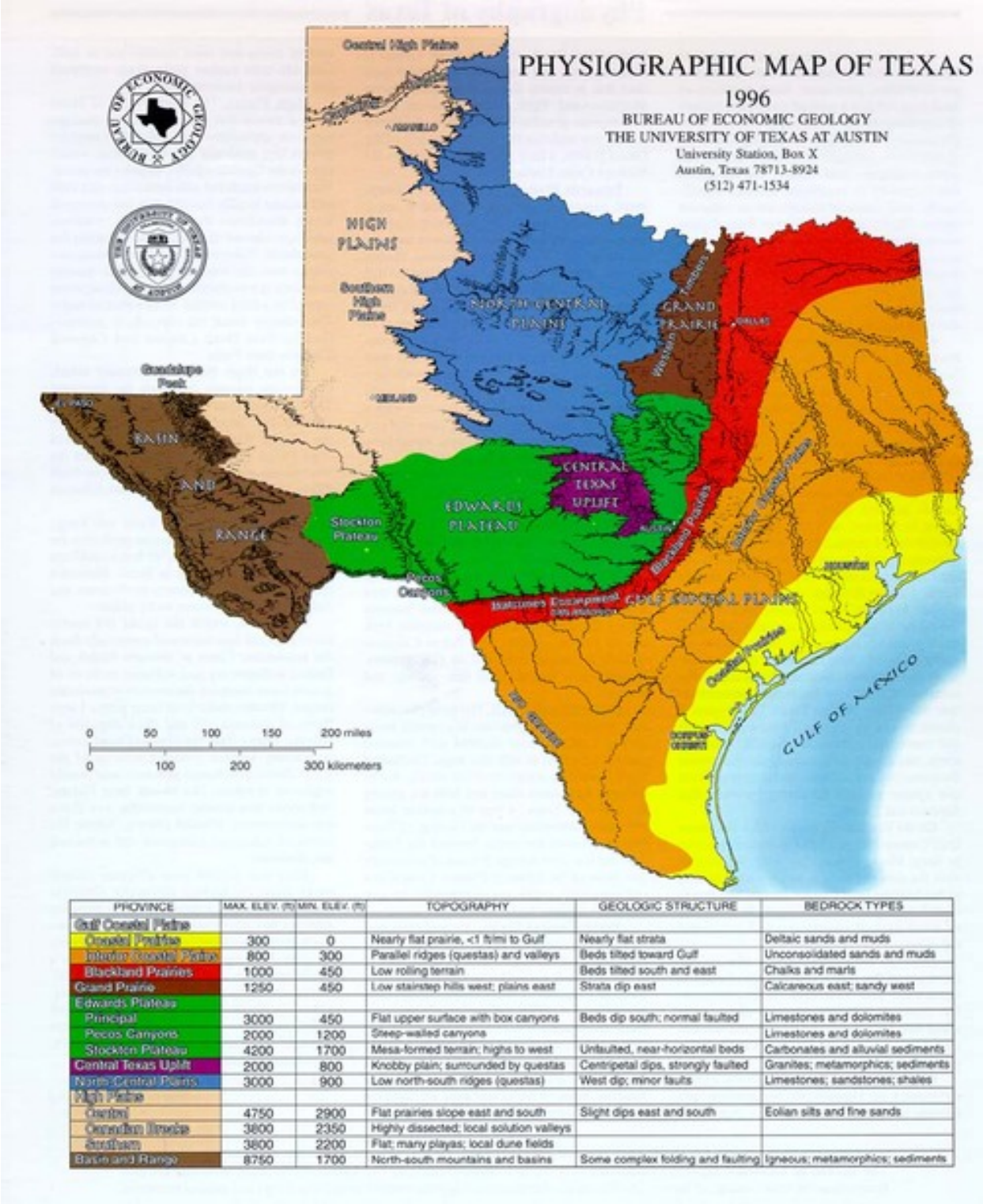
Geologic Resources

Existing Condition

Geological resources are the topography, geology, mining, and soils of a given area. Topography describes the physical characteristics of the land such as slope, elevation, and general surface features. The geology of an area includes bedrock materials and mineral deposits. Mining refers to the extraction of resources (e.g. gravel). Soil refers to unconsolidated earthen materials overlying bedrock or other parent material.

Topography

The study area lies within the West Gulf Coast section of the Coastal Plain physiographic province (Figure 2–1). Most of the area is part of the low-lying, delta portion of the Rio Grande floodplain. The land surface is gently rolling to flat, sloping gradually toward the coast and the river. Elevations in the study area range from 40 feet above mean seal level (AMSL) in the northwestern corner to 20 feet AMSL in the southeastern portion. Several abandoned former courses of the Rio Grande and its tributaries cross the area. Other meander scars or abandoned river beds also exist and are evidenced by elongated, curved but often unconnected, low-lying areas, which are subject to frequent flooding.



PROVINCE	MAX. ELEV. (ft)	MIN. ELEV. (ft)	TOPOGRAPHY	GEOLOGIC STRUCTURE	BEDROCK TYPES
Gulf Coastal Plains					
Coastal Prairies	300	0	Nearly flat prairie, <1 ft/mi to Gulf	Nearly flat strata	Deltaic sands and muds
Interior Coastal Plains	800	300	Parallel ridges (questas) and valleys	Beds tilted toward Gulf	Unconsolidated sands and muds
Blackland Prairies	1000	450	Low rolling terrain	Beds tilted south and east	Chalks and marls
Grand Prairie	1250	450	Low stairstep hills west; plains east	Strata dip east	Calcareous east; sandy west
Edwards Plateau					
Principal	3000	450	Flat upper surface with box canyons	Beds dip south; normal faulted	Limestones and dolomites
Pecos Canyons	2000	1200	Steep-walled canyons		Limestones and dolomites
Stockton Plateau	4200	1700	Mesa-formed terrain; highs to west	Unfaulted, near-horizontal beds	Carbonates and alluvial sediments
Central Texas Uplift	2000	800	Knobby plain; surrounded by questas	Centripetal dips, strongly faulted	Granites; metamorphics; sediments
North Central Plains	3000	900	Low north-south ridges (questas)	West dip; minor faults	Limestones; sandstones; shales
High Plains					
Caprock	4750	2900	Flat prairies slope east and south	Slight dips east and south	Eolian silts and fine sands
Canadian Breaks	3800	2350	Highly dissected; local solution valleys		
Southern	3800	2200	Flat; many playas; local dune fields		
Basin and Range	8750	1700	North-south mountains and basins	Some complex folding and faulting	Igneous; metamorphics; sediments

Figure 2–1: West Gulf Coast Section of the Coastal Plain Physiographic Province

Soils

Within the study area, historic soils are primarily comprised of Laredo silty clay loam (LAA and LAB). The Laredo soils consist of deep, well-drained, calcareous soils found on old flood plains and delta with nearly level to gentle slope. In addition, pockets of Olmito silty clay (OM) soils are interspersed throughout the resaca areas. These three soil types are still represented within the study area; however, the cut and fill activities often associated with the more urbanized areas have resulted in modifications to the historic soils; therefore, soils within the urbanized areas of the study area are now classified as Laredo-Urban land complex soils. The urban soil complex consists of stratified layers of silt loam and silty clay loam extending 72 inches into the soil profile.

Prime or Unique Farmlands

The Farmland Protection Policy Act (FPPA) does not cover soils within the study area. The FPPA is intended to minimize the impact federal programs would have on the unnecessary and irreversible conversion of farmland to nonagricultural uses. The FPPA does not authorize the federal government to regulate the use of private or non-federal land, or in any way, affect the property rights of owners.

Future Without Project Condition

The geologic character of the study area should remain relatively unchanged. However, soils should continue moving throughout the system and silting-in the resacas. The topography of the study area would change with accretion and erosion activities throughout the riverine system in the study area.

The conversion of native soil profiles to disturbed urban complex soils will continue as development increases. Increased urbanization would also increase the topography of the area by varying elevations of constructed features.

Water Resources

Existing Condition

Water resources include both surface water and groundwater resources, associated water quality, and floodplains. Surface water includes all lakes, ponds, rivers, streams, impoundments, and wetlands within a defined area or watershed. Subsurface water, commonly referred to as groundwater, is typically found in certain areas known as aquifers. Aquifers are areas with high porosity rock where water can be stored within pore spaces. Water quality describes the chemical and physical composition of water as affected by natural conditions and human activities.

Floodplains are relatively flat areas adjacent to rivers, streams, watercourses, bays, or other bodies of water subject to inundations during flood events. A 100-year floodplain is an area subject to a one percent chance of flooding in any particular year, or, on average, once every 100 years.

Surface Water

The study area is within the LRGV, which extends from Fort Quitman, Texas, along the U.S. and Mexico border, to the Gulf of Mexico (Figure 2–2). The LRGV lies within the much larger Rio Grande Basin, which extends from southern Colorado and through New Mexico and Texas. Between El Paso, Texas, and the Gulf of Mexico, the Rio Grande forms the International Boundary between the U.S. and Mexico. The border forms a straight-line distance of 700 miles and a river mile distance of nearly 1,250 miles. Once the river reaches Fort Quitman, Texas, just downstream from El Paso, diversions have significantly depleted riverflows.

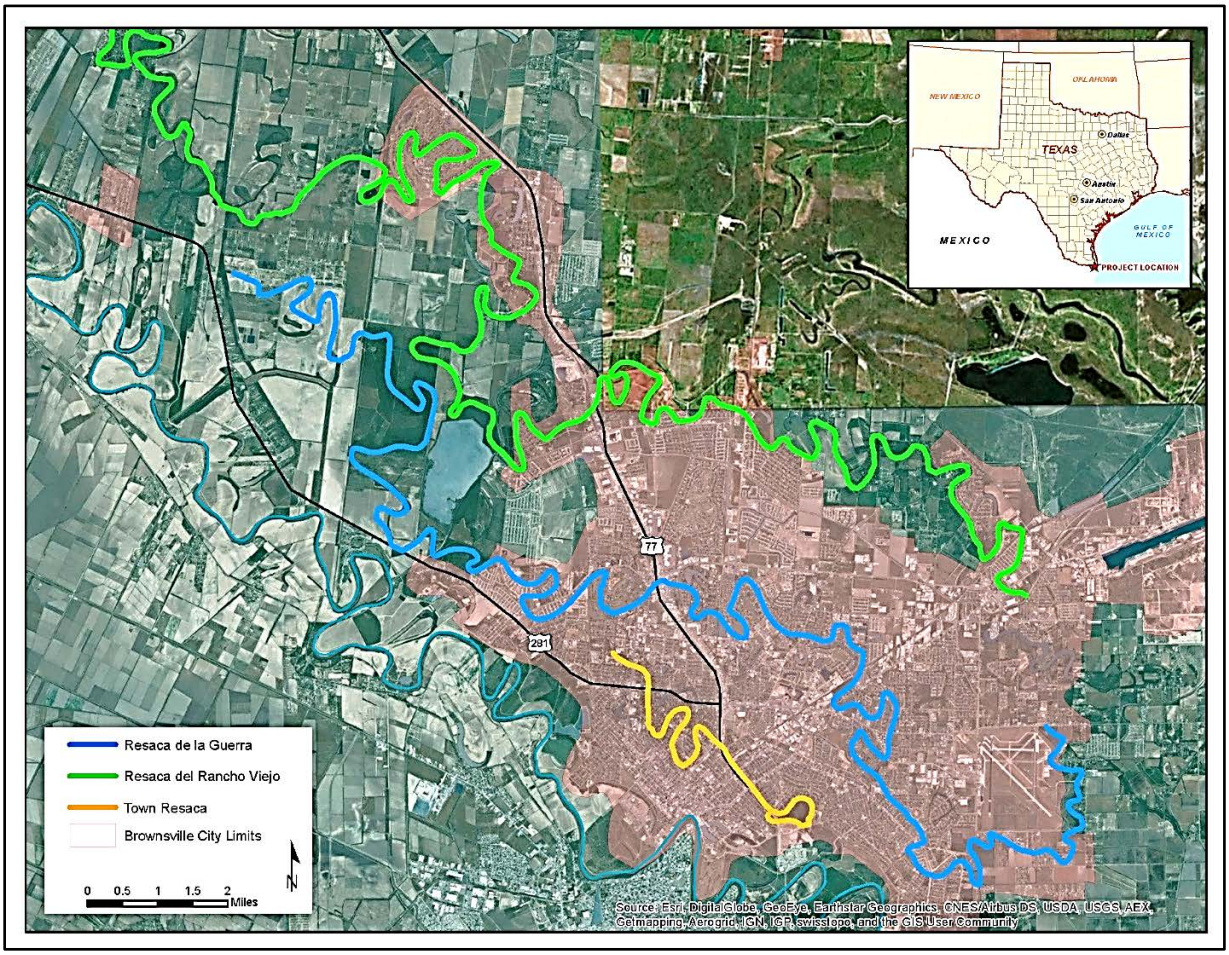


Figure 2–2: Map of the Lower Rio Grande River Basin and Study Area

The Texas portion of the basin contributing to the LRGV encompasses approximately 54,000 square miles, 8,100 square miles of which are closed sub-

basins not contributing flows to the Rio Grande. The Pecos and Devils Rivers are the principal tributaries of the Rio Grande. Both rivers flow into Amistad Dam and Reservoir, located upstream of the City of Del Rio, Texas, about 600 river miles from the mouth of the Rio Grande.

Nearly all of the dependable surface water supply available to the LRGV is from the Amistad Dam and Reservoir and Falcon International Reservoir. These reservoirs provide controlled storage of more than 8.0 million acre-feet of water owned by the U.S. and Mexico, with allocation of 2.25 million acre-feet for flood control purposes and 6.05 million acre-feet for water supply.

Resacas

Many sinuous waterways, locally called resacas, cross the study area. Other meander scars or abandoned river beds also exist and are evidenced by elongated, curved, but often unconnected low-lying areas that are subject to frequent flooding. All surface waterways in the study area eventually empty into the Laguna Madre or any of several lakes or bays along the Laguna Madre. These resacas form an extensive freshwater system.

The resacas are linear aquatic features over the landscape comprised of old Rio Grande delta distributaries and paleochannels. Flows within the resacas are extremely slow and the resacas function as a series of pooled segments instead of a flowing system. Many of the resacas have filled with sediments over the last 100 to 150 years. Sedimentation has been detrimental for affecting water temperatures, dissolved oxygen concentrations, and water depths throughout the resaca systems.

Resacas were historically numerous throughout the LRGV; however, most have been heavily altered by agriculture, development, and changes in hydrology. Within Cameron and Willacy County there are about 130 square miles of resaca channels and approximately 190 linear miles of water-filled resaca channels in various stages of degradation.

The City of Brownsville is estimated to have a total of 3,500 acres of resacas (ranging from less than one to over 50 acres in size). In addition to the urban resacas, several higher quality resacas have been set aside, including at the Resaca de la Palma State Park, Southmost Preserve, Palo Alto National Battlefield, and the Lower Rio Grande Valley National Wildlife Refuge complex (Figure 2–3). The remaining undeveloped resacas are under intense pressure as housing developments target waterfront real estate.

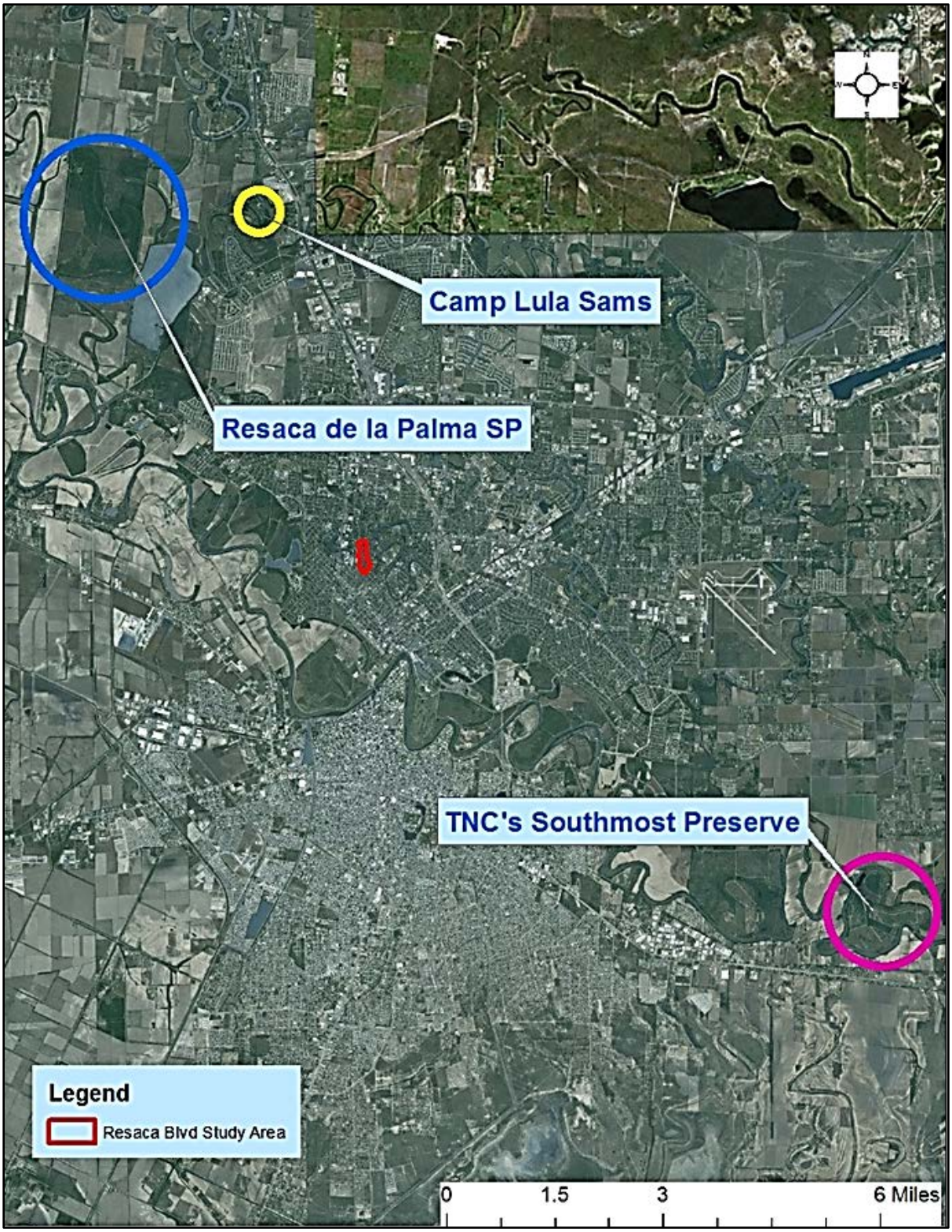


Figure 2–3: Location of Reference Condition Resacas

Resacas provide multiuse water services. In addition to providing important habitat for fish and wildlife resources, the resacas serve as conveyance channels through

the City of Brownsville. The Brownsville Public Utilities Board (BPUB) and the irrigation districts use the resaca systems for transportation of water to treatment for drinking water, agricultural irrigation, storm water storage, and recreation. Stormwater management areas contribute to Resaca degradation through passage/storage of road runoff and entrained suspended sediments and floating debris/trash. The city is controlling illegal trash dumping.

Property lines for most resacas extend to the center of the resaca; therefore, the beds of resacas are privately owned. The State of Texas retains ownership of the water in the resacas and authorizes use of the water by various local public agencies, including BPUB. Since the water is publicly owned, the public can use it for boating, fishing, or other activities.

The study area includes three main resaca systems: Resaca del Rancho Viejo, Resaca de la Guerra, and Town Resaca (Figure 2–4, Figure 2–5, and Figure 2–6). These areas eventually drain into Laguna Madre through the Port of Brownsville Ship Channel; however, runoff is sometimes pumped from the resacas to the Rio Grande River when the City of Brownsville operates its drainage pumps. The BPUB controls the water surface elevations of the resacas through a series of water control structures (Figure 2–7)

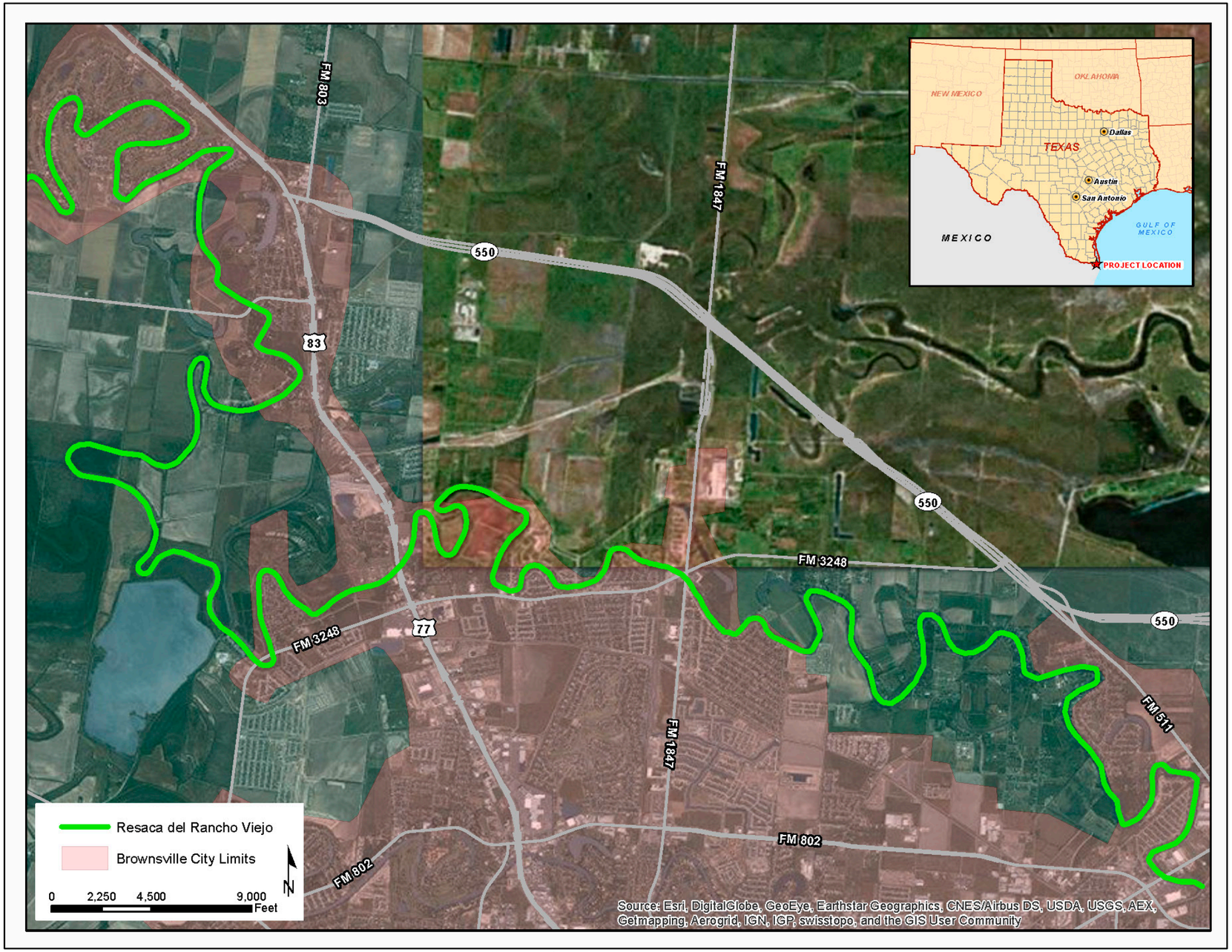


Figure 2–4: Location Line for the Resaca Rancho Viejo

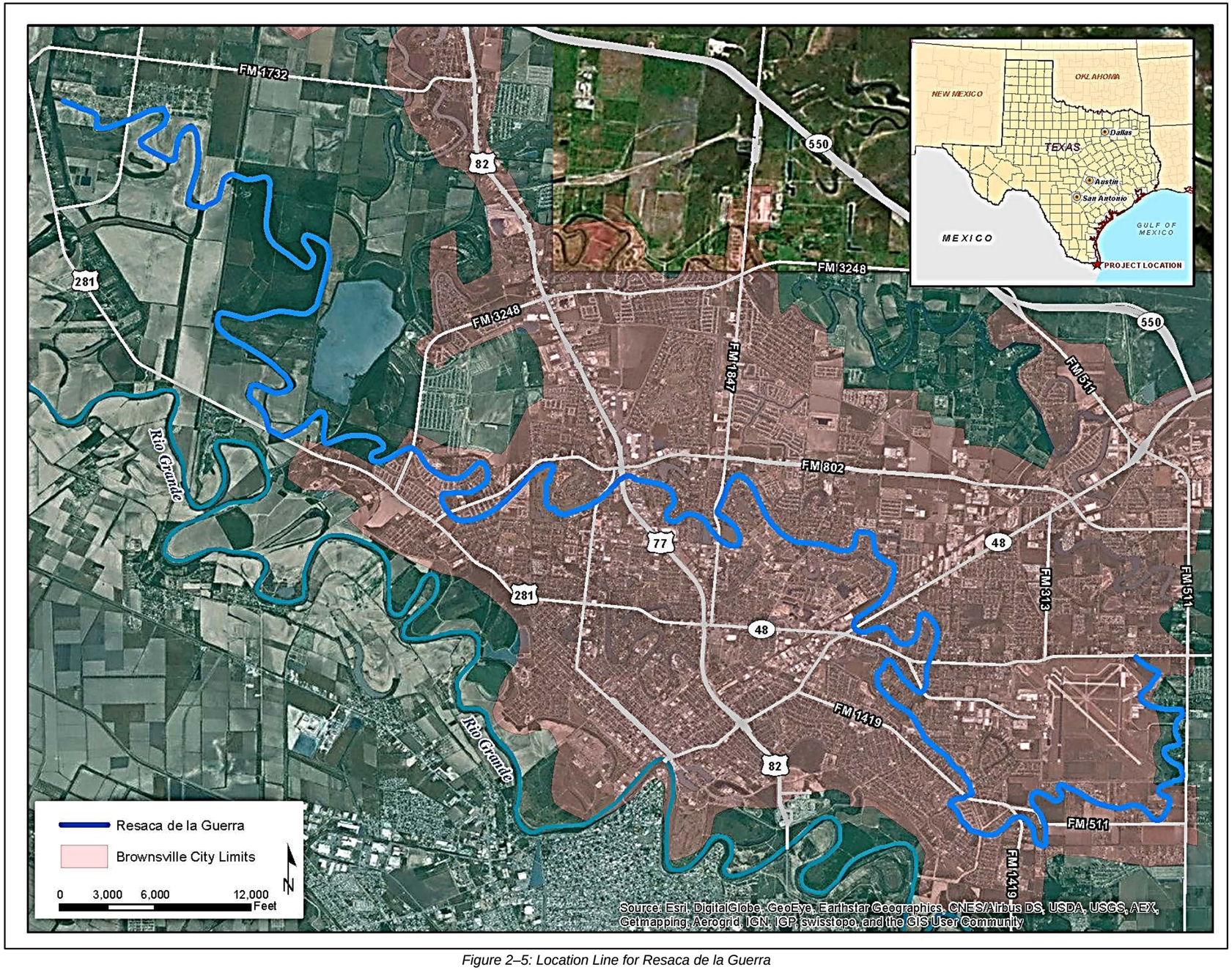


Figure 2–5: Location Line for Resaca de la Guerra

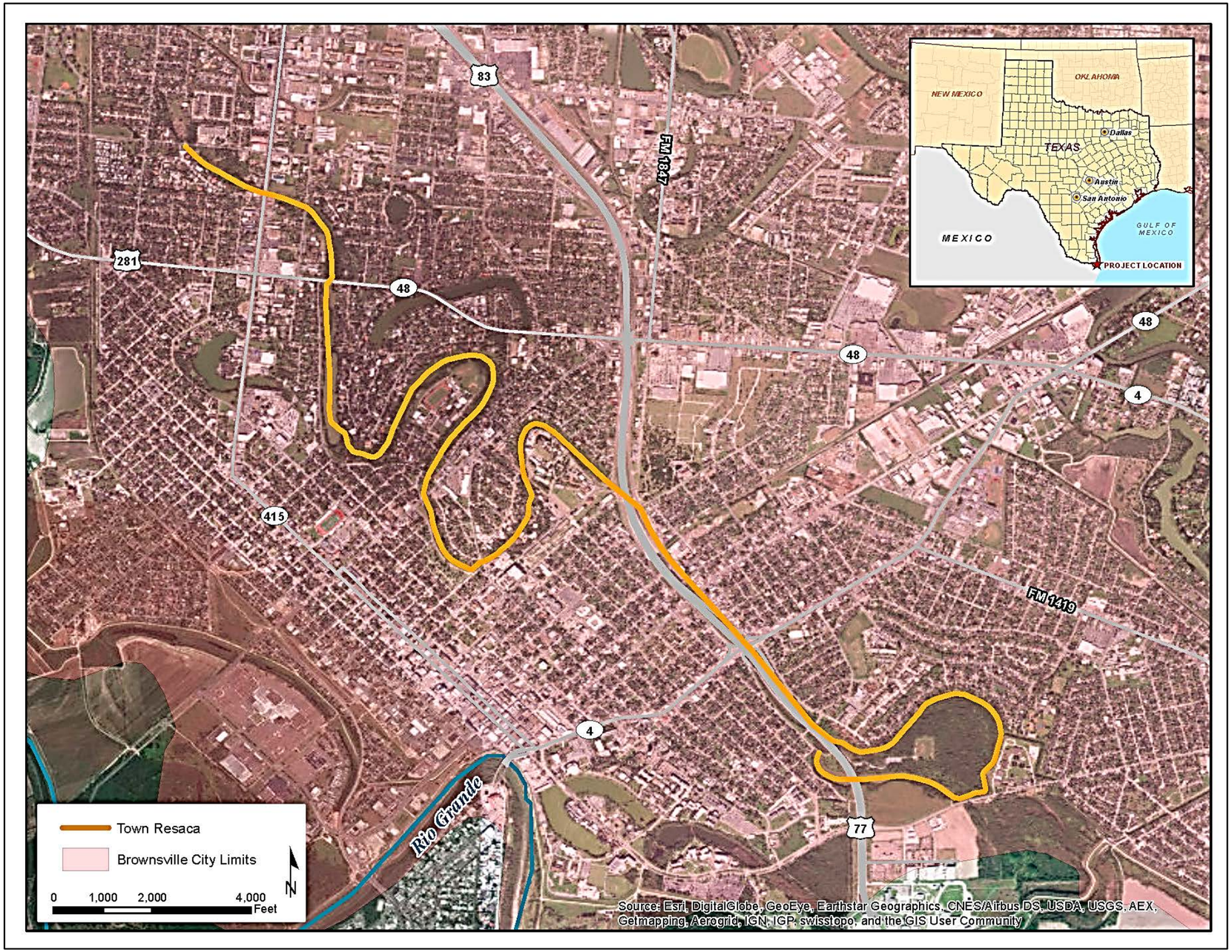


Figure 2–6: Location Line for Town Resaca

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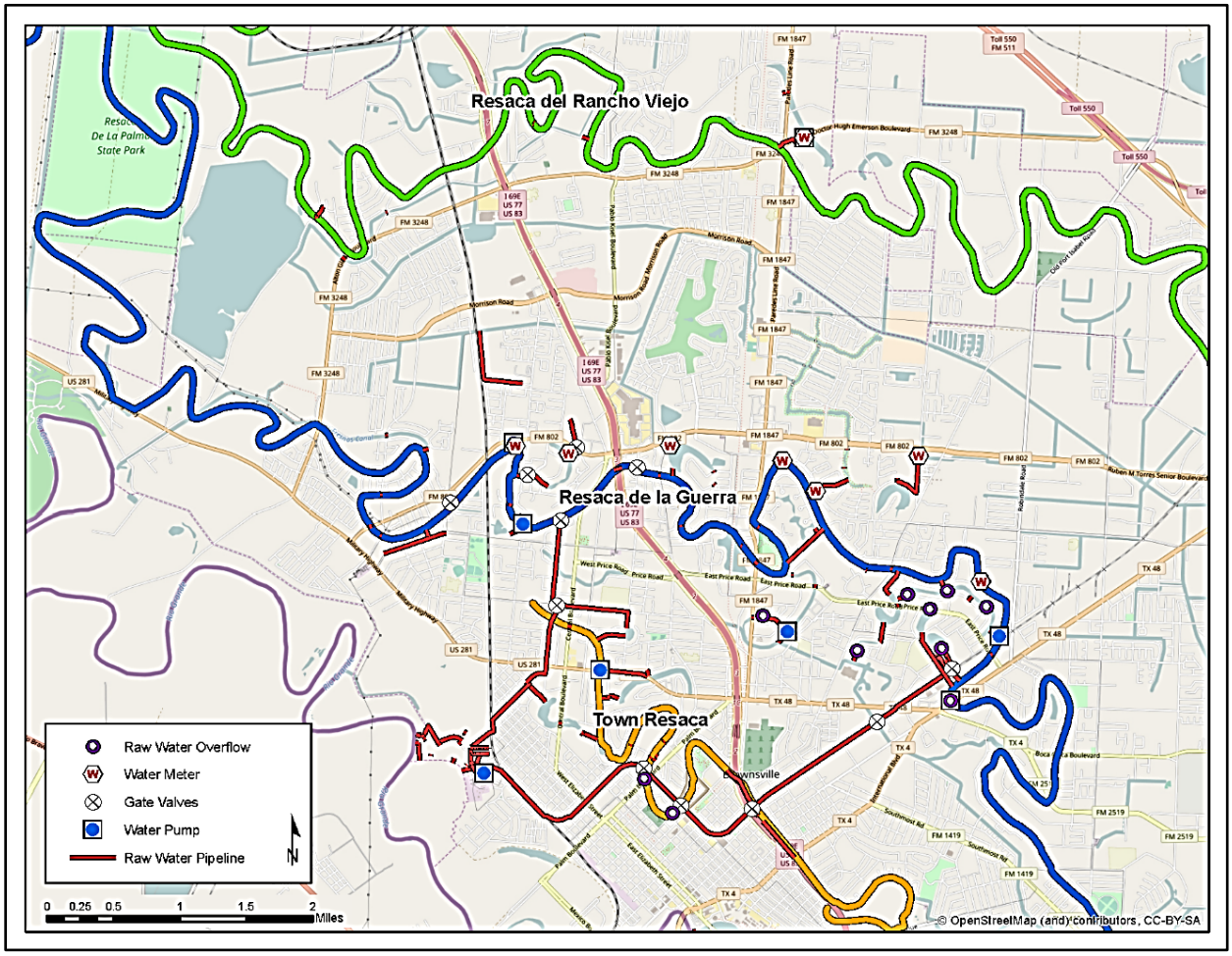


Figure 2–7: Water Control Structures for Resaca de la Guerra and Resaca del Rancho Viejo

Resaca de la Guerra

The Resaca de la Guerra is located between Town Resaca and Resaca del Rancho Viejo. Most of the resaca's water is pumped from the Rio Grande and is used for public consumption and irrigation. A weir located near 14th Street control water levels in Resaca de la Guerra. Residential and commercial development encompasses most of the land adjacent to the resaca. This resaca also provides extra drainage capacity during rainfall events with excess runoff routed to the Brownsville Navigation District Ship Channel.

Resaca del Rancho Viejo

The Resaca del Rancho Viejo is the northernmost of the three Brownsville resaca systems. The areas surrounding Resaca del Rancho Viejo are the least developed consisting of low density residential and agricultural uses. Water in the Resaca del Rancho Viejo system is primarily used for row crop and orchards irrigation. The resaca and irrigation flow is primarily gravity flow. The areas adjacent to the Resaca del Rancho Viejo system are undergoing rapid change due to Brownsville's urban expansion. Because of neighborhood development, there are several in-channel water control structures.

Town Resaca

The Town Resaca system originates approximately 800 feet east of the intersection of Los Ebanos Boulevard and Honeydale Street in Brownsville and extends southeasterly to the intersection of 30th Street and Hortencia Boulevard. The major source of water for the Town Resaca system is the Rio Grande River through the BPUB pipeline. In addition, smaller amounts of water also enter the Town Resaca System through storm sewers and natural surface drainage. The primary use of Town Resaca System is for storm water drainage.

Wetlands

Wetlands are areas inundated or saturated by surface or ground water at a frequency and duration sufficient to support vegetation typically adapted for saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas **Invalid source specified.**. Ecologically, wetlands are unique and critical habitat for many species of plants and wildlife.

Wetlands within the study area are concentrated along the banks of the resacas and in the areas between adjacent restoration areas. Additional wetland areas have also formed along drainage ditches and drain into the resacas. In addition, silted in resacas provide a relatively low sloping shoreline, or are seasonally inundated, and may provide the hydrology, soils, and vegetation to support wetland habitats.

The U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory (NWI) data with a 150-foot buffer around the resacas was used to estimate the spatial extent of the resacas wetlands. The NWI methodology identified approximately 11 percent of the areas adjacent to the resacas classified as wetlands. Table 2-1 lists the percentages and types of NWI wetlands within and adjacent to the Brownsville resacas.

Table 2-1: National Wetland Inventory Wetlands in and Adjacent to Resacas in Brownsville, Texas

NWI Class	System	Subsystem	Class	Subclass	Water Regime	Modifier	Acres	Percent of Wetland	Percent of Total
L1UBH	Lacustrine	Limnetic	Unconsolidated Bottom		Permanently Flooded		16.4 16.4	6.4	0.7
PAB3F	Palustrine		Aquatic Bed	Rooted Vascular			1.6 1.6	0.6	0.1
PEM1A	Palustrine		Emergent	Persistent	Temporarily Flooded		4.3		
PEM1C			Emergent	Persistent	Seasonally Flooded		11.1		
PEM1Ch			Emergent	Persistent	Seasonally Flooded	Diked Impounded	2.1	12.8	1.4
PEM1F			Emergent	Persistent	Semi-permanently Flooded		15.1 32.6		
PSS1A	Palustrine		Scrub-Shrub		Temporarily Flooded		0.5		
PSS1C			Scrub-Shrub		Seasonally Flooded		4.3	2.2	0.2
PSS1Cx			Scrub-Shrub		Seasonally Flooded	Excavated	0.8 5.6		
PUBF	Palustrine		Unconsolidated Bottom		Semi-permanently Flooded		5.3		
PUBH			Unconsolidated Bottom		Seasonally Flooded		151.5	75.9	8.5
PUBHh			Unconsolidated Bottom		Seasonally Flooded	Diked/ Impounded	24.5		
PUBHx			Unconsolidated Bottom		Seasonally Flooded	Excavated	12.6 194.0		
Total Wetlands							255.4	100.0	11.2
Riparian Acreage							2019.6		88.8
Total Study Area Acreage							2275.0		100.0

Water Quality

Existing water quality data for resacas is relatively limited. The Texas Commission on Environmental Quality (TCEQ) regulates surface water quality within the State of Texas. The resacas of Brownsville are unclassified with respect to Texas water quality standards. General criteria applied to all surface waters in Texas apply to the resacas; they are found in the Texas Administrative Code (TAC), Title 30, Part 1, Chapter 307. The TCEQ is investigating pollutant loads and impairments of resaca water quality resulting from nonpoint sources. Results of the study and designation of the resacas are pending.

No water quality data was identified for Resaca de la Guerra and Resaca del Rancho Viejo. The BPUB had water quality data at the adjacent Cemetery Resaca and Dean Porter Resaca within the Town Resaca system. This water quality data indicated oxygen levels and pH indicative of waters enriched with a high nutrient load. High pH and dissolved oxygen (percent saturation) indicate high photosynthetic rates. Abundant phytoplankton, benthic algae, and/or aquatic plants are responding to excess nutrients.

Nightly respirations of these plants decrease oxygen levels until sunrise. The resacas' average dissolved oxygen concentrations ranged 5.1 to 9.2 milligrams per liter (mg/L). Although dissolved oxygen concentrations exceeded the water quality criterion of 5.0 mg/L set for the Rio Grande (TCEQ, 2012) throughout much of the year, oxygen levels decreased significantly during the summer months. Water temperatures ranged from 59 degrees F in January to 70 degrees F in November.

McIntosh (2014) assessed water quality in three resacas east of Brownsville (two resacas located within the Sabal Palm Sanctuary) with similar results. Water temperatures in the resacas ranged from 54 degrees F in the winter to 95 degrees F in the summer. Dissolved oxygen in the resacas ranged from 2.1 to 12.8 mg/L. Similar to the Boulevard Resaca, the three resaca segments evaluated by McIntosh are considered eutrophic. This means they are rich in mineral and organic nutrients that promote a proliferation of algae and aquatic plants, resulting in a reduction of dissolved oxygen. In addition to collecting standard water quality parameters for the resacas, McIntosh also analyzed the resaca segments for total phosphorous, nitrite, nitrate, and ammonia. Nutrient loading was within the Texas Commission Environmental Quality water quality limits; however, these resacas were not adjacent to residential areas.

A Brownsville Urban Waterways Study **Invalid source specified.** found that there were high concentrations of fecal coliform in the Town Resaca. *(Fecal coliforms are an indication of animal or human waste.)* The contamination was attributed to the Gladys Porter Zoo, storm water runoff, and septic systems along the resacas. The study concluded the contamination could be attributed to a specific source, since concentrations of most other analytical parameters were not indicative of pollution.

Non-point source pollutants account for a significant portion of resaca contamination. Fertilizers and pesticides enter the resacas through runoff from residential and commercial landscapes. This adds to the nutrients contributing to the abundant aquatic flora in the resacas. Additionally, stormwater runoff carries petroleum byproducts, antifreeze, and trash into the resacas.

Ground Water

The study area overlies the LRGV aquifer. Recent alluvial deposits lie at the surface throughout the study area and over most of the county. These fluvial and deltaic sediments are underlain by several thousand feet of very similar but older Quaternary and Tertiary deposits. Locally, individual sand beds or lenses, are effectively separated. The complex intergradation and interfingering of the beds of the various sediments control the availability of water to wells and is the cause of significant differences in water quality over very short distances both horizontally and vertically.

Ground water occurs under a variety of conditions that range from pure water table to artesian conditions. Within the immediate vicinity of Brownsville, large amounts of

ground water are in storage in the upper 225 feet of the aquifer. In this area, the aquifer consists of three more or less separate producing zones, which can generally be differentiated both by water-producing characteristics (transmissibility, net sand thickness, particle sizes, etc.) and chemical quality of the produced water (Table 2-2).

Table 2-2: Lower Rio Grande Valley Aquifer Characteristics

Groundwater Zone	Depth (feet in depth)	Water Quality
Shallow	0-75	Poor - Highly mineralized water; limited amounts
Middle	75-150	Poor – limited amounts
Deep	150-225	Fresh to slightly saline water. Produces high amounts of water, uses are also restricted by water-quality problems. This water must be diluted with fresh surface water to be used for municipal uses

Floodplains

Executive Order (EO) 11988, enacted on May 24, 1977, states that each federal agency shall provide and shall take action to reduce the risk of the flood loss; to minimize the impacts of floods on human safety, health, and welfare; and to restore and preserve the natural and beneficial values served by floodplains.

Before construction of the International Falcon Dam and Reservoir and other lakes on the Rio Grande, the entire lower valley was subject to flooding during times of high river flow. The authorized purpose for building these reservoirs was to reduce flooding in the Rio Grande River floodplain. A system of levees also helps prevent flooding in the valley. The International Boundary and Water Commission maintain the levees. In the past 100 years, the construction of dams, flood control levees, and water management significantly minimized the risk of flooding the resacas and altered the floodplain connection of the resacas.

The FEMA Digital Flood Insurance Rate Maps were analyzed to establish the locations of the 100-year and 500-year flood zones (Figure 2–8). The study area is located within the 100-year floodplain of the Rio Grande River and the resacas.

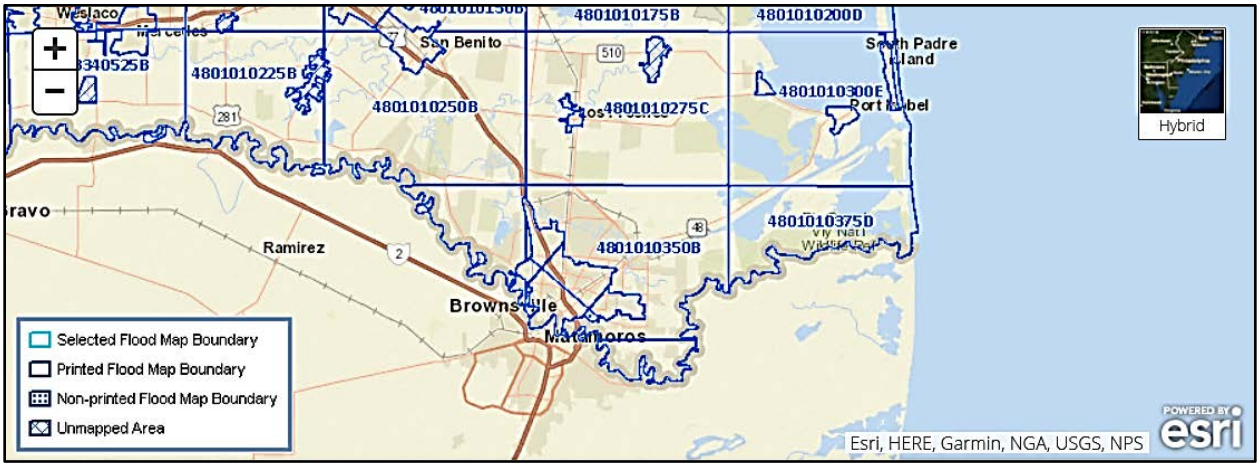


Figure 2–8: FEMA Flood Map for Lower Rio Grande Valley (Map courtesy of FEMA)

Water Supply

Brownsville relies almost entirely on the Rio Grande for its water supply. Because of poor quality, ground water must be combined with the Rio Grande supply for municipal use. With the connection to the Rio Grande, resacas play an integral role in Brownsville's water supply and management. Brownsville diverts water from the Rio Grande and operates two water treatment plants and two wastewater treatment plants. The combined capacity of Water Treatment Plant (WTP) No. 1 and WTP No. 2 totals 40 million gallons per day. The resacas are used as a conveyance to transport river water to WTP No. 2 (Figure 2–9). Of the average 18 million gallons of water per day used by the City of Brownsville, approximately 8 million gallons per day are transported along the Resaca de la Guerra system to WTP No. 2. The resacas also serve as limited reservoirs for water storage, a role becoming increasingly important during times of drought.

In addition to the municipal water used, two irrigation districts manage resaca water in the study area. Cameron County Irrigation District No. 6 and Brownsville Irrigation and Drainage District No. 5 are under agreement with the BPUB to manage scarce water supplies. Water demand consists of approximately 90 percent irrigation use and 10 percent municipal use. As economic growth continues to increase urban development, the percent of water dedicated to municipal uses is increasing.

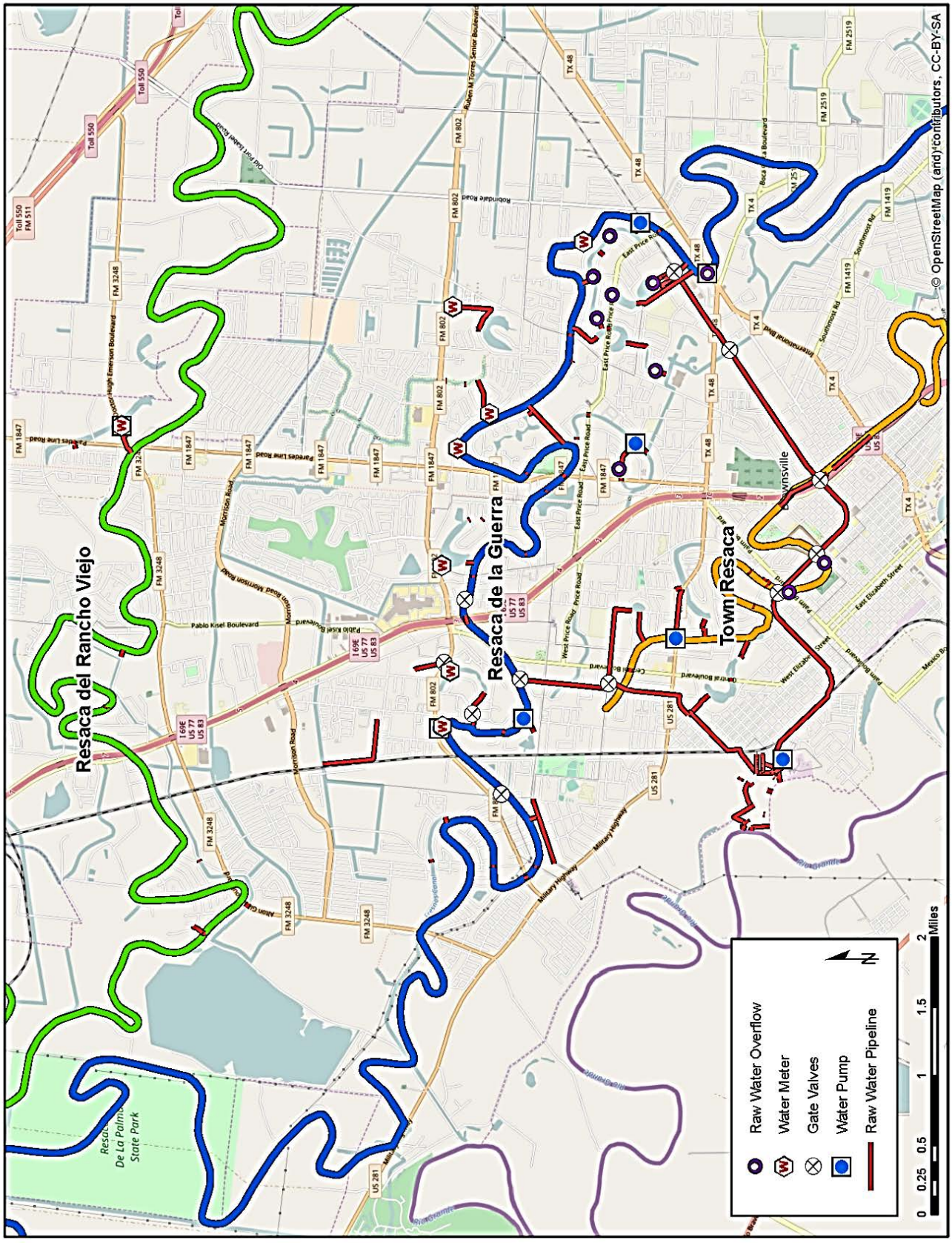


Figure 2–9: BPUB Water Management of the Resaca Systems

Future Without Project Condition

The resacas would continue along their successional pathway and continue to silt in, eventually converting the aquatic feature into rich upland thornscrub habitat. Other wetland habitat would also be expected to decrease in overall quality and eventually convert to upland thornscrub habitat. Recently the BPUB dredged the Resaca Boulevard Resaca, the Cemetery Resaca, the Dean Porter Park Resaca, and the Gladys Porter Zoo Resaca. These four named resacas are included in Town Resaca. These operation and maintenance projects are necessary because sediment, trash, and debris have built up over the years, impeding water flow in these waterways.

The aquatic component of several resacas would likely be maintained by local agencies responding to public interest in the aesthetic value of the area, while other aquatic and riparian habitats associated with natural resaca systems may not benefit from that level of attention or action.

The BPUB would implement conservation measures in response to forecast economic and population growth to ensure the availability of water.

Urbanization increases flood volume, frequency, and peak flood value because it brings with it more impervious surfaces, such as roads and large paved areas. This causes increased runoff that would occur more rapidly and with a greater peak flows than under rural conditions. Urbanization would tend to increase flash flooding, turbidity, pollutant loads, and bank erosion. Increases in dissolved solutes (conductivity), suspended solids (turbidity), fecal bacteria, nitrogen and phosphates, dissolved oxygen, and/or toxics (e.g. metals, pesticides, pharmaceuticals, other organic pollutants) would tend to increase. Additionally, chloride, sulfates, ammonia, and bacteria by infiltration from surface water polluted by municipal and industrial wastes and/or from leaking sewer lines could contaminate the groundwater.

To address the potential for an increase in contaminants entering water sources, the TCEQ and EPA would continue to update and enforce regulations addressing and minimizing the pollutant effects on water quality.

Biological Resources

Biological resources include plants, animals, and the habitats in which they occur. Biological resources are important because: 1) they influence ecosystem functions and values; 2) they have intrinsic value and contribute to the human environment; and 3) they are the subject of a variety of statutory and regulatory requirements.

Existing Condition

Modeling Efforts

The USACE, in cooperation with the USFWS, the TPWD, the NPS, the BPUB, and university biologists, developed a Resaca Reference Condition Model (RRCM). The purpose of the model was to quantify and assess the existing habitat conditions, the future without project conditions, and the future with-project conditions (alternatives). The RRCM uses data collected from high quality resaca sites within the Resaca de la Palma State Park, the Nature Conservancy's Southmost Preserve, and Camp Lula Sams. The RRCM is comprised of three modules with each module dedicated to one of the resaca vegetation communities: Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland.

Each RRCM module is comprised of three components to quantify habitat quality: (1) vegetation composition, (2) bank structure, and (3) invasive species. The vegetation and bank structure composition metrics are a goodness of fit index. This is based on the species diversity, composition, stream bank topography, and emergent and terrestrial vegetation canopy overhanging the shoreline. The invasive species metric incorporates an index accounting for the percent composition of non-native and invasive species.

An overall Resaca Reference Condition Index (RRCI) incorporated these indices. A score of 1.0 indicates the site equals or exceeds the high quality reference resaca habitat and a score of 0.0 describes a completely modified resaca where, with the exception of the presence of water, there is no semblance of the native resaca ecosystem intact.

The Ecosystem Restoration Planning Center of Expertise submitted the RRCM to the USACE Headquarters model certification panel. The model was approved for use on Jan. 10, 2017 in compliance with Engineering Circular (EC) 1105-2-412). Information about the modeling effort is presented in Appendix B.

Habitat

The study area is within the Matamoran District of the Tamaulipan Biotic Province of southern Texas and northeastern Mexico. The Matamoran District is commonly referred to as the Lower Rio Grande Valley, which covers an area of 4,300 square miles in the Tamaulipan Thornscrub and Gulf Coast Prairies and Marshes ecoregions. Although rainfall is sporadic, the climate contributes to growth of western desert, north coastal, and tropical plants making this region unique in Texas. The vegetation communities represent a distinctive difference between temperate and tropical conditions. These areas exhibit high biodiversity of plants and animals, some of which are found in few other places, if any, and are restricted to the LRGV of Texas (Cameron, Hidalgo, and Willacy counties) and Mexico.

The area is home to plant and animal species found nowhere else in the United States. The presence of rare communities combined with the areas' rich diversity of bird and butterfly species make this area one of the state's most popular nature tourism destinations.

The predominant vegetation type in this area is thorny brush (Figure 2–10), but there is overlap with the vegetative communities of the Chihuahuan desert to the west, the Balconian province to the north (Texas Hill Country), and the tropical plant communities of Mexico to the south. Xeric plants such as mesquite (*Prosopis glandulosa*), leatherstem (*Jatropha dioica*), lotebrush (*Ziziphus obtusifolia*), and brasil (*Condalia hookeri*) are found in this area. Sugar hackberry (*Celtis laevigata*) and Texas persimmon (*Diospyra texana*), more prevalent to the north, are also located in the LRGV. Other common species such as lantana (*Lantana horrida*), Mexican olive (*Cordia boisierri*), and Texas ebony (*Pithecellobium ebano*) are typically more tropical. Montezuma bald cypress (*Taxodium mucronatum*), Gregg wild buckwheat (*Eriogonum greggi*), Texas ebony, and anacahuita (*Mexican olive*) have their northernmost extension in the LRGV. Large elms (*Ulmus crassifolia*) dominate the floodplain in some areas and there is usually an alteration of elm dominants and brush species. Surface water briefly remains in arroyos following substantial rainfall. Because of water scarcity, the resulting vegetation types are closely correlated to topographic characteristics.

More than 90 percent of total riparian vegetation and 95 percent of Tamaulipan Thornscrub have been cleared since the 1900s. This region is home to some of the most imperiled habitat on earth. Clearing for ranching, agriculture, and urbanization resulted in the loss of more than 95 percent of the wildlife habitat. The remaining habitat is crucial to the species that rely on it to survive.

Because of the habitat losses, three vegetation communities associated with resacas are identified as globally imperiled with extinction including the (1) Texas Ebony Resaca Forest (G1 ranking[1]), (2) Subtropical Texas Palmetto Woodland (G2[2]), and (3) Texas Ebony/Snake-eyes Shrubland (G2) (NatureServe 2017). The three vegetation communities evolved specifically with the natural dynamics interactions of the resacas and the Rio Grande. These communities do not occur at any other

Figure 2–10: Vegetation includes All-thorn, Bisbirinda, Chaparro, and Goatbush.

[1] G1 rankings indicate critically imperiled species or communities at extreme rarity, very steep declines, or other factors.

[2] G2 rankings are for imperiled species at high risk of extinction or elimination due to very restricted range, very few populations, steep declines, or other factors.

place on earth. There are three reasons for the NatureServe Ranking. The range of these communities is highly restricted. The loss of hydrologic function threatens the extinction of these communities. Most of the existing or natural vegetation has been destroyed.

The RRCM was used to quantify the extent to which the potential reference sites mirrored reference conditions. The RRCM used habitat-specific features to integrate measures to improve resaca habitat. Table 2-3 includes the existing RRCM metrics and index scores for the potential restoration areas.

Wildlife

Diversity of habitat types results in a diverse vertebrate fauna, including species of subtropical, southwestern desert, prairie, coastal marshland, eastern forest, and marine affinities. Tamaulipan brush land provides important feeding, nesting, and cover habitats for many species. Brush clearing and other human activities have had a profound impact on a variety of vertebrates and invertebrates in the LRGV. The region is a convergence zone for migrating bird species from the Central and Mississippi Flyway. About 700 vertebrate species are documented in the area. Some of these vertebrate species are not found in any other region of the United States.

There are numerous species found in Mexico and Central America whose ranges reach their northern most limit in the lower Rio Grande valley. Included among these: brown jay (*Cyanocorax morio*), ringed kingfisher (*Ceryle torquata*), red-billed pigeon (*Columba flavirostris*), Chachalaca (*Ortalis vetula*), speckled racer (*Drymobius margaritiferus*), and Mexican treefrog (*Smilisca baudinii*).

In the Fish and Wildlife Coordination Act Report, of August 10, 2017, (Appendix D-2) the USFWS described the migratory birds and other wildlife resources as diverse as are the high biodiversity found in the resacas' vegetation communities. The loss of natural habitat means the remaining resacas are crucial for the existence of the remaining species. These include those identified as state and federally listed threatened and endangered species.

Resacas provide loafing, breeding, and refuge habitat for a variety of resident and migratory birds. There are 50 species of migratory birds of conservation concern found within Cameron County. The USFWS Birds of Conservation Concern (2008) lists 27 avian species that may utilize Tamaulipan brushlands and may be found within the resacas. The LRGV is considered one of the most species-rich butterfly areas in the United States (Wauer 2004) with greater than 50 percent of observed species considered Lower Rio Grande Valley specialists or rarely found elsewhere **Invalid source specified.**. Remnant resacas also provide stepping stones of quality habitat for wildlife within the urban conditions of Cameron County, thus connecting remaining habitat parcels in the region. Fragmentation is a major cause of decline in many native species from different Orders, making restoration and connectivity a critical factor in conserving wildlife.

Habitats in the region support a unique invertebrate fauna, many reaching their northern limits of distribution in south Texas. Invertebrate populations have received little research attention, and their status is largely unknown. Habitat alterations likely have been detrimental to the area's invertebrate fauna.

Table 2-3: RRCM Index Scores for the Brownsville Resacas Existing Conditions

Restoration Area	Slope 1:X	Percent Canopy Cover				Spp Composition	Spp Richness	Water Depth (feet)	RRCM Index
		Bank	Riparian	Aquatic	Invasive				
Town Resaca									
3	2	80	70	0	85	0.16	0.38	3	0.46
4	2	80	70	0	85	0.16	0.38	3	0.46
5	2	80	70	0	85	0.16	0.38	3	0.46
6	2	80	70	0	85	0.16	0.38	3	0.46
7	12	85	75	20	60	0.15	0.33	3	0.63
8	2	80	70	0	85	0.16	0.38	3	0.46
10	2	80	70	0	85	0.16	0.38	3	0.46
13	15	90	85	25	70	0.26	0.71	3	0.67
19	1	90	75	5	5	0.46	0.71	2	0.68
39	2	80	70	0	85	0.16	0.38	3	0.46
Resaca de la Guerra									
40	6	70	80	50	80	0.35	0.46	3	0.58
41	1	80	75	50	70	0.36	0.79	3	0.59
42	20	75	62	0	55	0.22	0.38	6	0.69
43	20	75	62	0	55	0.22	0.38	6	0.69
44	1	65	40	0	50	0.28	0.58	3	0.53
45	15	35	80	0	25	0.26	0.33	6	0.72
46	10	85	90	0	45	0.30	0.46	3	0.66
53	2	90	70	5	80	0.17	0.29	3	0.48
54	2	90	70	5	80	0.17	0.29	3	0.48
59	2	40	1	0	70	0.14	0.25	5	0.43
60	2	40	1	0	70	0.14	0.25	5	0.43
61	1	35	70	2	2	0.28	0.63	4	0.65
62	1	35	70	2	2	0.28	0.63	4	0.65
66	1	35	70	2	2	0.28	0.63	4	0.65
67	8	70	80	0	25	0.19	0.42	4	0.69
71	1	30	60	0	70	0.38	0.54	6	0.48
72	8	70	80	0	25	0.19	0.42	4	0.69
74	0.01	0	0	0	80	0.00	0.00	3	0.25
75	4	20	10	0	99	0.25	0.42	3	0.32
76	4	20	10	0	99	0.25	0.42	3	0.32
77	4	20	10	0	99	0.25	0.42	3	0.32
78	4	20	10	0	99	0.25	0.42	3	0.32
79	4	20	10	0	99	0.25	0.42	3	0.49
80	1	20	50	0	50	0.15	0.42	5	0.49

INVENTORY AND FORECASTING CONDITIONS

Restoration Area	Slope 1:X	Percent Canopy Cover				Spp Composition	Spp Richness	Water Depth (feet)	RRCM Index
		Bank	Riparian	Aquatic	Invasive				
81	1	85	87	0	55	0.07	0.13	5	0.57
82	1	75	70	0	60	0.19	0.38	3	0.52
83	0.01	5	25	0	50	0.13	0.21	2	0.35
84	0.5	40	35	0	80	0.15	0.29	2	0.35
93	2	99	99	0	2	0.73	1.00	0	0.56
94	2	0	0	0	80	0.00	0.00	0	0.07
95	2	85	80	0	25	0.21	0.33	0	0.42
96	1.5	75	50	5	18	0.20	0.42	3	0.62
161	15	65	70	0	0	0.15	0.33	0	0.57
Resaca del Rancho Viejo									
98	2	60	50	0	75	0.56	0.96	5	0.56
99	2	60	50	0	75	0.56	0.96	5	0.56
100	2	60	50	0	75	0.56	0.96	5	0.56
101	2	30	30	0	50	0.13	0.29	5	0.49
104	1	80	75	0	80	0.19	0.29	5	0.52
105	2	85	80	0	25	0.21	0.33	2	0.60
108	2	85	85	0	40	0.17	0.33	3	0.59
109	4	65	50	0	20	0.10	0.21	3	0.60
110	0.01	70	60	0	20	0.14	0.25	5	0.64
111	0.01	40	40	0	80	0.13	0.17	3	0.36
112	7	65	60	5	25	0.20	0.29	5	0.68
116/117	12	77	80	30	25	0.17	0.38	3	0.74
142	0.01	5	70	0	40	0.30	0.42	3	0.45
148/167	20	75	62	0	55	0.22	0.38	3	0.64
149	8	80	60	10	28	0.45	0.50	3	0.69
150	0.01	40	40	0	80	0.13	0.17	1	0.31
151	0.01	40	40	0	80	0.13	0.17	1	0.31
165	8	50	50	0	60	0.29	0.46	0	0.33
166	10	13	32	0	40	0.28	0.42	0	0.32
1000	4	70	75	0	28	0.46	1.00	5	0.73
1001	1	50	60	0	60	0.22	0.54	5	0.53

Special Status Species

The USFWS threatened and endangered species list for Cameron County identifies 10 endangered, four threatened, and two candidate species (Table 2-4). Additionally, the TPWD listed other species as state threatened or endangered and are monitoring the conservation status of numerous other rare species of concern in the county. Many, including the ocelot, jaguarundi, and black-striped snake, rely on non-urban resacas for breeding, foraging, and escape cover. Species such as the red-crowned parrot, black-spotted newt, south Texas siren, and southern yellow bat occur in the City of Brownsville's urban resaca habitats. The bolded species listed in Table 2-4 indicate species utilizing resaca habitats in the area.

Table 2-4: Rare, Threatened, and Endangered Species of Cameron County, Texas

Common Name	Scientific Name	USFWS	TPWD	Resaca Habitat
Amphibians				
Black-spotted newt	*Notophthalmus meridionalis*		T	R
Mexican treefrog	*Smilisca baudinii*		T	R
Sheep frog	*Hypopachus variolosus*		T	R
South Texas siren	*Siren sp 1*		T	R
White-lipped frog	*Leptodactylus fragilis*		T	R
Birds				
Audubon's oriole	*Icterus graduacauda audubonii*		SOC	R
Brownsville common yellowthroat	*Geothlypis trichas insperata*		SOC	R
Cactus ferruginous pygmy-owl	*Glaucidium brasilianum cactorum*		T	R
Common black-hawk	*Buteogallus anthracinus*		T	R
Eskimo curlew	*Numenius borealis*		E	
Gray hawk	*Asturina nitida*		T	R
Interior least tern	*Sterna antillarum athalassos*	E	E	
Northern aplomado falcon	*Falco femoralis septentrionalis*	E	E	
Northern beardless-tyrannulet	*Campostoma imberbe*		T	R
Peregrine falcon	*Falco peregrinus*		T	R
Piping plover	*Charadrius melodus*	T	T	
Red knot	*Calidris canutus rufa*	T	T	
Red-crowned parrot	*Amazona viridigenalis*	C		R
Reddish egret	*Egretta rufescens*		T	
Rose-throated becard	*Pachyramphus aglaiae*		T	R
Sennett's hooded oriole	*Icterus cucullatus sennettii*		SOC	R
Snowy plover	*Charadrius alexandrinus*		SOC	
Sooty tern	*Sterna fuscata*		T	
Sprague's pipit	*Anthus spragueii*	C	SOC	
Texas Botteri's sparrow	*Aimophila botterii texana*		T	
Tropical parula	*Parula pitiayumi*		T	R
Western burrowing owl	*Athene cunicularia hypugaea*		SOC	
White-faced ibis	*Plegadis chihi*		T	R
White-tailed hawk	*Buteo albicaudatus*		T	
Wood stork	*Mycteria americana*		T	R
Zone-tailed hawk	*Buteo albonotatus*		T	
Fishes				
American eel	*Anguilla rostrata*		SOC	
Mexican goby	*Ctenogobius claytonii*		T	R
Opossum pipefish	*Microphis brachyurus*		T	
Rio Grande shiner	*Notropis jemezanus*		SOC	R
Rio Grande silvery minnow	*Hybognathus amarus*		E	R
River goby	*Awaous banana*		T	R
Smalltooth sawfish	*Pristis pectinata*		E	
Insects				

A royal moth	*Sphingicampa blanchardi*		SOC	R
Manfreda giant-skipper	*Stallingsia maculosus*		SOC	R
Smyth's tiger beetle	*Cicindela chlorocephala smythi*		SOC	
Subtropical blue-black tiger beetle	*Cicindela nigrocoerulea subtropica*		SOC	
Tamaulipan agapema	*Agapema galbina*		SOC	R
Mammals				
Coues' rice rat	*Oryzomys couesi*		T	R
Jaguar	*Panthera onca*		E	
Jaguarundi	*Herpailurus yaguarondi*	E	E	R
Mexican long-tongued bat	*Choeronycteris mexicana*		SOC	
Ocelot	*Leopardus pardalis*	E	E	R
Plains spotted skunk	*Spilogale putorius interrupta*		SOC	
Southern yellow bat	*Lasiurus ega*		T	R
West Indian manatee	*Trichechus manatus*	E	E	
White-nosed coati	*Nasua narica*		T	R
Mollusks				
False spike mussel	*Quadrula mitchelli*		T	
Salina mucket	*Potamilus metnecktayi*		T	R
Texas hornshell	*Popenaias popeii*		T	
Reptiles				
Atlantic hawksbill sea turtle	*Eretmochelys imbricata*	E	E	
Black-striped snake	*Coniophanes imperalis*		T	R
Green sea turtle	*Chelonia mydas*	T	T	
Keeled earless lizard	*Holbrookia propinqua*		SOC	
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	E	
Leatherback sea turtle	*Dermochelys coriacea*	E	E	
Loggerhead sea turtle	*Caretta caretta*	T	T	
Northern cat-eyed snake	*Leptodeira septentrionalis septentrionalis*		T	R
Speckled racer	*Drymobius margaritiferus*		T	R
Texas horned lizard	*Phrynosoma cornutum*		T	
Texas indigo snake	*Drymarchon melanurus erebennus*		T	R
Texas scarlet snake	*Cemophora coccinea lineri*		T	
Texas tortoise	*Gopherus berlandieri*		T	
Plants				
Bailey's ballmoss	*Tillandsia baileyi*		SOC	R
Buckley's spiderwort	*Tradescantia buckleyi*		SOC	R
Green Island echeandia	*Echeandia texensis*		SOC	
Large selenia	*Selenia grandis*		SOC	R
Lila de los llanos	*Echeandia chandleri*		SOC	
Marsh-elder dodder	*Cuscuta attenuata*		SOC	R
Mexican mud-plantain	*Heteranthera mexicana*		SOC	R
Plains gumweed	*Grindelia oolepis*		SOC	
Runyon's cory cactus	*Coryphantha macromeris var. Runyonii*		SOC	
Runyon's water-willow	*Justicia runyonii*		SOC	R
Shinner's rocket	*Thelypodiopsis shinnersii*		SOC	R
Siler's huaco	*Manfreda sileri*		SOC	
South Texas ambrosia	*Ambrosia cheiranthifolia*	E	E	R
South Texas spikesedge	*Eleocharis austrotexana*		SOC	R
Star cactus	*Astrophytum asterias*		E	
Texas ayenia	*Ayenia limitaris*	E	E	
Texas milk vetch	*Astragalus reflexus*		SOC	
Texas stonecrop	*Lenophyllum texanum*		SOC	
Wright's trichocronis	*Trichocoronis wrightii var. Wrightii*		SOC	R
Yellow-flowered alicoche	*Echinocereus papillosus*		SOC	

E=Endangered T=Threatened SOC=Species of concern R=Rare

Invasive Species

The Brownsville resacas degradation resulted in the loss of habitat quality to support native fish and wildlife resources. Linked to the habitat degradation is the loss of native

aquatic and riparian plant species, which is vital to the aquatic and riparian environment. Much of the loss is also attributable to the spread of invasive and non-native species throughout the study area. Urbanization (loss of habitat and introduction of nonnative ornamental plants) and improved transportation have exacerbated the spread of invasive species.

There are accounts for at least 110 noxious and invasive species recorded in Texas (iNaturalist, 2017). Table 2-5 lists some of the Study area's common invasive plant and animal species. Limited distribution records were identified for fish, mussel, or insects. It is assumed there are additional invasive and non-native species present in the study area.

Table 2-5: Common Invasive Species near Brownsville, Texas

Species	Scientific name	Habitat impact
Plants		
Guinea grass	*Urochloa maxima*	Monoculture over takes native vegetation
Chinese tallow tree	*Triadica sebifera*	Monoculture over takes native vegetation
Salt cedar	*Tamarix ramosissima*	Interfere with natural aquatic systems
Chinaberry tree	*Melia azedarach*	Outcompetes native vegetation
Buffelgrass	*Pennisetum ciliare*	Outcompetes native vegetation
Brazilian peppertree	*Schinus terebinthifolius*	Monoculture over takes native vegetation
Hydrilla	*Melia azedarach*	Degrades water quality; accelerates evaporation
Water hyacinth	*Eichhornia crassipes*	Degrades water quality
Giant reed	*Arundo donax*	Chokes riversides and stream channels, crowds out native plants
Water lettuce	*Pistia stratiotes*	Degrades water quality
Popinac	*Leucaena leucocephala*	Monospecific thickets threatens native plant communities
Animals		
Nutria	Myocastor coypus	Destroys habitat
Nilgai antelope	Boselaphus tragocamelus	Competes with native species for food
Feral hog	Sus scrofa	Habitat destruction; Replaces native species
Sailfin catfish	Pterygoplichthys disjunctivus	Impact on the aquatic food base and, therefore, negatively effecting native invertebrate and vertebrate species

Source: Texasinvasives.org (2017), USFWS FWCAR, 2017

Future Without Project Condition

The RRCM was used to forecast future conditions. The period of analysis was 75 years. The existing RRCM indices were multiplied by the acreage of habitat restoration for each restoration area to come up with the existing habitat units for the study.

The forecast assumptions were that the resacas would continue to accumulate sediment over time; water depths would decrease; and non-native species would spread. The non-native, invasive plant species would continue to adversely impact fish and wildlife habitats. The lower quality habitats would then limit the diversity and sustainability of fish and wildlife species.

Table 2-6 presents the resulting indices and habitat units for the existing and without project condition.

Table 2-6: List of Restoration Areas with Existing and Future Without Project Benefits

Restoration Area	Existing Resaca Depth (feet)	FWOP Resaca Depth (feet)	Existing RRCI	FWOP Annualized RRCI	Acres	Existing Habitat Units	FWOP Habitat Units
Town Resaca							
3	3	0	0.46	0.33	0.69	0.34	0.23
4	3	0	0.46	0.33	1.83	0.84	0.61
5	3	0	0.46	0.33	5.53	2.54	1.85
6,7	3	0	0.63	0.45	24.02	15.13	10.74
8	3	0	0.46	0.33	0.02	0.01	0.01
10	3	0	0.46	0.33	7.11	3.27	2.38
13	3	0	0.67	0.5	8.44	5.65	4.25
17,18,19	2	0	0.68	0.41	96.49	65.61	39.82
39	3	0	0.46	0.33	1.18	0.54	0.39
Resaca de la Guerra							
40	3	0	0.58	0.37	32.71	18.97	11.99
41	3	0	0.59	0.41	21.24	12.53	8.60
42	6	0	0.69	0.51	54.75	37.78	27.83
43	6	0	0.69	0.51	33.99	23.45	17.28
44	3	0	0.53	0.34	19.54	10.36	6.74
45E	6	0	0.72	0.49	5.05	3.64	2.49
45,46	6	0	0.66	0.47	4.96	3.27	2.32
53	3	0	0.48	0.34	1.62	0.78	0.56
54	3	0	0.48	0.34	8.61	4.13	2.95
59	5	0	0.43	0.31	3.62	1.56	1.12
60	5	0	0.43	0.31	1.81	0.78	0.56
61	4	0	0.65	0.42	26.10	16.97	10.90
62	4	0	0.65	0.42	3.22	2.09	1.34
66	4	0	0.65	0.42	20.37	13.24	8.51
67	4	0	0.69	0.48	19.54	13.48	9.34
71	6	0	0.48	0.37	7.77	3.73	2.91
72	4	0	0.69	0.48	8.76	6.04	4.19
74	3	1	0.25	0.22	4.98	1.25	1.08
75	3	0	0.32	0.2	13.46	4.31	2.73
76	3	0	0.32	0.2	0.86	0.28	0.17
77,78	3	0	0.32	0.2	4.11	1.32	0.83
79	5	0	0.49	0.3	3.39	1.66	1.03
81	5	0	0.57	0.43	4.42	2.52	1.90
82	3	0	0.52	0.36	21.43	11.14	7.65
83	2	0	0.35	0.17	12.61	4.41	2.18
84	2	0	0.35	0.22	18.27	6.39	4.03
93	0	0	0.56	0.42	10.49	5.87	4.40
94	0	0	0.07	0.06	10.87	0.76	0.60
95	0	0	0.42	0.33	45.07	18.93	15.06
96	3	0	0.62	0.38	12.89	7.99	4.94
Resaca del Rancho Viejo							
98	5	0	0.56	0.45	19.60	10.98	8.89
99	5	0	0.56	0.45	10.13	5.67	4.60
100	5	0	0.56	0.45	16.90	9.46	4.00
101	5	0	0.49	0.34	47.64	23.34	16.25
104	5	0	0.52	0.42	20.27	10.54	8.47
105	2	0	0.60	0.39	43.95	26.37	17.03
108	3	0	0.59	0.37	5.78	3.41	2.14
109	3	0	0.60	0.37	17.18	10.31	6.28
110	5	0	0.64	0.47	10.94	7.00	5.16
111	3	0	0.36	0.22	13.34	4.80	2.87
112	5	0	0.68	0.5	15.97	10.86	7.98
116/117	3	0	0.74	0.51	30.30	22.42	15.45
142	3	0	0.45	0.25	32.50	14.63	8.25
149	3	0	0.69	0.47	9.82	6.78	4.63
150	1	0	0.31	0.16	2.49	0.77	0.40
151	1	0	0.31	0.16	2.44	0.76	0.40
161	0	0	0.57	0.41	53.16	30.30	22.02
165	0	0	0.33	0.29	4.29	1.42	1.23
166	0	0	0.32	0.24	10.76	3.44	2.63
167,148	3	0	0.64	0.46	81.53	52.18	37.18
1000	5	0	0.73	0.55	51.70	37.74	28.25
1001	5	0	0.53	0.39	17.26	9.15	6.78
Average	3.33	0	0.52	0.36	-	-	-
Total	-	-	-	-	1,099.77	635.89	437.40

Cultural and Historic Resources

Existing Condition

Cultural resources include buildings, structures, sites, districts, and objects eligible for or included in the National Register for Historic Places (NRHP), cultural items, Indian sacred sites, archaeological artifact collections, and archaeological resources.

The National Historic Preservation Act (NHPA) of 1966, as amended, Section 106, requires federal agencies to, "… take into account the effects of their undertakings on historic properties". Additionally, it requires the agencies to consider alternatives, "… to avoid, minimize or mitigate the undertaking's adverse effects on historic properties" [(36 CFR 800.1(a-c)] in consultation with the State Historic Preservation Officer (SHPO) and appropriate federally recognized Indian Tribes (Tribal Historic Preservation Officers - THPO) [(36 CFR 800.2(c)]. Other applicable cultural resources laws, rules, and regulations dictate how investigations and evaluations will proceed throughout the study and implementation phases (e.g., Archeological and Historic Preservation Act of 1974, National Environmental Policy Act of 1969, Native American Graves Protection (NAGPRA) and Repatriation Act, Engineer Regulation 1105-2-100).

Humans have occupied the study area since the Paleoindian Period, dating to around 11,500 before present (BP) (Hester, 1995). The resacas are generally filled with clays and silts, and are surrounded by overbank flood deposits. Anderson (1930) and Terneny (2005) documented hundreds of recorded archaeology sites in the silty clay dunes surrounding these abandoned river channels. The Paleoindian Period in this region persisted until approximately 8,000 BP, and is not well documented due to rising sea levels, which have left coastal Paleoindian sites submerged on the continental shelf. Tool types recorded at these sites include Clovis, Folsom, and Angostura points, representing the earliest stone tool technologies in North America.

Archaic Period (8,000-500 BP) sites are more common and contain evidence of increased populations, use of cemeteries for human burial, and intensified plant processing using earth ovens and grinding implements (Hester, 1995). During the Late Prehistoric Period (1,300-500 BP/1500 AD), bow and arrow artifacts appear, and the presence of Tancol Polychrome pottery, jade, and obsidian artifacts indicate links with Mexican Gulf Coast cultures (Terneny, 2005).

The Protohistoric Period spans from approximately 500 years BP (1500 AD) to 1750 AD. Traces of European-introduced material culture are evident at Protohistoric Period sites but do not appear to substantially alter local economies or other aspects of culture. By the Historic Period (early-mid 1700s), conflicting colonial interests had begun to drastically affect the cultural landscape of the Lower Rio Grande Delta. Aggressive American Indian removal took place throughout the 1800s, and in May of 1846, the

second battle of the Mexican American War was fought at Resaca de la Palma. The site of the battle, located within the study area, is now a National Park Service (NPS) managed National Historic Landmark. Historic documentation and excavations associated with residential construction confirm Mexican soldiers were buried in mass graves of 50-100 individuals after the decisive loss to American forces (Wescott et al., 2012).

Today, the area is known as the city of Brownsville and has more than 183,000 residents. The modern landscape is significantly altered by urbanization , though many historic standing structures remain in the central historic area of the city.

Future Without Project Condition

Under the FWOP condition, there would be no change to cultural resources.

Land Use

Existing Condition

The historic natural vegetation was cleared for intensive winter garden and orchard agricultural uses. The agricultural land use is now transitioning to residential, commercial, and industrial development as the economic growth of the area has increased. Figure 2–11 and Figure 2–12 indicate, the urban core of Brownsville gives way distally to open space and agriculture. Table 2-7 shows total acreage and percent of land uses immediately around each resaca. The table also shows the expected pattern of development with Town Resaca in the oldest part of Brownsville being more densely developed than the more rural resacas associated with the Resaca del Rancho Viejo system.

Future Without Project Condition

Under the FWOP, land use at the perimeter of the study area would continue to transition into residential and commercial development, while the more centralized urban areas would continue to transition to a more densely urban land use.

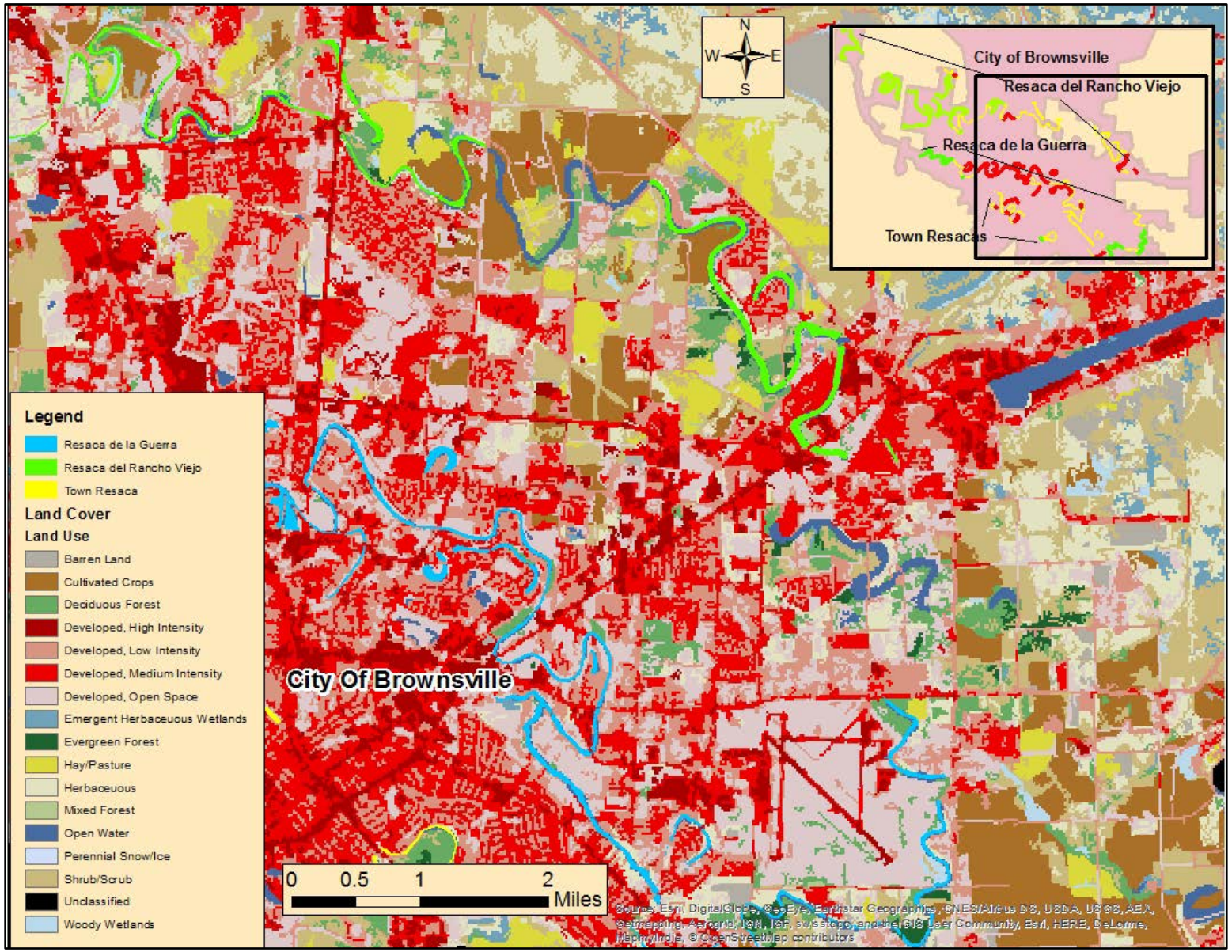


Figure 2–11: Existing Condition Land Use Map of Resacas Study Area (East)

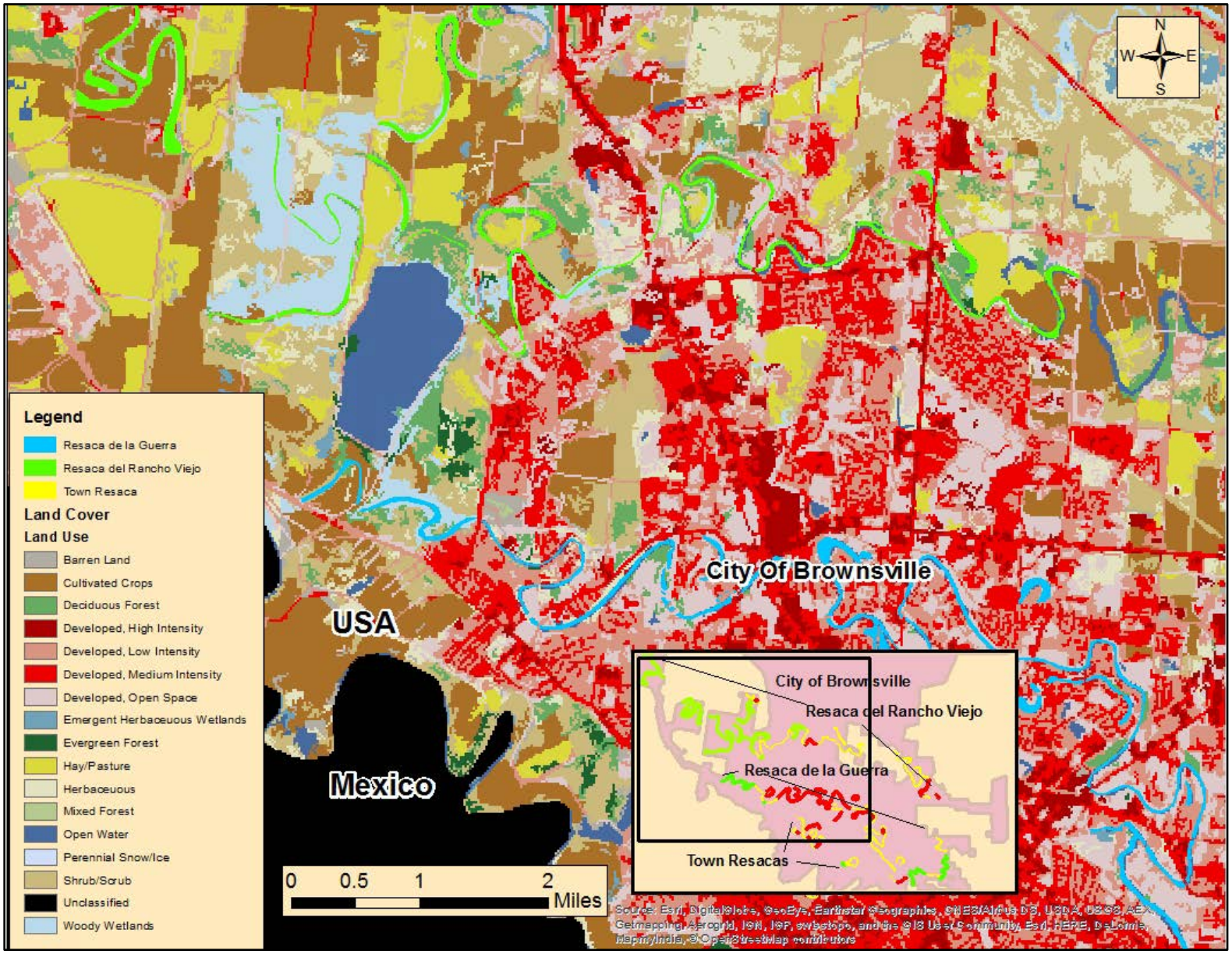


Figure 2–12: Existing Land Use Map of Resacas Study Area (West)

Table 2-7: Land Use in the Resaca Study Area.

Land Use	Resaca de la Guerra		Resaca del Rancho Viejo		Town	
	Acres	Percent Area	Acres	Percent Area	Acres	Percent Area
Urban or Built-up Land						
Residential	2,171.9	33.7	277.8	5.1	788.3	63.6
Commercial	179.1	2.8	127.4	2.3	181.0	14.6
Industrial	1.9	0.0			0.8	0.1
Transportation, Communications	60.6	0.9	102.7	1.9	75.0	6.1
Mixed Urban or Built-up Land	13.8	0.2				
Other Urban or Built-up Land	364.0	5.6	5.4	0.1	78.0	6.3
Agriculture Land						
Cropland and Pasture	2,902.0	45.0	4,076.9	74.9	57.7	4.7
Orchards, Groves, Vineyard, Nurseries	166.4	2.6	463.0	8.5	58.1	4.7
Rangeland						
Herbaceous Rangeland	78.8	0.0	141.0	2.6		
Shrub and Brush Rangeland	84.2	1.3	201.1	3.7		
Mixed Rangeland	130.8	2.0				
Forest Land						
Evergreen Forest Land	4.6	0.0				
Water						
Lakes			42.0	0.8		
Reservoirs	13.4	0.0	8.4	0.2		
Barren Land						
Barren Land	281.1	4.4				
Total Acres	6,452.7	100	5,445.7	100	1,238.9	100

Sources: Texas Natural Resources Information System and G.E.C., Inc.2017

State parks, conservation areas, and other areas of recreational, ecological, scenic, or aesthetic importance

The Brownsville area offers a wealth of nature, recreation, and historic areas. These areas are free of houses or other buildings and provide opportunities to relax, exercise, hunt, fish, and nature watch. These areas protect sensitive plants and wildlife.

Brownsville also manages 37 parks encompassing over 1,000 acres of parkland, that feature 32 miles of hike/bike trails, 3 gymnasiums and pools, 50 buildings and structures, over 55 athletics fields, and the Catherine Stillman Dog Park. Table 2-8 shows notable charitable, city, state, and federal parks in or near the planning area.

Table 2-8: Notable Brownsville Park Resources

Manager*	Park Name	Primary Purpose
TPWD	Resaca De La Palma State Park & World Birding Center	Birding in a 1,200-acre space, with bike trails, observation decks, butterfly garden & tram tours
City	Gladys Porter Zoo	Zoological and botanical park
NPS	Palo Alto Battlefield National Historic Park	Preserves the grounds of the May 8, 1846, Battle of Palo Alto.
USFWS	Laguna Atascosa National Wildlife Refuge	Wildlife management
USFWS	Santa Ana National Wildlife Refuge	Wildlife management
City	Prax Orive (Sunrise) Park	Bird watching, biking, picnicking
TPWD	Boca Chica State Park	Bird watching, camping
TPWD	Las Palomas Wildlife Management Area - Voshell Unit	wildlife viewing
City	Morningside Park	Sports fields, birdwatching
TNC	Southmost Preserve	Wildlife viewing and conservation

**TWPD=Texas Parks and Wildlife Division NPS=National Park Service USFWS=US Fish and Wildlife Service TNC=The Nature Conservancy. Add the following sentence: The planning area does not contain any waterbodies meeting the Wild and Scenic Rivers Act criteria, and therefore not listed as a wild or scenic waterway.*

Future Without Project Condition

The Brownsville parks, wildlife, historical, and recreation areas would remain an important part of the community. Because these areas are in public ownership, their popularity should increase as other non-public lands become more urbanized.

Socioeconomics

Socioeconomics is defined as the basic attributes and resources associated with the human environment, particularly population, demographics, and economic development. Demographics entail population characteristics and include data pertaining to race, gender, income, housing, poverty status, and educational attainment. Economic development or activity typically includes employment, wages, business patterns, an area's industrial base, and its economic growth.

Existing Condition

Population

The LRGV (four county area) is one of the fastest growing areas in the U.S., with population on both sides of the border of approximately two million people. Population growth increased over 60 percent in the last 20 years surpassing the projected growth rates. Total tourism in the LRGV tourist population has surpassed projected growth numbers. Population growth is equaled by bordering cities in Mexico whose combined growth with the U.S. in the LRGV is projected to grow to 4.3 million by year 2020.

Brownsville's population is overwhelmingly Hispanic or Latino (94.0 percent) and young. Table 2-9 and Appendix A present information comparing the resaca areas in the context of the City of Brownsville, Cameron County, and Texas on a number of social and demographic variables. Table 2-9 shows the racial and ethnic breakdown for the City of Brownsville, Cameron County, Texas. Appendix A shows the same detailed racial and ethnic information for selected census tracts surrounding the resacas as well as the number and percent of persons below the poverty level. Figure 2–13 shows the location of the census tracts relative to the resacas restoration areas. Appendix presents age, gender, racial/cultural, and income characteristics for City of Brownsville, Cameron County, Texas and selected resaca area census tracts.

Table 2-9: Population Characteristics for the City of Brownsville, Cameron County, and Texas

Category	Texas	Percent	Cameron County	Percent	Brownsville	Percent
Total	**26,956,435**	**100.0%**	**418,785**	**100.0%**	**182,110**	**100.0%**
White alone	11,705,684	43.4%	40,622	9.7%	8,665	4.8%
Black or African American alone	3,134,962	11.6%	1,597	0.4%	461	0.3%
American Indian and Alaska Native alone	63,336	0.2%	371	0.1%	252	0.1%
Asian alone	1,161,742	4.3%	2,580	0.6%	1,309	0.7%
Native Hawaiian or Other Pacific Islander alone	18,990	0.1%	26	0.0%	4	0.0%
Some other Race alone	35,509	0.1%	137	0.0%	60	0.0%
Two or more races	423,062	1.6%	767	0.2%	260	0.1%
Hispanic or Latino	10,413,150	38.6%	372,685	89.0%	171,099	94.0%
Source: U.S. Census Bureau, 2012-2016 American Community Survey 5 year estimates						

Source: U.S. Census, 2016

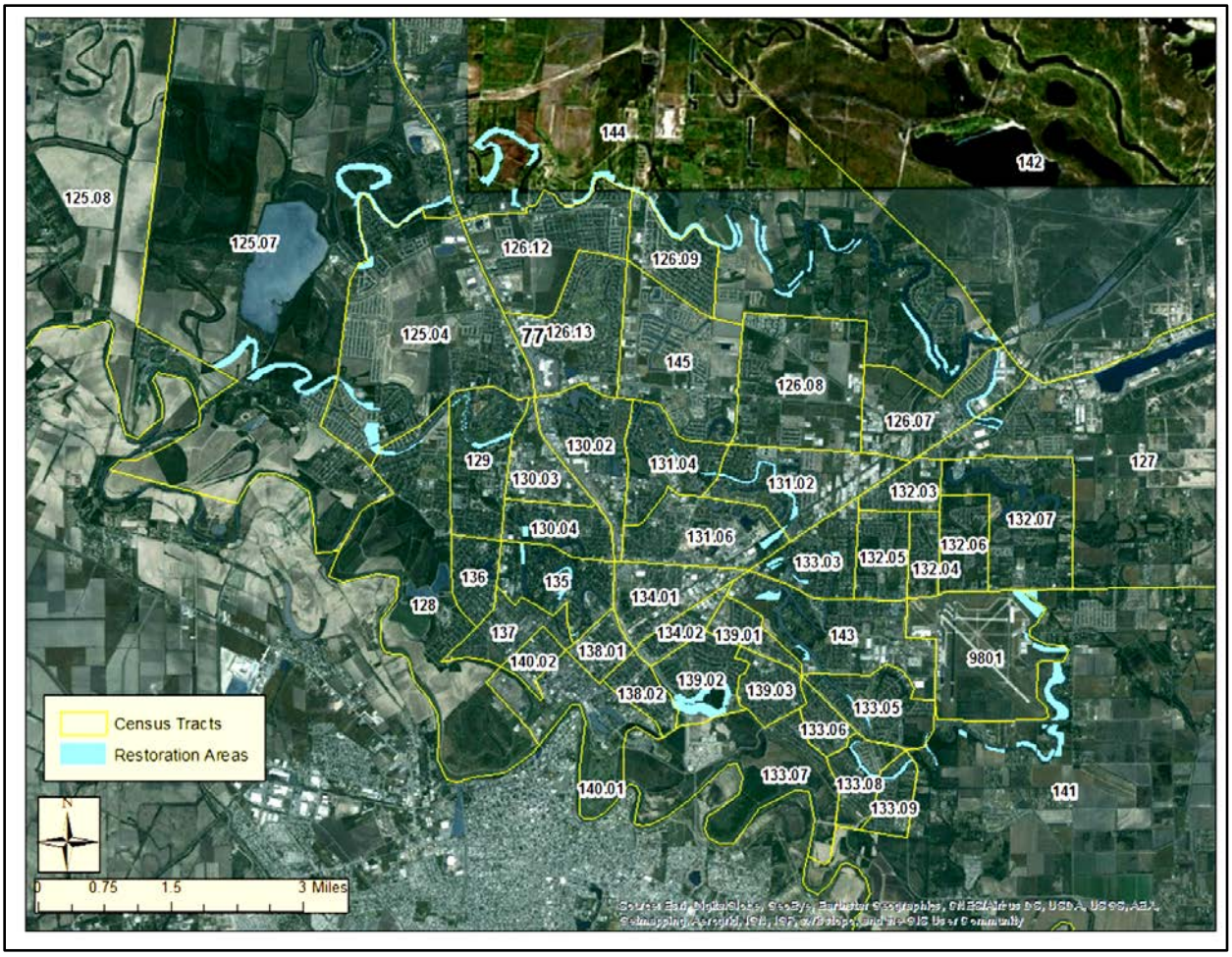


Figure 2–13: Census tracts in relation to resaca restoration areas.

Economic Development

Since the early 1920s, the setting of the LRGV socioeconomic dominant element is the agricultural industry, mainly farming. As the agricultural industry grew, both in the U.S. and in Mexico, the population of the LRGV and associated infrastructure (housing, industry, malls, etc.) expanded. Subsequently, urbanization in the LRGV drove economic growth over the next few decades. More recently, trade and manufacturing have increased steadily and are surpassing the once dominant agricultural industry as the leading economic industries. The “maquiladora” (twin plant) industry, where U.S. companies establish manufacturing plants in Mexico and then retail the products in the U.S., has increased. The LRGV labor market is showing growth in health care services, administration, service industry, professional, scientific, and technical serves, as well local government.

While ranching and agriculture are the traditionally dominant industries in the area, landowners are increasingly turning to alternative uses for their land. Wildlife-related activities, such as hunting and bird watching, are growing in popularity. Landowners in south Texas often derive more income-per-acre from hunting leases than from other uses. The economic impact of bird watching and other forms of nature tourism were more than $6.2 billion per year (2011 TX A&M study). This comprises a significant portion of the impact of all travel to the region, estimated at $675 million per year. The number of eco-tourists visiting the region is dependent on the environmental quality of the habitat and wildlife.

In spite of growth in some sectors of the economy, the region as a whole experiences significantly lower income and higher unemployment than the rest of Texas and the nation as a whole. There is a clear division between the urban growth centers (Brownsville) and smaller rural towns and colonias.

Future Without Project Condition

The area populations would continue to increase and, concurrently, development would also continue to increase.

Minority and low-income populations (Environmental Justice)

The impetus behind environmental justice is to ensure all communities, including minority, low-income or federally recognized tribes, live in a safe and healthful environment and no group of people including racial, ethnic, or socioeconomic, should bear a disproportionate share of the negative consequences resulting from the execution of federal, state, local, and tribal programs and policies. Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, addresses concerns over disproportionate environmental and human health impacts on minority and low-income populations. The goal of fair treatment is not to shift risks among populations, but to identify potential disproportionately high and adverse effects and identify alternatives mitigating these effects.

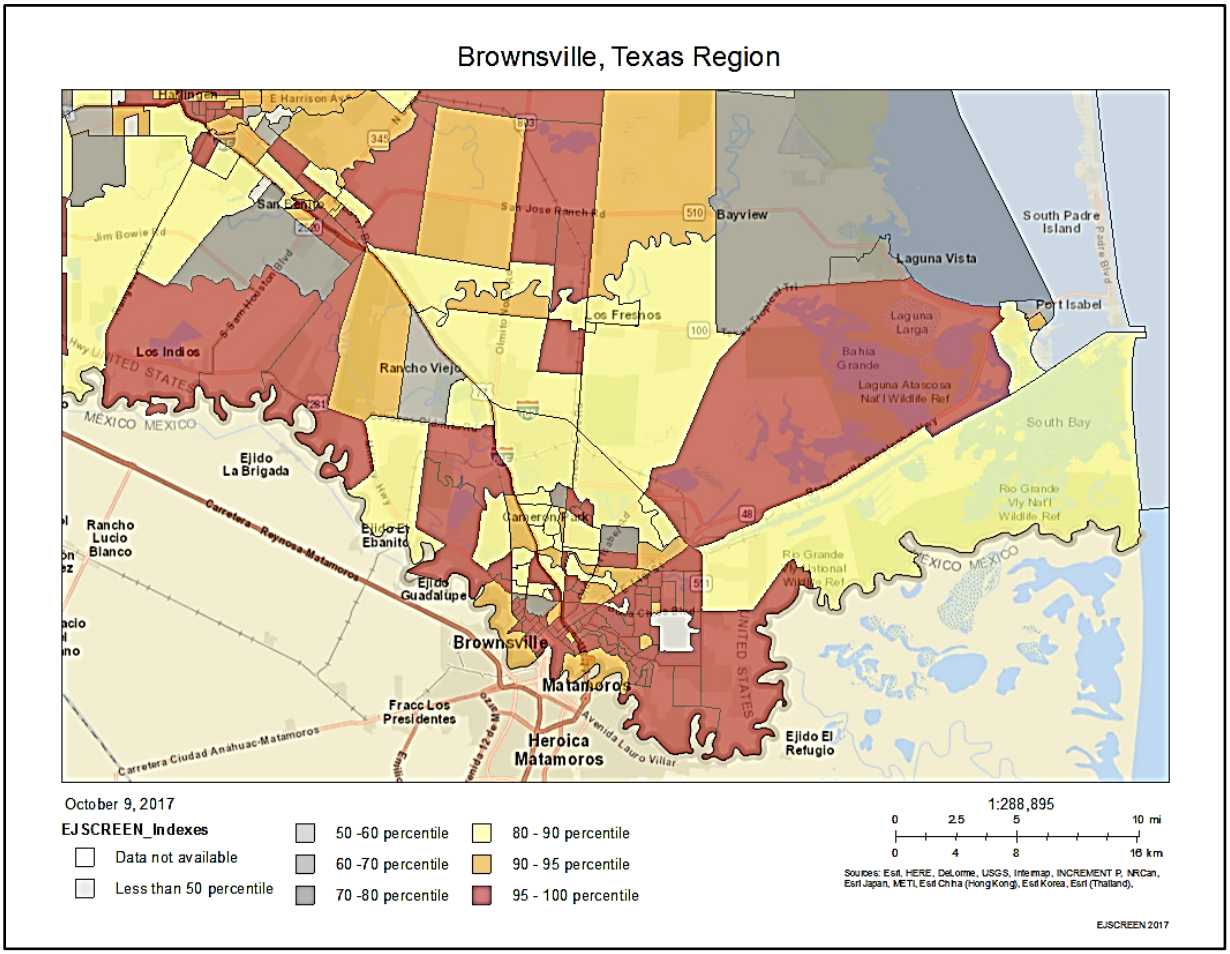
The purpose of Environmental Justice is to analyze whether the demographics of the affected area differ in the context of the broader region; and if so, determine if differences meet CEQ criteria for an Environmental Justice community. The CEQ criteria is for a population less than 50 percent minority or minority population is meaningfully greater than the minority population percentage in the geographic analysis.

Existing Conditions

The study area is predominately Hispanic or Latino (90.9 percent) making the entire study area an Environmental Justice community (Figure 2–14). The racial makeup of the study area is representative of the City of Brownsville and the south Texas region. Because of the overwhelming number of Spanish speaking individuals in the area, most of the signage in the study area is in Spanish or bilingual.

Future Without Project Condition

The study area is predominately Hispanic or Latino (94.0 percent) and predominantly low income making the entire study area an Environmental Justice community. Figure 2–14 show a composite environmental justice index of race and income levels by census tract. The racial makeup of the study area is representative of the City of Brownsville and the south Texas region. Because of the overwhelming number of Spanish speaking individuals in the area, most of the signage in the study area is in Spanish or bilingual.



Source EPA, August 10, 2016

Figure 2–14: Brownsville Area's Percent of Meeting Environmental Justice Percentile

Visual Aesthetics

Existing Condition

Resacas are an important component of the Brownsville ecotourism landscape. The resacas provide waterside real estate and recreational opportunities. Many residences have picnic tables, decks, or even wharf-like structures built next to or over the water. Many resacas in commercial and residential areas are bulkheaded to reduce erosion and form a neat, straight-lined landscape.

Existing artificial light sources within the study area can be attributed to streetlights, motorized traffic, and fugitive light sources from the adjacent neighborhood. Because of the urban landscape, sky glow (diffuse light escaping from urban sources) is also a source of fugitive light.

Future Without Project Condition

Increased urbanization would decrease the natural aesthetic value of the study area. Small areas of natural lands are forecast to be protected to provide green space and provide locations for ecotourism.

Noise

Noise pollution is the exposure of people or animals to annoying, stressful, or damaging levels of sound. Although loud and frightening sounds are part of nature, urbanization causes an increase in the level and frequency of noise exposure. Ambient noise pollution comes from automobiles, trucks, construction equipment, farm machines, and aircraft. Other noise pollution sources are home appliances, shop tools, yard equipment, guns, fireworks, and loud music.

Table 2-10: Decibel Levels of Common Noise Sources

Noise Source	dBA
Normal Breathing	10
Soft Whisper	30
Rainfall	50
Air Conditioner	50 - 75
Normal Conversation	60
Vacuum Cleaner	60 - 85
Power Lawn Mower	65 - 95
Freeway Traffic	70
Ringing Telephone	80
Motorcycle	95 -110
Baby Crying	110
Leafblower	110
Football Game (Stadium)	117
Thunder	120
Jet Engine Taking Off	150
Firecracker	150
Fireworks (At 3 Feet)	150
Handgun	160

Sound intensity is measured in units called decibels (dB). The decibel scale is logarithmic. Sound levels measured in decibels are commonly weighted to better approximate the way a human ear perceives sound. Sound level values obtained using this weighting network are referred to as "A-weighted" sound levels and are signified by the identifying unit dBA. Table 2-10 lists typical decibel levels of common noise sources. Exposure to excessive noise has been related to hearing loss, stress, high blood pressure, sleep loss, distraction, and lost productivity.

Existing Condition

Regional growth is bringing an increase in noise sources. Primary noise sources include major local and international roadways, railways, and the Brownsville/South Padre Island International Airport. Other common sources of urban noise include lawn and yard equipment, construction projects, and loud music. Because of Brownsville’s urban nature, many major noise sources are located in close proximity to residential and public areas.

Brownsville has a noise restriction ordinance. Noise violations are handled on a case-by-case basis.

The Brownsville/South Padre Island International Airport is located within the city of Brownsville. The airport serves approximately 140,000 passengers and logs approximately 35,000 landings and takeoffs annually. The FAA approved a Noise Compatibility Plan on January 29, 2003, Federal Register, (Vol. 68, No. 19).

The Port of Brownsville is located about two miles northeast of Brownsville. Many activities conducted at the port may contribute to excessive noise, including offshore drilling rigs construction, ship repairing and dismantling, steel fabrication, boat construction, rail car rehabilitation, liquefied petroleum gas, storage/distribution, waste oil recovery, bulk terminaling for miscellaneous liquids, and grain handling and storage.

Future Without Project Condition

The noise within the study area is anticipated to slightly increase due to an increase in population and economic development.

Hazardous, Toxic, and Radioactive Waste

In order to complete a feasibility level Hazardous, Toxic, and Radioactive Waste (HTRW) evaluation, a report following the rules and guidance of ER 1165-2-132: *HTRW Guidance for Civil Works Projects,* and ASTM E1527-13*: Standard Practice for Environmental Site Assessment: Phase 1 Environmental Site Assessment Process* was completed. These guidelines outline a process that have three main components (excluding the report itself): a records review, site reconnaissance, and interviews.

Existing Condition

During the records review phase, publicly available databases and sources were used to find potential HTRW sites relevant to the study. This records review used the proposed footprint of the project, and the standard ASTM environmental record sources and search distances (Table 2-11). The records search was used to identify recognized environmental conditions (RECs) currently affecting the proposed project area or need further investigation. Due to the conservative search distances and specifics of the proposed project, no sites with RECs were found.

Table 2-11: Standard ASTM Search Distances, Records Review Results, and Sources

ASTM Source	ASTM Distance (mi)	Number of Sites	Notes	Source
Federal National Priorities List (NPL) site list	1.0	0	--	Environmental Protection Agency (EPA) Cleanups In My Community
Federal Delisted NPL site list	0.5	0	--	EPA Cleanups In My Community
Federal Comprehensive Environmental Response, Compensation, and Liability Information System CERCLIS (SEMS) list	0.5	0	--	EPA EnviroFacts
Federal No Further Remedial Action Planned (NFRAP) (SEMS archive) site list	0.5	0	--	EPA EnviroFacts
Federal Resource Conservation and Recovery Act (RCRA) Corrective Action facilities list	1.0	0	--	EPA Cleanups In My Community
Federal RCRA TSD facilities list	0.5	0	--	EPA EnviroFacts
Federal RCRA generators list	Property and adjacent properties only	3	One classified: conditionally exempt small quantity generator One: small quantity generator One: unknown; facility is used as an auto parts manufacturer's warehouse, and not expected to interact with the proposed project.	EPA EnviroFacts
Federal Institutional Controls (ICs)/Engineering Control registry	Property only	0	--	Source not found*
Federal Emergency Response Notification System (ERNS) list	Property only	594	From available data, the location of releases is uncertain over the entire database period (1982-2016). All reported releases in 2016 occurred in the Brownsville Ship Channel, well away from the study area. Some releases occurred in the resacas; however, there is no specific data to determine risk.	Right To Know database (rtk.net)
State and tribal equivalent National Property List (NPL) list	1.0	0	--	Texas Commission on Environmental Quality (TCEQ) Central Registry
State and tribal equivalent CERCLIS	0.5	0	--	TCEQ Central Registry
State and tribal landfill and/or solid waste disposal sites	0.5	1	Flor de Mayo pit: located at the intersection of W Alton Gloor Blvd. and State Highway 281 has an active municipal solid waste permit. The exact location, type of waste accepted or contact information was unavailable.	TCEQ Central Registry
State and tribal leaking underground storage tanks (USTs) and aboveground storage tanks (ASTs) sites	0.5	4	Active Remediation Underway-- City Stop 22: 5405 South Padre Island Hwy Dan's Quick Stop: 7878 Boca Chica Blvd. Magic Mart: 2100 E Price Rd. Four Corners Texaco: 3375 Boca Chica Blvd.	TCEQ Central Registry
State and tribal registered storage tank list*	Property and adjacent properties only	326	Existence of a registered UST/AST is not sufficient to conclude a contamination is likely to be generated.	TCEQ Central Registry
State and tribal ICs/Engineering Control registry	Property only	0	--	Source could not be accessed due to proprietary restrictions
State and tribal voluntary cleanup sites	0.5	0	--	TCEQ Central Registry
Federal, State and Tribal Brownfields site list*	0.5	1	Located at 5800 Stagecoach Trail; currently houses a church. EPA documentation shows site was investigated, but no further action taken	EPA Cleanups In My Community

Future Without Project Condition

Under FWOP, there is no anticipated change to HTRW risks.

Next Step

In this chapter, the resources potentially affected by alternatives were identified and conditions for these resources were forecast over the period of analysis. In Chapter 3, measures are identified, and alternatives are formulated to address the resaca problems. At the end of Chapter 3, a final array of alternatives is identified.

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CHAPTER 3: FORMULATE ALTERNATIVE PLANS

INTRODUCTION

In Chapter 1, the problems and opportunities were identified. The objectives were established for use in evaluating how well potential alternatives would address the problems and achieve the opportunities. Constraints were identified to avoid undesirable impacts of potential alternatives.

In Chapter 2, the existing and forecast conditions were described if no federal action was undertaken to restore the resacas.

In Chapter 3, restoration (management) measures will be identified to meet the objectives. The measures will be combined through multiple applications a cost effectiveness and incremental cost analysis and as guided by a connectivity analysis. The result will be the identification of a final array of six alternatives.

Identification and Screening of Management Measures

Measures are generalized concepts or approaches. They may address one or more opportunities.

A previous USACE Section 206 Continuing Authority Program (CAP) Resaca Restoration Study was reviewed to build upon the evaluation and screening efforts of measure screening. The measures eliminated based on cost, economic impact, and low ecological success were reexamined and found to be not applicable for restoration of the resacas in the Vicinity of Brownsville feasibility study for the same reasons. Table 3-1 provides a list of the screened measures.

The screening rationale was reviewed and the CAP screening conclusions were confirmed it remains valid for this study. Therefore, the screened measures were not reassessed for the resacas feasibility study.

Table 3-1: Measures Eliminated from Further Study

Eliminated Measure	Screening Criteria
Removal of upstream dams, levees, and major modifications to the existing irrigation network,	Economic loss and flood risk increase
Active control of the non-native vermiculated sailfin catfish (*Pterygoplichthys disjunctivus*)*	Chemical control techniques have limited success short term basis and cam negatively impact other native aquatic animals.
Island habitat creation in the resacas	Anticipated low ecological success

**The PDT carried forward a sailfin catfish Passive control techniques measure as part of alternative development.*

Evaluation of Management Measures

A focused approach identified restoration measures that would address the ecological structure or function identified that are found in high quality resacas. The measure descriptions below relate to high quality reference resacas observed in the Brownsville area. Each measure would address a means to return the resaca to a reference condition. This concept was further developed and modeled for the quantification of habitat quality in the assessment of alternatives. The model is further explained in Appendix A. A description of each management measure follows:

- Dredging
- Riparian Soil Supplementation with Dredged Material
- Planting Riparian Species
- Bank Slope Restoration
- Bank Stabilization
- Plant Aquatic and Emergent Vegetation
- Water Control Structure/Flow Management
- Invasive Plant Species Management

The resaca restoration measures developed for this study are reflective of the structure and function of high quality reference condition resacas. Each of the restoration measures can be tied directly to a component of species or habitat improvement within the study area. The dredging and excavating of sedimented resacas and the installation or modification of water control structures form the base of resaca ecosystem restoration because the presence of water drives the diversity of the ecosystem. The planting of a mixed community of native vegetation consistent with the aquatic, emergent, and riparian planting measures supports the fish and wildlife inherent in resaca habitats. Similarly, the control of invasive species

promotes the establishment of plant diversity in the restored areas. The bank slope measure facilitates the migration of amphibian species like the black spotted newt, moving between their aquatic forms to their terrestrial forms. The bank slope measure promotes the growth of aquatic and emergent plant species that provide cover habitat for small fishes and amphibians.

Figure 3-1: Black Spotted Newt

The measures were identified with the benefit of restoration methods already proven successful at sites in the LRGV over the last quarter-century. The USFWS, the TPWD, the NPS, and TNC have successfully propagated native plant species representative of the resaca habitats, and have reestablished native vegetation on national wildlife refuges, state parks and wildlife management areas, conservation easements, and ecological preserves.

Dredging

Historically, the resacas were sustained by the flushing function of floodwaters for the periodic removal of accumulated sediments. Flood control projects implemented within the Rio Grande Basin have reduced flood frequency and intensities in the LRGV. Under current conditions it would be necessary to artificially accomplish the flushing function. The dredging measure would mimic the sediment flushing function in the resacas by physically removing accumulated sediments down to the clay layer of the resaca bed. The dredging would increase the water depth and storage capacity of the resaca, and in turn provide ancillary water quality benefits by mediating water temperatures and dissolved oxygen concentrations. The dredging measure was considered for resacas with average depths less than five feet and would require dredging the resaca to a depth of six feet or until the clay layer of the resaca is detected.

Dredging would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. Dredging would also increase the quantity and quality of aquatic habitat

and to give priority to the combined ecosystem function output opportunities of co-located aquatic and terrestrial complexes.

Direct linear connectivity (as discussed in Chapters 1 & 2) for aquatic species would be achieved through dredging and excavation of restoration areas. This direct aquatic connection would benefit fish, amphibian, and reptile species such as the Rio Grande perch, red-eared sunfish, black-spotted newt, and south Texas siren. The newt and siren, are especially significant because they are known to inhabit urban portions of the resacas. The direct connectivity of aquatic habitats would enable restoration of the amphibian populations.

Riparian Soil Supplementation with Dredged Material

Historically, frequent flooding events of the Rio Grande distributed nutrients and sediments across the floodplain. Without this, the nutrient cycling function was lost. This measure would incorporate the beneficial use of dredged material from the resacas by supplementing the soils of riparian habitats surrounding the resacas with clean dredged material. The soil supplementation would restore certain nutrients leached out over the previous 150 years. The enriched sediment would promote the establish and growth of native vegetation communities. The nutrients would benefit native invertebrate, amphibian, avian, and mammalian communities dependent on healthy resaca environments.

Riparian Soil Supplementation with Dredged Material would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. This measure would also contribute to invasive species management. Invasive plant species would be removed before placing the dredged material.

Planting Riparian Species

The riparian vegetation communities are threatened with extinction. This measure includes the restoration of a Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland. It takes many years for these vegetation associations to mature. Therefore native south Texas grassland species would be planted to provide interim habitat, minimize the spread of non-native invasive species, and stabilize the riparian soils while the target vegetative community becomes established. Invasive and non-native vegetation would be removed before planting of native species and would be managed throughout the lifetime of the project.

Planting riparian species measures would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. Riparian improvements would restore connectivity of the Brownsville resaca to the high quality thorn-scrub and resaca habitats of the surrounding ecosystem. This measure would maximize the quantity and quality of aquatic habitat and give priority to the combined ecosystem function output opportunities of co-located aquatic and terrestrial complexes.

Bank Slope Restoration

Natural banks and shorelines are significant features of stable, functioning aquatic systems providing habitat for fish, wildlife, and plant species. The natural banks and shoreline ecosystem benefits include improved connection between the aquatic and riparian habitats that are vital for amphibians as they transition from aquatic to terrestrial forms. Natural banks are more effective at absorbing erosive energies during flood events and wind and wave erosion. High quality reference resacas exhibit gradual slopes of 1 vertical to 10 horizontal (1V:10H) or greater between the riparian and aquatic habitats. The reference resacas relaxed slopes allow the dissipation of erosive energies to be spread over a greater area thereby reducing bank erosion and sedimentation. This measure would restore the slopes of the resaca shorelines to reference conditions.

Bank slope restoration would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable. This measure would facilitate amphibian and other wildlife movement from the aquatic habitat to the riparian habitat. This measure would contribute to invasive species management by reducing the reproduction habitat of the sailfin catfish.

Bank Stabilization

The characteristics of native riparian vegetation ecosystems include the filtration of surface runoff, stable shoreline, attenuation of flows, shoreline shading, and habitat for wildlife to reproduce, have cover, and forage. The grassland species identified in Chapter 6 would stabilize localized erosion along swales feeding into the resaca and would reduce sedimentation into the resaca while providing habitat for invertebrate species. If needed, armoring using willow (*Salix interior or S. Nigra*), log or rock vanes, or other natural armoring methods could be utilized in localized areas. If hard structures are required to stabilize erosion areas, large rock or other appropriate materials would be designed to provide habitat structure for aquatic and riparian species while providing bank stabilization.

Planting Aquatic and Emergent Vegetation

Typical aquatic and emergent plant species identified in Chapter 6 provide habitat for invertebrate, fish, amphibian, and avian species found in the resacas. This measure would entail planting of native aquatic and emergent vegetation along the shoreline of the resacas. Native aquatic and emergent plant species would be planted to establish aquatic habitat in the resacas.

The restoration plantings would provide reproductive, foraging, and protective cover for fish and amphibian species, as well as foraging habitat for waterbirds and waterfowl. The vegetation would assist in the stabilization of the near shore substrate. Abundant vegetation would improve water quality within the resacas by stabilizing the bank and reducing turbidity and uptake of nitrogen and phosphorus.

The measure would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable.

Water Control Structure/Flow Management

The natural hydrologic processes of resacas involve highly fluctuating surface water elevations. Historically, the resacas were replenished by stormwater runoff and Rio Grande floodwaters. The resacas would draw down between flood events. Fluctuating water levels would influence the vegetation, fish, and wildlife habitat of the resacas.

Allowing the resacas to drawdown to the scale of historic conditions would not be compatible with the multiple uses of the resaca systems including water supply and stormwater management. Seasonal management of the resacas pool elevations on a smaller scale would still provide benefits to riparian and emergent vegetation. The fluctuation of pool elevations would provide a dynamic habitat delivering benefits. This measure includes the construction or modification of water control structures to mimic, to the extent practicable, the natural water surface fluctuations of the resacas. The project sponsor would need to manage the water control structures to mimic seasonal fluctuations.

The Water Control Structure/Flow Management measure would restore impacted resaca aquatic and terrestrial complexes to functional and self-regulating systems that mirror reference resaca to the extent practicable.

Invasive Plant Species Management

Because of urbanization and landscaping around many of the resacas, invasive and non-native plant species have proliferated. The removal of and the continued management of non-native invasive species from the restoration areas is essential for the resiliency of the restoration project. This measure would include the appropriate mechanical, chemical, and/or biological control of non-native species. The measure would also include the development of an invasive species management plan to address the encroachment of non-native invasive species throughout the life of the project.

Invasive Plant Species Management would contribute to the reduction or elimination of aquatic invasive species, particularly the vermiculated sailfin catfish, and invasive and non-native riparian plant species.

Management Measure Cost Estimating

The costs and the risks associated with each ecosystem restoration management measure were calculated for each restoration area and are reported in the Cost Engineering and Cost and Schedule Risk Analysis Appendices (Appendix D-2 and D-3 respectively).

Alternative Formulation Strategies

The rare and unique aquatic and riparian habitats of the resacas ties in directly with the resource significance of the system. The resacas aquatic and riparian habitat viability and sustainability depend on hydrologic connection. Therefore, the alternatives were carried forward that include aquatic and riparian plant community restoration as well as resacas hydrologic function restoration.

Restoration plans within each resaca were initially screened out over several iterations using the Cost Effective/Incremental Cost Analysis (CE/ICA) in the USACE Institute of Water Resources (IWR) Planning Suite 2.0.6.1. The Planning Suite is a USACE certified model used to assist in the identification of a cost effective recommended plan that can be incrementally justified both economically and ecologically.

In addition to using the CE/ICA, the resacas **connectivity** value was integrated as an important formulation component. The ecological connection bridges the resaca project's aquatic and riparian restoration with the high quality upland habitat managed in perpetuity by others. The connection would serve many species, including the ocelot, jaguarundi, and other large mammals. The connectivity component was used for formulation not only with a view of least cost restoration

contributions within its footprint, but in consideration of wherever those restoration features would contribute to the value and function of the overall ecosystem.

Alternative Formulation

Several iterations of screening were conducted to identify restoration plans within a group of restoration areas and subsequently within each resaca system.

- Phase 1 - Cost effective ranking for each restoration area within each resaca and their contribution to ecosystem connectivity. First, best buy plans were identified among all of the possible restoration areas within each resaca segment to carry forward and combine with the **best buy plans for the possible restoration areas within each resaca**. Phase 1 also evaluated the individual restoration areas' contributions to ecosystem connectivity in relation to other nearby restoration areas (stepping stones);
- Phase 2 - Cost effective ranking combinations of all plans carried forward for each resaca. The second cost effective ranking phase identified the **best buy combinations of all plans carried forward for each resaca** to form a suite of best buy plans for each resaca;
- Phase 3 - Connectivity value in combination with the restoration of the three resacas as a system. A final array of alternatives was selected using the connectivity **value in combination with the restoration** of the three resacas as a system.

Phase 1 - Cost effective ranking for each restoration area within each resaca and their contribution to ecosystem connectivity

Although all the resacas receive water from the Rio Grande and stormwater runoff, different segments of the resaca systems are connected by different water distribution systems. In Resaca de la Guerra, a water control valve is located between Restoration Areas 76 and 77 (Figure 3-2). Water from this valve can be release into the resaca system to Restoration Areas 77-84 and flow downstream to Restoration Areas 74-76. In other areas, dry resaca segments and roadways separate the restoration areas. This is the case between two restoration areas on Resaca del Rancho Viejo where U.S. Hwy 77 separates Restoration Area 165 from Restoration Area 113 (Figure 3-3). An existing irrigation canal provides water to Resaca del Rancho Viejo at Restoration Area 113 and can be managed separately from the upstream resaca segments.

Hydrological groups of restoration areas were identified within each resaca system (Resaca de la Guerra, Resaca del Rancho Viejo, and Town Resaca). Figure 3-3 and Figure 3-4 show the study areas for Resaca del Rancho Viejo and Town Resaca.

Within each hydrologically distinct resaca segment, fully formed plans were developed with the assumption that the uppermost restoration area must be able to convey water to benefit downstream resaca segments. It was also assumed that measures proposed at certain restoration areas could be implemented without improvements to upstream restoration areas. These restoration areas are typically on the downstream ends of the resacas where the water is generally deeper and more dependable, such as Restoration Areas 40-46. Each of these restoration areas were incorporated as stand-alone plans in the CE/ICA. The resaca segments are presented in Table 3-2.

The restoration areas' contribution to ecosystem connectivity is detailed in Appendix A.

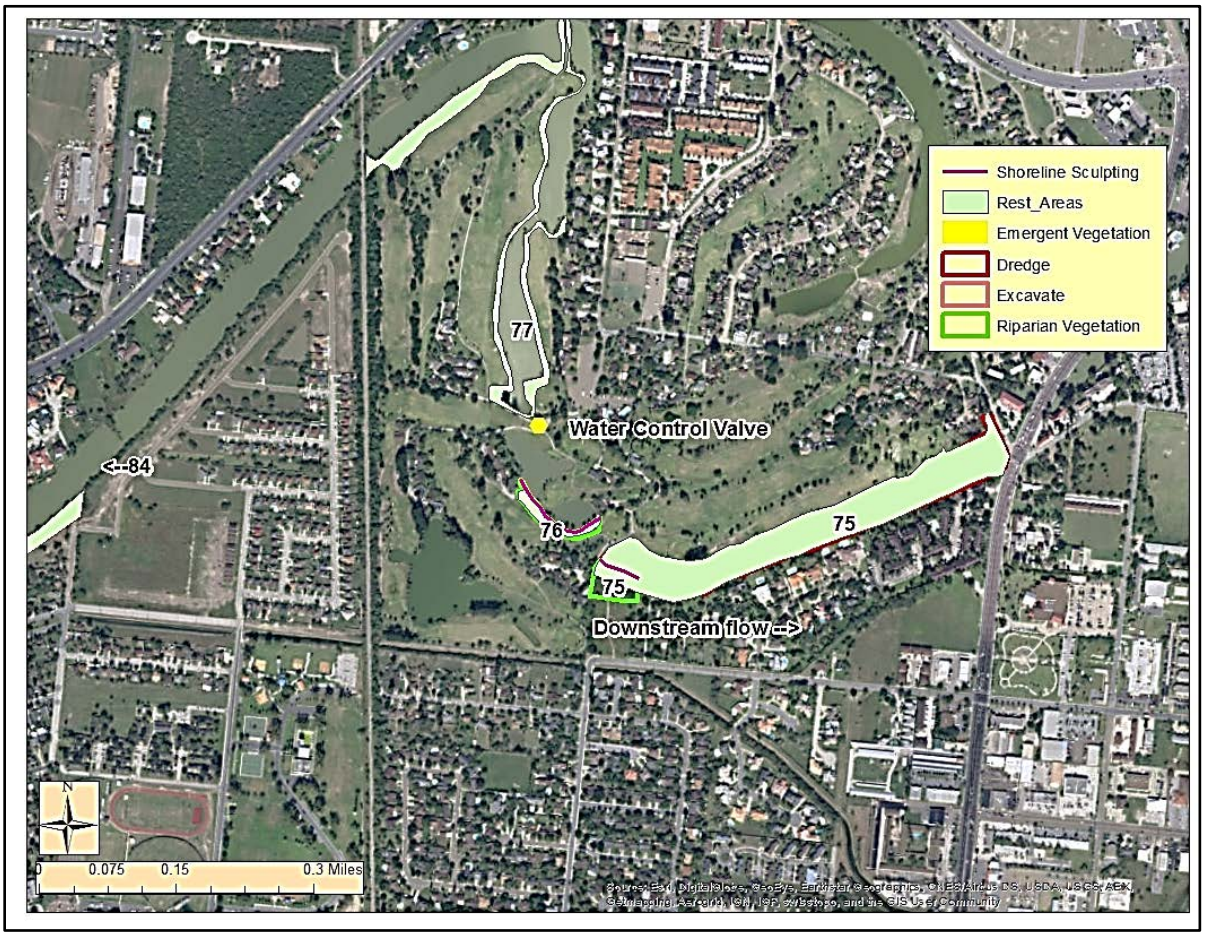

Figure 3-2: Water supply for Resaca de la Guerra at the Brownsville Country Club.

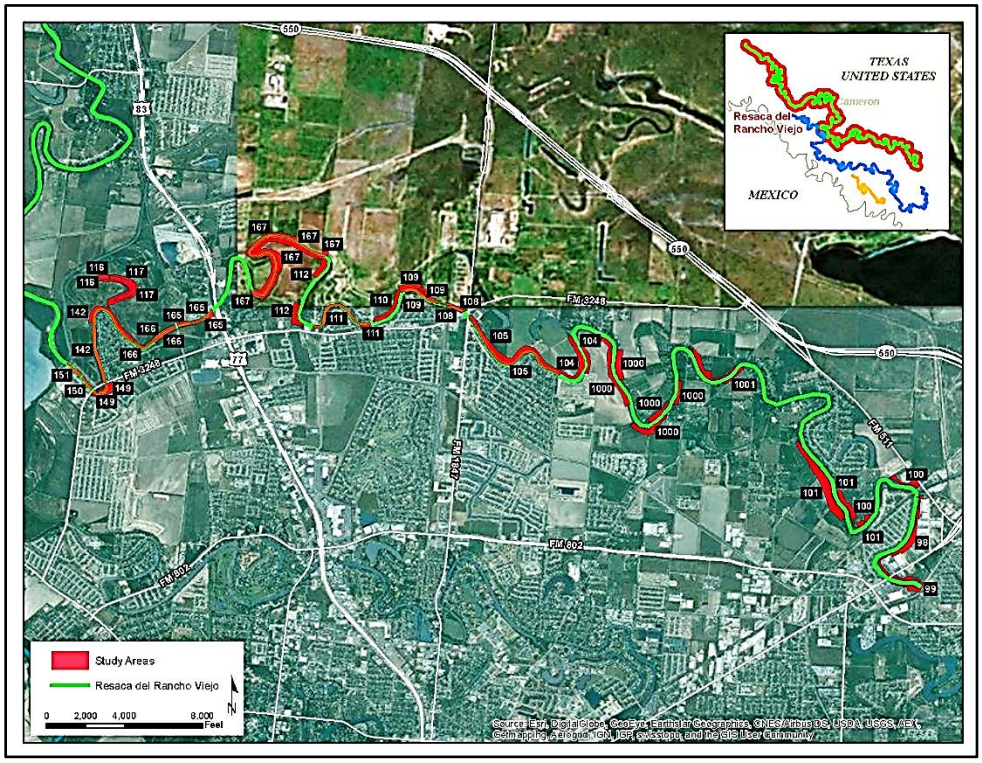

Figure 3-3: Resaca del Rancho Viejo where U.S. Highway 77 separates Restoration Area 165 from Restoration Area 113.

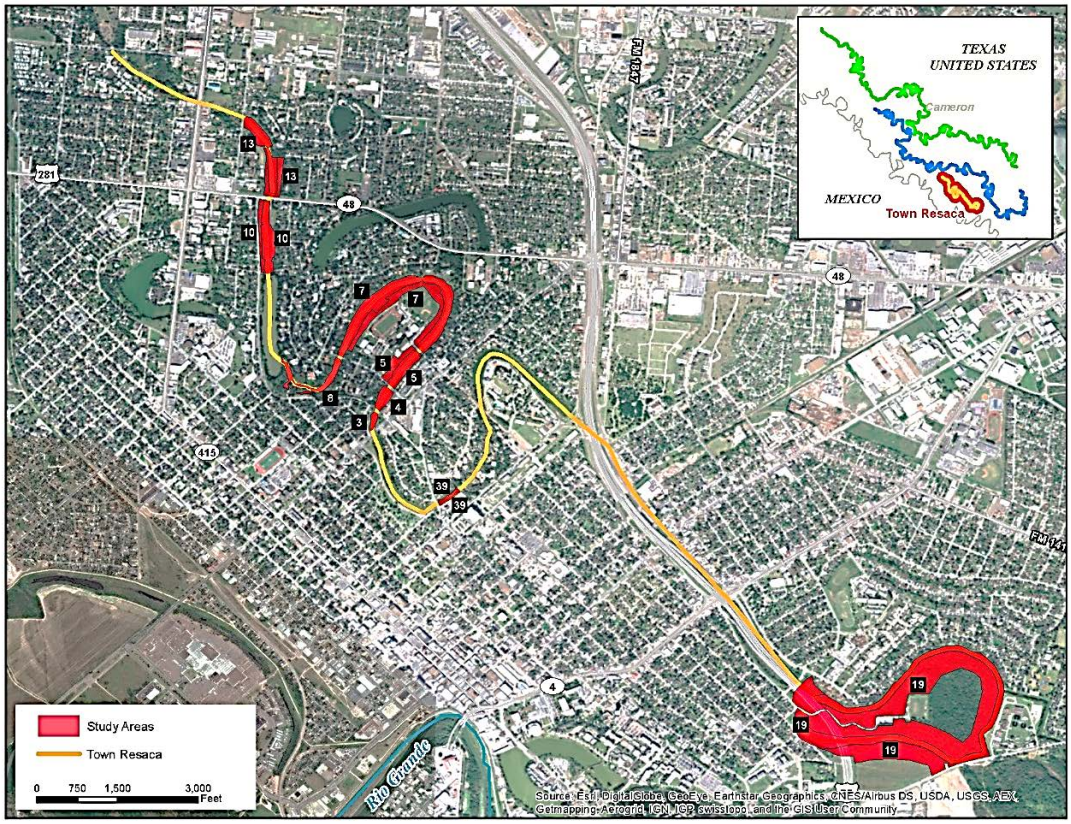

Figure 3-4: A View of the Town Resaca Study Areas

Table 3-2: Resaca Segments Used in the CE/ICA.

Resaca	Resaca Segment	Restoration Area(s)
Town Resaca	T1	3, 4, 5, 6, 7, 8, 9, 10, 13
Town Resaca	T2	17, 18, 19, 36
Resaca de la Guerra	G1	77, 78, 79, 81, 82, 83, 84, 95, 161
Resaca de la Guerra	G2	74, 75, 76
Resaca de la Guerra	G3	53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 96
Resaca de la Guerra	G4	93, 94
Resaca de la Guerra	G5	40
Resaca de la Guerra	G6	41
Resaca de la Guerra	G7	42
Resaca de la Guerra	G8	43
Resaca de la Guerra	G9	44
Resaca de la Guerra	G10	45E
Resaca de la Guerra	G11	45W, 46
Resaca del Rancho Viejo	V1	142, 149, 150, 151, 165, 166, State Fish Hatchery
Resaca del Rancho Viejo	V2	105, 108, 109, 110, 111, 112, 148, 167
Resaca del Rancho Viejo	V3	104
Resaca del Rancho Viejo	V4	1000
Resaca del Rancho Viejo	V5	1001
Resaca del Rancho Viejo	V6	101
Resaca del Rancho Viejo	V7	100
Resaca del Rancho Viejo	V8	98
Resaca del Rancho Viejo	V9	99

Resaca de la Guerra initial screening of segments.

For Resaca de la Guerra, best buy plans were identified utilizing the IWR Planning Suite for all possible combinations of resaca segment plans within each of the separate G1 and G3 resaca segments. Resaca G2 and G11 only contained 3 and 2 resaca restoration segments and they were all carried forward to the next phase of the screening analysis. The remainder of the resaca segments were standalone and were carried forward to the next screening phase.

The screening for Segment G1 resulted in the identification of four best buy plans which were carried forward to the next screening phase; only one best buy plan was identified for Segment G3. The best buy plans for the two segments and the standalone plans that were carried forward are provided in Table 3-3

Table 3-3: Resaca de la Guerra Segments Evaluated in Phase 1 of the CE/ICA.

Resaca Segment	Plan	Restoration Area(s)
G0	-	No Action
G1	GP1-1	95, 161
G1	GP1-2	84, 95, 161
G1	GP1-3	77, 78, 79, 81, 92, 93, 94, 95, 161
G1	GP1-4	161
G2	GP2-1	76
G2	GP2-2	75, 76
G2	GP2-3	74, 75, 76
G3	GP3-1	53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 96
G4	GP4-1	93
G4	GP4-2	94
G4	GP4-3	93, 94
G5	GP5-1	40
G6	GP6-1	41
G7	GP7-1	42
G8	GP8-1	43
G9	GP9-1	44
G10	GP10-1	45E
G11*	GP11-1	45W, 46

** Although G11 contains two resaca pools, it comprises a single restoration feature and is therefore treated as a standalone plan.*

Resaca del Rancho Viejo Initial Screening of Segments

The list of Resaca del Rancho Viejo plans contained standalone plans (V3-V9) and two segments containing a large number of plans (V1 and V2). All possible plan combinations within each of these two segments were screened using the IWR Planning Suite. Three best buy plans were identified for Segment V1 and four best buy plans for Segment V2. These best buy plans were carried forward with the standalone plans into the next screening phase (Table 3-4).

Table 3-4: Resaca del Rancho Viejo Segments Evaluated in Phase1 of the CE/ICA.

Resaca Segment	Plan	Restoration Area(s)
V0	-	No Action
V1	VP1-1	142, 149, 150, 151, 166, State Fish Hatchery
V1	VP1-2	142, 149, 150, 151, 165, 166, State Fish Hatchery
V1	VP1-3	142, 149, 150, 151, 166
V2	VP2-1	110, 111, 112, 148, 167
V2	VP2-2	109, 110, 111, 112, 148, 167
V2	VP2-3	105, 108, 109, 110, 111, 112, 148, 167
V2	VP2-4	110, 148, 167
V3	VP3-1	104
V4	VP4-1	1000
V5	VP5-1	1001
V6	VP6-1	101
V7	VP7-1	100
V8	VP8-1	98
V9	VP9-1	99

Town Resaca initial cost effective ranking of segments.

Due to the smaller number of restoration areas and resaca segments found in the Town Resaca system, no CE/ICA was conducted within a resaca segment. All ecologically valid combinations of resacas were inputted into the IWR Planning Suite to identify the best buy plans for Town Resaca.

Phase 2 -- Cost effective ranking combinations of all plans carried forward for each resaca

The next cost effective ranking phase's goal was to select the combinations of plans and identify the best buy plans each resaca. The best buy plans identified in this screening phase were carried forward to the final screening of the analysis.

Resaca de la Guerra Screening

The second phase of analysis incorporated the 18 restoration plans. They included (four G1 best buy plans, three G2 plans, one best buy G3 plan, three G4 plans, and seven remaining standalone plans). To avoid duplication, each of the 18 restoration plans for each resaca segment was entered as a separate scalable solution and then compiled resulting in 20,480 possible plans for Resaca de la Guerra. The analysis identified 237 cost effective plans and 17 best buy plans (including the no action alternative). Table 3-5 presents the best buy plans identified for the Resaca de la Guerra system. Each resaca system plan builds on the previous plan with the bolded resacas and resaca plans identifying changes from the previous resaca system plan.

Table 3-5: Resaca de la Guerra Phase 2 CE/ICA.

Resaca System Plan	Resaca Plan(s)	Restoration Area(s)
GSP-0	-	No Action
GSP-1	GP8-1	43[1]
GSP-2	GP7-1,GP8-1	**42**, 43
GSP-3	GP7-1, GP8-1,GP9-1	42, 43, **44**
GSP-4	GP1-4,GP7-1,GP8-1, GP9-1	42, 43, 44, **161**
GSP-5	GP1-4,GP7-1,GP8-1, GP9-1, GP10-1	42, 43, 44, **45E**, 161
GSP-6	GP1-4,GP5-1,GP7-1, GP8-1,GP9-1, GP10-1	**40**, 42, 43, 44, 45E, 161
GSP-7	GP1-4,GP4-2,GP5-1, GP7-1,GP8-1,GP9-1, GP10-1	40, 42, 43, 44, 45E, **94**, 161
GSP-8	GP1-1,GP4-2,GP5-1, GP7-1,GP8-1,GP9-1, GP10-1	40, 42, 43, 44, 45E, 94, **95**, 161
GSP-9	GP1-1,GP4-2,GP5-1, GP6-1,GP7-1,GP8-1, GP9-1,GP10-1	40, **41**, 42, 43, 44, 45E, 94, 95, 161
GSP-10	GP1-1,GP4-2,GP5-1, GP6-1,GP7-1,GP8-1, GP9-1,GP10-1,GP11-1	40, 41, 42, 43, 44, 45E, **45W, 46**, 94, 95, 161
GSP-11	GP1-2,GP4-2,GP5-1, GP6-1,GP7-1,GP8-1, GP9-1,GP10-1,GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, **84**, 94, 95, 161
GSP-12	GP1-2,GP2-2,GP4-2, GP5-1,GP6-1,GP7-1, GP8-1,GP9-1, P10-1, GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, **75, 76**, 84, 94, 95, 161
GSP-13	GP1-2,GP2-2,GP4-3, GP5-1,GP6-1,GP7-1, GP8-1,GP9-1,GP10-1, GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, 75, 76, 84, **93**, 94, 95, 161
GSP-14	GP1-2,GP2-2,GP3-1, GP4-3,GP5-1,GP6-1, GP7-1,GP8-1,GP9-1, GP10-1,GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, 53, **54, 59, 60, 61, 62, 66, 67, 71, 72**, 75, 76, 84, 93, 94, 95, 161
GSP-15	GP1-3,GP2-2,GP3-1, GP4-3,GP5-1,GP6-1, GP7-1,GP8-1,GP9-1, GP10-1,GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, 53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 75, 76, 84, 93, 94, 95, **96**, 161
GSP-16	GP1-3,GP2-3,GP3-1, GP4-3,GP5-1,GP6-1, GP7-1,GP8-1,GP9-1, GP10-1,GP11-1	40, 41, 42, 43, 44, 45E, 45W, 46, 53, 54, 59, 60, 61, 62, 66, 67, 71, 72, **74**, 75, 76, 84, 93, 94, 95, 96, 161

[1]Bolded numbers refer to resacas that are new to that alternative

Resaca del Rancho Viejo

The second phase of analysis incorporated 14 restoration plans. They included three V1 best buy plans, four V2 best buy plans, and seven remaining standalone plans. Restoration plans for the same resaca segment were entered as separate scalable solution effects to ensure the restoration plans would not be duplicative. All combinations of these 14 restoration plans were then compiled resulting in 2,560 possible plans for Resaca del Rancho Viejo.

The IWR Planning Suite identified 121 cost effective plans and 15 best buy plans (including the no action alternative). Table 3-6 presents the best buy plans identified for the Resaca del Rancho Viejo system. As with the previous resaca, each resaca system plan builds on the previous plan with the bolded resacas and resaca plans identifying changes from the previous resaca system plan.

Table 3-6: Resaca del Rancho Viejo Phase 2 CE/ICA.

Resaca System Plan	Resaca Plan(s)	Restoration Area(s)
VSP-0	-	No Action
VSP-1	VP6-1	**101**
VSP-2	VP3-1,VP6-1	101,**104**
VSP-3	VP3-1,VP5-1,VP6-1	101,104,**1001**
VSP-4	VP3-1,VP5-1,VP6-1, VP8-1	**98**,101,104,1001
VSP-5	VP3-1,VP4-1,VP5-1, VP6-1,VP8-1	98,101,104,**1000**,1001
VSP-6	VP2-4,VP3-1,VP4-1, VP5-1,VP6-1,VP8-1	98,101,104,**110**,**148**,**167**,1000,1001
VSP-7	VP2-1,VP3-1,VP4-1, VP5-1,VP6-1,VP8-1	98,101,104,110,**111,112**,148,167,1000,1001
VSP-8	VP2-1,VP3-1,VP4-1, VP5-1,VP6-1,VP8-1, VP9-1	98,**99**,101,104,110,111,112,148,167,1000, 1001
VSP-9	VP2-1,VP3-1,VP4-1, VP5-1,VP6-1,VP7-1, VP8-1,VP9-1	98,99,**100**,101,104,110,111,112,148,167,1000,1001
VSP-10	VP2-2,VP3-1,VP4-1, VP5-1,VP6-1,VP7-1, VP8-1,VP9-1	98,99,100,101,104,**109**,110,111,112,148,167, 1000,1001
VSP-11	VP2-3,VP3-1,VP4-1, VP5-1,VP6-1,VP7-1, VP8-1,VP9-1	98,99,100,101,104,**105**,**108**,109,110,111,112, 148,167,1000,1001
VSP-12	VP1-3,VP2-3,VP3-1, VP4-1,VP5-1,VP6-1, VP7-1,VP8-1,VP9-1	98,99,100,101,104,105,108,109,110,111,112, **142**,148,**149**,**150**,**151**,**166**,167,1000,1001
VSP-13	VP1-1,VP2-3,VP3-1, VP4-1,VP5-1,VP6-1, VP7-1,VP8-1,VP9-1	98,99,100,101,104,105,108,109,110,111,112, 142,148,149,150,151,166,167,1000,1001, **State Fish Hatchery**
VSP-14	VP1-2,VP2-3,VP3-1, VP4-1,VP5-1,VP6-1, VP7-1,VP8-1,VP9-1	98,99,100,101,104,105,108,109,110,111,112, 142,148,149,150,151,**165**,166,167,1000,1001, State Fish Hatchery

[1]*Bolded numbers refer to resacas that are new to that alternative*

Town Resaca Screening

For the Town Resaca, all ecologically viable combinations of restoration plans were evaluated (Table 3-7). Two of the restoration plans (TownSP5 and TownSP6) were carried forward into the final screening phase.

Table 3-7: Town Resaca Phase 2 CE/ICA.

Resaca System Plan	Restoration Areas	Results
TownSP0	-	No Action
TownSP1	10,13	Cost Effective
TownSP2	8,10,13	-
TownSP3	6,7,8,10,13	Cost Effective
TownSP4	3,4,5,6,7,8,10,13	Cost Effective
TownSP5	17,18,19,39	Best Buy
TownSP6	3,4,5,6,7,8,10,13	Best Buy

Phase 3 - Connectivity value in combination with the restoration of the three resacas as a system

A connectivity screening phase was used for each resaca system plan to assess connectivity through the restoration of *"stepping stone"* habitats along the resaca corridor. A connectivity metric is not part of the RRCM habitat model because of the area's high diversity of fish and wildlife and their need to traverse the low quality gaps in bordering habitats.

For aquatic/amphibian species, the connectivity is built into the plan formulation as the hydraulic connectivity of the system is a requirement for the resaca ecosystem restoration. Habitat connectivity was qualitatively assessed with the assumptions that most terrestrial wildlife species would be able to traverse inhospitable terrestrial habitats to some extent.

Stepping stone habitats are designed to minimize the distance of inhospitable habitats between the stepping stone areas. This increases the probability that individual animals would successfully emigrate to nearby high quality habitats, thus establishing a new population to fill the vacant niche in the sink habitat. Each resaca system study plan was qualitatively assessed to find the ones meeting the habitat connectivity objective of the study because of factors such as degree of development, suboptimal habitat patches between stepping stones, and structural barriers to migration.

Town Resaca was separated into two areas separated by Interstate Highway 69E. A tunnel of about a mile in length connects the two areas. Restoration costs were found to be relatively high. The high cost resulted in the screening of all alternatives containing Town Resaca segments.

The results of the connectivity qualitative analysis for each resaca system found six individual plans that meet the connectivity goal and provide best buy plan cost justified benefits. The plans chosen to be carried forward include two resaca system plans for Resaca del la Guerra and four for Resaca del Rancho Viejo. Highlighted areas of Table 3-5 and Table 3-6 show the plans.

Final Array of Alternatives

Because each of the six resaca system plans independently provide connectivity and cost justified ecosystem benefits, each Resaca de la Guerra resaca system was paired with each Resaca del Rancho Viejo Plan resulting in the final array of alternatives (Table 3-8).

Table 3-8: Final Array of Alternative's Benefits and Cost (input for CE/ICA).

Alternative	Resaca System Plan	Cost ($1,000)	Benefit (AAHU)
G1	GSP-15	3,237	240
G1V1	GSP-15, VSP-11	6,232	433
G1V2	GSP-15, VSP-12	7,108	470
G1V3	GSP-15, VSP-13	7,428	483
G1V4	GSP-15, VSP-14	7,536	486
G2	GSP-16	3,894	264
G2V1	GSP-16, VSP-11	6,853	456
G2V2	GSP-16, VSP-12	7,730	493
G2V3	GSP-16, VSP-13	8,050	507
G2V4	GSP-16, VSP-14	8,157	510
V1	VSP-11	2,959	193
V2	VSP-12	3,835	230
V3	VSP-13	4,156	243
V4	VSP-14	4,263	246

The array of alternatives from Table 3-8 results in the following composition of restoration areas per alternative. Each successive alternative incorporates the previous alternative. The composition of restoration areas in each alternative is shown in Table 3-9.

Table 3-9: Final Array Composition

Alternative Composition					
1	**2**	**4**	**5**	**6**	**7**
40, 41, 42, 43, 44, 45E, 45, 46, 53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 75, 84, 93, 94, 95, 96, 161	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1
	98, 99, 100, 101, 104, 105, 108, 109, 110, 111, 112, 167, 148, 1000, 1001	Alternative 2	Alternative 2	Alternative 2	Alternative 2
		142, 149, 150, 151, 166	Alternative 4	Alternative 4	Alternative 4
			116, 117	Alternative 5	Alternative 5
				77, 78, 79, 81, 82, 83	Alternative 6
					165

Chapter 4 presents the evaluation of potential restoration measures, combined as alternatives. The evaluation compares to the alternatives to the forecast conditions (without restoration).

CHAPTER 4: EVALUATE ALTERNATIVE PLANS

Introduction

In Chapter 1, the problems and opportunities were identified. The objectives were established for use in evaluating how well potential alternatives would address the problems and achieve the opportunities. Constraints were identified to avoid potential undesirable impacts of potential alternatives.

In Chapter 2, the existing and forecast conditions were described if no Federal action was undertaken to restore the resacas.

In Chapter 3, restoration measures were identified to meet the objectives. The measures were combined through multiple applications of the cost effectiveness and incremental cost analysis and guided by an equally important connectivity analysis. The result was the identification of a final array of six alternatives.

In Chapter 4, the final array of six alternatives is evaluated against the without-project condition (the no action plan).

The evaluation of alternatives involved two distinct, complementary, and sequential assessments: CE/ICA and connectivity.

The first evaluation (Step 1) was the cost effectiveness of restoration within the footprint of the alternative array. The second evaluation (Step 2) was the potential contribution to surrounding ecosystem value and function (connectivity) and relied on a cadre of professional experts. This step was facilitated, in part, by the incremental cost analysis component of the CE/ICA model.

Evaluation Step 1, Cost Effective/Incremental Cost Analysis (CE/ICA)

The first assessment used the model in the USACE Institute of Water Resources (IWR) Planning Suite 2.0.6.1. This tool was used to assess fully formed plans and identify the “best buy plans”. In other words, to identify which combinations of restoration areas would provide the most habitat uplift from degraded to restored conditions for the least cost per habitat unit gained.

In essence, the Planning Suite developed a priority list for implementation based on cost effectiveness. Because the resaca areas are segmented, the tool was used in three iterations:

1. The initial effort identified small groups of neighboring segments to optimize the scale of the restoration areas within these aquatic and terrestrial complexes.

2. The next effort identified cost effective additions of the small groups within each of the three individual resacas.

3. The third effort identified optimal groups of segments across the three resacas.

This first assessment was an essential step prioritizing the efficient use of financial resources. Application of the cost effectiveness model reflects integration with the USACE Campaign Plan Objective 2c, Action 2c3, to develop, restore, and protect waters, wetlands, and natural resources.

Potential alternatives would have a relatively large footprint. Alternatives would utilize the same measures (plantings, dredging, shoreline sculpting, etc.) and would require similar adaptive management and monitoring activities. The adaptive management and monitoring would be similar for all alternatives and therefore would not affect the cost component of the CE/ICA or formulation decisions. The costs associated with operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) would be dependent on acreage. Larger alternatives would have greater costs and those costs might affect formulation decisions. Therefore, OMRR&R costs were included in the CE/ICA.

Evaluation Step 2, Connectivity

The second step used the professional judgement of USACE and resource agency experts to refine and expand the scope of the cost effectiveness assessment. This step was essential because the CE/ICA tool does not evaluate all relationships and ecological connections of a proposed restoration effort to the broader ecosystem opportunities surrounding a potential project area. Not only is the broader assessment a logical ecological approach, it is integrally threaded throughout the USACE Campaign Plan 2015-2018 and is a fundamental aspect of the NEPA.

All related past, present, and forecast ecological efforts within the study area vicinity were considered. A larger connectivity opportunity was identified that would, facilitate wildlife transportation corridors across Brownsville, and restore historic connectivity once provided by the study area resacas to the surrounding resaca habitat and uplands.

The USACE Campaign Plan applies to Objective 2a, Action 2a3 Outcome, Objective 2c, Action 2c3, and Objective 2d, Action 2d3. The alternatives were optimized to address water resources problems and opportunities based on risk informed analysis developed in close collaboration with stakeholders and partners(2a3) to develop, restore, and protect waters, wetlands, and natural resources(2c3) and optimize operations and maintenance efficiencies(2d3).

For evaluation step 2, the connectivity assessment was based on recovery plans for the federally endangered ocelot and jaguarundi. Connectivity is an important ecological concept in fragmented habitats such as the urban and agricultural landscapes of the Brownsville resacas. Travel corridors connecting isolated patches are critical for the dispersal and survival of species. Aquatic and riparian corridor habitat does not need to be continuous to be suitable for all wildlife movement. Many species effectively navigate across urban environments when there are adequate areas of habitat interspersed within urban improvements. The “stepping stone” approach of the recovery plans has been proven to be effective in the managed lands in the area. Connectivity was assessed with this approach.

The assessment considered transportation opportunities of all wildlife identified in the study area and forecast to utilize the wildlife transportation corridors in the future 75-year period of analysis. For many species, these connections would extend the ecological reach of the recommended project from a radius of 5 miles within Brownsville to as much as 30 miles to the highest quality managed areas. That radius would include connections to up to 125,000 acres of high quality, managed habitat.

The USACE, including the Engineering Development and Research Center (ERDC), the USFWS, TNC, and TPWD, and subject matter experts (SME) evaluated and compared the project alternatives. Appendix A details the SME team’s connectivity observations, assumptions, and recommendations.

Restoration Areas Considered

The Resaca Reference Condition Model (RRCM) was developed in cooperation with the USFWS, the TPWD, the NPS, the BPUB, and university biologists. The model was used to quantify and assess existing and future habitat conditions, with and without the study alternatives. The RRCM used data collected from high quality resaca sites within the Resaca de la Palma State Park, TNC Southmost Preserve, and Camp Lula Sams (Figure 4–1).

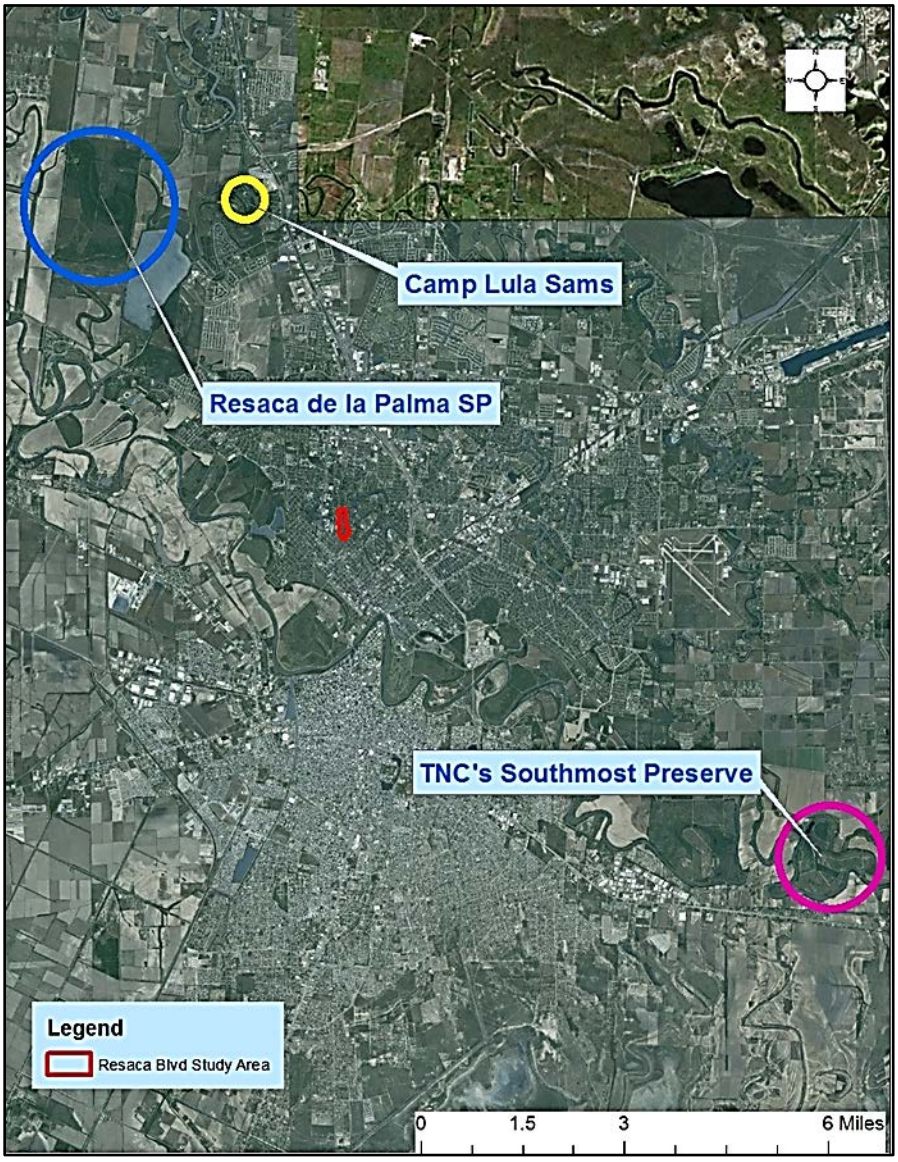

Figure 4–1: Location of Reference Condition Resacas

The RRCM is comprised of three modules with each module dedicated to one of the three resaca vegetation communities: Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland.

Sixty-six restoration area locations were considered for alternative formulation across the three resacas. (Figure 4–2, Figure 4–3, and Figure 4–4).

Under evaluation step 1, the restoration plans within each resaca were evaluated using the IWR Planning Suite CE/ICA tool. The first two iterations screened the restoration plans within 1) a group of restoration areas and 2) within each resaca system. The third iteration was used to identify a final array of alternatives potentially incorporating all the resacas system.

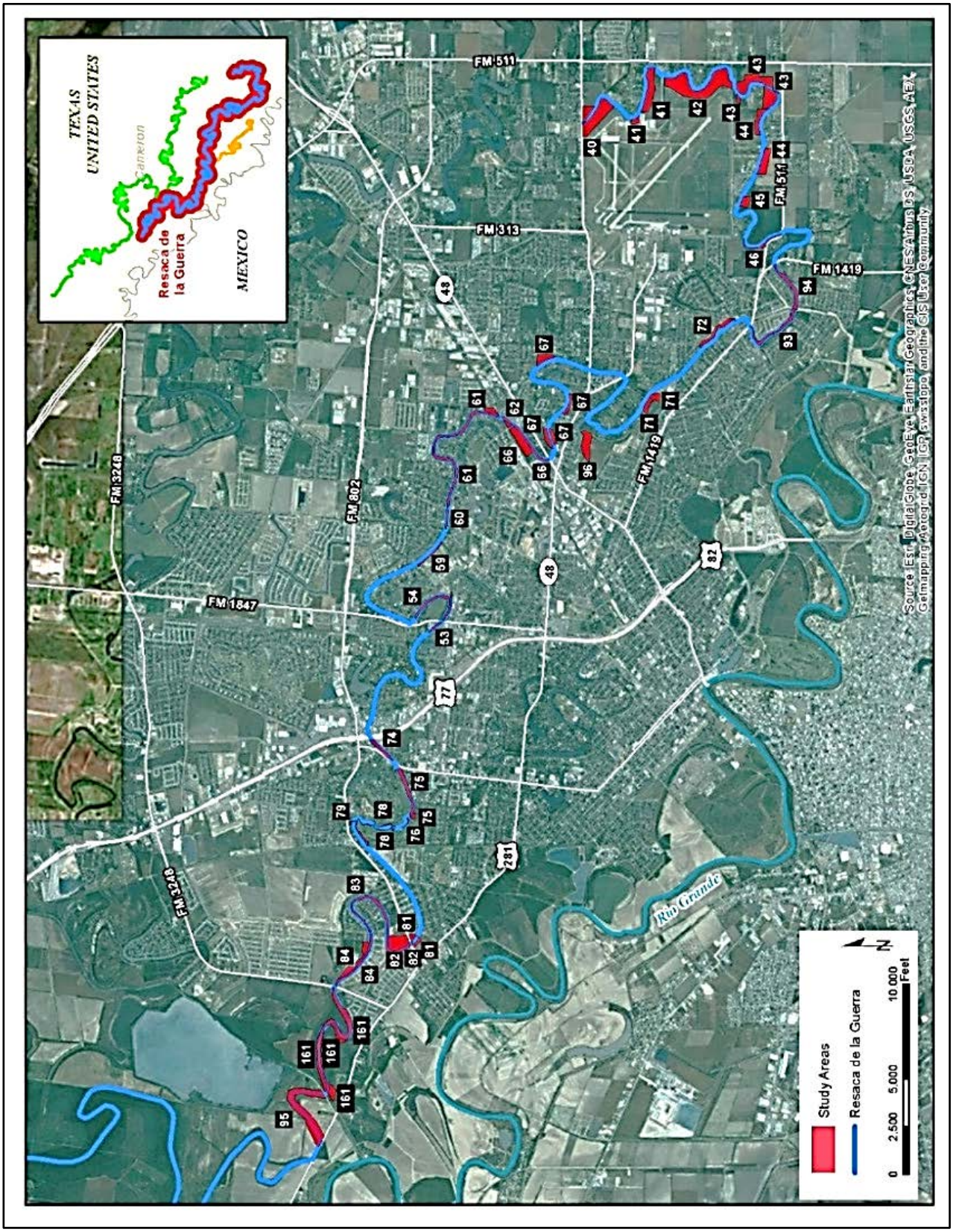

Figure 4–2: Resaca de la Guerra Potential Restoration Areas

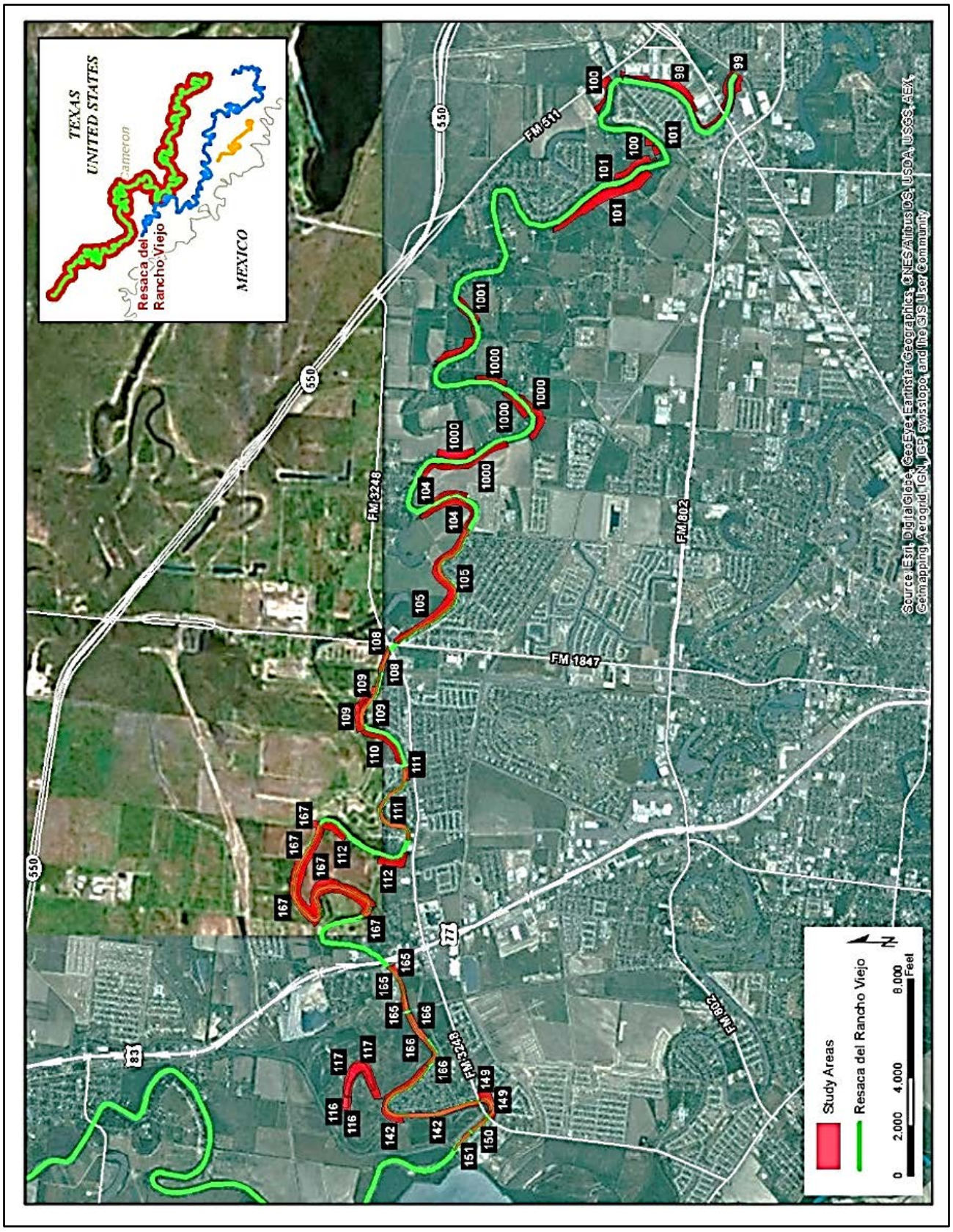

Figure 4–3: Resaca del Rancho Viejo Potential Restoration Areas

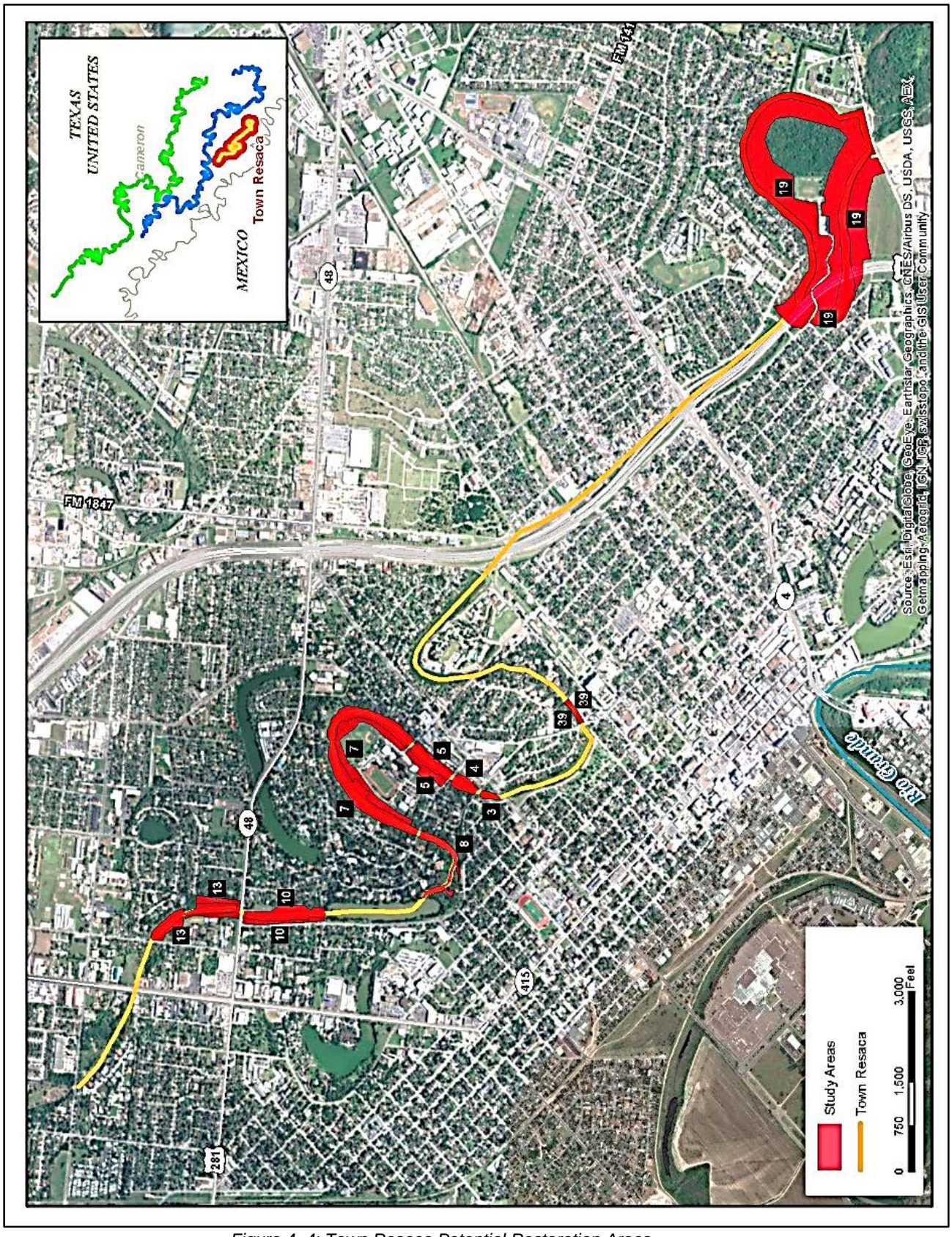

Figure 4–4: Town Resaca Potential Restoration Areas

Final Array of Alternatives

The two evaluation steps were equally important in the development of alternatives. The first step screened out the combinations of restoration areas that did not meet the effectiveness criteria. The second step utilized the alternatives identified in step one and quantitatively assessed alternatives that maximized connectivity.

The resacas' restoration areas were combined into logical and practicable alternatives for detailed analysis. The no action plan and the six alternatives are identified below. The period of analysis was from 2018 to 2113.

No Action

The no action plan is the forecast without project condition.

Alternative 1

Alternative 1 would include the restoration of a significant portion of Resaca del La Guerra. Alternative 1 includes 26 restoration areas.

Alternative 2

Alternative 2 would add 15 Resaca del Rancho Viejo resaca restoration areas to Alternative 1.

Alternative 3

Alternative 3 was screened from further analysis. This alternative included the Town Resaca restoration areas. Town Resaca is in the oldest part of Brownsville being more densely developed than the more rural resacas associated with the Resaca del Rancho Viejo system. Town Resaca would not add to the overall resaca system connectivity and the incremental cost of restoration was higher per habitat unit.

Alternative 4

Alternative 4 would add five restoration areas located in the northwest section of Resaca del Rancho Viejo to Alternative 2. Alternative 4 would establish connectivity to high quality upland thornscrub habitat.

Alternative 5

Alternative 5 would add one restoration area to Alternative 4.The area would be the TPWD State Fish Hatchery property located in northwest section of Resaca del Rancho Viejo. Alternative 5 would establish additional connectivity to high quality upland thornscrub habitat.

Alternative 6

Alternative 6 would complete the proposed restoration of Resaca de la Guerra through the addition of 6 restoration areas to Alternative 5.

Alternative 7

Alternative 7 would add restoration area 165, which includes the excavation of 4.3 acres of a dry resaca segment. The restoration of area 165 would complete the hydrologic connection of Resaca del Rancho Viejo.

On the following pages, Figure 4–5, Figure 4–6, Figure 4–7, Figure 4–8, Figure 4–9, and Figure 4–10 show the restoration areas for each Alternative. The composition of restoration areas in each alternative is shown in Table 4-1.

Table 4-1: Final Array Composition

Alternative Composition					
1	**2**	**4**	**5**	**6**	**7**
40, 41, 42, 43, 44, 45E, 45, 46, 53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 75, 84, 93, 94, 95, 96, 161	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1
	98, 99, 100, 101, 104, 105, 108, 109, 110, 111, 112, 167, 148, 1000, 1001	Alternative 2	Alternative 2	Alternative 2	Alternative 2
		142, 149, 150, 151, 166	Alternative 4	Alternative 4	Alternative 4
			116, 117	Alternative 5	Alternative 5
				77, 78, 79, 81, 82, 83	Alternative 6
					165

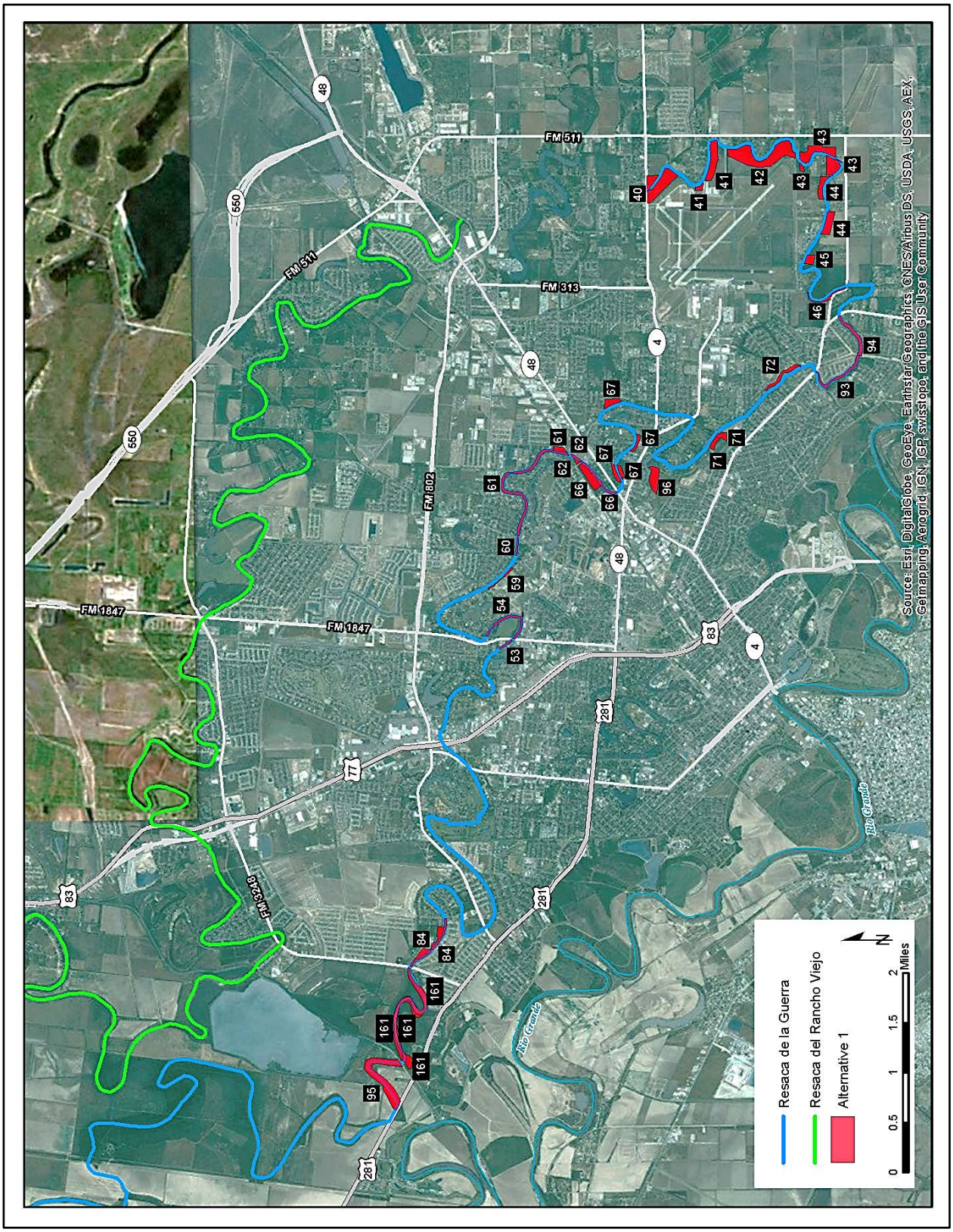

Figure 4–5: Alternative 1

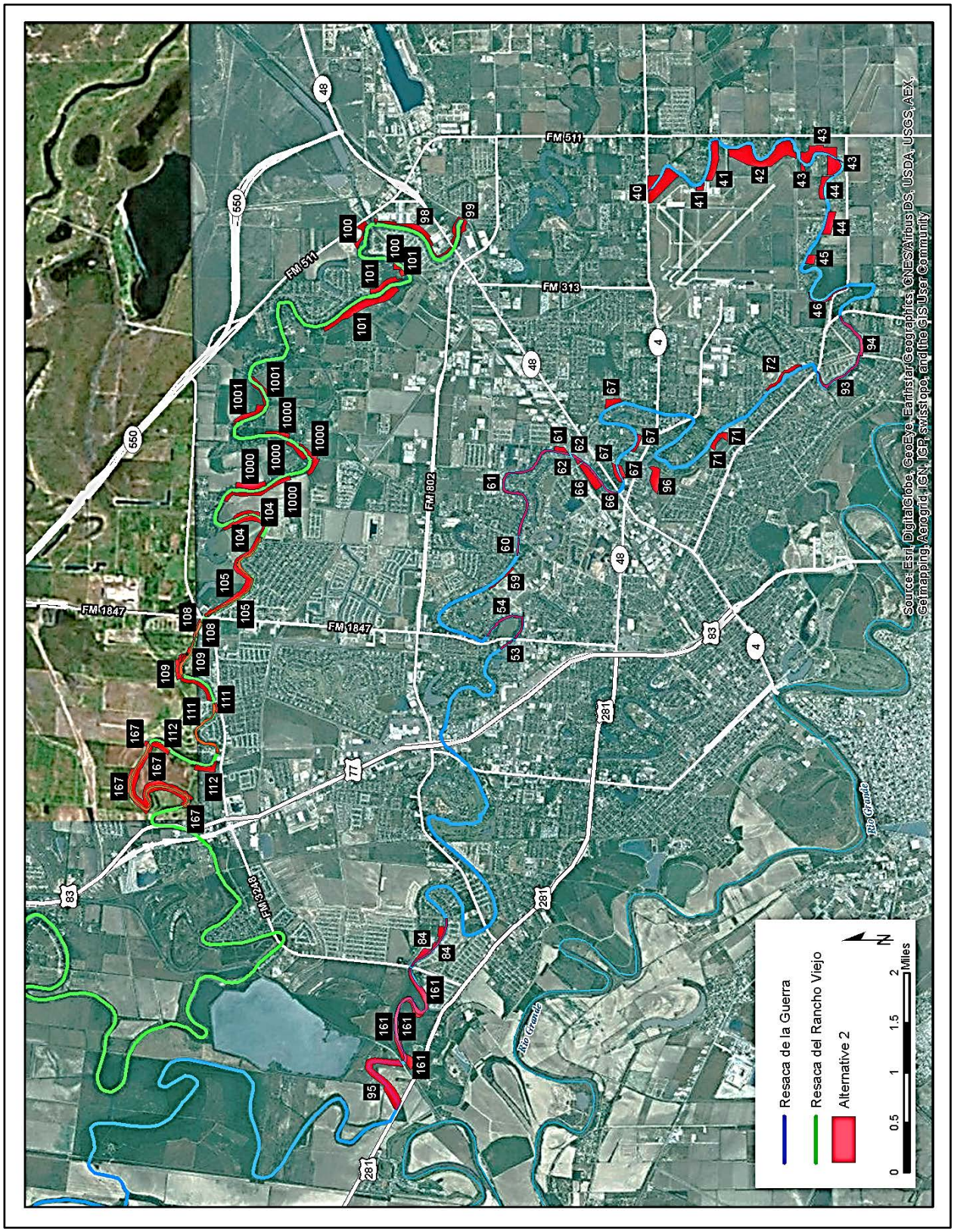

Figure 4–6: Alternative 2

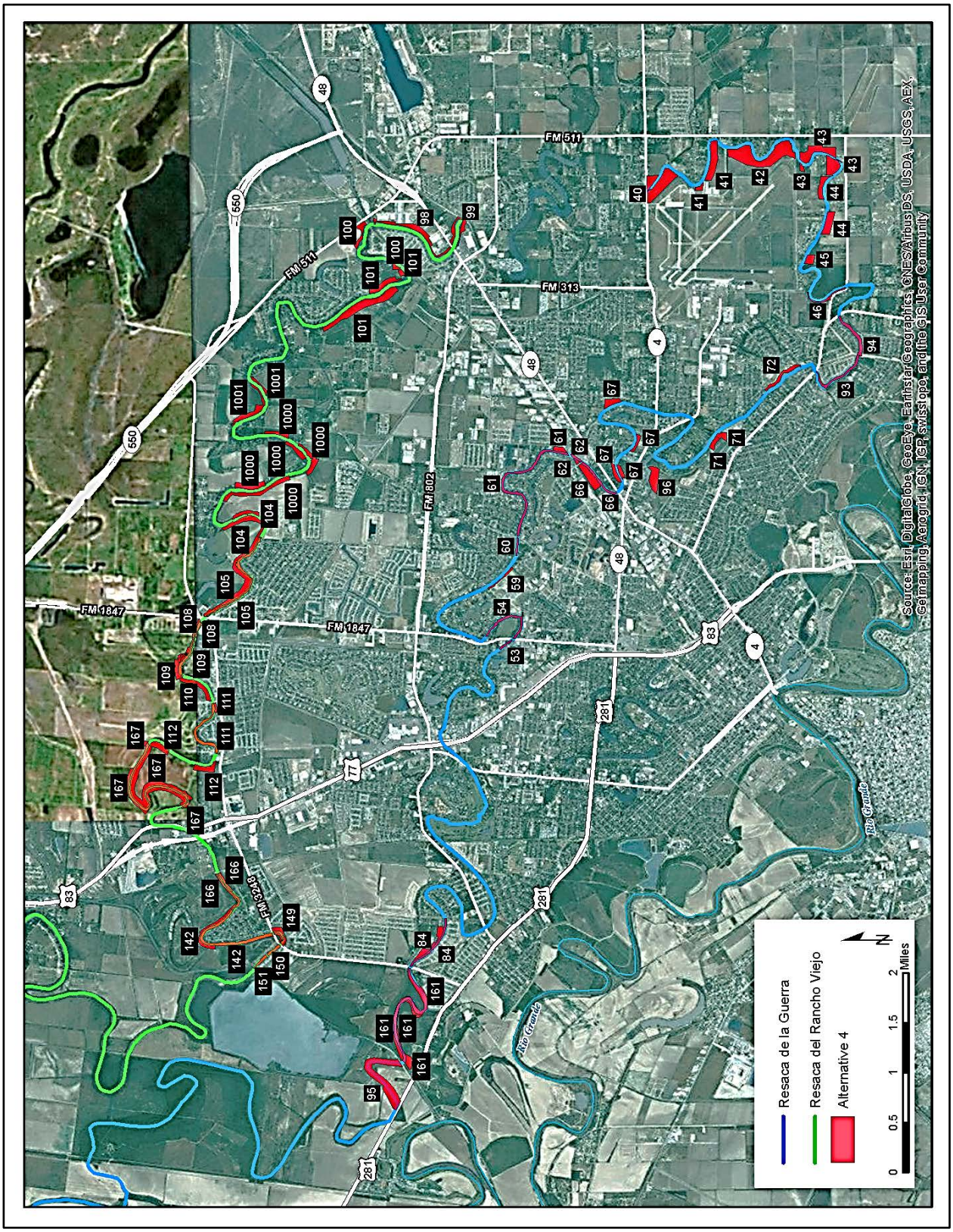

Figure 4–7: Alternative 4

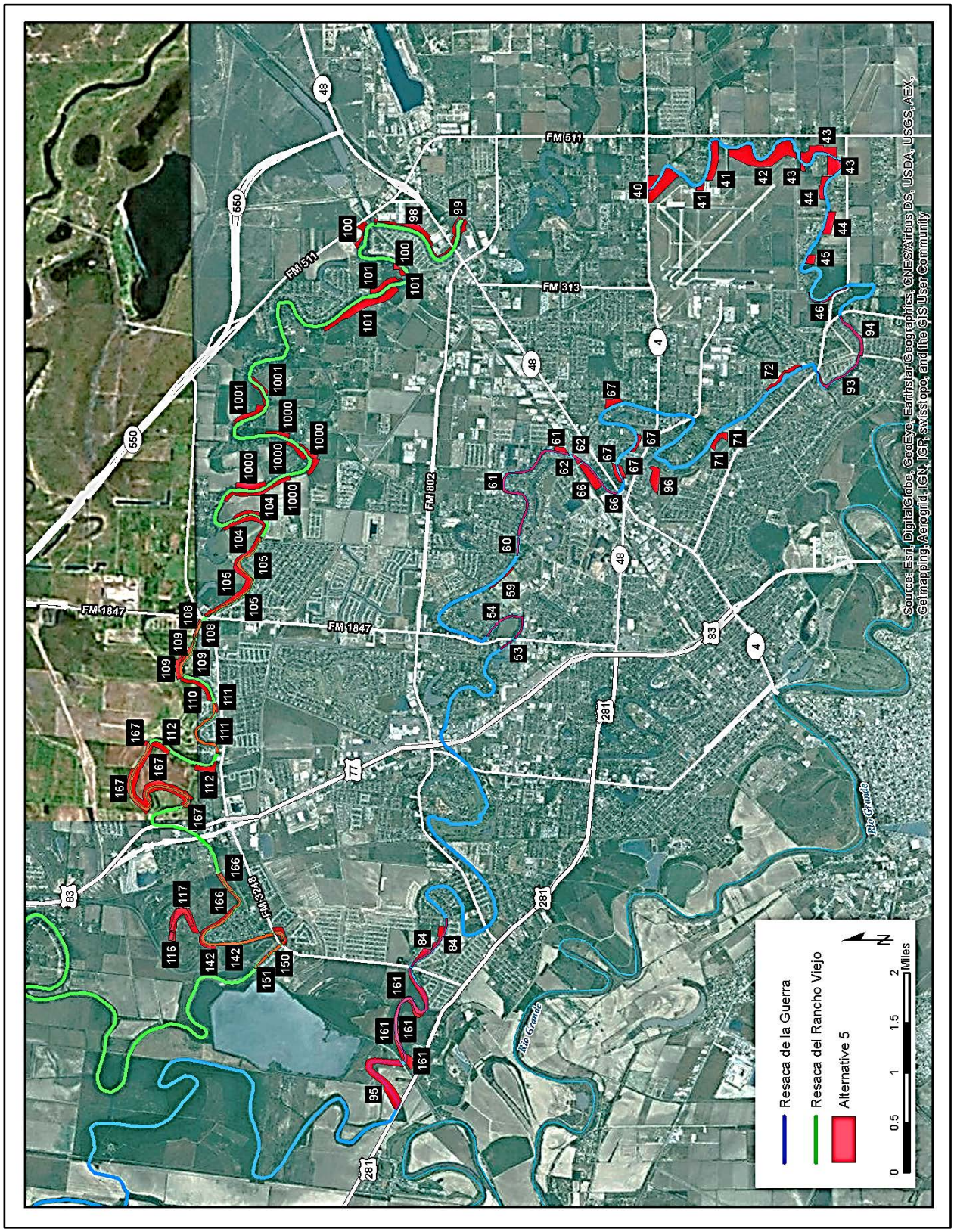

Figure 4–8: Alternative 5

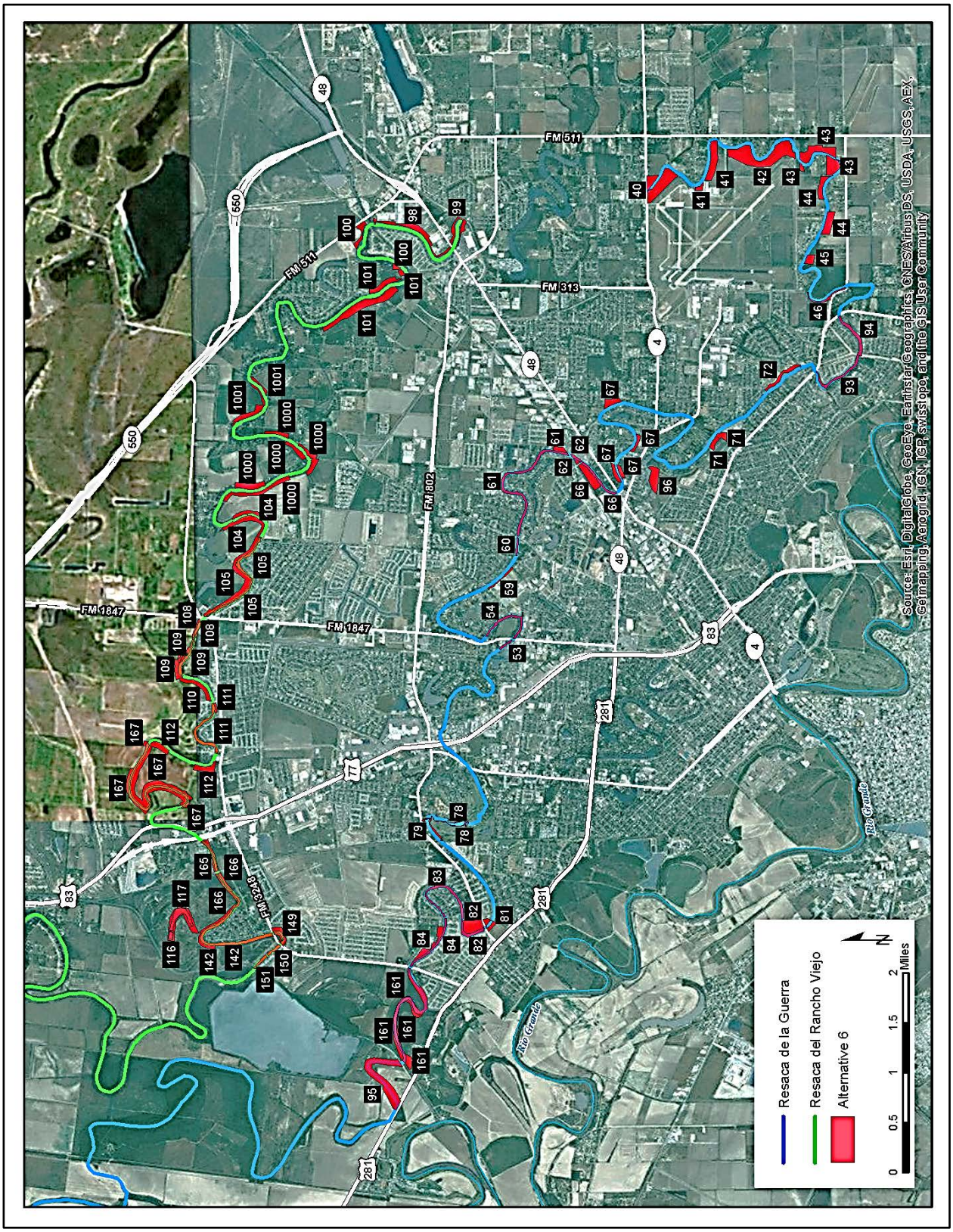

Figure 4–9: Alternative 6

All fully formed plans from the final array of alternatives and associated AAHU and average annual costs (AAC) were input into the IWR Planning Suite. The IWR Planning Suite compared each alternative for cost effectiveness and an incremental cost analysis was performed on the remaining cost effective plans (Figure 4–10 and Table 4-2). The final array identifies the combinations of fully formed plans, for each resaca and with the two resacas combined, and identifies the incremental annual benefit for the incremental annual cost.

The cost effective analysis for all the plans is presented below in Figure 4–10 and Table 4-2. The graphic shows the cost effectiveness of the final array of alternatives and identifies best buy plans carried forward for the incremental cost analysis. This analysis is one of two steps needed for evaluations using Objective 1 (Cost Effective Restoration Prioritization).

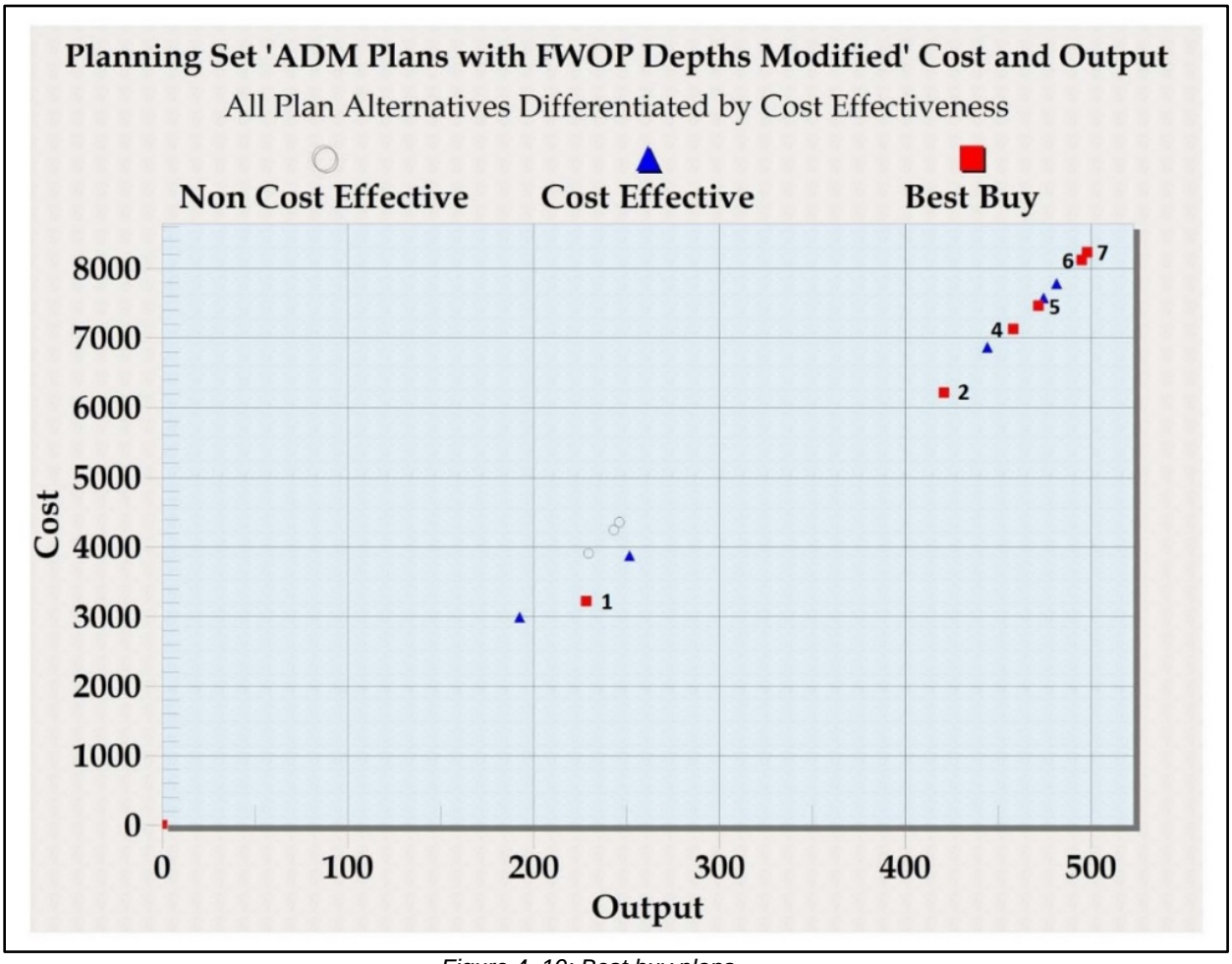

Figure 4–10: Best buy plans.

Table 4-2: Best Buy Plans

Cost and Benefit Category	Alternative					
	1	2	4	5	6	7
First Cost ($1,000)	90,318	172,198	196,277	205,501	223,542	226,611
AAC ($1,000)	3,273	6,232	7,108	7,428	8,050	8,157
IDC ($1,000)	652	1,258	1,444	1,515	1,654	1,678
OMRR&R ($1,000)	248	506	578	593	618	624
Project Acres	448.7	826.2	884.2	914.5	963.0	968.6
FWP AAHU	393	762	815	846	883	888
FWOP AAHU	153	329	346	362	376	378
Net Benefit ($1,000)	240	433	470	483	507	510
Benefit/Acre AAHU	0.53	0.92	0.92	0.93	0.92	0.92
Incremental Benefit AAHU	240	193	37	13	23	3
AAC/AAHU ($1,000)	13.6	14.4	15.1	15.4	15.9	16.0
Incremental AAC	13.6	6.8	1.9	0.7	1.2	0.2
Incremental AAC/AAHU ($1,000)	13.6	15.4	23.5	23.7	26.7	37.5
Total Cost./Acre ($1,000)	201.28	208.42	221.98	224.71	232.13	233.96
AAC/Acre ($1,000)	7.29	7.54	8.04	8.12	8.34	8.42

Figure 4–11 presents the incremental cost analysis. This analysis is the second of two steps needed for evaluations using Objective 1 (Cost Effective Restoration Prioritization). Notes within the figure relate to Objective 2 to the alternatives connectivity to the surrounding ecosystem. This figure is shown again in Chapter 5 that compares the alternatives to each other and identified the recommended plan, the National Ecosystem Restoration plan.

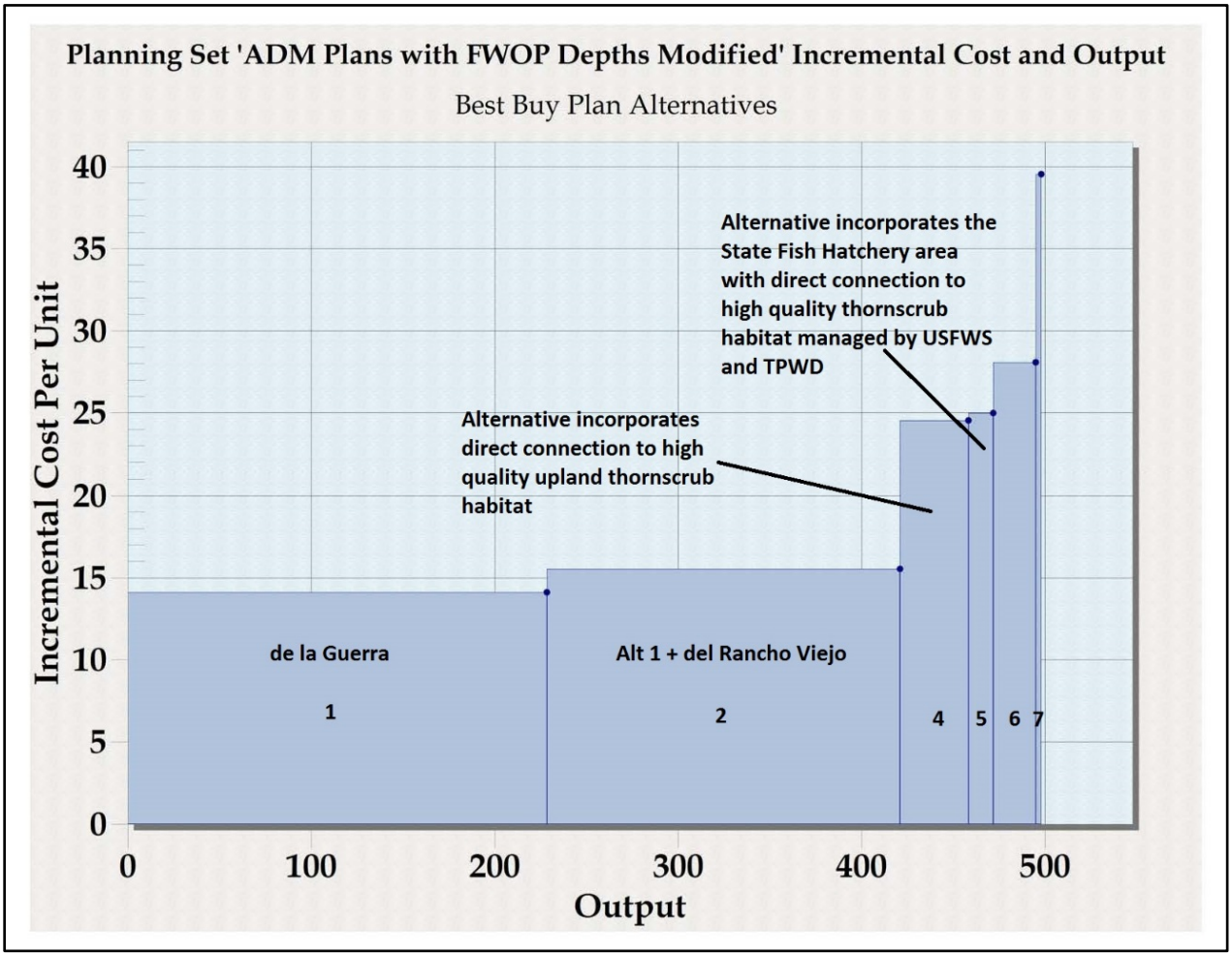

Figure 4–11: Alternative Costs and Habitat Outputs

Implementation Note

Each restoration area is incrementally justified (Table 4-3). The timing of implementation of the measures on USFWS lands or other project lands would not significantly alter the project's benefits. There are five tracts within segments 142, 161, and 166 that are owned by the federal government and are operated by the USFWS. The economic value of USFWS resources was considered in the economic analysis. The value was not included in the financial costs (such as the total project cost, see page 4-16). The benefits of the project are compared to the economic costs. Preliminary coordination with the USFWS has been conducted and the service is interested in the potential for joint implementation. That coordination is documented in Appendix C. Detailed coordination would be conducted during the pre-construction engineering and design phase of the USACE implementation.

Table 4-3: Final Array Composition

Alternative Composition					
1	**2**	**4**	**5**	**6**	**7**
40, 41, 42, 43, 44, 45E, 45, 46, 53, 54, 59, 60, 61, 62, 66, 67, 71, 72, 75, 84, 93, 94, 95, 96, 161	Alternative 1	Alternative 1	Alternative 1	Alternative 1	Alternative 1
	98, 99, 100, 101, 104, 105, 108, 109, 110, 111, 112, 167, 148, 1000, 1001	Alternative 2	Alternative 2	Alternative 2	Alternative 2
		142, 149, 150, 151, 166	Alternative 4	Alternative 4	Alternative 4
			116, 117	Alternative 5	Alternative 5
				77, 78, 79, 81, 82, 83	Alternative 6
					165

CHAPTER 5: COMPARE ALTERNATIVE PLANS

Introduction

Chapter 4 described how the measures were combined in groups of restoration areas and evaluated against the forecast without project conditions (no action plan), how those groups were further combined and evaluated, and how a final array of six alternatives was identified.

Chapter 5 compares the six alternatives to each other using costs, habitat benefits, environmental impacts, and other project metrics to identify the National Ecosystem Restoration (NER) plan.

"Is It Worth It" Analysis for Final Array of Alternatives (Best Buy Array)

To identify the NER plan, the final array of alternatives were compared incrementally. At each increment a determination was made to answer the question,

"Is it worth it to spend the incremental cost to go to the next larger and more expensive alternative?"

Each alternative builds on the previous by adding one or more restoration areas.

The NER plan is identified when the additional incremental cost can no longer be justified. One component of the justification is a quantitative assessment using the Resaca Reference Condition Model (RRCM) and the Cost Effectiveness and Incremental Cost Analysis (CE/ICA) tool described below. A second, and equally important component of the justification is a qualitative professional assessment by the USACE and resource agency professionals that are subject matter experts in resaca restoration.

National Ecosystem Restoration Plan Identification Process

The RRCM habitat model was used to estimate how well a particular habitat area represents the highest quality reference resaca habitats. Specifically, the three critically imperiled resaca habitats are: Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes Shrubland. Each alternative in the final array includes resaca restoration within each of these critically imperiled ecosystems.

The RRCM was used to determine the potential habitat changes with regard to the Brownsville resacas ecosystem restoration objectives. The RRCM index (habitat quality) is multiplied by the number of acres (habitat quantity) resulting in habitat benefits, also known as habitat units (HUs). The HUs were amortized over a 75-year period of analysis to derive the Average Annual Habitat Units (AAHUs). The future without-project conditions (FWOP) AAHUs were subtracted from the future with-project (FWP) condition AAHUs to determine the net AAHUs. First costs were estimated using October 2015 prices and were annualized over 75 years with a federal discount rate of 3.125 percent to calculate average annual costs (AAC). *Note: The price level and interest rate were later updated for the recommended plan to October 2017 prices and a federal discount rate of 2.75 percent.*

Cost Effectiveness and Incremental Cost Analysis (CE/ICA)

The final array of alternatives were compared using the IWR Planning Suite software. A comparison was done for each alternative for cost effectiveness and incremental cost. The final array identified the combinations of fully formed plans within each resaca, with the two resacas combined, and identifies the incremental annual output for the incremental annual cost. Table 5–1 lists the resulting best buy alternatives (1, 2, 4, 5, 6, 7). Figure 5–1 shows the cost effective ranking of the final array of alternatives and identifies best buy plans carried forward for incremental cost analysis.

Table 5–1: Best-Buy Array from CE/ICA (October 2015 Prices, 3.125 Percent Interest, 75 years)

Cost and Benefit Category	Alternative					
	1	2	4	5	6	7
First Cost ($1,000)	90,318	172,198	196,277	205,501	223,542	226,611
AAC ($1,000)	3,273	6,232	7,108	7,428	8,050	8,157
IDC ($1,000)	652	1,258	1,444	1,515	1,654	1,678
OMRR&R ($1,000)	248	506	578	593	618	624
Project Acres	448.7	826.2	884.2	914.5	963.0	968.6
FWP AAHU	393	762	815	846	883	888
FWOP AAHU	153	329	346	362	376	378
Net Benefit (AAHU)	240	433	470	483	507	510
Benefit/Acre (AAHU)	0.53	0.92	0.92	0.93	0.92	0.92
Incremental Benefit (AAHU)	240	193	37	13	23	3
AAC/AAHU ($1,000)	13.6	14.4	15.1	15.4	15.9	16.0
Incremental AAC ($1,000)	13.6	6.8	1.9	0.7	1.2	0.2
Incremental AAC/AAHU ($1,000)	13.6	15.4	23.5	23.7	26.7	37.5
Total Cost/Acre ($1,000)	201.28	208.42	221.98	224.71	232.13	233.96
AAC/Acre ($1,000)	7.29	7.54	8.04	8.12	8.34	8.42

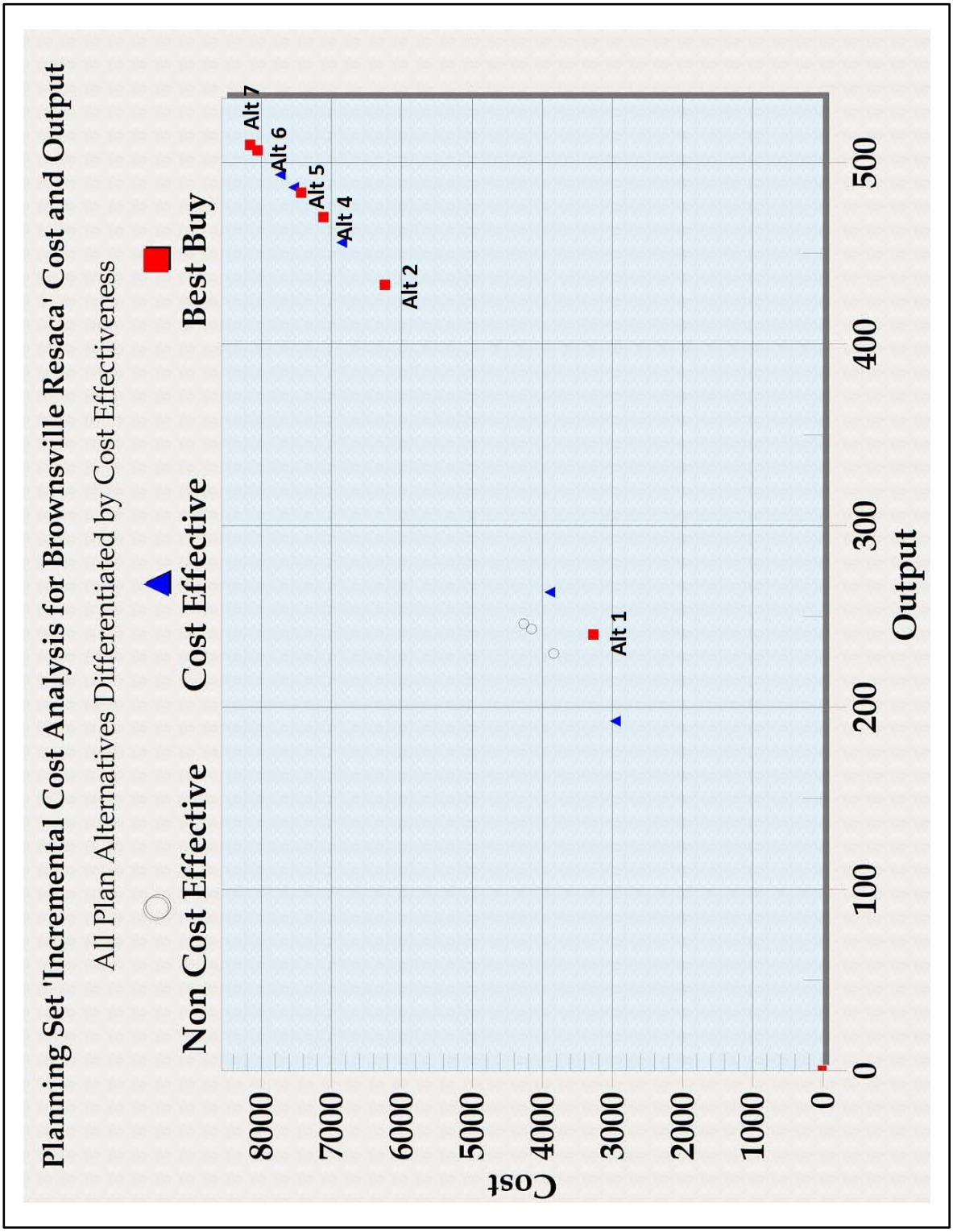

Figure 5–1: CE/ICA Cost-effective and Best-buy Plans.

CE/ICA Best Buy Array

The final array of alternatives represents an incremental cost ranking of plans that would best meet the study objectives for restoration. Some plans come closer to fully meeting the objectives than others, but all provide cost effective levels of restoration and habitat connectivity. The following sections compare each successively larger best buy plan to the previous plan. Alternative 1 is compared to the no action plan.

Comparing Alternative 1 to the No Action Plan

The no action plan is included as a point of comparison to other alternatives. With the no action plan, no expenditure of federal funds would occur to implement resaca restoration. The Brownsville resacas would continue to degrade. Without intervention, the resacas would eventually complete their successional life cycle, dry up, and revert to upland habitats. Without restoration, non-native and invasive plant species would dominate many of these upland areas, and wildlife value of the ecosystem would significantly decrease.

Alternative 1 would restore a significant portion of Resaca del La Guerra. Alternative 1 would include 25 restoration areas. The drawings at the end of the main report show each of these restoration areas. The measures for each restoration area are shown in Table 5–2. Figure 5–2 shows an overall graphical representation of Alternative 1.

The alternative would include the removal and management of non-native and invasive species within the restoration area. Chapter 2, Table 2-5 lists the planning area's common invasive plant species.

Alternative 1 would include dredging several resaca segments. Dredging would ensure the resaca ecosystem sustainability by providing the aquatic habitat component necessary to support the resaca ecosystem. The alternative would include reshaping the resaca bank slope and excavating the silted in areas to a depth of six feet, or until the clay layer of resaca is detected. These measures would increase the quantity of aquatic habitat and would restore the connection of the aquatic habitat to the riparian habitat. This would be of particular benefit to the amphibian species dependent on the two habitat types for successful reproduction and development.

Alternative 1 would provide a total of 393 total AAHUs (240 AAHUs incremental) at a project first cost of $90,318,000. Alternative 1 would meet the study objectives by restoring 326 acres of globally imperiled Texas Ebony Resaca Forest and 119.9 acres of aquatic and emergent resaca habitat, while the no action alternative would result in further loss of this valuable resource. The loss of resaca habitats is compounded by the fact that modified floodplain conditions no longer enable additional resacas to form. Alternative 1 would restore a total of 445.9 acres of

resaca habitat at an average cost per restored habitat unit of $13,600. The incremental cost of Alternative 1 would be worth the federal and local investment.

Table 5–2: Restoration Measures and Benefits for Alternative 1

Restoration Area	Riparian Restoration Acres	Aquatic/Emergent Restoration Areas	Bank Sculpting (lf)	Invasive Species Management Acres	Dredging or Excavation Acres	Net Gain in AAHU
40	32.7	1.2	3,545	33.9	0.0	19
41	21.2	0.9	2,575	22.1	0.0	12
42	54.8	1.7	4,950	56.5	0.0	25
43	34.0	0.0	0	34.0	0.0	15
44	19.5	0.9	2,700	20.4	0.0	12
45E	5.1	0.2	525	5.3	0.0	2
45,46	5.0	0.9	2,525	5.9	0.0	2
53	0.0	0.0	0	0.0	1.6	1
54	0.0	0.0	0	0.0	8.6	2
59	3.6	0.6	1,710	4.2	0.00	2
60	0.0	0.0	0	0.0	1.8	1
61	3.6	0.3	768	3.9	22.5	13
62	1.4	0.2	658	1.6	1.8	2
66	13.8	0.6	1,600	14.4	6.6	11
67	19.5	1.3	3,900	20.8	0.0	9
71	7.8	0.3	989	8.1	0.0	5
72	8.8	0.8	2,336	9.6	0.0	4
75	10.6	1.9	5,540	12.5	9.9	10
76	0.9	0.2	620	1.1	0.0	1
84	10.5	1.1	3,191	11.6	7.8	13
93	6.1	1.8	5,148	7.9	4.4	6
94	6.1	1.3	3,750	7.4	4.8	10
95	24.2	3.3	9,670	27.5	20.9	28
96	12.9	0.5	1,345	13.4	0.0	7
161	23.9	5.1	14,815	29.0	29.2	30
Total	326	24.9	72,240	350.0	119.9	240

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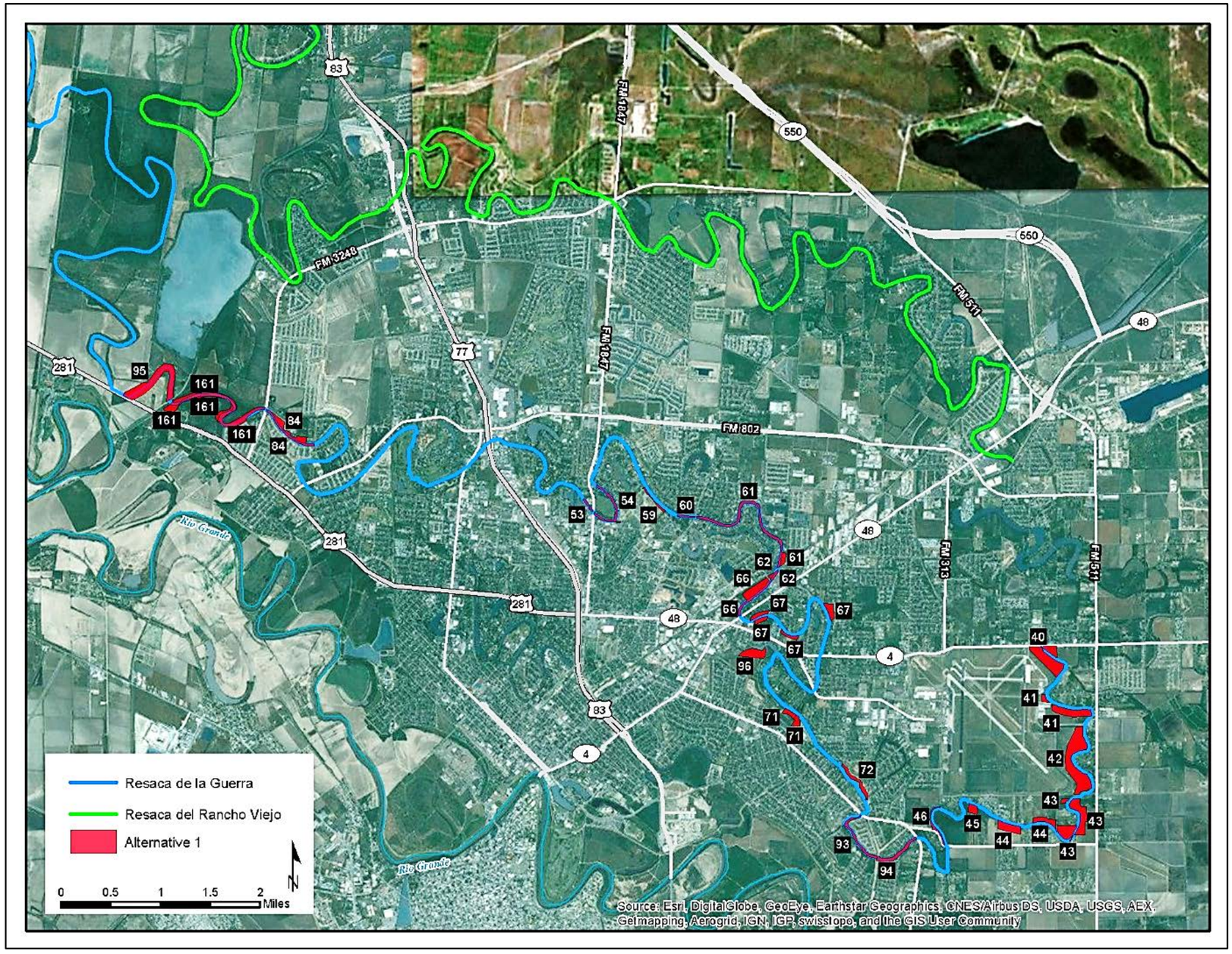

Figure 5–2: Alternative 1

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Comparing Alternative 2 to Alternative 1

Alternative 2 would add 15 Resaca del Rancho Viejo restoration areas to Alternative 1 (Resaca de la Guerra restoration areas). Appendix A provides additional Resaca del Rancho Viejo Resacas graphic and site specific detail. Table 5–3 presents the habitat benefit outputs for each restoration area. Figure 5–3 shows an overall graphical representation of Alternative 2.

Alternative 2 would provide an additional 193 AAHUs of benefit for a total of 762 AAHUs at a first cost of $172,198,000. Alternative 2 would meet the study objectives by restoring 638.2 acres of globally imperiled Texas Ebony Resaca Forest and 172.4 acres of aquatic and emergent resaca habitat.

Alternative 2 would add significant restoration to an additional resaca system (Resaca del Rancho Viejo) providing an incremental annual benefit of 193 AAHUs. Alternative 2 would restore a total of 810.6 acres at an average cost per restored habitat unit of $14,400. That would be an 82 percent increase in restored acres at a 6 percent increase in cost per restored habitat unit compared to Alternative 1.

Table 5–3: Restoration Measures and Benefits for Alternative 2.

Restoration Area	Riparian Restoration Acres	Aquatic/ Emergent Restoration Acres	Bank Sculpting (LF)	Invasive Species Management (Acres)	Dredging or Excavation (E) (Acres)	Net Gain in AAHU
98	19.6	1.7	4,887	23.1	0.0	10
99	10.1	1.1	3,118	11.2	0.0	5
100	8.8	0.7	1,930	9.5	0.0	4
101	47.6	2.3	6,762	49.9	0.0	29
104	20.3	1.6	4,727	21.9	0.0	11
105	31.3	2.2	6,409	33.5	12.7	25
108	3.6	0.7	2,053	4.3	2.2	3
109	10.2	1.1	3,171	11.3	7.0	10
110	10.9	0.8	2,345	11.7	0.0	5
111	1.8	0.8	2,201	2.6	11.6	10
112	16.0	0.9	2,465	16.9	0.0	7
167, 148	63.0	6.0	17,321	69.0	(E) 19.0	41
1000	51.7	3.5	10,137	55.2	0.0	22
1001	17.3	1.7	4,790	19.0	0.0	10
Sub Total	312.2	25.1	72,316	337.3	52.5	192
Alt 1 Total	326.0	25.1	72,860	351.1	119.9	240
Alt 2 Total	638.2	50.2	145,176	688.4	172.4	433

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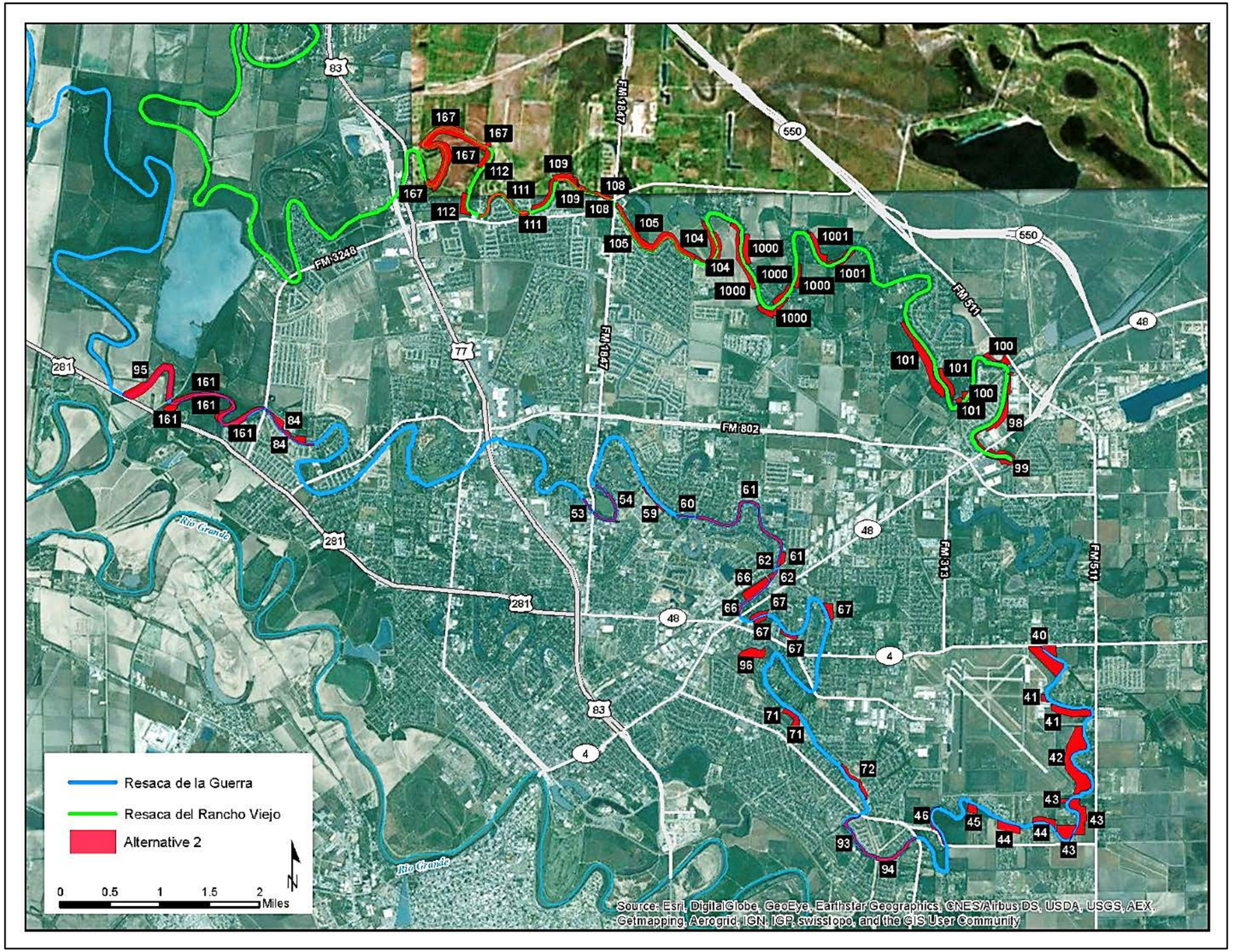

Figure 5–3: Alternative 2

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The incremental cost of Alternative 2 would be relatively small compared to the increase in benefits. Alternative 2 would double restoration benefits by adding an additional 15 restoration areas.

The rarity of the habitat, the incredible biodiversity of the resaca ecosystems, and the reliance of numerous resaca-dependent and rare wildlife species on the habitat justify the ecological value of the expenditure of the additional incremental. The incremental cost associated with Alternative 2 would be worth the federal and local investment.

Comparing Alternative 4 to Alternative 2

Alternative 4 would add five additional restoration areas located in the northwest section of Resaca del Rancho Viejo to Alternative 2 restoration areas. Appendix A includes detailed graphics of these individual restoration areas. Table 5–4 details the restoration measures' habitat benefit outputs and costs. Figure 5–4 shows an overall graphical representation of Alternative 4.

Table 5–4: Restoration Measures and Benefits for Alternative 4.

Restoration Area	Riparian Restoration Acres	Aquatic/ Emergent Restoration Acres	Bank Sculpting (LF)	Invasive Species Management (Acres)	Dredging (Acres)	Net Gain in AAHU
142	11.6	1.7	5,047	13.3	20.9	23
149	8.0	1.1	3,229	9.1	1.8	5
150	0.0	0.0	0	0.0	2.5	1
151	0.0	0.0	0	0.0	2.4	1
166	6.5	1.8	5,071	8.3	4.3	8
Sub Total	18.22	4.60	13,347	23.9	31.91	38
Alt 2 Total	638.2	50.2	145,176	688.4	172.4	433
Alt 4 Total	664.3	54.8	158,523	719.1	204.3	470

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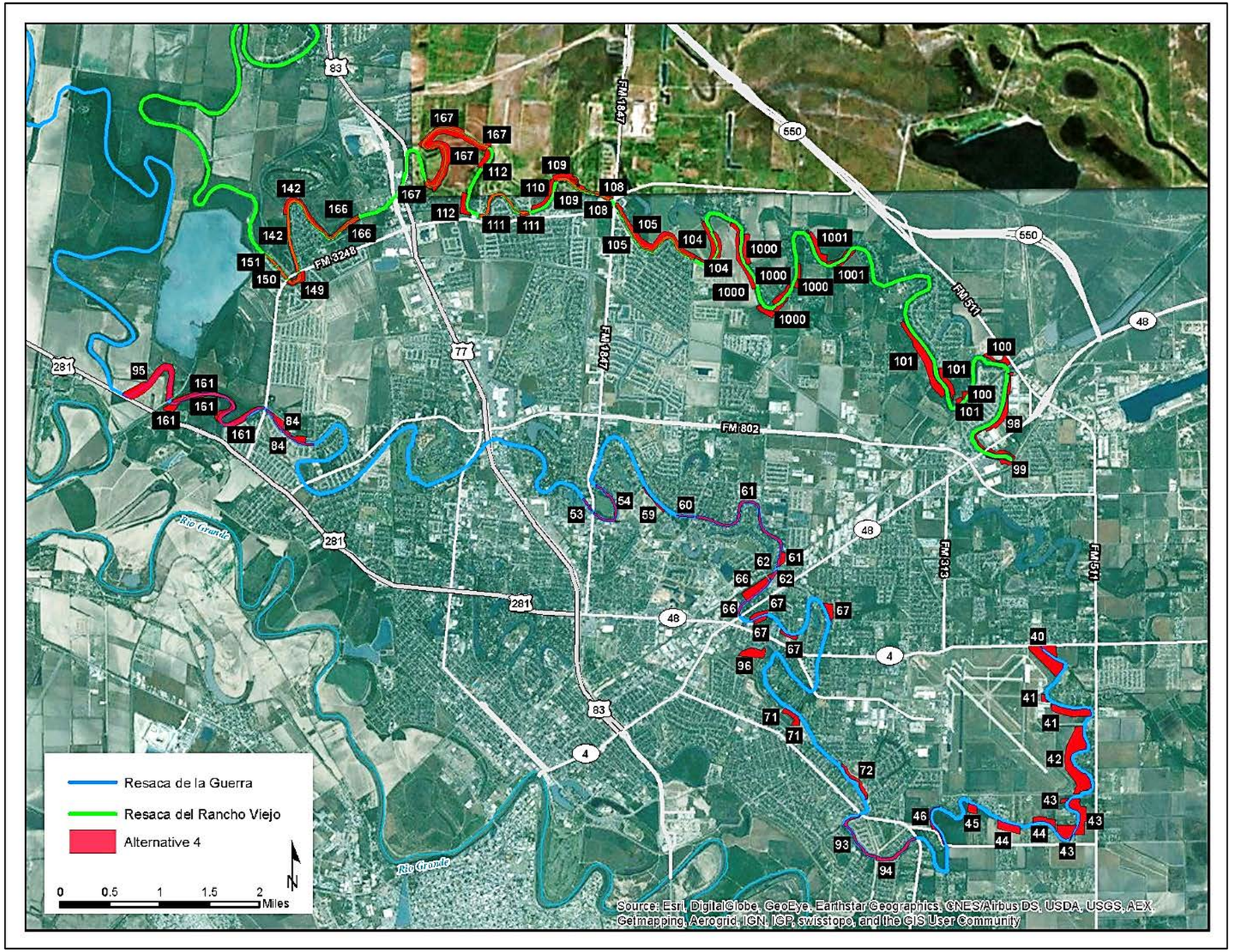

Figure 5–4: Alternative 4

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Alternative 4 would provide an additional 37 AAHUs of benefit for a total of 815 AAHUs at a first cost of $196,277,000. Alternative 4 would meet the study objectives by restoring 664.3 acres of globally imperiled Texas Ebony Resaca Forest and 204.3 acres of aquatic and emergent resaca habitat.

Alternative 4 would restore a total of 868.6 acres at an average cost per restored habitat unit of $15,100. That would be a 6 percent increase in restored acres at a less than 5 percent increase in cost per restored habitat units compared to Alternative 2. The restoration areas associated with Alternative 4 would provide stepping stone connectivity with high quality resaca habitats currently under federal, state, and NGO resource management entities. The alternative would provide connectivity to a 330 acre tract of high quality thornscrub habitat managed by the USFWS and TPWD on the west side of Brownsville.

Connecting the resacas to these high quality habitats would link the resacas directly to fish and wildlife source populations in the surrounding ecosystem. The value of expanding the high quality habitat associated with these natural resource management areas and directly connecting the restoration efforts to these large high quality habitats provides the ecological justification for the expenditure of the added incremental cost associated with the restoration measures proposed in Alternative 4.

The incremental cost of Alternative 4 would be worth the federal and local investment based on the rarity of the habitats, the diversity of the ecosystem, and the ecological value of connecting the restoration areas to high quality, managed source populations.

Comparing Alternative 5 to Alternative 4

Alternative 5 would add two restoration areas to Alternative 4. Alternative 5 would add the restoration of an old resaca within the TPWD State Fish Hatchery property (areas 116 and 117) located in the northwest section of Resaca del Rancho Viejo. Appendix A includes detailed graphics of these restoration areas, 116/117. Table 5–5 shows the restoration measures. Figure 5–5 shows an overall graphical representation of Alternative 5.

Table 5–5: Restoration Measures and Benefits for Alternative 5

Restoration Area	Riparian Restoration Acres	Aquatic/ Emergent Restoration Acres	Bank Sculpting (LF)	Invasive Species Management (Acres)	Dredging (Acres)	Net Gain in AAHU
116/117	16.7	2.1	6,070	18.8	13.6	14
Alt 4 Total	664.3	54.8	158,523	719.1	204.3	470
Alt 5 Total	681.0	56.9	164,593	737.9	217.9	483

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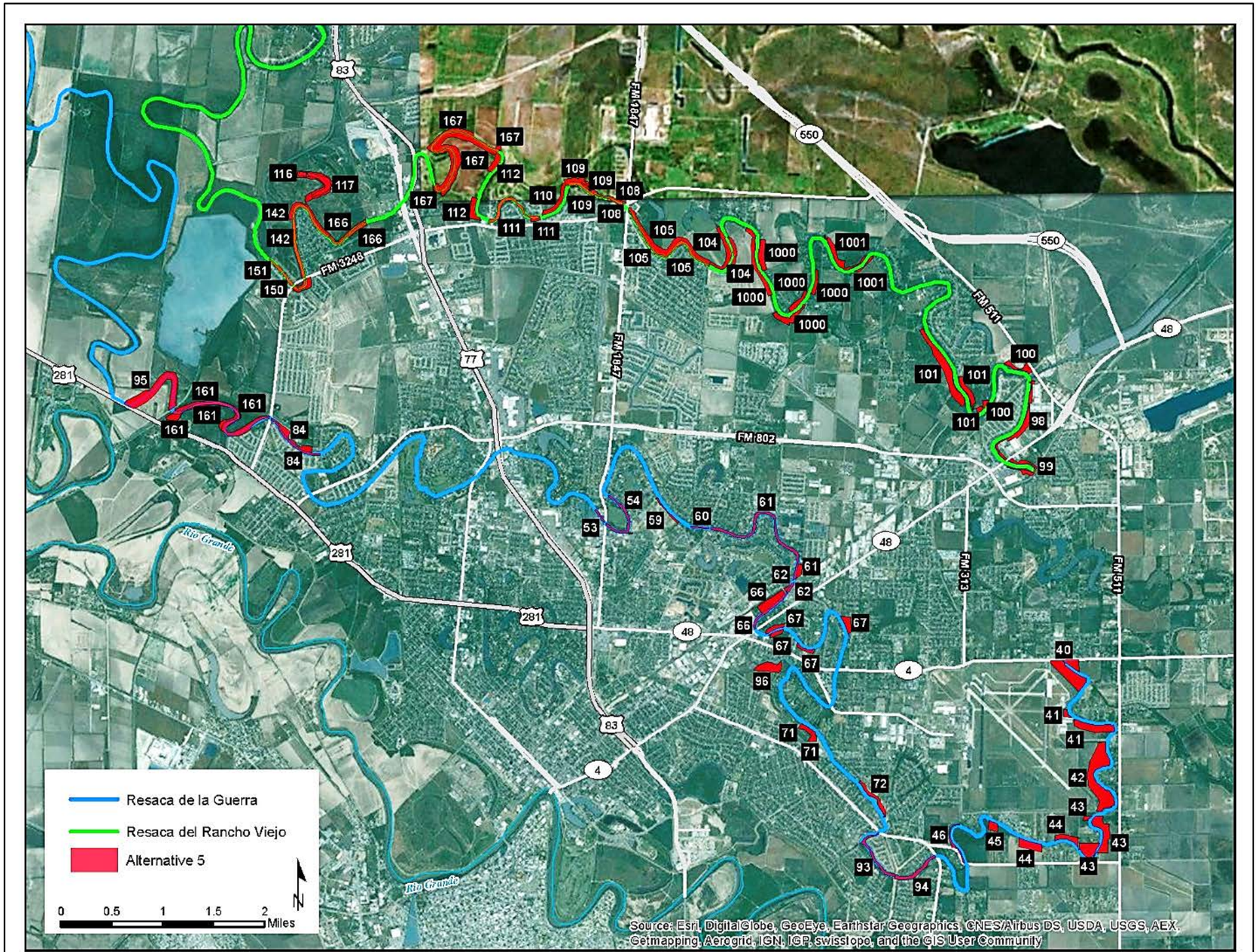

Figure 5–5: Alternative 5

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Alternative 5 would provide an additional 13 AAHUs of benefit for a total of 846 AAHUs at a first cost of $205,501,000. Alternative 5 would meet the study objectives more effectively than Alternative 4 by restoring 681.0 acres of globally imperiled Texas Ebony Resaca Forest and 217.9 acres of aquatic and emergent resaca habitat.

Alternative 5 would restore a total of 898.9 acres at an average cost per restored habitat unit of $15,400. That would be less than a 4 percent increase in restored acres at less than a 2 percent increase in cost per restored habitat unit. Compared to Alternative 4, Alternative 5 would restore the habitat located on the TPWD managed State Fish Hatchery property. The hatchery was used to rear sportfish. Although the resaca was portioned off with a series of levees and dams, the adjacent habitat consists of high quality south Texas thornscrub habitat. The incremental cost increase over Alternative 4 would be about $700 per AAHU.

There are several justifications involved with moving between Alternative 4 and Alternative 5. There is a relatively small incremental cost, a relatively large incremental benefit, and Alternative 5 would add restoration of the aquatic component of the State Fish Hatchery area. The incremental cost of Alternative 5 would be worth the federal and local investment.

Comparing Alternative 6 to Alternative 5

Alternative 6 would complete the proposed restoration of Resaca de la Guerra through the addition of six more restoration areas to Alternative 5. Appendix A includes detailed graphics for this individual restoration area. Table 5–6 shows the restoration measures. Figure 5–6 shows an overall graphical representation for Alternative 6.

Table 5–6: Restoration Measures and Benefits for Alternative 6

Restoration Area	Riparian Restoration Acres	Aquatic/ Emergent Restoration Acres	Bank Sculpting (LF)	Invasive Species Management (Acres)	Dredging (Acres)	Net Gain in AAHU
77, 78	4.1	1.5	4,376	2.60	0.0	3
79	3.4	0.6	1,860	2.75	0.0	2
81	4.4	0.4	1,166	4.02	0.0	2
82	15.5	0.9	2,644	14.57	6.0	13
83	0.0	0.0	0.00	0.00	12.6	3
Subtotal	27.4	3.4	10,046	30.8	18.6	23
Alt 5 Total	681.0	56.9	164,593	737.9	217.9	483
Alt 6 Total	708.4	60.5	174,639	768.7	236.5	507

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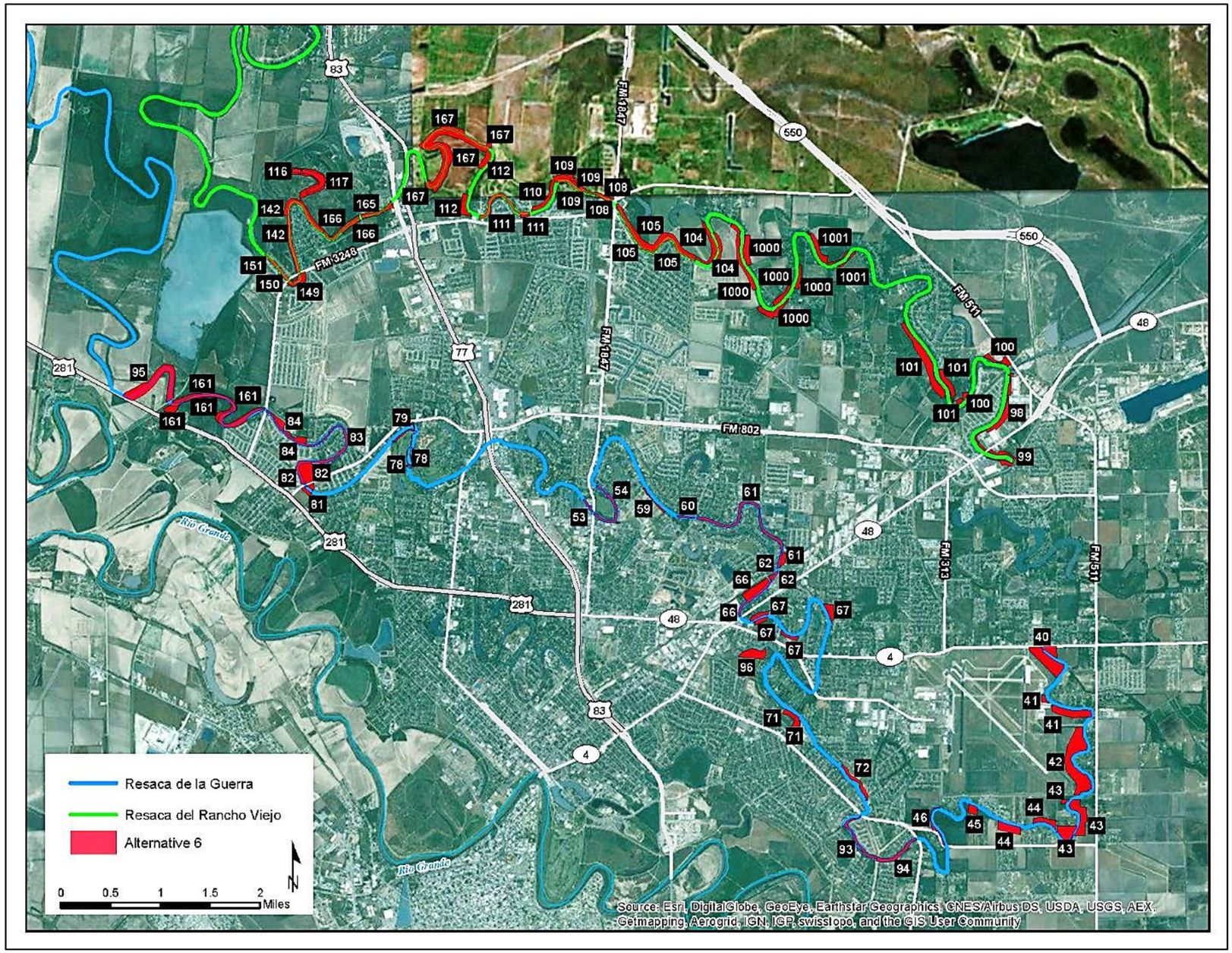

Figure 5–6: Alternative 6

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Alternative 6 would provide an additional 23 AAHUs for a total of 883 AAHUs at a first cost of $223,542,000. Alternative 6 would meet the study objectives by restoring 708.4 acres of globally imperiled Texas Ebony Resaca Forest and 236.5 acres of aquatic and emergent resaca habitat.

Alternative 6 would restore a total of 944.9 acres at an average cost per restored habitat unit of $15,900. That would be a 5 percent increase in restored acres at a 3 percent increase in cost per restored habitat unit compared to Alternative 5. The incremental cost associated with moving from Alternative 5 to 6 is higher than the previous alternatives.

Although Alternative 6 would provide additional habitat connectivity for Resaca de la Guerra and increase the extent of restored critically imperiled habitats, the improved habitat connectivity would not warrant the expenditure of the higher incremental costs. The incremental cost of Alternative 6 would not be worth the federal and local investment.

The CE/ICA tool ranks alternatives based on cost effectiveness. Because Alternative 6 was not determined to be not be worth the investment, by definition Alternative 7 would not be worth the investment.

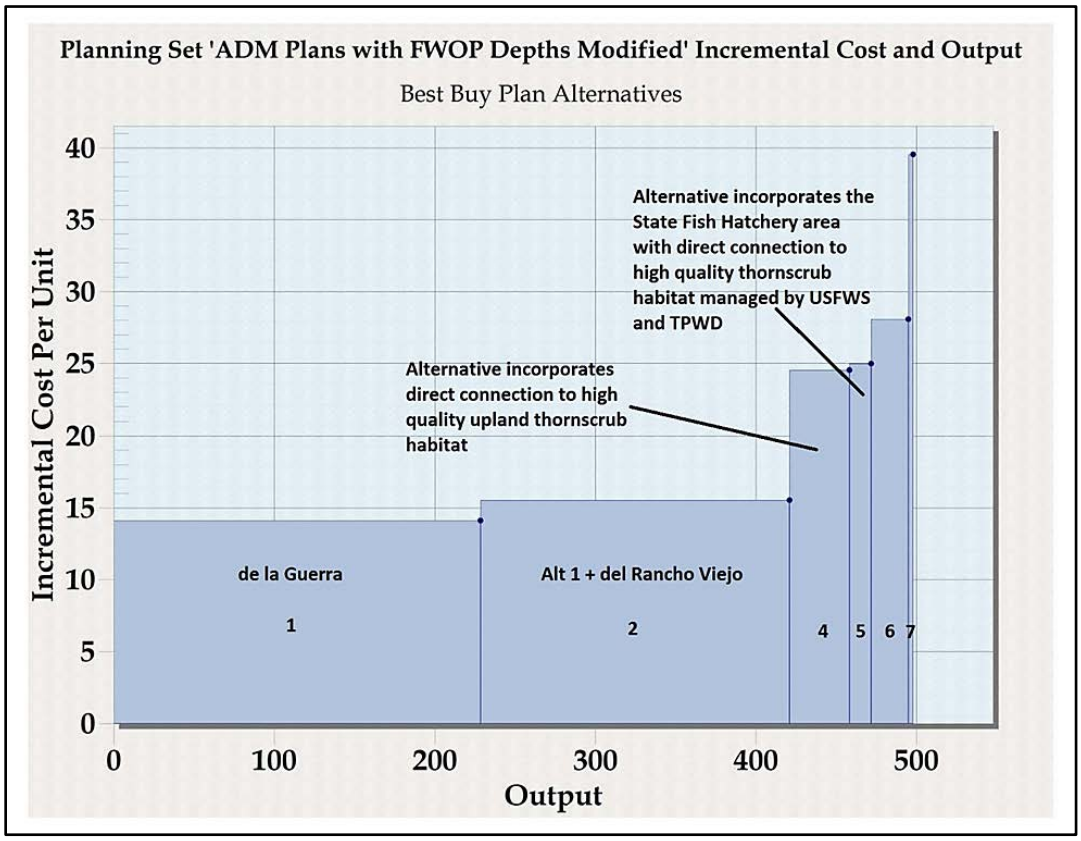

Figure 5–7: Best Buy Array from CE/ICA.

With-Project Conditions Environment Summary

In addition to cost and habitat benefits, environmental impacts and environmental compliance were also considered to verify best plan selection. An environmental impact, or effect, may be described in terms of significance, duration, frequency, location, magnitude, or other characteristics, such as reversibility, retrievability, and the relationships to long-term productivity.

Chapter 2 describes in detail the no action plan. Table 5–7 summarizes environmental impacts in a qualitative assessment. Impacts to environmental resources were considered to be similar in nature across the range of with-project alternatives. However, the magnitude of adverse and beneficial impacts to resources for the with-project alternatives were considered to be proportional to the size of each restoration alternative.

Table 5–7: Summary of Environmental Impacts

Public Interest Category/Measure	Alternatives						
	No Action	1	2	4	5	6	7
Air quality	o	o	o	o	o	o	o
Sustainability, greening & climate change	o	o	o	o	o	o	o
Geological resources	o	o	o	o	o	o	o
Water resources	-	++	++	++	++	++	++
Biological resources	--	++	++	++	++	++	++
Cultural and Historic Resources	o	o	o	o	o	o	o
Land use	o	o	o	o	o	o	o
State parks, and other aesthetic resources	o	o	o	o	o	o	o
Socioeconomics	o	+	+	+	+	+	+
Minority and low-income populations	o	o	o	o	o	o	o
Human health & safety	o	o	o	o	o	o	o
Aesthetics & visual resources	--	+	+	+	+	+	+
Noise	o	o	o	o	o	o	o
Constructed resources	o	o	o	o	o	o	o
Recreation	--	+	+	+	+	+	+
Hazardous substances, toxic, radioactive waste (HTRW)	o	o	o	o	o	o	o

++ Expected major long-term environmental or social benefit as a result of alternative implementation.
+ Expected moderate long-term environmental or social benefit as a result of alternative implementation.
o No or minor expected long-term environmental or social benefit or impact as a result of alternative implementation.
- Expected moderate long-term environmental or social impact as a result of alternative
-- Expected major long-term environmental or social impact as a result of alternative implementation.

Significance

Resource significance is determined by the importance and non-monetary value of the resource based on institutional, public, and technical recognition in the study area. The potential significant impacts of the project were taken into account in compliance with the Council of Environmental Quality (CEQ) NEPA regulations (40 Code of Federal Regulations (CFR) 1500.1(b), 1501.7(a)(2) and (3), and 1502.2(b)). The guidance for

USACE ecosystem restoration projects requires the identification of significant resources and attributes that are likely to be affected by one or more of the alternative plans (U.S. Water Resources Council, 1983). "Significant" is defined as, "likely to have a material bearing on the decision-making process" (Apogee Research, Inc., 1996).

The P&G defines these significance criteria as:

- Institutional Recognition: The importance of the resource or attribute is acknowledged in the laws, adopted plans, and other policy statements of public agencies or private groups.
- Public Recognition: The resource or attribute is considered important by some segment of the general public.
- Technical Recognition: The importance of the resource or attribute is based on scientific or technical knowledge or judgment of critical resource characteristics.

Air Quality

The construction activities of the alternatives would generate air pollutant emissions as a result of excavation, demolition, grading, compacting, trenching, and construction operations. These emissions would be temporary and would not be not expected to generate offsite effects or exceed state or federal air quality standards.

The construction activities would result in short-term emissions of criteria pollutants as combustion products resulting from construction and transportation equipment, as well as evaporative emissions from asphalt paving operations. Minor short-term increases would also result fromdetours required by temporary rpoad closures other activities.

Construction activities would generate particulate matter emissions, such as fugitive dust. Fugitive dust in particulate matter, solid particles that come primarily from soil, that become suspended in the air by wind and human activities. Fugitive dust emissions would be greatest during initial site preparation activities and would vary daily depending on the construction phase, level of activity, and prevailing weather conditions. The quantity of uncontrolled fugitive dust emissions from a construction site are generally proportional to the area of land being worked and the level of construction activity. Appropriate fugitive dust control measures would be employed to suppress emissions, such as using mulch, water sprinkling, temporary enclosures, and other appropriate methods as needed.

The alternatives would generate emissions below de minimis levels. Cameron County is classified as an attainment area for all criteria pollutants. Therefore General Conformity Rule requirements would not be applicable. The construction contractor would be required to use low greenhouse gas-emitting vehicles to the extent possible and available, such as clean diesel technologies.

Direct emissions would include air pollution potentially resulting from any of the alternatives. Indirect emissions associated would include emissions resulting from maintaining the functionality of the project, such as periodic inspections, operation and maintenance, control structure operations, mowing and vegetation removal, structural repairs, and adaptive management measures for wetland mitigation areas. The non-federal project sponsor would be responsible for these activities.

All alternatives would be in compliance with the Clean Air Act.

Sustainability, Greening and Climate Change

The USACE policy is to integrate climate change preparedness and resilience planning into all of its activities. This integration enhances the resilience resource infrastructure, the effectiveness of the military support mission, and reduces potential infrastructure and mission climate change vulnerability. The limited scale of the restoration effort would preclude change to climatic conditions.

The Brownsville resacas are located near typical urban greenhouse gas generators. The alternatives would produce de minimis greenhouse gas emissions during construction. The temporary emissions would not reach the reportable threshold. The aquatic and riparian vegetation proposed for restoration would have net benefits in reducing greenhouse gases.

The alternatives would use site-specific native plant species that have evolved with cyclical drought patterns. These species are suited to prolonged periods of extended drought followed by intense flooding. Construction measures would utilize management and irrigation strategies to ensure the successful establishment of vegetation.

The proposed native plant species would be able to adapt to weather extremes anticipated as the result of climate change. The increased depth of the resacas from dredging and the restoration of riparian buffers from plantings would improve the resiliency of the resaca ecosystem.

The effects of climate change on resaca flows are similarly uncertain as prolonged drought periods may affect the aquatic resources of the resaca. Due to the high uncertainty regarding the impacts of climate change on temperature and precipitation patterns in Texas (Schmandt et al, 2011), the impacts of climate change on the success of restoration efforts is unknown.

Geologic Resources

Alternatives would include dredging and excavation along shoreline and riparian areas. Maximum depth of excavation would be about 6 feet within the resacas, and 1 to 3 feet along the shorelines and riparian areas. Excavation would not impact sensitive or significant geological features.

The study area is located within the city limits of Brownsville and the Brownsville Extraterritorial Jurisdiction. The requirements of Section 1541(b) of the Farmland Protection Policy Act of 1980 and 1995, 7 U.S.C. 4202(b), would not apply to prime farmland soil types within the project footprint.

Alternative implementation activities during construction would have the potential to expose soils to increased wind and water erosion because of vegetation removal. Activities would include, dredging, excavation of dry resacas, shaping the resaca bank slopes, and soil preparation for planting the riparian habitats.

The upper six inches of soil within the riparian areas would be excavated to remove the non-native seedbank. Herbicide would be applied to prevent non-native species from resprouting. The exposed subsoil would then be ripped to a depth of 12 inches, 8 inches of organic topsoil would be distributed throughout. The affected area would be revegetated with site-specific native vegetation to stabilize the soils and restore ecological functions. Potential impacts would be minimized the application of best management practices, such as controlling runoff, erosion, and sedimentation.

Soils along the resacas would stabilize because of the presence of plantings of native riparian vegetation. Additionally, the soils would be from dredged material, thus nutrient-rich, and would improve the establishment of native trees and shrubs.

Minerals

The location of active hard mineral leases (minerals other than oil and gas) was determined from data from the Texas State General Land Office. While there were active hard mineral leases within the Brownsville area, there were none located within the project footprint.

Water Resources

Implementation of any alternative would restore a level of resaca ecosystem restoration function. The resaca resources encompass ecological elements comprising a healthy, functioning, aquatic ecosystem, including the aquatic, riparian, and adjacent upland environments. Ecosystem restoration would have beneficial affects on resaca resources, including water resources.

- Surface water
- Wetlands
- Water Quality
- Ground water
- Floodplains
- Water supply

Surface Water

The alternatives would restore the resaca aquatic component. The dredging measure would mimic a natural flood event by mobilizing accumulated sediments and restoring the aquatic capacity of the resaca. The restored resaca depth from dredging would increase the aquatic habitat quantity and quality by providing greater water volume, more cover, lower water temperatures, and increased dissolved oxygen concentrations for fish and amphibian species.

All alternatives would impact surface waters. Alternatives restoring greater areas would have greater beneficial affects.

Wetlands

The Brownsville resacas are U.S. jurisdictional waters and are subject to protection under the Clean Water Act, Sections 401 and 404. The alternatives would not result in a net loss of wetlands or waters of the U.S. The alternatives would increase the extent of wetlands and waters of the U.S. The proposed alternatives would be in compliance with the Clean Water Act.

Water Quality

The resacas surface water quality is affected by adjacent land use that produces sediments and contaminants (petroleum products, chemicals, fertilizers, etc.). Generally, higher densities of development (i.e. urban areas such as the resacas study area) require more intensive degrees of storm water management because of rapid storm runoff produced by higher proportions of impervious surfaces.

The alternatives would directly impact surface waters through construction activities associated with dredging, excavation, and bank slope reshaping. During construction, dredging and ground disturbing activities would temporarily degrade water quality. Erosion and sedimentation controls would be required during construction, such as silt curtains, silt fencing, and sediment traps, and the application of water sprays. Revegetation of disturbed areas would be prompt to reduce and control siltation or erosion impacts. Every construction alternative poses a potential contamination risk from petroleum or chemical spills. The contractor would be required to prepare and follow a site-specific spill prevention plan to reduce the risk of such contamination. The plan would include best management practices such as, proper storage, handling, and emergency preparedness. Anticipated impacts to surface waters during construction would be temporary and insignificant.

Dredging and excavation of the resacas would increase the acres of surface waters in the study area. Establishment of aquatic plants and revegetation of the resaca banks and riparian areas with native grasses, forbs, and woody species, would act as effective vegetative filters, reducing amounts of sediments and other contaminants. The vegetation would improve water quality over existing conditions. The long-term water quality impacts of constructing any of the proposed alternatives would be beneficial, and would include an increase in water surface area, reduction in water temperature by vegetational influences, improved water chemistry, and increase organic allochthonous materials.

The TCEQ provided a water quality certification on 26 July 2017.

Ground Water

The Brownsville resacas are not located in an aquifer recharge zone. None of the alternatives would affect groundwater resources.

Floodplains

All of the alternatives are located within the resacas floodplains. Alternatives should not result in a decrease in floodplain capacity or an increase in flood risk.

The 100-year and 500-year flood zones were determined from the FEMA Digital Flood Insurance Rate Map. None of the alternatives would result in a decrease in the floodplain capacity or an increase in flood risk. The proposed action would be in compliance with EO 11988.

Water Supply

For water supply information refer to the Hydrology and Hydraulics Appendix.

Biological Resources

- Habitat
- Threatened and endangered species
- Red-Crowned Parrot
- Ocelot and jaguarundi
- State-listed threatened or endangered species
- Migratory birds
- Invasive species

Habitat

The alternatives would improve habitat conditions throughout the resaca system using the measures identified in Chapter 3.

For each of the action alternatives, the proposed riparian vegetation would increase the organic allochthonous material to the aquatic system and provide energy to the lower trophic organisms. Restoration of the native aquatic and riparian habitats would provide additional resources (food, shelter, and reproductive habitats) for mammals, birds, amphibians, reptiles, invertebrates, and fishes.

The restoration would minimize the distances between stepping stone habitats and increase connectivity throughout the resaca systems.

The study area is located within the Mississippi and Central Flyways. The ability of migratory species to find adequate resources along the migratory corridors ultimately determines their ability to arrive at their breeding grounds in a healthy condition to establish territories, find mates, reproduce, and fledge young. Restoration would increase migratory, breeding, and wintering habitats for waterbirds, waterfowl, and

neotropical and temperate migrants. The restoration would specifically support breeding birds successful reproduction and fledging. The restoration measures would also provide high quality habitat for amphibian species requiring both aquatic and terrestrial habitats to successfully reproduce.

The application of best management practices, such as erosion control and tree protection, would reduce the risk of temporary impacts. Staging areas would be located in existing project areas or adjacent hardened surfaced areas therefore temporary construction impacts to vegetation would not be anticipated. The establishment of appropriate vegetation would enhance connectivity of the stepping stone habitats and improve the habitat connectivity of the resaca ecosystems.

The restoration of the aquatic, wetland, and riparian habitats would improve habitat for several species such as the black-spotted newt and south Texas siren that are listed by the state of Texas and being considered for listing under the ESA. Many of these species are limited to the south Texas region and the restoration of resaca habitats may be the key to keep these species from being listed in the future. Implementation of any alternative would comply with the Migratory Bird Treaty Act, Migratory Bird Conservation Act, and Executive Order 13186, Migratory Birds.

Red Crowned Parrot

Federal Threatened and Endangered Species

The proposed action would have no effect on federally endangered or threatened species. The USFWS, in their August 10, 2017 Fish and Wildlife Coordination Act Report, concurred with the determination of no effect [Appendix D]. The proposed action would have the potential to positively affect three species listed or proposed for listing under the Federal Endangered Species Act, the red-crowned parrot, ocelot, and jaguarundi. All federal and state listed rare, threatened, and endangered species, with an indication of which species use the resaca habitat is shown in Table 2-4.

Ocelot

Red-Crowned Parrot

The red-crowned parrot (a candidate for federal listing on the endangered species list) would benefit from the proposed action. The restoration of native vegetation, including Texas sabal palms, would provide forage and nesting habitat for the parrots.

Ocelot and Jaguarundi

The ocelot and jaguarundi are species of national significance. The range of the jaguarundi extends about 600 miles along the Rio Grande upstream of Brownsville. The range of the ocelot once extended into Texas, Arizona, Arkansas, and Louisiana, but is now generally restricted in the U.S. to a small areas in Arizona and south Texas, including the nearby Laguna Atascosa National Wildlife Refuge. The alternatives were not formulated to specifically benefit the ocelot or jaguarundi, but the connection provided to the surrounding ecosystems would inherently benefit both.

Restoring habitat along a former Rio Grande corridor would simulate a natural resaca environment and encourage movement of these large cats between areas of preferred habitat on either side of Brownsville and beyond, thereby increasing genetic diversity and population expansion.

While not providing preferred habitat for these cats, the alternatives would create the stepping stone corridors that provide ecological connectivity to their preferred habitat of concealed areas. Both species are secretive in nature and the corridors would be conducive for undetected movement that would protect them from predators and human interactions as they pass through the urban landscape of Brownsville. By minimizing the threat of predation, the proposed action would help sustain the ocelot and jaguarundi population.

These benefits would compliment ocelot and jaguarundi restoration efforts by others. Specifically, the proposed action would support the Endangered Species Act (dated August, 2016 & December 2013, respectively) ocelot and jaguarundi recovery plans.

State-Listed Threatened Or Endangered Species

Jaguarundi

The proposed alternatives would not have long term negative impacts to state listed species.

Migratory Birds

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. Specifically, the USFWS Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed action would contribute directly to the USFWS Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations.

Implementing any of the action alternatives would comply with the Migratory Bird Treaty Act, Migratory Bird Conservation Act, and EO 13186, Migratory Birds.

Invasive Species

The proposed action included in the Brownsville resaca ecosystem restoration study would reduce the invasive plant species and the seed bank in the top six inches of topsoil and replace them with native plant species adapted to the study area. The non-Federal sponsor's resacas long-term operation and maintenance would keep the negative influence of non-native invasive plants at a minimum.

Implementing any of the alternatives would be in compliance with EO 13112 by restoring native aquatic and riparian vegetation species to the degraded habitat.

Cultural and Historic Resources

A desktop review and assessment of resources within the study area was conducted using the Texas Historical Commission's ATLAS online database. Two previously recorded archaeology sites are recorded within the proposed area of disturbance; one of these (41CF3) is the Resaca de la Palma National Battlefield and USACE continues to work closely with the NPS to avoid and minimize potential impacts to associated cultural resources in relation to the undertaking. The second site (41CF188), is a historic debris scatter previously determined ineligible for listing on the National Register of Historic Places (NRHP).

Much of the study area is within the central portion of the City of Brownsville, resulting in a lower potential for inadvertent discovery and significant impacts to cultural resources.

Because the proposed action would consist of habitat restoration and would not significantly alter the viewshed, the finding of no potential to have adverse effects to built historic resources is anticipated. Cultural resource investigations were conducted during this feasibility phase and the resulting report/determinations provided to the Texas SHPO. The agency concurred that the proposed project would not result in any adverse effects on historic properties (Appendix D-1-a). There will not be any further concurrence from SHPO until our investigations are conducted in PED and the USACE provides a report/determinations for SHPO concurrence. Additional cultural surveys of standing structures would not be not anticipated. All archaeological investigations, as well as inadvertent discoveries would be treated in accordance with The Native American Graves Protection and Repatriation Act (NAGPRA). Applicability of NAGPRA would be specified in the Corps' final determination. Detailed provisions matching the requirements of NAGPRA are included in the Programmatic Agreement (Appendix D-1-b).

Land Use

Ecosystem restoration along the resaca systems is consistent with current land uses and would enhance the existing public use areas and general quality of life for local residents. The alternatives would not alter existing land uses or transportation facilities within the study.

Several public areas are adjacent to a proposed resaca restoration areas including the former State fisheries hatchery and city parks. None of the alternatives would negatively impact the community state parks, conservation areas, and other areas of recreational, ecological, scenic, or aesthetic importance (per 40 CFR 1508.27(b)(3)).

The proposed action would not impact any waterbodies designated as a wild or scenic waterway, in accordance with the Wild and Scenic Rivers Act.

Socioeconomics Resources

Minority and Low-Income Populations (Environmental Justice)

The alternatives would not negatively impact minority populations. None of the proposed alternatives would block people from hospitals, schools, shopping or split neighborhoods into smaller segments. The long-term environmental restoration would be a community benefit whereby the Brownsville citizens would have a higher quality natural resources to enjoy.

Human Health and Safety

The proposed action would not impact human health and safety. Construction impacts would be fenced or barricaded.

Aesthetics and Visual Resources

The alternatives would not introduce additional lighting to the Brownsville resaca study area. Construction would occur during daylight hours and no construction lighting would be required. No adverse impacts from lighting would be anticipated. Long-term beneficial impacts would include restoration of natural resource areas.

Noise

The use of heavy equipment, such as dredging equipment, backhoes, front-end loaders, and dump trucks, would be associated with short-term, localized increases in noise levels. These short-term increases would not be expected to substantially affect adjacent noise sensitive receptors or wildlife areas. Construction noise levels would be attenuated by distance, topography, and vegetation.

Construction would occur during daylight hours, thus reducing day-night average sound levels. The use of best management practices, such as keeping equipment in good operating condition, proper training, and providing appropriate health and safety equipment would minimize potential noise impacts. Construction would be conducted in accordance with City noise ordinances.

Constructed resources

The alternatives should not have negative impacts to constructed resources.

For the alternatives, short-term, insignificant impacts to traffic volumes would be expected during construction activities. Local roads are well designed and are capable of handling a large volume of vehicles. During construction, traffic congestion could occur, particularly during morning and evening rush hour as construction vehicles enter and exit the project area, or transport construction debris to the disposal site. It is not anticipated that road closures or restricted access would be needed. Temporary detours or traffic control may be needed during working hours. A traffic control plan would be prepared by the construction contractor and submitted for approval to federal and local officials prior to the start of any construction activities.

Recreation

Recreation opportunities may be improved as several restoration areas are located adjacent to public parks and existing recreation areas. The restoration of resaca habitats throughout the resaca systems would also provide improved eco-recreation opportunities such as birding, wildlife viewing, and kayaking that would be developed by the City of Brownsville.

Hazardous, Toxic, and Radioactive Waste (HTRW)

None of the alternatives would be expected to affect HTRW sites within the City of Brownsville. The footprint of the resacas would not be expanded beyond what already exists, so distances between the resacas and known HTRW sites would not change. An abbreviated Phase 1 Environmental Assessment (see Appendix A) did not identify any major sites near the resacas, that could potentially affect the proposed action.

Action Alternative Environmental Impact Summary

A short-term environmental impact would be expected with the alternatives. No alternatives were screened based on environmental impacts. Based on the anticipated costs, environmental benefit outputs, and limited environmental impact, Alternative 5 was selected as the recommended plan.

RECOMMENDED PLAN/NATIONAL ECOSYSTEM RESTORATION PLAN

The recommended plan Alternative 5, would provide restoration of the aquatic and riparian habitats for Resaca de la Guerra and Resaca del Rancho Viejo and is the National Ecosystem Restoration Plan (NER). The plan entails the planting of over 624.5 acres of Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snakeyes Shrubland throughout the two resacas for the restoration of over 625 acres of resaca riparian habitat. The NER plan would restore over 218 acres of aquatic habitat by the dredging and excavation of resaca segments and by the planting of aquatic and emergent vegetation. The NER plan would include the shaping of over 33 miles of resaca bank shoreline to reconnect the riparian terrestrial habitats with the aquatic habitats. This feature would specifically benefit native amphibians as the lesser bank slope facilitates their transition from aquatic to terrestrial forms. The plan entails the management and control of non-native invasive plant species throughout the restoration areas. The combined riparian and aquatic restoration encompasses about 845 acres of resaca habitats along the two resacas.

Chapter 6 describes the recommended plan in detail and provides references to supporting documentation.

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CHAPTER 6: SELECT A PLAN

INTRODUCTION

Chapter 6 describes the recommended plan, how the plan meets the study and objectives, and how the plan complies with the constraints.

Discussion of the Recommended Plan

Alternative 5 is the basis of the National Ecosystem Restoration (NER) plan that would restore Resaca de la Guerra and Resaca del Rancho Viejo. The following sections summarize aspects of the recommended plan.

- Drawings at the end of the main report include 118 restoration plans details.
- Appendix A provides details about the environmental resources and formulation of the NER Plan.
- Appendix C provides the monitoring and adaptive management plan.
- Appendix D provides information about agency consultation and environmental compliance coordination.
- Appendix E provides details regarding engineering and plan design.
- Appendix F is the Real Estate Plan that describes the real estate requirements.

Restoration Features

The proposed restoration features for each restoration area depend on the habitat losses or damages of each area. The ecosystem restoration measures available for each area include:

- Dredging of sediments to increase resaca depth to historical depth or 6 feet, whichever is less;
- Riparian soil supplementation with dredged material
- Planting of native riparian vegetation consistent with the three critically imperiled with extinction vegetation associations
- Resaca bank slope restoration to reduce the slope to reference conditions;
- Bank stabilization to reduce sedimentation and promote aquatic and amphibian life cycles:
- The aquatic and emergent vegetation planting along the edge of the dredged resacas and modified bank slopes;
- Water control structure/flow management; and,
- The management and control of non-native, invasive plant species.

When the measures are combined, they would function as shown in Figure 6-1.

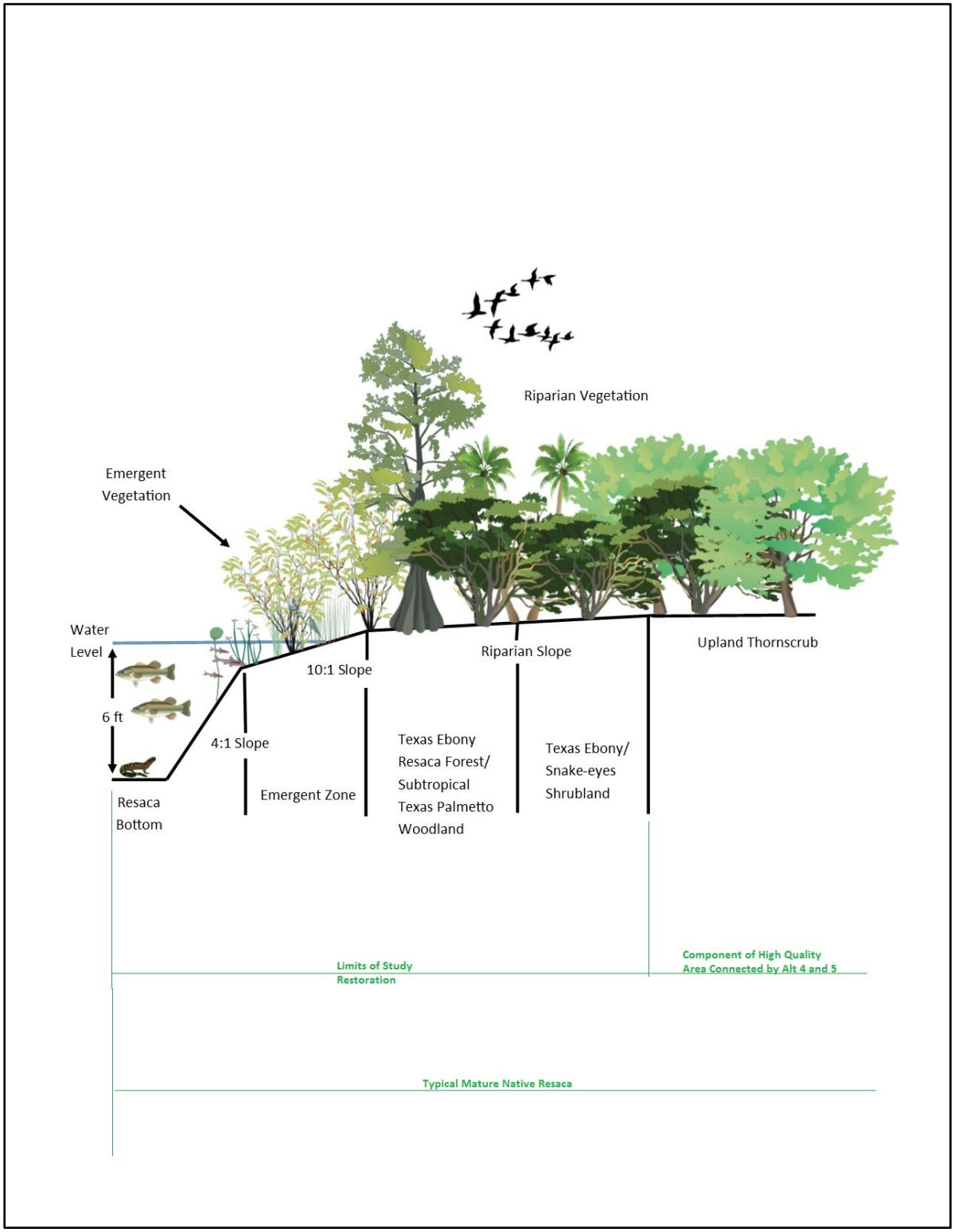


Figure 6-1: Resacas Conceptual Diagram with Vegetation Association

Dredging

The dredging would mimic the lost natural process of sediment flushing by physically removing sediments. The dredging would increase the water depth to six feet or greater. Dredging would increase the volume of the aquatic habitat. The greater volume would provide ancillary water quality benefits by lowering high summer water temperatures and increasing dissolved oxygen concentrations.

The study area also includes silted in resacas segments that would be excavated to a depth of six feet or until the clay layer of the resaca is detected. The excavation of the sediments in the filled in resacas would increase the aquatic habitat and would restore the aquatic component of the resacas habitat.

The volume of aquatic habitat restored by dredging and excavation would be about 806 additional acre-feet.

Riparian soil supplementation

The resaca nutrient cycling function has been lost due to the flood control projects implemented along the Rio Grande. Riparian soil supplementation would employ the beneficial use of dredged material from the resacas by supplementing the soils of riparian habitats surrounding the resacas with clean dredged material. The soil supplementation would restore nutrients to the riparian soils leached out over the extended period of flood control, about 150 years. The nutrient enrichment would promote establishment and growth of native vegetation communities to be planted. In addition, the restored vegetation communities would benefit native invertebrate, amphibian, avian, and mammalian communities dependent on healthy resaca environments.

Riparian vegetation planting

Planting would include the reestablishment of site-specific, native plant species associated with Texas Ebony Resaca Forest, Subtropical Texas Palmetto Woodland, and Texas Ebony/Snake-eyes vegetation associations. The following herbaceous and woody species would be included, but not limited to, the following:

anacua (*Ehretia anacua*)
apaac (*Urvillea ulmacea*)
Bailey's ballmoss (*Tilandsia baileyi*)
ballonvine (*Cardiospermum corindum*)
Barbados cherry (*Malphighia glabra*)
Berlandier's jopoy (*Esenbeckia berlandieri*)
Berlandieri fiddlewood (*Cithrarexylum berlandieri*)
black mimosa (*Mimosa pigra*)
brasil (*Condalia hookeri*)
brush holly (*Xylosma flexuoas*)
Buckley's dropseed (*Sporobolus buckleyi*)
bunch cutgrass (*Leersia monandra*)
cedar elm (*Ulmus crassifolia*)
chilipequin (*Capsicum annuum*)
coma (*Sideroxylon celastrinum*)
crucillo (*Randia rhagocarpa*)
David's milkberry (*Chiococca alba*)
devil's claw (*Pisonia aculeata*)
doctorbush (*Plumbago scandens*)
elbowbush (*Forestiera angustifolia*)
garlicweed (*Petiveria alliacea*)
granjeno (*Celtis pallida*)
guayacan (*Guaiacum angustifolium*)
honey mesquite (*Prosopis glandulosa*)

huisache (*Acacia smallii*)
jara dulce (*Baccharis neglecta*)
lime pricklyash (*Zanthoxylum fagara*)
littlefruit supplejack (*Serjania brachycarpa*)
lotebush (*Zizphus obtusifolia*)
Mexican ash (*Fraxinus berlandieriana*)
orientvine (*Cocculus diversifolius*)
Palmer's bloodleaf (*Iresine palmeri*)
pigeonberry (*Rivinia humilis*)
potatotree (*Solanum erianthum*)
retama (*Parkinsonia aculeata*)
Sierra Madre torchwood (*Amyris madrensis*)
softleaf mimosa (*Mimosa malacophylla*)
sugar hackberry (*Celtis laevigata*)
tenaja (*Havardia pallens*)
tepeguaje (*Leucaena pulverulenta*)
Texas persimmon (*Diospyros texana*)
Texas sabal palm (*Sabal mexicana*)
Texas snake-eyes (*Phaulothamnus spinescens*)
Texas torchwood (*Amyris texana*)
Vasey's adelia (*Adelia vaseyi*)
wild olive (*Cordia boissieri*)

A grassland seed mix would include early successional native plant species. The grass establishment would minimize erosion in the riparian area while the native species become established. The mix would include:

green sprangletop *(Leptochloa dubia)*
hooded windmillgrass *(C. Cucullata*)
red-seeded plantain (*Plantago rhodosperma)*
Rio Grande clammyweed *(Polanisia dodecandra ssp. Riograndensis)*
shortspike windmillgrass *(Chloris x subdolistachya)*
slender grama *(Bouteloua repens)*
tallow weed *(Plantago hookeriana)*
Texas panicum *(Urochloa texana)*

A collection of native grassland species would be planted to establish a diverse habitat while the planted riparian vegetation become established. These plants would compete with non-native invasive species to ensure early establishment of the planted riparian species. Typical species would include:

awnless bush sunflower (*Simsia calva*)
false rhodesgrass (*Trichloris crinita*)
hairy grama (*Bouteloua hirsute*)
little bluestem (*Schizachyrium scoparium*)
orange zexmania (*Wedelia hispida*)
plains bristlegrass (*Setaria leucopila*)
wand-like bundleflower (*Desmanthus virgatus*) and/or others
whiplash pappusgrass (*Pappophorum bicolor*)

Aquatic and emergent vegetation planting

Resaca shorelines and wetlands would be planted with hydrophilic (water loving) vegetation making these areas highly productive environments for many species of fish, reptiles, amphibians, birds, invertebrates, and mammals. There would be significant beneficial effects from planting about 218 acres of aquatic and emergent vegetation.

The proposed vegetation would improve water quality by filtering out sediments and chemical constituents. Additionally, it would provide forage, cover, and organic inputs to the resaca ecosystem, developing the lower trophic levels utilized by fish and wildlife species that have been absent from many of the potential restoration areas.

Typical species would include:

bulrush (*Scirpus* spp.*; Schoenoplectus* spp.)
flatsedges (*Cyperus* spp.)
mudplantain (*Heteranthera* spp.)
smartweed (*Polygonum* spp.)
spikerush (*Eleocharis* spp.)
water clover (*Marsilea macropoda*)
water primrose (*Ludwigia peploides*)

Bank slope restoration and stabilization

Bank slope restoration would alter the existing steep bank to a varied 1:10 to 1:15 grade. This moderate slope would benefit native amphibians as the flatter bank slope facilitates their transition from aquatic to terrestrial forms. It would also inhibit vermiculated sailfin catfish spawning. The relaxed slope would allow the dissipation of erosive energies to be spread over a greater area, reducing bank erosion and sedimentation of the resacas. In areas covered by riprap or areas where there is a retaining wall, the shoreline would be assessed to determine if “green” erosion control measures could be implemented to ensure bank stability on the newly shaped banklines.

Water control structure/flow management

Water control includes the construction or modification of water control structures for the purpose of providing a sustainable water budget. To the extent practicable, the natural water surface fluctuations of reference resacas would be mimicked. Historically, resacas would periodically dry out facilitating the spread and growth of emergent vegetation. With the restored bank slope, a lowered water surface of 6-12 inches would expose an average of 5 to 10 feet of bank slope, exposing between 20 and 40 acres of bank for emergent vegetation. Water control structures would be monitored and managed to ensure seasonal fluctuations and would be modified to maximize ecological benefits. The degree of drawdowns would be constrained by the multi-use nature of the resacas.

Invasive species management

Invasive species include terrestrial invasive plant management and sailfin catfish control. Management would include the appropriate mechanical, chemical, and/or biological control of nonnative species within the study area.

Terrestrial plant management would reduce the invasive plant species and the seed bank in the top six inches of topsoil and replace them with native plant species. The non-Federal sponsor would conduct long-term plant management to keep the negative influence of nonnative invasive plants at a minimum.

Vermiculated sailfin catfish management would consist of reshaping the slopes of the banks. The current banks of the resacas (those not already structurally maintained) are steep. The catfish currently excavates or utilizes cavities in the banks for nesting. Eggs in these cavities are more easily protected from predation. Flatter bank slopes reduce the opportunity for cavities and therefore increase predation of the invasive species eggs, thus reducing the population of invasive catfish over time. The flatter slopes would also support a broader, more sustainable band of emergent vegetation growth for varying water depths.

See the Drawings section following the main report for the following:

- Recommended Plan Restoration Plan Drawings – Restoration Areas
- Recommended Plan Design Drawings
- Recommended Plan Design Drawings – Water Control
- Recommended Plan Real Estate Drawings

USFWS COORDINATION

The USFWS identified seven recommendations in the Fish and Wildlife Coordination Act Report, Appendix D-2a. The USACE responses to each recommendation are discussed in Appendix D-2b. The recommendations were considered for adoption based on effectiveness, efficiency, completeness, and acceptability. Most recommendations reflected the measures and ecosystem processes identified by the USACE for implementation and, which were developed in cooperation with the USFWS and TPWD. The following summary identifies the recommendations and the USACE responses. All recommendations were adopted.

1. The USFWS requested justification for utilizing the bank slope measure without further control of the invasive vermiculated sailfin catfish. Active and passive catfish control methods had been evaluated prior to USFWS coordination. Active control, consisting of physical or chemical methods of control was found to be less cost effective

than passive control. Passive control such as bank modification to remove preferred nesting areas would provide perpetual long term benefits versus shorter term benefits of active control measures that would be required periodically over the period of analysis. The proposed action includes the passive control measure to flatten resaca banks to remove preferred nesting sites.

2. The USFWS recommended inclusion of non-native Washington fan palms (Washington robusta) and Texas sabal palm snags (dead palms) for Red-crowned parrot nesting cavities. The cavities are made by Golden-fronted woodpeckers for nesting, and then taken over by parrots. The recommendation is incorporated in the proposed action. The proposed action includes leaving existing palm snags in place for cavity nesters and incorporates the killing of selected Washington palms as a component of the riparian planting measure. The killed palm trees would be left in place to serve as cavity nesting structures for the red-crowned parrot.

3. The USFWS recommended the proposed action consider the endangered Texas ayenia (Ayenia limitaris) in the restoration plan wherever possible. The Texas ayenia has a restricted range in the U.S., only occurring in isolated fragments of Texas Ebony/Anacua/Brasil Shrubland and Texas Ebony/Snake-eyes Shrubland in the Rio Grande Delta in Cameron, Hidalgo, and Willacy counties. Occupied habitats include isolated fragments of woodlands and shrublands in the watersheds and deltas of rivers draining into the Gulf of Mexico. The proposed action includes the Texas ayenia in the riparian planting list for the restoration areas. If a remnant population of Texas ayenia is discovered before or during project implementation, the plan will allow for restoration of the plant to promote its survivability and propagation.

4. The USFWS recommended that the riparian corridors along the resacas be widened as much as possible to serve as habitat and buffer zones to the resacas. The USACE restoration strategy for the identification of restoration areas was based on the concept of widening the resaca riparian habitats as much as feasible and to maximize the connectivity between restoration areas as much as possible based on reference resaca habitat conditions.

5. The USFWS recommended the proposed action mimic the floodplain process of riparian area nutrient supplementation by utilizing nutrient rich dredge material to augment soils in the riparian habitat planting areas. The USACE had identified the use of dredged material to augment riparian planting areas as a beneficial use of dredged material for riparian area soil supplementation. The measure was incorporated as a measure in the development of alternatives and is included in the proposed action.

6. The USFWS recommended planting native aquatic and emergent plant species along the resaca edges, including woody emergent vegetation. The USACE had proposed planting of aquatic and emergent plant species as a core measure for resaca

restoration. The measure was incorporated in all action alternatives and is included in the proposed action.

7. The USFWS requested that a written monitoring and adaptive management plan be developed to track restoration progress over time. The plan should include provisions for the control of invasive species. The USACE is required to have a monitoring and adaptive management plan. The proposed action has a management and adaptive management plan. The plan will be further developed in more detail during the preconstruction engineering and design phase of the project.

Risk and Uncertainty

Risk is defined as the probability or likelihood for an outcome. Uncertainty refers to the likelihood an outcome results from a lack of knowledge about critical elements or processes contributing to risk or natural variability in the same elements or processes. Throughout project planning, risk and uncertainty were identified. Risk informed decisions were made regarding the reliability of estimated benefits and the costs of alternative plans.

Measures were developed to manage risk, expanding on and referencing successful similar work completed by previous ecosystem restoration projects in the Brownsville area as well as nationwide. Experience from previous projects helped in the identification of possible risks and decrease uncertainty in plan formulation. No measure or alternative in the recommended plan is burdened by significant risk or uncertainty regarding its eventual success. Significant risks were avoided by using proper design, appropriate selection, and correct seasonal timing of applications. Risks were also managed through extensive coordination with other agencies and USACE experts. The dynamic and complex nature of resaca environmental processes is a principal source of uncertainty. Post-construction monitoring and adaptive management plans would be used to address uncertain outcomes in all the plan’s components.

Riparian vegetation planting success was identified as a low risk. The team was able to lower the risk by determining the optimal elevation for successful growth through hydraulic analysis and through the selection of restoration plant species. This design would increase survivability, and lead to a better understanding of tree survivability in the resaca ecosystem.

Sea level rise is not expected to impact the recommended plan because the project is located well above mean sea level. A potential risk and uncertainty associated with climate change is an increase in sediment deposition from increased aggradation and flooding.

PROJECT MONITORING

The 2007 Water Resources Development Act (WRDA), Section 2039 of 2007 directs the Secretary of the Army to ensure, when conducting a feasibility study for a project (or component of a project) for ecosystem restoration the recommended project includes a plan for monitoring the success of the ecosystem restoration. The implementation guidance for Section 2039, in the form of a CECW-PB Memo dated 31 August 2009, also requires an adaptive management plan be developed for all ecosystem restoration projects.

PERFORMANCE ASSESSMENT MONITORING

Monitoring is necessary to determine if a project is meeting its performance standards, and to determine if measures are necessary to ensure that the project is accomplishing its objectives. The submission of monitoring reports to assess the development and condition of the project is required. The content and level of detail for those monitoring reports will be commensurate with the scale and scope of the project. The assessment plan must address the monitoring requirements, including the parameters to be monitored, the length of the monitoring period, the party responsible for conducting the monitoring, the frequency for submitting monitoring reports to the district engineer, and the party responsible for submitting those monitoring reports to the district engineer.

Compensatory monitoring methods should include quantitative sampling methods following established, scientific protocols. Sampling documentation, as part of monitoring reports, should include maps showing locations of sampling points, transects, quadrants, etc. Permanent photo stations should be established coincident with sampling locations. Where structures are placed in waters of the U.S., photo stations should be established that capture the structures and any consequent effect on channel morphology.

This section summarizes the monitoring and data collection aspects of long term project performance assessment monitoring and short term Monitoring and Adaptive Management. The performance assessment is designed to gauge progress toward meeting these objectives of the study – the intended output. The Monitoring and Adaptive Management plan is intended to increase the ability to make timely responses based on new information from monitoring to maximize the objectives of the restoration effort. An adaptive management plan considers the planned restoration activities and establishes a framework for evaluation of the ecosystem performance; and it identifies uncertainties that will be addressed through monitoring. As monitoring data is collected and assessed, the management plan guides the decision to a) continue the restoration plan without modification, or b) to modify the restoration plan.

Table 6-1 presents overall types, purposes, and responsibilities for performance assessment monitoring. Performance assessment monitoring begins during feasibility phase studies (pre-project), continues during design and construction, and extends throughout the operation of the project.

Table 6-1: Overall Types, Purposes, and Responsibilities of Monitoring and Data Collection

Project Phase	Type of Activity	Purpose	Responsible Agency	Implementing Agency	Funding Source
Pre-Project	Pre-Project Monitoring	Identify and define problems at each resaca. Establish need of proposed Project measures.	Sponsors	Sponsors	Sponsors
	Baseline Monitoring	Establish baselines for performance evaluation.	Corps	Sponsors Cooperative Agreements or Corps	Sponsors
Design	Data Collection for Design	Include quantification of Project objectives, design of Project, and development of Performance Evaluation Reports.	Corps	Corps	Sponsors
Construction	Construction Monitoring	Assess construction impacts; assure permit conditions are met.	Corps	Corps	Sponsors
Post-Construction	Performance Evaluation Monitoring	Determine success of Project as related to objectives.	Corps (quantitative) Sponsors (field observations)	Cooperative Agreement, Sponsors thru O&M, or Corps	Sponsors
	Biological Response Monitoring	Use performance monitoring and Adaptive Management and Monitoring results to evaluate predictions and assumptions of the habitat benefit evaluation.	Corps	Corps	Corps

Monitoring and Adaptive Management

The feasibility level monitoring and adaptive management plan is presented in Appendix C. The monitoring and adaptive management plan describes activities proposed for the project and estimates associated costs and duration.

Monitoring and if necessary, adaptive management would occur for a period of ten years as evidence for successful establishment of the project prior to the project being turned over to the non-federal sponsor for operation and maintenance. Monitoring efforts would be conducted with the City of Brownsville (Brownsville) and USACE personnel. See Appendix C for the Monitoring and Adaptive Management Plan. The plan would be further refined during PED and would continue to be refined during implementation. Because the construction schedule spans 16 years, monitoring and adaptive management would be phased over 16 years and would be completed for each phase of construction before each phase was turned over to the City for operation, maintenance, repair, replacement and rehabilitation (OMRR&R).

Costs for monitoring to determine the extent the project is meeting the success criteria and for informing potential adaptive management decisions are summarized in Table 6-2. Cost estimates include monitoring equipment, photo point establishment, data collection, quality assurance and quality control, data analysis, assessment, and reporting. Unless otherwise noted, preconstruction monitoring costs would begin at the onset of preconstruction engineering and design of the first construction phase. Monitoring would be budgeted as construction costs and cost shared.

Table 6-2: Summary of Monitoring and Adaptive Management Plan Costs.

Category	Activities	PED Set-up & Data Acquisition	Construction	10-year Post Construction	Total
Monitoring: Planning and Management	Monitor workgroup, draft detailed monitoring plan, work with PDT on performance measures	$25,000			$25,000
Monitoring: Data Collection	Data collection		$50,000	$450,000	$500,000
Data Analysis	Assess monitoring data and performance standards		$25,000	$75,000	$100,000
Adaptive Management Program	Detailed adaptive management plan and program	$25,000			$25,000
	Establish adaptive management program			$600,000	$600,000
Database Management	Database development, management, and maintenance		$10,000	$30,000	$40,000
Total		**$50,000**	**$85,000**	**$1,155,000**	**$1,290,000**

Performance Assessment Monitoring. Example costs items for collection of basic site-inspection data to report long-term project performance are summarized in Table 6-3. These costs include preparation of Performance Evaluation Reports that summarizes the long term ability of the project to meet project success criteria, inform OMRR&R adjustments, and provide basic data future for planning efforts. This monitoring would start following completion of the 10-year post-construction monitoring and adaptive management considerations.

The monitoring plan would provide for invasive species control and opportunities for long term adaptive management, as needed. Performance assessment monitoring would be a local sponsor cost. That cost is currently estimated as part of the total OMRR&R estimated as a percentage based on a similar operating project.
The long term monitoring costs would be developed during preconstruction engineering design phase.

Table 6-3: Example of Long-Term Annual Monitoring Cost Items ($)

Site Inspections	Unit Cost	Frequency	Year Start	Quantity	Total Cost	Annualized Cost
Dredging						
Riparian Vegetation Surveys						
Aquatic Vegetation Surveys						
Bank Line Surveys						
Invasive Species Surveys						
Reporting						
Total						

Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R)

The non-federal sponsor would be responsible for the OMRR&R of the completed project. An OMRR&R plan would be developed in cooperation with Brownsville. The plan would include management strategies for sustainable resaca ecosystem. The plan would be provided upon the successful completion of the project construction (or a representative portion thereof), prior to turning over the project to the non-federal sponsor. The OMRR&R would be comprised of the structural integrity of the bank slopes, water control structures, and planting development and invasive species management.

Based on a survey of other riparian ecosystem recreation studies, costs for the OMRR&R were estimated at $1,900 per acre, yielding a total cost of $24,700,000 for the resacas project area. This assumes that after twenty years, plantings would become self-sustaining and OMRR&R costs would decrease by half for the remainder of the planning horizon. The estimated annualized OMRR&R costs for the ecosystem restoration components is $624,000 at October 2017 prices and a federal discount rate of 2.75 percent.

Routine maintenance would include periodic inspection of water control structures, repair of localized erosion, removal of excess sediment and debris, and replacement of dislodged riprap and rock. Some vegetation loss would likely occur during years 3-5 of implementation phases, particularly if the area experiences a significant flood event, which is unlikely. This potential loss of habitat would be mitigated by the use of seedlings for tree and shrub plantings. Seedlings would be more likely to withstand flood forces while root systems become firmly established. An increase in debris is expected during and after flood events. The OMRR&R estimate accounts for debris removal.

PROJECT FIRST COST AND COST SHARING

Table 6-4 shows the total project cost for the recommended plan, which include utility relocations, dredging of resacas, and fish and wildlife facilities as well as planning, engineering, and design, and construction management.

Utility relocations include the demolition and reconstruction of water, and wastewater lines as necessary to construct, operate, and maintain the proposed project. Dredging operations include dredging, excavation, grading, construction materials for the water control structures and bank stability. Fish and wildlife facilities include the ecosystem restoration measures.

Planning, engineering, and design (PED) is the cost to complete a Design Documentation Report (DDR). Also, the PED includes the development of plans and specifications (P&S), a Project Partnership Agreement (PPA), and award of construction contract(s).

Construction management reflects the costs to oversee the construction of the project and complete an Operation and Maintenance Manual.

Restoration project features would be cost shared 65 percent federal and 35 percent non-federal. The non-federal share would include the value of all lands, easements, rights of way, relocations, and disposal areas (LERRD). If the non-federal share is less than 35 percent of the total project cost, a cash contribution would be required to make the non-federal share an equal 35 percent.

Table 6-4: Project First Cost and Cost Sharing

Item October 2017 Prices		Federal ($1K)	Non- Federal LERRD ($1K)	USACE & Non-Federal ($1K)	USFWS ($1K)	Total ($1K)
	USACE			$45,595		$45,595
01 Lands & Damages	USFWS	$521	$45,595		$531	$531
	USACE			$4,957		$4,957
02 Relocations (4)	USFWS	$656	$4,957		$656	$656
	USACE	$99,137		$99,137		$99,137
06 Fish & Wildlife Services	USFWS	$13,114			$13,114	$13,114
30 Planning Engineering &	USACE	$18,284		$18,284		$18,284
Design	USFWS	$2,470			$2,470	$2,470
	USACE	$15,614		$15,614		$15,614
31 Construction Management	USFWS	$2,146			$2,146	$2,146
Total Project Cost		$151,942	$50,552	$183,587	$18,907	$202,492
Federal Share				(1) $119,332	$18,907	(3) $138,238
Non-Federal Share				(2) $64,255	$0	$64,255

1) USACE Share at 65 percent
2) Non Federal Share at 35 percent
3) Total Federal Project First Cost
4) No relocations have been identified, but values have been included based on cost engineering experience.

The local sponsor would cost share the project features on lands other than those on USFWS lands. That project first cost would be $183,587,000 shared between the USACE and the non-federal sponsor. Because the costs of LERRDs is less than 35 percent of $183,587,000, the non-federal sponsor would provide funds necessary to make its total contribution equal to 35 percent of total USACE project costs.

INVESTMENT AND ANNUAL COSTS

Investment and annual costs for the recommended plan are shown in Table 6-5. Calculations are based on October 2017 Prices, 2.75 percent, a 75 year period of analysis, and sixteen one-year consecutive construction periods.

Table 6-5: Recommended Plan Annual Costs
(October 2017 Prices)

Investment	
Estimated First Cost	$202,492,000
Federal Discount Rate (percent)	2.750
Period of Analysis (years)	75
Construction Period (months)	12
Compound Interest Factor	12.15
Capital Recovery Factor	0.0316356
Interest During Construction	$2,772,000
Investment Cost	$205,264,000
Annual Costs	
Interest	$5,645,000
Amortization	$849,000
OMRR&R	$624,000
Total Annual Cost	$7,118,000

PROJECT IMPLEMENTATION SCHEDULE

A 16-year construction schedule was developed through coordination with the sponsor and the Cost Engineering Mandatory Center of Expertise. The MCX subject matter experts considered the recommended plan restoration measures, the sponsor's fiscal capabilities, and the prerequisite real estate actions necessary for the initiation of construction. These parameters and others were considered in development of the cost and schedule risk analysis (CSRA). The construction schedule assumed an optimal funding stream for the federal budget and a capability construction schedule for the local sponsor. The relevant issues for the schedule were the large number of real estate acquisitions, the large volume of restoration effort to be conducted in 44 different areas

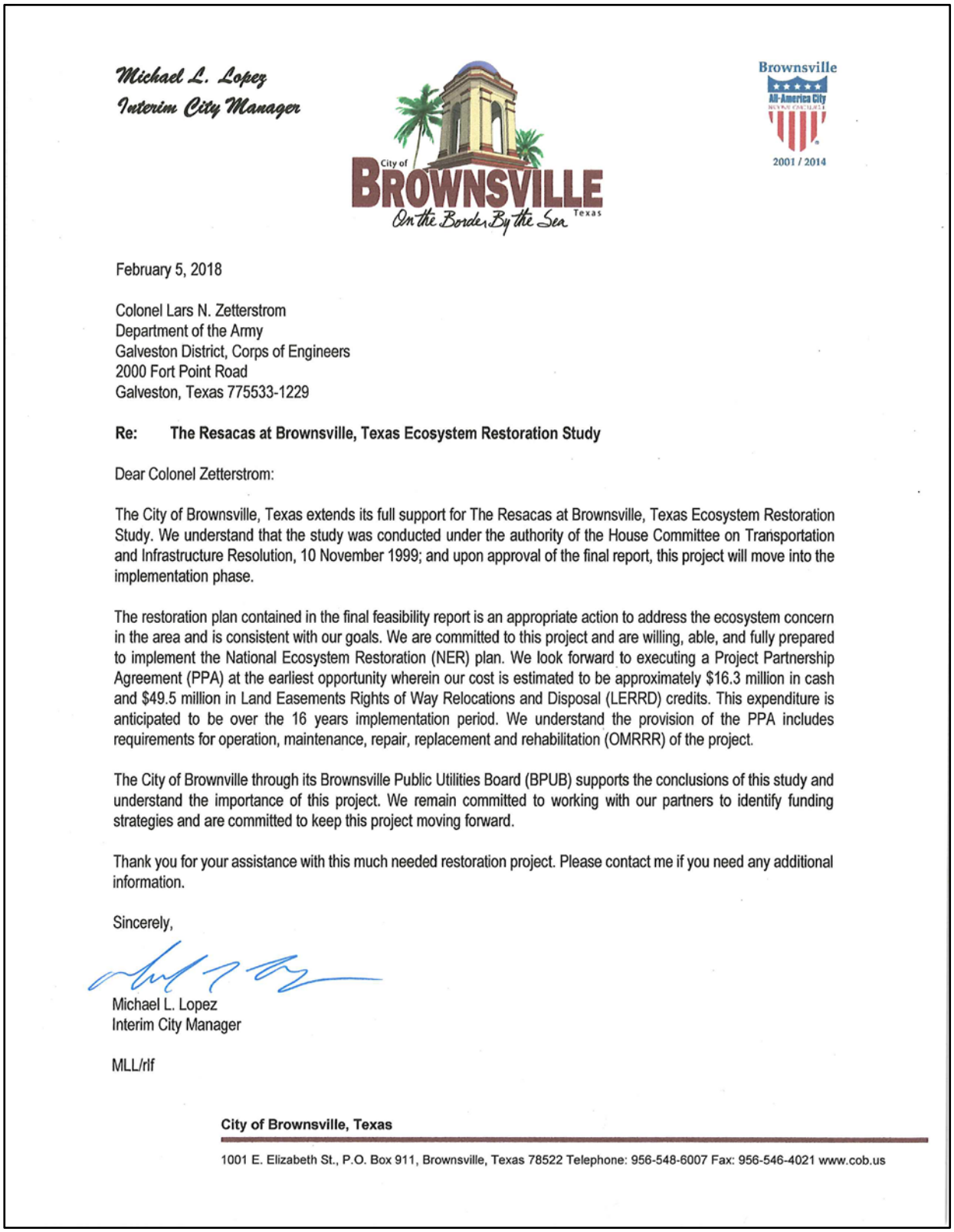
across Brownsville, and the budget capability of the non-federal sponsor. The construction schedule is shown in Table 6-6.

Table 6-6: Purposed Project Implementation Schedule for Resacas

Construction Year Start	Resaca Areas
2021	149, 150, 151
2022	116, 117, 142
2023	166
2024	148, 167
2025	108, 109, 110, 111, 112
2026	104, 105
2027	98, 99, 100, 101, 1000, 1001
2028	161
2029	84
2030	75, 95
2031	53, 54, 59, 60
2032	61
2033	62, 66, 67, 71, 72, 96
2034	93, 94
2035	45, 46
2036	40, 41, 42, 43, 44

VIEWS OF THE LOCAL SPONSOR

The City of Brownsville is the non-federal sponsor. The City supports the recommended plan and intends to participate in its implementation. The letter of support stating this intent is shown in Figure 6-2.



Michael L. Lopez
Interim City Manager

City of BROWNSVILLE
On the Border, By the Sea
Texas

Brownsville
All-America City
2001 / 2014

February 5, 2018

Colonel Lars N. Zetterstrom
Department of the Army
Galveston District, Corps of Engineers
2000 Fort Point Road
Galveston, Texas 775533-1229

Re: The Resacas at Brownsville, Texas Ecosystem Restoration Study

Dear Colonel Zetterstrom:

The City of Brownsville, Texas extends its full support for The Resacas at Brownsville, Texas Ecosystem Restoration Study. We understand that the study was conducted under the authority of the House Committee on Transportation and Infrastructure Resolution, 10 November 1999; and upon approval of the final report, this project will move into the implementation phase.

The restoration plan contained in the final feasibility report is an appropriate action to address the ecosystem concern in the area and is consistent with our goals. We are committed to this project and are willing, able, and fully prepared to implement the National Ecosystem Restoration (NER) plan. We look forward to executing a Project Partnership Agreement (PPA) at the earliest opportunity wherein our cost is estimated to be approximately $16.3 million in cash and $49.5 million in Land Easements Rights of Way Relocations and Disposal (LERRD) credits. This expenditure is anticipated to be over the 16 years implementation period. We understand the provision of the PPA includes requirements for operation, maintenance, repair, replacement and rehabilitation (OMRRR) of the project.

The City of Brownville through its Brownsville Public Utilities Board (BPUB) supports the conclusions of this study and understand the importance of this project. We remain committed to working with our partners to identify funding strategies and are committed to keep this project moving forward.

Thank you for your assistance with this much needed restoration project. Please contact me if you need any additional information.

Sincerely,

Michael L. Lopez
Interim City Manager

MLL/rlf

City of Brownsville, Texas

1001 E. Elizabeth St., P.O. Box 911, Brownsville, Texas 78522 Telephone: 956-548-6007 Fax: 956-546-4021 www.cob.us

Figure 6-2: Letter of Full Support for Restoration Study from the City of Brownsville

VIEWS OF THE RESOURCE AGENCIES

The USFWS, TPWD, the U.S. Park Service, and The Nature Conservancy support the recommended plan. The plan fulfills a number of missions and objectives common to these organizations. The organizations provided input throughout the study and were involved in plan formulation, data collection, and model development.

Benefits Gained for Nationally, Regionally, and Locally Significant Resources

The proposed Brownsville Resaca Ecosystem Restoration project benefits are defined by the following criteria: scarcity, representativeness, status and trends, connectivity, limiting habitat, and biodiversity.

Scarcity

The resaca ecosystems are the aquatic components of the Tamaulipan shrubland ecoregion of south Texas. Over 95 percent of native Tamaulipan shrubland habitats have been lost due to agricultural and urban development. Ninety nine percent of resaca habitat has been lost. Numerous rare species have evolved in the unique ecology of the resacas. A large community of organisms are strictly dependent on the resaca ecosystems. No new resacas will be created because the Rio Grande has been modified through the construction of many structures to reduce flood risk. The remaining resacas will continue convert to upland habitats over time. The proposed action would maintain and restore these increasingly scarce habitats.

Representativeness

The ability of the City of Brownsville resacas ability to exemplify a natural habitat or ecosystem in south Texas can be demonstrated in the reference resacas used in the RRCM development. Resaca de la Palma State Park, Southmost Preserve, and Camp Lula Sams provide high quality resaca habitats in the suburban areas surrounding the City of Brownsville. These areas provide resaca dependent fish and wildlife habitat with resources.

Status and Trends

Urbanization will continue to shift the region from rural to urban areas with an increasing number of people. As a result, the Brownsville resaca ecosystem will decline in quality and quantity. Without restoration, this unique ecosystem will be lost.

Connectivity

One of the project’s objectives was to reestablish connectivity between existing high quality resaca habitats using stepping stone habitats. The resacas project would provide

direct hydraulic connectivity between each of the restoration areas and would minimize the gaps between riparian habitats across the study area. Without proactive restoration efforts, the potential for fish and wildlife to successfully disperse east to west across the study area would be negligible. The stepping stone habitats would increase the value of habitat for wildlife within the restoration areas and therefore provide connectivity across the urban landscape.

Limiting Habitat

Limiting habitat is defined in ER 1105-2-100 as, “habitat essential for the conservation, survival, or recovery of one or more species”. The recommended plan would restore that are habitats critically imperiled with extinction. The wildlife species dependent on those habitats are equally rare. The resaca habitats are a high priority for conservation for the USFWS, TPWD, and TNC. Most remaining resaca habitats are highly altered and fragmented. Stepping stone habitats are the primary need identified for the endangered ocelot, the jaguarundi, and most resaca species. The species recovery plan for them would identify, restore, conserve, and preserve high quality habitats and identify and develop stepping stone habitats across the landscape to promote dispersal and emigration of the species.

Biodiversity

The success of the resaca restoration would be defined by the degree and magnitude of biodiversity attained. Increasing species diversity in the resaca aquatic and riparian communities is a primary component of the RRCM and it supports life across the panorama of the ecosystem. Rich biodiversity would provide resources for species variety among the lower trophic level organisms and that would directly support diversity in the upper level trophic community of mammals, birds, reptiles, and amphibians. This component of the plan would address the resource of significance and measure the degree of biodiversity improvement.

Benefits of the Recommended Plan to Other Federal Goals and Objectives

The USACE formulates, designs, and constructs projects for specific missions and authorities including ecosystem restoration and recreation. The USACE investment decisions are based on an established methodology to account for a project’s benefit toward advancing a specific mission area. However, the lack of an accepted method to quantify the benefits a USACE project may have toward advancing other national priorities can leave much of the project’s value to the nation unaccounted.

Using the ecosystem restoration and recreation benefits as a foundation, a project such as the proposed resaca restoration could provide other nationally significant benefits. The recommended plan would contribute towards meeting environmental and water quality goals in a densely populated urban area, promoting comprehensive watershed

management, improving neighborhood transportation safety, and reconnecting city residents to the resaca system through an outdoor living classroom for students of all ages to explore and learn about a restored urban ecosystem.

Projects holistically meeting the goals of multiple Federal agencies reflect a more realistic and modern view of governmental spending. The proposed Brownsville resaca ecosystem restoration project would assist in advancing several other Federal goals, initiatives and missions. These include the Executive Office, Environmental Protection Agency (EPA), Department of Interior (DOI), Council on Environmental Quality (CEQ), the Centers for Disease Control and Prevention (CDC), Housing and Urban Development (HUD) and former First Lady Michelle Obama's campaign to improve the health of America's youth through the Let's Move and Let's Move Outside initiatives.

The EO 13186 states the Responsibilities of Federal Agencies to Protect Migratory Birds and EO 13112 regarding Invasive Species. EO 13186 states,

> "…*each agency shall, to the extent permitted by law and subject to the availability of appropriations and within Administration budgetary limits and harmony with agency missions … restore and enhance the habitat of migratory birds as practicable; and design migratory bird habitat and population conservation principles, measures, and practices into agency plans and planning processes (…watershed planning) as practicable, and coordinate with other agencies and non-Federal partners in planning efforts."*

The EO 13112 states

> "*Each Federal agency whose actions may affect the status of invasive species shall, to the extent practicable and permitted by law, identify such actions; …to provide for restoration of native species and habitat conditions in ecosystems that have been invaded."*

The recommended plan would have net positive impacts on both EO goals.

The EPA leads the Urban Waters Federal Partnership aiming to stimulate regional and local economies, create local jobs, improve quality of life, and protect Americans' health by revitalizing urban waterways in under-served communities across the country. The EPA notes,

> *"Urban patterns of development often make waterways inaccessible to adjacent neighborhoods. Lack of access limits a community's ability to reap the benefits of living so close to the water, whether through recreation, fishing or access to real estate."*

The national benefits that would result from the proposed resaca restoration project extend beyond. The ecosystem restoration benefits evaluated. The environmental and

indirect recreation benefits would provide greater national value. The restoration project would indirectly support healthy living, sustainable communities, stewardship of natural resources, urban outdoor recreation, and ecotourism.

National and Regional Economic Development, Environmental Quality, and Other Social Effects

In addition to the NER benefits that capture the effects of the recommended plan on the Environmental Quality (EQ) account, three other accounts identified in ER 1105-2-100, Planning Guidance Notebook are considered. The three accounts are: National Economic Development (NED), Regional Economic Development (RED), and Other Social Effects (OSE). The following provides a description of these accounts and the potential effects of the recommended plan.

The NED account recognizes changes in the economic value of the national output of goods and services. Often in an ecosystem restoration study, recreation benefits may be used to calculate NED benefits. However, the recommended plan does not include the initial implementation of recreation measures. The sponsor has indicated an intent to implement compatible recreation features, such as trails and ecosystem education features. However, no NED benefits were quantified.

The RED account recognizes changes in the distribution of regional economic activity that would be forecast to result from implementation of the recommended plan. The Lower Rio Grande Valley region is in the heart of central flyway for migrating birds. The flyway has an associated eco-tourism economy that serves birding enthusiasts. The recommended plan would support the migratory birds in the region through the restoration of about 845 total acres of resaca restoration and thereby increase eco-tourism opportunities in Brownsville. However, no RED benefits were quantified.

The OSE account recognizes effects that are relevant to the planning process, but not reflected in the other accounts. Implementation of the recommended plan would create and maintain natural areas within a highly urbanized area that would connect the Brownsville community to unique and high value habitat threaded throughout the urban area. Both the construction and ultimate development of the habitat over about 75 years would bring the community consciousness in line with ecosystem values.

The restored resacas would provide educational opportunities to schools in the city of Brownsville and regionally. Locally planned recreation features, such as hike and bike trails, will further integrate ecosystem values within the community. Other potential OSE benefits would include carbon sequestration, water quality improvements, and air quality benefits. However, no OSE benefits were quantified.

ENVIRONMENTAL OPERATING PRINCIPLES AND CAMPAIGN PLAN GOALS

The Brownsville Resacas Ecosystem Restoration Project would incorporate environmental sustainability by returning resaca into a more naturally functioning resaca ecosystem. The project would create aquatic and riparian habitats required by numerous fish and wildlife species that have evolved with the resaca ecosystem. The project would balance ecosystem restoration by restoring habitat without increasing the existing flood risk. The restoration would be consistent with all applicable laws and policies. The USACE and the non-federal sponsors would meet their corporate responsibility and accountability for the project in accordance with those laws and policies.

The feasibility study and implementation would be an interim response to the study authority. The resource is nationally significant and consists of vegetation communities that are extremely rare and at a high risk of extinction. The destruction of 95 percent of thorn-scrub habitat in the Lower Rio Grande Valley and 99 percent of riparian resaca habitats shows the severe impact to this ecosystem.

There are about 3,500 acres of remaining resaca habitat in the study area described by the authorization – the vicinity of Brownsville, Texas. The recommended plan would restore about 24 percent of that habitat. By identifying this feasibility study as an interim response to the authorization, an opportunity would be preserved to restore additional resaca habitat in the future. The significance of the resaca habitat and its value to the surrounding ecosystem are of national importance. Preserving the opportunity to restore additional habitat in the future is supported by the USACE Environmental Operating Principles and Campaign Plan goals.

The principles are:

1. Foster sustainability as a way of life throughout the organization.

2. Proactively consider environmental consequences of all Corps activities and act accordingly.

3. Create mutually supporting economic and environmentally sustainable solutions.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments.

5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.

6. Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner.

7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities.

The recommended plan would address these principle in the following ways:

1. The recommended plan would incorporate environmental sustainability by returning resaca into a more naturally functioning resaca ecosystem.

2. Coordination with resource agencies and stakeholders through development of the study identified and resolved or reduced the risk of environmental consequences of implementation of the recommended plan

3. The recommended plan would create aquatic and riparian habitats required by numerous fish and wildlife species that have evolved with the resaca ecosystem. The economic benefits were not quantified, but would tend to invigorate the existing ecotourism economy associated with the resacas. The fiscal capabilities of the local sponsor were assessed to be fully sufficient to cost share in the implementation of the project and to maintain the project under the items of local cooperation. Implementation would not impact flood risks or floodplain development and would not cause negative environmental impacts

4. The project has been reviewed and found to be consistent with all applicable laws and policies, including those related to potential impacts to human and natural environments. The USACE and the non-federal sponsors would meet their corporate responsibility and accountability for the project in accordance with those laws and policies.

5. The project would balance ecosystem restoration by restoring habitat without increasing the existing flood risk. Cost and schedule risk assessment was considered for project implementation to assure costs and construction schedules were achievable. Risk management was also applied in the development of the monitoring and adaptive management plan to assure restoration plans realized forecast environmental outputs. A long term monitoring plan would be implemented to provide data throughout the project life cycle to aid in the management on this project and inform the USACE ecosystem restoration program.

6. An existing Section 206 restoration project was used to leverage cost date. The knowledge of resource agency subject matter experts was leveraged in the collection of field data and to develop and apply the Resaca Reference Condition Model used to evaluate the field data.

7. The study process involved coordination with and the participation of numerous agencies and interested resource partners. Both the local sponsor and the USACE met with the public to seek input at the beginning and during the study.

Appropriate ways and means were used to assess cumulative impacts to the environment through the NEPA and use of engineering models, environmental surveys, and coordination with natural resource agencies. Because of employing a risk management and systems approach throughout the life cycle of the project, the project

design evolved to address as many concerns as possible with no mitigation required to address adverse impacts.

The USACE Campaign Plan a strategic change decision document. It drives and aligns strategic change; anticipates and shapes future operating and fiscal environments; unites all of USACE with a common vision, purpose, and direction; and responsively adapts to mission and “battle space” changes. The plan is composed of four goals: Support National Security, Deliver Integrated Water Resource Solutions, Reduce Disaster Risk, and Prepare for Tomorrow. The recommended plan relates to the second goal. The second goal reflects an effort to operationalize the civil works strategic plan by focusing on holistic integrated water resource management. The goal has four objectives: deliver quality water resources solutions and services, deliver the civil works program using innovative solutions, develop the civil works program to meet the future water resources needs of the Nation, and manage the life-cycle of water resources infrastructure systems to consistently deliver reliable and sustainable performance. Each objective has three action items. Of the twelve items, those to which the recommended plan relates are listed below: The applicable Campaign Plan goal is Goal 2 – Deliver Integrated Water Resource Solutions. The goal has four objectives

1. Deliver Quality Water Resource Solutions and Services
2. Deliver the Civil Works Program and innovative solutions
3. Develop the Civil Works Program to meet the future needs of the Nation
4. Manage the life-cycle of water resources infrastructure systems to consistently deliver reliable and sustainable performance

The preserved study opportunity would apply to the Campaign Plan goal’s objectives one and three by maintaining the ability to initiate a restoration study in the timeliest manner in the future. By identifying this feasibility study as an interim response to the authorization, an opportunity would be preserved to restore additional resaca habitat in the future. The significance of the resaca habitat and its value to the surrounding ecosystem are of national importance.

Appropriate ways and means were used to assess cumulative impacts to the environment through the NEPA and use of engineering models, environmental surveys, and coordination with natural resource agencies. Because of employing a risk management and systems approach throughout the life cycle of the project, the project design evolved to address as many concerns as possible with no mitigation required to address adverse impacts.

ENVIRONMENTAL COMPLIANCE

The USACE prepared this integrated report to satisfy the requirements of all applicable environmental laws and regulations. The USACE efforts comply with the Council on Environmental Quality (CEQ) NEPA regulations (40 CFR Part 1500–1508) and the USACE's regulation ER 200-2-2 - Environmental Quality: Policy and Procedures for Implementing NEPA, 33 CFR 230. In implementing the recommended plan, the USACE would follow provisions of all applicable laws, regulations, and policies related to the proposed actions. The following sections present brief summaries of federal environmental laws, regulations, and coordination requirements applicable to this study.

Clean Water Act

The Clean Water Act was enacted to restore and maintain the integrity of the nation's waters. There are two fundamental goals: to eliminate the discharge of pollutants into the nation's waters, and to achieve water quality levels that are fishable and swimmable. Two sections of the Act are discussed below.

Section 404(b)1

The USACE under the direction of Congress regulates the discharge of dredged and fill materials into all waters of the United States, including wetlands. Although the USACE does not issue itself permits for construction activities affecting waters of the U.S., it must meet the legal requirement of the Act. As directed in Wetlands and Waters of the U.S., a Clean Water Act, Section a 404(b)(1) analysis was prepared for the Brownsville resacas study (Appendix D-3).

The Section 404(b)1 analysis was provided to the TCEQ and the agency provided the water quality certification for the study in accordance with Section 401 of the Clean Water Act.

Section 402

Disturbance of upland areas resulting from any construction activities (land above Section 404 jurisdictional waters) are subject to National Pollutant Discharge Elimination System (NPDES) requirements of the Clean Water Act Section 402(p). Within Texas, the TCEQ is the permitting authority and administers the federal NPDES program through its Texas Pollutant Discharge Elimination System (TPDES) program. Construction activities disturbing one or more acres are subject to complying with the TPDES NPDES requirements.

If construction activities would disturb five or more acres, the construction operator must prepare a Storm Water Pollution Prevention Plan (SWPPP), submit a Notice of Intent to the TCEQ, conduct onsite posting and periodic self-inspection, and follow and maintain

the requirements of the SWPPP. During construction, the operator would assure measures are taken to control erosion, reduce litter and sediment carried offsite (silt fences, hay bales, sediment retention ponds, litter pick up, etc.), promptly clean up accidental spills, utilize BMPs onsite, and stabilize site against erosion before completion.

Clean Air Act of 1970

Federal agencies are required by this Act to review all air emissions resulting from federal funded projects or permits to insure conformity with the SIPs in non-attainment areas. The Brownsville metropolitan area is currently in attainment for all air emissions. The recommended plan would be in accordance with the Clean Air Act.

Endangered Species Act (ESA)

The recommended plan would have “no effect” on any federally listed endangered or threatened species. “No effect” means the proposed project would not affect, directly or indirectly any ESA-listed species or critical habitat. Generally, this means no ESA-listed species or critical habitat would be exposed to any potentially harmful/beneficial elements of the action. While the project may have beneficial impacts on listed species (Chapter 2 & 5), additional documentation is not required under this Act for consultation with the USFWS. The “no effect” determination, fulfilled the USACE ESA, Section 7 consultation requirements.

Executive Order 13112, Invasive Species

The Executive Order (EO) 13112 recognizes the significant contribution native species make to the well-being of the nation’s natural environment and directs federal agencies to take preventative and responsive action to the threat of the invasion of non-native plants and wildlife species in the United States. This EO establishes processes to deal with invasive species and among other items establishes that Federal agencies “*will not authorize, fund, or carry out actions that it believes are likely to cause or promote the introduction or spread of invasive species in the United States or elsewhere unless, pursuant to guidelines that it has prescribed, the agency has determined and made public its determination that the benefits of such actions clearly outweigh the potential harm caused by invasive species; and that all feasible and prudent measures to minimize risk of harm will be taken in conjunction with the actions.*”

The proposed action would be in compliance with EO 13112 by restoring native aquatic and riparian vegetation species lost because of the degradation of the habitat of the Brownsville resacas. The measures would reduce the invasive plant species and the seed bank in the top six inches of topsoil and replace with native plant species adapted to the study area. The non-federal sponsor would provide operation and maintenance which would minimize the negative influence of non-native plants.

Executive Order 11988, Floodplain Management

The EO 11988 was enacted May 24, 1977, in furtherance of the National Environmental Policy Act of 1969, as amended (42 U.S.C. 4321 et seq.), the National Flood Insurance Act of 1968, as amended (42 U.S.C. 4001 et seq.), and the Flood Disaster Protection Act of 1973 (Public Law 93-234, 87 Star.975). The purpose of the EO was to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative.

The order states that each agency shall provide and shall take action to reduce the risk of the flood loss, to minimize the impacts of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out its responsibilities for (1) acquiring, managing, and disposing of federal lands and facilities; (2) providing Federally undertaken, financed, or assisted construction and improvements; and (3) conducting Federal activities and programs affecting land use, including but not limited to water and related land resources planning, regulating, and licensing activities.

The FEMA digital flood insurance rate maps of the study area were analyzed to establish the locations of the 100-year and 500-year flood zones. All alternatives were designed to ensure that the combination of all ecosystem restoration measures proposed would not result in a decrease in the floodplain capacity and an increase in flood risk to the study area. The proposed action would be compliance with EO 11988 by protecting the resacas floodplain.

The alternatives would be implemented within the 100-year floodplain, but there would be no direct or indirect impact to the floodplain or related to floodplain development. It was not necessary to apply the eight-step process required by the Water Resources Council, Floodplain Management Guidelines for Implementing E.O. 11988, February 10, 1978. Acquisition of property for ecosystem restoration, within the conditions of items of local cooperation, would restrict development in the floodplain on project lands.

Migratory Bird Treaty Act, Migratory Bird Conservation Act, and Executive Order 13186, Migratory Birds

The importance of migratory non-game birds to the nation is embodied in numerous laws, executive orders, and partnerships. The Fish and Wildlife Conservation Act of the Army for Civil Works demonstrates the Federal commitment to conservation of non-game species. Amendments to the Act adopted in 1988 and 1989 direct the Secretary to undertake activities to research and conserve migratory non-game birds. The EO 13186 directs Federal agencies to promote the conservation of migratory bird populations, including restoring and enhancing habitat. Migratory Non-Game Birds of Management Concern is a list maintained by the USFWS. The list helps fulfill the primary goal of the USFWS to conserve avian diversity in North America. The USFWS

Migratory Bird Plan is a draft strategic plan to strengthen and guide the agency's Migratory Bird Program. The proposed ecosystem restoration would contribute directly to the USFWS Migratory Bird Program goals to protect, conserve, and restore migratory bird habitats to ensure long-term sustainability of all migratory bird populations.

Executive Order 12898, Environmental Justice

EO 12898 "*Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*" dated February 11, 1994, requires all Federal agencies to identify and address disproportionately high and adverse effects of its programs, policies, and activities on minority and low-income populations. Data was compiled to assess the potential impacts to minority and low-income populations within the study area. Environmental justice is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies. Even though minorities account for a large portion of the local population and the low-income population is above the national averages, construction of the proposed alternatives would not have a disproportionately high or adverse effect on these populations. Because of the high number of Spanish speaking individuals in the Brownsville resacas area, public meetings had and will continue to have translators. All notices regarding the project would have Spanish versions and construction signs would be posted in both English and Spanish. No environmental justice concerns are anticipated. The proposed action would be consistent with EO 12898.

Executive Order 13045, Protection of Children

EO 13045 "*Protection of Children from Environmental Health Risks*" dated April 21, 1997 requires Federal agencies to identify and address the potential to generate disproportionately high environmental health and safety risks to children. This EO was prompted by the recognition that children, still undergoing physiological growth and development, are more sensitive to adverse environmental health and safety risks than adults.

Short-term impacts on the protection of children would be expected. Numerous types of construction equipment such as backhoes, bulldozers, dredgers, grader, and dump trucks, and other large construction equipment would be used throughout the duration of the construction of the proposed action. Because construction sites and equipment can be enticing to children, activity could create an increased safety risk. The risk to children would be greatest in construction areas near densely populated neighborhoods. During construction, safety measures would be followed to protect the health and safety of residents as well as construction workers. Barriers and "*No Trespassing*" signs would be placed around construction sites to deter children from playing in these areas, and construction vehicles and equipment would be secured

when not in use. Because the construction area would be flagged or otherwise fenced, the proposed action would be consistent with the EO.

Farmland Protection Policy Act of 1981

Because the recommended plan addresses existing riparian and aquatic areas, the proposed project would not require permanently converting farmland to resaca restoration areas. There may be temporary staging and haul roads in some existing farm fields, but once construction is finished, farming would continue. The PDT did not complete a Farmland Conversion Impact Rating (AD-1006) for this project. A Farmland Conversion Impact Rating analysis is not necessary for the project site since most of the riparian restoration would be completed on hydric soils and creation of wetlands on hydric soils is consistent with the direction of various NRCS programs for agricultural settings.

Rivers and Harbors Act

Section 10 (30 Stat. 1151; 33 U.S.C 403, 1899)

The proposed plan would not place any permanent obstruction across navigable water nor would it place obstructions to navigation outside established federal lines.

Section 122 (PL 91-6110, 1970) 17 Points

This Act assured the USACE will consider all possible adverse economic, social and environmental effects relating to any proposed project have been fully considered in developing such project. The final decisions on the project are made in the best overall public interest taking into consideration the need for flood control, navigation, and associated purposes, and the cost of eliminating or minimizing such adverse effects. The Act referred to specific resources all projects need to take into account during the planning process. Table 6-7 outlines each of these resources and the project's possible impacts. These resources are commonly called the 17 Points.

Table 6-7: Rivers and Harbors Act – 17 points

Resource	Possible Project Effects	Reasons
Air	Short term minor effect; no long term effect	Localized temporary construction (exhaust, dust)
Noise	Short term minor effect; no long term effect	Localized, temporary construction (equipment)
Water pollution	No short term effect; long term positive effect	Less flooding will reduce contamination entering the river from the floodplain
Man-made resources	Positive effect	added flood risk reduction
Natural resources	Short term minor effect; no long term effect	Localized construction disturbance
Esthetic[sic] values	No effect	Minimal change to flood height
Community cohesion	Positive effect	added flood risk reduction
Availability of public facilities and services	Positive effect	added flood risk reduction
Availability of public services	Positive effect due to added flood risk reduction	added flood risk reduction
Employment	Positive effect	Local construction stimulus and long term sustainment from added flood risk reduction
Tax income value losses	No effect	Continued land use with project
Property value losses	No effect	Continued land use with project
Displacement of people	No effect	added flood risk reduction
Business and Industrial Growth	Positive effect	Added confidence with additional flood risk reduction
Farms	Short term minor effect; no long term effect	Possible construction (haul roads, staging areas)
Community growth	Positive effect	added flood risk reduction
Regional growth	Positive effect	added flood risk reduction

Engineer Regulation 1105-2-100

In addition to the resources listed in Table 6-8, the USACE planning guidance (ER 1105-2-100, 1983) identifies other resources needed to take in to account in their project planning (Table 6-8).

Table 6-8: ER 1105-2-100 Resources

Resource	**Possible Project Effects**	**Reasons**
Life	Positive effect	Added flood risk reduction
Health	Positive effect	Added flood risk reduction
Safety	Positive effect	Added flood risk reduction
Long term productivity	Positive effect	Added confidence with additional flood risk reduction
Energy requirements	Short term minor effect; no long term effect	Localized, temporary construction fuel needs
Energy conservation	Positive effect	Less energies required for future flood fight requirements

Executive Order 11990 Protection of Wetlands

This EO states that each federal agency shall avoid undertaking new construction located in wetlands unless there is no practicable alternative to such construction, and

the proposed action includes all practicable measures to minimize harm to wetlands. This wetland restoration project takes place in resaca habitat, an imperiled wetland habitat. The recommended plan would have positive impacts to wetlands. The proposed project is in full compliance with the EO.

Wild and Scenic Rivers Act of 1968, as amended

The Brownsville resacas are not listed in the National Rivers Inventory (NRI). The NRI is used to identify rivers that may be designated by Congress to be Component Rivers in the National Wild and Scenic Rivers System.

Federal Water Project Recreational Act of 1966

The Act states, “it is the policy of Congress and the intent of this Act that in investigating and planning any federal navigation, flood control, reclamation, hydroelectric, or multipurpose water resource project that consideration shall be given to the opportunities, if any, which the project affords for outdoor and for fish and wildlife enhancement ...”

Recreation measures were removed from consideration because of the incompatibility of the restoration measures with recreation. This does not preclude the future construction of recreation features adjacent to the restoration areas. Recreation opportunities may be improved with the project, as several potential restoration areas are located adjacent to public parks and existing recreation areas. The restoration of resaca habitats throughout the resaca systems would provide improved eco-recreation opportunities such as birding, wildlife viewing, and kayaking.

National Historic Preservation Act of 1966

Federal agencies are required under Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended, to *“take into account the effects of their undertakings on historic properties”* and consider alternatives *“to avoid, minimize or mitigate the undertaking’s adverse effects on historic properties” [*(36 CFR 800.1(a-c)] in consultation with the State Historic Preservation Officer (SHPO) and appropriate federally recognized Indian Tribes (Tribal Historic Preservation Officers - THPO) [(36 CFR 800.2(c)].

Other applicable cultural resources laws, rules, and regulations will inform how investigations and evaluations will proceed throughout the study and implementation phases (e.g., Archeological and Historic Preservation Act of 1974, National Environmental Policy Act of 1969, Native American Graves Protection and Repatriation Act, Engineer Regulation 1105-2-100).

In accordance with Section 106 of the NHPA, the USACE has consulted with the Texas SHPO, as well as all federally recognized Native American Tribes with an interest in the project area, regarding the potential to impact historic properties from the proposed

undertaking (Appendix D). Based on background research and correspondence with the SHPO, there was a finding of no potential to have adverse effects to built historic resources. The SHPO and USACE concur that the landforms adjacent to resacas generally display a high probability for containing buried archaeological resources the potential for undisturbed archaeological resources remains and that additional cultural resource surveys may be required in areas of significant ground disturbance.

A Programmatic Agreement (PA) with all consulting parties has been executed per 36 CFR 800.14(b)(1)(ii) as required when effects on historic properties cannot be fully determined prior to approval of an undertaking. The PA stipulates that outlining efforts (surveys, testing, evaluation, effects determination, mitigation) shall be completed during PED and before construction (also see ER 1105-2-100, page C-30). See Appendix D-1-b.

Archaeological and Historic Preservation Act

The Archaeological and Historic Preservation Act of 1974 amends the 1960 Reservoir Salvage Act by providing for the preservation of significant scientific, prehistoric, historic and archaeological materials and data that might be lost or destroyed as a result of flooding, the construction of access roads, relocation of railroads and highways, or any other federally funded activity associated with the construction of a dam or reservoir.

The recommended plan would not create any new dams, raise water levels beyond the existing conditions, or increase flooding. No impact to any project significant scientific, prehistoric, historic, and archaeological materials and data is anticipated.

A qualified archeologist will conduct a systematic cultural resources survey before construction. The scope of the survey and resulting reports will be coordinated with the Texas Historical Commission. If any significant resource would be discovered, construction would stop until all cultural resources issues are properly coordinated and are in full compliance.

A PA among the Texas Historical Commission, the USACE, and the non-federal sponsors (NFS) has been developed. The agreement stipulates the methods by which the USACE and the NFS will meet the requirements of the NHPA and other applicable laws. This agreement is included in Appendix D-1-b. The USACE has invited the Advisory Council on Historic Preservation and appropriate federally recognized Tribes to participate in the agreement; all have declined the opportunity to participate in the agreement at this time.

Fish and Wildlife Coordination Act

The Fish and Wildlife Coordination Act (FWCA) requires federal agencies that are impounding, diverting, channelizing, controlling, or modifying the waters of any stream or other water body to consult with the USFWS and appropriate state fish and game agency to ensure wildlife conservation receives equal consideration in the development

of such projects. The USFWS and the TPWD have been involved in the planning process of the resaca study since the initial stages participating in the planning process, data collection efforts, providing input and comment throughout the process. The USFWS Joint Planning Aid Letter/Coordination Act Report is located in Appendix D-2.

Advisory Circular 150/5200-33A – Hazardous Wildlife Attractants on Near Airports

The advisory circular provides guidance on locating certain land uses having the potential to attract hazardous wildlife to or in the vicinity of public-use airports. The circular provides guidance on wetlands in and around airports and establishes notification procedures if reasonably foreseeable projects either attract or may attract wildlife.

In response to the advisory circular, the U.S. Army as well as other federal agencies, signed a Memorandum of Agreement (MOA) with the FAA to address aircraft-wildlife strikes. The MOA establishes procedures necessary to coordinate their missions to more effectively address existing and future environmental conditions contributing to aircraft-wildlife strikes throughout the U.S.

The project area is located adjacent to the Brownsville-South Padre Island International Airport. In accordance with the advisory ircular, the USACE is coordinating with the FAA to address potential hazardous wildlife attractants near the airport with respect to the proposed action. Copies of all coordination are included in Appendix D.

The FAA identified a potential increased risk of bird strikes if restoration areas in proximity to the Brownsville Airport included emergent planting (Figure 6-1). The USACE and the FAA, agreed to a 1,000-foot buffer along each side of the two runways. These restoration areas would not include emergent vegetation plantings since this type of vegetation may attract geese and other waterfowl. This stipulation is in compliance with FAA Advisory Circular 150/5200-33B, Hazardous Wildlife Attractants on or Near Airports. Other restoration measures (such as riparian planting) would not be restricted. The buffer area is shown in white in Figure 6-3. The buffer intersections with the resacas considered (and included in the recommended plan) are shown in red. No emergent vegetation planting would be included in the intersection of the buffer and the resacas for plans considered or recommended by this feasibility study.

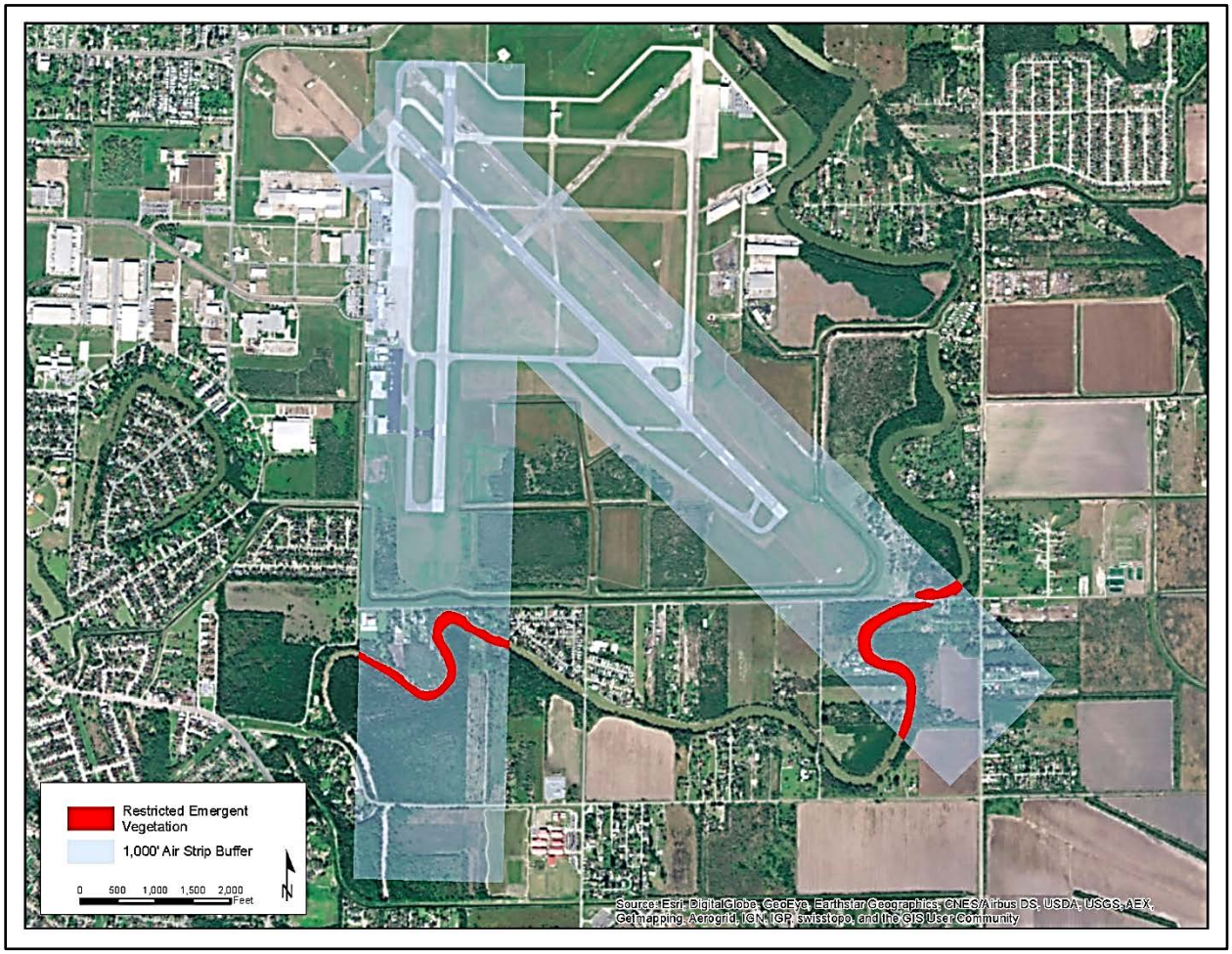


Figure 6-3: Aerial view of Restricted Emergent Vegetation Planting Areas

Texas Commission on Environmental Quality (TCEQ), Texas Coastal Management Program (CMP)

Approval of the CMP gave Texas the authority to review proposed federal actions and activities that are located in or may affect land and water resources in the Texas coastal zone. This process, called federal consistency review, ensures the state's interest is fairly represented, and allows the state the opportunity to provide input into policies, procedures, or actions and activities that may affect the management of coastal areas, including:

Federal actions and activities within or outside the Texas coastal zone that affect coastal natural resource areas must be consistent with enforceable policies of the CMP to the maximum extent practicable. If the state finds a given action or activity to be inconsistent, with a few exceptions, the action cannot be undertaken.

Appendix D-5 includes documentation from the Texas Commission on Environmental Quality indicating, "The TCEQ has reviewed this proposed action for consistency with the Texas Coastal Management Program (CMP) goals and policies in accordance with

the CMP regulations (Title 31, Texas Administrative Code (TAC), Section (505.30) and has determined that the action is consistent with the applicable CMP goals and policies."

Relationship between Short-Term Use and Long-Term Productivity

Construction activities would temporarily disrupt wildlife and human use of the project area. Long-term productivity for natural resource management would benefit considerably by construction of this project. Long-term productivity would be enhanced through improved riparian habitat, establishment of submerged, emergent wetland vegetation, and providing improved resaca depth and slopes. Overall habitat diversity would increase, and both game and nongame wildlife species would benefit. Both consumptive and non-consumptive users would realize heightened opportunities for recreational use of the resacas. Negative long-term impacts are expected to be minimal on all ecosystems associated with the recommended plan.

Relationship to Land Use Plans

The current land use plan will not change because the project is compatible with all existing land use plans. The land use remains the same because the project would seek to improve the existing resaca habitat, and no new resaca would be built.

This project is compatible with and supports the TPWD Land and Water Resources Conservation and Recreation Plan (TPWD, 2015) and the Texas Conservation Action Plan (TPWD, 2012)

Irreversible and Irretrievable Commitment of Resources

The recommended plan would not entail significant irretrievable or irreversible commitments of resources. Construction of the ecosystem restoration measures would require minor consumption of petroleum products, and importing materials such as rock, soil, gravel, and vegetation. Long-term sustainability actions were included for the restored environmental resources.

Indirect Effects

Indirect effects, as defined by the CEQ regulations, are "caused by the proposed action and occur later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density, or growth rate, and related effects on air and water and other natural systems, including ecosystem" (40 CFR 1508.8). Indirect effects differ from direct impacts associated with the construction and operation of the proposed project and are caused by an action or actions having an established relationship or connection to the proposed project.

Indirect effects can be linked to direct effects in a causal chain, which can be extended as indirect effects producing further consequences.

As previously discussed, implementation of the proposed action would directly result in a net beneficial impact to the Brownsville resacas and the associated vegetation and wildlife. In addition, the proposed resaca ecosystem restoration measures would result in benefits extending farther outside the study area for several notable environmental resources. These benefits would increase over time as the resaca habitats develop and mature.

The establishment of wildlife corridors through the development of stepping stone habitats has been documented in this report. The indirect effects of this study are directly linked to these wildlife corridors as the recommended plan would facilitate the emigration and dispersion of wildlife across an urbanized interface, providing connectivity for habitats currently disconnected. The improved resaca habitats would improve water quality downstream as aquatic, wetland, and riparian vegetation would filter pollutants and sediments.

Cumulative Impacts

The CEQ regulations define a cumulative impact as an effect which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions (40 CFR Section 1508.7). Relatively minor individual impacts may collectively result in significant cumulative impacts. Project-related direct and indirect impacts must be analyzed in the context of non-project-related impacts affecting the same resources. Cumulative impacts are the incremental impacts the project has, directly or indirectly, on a resource in the context of other past, present, and future effects on the resource from related or unrelated activities. Unlike direct impacts, quantifying cumulative impacts may be difficult since a large part of the analysis requires forecasting future trends of resources in the study area and future projects that may impact these resources.

The initial step of the cumulative impacts analysis uses information from the evaluation of direct and indirect impacts in the selection of environmental resources that should be evaluated for cumulative impacts. The proposed action would not contribute to a cumulative impact if it would not have a direct or indirect effect on the resource. Similarly, CEQ guidance recommends narrowing the focus of cumulative impacts analysis to important issues of national, regional, or local significance. Therefore, the cumulative impact analysis for the recommended plan focused on those resources substantially directly or indirectly impacted by the study and resource at risk or in declining health even if the direct/indirect impacts were insignificant.

The cumulative impacts analysis included riparian vegetation and associated wildlife resources. Each of these resources would be substantially directly and/or indirectly impacted by the resacas project. For the purposes of this cumulative analysis, the

resource study area for the riparian vegetation and wildlife is the historical extent of the resaca habitats.

Past, Present, and Reasonably Foreseeable Projects with-in the Resaca Study Area

Past Actions

The resaca aquatic and riparian habitats have been in critical decline in quantity and quality over the last century. Agriculture and urban development are the major influences in the habitat decline. The USFWA and the TPWD initiated conservation efforts in the last 20 years but continued urbanization of the area is expected. Although the proposed ecosystem restoration study would result in the restoration of a small proportion of historical habitat, it represents a substantial proportion of the remaining habitat.

Present Actions

The USFWS and the TPWD have undertaken conservation efforts over the past two decades to restore the degraded habitat of the Brownsville resacas. Other current activity would be the proposed ecosystem restoration study that would restore connectivity to a small portion of historical habitat with stepping stones.

Future Actions

It is anticipated that there would be continued urbanization and infrastructure updates into the foreseeable future. Highway and other utility updates would cause temporary impacts during their construction as well as support an increasing demand on water and energy resources. These updates would have indirect impacts to the resacas such increased runoff or an increase in water supply demand. Increased public use and the acknowledgement that quality resaca habitat contributes to the quality of life, support for improved resaca habitat should offset the negative effects. The resource agencies are actively trying to preserve and restore the remaining patches of Tamaulipan scrubland and the USACE has the opportunity to take part and participate in the restoration of the aquatic component of this system for years to come.

Discussions continue concerning the U.S. government’s proposal to build an improved wall along the U.S. and Mexican border. While a right of way has not been finalized, initial proposed locations are near the Rio Grande River and not the resaca project. While this project may not directly affect the resaca habitat, it may limit the connectivity between the resacas and Rio Grande Valley. Private land, U.S. eminent domain lawsuits, politics, flood plain construction challenges, local businesses, racial tensions, wildlife habitat and many environmental concerns are among the issues that must be resolved before a detailed construction schedule for the border wall can be established.

ADAPTIVE MANAGEMENT AND MONITORING PLAN

Monitoring and if necessary, adaptive management would occur for ten years as evidence for successful establishment of the project before the project would be turned over to the non-federal sponsor for operation and maintenance. Monitoring efforts would be conducted by BPUB and USACE personnel. See Appendix C for the Monitoring and Adaptive Management Plan.

Mitigation

Implementation of the recommended plan would result in net ecological benefits to the resaca ecosystem; therefore, the project would not require mitigation. During construction and maintenance of the restorative measures, best management practices would be followed to minimize impacts to the environment. All practicable means to avoid or minimize environmental impacts from construction of the recommended plan would be considered. The recommend plan would be designed with the smallest practicable footprint to still meet the requirements of the proposed project.

CONCLUSIONS

The proposed alternatives, including the no action plan, have been evaluated in this integrated feasibility document. No significant impacts to the human environment are identified from the implementation of the recommended plan. The plan would restore aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo. Terrestrial riparian habitat would be cleared of invasive species of plants and native species would be replanted. An **implementation plan** would restore aquatic habitat through the removal of sediment by widening some resacas (excavating), by shaping banks, and by planting emergent vegetation. After implementation, a **management plan** would continue with monitoring and with management and control of invasive species.

The restoration would cause no long-term adverse environmental impacts. There would be no adverse impacts to habitat for threatened or endangered species as the impacts to all wetlands and waters of the U.S in a 404(b)(1) analysis was evaluated. The Section 404(b)1 analysis was provided to the TCEQ and the agency provided the water quality certification for the study in accordance with Section 401 of the Clean Water Act. Adverse impacts to cultural resources, either buried or in the cultural landscape would be identified and appropriate mitigation would be completed prior to project construction.

As an ecosystem restoration project, the recommended plan (Alternative 5) is intended to have long-term beneficial impacts to the Brownsville resaca and surrounding areas. The City of Brownsville, the USFWS, the TPWD, and TNC support the recommended plan.

The level of detail for the recommended plan was increased to reduce schedule and cost risks. The area delineations of the restoration areas were refined. Relatively minor changes were noted for all resaca areas. Consequently, the acreages noted for the recommended plan in Chapter 7 are different than those presented for Alternative 5 in Chapter 5. The level of detail for the cost engineering estimate was also increased, which resulted in differences in costs presented for the recommended plan versus Alternative 5. The level of detail changes were found to apply to essentially all of the 66 areas investigated for restoration. The potential for these changes to alter the plan formulation decisions was reviewed and the plan formulation was confirmed to be valid.

Taking into account the findings of this section, an EIS would not be necessary. A Draft Finding of No Significant Impact (FONSI) was prepared for the proposed action.

Description of the Recommended Plan

The recommended plan was identified as the National Ecosystem Restoration plan and ecosystem restoration was found to be justified. The plan would restore about 845 acres of aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo in the vicinity of Brownsville, Texas. The total restoration acreages would consist of about 625 acres of riparian habitat restoration, by clearing invasive species and replanting native species of plants, and about 220 acres of aquatic habitat restoration, through the removal of sediment, expanding aquatic areas, shaping banks, and by planting aquatic and emergent vegetation along 33 miles of shoreline. After implementation, a management plan would continue with monitoring and adaptive management of the restoration features. The recommended plan identified cost effective restoration measures on 763 acres of city and private lands; 28 acres of state Texas Parks and Wildlife Department (TPWD) lands, and 54 acres of federal U.S. Fish and Wildlife Service (USFWS) lands. Figure 6-4 shows the recommended plan.

The USACE would not cost share in the implementation on the USFWS lands. That implementation would be further coordinated with the USFWS and the non-federal sponsor during the USACE preconstruction engineering and design for the potential of two federal sponsors.

The plan is composed of eight restoration measures applied to 44 restoration areas among the two Resacas. The eight management measures are:

Dredging (removing sediment from the resacas and excavating to restore aquatic habitat)

Riparian Soil Supplementation with Dredged Material (nutrient enrichment of the riparian area)

Planting Riparian Species (replanting native species appropriate for the natural habitat)

Bank Slope Restoration (restoring flatter bank slopes represented in reference sites to benefit species movement from the aquatic habitat to the terrestrial habitat)

Bank Stabilization (stabilizing banks to reduce sediment from runoff)

Plant Aquatic and Emergent Vegetation (replanting native species to benefit aquatic fishes and amphibian species life cycles)

Water Control Structure/Flow Management (water management to mimic the water budget of natural resacas)

Invasive Plant Species Management (removal and management of non-native and invasive species)

The total project first cost is estimated to be $202,492,000 at October 2017 prices, with a federal share of $138,238,000 (by the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS)) and a local sponsor share of $64,255,000. The project first cost would be shared between two federal agencies with the USACE share estimated at $119,332,000 and the USFWS share estimated at $18,907,000.

The non-federal sponsor is the City of Brownsville, Texas. The non-federal sponsor would cost share the project first cost of the restoration of resaca measures on lands acquired for the project, including lands held by the TPWD (28.21 acres) but excluding the cost of restoration measures on lands held by the USFWS (54 acres). Annual operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs are estimated to be $624,000 at October 2017 prices and Federal discount rate of 2.75 percent and a period of analysis of 75 years.

The restoration areas and the implementation quantities are shown in Table 6-9.

A 16-year construction schedule was developed through coordination with the sponsor and the Cost Engineering Mandatory Center of Expertise. The relevant issues for the schedule were the large number of real estate acquisitions, the large volume of restoration effort to be conducted in 44 different areas across Brownsville, and the budget capability of the non-federal sponsor. The construction schedule is shown in Table 6 6.

Initial coordination to outline the component of USFWS implementation during the feasibility phase was positive and detailed coordination would continue during the USACE preconstruction engineering and design. Failure to come to an agreement on implementation, or conflicting USFWS priorities would potentially result in the USACE implementing a slightly smaller plan or refinements to the recommended plan. The final array of alternatives was coordinated with the public and resource agencies. Adoption of a smaller alternative would not require additional NEPA documentation or review.

The recommended plan includes the cost of post-construction monitoring and adaptive management for a period of 10 years to ensure project performance. Because implementation of the recommended plan would not have any significant adverse effects, no mitigation measures (beyond management practices and avoidance) or compensation measures would be required.

Table 6-9: Retitle to Restoration Areas and Implementation Quantities

		Construction Item												
Restoration Area	Silt Fence	A.	B.	C.	D.	*E.*	F.	G.	H.	I.	J.	K.	L.	M.
No.	LF	EA	EA	EA	Acres	CY	EA	Acres	EA	Acres	EA	CY	EA	CY
40	3,545	2		1	31.49	*2889*	9441	31.47	38	31.49	6,818			944
41	2,575	2		1	15.80	*2098*	6105	20.35	27	20.35	4,973		1	861
42	4,950	1		1	35.18	*4033*	15913	53.04	53	53.05	9,500		1	1,319
43	4,800	3		1	33.99		10194	33.98		33.99				
44	2,700	2		1	5.55	*2200*	5583	18.61	29	18.61	5,197			718
45	525	1		1	4.87	*428*	1461	4.87	5	4.87	1,005			139
46	2,525	2		1	4.09	*2057*	1224	4.08	27	4.09	4,862			667
53		1	1	1								7,863		
54		1	1	1								41,665		
59	1,710	1		1	1.68	*1,393*	909	3.03	18	3.03	3,297		1	472
60		1	1	1								14,571		
61	768	1	1	1	3.81	*142*	999	3.33	8	3.3	1,453	72,713		236
62	658	1	1	1	1.38	*341*	357	1.19	7	1.21	1,285	14,341		194
66	1,600	1	1	1	14.02	*830*	3990	13.30	17	13.25	3,073	21,198		1,111
67	3,900	3		1	10.46	*3,178*	5460	18.20	42	18.2	7,488			1,051
71	989	2		1	5.45	*806*	2226	7.42	10	7.43	1,900			278
72	2,336	1		1	4.37	*1,903*	1548	5.16	25	7.96	4,471			694
75	5,540	1	1	1	0.25	*4,514*	513	1.71	60	1.07	10,674	47,920		764
84	3,191	2	1	1	5.58	*2,600*	2814	9.38	34	9.41	6,147	50,101		833
93	5,148	2		1	13.25		1296	4.32	55	4.36	9,892	*42,235	1	958
94	3,750	2		1	9.67		1431	4.77	40	4.79	7,209	*46,351	1	694
95	9,670	2		1	20.87		6246	20.82	104	20.87	18,610	*202,035	1	2,778
96	1,345	2		1	12.43	*1,096*	3729	12.43	14	12.43	2,570			431
161	14,815	2		1	18.83		5700	19.00	160	18.83	28,502	*141,460	1	4,444
98	4,887	1		1	7.88	*3,982*	5376	17.92	52	17.92	9,389			1,417
99	3,118	1		1	5.95	*2,541*	2718	9.06	33	9.06	5,979		1	861
100	1,930	2		1	7.72	*1,573*	2442	8.14	21	8.14	3,744		1	500
101	6,762	1		1	21	*5,510*	13053	43.51	73	45.31	13,021			1,833
104	4,727	1		1	5.71	*3,852*	5589	18.63	51	18.64	9,109			1,278
105	6,409	1	1	1	11.72	*2,374*	8067	28.89	69	29.04	12,351	81,985	1	1,750
108	2,053	1	1	1	1.91	*1,977*	789	2.63	22	2.91	3,968	10,466		236

		Construction Item												
Restoration Area	Silt Fence	A.	B.	C.	D.	*E.*	F.	G.	H.	I.	J.	K.	L.	M.
No.	LF	EA	EA	EA	Acres	CY	EA	Acres	EA	Acres	EA	CY	EA	CY
109	3,171	1	1	1	8.17	*2,584*	2421	8.07	34	9.08	6,091	33,951	1	1,333
110	2,345	1		1	8.68	*1,911*	2940	9.80	25	10.13	4,526			639
111	2,201	1	1	1	0.38	*1,793*	477	1.59	23	1.33	4,247	56,056		139
112	2,465	2		1	15.47	*3,378*	4536	15.12	26	15.12	4,750			667
117	6,070	3	1	1	15.17	*4,946*	4383	14.61	65	14.58	11,680	65,971	1	944
142	5,047	1	1	1	8.79	*4,112*	7059	23.53	54	9.86	9,724	134,844	1	1,333
149	3,229	3	1	1	8.73	*2,631*	2073	6.91	34	6.89	6,203	11,748		556
150		1	1	1								20,053		
151		1	1	1								19,715		
166	5,071	1		1	11.29		2109	7.03	55	7.15	9,780	*20,605	1	1,306
167	17,321	1	1	1	60.62		16440	54.80	187	56.60	33,308	122,404		4,028
201	10,137	1		1	29.47	*8,260*	14448	48.16	109	48.21	19,504			2,736
202	4,790	3		1	9.71	*3,903*	4683	15.61	51	15.61	9,221			1,361
Total	**168,773.00**	**67**	**18**	**44**	**491.39**	***85,835***	**186,742**	**624.47**	**1,757**	**618.17**	**315,521**	**1,280,251**	**14**	**41,867**

**** Items with this denotation indicate the Resaca is dry therefore land based equipment was used in lieu of dredging equipment.***

- A. – Construction Entrance and Exit (ea)
- B. – Turbidity Curtain (ea)
- C. – Environmental Protection (ea)
- D. – Clearing and Grubbing (acres)
- E. – Pervious Backfill (cy)
- F. – Riparian Planting (Shrubs) (ea)
- G. – Riparian Turfing (acres)
- H. – Emergent Habitat Planting (ea)
- I. – Removal of Invasive Species (acres)
- J. - Emergent Habitat Planting (Herbaceous) (ea)
- K. – Dredging (cy)
- L. – Control Structure Modifications (ea)
- M. – Top Soil (cy)

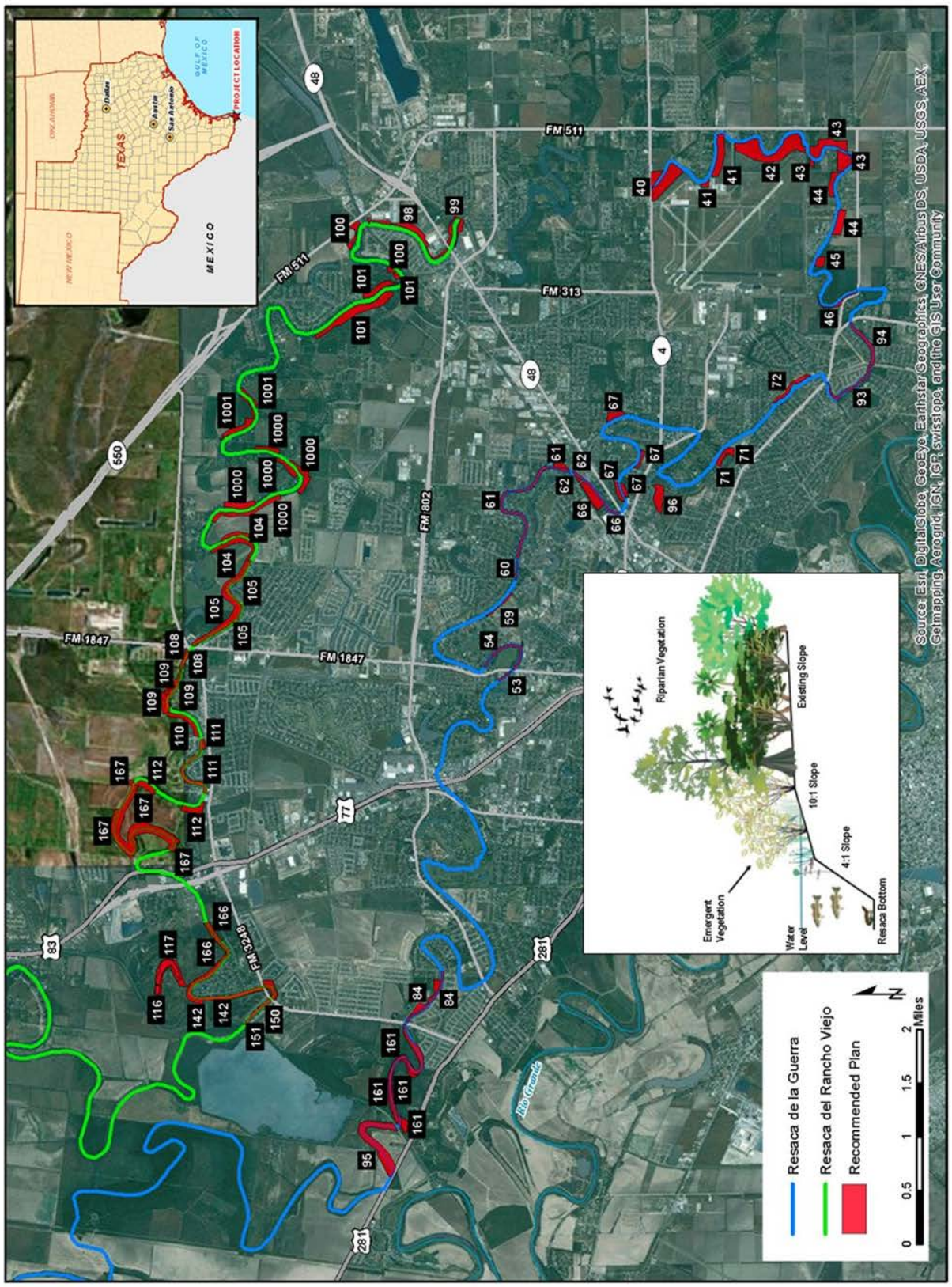


Figure 6-4: The Recommended Plan

Chapter 7 contains the USACE SWG Commander's findings and recommendations based on the integrated feasibility report and NEPA document, an environmental assessment (EA).

Chapter 7 also contains the Commander's finding of no significant impact (FONSI) based on the integrated feasibility report and EA.

CHAPTER 7: RECOMMENDATION AND FINDING OF NO SIGNIFICANT IMPACT

This chapter contains the findings and recommendation of the USACE Galveston District Commander.

About Recommendations

When a project is authorized by Congress, the recommendations contained in the feasibility report become the basis for proceeding with the project as a federal undertaking. Authorizing legislation normally references the "recommendations" of the Chief of Engineers, which are derived from the recommendations of the District Commander. The provisions of the recommendations provide a legislative basis that will not change unless modified by Congress through applicable general legislation or by specific legislative action for the particular authorization in question. Accordingly, the wording of recommendations, incorporated by reference in the authorizing act, has the force of law for the project.

About the Finding of No Significant Impact (FONSI)

A FONSI is prepared, as noted in the National Environmental Policy Act (NEPA) of 1969 (40 CFR 1508.13), when environmental analysis and interagency review have determined a proposed action would have no significant impacts on the quality of the environment. A FONSI presents the reasons why a proposed action would not have a significant impacts on the human environment. A FONSI is prepared for a proposed action when an Environmental Impact Statement will not be prepared. An Environmental Assessment is the NEPA documentation that supports a finding of no significant impact. For this feasibility report, the Environmental Assessment is fully integrated in the feasibility documentation and is not a separate document and there are np separate sections specifically identified as a NEPA document.

A notice of availability of the FONSI was sent to concerned agencies, organizations and the interested public as required by the NEPA (40 CFR 1501.4(e)(1). The draft FONSI and integrated Environmental Assessment were circulated for a minimum 30-day review on 8 June 2017 to concerned agencies, organizations, and the interested public as required by the NEPA (40 CFR 1501.4(e)(2)). There were four comments, which were supportive of the proposed action, Alternative 5. No modification of the draft FONSI was required as a result of review or comments (Appendix D-7).

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Recommendation
for the proposed implementation of
The Resacas
In the Vicinity of the City of Brownsville, Texas,
Interim Ecosystem Restoration Feasibility Study and Environmental Assessment

I recommend implementation of the National Ecosystem Restoration plan, identified as Alternative 5 in the Interim Ecosystem Restoration Feasibility Study and Environmental Assessment, The Resacas in the Vicinity of the City of Brownsville, Texas, Feb. 2018, with such modifications thereof as in the discretion of the Commander, Headquarters, U.S. Army Corps of Engineers (HQUSACE), may be advisable. Implementation of the plan would restore aquatic and terrestrial complexes within two resacas: Resaca de la Guerra and Resaca del Rancho Viejo through the restoration of 44 “stepping stone” areas. About 845 acres of aquatic and riparian habitat would be restored. Terrestrial riparian habitat would be restored by removing invasive plants and replanting native species on about 625 acres. Aquatic habitat would be restored by removing sediment, shaping banks, and planting aquatic and emergent vegetation along the shaped banks on about 220 acres. Restored shoreline would total about 33 miles. The sediment removed from the resacas would be placed in restored riparian areas to mimic the nutrient supplementation of former systems natural processes. Hydrologic reliability of the system would be assured through the implementation of in-channel water control measures, modifying an existing local system.

The total project first cost is estimated to be $202,492,000 at October 2017 prices, with a federal share of $138,238,000 (by the U.S. Army Corps of Engineers (USACE) and the U.S. Fish and Wildlife Service (USFWS)) and a local sponsor share of $64,255,000. The project first cost would be shared between two federal agencies with the USACE share estimated at $119,332,000 and the USFWS share estimated at $18,907,000. The local sponsor would cost share the project first cost of the restoration of resaca measures on lands acquired for the project, including lands held by the Texas Parks and Wildlife Division (TPWD) (28.21 acres) but excluding the cost of restoration measures on lands held by the USFWS (54 acres). Annual operation, maintenance, repair, rehabilitation, and replacement costs are estimated to be $624,000 at October 2017 prices, a Federal discount rate of 2.75 percent, and a period of analysis of 75 years.

The non-federal sponsor would be The City of Brownsville, Texas.

I make this recommendation with the provision that prior to implementation the local sponsor enter into a binding project partnership agreement (PPA) with the Secretary of the Army that defines the terms and conditions of cooperation for the project. In this agreement, the local sponsor would agree to comply with applicable federal laws and policies, including, but not limited to, the items of local cooperation, as specified below:

a. Provide 35 percent of total ecosystem restoration costs as further specified below:

1. Provide the required non-federal share of design costs in accordance with the terms of a design agreement entered into prior to commencement of design work for the project;
2. Provide, during the first year of construction, any additional funds necessary to pay the full non-federal share of design costs;
3. Provide all lands free of contamination, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct all improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material all as determined by the government to be required or to be necessary for the construction, operation, and maintenance of the project;
4. Provide, during construction, any funds necessary to make its total contributions equal to 35 percent of total project costs.

b. Provide work-in-kind during final design and construction as well as providing the post-construction monitoring. The value of lands, easements, rights of way, and relocations and disposal (LERRD) needed for the project are credited against the non-federal sponsors' cost-sharing requirement;

c. Shall not use funds from other federal programs, including any non-federal contribution required as a matching share therefore, to meet any of the non-federal obligations for the project unless the federal agency providing the federal funds verifies in writing that such funds are authorized to be used to carry out the project.

d. Prevent obstructions or encroachments on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) such as any new developments on project lands, easements, and rights-of-way or the addition of facilities which might reduce the outputs produced by the ecosystem restoration features, hinder operation and maintenance of the project, or interfere with the project's proper function;

e. Shall not use the ecosystem restoration features or lands, easements, and rights-of-way required for such features as a wetland bank or mitigation credit for any other project;

f. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 USC 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way required for construction, operation, and maintenance of the project, including those necessary for relocations, the borrowing of materials, or the disposal of dredged or excavated material; and inform al affected persons of applicable benefits, policies, and procedures in connection with said Act;

g. For so long as the project remains authorized, operate, maintain, repair, rehabilitate, and replace the project, or functional portions of the project, including any mitigation features, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government;

h. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor owns or controls for access to the project for the purpose of completing, inspecting, operating, maintaining, repairing, rehabilitating, or replacing the project;

i. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, rehabilitation, and replacement of the project and any betterments, except for damages due to the fault or negligence of the United States or its contractors;

j. Keep and maintain books, records, documents, or other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, or other evidence are required, to the extent and in such detail as will properly reflect total project costs, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments in 32 CFR Section 33.20;

k. Comply with all applicable federal and state laws and regulations, including, but not limited to: Section 601 of the Civil Rights Act of 1964, Public Law 88-352, (42 USC 2000d) and Department of Defense Directive 5500.11 issued pursuant thereto; Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army"; and all applicable federal labor standards requirements including, but not limited to, 40 USC. 3141 - 3148 and 40 USC 3701 - 3708 (revising, codifying and enacting without substantial change the provisions of the Davis-Bacon Act, (formerly 40 USC 276a et seq.), the Contract Work Hours and Safety Standards Act, (formerly 40 USC 327 et seq.), and the Copeland Anti-Kickback Act,(formerly 40 USC 276c et seq.);

l. Comply with Section 221 of, Flood Control Act of 1970, Public Law 91-611 as amended (42 USC 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 USC 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

m. Assume, as between the federal government and the non-federal sponsors, complete financial responsibility for all necessary cleanup and response costs of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), Public Law 96-510 (42 USC 9601-9675) that are located in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project;

n. Agree, as between the federal government and the non-federal sponsors, that the non-federal sponsors shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, repair, rehabilitate, and replace the project in a manner that will not cause liability to arise under CERCLA;

o. Comply with Section 221 of, the Flood Control Act of 1970, Public Law 91-611, as amended (42 USC 1962d-5b), and Section 103(j) of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 USC 2213(j)), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until each non-federal interest has entered into a written agreement to furnish its required cooperation for the project or separable element.

p. Perform or ensure performance of, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the CERCLA, Public law 96-510, as amended (42 USC 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for construction, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government shall perform such investigations unless the federal government provides the non-federal sponsor with prior specific written direction, in which case the non-federal sponsor shall perform such investigations in accordance with such written direction.

Lars N. Zetterstrom
Colonel, U.S. Army Corps of Engineers
District Commander

Date 1 MAR 16

The recommendations contained herein reflect the information available at this time, and current Department of the Army, and U.S. Army Corps of Engineer policies governing formulation of individual projects. The recommendations do not reflect the program and budget priorities inherent to the formulation of a national Civil Works construction program, nor the perspective of higher review levels within the Executive Branch of the U.S. Government. Consequently, the recommendations may be modified before they are transmitted to Congress as proposals for implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other interested parties will be advised of any modifications, and be afforded the opportunity to comment further.

FINDING OF NO SIGNIFICANT IMPACT
for the proposed implementation of
The Resacas
In the Vicinity of the City of Brownsville, Texas,
Interim Ecosystem Restoration Feasibility Study and Environmental Assessment

Purpose. The United States Army Corps of Engineers (USACE) has conducted an environmental assessment to assess potential environmental consequences resulting from implementation of proposed ecosystem restoration of the Resacas in the vicinity of the City of Brownsville, Texas. The purpose of the aquatic ecosystem restoration feasibility study was to evaluate the potential to restore habitat destroyed along three resacas: Resaca de la Guerra, Resaca del Rancho Viejo, and Town Resaca. The environmental assessment is integrated in the feasibility report. The feasibility study was conducted under the authority of House Committee on Transportation and Infrastructure Resolution (10 November 1999) guided by the requirements of Section 206 of the Water Resources Development Act of 1996, (Public Law 104-303), as amended. The Environmental Assessment was conducted in accordance with the National Environmental Policy Act of 1969 (NEPA) (40 CFR Parts 1500-1508) and the Council on Environmental Quality (CEQ) regulations to document findings concerning the environmental impacts of the proposed action.

Proposed Action. The proposed action, the National Ecosystem Restoration plan - Alternative 5, would restore aquatic and terrestrial complexes as self-regulating, connected, functioning systems within two resacas: Resaca de la Guerra and Resaca del Rancho Viejo through the restoration of 44 “stepping stone” areas. The restoration would provide connectivity within the project area and to surrounding high value habitat outside of the project area. In total, the plan would restore about 845 acres of aquatic and riparian habitat along the Resaca de la Guerra and Resaca del Rancho Viejo. About 625 acres of terrestrial riparian habitat would be restored by clearing invasive plants and replanting native riparian vegetation found in reference areas consisting of the Texas Ebony Resaca Forest, Texas Ebony/Snake-eyes Shrubland, and Subtropical Texas Palmetto Woodland. About 218 acres of aquatic habitat would be restored by removing sediment, shaping banks, and planting aquatic and emergent vegetation along the shaped banks. The total restored shoreline would be about 33 miles. The sediment removed from the resacas would be placed in restored riparian areas to mimic the nutrient supplementation of former systems natural processes. Hydrologic reliability of the system would be assured through the implementation of in-channel water control measures, modifying an existing local system.

Alternatives Considered. The USACE identified 66 potential restoration areas along the three resacas. Alternatives were first formulated to achieve ecological connectivity within each resaca through the restoration of degraded or destroyed habitat, and then

formulated to achieve connectivity among the resacas and to the surrounding ecosystem. The formulation was aided by evaluation of cost effectiveness and incremental cost analysis to evaluate the large number of potential combinations of restoration areas against the forecast conditions of taking no action (the no action plan). A final array of six alternatives was identified and ranked based on cost effectiveness. Each successively larger alternative incorporated the restoration plan of the previous alternative. Identification of the National Ecosystem Restoration plan was also guided by one of the study objectives to restore connectivity across the City of Brownsville to surrounding high quality habitat managed by other agencies and environmental interests. Bridging the surrounding habitat would mimic ecosystem conditions resacas historically provided in the lower Rio Grande floodplain. Those conditions existed before the construction of flood risk management projects throughout the Rio Grande basin and before agriculture and urbanization expanded in the lower Rio Grande valley delta and destroyed the resaca habitat. Connectivity through the City of Brownsville would provide some species access to 125,000 acres of high quality managed habitat distributed around the City.

Environmental Effects. Potential impacts assessed for the proposed action included, but were not limited to, those related to water resources, hydrology and floodplains, riverine resources, biological resources, federally threatened and endangered species, cultural resources, land use/recreation/transportation, socioeconomics, aesthetics, health and safety, hazardous and toxic substances, and geology and soils. Cumulative negative impacts due to implementation of the proposed ecosystem restoration components are anticipated to be minimal, while benefits to resacas ecosystem are anticipated to be significant.

The proposed action would restore the degraded ecosystem structure, function, and dynamic processes to a less degraded, sustainable, more natural condition. Existing aquatic habitat isolation and risks of desiccation would be restored through removal of sediment, excavation to expand aquatic habitat, and modification of existing water control features. Existing riparian invasive plant species would be removed and replaced with native plant communities. A sustainable and diverse habitat would be restored for native mammals, birds, reptiles, amphibians and migratory waterfowl. The stepping stone restoration areas would provide a transportation corridor that would support threatened and endangered species in the region. The project would restore fish habitat, support aquatic and riparian vegetative growth, and contribute to more resilient habitat for migrant and resident wildlife. The restored habitat and connectivity would contribute to the continued recovery of state listed Black Spotted Newt and South Texas Siren, and federal listed Red Crowned Parrot, Jaguarundi, and Ocelot.

All practicable means to avoid or minimize environmental impacts due to construction of the proposed action have been considered. The proposed action has been designed with the smallest practicable footprint to meet the objectives. A monitoring and adaptive management plan has been developed to ensure success after implementation. Best management practices associated with construction activities and the timing of construction efforts would be adhered to during implementation to avoid negative impacts to existing biotic, threatened and endangered, cultural and archeological, land use, recreation, transportation, socio-economic, visual/aesthetic, utility, health/safety, HTRW, and soil resources.

Coordination. The proposed action has been fully coordinated with Federal, State, Tribal, and local governments with jurisdiction over the ecological, cultural, and hydrological resources of the project area. A public meeting was held on Wednesday, June 14, 2017 from 5:30-7:30 pm at the Ringgold Civic Pavilion located at 501 East Ringgold, Brownsville, Texas, 78520. The draft feasibility and integrated environmental assessment report was released for a 45-day public review period on March 30, 2017. Four comments were received; all comments were supportive of the project.

Findings. Based on review of the environmental assessment, I conclude the proposed action would not significantly affect the quality of the human environment within the meaning of Section 102(2)(c) of the National Environmental Policy Act of 1969, as amended. I have determined that an environmental impact statement is not required under the provisions of NEPA, Section 102 and applicable regulations of the USACE, and that the proposed project may be implemented.

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Lars N. Zetterstrom
Colonel, U.S. Army Corps of Engineers
District Commander

Date

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