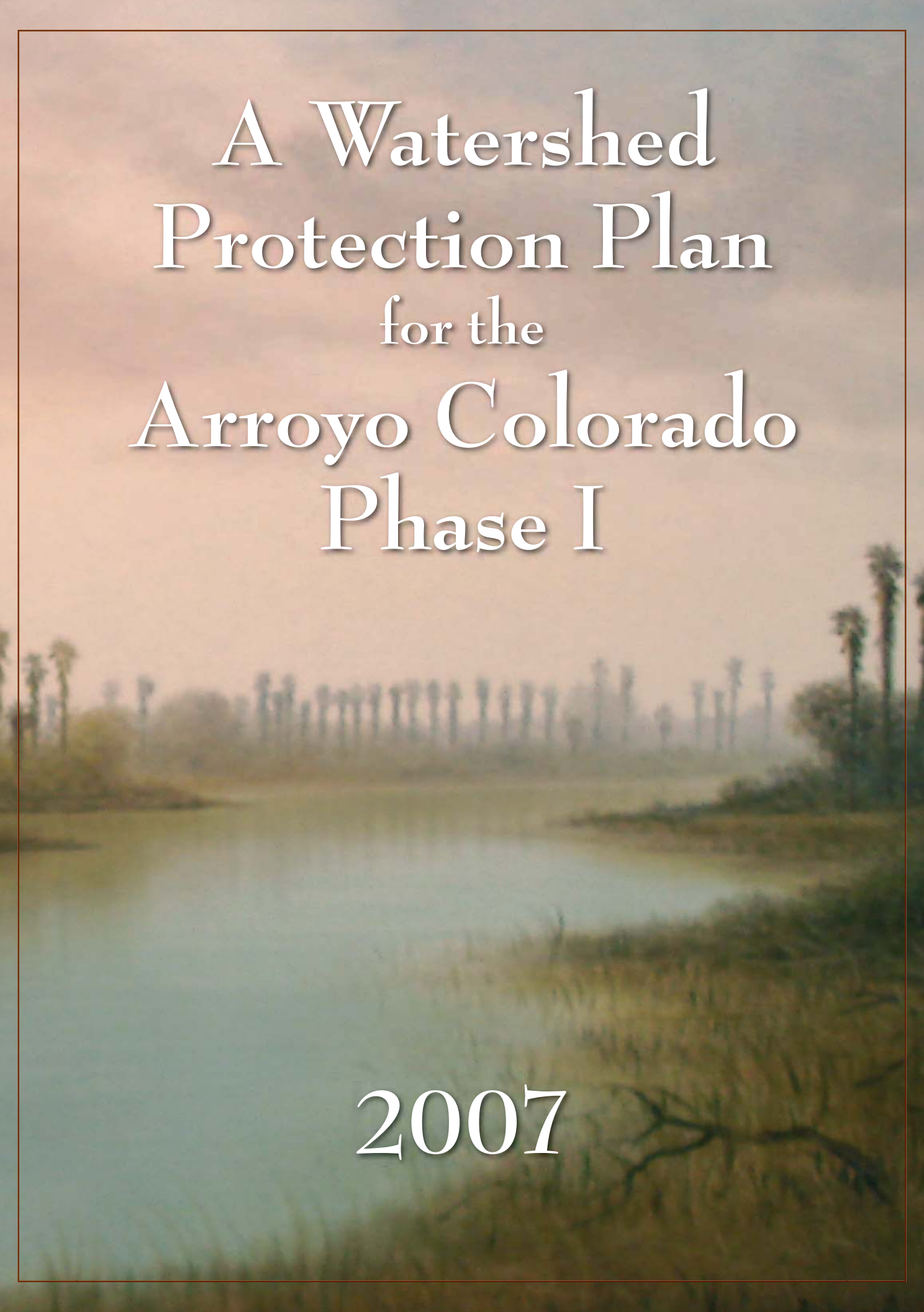

A Watershed Protection Plan for the Arroyo Colorado Phase I

2007

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A Watershed Protection Plan for the Arroyo Colorado Phase I

A Report of the Arroyo Colorado Watershed Partnership and Texas Sea Grant Pursuant to a 2003 USEPA Clean Water Act Section 319(h) Grant Awarded through Texas Commission on Environmental Quality Contract Agreement 583-4-65618

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ACW Partnership Steering Committee meeting in the Rio Red classroom of the TAMUK Citrus Center

EXECUTIVE SUMMARY

The Arroyo Colorado Watershed (ACW) Protection Plan is a comprehensive watershed-based strategy to improve water quality and aquatic and riparian habitat in the Arroyo Colorado. Developed by the Arroyo Colorado Watershed Partnership, a coalition of public and private organizations and concerned individuals known collectively as "stakeholders," the ACW Protection Plan is designed to address impairments and concerns identified in the 2004 Texas Water Quality Inventory and 303(d) List (TCEQ 2004a). The implementation period for Phase I of the ACW Protection Plan is 2006-2015. However, the plan is considered a "living" document subject to revision and modification every 5 years in coordination with revisions made to the Rio Grande (Region M) Regional Water Plan. Phase I of the ACW Protection Plan describes the state of the watershed, presents a strategic plan to improve environmental conditions, and proposes a monitoring plan to document improvements during, and following, implementation of the Plan. Subsequent phases of the Plan will make use of the knowledge gained during implementation of Phase I of the Plan to further improve conditions in the Arroyo Colorado.

The ACW Protection Plan considers the current uses of the Arroyo Colorado, including flood control, navigation, conveyance of municipal/industrial wastewater discharges and irrigation return flows (*i.e.*, tail water), recreation, and environmental uses and presents a detailed strategy to restore and protect these uses. Furthermore, the plan describes the institutional framework for current management programs and proposes a strategy for improving management of water quality in the future in the Arroyo Colorado.

The ACW Protection Plan presents a history and background of water quality in the Arroyo Colorado, identifies the physical characteristics of the watershed, and addresses the nine elements required for Federal Clean Water Act Section 319 grant funding, including:

a. Identifying the causes and sources of pollution
b. Estimating pollution reductions
c. Describing the management measures proposed in the plan
d. Estimating the amount of technical and financial assistance required
e. Establishing a plan for educating and informing the public
f. Establishing a schedule of implementation
g. Describing interim milestones to verify implementation of management measures
h. Describing the criteria for assessing load reductions and water quality improvement
i. Establishing a water quality monitoring plan

The goal of the ACW Protection Plan is to reduce the addition (*i.e.*, loading) of pollutants such as oxygen-demanding substances, nitrogen, phosphorus and sediment to the Arroyo Colorado and to improve natural habitat to the degree necessary to meet the uses designated by the State of Texas and specified in the State's Water Quality Standards (30 TAC §§307.1-307.10). Although not specifically targeted for reduction, fecal bacteria loading to the Arroyo Colorado is also expected to diminish as an ancillary effect of ACW Protection Plan implementation.

Basing decisions on sound science, but also on social and economic reality, the Arroyo Colorado Watershed Partnership (ACW Partnership) set the following realistic load reduction targets for pollutants of concern over the 10-year period of Phase I of the Plan:

Barge moving through the tidal segment of the Arroyo Colorado

Pollutant	Load Reduction (% of current load)
Biochemical Oxygen Demand (BOD)	7%
Sediment	19%
Total Nitrogen	11%
Total Phosphorus	9%

The ACW Partnership expects water quality to improve as a result of implementation of Phase I of the ACW Protection Plan and will assess the success of the Plan over the 10-year implementation period. If necessary, the ACW Partnership will propose additional reductions in pollutant loading and habitat improvements in subsequent phases of the plan in order to achieve State Water Quality Standards.

The Arroyo Colorado Watershed (ACW) Partnership

The ACW Partnership is an organization of more than 400 dedicated individuals who share an interest in the welfare of the Arroyo Colorado and the Lower Laguna Madre. The strategy to protect and restore the Arroyo Colorado described in the ACW Protection Plan was developed by the ACW Partnership. The ACW Partnership grew out of smaller groups of local stakeholders involved in the Total Maximum Daily Load process and is now the leading stewardship organization in the watershed.

The ACW Partnership formed Work Groups to investigate and address topic-specific issues and develop recommendations for the ACW Protection Plan. The seven Work Groups formed were the following:

- Wastewater Infrastructure
- Agricultural Issues
- Habitat Restoration
- Further Study/Phase II TMDL Analysis
- Outreach and Education
- Land Use and Development
- Water Quality Monitoring

Work Group members included technical experts in the various disciplines associated with the specific Work Group topics as well as private individuals and representatives of organizations that are part of the ACW Partnership. The Work Groups developed topic-specific recommendations for consideration by the ACW Partnership and for inclusion into the Plan.

State of the Watershed

The current state of the Arroyo Colorado watershed is not good. Decades of human use have degraded habitat and water quality in the Arroyo Colorado and have strained its ability to assimilate pollutants. The Arroyo Colorado watershed is experiencing rapid urban growth (the population is expected to triple within the next 40 years in the upper portion of the watershed) signifying a future increase in urban wastewater and storm water contributions with time. Improvement of water quality in the Arroyo Colorado necessitates actions and measures that include habitat restoration as well as a reduction in the loading of pollutants from the watershed. Significant wastewater and storm water infrastructure has been installed and more is planned in the Arroyo Colorado watershed over the next 10 years. The ACW Protection Plan includes improved wastewater infrastructure, enhanced treatment of wastewater, large-scale and small-scale habitat restoration projects, implementation of agricultural best management practices on irrigated crop land and a comprehensive Education and Outreach campaign.

Monarch butterfly on its journey south

Habitat

Approximately 95% of the natural habitat in the Arroyo Colorado Watershed has been cleared to make room for agriculture and urban development. In addition to the clearing of stream bank habitat, the main channel of the stream itself has been modified to accommodate functional uses of the stream such as navigation and conveyance of flood waters. Habitat alterations in the Arroyo Colorado include modification of hydrology, dredging, stream bank destabilization, and the loss or degradation of wetlands and riparian environments along the stream. The combined impacts of these actions contribute to the occurrence of low dissolved oxygen (DO) in the tidal segment of the Arroyo Colorado. The straightening, widening and deepening of the tidal segment of the Arroyo Colorado, to facilitate barge traffic, effectively reduces the velocity of the stream, reduces instream circulation, and lowers re-aeration rates in the stream. Removal of sand bars and woody debris has also eliminated potential areas of turbulence that would facilitate re-aeration of the water column.

Invasive plant species, both native and introduced, are plentiful in the land and aquatic habitats associated with the Arroyo Colorado and the Lower Rio Grande Valley. These invasive species have a negative impact on native plant and wildlife populations in the Arroyo Colorado.

The Arroyo Colorado's natural ability to assimilate pollutants and to meet state aquatic life use criteria is limited by habitat loss and by the physical modifications made to the stream for flood control and navigation. Improving natural habitat in the Arroyo Colorado will improve water quality by reducing erosion, removing nutrients, and increasing dissolved oxygen in the stream. The ACW Protection Plan includes the following Actions for habitat improvement in the Arroyo Colorado:

Action 1 - Support the ongoing efforts of the federal, state and local agencies to implement terrestrial habitat conservation objectives in the Arroyo Colorado watershed through partnerships and funding.

Action 2 - Protect and restore existing riparian areas, *resacas* and freshwater wetlands.

Action 3 - Work with drainage districts to modify drainage ditches and maintenance practices to reduce channel and stream bank erosion.

Action 4 - Participate with IBWC during development of maintenance or new work projects for the Arroyo Colorado.

Action 5 - Develop partnerships with the IBWC, drainage districts, and private landowners to implement bank/slope stabilization projects along the Arroyo Colorado or in drainages within the watershed.

Action 6 - Implement projects intended to reduce storm water runoff, reduce sediment load and reduce the volume and velocity of the flow of the runoff in drainage ditches and the Arroyo Colorado.

Action 7 - Support increased use of vegetated filter strips around agricultural production and urban development areas to slow storm water runoff from these areas.

Action 8 - Construct storm water wetland systems in urban developments, redevelopments and areas under agricultural production.

Action 9 - Build wetlands for tertiary treatment of waste streams from individual wastewater treatment plants and/or for polishing flows from multiple wastewater treatment plants in close proximity (incorporating habitat features when feasible).

Action 10 - Build large off-channel wetlands capable of treating flows from multiple sources including wastewater treatment facilities and non-point source runoff from urban and agricultural areas.

Water Quality

Water quality in the tidal segment of the Arroyo Colorado does not support aquatic life because of occasional occurrences of low dissolved oxygen (DO). Water quality in the non-tidal segment of the Arroyo Colorado does not support contact recreation because of high fecal bacteria concentrations. Nutrient concentrations (nitrogen and phosphorus compounds) are high in both segments of the Arroyo Colorado. The concentration of nitrogen compounds such as ammonia and nitrate in the Arroyo Colorado are among the highest in the state, exceeding the 85th percentile of all other tidal water bodies in the state, and historical water quality data indicate an increasing trend over time for these pollutants. Chlorophyll-*a* concentrations, a measure of the stream's algal productivity, consistently exceed the screening criteria in the tidal segment of the Arroyo Colorado and have reached very high levels within recent years (2000-2006), displaying a trend similar to that of nitrogen-containing compounds. Productivity overall is high in the tidal segment of the Arroyo Colorado, and algal blooms, indicative of ecological imbalance, are common in the spring and summer months. Wide daily swings in DO often accompany periods of high algal productivity. A reduction in nutrients in the Arroyo Colorado will help control excessive algal growth and will improve dissolved oxygen levels in the Arroyo Colorado's Zone of Impairment.

Sea birds in the Arroyo Colorado Tidal Segment

Wastewater Infrastructure

The Arroyo Colorado receives treated wastewater from fourteen municipalities and two water supply corporations located in the watershed. The Arroyo Colorado also receives substantial volumes of untreated or poorly treated wastewater generated in *colonias*, which are low income, unincorporated border communities lacking adequate water and wastewater infrastructure. The most recent population estimates (2003) show there are approximately 200,000 residents living in *colonias* in Hidalgo, Cameron and Willacy counties. Most of these residents live within the Arroyo Colorado watershed.

Since the year 2000, compliance with state effluent limits has improved substantially among wastewater treatment facilities in the Arroyo Colorado, and 11 municipalities have significantly increased their wastewater infrastructure, providing new sanitary sewer services to over 37,000 *colonia* residents. During that period (2000-2006), two new wastewater treatment facilities were built and one facility was upgraded.

As part of the ACW Protection Plan, municipalities in the Arroyo Colorado watershed will provide wastewater services to an additional 68,000 *colonia* residents (approximately 42% of the current *colonia* population in the Rio Grande Valley) and six new wastewater treatment facilities and nine upgrades and/or expansions to existing wastewater facilities are planned.

The ACW Protection Plan also includes 11 enhanced wastewater treatment projects (small wetlands and pond systems designed to remove nutrients from treated wastewater), a 500-acre regional wetland system and a 300-acre regional wetland system planned for construction between 2008 and 2015.

Agriculture

The Arroyo Colorado watershed contains approximately 333,000 acres of agricultural land. This land area amounts to approximately half of the land use in the Arroyo Colorado watershed. Cotton and grain sorghum are the primary crops. However, corn, sugarcane and citrus are also commonly grown in the area.

Agricultural production contributes approximately 41% of the BOD, 68% of the total nitrogen, 49% of the total phosphorus, and 87% of the sediment entering the Arroyo Colorado. The goal of the ACW Protection Plan is to achieve the voluntary adoption of agricultural best

management practices (BMPs) on 33% of the irrigated cropland (approximately 100,000 acres) by 2010 and 50% (approximately 150,000 acres) by 2015.

Storm Water Management

Until recently, pollution from urban storm water was largely unregulated in the Arroyo Colorado watershed. Since 2003, efforts to control urban storm water runoff in the Arroyo Colorado watershed have been limited to outreach and education for municipalities in the Rio Grande Valley in efforts to familiarize them with the requirements of the recent federal (Phase II) storm water regulations for small Municipal Separate Storm Sewers (MS4s). However, in 2007, local governments will begin developing Storm Water Management Programs (SWMPs) for more than 60 Urbanized Areas located in the Arroyo Colorado watershed. The ACW Partnership will work with the Lower Rio Grande Valley TPDES Storm Water Task Force, a local partnership of 18 municipalities and Texas A&M University–Kingsville established to ensure compliance with Phase II Storm Water requirements for small MS4s in the Rio Grande Valley, to focus SWMPs on preventing nonpoint source pollution of the Arroyo Colorado. The SWMPs are expected to reduce loading of pollutants of concern to the Arroyo Colorado. The ACW Partnership will also work with the TCEQ to complete demonstration projects showing the effectiveness of non-structural BMPs in reducing urban nonpoint source pollution.

Education and Outreach

Prior to 2000, only limited outreach and education (E&O) efforts were conducted by state and local governments in the Rio Grande Valley focusing specifically on the water quality issues associated with the Arroyo Colorado.

Since 2004, the ACW Partnership has provided E&O to stakeholders and citizens about topics and issues that affect water quality and habitat in the Arroyo Colorado. In 2006, the ACW Partnership commissioned a social marketing report to guide outreach efforts in the watershed. The report forms the basis for the E&O campaign described in the ACW Protection Plan. The campaign consists of nine major **Strategies** and uses a combination of broad and targeted outreach efforts with a variety of message delivery vehicles. The **Strategies** are the following:

Strategy 1 - Establish a Brand.

Acknowledging the contribution of Cameron County Drainage #5 to the development of an educational wetland in Mercedes

Strategy 2 - Deliver Basic Facts about the Arroyo Colorado.

Strategy 3 - Raise Awareness and Increase Community Involvement in the Arroyo Colorado Watershed Partnership Initiative.

Strategy 4 - Develop Partnership Agreements for Message Distribution.

Strategy 5 - Create Micro-Campaigns for Specific Target Audiences.

Strategy 6 - Institutionalize a Practice of Ongoing Campaign Evaluation.

Strategy 7 - Establish Volunteer Monitoring Programs on the Arroyo Colorado and Associated Drainages.

Strategy 8 - Collaborate with Government Agencies Offering Environmental E&O.

Strategy 9 - Collaborate with Non-Governmental Organizations (NGOs) Supporting Environmental Education and Conservation Programs in the Watershed.

Sources and Causes of Pollution

A thorough review of the sources and causes of poor water quality in the Arroyo Colorado reveals high nutrient loading from municipal wastewater, agriculture, and urban storm water. These loadings, along with the loss of natural habitat and the physical modifications made to the stream, cause low dissolved oxygen in the tidally influenced portion of the Arroyo Colorado.

Permitted wastewater outfalls account for 20-40% of the loading of pollutants of concern to the Arroyo Colorado; 18 municipal wastewater treatment facilities account for more than 95% of the permitted point source load. These 18 facilities are considered to be the "Principal Point Source Contributors" of pollutants in the Arroyo Colorado Watershed. The Arroyo Colorado also receives pollutant loading (approximately 4%) from poorly treated and essentially untreated wastewater generated by *colonias*. Urban storm water contributes 6-26% of the loading of pollutants of concern to the Arroyo Colorado and agriculture accounts for approximately 49-68% of the nutrient loading to the Arroyo Colorado and 87% of the sediment loading.

Since 2000, investments in wastewater infrastructure and the implementation of agricultural BMPs have reduced both point and nonpoint source loadings of pollutants to the Arroyo Colorado. However, high ammonia and nitrate nitrogen concentrations in the Arroyo Colorado indicate excessive loading of nutrients continues to be a problem in the watershed.

Institutional Framework

Federal, state and local governments share responsibility for managing water quality and habitat in the Arroyo Colorado. Federal, state, regional and local government agencies involved in developing and implementing the ACW Protection Plan include the following:

Federal Agencies

U.S. Environmental Protection Agency (USEPA)

U.S. International Boundary and Water Commission (USIBWC)

National Oceanic and Atmospheric Administration (NOAA)

U.S. Army Corps of Engineers (USACE)

U.S. Geological Survey (USGS)

State Agencies

Coastal Coordination Council (CCC)

Texas General Land Office (GLO)

Texas Parks and Wildlife Department (TPWD)

Texas State Soil and Water Conservation Board (TSSWCB)

Texas Commission on Environmental Quality (TCEQ)

Texas Sea Grant, Texas Cooperative Extension and the Texas A&M University System (TAMU)

Texas Water Resource Institute (TWRI)

Local/Regional Agencies

Nueces River Authority (NRA)

Local Drainage Districts

Local Irrigation Districts

Rio Grande River Water Authority (RGWA)

Lower Rio Grande Valley Development Council (LRGVDC)

Lower Rio Grande Valley TPDES Storm Water Task Force

Port of Harlingen Authority (POH)

Refer to Appendix A for a complete list of acronyms.

Although state and federal governments play an important role in protecting water quality and habitat in the Arroyo Colorado, local stewardship and the actions of local governments have the greatest direct impact on the overall health of the stream. Irrigation districts and drainage districts play a particularly important role in the management of water quality in the Arroyo Colorado because they control conveyance of water to the stream. Regional entities such as The Lower Rio Grande Valley Development Council (LRGVDC) and the Lower Rio Grande Valley (LRGV) Texas Pollution Discharge Elimination System (TPDES) Storm Water Task Force often provide direction in planning and implementation efforts. These efforts are enhanced by the coordination efforts of the ACW Partnership.

Elements of the Watershed Protection Plan

The ACW Protection Plan is composed of seven principal components, including wastewater infrastructure, agriculture, industrial practices, urban storm water runoff, land use, education and outreach (E&O) and monitoring. Each component or element of the plan relates to a particular need or concern identified by the stakeholders or a requirement under state or federal regulations.

The measures contained in the Plan include:

- Construction of small wetland cells and pond systems for removal of nutrients from treated wastewater,
- Construction of regional wetland systems to improve habitat and remove nutrients from urban and agricultural runoff,
- Revised effluent limits for existing and proposed wastewater treatment systems permitted by the State of Texas,
- Improved wastewater infrastructure for municipalities and rural communities in the watershed,
- Floodplain and stream stabilization to reduce bank erosion and improve riparian and aquatic environments,
- Increased implementation of agricultural management practices designed to mitigate pollutants from farming in the watershed,
- Improved management measures at and near the Port of Harlingen designed to mitigate unauthorized releases of fertilizer and raw sugar into the tidally influenced portion of the Arroyo Colorado,
- Water quality monitoring to assess the health of the Arroyo Colorado and gain additional knowledge of the pollutant sources and water quality problems, and
- Increased E&O efforts to inform and engage stakeholders and the public.

Monitoring and Measuring Progress

The most direct indicator of the success of the ACW Protection Plan is the quality of water in the Arroyo Colorado; specifically, lower nutrient concentrations for the entire Arroyo Colorado and higher levels of dissolved oxygen in the tidally-influenced portion of the Arroyo Colorado, where the levels of dissolved oxygen are persistently low under warm and dry conditions. Research has shown that nutrient and sediment inflows into the tidally influenced portion of the Arroyo Colorado contribute significantly to the low dissolved oxygen observed in this area of the stream. The Water Quality Monitoring Plan detailed in the ACW Protection Plan is an important tool to help assess the effectiveness of the Plan, to gain a greater understanding of causes of low dissolved oxygen in the Arroyo Colorado, and to better characterize the sources of pollution in the watershed. The ACW Partnership acknowledges that watershed planning and water quality management is an iterative and adaptive process that will continue to evolve with time. As more is learned about the causes and the solutions to environmental degradation, the ACW Partnership will do everything in its power

to institute the measures necessary to restore, protect and preserve water quality and habitat in the Arroyo Colorado and the Lower Laguna Madre. The Water Quality Monitoring Plan contained in the ACW Protection Plan is comprised of three principal components.

Watershed-scale Water Quality Monitoring

Twelve monitoring sites were chosen by the ACW Partnership to assess water quality and evaluate the ACW Protection Plan's effectiveness on a watershed scale. The sites are long-term monitoring stations with robust volumes of historical data; the majority of the watershed-scale monitoring stations are located at sub-basin boundaries facilitating spatial and temporal trend analysis of data. Watershed-scale water quality monitoring will be conducted on a quarterly basis (four times per year) in the Arroyo Colorado.

Wastewater Effluent Monitoring

Two different types of effluent quality monitoring are planned under the ACW Protection Plan. In addition to reporting flow and effluent concentrations of parameters required under existing TPDES discharge permits, 13 municipalities and two water supply corporations participating in the plan will collect and report nutrient and bacteria parameters. Additionally, wastewater treatment facility operators implementing enhanced treatment projects under the ACW Protection Plan will also monitor flow, biochemical oxygen demand, total suspended solids and nutrients at the polished outfall locations downstream of the enhanced treatment areas.

Project Specific Monitoring

Project-specific monitoring includes data collection for specific activities and interests of the ACW Partnership. These activities include:

- Data collection efforts associated with the development of Total Maximum Daily Loads (TMDLs) for the Arroyo Colorado or to fill known data gaps, and
- Projects assessing the impact of agriculture or the effectiveness of agricultural BMPs.

In addition to water quality monitoring and the associated environmental indicators measured as part of the monitoring plan (*i.e.*, levels of dissolved oxygen, nutrient concentrations, etc.), the ACW Partnership established a set of milestones and measures of success for the ACW Protection Plan that include programmatic, social and environmental indicators. Programmatic indicators will measure the relative success achieved in implementing the individual actions and measures included in the plan; these include estimates of acres of restored or created wetlands, number and types of BMPs installed, number of *colonia* residents provided with centralized water services, number of voluntary water quality monitors trained, etc. Social indicators include the number of watershed residents surveyed with increased knowledge of watershed issues, number of ACW Partnership participants, etc. Finally, environmental indicators will measure the overall health of the Arroyo Colorado as the ACW Protection Plan is implemented; these include in-stream chemical parameters as well as the occurrences of algal blooms, occurrence of fish kills, etc.

The Arroyo Colorado looking east from the bridge at Highway 77 in Harlingen

INTRODUCTION

In its most pristine condition, before the arrival of European settlers, the Arroyo Colorado was undoubtedly a coastal stream of extraordinary grace and beauty. Its pools of mirror-still water bore the reflection of a diverse and unique semi-tropical, coastal environment which exists today only in very few and very special places. Gliding across the delta plain of the once mighty Rio Grande River, the quiet waters of the Arroyo Colorado would have crept almost unnoticed through a haunting maze of moss-draped hardwoods that crowded its banks tethered by woody vines and shading a thick, thorny understory of acacias, low palms, scrub brush and cactus. In its slow journey to the coast, the Arroyo Colorado flowed into large expanses of brackish marshland where shorter but equally dense vegetation concealed a complex coastal ecosystem no less exotic than the rich wildlife community that thrived in the headwaters of the upper delta region. Sadly, this image of the Arroyo Colorado vanished long ago along with those who were fortunate enough to behold it.

Shortly after the beginning of the 20th century, large-scale agricultural production began in earnest in the Lower Rio Grande Valley and in the Arroyo Colorado watershed. The clearing of native plant cover was the first necessary step to accessing the rich organic soils of the delta plain. This clearing was accomplished on a massive scale in the Rio Grande Valley in the 1920s and 1930s.

The semi-arid climate of the region led to the second necessary step for agricultural development, which was construction of a world-class irrigation system capable of extracting, conveying and distributing huge quantities of water over large areas of farm land. Although canal building began in the 1900s, the modern irrigation system in the Rio Grande Valley was not completed until the early 1930s.

Brush clearing brush in the Arroyo Colorado Watershed

Center for American History, UT-Austin Robert Runyon Photography Collection

Canal-building in the 1900s

The flat topography and flood-prone nature of the Rio Grande Delta led to the third necessary step in the development of the Lower Rio Grande Valley, which was construction of a flood-control system capable of mitigating the effects of catastrophic flooding, a relatively frequent and regular event in all natural deltaic systems.

To this end, in 1947 the United States Section of the International Boundary and Water Commission completed the Lower Rio Grande Valley Flood Control Project, a massive flood control system spanning the entire length of the Lower Rio Grande Valley from the City of Mission (in the west) to the City of Harlingen (in the east) and the City of Brownsville (in the southeast).

Today the Arroyo Colorado is a hard-working stream. With very little native vegetation remaining along its banks, the Arroyo Colorado forms the heart of the Lower Rio Grande Valley Flood Control Project by serving as the pilot channel for the Main Floodway (Figure 1). Regularly dredged from its confluence with the Laguna Madre to the Port of Harlingen, located approximately 23 miles inland, the tidally influenced portion of the Arroyo Colorado is also an important navigational channel used extensively for agricultural commerce. As the main system for conveyance of wastewater and irrigation return flows out of the Rio Grande Valley, the Arroyo Colorado is the primary source of fresh water for the Lower Laguna Madre, an important nursery for fish, shrimp and crab, and a popular site for recreational fishing and boating.

Figure 1. Hydrologic Map of the Arroyo Colorado Showing Floodway Systems

Tugboat moving through Tidal Segment of the Arroyo Colorado

After nearly a century of service, the wear of human use has taken its toll on the Arroyo Colorado. This once beautiful and serene coastal stream now suffers from some of the poorest water quality in the State of Texas, a problem that may also eventually affect the prolific fisheries of the Lower Laguna Madre.

The ACW Partnership is committed to the restoration and protection of the Arroyo Colorado. As a coalition of concerned stakeholders, the Partnership recognizes the intrinsic value of the natural resources that comprise the Arroyo Colorado-Laguna Madre estuarine system and have developed an infrastructure and a strategy to improve conditions in the Arroyo Colorado. Given the magnitude of the problems and issues associated with this important coastal stream, the ACW Partnership is under no illusion that restoring and protecting the Arroyo Colorado will be a simple or quick undertaking.

Phase I of the ACW Protection Plan represents the first comprehensive step toward restoring and protecting water quality and natural habitat in the Arroyo Colorado. This document should be viewed as a planning tool containing feasible proposals for improving the current condition of the Arroyo Colorado and for monitoring progress toward that goal. The ACW Partnership will revise and adjust the Plan every five years as the restoration and protection measures contained in the Plan are implemented and additional information on the health of the Arroyo Colorado becomes available.

The ultimate goal of the ACW Protection Plan effort is to achieve state water quality standards that are currently not being met in the stream. However, predictable cause-and-effect relationships between pollutant loading and observed water quality are hard to establish in most water bodies and these relationships are particularly confounded in streams like the Arroyo

Aerial view of the Arroyo Colorado Tidal Segment

Colorado, where physical modifications and habitat destruction contribute significantly to poor water quality. Hard as it may be to predict water quality from changes in pollutant loading, predicting changes in water quality brought about from restoration of channel features and aquatic and riparian habitat is nearly impossible. For this reason, the ACW Partnership is using an adaptive management approach to implementing the ACW Protection Plan. The ACW Partnership will monitor changes in pollutant loading, habitat, and water quality in the Arroyo Colorado during implementation of Phase I of the ACW Protection Plan. The information gathered during Phase I of the plan will be used to develop subsequent phases of the Plan.

Watersheds

In order to effect significant change in the condition of the Arroyo Colorado, or any natural water body, the strategies and plans designed to improve water quality and/or habitat must encompass all elements that contribute flow and pollutant loading to the aquatic system. For this reason, virtually all plans designed to restore and/or protect aquatic resources are watershed-based plans.

A watershed is the land surface that drains into a specific water body (*i.e.*, creek, stream, river, lake, wetland, marsh, bayou or bay). In most river systems, the creeks and streams that drain small land surfaces are known as first order streams. These small streams eventually run into bigger second and third order streams that represent the drainage of bigger and bigger areas of land (Figure 2). Watersheds are defined by both the water body receiving the drainage and by the terrain or topography of the land surface that drains into the water body.

A collection of watersheds forms a drainage basin, and a collection of drainage basins forms a drainage system. An easy way to understand watersheds, drainage basins and drainage systems is to think of them as a series of bowls that flow into each other (Figure 3). The "bowls" become successively larger as the size of the receiving water body increases and the number of "bowls" flowing into each successively larger "bowl" also increases with the size of the receiving water body.

Figure 3. Diagram Showing the Relationship Between the Arroyo Colorado Watershed, the Laguna Madre Drainage Basin and the Gulf of Mexico Drainage System

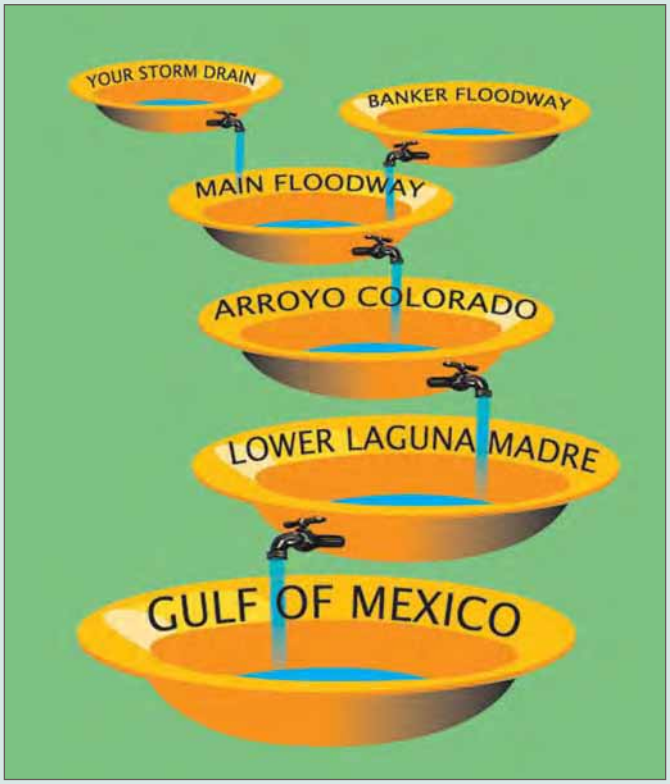
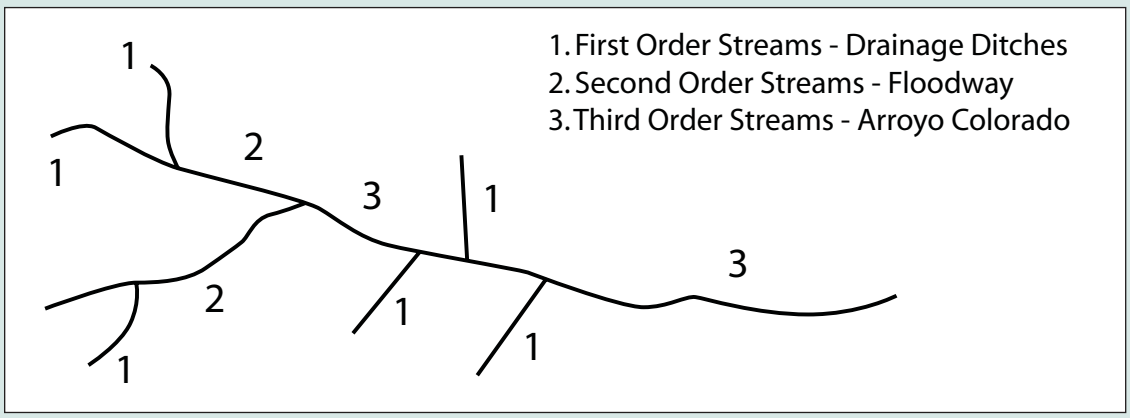


Figure 2. Diagram Representing Stream Order as it Relates to the Arroyo Colorado



Watershed Stewardship

Virtually everyone lives or works in a watershed. Even if a person's home is not located near water, that home is certain to be on land that drains into a creek, river, lake or estuary. As homeowners and citizens, we often engage in activities that affect the quality of the water that drains from the areas in which we live and work. Individual actions may not seem like much, but collectively, they can have a big impact on the health of our natural water bodies. Because watersheds are defined by natural topography, which in turn defines drainage area, watersheds make good units for managing aquatic resources, although they often cross the jurisdictional boundaries of local governments. Using watersheds as management units, the aquatic resource becomes the focal point, and managers are able to gain a more complete understanding of overall conditions in an area and the stressors that affect those conditions (USEPA 1996). However, resource managers cannot effect change in water quality by themselves. Ultimately, it takes the caring stewardship of the citizens living within the watershed to restore and protect the aquatic resources offered by the receiving water bodies.

Recreational fishermen in the Arroyo Colorado Tidal Segment

View of the south shore of the Arroyo Colorado at Arroyo City

THE ARROYO COLORADO WATERSHED PARTNERSHIP

The Arroyo Colorado Watershed Partnership (ACW Partnership) is a coalition of organizations and concerned citizens committed to restoring and protecting the aquatic resources of the Arroyo Colorado-Lower Laguna Madre Estuarine System. The Partnership is composed of approximately 400 dedicated individuals or stakeholders. A stakeholder is an individual or organization with an interest (*i.e.*, a stake) in the welfare of a particular natural resource or that is affected in a significant way by the implementation of recommendations designed to protect and restore the resource. The ACW Partnership grew out of two smaller groups of local stakeholders formed in 1998 as part of the State of Texas' Total Maximum Daily Load process. The groups went by the names Arroyo Colorado Total Maximum Daily Load (TMDL) Steering Committee and Science and Technology Advisory Committee (STAC). The State of Texas' efforts to develop TMDLs for the Arroyo Colorado are discussed in more detail in other sections of this document.

Organizational Structure

The ACW Partnership is structured in a way that allows debate and input from all participants while retaining the ability to make decisions in an organized and timely manner. Members of the Partnership (more than 400) participate in decision-making through Work Groups that focus on issues that affect the health of the Arroyo Colorado (Figure 4). The Work Groups

Figure 4. Organizational Structure of the Arroyo Colorado Watershed Partnership

(7 in total) develop recommendations that form the basis for the components of the Watershed Protection Plan. All seven Work Groups report to a 25 member Steering Committee composed of members of the ACW Partnership with diverse backgrounds and interests. The Steering Committee receives recommendations from the Work Groups and makes decisions on behalf of the Partnership based on these recommendations.

Steering Committee

The ACW Partnership Steering Committee (Steering Committee) was formed by the ACW Partnership to guide decision-making while providing equitable representation of the Partnership members. In addition to guiding the development and implementation of the ACW Protection Plan, the Steering Committee also advises the TCEQ on on-going efforts to establish Total Maximum Daily Loads (TMDL) for the Arroyo Colorado.

Early in its formation, the ACW Steering Committee agreed to a set of Ground Rules under which it currently operates (Appendix B). The proceedings of the Steering Committee are carried out mainly by consensus, although on rare occasions there is a call for vote on a particular issue. On these occasions, issues are decided by a simple majority a vote.

Steering Committee meeting at Harlingen Public Library

Specific roles of the Steering Committee include:

- Identifying measurable water quality and habitat restoration goals,
- Making recommendations to state and regional agencies regarding water quality monitoring and modeling needed to identify and assess the sources of pollution in the Arroyo Colorado watershed,
- Estimating pollution reduction targets necessary to comply with state and federal water quality standards,
- Developing and updating the ACW Protection Plan to improve water quality and aquatic habitat,
- Leading efforts to implement the Watershed Protection Plan at the local level, and
- Communicating the progress of the Plan to other interested parties in the watershed.

The current Steering Committee consists of representatives of the following organizations as well as private individuals:

- Atascosa National Wildlife Refuge/U.S. Fish and Wildlife Service
- Cameron County Drainage District #5
- Coalition to Save the Arroyo Colorado
- Cotton Growers' Association
- East Rio Hondo Water Supply Corporation
- Harlingen Irrigation District Cameron County #1
- Harlingen Waterworks System
- International Boundary and Water Commission
- Lower Laguna Madre Foundation
- Lower Rio Grande Development Council
- LRGV TPDES Storm Water Task Force
- McAllen Public Utilities
- Military Highway Water Supply Corporation
- Nueces River Authority
- Port of Harlingen Authority
- Rio Grande Valley Sugar Growers Coop
- Sierra Club – Lone Star Chapter
- Texas A&M University-Kingsville
- Texas Citrus Mutual
- Texas Department of Agriculture
- Texas Parks and Wildlife Department
- Texas Sea Grant
- Texas State Bank
- Texas State Soil Water Conservation Board
- Texas Water Development Board
- The University of Texas at Brownsville

A complete list of the members of the ACW Partnership Steering Committee can be found in Appendix C of this document.

Work Groups

The ACW Partnership formed Work Groups to investigate and address topic-specific issues and develop recommendations for the Plan.

The seven Work Groups formed are as follows:

- Wastewater Infrastructure
- Agricultural Issues
- Habitat Restoration
- Further Study/Phase II TMDL Analysis
- Outreach and Education
- Land Use and Development
- Water Quality Monitoring

Work Group members include technical experts

Habitat work group meeting

in the various disciplines associated with the specific Work Group topics as well as private individuals and representatives of organizations that are included in the Partnership. The Steering Committee selected the leaders of the Work Groups based on qualifications, professional affiliations and level of interest. The main responsibility of the Work Group leaders is to guide the development of topic-specific recommendations for consideration by the Steering Committee and for inclusion into the Plan. Work Group leaders are also responsible for developing Work Group meeting agendas, facilitating the Work Group meetings, disseminating Work Group meeting announcements and producing Work Group meeting summaries. Collectively, the goal of the Work Groups is to investigate and address topic-specific aspects of water quality and habitat impairments in the Arroyo Colorado.

The ACW Protection Plan is based largely on the efforts of the seven Work Groups listed previously, in consultation with the Steering Committee. A complete list of the individuals who participated in each of the Work Groups is included in Appendix D. The Wastewater Infrastructure, Habitat Restoration and Agricultural Issues Work Groups produced detailed supporting documents that formed the major components of the Plan. These three reports, along with the Draft Phase I Dissolved Oxygen TMDL report, a feasibility study for habitat restoration and a social market survey, were used to develop the Plan.

Table 1. Work Groups of the Arroyo Colorado Watershed Partnership and Work Group Leaders by Affiliation

Work Group	Work Group Leader by Affiliation
Wastewater Infrastructure	Texas Commission on Environmental Quality
Agricultural Issues	Texas State Soil and Water Conservation Board
Habitat Restoration	Texas Parks and Wildlife Department
Further Study/TMDL	Texas Commission on Environmental Quality
Outreach and Education	Texas Sea Grant
Land Use	Texas Sea Grant
Monitoring	Nueces River Authority

Work Group members tour the Arroyo Colorado Above Tidal

Mission

The following mission statement was adopted by the ACW Partnership:

"Reduce the additions of pollutants to the Arroyo Colorado to the maximum extent possible in order to meet state water quality standards and improve the natural terrestrial, riparian, and aquatic habitat associated with the Arroyo Colorado Watershed."

Vision

The ACW Partnership adopted the following Vision:

"An ecologically sound Arroyo Colorado and Lower Laguna Madre that is understood and valued by all residents of the Lower Rio Grande Valley."

Goals

The ACW Partnership adopted the following goals:

- Reduce the additions (*i.e.*, loading) of nitrogen, phosphorus, ammonia, sediment, bacteria and biochemical oxygen-demanding substances by 7-19% over the next 10 years,
- Improve the awareness and understanding of the water quality issues associated with the Arroyo Colorado, its connection to the Lower Laguna Madre and the value both these natural resources bring to the communities of the Lower Rio Grande Valley,
- Improve water quality to minimize fish kills and maintain aquatic diversity,
- Encourage the voluntary adoption of best management practices (BMPs) to reduce suspended solids from cropland erosion, BOD from crop residue and nitrogen and phosphorus fertilizer runoff from irrigated and non-irrigated cropland,
- Improve the quality of treated effluent from wastewater treatment facilities,
- Increase wastewater and storm water infrastructure development for rural and unincorporated low-income communities (*i.e.*, *colonias*) in the Arroyo Colorado watershed,
- Implement enhanced biological treatment projects to remove nutrients from wastewater treatment facility effluent,

Arroyo Colorado near Harlingen

- Focus Phase II Storm Water Management Programs for small MS4s on the pollutants of concern in the Arroyo Colorado,
- Protect and restore valuable terrestrial habitat areas throughout the watershed,
- Protect and restore riparian areas, *resacas*, and freshwater and coastal wetlands,
- Reduce erosion and nonpoint source runoff through enhanced structural control measures along the stream banks of the Arroyo Colorado and throughout the watershed,
- Coordinate decision-making for the protection, restoration, and enhancement of the Arroyo Colorado and its watershed, and
- Introduce and encourage alternative urban development designs that help protect and restore water quality.

Background

The effort to produce a Watershed Protection Plan for the Arroyo Colorado evolved from the State of Texas' effort to develop a Total Daily Maximum Load (TMDL) to address low dissolved oxygen in the stream. The goal of Texas' TMDL program is to restore water quality in water bodies that do not meet the State's Water Quality Standards; these water bodies are often referred to as "impaired." TMDLs are established using analytical methods that determine a water body's capacity to assimilate pollutants. Based on these estimates, TMDLs assign a "budget of pollution" to all the sources in the watersheds of the impaired water bodies.

For as long as the state of Texas has been assessing water quality in the State, the Arroyo Colorado has consistently failed to meet the States' Water Quality Standards. As required by federal law, the Texas Commission on Environmental Quality (TCEQ) established TMDLs for four legacy pesticides in 2001 and added eight additional TMDLs for toxic organic compounds in 2003. In addition to these TMDLs, the TCEQ also completed a TMDL study to address low dissolved oxygen (DO) in 2002. The TMDL study showed that extensive physical modifications and excessive nutrient concentrations were the cause of periodic, but occasionally severe, oxygen depletion in the boundary between the fresh water and tidally influenced portions of the stream. The DO TMDL study also found that, in order to meet the DO criteria specified in the States' Water Quality Standards, the loading of nitrogen and phosphorus-based pollutants to the Arroyo Colorado would have to be reduced by as much as 90%. This is due, in part, to the physical modifications imposed on the stream (*i.e.* dredging and channelization for navigational purposes), which greatly diminish its capacity to assimilate pollutants.

Because of the uncertainty associated with the DO TMDL analysis (referred to hereafter as the Phase I TMDL Study) and because the TCEQ did not consider a load reduction target of 90% to be realistically achievable, a TMDL to address low DO in the Arroyo Colorado was not established (TCEQ 2003). However, the Phase I TMDL study showed that improvements in water quality, including higher DO levels, can be achieved by reducing the amounts of nutrients and BOD entering the stream.

Storm over the watershed

Following completion of the Phase I TMDL study in 2002, the TCEQ began efforts to develop a comprehensive strategy to improve water quality in the Arroyo Colorado. The Phase I TMDL study included a thorough investigation of the causes and sources of pollution and provided a starting point for the development of the ACW Protection Plan.

Through a Clean Water Act (CWA) Section 319(h) grant awarded by the U.S. EPA, the TCEQ provided financial support to the Texas Sea Grant College Program, a division of the Texas A&M University System, to facilitate and coordinate the development of a community-based watershed protection plan for the Arroyo Colorado. Using the existing framework for stakeholder involvement and public participation, Texas Sea Grant facilitated the formation of the ACW Partnership to foster watershed stewardship and develop the ACW Protection Plan.

With substantial technical support from the TCEQ, Texas Parks and Wildlife Department (TPWD), Texas State Soil and Water Conservation Board (TSSWCB), U.S. Fish and Wildlife Service (USFWS), U.S. Geological Survey (USGS), Texas Parks and Wildlife Department (TPWD), and the U.S. International Boundary Water Commission (IBWC), the ACW Partnership developed a comprehensive plan to restore and protect the uses designated to the Arroyo Colorado and the Lower Laguna Madre by the State of Texas, including a high aquatic life use and contact

Tidal Segment near Arroyo City

recreation. This strategy is described in detail in this Watershed Protection Plan document and in supporting documents. The TCEQ is continuing efforts to establish a TMDL to address low dissolved oxygen in the Arroyo Colorado and expects to complete Phase II of the Arroyo Colorado DO TMDL in 2009.

Supporting Documents

- *Four Total Maximum Daily Loads for Legacy Pollutants in the Arroyo Colorado Above Tidal and the Donna Reservoir and Canal System*, January 2001, adopted by the Texas Commission on Environmental Quality.
- *Twelve Total Maximum Daily Loads for Legacy Pollutants in the Arroyo Colorado Above Tidal and the Donna Reservoir and Canal System*, July 2003, adopted by the Texas Commission on Environmental Quality.
- *Pollutant Loading and Dissolved Oxygen Dynamics in the Tidal Segment of the Arroyo Colorado*, Draft Report, July 2003, developed by the Texas Commission on Environmental Quality.
- *Arroyo Colorado Watershed Protection Plan: Components Addressing Agricultural Nonpoint Source Pollution*, 2005, developed by the Agricultural Issues Work Group of the Arroyo Colorado Watershed Partnership and prepared by the Texas State Soil and Water Conservation Board.
- *Pollutant Reduction Plan for the Arroyo Colorado: Segments 2201 and 2202 Hidalgo, Cameron, and Willacy Counties*, July 2006, developed by the Wastewater Infrastructure Work Group of the Arroyo Colorado Watershed Partnership and prepared by the Texas Commission on Environmental Quality.
- *Arroyo Colorado Habitat Restoration Plan*, April 2006, developed by the Habitat Restoration Work Group of the Arroyo Colorado Watershed Partnership and prepared by Kay Jenkins, Texas Parks and Wildlife Department.
- *Feasibility Study for Habitat Restoration/ Modification to Improve Water Quality in the Arroyo Colorado*, January 2006, developed by Alan Plummer Associates, Inc., in association with CRESPO Consulting Services, Inc.
- *Final Report for the WQMP Implementation Assistance in the Arroyo Colorado Watershed Management Project*. FY99 Clean Water Act, Section 319(h) Nonpoint Source Grand. Contract No. 99-104. Texas State Soil and Water Conservation Board.
- *Arroyo Colorado Watershed Partnership Education and Outreach Campaign*, May 2006, developed by SumaOrchard in collaboration with White Hat Creative and the Arroyo Colorado E&O Work Group.

These and other supporting documents are available at <http://www.arroyocolorado.org>.

Riparian wildlife

THE ARROYO COLORADO WATERSHED

The Arroyo Colorado is located in the Lower Rio Grande Valley of South Texas and flows through the middle of Hidalgo and Cameron counties. The lower 16 miles of the Arroyo Colorado form the boundary between Cameron and Willacy counties (Figure 5). The Arroyo Colorado drainage area (*i.e.*, watershed) is a sub-watershed of the Nueces-Rio Grande Coastal Basin, also known as the Lower Laguna Madre Watershed (Hydrologic Unit Code 12110208).

The streams of the Nueces-Rio Grande Coastal Basin, including the Arroyo Colorado, drain to the Laguna Madre, which is considered to be one of the most productive hypersaline lagoon systems in the world (TPWD 2006a). The Rio Grande River is the largest fluvial system of the lower coast of Texas and forms the border between the United States and Mexico. The Lower Rio Grande Valley comprises the northern part of the Rio Grande Delta, a broad fluvio-deltaic plain laid down over tens of thousands of years by the ancestral Rio Grande. The Arroyo Colorado is thought to have been an ancient channel of the Rio Grande that became isolated from the main flow of the river during one of many flood events that caused the river to change its course. Just as the Rio Grande is the major source of fresh water for the Lower Rio Grande Valley, the Arroyo Colorado System serves as the main drainage stream for this area of Texas.

Arroyo Colorado Watershed Characteristics

The Arroyo Colorado Watershed is approximately 1,828 square kilometers (706 square miles). It is bounded on the west and south by the drainage divide to the Rio Grande, on the north by the drainage divide to the North Floodway and on the east by the Lower Laguna Madre.

The Arroyo Colorado is part of the United States International Boundary Water and Commission's (IBWC's) Lower Rio Grande Valley Flood Control Project, a flood control system that consists of interior floodways including the Banker, Main, North and Arroyo Colorado Floodways. In its uppermost reaches, the Arroyo Colorado is the pilot channel for the Main Floodway (Figure 1). The first major tributary to the Arroyo Colorado in Hidalgo County is the Banker Floodway. The North Floodway branches off of the Main Floodway at the Llano Grande, a shallow lake located southwest of the city of Mercedes. Beyond

Figure 5. Arroyo Colorado Watershed and Lower Laguna Madre Drainage Basin (Hydrologic Unit Code HUC 12110208)

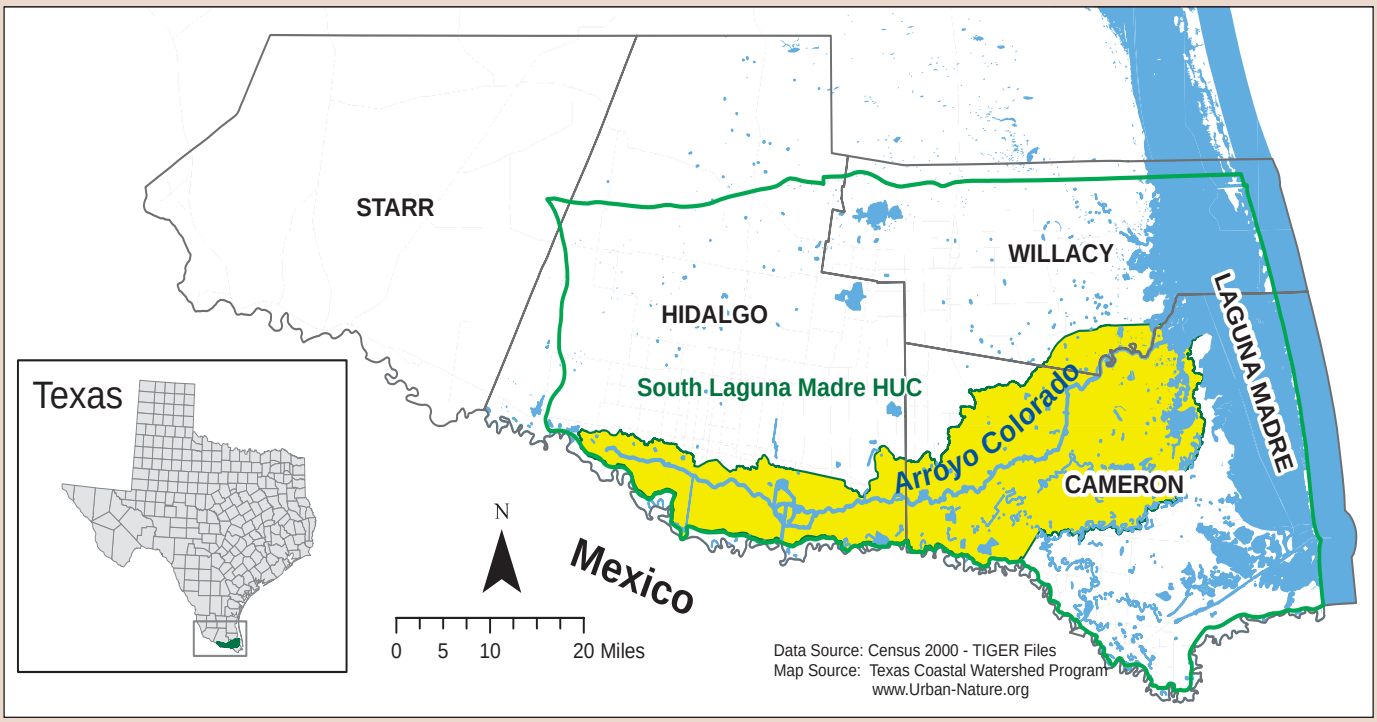
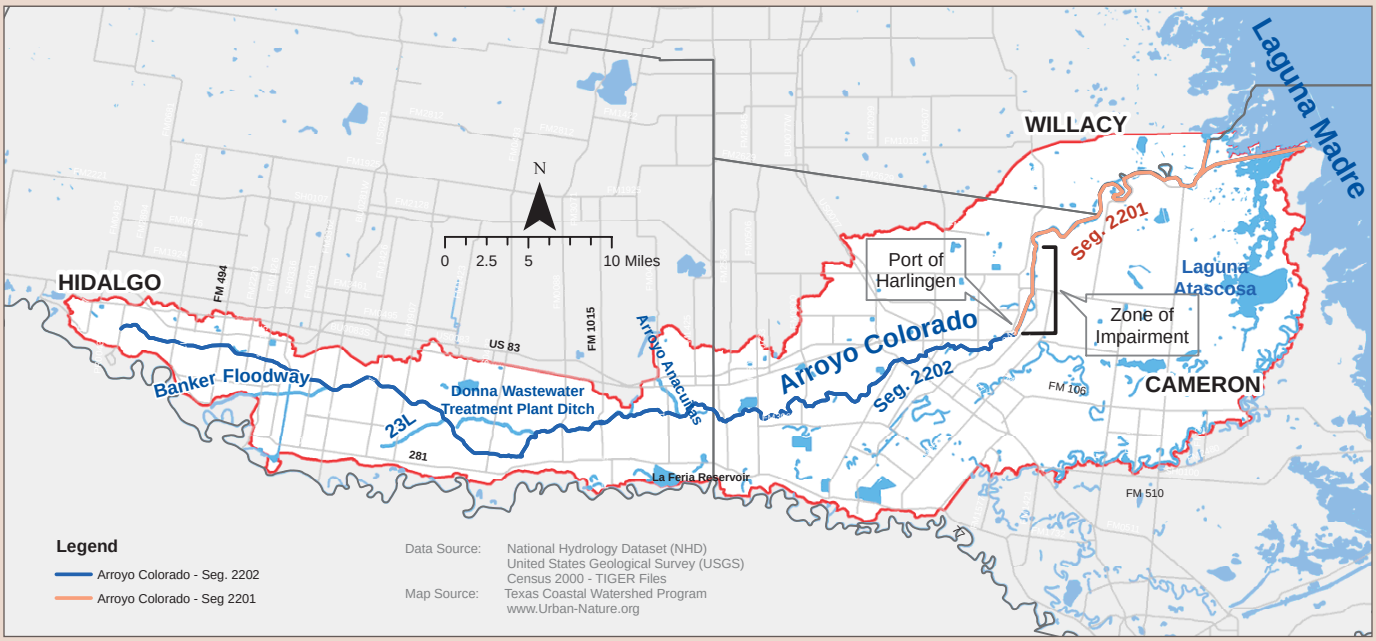


Figure 6. Arroyo Colorado Watershed and Major Stream Segments



the Llano Grande, the Arroyo Colorado ceases to be the pilot channel for the Main Floodway and continues eastward towards the city of La Feria on its way to the Lower Laguna Madre. Together, the Main and North Floodways drain a total 2,344 square miles (TWC 1990). During flood conditions, which the IBWC defines as flow exceeding 1,400 cubic feet per second, approximately 80 percent of the flow in the Arroyo Colorado is diverted to the North Floodway (IBWC 2003).

Water Body and Watershed Description

The Arroyo Colorado extends approximately 90 miles from its headwaters southwest of the city of Mission, to its confluence with the Lower Laguna Madre in the northeast portion of Cameron County. For much of its course, the Arroyo Colorado is a floodway and a conduit used for wastewater conveyance. The lower third of the stream serves as an inland waterway for commercial barge traffic and as a recreational area for boating and fishing. Near the coast, the Arroyo Colorado also serves as an important nursery and foraging area for numerous species of marine fish, shrimp and crab.

The Arroyo Colorado is described by the state of Texas as having a freshwater segment and a tidally influenced (*i.e.*, marine) segment. The State of Texas has classified two portions of the Arroyo Colorado separately based on the distinct physical characteristics of each segment of the stream. The tidally influenced segment of the Arroyo Colorado is approximately 26 miles long and is referred to as Segment 2201, the Arroyo Colorado Tidal. It extends from the confluence with the Laguna Madre in Cameron/Willacy County to a point 100 meters south of the Port of Harlingen in Cameron County and includes the Port of Harlingen turning basin (Figure 6). Segment 2201 has designated uses that include Contact Recreation and High Aquatic Life.

The other portion of the Arroyo Colorado designated by the State of Texas is the freshwater segment of the stream. It is approximately 63 miles long and is referred to as Segment 2202, the Arroyo Colorado Above Tidal. It extends from the tidal segment boundary, south of the Port of Harlingen, to its headwaters located southwest of the city of Mission. At its headwaters, the Arroyo Colorado flows between floodway levees near the Abram-Perezville drain in western Hidalgo County, where it is known as the Main Floodway.

Perennial (year-round) flow in the Arroyo Colorado is sustained mainly by flows from municipal wastewater treatment facilities. Irrigation return flows and urban runoff supplement the flow on a seasonal basis. Shallow groundwater is also known to contribute base flow to the stream, primarily in Cameron County.

The Arroyo Colorado Above Tidal (Segment 2202) is an extensively modified natural channel designed to carry flood water from the Rio Grande and the Lower Rio Grande Valley to the Laguna Madre. It is characterized by a steep-walled channel entrenched within a wide floodplain bounded by flood control

Measuring flow above tidal influence

levees. This freshwater segment of the Arroyo Colorado averages less than 40 feet wide and is approximately two to three feet deep. The channel bottom is composed mainly of loosely consolidated silty-clay sediments and the sparsely vegetated banks are in a continual state of sloughing.

The Arroyo Colorado Tidal (Segment 2201) is dredged to accommodate barge traffic to the Port of Harlingen and is characterized by steep eroding slopes with bank heights up to 50 feet. The steep banks are partly the result of the placement of dredge spoil material on the banks of the stream. In the upper portions of the tidal segment, the steep banks are thought to occasionally impede the flow of air across the surface of the stream, which can reduce aeration and vertical mixing, factors that contribute to the low levels of dissolved oxygen observed in this portion of the stream. The average width of the tidal segment of the Arroyo Colorado is about 200 feet and the average depth is 13 feet. Being tidally influenced, it is brackish to saline (slightly salty to very salty) and usually stratifies under warm weather conditions, forming layers of warmer, fresher water on the surface and cooler, more saline water near the bottom. For most of its course, the tidal segment of the Arroyo Colorado has a significant degree of natural sinuosity. However, sinuosity in the tidal segment of the Arroyo Colorado is severely diminished in the final four miles of the stream as the Arroyo Colorado flows into a man-made channel that leads to the Intracoastal Waterway and the Lower Laguna Madre.

Tributary inflows to the Arroyo Colorado occur through an extensive network of drainage ditches. The four major tributary ditches that flow into the Arroyo Colorado are the Banker Floodway, Arroyo Anacuitas, the Donna Wastewater Treatment Plant ditch (unnamed), and an unnamed ditch at IBWC Gate No. 23-L (Figure 6). Natural overland drainage to the Arroyo Colorado is restricted due to the absence of significant topographic relief and intense land development. Subsurface drainage, similarly, is limited because soils are generally saturated due to shallow groundwater levels. The shallow water table tends to intersect even shallow channels, which, when combined with the high permeability of host sediments, result in a high degree of communication between groundwater and surface water (TWC, 1990).

Topography

Generally, water flows on gentle slopes from west to east through the heart of the Lower Rio Grande Valley. The region is a flat coastal plain with an average slope of less than 1.5 feet per mile. The highest elevation in the Arroyo Colorado watershed is about 120 feet above mean sea level. Some common natural landscape features in the Lower Rio Grande Valley are depressions, *resacas* (oxbow lakes), salt lagoons, coastal marshes, tidal flats, point-bars and barrier islands. Man-made landscape features include levees, drainage ditches and raised irrigation canals.

Geology and Soils

The upper two-thirds of the Arroyo Colorado are underlain by alluvium consisting mostly of muds and silts deposited by the Rio Grande, while the lower one-third is underlain by barrier island deposits of mostly sand with some silt and clay. Almost all of the deposits underlying the Arroyo Colorado are of Holocene origin except for a short distance in the lower one-third of its course where the Beaumont Formation, of Pleistocene

Channelized portion of the Arroyo Colorado Tidal near the confluence with the Lower Laguna Madre.

origin, abuts the northern and western banks of the Arroyo Colorado (Brown *et. al.,* 1980).

The geologic age of the sediments in the region increase in age from east to west. The Pleistocene sediments, otherwise called the Beaumont Formation, were deposited after the last interglacial period about 70,000 years ago. This formation is composed mostly of clay with some fine sand and silt. The Holocene sediments (approximately 10,000 years old) consist of sands and silts and are both open marine and meandering fluvial (Figure 7).

The Lower Rio Grande Valley region is characterized by its unconsolidated soil substrate. The soils in the Arroyo Colorado watershed are clays, clay loams and sandy loams (Figure 8). Most soil depths range from about 63-78 inches. The Harlingen, Mercedes and Raymondville soil series consist predominantly of clay soils with low permeability. A representative soil profile consists of about 71-78 inches of clay. The Hidalgo, Rio Grande and Willacy soil series consist predominantly of sandy loam and sandy clay loam soils with moderate permeability. A representative soil profile consists of about 14-15 inches of sandy loam overlying 48-60 inches of sandy clay loam.

The Arroyo Colorado flows over the fluvio-deltaic plain of the Rio Grande. Fluvio-deltaic plains are large geographic features that form in coastal areas near the outlet of large rivers. Fluvio-deltaic sediments are typically composed of interwoven lenses of sands, silts and clays deposited by rivers as they reach the coast and distribute their load of fine, organic-rich sediment

Areal view of the Arroyo Colorado above the Laguna Atascosa

over a triangular coastal region known as the delta plain. The entire delta plain of the Rio Grande slowly subsides or sinks, as does the entire Gulf Coast. However, subsidence rates in the Rio Grande Valley (~6 mm/yr) are some of the lowest in the Gulf Coast.

Delta plains are typically fertile and make ideal environments for agricultural development. Natural sedimentation in a delta plain occurs as the result of overbank deposition during natural cycles of flooding. Much of the natural sedimentation that formed the fluvio-deltaic plain of the Rio Grande is, today, largely inhibited by flood control and conveyance structures that protect urban areas from catastrophic flooding and divert water for human use.

Groundwater in the Rio Grande Valley is typically

Figure 7. Surface Geology in the Arroyo Colorado Watershed

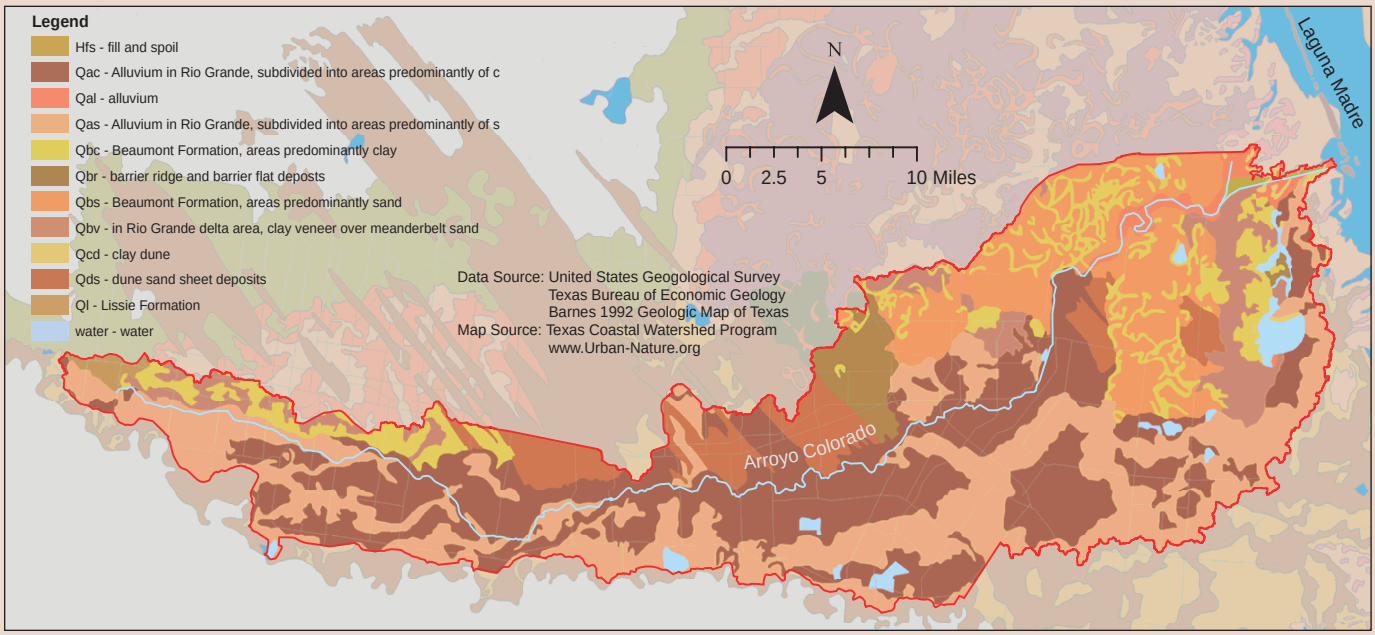
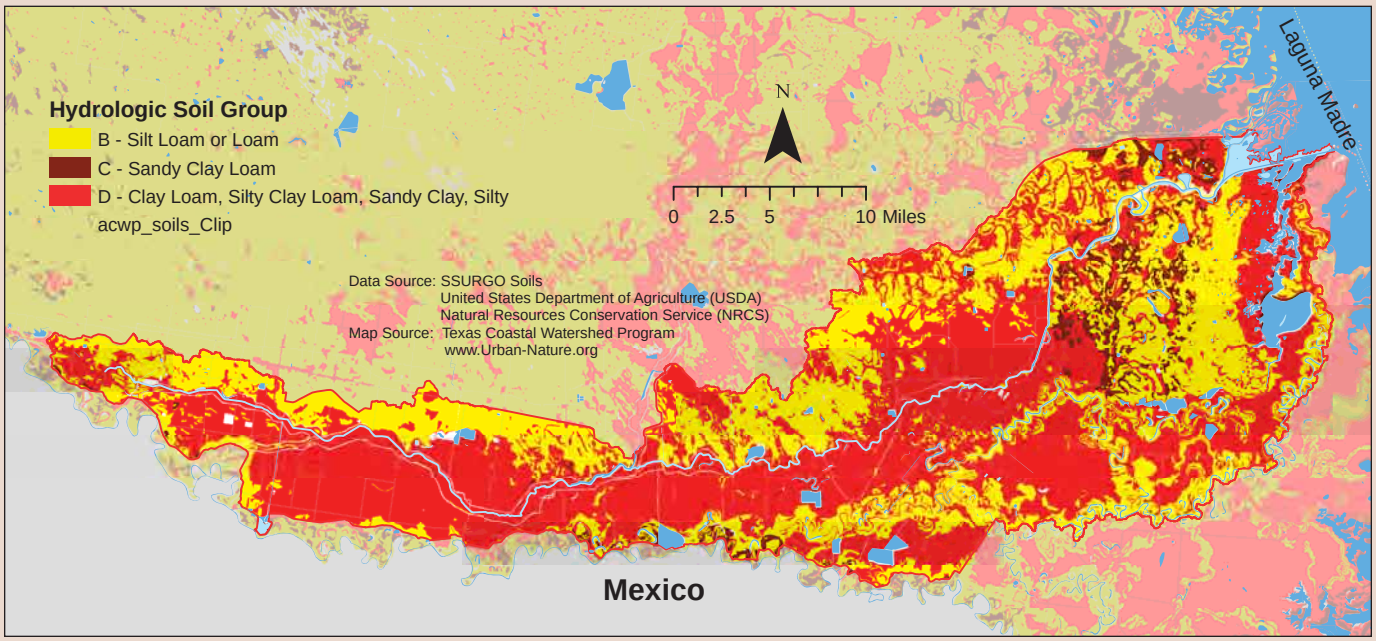
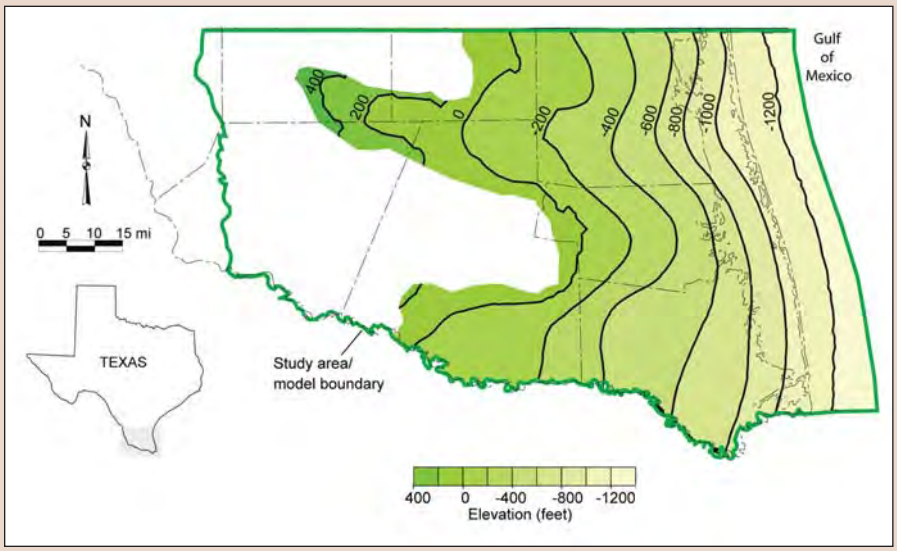


Figure 8. Simplified Soil Types in the Arroyo Colorado Watershed



shallow (1-30 feet from the surface) and varies in quality from very fresh to very brackish (TDS <1000 mg/l to TDS >10,000) with local occurrences of high nitrate, sodium, chloride and boron. The shallowest groundwater is found throughout the watershed in surface sand deposits that alternate with layers of clays and silts in the shallow subsurface. In the upper portion of the Arroyo Colorado watershed, the Gulf Coast Aquifer is sometimes used as a consistent source of groundwater. The aquifer typically produces fresh to brackish groundwater from the Chicot (0-1000 feet) and Evangeline (0-2500 feet) formations (Figures 9 and 10). Groundwater quality in the Gulf Coast Aquifer generally decreases in the direction of the coast and is generally too brackish for human use in Cameron and Willacy counties (TWDB 2003a).

Figure 9. Estimated Surface Elevation of the Chicot Aquifer in South Texas (Source: TWDB 2003a)



Climate and Rainfall

The climate of the Rio Grande Valley is hot, windy, dry and subject to frequent droughts and occasional floods. Winters are mild and pleasant, but subject to arctic cold fronts which produce freezing temperatures. The climate of the Lower Rio Grande Valley is dominated by the meeting of temperate and tropical climates and is considered to be semi-arid and subtropical. Average annual precipitation in the area is about 26 inches and the mean annual temperature is 72.35 degrees Fahrenheit. Freezing temperatures typically occur in the Rio Grande Valley for 2-7 hours on a frequency of approximately one out of every six years.

Demographics, Socio-Economics, and Growth

The Lower Rio Grande Valley is one of the fastest growing regions in the nation. There are 10 cities with populations greater than 10,000 within the Arroyo Colorado watershed (Table 2). The city of McAllen, located in southern Hidalgo County, is the largest, with

Table 2. Populations of Cities and Communities in the Arroyo Colorado Watershed with a Population Greater than 1,000 *(includes 2000 Census figures and 2005 estimates)*

City	2000 Census Population	Jan. 1, 2005 Estimated Population
McAllen	106,414	120,865
Harlingen	57,564	66,411
Pharr	46,660	57,903
Mission	45,408	60,421
Weslaco	26,935	30,571
San Juan	26,229	31,215
San Benito	23,444	25,391
Donna	14,768	16,084
Alamo	14,760	17,157
Mercedes	13,649	14,891
La Feria	6,115	6,836
Hidalgo	7,322	10,310
Progreso	4,851	5,291
Palmview	4,107	4,630
Rio Hondo	1,942	2,157

an estimated population of 120,865 as of January 1, 2005 (Texas State Office of Demographics). The population of Hidalgo County is expected to almost triple in the next 40 years and the population of Cameron County is estimated to double over the same time period (Table 3). The majority of the growth is expected to occur in the urban sector.

The Lower Rio Grande Valley Region is home to a mix of cultures, traditional ethnic lifestyles and rural and urban communities. It is characterized by rapid urban development and increasing industrial production through the advent and growth of international manufacturing and assembly plants known as *maquiladoras*.

The Lower Rio Grande Region also benefits from large flows of international goods and services that result from intense cross-border trade. However, the region is also known to have a high incidence of poverty and disease. Although the Lower Rio Grande Valley is a booming region and fast becoming an important commercial center of the southern United States, it is one of the poorest parts of the country. In terms of median household income in 1999, Cameron, Hidalgo and Willacy counties ranked 220, 236 and 246, respectively, out of the 254 counties in Texas (Table 4).

In spite of the prolific trade and high industrial production occurring across the Lower Rio Grande border area, the Arroyo Colorado watershed is located in an economically distressed area of the state of Texas as defined by the Texas Water Development Board (TWDB). Many communities within, or adjacent to, the Arroyo Colorado watershed have inadequate water and wastewater infrastructure facilities or lack these facilities altogether. These communities are typically unincorporated developments of low income housing known as "*colonias*" and are frequently found near many of the population centers located along the Texas-

Figure 10. Estimated Surface Elevation of the Evangeline Aquifer in South Texas (Source: TWDB 2003a)

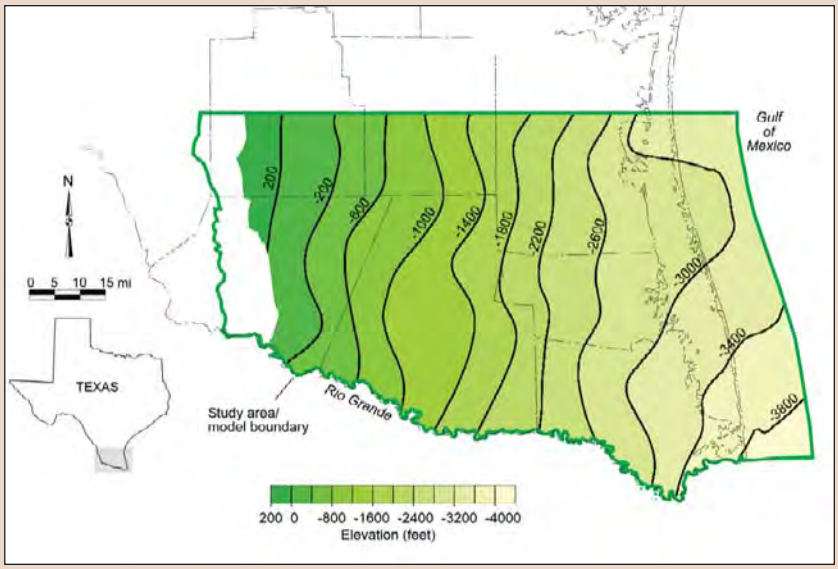


Table 3. Population Projections for Cameron, Hidalgo and Willacy Counties (Source: Texas State Office of Demographics)

County	2000	2010	2020	2030	2040	2050
Cameron	335,227	415,136	499,618	586,944	673,996	761,073
Hidalgo	569,463	744,258	948,488	1,177,243	1,424,767	1,695,114
Willacy	20,082	22,519	24,907	27,084	28,835	30,028

Table 4. Median Household Income for Cameron, Hidalgo, and Willacy Counties, 1989 and 1999 (Source: U.S. Census Bureau)

County Name	Median Household Income 1989	Median Household Income 1999
Cameron	$17,336	$26,155
Hidalgo	$16,703	$24,863
Willacy	$14,590	$22,114
TEXAS	**$27,016**	**$39,927**

Mexico border. There is much evidence that the lack of sanitary sewage, storm water drainage and solid waste disposal facilities in *colonias* significantly contributes to water quality problems in the Arroyo Colorado.

History of Human Activity

Early records tell of prosperous and often friendly Native American people living in South Texas and northeastern Mexico. This area was known as the Coahuiltecan region, where more than a hundred small bands of nomadic hunter-gatherers lived much like the pre-horse, buffalo-hunting Native Americans of the southern Plains (Moore, 2006).

The Coahuiltecans lived during a time period known as the "Little Ice Age" During this period, South Texas was cooler and wetter and the climate and environment in those times provided plenty of food resources. Water and wild grasses were abundant, and buffalo and other game animals were numerous. Around the end of the 1700s, the climate began to change, slowly getting hotter and dryer, and by the end of the 1800s, South Texas became the semi-arid region it is today.

The Coahuiltecan culture changed significantly after coming into contact with European settlers. The Spanish arrived in the area in the mid-1700s and started missions and settlements. Attracted by the steady source of food, water and protection from stronger tribes, many of the Coahuiltecan bands moved into the Spanish missions. Once in the missions, many of the Coahuiltecan women married Spanish soldiers and settlers. By the end of the 1800s, the native Coahuiltecans had disappeared, largely through assimilation. However, the native Coahuiltecans left descendants who still live in South Texas.

Spanish settlements were first established along the lower Rio Grande by José de Escandón beginning in 1749 (Best 2004). These early settlers brought with them grazing animals, including cattle, horses, mules and sheep, to feed mostly in the pastures north of the Rio Grande. In 1757, the total population of these animals outnumbered the human population in the early settlements by almost 50 to 1. Historical accounts from the 1800s of the habitats in South Texas include descriptions of a riparian forest belt from 5 to 30 miles wide on the United States side of the Rio Grande (Best 2004).

Water supply and flood control projects began on the Rio Grande in the 1920s to create reservoirs and floodways. The Lower Rio Grande Valley Flood Control Project was agreed upon between the United States and Mexico in 1932. The project was completed in 1947 and made irrigation waters available for agriculture on a large scale. Today, the Arroyo Colorado watershed contains approximately 290,000 acres of irrigated cropland. The principal agricultural crops in the watershed include cotton, corn, grain sorghum, sugar cane, citrus and a variety of vegetables (TAES 2000).

In addition to the benefits afforded to local agriculture, the Lower Rio Grande Valley Flood Control Project conferred to the local population protection from catastrophic flooding associated with the Rio Grande. The project resulted in the construction of a floodway system stretching across Hidalgo, Cameron and Willacy counties. In order to ensure efficient conveyance, the

Encampment of Coahuiltecan Indians as depicted by artist Frank Weir < http://www.texasbeyondhistory.net/st-plains/images/he6.html>

Arroyo Colorado was modified extensively to serve as the pilot channel for the Main and Arroyo Colorado floodways; this included channelization and, in some sections also, the repositioning of the channel within the floodway. The land within the floodways themselves was cleared of buildings, trees and brush to reduce roughness during flood flows. To this day, the IBWC ensures that land use within the floodways does not diminish the ability to convey floodwater. This includes restricting vegetation growth and development inside the floodway. Unfortunately, this prevents the Arroyo Colorado from having a healthy riparian environment and contributes to the severe bank erosion observed over much of its course.

In 1933, the IBWC implemented Federal Project #5, which involved cutting five channels and straightening the Arroyo Colorado from Harlingen to its outlet at the Laguna Madre. The channel construction and straightening projects cut off some of the bends in the original stream channel and modified the bed and banks of the tidal portion of the stream.

Prior to the construction of dams on the main channel of the river, the Rio Grande overflowed its banks annually, depositing new sediments and moving fresh water into a variety of abandoned river segments and meander channels that became cut off from the main flow of the river. These old abandoned channels of the Rio Grande are known collectively as *resacas*. The Arroyo Colorado can be considered a special type of resaca that once flowed naturally into the Laguna Madre. *Resacas* are found scattered throughout the Rio Grande Valley, where they form isolated freshwater reservoirs and wetlands.

Map of the Arroyo Colorado 1847

Resacas (Oxbow Lakes)

Large-scale irrigation and flood control projects in the Rio Grande Valley, including levee construction, eliminated floodwaters as a source of flow to the inland and coastal wetlands and reservoirs that now depend on rainfall and groundwater recharge as the sole natural source of fresh water inflow. Currently there are 270 miles of levees associated with the Lower Rio Grande Valley Flood Control Project; 102 miles of levees are Rio Grande levees and 168 miles of levees make up the interior floodway system that includes the two large segments of the Arroyo Colorado (*i.e.*, Main and Arroyo Colorado floodways), a major tributary (Banker Floodway) and a distributary branch of the Arroyo Colorado (North Floodway). Today, floodwater overflows from the Rio Grande into the Arroyo Colorado and local *resacas* are rare.

The next major alteration to the Arroyo Colorado began in 1945 when the U.S. Army Corps of Engineers (USACE) was authorized to excavate the Laguna Madre section of the Gulf Intracoastal Waterway (GIWW). The GIWW provides shallow-draft navigation between the Rio Grande Valley and interconnecting waterways along the Gulf Coast to Florida. The GWWI was opened to navigation in 1951. The Arroyo Colorado Navigation District of Cameron and Willacy counties granted a perpetual easement in 1947 to the USACE to use specific placement areas for the dredged material from the GIWW and the Tributary Channel to

Resaca

Harlingen (USACE 1975). Although the USACE did some additional straightening and bend-easing of the navigation channel, several of the larger oxbows on the Arroyo Colorado were already bypassed during earlier federal projects implemented by the IBWC. As part of the navigation project, which encompasses the lower portion of the Arroyo Colorado Tidal from river mile 7 to the mouth, the old bed of the Arroyo Colorado was bypassed completely and a new channel was completed to the Gulf Intracoastal Waterway in the Laguna Madre, approximately 21 miles north of Port Isabel, Texas (Bryan 1971).

The maintenance dredging cycle of the channel varies with location. The channel's intersection with the Gulf Intracoastal Waterway has a historical dredging cycle of about three years and the (barge) turning basin at the farthest upstream end of the channel in the Port of Harlingen has a historical dredging cycle of about 2.5 years. The middle reach of the channel has a historical dredging cycle of five to eight years. The authorized depth of the Tributary Channel to Harlingen is 12 feet below Mean Low Tide (USACE Datum). Also authorized are two feet of advanced maintenance dredging and one to two feet of overdepth dredging, so the channel can be dredged to 16 feet at Mean Low Tide. The authorized width of the bottom cut of the channel is 125 feet. The bottom cut dimensions of the turning basin at the Port of Harlingen, located at the far upstream end of the tidal segment, are 400 feet by 500 feet, with a 200-foot transition where it narrows from 400 feet to 125 feet. The authorized depth of the Port of Harlingen Turning Basin is 14 feet below Mean Low Tide. Also authorized are four feet of advanced maintenance dredging and one to two feet of overdepth dredging, so the basin could be dredged to 18 feet below Mean Low Tide.

Soldiers working on levee, circa 1917

Center for American History, UT-Austin
Robert Runyon Photography Collection

Significant urbanization began in the Rio Grande Valley in the late 1980s, concentrating in areas along the Arroyo Colorado where it continues today. Conversion from agricultural use to urban development is the principal land use change occurring in the Arroyo Colorado watershed (TCEQ 2003). Between 1970 and 1990, the population in Hidalgo County more than doubled, while that of Cameron County nearly doubled (Chapman et al., 1998). This urbanization trend continued in the decade between 1990 and 2000 and is currently the principal trend in land use change in the Arroyo Colorado watershed.

Urbanization has a tendency to change the hydrology of a water body, making it more prone to flash flooding. By increasing the amount of impervious cover in a watershed, urbanization increases the intensity of rainfall runoff into nearby lakes and streams. Natural vegetation captures rainfall in leaves and root systems, absorbing and reducing runoff; this phenomenon is known as *interception storage*. Vegetation also has a mediating effect on runoff, holding back and regulating storm water that otherwise would flow directly into a receiving water body. Urbanization can also have a negative effect on the quality of the rainfall runoff. When not properly applied, fertilizers and pesticides used in urban gardens and landscaping are washed away quickly in urban runoff along with carelessly discarded pet waste and human waste from leaking sewer lines and failing septic systems.

Arroyo Colorado banks

Mesquite forest

STATE OF THE WATERSHED

From a natural resource and ecological perspective, the state of the Arroyo Colorado watershed is not good. Loss of natural habitat, engineered modifications, and pollution from human activities have significantly degraded water quality in the Arroyo Colorado. The most visible evidence of water quality problems in the Arroyo Colorado is the periodic occurrence of fish kills, most commonly in the upstream portion of the Tidal segment. Texas Parks and Wildlife Department investigates massive fish and wildlife die-offs in Texas. Information regarding those investigations is available from the Texas Parks and Wildlife Department at <http://www.tpwd.state.tx.us/landwater/water/environconcerns/kills_and_spills/>.

Forty-two fish kills were documented by Texas Parks and Wildlife Department in the Arroyo Colorado from 1976-2004. The general sources of the mortality events vary and are attributed to agriculture (7), aquaculture (1), industry (12), municipal (5), natural processes (8), unknown (4) and weather (5). In 34 of the 42 events, the direct cause of the fish kills was low dissolved oxygen in the water column. Most of the documented fish kills occurred in the tidal segment of the Arroyo Colorado. The larger fish kills that resulted in the death of more than one million fish per event occurred in the Zone of Impairment in the upper portion of the Tidal segment.

While the Phase I TMDL study conducted on the Arroyo Colorado in 2002 identified pollutant loading as one of the most important causes of water quality problems in the Arroyo Colorado, the study also pointed to the degradation and loss of aquatic and riparian habitat as an equally important cause of poor water quality.

Habitat

Water quality problems associated with habitat degradation occur in rivers and streams throughout the United States. For these reasons there have been several national, state and local efforts to conserve important habitats for protection and restoration of water quality. Federal, state and local resource agencies and conservation groups have recognized the significance of natural habitats in the Lower Rio Grande Valley and the freshwater and estuarine resources they provide. Knowing the effect these environments have on the health and well-being of the wildlife and citizens of the area, these agencies have developed conservation plans and have implemented habitat conservation projects throughout the region. A detailed description of current and historic habitat conditions, ongoing conservation efforts and recommendations for habitat improvements can be found in the *Arroyo Colorado Habitat Restoration Plan* (TPWD 2006b). Habitats already under conservation are excellent reference sites for guiding restoration of degraded or destroyed habitats.

The Lower Rio Grande Valley has experienced extensive loss and degradation of terrestrial and aquatic habitats. More than 95% of the native brush land in the Lower Rio Grande Valley has been cleared for agriculture and urban development (Jahrsdoefer and Leslie 1988). Approximately 91% of the loss is due to the conversion of native land to farmland in Cameron County (Tremblay et al., 2005). Threats to the remaining natural environment continue as human development expands in the region.

Wetlands are common natural environments of the Rio Grande Valley. Saltwater wetlands occur along the coast while freshwater wetlands and *resacas* are

Drainage ditch flowing into the Arroyo Colorado

found scattered throughout the coastal plain of the Rio Grande Valley. Wetlands were once very prolific in this region of the Rio Grande due to an ample supply of freshwater from the nearly annual flooding of the fluvio-deltaic plain of the river. But, the water supply and flood control projects constructed since the 1920s have effectively eliminated this source of water to the wetlands and *resacas* in the delta plain, making them dependent on rainfall alone as a source of freshwater inflows (Jahrsdoerfer and Leslie 1988).

Resacas and other depressional freshwater wetlands (potholes) remain good habitat for waterfowl, shorebirds, wading birds and several species of mammals, fish and invertebrates, including the state-listed threatened black-spotted newt and lesser Rio Grande siren (TPWD 1997). The riparian areas bordering the remaining natural *resacas* often retain the same forest and woodland vegetation communities that were once prevalent throughout the deltaic plain of the Rio Grande, especially along the river and its distributaries.

Resaca

The dense brush habitat and wetlands found in this region of Texas provide feeding, nesting and cover habitat for many wildlife species. The Rio Grande, Arroyo Colorado, area *resacas* and their associated riparian forests serve as corridors connecting the last remaining remnant tracts of undisturbed terrestrial habitats in the Lower Rio Grande Valley. The area supports an abundance of neotropical migratory songbirds, mammals, snakes, lizards and salamanders. It is also home to rare and unique plant and animal species, many of which reach the northernmost limits of their distribution in the Lower Rio Grande Valley (USFWS 1997). Several state and federally listed

Lesser Rio Grande Siren

threatened and endangered species are found in the region including the ocelot (*Leopardus pardalis*) and the jaguarundi (*Herpailurus yaguarondi*). A complete list of rare plants and animals that occur within the Arroyo Colorado watershed is provided in Appendix E.

Historically, the banks of the Arroyo Colorado Above Tidal were probably dominated by mesic woodland sub-tropical plant communities, remnants of which can be found today along some portions of the Rio Grande and its former channels. These communities have a relatively high canopy dominated by Texas ebony and anacua, a dense shrub layer dominated by brasil (*Condalia hookeri*), and a sparse ground layer dominated by plant litter.

In urban areas of the Lower Rio Grande Valley, many *resacas* have been modified to serve as water supply storage systems, storm water retention areas and/or amenities within commercial and residential developments. The shorelines are often bulkheaded and the water levels are artificially maintained at high levels year round. In addition, the riparian zones of

Ocelot

resacas located in urban areas have been cleared to build homes and other developments and the natural plant communities have been replaced with nonnative landscapes.

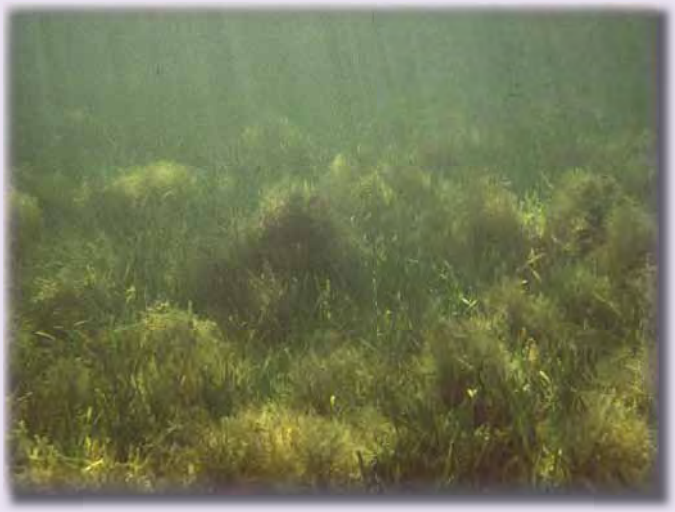
Resaca bulkheads

The Arroyo Colorado flows through some of the most urbanized and/or intensively farmed land in the Rio Grande Valley, yet some of the most diverse vegetation remaining in the Rio Grande Valley occurs along the banks of the Arroyo Colorado in small, dense stands of native brush. Ecological systems recognized by The Nature Conservancy of Texas found along the Arroyo Colorado include Lower Rio Grande and Tamaulipan Riparian Woodlands and Forests and Tamaulipan Mesquite Woodlands (Elliott 2004).

High and steep cut-banks occur regularly along the Arroyo Colorado. Erosion is a natural process along riverine systems and accounts for changes in natural river courses, but it also contributes to pollutant loading in those systems. Erosion can be exacerbated by adjacent land uses including the clearing of woody vegetation on or near the banks for development, crop production, roads/trails and livestock grazing. When riparian areas of streams are no longer intact, they cannot intercept and slow runoff from adjacent uplands. When this occurs, gullies begin to form, reducing the integrity of the stream bank. Channel and stream bank erosion along the drainages leading to the Arroyo Colorado and along the floodway pilot channel (in Hidalgo County) contributes to low water quality in the Arroyo Colorado from high sediment and nonpoint source pollutants. Bank erosion also contributes to the loss of riparian habitats in the Arroyo Colorado.

The mangrove swamps, flats and marshes associated with the tidal portions of the Arroyo Colorado and the Rio Grande provide valuable feeding and nursery habitat for important marine fish species and a feeding habitat for a number of avian species. The productivity of these coastal environments is highly dependent on water quality. Water quality in estuarine systems is particularly complex and results from a delicate balance of physical and chemical factors that typically occur in areas where rivers meet marine environments. Man-induced changes in this balance can have dramatic effects on the productivity of these coastal systems. For example, excessive algal growth resulting from high nutrient pollution can reduce light penetration in shallow areas of the bay, threatening the growth of sea grasses and reducing the important shallow bottom habitat they provide for juvenile marine species.

Habitat alterations, including modification of hydrology, dredging, stream bank destabilization and the loss or degradation of wetlands also contribute to impaired water quality in streams and rivers (USEPA 2005). The combined impacts of physical modifications, placement of dredge materials and loss of riparian habitat are thought to be exacerbating low dissolved oxygen (DO) concentrations in the tidal segment of the Arroyo Colorado (TCEQ 2003). The straightening, widening and deepening of the tidal segment of the Arroyo Colorado to facilitate barge traffic effectively reduces velocity of the stream flow, reduces circulation and lowers re-aeration rates in the stream. Removal of sand bars and woody debris also removes potential



Sea grass

Invasive giant reeds on unstable Arroyo Colorado banks

areas of turbulence that would facilitate re-aeration of the water column (APAI 2006).

Invasive plant species, both native and introduced, occur in terrestrial and aquatic habitats associated with the Arroyo Colorado and the Lower Rio Grande Valley. Invasive species often have a negative impact on native plant and wildlife populations. Common reed (*Phragmites australis*) and giant reed (*Arundo donax*), which occur along the banks of the Arroyo Colorado, spread so quickly that they form expansive monospecific stands; this decreases plant diversity and excludes species that have a higher value to wildlife over large areas. Exotic plants of various species exclude other plant species from growing near or beneath them either directly, through allelopathic processes (suppression of growth through the release of toxins) as is the case with tamarisk (*Tamarix sp*.) and buffelgrass (*Pennisetum ciliare*), or indirectly, through competition for water and/or light, as with Brazilian pepper (*Schinus terebinthifolius*). Other invasive species, such as guinea grass (*Panicum maximum*), reduce the vigor and density of desirable native species around them through resource competition. Invasive plant species, particularly exotics, generally provide lower quality habitat (including food, cover, and nesting sites) for native wildlife species than do non-aggressive native plant species. Some of the most common invasive plant species found in the Lower Rio Grande Valley area are provided in Table 5.

Table 5. Predominant Invasive Plant Species Known to Occur in Terrestrial and Aquatic Habitats Associated with the Arroyo Colorado in Hidalgo, Cameron and Willacy Counties

Plant Species	Native (N) or Introduced (I) to Watershed
UPLAND GRASSES	
Bermudagrass (*Cynodon dactylon*)	I
Buffelgrass (*Pennisetum ciliare*)	I
Guinea Grass (*Panicum maximum*)	I
King Ranch bluestem (*Bothriochloa ischaemum*)	I
UPLAND TREES/SHRUBS	
Black mimosa (*Mimosa pigra*)	N
Black willow (*Salix nigra*)	N
Brazilian pepper (*Schinus terebinthifolius*)	I
Chinaberry (*Melia azedarach*)	I
Chinese tallow (*Sapium sebiferum*)	I
Jara (*Baccharis salicifolia*)	N
Retama (*Parkinsonia aculeata*)	N
Roosevelt willow (*Baccharis neglecta*)	N
Salt cedar (*Tamarix sp.*)	I
Tree morning glory (*Ipomoea carnea*)	I
Tree tobacco (*Nicotiana glauca*)	I
TRANSITIONAL GRASSES	
Common reed (*Phragmites australis*)	N
Giant cane (*Arundo donax*)	I
WETLAND AND AQUATIC PLANTS	
Cattail (*Typha domingensis*)	N
Hydrilla (*Hydrilla verticillata*)	I
Water hyacinth (*Eichornia crassipes*)	I

Water Quality

Water quality in the Arroyo Colorado has been monitored and assessed by the State of Texas since 1974 to satisfy the requirements of Sections 305(b) and 303(d) of the Clean Water Act (CWA). Section 305(b) requires states and other jurisdictions to survey the health of their surface water bodies every two years and submit a report summarizing the results of the survey to the USEPA. Title 30, Chapter 307 of the Texas Administrative Code (30 TAC Chapter 307) describes the Texas Surface Water Quality Standards (TCEQ 2000). These regulations specify the designated uses of surface water bodies in Texas and the water quality criteria used to determine if these uses are met. When a water body fails to meet the criteria associated with a specific designated use, it is placed on the state's list of impaired water bodies as specified by Section 303(d) of the Clean Water Act (which requires monitoring, assessment, planning, and action). Table 6 shows the designated uses assigned to the different segments of the Arroyo Colorado and the Lower Laguna Madre and the impairment and/or concerns associated with the designated use. Table 7 shows the numeric criteria used by the State of Texas to assess the attainment of uses in the Arroyo Colorado and the Laguna Madre.

In 1991, the Texas Legislature passed the Texas Clean Rivers Act, which requires basin-wide water quality assessments to be conducted for each river basin in Texas. Under this act, the Clear Rivers Program (CRP), a state fee-funded program for water quality monitoring, assessment and public outreach was developed. This program provides an opportunity to approach water quality issues within a watershed or river basin locally and regionally through coordinated efforts among diverse organizations <http://www.tceq.state.tx.us/compliance/monitoring/crp>.

Under the CRP, the TCEQ has partnered with the Nueces River Authority (NRA) to monitor and assess the quality of water in the Arroyo Colorado. Currently, four sites are monitored in the Arroyo Colorado Tidal segment and three sites are monitored in the Arroyo

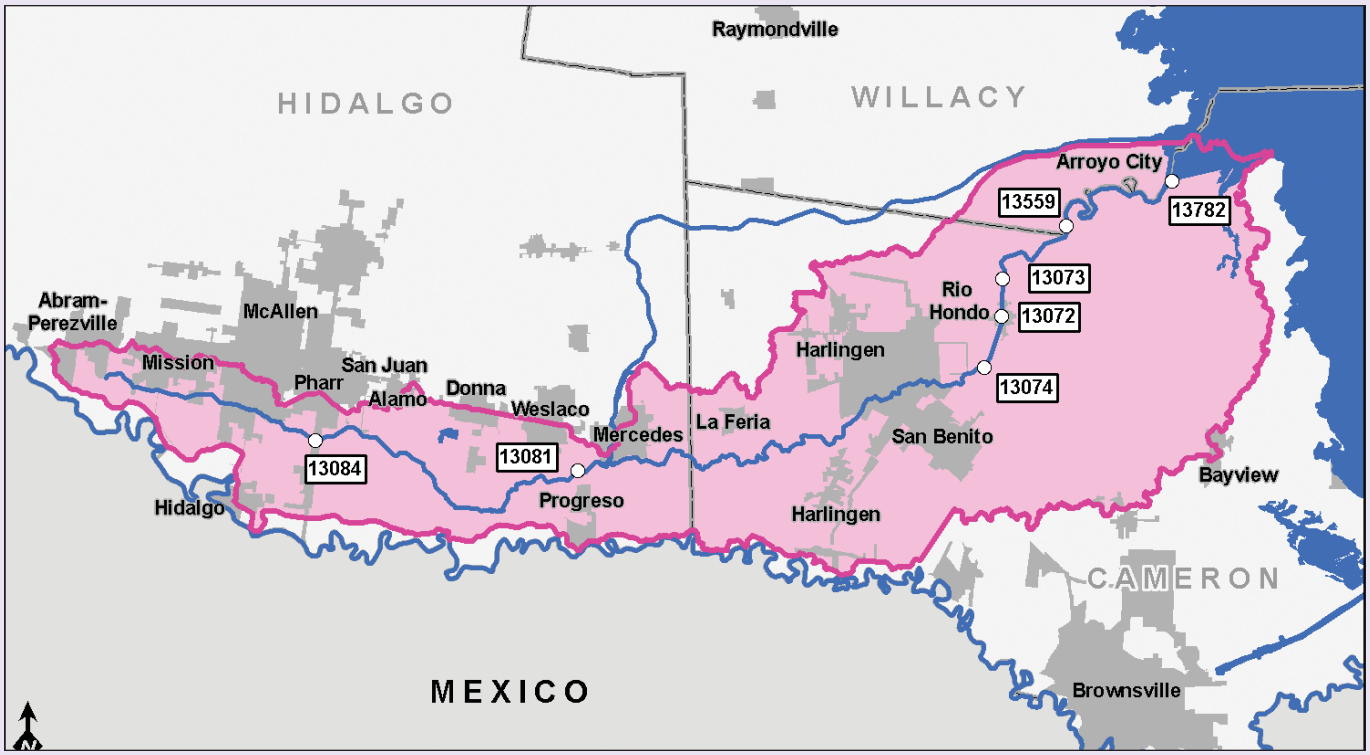
Table 6. Designated Uses, Impairments and Concerns for the Arroyo Colorado and Lower Laguna Madre

Water Body	Designated Uses*	Impairments and Concerns**
Arroyo Colorado Above Tidal, Segment 2202	Contact Recreation	Bacteria
	Consumption	Chlordane, DDE and Toxaphene in Small Mouth Buffalo
	Intermediate Aquatic Life Use	*Ammonia, Ortho-phosphorus, Total Phosphorus, Excessive Algae*
Arroyo Colorado Tidal, Segment 2201	Contact Recreation,	None
	High Aquatic Life Use	Low dissolved oxygen *Nitrate+Nitrite Nitrogen, Ammonia*
Lower Laguna Madre, Segment 2491	Contact Recreation,	None
	Exceptional Aquatic Life Use	Low dissolved oxygen *Ammonia, Ortho-phosphorus, Total Phosphorus, Nitrate+Nitrite Nitrogen*
	Consumption	*Bacteria in Oyster Water 18.1 sq mi near the Arroyo Colorado and along the Gulf Intracoastal Waterway*

** As described in Texas Surface Water Quality Standards (TAC 307.1-307.10)*

*** Concerns are shown in italics*

Figure 11. Location of Water Quality Monitoring Stations on the Arroyo Colorado Currently Monitored by the Texas Commission on Environmental Quality (TCEQ) and the Nueces River Authority (NRA)



Colorado Above Tidal segment (Figure 11). Table 8 describes the monitoring sites, the parameters sampled, the sampling frequency, and the agency conducting the sampling.

The 2004 Texas Clean Water Act Section 305(b) Water Quality Inventory Report and 303(d) list reaffirmed a long-standing water quality impairment in the upper 7.1 miles of the tidally influenced segment of the Arroyo Colorado, where DO concentrations are sometimes lower than the criteria established to assure optimum conditions for aquatic life. This portion of the Arroyo Colorado is known as the "Zone of Impairment" and was the focus of the Phase I TMDL study. Nutrient enrichment concerns are also noted for this portion of the Arroyo Colorado in the 305(b) Report, indicating that concentrations of ammonia and nitrate plus nitrite exceed the 85th percentile of all tidal streams assessed in Texas (TCEQ 2004a).

In the freshwater segment of the Arroyo Colorado (Segment 2202) fecal coliform bacteria concentrations currently exceed levels established by the state for safe contact recreation. Finally, in the portion of the Lower Laguna Madre located near the confluence with the Arroyo Colorado, DO concentrations are also sometimes lower than the criteria established to assure optimum conditions for aquatic life. Preliminary data collected by the USGS also provides evidence that the Lower Laguna Madre is beginning to show adverse

Table 7. Water Quality Standards for the Designated Uses for the Two Segments of the Arroyo Colorado and the Laguna Madre

Segment No.	Segment Name	Uses	Cl^{-1} (mg/l)	SO_4^{-2} (mg/l)	TDS (mg/l)	DO (mg/l)	pH Range (SU)	Bacteria[1] #/100ml	Temp (F)
2201	AC Tidal	CR, H				4.0	6.5-9.0	35/200	95
2202	AC Above Tidal	CR, I	1,200	1,000	4,000	4.0	6.5-9.0	126/200	95
2491	Laguna Madre	CR, E/O	NA	NA	NA	5.0	6.5-9.0	14*	95

CR = Contact Recreation
H = High Aquatic Life Use
I = Intermediate Aquatic Life Use
E/O = Exceptional Aquatic Life Use/Oyster Waters Life
mg/l = milligrams per liter
NA = Not applicable

[1] = The indicator bacteria for freshwater is E. coli and Enterococci for saltwater. Fecal coliform is an alternative indicator.
** = Oyster water criterion (fecal coliform)*
Cl^{-1} = Chlorides
SO_4^{-2} = Sulfate
TDS = Total Dissolved Solids
DO = 24 hour dissolved oxygen

Table 8. Description of Sampling Locations, Parameters Analyzed, Sampling Frequency and Agency Currently Conducting Water Quality Sampling in the Arroyo Colorado *(Source: CRP 2006 Coordinated Monitoring Schedule available at <http://cms.lcra.org/>)*

Sample Location	Segment	Parameter*	Frequency	Agency
13084 – Upper 19 miles at U.S. 281 South of Pharr	2202	Conventional	4	TCEQ Region 15
		Bacteria	4	
		Flow	4	
		Field	4	
13081 – Lower 4 miles – Main Floodway in Llano Grande at FM 1015 South of Weslaco	2202	24 hr DO Ave.	2	NRA
		Conventional	4	TCEQ Region 15
		Bacteria	4	
		Field	4	
13074 – 14 miles upstream to 11 miles downstream of FM 1015 at Low Water Bridge at Port of Harlingen	2202	24 hr DO Ave.	2	NRA
		Metals in Sediment	2	TCEQ Region 15
		Organics in Sediment	2	
		Conventional	4	
		Bacteria	4	
		Field	4	
13072 – Upper 4 miles – FM 106 Bridge at Rio Hondo	2201	24 hr DO Ave.	2	NRA
		Conventional	4	TCEQ Region 15
		Bacteria	4	
		Field	4	
13073 – At Camp Perry North of Rio Hondo	2201	24 hr DO Ave.	2	NRA
		Conventional	4	TCEQ Region 15
		Bacteria	4	
		Field	4	
13559 – At Marker 27 (Mile 15) 0.5 mile North of the Point where channel becomes the boundary between Willacy and Cameron counties	2201	Conventional	4	TCEQ Region 15
		Bacteria	4	
		Field	4	
13782 – Lower 9 miles near CM 16 at Arroyo City, KM 10.9	2201	Conventional	4	TCEQ Region 15
		Bacteria	4	
		Field	4	

**** For lists of all conventional and field parameters see Table 19 in the Water Quality Monitoring Plan Section of this document.***

effects from excessive nutrient loadings, which can be linked directly to the Arroyo Colorado (Onuf 1999). The USGS study cites the possibility that over-stimulation of growth in drift algae induced by excessive nutrient loading may hamper the propagation of sea grasses, thereby reducing important fish habitats (Onuf 1996). Segment 2202 has also appeared on State of Texas 303(d) lists prior to 2004 because of the presence of pesticides in fish tissue.

The most current information and status of water quality of the entire State of Texas is compiled by the TCEQ's Surface Water Quality Monitoring (SWQM) program. The NRA also maintains a database that includes water quality data on the Arroyo Colorado. Data from both these databases were used to describe historic and current water quality of the Arroyo Colorado. Seven key parameters were chosen for detailed discussion—dissolved oxygen (DO), fecal coliform bacteria, nitrogen, phosphorus, biological oxygen demand (BOD), sediment and chlorophyll-*a*. Additionally, a discussion of legacy pesticide contamination in fish is included in this section.

Dissolved Oxygen

Dissolved oxygen, normally reported in milligrams of oxygen per liter of water (mg/l), is a traditional measure of aquatic health because aquatic organisms depend on it for survival. If DO concentrations become too low in a water body, large-scale die-offs of aquatic life (*i.e.*, fish kills) can occur. Fish kills typically result when concentrations of DO fall below 2 mg/l. High DO concentrations (greater than 10 mg/L) during the daytime can also be indicative of an unhealthy aquatic environment because they typically result from high photosynthetic activity caused by excessive algal growth. At night, the same algal cells that produce DO during the daytime can consume large amounts of DO, which causes the water body to become DO-depleted, making the water column unsuitable for aquatic life.

The Texas Surface Water Quality Standards (30 TAC §§307.1-307.10) specify the dissolved oxygen criteria that must be met for limited, intermediate, high and exceptional aquatic life uses in water bodies of the State of Texas. Having received a High Aquatic Life use designation by the State of Texas, the Tidal segment of the Arroyo Colorado has an associated 24-hour average DO criterion of 4.0 mg/l and a 24-hour DO minimum criterion of 3.0 mg/l (Table 7). The Texas Surface Water Quality Standards also state that, in tidal streams, under conditions of density stratification, the DO criteria must be met in the mixed surface layer of the water column, which is defined by the TCEQ as the vertical portion of the water column located between the surface and the depth at which the conductivity of the water is 6,000 umhos higher than the conductivity at the surface.

DO concentrations are largely dependent on the temperature and salinity of water. The amount of air-mixing or aeration from wind and water turbulence is also a key factor determining DO concentrations, as is the presence of oxygen-demanding substances and living organisms in the water. Dissolved oxygen levels typically fluctuate during the daily cycle. Higher DO levels are typically observed in the afternoon, at the height of photosynthetic activity, while the lowest DO levels typically occur in the early morning, when algal respiration (*i.e.*, oxygen consumption) is at its maximum.

Water sampling in the Arroyo Colorado Tidal

Dissolved oxygen probes

Elevated nutrient levels in the tidal portion of the Arroyo Colorado also contribute to periodic low DO levels. The wide diurnal fluctuations in DO observed in the tidal segment of the Arroyo Colorado (DO concentrations ranging from 0 to 12/mg/l) are characteristic of a eutrophic (*i.e.*, high algal productivity) water body (APAI 2006).

During the Phase I TMDL study, data from 48 stations were used to assess water quality in the tidal segment of the Arroyo Colorado (Figure 12). Of the 13 monitoring stations representing the upper portion of the Arroyo Colorado tidal segment, six showed DO values below the criteria yielding a 64% compliance rate (eight non-compliant samples out of 22 measurements). In the lower portion of the tidal segment, only one of the 35 remaining downstream stations produced DO values below the assessment criteria yielding a 99% compliance rate (one non-compliance sample out of 109 measurements). For most of these stations, however, compliance with the DO criteria was based on instantaneous DO measurements, which shows an incomplete picture of DO dynamics at specific locations within a water body. Subsequent water quality assessments have made use

Figure 12. Location of Water Quality Monitoring Stations on the Arroyo Colorado Used in the Phase I TMDL Study and Arroyo Colorado Sub-basins

of 24-hour DO data collected between 2000 and 2005 at several stations in the tidal segment and two stations in the above-tidal segment of the Arroyo Colorado.

The most recent DO data for the Arroyo Colorado shows modest but encouraging improvements in the 24-hour average DO at stations located in the Zone of Impairment. Although the minimum DO concentrations over a 24-hour period are occasionally below the criteria at these stations, the 24-hour average DO concentration was recorded below the criteria only once since 2002 (Figure 13).

USDA personnel preparing for water quality sampling on the Arroyo Colorado

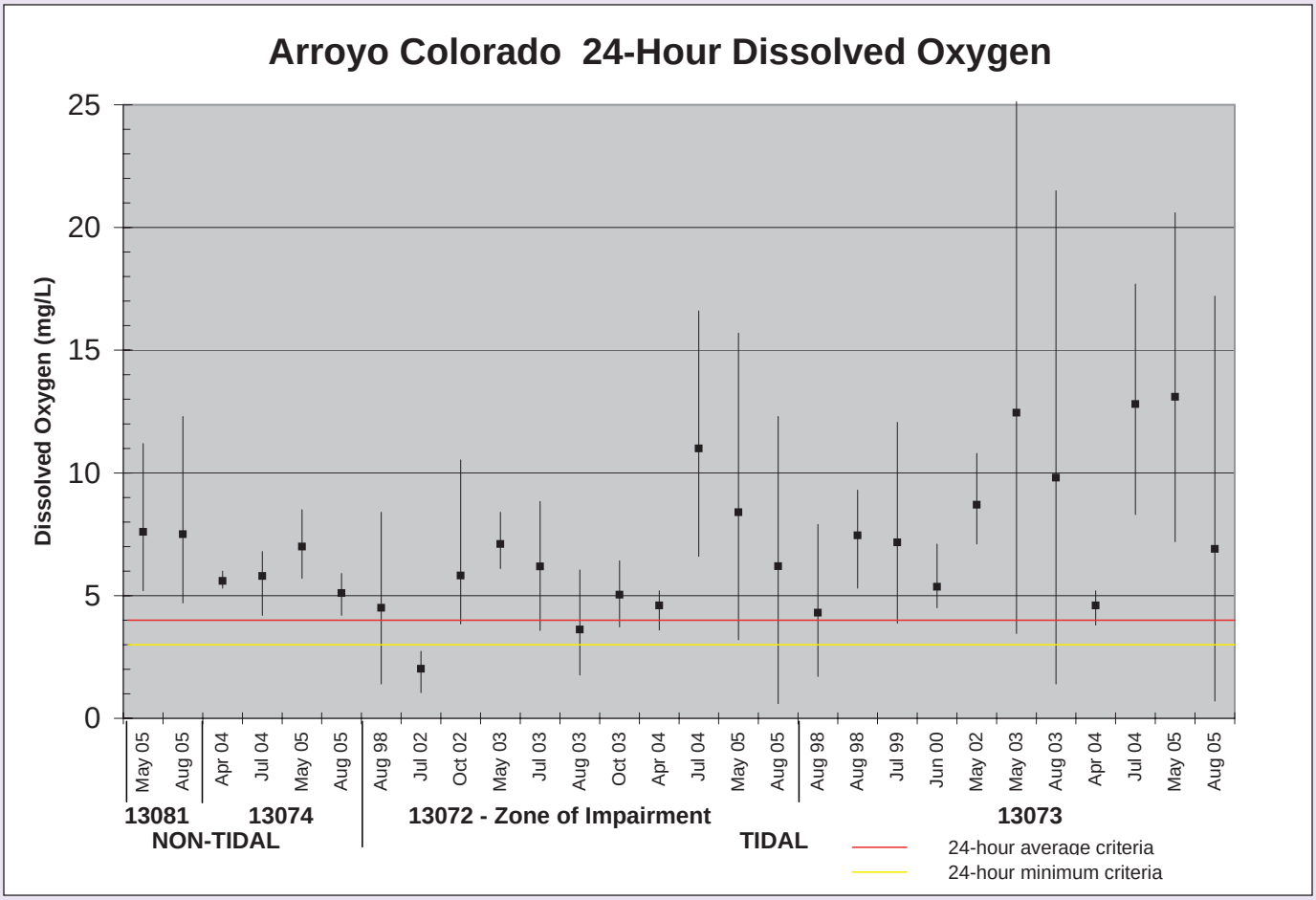
Biochemical Oxygen Demand

Biochemical oxygen demand (BOD) is a collective measure of all oxygen-demanding substances dissolved and suspended in a particular sample of water. BOD is, essentially, a measure of the organic matter that is prone to decomposition in water. Like many other organisms, bacteria use organic matter as food and, in order to use the food for energy and cell growth, bacteria must first break down the organic matter into more simple chemical structures. To do this, most bacteria use a process called *respiration*, in which oxygen is combined with the organic matter to break down complex molecules into simple ones. The respiration process can consume large amounts of dissolved oxygen in the water column. To measure only the dissolved fraction of BOD, water samples are sometimes filtered to remove suspended particles.

The most significant contributors of BOD to the Arroyo Colorado are nonpoint sources including rainfall runoff and irrigation return flows from agricultural land, urban runoff, nonpoint source wastewater from *colonias* and improperly functioning septic systems. A sizable loading of BOD to the Arroyo Colorado (23%) also comes from permitted wastewater outfalls (TCEQ 2003).

In general, in-stream BOD levels are not considered to be very high in the Arroyo Colorado. Based on

Figure 13. 24-hour Dissolved Oxygen Values for Stations in the Tidal (13072 and 13073) and Above Tidal (13074 and 13081) Segments of the Arroyo Colorado



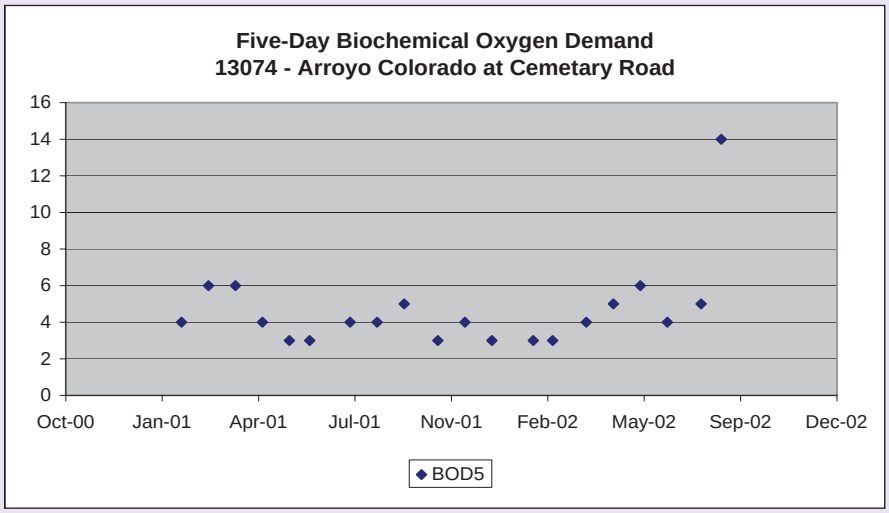
analysis of water samples collected in the Arroyo Colorado between 2000 and 2002, the average concentration of five-day biochemical oxygen demand (BOD_5) at the downstream end of the non-tidal segment of the Arroyo Colorado was 4.7 mg/l (Figure 14).

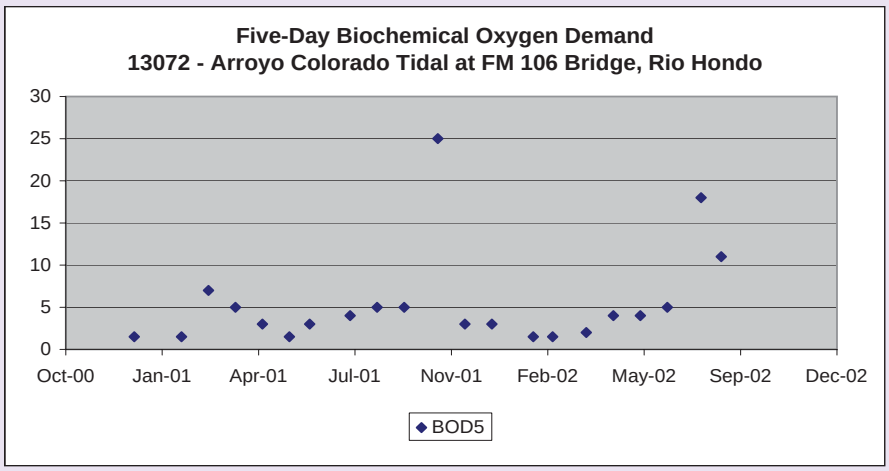
Average BOD_5 concentrations were found to be slightly higher in the upper portion of the tidal segment of the Arroyo Colorado (6.7 mg/l). However, this is thought to be the result of periodically high organic matter production in-stream. The higher growth of microscopic algae during algal blooms in the upper portion of the tidal segment of the Arroyo Colorado produces suspended organic matter in the form of millions of algal cells. These cells produce large amounts of BOD as they die and are decomposed by bacteria. Filtered water samples from the tidal segment of the Arroyo Colorado show an average BOD_5 concentration comparable to that of the non-tidal segment (4.7 mg/l).

Nitrogen

Nitrogen is an essential plant nutrient. Along with other nutrients such as phosphorus, plants need only water and light to grow. This includes microscopic aquatic algae also known as phytoplankton. Low concentrations of nutrients can reduce plant growth and therefore impede the production of food for organisms that are dependent on this growth, while high concentrations of nutrients can cause excessive and uncontrolled growth of algae in aquatic systems (*i.e.*, algal blooms). Nitrogen-containing substances are often measured to assess water quality on a short-term (acute) or long-term (chronic) basis. Elevated ammonia nitrogen levels can contribute to high phytoplankton growth rates, but high levels of ammonia nitrogen can also have an acute (toxic) effect on aquatic life. Elevated levels of nitrate and nitrite nitrogen often lead to nutrient enrichment concerns, especially in coastal water bodies. High levels of ammonia and nitrate nitrogen are often caused by nonpoint source

Figure 14. Five-Day Biochemical Oxygen Demand (BOD_5) Concentrations in Monitoring Stations Located in the Tidal (13072) and Above Tidal (13074) Segments of the Arroyo Colorado





(stormwater runoff) pollution and from wastewater outfalls. Nitrogen parameters measured in the Arroyo Colorado include nitrate-nitrite nitrogen, total Kjeldahl nitrogen and ammonia nitrogen, all reported in mg/l.

Based on samples collected between 1990 and 2006, the average concentration of nitrate plus nitrite nitrogen at the downstream portion of the non-tidal segment of the Arroyo Colorado (just upstream of the Zone of Impairment) is 3.23 mg/l. The screening criteria (based on the 85th percentile of tidal streams in Texas) for nitrate plus nitrite nitrogen is 2.76 mg/l (Figure 15).

Average concentrations of nitrate plus nitrite nitrogen continue to exceed the screening criteria, indicating a concern for nutrient enrichment. Furthermore, there is evidence that nitrate plus nitrite nitrogen concentrations have remained the same or have increased over the past five years (2000-2006). This trend is also shown for water quality monitoring stations located in the tidal segment of the Arroyo Colorado (Figure 16).

Phosphorus

Phosphorus is another nutrient essential for plant growth. Low concentrations of phosphorus often limit plant growth, including that of phytoplankton. Phosphorus concentrations in water are measured almost exclusively to assess algal dynamics in the water body. Elevated phosphorus levels can contribute to the occurrence of algal blooms, which can cause wide daily swings in dissolved oxygen. Like nitrogen, high phosphorus concentrations are often caused by nonpoint source (stormwater runoff) pollution and from wastewater outfalls. Phosphorus parameters measured in the Arroyo Colorado include orthophosphate phosphorus and total phosphorus reported in mg/l.

Figure 15. Nitrate plus Nitrite Nitrogen Concentrations at Monitoring Station 13074 Located Immediately Upstream the Arroyo Colorado Tidal Boundary

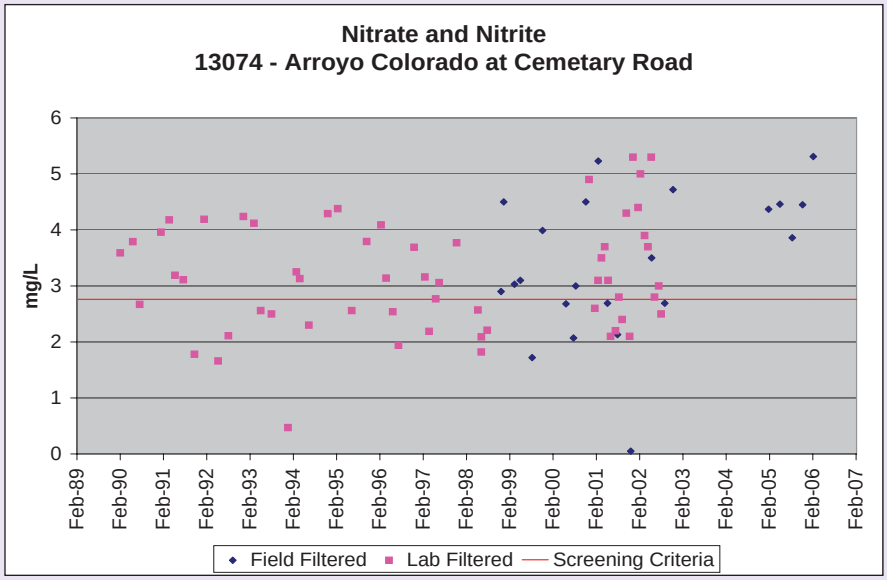
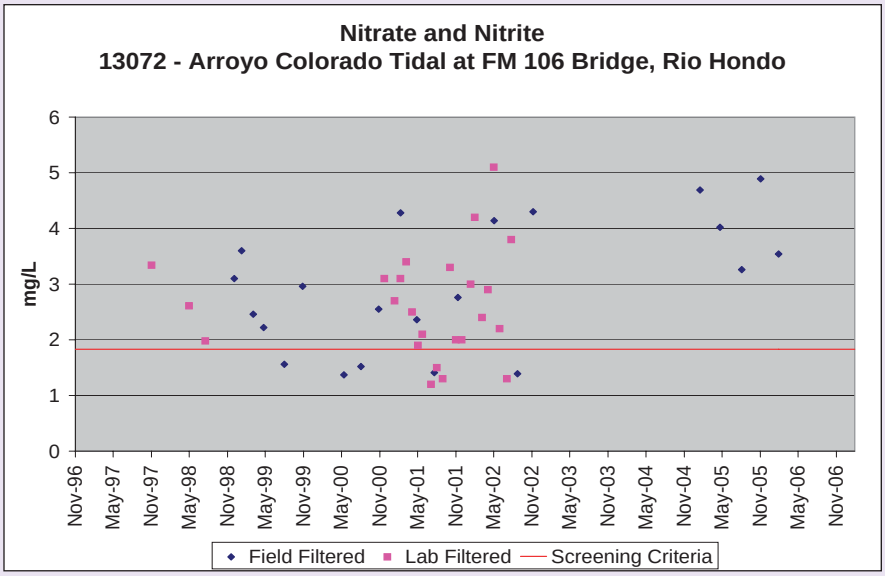


Figure 16. Nitrate plus Nitrite Nitrogen Concentrations at Water Quality Monitoring Station 13072 located in the Tidal Segment of the Arroyo Colorado at the Zone of Impairment



Phosphorus concentrations continue to exceed the screening criteria, indicating a concern for nutrient enrichment in the Arroyo Colorado. Based on samples collected between 1990 and 2006, the average concentration of total phosphorus at the downstream end of the non-tidal portion of the Arroyo Colorado (just upstream of the Zone of Impairment) is 0.9 mg/l. The screening criteria for total phosphorus (based on the 85th percentile of tidal streams in Texas) is 0.8 mg/l (Figure 17). Phosphorus concentrations have remained largely unchanged throughout the period of record (1990-2006), and this trend is similar for water quality monitoring stations located in the tidal segment of the Arroyo Colorado (Figure 18). Phosphorus concentrations at stations in the tidal segment also exceed the screening criteria. However, the average total phosphorus concentration at station 13072, a water quality monitoring station located in the middle of the Zone of Impairment at the Rio Hondo Bridge, are below the screening criteria.

Chlorophyll-*a*

Chlorophyll-*a* is a pigment used by plants during photosynthesis. The concentration of this compound in water, usually in micrograms per liter (µg/l), is an indicator of the algal population (*i.e.*, phytoplankton) and hence a measure of the photosynthetic activity occurring in a water body (Figure 19). High chlorophyll-*a* levels may indicate excessive algal growth. Consequently, chlorophyll-*a* is an important measure of stream health.

Chlorophyll-*a* concentrations continue to exceed the screening criteria for the Tidal and Above Tidal Segments of the Arroyo Colorado and have reached very high levels within recent years (2000-2006), displaying a trend similar to that of nitrogen-containing compounds. This is an indication that primary productivity overall is high in the Arroyo Colorado. Algal blooms are common in the Arroyo Colorado in the spring and summer months, especially in the tidal segment. Wide daily swings in the concentration of DO often accompany periods of high productivity. Due to the high concentration of phosphorus and nitrogen in the stream, efforts to identify a limiting nutrient in the Arroyo Colorado have not been successful. Research conducted by TAMU in 1999 concluded that the Arroyo Colorado is neither nitrogen-nor phosphorus-limited and that the factor which most limits algal growth in the Arroyo Colorado is light availability (Matlock and Demich 1999).

Figure 17. Total Phosphorus Concentrations at Water Quality Monitoring Station 13074 Located Immediately Upstream of the Arroyo Colorado Tidal Boundary

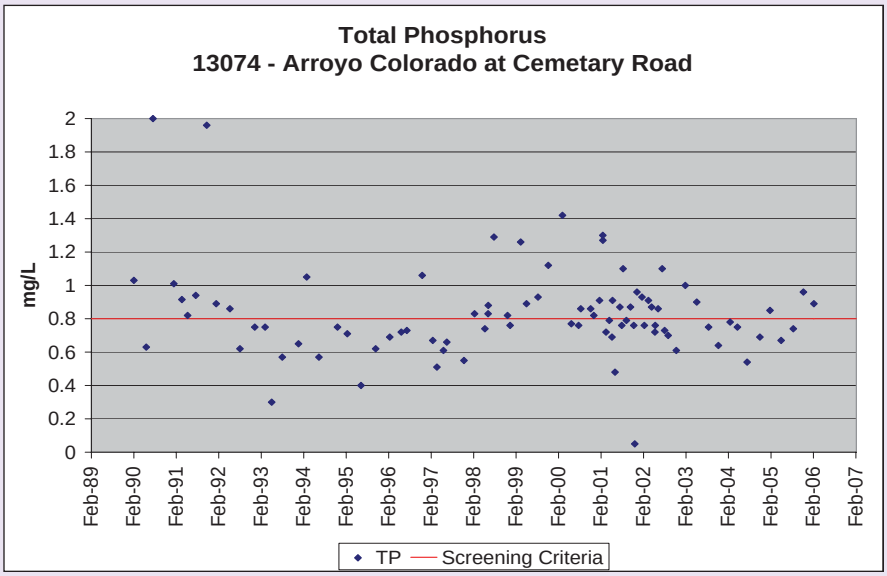
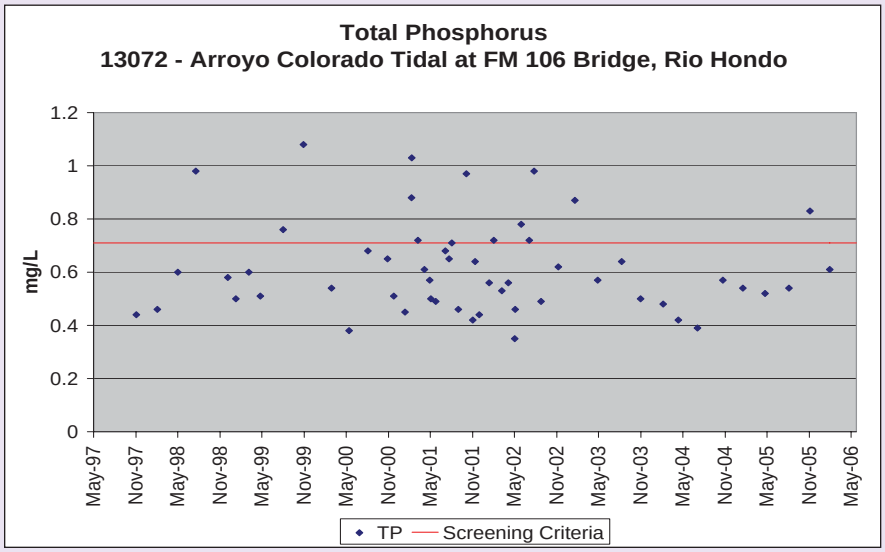


Figure 18. Total Phosphorus Concentrations at Water Quality Monitoring Station 13072 Located in the Tidal Segment of the Arroyo Colorado at the Zone of Impairment



which is, in essence, biochemical oxygen demand in sediment deposited at the bottom of some water bodies.

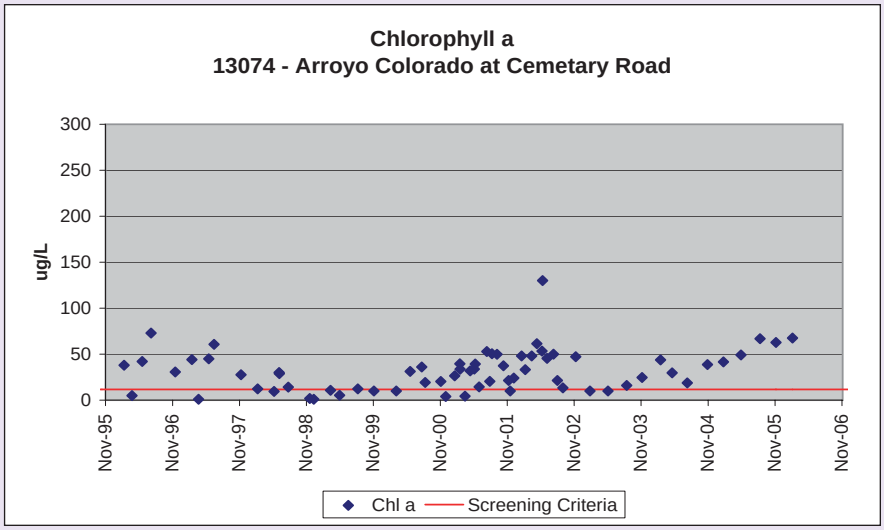
Sediment loads to the Arroyo Colorado are dominated by nonpoint source loadings from agricultural and urban runoff. However, suspended sediment loads occur during dry weather flows due to the significant sediment loading contributed by municipal and industrial point-source discharges (APAI 2006). In-channel erosion of the pilot channel of the Arroyo Colorado and excessive algal growth, due to high nutrient levels, also contributes to suspended solids

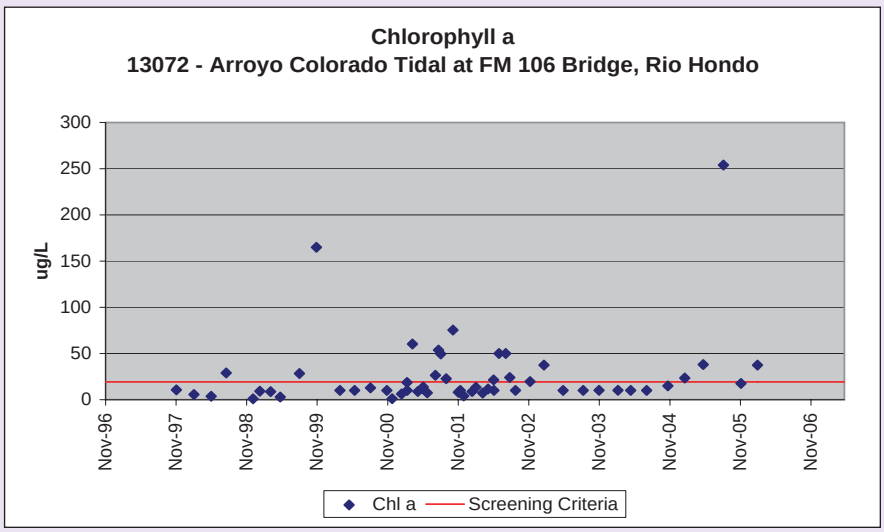
Sediment

Suspended sediment is a term used to describe small particles of mineral matter and organic matter that travel suspended in water. Total Suspended Solids (TSS) is the term used to describe the measurement of suspended sediment in natural waters. Since TSS is a measure of all suspended solids in water (mineral and organic), high algal concentrations can sometimes result in high TSS values.

Suspended sediment can have adverse effects on aquatic life at high concentrations. Many pollutants are also transported into the waters of the Arroyo Colorado and Lower Laguna Madre attached to sediment particles. These compounds may remain in the sediments for many years or may be released over a period of time and could even be passed up the food chain to humans. Contaminants in sediments often include nutrients, metals and/or organic compounds that originate from natural or man-made sources. Organic matter in suspended sediment can also contribute to DO depletion of bottom water through the creation of sediment oxygen demand,

Figure 19. Chlorophyll *a* concentrations for Water Quality Monitoring Stations Located Upstream (13074) and Downstream (13072) of the Arroyo Colorado Tidal Boundary





in the Arroyo Colorado (APAI 2006).

Figure 20 shows TSS concentrations at stations located upstream and downstream of the tidal/non-tidal boundary. Based on samples collected between 1990 and 2006, the average concentration of TSS at the downstream end of the non-tidal portion of the Arroyo Colorado (just upstream of the Zone of Impairment) is 147 mg/l. The average concentration of TSS at a station located in the tidal portion of the Arroyo Colorado (at the Zone of Impairment) is 27 mg/l (Figure 20). Although occasionally high (80-90 mg/l), TSS in the Tidal Segment of the Arroyo Colorado is generally much lower than in the Above Tidal Segment due to the change in stream velocity that occurs at the tidal boundary. As the freshwater from the Arroyo Colorado Above Tidal enters the Port of Harlingen, it slows down, causing sediment to fall out of suspension. Most of the sediment lost at the beginning of the tidal segment is thought to be deposited at or near the Port of Harlingen. Suspended sediment is thought to play an important role in oxygen depletion and nutrient cycling in this portion of the Arroyo Colorado. The TSS data shown in Figure 20 shows no apparent trend with time or season of the year.

Escherichia coli

Fecal Bacteria

Fecal coliform bacteria are biological indicators of infectious disease. They are present in the intestines of many animals including humans and, although many of these bacteria do not typically cause illness in humans, their presence in water indicates the possibility that other disease-causing microbes could also be present. *Escherichia coli* (E. coli) is a type of fecal coliform that is thought to be more specifically linked to human and animal waste. The presence and abundance of E. coli in water is an important measure of the impact human and animal waste may have on a water body. In marine water bodies, Enterococcus bacteria are used to measure the disease potential. A water quality criterion for individual E.coli samples has been set by the State of Texas at a maximum 394 colony-forming units per one hundred milliliters (cfu/100ml) and 89 (#/100ml) for Enterococcus to be protective of swimmers. In preparing the 2004 Texas Water Quality Inventory, if the screening level was exceeded by more than 25% of the samples collected in the assessment period; the water body was listed as impaired by the TCEQ.

Figure 21. shows E. coli and Enterococcus concentrations at water quality stations located upstream (13074) and downstream (13072) of the Tidal Segment boundary of the Arroyo Colorado from 2001 to 2006. E. coli concentrations in the Above Tidal Segment of the Arroyo Colorado exceed the criteria more frequently than in the Tidal Segment. The Above Tidal Segment of the Arroyo Colorado is currently listed on the 2004 Texas 303(d) list for elevated levels of E. coli.

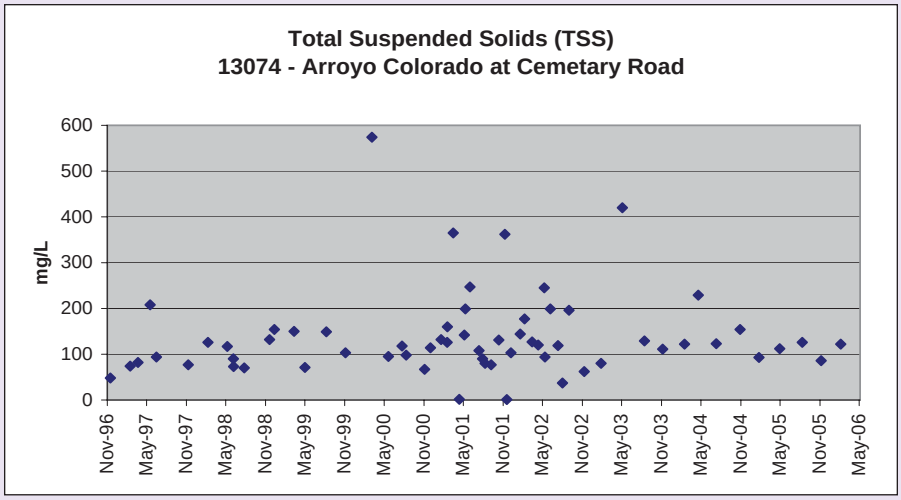
Legacy Pollutants

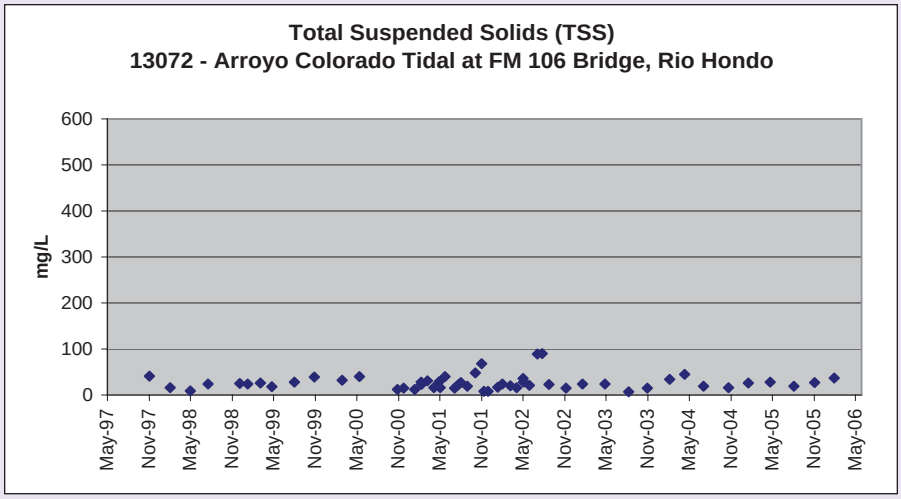
The term legacy pollutant is used to describe toxic chemicals that persist in the environment long after their use has been banned or severely restricted. Prior to 2004, the Arroyo Colorado appeared in the State of Texas' 303(d) Lists for failing to meet the fish consumption use. Legacy pesticides such as DDD, DDT, DDE, chlordane, dieldrin, endrin, heptachlor, heptachlor epoxide, hexachlorobenzene, lindane and toxaphene were found in concentrations that exceeded the human health risk criteria in the Above Tidal segment of the Arroyo Colorado, causing the Texas Department of Health to issue fish consumption advisories in 1980 and 1993.

In 2000, the TCEQ completed TMDLs for the legacy pollutant impairments in the Arroyo Colorado. The USEPA approved TMDLs for chlordane, DDE and toxaphene in fish tissue on June 14, 2001, and for DDD, DDT, dieldrin, endrin, heptachlor epoxide, hexachlorobenzene and lindane in fish tissue on May 15, 2004. A TMDL implementation plan designed to reduce legacy pollutant concentrations in fish tissue in the Arroyo Colorado

Fish consumption warnings

Figure 20. Total Suspended Sediment Concentrations (TSS) at Water Quality Monitoring Stations Located Upstream (13074) and Downstream (13072) of the Arroyo Colorado Tidal Segment Boundary





Above Tidal and the Donna Reservoir and Main Canal (Segment 2202A) was approved by the TCEQ in September of 2001. Since these TMDLs and TMDL implementation Plans were completed and approved by the TCEQ, legacy pollutants in fish tissue have declined significantly, prompting the Texas Department of State Health Services to modify the fish consumption advisory in the Arroyo Colorado to include only one species of fish (Smallmouth Buffalo). Legacy pollutants in fish tissue have been removed from the most current 303(d) list (TCEQ 2004b). More information on legacy pollutants in the Arroyo Colorado can be found at the following URL: <http://www.tceq.state.tx.us/implementation/water/tmdl/07-arroyoleg.html>

Wastewater Infrastructure

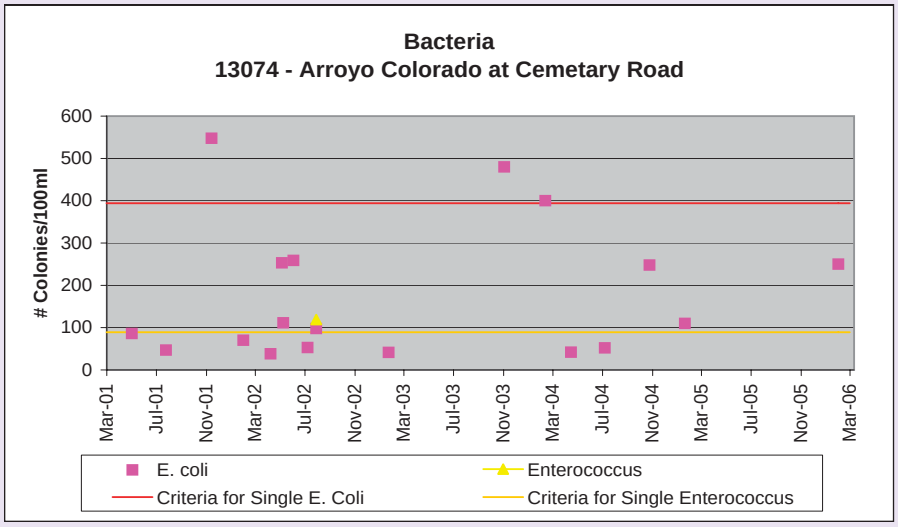
In 2002, the TCEQ compared the permit limits of BOD and ammonia nitrogen to historical effluent concentrations of BOD and ammonia nitrogen from self-reported data. The comparison provided historical confirmation that several of the municipal wastewater facilities were not continuously complying with permit limitations during the 10-year period. Since 2000, there have been marked improvements in permit compliance; however, some facilities continue to exceed the effluent limits specified in their discharge permits, partially because some of the facilities are out-dated.

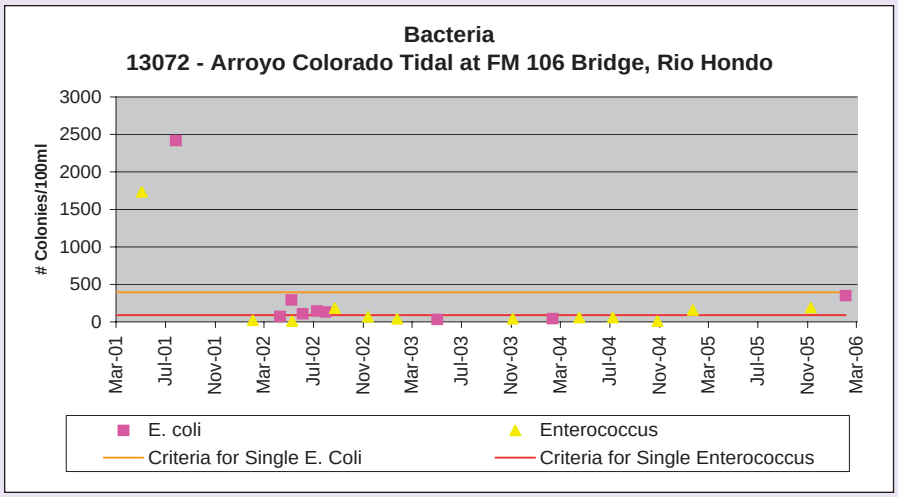
Overall, the state of the watershed in relation to wastewater infrastructure looks promising. All the municipalities in the Arroyo Colorado watershed have recently upgraded or plan to upgrade their facilities and all have agreed to participate in and support the Pollutant Reduction Plan (PRP) for the Arroyo Colorado. The PRP is the wastewater infrastructure component of the ACW Protection Plan. The organizations participating in the Arroyo Colorado PRP include the following:

- The City of Alamo
- The City of Donna
- The City of Harlingen (two facilities)
- The City of Hidalgo
- The City of La Feria

Wastewater Treatment Facility

Figure 21. E. coli and Enterococcus Concentrations at Water Quality Monitoring Stations Located Upstream (13074) and Downstream (13072) of the Arroyo Colorado Tidal Boundary





- The City of Mercedes
- The City of Mission
- The City of Pharr
- The City of Rio Hondo
- The City of San Benito
- The City of San Juan
- The City of Weslaco
- The East Rio Hondo Water Supply Corporation
- The McAllen Public Utility Board
- The Military Highway Water Supply Corporation (three facilities)

The wastewater treatment facilities operated by the participants in the Arroyo Colorado PRP account for more than 95% of all point source loading of pollutants of concern entering the Arroyo Colorado upstream of the Zone of Impairment. These facilities are considered to be the "Principal Point Source Contributors" of pollutants in the Arroyo Colorado Watershed. A more detailed discussion of the wastewater treatment facilities in the Arroyo Colorado is included in the section of this document titled "Sources and Causes of Pollution in the Arroyo Colorado."

Municipal

The permitted discharge limits for municipal treatment facilities vary widely within the Arroyo Colorado watershed. The permits include limits on effluent concentrations of five-day biochemical oxygen demand (BOD_5) and total suspended solids (TSS). These permits are commonly referred to by the effluent limitation sets of BOD and TSS. For example, a permit allowing discharge of up to 30 mg/l of BOD_5 and 90 mg/l of TSS is called a 30/90 permit. Permits are also commonly issued for effluent sets of 20/20 or 10/15 for the same constituents (BOD/TSS).

Of the 18 wastewater treatment facilities considered to be the Principal Point Source Contributors of Pollutants in the Arroyo Colorado watershed, nine are currently at the 10/15 treatment level, five are at the 20/20 level, and four are at the 30/90 level.

Since 2000, two new wastewater treatment facilities were constructed and one facility was upgraded. As part of the ACW Protection Plan, five additional new

Colonia

facilities and seven expansions and/or upgrades to existing facilities are planned for the period of 2006-2010 and one new facility and two facility expansions or upgrades are planned for the period of 2011-2015.

The ACW Protection Plan also includes eight enhanced wastewater treatment projects (small wetlands and pond systems) planned for construction in the period of 2006 through 2010, and three enhanced wastewater treatment projects are also planned for construction in the planning interval of 2011 through 2015.

On-Site Wastewater Systems and *Colonias*

Recent population estimates show there are 199,529 residents living in *colonias* in the Hidalgo, Cameron and Willacy counties (TWDB 2003). Most of these residents are within the Arroyo Colorado watershed. The Phase I DO TMDL analysis of the Arroyo Colorado (2002) accounted for the loading from *colonias* (low-income unincorporated communities) that were not connected to centralized wastewater systems as urban nonpoint source pollution (NPS). Extending wastewater service to these residents will result in a decrease in urban NPS loadings and an increase in urban point source loading (see Estimated Loadings section). New municipal wastewater facilities, expansions and upgrades are planned to accommodate a growing urban and suburban population, and to provide service to populations that currently use on-site treatment systems. From 2000 to 2005, more than 37,000 residents of *colonias* were supplied with centralized wastewater service by neighboring municipalities (TCEQ 2006). There are plans to serve an additional 58,610 residents during the period from 2006 to 2010 and 9,471 from 2011 through 2015 (TCEQ 2006).

Pilot channel in the Main Floodway

Reuse of Wastewater

The partial reuse of effluent from wastewater treatment facilities is a practice that can limit nutrient loading to the Arroyo Colorado and one that is favored by municipalities in the watershed as a water conservation strategy. Five municipalities are currently reusing approximately 2.5 MGD of wastewater effluent for irrigation. As part of the ACW Protection Plan, several municipalities plan to reuse an additional 1.75 MGD of wastewater effluent by 2015 and other municipalities are also considering the reuse option in their plans for future wastewater improvements.

Cultivation

Agriculture

Agriculture is an important part of the economy of the Lower Rio Grande Valley. According to the 2002 Census of Agriculture, the market value of crops sold is over $62 million in Cameron County and more than $182 million in Hidalgo County. The Lower Rio Grande Valley is one of the most intensely farmed regions in Texas, with approximately 28% of the land area classified as cropland and approximately 72% of available cropland in active cultivation (NOAA, 1992). Loss of farmland to increasing urbanization of the Lower Rio Grande Valley is of great concern to local farmers. It is estimated that in the next 25 years, a 14% loss of irrigated cropland will occur in Cameron County due to urbanization and a 26% loss is expected in Hidalgo County.

It is estimated that agricultural activity accounts for more than half of the nutrients and suspended sediment entering the Arroyo Colorado (see Estimated Loadings Section). With the help of state and federal agricultural agencies, many management practices designed to reduce nutrient and pesticide runoff from agricultural land have been implemented in the Arroyo Colorado

Cotton field

watershed over the past 10 years. These practices, commonly known as agricultural best management practices or BMPs, have been applied to agricultural land in the Arroyo Colorado watershed on a producer-by-producer basis under voluntary federal programs such as the USDA Natural Resource Conservation Services' Environmental Quality Incentives Program (EQIP) and similar state programs such as the TSSWCB's Water Quality Management Program (also referred to as the SB503 Program). Separately and in combination, these cost-share programs provide incentives for individual producers to establish Resource Management Systems (RMSs) and Water Quality Management Plans (WQMPs) for agricultural land currently in production. Under these plans, participants institute a combination of BMPs tailored to the needs of the producer and protective of water quality and natural habitats in the watershed. Since 1998, RMSs and WQMPs have been implemented on approximately 50,000 acres of agricultural land in the Arroyo Colorado watershed.

Under the ACW Protection Plan, the TSSWCB and USDA plan to expand to 150,000 acres the amount of agricultural land on which RMSs and WQMPs are implemented in the Arroyo Colorado watershed.

The ACW Partnership is also participating in an effort to better characterize loadings of nutrients and BOD from agricultural fields in the Arroyo Colorado watershed. With financial help from the USEPA and the TSSWCB, ACW Partnership, TEAS, TRWI, TAMUK, and TCE are currently collecting water quality data to better characterize agricultural runoff using edge-of-field monitoring of rainfall runoff and irrigation return flows. The results if the study will help to accurately quantify pollutant loading from agricultural activity in the watershed and help formulate a strategy to mitigate agricultural loading. Additionally, the study has an educational component designed to disseminate available information on agricultural BMPs and the information learned from the study to agricultural producers in the watershed.

Urban Development

At current development densities, urban growth will add an additional 400-600 square miles of new urbanization in the Lower Rio Grande Valley by the year 2020 (Jacob 2006). This is an area equivalent to the entire Arroyo Colorado watershed. The runoff from the yet-to-be built urbanized areas will likely be of a different quantity and quality from that of the farm and rangelands that it will replace. In many, perhaps most, cases the quality of runoff could be substantially worse. Under current development patterns, there will not only be much more wastewater generated in the watershed, but also more lawns maintained with fertilizers and pesticides, more vehicle miles driven, more nitrogen oxides (NOxs) created and deposited from engine exhaust, and more road contamination from wear on brakes and tires.

The impacts of such high rates of urban growth can be minimized by reducing pollutants entering into urban runoff and by reducing runoff itself as much as possible. By promoting more compact forms of development that rely more on public space and public transportation, the impact of the new growth can be reduced and

New home construction

controlled. Other alternatives include promoting urban architecture that uses more open space, less impermeable land cover and incorporates wetland and pond systems capable of treating runoff and wastewater through biological means while enhancing the esthetic value of the urbanization. Regardless of how the impacts of growth are mitigated, the citizens of the Arroyo Colorado watershed must act now to preserve important remaining natural areas in the watershed, because these areas help to protect water quality.

Flooding and Flood Control

The Arroyo Colorado watershed and the entire Rio Grande Valley are flat coastal areas that are prone to flooding. The Lower Rio Grande Flood Control Project is an important floodway system that protects municipalities in the Rio Grande Valley from catastrophic flooding by channeling excess floodwaters into a system of levees and flood control structures. The project is managed by the IBWC. As in most areas located in flat coastal plains, drainage in the Arroyo Colorado watershed is poor. Drainage districts were created in the Rio Grande Valley in the 1920s and 1930s to help improve local drainage and flood control.

Drainage districts are important stakeholders in the Arroyo Colorado watershed. The districts control land use in and near drainage easements and have an important role to play in the platting and construction of new urban developments. Drainage districts can influence the way rainfall runoff is distributed, conveyed, stored and treated in the Arroyo Colorado watershed, and their participation in the ACW Protection Plan is critical.

One of the most promising recommendations in the Habitat Restoration Component of the ACW Protection Plan is the redesign and modification of drainage ditches to create wetland swales that would hold and treat storm water within the drainage channels themselves. The ACW Partnership and the drainage districts are jointly investigating ways of implementing these ditch modifications.

In strictly urban settings, it is the municipal governments that control storm water runoff quantity and quality through the Phase I and II Storm Water Regulations, which are implemented nationally under the National Pollutant Discharge Elimination System (NPDES) and in Texas under the Texas Pollutant Discharge Elimination System (TPDES). A more detailed discussion of urban storm water regulation is presented later in this document.

Storm Water Quality Management

Pollutant discharges from urban storm water have been largely unregulated in the Arroyo Colorado watershed. Since 2003, efforts to control urban storm water runoff in the Arroyo Colorado watershed have been limited to outreach and education for municipalities in the Rio Grande Valley aimed at familiarizing them with the requirements of the Phase II Storm Water Small MS4 Regulations. However,

Valley flooding

beginning in 2006, local governments will begin developing Storm Water Management Programs (SWMPs) for designated urbanized areas (UAs) located in the Arroyo Colorado watershed. The programs will focus on pollutants of concern in the Arroyo Colorado. Although difficult to quantify at early stages of implementation, the effect of these SWMPs will be to reduce pollution from urban storm water runoff.

Awareness of Water Quality Issues

In addition to the efforts of the ACW Partnership, there are limited outreach and education efforts that focus specifically on the water quality issues associated with the Arroyo Colorado. Between 1999 and 2006, different groups have sponsored events in the Rio Grande Valley focusing on water issues that have included discussions about the Arroyo Colorado. These groups include the McAllen International Museum of Arts and Science (IMAS), Lower Rio Grande Valley Texas Pollutant Discharge Elimination System Storm Water Task Force (Storm Water Task Force), Region M Water Planning Group, Texas Clean Rivers Program, Texas Commission on Environmental Quality, Texas Cooperative Extension, Texas Parks and Wildlife Department, Texas Watch and U.S. International Boundary and Water Commission.

The Valley Sportsman Club has an annual "Arroyo/Bay Clean-up," and a variety of local public and grass-roots organizations that sponsor events such as trash clean-ups, reforestation projects and wildlife education. A complete list of organizations conducting water quality and environmentally related conservation and outreach efforts is included in Appendix F.

Tour of Estero Llano Grande

Lower Rio Grande Valley newspapers routinely provide information about the Arroyo Colorado, the ACW Partnership and the ACW Protection Plan effort. In 2005, seven articles were published in local newspapers specifically about the Arroyo Colorado planning effort and two additional articles were published in 2006.

Educators of all levels, especially teachers of the sciences, have been key players in providing information and education on local environmental issues. IMAS and the Storm Water Task Force have become important partners in increasing awareness of water quality issues associated with the Arroyo Colorado and water-related outreach and education in general.

Community interest in the Arroyo Colorado began to grow when the TMDL process began in 1998, and because of the promotional efforts of the Watershed Coordinator and Arroyo Colorado Outreach and Education Work Group, general public and stakeholder knowledge of the issues associated with the Arroyo Colorado continues to expand. Promotional events in 2005 and 2006 centered on water quality issues and development of the ACW Protection Plan. The events also provided information to stakeholders on how they could become involved with the Arroyo Colorado planning effort. With additional funding provided by the USEPA and the TCEQ, the ACW Partnership hired consultants to assist in the short-term efforts to promote development of the ACW Protection Plan and to conduct research on environmental awareness related to the Arroyo Colorado.

Tree planting

One-on-one stakeholder interviews, focus group meetings and a telephone market survey were conducted in 2006 to evaluate the level of awareness, attitudes and beliefs of specific targeted audiences concerning the Arroyo Colorado. The telephone survey of the general public revealed a pervasive lack of awareness and knowledge about the Arroyo Colorado by the vast majority of residents, including stakeholder groups. The survey revealed that, when given information about the water quality impairment of the Arroyo Colorado, more than half (54%) of the respondents were "very concerned" about the condition of the Arroyo Colorado and that nearly all (94%) believe a "clean environment" is "very important." This rated as more important than new jobs and business opportunities and lower taxes (Suma/Orchard 2006). The market research revealed a general belief that no one group bears responsibility for the situation of the Arroyo Colorado and it is up to all residents of the watershed to help improve environmental conditions in the Arroyo Colorado. The strong sentiment expressed was that "we are all in it together" and "we must all do our parts to help clean it up."

In 2003, USEPA Region 6 conducted an assessment to determine the need for training and education materials along the U.S. border with Mexico. In the study report, "Training and Environmental Education Materials" (TEEMS), water issues, including availability and pollution, dominated the list of environmental priorities by a large margin among U.S. respondents (IMAS 2003). Leaders and citizens of the Lower Rio Grande Valley consider water quality and conservation to be vital for the continued growth of urban areas and economic development in the Lower Rio Grande Valley. When asked about sources of environmental information, television was cited as the top source. Other sources mentioned in the TEEMS report included environmental organizations, science classes, newspapers, radio, word of mouth, local meetings and the Internet.

While educational levels vary significantly among watershed residents, more that half do not have access to the Internet, and many may not read beyond an eighth grade level. Previous social marketing efforts in the area have confirmed that residents in low-income groups, particularly those living in *colonias*, best receive educational information from trusted people and *promotoras* (promoters) who live nearby. Word-of-mouth information received in small groups or individually is the most trusted source. The second most trusted source is messages distributed from schools. Colorful illustrations, demonstrations and motivational messages are generally well received.

Arroyo-Travel-Display

Television and radio, particularly Spanish-language stations, are also powerful purveyors of messages to this audience. The recently completed market survey substantiates and expands on the finding of the TEEM report.

The main result of the project's outreach and educational efforts, so far, is a consistent turnout to work group and Steering Committee meetings and a general "buzz" among stakeholders and the general public that something is beginning to happen. The ACW Partnership is consequently in a favorable position to begin the next phase of implementing a strategic outreach and educational plan for the Arroyo Colorado. A detailed description of such a plan can be found in the Education and Outreach (E&O) section of this document.

Agricultural E&O Event

ACW Partnership Steering Committee Meeting

SOURCES AND CAUSES OF POLLUTION IN THE ARROYO COLORADO

When discussing the sources and causes of pollution in the Arroyo Colorado, it is necessary to include two main topics: 1) the additions or loading of pollutants into the stream and 2) the stream's ability to assimilate pollutants. In the case of the Arroyo Colorado, these two topics are equally relevant because the Arroyo Colorado suffers from two major man-induced conditions: 1) excessive loading of pollutants and 2) a severely diminished capacity to assimilate pollutants.

The Phase I TMDL study completed in 2002 provided a thorough assessment of sources, causes and conditions that contribute to low DO levels in the Arroyo Colorado. The study included a review of historical water quality and pollution source analyses that focused primarily on the sources of pollutants commonly associated with dissolved oxygen dynamics in surface water, including BOD, ammonia nitrogen, nitrate plus nitrite nitrogen, orthophosphate phosphorus, organic nitrogen, organic phosphorus and sediment. The Phase I TMDL study determined that the two main sources of pollution in the Arroyo Colorado watershed were agricultural nonpoint source runoff and municipal wastewater point sources. Other sources of pollution include urban stormwater, individual onsite wastewater treatment systems, *colonias* and industrial activity near the Port of Harlingen.

Fish kill

The physical modifications made to the Arroyo Colorado for flood control and navigation also contribute to the occurrence of low dissolved oxygen in the upper portion of the tidal segment. Actions such as deepening and widening the stream in specific areas, and placing dredge spoils along the banks, contribute significantly to the low dissolved oxygen concentrations observed in the Zone of Impairment by reducing mixing in the water column, lowering aeration rates and increasing temperature and sediment oxygen demand. The removal and suppression of stream bank vegetation along the length of the Arroyo Colorado diminishes the stream's ability to assimilate pollutants by exacerbating stream bank erosion and increasing the sediment load.

The cause of elevated levels of fecal bacteria in the Arroyo Colorado is thought to be poorly treated and untreated wastewater and pet and other animal waste. However, more information is needed to conclusively determine the causes of bacterial pollution in the Arroyo Colorado.

Wastewater

There are currently 36 active permits (Figure 22) to discharge wastewater into the Arroyo Colorado (31 municipal and domestic facilities, five industrial facilities). Together, these facilities have a total permitted flow of 209 million gallons per day (209 MGD). Of the 31 discharge permits, only 23 have outfalls that discharge wastewater directly into the Arroyo Colorado or to drainage ditches that flow into it. The combined permitted flow of these 23 facilities is approximately 56 million gallons per day (56 MGD).

Two of the five industrial facilities permitted by the state to discharge wastewater into the Arroyo Colorado are aquaculture facilities (*i.e.*, shrimp farms). These facilities discharge wastewater directly into the Arroyo Colorado on a seasonal basis. The total permitted

Wastewater facility

discharge amount from these aquaculture facilities is 150 million gallons per day (MGD). The discharge point for these facilities is located approximately 15 miles downstream of the Zone of Impairment. Additionally, several industrial facilities discharge effluent into the Arroyo Colorado via municipal wastewater treatment facilities operated by several municipalities in the watershed.

The Phase I TMDL analysis of the Arroyo Colorado concluded that between 1989 and 1999, municipal wastewater facilities accounted for the following portion of pollutant loads (TCEQ, 2003):

- 23% of the BOD
- 22% of the ammonia nitrogen
- 20% of the nitrate nitrogen
- 40% of the orthophosphate
- 1% of the sediment

In all, 18 municipal wastewater treatment facilities account for more than 95% of all point source loading of pollutants of concern entering the Arroyo Colorado upstream of the Zone of Impairment. These eighteen facilities are considered to be the "Principal Point Source Contributors" of pollutants in the Arroyo Colorado Watershed (Figure 23).

Colonias

Of the 1,200 *colonias* located along the US-Mexico border, about 75 % are located in Lower Rio Grande Valley (TWDB 1997). The most recent population estimates show there are 199,529 residents living in *colonias* in Hidalgo, Cameron and Willacy counties (TWDB 2003b). However, the number of colonia residents in the Rio Grande Valley is increasing. Between 1996 and 2003, the *colonia* population in these three counties increased by more than 20,000. The TWDB estimates that in Hidalgo County alone, 73,000 residents live with inadequate wastewater services (TWDB 2003b). Figure 24 shows the location of known *colonias* in the Arroyo Colorado watershed.

Figure 22. Location of Wastewater Outfalls in the Arroyo Colorado Watershed

Figure 23. Principal Point Source Contributors of Pollutants of Concern to the Arroyo Colorado

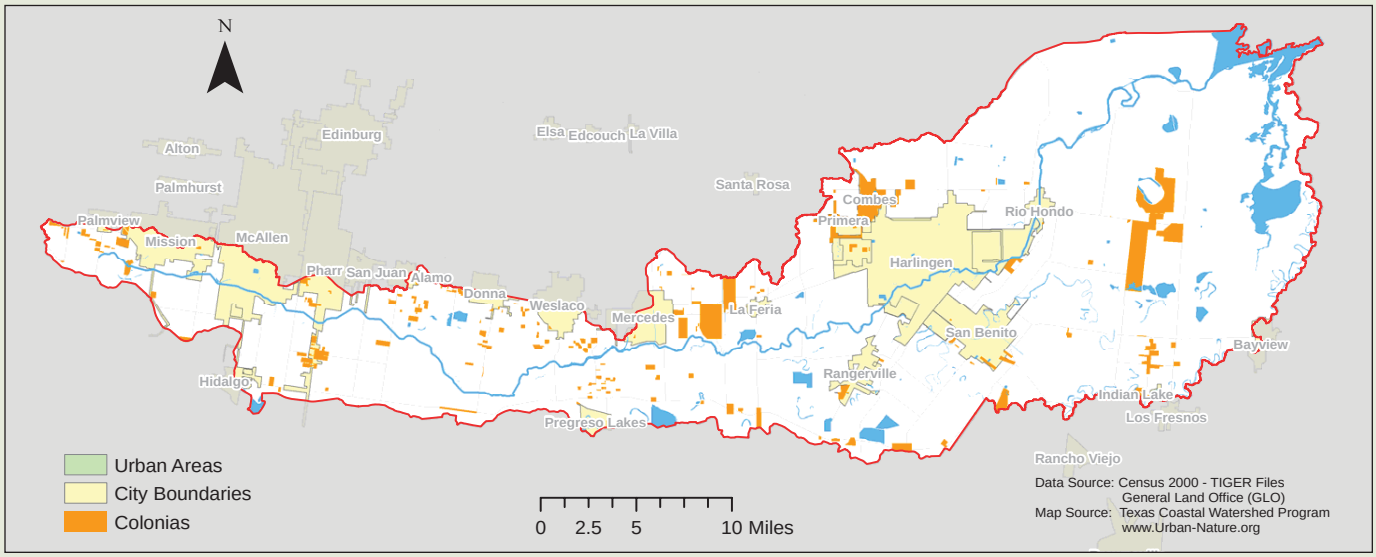
The Arroyo Colorado receives much of the untreated or poorly treated wastewater generated in *colonias* directly from ditches that drain colonia communities. The TCEQ estimated the pollutant loading from *colonias* in the Arroyo Colorado watershed as part of the Phase I TMDL Study in 2002 and concluded that between 1989 and 1999, *colonias* accounted for the following portion of pollutant loads (TCEQ, 2003):

- 4.3 % of the BOD
- 4.0% of the ammonia nitrogen
- 4.3% of the nitrate nitrogen
- 4.1% of the orthophosphate
- 0.1% of the sediment

Agriculture

The Arroyo Colorado watershed contains approximately 333,000 acres of agricultural land, 290,000 acres of which are irrigated cropland (Figure 25). Cotton and grain sorghum are the primary crops. However, corn, sugarcane and citrus are also commonly grown in the area.

Figure 24. Colonia Areas in the Arroyo Colorado Watershed



Irrigation field

According to the Phase I TMDL study, agricultural production contributes significant amounts of BOD, nutrients and sediment to the Arroyo Colorado. The study concluded that between 1989 and 1999, agricultural activity in the Arroyo Colorado watershed accounted for the following portion of pollutant loads:

- 41% of the BOD
- 64% of the ammonia nitrogen
- 68% of the nitrate nitrogen
- 49% of the orthophosphate
- 87% of the sediment

The Arroyo Colorado receives pollutants from agricultural runoff in three ways:

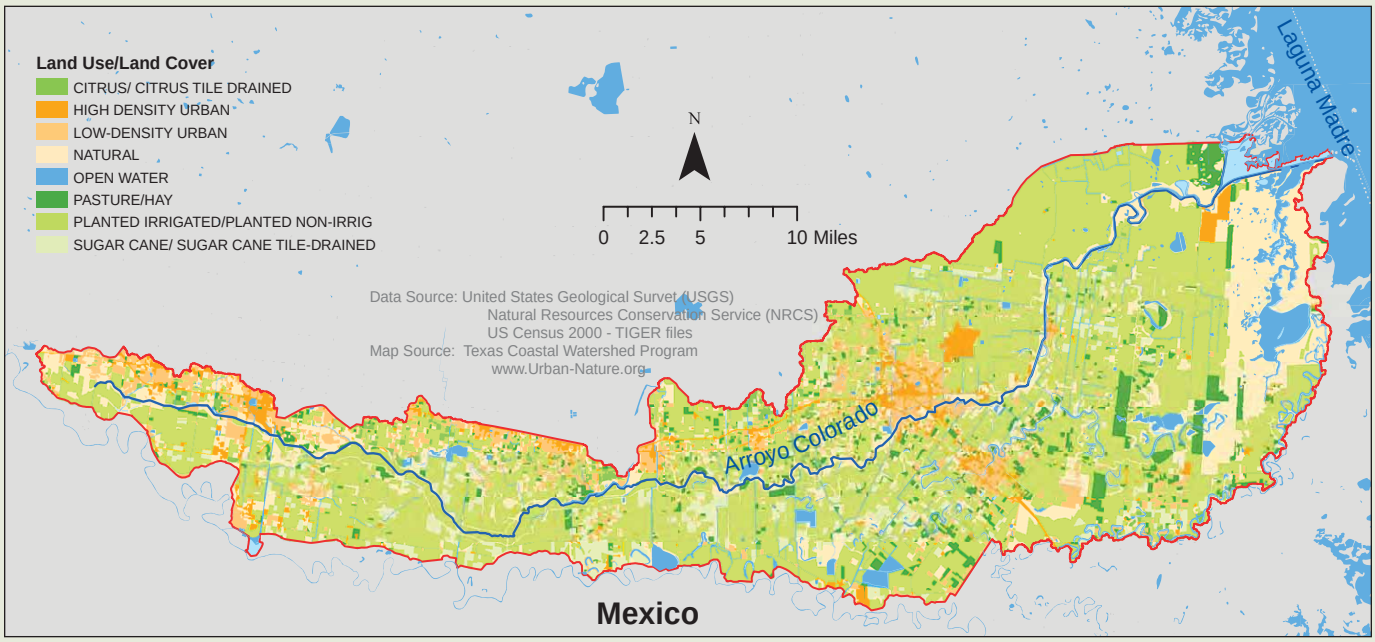
1) Direct surface rainfall runoff from agricultural fields via drainage ditches
2) Direct surface irrigation return flow from agricultural fields via drainage ditches
3) Indirect irrigation return flow from agricultural fields via shallow groundwater base flow

The ACW Partnership used the best data available to estimate sediment and nutrient loadings into the Arroyo Colorado from agriculture. However, additional monitoring is being conducted at the edge-of-field scale and sub-watershed scale to develop better estimates of pollutant loading from agricultural activities in the watershed.

Urban Storm Water

Storm water discharges are generated by rainfall runoff from land and impervious areas such as paved streets, parking lots and building rooftops. These storm flows often contain pollutants in quantities that can adversely affect water quality. Most urban stormwater discharges are considered point sources and require coverage by an NPDES (National Pollution Discharge Elimination System) permit. Despite implementation of USEPA's NPDES Phase II stormwater regulations nationwide in 2000, urban stormwater pollution remains largely unregulated in the Arroyo Colorado watershed.

Figure 25. Land Use in the Arroyo Colorado Watershed



According to the Phase I TMDL study of the Arroyo Colorado, between 1989 and 1999, urban storm water in the Arroyo Colorado watershed accounted for the following portion of pollutant loads:

- 26% of the BOD
- 9% of the ammonia nitrogen
- 7% of the nitrate nitrogen
- 6% of the orthophosphate
- 10% of the sediment

Industrial Activity

Sources of pollution to the Arroyo Colorado include releases of concentrated fertilizer and raw sugar during barge off-loading and loading operations at the Port of Harlingen and at similar facilities located near the port and city of Rio Hondo. In addition to the spillage of dry fertilizer and raw sugar directly into the Arroyo Colorado, these facilities may also be contributing pollutants to the Arroyo Colorado from stormwater runoff. The magnitude of pollutant contributions from these operations has not been quantified but may be substantial. The spillage and runoff of dry fertilizer and raw sugar occurs in the portion of the Arroyo Colorado identified as the Zone of Impairment, where the highest incidence of low dissolved oxygen occurs in the Arroyo Colorado.

Raw sugar being loaded into barges at the Port of Harlingen

Off-loading commercial dry fertilizer at the Port of Harlingen

The Role of Physical Modifications

The Arroyo Colorado is a constructed floodway through approximately half of its course in southern Hidalgo County. Between 1932 and 1947, the IBWC built flood levees and converted the main channel of the Arroyo Colorado into a pilot channel designed to convey low flow drainage and floodwaters from the Rio Grande Valley. Between 1945 and 1951, the USACE dredged and straightened the tidal portion of the Arroyo Colorado, widening an area near Harlingen to accommodate barge traffic from the Laguna Madre to the Port of Harlingen. These two large-scale physical modifications limit the Arroyo Colorado's ability to assimilate pollutants naturally and meet the uses designated by the State of Texas.

The designed flow velocity of the pilot channel in the Main Floodway (*i.e.*, the Arroyo Colorado above Tidal in southern Hidalgo County) is significantly higher than the slow movement of water that normally occurs in oxbow lakes and other types of natural *resaca* systems. High flow velocities create an unstable, erosional regime in a coastal stream like the Arroyo Colorado. Adding to the instability of the Arroyo Colorado is the loss of sinuosity in the main channel from rectification and channelization and a lack of adequate riparian vegetation to protect the banks from erosion.

Stream instability helps keep suspended sediment

Storm Drain

loads high in the Arroyo Colorado, and high suspended sediment prevents the Arroyo Colorado from assimilating nutrients along its course. Under normal conditions, ammonia and nitrates are removed by algae, which use these nutrients to grow. However, algal growth is suppressed when sediment loads are high because light penetration limits photosynthesis. Also, suspended sediments help to transport phosphate, another important nutrient, by adhering to it and releasing it downstream.

The lack of an adequate riparian habitat can also help keep dissolved oxygen levels lower in a stream by keeping surface water temperatures higher. Oxygen gas stays dissolved in water better at cooler temperatures. The canopy offered by trees and other riparian vegetation shade the banks of natural streams, helping to keep surface water temperatures lower, and thereby increasing the solubility of oxygen.

Dredging in the tidal portion of the Arroyo Colorado also contributes significantly to the stream's inability to meet the State's Water Quality Standards for a high aquatic life use. The removal of bottom sediments from the bed of the Arroyo Colorado results in the deep intrusion of hypersaline (very salty) water from the Laguna Madre to the Port of Harlingen. The intrusion of salt water this far inland causes the upper and lower portions of the water column of the Arroyo Colorado to segregate into distinct density layers that do not mix well vertically; this phenomenon is known as density stratification. During periods of low fresh water flow and warm temperatures, the bottom depths (~3m) of the water column in much of the tidal segment of the Arroyo Colorado become almost completely depleted of oxygen (0-1.5 mg/l), leaving a surface layer of less than one meter with adequate conditions for aquatic life (DO between 4-6 mg/l).

Natural aeration (*i.e.*, oxygenation) in coastal streams is largely dependent on wind action. Oxygen is introduced into the surface layers of coastal water bodies through mechanical agitation caused by wind movement. Wind aeration can be inhibited in stream

Llano Grande Lake

The Arroyo Colorado was widened and deepened to create the Barge Turn Basin at the Port of Harlingen immediately downstream of the tidal boundary

channels with steep banks such as those of entrenched (*i.e.*, excavated) channels. The Arroyo Colorado Tidal is an excavated channel that is maintained through periodic dredging (approximately every five years). Placement of dredge material is commonly on or near the banks of the excavated channel, creating bank heights of 30-50 ft. Lower bank heights in the Arroyo Colorado Tidal Segment would help increase surface aeration in the stream by allowing more wind action on its surface.

The widening of the Arroyo Colorado at the Port of Harlingen (barge) Turning Basin reduces the flow velocity of the non-tidal segment of the Arroyo Colorado as it enters the tidal segment. This slowing of flow causes suspended sediment and particles of organic matter to drop out of suspension and deposit in the turning basin, reducing turbidity in the water column downstream of the turning basin. Less turbid water allows for deeper light penetration, and plentiful nutrients complete the stage for perfect algal growth conditions. Algal blooms are common in the Arroyo Colorado Tidal in the spring and summer.

During the day, algal blooms can produce high levels of dissolved oxygen through photosynthesis. But during the night, the same oxygen-producing algae can consume large amounts of oxygen through respiration. This can deplete the water column of oxygen, depriving aquatic animals of this life-sustaining element. Excessive algal growth can also create large amounts of organic matter from the reproduction and death of individual algal cells. Bacteria in natural waters decompose the dead algae and other sedimentary organic particles and, in doing so, also consume large amounts of dissolved oxygen through respiration. Consequently, excessive algal growth and the deposition of sedimentary organic matter can lead to depletion of dissolved oxygen from algal and bacterial respiration.

Dredging

INSTITUTIONAL FRAMEWORK

Successful management of water and other natural resources depends on a thorough knowledge of the federal, state and local laws and regulations governing the use of these resources and the organizations charged with ensuring that laws and regulations are followed. The landmark national environmental legislation known as the federal Clean Water Act is the main driving force behind the development of the ACW Protection Plan because restoring the Arroyo Colorado and maintaining it as a "fishable and swimmable" stream is a goal of both the Clean Water Act and the Arroyo Colorado Partnership. Because a number of federal and state agencies are responsible for the protection and restoration of natural resources in Texas, representatives of these agencies were actively involved in the development the ACW Protection Plan. However, it is clear from experience that local stewardship and the actions of local governments have the greatest effect on water quality.

A list of all federal and state legislation governing water quality and habitat protection and restoration in the Arroyo Colorado is provided in Appendix G of this document. The following sections provide a brief overview of the federal, state and local governing entities and programs associated with resource management in the Arroyo Colorado watershed.

Federal Agencies and Programs

Several federal agencies have authority and jurisdictions over the natural resources in the Arroyo Colorado watershed. Following is a description of federal entities, their roles in the management of natural resources in the Arroyo Colorado watershed, and the programs they administer.

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers (USACE) administers regulatory programs and issues permits under Section 404 of the Clean Water Act and Section 10 of the Rivers and Harbors Act. In addition to its military role, USACE leads efforts in planning, designing, building and operating water resources and other civil works projects for purposes such as navigation, flood control, environmental protection and disaster response <http://www.usace.army.mil/>.

The Arroyo Colorado Navigation District of Cameron and Willacy Counties granted a perpetual easement in 1947 to the USACE to use specific placement areas for the dredged material from the GIWW and the Tributary Channel (USACE 1975). The Arroyo Colorado Navigation District of Cameron and Willacy Counties dissolved in 1983. The Port of Harlingen Authority is currently the local sponsor of the GIWW–Tributary Channel to Harlingen.

The U.S. Army Corps of Engineers and its local sponsor maintain the Tributary Channel which comprises most of the Tidal Segment of the Arroyo Colorado.

U.S. Department of Agriculture (USDA)

The U.S. Department of Agriculture (USDA) is active in natural resource management, particularly through the Natural Resource Conservation Service (NRCS) and the U.S. Forest Service (USFS). Both organizations provide resources for conservation of natural resources, public land management and educational programs. The USDA's Resource Conservation and Development (RC&D) program promotes the development and utilization of natural resources and improvement of economic activity through conservation

Citrus Farmer, USDA-ARS Researcher, and Independent Soil Fertility Consultant at Calpine Orchard

and enhancement of the environment and standard of living in designated RC&D areas. Similarly, the USDA's Rural Development Program (USDA-RD) offers grants and low interest loans for water and wastewater development or improvement projects in rural communities <http://www.usda.gov>.

U.S. Environmental Protection Agency (USEPA)

The U.S. Environmental Protection Agency (USEPA) works to develop and enforce regulations that implement environmental laws enacted by Congress, such as the Clean Water Act and Clean Air Act. EPA is responsible for researching and setting national standards for a variety of environmental programs and delegates to states and tribes the responsibility for issuing permits and for monitoring and enforcing compliance with regulations and permit requirements. Where national standards are not met, EPA can issue orders and take other steps to assist the states and tribes in reaching the desired levels of environmental quality. The EPA also sponsors several initiatives and grant programs that provide assistance to organizations involved in watershed management, pollution prevention, education and sustainable development. <http://www.epa.gov/>.

Federal Emergency Management Administration (FEMA)

The Federal Emergency Management Administration (FEMA) has undertaken a massive effort of flood hazard identification and mapping to produce Flood Hazard Boundary Maps, Flood Insurance Rate Maps, and Flood Boundary and Floodway Maps. The maps identify Special Flood Hazard Areas (SFHAs), which are regulated to minimize potential loss of life, property and economic benefits that would result from floodplain development. Development may take place within the SFHA, provided that development complies with local floodplain management ordinances, which must in turn meet the minimum federal requirements. Flood insurance is required for insurable structures within the SFHA to protect federal financial investments and assistance used for acquisition and/or construction purposes within communities participating in the National Flood Insurance Program <http://www.fema.gov/>.

Ernesto Reyes with the U.S. Fish and Wildlife Service

U.S. Fish and Wildlife Service (USFWS)

The U.S. Fish and Wildlife Service (USFWS), part of the Department of the Interior, protects America's diverse fish and wildlife resources. The USFWS' Texas Coastal Program focuses on restoring and protecting economically, recreationally and ecologically important coastal fish and wildlife habitats through partnerships by sharing biological knowledge, offering technical assistance identifying and designing restoration projects, identifying habitat protection opportunities and providing federal matching funds to implement projects USFWS' Texas Coastal Program biologists play an important role in supporting and implementing coastal conservation initiatives through partnerships <http://texascoastalprogram.fws.gov/TCPinfo.htm>.

U.S. Geological Survey (USGS)

The U.S. Geological Survey (USGS) is a bureau of the Department of the Interior. The USGS serves the nation by providing reliable scientific information to 1) describe and understand the earth, 2) minimize loss of life and property from natural disasters, 3) manage water, biological, energy and mineral resources, and 4) enhance and protect our quality of life. The Water Resources Discipline (WRD) provides reliable, impartial, timely information needed to understand

the water resources of the United States. Locally, the WRD provides routine monitoring of surface- and groundwater resources, collects site-specific data and conducts hydrologic investigations for federal, state and local agencies. These investigations provide valuable information to managers for decision-making. WRD also provides data for water-resource modeling and information related to land-surface subsidence, flood-warning systems, freshwater inflows, water and sediment quality and coastal ecology. Through the USGS Cooperative Funding Agreement program, the USGS is able to provide matching funds for scientific studies, create local partnerships and provide real-time information available on the Internet <http://tx.usgs.gov>.

USGS Technician filtering water sample

U.S. International Boundary and Water Commission (IBWC)

Established in 1889, the International Boundary and Water Commission (IBWC) is responsible for applying the boundary and water treaties between the United States and Mexico and resolving differences on issues covered by the treaties. The IBWC is an international body composed of the United States Section and the Mexican Section, each headed by an Engineer-Commissioner appointed by his/her respective president. The United States Section of the International Boundary and Water Commission (USIBWC) is headquartered in El Paso, Texas <http://www.ibwc.state.gov>.

The United States International Boundary and Water Commission (IBWC) maintains perpetual levee and floodway easements or rights of way along the Arroyo Colorado to manage the stream for flood control and flood conveyance. The State of Texas granted and conveyed to the United States of America the perpetual right and easement to enter and reenter in and upon the beds and banks of the Arroyo Colorado in Hidalgo County, Cameron County and Willacy County to facilitate the acquisition, operation and maintenance of the Lower Rio Grande Flood Control Project. The State of Texas, however, retains concurrent jurisdiction with the IBWC over the lands included in the granted easement and did not relinquish any rights that the State of Texas or its citizens or owners of property had to the waters of the Arroyo Colorado and in the use of or access to those waters.

Structures or projects built on the levees or within the Arroyo Colorado floodway require a license or permit from the IBWC. Agricultural production is permitted in the floodway, however there are restrictions on the types of crops. The IBWC levee easements end downstream of FM 800 near Palm Valley, although the IBWC still manages the stream channel downstream to the Laguna Madre.

National Oceanic and Atmospheric Administration (NOAA)

NOAA Fisheries is a division of the National Oceanic and Atmospheric Administration. NOAA Fisheries works to restore and maintain sustainable fisheries, promote the recovery of protected species and protect and maintain the health of coastal marine habitats. The agency conducts research to restore and create fish habitat, reviews coastal development and water projects that may alter or destroy habitat, and recommends measures to offset development and use impacts. NOAA works to achieve its goals by its own actions in cooperation with other resource protection agencies, conservation organizations and local communities, and by sponsoring national programs such as the Coastal Management Program and Community-Based Restoration Program <http://www.noaa.gov/>.

USDA personnel processing waters samples collected on the Arroyo Colorado

Texas State Agencies and Programs

Several state agencies also have various authorities and jurisdictions over the natural resources in the Arroyo Colorado watershed. Below is a description of state entities, their roles in the management of natural resources in the Arroyo Colorado watershed and the state programs they administer.

Coastal Coordination Council (CCC)

The Coastal Coordination Council (CCC) is the policy board for the Coastal Management Program (CMP). The Council is made up of representatives from state resource agencies, local governments, small business, citizens and agriculture and gubernatorial appointees. The Council adopts uniform goals and policies to guide decision-making by all entities regulating or managing natural resources within the Texas coastal area. The Council reviews significant actions taken or authorized by state agencies and subdivisions that may adversely affect coastal natural resources to determine their consistency with the CMP goals and policies. In addition, the Council oversees the CMP grants program, which provides funding for coastal conservation projects, and the Small Business and Individual Permitting Assistance Program, which provides assistance to small businesses on regulatory issues in the CMP. <http://www.glo.state.tx.us/coastal/ccc.html>.

Texas A&M University System (TAMU)

The Texas A&M University System (TAMU) is home to the Texas Cooperative Extension, the Texas Agricultural Experiment Station, Texas Sea Grant and the Texas Water Resource Institute <http://www.tamu.edu/>.

Texas Cooperative Extension (TCE) and Texas Sea Grant

TCE and TSG programs offer practical how-to education, based on university research, to the public in Texas. TCE county extension agents and TSG marine agents assist with a variety of water quality education programs and demonstration projects in the Arroyo Colorado watershed. The Texas Coastal Watershed Program (TCWP) is a joint regional initiative of TSG and TCE that provides tools and resources for watershed education and stewardship development and has an active watershed coordination and education program in the Arroyo Colorado watershed <http://www.urban-nature.org>.

Texas Agricultural Experiment Station (TAES)

The TAES is a unit of the Texas A&M University System that conducts agricultural research to assure the highest quality food and fiber products, promote a sustainable environment and foster economic viability throughout the Texas and national agricultural industry. The TAES also administers programs that benefit the citizens of Texas by ensuring the quality of feeds and fertilizers. TAES representatives are currently assisting the ACW Partnership to conduct research and to implement monitoring and demonstration projects on agricultural land in the Arroyo Colorado watershed <http://agresearch.tamu.edu/>.

Texas Water Resources Institute (TWRI)

TWRI is a sub-unit of the Texas Agricultural Experiment Station and Texas Cooperative Extension and a member of the National Institutes for Water Resources. TWRI provides leadership to stimulate priority research and extension educational programs in water resources within the Texas A&M University System and throughout Texas.

TWRI thrives on collaborations and partnerships

managing projects across the state. TWRI links academic expertise with agencies and stakeholders to provide research-derived, science-based information to help answer diverse water questions and to produce communications materials to convey critical information and to gain visibility for its cooperative programs. The ACW Partnership anticipates working closely with TWRI to implement the ACW Protection Plan <http://twri.tamu.edu>.

Texas Department of Agriculture (TDA)

The Texas Department of Agriculture (TDA) regulates agricultural pesticide use in Texas by ensuring that regulated products are used in a manner that is safe to health and environment through licensing, inspection and testing. TDA also ensures the quality of consumer products before they are sold and provides financial assistance to beginning farmers and ranchers and value-added enterprises.

The TDA's Pesticide Programs Division encompasses worker protection, registration, certification and training; endangered species; risk assessment and toxicology; compliance and program development; and laboratory services. The TDA's Rural Economic Development (RED) division is committed to rural economic and agribusiness development. TDA works closely with the Office of the Governor, Economic Development and Tourism, Texas Cooperative Extension Service (TCE) and many other public and private partners to increase opportunities for rural and agribusiness development and to promote and assist rural communities. TDA has several programs that work to assist and promote value-added production and the processing and marketing of agricultural products <http://www.agr.state.tx.us/>.

Texas Commission on Environmental Quality (TCEQ)

The Texas Commission on Environmental Quality (TCEQ) is responsible for regulating the discharge of contaminants to surface water, groundwater, soil and air through a wide variety of programs and conducts public E&O in support of these programs. The TCEQ also monitors and assesses the health of surface waters to determine compliance with state's Surface Water Quality Standards. Additionally, the TCEQ conducts CWA Section 401 certification reviews of CWA Section 404 permit applications sent to the USACE for the discharge of dredged or fill material into waters of the United States, including wetlands. These certification reviews determine whether a proposed discharge or other permit action will comply with state's Surface Water Quality Standards.

State-federal agency meeting on Aeration structures

The TCEQ administers several programs designed to fund environmental improvements, including the Supplemental Environmental Project Program and the Urban Nonpoint Source Grant Program, which can be used to fund a wide variety of activities including wetland protection and restoration <http://www.tceq.state.tx.us>.

Texas General Land Office (GLO)

In Texas, near-shore waters below the mean high-tide mark belong to the state. Texas state law delegates regulation of activities conducted in coastal areas on state-owned lands such as the construction of marinas, piers, docks, etc., to the Texas General Land Office (GLO). Although federal regulations also apply in most of these circumstances, GLO review of construction permits provides an additional level of scrutiny of impacts to state waters and the public. Any lands that accumulate as a result of activities within waters over state-owned lands generally revert to the state. The General Land Office administers several important coastal conservation and resource management programs that affect planning and management of resources in the Arroyo Colorado watershed, including Coastal Texas 2020, the Coastal Management Program <http://www.glo.state.tx.us/>.

Texas Parks and Wildlife Department (TPWD)

The mission of the Texas Parks and Wildlife Department (TPWD) is to manage and conserve the natural and cultural resources of Texas and to provide hunting, fishing and outdoor recreation opportunities for the use and enjoyment of present and future generations of Texans. TPWD provides outdoor recreational opportunities by managing and protecting fish and wildlife and their habitat and acquiring and managing parklands and historic areas. The responsibilities of TPWD include enforcing hunting and fishing regulations, managing and preserving state parks, wildlife and historical areas, protecting natural resources, educating hunters, fishermen, outdoors enthusiasts and the public. TPWD's Recreation Grants Program offers matching funds for communities wishing to construct recreational facilities. TPWD's Private Lands Initiative and the Wildscapes Program are also available to assist landowners in managing their property in an ecologically friendly manner <http://www.tpwd.state.tx.us/>.

USDA researchers

Texas State Soil and Water Conservation Board (TSSWCB)

The Texas State Soil and Water Conservation Board (TSSWCB) was established by the Texas Legislature to administer the Texas Soil Conservation Law and is the lead agency for the planning, management and abatement of agricultural and silvicultural nonpoint source pollution in the state.

The TSSWCB maintains regional offices in strategic locations across the state to help carry out the agency's water quality responsibilities. With state headquarters in Temple, Texas, the TSSWCB offers technical assistance to the state's 217 Soil and Water Conservation Districts (SWCDs). The TSSWCB also serves as the state-level administrative agency for local SWCDs. TSSWCB field representatives in six regional offices meet regularly with representatives of the SWCDs throughout the state to provide assistance and implement TSSWCB programs <http://www.tsswcb.state.tx.us>.

The TSSWCB administers the state's Water Quality Management Plan Program (*i.e.*, SB 503 Program) and the CWA Section 319(h) program for controlling and abating agricultural and silvicultural nonpoint source pollution.

Texas Water Development Board (TWDB)

The Texas Water Development Board (TWDB) provides loans to local governments for water supply, water and wastewater treatment, water quality, flood control and agricultural water conservation projects, and for groundwater district creation expenses. TWDB helps regions of the state develop regional water plans that seek to ensure an adequate supply of water for expected demands, collects data and conducts studies concerning the freshwater needs of the state's bays and estuaries, administers the Texas Water Bank, which facilitates the transfer, sale or lease of water and water rights throughout the state, and administers the Texas Water Trust, where water rights are held for environmental flow maintenance purposes. The TWDB also administers the EDAP program which provides grants and low-interest loans for basic water and wastewater services for *colonias* and prevents the continued development of substandard subdivisions through the implementation of Model Subdivision Rules, state rules that establish minimum standards and

criteria for construction of residential developments. The TWDB maintains a centralized data bank of information on the state's natural resources, called the Texas Natural Resources Information System, and manages the Strategic Mapping Program, a Texas-based, public and private sector cost-sharing program designed to establish a consistent and updated geographic information database, and to develop large-scale computerized maps of geographic features and natural resources in Texas <http://www.twdb.state.tx.us>.

Local Entities and Programs

A number of regional and local entities are also involved in the management of risk and natural resources in the Arroyo Colorado watershed. Most of these organizations are associated with water resource management, flood control and navigation.

Drainage Districts

Drainage districts were first authorized by the Texas Legislature in 1905. The districts are organized for the construction of canals, drains, ditches and levees. The governing board is composed of commissioners selected by the County Commissioners' Court for four-year terms. The board has the authority to examine levees, railroad culverts, ditches and other drainage structures on land in or out of the district and can acquire right-of-ways for the purpose of surveying or drawing plans. The board can also call for construction bids and awards contracts to the lowest bidders. <http://www.tsha.utexas.edu/handbook/online/articles/DD/mwd1.html>.

Six drainage districts are authorized within the Arroyo Colorado watershed. There is one drainage district in Hidalgo County, Hidalgo County Drainage District 1, and five drainage districts in Cameron County (Figure 26), including Cameron County Drainage Districts 1, 2, 3, 4 and 5.

Irrigation Districts

Irrigation districts were first authorized by the Texas Legislature in 1905. The law, however, was replaced in 1913 by a new irrigation act. A board of directors of three to five members, constitutes the governing body. The directors can determine the needed employees and procedures to manage proper irrigation. Irrigation districts can also exercise the right of eminent domain in matters such as constructing canals, pump sites, levees and drainage ditches. An irrigation district can consist of part or all of one or more counties, including a town or city, if the land is classified as agricultural. <http://www.tsha.utexas.edu/handbook/online/articles/II/mwi1.html>.

Eighteen irrigation districts exist within the Arroyo Colorado watershed (Figure 27). Irrigation districts are very important organizations in the Rio Grande Valley and in the Arroyo Colorado Watershed. Over 985,000 acre-ft of water are conveyed and distributed annually by irrigation districts in the Rio Grande Valley, most of it for agricultural irrigation (Fipps 2000). According to the Phase I TMDL study, agriculture is the source of one half to two thirds of pollutants entering the Arroyo Colorado. Efficiency and effectiveness in irrigation conveyance and practice is key to successful implementation if the ACW Protection Plan. Participation by the irrigation districts is essential in this effort.

Soil and Water Conservation Districts (SWCDs)

Soil and Water Conservation Districts are independent political subdivisions of the State of Texas. The districts promote conservation and the wise and judicious use of renewable natural resources by providing assistance to local farmers based on local needs. SWCDs are governed by directors elected by landowners in the district. The elected board of

Ditch draining to the Arroyo Colorado

directors has the responsibility of developing a program and plan of work according to the local needs of the district. The program is actually an inventory of the land and water resources and problems of the district. It describes the actual conditions bearing on land and its use. The plan of work discusses land capabilities, physical conditions and socio-economic conditions creating conservation problems. Conservation needs and treatment, as well as district policy, are outlined in the program and plan of work, which also details solutions to problems and resources available to accomplish district objectives.

Help or assistance comes to SWCD from various federal, state and local agencies. A primary source of help a district offers agricultural landowners or operators is the technical assistance of the Natural Resources Conservation Service (NRCS), an agency of the United States Department of Agriculture (USDA). Through Memoranda of Understanding with USDA and NRCS, local SWCDs are able to furnish technical assistance to farmers and ranchers in the preparation of a complete soil and water conservation plan to meet each land unit's specific capabilities and needs.

The TSSWCB, the state agency charged with the overall responsibility of coordinating the SWCD programs in Texas, also makes technical assistance funds available to districts through a grant program. Local SWCD employees work cooperatively with NRCS employees to help agricultural landowners/operators plan and install conservation practices. Districts also work with the USDA-Farm Service Agency, Texas Agricultural Extension Service, Texas Forest Service, U.S. Forest Service and others when necessary to assist agricultural landowners/operators meet individual land use needs.

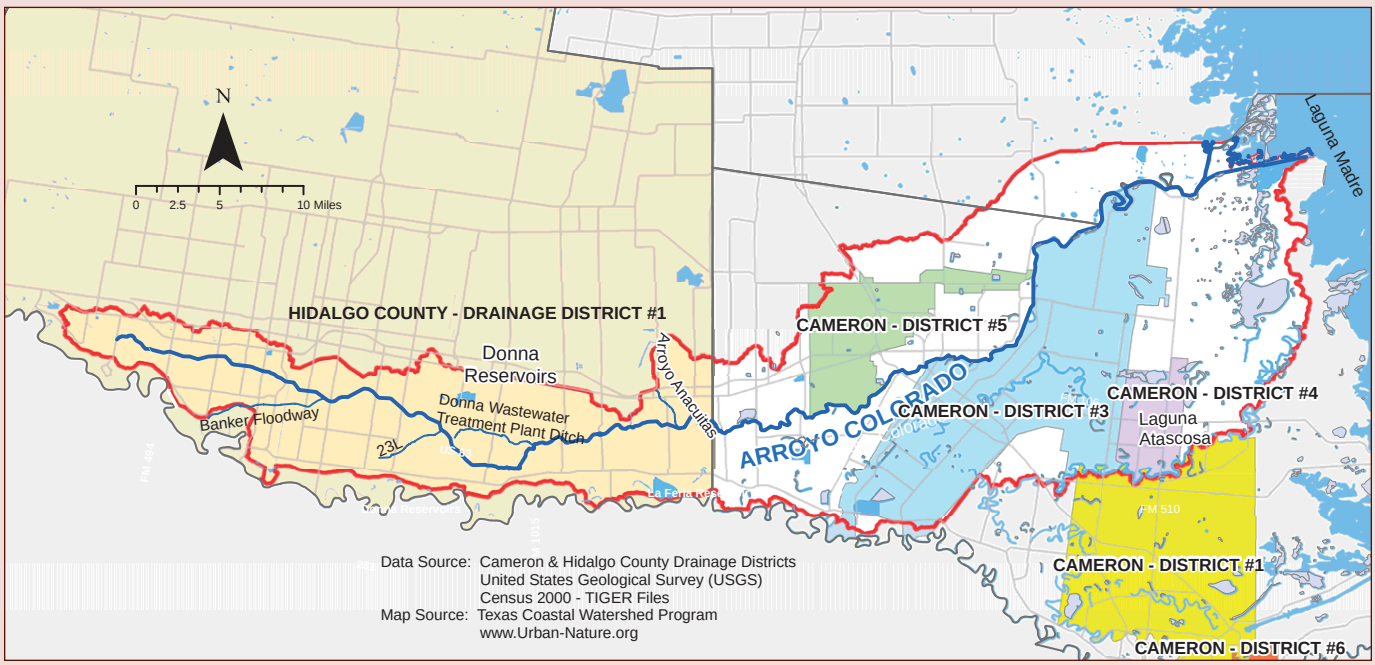
Two local SWCDs participated in the development of the ACW Protection Plan and are included in the ACW Partnership, the Hidalgo SWCD #350 and the Southmost SWCD #319. These districts will play an important role in the implementation of many of the agricultural components of the ACW Protection Plan.

Rio Grande Regional Water Authority (RGRWA)

The Rio Grande Regional Water Authority (RGRWA) was created by the 78th Legislature, which enacted SB 1902 in 2003. The RGRWA covers six counties in the Middle and Lower Rio Grande Valley: Willacy, Cameron, Hidalgo, Starr, Zapata and Webb (excluding the City of Laredo). The Authority was specifically created to supplement (not replace) the services, regulatory powers and authority of irrigation districts, water development supply corporations, counties, municipalities and other political subdivisions within its borders. It has assumed the functions of the former Lower Rio Grande Authority (LRGA).

As a conservation and reclamation district established under the Texas Constitution, the RGRWA has powers, rights, privileges and responsibilities

Figure 26. Drainage Districts in the Rio Grande Valley



pertaining to the use of water resources in the Rio Grande Valley. The RGRWA's enabling legislation also gives it specific authority to "investigate, plan, acquire, construct, maintain, or operate any property the authority considers necessary or proper for the accomplishment of the purposes of the authority, including water treatment, wastewater treatment, water conveyance, and desalination of water" <http://www.rgrwa.org/about.html>.

Lower Rio Grande Valley Development Council (LRGVDC)

The Lower Rio Grande Valley Development Council (LRGVDC) is a voluntary association of local governments created in 1967 to deal with the regional planning needs that cross the boundaries and jurisdictions of individual local governments. The LRGVDC accomplishes this through cooperative action by Cameron, Hidalgo and Willacy counties and municipal governments in the Rio Grande Valley.

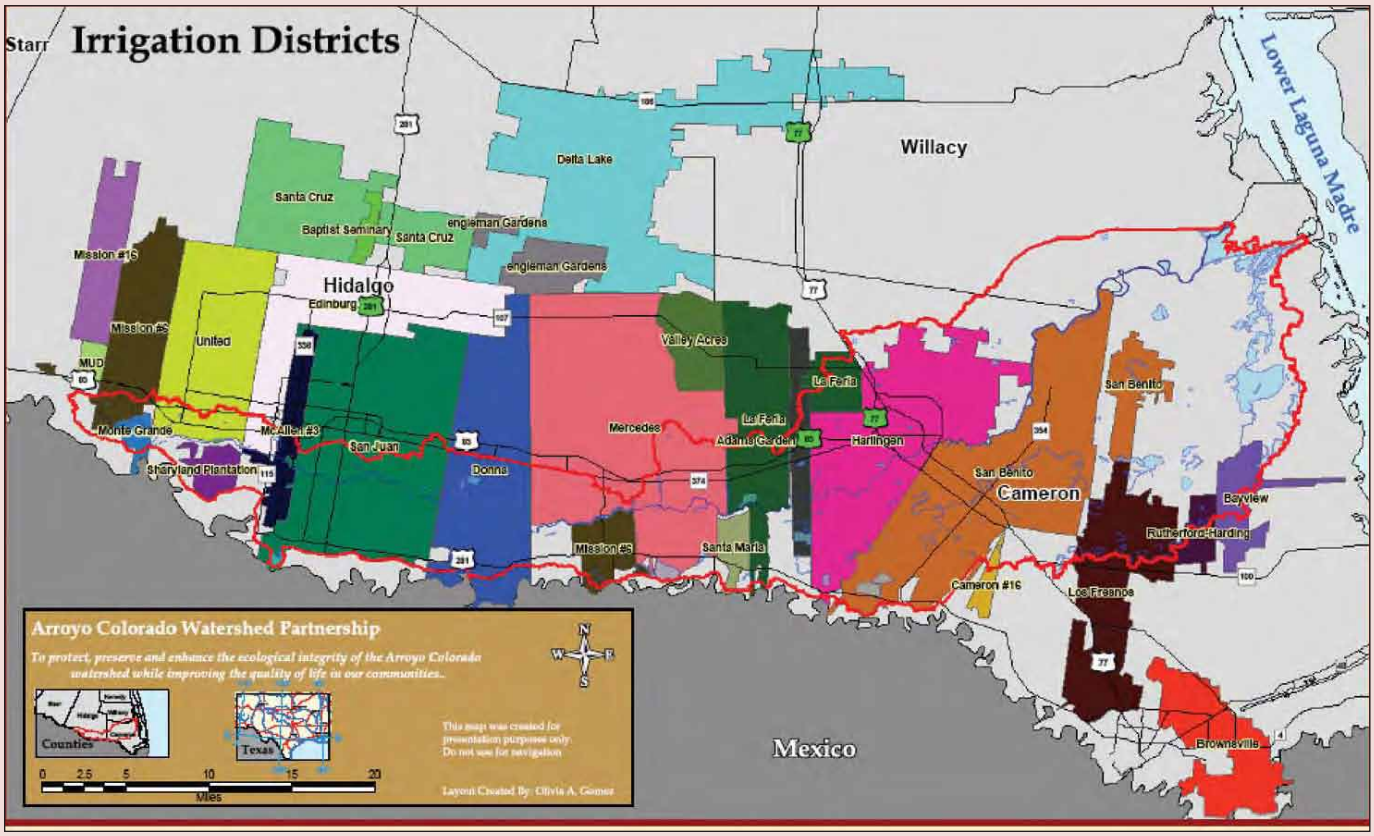
The LRGVDC provides an effective link between both federal and state government programs and the cities and counties where people are served. The purpose of LRGVDC is to plan for the unified, far-reaching development of the region, eliminate duplication of services and promote economy and efficiency in government services through coordinated efforts.

LRGVDC programs and services include Transportation Planning and Services, Natural Resources Planning, Federal/State Application Review, Technical Assistance to Local Governments, 9-1-1, Criminal Justice Assistance, Regional Police Academy, Substance Abuse Prevention, Business Loan Financing, and Area Agency on Aging <http://www.lrgvdc.org/>.

Lower Rio Grande Valley TPDES Storm Water Task Force

The Lower Rio Grande Valley Texas Pollutant Discharge Elimination System (TPDES) Storm Water Task Force (Task Force) is a voluntary association of 18 municipal governments from cities in the Rio Grande Valley affected by federal stormwater regulation. The

Figure 27. Irrigation Districts in the Rio Grande Valley



Task Force was formed in 2003 to integrate efforts to address the EPA's Phase II NPDES program and the state's TPDES program on a regional basis. With the assistance of Texas A&M University-Kingsville (TAMUK), the Task Force is helping local governments comply with Phase II stormwater regulations, including development of individual stormwater pollution prevention plans for listed urbanized areas in the Arroyo Colorado watershed. The Task Force is working with the ACW Partnership to help address water quality issues directly associated with the Arroyo Colorado. TAMUK serves as the facilitator and liaison for the organization.

Port of Harlingen Authority

As the sole commercial navigation port on the Arroyo Colorado, the Port of Harlingen Authority is the current local USACE sponsor of the GIWW–Tributary Channel to Harlingen.

The Port of Harlingen provides terminal docks and other facilities for shipping into and out of the Rio Grande Valley. The port also provides over 150 acres of on-and-off channel sites for lease for transportation activities and warehousing. The Port of Harlingen is an important link in the comprehensive transportation network of the Rio Grande Valley, especially in agricultural commerce. Links to major rail systems keep products moving to Texas locations and throughout the United States and Mexico <http://www.portofharlingen.com/>.

Butch Palmer, Port of Harlingen Authority

South View of the Port of Harlingen

ELEMENTS OF THE ARROYO COLORADO WATERSHED PROTECTION PLAN

The ACW Partnership developed the ACW Protection Plan as an integrated set of components based largely on the recommendations of the Work Groups created by the Partnership to examine the various issues associated with water quality and habitat improvement in the Arroyo Colorado. The Work Groups provided separate reports containing recommendations for each of the components of the Plan. The sections below offer condensed summaries of these reports. More detailed information can be found in the original Work Group reports, which are included in the list of supporting documents for this Plan and can be viewed and downloaded from the ACW Partnership website <http://www.arroyocolorado.org>.

Habitat Restoration

The plan to improve water quality in the Arroyo Colorado through habitat restoration is a multifaceted strategy that involves the construction of wetlands, conservation and restoration of existing riparian and wetland habitats, and reduction of channel and stream bank erosion.

The ACW Partnership adopted the following **Action** items for habitat restoration in the Arroyo Colorado :

Action 1 - Support ongoing efforts of federal, state and local agencies and other organizations to implement terrestrial habitat conservation objectives in the Arroyo Colorado watershed through partnerships and funding, including the following efforts:

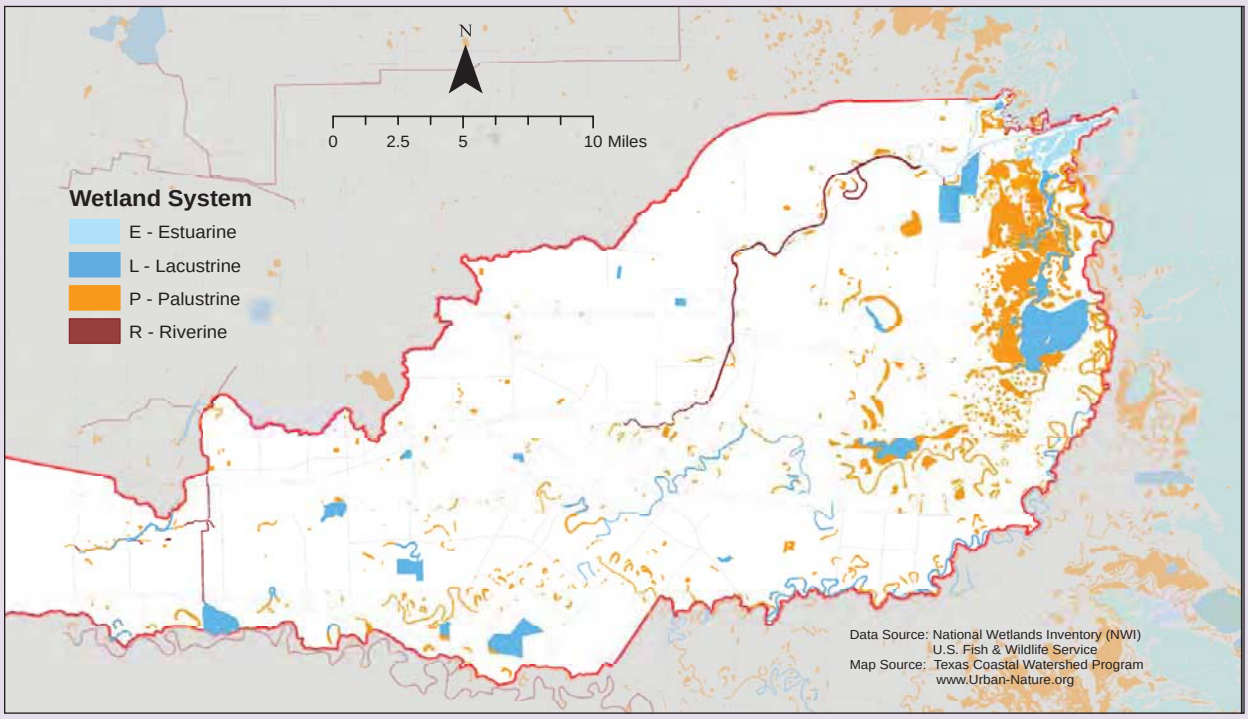
- Laguna Atascosa National Wildlife Refuge Proposed Refuge Expansion Plan, including acquisition of land along the shores of the Arroyo Colorado from the current refuge boundaries to the Port of Harlingen (USFWS 1999).
- U.S. Fish and Wildlife Service Wildlife Corridor Project.
- Texas Parks and Wildlife Department's Private Lands Enhancement and Landowner Incentive Program.
- The Consolidated Farm Service Agency's Conservation Reserve Program and Agricultural Conservation Program, and the Natural Resources Conservation Services' Wetland Reserve Program.
- The Nature Conservancy of Texas conservation and restoration of native terrestrial vegetation through cooperative projects and private lands.

Llano Grande Lake

Action 2 - Protect and restore existing riparian areas, *resacas*, and freshwater wetlands (Figure 28).

- Conserve riparian areas through acquisition, voluntary conservation easements and other conservation actions.
- Restore riparian areas by partnering with public and private landowners to reduce habitat clearing or overgrazing on lands adjacent to drainages and the Arroyo Colorado, control invasive plant species, restore hydrology (occasional flooding) and re-vegetate with native riparian plant species.
- Protect and restore *resacas* and freshwater wetlands through acquisition and restoration of hydrology.
- Support the use of native plants in vegetated filter strips (Strategy 5 in APAI 2006) employed near riparian areas, *resacas* and other freshwater wetlands.

Figure 28. Remaining Natural Wetland Systems in the Arroyo Colorado Watershed



Action 3 - Work with drainage districts to modify drainage ditches and maintenance practices to reduce channel and stream bank erosion.

- Support the voluntary creation of wider easements for drainages to allow for the modification of drainage ditches and for implementation of Strategies 2, 4, 5 and 6 in the final technical report (APAI 2006).
- Participate with drainage districts to develop channel configurations that do not require as much vegetation removal through mechanical means or the use of herbicides.
- Develop partnerships with drainage districts and adjacent landowners to allow for improved channel configuration designs that support wetlands within the channels and riparian areas along the banks (Strategies 2, 4 and 6 in the final technical report by APAI 2006).

Action 4 - Participate with IBWC during development of maintenance or new work projects for the Arroyo Colorado. Representatives of the ACW Partnership could serve in advisory capacities to assist in the development of pilot channel configurations with banks that are less steep and that can support vegetation such as riparian woodland plants or native prairie grasses.

- Assist the IBWC in developing policies for land use practices in the floodway that seek to reduce channel and stream bank erosion.
- Assist the IBWC and landowners in identifying channel and stream bank erosion hot spots.

Action 5 - Develop partnerships with the IBWC, drainage districts, and private landowners to implement bank/slope stabilization projects in hot spots along the Arroyo Colorado or in drainages within the watershed.

Action 6 - Implement projects that would detain stormwater runoff, reduce sediment load and reduce the volume and velocity of runoff in drainage ditches and the Arroyo Colorado.

Action 7 - Support ongoing and increased use of vegetated filter strips around agricultural production and urban development areas to slow stormwater runoff from these areas.

Action 8 - Implement stormwater wetland systems in urban developments, redevelopments and in areas under agricultural production to reduce nonpoint source pollutant loading to the Arroyo Colorado.

Action 9 - Build constructed wetlands for tertiary treatment of waste streams from individual wastewater treatment plants and/or for polishing flows from multiple wastewater treatment plants in close proximity with habitat features when feasible.

Assessing habitat restoration

Action 10 - Construct large off-channel treatment wetlands that treat flows from multiple sources including wastewater treatment facilities and nonpoint source runoff from urban and agricultural areas.

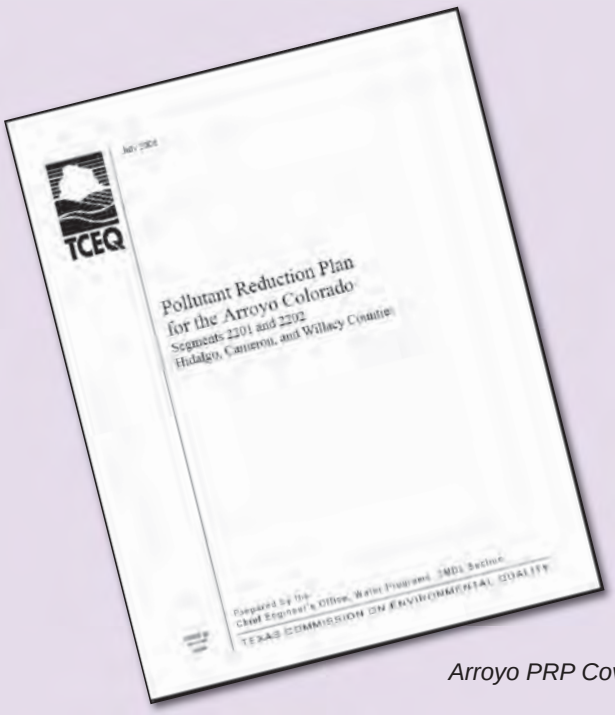
Wastewater Infrastructure

The wastewater infrastructure component of the ACW Protection Plan is the Arroyo Colorado Pollutant Reduction Plan (PRP), an agreement between local wastewater operators and the TCEQ to reduce the amount of pollutants from domestic and municipal wastewater entering the Arroyo Colorado to the maximum extent feasible. The Arroyo Colorado Pollutant Reduction Plan (PRP) proposes to reduce the amount of pollutants from wastewater from municipalities and unincorporated communities through more stringent wastewater discharge permit limits, additional treatment of the wastewater discharged and wastewater infrastructure improvements. Through a series of work group meetings and one-on-one meetings with city managers and directors of wastewater departments and public utilities, voluntary and regulatory measures were agreed upon for each individual wastewater treatment facility and/or community. The PRP details historic (2000-2005), near-term (2006-2010) and long-term (2011-2015) load reduction measures planned for many of the municipalities and unincorporated urban and suburban areas in the Arroyo Colorado Watershed (the document titled “Pollutant Reduction Plan for the Arroyo Colorado: Segments 2201 and 2202, Hidalgo, Cameron, and Willacy Counties” [TCEQ 2006] can be found on the world wide web at <http://www.tceq.state.tx.us and at www.arroyocolorado.org>.

The first priority of the Arroyo PRP is to eliminate permits that allow the least stringent levels of wastewater treatment (30/90) into the Arroyo Colorado watershed by the year 2010. The second priority of this plan component is to transition all other facilities to treatment levels of 10 mg/l BOD_5 and 15 mg/l TSS (10/15) or lower by the year 2015. Nine of the 18 principal wastewater treatment facilities in the watershed are currently at this (10/15) treatment level. Table 9 shows a comparison of current effluent limits and effluent limits proposed under the Arroyo PRP.

The Arroyo Colorado PRP also calls for wastewater infrastructure upgrades designed to improve current wastewater treatment levels and to limit the amount of pollution generated by faulty or improperly maintained on-site septic systems. Wastewater infrastructure improvements under the Arroyo Colorado PRP will also provide treatment of previously untreated or poorly treated wastewater from *colonias* and other existing unincorporated communities.

The projected increases in permitted effluent flows at many of the wastewater treatment facilities shown in Table 9 do not necessarily result in an overall increase in loading to the Arroyo Colorado despite the fact that treatment levels for some of these facilities may remain unchanged through the year 2015. This is because much of the increase in treated effluent from



Arroyo PRP Cover

Table 9. Summary of Projected Changes in Discharge Permits in the Arroyo Colorado Watershed from January 2006 through December 2015

Facility Name	TPDES Permit No.	Old Flow (MGD) and Effluent Set (mg/l) BOD_5/TSS/NH3-N	New Flow (MGD) and Effluent Set (mg/l) BOD_5/TSS/NH3-N	Year of Permit Action
City of La Feria	WQ0010697-001/2	(0.5) 30/90/NA	(1.25) 10/15/3	2006
City of Donna*	WQ0010504-001	(2.7) 20/20/NA	(3.0) 10/15/3	2007
City of Pharr	WQ0010596-001	(5.0) 10/15/3	(8) 7/12/2	2007
City of Rio Hondo*	WQ0010475-002	(0.4) 20/20/NA	(0.4) 20/20/NA	2007
City of Hidalgo	WQ0011080-001	(1.2) 10/15/3	(1.4) 10/15/3	2007
Harlingen Water Works System (HWWs) Plant No. 1	WQ0010490-002	(3.1) 20/20/NA	(3.1) 10/15/3	2008
Military Highway Water Supply Corporation (MHWSC) (Progreso)	WQ0013462-001	(0.4) 30/90/NA	(0.75) 10/15/3	2008
City of San Benito	WQ0010473-002	(2.5) 10/15/3	(3.75) 10/15/3	2008
City of Alamo	WQ0013633-001	(2.0) 30/90/NA	(2.5) 10/15/3	2009
City of Rio Hondo	WQ0010475-002	(0.4) 20/20/NA	(0.65) 10/15/3	2010
City of Mercedes	WQ0010347-001	(2.3) 10/15/3	(3.2) 10/15/3	2010
East Rio Hondo Water Supply Corporation (ERHWSC)	WQ0014558-002	NA	(0.16) 10/15/3	2011
City of Mission	WQ0010484-001	(9.0) 10/15/2	(13.5) 10/15/2	2014

NA signifies that no limit is applicable.

**** Amendment includes increase in minimum DO effluent concentration from 2.0 mg/l to 4.0 mg/l***

these facilities represents a mitigation of untreated or poorly treated wastewater which would ordinarily enter the Arroyo Colorado from *colonias* and failing septic systems.

The Arroyo Colorado PRP encourages the voluntary utilization of enhanced treatment projects to reduce the loading of pollutants (BOD_5, TSS, NH3-N, TP and TN) to the Arroyo Colorado using tertiary treatment mechanisms or post-treatment biological systems to polish treated effluent produced through conventional wastewater treatment. The enhanced treatment projects include:

- Reuse of wastewater effluent through landscape irrigation,
- Effluent polishing pond systems,
- Small-scale, constructed wetland systems for enhanced wastewater treatment and
- Tertiary wastewater treatment using denitrification.

Except for reuse through irrigation and tertiary treatment, all enhanced treatment projects proposed in the Arroyo Colorado PRP include structures that facilitate collection of water quality samples and measurement of flow downstream of the treatment system. Table 10 summarizes the enhanced treatment projects completed to date and those proposed for implementation by 2015.

The reuse of effluent is recognized as a viable option for reducing the amounts of pollutants entering the Arroyo Colorado as long as in-stream water needs for aquatic life are considered. In the Rio Grande (Region M) Regional Water Plan approved by TWDB in 2001, the Arroyo Colorado is recognized as an important source of freshwater inflows to the Lower Laguna Madre, which is both economically and ecologically important to the region (RGRPG 2001). The Region M Water Plan also lists the Arroyo Colorado as representing a second potential water supply, although use is limited due to poor quality conditions.

Wetland

Near-Term Goals for Wastewater Infrastructure (2006-2010)

Eleven load reduction measures associated with institutional controls (*i.e.*, new discharge permits or amendments of existing permits) are planned for 2006 through 2010. These measures include construction of five new wastewater treatment facilities—East Rio Hondo Water Supply Corporation (ERHWSC) south of Rio Hondo, the City of San Benito, the City of La Feria, the City of Alamo and Military Highway Water Supply Corporation (MHWSC) in Progreso—and six expansions and/or upgrades of existing treatment facilities—City of Rio Hondo, City of Hidalgo, City of Pharr, City of Donna, City of Weslaco and Harlingen Water Works System's (HWWS) #1 facility.

Also within the planning period of 2006 through 2010, 58,610 colonia residents living in the Arroyo Colorado Watershed will be connected to various municipal wastewater collection systems (approximately 16,927 total connections) and eight enhanced wastewater treatment projects will be completed. These projects include:

1) Construction of a 4-acre wetland and pond system and conversion of a 6.75-acre wastewater treatment lagoon into a wetland cell system for effluent polishing for the City of La Feria,

Table 10. Summary of Proposed Enhanced Wastewater Treatment Projects for the Period 2006 through 2015

Wastewater Operator	Near-Term 2006-2010	Long-Term 2011-2015
Harlingen Waterworks System (HWWS), Facility No. 2	NA	Reuse (unknown quantity)
City of Alamo	NA	10-acre wetland
City of San Juan	5-acre wetland	NA
City of Pharr	NA	Reuse 0.4 MGD 20-acre pond
McAllen PUB	NA	Reuse 1.0 MGD
City of Mission	NA	Denitrification
City of La Feria	4-acre wetland 6.75-acre lagoon conversion to wetland	Reuse 0.33 MGD 2-acre wet pond 6-acre wetland
City of San Benito	20-acre wetland	NA
City of Mercedes	10-acre wetland	1 MGD to Regional Wetland
Military Highway WSC (Progreso)	14-acre wetland	0.3 MGD to Regional Wetland
City of Weslaco	25-acre wetland on TPWD land	1 MGD to Regional Wetland
City of Donna	NA	2 MGD to Regional Wetland
City of Hidalgo	1-acre pond	NA
City of Rio Hondo	NA	0.5 MGD to Regional Wetland

2) Construction of a 5-acre wetland cell system for effluent polishing for the City of San Juan,

3) Conversion of a 20-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the City of San Benito,

4) Construction of a 10-acre wetland for effluent polishing for the City of Mercedes,

5) Conversion of a 14-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the MHWSC in Progreso,

6) Construction of a 1-acre effluent polishing pond for the City of Hidalgo,

7) Expansion of irrigation reuse by the McAllen PUB and

8) Construction of a 25-acre wetland cell system on TPWD property that will receive treated effluent from the City of Weslaco.

In addition to these projects, a 500-acre regional wetland system is planned for construction in the planning period of 2006 through 2010 on undeveloped land located southeast of the Port of Harlingen. If financial support is secured for this regional wetland project, wastewater treatment facilities operated by the cities of San Benito, Rio Hondo and MHWSC-Lago will contribute effluent to the regional wetland, providing further enhanced treatment of point source pollution.

Wastewater outfall in Harlingen

Long-Term Goals for Wastewater Infrastructure (2011-2015)

Four load reduction measures associated with institutional controls are planned for the planning period of 2011 through 2015. These measures include construction of one new wastewater treatment facility (ERHWSC near Arroyo City) and expansions and/or upgrades of three existing facilities (City of Mission, City of Mercedes and City of Rio Hondo).

Also within the planning period of 2011 through 2015, an additional 9,471 colonia residents living in the Arroyo Colorado watershed will be connected to various municipal wastewater collection systems (approximately 2,706 total connections).

Four enhanced wastewater treatment projects are also planned for construction in the planning interval of 2011 through 2015. These projects include:

1) Construction of a 10-acre wetland for effluent polishing for the City of Alamo,

2) Construction of a 6-acre wetland and 2-acre pond system as part of the expansion of the City of La Feria's nature park,

3) Conversion of a 20-acre resaca (*e.g.*, oxbow lake) located in the City of McAllen into an effluent polishing pond receiving treated effluent from the City of Pharr and

4) Expansion of irrigation reuse by the Harlingen Water Works System (HWWS).

In addition to these projects, a 300-acre regional wetland system is planned for construction in the planning period of 2011 through 2015 on undeveloped land located in the Llano Grande area of the Arroyo Colorado. If financial support is secured for this regional wetland project, wastewater treatment facilities operated by the cities of Donna, Weslaco, Mercedes and MHWSC-Progreso will contribute effluent to the regional wetland, providing further enhanced treatment of point source pollution.

Agriculture

To reduce pollutant loading from agricultural fields in the Arroyo Colorado watershed, state and federal governments are working with local stakeholders in the watershed to focus state and federal cost share and educational programs on agricultural issues in the Arroyo Colorado watershed. The programs encourage and support the voluntary adoption of Resource Management Systems (RMS) and Water Quality Management Plans (WQMPs) by local landowners. Together the programs accomplish the following:

- Provide technical assistance to individual landowners to help develop individual farm water quality management plans,
- Help farmers pay for the practices through cost share assistance for their individual farm plans,
- Provide educational programs to keep farmers current on proper management and production techniques and
- Monitor and assess agriculture's contribution of pollutants and evaluate and demonstrate the benefits of BMP implementation and measure progress.

RMSs and WQMPs are site-specific plans that outline the appropriate land treatment practices and a schedule for their implementation appropriate for each individual farm. The criteria established for developing Resource Management Systems and Water Quality Management Plans is contained within the U.S. Department of Agriculture Natural Resources Conservation Service (NRCS) Field Office Technical Guide (FOTG). The NRCS Field Office Technical Guide contains technical information, important conservation considerations for natural resources, quality criteria and treatment levels, conservation management system guide sheets by land use, information on the effects of applied conservation treatments and practice standards and specifications.

Cotton

Table 11. Priority BMPs Covered Under TSSWCB and USDA Programs and Targeted for Implementation as Part of the ACW Protection Plan

Best Management Practice (BMP)	Code Number
Conservation Crop Rotation	328
Residue Management	344
Irrigation Water Management	449
Irrigation System	441-443
Irrigation Tail Water Recovery	447
Nutrient Management	590
Pest Management	595
Irrigation Land Leveling	464
Subsurface Drain	606
Irrigation Pipeline	430
Grade Stabilization Structures	410
Pasture and Hay Planting	512
Filter Strip	393

Table 11 shows a list of the specific BMPs targeted for implementation as part of the ACW Protection Plan and covered under the TSSWCB and USDA programs. Additional BMPs listed in the NRCS Field Office Technical Guide (FOTG) that may help improve habitat and water quality in the Arroyo Colorado are presented in Table 12.

Priority will be placed on encouraging voluntary implementation of practices in close proximity to the impaired segment first and progress outward. Highest priority will be given to practices that reduce runoff from fields (*e.g.* subsurface drains, land leveling, etc.) and reduce runoff of nutrients (*e.g.* nutrient management). Through the voluntary implementation of WQMPs and RMS, the following BMPs will be given a highest priority for implementation on all irrigated cropland:

- **Conservation Crop Rotation (Code 328)** – growing various crops on the same piece of land in a planned sequence

Table 12. Additional BMPs Listed in the NRCS Field Office Technical Guide (FOTG) which may Help Improve Water Quality and Natural Habitat in the Arroyo Colorado

Best Management Practice (BMP)	Code Number
Channel Stabilization	584
Channel Bank Vegetation	322
Constructed Wetland	656
Contour Buffer Strip	332
Critical Area Planting	342
Dam Diversion	348
Drain Water Management	554
Early Successional Habitat Development Management	647
Fish Passage	396
Grass Waterways	412
Mulching	484
Ponds	378
Recreation Area Improvement	562
Restoration and Management of Declining Habitats	643
Riparian Forest Buffer	391
Riparian Herbaceous Cover	390
Rock Barrier	555
Runoff Management System	570
Sediment Basin	350
Shallow Water Management for Wildlife	646
Stream Habitat Improvement and Management	395
Structure for Water Control	587
Salinity and Sodic Soil Management	610
Tree/Shrub Establishment	612
Upland Wildlife Management	645
Vegetative Barriers	601
Waste Utilization	633
Wetland Creation	658
Wetland Enhancement	657
Wetland Wildlife Habitat Management	644
Wildlife Water Facility	642

- **Residue Management (Code 344)** – managing to leave protective amounts of crop residue on the soil's surface during a prescribed time of the year, by delaying primary tillage or seedbed preparation until immediately prior to planting time,
- **Irrigation Water Management (Code 449)** – process of determining and controlling the volume, frequency and application rate of irrigation water in a planned, efficient manner,
- **Irrigation System (Code 443)** – system in which all necessary water-control structures have been installed for the efficient application of water,
- **Nutrient Management (Code 590)** – managing the amount, placement, and timing of plant nutrient applications to obtain optimum yields and minimize the risk of surface and ground-water pollution and
- **Pest Management (code 595)** - utilizing environmentally sensitive prevention, avoidance, monitoring and suppression strategies to manage weeds, insects, diseases, animals and other organisms (including invasive and non-invasive species) that directly or indirectly cause damage or annoyance.

Where necessary, the following additional practices should also be considered to reduce erosion and runoff of crop residues:

- **Irrigation Land Leveling (Code 464)** – reshaping the surface of the land to be irrigated to planned grades,
- **Subsurface Drain (Code 606)** – conduit, such as corrugated plastic tubing, tile or pipe, installed beneath the ground surface to collect and/or convey drainage water,
- **Irrigation Pipeline (Code 430)** – pipeline and appurtenances installed in an irrigation system,
- **Grade Stabilization Structure (Code 410)** – a structure used to control the grade and head cutting in natural or artificial channels,
- **Pasture and Hay Planting (Code 512)** – Establishing native or introduced forage species,
- **Filter Strip (Code 393)** – a strip or area of herbaceous vegetation situated between cropland, grazing land or disturbed land (including forestland) and environmentally sensitive areas.

A complete description of each of these practices can be found at the following website: <http://www.nrcs.usda.gov/technical/Standards/nhcp.html>.

Proper nutrient and irrigation water management is being voluntarily practiced on additional acres as a result of educational programs within the watershed.

Utilizing cost share provided through CWA Section 319(h) Grant funds, the SB503 Program, EQIP and the Section 6217 Program, approximately 50,000 acres have been voluntarily treated by producers within the watershed to date (through FY06). The number of acres treated to date will be verified through the ACW Monitoring Plan. BMPs implemented on irrigated cropland in the Arroyo Colorado watershed include (but are not limited to) conservation crop rotation, crop residue management, irrigation water management, nutrient management, and integrated pest management.

Many of the irrigation-related BMPs implemented in the Arroyo Colorado watershed require extensive engineering assistance. Some of these practices are common in the watershed. For example, approximately 85% of the agricultural land in the Arroyo Colorado watershed is leveled (Garza 2006). Other agricultural BMPs involve modification of existing production practices. For example, conservation tillage, crop residue management, nutrient management and integrated pest management are all BMPs that involve modification of current practices.

Global positioning land leveling system

Near-Term Goals for Agricultural Issues (2005-2010)

Over the first five years of the Plan, the goal will be to encourage the voluntary implementation of conservation plans on 33% of the irrigated cropland in the watershed by providing educational programs, technical assistance and cost-share assistance. This additional 50,000 acres will bring the total number of acres under conservation plans up to roughly 100,000 acres. Proper nutrient and irrigation water management is expected on additional acres as a result of educational programs within the watershed. Achievement of this goal is contingent on the availability of funding for cost-share, technical assistance and educational programs.

Citrus

Long-Term Goals for Agricultural Issues (2011-2015)

The long-term goal is to encourage the voluntary implementation and maintenance of conservation plans on at least 50% of the irrigated cropland in the watershed (approximately 150,000 acres) by providing educational programs, technical assistance and cost-share assistance. As some practices reach the end of their design life, additional assistance, both technical and financial, will be needed to rehabilitate them. Proper nutrient and irrigation water management is expected on additional acres as a result of educational programs within the watershed. Achievement of this goal is contingent on the availability of funding for cost-share, technical assistance and educational programs.

In addition to these resources, the Texas Cooperative Extension also provides nutrient management training along with soil testing resources to local producers in the watershed to help reduce nutrient runoff into the Arroyo Colorado.

Commercial development

Land Use

The ACW Partnership seeks to develop, promote and achieve sound land use practices that protect and preserve watershed resources, maintain water quality and minimize pollutants entering the Arroyo Colorado. The most notable change in land use occurring in the Arroyo Colorado watershed is urban development. One of the goals of the ACW Protection Plan is to increase awareness of and promote development options that incorporate elements of *Smart Growth*, conservation design for subdivisions and *Low-Impact Development* (SGN 2006).

Preserving Natural Areas

The ACW Partnership believes preserving large areas of undeveloped land is an inexpensive and important investment citizens can make to preserve and protect water quality. Also, developing natural space often produces increased flooding. It has been shown that no other water quality improvement practices equal the water quality benefits of undisturbed natural areas. Preserving natural areas produces assets to manage this problem.

The first step in achieving preservation is to conduct a natural area inventory. Initially, this can be as simple as an inventory of developed versus undeveloped land, which could be derived from an existing land use map, for example. Eventually, all the natural areas in a community need to be mapped out – wetlands, woodlands, prairies, marshes and all the rest.

The next step is to prioritize natural areas in terms of which should be preserved first. In general, the larger the tract and the more undisturbed it is, the more valuable it is in terms of green infrastructure. Lands that are adjacent to streams have particularly high value because they act as a buffer to help cleanse stormwater runoff before it enters the waterway.

Finally, there must be a plan for the actual acquisition or setting aside of the properties. A variety of tools, too numerous to mention in this document, are available. Land can be zoned or regulated out of development, but experience shows these options have political costs and are not pursued in many communities. If outright purchase is impossible, there are several legal instruments that can be used to protect natural areas. A simple conservation easement, for example, might allow owners to maintain use of their property but prohibit development. Such easements can be purchased for much less than the sale price of real property, and some landowners will donate the easements or provide them at less than market value.

The ACW Partnership provides education to citizens' groups and the public regarding the value of natural areas in relation to water quality. The partnership also provides a unique forum for citizens to discuss and prioritize needs for the preservation of natural areas in the Arroyo Colorado watershed. As part of the E&O component of the ACW Protection Plan, the ACW Partnership will extend this outreach effort to target influential groups of citizens and organizations capable of funding or developing partnerships to fund natural area inventory efforts and land conservation projects in the AC watershed. The ACW Partnership will also provide resources for grant writing and help to establish partnerships for resource sharing among non-profit and citizens groups to facilitate funding for conservation projects.

Natural area

Low-Impact Development and Storm Water Management

The basic idea behind stormwater management through *Low-Impact Development* is to keep as much stormwater as possible onsite by using every tool available to give stormwater a chance to infiltrate into the soil. Practices include onsite measures such as vegetated swales, rain gardens, green roofs, porous pavement and larger-scale practices such as retention ponds.

These practices are most appropriate in suburban settings where there is sufficient space to implement them. Vegetated swales, for example, are not always appropriate in dense urban areas. A green roof, however, could find application in almost any setting.

Porous pavement

Compact Growth

Densifying urban growth may be the best option to conserving natural areas and reducing polluted runoff. Increasing density may seem counterintuitive at first glance as a way to decrease polluted runoff. On a per acre basis, there is no question that greater urban density will result in more polluted runoff as compared with less dense areas. But the scale of interest is the watershed, not a single acre or even a single site. On a watershed scale, higher density will result in much less polluted runoff, because much less land is occupied. For example, at typical suburban densities of 3,000 people per square mile, 100,000 people occupy at least 30 square miles of land. At 15,000 people per square mile, the approximate density of the French Quarter in New Orleans, only about 7 square miles of land are used, a savings of 23 square miles of natural area.

Density does not have to mean crowded. To be an attractive alternative, compact development must use good design. Well-planned traditional development can actually be more livable than spread-out conventional subdivision development.

What kind of density might be achievable in the Lower Rio Grande Valley? Some of the well-designed compact communities developed under the emerging *New Urban or Smart Growth* principles can easily achieve densities of 15,000 to 30,000 people per square mile. It is unlikely that all new growth in the Arroyo Colorado watershed will occur at that density. If it were possible to channel all of the new 1.2 million people expected under a conservative growth scenario (Table 13) into developments with at least 30,000 people/square mile, 360 square miles of open space would be conserved in the entire Rio Grande Valley—including farm, ranchlands and natural areas. But even a very minimal increase in density, to 6,000 people/square mile, easily achieved just by narrowing lot sizes and street widths and encouraging a few more townhome developments, would result in a open space savings of 200 acres. A geographic advantage of the area in this respect, is the fact that most towns and cities in the Rio Grande Valley originally developed on a grid pattern conducive to mixed-use development that encourages walking and promotes density.

Table 13. Land Development Under Varying Densities for an Increase of 1.2 Million Rio Grande Valley Residents

Density (people/ sq. mile)	3,000	6,000	15,000	30,000
Land developed (acres)	400	200	80	40

The ACW Partnership's E&O Work Group has developed outreach tools to promote *Low-Impact Urban Development*. These tools will be used to build awareness of this issue during implementation of the ACW Protection Plan's E&O strategy.

Residential Housing

Urban Storm Water Runoff

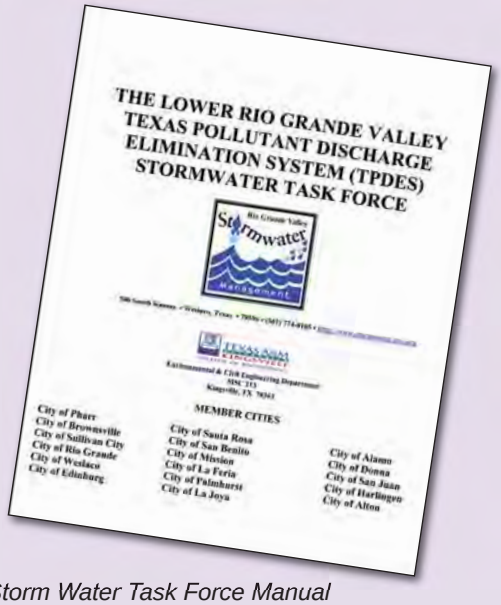
The most effective method to control storm water discharges is the use of best management practices. On September 14, 1998, the United States Environmental Protection Agency (EPA) authorized the State of Texas to develop and implement the TPDES Storm Water Program. Prior to that time, the EPA Region 6 (located in Dallas) served as the permitting authority. Under the terms of this authorization, the Texas Commission on Environmental Quality (TCEQ) assumed the role of storm water permitting authority for NPDES activities. In December 1999, the EPA issued a final rule on Phase II Storm Water Permitting Regulations. These regulations require all Municipal Separate Storm Sewer Systems (MS4s) to obtain permits by March 10, 2003. The TCEQ is in the process of issuing a final general permit for regulated small MS4s, (TCEQ permit TXRO4000). However the Federal NPDES Phase II Final Rule already describes permit requirements.

Areas covered under the Phase II small MS4 system regulations are based on total population and population density. Urban areas with populations of 10,000 or more and with population densities of 1,000 per square mile are designated *Urbanized Areas* (UAs) requiring coverage under a TPDES storm water permit. Based on 2,000 U.S. Census data, 63 *Urbanized Areas* have been designated in the Arroyo Colorado watershed.

Under the TPDES Storm Water Program for small MS4s, operators of regulated small MS4s are required to design and implement a storm water management program that:

- Reduces the discharge of pollutants to the "maximum extent practicable" (MEP),
- Protects water quality, and
- Satisfies the appropriate water quality requirements of the Clean Water Act.

In 2002, the major municipalities in the Rio Grande Valley, in partnership with Texas A&M University–Kingsville (TAMUK), created The Lower Rio Grande Valley TPDES Storm Water Task Force (Storm Water Task Force). The Storm Water Task Force is actively comprised of 18 Valley municipalities that directly or indirectly discharge nonpoint source runoff water into the Arroyo Colorado and/or the Lower Laguna Madre. One of the most difficult tasks these municipalities are confronted with is the regulation of urban nonpoint source runoff pollution. The purpose of the Storm Water Task Force is to facilitate compliance with all aspects of federal and state Phase II storm water regulations. The first two years of efforts have focused on outreach and education familiarizing the cities in the Rio Grande Valley with the requirements of the regulations. However, beginning in 2007, the Storm Water Task Force will begin developing Storm Water Management Programs (SWMPs) for municipalities in the Rio Grande Valley including those located in the Arroyo Colorado watershed. The Storm Water Task Force plans to maintain strong outreach and education components designed to promote the use of BMPs to reduce storm water pollution.


THE LOWER RIO GRANDE VALLEY
TEXAS POLLUTANT DISCHARGE
ELIMINATION SYSTEM (TPDES)
STORMWATER TASK FORCE

MEMBER CITIES

LRGV Storm Water Task Force Manual

The TPDES Storm Water Program for small MS4s will provide the regulatory framework needed to enforce SWMPs and other pollution abatement requirements. Since the municipalities have the capability of developing rules and ordinances, and since local government laws may be required to meet

the requirements of TPDES storm water regulations, the ACW Protection Plan can benefit from the development of SWMPs for small MS4s in the Arroyo Colorado watershed. The ACW Partnership will ensure the SWMPs for UAs in the Arroyo Colorado watershed are consistent with the goals of the ACW Protection Plan, that adequate information is disseminated and that resources are shared to achieve mutually beneficial goals.

In addition to the work of the TPDES Storm Water Task Force, the TCEQ is funding important demonstration projects in the Rio Grande Valley to implement and showcase composting technology for reducing fertilizer and pesticide use by businesses and private citizens. The project, known as *Texas Greenscapes*, is being funded with a Federal CWA §319 grant and has the objective of reducing pollutants in urban storm water runoff. A detailed description of the Texas Greenscapes project is included in the E&O section of this document.

The Storm Water Task Force is committed to incorporating as many measures that will reduce pollutant loading to the Arroyo Colorado as possible into the individual SWMPs. Because pollution control requirements typically found in Phase II SWMPs for small MS4s are largely tailored to each specific storm water system, quantifying the pollutant load reductions to the Arroyo Colorado resulting from implementation of the phase II SWMPs is not possible prior to the development of these plans. Consequently, the ACW Partnership made no attempt to include these load reduction calculations in the ACW Protection Plan.

Working with the ACW Partnership, TAMUK and the Storm Water Task Force will incorporate the issues of concern associated with the ACW Protection Plan into the urban runoff protection plans being developed by the Task Force.

Industrial Practices

Two fertilizer storage and distribution facilities located along the tidal segment of the Arroyo Colorado (Wilbur-Ellis and Agriliance, LLC) have agreed to institute management practices to minimize the amount of dry fertilizer lost to the Arroyo Colorado during barge off-loading operations. Beginning in 2006, both companies will install tarp enclosures around the conveyor hoppers on the docks to catch spillage. This measure is estimated to reduce spillage of dry fertilizer into the Arroyo Colorado by 50%. In addition to this measure, the companies have revised their Standard Operating Procedures to include the following provisions:

1) All bulk dry load-out will be performed on contained concrete surfaces. The surfaces will be swept free of any spillage on a daily basis when operating and prior to any significant rainfall.
2) All bulk dry loading by rail will be controlled to keep the material in maintenance pit areas. These areas will be cleaned on a daily basis when operating and prior to any significant rainfall.
3) All liquid fertilizer unloading from barges will be controlled by facility personnel who are familiar with emergency shutdown procedures.
4) All fertilizer reacting (involving anhydrous ammonia and super phosphoric acid) will be performed on a concrete pad with containment. The process will be controlled to prevent spillage.
5) All liquid fertilizer volumes will be well monitored and controlled throughout the load-out process.

Wilbur-Ellis and Agriliance, LLC have plans to build new containment systems for fertilizer loading operations in 2007. The companies are also working with the TCEQ to learn how to further minimize the spillage and runoff of pollutants from these facilities into the Arroyo Colorado.

In addition to the fertilizer transport and storage operations, a significant volume of raw sugar is shipped out of the Rio Grande Valley from the Port of Harlingen. Raw sugar, alone comprises 80%-90% of annual north-bound shipments from the Rio Grande Valley through the GIWW to points north of the Lower Laguna Madre (TCPS 2001).

Prior to 2006, the standard operating procedures used for shipping by Rio Grande Valley Sugar Growers, Inc., the leading sugar processing company in the Arroyo Colorado watershed, included dumping truckloads of raw sugar onto the loading platforms at the Port of Harlingen and using front-end loaders (*i.e.*, bulldozers) to load the sugar from the platforms onto barges for shipment north through the GIWW. At the end of each sugar loading operation, the loading platforms were sprayed with large fire hoses and the excess sugar remaining on the platforms was washed directly into the Arroyo Colorado, increasing the loading of BOD into this portion of the stream.

Loading raw sugar for shipment north

Beginning in 2006, Rio Grande Valley Sugar Growers, Inc., began testing an alternative method for removing excess raw sugar remaining on the loading platforms at the end of loading operations. The method involves using a street sweeper to collect and dispose of the excess raw sugar left on the loading platforms. Rio Grande Valley Sugar Growers, Inc., is currently evaluating the effectiveness of this and other methods of preventing the loading of excess raw sugar into the Arroyo Colorado. This includes plans for construction of a new loading facility located in an area adjacent to the Port of Harlingen. The new facility will use the most current loading and storage technology designed to prevent loss of raw product to the environment. The new facility is scheduled to be built between the years 2010 and 2015.

The ACW Partnership recognizes that the occurrence of low DO in the upper portion of the Arroyo Colorado Tidal is due, at least in part, to hydraulic effects that occur in the dredged navigation channel under certain conditions. It is unclear if these effects will continue to cause low DO in the Arroyo Colorado periodically despite improvement in water quality. The ACW Partnership has participated in discussions with individual stakeholders regarding artificial enhancement of aeration in the Zone of Impairment of the Arroyo Colorado using mechanical aerators or other engineering or structural controls. However, not much site-specific research has been conducted to date to assess the feasibility of these types of controls. Engineering controls for enhancing DO in the Arroyo Colorado remain an option for consideration in subsequent phases of the ACW Protection Plan.

Top Strategies for Water Quality Improvement

The ACW Partnership prioritized the strategies for improving water quality in the Arroyo Colorado identified by the partnership's Work Groups and developed the following list of the top 10 water quality improvement strategies to guide implementation of the ACW Protection Plan:

- Construction of individual wetlands and pond systems for removal of nutrients from treated wastewater
- Construction of regional wetland systems for removal of nutrients from multiple sources
- Implementation of WQMPs and RMSs on agricultural land in the watershed
- Improvement of wastewater infrastructure
- Conservation and restoration of existing riparian and wetland habitats
- Stabilization of floodplain and stream to reduce bank erosion and improve riparian and aquatic environments
- Elimination of data gaps and implementation of additional water quality monitoring to aid in decision-making and to enhance E&O
- Promotion and evaluation of urban BMPs that focus on water quality improvements
- Enhancement of efforts to inform and engage stakeholders and the public
- Creation of a geographical information system (GIS) to manage data in ways that support adaptive management

EDUCATION AND OUTREACH

Fostering local stewardship through outreach and education is an integral part of the solution to habitat degradation and poor water quality in the Arroyo Colorado. Without local stewardship, even resource-intensive efforts to improve water quality can be unsuccessful. In turn, stewardship is only possible after local watershed residents are empowered with knowledge and develop a willingness to participate in the stakeholder process. The following sections describe the Education & Outreach (E&O) Component of the ACW Protection Plan. Its goal is to help address the problems of low dissolved oxygen and high nutrients and bacteria in the Arroyo Colorado by enhancing public awareness of these issues and fostering local stewardship in the watershed. The E&O Component of the ACW Protection Plan was developed by the Arroyo Colorado Partnership's E&O Work Group. It is considered to be the integrating aspect of the ACW Protection Plan and is recognized by the ACW Partnership as key to successful implementation of the entire ACW Protection Plan.

'Getting in Step' Cover

'Getting In Step' Program

The ACW Partnership's E&O Work Group followed the U.S. Environmental Protection Agency's "Getting in Step" program to create the E&O Component of the ACW Protection Plan (ACW E&O Plan). "Getting in Step" was developed specifically for watershed outreach efforts and is based on social marketing practices. The program helps create a comprehensive strategy to increase public awareness and involvement, as well as foster local stewardship. The program steps are the following:

(1) Define the driving forces, goal and objectives.
(2) Identify and analyze the target audience.
(3) Create the message.
(4) Package the message.
(5) Deliver the message.

Driving Force, Goals and Objectives

The **driving force** for the development of the Arroyo Colorado outreach campaign is the fact that the Arroyo Colorado is an impaired water body currently not meeting state water quality standards. The **goal** of the ACW E&O Plan is to help address the low DO and high fecal bacteria in the Arroyo Colorado by increasing public awareness and fostering local stewardship in the watershed. The ACW Partnership's E&O Work Group developed the following overall objectives for the ACW E&O Plan:

Objectives

- Increase public awareness.
- Develop teaching aids such as fact sheets and PowerPoint presentations to educate the general public on the importance of the Arroyo Colorado as a resource to the Lower Rio Grande Valley.
- Present the watershed planning effort to Valley organizations such as Lions Clubs, Boards of Realtors, Chambers of Commerce, Rotary Clubs, recreational groups, the different city and public utility boards, etc.
- Identify and list other area groups conducting environmental outreach and education.
- Disseminate water quality information relative to the Arroyo Colorado to those groups.
- Work with the other Arroyo Colorado Work Groups to identify the outreach and education needs that support their identified plan strategies.
- Collaborate with the LRGV Storm Water Task Force in outreach and education efforts.
- Collaborate with the LRGVDC in water quality outreach and education efforts.

- Develop a partnership with Texas Watch and other E&O organizations to engage the general public and share resources for common goals in volunteer water quality monitoring.
- Identify and pursue sources of funding for water quality E&O.

Identifying and Analyzing Target Audiences

The "Getting in Step" program describes the importance of conducting a market survey prior to initiating outreach product development. With funds provided by the TCEQ from a federal CWA 319 grant, the ACW Partnership procured the services of White Hat Creative and its subcontractor SUMA/Orchard Social Marketing to conduct a social market survey to identify the target audiences, quantify their level of existing awareness, identify deficiencies and help design an effective campaign to address those deficiencies. The Social Marketing Survey for the Arroyo Colorado was completed in May 2006. The research identified the following **target audiences**:

- Farmers and Agricultural Organizations
- Sportsmen, Fishermen and Other Recreation Groups
- Ecotourism Vendors and Promoters
- Schools and Education Groups
- Gardeners/Homeowners
- Influentials
    - Elected officials such as county judges and commissioners, city mayors and council members, state legislators or congressional representatives
    - Irrigation District Managers
    - Drainage District Managers
    - Media Personnel
    - Chambers of Commerce
    - Civic Organizations such as the Rotary and Lions Clubs, Junior League, Knights of Columbus
    - Clergymen or women with a high community profile
    - Business or community leaders with a high profile in community affairs

Arroyo stakeholders

While each of the target audiences shares some commonality, each has a set of unique interests and motivations relative to the Arroyo Colorado. Many of the target audiences lack basic awareness of the Arroyo Colorado's existence, function, value or problems.

Consultants' Conclusions and Recommendations

The 2006 report produced by SUMA/Orchard Social Marketing included the following recommendations:

- Building awareness of the current pollution of Arroyo Colorado needs to include:
    - Awareness of the Arroyo Colorado as a drain for residential water. Most are uncertain of their water source, where their wastewater drains to, or about statements describing the Arroyo Colorado and its current state of pollution.
    - Awareness of who lives in the watershed and who is impacted by the pollution of the Arroyo Colorado. Some (25%) do not believe they live in the Arroyo Colorado watershed.
    - Awareness of actions residents and communities can take to improve the health of the Arroyo Colorado. Most (74%) say "All citizens living in the Arroyo Colorado watershed can do their part to help keep it clean."

- Distribution channels for messages and advertising about the Arroyo Colorado should combine various media including TV, newspaper and direct mail.
- Messages should use the term “Arroyo Colorado” rather than “Main Floodway” as it has higher awareness by itself.
- Make the message positive and motivate viewers to action by showing the effects of how the combined efforts of a family and a community can improve their water quality today. For example, limiting use of pesticides and fertilizers, reporting fish kills and providing ways to be vocal for clean wastewater treatment plants have positive reactions.
- Messages will be best if simple, clear and contain graphics to portray how the current state of pollution will have an impact on residents. The focus for many is day-to-day life and not the distant future.
- Messages should focus on “the here and now” and how the pollution of the Arroyo Colorado affects them every day. The top priority for most citizens is providing for children and their families as well as being “a good parent” for their children.
- Messages that show the direct impact of how the health of their children and families are in jeopardy will be motivating for action.
- Part of being a good parent is helping children get a good education, therefore information children bring home from school will most likely be discussed with the parents.

Family fishing in the Arroyo Colorado

A complete understanding of existing awareness levels and motivations is included in the research findings presented in the document titled *Arroyo Colorado Watershed Partnership Education and Outreach Campaign*, May 2006, developed by SumaOrchard in collaboration with White Hat Creative and the Arroyo Colorado E&O Work Group <http://www.arroyocolorado.org>.

Message Development and Delivery

Based on research findings, other factual messages have been developed to define and support the ACW Partnership brand. These messages address the overall E&O objectives of the Partnership and highlight the value of the natural resources associated with the Arroyo Colorado, its problems and the actions and measures that can bring about solutions.

Messages defining the **value** of the natural resource include the following:

- The Arroyo Colorado stretches for 90 miles through the heart of the Lower Rio Grande Valley. It originates near Mission and empties into the Lower Laguna Madre. There, it delivers the primary source of fresh (non-saline) water to the laguna – the breeding ground for many valuable fish and shrimp species.
- A watershed is all the land that drains into a particular stream, river or waterway. The Arroyo Colorado’s watershed encompasses about 500,000 acres, most of it is used for agriculture. It also includes 10 municipalities with populations of more than 10,000 people – a number expected to grow substantially over the next 20 years.
- Often, depending on it’s function and locale, the Arroyo Colorado is known by other names, including Interior Floodway, Banker Floodway, Main Drain, Main Floodway, Llano Grande, and The Ditch. All of these form a connected

Volunteer monitors train in McAllen

waterway system, and they all are a part of the Arroyo Colorado.

- Many residents live near the Arroyo Colorado or cross over it many times a day and don't even realize it.
- Originally a stream channel of the Rio Grande, the Arroyo Colorado now serves many more purposes, including flood control and drainage, a route for commercial barge traffic from the Port of Harlingen to Arroyo City, a receptacle for treated wastewater from a number of municipal plants, a channel for storm water runoff and excess irrigation waters, a bird sanctuary, and a place for family and tourist recreation, including swimming, fishing, hiking and birdwatching.

Messages defining the **problems** include the following:

- The Arroyo Colorado is not in good shape. It's officially known as an "impaired waterway." This simply means it's dangerously polluted and the water quality does not meet clean water act standards.
- From 1990 to 2004, 26 million fish died in 19 separate documented fish kills in the Arroyo Colorado. These disasters were caused from low levels of dissolved oxygen, a situation created by too many nutrients and sediments being washed into the waterway. Fish and many other aquatic organisms must have adequate dissolved oxygen in the water in order to live.
- The Laguna Madre supports major fish and bird populations, and it provides jobs and recreational opportunities that bring millions of dollars from tourism and commercial fishing; the Arroyo Colorado's pollution problems threaten the health of the Lower Laguna Madre.
- The Arroyo Colorado is used for irrigation, discharge of treated municipal wastewater, navigation and flood control, and each of these uses has a water quality consequence. These consequences can be minimized through education and involvement of the public.

Messages defining the recommended **solutions** include the following:

- Construction of regional wetland systems will improve habitat and remove nutrients from urban and agricultural runoff.
- Construction of small wetland cells and pond systems will remove nutrients from treated wastewater.
- Increased agricultural management designed to mitigate pollutants from farming in the watershed will reduce pollutant loading to the Arroyo Colorado.
- Improved wastewater infrastructure for municipalities and rural communities in the watershed will reduce pollutants in the Arroyo Colorado.
- Water quality monitoring to assess the health of the Arroyo Colorado and to gain additional knowledge of the pollutant sources and water

Stakeholders discuss habitat issues

quality problems in the Arroyo Colorado will help target load reduction measures.

- Floodplain and stream stabilization to reduce bank erosion and improve riparian and aquatic environments will help improve water quality.
- Improved management measures at and near the Port of Harlingen designed to mitigate unauthorized releases of fertilizer and sugar into the tidally influenced portion of the Arroyo Colorado will reduce nutrient loading.

Messages defining **what individuals can do to help** include the following:

- Find out where you live in relation to the Arroyo Colorado.
- Get to know the Arroyo Colorado, both near your home and in other areas of the Lower Rio Grande Valley.
- Ask your county and city elected officials to address pollution issues within your community.
- Support local efforts to repair or replace outdated wastewater treatment facilities and infrastructure.
- Support habitat conservation and restoration projects and preservation of open lands, farmland and green spaces.
- Volunteer for environmental projects in your community, such as the Texas Watch program for monitoring water quality in the Arroyo, local trash cleanups and habitat restoration projects.
- Participate in, or encourage storm drain stenciling in your community.
- Adopt a zero tolerance attitude toward littering, a potential source of pollution.

Presentations at public events

- Sign up to get news updates from the Watershed Coordinator.
- Become a part of the Arroyo Colorado Watershed Partnership.

The Arroyo Colorado Education & Outreach (ACW E&O) Plan

Based on independent research and the recommendations of consultants, the ACW Partnership's E&O Work Group developed the following (nine) strategies for the ACW E&O Plan:

Strategy 1 - Establish a Brand

Strategy 2 - Deliver Basic Facts about the Arroyo Colorado

Strategy 3 - Raise Awareness and Increase Community Involvement in the Arroyo Colorado Watershed Partnership Initiative

Strategy 4 - Develop Partnership Agreements for Message Distribution

Strategy 5 - Create Micro-campaigns for Specific Target Audiences

Strategy 6 - Institutionalize a Practice of Ongoing Campaign Evaluation

Strategy 7 - Establish Volunteer Monitoring Programs on the Arroyo Colorado and Associated Drainages

Strategy 8 - Collaborate with Government Agencies Offering Environmental E&O

Strategy 9 - Collaborate with NGOs Supporting Environmental Education and Conservation Programs

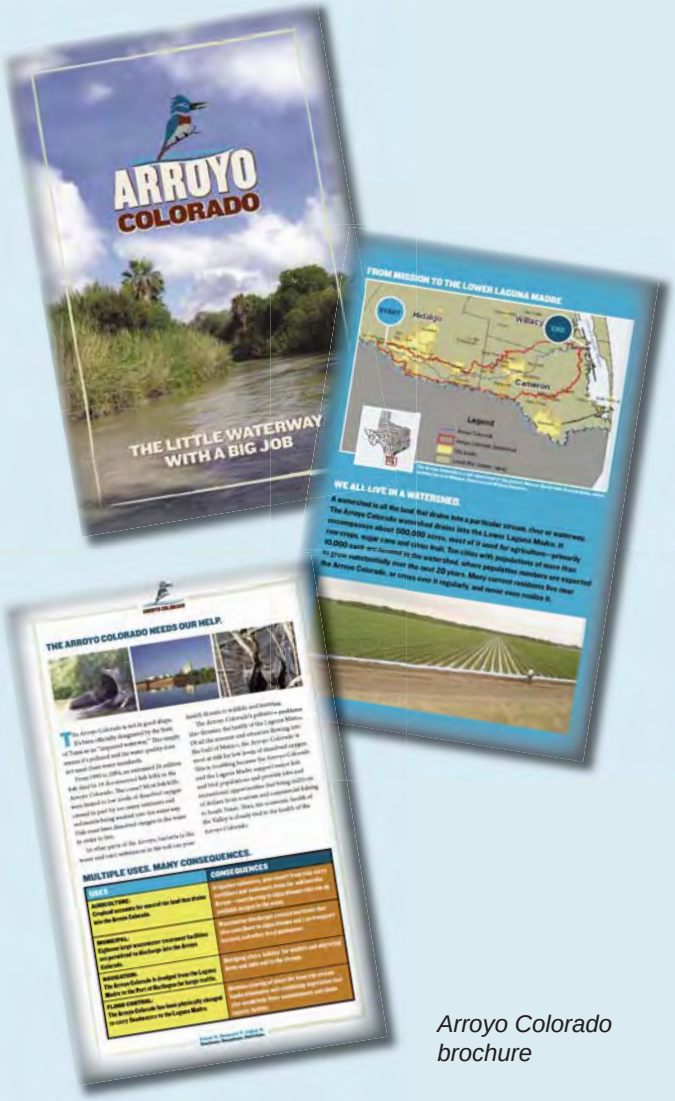
The following sections explain the nine E&O strategies in detail and describe the measures the ACW Partnership will take to implement them. More detailed information about the E&O associated with the ACW Protection Plan can be found in the supporting document titled *Arroyo Colorado Watershed Partnership Education and Outreach Campaign* available at <http://www.arroyocolorado.org>.

Strategy 1 - Establish a Brand

Development of a campaign brand ensures consistent delivery of key messages throughout the E&O Campaign. The initiative to improve water quality in the Arroyo Colorado was branded in 2006 based on specific research findings and with the identified target audiences in mind. The logo, a Kingfisher with a fish in its beak, and the tag line, "Know it. Respect it. Enjoy it." embodies the Arroyo's natural setting and appeal, reflects research, identifies preferences and issues a call to action.

ARROYO COLORADO
Know it. Respect it. Enjoy it.
Conócelo. Respétalo. Disfrútalo.

Arroyo Colorado logo



Arroyo Colorado brochure

Recommendations for the use of the brand message include the following:

- The brand should be affixed to all materials emanating from the Partnership.
- Emphasis should be placed on diverse partners. The ACW Partnership should reflect "strength in numbers" by displaying the brand and listing its members and partners at every opportunity.
- Apply efforts to recruit multiple spokespersons for the campaign. The ACW Partnership should recruit "champions" within the target segments to speak to their own constituencies and to reach out to their own natural community alliances.
- Ensure consistent delivery of the basic message in simple language at every presentation, conversation or media interview.
- The overriding tone of the brand and campaign should be factual, concerned (but not overly so), inviting and inclusive.

Strategy 2 - Deliver Basic Facts about the Arroyo Colorado

Research indicates a pervasive lack of awareness and knowledge about the Arroyo Colorado among all stakeholder groups. Even the most "Valley savvy" respondents in the stakeholder interviews and focus groups admitted to minimal knowledge of the Arroyo Colorado – where it is, what it does, and its value to the community.

Objectives:

- Distribute the basic facts about the Arroyo Colorado to targeted audiences.
- Deliver basic facts needed by all audiences through simple, accessible copy points in small group settings or one-on-one. Small group settings and personal delivery of information by trained presenters have the most powerful impact with most audiences.

- Develop campaign brochures designed with the reluctant reader in mind. In other words, more photographs or illustrations, simple text (at 6th grade level for ease of reading), including maps and simple graphics.
- Develop presentations for targeted audiences.
- Create fact sheets and FAQs (Frequently Asked Questions).
- Produce a 6-8 minute video to supplement the informational brochure and/or fact sheets as a take-away product, depending on the size and type of audience.

Strategy 3 - Raise Awareness and Increase Community Involvement in the Arroyo Colorado Watershed Partnership Initiative

Telephone survey and focus group respondents strongly indicate belief that no one group owns responsibility for the situation of the Arroyo Colorado and that it is up to all residents of the watershed to help. Most respondents indicated a willingness to do their part to help clean up the Arroyo Colorado *if they are told ways they can help*. Telephone respondents strongly indicated a preference for their messages to come via television or by direct mail.

The E&O consultants recommended that the messages be personal, inspirational and motivational with clear, actionable suggestions for behavior change. The awareness and involvement message should offer punchy, concrete ways to reinforce the brand and tagline, “Know it. Respect it. Enjoy it.”

Objectives:

- Raise awareness of the Arroyo Colorado throughout the Valley through the use of television, radio, outdoor signage and through targeted advertising strategies.
- Seek grants to develop and distribute television PSAs.
- Seek out and work with other groups developing environmental PSAs.
- Create “backpack stuffers” for distribution in area schools.
- Create utility bill inserts.
- Work to have roadway signage indicating location of Arroyo Colorado watershed or significant crossing areas.
- Explore the use of free or discounted billboards through the Lamar Company.
- Work with cities within the watershed to stencil storm drains to raise awareness of the connection between storm water and pollution.

Advertisement for the “No la rieges” *water conservation campaign in the Rio Grande Valley, featuring* “Don Aguas”

Strategy 4 - Develop Partnership Agreements for Message Distribution

Research and common belief dictate that successful E&O campaigns employ partnerships to reach particular target audiences. Successful partnerships are built on successful relationships. Therefore, face-to-face visits are strongly recommended with each potential partner. Local businesses and community-based organizations are natural partners in the effort to clean up the Arroyo Colorado and its watershed. Focus group findings indicate ecotourism vendors are likely to be enthusiastic partners, and should be approached first.

Objectives:

- Develop partnership agreements with business and community-based organizations for message distribution including:
  - Agricultural organizations, such as the Rio Grande Valley Sugar Cooperative, the Cotton Growers Association and the Sustainable Agronomic Education Association. All work will be accomplished in coordination with Texas Cooperative Extension agents.
  - Sportsmen, including the CCA and Valley Sportsmen Club.
  - Ecotourism vendors, including chambers of commerce, world birding centers and cities.
  - Schools and educational organizations, including the International Museum of Arts

ACW Partnership Work Group meeting

and Science, science teachers and school-based associations.

- Gardeners/homeowners.
- Influentials.

- Create an outreach campaign targeting local businesses and community-based organizations to:
  - Inform them of the initiative.
  - Inform them about ways that the problems faced by the Arroyo Colorado impact them.
  - Tell them ways they can help both personally or professionally, with an emphasis on allowing their venue to be a distribution point for information on the ACW Partnership.
- Form partnership agreements/resolutions explicitly stating each party's responsibilities and expectations.

Strategy 5 - Create Micro-campaigns for Specific Target Audiences

In order to ensure the effectiveness of E&O efforts, the ACW Partnership will focus on, and customize outreach efforts to the target audiences identified during the E&O research conducted in 2006.

I. Micro-campaign Target Audience A: Agricultural Producers

In focus group discussions and one-on-one meetings with agricultural stakeholders, farmers were identified as the most knowledgeable segment audience. Given the wealth of information found in this group, farmers were the most distrustful of "fact sheets" that did not offer sources for the data presented. They strongly indicated they trust agricultural extension agents (TCE agents) most to offer them information about the Arroyo Colorado and its problems, and that they accepted suggestions most willingly from their TCE county agents.

Objectives

- Engage reputable and well-connected farmers and the TCE agents and rely on the agricultural extension to work with area farmers.
- Encourage the development/customization of technical guidance documents to help producers implement best management practices that benefit water quality in the Arroyo Colorado watershed.

II. Micro-campaign Target Audience B: Sportsmen

In focus group conversations, the sportsmen indicated their genuine fondness and concern for the Arroyo Colorado. They indicated a high motivation to help in whatever way they can.

Objectives:

- Distribute basic fact brochures at local fishing support businesses, such as sporting goods stores, bait camps, fishing guide businesses, boat stores, etc.
- Include a call for specific actions fishermen can

Laura de la Garza, Arroyo Colorado Watershed Coordinator with Steve Bearden of Rio Grande Valley Sugar Growers, Inc.

take to do their part to help clean up the Arroyo Colorado.

- Organize a fishing tournament on the Arroyo Colorado and distribute fact sheets to each fisherman as part of the entry.
- Organize fishermen for clean up days.

III. Micro-campaign Target Audience C: Ecotourism Vendors

Ecotourism vendors are most likely to join a partnership to clean up the Arroyo Colorado because of their economic stake and passion for the environment. The consultants recommended that they be the priority group the ACW Partnership tries to engage. In focus group discussions, they indicated a strong willingness to assist with the dissemination of informational materials about the Arroyo Colorado.

Objectives:

- Compile and keep current a comprehensive list of ecotourism vendors.
- Host an informational reception or luncheon for this target audience, including a presentation and invitation to the Partnership.
- Provide partnership pledges they can sign committing them to distribution of materials and information about the Arroyo Colorado.
- Plan follow-up or semi-annual gatherings for this group to discuss their environmental concerns.
- Work with vendors to integrate educational messages about the Arroyo Colorado into their educational programs, if they exist.
- Include vendors in group e-mails and in updates from the ACW Partnership.

IV. Micro-campaign Target Audience D: Schools

Stakeholders, focus group respondents and telephone survey respondents all indicate they believe that children teach parents and therefore are strong messengers. Furthermore, parents often engage in activities and projects with or for their children that they would otherwise not be motivated to try. Therefore schools are a good partner for the ACW Partnership. However, the heavy demands of teaching require schools to tightly structure their programs. Thus, while many of the issues facing the Arroyo Colorado offer "teachable" moments, they may not easily fit with existing curricula. Given the stringent guidelines many schools must follow during the school day, a more accessible approach involves service learning in after-school programming.

Boy fishing in the Arroyo Colorado

Objectives:

- Identify all area after-school programs, including *21st Century Learning Centers*, private after-school care, high school extracurricular programming (such as science clubs and ecology clubs), etc.
- Work with Texas Watch and other local organizations to create a service learning curriculum for the Arroyo Colorado.
- Offer regional training or in-service for after-school teachers and coordinators and provide them with teaching aids.
- Use schools as a distribution point for basic information about the Arroyo Colorado to distribute to the families of school children.
- Develop a large-scale, three-dimensional model to show the topography of the entire

Arroyo Colorado Watershed and the Lower Rio Grande Valley. This type of model has been a very successful educational tool with the Nueces River Authority. Students get a close-up, bird's eye view of the watershed, and through some simple activities with the model, begin to understand the connectivity between the land and water systems.

- Reach out to area science teachers through the regional education service center to provide basic facts about the ACW Partnership and offer them options for school projects they can do to raise awareness and interest among students about the Arroyo Colorado.
- Provide print materials to distribute to students and families.
- Create an affinity interest group to meet at least twice yearly to share lesson plans and brainstorm ideas for educating students about water quality in the Lower Rio Grande Valley (this may be done in partnership with other ecological interest groups).
- Check science and geography textbooks to ensure the Laguna Madre is placed in its proper context. For example, textbooks calling bodies of water like the Laguna Madre "bayous" or "bays" may not be relevant to Valley students, who understand "Laguna" but may not know that ecologically it is the same as a "bay." Use this kind of insight in work with teachers and after-school coordinators to enhance interest in the work of the ACW Partnership.

Arroyo Colorado TMDL kickoff event 1998

V. Micro-campaign Target Audience E: Influentials

Influentials are people in the community who either make decisions because they are elected or paid to do so, or who influence decision makers because they have high public exposure, status, money, or the power of the press behind them. Influentials in the Rio Grande Valley area impacting Arroyo Colorado issues may include:

- Elected officials such as county commissioners and city council members, state legislators or congressional representatives
- Members of the news media, such as editors or newspaper, television or radio reporters
- Business and community leaders with a high profile in community affairs
- Leaders of service organizations such as Junior League, Rotary Club, Knights of Columbus, or the various Chambers of Commerce
- Clergymen or women with a high community profile, or who frequently speak on issues of concern to the community.

Influentials interviewed for E&O research showed a range of knowledge about the Arroyo Colorado, ranging from very little to very informed; some were familiar with the Partnership effort, others were not. Most indicated an interest in this issue, but cautioned that their constituencies may have higher priorities. A major difference between influentials and the general audience interviewed in the telephone survey is they are significantly more likely to get their news from newspapers.

Objectives:

- Seek frequent media contact to ensure the ACW Partnership is making news.
- Continue to meet one-on-one or in small groups of influentials to ensure they are aware and kept apprised of the progress of the ACW Partnership.
- As awareness is raised of the Arroyo Colorado initiative, communicate its progress through a variety of media, including television, local radio talk shows, Internet and e-bulletins, etc.
- Continue to speak to service clubs throughout the Valley and speak about the state of the Arroyo Colorado and its impact on business,

industry, development and tourism in the Valley. If needed, create a speaker's bureau for the Partnership and train speakers on the message so they can deliver it to their peers.

- Create partnerships with local Chambers of Commerce to create web links to the ACW Partnership for their constituents and set up pages to specifically address how the Arroyo Colorado impacts business, industry and tourism in the Lower Rio Grande Valley and what they can do to address the problem.
- Encourage the Chambers of Commerce to work with their business leadership programs, designed for outstanding young business executives viewed as future leaders of the Rio Grande Valley. Working with them offers the opportunity to increase buy-in from business community members who can deliver the ACWP message to future influentials. It is noted that younger people, specifically in the 20-30 age group, appear very concerned about the environment and may offer a more sympathetic audience for the message than older business people.
- If possible, employ the services of a public relations contractor to ensure the Partnership receives its share of earned (or unpaid) media through news coverage. Every school service project, new partnership, event, or bit of progress is news. Every accomplishment should be reported, and the brand reinforced as the ACW Partnership makes news.

Stakeholders assessing aeration structures

VI. Micro-campaign Target Audience F: Gardeners/ Homeowners

Telephone survey respondents indicated a high motivation to do something in their homes. One action many said they could take is to exercise more caution when fertilizing lawns and using pesticides. The ACW Partnership will educate the community about the impact of fertilizers and pesticides on the Arroyo Colorado and the environment at large. The campaign may include decorative signs for people to place on their lawns identifying them as environmentally friendly.

Objectives:

- Create partnerships with large retail sellers of garden supplies or other fertilizer or pesticide vendors to educate them about the use of fertilizers in more environmentally responsible ways.
- Promote neighborhood association recognition for environmentally friendly landscaping.
- Work with the other local organizations such as the LRGV DC, the LRGV TPDES Storm Water Task Force and TCE agents to promote environmentally friendly landscapes.

Strategy 6 - Institutionalize a Practice of Ongoing Campaign Evaluation

Social marketing campaigns such as the one presented in this document are built around the expressed preferences and needs of the target audiences. A cornerstone of the social marketing model is to evaluate campaign results periodically and consistently to insure that 1) it is accomplishing the expressed goals, and 2) that the results brought about by any strategy or tactic are relatively cost-effective. Consistent evaluation is also an important tool for showing success to funders and potential grantors of funds to continue the important work of the ACW Partnership. However, the ultimate evaluation comes with observable behavior change and improvement in water quality.

Objectives:

- Create an evaluation instrument for presenters to circulate at each presentation to assess the effectiveness of their tools and their presentation style. Ask audience members to gauge their increase in awareness after the presentation.

- Conduct periodic telephone research (as was conducted to assist in the formulation of this Plan) to assess the penetration and reach of the awareness campaign.
- Conduct periodic interviews with stakeholders and ACW Partnership members to assess their satisfaction with the campaign, their sense of how it is penetrating in their demographic sector and to ask for suggestions for changes or improvements.
- Integrate audience and stakeholder suggestions to improve message production and delivery and add new data to the ongoing programs to continuously shape the messages and tactics to match the audience's level of awareness.

Strategy 7 – Establish Volunteer Monitoring Programs on the Arroyo Colorado and Associated Drainages

Volunteer monitoring is a proven strategy for increasing public awareness of water quality issues. The *Texas Watch Program* is the leading volunteer monitoring program in Texas. In coordination with the ACW Partnership, *Texas Watch* will increase awareness, understanding and involvement in watershed and nonpoint source pollution prevention, control, and management practices through engagement and participation of volunteers, teachers, students, partners, government agencies, businesses, planning agencies and the general public. To accomplish this, the *Texas Watch* will plan, coordinate and implement public participation activities including:

- Supporting and promoting volunteer environmental monitoring activities
- Conducting water quality and nonpoint source pollution conferences and workshops
- Developing partnerships with local governments with jurisdiction over Urbanized Areas, as defined in Phase II TPDES storm water regulations for small MS4s, for cooperation and assistance in E&O activities included in individual SWMPs.

Texas Watch will emphasize data collection efforts by volunteers to help identify baseline environmental conditions, identify potential nonpoint source pollution problems, and contribute to local decision making and watershed planning activities at the watershed. *Texas Watch* will also provide assistance to schools, groups, organizations, agencies, and individuals interested in developing watershed education programs which include nonpoint source pollution and watershed protection education and water quality monitoring programs. An explanation of the TCEQ's Clean Rivers and TMDL Programs and the value of stakeholder participation (including data collection) will also be included as part of all *Texas Watch* presentations and coordination efforts.

Objectives:

Texas Watch will work with existing and new Partners and volunteers to support watershed/NPS education through water quality monitoring on 10 sites.

Emphasis will be placed on the importance of ongoing data collection efforts and the value of volunteer stakeholder participation.

Based on available resources, *Texas Watch* may also provide ongoing support to active volunteer monitors in an effort to decrease attrition and increase volunteer data submittal. This will include monitoring group development activities such as identifying funding sources for equipment, coordinating with trainers and trainers-in-training, and pro-actively supporting volunteer monitors. *Texas Watch* will provide priority support to individuals and partners who support the *Texas Watch* Project Objectives, including submission of data.

Texas Watch will maintain certification through the Texas Education Agency's Texas Environmental Education Advisory Committee (TEEAC), the State Board of Education (SBEC) or Continuing Professional Education (CPE), which will provide teachers the option of receiving certification credit of nine hours for completion of *Texas Watch* certification training.

To support monitoring efforts, Texas Watch will maintain a Quality Assurance Project Plan (QAPP) to cover all *Texas Watch* water quality monitoring activities. The QAPP will include all *Texas Watch* volunteer monitoring parameters and sampling protocols and will serve as the project's statewide quality assurance plan. The data collected under the QAPP will be used to support education and research, problem identification, local decision making and planning. Any data collected under the QAPP will be included on the *Texas Watch* Data Viewer <http://texaswatch.geo.txstate.edu>.

Strategy 8 – Collaborate with Government Agencies Offering Environmental E&O

Several federal, state and local government agencies provide public E&O on diverse environmental subjects, including litter control, urban pesticide and fertilizer use, water conservation, management of pet waste, waste disposal into storm drains and general nonpoint source pollution control. The agencies providing this information often benefit from the assistance of local stewardship organizations like the ACW Partnership by gaining the ability to target E&O efforts more effectively. In turn, the ACW Partnership gains resources for targeted E&O efforts.

Collaborative E&O efforts between government agencies and the ACW Partnership are already at work in the Arroyo Colorado watershed. *Texas Watch*, the Texas TMDL *Outreach Project*, *Clean Texas Greenscapes* and TPWD's *Wildlife Expos* provide good examples of state government agency initiatives that have been customized for local implementation as a result of collaborative efforts with the ACW Partnership.

Agricultural E&O Event

Texas TMDL Outreach Project

The Texas TMDL *Outreach Project* is an initiative of the Small Business and Environmental Assistance Division of the TCEQ. The goal of the project is to reduce the discharge of landscaping chemicals into streams, lakes and aquifers in major metropolitan areas of the state by changing citizen behavior through a public E&O campaign. The first phase of the project targets six TMDL areas state-wide, one of which is the Rio Grande Valley. The project leverages the resources of state and local programs that promote mulching, composting, xeriscaping and integrated pest management, all of which reduce the need for landscaping chemicals and reduce urban runoff.

Tour of Estero Llano Grande Wetland System

The project utilizes the E&O strategies of the *Grow Green Program*, a partnership between the City of Austin's Watershed Protection and Development Review Department and the TCE. *Grow Green* has been recognized by the TCEQ as an exemplary program and has been endorsed by the Texas Nursery and Landscape Association as a model for government and business partnerships. Through point-of-purchase fact sheets that will be available in target areas, including the Arroyo Colorado watershed, *Grow Green* will provide information on less problematic alternatives to common lawn chemicals. Sixty percent of Grow Green retail partners have seen an increase in the sale of organic fertilizer and least-toxic pesticides as a result of the program.

TCEQ established a partnership with *Keep Texas Beautiful*, a statewide non-profit organization, to host a program website that provides the following:

- comprehensive information on environmentally responsible landscape management practices

- links to program partners and other resources
- information on project-related activities

Also, under the Texas TMDL *Outreach Project*, the TCEQ and *Keep Texas Beautiful* will work with local organizations to develop television and radio public service announcements (PSAs) to be distributed to stations in the TMDL areas, including the Rio Grande Valley. Contractors will solicit partners for PSA production and distribution. The TCEQ will also coordinate media events and workshops for community leaders and representatives of home improvement centers, nurseries and landscape businesses in the targeted urban areas. The TCEQ estimates the Texas TMDL *Outreach Project* has the potential to reduce nutrients significantly in major urban areas of the state.

The ACW Partnership has agreed to partner with the TCEQ on the Texas TMDL *Outreach Project* in the Rio Grande Valley. Activities for the project are expected to be completed by the summer of 2008.

Clean Texas GreenScapes

Clean Texas GreenScapes is another environmental E&O initiative of the TCEQ focused on the utilization of compost and mulch as an urban Best Management Practice (BMP) and is administered by the Small Business and Environmental Assistance Division of the TCEQ. The initiative seeks to establish partnerships with local governments, other state agencies and the commercial landscaping industry. A mutual objective of the participants is to reduce nonpoint source pollution, reduce erosion, promote eco-friendly gardening practices and conserve water.

Clean Texas GreenScapes funds various activities to achieve the goal of reducing nonpoint source runoff and pollutant loadings to endangered rivers, bays and estuaries. These activities include providing onsite technical assistance, funding BMP demonstration projects, holding public education workshops and developing *Clean Texas GreenScape* partnerships with local governments, local stewardship organizations and landscaping businesses.

Clean Texas GreenScape partners assist in identifying and securing demonstration sites and coordinating project activities among the TCEQ, local governments and participating businesses.

The ACW Partnership and the Lower Rio Grande Valley TPDES Storm Water Task Force have partnered with the TCEQ, the City of McAllen and the City of Weslaco to establish demonstration projects for utilization of compost and mulch to reduce fertilizer and pesticide usage and runoff from plant nurseries and landscaping businesses. The participants in the demonstration projects will:

- collect baseline water quality data on the demonstration sites
- install automatic sensors on demonstration site irrigation controllers
- monitor and document demonstration site activities and document site progress
- archive data and prepare activity reports
- install best management practices to reduce runoff
- collect soil samples over the projects' three-year period to determine and document the effectiveness of the BMPs
- create a public awareness campaign highlighting the demonstration project
- conduct educational and outreach activities to increase public awareness of the BMPs

Activities for the initiative in the Arroyo Colorado watershed are expected to be completed by the summer of 2008.

Texas Parks and Wildlife Department (TPWD) Wildlife Expos

Wildlife Expos are E&O events held annually by the TPWD. The ACW Partnership has participated in two of these events (2005 and 2006) in the Rio Grande Valley. At both events, the ACW Partnership erected and operated a booth with general information about the Arroyo Colorado and the water quality and habitat issues associated with the stream. ACW Partnership representatives answered questions, distributed printed information and discussed issues one-on-one with

members of the public. The ACW Partnership plans to continue collaborating with the TPWD on these events over the 10-year period of the ACW Protection Plan.

Wildlife Expo

Strategy 9 - Collaborate with Non-governmental Organizations (NGOs) Supporting Environmental Education and Conservation Programs

A number of national, state and local non-governmental organizations (NGOs) provide public E&O in the Rio Grande Valley on environmental issues that affect the Arroyo Colorado. The information provided by these organizations varies widely and includes topics such as habitat restoration and protection, endangered species protection, organic gardening, the value of green space and general environmental conservation. As with government agencies providing environmental E&O, NGOs often benefit greatly from partnerships with local stewardship organizations like the ACW Partnership by leveraging scarce resources available to both organizations.

The ACW Partnership has nurtured relationships and established partnerships with several NGOs in the Rio Grande Valley, sharing information and participating in small outreach activities sponsored by the NGOs. The ACW Partnership plans to increase the collaboration with these and other NGOs in the Rio Grande Valley to help disseminate information about the ACW Protection Plan over the next 10 years.

A list of NGOs supporting natural resource conservation and providing environmental education in the Lower Rio Grande Valley is provided in Appendix F of this document.

Agricultural Education Program

Education and Outreach (E&O) on agricultural issues has traditionally been provided to farmers and ranchers in the watershed through the TCE, SWCDs, TAES, NRCS, TSSWCB and TAMUK.

Through a EPA-funded project administered by the TSSWCB, the Texas Water Resources Institute (TWRI), working through Texas Cooperative Extension (TCE), will organize an integrated team of multiple agencies and groups involved with the project to develop a comprehensive plan to efficiently achieve the educational goals of the ACW Partnership Agricultural Issues Workgroup. TWRI and TCE will host educational meetings within the three-county area in accordance with priority issues identified by the Agricultural Issues Workgroup.

Specifically, the educational programs will serve two purposes. First, TCE will utilize existing resources provided under this project to educate producers on proper agricultural management and production techniques. Programs will address cotton, grain sorghum, sugar cane, citrus and vegetable production and proper nutrient management practices including a soil testing campaign. Workshops will be held to discuss water quality issues in the watershed and BMPs for reducing agriculture's impact on water quality. Information and outreach will be provided at the following events:

- Annual Irrigation Conference in McAllen
- Water Summits
- Cotton Growers Conferences

Outreach will also be provided through newspaper articles, public service announcements (PSAs) and articles in newsletters such as the *Texas Citrus Mutual Newsletter*, *FSA Newsletter* and others.

Second, TCE will promote the cost-share programs associated with water quality protection, for example, cost-share programs to support implementation of BMPs and technologies previously developed in the area that did not reach full potential due to a lack of awareness among producers will be promoted as

part of the Agricultural E&O effort. TCE will be able to promote these programs and also provide education on the proper use of these technologies following installation. Finally, the ACW Agricultural Education Program will be highly coordinated with the project-specific water quality monitoring so that current, up-to-date information on the contributions by agriculture and the effectiveness of BMPs can be transmitted to agricultural producers.

These outreach activities will be coordinated with other ongoing information/education programs in the watershed being conducted by SWCDs, TSSWCB, TCE, irrigation districts, TDA's pesticide applicator license CEU program and through other watershed work groups.

One of the goals of the ACW Partnership is to assess the level of BMP implementation outside of conservation plans resulting from educational activities.

Conservation tillage

Agricultural Education and Outreach event

ESTIMATED WATERSHED LOADINGS AND LOAD REDUCTIONS

The State of Texas conducted an exhaustive analysis of the sources of pollution to the Arroyo Colorado as part of the Phase I TMDL study completed in 2002. The analysis resulted in a quantitative assessment of loadings of pollutants and estimates of pollutant loading by sector and land use. The TCEQ used the Hydrologic Simulation Program – Fortran (HSPF) software to simulate watershed processes at the sub-watershed level for the entire Arroyo Colorado watershed, including all permitted wastewater facilities. The TCEQ defined 14 sub-watersheds (*i.e.*, sub-basins) of the Arroyo Colorado by determining the portions of the watershed draining to different pour points selected at locations in the stream where historical flow and water quality information were sufficient for model calibration (Figure 29); nine of the 14 sub-basins contribute flow and pollutant loading to the Arroyo Colorado upstream of the Zone of Impairment. The TCEQ conducted model runs for data collected for the Arroyo Colorado watershed over an 11-year period from January 1, 1989, through December 31, 1999.

The watershed model was calibrated using observed water quality data and the TCEQ estimated pollutant loadings from the different types of land use in the watershed, such as urban or agricultural, and from permitted point sources in the watershed. Figure 30 shows the distribution of pollutant loads for four major pollutants in the Arroyo Colorado watershed by source. The chart represents total loadings of each constituent between 1989 and 1999 as estimated using Arroyo Colorado HSPF watershed model simulations. Estimates of loading and loading reductions associated with the ACW Protection Plan are presented in this document beginning in the year 2000 and use the year 2000 as a benchmark or baseline for comparison of conditions prior to and after implementation of the ACW Protection Plan.

With the exception of suspended sediment, which is contributed in much greater amounts by agricultural land, the sources of pollutants in the Arroyo Colorado are distributed almost evenly between urban and agricultural land uses.

In 2005-2006, Alan Plummer Associates, Inc., and CRESPO Consulting Services (CRESPO), Inc., compiled data provided by the TCEQ to summarize, further define and map the pollutant loading to the Arroyo Colorado. Estimated loading values derived from the TCEQ HSPF Arroyo Colorado watershed 1989-1999 simulation were used to estimate pollutant loading by land use type, by individual wastewater treatment

Figure 29. Arroyo Colorado Sub-basins and Pour Points

facility, and by sub-basin for dry and storm conditions and from the 18 largest wastewater treatment facilities (WWTF) discharging to the Arroyo Colorado or one of its tributaries. Figure 31 shows the distribution of nutrient and suspended sediment loads estimated for each sub-basin of the Arroyo Colorado (APAI 2006).

Permitted Wastewater Treatment Facilities

Much of the information known about permitted point source contributions to the Arroyo Colorado comes from monthly effluent data submitted to the TCEQ as part of self-reporting requirements specified in individual Texas Pollution Discharge Elimination System (TPDES) permits. The TCEQ assembled detailed data on flow and effluent concentrations of BOD_5, TSS and, in some cases, ammonia nitrogen produced by municipal point sources in the watershed. The TCEQ also obtained information regarding municipal point source loadings of constituents such as nitrate plus nitrite, total phosphorus and orthophosphate from monitoring of wastewater effluents performed voluntarily by permitted wastewater treatment facilities in the watershed and from special effluent monitoring conducted by the Texas Natural Resource Conservation Commission (now the TCEQ) as part of the Phase I TMDL effort in 2000 and 2001. This information was assembled and entered into a Watershed Data Management File (WDM file) in the form of time series for input into a dynamic watershed

Figure 30. Distribution of Loads for Pollutants of Concern in the Arroyo Colorado by Source

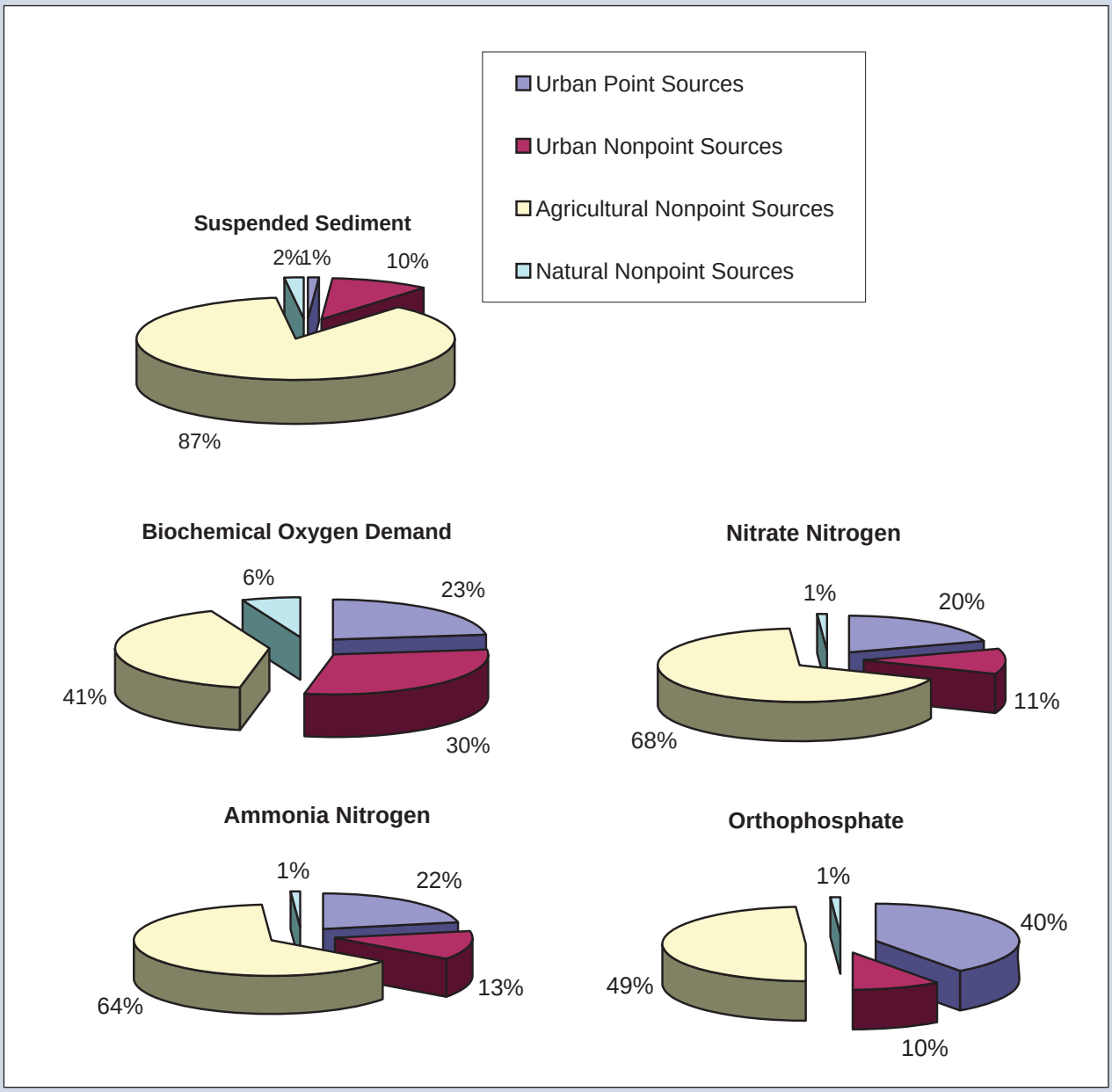
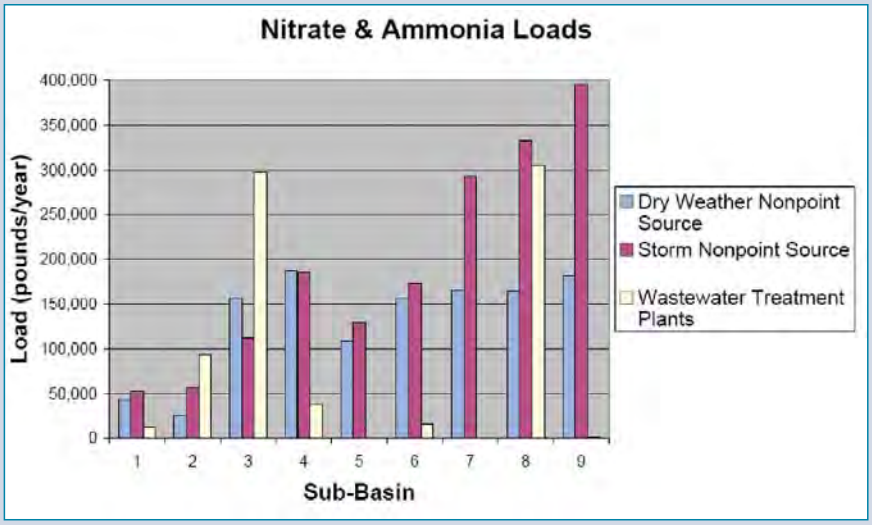
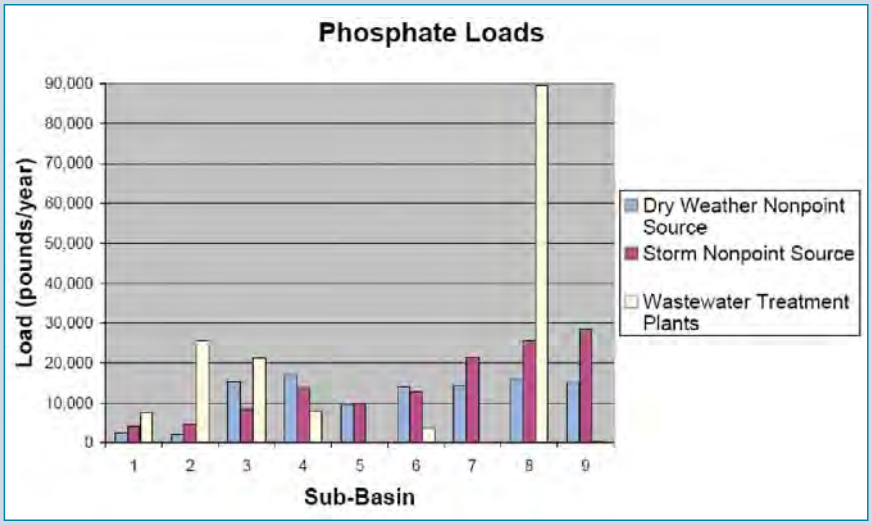


Figure 31. Distribution of Nutrient and Suspended Sediment Loads for Each Sub-basin of the Arroyo Colorado Contributing Pollutants to the Zone of Impairment.





model used to simulate water quality in the Arroyo Colorado (e.g., HSPF model).

According to the Phase I TMDL estimates, 23 percent of the BOD, 22 percent of the ammonia, 20 percent of the nitrate and 40 percent of the orthophosphate entering the Arroyo Colorado comes from municipal wastewater facilities (TCEQ 2003).

Pollutant loading from permitted point sources is not evenly distributed across the Arroyo Colorado watershed. The first four sub-basins in the watershed receive a disproportionately high contribution of nutrients from wastewater (Figure 31.) Sub-basin 8 of the Arroyo Colorado watershed, which includes the cities of Harlingen and San Benito, is heavily impacted by urban wastewater. Significant loads of nitrogen and phosphorus are also contributed by nonpoint sources, including urban areas, land application of permitted discharges, nonpoint source wastewater from *colonias* and septic systems, and agricultural cropland (APAI 2006). Sub-basins contributing large loads of phosphate include Sub-Basins 2, 8 and 9 (Figure 31).

Table 14 shows the estimated pollutants load to the Arroyo Colorado from municipal and domestic wastewater, including permitted wastewater outfalls and loading from *colonias* and septic systems over the course of implementation of the ACW Protection Plan.

The year 2000 was chosen as the starting benchmark for load calculations because many of the wastewater infrastructure improvement projects implemented in the Arroyo Colorado watershed under the TWDB's Economically Distressed Area Program (EDAP) and other similar programs reached completion only after 1999. Also, Phase I of the Arroyo Colorado TMDL project began in 1998 and was completed in 2002.

Floating aerator, Mission wastewater outfall

The changes in loading resulting from the measures described in the previous sections of this document are summarized in Table 15. The methodology used to calculate the load reductions (or increases) associated with changes in permit effluent requirements are simple mass balance calculations involving differences in permitted mass flux (mass flux = flow * concentration). The values shown in Table 15 under Institutional Controls represent permitted loadings. It is important to note that permitted loading and actual loading often differ significantly. Properly operated wastewater treatment facilities generally discharge less loading than allowed by their permit limits and some reduction of discharged loading is realized through natural attenuation as effluent flows and mixes with water in ditches before reaching a receiving water body. Therefore, the values shown in Table 15 probably over-represent actual daily loading from permitted wastewater outfalls, particularly in periods immediately following new permits and permit amendments. The five-year implementation intervals used to calculate the overall loadings serve to smooth the differences between permitted loading and actual loading over each implementation interval.

Table 14. Changes in Wastewater Loading Expected from Implementation of the ACW Protection Plan in Tons per Year

Year	Estimated Load to the Arroyo Colorado from Municipal and Domestic Wastewater (tons)				
	BOD_5	TSS	NH3-N	TN	TP
2000	1128	733	312	564	47
2005	1153	817	317	578	48
2010	968	474	228	492	33
2015	933	383	196	384	24

Table 15. Summary of Waste Water Load Reductions Expected from Implementation of the ACW Protection Plan in Tons

Load Reduction	Near-Term 2006-2010					Long-Term 2011-2015				
	BOD_5	TSS	NH3-N	TN	TP	BOD_5	TSS	NH3-N	TN	TP
Institutional Controls	524	1200	349	262	22	-93	-306	-118	-47	-4
Infrastructure Improvements*	57	45	11	28	2	9	7	1	5	0.4
Enhanced Treatment	222	471	83	139	11	286	749	275	614	53
Total	803	1716	443	429	35	202	450	158	572	49

Net NPS loading reductions from colonia wastewater connections (e.g., gross loadings x 0.01). Negative numbers signify increases in loading.

Where outfall-specific permit information was not available for a specific constituent, as is universally the case for TP and TN, the stoichiometric ratios of 1.0:0.042:0.5:0.2 relating BOD:TP:TN:NH3-N were used. These ratios were based on published values for organic waste loads found in treated effluent (San Diego-McGlone *et. al.* 2000).

Onsite Treatment Systems and *Colonias*

The TCEQ modeled individual onsite treatment systems in the Arroyo Colorado watershed using population figures and Geographic Information System (GIS) coverages and shape files provided by the TWDB and the LRGVDC for areas in the watershed served by these systems. To model loadings to the Arroyo Colorado, the TCEQ used the population and GIS data along with assumptions regarding the average volume of wastewater produced per capita (100 gal/day), average size of most septic drain fields (1,200 ft^2), and average concentrations of constituents found in wastewater.

Colonia flooding, Cameron County

The TCEQ modeled loading of nutrients and BOD into the Arroyo Colorado from *colonias* in a similar fashion to that of onsite treatment systems. The TCEQ used *colonia* population figures and GIS coverages obtained from the TWDB along with assumptions regarding per capita wastewater production (100 gal/day), disposal areas (600 ft^2), and effluent quality to model daily loading of nutrients and BOD to the Arroyo Colorado. However, wastewater application for *colonias* was assumed to be a surface process, and the wastewater volume and pollutant concentrations used in the watershed model were assumed to be that of essentially raw, untreated wastewater applied to the standard disposal areas. Onsite treatment systems and *colonias* accounted for approximately 4% of the BOD and nutrient load to the Arroyo Colorado in 2000 (TCEQ 2003).

The loading calculations associated with mitigation of NPS waste loads resulting from the connection of *colonia* residents to centralized wastewater systems are based primarily on the total population connected. In instances where only the number of connections was known, an assumption of 3.5 residents per connection was used to calculate the population served. This value is the amount typically used by the TWDB, local planning organizations and municipalities to design wastewater treatment systems for residents of the area.

To generate Colonia and onsite treatment system loading values with units of lbs/day, concentrations of BOD_5, TSS, NH3-N, TP and TN of 125 mg/l, 100

mg/l, 25 mg/l, 5.25 mg/l and 62.5 mg/l were applied, respectively, to the assumed 100 gal/day per capita wastewater volume. The constituent concentrations used in the calculations were derived using the medians of values obtained from published studies (Benfield 2002) and modified using best professional judgment. It should be noted that the timing, volume, dynamics and overall nature of steady-state vs. dynamic pollutant loading makes direct comparison of point and nonpoint source loads difficult even with the use of attenuation factors and averaging periods.

The estimated NPS loadings from (*colonia*) wastewater presented in this document were calculated to represent loading at the point of origin and do not represent what would be expected to enter the Arroyo Colorado after transport over land, in subsurface interflow and in tributary ditches. In order to compare and sum of loading reductions from the various measures described in this plan, a factor of 0.01 was applied to the gross NPS loading reductions estimated for all infrastructure improvements associated with *colonia* connections. The factor was developed through a comparison of simulated gross vs. simulated net loading using the HSPF watershed model developed for the Phase I Arroyo Colorado TMDL.

The loading calculations associated with enhanced treatment projects are based on information gathered from published reports on the effectiveness of pollutant removal from reuse via irrigation and on different biological effluent polishing systems or systems that employ similar methods to remove BOD, TSS and nutrients from wastewater or storm water (APAI 2006).

The removal efficiencies used to calculate load reductions associated with enhanced treatment systems are shown in Table 16. For irrigation reuse, the calculations assume that a minimum of 50 acres of irrigated land are needed for every million gallons per day (MGD) of effluent treated to reach the effectiveness values shown in Table 16 (EPA 2002). For wetland cell polishing systems, maximum treatment flow volumes were calculated using an assumption that 27 acres of wetland cells (with 12-18 inches of standing water) are needed to treat 1 MGD of effluent. For effluent polishing ponds, an assumption of 20 acres of pond surface with an average depth of 6 ft for treating 1 MGD of effluent was used to calculate maximum treatment flow volumes (TCEQ 2006).

Agriculture

Approximately half of the BOD and orthophosphate (*i.e.*, reactive phosphorus) loading and two-thirds of the ammonia and nitrate loading in the Arroyo Colorado comes from agricultural activity in the watershed (Figure 30.) The vast majority of the sediment load (87%) is also the result of agricultural activity. The nitrogen load to the Arroyo Colorado is dominated by nonpoint source loadings from agricultural runoff, including irrigation return flows in each sub-basin of the Arroyo Colorado watershed. Based on the HSPF modeling conducted by the TCEQ, sub-basins of the Arroyo Colorado watershed contributing large loads of nitrate and ammonia are Sub-Basins 3, 7, 8 and 9 (Figure 31).

The SWAT (Soil and Water Assessment Tool) modeling software was used by Rosenthal in 2001 to estimate loading reductions resulting from implementation of agricultural BMPs in the Rio Grande Valley. SWAT is a physically based watershed and landscape simulation model developed by the Agricultural Research Service of the USDA (Arnold et al., 1993). SWAT modeling software is capable of simulating watershed hydrology, erosion, soil and water temperature, crop growth, nutrient fate and transport, pesticide fate and transport and the effects of agricultural management practices on flow and water quality. SWAT also has the ability to predict changes in sediment, nutrients – such as organic and inorganic nitrogen and organic and soluble phosphorus, pesticides, dissolved oxygen, bacteria and algae loadings from different management conditions in large un-gaged basins. Rosenthal used SWAT because it represents landscape processes and the impacts

Table 16. Pollutant Removal Efficiencies of Enhanced Treatment Systems

Treatment System	Removal Efficiency (%)				
	BOD_5	TSS	NH3-N	TN	TP
Irrigation Reuse Systems	96	90	80	80	87
Wetland Cell Systems	50	90	80	80	65
Polishing Pond Systems	15	80	40	33	51

Irrigation return flow (tail water)

of agricultural management and land uses on water quality (Rosenthal 2001).

Through the SWAT modeling conducted by Rosenthal, TAMU estimated that BMPs implemented through WQMPs in the Arroyo Colorado watershed reduced annual pollutant loadings as listed in Table 17.

Based on current irrigated cropland acreages (approximately 300,000), the ACW Partnership estimates that if the agricultural strategy proposed in the ACW Protection Plan is fully implemented, then annual sediment, nitrogen and phosphorus reductions will be 15,000 tons per year, 42.5 tons per year and 7.1 tons per year, respectively. More information about the Agricultural Component of the ACW Protection Plan is presented in the section of this document titled "Elements of the Arroyo Colorado Watershed Protection Plan."

Loading estimates derived using the SWAT model were very similar to those calculated using the HSPF model (used for the Phase I TMDL) except in the case of sediment, which differed by approximately a factor of 10. Efforts are under way to refine the estimated load contribution from agriculture in the Arroyo Colorado watershed. Data collected during a series of edge-of-field and sub-watershed scale sample collection efforts currently under way will be used to better characterize the quality of agricultural runoff at the field level. Sub-watershed monitoring will also be conducted to characterize and assess runoff from predominantly agricultural sub-watersheds at a slightly larger scale.

Urban Storm Water

The TCEQ characterized contributions of nutrients, BOD, fecal bacteria, and suspended solids from urban storm water in the Arroyo Colorado watershed and included these loading estimates in the Phase I TMDL analysis. A lack of area-specific stormwater quality data forced the use of accumulation and export rates estimated from published values of event mean concentrations measured for similar urban land use categories in other metropolitan areas of Texas. Of note is the fact that the "Urban Nonpoint Source" category shown in Figure 30 includes urban stormwater from pervious and impervious cover, which includes loading from *colonias* within a city's Certificate of Convenience and Necessity (CCN). Developing municipal stormwater management programs to mitigate the effects of urban runoff on the Arroyo Colorado will help keep the stream healthy. Municipalities in the Arroyo Colorado watershed are already helping to mitigate the impacts of urban stormwater by building drainage infrastructure

Table 17. Estimated Annual Sediment, Total Nitrogen and Total Phosphorus Reductions Resulting from Implementation of the Agricultural Component of the ACW Protection Plan in Tons

Constituent	Est. Reductions Per Treated Acres	Est. Annual Reductions From Treated Acres		
		50,000 acres	100,000 acres	150,000 acres
Sediment*	200 lbs/acre	50,000 tons	100,000 tons	150,000 tons
Total Nitrogen	0.567 lbs/acre	14.2 tons	28.4 tons	42.5 tons
Total Phosphorus	0.0947 lbs/acre	2.4 tons	4.7 tons	7.1 tons

Adjusted for comparison to HSPF-generated loading estimates (e.g., SWAT estimate x .1)

and supplying centralized wastewater services to colonia residents. These actions represent a reduction in the overall loading of BOD and nutrients from urban and sub-urban stormwater sources.

According to the Phase I TMDL study, 30 percent of the BOD, 13 percent of the ammonia, 11 percent of the nitrate and 10 percent of the orthophosphate entering the Arroyo Colorado comes from urban stormwater (TCEQ 2003).

Although several of the concepts and strategies included in the Habitat Restoration Component of this plan address typical (non-*colonia*) urban storm water pollution, no load mitigation measures specifically targeting urban storm water are currently included in Phase I of the ACW Protection Plan. Consequently, the loading reduction estimates presented in this section do not include mitigation of loading from non-*colonia*-related urban stormwater.

Figure 32. Expected Reductions in BOD from Implementation of the ACW Protection Plan

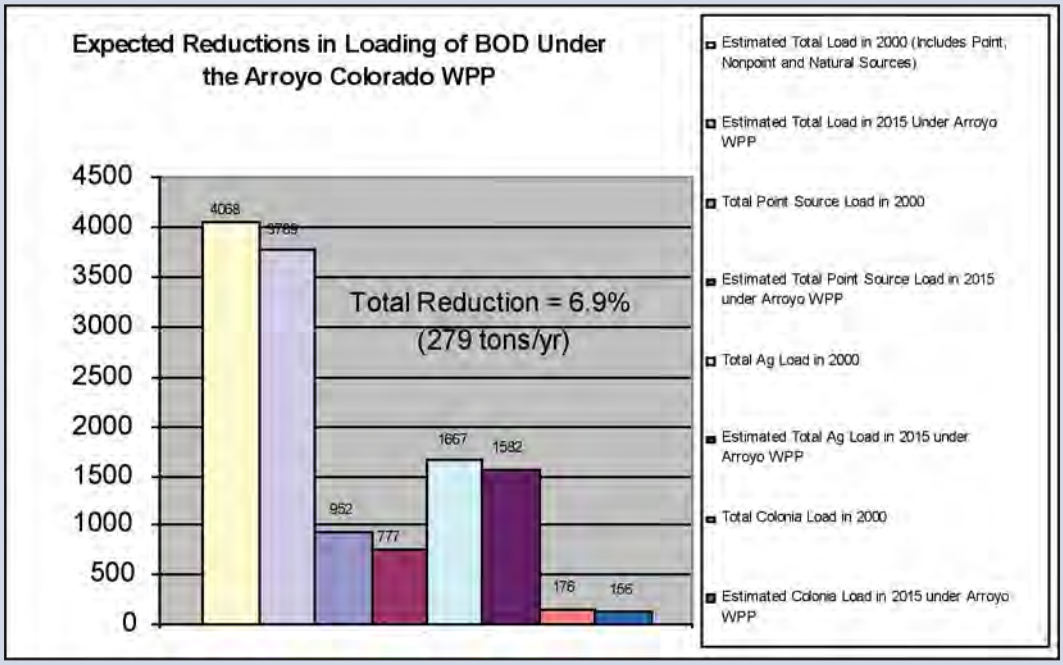
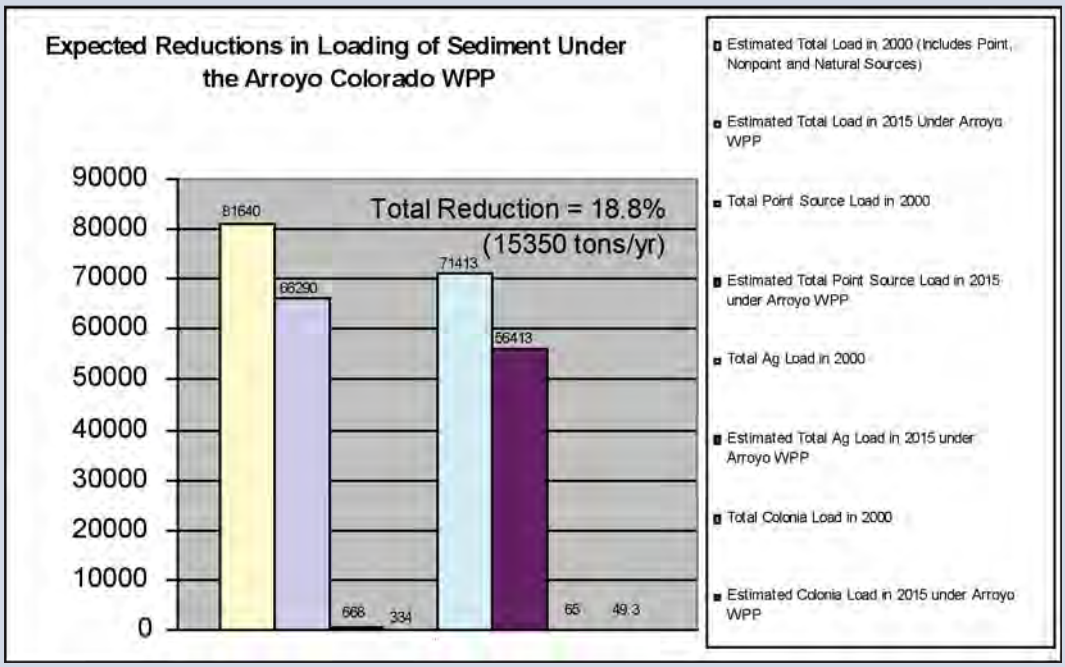


Figure 33. Expected Reductions in Sediment from Implementation of the ACW Protection Plan



Predicted Load Reductions

Figures 32-35 show the estimated total loading and load reductions predicted as a result of implementation of the ACW Protection Plan for each major pollutant of concern within the period 2000-2015. The total watershed loadings shown in the figures include loadings from natural sources as well as point sources and non-point sources of pollution from human activities. Loading reductions range from 7% to 19% depending on the pollutant. Because of the uncertainty associated with load reduction estimates, actions and measures with ill-defined geographic extent, unknown feasibility and/or for which there is little information to calculate load reductions are not included in these

estimates. This includes E&O, implementation of SWMPs and implementation of some habitat restoration measures.

Phase I TMDL Analysis Results

In addition to providing a detailed examination of sources of pollutant loading, the TMDL analysis concluded that the altered physical condition of the Arroyo Colorado contributes significantly to the observed DO impairment in the tidal segment of the stream and that even extreme reductions (up to 90%) in the loading of constituents of concern into the Arroyo Colorado will not achieve the targeted water quality criteria, defined as a 90% rate of compliance with the DO criteria currently applied to the tidal segment of the Arroyo Colorado (24-hour average DO of 4.0 mg/l and a 24-hour minimum DO of 3.0 mg/l). Under the current TMDL analysis, the TCEQ does not regard the TMDL load reduction target of 90% to be realistically achievable.

A second conclusion of the TMDL analysis, based primarily on self-reported data and available monitoring, is that a significant volume of poorly treated and essentially untreated wastewater enters the Arroyo Colorado between the cities of Mission and Rio Hondo along with nutrients, BOD and sediment from agricultural nonpoint sources.

Given the first conclusion of the TCEQ's TMDL study, the 2002 TMDL analysis did not support a quantitative, water quality target-based allocation of loadings of pollutants associated with DO dynamics in the tidal segment of the Arroyo Colorado. However, the TMDL analysis shows that improvements in water quality and a potential reduction in the environmental stresses to

Figure 34. Expected Reductions in Total Nitrogen from Implementation of the ACW Protection Plan

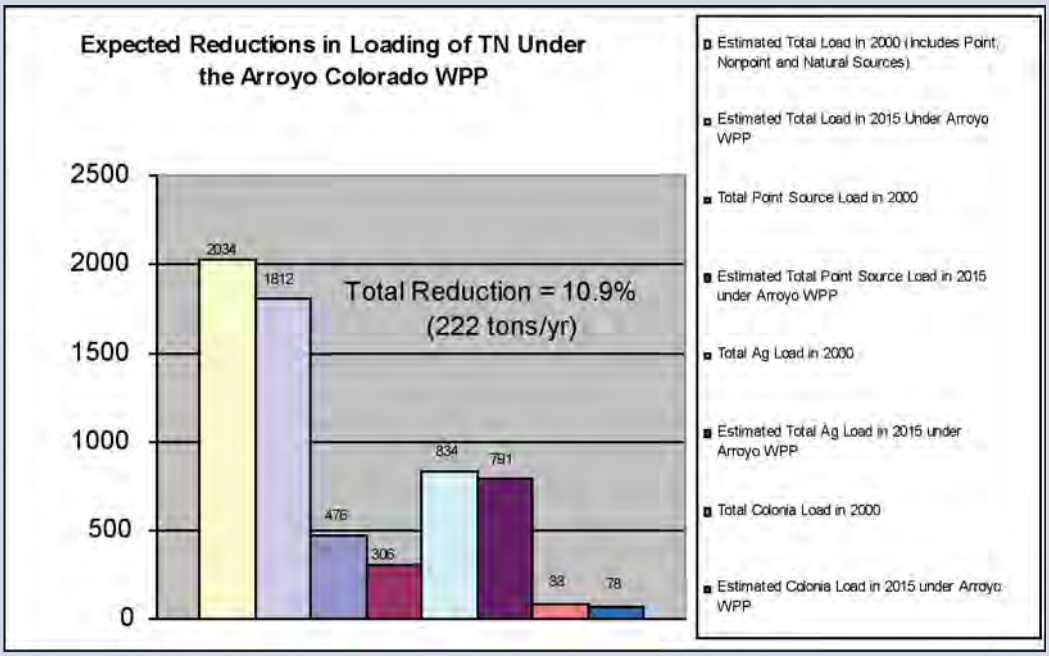
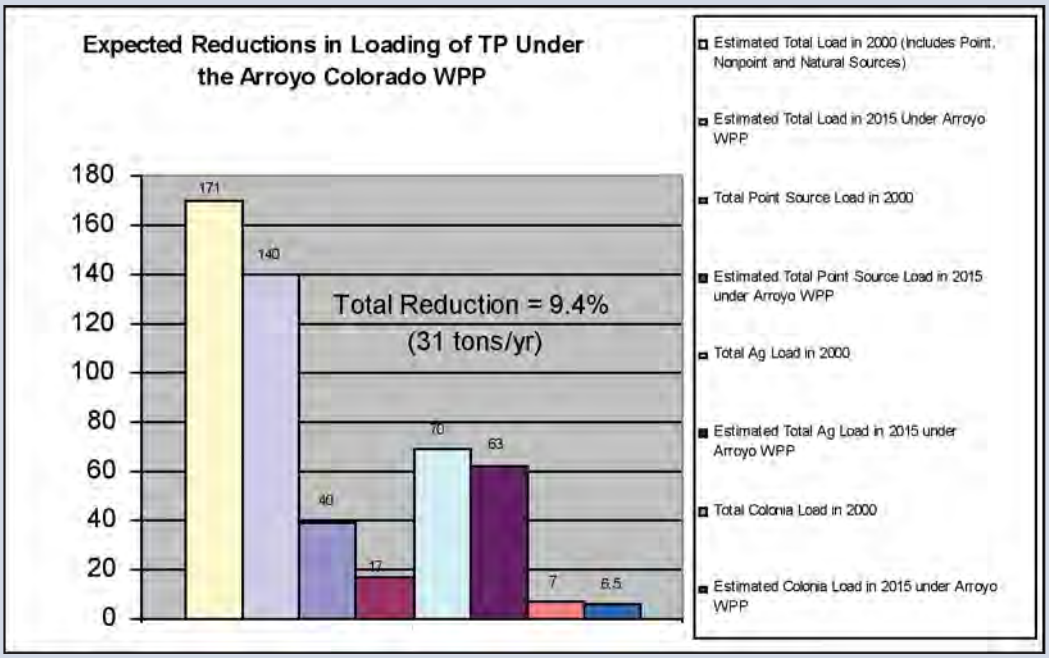


Figure 35. Expected Reductions in Total Phosphorus from Implementation of the ACW Protection Plan



aquatic life can be achieved through the reduction of nutrients, BOD and sediment loadings into the Arroyo Colorado (TCEQ 2003).

Sources of Uncertainty

The effects of uncertainty on the results of the Phase I TMDL analysis, including loading estimates, have only been partially quantified. However, the study provided an accounting of the potential sources of error that contribute to the total measure of uncertainty in a TMDL analysis. Sources of error can be found in many aspects of a TMDL analysis. The following are a few examples of the sources of error in most TMDL analyses:

- Measurement error in observational data
- Error associated with the inability of models to accurately represent complex natural processes mathematically (model equations and parameters)
- Error in parameter estimation (*e.g.*, interception storage, roughness, reaeration, etc.).
- Computational limitations (*e.g.*, time steps, number of elements, etc.)

Sources of error are not specific to any particular TMDL analysis and become reduced in time through refinement of methods and general advances in technology and research; most TMDL analyses simply compensate for the uncertainty introduced by sources of error by using conservative assumptions and model parameters.

In order to gain further understanding regarding the magnitude of uncertainty associated with the Arroyo Colorado TMDL assessment, the following section offers a discussion of the potential sources of error that are specific to Arroyo Colorado (DO) TMDL analysis:

Irrigation return volumes were estimated based on a combination of information that includes data on irrigation water use (*i.e.*, monthly surface water diversions by local irrigation districts, geographic area of each irrigation district within the Arroyo Colorado watershed sub-basins, typical irrigation needs by crop type and local irrigation practices) and flow analysis (in-stream water mass balance calculations of irrigation return inflows based on reconciliation of non-irrigation inflows to the Arroyo, evapotranspiration and gaged instream flow). Because irrigation return flows were not (and currently cannot accurately) be measured directly, there is considerable uncertainty associated with the irrigation return flow volume used in the model.

Deploying 24-hour DO monitors

Surface accumulation rates, surface storage limits and interflow concentrations of constituents of concern for the different permeable and impermeable land units represented in the model were estimated based on the results of 49 published studies (four of which were conducted in the Arroyo Colorado watershed) and also on limited, unpublished data (TCEQ 2003).

Although data for average daily flow, suspended solids, BOD and (in some cases) ammonia nitrogen concentrations from wastewater treatment facilities in the watershed were, for the most part, available through self-reported monthly effluent reports, data on nutrient parameters from these facilities were sparse or non-existent. This fact, combined with some substantial data gaps in the self-reported effluent data and the use of average daily values for each month, introduces a significant measure of uncertainty into the loading estimates from these point sources.

Sources of essentially untreated wastewater (*i.e.*, *colonias*) in the Arroyo Colorado watershed are not well characterized. The potential error in loading estimates of constituents from these sources may be significant.

Background concentrations of constituents in soils, runoff and irrigation return flows from sources such as atmospheric deposition and irrigation water are not well known. There is a potential error in loading estimates of constituents from these sources.

The TMDL analysis, as a whole, would benefit greatly from additional knowledge regarding several key physical and chemical input variables (*i.e.* hydraulic parameters, reaeration rates, BOD decay rates, SOD, etc.). First-order error analysis shows that a more detailed knowledge of the oxygen flux rate (transfer of DO from the mixed surface layer to the lower hypoxic layer) and algal oxygen production and consumption rates in the upper portions of Segment 2201 would reduce the greatest source of uncertainty associated with the in-stream water quality modeling effort (TCEQ 2003).

Although there are limitations to any study and modeling efforts, best available data were compiled and used in the Arroyo TMDL study along with best professional judgment and verification sampling and model calibration. In the end, there is uncertainty associated with one of the most important sources of error in the Arroyo Colorado TMDL analysis, watershed loading estimates, which is one of the least quantifiable without additional study.

Need for Further Characterization

Characterization of watershed loadings, in-stream rates and constants, and DO dynamics in the Arroyo Colorado should be improved to enhance understanding of the cause-and-effect relationships between flow, loadings, biochemical interactions and physical setting. Studies should include edge-of-field measurements of flow and constituent concentrations resulting from runoff and irrigation events, measurements of irrigation return flow volumes, direct monitoring of nutrient loading from municipal wastewater facilities, measurements of SOD in the upper portion of Segment 2201, measurements of nutrient cycling and algal productivity, measurements of particulate organic matter loadings from various sources in the watershed and measurement of the deposition and accumulation rates of particulate organic matter in the upper portion of Segment 2201. The results of the data collection efforts described above would be used to enhance the sophistication of modeling efforts and to refine the overall TMDL analysis of the Arroyo Colorado.

More detailed hydrodynamic modeling should be conducted on the tidal segment of the Arroyo Colorado in order to better characterize the effects of the complex hydraulic environment that exists in Segment 2201. Additional data collection should be conducted to document kinetic rates, productivity parameters and nutrient cycling parameters for use in the hydrodynamic model.

Productivity measurements in the Tidal Segment of the Arroyo Colorado

WATER QUALITY MONITORING PLAN

Water quality monitoring plays an important role in tracking progress toward meeting ACW Protection Plan goals and quantifying improvements to the Arroyo Colorado. This section describes the Water Quality Monitoring Component of the ACW Protection Plan (ACW Water Quality Monitoring Plan). In addition to ensuring that changes in water quality in the Arroyo Colorado are recognized and documented, water quality monitoring in the Arroyo Colorado watershed will provide the tools necessary to implement the load reduction measures specified in the plan using an adaptive management approach. The information provided by the monitoring efforts described in this section will be used by the ACW Partnership to adjust Phase I of the ACW Protection Plan and to develop subsequent phases of the plan.

Historical Monitoring

The State of Texas has monitored water quality in the Arroyo Colorado since 1974. There are 160 documented Surface Water Quality Monitoring (SWQM) stations in the Arroyo Colorado watershed, 94 of which are on the main stem of the Arroyo Colorado. Water quality data are available from as early as 1982 for some of these sites. Water quality data collected by the State of Texas are stored in the state's SWQM database. The most recent water quality data in the SWQM database (last five years) are used by the TCEQ to assess compliance with water quality criteria specified in the Texas Surface Water Quality Standards.

Current Monitoring

The State of Texas monitors water quality in the Arroyo Colorado under the TCEQ's Surface Water Quality Monitoring (SWQM) program and Clean Rivers Program (CRP).

Texas Surface Water Quality Monitoring Program (SWQM)

Composed of over 8000 stations, the TCEQ's Surface Water Quality Monitoring (SWQM) program is the State of Texas' water quality monitoring network and the primary means for assessing water quality in Texas. Active stations are commonly monitored quarterly for field and conventional parameters. Selected stations are monitored for toxic compounds, metals and toxicity. A complete list of field and conventional parameters can be found in Table 18.

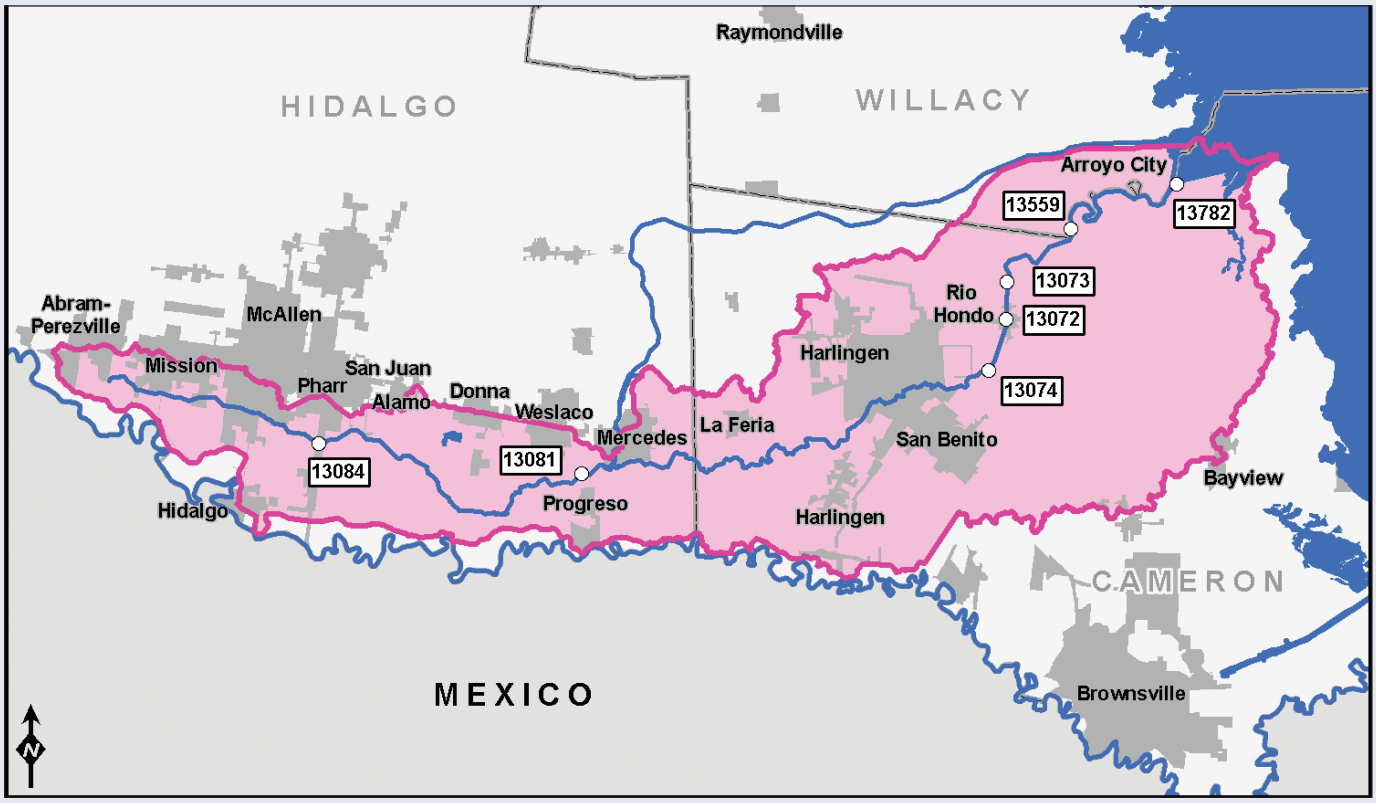
The Texas Clean Rivers Program (CRP)

The Texas Clean Rivers Program (CRP) is a state fee-funded program for water quality monitoring, assessment and public outreach. The CRP is a collaboration of 15 partner agencies and the TCEQ. The CRP provides the opportunity to approach water quality issues within a watershed or river basin locally and regionally through coordinated efforts among diverse organizations.

Coordinated monitoring makes collecting and analyzing surface water quality data in Texas more efficient for the state and its program participants. The SWQM and CRP programs allow participation of federal, local and regional entities in water quality monitoring by establishing a coordinated monitoring plan and monitoring schedule for designated water quality segments and some unclassified water bodies

Water quality sampling in the Tidal Segment

Figure 36. Coordinated Monitoring Sampling Stations in the Arroyo Colorado



of the state. The coordinated monitoring schedule is usually planned and developed from January through May of the preceding fiscal year.

The TCEQ Region 15 office performs the monitoring for the SWQM program and the Nueces River Authority (NRA) monitors for the CRP.

SWQM monitoring in the Arroyo Colorado Watershed consists of seven routine sites, which are monitored quarterly. Four of the sampling sites are in the Arroyo Colorado Tidal Segment and three sites are in the Arroyo Colorado Above Tidal Segment (Figure 36). Table 18 lists typical bacteria, conventional and field parameters that are collected quarterly at the SWQM and CRP sites. Samples for metals and toxic organics compounds in sediment are also collected at one of the sites annually. CRP monitoring consists of 24-hour dissolved oxygen (DO) measurements taken twice during the year at stations 13074 and 13081.

Watershed Protection Plan Monitoring

The ACW Partnership will oversee three types of monitoring during implementation of the ACW Water Quality Monitoring Plan, including watershed-scale monitoring, wastewater effluent monitoring and project-specific monitoring. All monitoring data will be collected by ACW Partnership member organizations, including the TCEQ, NRA, IBWC, UTB, TAMUK, 12 local municipalities and two local water supply corporations. The data will be submitted to the ACW Partnership for analysis and storage. The ACW Partnership will make the results of all analysis of the data collected under the ACW Water Quality Monitoring Plan available on the ACW Partnership website. In addition, the ACW Partnership will report the results of all monitoring data analysis to the TCEQ in writing.

Watershed-scale Water Quality Monitoring

In order to gauge the overall effect on water quality in the Arroyo Colorado of implementing the ACW Protection Plan, the ACW Partnership developed a watershed-scale monitoring plan designed to measure field and conventional water quality parameters, including flow and indicator bacteria, at 12 sites along the Arroyo Colorado (Table 19). Figure 37 shows the 12 sites selected for the watershed-scale monitoring; Table 20 lists the station descriptions. Seven of the 12 stations are SWQM and/or CRP routine monitoring sites and will be monitored quarterly as part of these programs. The five remaining sites will be sampled by the IBWC and the University of Texas at Brownsville

Table 18. Parameters Included in Routine SWQM and CRP Monitoring

Parameter Code	Description
Field Parameters	
00010	Water temperature (°C)
00061	Flow
00078	Transparency (Secchi Disc)
00094	Conductivity
00300	Dissolved Oxygen
00400	pH
00480	Salinity (Tidal section only)
Bacteria	
31699	E. coli
31701	Enterococci
Conventional Parameters	
00410	Alkalinity
00530	Total Suspended Solids
00535	Volatile Suspended Solids
00593	Nitrate+Nitrite
00610	Ammonia
00625	Total Kjeldahl Nitrogen
00665	Total Phosphorus
00680	Total Organic Carbon
00940	Chloride
00945	Sulfate
00951	Total Flouride
32211	Chlorophyll-*a*
32218	Pheophytin
70300	Total Dissolved Solids
70507	Ortho-phosphate

(UTB) in cooperation with the ACW Partnership. The watershed-scale monitoring stations will be sampled quarterly over the 10-year implementation period of the ACW Protection Plan. The ACW Partnership will analyze the data collected as part of the watershed-scale monitoring efforts every two years to determine compliance with state water quality criteria and to determine spatial and temporal trends.

Wastewater Effluent Monitoring

As part of the ACW Protection Plan, two different types of effluent quality monitoring are planned in the Arroyo Colorado watershed. The municipalities and water supply corporations participating in the Arroyo Colorado PRP (Figure 23) will monitor flow, BOD_5, TSS, nutrients and bacteria at each of the 18 permitted outfall locations that constitute the Principal Point Source Contributors of Pollution to the Arroyo Colorado. Table 21 shows the nutrients and bacteria parameters participants will monitor as part of the Arroyo PRP. Sampling, analysis and reporting of these parameters will be conducted in the same fashion as the sampling, analysis and reporting of other parameters currently required under the individual TPDES permits for each of the 18 facilities shown in Figure 23.

In addition to this monitoring, wastewater treatment facility operators implementing enhanced treatment projects under the ACW Protection Plan will also monitor flow, BOD_5, TSS and nutrients at the polished outfall locations downstream of the enhanced treatment areas. PRP participants will collect samples monthly

Table 19. Parameters Included in the ACW Protection Plan Monitoring

Parameter Code	Description
Field Parameters	
00010	Water temperature (°C)
00061	Flow
00078	Transparency (Secchi Disc)
00094	Conductivity
00300	Dissolved Oxygen
00400	pH
00480	Salinity (Tidal section only)
Bacteria	
31616	Fecal coliform
31699	E. coli
31701	Enterococci
Conventional Parameters	
00314	Biochemical Oxygen Demand
00410	Alkalinity
00530	Total Suspended Solids
00535	Volatile Suspended Solids
00610	Ammonia
00625	Total Kjeldahl Nitrogen
00665	Total Phosphorus
00671	Ortho-phosphate
00680	Total Organic Carbon
00940	Chloride
00945	Sulfate
32211	Chlorophyll-*a*
32218	Pheophytin
70300	Total Dissolved Solids

Figure 37. Watershed-Scale Monitoring Stations Selected for the ACW Protection Plan Monitoring

over the 10-year implementation period of the ACW Protection Plan and will report the data collected to the ACW Partnership on a quarterly basis. The ACW Partnership will analyze the data every two years to assess compliance with permit effluent limits, characterize nutrient loading from wastewater facilities and document pollutant load reductions from implementation of enhanced treatment projects.

Project-specific Monitoring

Several ACW Partnership member organizations will collect water quality information as part of specific projects and activities designed to eliminate data gaps and to reduce uncertainty in pollutant loading estimates. These include efforts to characterize physical and biochemical rates and constants in the Arroyo Colorado Tidal and also to assess the impacts of agricultural activities, urban storm water runoff and habitat restoration on the entire Arroyo Colorado.

Table 20. Description of Watershed-Scale Monitoring Stations Selected for the ACW Protection Plan Monitoring

Station ID	Description
13086	Arroyo Colorado at FM 336 South of McAllen
13084	Arroyo Colorado at US 281 South of Pharr
13082	Arroyo Colorado at FM 493 South of Donna
13081	Arroyo Colorado Main Floodway in Llano Grande at FM 1015 South of Weslaco
13080	Arroyo Colorado at FM 506 South of La Feria
16445	Arroyo Colorado at Low Water Crossing at Dilworth Road, East of La Feria
13079	Arroyo Colorado at U.S. 77 in Southwest Harlingen
13074	Arroyo Colorado at Low Water Bridge at Port Harlingen
13072	Arroyo Colorado Tidal FM 106 Bridge at Rio Hondo
13073	Arroyo Colorado Tidal at Camp Perry North of Rio Hondo
13559	Arroyo Colorado Tidal at Marker 27 (Mile 15) 0.5 Mile North of the Point Where Channel Becomes Boundary Between Willacy and Cameron Counties
13782	Arroyo Colorado Tidal Near CM 16 at Arroyo City, KM 10.9

Table 21. Nutrient and Bacteria Parameters Monitored Under the Arroyo Colorado Pollutant Reduction Plan (PRP)

Parameter	Parameter. Code
Total Phosphorus as P (mg/l)	00665
Total Phosphate as PO4-3 (mg/l)	00650
Total Ammonia Nitrogen as N (mg/l)*	00610
Total Kjeldahl Nitrogen as N (mg/l)	00625
Total Nitrite + Nitrate Nitrogen as N (mg/l)	00630
E. coli (#/100ml)*	31648

*** Monitoring is only required if this parameter is not already being monitored**

TMDL Monitoring

Despite the development of predictive water quality models for the Arroyo Colorado in 2001 and 2002, efforts to develop a TMDL for DO in the Arroyo Colorado have been limited by the availability of physical, biological and biochemical data for critical areas of the tidally influenced segment. Information on hydrodynamics, primary productivity, the dynamics of biochemical oxygen production/consumption, nutrient cycling and the relationship between these processes and dissolved oxygen dynamics in Segment 2201 is very limited. These data limitations have contributed to a significant level of uncertainty associated with existing water quality models developed in 2001 and 2002.

In 2004 the TCEQ entered into a cooperative funding agreement with the USGS to collect the information necessary to address the current data limitations and information gaps associated with the topics of hydrodynamics, primary productivity, biochemical oxygen demand dynamics and nutrient cycling in the Arroyo Colorado. The purpose of the study was to:

1. Characterize water quality of the Arroyo Colorado by measuring hourly temperature, pH, DO and conductivity at two depths at four locations in the Arroyo Colorado over two 24-hour periods during two synoptic events.
2. Characterize the nutrient and carbon flux through a study reach including pertinent nitrogen and phosphorus species, BOD, total organic carbon (TOC), TSS and volatile suspended sediment (VSS).
3. Measure the seasonal, nutrient-dependent algal growth and algal productivity rates in the water column for each study reach.
4. Measure biochemical oxygen consumption and production rates, respiration rates and sediment and carbon deposition rates.

To complete these tasks, the USGS and TCEQ are collecting surface water quality data and biological data to produce estimates of rates and constants necessary for detailed calibration of hydrodynamic and water quality models that will be used to determine a TMDL for the Arroyo Colorado, which is scheduled to be completed in 2009. Data collection for this project began in 2006.

Continuous Meteorological, Stage and Water Quality Monitoring in the Zone of Impairment

In 2006 the TCEQ, in cooperation with the IBWC, installed and began testing a continuous monitoring station capable of monitoring air temperature, wind speed, wind direction, water surface elevation, water temperature, pH in water, specific conductance in water and dissolved oxygen at two water depths in the Zone of Impairment of the Arroyo Colorado near Rio Hondo (Station 13072). When testing is completed, the automated measurements taken hourly at the site will be transmitted directly to the TCEQ via telephone modem. The data will be displayed in near real-time on a dedicated TCEQ website.

The data generated by the continuous water quality monitoring station will be used to increase current understanding of the role of physical factors such as meteorological conditions and tidal cycling in the occurrence of low DO in the Zone of Impairment and the relationship between hydrodynamics and in-stream biochemistry in the Arroyo Colorado.

Monitoring of Agricultural Activities

The ACW Partnership will monitor water quality resulting from agricultural activities to:

- better characterize pollutant loading from agricultural runoff
- evaluate/demonstrate agricultural BMP effectiveness
- measure progress toward meeting ACW Protection Plan goals

To accomplish these objectives, ACW Partnership member organizations will conduct monitoring on three different scales: 1) at the sub-watershed scale, 2) at the transitional flow zone scale and 3) at the edge-of-field

Automated continuous water quality monitoring station on the Arroyo Colorado Tidal at Rio Hondo

scale. The parameters monitored will include flow, total nitrogen, total phosphorus, total suspended sediment and BOD_5.

TAMUK and the Texas Agricultural Experiment Station (TAES) will conduct sub-watershed monitoring at four locations representing pour points for predominately agricultural sub-watersheds of the Arroyo Colorado. In addition, TAMUK and TAES will conduct edge-of-field monitoring to better characterize agricultural runoff at the field level, to demonstrate to producers how BMPs impact the water quality and to provide information on expected pollutant load reductions associated with agricultural BMP implementation.

Sub-watershed monitoring activities will consist of automated storm water sampling, monthly ambient grab sampling and instantaneous stream flow measurements. Field measurements of dissolved oxygen, water temperature, specific conductance and pH will occur with all grab sampling events. Storm water samples will be retrieved on a daily basis during storm events and flow-composited into a single sample. Various forms of nitrogen and phosphorus will be included in the laboratory analyses to provide a more complete indication of macronutrient conditions in the watershed, to evaluate whether agricultural BMPs are reducing nutrients (nitrogen and phosphorus) and to ensure that efforts to reduce one nutrient is not inadvertently increasing another. All water samples will be analyzed for total phosphorus, dissolved orthophosphate phosphorus, total Kjeldahl nitrogen, dissolved ammonia, dissolved nitrite plus nitrate and total suspended sediments (TSS). In addition, monthly grab samples will be analyzed for BOD_5.

Transitional flow zone monitoring will be conducted to characterize contributions of nutrients and BOD_5 to the Arroyo Colorado from shallow groundwater transport of agricultural pollutants. TAMUK will perform isotope analysis of shallow groundwater samples to evaluate groundwater-surface water interactions. TAMUK will also evaluate nutrients in shallow groundwater in close proximity to drainage ditches and the main channel of the Arroyo to assess the impacts of loading from agricultural activities to shallow groundwater and determine the degree by which nitrate in shallow groundwater in the Arroyo watershed is naturally occurring or anthropogenic. TAMUK will also evaluate irrigation water loss to shallow groundwater in the Arroyo watershed.

Edge-of-field monitoring will represent both tiled and non-tiled irrigated cropland fields that drain to ditches and subsequently directly into the Arroyo Colorado. Surface runoff, along with outflow from the tile drainage system, will be monitored. Surface runoff and tile drain samples will be retrieved on an event-basis and flow-composited into a single sample. As with the agricultural sub-watershed monitoring, all water samples collected as part of the edge-of-field monitoring will be analyzed for various nutrient forms (*i.e.*, total phosphorus, dissolved orthophosphate phosphorus [frequently referred to as soluble reactive phosphorus], total Kjeldahl nitrogen, dissolved ammonia, dissolved nitrite plus nitrate) and total suspended sediments. In addition, monthly grab samples will be analyzed for BOD_5.

TAMUK and TAES staff will also maintain equipment to record instantaneous water level information and gather the required physical measurements and flow data needed to develop, maintain and update the stage-discharge relationships (rating curves) at all monitoring locations as needed.

Automated storm water sampling instrument

Arroyo Colorado Tidal Biodiversity Assessment

Nutrient and DO levels can affect productivity in aquatic environments. TPWD has documented changes in productivity in the Arroyo Colorado Tidal since 1966. The Arroyo Colorado Tidal Biodiversity Assessment will measure the biodiversity in species richness, relative abundance and distribution of aquatic organisms (nektonic and benthic) as an assessment of 1) estuarine community health and 2) success of efforts to reduce nutrient concentrations and improve dissolved oxygen levels in the tidal portion of the Arroyo Colorado. Base line studies of the aquatic community in the Arroyo Colorado Tidal segment were conducted by TPWD in 1966-69 and by the TPWD and the TCEQ in 2001-03 and are available for comparison. The success of efforts to reduce nutrient loading and improve DO levels in the Arroyo Colorado will be measured by periodically assessing the health of aquatic communities in the Arroyo Colorado Tidal as an ultimate measure of success of the ACW Protection Plan.

Irrigated crops

Irrigation monitoring


VECTURIAN
NEW ORLEANS, LA

TECHNICAL AND FINANCIAL ASSISTANCE REQUIRED

As specified in federal EPA guidance for CWA Section 319 (h) grant funding, the ACW Partnership estimated the amount of technical and financial assistance needed to implement Phase I of the ACW Protection Plan. Technical assistance needs were assessed based on information obtained from federal and state agencies currently implementing conservation and pollution mitigation programs in the watershed and through discussions and deliberations of the various Work Groups of the ACW Partnership. Estimates of the funding necessary to implement the individual measures contained in the Plan were based largely on compilations of cost estimates for similar measures implemented inside and outside the Arroyo Colorado watershed. These estimates were provided to the ACW Partnership by consultants and the federal and state agencies and local organizations involved in the ACW Protection Plan effort. A complete listing of organizations involved in developing the ACW Protection Plan can be found in the "Acknowledgements," "Introduction," and "Institutional Framework" sections of this document.

Global positioning-based land surveying

Technical Assistance Needs

Many of the measures described in the ACW Protection Plan require technical assistance beyond that which is available to the stakeholders in the watershed under existing federal, state and local programs. The following sections describe the type and amount of technical assistance needed to implement each of the components of the ACW Protection Plan. Table 22 shows the total amount of technical assistance needed to implement the ACW Protection Plan over the next 10 years.

Habitat Restoration

Habitat restoration projects are particularly dependent on proper engineering design, construction and maintenance for successful implementation. While the information gathered by the ACW Partnership's Habitat Restoration Work Group and the documents produced by the Partnership's consultants prioritized the most effective habitat restoration projects and provided general guidance and a "tool box" for implementing these projects, each individual habitat

Table 22. Summary of Total Technical Assistance Needed to Implement the Arroyo Colorado Watershed Protection Plan

Load Reduction Measures	Near-Term 2006-2010 (working hours)	Long-Term 2011-2015 (working hours)	ACWPP Total 2006-2015 (working hours)
Wastewater Infrastructure*	680	550	1,230
Agricultural Issues	20,480	22,100	42,580
Outreach and Education**	3,745	1,875	5,620
Total	**24,905**	**24,525**	**49,430**

**** includes quantifiable portions of the Habitat Restoration Component of the ACWPP***

***** includes E&O activities associated with Land Use/Development and Storm Water Components of the ACWPP***

restoration project necessitates a site-specific assessment of environmental conditions, a feasibility study tailored to the site, a detailed engineering design of the measures deemed feasible for the site and professional oversight of construction to insure proper installation and maintenance of the project.

Technical resources currently available to help implement habitat restoration projects include services provided to the general public by the TPWD, USFWS, NRCS, TCE and Texas Sea Grant. Additional technical assistance for designing and implementing habitat restoration projects is available from several local universities, including UTB, UTPA and TAMUK. However, the type and amount of consulting services these organizations are able to provide for individual ACW Protection Plan-related habitat restoration projects is limited and general in nature and will be dependent on the amount of excess resources available beyond those necessary to fulfill the general public obligations of these organizations.

The most pressing need for technical assistance associated with the Habitat Restoration Component of the ACW Protection Plan is in grant writing and partnership development to fund and implement large habitat restoration projects such as constructed wetlands.

Technical Assistance Needs for Habitat Restoration (2006-2015)

The Habitat Restoration Work Group and the ACW Partnership did not produce an independent estimate of the amount of technical support required to implement all of the measures included in the Habitat Restoration Component of the ACW Protection Plan because of the uncertainty associated with implementing small habitat restoration projects in ill-defined geographic locations. These small projects include installation of stream bank stabilization structures, creation of wetland swales in drainage channels and installation of vegetated filter strips.

Pending individual assessments of feasibility, implementation of these measures may be appropriate in some areas but not in others. Also, implementation of some of the measures may be dependent on landowner cooperation and also, in some cases, permit authorization must be obtained from agencies such as the IBWC, USACE, municipal and county governments, and irrigation and drainage districts, which normally require site-specific information for authorization. For these reasons, the ACW Partnership focused estimates of the technical assistance needed to implement the Habitat Restoration Component of the ACW Protection Plan on the measures of the Plan that can be easily quantified. These measures include construction of wetlands for tertiary treatment of waste streams from individual wastewater treatment plants and/or for polishing flows from multiple wastewater treatment facilities in close proximity, and construction of large regional wetlands that treat flows from multiple sources including wastewater treatment facilities and nonpoint discharges from urban and agricultural areas or water pumped directly from the Arroyo Colorado. Because of the obvious connection these measures have to wastewater, estimates of the technical assistance needed to implement habitat restoration projects have been included in the estimates of the technical assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan.

Assessing habitat restoration

Wastewater Infrastructure

Successful implementation of the wastewater infrastructure component of the ACW Protection Plan depends on the availability of technical assistance for the operators of the wastewater treatment facilities that represent the Principal Point Source Contributors of Pollutants of concern to the Arroyo Colorado. Small municipalities and water supply corporations, in particular, lack the staffing needed to compile site-specific data and information to conduct initial scoping, cost and feasibility analyses to develop preliminary designs of proposed biological treatment systems.

Wastewater outfall, Mission

Technical staff is also needed to apply for grants and/or low-interest loans to fund the enhanced treatment measures, which often require preliminary site-specific designs and information.

Near-term Technical Assistance Needs for Wastewater Infrastructure (2006-2010)

The total amount of technical assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan in the near-term (2006-2010) is 680 working hours. During this period (2006-2010), five enhanced treatment projects are planned that will require technical assistance to secure grant and/or loan funding, to develop preliminary designs and to oversee proper construction and maintenance of the projects. These projects include:

1) conversion of a 6.75-acre wastewater treatment lagoon into a wetland cell system for effluent polishing for the City of La Feria,
2) conversion of a 20-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the City of San Benito,
3) a 10-acre wetland system for effluent polishing for the City of Mercedes,
4) conversion of a 14-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the MHWSC in Progreso and
5) a 1-acre effluent polishing pond for the city of Hidalgo.

The Arroyo Colorado Wastewater Infrastructure Work Group estimates a minimum of 80 work hours of technical assistance by qualified professional staff will be required for each of the projects described above for a total of 480 working hours for the planning interval of 2006 through 2010. Additionally, a 500-acre regional wetland system is planned for construction during this period. The ACW Partnership estimates 180-200 additional working hours of technical assistance will be required to secure grant and/or loan funding, to establish engineering consulting services contracts and to oversee proper construction and maintenance of the large wetland project.

Long-Term Technical Assistance Needs for Wastewater Infrastructure (2011-2015)

The total amount of technical assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan in the long-term (2011-2015) is 550 working hours. During this period, (2011-2015), three enhanced treatment projects are planned that will require technical assistance to secure grant and/or loan funding. These projects include:

1) a 10-acre wetland system for effluent polishing for the City of Alamo,
2) a 6-acre wetland system and 2-acre pond system as part of the expansion of the City of La Feria's nature park and
3) a 20-acre effluent polishing pond (e.g., oxbow lake) for the City of Pharr and the City of McAllen.

The Arroyo Colorado Wastewater Infrastructure Work Group estimated a total of 250 work hours of technical assistance by qualified professional staff will be required for all three projects over the planning interval of 2011 through 2015. Additionally, a 300-acre regional wetland system is planned for construction during this period. The ACW Partnership estimates 180-200 additional working hours of technical assistance will be required to secure grant and/or loan funding, to establish engineering consulting services contracts and to oversee proper construction and maintenance of the large wetland project.

Agricultural Issues

The NRCS, TSSWCB and SWCDs work with owners and operators of agricultural lands to provide assistance on the planning, installation and maintenance of various conservation practices. This service is provided through the NRCS Field Offices, SWCD Offices and TSSWCB Harlingen Regional Office. In order to meet the water quality goals described in the ACW Protection Plan, the pace of implementation of conservation practices must be accelerated. To accomplish this, significant technical assistance will be needed to help local producers design and implement RMSs and WQMPs. Estimates of the technical assistance needed are based on work performed by a full-time planner, half-time planner, TSSWCB engineering technicians, NRCS engineering technicians and a consulting engineer.

Near-term Technical Assistance Needs for Agricultural Issues (2006-2010)

For the planning interval of 2006-2010, the ACW Partnership estimates 20,480 working hours of technical assistance will be required to help local producers design and implement RMSs and WQMPs on 50,000 acres of agricultural land.

Tillage operation

Long-term Technical Assistance Needs for Agricultural Issues (2011-2015)

For the planning interval of 2011-2015, the ACW Partnership estimates 22,100 working hours of technical assistance will be required to help local producers design and implement RMSs and WQMPs on an additional 50,000 acres of agricultural land.

Compact Urban development

Land Use and Urban Development

The technical assistance needs associated with minimizing the impact of land use and urban development practices on habitat and water quality in the Arroyo Colorado are related to efforts to promote the principles of *Smart Growth* and to educate influential citizens and organizations involved with urban development about the benefits of preserving natural areas. Both of these efforts are considered to be E&O activities and have been incorporated into the E&O Component of the ACW Protection Plan. The ACW Partnership's E&O Work Group has developed outreach tools to promote low-impact urban development and natural land preservation. These tools will be used to build awareness of this issue during implementation of the ACW Protection Plan's E&O campaign and have been included in the overall assessment of technical needs for the E&O Component of the ACW Protection Plan. For a complete assessment of the technical needs associated with the E&O campaign of the ACW Protection Plan, see the E&O portion of the "Technical Assistance Needs" section of this document.

The ACW Partnership assessed the technical resources necessary to assist citizen's groups and non-profit organizations with grant writing, establishing

partnerships for resource-sharing and to facilitate the funding of conservation projects. These needs have been incorporated into the Habitat Restoration portion of the "Technical Assistance Needs" section of this document.

Urban Storm Water

In the spring of 2007, municipalities within the Arroyo Colorado watershed will begin developing Storm Water Management Programs (SWMPs) for areas within the respective jurisdictions designated as "Urbanized Areas" under Phase II TPDES storm water regulations. The portions of these programs that may impact the Arroyo Colorado were discussed by the Rio Grande Valley TPDES Storm Water Task Force Task Force and the ACW Partnership during the spring and summer of 2006 and will be incorporated into the individual SWMPs.

Because Phase II SWMPs for small MS4s are largely tailored to each specific MS4 system, quantifying the technical assistance needs associated with their development and implementation is very difficult at present. However, one of the major components of Phase II SWMPs that all permit holders will have in common is the development of an E&O plan for storm water issues. An assessment of the technical assistance needs associated with the development and implementation of storm water E&O plans has been included in the overall assessment of technical needs for the E&O Component of the ACW Protection Plan. For a complete assessment of the technical needs associated with the E&O Component of the ACW Protection Plan see the E&O portion of the "Technical Assistance Needs" section of this document.

Education and Outreach

Aside from the technical assistance needs associated with implementation of the Agricultural Issues Component, the biggest need for technical assistance associated with the ACW Protection Plan is in the implementation of the E&O Component of the Plan. The E&O Component of the ACW Protection Plan is multifaceted and incorporates aspects of every other component of the watershed plan. Technical expertise in areas such as agricultural management practices, management of urban runoff and sustainable urban development are crucial to E&O efforts in the Arroyo Colorado watershed. The ACW Partnership estimates that general efforts to increase awareness of the water quality issues associated with the Arroyo Colorado alone (Strategies 1-4 and 9) will require at least 3,120 work hours over the next 10 years. However, as this work progresses, the ACW Partnership anticipates that other individuals, groups and organizations will become actively involved in the effort to increase awareness of the water quality issues associated with the Arroyo Colorado and the Lower Laguna Madre and will execute many of the objectives outlined in this plan, diminishing the need for technical support for general E&O tasks.

Capturing the beauty of riparian flora

The ACW Partnership estimates that creation and implementation of micro-campaigns for specific target audiences (Strategy 5), evaluation of E&O campaigns (Strategy 6) and involvement in and support of *Smart Growth* and stormwater E&O efforts will require an additional 2,500 work hours over the next 10 years.

Near-term Technical Assistance Needs for Education and Outreach (2006-2010)

For the planning interval of 2006-2010, the ACW Partnership estimates 3,745 working hours of technical assistance will be required to implement the near-term tasks associated with the E&O Component of the ACW Protection Plan.

Long-term Technical Assistance Needs for Education and Outreach (2011-2015)

For the planning interval of 2011-2015, the ACW Partnership estimates 1,875 working hours of technical assistance will be required to implement the long-term tasks associated with the E&O Component of the ACW Protection Plan.

Financial Assistance Needs

The following sections describe the financial assistance needed to implement each of the components of the ACW Protection Plan. In estimating financial assistance needs, the ACW Partnership assessed only those actions and measures for which general feasibility for implementation had been established and for which a realistic schedule for implementation had been developed. Consequently, the total amount of financial assistance needed to implement the ACW Protection Plan over the next 10 years may exceed the figure(s) presented below and will depend largely on the success of outreach and education efforts and the ability of the ACW Partnership to implement measures with ill-defined geographic locations or lacking stakeholder/landowner support or for which authorization by permitting agencies is uncertain (*i.e.*, IBWC, USACE, county governments, drainage districts, etc.). Table 23 shows the total amount of technical assistance needed to implement the ACW Protection Plan over the next 10 years.

Habitat Restoration

As with assessments of technical assistance needs, assessments of the financial assistance needed to implement the Habitat Restoration Component of the ACW Protection Plan necessitates site-specific assessments of environmental conditions and some measure of the feasibility of implementation for each project envisioned in the plan. As a result, the ACW Partnership focused its assessment of the financial needs associated with habitat restoration on projects with well-defined geographic locations and, at least, general measures of feasibility. With this in mind, the ACW Partnership determined that the most pressing need for financial assistance associated with the Habitat Restoration Component of the ACW Protection Plan is in the implementation of large habitat restoration projects such as constructed wetlands.

Financial Assistance Needs for Habitat Restoration (2006-2015)

The ACW Partnership focused estimates of the financial assistance needed to implement the Habitat Restoration Component of the ACW Protection Plan on measures that could be easily quantified. These measures include construction of wetlands for tertiary treatment of waste streams from individual wastewater treatment plants and/or for polishing flows from multiple wastewater treatment plants in close proximity and construction of large regional wetlands that treat flows from multiple sources, including wastewater treatment facilities and nonpoint discharges from urban and agricultural areas or water pumped directly from the Arroyo Colorado. Because of the obvious connection these measures have to wastewater, estimates of the financial assistance needed to implement habitat restoration projects have been combined with, and included in, the estimates of the technical assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan.

Wastewater Infrastructure

The amount of financial assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan is presented in Table 23. Due to the uncertainty and variability associated with maintenance costs, only costs of construction are presented in this report. However, a reasonable assumption for estimating maintenance costs is to use a value equivalent to 10% of project construction costs per year. Detailed descriptions of each of the measures included in the funding estimates in Table 23 are provided in the following sections.

Near-Term Financial Assistance Needs for Wastewater Infrastructure (2006-2010)

The total amount of financial assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan in the near-term is

$36,220,286 (Table 23). During this period (2006-2010), 10 load reduction measures associated with institutional controls (*i.e.*, new discharge permits or amendment of exiting permits) will be implemented. These measures include construction of five new wastewater treatment facilities (ERHWSC south of Rio Hondo, the City of San Benito, the City of La Feria, the City of Alamo and MHWSC in Progreso) and six expansions and/or upgrades of existing treatment facilities (City of Rio Hondo, City of Hidalgo, City of Pharr, City of Donna, City of Weslaco and HWWS's #1 facility).

The total estimated cost of these load reduction measures is $18,177,700. However, $7,577,700 was subtracted from this estimate because financial resources have already been secured for the projects in San Benito, La Feria, Pharr and ERHWSC. Funding has not yet been secured for the remaining projects (upgrade of HWWS#1 Facility, MHWSC's new facility in Progreso, expansion of the City of Weslaco's facility, expansion and upgrade of the City of Donna's facility, a new facility for the City of Alamo and expansion of the City of Hidalgo's existing facility). The resulting total cost of load reduction measures associated with institutional controls for the planning period of 2006 through 2010 is $10,600,000.

Within the planning period of 2006 through 2010, 58,610 *colonia* residents living in the Arroyo Colorado Watershed will be connected to various municipal wastewater collection systems (approximately 16927 total connections). Using an average cost of $1,500/connection, the total estimated cost of these connections is $25,391,143. However, $11,517,857 of this total has already been secured through grants and low-interest loans from various *colonia* infrastructure-funding agencies (*i.e.*, TWDB, ORCA, USDA-RD, NADBANK, etc.). The resulting total cost of non-funded load reduction measures associated with wastewater infrastructure improvements for the planning period of 2006 through 2010 is $13,873,286.

Eight enhanced wastewater treatment projects and a 500-acre regional wetland system are planned for construction in the period of 2006 through 2010. These projects include:

1) construction of a 4-acre wetland and pond system and conversion of a 6.75-acre wastewater treatment lagoon into a wetland cell system for effluent polishing for the City of La Feria,

2) construction of a 5-acre wetland cell system for effluent polishing for the City of San Juan,

3) conversion of a 20-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the City of San Benito,

4) a 10-acre wetland for effluent polishing for the City of Mercedes,

5) conversion of a 14-acre wastewater treatment lagoon system into a wetland cell system for effluent polishing for the MHWSC in Progreso,

6) a 1-acre effluent polishing pond for the City of Hidalgo,

7) expansion of irrigation reuse by the McAllen PUB and

8) construction of a 25-acre wetland cell system on TPWD property which will receive treated effluent from the City of Weslaco.

In addition to these projects, a 500-acre regional wetland system is planned for construction on undeveloped land located southeast of the Port of Harlingen. If financial support is secured for this regional wetland project, wastewater treatment facilities

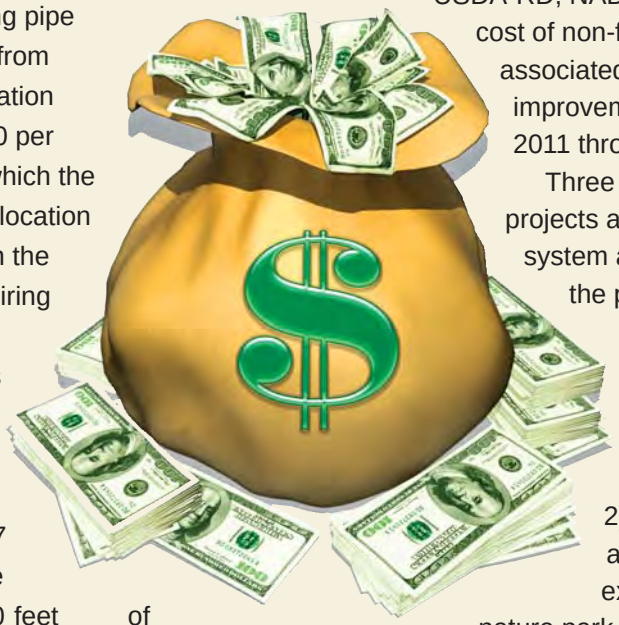
Table 23. Summary of Total Financial Assistance Needed To Implement the Arroyo Colorado Watershed Protection Plan

Load Reduction Measures	Near-Term 2006-2010	Long-Term 2011-2015	ACWPP Total 2006-2015
Wastewater Infrastructure*	$36,220,286	$19,894,800	$56,115,086
Agricultural Issues	$3,925,000	$4,300,000	$8,225,000
Outreach and Education**	$447,923	$572,077	$1,020,000
Total	**$40,667,286**	**$24,692,380**	**$65,359,666**

**** includes quantifiable portions of the Habitat Restoration Component of the ACWPP***
***** includes E&O activities associated with Land Use/Development and Storm Water Components of the ACWPP***

operated by the cities of San Benito, Harlingen and Rio Hondo and MHWSC-Lago will contribute effluent to the regional wetland, providing further enhanced treatment of point source pollution.

Cost estimates for wetland construction are based on average per-acre values suggested in the report titled *Feasibility Study for Habitat Restoration/ Modification to Improve Water Quality in the Arroyo Colorado* by Alan Plummer and Associates Inc., with modifications based on best professional judgment. The cost estimates of effluent reuse through irrigation was based on the cost of setting pipe over the conveyance distance from the outfall to the proposed irrigation application location plus $3,000 per pumping unit for instances in which the proposed irrigation application location was at an elevation higher than the current wastewater outfall requiring additional engineering work.



Based on construction costs of $20,000/acre for wetland cells, $13,000/acre for wet pond systems and $1/linear foot for installed piping and 567 acres of wetland area, a 1-acre effluent polishing pond, 28,000 feet of installed pipe and two effluent pumping systems, the estimated total cost of load reduction measures associated with enhanced treatment systems for the planning interval of 2006 through 2010 is $11,747,000.

Long-Term Financial Assistance Needs for Wastewater Infrastructure (2011-2015)

The total amount of financial assistance needed to implement the Wastewater Infrastructure Component of the ACW Protection Plan in the long-term is $19,894,800. During this period (2011-2015), four load reduction measures associated with institutional controls will be implemented. These measures include construction of one new wastewater treatment facility (ERHWSC near Arroyo City) and expansions and/or upgrades of three existing facilities (City of Mission, City of Mercedes, City of Rio Hondo). The total estimated cost of the load reduction measures associated with institutional controls is $7,550,000 for the planning interval of 2011 through 2015. Financial resources have not been secured for any of the institutional control projects described above.

Also within the planning interval of 2011 through 2015, 9,471 *colonia* residents living in the Arroyo Colorado Watershed will be connected to various municipal wastewater collection systems (approximately 2,706 total connections). The total estimated cost of these connections is $4,051,000. However, $3,984,000 is either funded or earmarked for funding through grants and low-interest loans from various *colonia* infrastructure-funding agencies (*i.e.*, TWDB, ORCA, USDA-RD, NADBANK, etc.). The resulting total cost of non-funded load reduction measures associated with wastewater infrastructure improvements for the planning interval of 2011 through 2015 is $75,000.

Three enhanced wastewater treatment projects and a 300-acre regional wetland system are planned for construction in the planning interval of 2011 through 2015. These projects include:

1) a 10-acre wetland for effluent polishing for the City of Alamo,

2) a 6-acre wetland and 2-acre pond system as part of the expansion of the City of La Feria's nature park,

3) a 20-acre effluent polishing pond (e.g., oxbow lake) for the City of Pharr and the City of McAllen and

4) a 300-acre regional wetland system in the Llano Grande area of the Arroyo Colorado.

The estimated total cost of construction for the load reduction measures associated with enhanced treatment systems for the planning interval of 2011 through 2015 is $12,269,800. Financial resources have not been secured for any of the enhanced treatment projects described above.

Agricultural Issues

The total amount of financial assistance needed to implement the Agricultural Issues Component of the ACW Protection Plan is $445,000 (Table 23). Each year, $173,316 in SB 503 Water Quality Management Plan Program cost share funds are allocated by the TSSWCB to the three SWCDs in the Arroyo Colorado

watershed (*i.e.*, Southmost SWCD, Willacy SWCD and Hidalgo SWCD).

In FY05, CWA Section 319 Grant provided $172,373 for education, $780,000 for cost share assistance and $190,478 for technical assistance. In 2005, $106,000 in cost-share from EQIP was made available to each SWCD in the state for addressing local concerns. In addition, $540,508 in cost share through EQIP is available to the Lower Rio Grande Valley Irrigation Area for addressing the State Resource Concern of Water Quantity – Irrigation.

The TWDB Board authorized funding ($3.7 million over 10 years) for Agricultural Demonstration Initiative grants in September of 2004 for the Harlingen Irrigation District-Cameron County No. 1 for a project expected to last until 2014. The project includes implementation of demonstration projects designed to maximize the efficiency of flood irrigation by demonstrating the effectiveness of all major irrigation technologies and disseminating beneficial findings from the field demonstration sites to irrigation districts and farmers. Producer Advisory Councils or Committees will be formed and will have a big role in the activities of the initiative. The focus of the initiative will be on water efficiency and the associated profitability for producers. The multi-year funding will allow continuation of funding after installation of monitoring equipment and will allow for long-term data collection, analysis, technology transfer and education over a meaningful period of time. This agricultural demonstration initiative is not isolated to the Arroyo Colorado, but the majority of the program is being implemented with the watershed. The program targets water conservation, but is also designed to mitigate pollution runoff.

Agricultural land leveling

Near-term Financial Assistance Needs for Agricultural Issues (2006-2010)

In addition to the existing technical assistance provided by the TSSWCB and NRCS, as well as the existing education programs provided by TCE, the following resources will be necessary in order to meet the near-term (five-year) goals for addressing agricultural issues in the Arroyo Colorado watershed:

- Technical Assistance = $475,000 (based on costs for two full-time employees)
- Cost Share Assistance = $2.7 million (based on 270 WQMPs @ 185 ac/WQMP)
- Monitoring/Assessment = $750,000 (based on ~20% of total)
- **Total Needed = $3.93 million**

Long-term Financial Assistance Needs for Agricultural Issues (2011-2015)

Assuming an annual inflation rate of 3%, the following resources will be necessary to meet the long-term goal (year 5-15) in addition to the existing technical assistance already provided by the TSSWCB, NRCS, and TCE:

- Technical Assistance = $500,000
- Cost Share Assistance = $3 million
- Monitoring/Assessment = $800,000
- **Total Needed = $4.3 million**

Thereafter, approximately $100,000 per year will be needed to continue providing technical assistance and cost share to agricultural producers (funding for one SWCD and one TCE employee).

Land Use and Urban Development

Because much of the ACW Partnership's efforts to minimize the impact of land use and urban development practices on habitat and water quality in the Arroyo Colorado are related mainly to E&O, the ACW Partnership incorporated the assessment of the financial assistance needed to implement these efforts into the E&O Component of the ACW Protection Plan. A complete assessment of the financial needs associated with the E&O Component of the ACW Protection Plan can be found in the E&O portion of the "Financial Assistance Needs" section of this document.

Urban Storm Water

Quantifying the financial assistance needs associated with the development and implementation Phase II SWMPs for small MS4s in the Arroyo Colorado watershed is beyond the scope of this document. However, one of the major components of Phase II SWMPs that all permit holders will have in common is the development of an E&O plan for storm water issues. An assessment of the financial assistance needs associated with the development and implementation of storm water E&O plans has been included in the overall assessment of financial needs for the E&O Component of the ACW Protection Plan.

Education and Outreach

The total amount of financial assistance needed to implement the Education and Outreach Component of the ACW Protection Plan is $1,020,000 (Table 23). The ACW Partnership estimates that general efforts to increase awareness of the water quality issues associated with the Arroyo Colorado (Strategies 1-4 and 9) will require at least $93,625 over the next 10 years. The ACW Partnership estimates that creation and implementation of micro-campaigns for specific target audiences (Strategy 5), evaluation of E&O campaigns (Strategy 6) and involvement in, and support of *Smart Growth* and storm water E&O efforts will require an additional $46,875 over the next 10 years. Additionally, the ACW Partnership estimates the cost of developing and distributing E&O materials, including television PSAs, "backpack stuffers," utility bill inserts, road signage and billboard advertisements, will be $305,000 over the next 10 years.

Near-term Financial Assistance Needs for Education and Outreach (2006-2010)

For the planning interval of 2006-2010, the ACW Partnership estimates $172,923 will be required to implement the near-term tasks associated with the E&O Component of the ACW Protection Plan.

Long-term Financial Assistance Needs for Education and Outreach (2011-2015)

For the planning interval of 2011-2015, the ACW Partnership estimates $272,077 will be required to implement the long-term tasks associated with the E&O Component of the ACW Protection Plan.

Arroyo Colorado Above Tidal near Donna, Texas

SOURCES OF TECHNICAL AND FINANCIAL ASSISTANCE

Technical Resources

Several federal and state programs offer the type of technical assistance needed to implement the actions and measures described in the ACW Protection Plan, including consulting services for habitat restoration, urban and agricultural BMP implementation, E&O for stakeholders and the public, water quality monitoring and grant writing. Although the level of effort required to implement the ACW Protection Plan is beyond the scope of services normally provided by federal and state programs, the technical expertise needed to implement the ACW Protection Plan is abundant in the organizations and agencies that administer the programs. The success of the ACW Protection Plan depends largely on the ability of state and federal agencies to focus available resources on the Arroyo Colorado watershed.

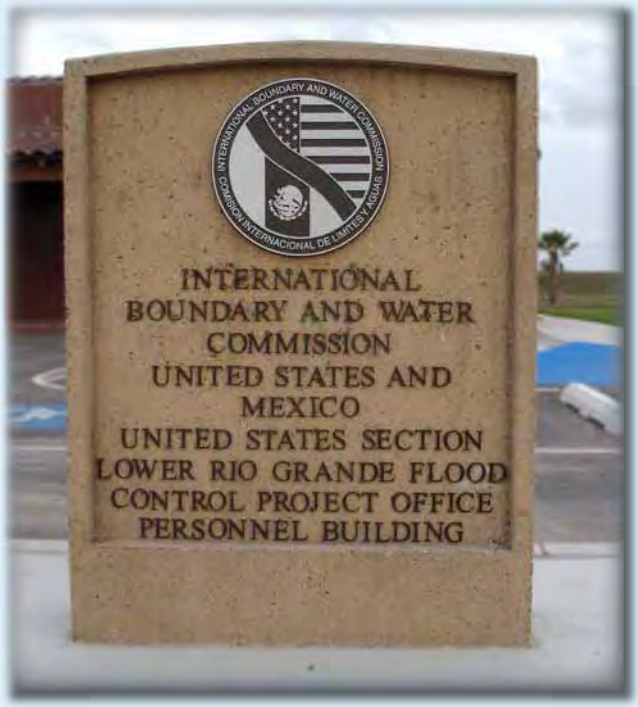
Non-governmental organizations (NGOs) often assist local governments with efforts such as land acquisition for conservation and restoration projects, preliminary design and construction of biological treatment systems, and design and installation of erosion control systems, especially if these efforts also provide habitat for native species. Creating partnerships with NGOs is also key to leveraging technical resources beyond those available through the public sector.

Federal

Federal programs capable of providing the type of technical assistance needed to implement the ACW Protection Plan include programs for land management, wildlife management and flow and water quality monitoring. A brief description of the resources available from federal agencies follows:

U.S. Army Corps of Engineers (USACE)

The U.S. Army Corps of Engineers (USACE) is involved in the design of levees and flood control structures in the Lower Rio Grande Valley Flood Control Project, including the interior floodways associated with the Arroyo Colorado. USACE staff engineers perform hydrologic modeling and analyses to help determine the effects of flooding on the structural integrity of floodway structures. The USACE is currently preparing an Environmental Impact Statement (EIS) for the IBWC specifically to address vegetation maintenance practices in the floodways. BMP design and implementation, design and installation of erosion control structures and habitat restoration projects planned for implementation in the floodways would benefit from engineering consultation that can be provided by USACE.



IBWC building, Mercedes, Texas

United States International Boundary and Water Commission (IBWC)

By international treaty, the International Boundary and Water Commission (IBWC) was authorized to construct and operate the Lower Rio Grande Valley Flood Control Project and is responsible for maintenance of all interior floodways associated with the Arroyo Colorado. However, under court order, the IBWC must also assess the environmental effects of construction and maintenance practices in the floodways. The IBWC also helps assess the health of the Arroyo Colorado by monitoring flow and helping to monitor water quality under the Texas Clean Rivers Program. Implementation of ACW Protection Plan measures within the levees of any of the interior

floodways associated with the Arroyo Colorado would benefit from engineering consultation provided by the IBWC. Continued technical support of flow and water quality monitoring on the Arroyo Colorado by the IBWC will allow leveraging of available state funding for monitoring through the Texas Clean Rivers Program.

U.S. Department of Agriculture (USDA)

The U.S. Department of Agriculture (USDA) provides technical assistance to producers, particularly through the Natural Resource Conservation Service (NRCS) and the U.S. Forest Service (USFS). Much of the federal technical assistance associated with agricultural BMP implementation reaches producers in the Arroyo Colorado watershed through the USDA's Environmental Quality Incentives Program (EQIP). Successful achievement of the agricultural pollutant load reduction goals in the ACW Protection Plan relies on the focusing of technical assistance through the EQIP. The USDA Rural Development Program (USDA-RD) offers technical assistance and information to help agricultural and other cooperatives get started and improve the effectiveness of their member services. USDA also provides technical assistance to help communities undertake community empowerment programs.

U.S. Fish and Wildlife Service (USFWS)

The U.S. Fish and Wildlife Service (USFWS) offers technical assistance to stakeholders and the public for identifying and designing restoration projects and identifying habitat protection opportunities. USFWS biologists often have specialized knowledge of local ecosystems and can provide valuable insights of local conditions. Implementation of the conservation and habitat restoration efforts described in the ACW Protection Plan would benefit from the consultation that can be provided by USFWS.

State

State programs that provide the type of technical assistance needed to implement the ACW Protection Plan include programs for land management, wildlife management, flow and water quality monitoring and E&O. A brief description of the technical resources available from the State of Texas follows:

Rick Reyes and Chris Anzaldua of the IBWC

Texas State Soil and Water Conservation Board (TSSWCB) and Soil and Water Conservation Districts

The Texas State Soil and Water Conservation Board (TSSWCB) and Soil and Water Conservation Districts (SWCDs) provide technical assistance to producers mainly through the SB 503 Water Quality Management Plan Program and the USDA's EQIP. Successful achievement of the agricultural pollutant load reduction goals in the ACW Protection Plan relies on the ability to focus SB 503 Program and EQIP resources on the Arroyo Colorado Watershed.

Texas Parks and Wildlife Department (TPWD)

The Texas Parks and Wildlife Department (TPWD) provides information and technical assistance to stakeholders and the general public on conservation and habitat restoration efforts as well as land and wildlife management practices. TPWD was instrumental in developing the Habitat Restoration Component of the ACW Protection Plan. TPWD biologists are currently working with several local governments in the ACW watershed to design constructed wetland systems for enhanced treatment of wastewater. The ACW Protection Plan would benefit from the consultation that TPWD biologists can provide.

Texas Commission on Environmental Quality

The Texas Commission on Environmental Quality (TCEQ) monitors water quality in the Arroyo Colorado directly through the state's SWQM program and through partnerships with its Texas Clean Rivers Program (CRP) partners. Participation of the TCEQ in the ACW Water Quality Monitoring Plan is critical to its implementation. The technical assistance provided by the TCEQ and its CRP partners for monitoring in the Arroyo Colorado must be sustained, at least over the 10-year period of the ACW Protection Plan. The TCEQ also regulates wastewater discharges, urban stormwater discharges and enforces regulations against unauthorized discharges of pollutants into the Arroyo Colorado. Thus, the participation of the TCEQ is critical to the success of the ACW Protection Plan.

Texas Sea Grant and Texas Cooperative Extension of the Texas A&M University System

The Texas Cooperative Extension (TCE) program and the Texas Sea Grant College Program (TSG) offer educational and technical assistance to private landowners and local governments for land management. The ACW Protection Plan relies on the ability of the TCE, TSG and other programs of the Texas A&M University System to provide technical assistance to educate producers in the ACW watershed about agricultural BMPs.

Texas Watch

The *Texas Watch* program provides technical assistance for establishing volunteer monitoring programs and for educating the public about general water quality issues. *Texas Watch* currently plays an important role in the ACW Protection Plan. Continued participation of the *Texas Watch* program in the ACW Protection Plan will ensure complete implementation of the E&O Component of the Plan.

Regional and Local

Regional and local organizations also provide technical assistance to stakeholders and the public, mainly in the form of flow and water quality monitoring, research and E&O. A brief description of the technical resources available from the regional and local entities follows:

Nueces River Authority (NRA)

The Nueces River Authority (NRA) provides technical assistance in monitoring flow and water quality in the Arroyo Colorado. NRA is a CRP partner with the TCEQ and currently monitors several sites on the Arroyo Colorado Tidal.

Cattail wetlands cell Arroyo Colorado Above Tidal

Universities

Local universities such as UTB, UTPA and TAMUK conduct research on specific topics of direct relevance to the Arroyo Colorado and provide technical assistance for water quality monitoring, BMP implementation, habitat restoration and E&O. Academic institutions in the Arroyo Colorado watershed are already participating in the ACW Protection Plan by filling important data gaps identified by previous research.

Non-Governmental Organizations (NGOs)

Many non-governmental organizations (NGOs) are involved in conservation projects and general E&O. However, a number of NGOs also offer technical assistance to stakeholders and the public on management practices, grant writing and land acquisition.

Rio Grande Valley Chapter of the Texas Master Naturalist (RGVCTMN)

The Rio Grande Valley Chapter of the Texas Master Naturalist (RGVCTMN) program offers training on organic gardening, natural resource conservation and preservation of natural areas. The RGVCTMN has been active in the ACW Partnership and is an important participant in the ACW E&O Plan.

The Nature Conservancy

The Nature Conservancy plans to design local conservation strategies in the Rio Grande Valley that include developing private land conservation techniques in cooperation with local landowners in the Arroyo Colorado watershed. These efforts will be instrumental in restoring habitat along the Arroyo Colorado.

Available Sources of Funding

Several federal and state programs are available to finance many of the load reduction measures described in the ACW Protection Plan. Additionally, several national and regional non-governmental organizations offer financial support to local governments and the public to implement environmental projects.

Federal

Federal grant and low-interest loan programs designed to finance wastewater infrastructure or to mitigate urban and agricultural NPS pollution are critical to the success of the ACW Protection Plan. A brief description of the resources available from federal programs follows:

Clean Water Act State Revolving Fund (CWSRF) Programs

Clean Water Act State Revolving Fund (CWSRF) programs provides low-interest loans with flexible terms, and significant funding for wastewater treatment, nonpoint source pollution control and estuary protection projects. Eligible applicants include municipalities, communities of all sizes, farmers, homeowners, small businesses and nonprofit organizations. CWSRF creates partnerships among banks, nonprofits, local governments and federal and state agencies to provide the best water quality financing source for their communities. Many of the measures in the Arroyo Colorado PRP, the Wastewater Infrastructure Component of the ACW Protection Plan, target CWSFR funding specifically for implementation <http://www.epa.gov/owm/cwfinance/cwsrf/>.

Recreational fishing at dawn Laguna Madre

The USDA Rural Development Program (USDA-RD)

The USDA Rural Development Program (USDA-RD) offers grants and supports low-interest loans to rural communities for water and wastewater development projects. USDA-RD promotes economic development by supporting loans to businesses through banks and community-managed lending pools. Small, rural communities in the Arroyo Colorado watershed such as Rio Hondo, Progreso and Hidalgo have financed wastewater projects through the USDA-RD Program. These communities will again target USDA-RD for financing of additional wastewater infrastructure projects included in the ACW Protection Plan <http://www.rurdev.usda.gov/>.

North American Development Bank (NADB)

The North American Development Bank (NADB) is a binational financial institution capitalized and governed equally by the United States and Mexico for the purpose of financing environmental projects certified by the Border Environment Cooperation Commission (BECC). The two institutions work together with communities and project sponsors in both countries to develop and finance the infrastructure necessary for a clean and healthy environment for border residents. Many of the municipalities in the Arroyo Colorado watershed have financed wastewater infrastructure projects through NADB loans. Many of the measures described in the Arroyo Colorado PRP target NADB as a potential source of funding for implementation <http://www.nadb.org/>.

Continuing Authorities Program (CAP)

At the request of local interests, the U.S. Army Corps of Engineers (USACE) provides assistance in developing and implementing solutions to water

resources problems. Assistance is available under the Continuing Authorities Program (CAP). In creating the CAP program, the U.S. Congress delegated general authority to the USACE to plan, design and construct, within specified funding limits, certain types of water resources development projects. The CAP Program is comprised of individual programs for nine different types of projects, each with its own program authority and strict limits on the federal contribution. As favorable studies progress toward more detailed design and construction, certain project costs must be shared with the local sponsor, including any and all costs in excess of federal project limits under the program. For this reason, the local sponsor must be a non-federal entity with the power to raise revenue sufficient to satisfy the requirements of local cooperation <http://www.lre.usace.army.mil/who/projectmanagement/projectinformationsheets/continuingauthoritiesprogram/>.

Coastal Impact Assistance Program

The Coastal Impact Assistance Program (CIAP) authorizes funds to be distributed to outer continental shelf (OCS) oil and gas producing states. Under the CIAP, the Secretary of the Interior is authorized to distribute to producing states and coastal political subdivisions $250 million for each of the fiscal years 2007 through 2010. This money will be shared among Alabama, Alaska, California, Louisiana, Mississippi and Texas and will be allocated to each producing state and eligible coastal subdivision based upon allocation formulas prescribed by the Energy Policy Act of 2005 (Public Law 109-58). Pursuant to the Act, a producing state or coastal political subdivision shall use all amounts received under this section for projects and activities for the conservation, protection or restoration of coastal areas, including wetlands, and mitigation of damage to fish, wildlife or natural resources. CIAP funds are awarded to the state through the U.S. Minerals Management Service <http://www.mms.gov/offshore/CIAPmain.htm>.

Border 2012: U.S.-Mexico Environmental Program

The Border 2012 program is intended to protect the environment and the public's health in the U.S.-Mexico border region. The legal basis for the Border 2012 program is the 1983 Agreement on Cooperation for the Protection and Improvement of the Environment in the Border Area, known as the La Paz Agreement. Border 2012 is led by national coordinators from EPA and its Mexican counterpart, SEMARNAT. One of the broad goals of Border 2012 is to reduce water contamination. The ACW Protection Plan falls within the boundaries of this effort <http://www.epa.gov/usmexicoborder/>.

Barge on the Tidal Segment

Section 319(h) of the Federal Clean Water Act

Through the grant program established under Section 319 of the Federal Clean Water Act, the Environmental Protection Agency provides funding to the Texas State Soil and Water Conservation Board and the Texas Commission on Environmental Quality to implement activities that achieve Congress' goal of controlling and abating nonpoint source pollution. The TCEQ administers the CWA Section 319 program in Texas for non-agricultural nonpoint source management programs and the TSSWCB administers the program for agricultural and silvicultural nonpoint source issues <http://www.epa.gov/OWOW/NPS/cwact.html>.

Targeted Watersheds Grant Program

The Targeted Watersheds Grant Program is an EPA program designed to encourage successful community-based approaches and management techniques to protect and restore the nation's waters. The Targeted Watersheds Grant Program is a competitive grant program based on the fundamental principles of environmental improvement: collaboration, new technologies, market incentives and results-oriented strategies <http://www.epa.gov/twg/>.

The Environmental Quality Incentives Program (EQIP)

The Environmental Quality Incentives Program (EQIP) is an agricultural cost-share program administered by the NRCS (USDA). Reauthorized in the Farm Security and Rural Investment Act of 2002 (Farm Bill), EQIP is a voluntary conservation program for farmers and ranchers that promotes agricultural production and environmental quality as compatible national goals. EQIP offers financial and technical assistance to help eligible participants install or implement structural controls and management practices on eligible agricultural land <http://www.nrcs.usda.gov/PROGRAMS/EQIP/>.

Community Development Block Grants (CDBG)

The Community Development Block Grant (CDBG) program is a flexible program that provides communities with resources to address a wide range of unique community development needs. The CDBG program is one of the longest continuously run programs at the U.S. Department of Housing and Urban Development (HUD). The CDBG program provides annual grants on a formula basis to 1,180 general units of local government and states.

Citrus grove

USGS Cooperative Funding Agreements

Through the USGS cooperative funding program, the USGS is able to provide matching funds for scientific studies, create local partnerships and provide real-time natural resource and water quality information available on the Internet at <http://tx.usgs.gov>.

State

Many of the federal programs described in the previous section are implemented in one way or another by agencies of the State of Texas. The TWDB offers grant and low-interest loans to improve wastewater infrastructure in low-income communities under the CWA State Revolving Fund Program, Economically Distressed Area Program (EDAP) and *Colonia* Wastewater Treatment Assistance Program (CWTAP), which are federal programs overseen by the USEPA. Grants and low-interest loans for infrastructure are also available from the Texas Office of Rural and Community Affairs (ORCA) under federal programs administered by HUD, and several Texas General Land Office grant programs that fund environmental protection and restoration projects located or associated with the Coastal Zone Management Program are administered federally by NOAA. However, several state programs financed wholly or in part by state revenues are also available as sources of funding for implementation of the ACW Protection Plan. A brief description of the resources available from state programs follows:

Supplemental Environmental Project Program

The TCEQ's Supplemental Environmental Projects (SEP) program is an innovative approach to resolving enforcement actions and improving environmental quality. SEPs are a means for directing fines, fees and penalties for environmental violations toward environmentally beneficial uses. Through an SEP, a respondent in an enforcement matter can choose to invest penalty dollars in improving the environment, rather than paying the amount into the Texas General Revenue Fund. SEPs can be comprised of a wide variety of activities, including wetland protection and restoration.

Coastal Texas 2020

Coastal Texas 2020 is a GLO initiative to develop a strategic plan to address the challenges of coastal resource management in Texas. The goal of the initiative is to develop recommendations for legislative action and other legal mechanisms to address coastal issues. The initiative will also identify sources of funding for coastal resource management. To develop the recommendations, GLO seeks input from citizens, business leaders and government officials at the local, state, and federal levels <http://www.glo.state.tx.us/coastal/ct2020/index.html>.

Texas Coastal Management Program

Often referred to as Section 6217 grants, the Texas Coastal Management Program (CMP) is administered by GLO. The program provides a framework for coordinating state, local, and federal programs for the management of Texas coastal resources. The CMP was created in 1973 to establish a more coordinated and comprehensive approach to coastal resource management. The program promotes management measures listed in the Coastal NPS Program Document. The management measures are divided into five categories, one of which is Agriculture/Forestry. Cameron and Willacy counties are within the Coastal Zone Management Area (CZMA) as defined by NOAA and are eligible for this funding. The federally-approved coastal management program brings approximately $2.2 million in federal CZMA funds to state and local entities in Texas to implement projects and program activities in the coastal zone (Cameron and Willacy counties). Categories for use of these funds include critical areas enhancement, information and data availability, public E&O and water quality improvement <http://www.glo.state.tx.us/coastal/cmp.html>.

Arroyo dock

Water Quality Management Plan Program

Created by Senate Bill (SB) 503 of the 73rd Legislature in 1993 and administered by the TSSWCB, the Water Quality Management Plan program (also known as the SB 503 program) provides agricultural producers the opportunity to comply with state water quality laws through traditional, voluntary, incentive-based programs. Through this program, site-specific Water Quality Management Plans (WQMPs) are developed through local SWCDs at the request of the landowner. Plans include appropriate land treatment practices, production practices and management and technology measures to achieve a level of pollution prevention or abatement consistent with state water quality standards.

Incentives are then provided by the TSSWCB to landowners or operators with WQMPs for the installation of soil and water conservation and land improvement measures consistent with the purpose of controlling erosion, conserving water and/or protecting water quality <http://www.tsswcb.state.tx.us/programs.html>.

Economically Distressed Area Program

In 1989 the Texas Legislature established The Economically Distressed Area Program (EDAP) and TWDB was given the responsibility of administering it. The purpose of the EDAP program was to provide basic water and wastewater services to low-income, unincorporated communities, including *colonias,* and to stop the continued development of substandard subdivisions through the implementation of the *Model Subdivision Rules*, state rules that establish minimum standards and criteria for construction of residential developments <http://www.twdb.state.tx.us/assistance/financial/fin_infrastructure/edapfund.asp>.

Agricultural Water Conservation Program

The Agricultural Water Conservation Program provides grants and low-interest loans to political subdivisions of the state, state agencies and private individuals for agricultural water conservation and/or improvement projects. The funds can be used to finance demonstration projects, technology transfers and educational programs. The program also provides a linked deposit loan program for individuals to access TWDB funds through participating local and state depository banks and farm credit institutions <http://www.twdb.state.tx.us/assistance/financial/fin_infrastructure/awcfund.asp>.

Texas Farm & Ranch Lands Conservation Program

Created by Senate Bill (SB) 1273, the Texas Farm & Ranch Lands Conservation Program (TFRLCP) helps stem the fragmentation and loss of agricultural lands and natural resources in Texas. By awarding grants for the sale of agricultural conservation easements, TFRLCP provides landowners with a voluntary, free-market alternative to sub-dividing or selling for development <http://www.texasfrcp.org/>.

Non-Governmental Organizations

Several non-governmental organizations also offer grant funding for projects associated with environmental restoration and protection. Other programs are available to assist agricultural producers.

Ducks Unlimited (DU)

Ducks Unlimited (DU) is a nonprofit organization that conserves, restores and manages wetlands and associated habitats for North America's waterfowl. DU is the world's largest private, non-profit waterfowl and wetland conservation organization. By any measure, DU is one of the largest conservation/environmental groups in the world, with more than one million supporters in the U.S., Canada and Mexico. DU partners with other organizations to implement habitat conservation and restoration projects throughout North America, often using its own funds to leverage private sector financing for the projects <http://www.ducks.org/>.

The Nature Conservancy

The Nature Conservancy works to preserve and protect thousands of acres of ecologically sensitive land on both sides of the U.S. border. The Nature Conservancy as an organization is very experienced at acquiring land for environmental conservation, restoration and protection and has been an active member of the ACW Partnership for many years. The Nature Conservancy has expressed significant willingness to partner with other ACW Partnership members to implement many of the measures included in the Habitat Restoration Component of the ACW Protection Plan <http://www.nature.org/>.

The Valley Land Fund

The Valley Land Fund works to preserve, enhance and expand the native wildlife habitat of the Rio Grande Valley through education, land ownership and the creation of economic incentives. The Valley Land Fund is one of several conservation organizations in the Rio Grande Valley with a keen interest in acquiring land in the Arroyo Colorado watershed for restoration and/or conservation. As an organization, the Valley Land Fund has expressed significant willingness to work with the ACW Partnership to implement many of the measures included in the Habitat Restoration Component of the ACW Protection Plan <http://www.valleylandfund.com/>.

American Farmland Trust

The American Farmland Trust works with landowners and communities to protect agricultural lands from development and keep farms and ranches in production. AFT has worked with land trusts and other organizations around the country to protect thousands of acres of farm and ranch land. <http://www.farmland.org/default.asp>.

Edinburg World Birding Center

IMPLEMENTATION SCHEDULE

Federal CWA Section 319 guidance specifies that watershed plans must contain a schedule of implementation of the measures described in the plans. As with most planning efforts, implementation schedules contained in watershed protection plans are subject to a high degree of uncertainty due to factors such as availability of funding, degree of stakeholder commitment and potential delays associated with regulatory permitting procedures. For these and other reasons, the exact date of implementation for each individual load reduction measure described in the ACW Protection Plan cannot be estimated with a high degree of certainty. However, estimates of implementation of individual measures are possible with anticipated error factors of approximately one to two years.

Habitat Restoration

Among the goals of the Habitat Restoration Work Group was to provide a "tool box" for use in the development of habitat restoration projects in the Arroyo Colorado watershed. Other goals of the Habitat Restoration Work Group included identifying opportunities for water quality improvement through habitat restoration in the Arroyo Colorado. Very few goals of the ACW Partnership's Habitat Restoration Work Group have associated with them implementation time frames. However, a notable exception is the work group's commitment to developing small and large wetland systems to improve water quality and restore habitat. These wetland projects, including two regional wetland systems, are included in the timeline in Figure 38.

Wastewater Infrastructure

Figure 38 shows a timeline summarizing the implementation schedules for all the measures described in the Wastewater Infrastructure Component of the ACW Protection Plan. The timeline includes the two regional wetland systems discussed in the Habitat Restoration Component of the ACW Protection Plan. Apparent from the timeline is the fact that a large portion of the measures associated with wastewater infrastructure (*i.e.*, *colonia* connections, new wastewater treatment facility construction and wastewater treatment facility upgrades) are scheduled to occur in the initial stages of the plan with most of the enhanced treatment and regional wetland system construction occurring in the later stages of plan implementation.

Agricultural Issues

Table 24 shows a timetable for implementation of the actions and measures associated with the Agricultural Issues Component of the ACW Protection Plan. Because implementation of Water Quality Management Plans (WQMPs) and Resource Management Systems (RMSs) for agricultural land is accomplished through individual agreements between producers and the TSSWCB or NRCS, projections of the acreage of land under these management plans can only be estimated with reasonable certainty on a yearly basis at best. A more detailed estimate of the amount of agricultural land under these management plans can be found in the section of this document titled "Measuring Progress." Although all aspects of the Agricultural Issues Component of the ACW Protection Plan are subject to the availability of funding, the monitoring and E&O portions of the Plan are particularly dependent on the availability of funding because they extend beyond the services normally provided under existing cost-share programs (*i.e.*, SB 503 and EQIP).

Land Use and Urban Development

Virtually all efforts proposed in the ACW Protection Plan to mitigate pollutant loading and habitat degradation caused by land use and development practices are associated with E&O. The aspects of the ACW E&O Plan dealing with land use and development have been incorporated into strategies 3, 5, 8, and 9 of the E&O Plan. A discussion of the implementation

schedule for these strategies is provided in the E&O portion of this section (*e.g.,* Schedule of Implementation) of this document. A conceivable result of ACW E&O efforts targeting land use and urban development practices is the enactment of institutional controls that would limit land use and development practices considered harmful to the Arroyo Colorado. Although the prospect of this occurring in the watershed within the 10 year implementation period of the ACW Protection Plan is likely, there is no reliable way to predict when or if such an eventuality will occur.

Storm Water Management

Portions of the Phase II NPDES SWMPs for small MS4s in the Arroyo Colorado watershed will contain actions and measures that will help mitigate pollutant loading to the Arroyo Colorado. However, since the TCEQ has not yet established deadlines for the completion of SWMPs for small MS4s in the Texas and since the individual actions included in SWMPs for UAs in the Arroyo Colorado watershed are yet to be developed, the ACW Partnership is not able to provide a schedule of implementation of these actions and measures as of the time of publication of this document. The ACW Partnership anticipates municipalities in

Figure 38. Schedule for Implementation of the Wastewater Infrastructure and Habitat Restoration Components of the ACW Protection Plan

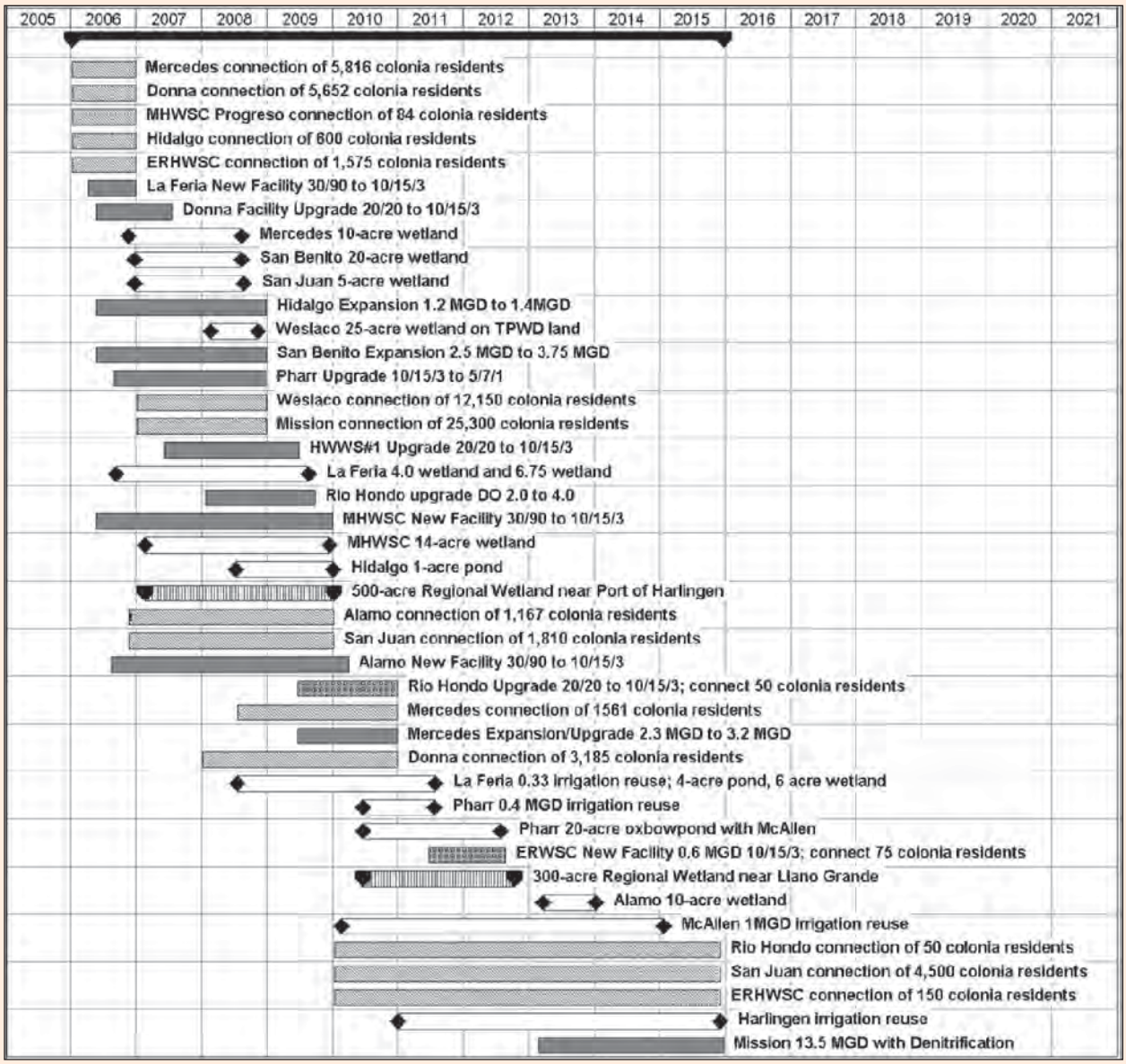


Table 24. Time table for Implementation of the Measures Associated with the Agricultural Issues Component of the ACW Protection Plan

Date	Management Measure
January 2007	Complete Watershed Protection Plan
November 2007	Submit proposals to TSSWCB for FY08 319 Funding for Education and WQMP Implementation Projects
March 2008	Finalize FY08 Education and WQMP Implementation Project Proposals for submittal to EPA if selected for funding
August 31, 2008	Finalize work on FY05 Education Project & WQMP Implementation Project
September 1, 2008	Initiate FY08 Education Project & WQMP Implementation Project if funded
November 2008	Submit proposal to TSSWCB for FY09 319 Funding for Monitoring
March 2009	Finalize FY09 Monitoring Proposal for submittal to EPA if selected for funding
August 31, 2009	Finalize work on FY06 Monitoring Project
September 1, 2009	Initiate FY09 Monitoring Project if funded
August 31, 2010	**33% of irrigated cropland (~100,000 ac) under management plan**
November 2010	Submit proposals to TSSWCB for FY11 319 Funding for Education and WQMP Implementation Projects
March 2011	Finalize FY11 Education and WQMP Implementation Project Proposals for submittal to EPA if selected for funding
August 31, 2011	Finalize work on FY08 Education Project and WQMP Implementation Project if funded
September 1, 2011	Initiate FY11 Education and WQMP Implementation Projects if funded
November 2011	Submit proposal to TSSWCB for FY12 319 Funding for Monitoring
March 2012	Finalize FY12 Monitoring Proposal for submittal to EPA if selected for funding
August 31, 2012	Finalize work on FY09 Monitoring Project if funded
September 1, 2012	Initiate FY12 Monitoring Project if funded
August 31, 2014	Finalize work on FY11 Education Project and WQMP Implementation Project if funded
August 31, 2015	Finalize work on FY12 Monitoring Project if funded
August 31, 2015	**50% of irrigated cropland (~150,000 ac) under management plan**

the Arroyo Colorado watershed will begin developing SWMPs in the spring of 2007. As SWMPs are developed for UAs in the Arroyo Colorado watershed, the ACW Partnership will incorporate these actions into updates of Phase I of the ACW Protection Plan and into subsequent phases of the Plan.

Education and Outreach

The ACW Partnership did not develop a detailed schedule for implementing the tasks associated with each of the strategies included in the ACW E&O Plan because of the continuous nature and frequency in which the tasks will be implemented and because of the uncertainty associated with the funding of some of the strategies. Instead the ACW Partnership chose to describe implementation of the E&O tasks in two broad implementation periods, near-term (2006-2010) and long-term (2011-2015). Implementation of the tasks associated with each of the strategies included in the ACW E&O Plan will occur as follows:

Near-term Education and Outreach Tasks (2006-2010)

- Recruitment of influential spokespersons.
- Partnership development for message distribution.
- Monthly presentations to different targeted audiences.
- Monthly meetings with influential individuals to deliver basic facts on the Arroyo Colorado.
- Quarterly production of news articles related to improving water quality in the Arroyo Colorado.

- Annual grant proposals for development and distribution of television PSAs.
- Annual telephone surveys to assess overall penetration and reach of awareness campaign, with the results summarized in an annual report.
- Annual stakeholder interviews, with the results summarized in an annual report.
- Storm drain stenciling in cities and communities within the Arroyo Colorado watershed.
- Fulfillment of first objectives listed in the micro-campaigns for each of the targeted audiences identified in Strategy 5.
- Creation of an evaluation instrument for assessment of individual E&O efforts.
- Establishing volunteer monitoring programs.
- Developing storm water and urban nonpoint source E&O programs.
- Developing E&O programs promoting *Smart Growth.*

Long-term Education and Outreach Tasks (2011-2015)

- Production and distribution of televisions PSAs.
- Production and distribution of "backpack stuffers."
- Production and distribution of utility bill inserts.
- Production and installation of roadway signage.
- Fulfillment of all objectives listed in the micro-campaigns for each of the targeted audiences identified in Strategy 5.
- Implementing storm water and urban nonpoint source outreach programs.
- Implementing E&O programs promoting *Smart Growth.*

Water Quality Monitoring

The following sections describe the schedule of implementation for each of the three main types of water quality monitoring proposed for the ACW Protection Plan.

Watershed-scale Water Quality Monitoring

In a limited way, watershed-scale monitoring has already begun in the Arroyo Colorado. Seven of the 12 monitoring sites selected for watershed-scale monitoring under the ACW Protection Plan are currently monitored on a quarterly basis as part of routine water quality monitoring conducted under the SWQM and CRP programs. Quarterly monitoring of the remaining five sites selected as watershed-scale monitoring sites will begin in 2007. The TCEQ, NRA, IBWC and UTB will continue to monitor water quality at all 12 watershed-scale monitoring sites on a quarterly basis for the 10-year implementation period of Phase I of the ACW Protection Plan.

Wastewater Effluent Monitoring

Municipalities and water supply corporations participating in the Arroyo Colorado PRP will begin monitoring treated wastewater effluent from their wastewater treatment facilities in 2007. The participants will sample and analyze the treated effluent on a monthly basis for the duration of Phase I of the ACW Protection Plan. Since the main purpose of the wastewater effluent monitoring portion of the ACW Protection Plan is to characterize the nutrient contributions of the Principal Contributors of Point Source Pollution to the Arroyo Colorado, monitoring frequencies may be decreased for those facilities that show consistent pollutant concentrations over time or a consistent pattern in pollutant concentrations over time. Facilities with decreased monitoring frequencies will resume monthly sampling when a major change is completed to the facilities' treatment system or to the associated collection system(s).

Project-specific Monitoring

The schedule of implementation for project-specific monitoring is dependent on the needs and duration of each individual project. The following sections describe the schedules of implementation of project-specific monitoring for each of the ACW Protection Plan projects currently planned or under way.

TMDL Monitoring

Water quality monitoring conducted for the purpose of developing specific rates and constants for use in Phase II of the Arroyo Colorado DO TMDL began in February of 2006. Although Phase II of the Arroyo Colorado will make use of all water quality monitoring data collected as part of the ACW Protection Plan, the water quality monitoring conducted specifically for Phase II of the Arroyo Colorado DO TMDL is scheduled to be completed by December of 2006.

Continuous Meteorological, Stage and Water Quality Monitoring in the Zone of Impairment

The TCEQ and the IBWC completed installation of a continuous water quality monitoring station on the Arroyo Colorado Tidal at Rio Hondo (Station 13072) in 2006. Initial testing of the site revealed serious problems associated with corrosion and bio-fouling of instruments in the highly productive surface waters and dysoxic bottom waters of the Arroyo Colorado Tidal. The TCEQ and the IBWC are continuing to test and assess instrumentation at the site to overcome these problems. The site is expected to be fully operational in January 2007 and will continue to operate indefinitely as long as there is a continuing need for the data and funding remains available for this data collection effort.

Monitoring of Agricultural Activities

In 2007, TAMUK and the TAES will begin monthly and event monitoring of flow and water quality in four tributaries of the Arroyo Colorado that drain primarily agricultural sub-watersheds. Also in 2007, TAMUK and the TAES will begin edge-of-field monitoring of irrigated agricultural land and shallow groundwater to better characterize the impact of agricultural activities on water quality in the Arroyo Colorado. The monitoring efforts are expected to last two years.

Arroyo Colorado Tidal Biodiversity Assessment

In 2007, the TPWD will resume monitoring abundance and biodiversity of aquatic species in the Arroyo Colorado Tidal. Pending the availability of funding for this monitoring effort, TPWD will conduct subsequent surveys of the Arroyo Colorado Tidal every three years through the duration of the implementation period of the ACW Protection Plan (2007-2015).

Boat dock Arroyo Colorado Tidal near the Laguna Madre

MEASURING PROGRESS

The ultimate measure of success of the ACW Protection Plan will be to determine whether state water quality standards are achieved in the Arroyo Colorado. Phase I of the ACW Protection Plan seeks to reduce the loading of pollutants of concern into the Arroyo Colorado to the maximum extent practicable through voluntary actions and existing regulatory controls and to monitor water quality during and after implementation of the Plan. To determine the level of success of Phase I of the ACW Protection Plan, the ACW Partnership will measure a selected set of indicators over the 10-year implementation period of the Plan. The ACW Partnership will use these measurements to assess the effectiveness of the Plan and to recommend modifications to Phase I of the Plan. Subsequent phases of the ACW Protection Plan will seek to reduce pollutant loading further, restore additional habitat and/or implement other measures if necessary to achieve state water quality standards in the stream.

Measures of Success

For the purposes of this document, milestones are defined as interim goals that mark progress towards an ultimate goal. Measures of success are defined as indicators or metrics by which progress toward an ultimate goal is gauged. In order to be meaningful, both of these definitions require a detailed description of the ultimate and interim goals of the ACW Protection Plan.

Ultimate Goal

The ultimate goal of the ACW Protection Plan is to achieve state water quality standards in the Arroyo Colorado by lowering pollutant loadings and restoring aquatic and riparian habitat through voluntary measures and existing regulatory controls. The Plan seeks to ensure the Arroyo Colorado meets an average 24-hour DO concentration of 4.0 mg/l or above and a daily minimum DO concentration of 2.0 mg/l or above during critical periods. The Water Quality Monitoring Plan portion of this document details the monitoring activities that will be used to determine if this DO criteria is met in the stream, particularly in the Zone of Impairment (*i.e.*, stations 13072 and 13073).

Interim Goals

The ACW Partnership developed the following interim goals marking progress toward achieving state water quality standards:

1. Reducing BOD, TSS and nutrient loading to the Arroyo Colorado by 7-19% through expanded coverage of centralized wastewater treatment, improved secondary wastewater treatment levels, enhanced biological treatment (*i.e.*, polishing) of wastewater effluent and implementation of agricultural and urban BMPs
2. Conserving and restoring aquatic and riparian habitat along the Arroyo Colorado and with the Arroyo Colorado watershed to the maximum extent practicable
3. Reducing unauthorized releases of commercial fertilizer and raw sugar at and in the vicinity of, the Port of Harlingen
4. Increasing E&O efforts to the maximum extent practicable

Actions

To achieve these interim goals, the ACW Partnership will oversee implementation of the following actions and measures as part of Phase I of the ACW Protection Plan:

- Construction of two regional wetland systems (500 acres and 300 acres) capable of removing nutrients, BOD, suspended sediment and bacteria from the Arroyo Colorado or from tributaries flowing into the Arroyo Colorado
- Stabilization of stream banks in the Arroyo Colorado (undetermined amount)
- Conservation and/or restoration of riparian land and wetlands along the Arroyo Colorado and within the Arroyo Colorado Watershed (undetermined amount)
- Construction of six new wastewater treatment facilities and expansion and/or upgrading of nine existing treatment facilities
- Reduction of permitted wastewater effluent limits for nine wastewater treatment facilities in the Arroyo Colorado watershed (all facilities to achieve 10/15/3 treatment levels by 2015)

- Extension of centralized wastewater treatment and/or provision of adequate and sustainable onsite wastewater treatment for 68,081 *colonia* residents (42% of all *colonia* residents currently living in the Arroyo Colorado watershed)
- Implementation of 12 enhanced wastewater treatment systems (including eight effluent polishing wetland systems, two effluent polishing ponds and two wastewater reuse projects)
- Implementation of agricultural management practices on approximately 150,000 acres of the agricultural land in the Arroyo Colorado watershed (50% of all agricultural land in the watershed)
- Improvement of management practices at and in the vicinity of the Port of Harlingen
- Education of stakeholders and the public on water quality and habitat issues associated with the Arroyo Colorado (undetermined amount)
- Expansion of stakeholder and public involvement in restoring and protecting habitat and water quality in the Arroyo Colorado (undetermined amount)

Indicators

The ACW Partnership identified the three categories of indicators to measure the success of the ACW Protection Plan. The indicator categories are the following:

- Programmatic Indicators
- Environmental Indicators
- Social Indicators

Stakeholders reaching new heights

Programmatic Indicators

Programmatic indicators will measure the relative success achieved in implementing the individual actions and measures included in the Plan; these include estimates of the number of acres of restored or created wetlands, miles of stream bank stabilized, number of wastewater treatment facilities upgraded, number of permitted wastewater effluent limits reduced, number of *colonia* residents provided with centralized wastewater services, number of enhanced wastewater treatment projects implemented, acres of agricultural land under WQMPs or RMSs, number of E&O Strategies implemented and number of volunteer water quality monitors trained.

Social Indicators

Social indicators are measurements of the knowledge and attitudes of the general public or subsections of the public that generally result in positive action toward improving environmental conditions. Social indicators include the number of watershed residents who have gained knowledge of the water quality and/or habitat problems associated with the Arroyo Colorado, the number of members and/or participants in the ACW Partnership over time or the number of citizens volunteering to help monitor, restore or protect the Arroyo Colorado.

Environmental Indicators

Environmental indicators are measurements of physical, chemical and/or biological attributes that can be used to gauge the overall health of the Arroyo Colorado as the ACW Protection Plan is implemented. They include scientific observations such as in-stream levels of dissolved oxygen, in-stream nutrient concentrations, in-stream suspended sediment concentrations, total documented load reductions by pollutant, number of occurrence of algal blooms, number of occurrence of fish kills and percent increase in the number, distribution and diversity of aquatic organisms.

Assessment Criteria

To measure the success of Phase I of the ACW Protection Plan, the ACW Partnership developed the following criteria to assess the three types of indicators identified by the Partnership as being adequate measures of success for the Plan.

Criteria for Assessing Programmatic Indicators

Table 25 shows the criteria for assessing programmatic indicators and the numerical targets associated with each. Since the ACW Partnership did

Table 25. Criteria for Assessing Programmatic Indicators and Associated Numerical Targets

Criteria for Assessing Programmatic Indicators	Numerical Target 2006-2010	Numerical Target 2011-2015
Acres of wetlands created or restored	386	538
Acres of land placed under conservation	NA	NA
Length of stream bank stabilized	NA	NA
Number of wastewater treatment facilities upgraded	6	3
Number of new wastewater treatment facilities built	5	1
Number of wastewater effluent limits reduced	7	2
Number of *colonia* residents provided with centralized wastewater treatment or adequate onsite wastewater treatment	58,610	9,471
Number of enhanced wastewater systems built or implemented	8	4
Acres of agricultural land in the watershed under WQMPs and RMSs	50,000	50,000
Pounds of commercial fertilizer spillage prevented at and near the Port of Harlingen	NA	NA
Pounds of raw sugar spillage prevented at and near the Port of Harlingen	NA	NA

NA – no target developed.

not develop numerical targets for land conservation, stream bank stabilization and industrial management practices at and near the Port of Harlingen, the targets for these indicators are not shown on Table 25. However, the totals for the criteria associated with these measures are expected to increase with time during implementation of the ACW Protection Plan. Therefore, success for these indicators will be measured in terms of a relative increase in the totals for the criteria associated with each indicator over time.

Criteria for Assessing Environmental Indicators

Table 26 shows the criteria for assessing environmental indicators and the numerical targets associated with each. Since the TCEQ does not include total suspended solids or BOD among the parameters assessed during development of the Texas Water Quality Inventory and 303(d) list, the numerical targets for these indicators are not shown on Table 26. Likewise, since the ACW Partnership did not develop numerical targets for the number of algal blooms reported, the number of fish kills reported and the abundance, diversity and distribution of aquatic life species in the Arroyo Colorado, the numerical targets for these criteria are also not included in Table 26. However, baseline data for these criteria are available from individual studies conducted in the Arroyo Colorado in the recent past. Therefore, success for these indicators will be measured in terms of a relative improvement in the numerical values of the totals for these criteria over time.

Criteria for Assessing Social Indicators

The ACW Partnership developed the following criteria for assessing social indicators:

- Estimated percentage of watershed residents knowledgeable about water quality issues in the Arroyo Colorado
- Number of watershed residents involved in restoring and protecting habitat and water quality in the Arroyo Colorado
- Number of volunteer water quality monitors trained in the watershed

Because of the inherent difficulty associated with quantifying the environmental effects of E&O, the ACW Partnership did not develop numerical targets for these criteria. However, baseline data for these criteria are available from individual studies conducted in the Arroyo Colorado in the recent past. Therefore, success for these indicators will be measured in terms of a relative improvement in the numerical values of the totals for these criteria over time.

Milestones

Table 27 shows the milestones selected by the ACW Partnership to mark the progress of the ACW Protection Plan. In defining interim goals or milestones for implementation of the ACW Protection Plan, the ACW Partnership focused attention on actions and measures in the plan that could be easily quantified.

Table 26. Criteria for Assessing Environmental Indicators and Associated Numerical Targets

Criteria for Assessing Environmental Indicators	Numerical Target 2006-2010	Numerical Target 2011-2015
Number of measurements at each monitoring station not meeting the DO criteria established by the state	<8 out of 20*	<8 out of 20
Average ammonia nitrogen concentrations measured at each monitoring station	<85th percentile of tidal streams in Texas	<85th percentile of tidal streams in Texas
Average nitrate and nitrite nitrogen concentrations measured at each monitoring station	<85th percentile of tidal streams in Texas	<85th percentile of tidal streams in Texas
Average orthophosphate concentrations measured at each monitoring station	<85th percentile of tidal streams in Texas	<85th percentile of tidal streams in Texas
Average total suspended solids concentrations measured at each monitoring station	NA	NA
Average biochemical oxygen demand concentrations measured at each monitoring station	NA	NA
Tons of five-day biochemical oxygen demand loading reduced	1,920	870
Tons of total nitrogen loading reduced	1,620	600
Tons of sediment loading reduced	76,750	75,210
Tons of total phosphorus loading reduced	220	90
Algal blooms reported	NA	NA
Fish kills reported	NA	NA
Abundance of aquatic species	NA	NA
Diversity of aquatic species	NA	NA
Distribution of aquatic species	NA	NA

NA – no target developed.

**** Threshold of noncompliance under the, currently used, binomial method of assessment.***

The milestones selected by the ACW Partnership fall into three main categories:

- Wastewater infrastructure
  - New wastewater connections for *colonia* residents
  - New wastewater treatment facilities
  - Wastewater facility upgrades
  - Enhanced wastewater treatment systems
- Habitat Restoration
  - Small and regional wetland systems
- Agricultural BMPs
  - Acres of agricultural land under WQMPs or RMSs

Although emphasis will be on achieving and documenting the milestones shown in Table 27, the ACW Partnership will also track implementation of additional measures as indicators of success. These measures include additional habitat restoration efforts, improved industrial management practices, urban storm water management efforts, E&O efforts, estimated pollutant load reductions and observed improvements in water quality.

Table 27. Milestones for Measuring Progress of the ACW Protection Plan

Date	Milestone
August 31, 2006	20% of irrigated cropland (~60,000 acres) under management plan
January 1, 2007	Connection of 13,547 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* Mercedes, Donna, Hidalgo, MHWSC and ERHWSC)
January 1, 2007	Construction completed for three new wastewater treatment facilities (*e.g.,* South Rio Hondo -ERHWSC, San Benito and La Feria)
August 31, 2007	23% of irrigated cropland (~70,000 acres) under management plan
January 1, 2008	Connection of 4,456 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* Pharr and La Feria)
August 31, 2008	27% of irrigated cropland (~80,000 acres) under management plan
January 1, 2009	Construction completed for four enhanced wastewater treatment wetland systems (*e.g.,* La Feria, San Juan, Mercedes, Weslaco, and San Benito)
January 1, 2009	Upgrades/expansions completed for five municipal wastewater treatment facilities (*e.g.,* Pharr, Donna, Hidalgo, San Benito and Rio Hondo)
January 1, 2009	Connection of 37,450 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* Weslaco and Mission)
August 31, 2009	30% of irrigated cropland (~90,000 acres) under management plan
January 1, 2010	Construction completed for two new wastewater treatment facilities (*e.g.,* Alamo and MHWSC-Progreso)
January 1, 2010	Upgrade completed for HWWS Plant #1 wastewater treatment facility
January 1, 2010	Construction completed for one enhanced wastewater treatment wetland system (*e.g.,* MHWSC-Progreso) and one pond system (*e.g.,* Hidalgo)
January 1, 2010	Construction completed of a 500-acre wetland system near the Port of Harlingen
August 31, 2010	33% of irrigated cropland (~100,000 acres) under management plan
January 1, 2011	Upgrades/expansions completed for two municipal wastewater treatment facilities (*e.g.,* Rio Hondo and Mercedes)
January 1, 2011	Connection of 6,162 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* Alamo, San Juan and Donna)
August 31, 2011	Wastewater irrigation reuse systems completed for two municipalities (*e.g.,* Pharr and La Feria)
August 31, 2011	37% of irrigated cropland (~110,000 acres) under management plan
January, 2012	Construction completed for a new wastewater treatment facility in Arroyo City (*e.g.,* ERHWSC)
August 31, 2012	Connection of 1,636 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* ERHWSC and Mercedes)
August 31, 2012	40% of irrigated cropland (~120,000 acres) under management plan
August 31, 2012	Construction completed for an enhanced wastewater pond treatment system (*e.g.,* Pharr/McAllen)
August 31, 2012	Construction completed of a 300 acre wetland system near Llano Grande
August 31, 2013	43% of irrigated cropland (~130,000 acres) under management plan
January, 2014	Construction completed for an enhanced wastewater treatment wetland system for the City of Alamo
August 31, 2014	47% of irrigated cropland (~140,000 acres) under management plan
January, 2015	Wastewater irrigation reuse system expansion for McAllen
August 31, 2015	50% of irrigated cropland (~150,000 acres) under management plan
December 31, 2015	Connection of 4,700 *colonia* residents to existing wastewater municipal collection systems completed (*e.g.,* Rio Hondo, San Juan and ERHWSC)
December 31, 2015	Wastewater irrigation reuse system expansion for Harlingen
December 31, 2015	Upgrade/expansion completed for Mission wastewater treatment facility to include denitrification

APPENDICES

APPENDIX A

List of Acronyms

ACW	Arroyo Colorado Watershed
APAI	Alan Plummer Associates, Inc.
BMP	Best Management Practice
BOD	Biochemical Oxygen Demand
BOD5	5-day Biological Oxygen Demand
CCC	Coastal Coordination Council
CCA	Coastal Conservation Association
CCN	Certificate of Conveyance and Necessity
cfu	Colony-Forming Units
CRESPO	CRESPO Consulting Services, Inc.
CRP	Clean Rivers Program
CSAC	Coalition to Save the Arroyo Colorado
CSREES	USDA-Cooperative State Research, Education, and Extension Service
CWA	Clean Water Act
CZMA	Coastal Zone Management Act
DDD	Dichlorodiphenyldichloroethylene
DDE	Dichlorodiphenydichloroethane
DDT	Dichlorodiphenyltrichloroethane
DEM	Digital Elevation Model
DO	Dissolved Oxygen
DU	Ducks Unlimited
ECO	Earth Care Organization
ECO-ED	Earth Care Organization Education Centers
E&O	Education and Outreach
EDAP	Economically Distressed Area Program
EPA	United States Environmental Protection Agency
EQIP	Environmental Quality Incentives Program
ERHWCS	East Rio Hondo Water Supply Corporation
FAQ	Frequently Asked Questions
FEMA	Federal Emergency Management Agency
FOTG	Field Office Technical Guide
ft^2	Square Feet
gal/day	Gallons Per Day
GIS	Geographic Information System
GIWW	Gulf Intracoastal Waterway
GLO	Texas General Land Office
GSF	Gorgas Science Foundation
HSPF	Hydrologic Simulation Program Fortran

HUC	Hydrologic Unit Code
HWWS	Harlingen Water Works System
IBWC	International Boundary and Water Commission
IMAS	International Museum of Arts and Science (McAllen, Texas)
km	Kilometer
LLM	Lower Laguna Madre
LLMF	Lower Laguna Madre Foundation
LRGV	Lower Rio Grande Valley
LRGVDC	Lower Rio Grande Valley Development Council
MEP	Maximum Extent Practicable
mg/l	Milligrams per Liter
MGD	Million Gallons Per Day
MHWSC	Military Highway Water Supply Corporation
MRLC	Multi-resolution Land Cover
MS4s	Municipal Separate Storm Sewers
NA	Not Applicable
NEPA	National Environmental Policy Act
NGO	Non-governmental Organization
NH3-N	Nitrogen-Ammonia
NOAA	National Oceanographic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NPP	Native Plant Project
NRA	Nueces River Authority
NRCS	USDA-Natural Resources Conservation Service
ORCA	Texas Office of Rural and Community Affairs
PCS	Permit Compliance System
PRP	Pollutant Reduction Plan (Arroyo Colorado Pollutant Reduction Plan)
PSA	Public Service Announcement
QUAL2E	Enhanced Stream Water Quality Model
RGVCTMN	Rio Grande Valley Chapter of the Texas Master Naturalist
RMS	Resource Management System
SEMARNAT	Secretaria de Ecologia Medio Ambiente y Recursos Naturales
SEPs	Supplementary Environmental Projects
SFHAs	Special Flood Hazard Areas
SOD	Sediment Oxygen Demand
STAC	Science and Technical Advisory Committee
SWAT	Soil and Water Assessment Tool
SWCDs	Soil and Water Conservation Districts
SWQM	Surface Water Quality Monitoring
TAC	Texas Administrative Code
TAES	Texas Agricultural Experiment Station

TAMU	Texas A&M University
TAMUK	Texas A&M University-Kingsville
TCE	Texas Cooperative Extension
TCEQ	Texas Commission on Environmental Quality
TCWP	Texas Coastal Watershed Program (TCE)
TDA	Texas Department of Agriculture
TDS	Total Dissolved Solids
TIAER	Texas Institute for Applied Environmental Research
TMDL	Total Maximum Daily Load
TN	Total Nitrogen
TP	Total Phosphorus
TPDES	Texas Pollution Discharge Elimination System
TPWD	Texas Parks and Wildlife Department
TSG	Texas Sea Grant College Program
TSS	Total Suspended Solids
TSSWCB	Texas State Soil and Water Conservation Board
TSU	Texas State University
TV	Television
TWC	Texas Water Commission
TWDB	Texas Water Development Board
TWRI	Texas Water Resources Institute
UAs	Designated Urbanized Areas
URL	Uniform Resource Locator
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USIBWC	United States International Boundary and Water Commission
UTB/TSC	University of Texas at Brownsville/Texas Southmost College
UTPA	University of Texas Pan American
VNC	Valley Nature Center
VSC	Valley Sportsmen Club
WBC	World Birding Center
WDM	Watershed Data Management
WQMP	Water Quality Management Plan
WRD	Water Resources Division (USGS)
WSC	Water Supply Corporation
WWTF	Wastewater Treatment Facility

APPENDIX B
Arroyo Colorado Partnership Steering Committee Ground Rules

These Ground Rules are a revision of the Arroyo Colorado Total Maximum Daily Load (TMDL) Watershed Steering Committee Ground Rules agreed to and signed by members of the Total Maximum Daily Load (TMDL) Watershed Steering Committee in August of 1998. This revision of the Ground Rules was undertaken to reflect the difference in goals between the Arroyo Colorado Total Maximum Daily Load (TMDL) Watershed Steering Committee and the Arroyo Colorado Watershed Steering Committee. The difference in goals between these two committees is the effort to develop a Watershed Protection Plan to restore water quality in the Arroyo Colorado that incorporates the development and refinement of TMDLs for the Arroyo Colorado.

The signatories to these Ground Rules agree as follows:

I. GOALS

The goal of the Arroyo Colorado Watershed Steering Committee (Committee) is to help develop and implement a Watershed Protection Plan that includes an effort to establish Total Maximum Daily Loads (TMDL) for the Arroyo Colorado Watershed for the pollutants listed on the State of Texas Clean Water Act §303(d) List. The watershed includes the drainage area for the Arroyo Colorado (Classified Segments 2201, 2202), which is also a portion of the drainage area for the Lower Laguna Madre (Classified Segment 2491) as described in the Texas Surface Water Quality Standards.

The Watershed Protection Plan will be designed to help restore the specific uses designated to the Arroyo Colorado and the Lower Laguna Madre by the State of Texas as described Texas Surface Water Quality Standards (TAC §§307.1-307.10). These include Intermediate (Segment 2202), High (Segment 2201) and Exceptional (Segment 2491) Aquatic Life and Contact Recreation (Segments 2201, 2202, and 2491). The Watershed Protection Plan will also incorporate, to the greatest degree possible, additional uses of the Arroyo Colorado and the Lower Laguna Madre (beyond those described in the Texas Surface Water Quality Standards) in a manner that:

- considers economic feasibility, affordability and growth,
- works to maintain and improve the unique environmental resources of the watershed,
- complements the regional water planning efforts under Senate Bill 1 (Region M), and
- facilitates regional cooperation.

These uses include: flood control, navigation, aquacultural water source, and conveyance of agricultural return flows and municipal, industrial, and aquacultural wastewater discharges.

Although formation of the Committee was facilitated by the Texas Commission on Environmental Quality (TCEQ) in partnership with the Texas State Soil and Water Conservation Board (TSSWCB), the Committee is an independent group of watershed stakeholders and individuals with an interest in restoring and protecting the described uses and the overall health of the Arroyo Colorado and the Lower Laguna Madre. The Committee is also the main vehicle for public participation in the TMDL process and will be instrumental in obtaining local support for actions aimed at restoring surface water quality in the Arroyo Colorado and the Lower Laguna Madre.

The TCEQ and the TSSWCB will support a Watershed Protection Plan and TMDLs developed by the Committee that meet all necessary legal and scientific requirements. The TCEQ is responsible for submitting TMDLs to the U.S. Environmental Protection Agency for final approval. The TCEQ and the TSSWCB reserve the right to take any action the agencies, individually or jointly, decide is necessary to comply with applicable law and regulation, or that the TCEQ or the TSSWCB decide is necessary for the successful development, implementation and approval of TMDLs. Notwithstanding any other provision of this document, nothing in this document constitutes or is intended to constitute a legal obligation enforceable against the TCEQ, the TSSWCB or the members of this Committee.

II. TIME FRAME

The development of a Watershed Protection Plan for the Arroyo Colorado will require at least an 18-month period from the date this document is approved and signed by the committee members. Development of a TMDL for pollutants causing low dissolved oxygen in the Arroyo Colorado is expected to require at least four years from the date this document is approved and signed by the committee members.

III. PARTICIPANTS

a. **Equitable Representation**: Solicitation of members was conducted under a process developed by the TCEQ and the TSSWCB. This process involved:

(1) consultation with members of the Texas Clean Rivers Program Lower Rio Grande Basin Steering Committee, local and regional government, various civic groups, and other interested parties to determine the stakeholder and public interests related to the uses described previously under Section I (Goals),

(2) meetings with the various stakeholder interest groups and individuals and

(3) self-nomination or requests by the various interest groups or individuals. Membership solicitation criteria included representation of the full geographic area within the watershed, representation from the full range of stakeholder and public interests and emphasis on establishing a Committee that was large enough to represent the full range of interests yet small enough to function effectively.

b. **Stakeholder**: The Committee is composed of stakeholders in the Arroyo Colorado/ Lower Laguna Madre watershed. A stakeholder is defined as someone who may be affected in a significant way by the implementation of recommendations included in the Watershed Protection Plan and the TMDL process, either economically or in quality of life.

c. **Members**: Membership in the Committee is open to any and all interested parties. However, if membership becomes so large that it becomes impossible or impractical to function, the Committee will institute a consensus-based system for limiting Committee membership. The Committee is composed of the members listed in the table (see Appendix C). If a member of the Committee resigns, dies, becomes incapacitated, is removed by the rest of the Committee or otherwise vacates his or her position, TCEQ may seek a replacement in consultation with the TSSWCB.

d. **Proxies**: All members hereby agree to make a good faith effort to attend all Committee meetings; however, the members recognize that emergencies may

arise necessitating the absence of a member. The absent member may designate in writing the name of a specific person who may participate on his/her behalf at any Committee meeting. The members agree that proxies shall not count toward member attendance.

e. **Additional Members**: The members agree that new individuals may be added to the Committee if

(1) a Committee member vacates a position or

(2) if important stakeholder interests are identified that are not represented by the existing membership.

In either event, the Committee will, when practical, accept additional members.

f. **Watershed Coordinator**: The watershed coordinator is an independent position, financed by the State of Texas through federal grant funds, whose responsibility it is to coordinate, facilitate and document the proceedings of the Committee. The Watershed Coordinator will also facilitate the development of a Watershed Protection Plan and ensure that such a plan is developed.

g. **Attendance at Meetings**: A Committee member may be accompanied by such other individuals as the Committee member believes to be appropriate; however, only the Committee member will have the privilege of sitting at the table, speaking during the meetings and participating in consensus determinations. Committee members are expected to attend all full meetings and participate fully in the Committee's deliberations.

h. **Absent Members**: All members agree to make a good faith effort to attend all Committee meetings; however, the members recognize that emergencies may arise necessitating the absence of a member. The absent member may:

(1) communicate to the Watershed Coordinator any issue or view that member wishes to convey to the other members. The Watershed Coordinator will present the absent member's position or view but will not argue for it or be an advocate on behalf of that member, or

(2) may designate a proxy as described in III.d.

I. **Work Groups**: Generally, the Committee will operate as a whole. However, some tasks (such as research or drafting) may be better performed by smaller groups. The Committee has discretion to form Work Groups to carry out specific assignments from the Committee. Committee members may serve on Work Groups; in addition, the Committee may invite outside individuals to attend Work Group meetings or conference calls if it feels particular expertise or perspectives not held by Committee members are needed. The Watershed Coordinator will notify each Committee member of all Work Group meetings, and each Committee member is welcome to attend any Work Group meeting. Work Groups are not authorized to make decisions for the Committee as a whole.

IV. DECISION MAKING

1. **Substantive and Major Procedural Matters**: In developing the Watershed Protection Plan and TMDLs, the Committee will operate by consensus to the extent possible, for both substantive matters (*e.g.,* determining interim and long-term corrective actions and developing load allocations) and major procedural matters (*e.g.,* adoption of the ground rules). Generally, "consensus" means that all members

of the Committee agree they can at least abide by the proposed approach, even if a member might prefer another approach.

2. **Minor Procedural Matters**: For minor procedural matters (*e.g.,* meeting times), the Watershed Coordinator may suggest options and the Committee will vote to determine an outcome.

V. PROCEDURES

a. **Open Meetings**: Committee meetings will be open to the public and, if time allows, the Committee may invite members of the public to comment during designated public comment periods. In addition, public workshops may be held in conjunction with scheduled Committee meetings in order to solicit additional public input to Committee deliberations.

b. **Meeting Summaries**: Draft summaries of Committee meetings will be prepared by the Watershed Coordinator and approved by the Committee.

c. **Agendas**: Meeting agendas will be drafted by the Watershed Coordinator and will be based on the Committee's instructions at the previous meeting. The agenda will be reviewed at the beginning of each meeting and may be refined by the Committee.

d. **Background Materials**: The Watershed Coordinator (and, on occasion, other sources) may provide background materials to Committee members in advance of Committee meetings. All requests for and distribution of background materials to all Committee members will occur through the Watershed Coordinator to ensure equal sharing of information. Members may draft position papers or provide other material to be circulated by the Watershed Coordinator. The Watershed Coordinator will use his or her best efforts to distribute any written information any member of the Committee wishes the Committee as a whole to receive.

e. **Thoroughness of Deliberations**: During the course of Committee deliberations, every relevant issue raised will be recorded and addressed. To expedite the process, agreed-upon lower priority issues may be recorded and set aside to be dealt with at a later date. If issues raised are not those identified by the Committee for deliberation, they will be recorded as such.

VI. ROLES AND RESPONSIBILITIES

a. **Watershed Coordinator**: The Watershed Coordinator will lead the meetings and work with all of the members to ensure that the process runs smoothly. The role of the Watershed Coordinator includes developing meeting agendas, focusing discussions, assuring fair opportunity for members to participate in Committee proceedings, working to resolve any impasses that may arise, distributing background materials, working with the Committee members to prepare meeting summaries, assisting in the location and/or preparation of background materials, distributing documents the Committee or a Work Group develops, assisting work groups, conducting public outreach and assuring appropriate public participation, moderating public workshops, providing assistance to Committee members regarding Committee business between meetings and other functions as the Committee requests.

b. **TCEQ and TSSWCB**: The TCEQ and the TSSWCB will prepare final TMDL documents for submittal to USEPA for federal approval. The TCEQ will maintain all records of the Committee proceedings.

c. **Committee Members**: Committee members will be expected to assist the Watershed Coordinator and the TCEQ and TSSWCB to:

- Identify the desired water quality conditions and measurable goals
- Make recommendations regarding water quality monitoring and modeling needed to identify and assess the sources of pollutant loadings in the Arroyo Colorado
- Help determine the pollution reduction targets
- Help develop a Watershed Protection Plan to improve water quality in the Arroyo
- Lead the effort to implement this plan at the local level
- Communicate implications of the Watershed Protection Plan and TMDLs to other interested parties in the watershed.

Committee members are expected to attend all full Committee meetings. In addition, members may be asked to participate in public meetings that may be held to obtain additional public input on a Watershed Protection Plan and TMDL activities. All members agree to act in good faith in all aspects of the Committee's deliberations. Committee members are expected to present their own personal opinions based on their experience, perspective and training and to work constructively and collaboratively with other members toward reaching consensus.

VII. SAFEGUARDS

a. **Right to Withdraw**: Any member may withdraw from the Committee at any time.

b. **Others' Positions**: By participating, members agree that they are entering into a covenant of mutual respect and professional courtesy. When speaking at outside public forums, each member may express his or her point of view about the issues before the Committee; however, members agree not to report, by name, any other member's position or point of view. The members also agree that they will not publicly predict the outcome of the Committee's deliberations. Personal attacks and prejudiced statements will not be tolerated at any time during the process.

c. **Information**:

(1) All members agree to openly exchange relevant information that is readily available to them. If a member believes he or she cannot or should not release relevant information, the member will provide the substance of the information in some form (such as aggregating data, deleting non-relevant confidential information, providing summaries or furnishing information to the facilitator for limited or restricted use or to abstract) or a general description of it and the reason for not providing it directly.

(2) Members will provide information as much in advance of the meeting at which it is to be discussed as is reasonably possible.

(3) Information and data provided to the Committee are a matter of public record.

(4) The Committee does not have authority to protect confidential business information (CBI). When information required for Committee deliberations can only be derived from CBI (*i.e.*, innovative technology, cost or pricing information), the information may only be received by the Committee in aggregate form so as to protect specific CBI from release.

(5) No member is expected to share advance information on its plans or strategy for filing or defending against litigation over a Watershed Protection Plan or other TMDL issues. No member is expected to share any information that is subject to attorney/client privilege.

d. **News Media**: Representatives from the news media may attend Committee meetings and may also ask members to comment or answer questions about the Committee's business. Committee members agree that each member may offer his or her individual perspective; each member agrees not to attribute positions or views to other members by name, nor predict the outcome of the Committee's deliberations. To ensure consistency and accuracy in reporting on general Committee operations, members are encouraged to direct press inquiries concerning overall Committee plans and procedures to TCEQ or the TSSWCB.

VIII. PRODUCTS

a. **Meeting Summaries**: The Watershed Coordinator, in consultation with the Committee, will prepare and distribute draft meeting summaries following each meeting of the Committee. Committee meeting summaries will be reviewed by Committee members and upon approval, they will become work products of the Committee.

b. **Watershed Protection Plan**: The Committee will provide input into a draft and a final Watershed Protection Plan that incorporates, but is not limited to, the development of TMDLs. All Committee members will be asked to sign the final plan.

c. **Final TMDL Documents**: The Committee will provide input into the preparation of a draft and final TMDL report, which include:

(1) problem identification,

(2) endpoint identification,

(3) source analysis,

(4) linkage between sources and receiving water,

(5) margin of safety,

(6) loading allocation, and

(7) supporting (technical) documents.

All Committee members will have the opportunity to review and comment on the draft and final documents. All Committee members will be asked to sign an agreement supporting the final TMDL reports.

IX. MEETING PLANS

a. **Number of Meetings**: There will be a minimum of 10 Committee meetings that are expected to occur in the 18-month period beginning with the first meeting July 30, 2003. The Committee will determine the scheduling of additional meetings. The Committee will also determine the timing and number of work group meetings.

b. **Location of Meetings**: To the extent possible, meetings will take place in central locations in the Arroyo Colorado watershed. However, meeting locations may vary depending on consensus opinions of the Committee and/or Work Groups.

APPENDIX C

Arroyo Colorado Watershed Partnership Steering Committee

Steve Bearden	Rio Grande Valley Sugar Growers
Jude A. Benavides	The University of Texas at Brownsville/Texas Southmost College
Paul Bergh	Coalition to Save the Arroyo Colorado/Lower Laguna Madre Foundation
Mary Lou Campbell	Frontera Audubon/Sierra Club
Richard Eyster	Texas Department of Agriculture
Rocky Freund	Nueces River Authority
Andy Garza	Texas State Soil and Water Conservation Board
Darrell Gunn	Harlingen Water Works System
Wayne Halbert	Harlingen Irrigation District Cameron County #1
Neil Haman	Texas Water Development Board
Joe Hinojosa	LRGV Storm Water Task Force
Alan Johnson	Texas State Bank
Ken Jones	Lower Rio Grande Valley Development Council
Kim Jones	Texas A&M University-Kingsville
***Clare Lee**	U.S. Fish and Wildlife Service
Mark Lingo	Texas Parks and Wildlife Department
Minerva Martinez	Arroyo Colorado Property Owner
Alan Moore	Cameron County Drainage District #5
Butch Palmer, Jr.	Port of Harlingen Authority
Marco Pedraza	City of McAllen
Ray Prewett	Texas Citrus Mutual
***Chris Rakestraw**	Coalition to Save the Arroyo Colorado
Tony Reisinger, Jr.	Texas Sea Grant Extension
Rick Reyes	International Boundary and Water Commission
Amado E. Salinas	Military Highway Water Supply Corporation
Sam Simmons	Cotton Growers Association
John Wallace	U.S. Fish and Wildlife Service, Laguna Atascosa National Wildlife Refuge

** Alternate/Supporting Member*

APPENDIX D

Arroyo Colorado Watershed Partnership Work Group Membership

HABITAT RESTORATION WORK GROUP

JUAN	ANCISO	TEXAS COOPERATIVE EXTENSION
CHRIS	ANZALDUA	U.S. IBWC
STEVE	BENN	LAS PALOMAS WMA
PAUL	BERGH	CSAC LLMF CCA
DONNA	BERRY	RGV CHAPTER TX MASTER NATURALIST
WALTER	BERRY	RGV CHAPTER TX MASTER NATURALIST
RANDY	BLANKINSHIP	TPWD
TOM	BROWN	NAISMITH ENG
HAROLD	BURGESS	CITIZEN
DAVE	BUZAN	TPWD
MARY LOU	CAMPBELL	FRONTERA AUDUBON/SIERRA CLUB
JIM	CHAPMAN	ALTERNATE/SUPPORTING MEMBER
CHRIS	CAUDLE	TCEQ - REGION 15
NI-BIN	CHANG	TAMUK
JIM	CHAPMAN	SIERRA CLUB
D J	DAVIS	TCEQ - REGION 15
LAURA	DE LA GARZA	TEXAS SEA GRANT
JESÚS	FRANCO	TPWD
ROCKY	FREUND	NUECES RIVER AUTHORITY
GINETTE	GARCIA	IMAS
OLIVIA	GOMEZ	TPWD
JOHNATHAN	GONZALES	
LINO	GONZALEZ	
SUE	GRIFFIN	ARROYO COLORADO AUDUBON SOCIETY
MARTIN	HAGNE	
NEIL	HAMAN	TWDB
CHRIS	HATHCOCK	TPWD
TOM	HEGER	TPWD
JAVIER	HINOJOSA	CITIZEN
DON	HOCKADAY	UTPA
JOHN	JACOB	TEXAS SEA GRANT
KAY	JENKINS	TPWD
GARY A.	JONES	U.S. IBWC
KIM	JONES	TAMUK
MIRANDA	KEY	
SELENA	KING	
CHERYL	LABERGE	CITY OF HARLINGEN
EARLENE	LAMBETH	TCEQ
RICK	LEDESNE	
GENE	LESTER	USDA
JOHN	LLOYD-REILLEY	USDA/NRCS

FRANK	MARTINEZ	IBWC
JAMES R.	MATZ	VALLEY PROUD
EDUARDO	MENDEZ	TSSWCB
ROGER	MIRANDA	TCEQ
LORETTA	MOKRY	ALAN PLUMMER & ASSOCIATES, INC
ALAN	MOORE	CAMERON COUNTY DRAINAGE DISTRICT #5
MICHAEL L.	MYERS	NRS
TIM	NOACK	ALAN PLUMMER & ASSOCIATES, INC
BUTCH	PALMER JR	THE PORT OF HARLINGEN AUTHORITY
SAM	PATTEN	
MARCO	PEDRAZA	CITY OF MCALLEN
JENNIFER	PIERCE	CITIZEN
CHRIS	RAKESTRAW	COALITION TO SAVE THE ARROYO COLORADO
RONNIE	RAMIREZ	TSSWCB
JOE	RAMOS	CITY OF RIO HONDO
TONY	REISINGER JR	TEXAS SEA GRANT EXTENSION
ERNESTO	REYES	USFWS
RANDY	RUSH	USEPA - REGION 6
BILLY	SNYDER	ARROYO COLORADO AUDUBON SOCIETY
STEVE	STECKER	CRESPO
SYLVIA	WAGGONER	USIBWC
JOHN	WALLACE	USFWS LAGUNA ATASCOSA NWR
CHRIS	WATENPOOL	TPWD
MIKE	WEEKS	TPWD
STEVE	WHISENANT	TAMU
LISA	WILLIAMS	THE NATURE CONSERVANCY
TOM	WILSON	CITY OF HARLINGEN

WASTEWATER INFRASTRUCTURE WORK GROUP

GILBERT	AGUILAR	CITY OF WESLACO
ASHLEY	ALMON	STUDENT
JUAN	ANCISO	TEXAS COOPERATIVE EXTENSION
JOHN	AVILEZ	CITY OF SAN JUAN
RANDY	BLANKINSHIP	TPWD
MARY LOU	CAMPBELL	SIERRA CLUB
IRENE	CASARES	TCEQ - REGION 15
CHRIS	CAUDLE	TCEQ - REGION 15
NI-BIN	CHANG	TAMUK
DJ	DAVIS	TCEQ - REGION 15
LAURA	DE LA GARZA	TEXAS SEA GRANT
RICHARD	EYSTER	TDA
JUAN	FLORES	CITY OF WESLACO
RENE	FLORES	
CARLOS	GARZA	MELDEN AND HUNT
DAVID	GARZA	CITY OF PHARR
JAIME	GARZA	TCEQ - REGION 15

OLIVIA	GOMEZ	TPWD
DARRELL	GUNN	CITY OF HARLINGEN
NEIL	HAMAN	TWDB
JOE	HINOJOSA	LRGV STORM WATER TASK FORCE
OSCAR J.	HINOJOSA	CITY OF MCALLEN
BING	HUNG	SHRIMP FARMER
JOHN	JACOB	TEXAS SEA GRANT
DARLA	JONES	CITY OF LA FERIA
KIM	JONES	TAMUK
EARLENE	LAMBETH	TCEQ
BRIAN E	MACMANUS	EAST RIO HONDO WATER SUPPLY CORP
ROGER	MIRANDA	TCEQ
JOSE L.	MORENO	CITY OF MCALLEN
RAY	PALOMO	
MARCO	PEDRAZA	CITY OF MCALLEN
SUNNY	PHILIP	CITY OF LA FERIA
CARLOS	RUBINSTEIN	TCEQ - REGION 15
DAVID	SALINAS	OMI
AMADO E	SALINAS	MILITARY HIGHWAY WSC
JUAN M.	SELVERA	CITY OF SAN BENITO
RON	THOMAS	HARLINGEN WATER WORKS SYSTEM
SALOMON	TORRES	U.S. CONGRESSMAN RUBEN HINOJOSA'S OFFICE
LEO	VILLARREAL	CITY OF MERCEDES
MICHEAL	WEEKS	TPWD

AGRICULTURAL ISSUES WORK GROUP

STEVE	BEARDEN	VALLEY SUGAR GROWERS ASSOCIATION
DENISE	BENTSCH	SYNGENTA
NI-BIN	CHANG	No longer with TAMUK
BRAD	COWAN	TEXAS COOPERATIVE EXTENSION
LAURA	DE LA GARZA	TEXAS SEA GRANT
DUSTIN	DICKERSON	FARMER
JUAN	ENCISO	TEXAS COOPERATIVE EXTENSION
RICHARD	EYSTER	TEXAS DEPARTMENT OF AGRICULTURE
ANDY	GARZA	TSSWCB
WAYNE	HALBERT	HARLINGEN IRRIGATION DISTRICT CAMERON COUNTY #1
ARTURO	IDARRA	USDA/NRCS
KAY	JENKINS	TPWD
JOHN L.	JIFON	TAMU
GENE	LESTER	USDA
TERRY	LOCKAMY	TEXAS COOPERATIVE EXTENSION
JAIME	LONGORIA	HIDALGO SWCD
OSVALDO	LONGORIA	USDA/NRCS
EDUARDO	MENDEZ	TSSWCB
RAY	PREWETT	TX CITRUS MUTUAL
RONNIE	RAMIREZ	TSSWCB

WESLEY	ROSENTHAL	TAMU
JESSE R	RUSSELL	FARMER
SAM	SIMMONS	COTTON GROWERS ASSOCIATION
LARRY	SKLOSS	FARMER/HIDALGO SWCD
BARBARA	STORZ	TEXAS COOPERATIVE EXTENSION
CECILIA	WAGNER	TWRI
KEVIN	WAGNER	TWRI
JEFF	WALKER	TWDB
AARON	WENDT	TSSWCB
BOB	WIEDENFELD	TAMU
SHANKAR		TAMUK STUDENT

EDUCATION AND OUTREACH WORK GROUP

PAUL	BERGH	CSAC LLMF
DONNA	BERRY	RGV CHAPTER TX MASTER NATURALIST
HOLLY	BJORUM	IMAS
LAYNE	BUDD	CITIZEN/BOY SCOUTS
DAVE	BUZAN	TPWD
CHRIS	CAUDLE	TCEQ - REGION 15
KAREN	CHAPMAN	ENVIRONMENTAL DEFENSE & RESEARCH FELLOW
LAURA	DE LAGARZA	TEXAS SEA GRANT
SANDRA	DE LEON	CITY OF BROWNSVILLE
KAREN	FORD	WHITE HAT CREATIVE
GINETTE	GARCIA	IMAS
JOE	HINOJOSA	LRGV STORM WATER TASK FORCE
DON	HOCKADAY	UTPA
KEN	JONES	LRGVDC
EARLENE	LAMBETH	TCEQ
SKY	LEWEY	NUECES RIVER AUTHORITY
MARK	LINGO	TPWD
ROGER	MIRANDA	TCEQ
RICHARD	MOORE	CITIZEN
TONY	REISINGER JR	TEXAS SEA GRANT EXTENSION
ROY	RODRIGUEZ	RENSSELAERVILLE INSTITUTE
J.D.	WHITE	CAMERON COUNTY PARKS & RECREATION DEPARTMENT

LAND USE AND DEVELOPMENT WORK GROUP

CHRIS	ANZALDUA	U.S. IBWC
LAURA	DE LA GARZA	TEXAS SEA GRANT
PATRICIA	FOGANTY	CITIZEN
JOHN	JACOB	TEXAS SEA GRANT
DARLA	LAPEYRE	CITY OF SOUTH PADRE ISLAND
FRANK	MARTINEZ	U.S. IBWC
ESTEVAN	PENA	CITY OF MERCEDES
BERNARD	RODRIGUEZ	CITY OF WESLACO

FURTHER STUDY/PHASE II TOTAL MAXIMUM DAILY LOAD WORK GROUP

JUDE A.	BENAVIDES	UTB/TSC
WILLIAM	BERG	UTB
DAVID	BUZAN	TPWD
CHRIS	CAUDLE	TCEQ - REGION 15
HUDSON R	DE YOE	UTPA
ROCKY	FREUND	NUECES RIVER AUTHORITY
ANDY	GARZA	TSSWC
ELIZABETH A.	HEISE	UTB/TSC
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DAVID	HICKS	UTB/TSC
KAY	JENKINS	TPWD
RICHARD	KIESLING	USGS
EARLENE	LAMBETH	TCEQ
CLARE	LEE	USFWS
ROGER	MIRANDA	TCEQ
BRIEN	NICOLAU	TEXAS A&M UNIVERSITY-CORPUS CHRISTI
WARREN	PULICH	TSU
WES	ROSENTHAL	TAES (TAMU-BLACKLANDS RESEARCH CENTER)
VENKATESH	UDDAMERI, PhD	TAMUK
KEVIN	WAGNER	TWRI
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WATER QUALITY MONITORING WORK GROUP

JUDE A.	BENAVIDES	UTB/TSC
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WAYNE	BELZER	IBWC
CHRIS	CAUDLE	TCEQ - REGION 15
HUDSON R	DE YOE	UTPA
ROCKY	FREUND	NUECES RIVER AUTHORITY
ANDY	GARZA	TSSWC
ANNETTE	HERNANDEZ	GRADUATE STUDENT TAMUK
KAY	JENKINS	TPWD
EARLENE	LAMBETH	TCEQ
CLARE	LEE	USFWS
ROGER	MIRANDA	TCEQ
MEGHAN	ROUSELL	USGS
VENKATESH	UDDAMERI, PhD	TAMUK
KEVIN	WAGNER	TWRI

APPENDIX E

Rare Plants and Animals Occurring within the Arroyo Colorado Watershed

Table heading abbreviations: TOES - Texas Organization for Endangered Species; TPWD - Texas Parks and Wildlife Department; and USFWS - United States Fish and Wildlife Service.

Conservation Status Key: E – Endangered; T – Threatened; PE – Proposed Endangered; PT – Proposed Threatened; C1 – Candidate for listing for which substantial supporting information exists; C2 – Candidate for listing for which substantial supporting information does not exist; C3 – Once candidate for listing, but is no longer; WL – Watch List; DL – De-listed; EX – Extirpated; "Blank" – rare, but no regulatory listing status.

Common Name	**Scientific Name**	**Conservation Status**		
Birds		**TOES**	**TPWD**	**USFWS**
Brown Pelican	*Pelecanus occidentalis*	E	E	E
Reddish Egret	*Egretta rufescens*		T	C2
Wood Stork	*Mycteria americana*	T	T	
White-faced Ibis	*Plegadis chihi*	T	T	C2
Muscovy Duck	*Cairina moschata*	WL		
Fulvous Whistling-Duck	*Dendrocygna bicolor*	T		
Harlequin Duck	*Histrionicus histrionicus*			C2
Masked Duck	*Oxyura dominica*	WL		
Golden Eagle	*Aquila chrysaetos*	WL		
White-tailed Hawk	*Buteo albicaudatus*	T	T	
Zone-tailed Hawk	*Buteo albonotatus*		T	
Gray Hawk	*Buteo nitidus*	T	T	C2
Northern Gray Hawk	*Buteo nitidus maximus*	T	T	C2
Common Black-Hawk	*Buteogallus anthracinus*	T	T	
Hook-billed Kite	*Chondrohierax uncinatus*			
American Swallow-tailed Kite	*Elanoides forficatus*	T	T	
Merlin	*Falco columbarius*	T		
Aplomado Falcon	*Falco femoralis*	E	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	E	E	DL
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	T	T	DL
Bald Eagle	*Haliaeetus leucocephalus*	E	E	E/PT
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	E	E	E
Snowy Plover	*Charadrius alexandrinus*			C3
Piping Plover	*Charadrius melodus*	T	T	T
Northern Jacana	*Jacana spinosa*	T		
Eskimo Curlew	*Numenius borealis*	E	E	E
Black Skimmer	*Rynchops niger*	T		
Coastal Least Tern	*Sterna antillarum antillarum*	T		
Interior Least Tern	*Sterna antillarum athalassos*	E	E	E
Sooty Tern	*Sterna fuscata*	WL	T	**Common**

Common Name	Scientific Name	Conservation Status		
Birds (continued)		**TOES**	**TPWD**	**USFWS**
Red-billed Pigeon	*Columba flavirostris*	T		
Cactus Ferruginous Pygmy-Owl	*Glaucidium brasillianum cactorum*	WL	T	PT
Western Burrowing Owl	*Speotyto cunicularia hypugea*			C2
Ringed Kingfisher	*Ceryle torguata*	WL		
Botteri's Sparrow	*Aimophila botterii*	T	T	C2
Texas (=Sennett's) Olive Sparrow	*Arremonops rufivirgatus*			C2
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	WL	T	
Brown Jay	*Cyanocorax morio*	WL		
Brownsville Common Yellowthroat	*Geothlypis trichas insperata*			C2
Sennett's Hooded Oriole	*Icterus cucullatus sennettii*			C2
Audubon's Oriole	*Icterus graduacauda audubonii*			C2
Altamira Oriole	*Icterus gularis*	WL		
Migrant Loggerhead Shrike	*Lanius ludovicianus migrans*			C2
Rose-throated Becard	*Pachyramphus aglaiae*	WL	T	
Tropical Parula	*Parula pitiayumi*	T	T	C2
Mammals				
Mexican Long-tongued Bat	*Choeronycteris mexicana*			C2
Gulf Coast Hog-nosed Skunk	*Conepatus leuconotus texensis*			C1
Mountain Lion	*Felis concolor*	WL		
Texas Margay	*Felis wiedii cooperi*		E	
Southern Yellow Bat	*Lasiurus ega*	WL	T	
Ocelot	*Leopardus pardalis*	E	E	E
Jaguarundi	*Leopardus yaguarondi*	E	E	E
Cave Myotis	*Myotis velifer*			C2
White-nosed Coati	*Nasua narica*	WL	E	
Coue's Rice Rat	*Oryzomys couesi*	T	T	C2
Jaguar	*Panthera onca*	E	E	E
West Indian Manatee	*Trichechus manatus*	E	E	E
Bottle-nosed Dolphin	*Tursips truncates*	T		
Molluscs				
Texas Hornshell	*Popenaias popeii*			C1
Insects				
Smyth's Tiger Beetle	*Cicindela chlorocephala smythi*			
Sub-tropical Blue-black Tiger Beetle	*Cicindela nigrocoerulea subtropica*			
Maculated Manfreda Skipper	*Stallingsia maculosus*			
Fishes				
River Goby	*Awaous banana*		T	
Fat Snook	*Centropomus parallelus*	WL		
Rio Grande Darter	*Etheostoma grahami*			
Rio Grande Darter	*Etheostoma radiosum*	T	T	C2

Common Name	Scientific Name	Conservation Status		
Fishes (continued)		**TOES**	**TPWD**	**USFWS**
Rio Grande Chub	*Gila pandora*			
Blackfin Goby	*Gobionellus atripinnis*	E	T	
Rio Grande Silvery Minnow	*Hybognathus amarus*	EX	E	PE
Headwater Catfish	*Ictalurus lupus*	WL		C2
Chihuahua Catfish	*Ictalurus sp.*			C2
Opposum Pipefish	*Microphis brachyurus*	T	T	
Rio Grande Shiner	*Notropis jemezanus*	T		C2
Phantom Shiner	*Notropis orca*	X	E	
Bluntnose Shiner	*Notropis simus*		T	
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	T	E	
Texas Pipefish	*Syngnathus affinis*	WL		
Turtles				
Loggerhead	*Caretta caretta*	T	E	T
Atlantic Green Turtle	*Chelonia mydas*	T	T	T
Leatherback	*Dermochelys coriacea*	E	E	E
Atlantic Hawksbill	*Eretmochelys imbricata*	E	E	E
Texas Tortoise	*Gopherus berlandieri*	T	T	
Atlantic Ridley	*Lepidochelys kempi*	E	E	E
Lizards				
Reticulated Collared Lizard	*Crotaphytus reticulatus*	T	T	C2
Keeled Earless Lizard	*Holbrookia propinqua*			
Texas Horned Lizard	*Phrynosoma cornutum*	T	T	C2
Snakes				
Scarlet Snake	*Cemophora coccinea*	WL	T	
Black-striped Snake	*Coniophanes imperialis*	WL	T	
Indigo Snake	*Drymarchon corais*		T	
Speckled Racer	*Drymobius margaritiferus*	WL	T	
Northern Cat-eyed Snake	*Leptodeira septentrionalis*	T	T	
Salamanders				
Black Spotted Newt	*Notophalmus meridionalis*	E	T	C2
Rio Grande Lesser Siren	*Siren intermedia texana*	E	T	C2
Frogs and Toads				
Giant Toad	*Bufo marinus*	WL		
Sheep Frog	*Hypopachus variolosus*	T	T	
White-lipped Frog	*Leptodactylus labialis*	E	T	
Mexican Burrowing Toad	*Rhinophrynus dorsalis*	T	T	
Mexican Treefrog	*Smilisca baudinii*	T	T	
Rio Grande Chirping Frog	*Syrrhophus guttilatus*	WL		
Plants				
Vasey's Adelia	*Adelia vaseyi*			
South Texas Ambrosia	*Ambrosia cheiranthifolia*	WL	E	E
Yellowshow	*Amoreuxia wrightii*	WL		
Prostrate Milkweed	*Asclepias prostrata*		T	
Star Cactus	*Astrophytum asterias*		E	E
Kleyber's Saltbrush	*Atriplex klebergorum*	WL		

Common Name	Scientific Name	Conservation Status		
Plants (continued)		**TOES**	**TPWD**	**USFWS**
Texas Ayenia	*Ayenia limitaris*		E	E
Chihuahua Balloon-vine	*Cardiospermum dissectum*	WL		
Texas Windmillgrass	*Chloris texensis*	WL		
Mission Fiddlewood	*Citharexylum spathulatum*	WL		
Runyon's Corycactus	*Coryphantha macromeris var. runyonii*		T	
Lila De Los Llanos	*Echeandia chandleri*	WL		
Small Yellow Alicoche	*Echinocereus berlandieri var. angusticeps*		T	
Gregg's Wild-buckwheat	*Eriogonum greggii*	WL		
Jopoy	*Esenbeckia runyonii*	WL		
Johnston's Frankenia	*Frankenia johnstonii*			E
Plains Gumweed	*Grindelia oolepis*	WL		
Runyon's Waterwillow	*Justicia runyonii*	WL		
Zapata Bladderpod	*Lesquerella thamnophila*		T	
Runyon's Huaco	*Manfreda longiflora*		T	
Walker's Manioc	*Manihot walkerae*		E	E
Falfurrias Milkvine	*Matelea radiara*		E	
Few-spine Prickly-pear	*Opuntia engelmannii*		T	
Texas Palmetto	*Sabal mexicana*		T	
Montezuma Baldcypress	*Taxodium mucronatum*		E	
Straw-spine Glory of Texas	*Thelocactus bicolor var. flavidispinus*		T	
Ashy Dogweed	*Thymoophylla tephroleuca*			E
Bailey's Ballmoss	*Tillandsia baileyi*	WL		

Source: Compiled by Chris Hathcock, January 2006

APPENDIX F

Locally Active Non-governmental Organizations (NGOs) Supporting Natural Resource Conservation and Environmental Education

Ducks Unlimited (DU) conserves, restores and manages wetlands and associated habitats for North American's waterfowl. DU is the world's largest private, non-profit waterfowl and wetland conservation organization. By any measure, DU is one of the largest conservation/environmental groups in the world, with more than one million supporters in the U.S., Canada and Mexico. Since its inception in 1937, DU has conserved more than 9.4 million acres of waterfowl habitat throughout North America. DU supporters have raised nearly $1.6 billion for conservation since 1937. No other conservation or environmental group can match DU's accomplishments on behalf of waterfowl, wetlands and related habitats.

The Friends of the Wildlife Corridor is a non-profit organization established to protect, support and enhance the Santa Ana and Lower Rio Grande Valley National Wildlife Refuges. The Friends regularly conduct canoe trips on the Rio Grande, providing tours of natural areas for educational purposes. All profits are directed to helping the refuges protect fish and wildlife for the benefit of all citizens.

The Frontera Audubon Society is a long-standing conservation organization dedicated to preserving native habitat along the Lower Rio Grande. Frontera owns and or manages a 20 + acre urban natural area in downtown Weslaco. The property includes historic and natural features and will be Frontera's headquarters known as the Audubon Center. Other projects include the Valley's Rare Bird Alert run by Fr. Tom Pincelli; 5th grade mini curriculum and "Welcome to the Wildlife Corridor," an Alta Mira newsletter and ongoing work with the leaders & national lobbyist to protect habitat throughout the four counties of the Lower Rio Grande Valley.

The mission of **The Nature Conservancy** is to preserve the plants, animals and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive. The Conservancy is working on both sides of the border to protect thousands of acres of ecologically valuable wetlands throughout the region. One of their long-term objectives is to design bi-national conservation strategies, including developing private land conservation techniques in cooperation with local landowners and identifying long-term sources of local revenue to help protect the surrounding native grasslands and brushlands. By working with landowners farther inland, in a region known as the Tamaulipan thornscrub, the Conservancy is helping protect the lands and waters surrounding the Laguna Madre.

The Lone Star Chapter of the Sierra Club is committed to achieving environmental justice for all Texans and is dedicated to promoting environmental education in our schools, homes and communities for people at all age levels but especially for the youth of our state. One of their priorities is the establishment of a sufficient level of public funds at the state and federal levels for the next ten years to enhance, manage and conserve the natural and cultural resources of Texas (through parkland acquisition, wildlife habitat protection, purchase of development rights, conservation easements and other mechanisms) for the use and enjoyment of present and future generations.

Valley Proud Environmental Council works to preserve the natural beauty and environment of the Lower Rio Grande Valley of Texas and Mexico by forging partnerships between grassroots organizations and the public and private sectors to improve the quality of life, to enhance economic development and tourism and to conserve public and natural resources through education and public awareness activities.

The Valley Sportsmen Club is a non-profit organization dedicated in 1948 to the conservation of wildlife. Its mission is to promote and foster a general and continued movement for the conservation, utilization, restoration, protection and scientific supervision in the State of Texas of all game, fish, fowl and other wildlife in its natural habitat. The VSC conducts an annual Arroyo Colorado trash clean-up.

The World Birding Center is a partnership with Texas Parks and Wildlife Department, U.S. Fish and Wildlife and the communities of Roma, Mission, McAllen, Hidalgo, Edinburg, Weslaco, Harlingen, Brownsville and South Padre Island. It consists of a network of nine sites dotted along 120 miles of river road from South Padre Island to Roma, with habitats ranging from dry chaparral brush and verdant riverside thickets to freshwater marshes and coastal wetlands. The mission of the WBC is to protect native habitat while increasing the understanding and appreciation of the birds and wildlife. This project is a global model for conservation and ecotourism development. The goal is to grow tourism and grow the number of acres protected in the Rio Grande Valley.

The Lower Laguna Madre Foundation (LLMF) is a non-profit corporation whose purpose is to preserve and protect the natural resources of the South Texas intercoastal bay system for the present day and posterity. LLMF encourages balanced economic use and conservation of the Lower Laguna Madre, informs and educates the public about the life of the bay, serves as an advocate and vigilantly monitors its use. LLMF will sponsor activities and events contributing to the welfare of the bay system and will promote increased public respect for its natural wealth and its great aesthetic, recreational and economic importance.

The Native Plant Project's primary objective is the compilation and dissemination of information about plants native to the Lower Rio Grande Valley. The NPP seeks to increase scientific knowledge of native plant propagation and penology for both horticultural and natural revegetation purposes. The NPP promotes the conservation of local native plants, habitats, plant communities, wildlife and environment. The NPP seeks to increase the public's knowledge and awareness of the importance of native plants in the Lower Rio Grande Valley by encouraging their use in public and private landscaping.

The mission of **The Valley Land Fund** is to preserve, enhance and expand the native wildlife habitat of the Rio Grande Valley through education, land ownership and the creation of economic incentives for preservation. The Valley Land Fund assists with conservation of native habitat through the protection of land in the southernmost counties of deep South Texas — the Lower Rio Grande Valley.

The Coalition to Save the Arroyo Colorado (CSAC) was formed in 1993 as a non-profit organization specifically to oppose the provisions of the shrimp farms wastewater discharge applications and later expanded its scope to include all water quality issues in the Arroyo Colorado. The board members of the CSAC are on the ACW Partnership Steering Committee and have been actively supporting the effort to produce a watershed protection plan.

Earth Care Organization (ECO) is a grassroots community organization founded in 1970 to make every day an Earth Day through education, civic engagement and environmental service to the community. The ECO-ED Center promotes sustainable development and a healthy environment through educational workshops, seminars, kids care conferences and newsletters. EARTH CARE KIDS is sponsored for kids of all ages, "kids at heart" or those who just care enough about kids to help them secure a clean, safe and just environment for their future.

Gorgas Science Foundation, (GSF) is a non-for-profit organization committed to education and conservation. It is GSF's firm belief that the key to effective conservation lies in the education of the general public and more importantly in the education of the young.

The mission of the McAllen **International Museum of Art and Science** (IMAS) is to promote a deeper appreciation of the arts and sciences through exhibitions, cultural events and educational programs and to preserve, expand and display its permanent art and science collection. The **Smart About Water** project aims to promote water conservation and environmental education in the Rio Grande Valley.

The Texas Master Naturalist Program is a non-profit organization sponsored by the Texas Parks and Wildlife Department and Texas Cooperative Extension and is governed by a statewide steering committee. The **Rio Grande Valley Chapter of the Texas Master Naturalist** (RGVCTMN) is organized exclusively for charitable, scientific and educational purposes, more specifically to develop a group of knowledgeable volunteers to provide education, outreach and service dedicated to the study and conservation of natural resources and natural areas within the Lower Rio Grande Valley of Texas.

The Valley Nature Center (VNC) has been in operation as a non-profit organization dedicated to environmental education since 1985. Environmental group members of the Valley Nature Center share meeting facilities with the ACW Partnership for VNC monthly meetings and programs. The VNC offers organizations a place to meet and also conducts seminars, has nature trails and provides other programs.

The mission of the **Arroyo Colorado Audubon Society of South Texas** is to promote an understanding of the unique and important natural habitats of the Lower Rio Grande Valley, the birds and other wildlife they support and their benefits to humans.

APPENDIX G
List of Federal and State Legislation and Programs Related to the Arroyo Colorado Watershed Protection Plan

Federal Legislation

National laws form the basis for the federal regulations governing the use of natural resources. Listed below are a selected set of important national laws with implications for natural resource management in the Arroyo Colorado watershed.

Clean Water Act (CWA)

The Federal Water Pollution Control Act Amendments (1972) (as amended, the Clean Water Act) stipulate broad national objectives to restore and maintain the chemical, physical and biological integrity of the Nation's waters. In addition, the amendments significantly expand provisions related to pollutant discharges. These include requirements that limitations be determined for point sources that are consistent with state water quality standards, procedures for state issuance of water quality standards, development of guidelines to identify and evaluate the extent of non-point source pollution, water quality inventory requirements, as well as development of toxic and pretreatment effluent standards.

Section 303(d) of the CWA requires all states to identify waters that do not meet, or are not expected to meet, applicable water quality standards. For each listed water body that does not meet a standard, states must develop a TMDL for each pollutant that has been identified as contributing to the non-attainment of water quality standards in that water-body. The TCEQ is the agency of the State of Texas responsible for ensuring that all waters of the state are in compliance with applicable Surface Water Quality Standards and that TMDLs are implemented to address pollutants responsible for non-attainment of surface water quality standards in a water body of the state.

Section 402 of the 1972 amendments established the National Pollutant Discharge Elimination System (NPDES) to authorize USEPA issuance of discharge permits program to control water pollution by regulating discharge of pollutants into waters of the United States. Industrial, municipal and other facilities must obtain NPDES permits if their discharges go directly to surface waters. In Texas, the permit program is administered by the Texas Commission on Environmental Quality. Since its introduction in 1972, the NPDES permit program is responsible for significant improvements to water quality.

Section 404 of the CWA regulates the discharge of materials into "waters of the U.S.," which have historically been interpreted to include wetlands. Filling of any waters of the U.S. requires a permit and mitigation to replace the function and value of the affected waters. Section 404 authorizes the U.S. Army Corps of Engineers to issue permits for the discharge of dredged or fill material into navigable waters at specified disposal sites. Applicants for federal permits or licenses for activities involving discharges into navigable waters are required to provide a state certification that the proposed activity will not violate applicable water quality standards. In Texas, the Texas Commission on Environmental Quality administers the 401 water certification program for most permit actions. The Texas Railroad Commission administers the program for discharges related to oil and gas exploration and development activities. The Environmental Protection Agency is given oversight authority that includes the ability to prohibit the use of a site as a disposal site based on a determination that discharges would have an unacceptable adverse effect on municipal water supplies, shellfish beds and fishery areas, wildlife or recreational uses.

Endangered Species Act

The Endangered Species Act provides for the conservation of ecosystems upon which threatened and endangered species of fish, wildlife and plants depend. The U.S. Fish and Wildlife Service is charged with administering the Act for non-marine species. The National Marine Fisheries Service administers the act for marine species. The Act authorizes the determination and listing of species as endangered and threatened; prohibits unauthorized taking, possession, sale and transport of endangered species; provides authority to acquire land for the conservation of listed species; and authorizes establishment of cooperative agreements and grants-in-aid to states that establish and maintain active and adequate programs for endangered and threatened wildlife and plants. Section 7 of the Endangered Species Act requires federal agencies to insure that any action authorized, funded or carried out by them is not likely to jeopardize the continued existence of listed species or modify their critical habitat.

Fish and Wildlife Coordination Act

The amendments of the Fish and Wildlife Coordination Act, enacted in 1946, require consultation with the U.S. Fish and Wildlife Service and the fish and wildlife agencies of States where the “waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted . . . or otherwise controlled or modified” by any agency under a Federal permit or license. Consultation is to be undertaken for the purpose of “preventing loss of and damage to wildlife resources.”

Magnuson-Stevens Act

The Magnuson-Stevens Act gives NOAA Fisheries the authority to regulate nearshore waters and substrate necessary for fish spawning, feeding and growth, or Essential Fish Habitat (EFH). Although regulatory authority is limited, EFH must be considered in activities within nearshore waters, especially with respect to federal projects.

National Environmental Policy Act (NEPA)

The National Environmental Policy Act ensures that all branches of government give proper consideration to the environment prior to undertaking any major federal action that significantly affects the environment. NEPA requirements are invoked when airports, seaports, highways, parkland purchases and other federal activities are proposed. Environmental Assessments and Environmental Impact Statements, which are assessments of potential impacts from alternative courses of action, are required from significant federally funded projects.

Rivers and Harbors Act

Section 10 of the Rivers and Harbors Act regulates placement of any wharfs, piers, jetties and other structures, as well as excavating or filling within navigable waters, under supervision of the Army Corp of Engineers.

National Flood Insurance Act

The National Flood Insurance Program (NFIP) is a federal program, established by the National Flood Insurance Act of 1968, enabling property owners in participating communities to purchase insurance protection against losses from flooding. This insurance is designed to provide an insurance alternative to disaster assistance to meet the escalating costs of repairing damage to buildings and their contents caused by floods.

Texas State Legislation

Much of Texas' state regulation consists of rules promulgated to implement or augment federal legislation. However, the few unique pieces of legislation with direct implications for the Arroyo Colorado watershed are described below.

Texas Water Code

The Texas Water Code (TWC) was enacted by the Texas Legislature in 1971 and amended in 1987. The law codified the general and permanent statutes relating to water rights, water development, water quality control, river compacts and general law districts. Chapter 26 of Subtitle D of the TWC deals specifically with water quality control. Chapter 26 of the TWC is the legislation that forms the basis for The Texas Surface Water Quality Standards (30 TAC §§307.1-307.10), which set the criteria for evaluating water quality in Texas.

Texas Estuaries Act

In 1999, the Texas Legislature passed the Texas Estuaries Act (HB 2561), making Texas Estuary Programs official programs of the State of Texas. The Texas Estuaries Act recognized the significance of Texas' estuaries, appointed the Texas Commission on Environmental Quality as the lead state agency for estuary programs, instructed other relevant state agencies to participate in the development and implementation of comprehensive conservation management plans for its estuaries and established the authority of estuary programs to grant and receive state and federal aid in estuary management activities. Currently, the Arroyo Colorado estuary is not part of this official program.

Senate Bill 1

Senate Bill 1, passed in 1997, created a comprehensive state water plan comprised of 16 regional water plans under the guidance of the Texas Water Development Board. The state plan will be updated every five years and will serve as a guide for water resource and management policy. The plan will address drought planning, state water project financing, groundwater and surface water management, water use and conservation, and funding mechanisms. The Lower Rio Grande Valley and the Arroyo Colorado is within the Rio Grande Regional Planning Group (Region M). The Region M plan lists the Arroyo Colorado as representing a second potential water supply for the Lower Rio Grande Valley while recognizing the limitations of its use due to poor quality conditions. The plan states that "regional watershed planning should be encouraged on both sides of the Rio Grande throughout the basin."

Senate Bill 2

Senate Bill 2, passed in 2001, established the Texas Water Policy Council to address Texas water policy issues, to advocate implementation of features within the State Water Plan, and to consider in-stream flows and estuary inflow needs. Senate Bill 2 also provides for conjunctive management of surface water and groundwater management, and it ratified groundwater conservation districts created in previous legislation.

APPENDIX H

List of Federal and State Threatened and Endangered Species Occurring within the Arroyo Colorado Watershed

Compiled by Chris Hathcock, January 2006

Table heading abbreviations: TOES - Texas Organization for Endangered Species; TPWD - Texas Parks and Wildlife Department; and USFWS - United States Fish and Wildlife Service.

Conservation Status Key: E – Endangered; T – Threatened; PE – Proposed Endangered; PT – Proposed Threatened; C1 – Candidate for listing for which substantial supporting information exists; C2 – Candidate for listing for which substantial supporting information does not exist; C3 – Once candidate for listing, but is no longer; WL – Watch List; DL – De-listed; EX – Extirpated; "Blank" – rare, but no regulatory listing status.

Common Name	Scientific Name	Conservation Status		
Birds		**TOES**	**TPWD**	**USFWS**
Brown Pelican	*Pelecanus occidentalis*	E	E	E
Reddish Egret	*Egretta rufescens*		T	C2
Wood Stork	*Mycteria americana*	T	T	
White-faced Ibis	*Plegadis chihi*	T	T	C2
Muscovy Duck	*Cairina moschata*	WL		
Fulvous Whistling-Duck	*Dendrocygna bicolor*	T		
Harlequin Duck	*Histrionicus histrionicus*			C2
Masked Duck	*Oxyura dominica*	WL		
Golden Eagle	*Aquila chrysaetos*	WL		
White-tailed Hawk	*Buteo albicaudatus*	T	T	
Zone-tailed Hawk	*Buteo albonotatus*		T	
Gray Hawk	*Buteo nitidus*	T	T	C2
Northern Gray Hawk	*Buteo nitidus maximus*	T	T	C2
Common Black-Hawk	*Buteogallus anthracinus*	T	T	
Hook-billed Kite	*Chondrohierax uncinatus*			
American Swallow-tailed Kite	*Elanoides forficatus*	T	T	
Merlin	*Falco columbarius*	T		
Aplomado Falcon	*Falco femoralis*	E	E	E
American Peregrine Falcon	*Falco peregrinus anatum*	E	E	DL
Arctic Peregrine Falcon	*Falco peregrinus tundrius*	T	T	DL
Bald Eagle	*Haliaeetus leucocephalus*	E	E	E/PT
Attwater's Greater Prairie-Chicken	*Tympanuchus cupido attwateri*	E	E	E
Snowy Plover	*Charadrius alexandrinus*			C3
Piping Plover	*Charadrius melodus*	T	T	T
Northern Jacana	*Jacana spinosa*	T		
Eskimo Curlew	*Numenius borealis*	E	E	E
Black Skimmer	*Rynchops niger*	T		
Coastal Least Tern	*Sterna antillarum antillarum*	T		
Interior Least Tern	*Sterna antillarum athalassos*	E	E	E

Common Name	Scientific Name	Conservation Status		
Birds		**TOES**	**TPWD**	**USFWS**
Sooty Tern	*Sterna fuscata*	WL	T	
Red-billed Pigeon	*Columba flavirostris*	T		
Cactus Ferruginous Pygmy-Owl	*Glaucidium brasillianum cactorum*	WL	T	PT
Western Burrowing Owl	*Speotyto cunicularia hypugea*			C2
Ringed Kingfisher	*Ceryle torguata*	WL		
Botteri's Sparrow	*Aimophila botterii*	T	T	C2
Texas (=Sennett's) Olive Sparrow	*Arremonops rufivirgatus*			C2
Northern Beardless-Tyrannulet	*Camptostoma imberbe*	WL	T	
Brown Jay	*Cyanocorax morio*	WL		
Brownsville Common Yellowthroat	*Geothlypis trichas insperata*			C2
Sennett's Hooded Oriole	*Icterus cucullatus sennettii*			C2
Audubon's Oriole	*Icterus graduacauda audubonii*			C2
Altamira Oriole	*Icterus gularis*	WL		
Migrant Loggerhead Shrike	*Lanius ludovicianus migrans*			C2
Rose-throated Becard	*Pachyramphus aglaiae*	WL	T	
Tropical Parula	*Parula pitiayumi*	T	T	C2
Mammals				
Mexican Long-tongued Bat	*Choeronycteris mexicana*			C2
Gulf Coast Hog-nosed Skunk	*Conepatus leuconotus texensis*			C1
Mountain Lion	*Felis concolor*	WL		
Texas Margay	*Felis wiedii cooperi*		E	
Southern Yellow Bat	*Lasiurus ega*	WL	T	
Ocelot	*Leopardus pardalis*	E	E	E
Jaguarundi	*Leopardus yaguarondi*	E	E	E
Cave Myotis	*Myotis velifer*			C2
White-nosed Coati	*Nasua narica*	WL	E	
Coue's Rice Rat	*Oryzomys couesi*	T	T	C2
Jaguar	*Panthera onca*	E	E	E
West Indian Manatee	*Trichechus manatus*	E	E	E
Bottle-nosed Dolphin	*Tursips truncates*	T		
Molluscs				
Texas Hornshell	*Popenaias popeii*			C1
Insects				
Smyth's Tiger Beetle	*Cicindela chlorocephala smythi*			
Sub-tropical Blue-black Tiger Beetle	*Cicindela nigrocoerulea subtropica*			
Maculated Manfreda Skipper	*Stallingsia maculosus*			
River Goby	*Awaous banana*		T	
Fat Snook	*Centropomus parallelus*	WL		
Rio Grande Darter	*Etheostoma grahami*			
Rio Grande Darter	*Etheostoma radiosum*	T	T	C2
Rio Grande Chub	*Gila pandora*			

Common Name	Scientific Name	Conservation Status		
Fishes		**TOES**	**TPWD**	**USFWS**
Blackfin Goby	*Gobionellus atripinnis*	E	T	
Rio Grande Silvery Minnow	*Hybognathus amarus*	EX	E	PE
Headwater Catfish	*Ictalurus lupus*	WL		C2
Chihuahua Catfish	*Ictalurus sp.*			C2
Opposum Pipefish	*Microphis brachyurus*	T	T	
Rio Grande Shiner	*Notropis jemezanus*	T		C2
Phantom Shiner	*Notropis orca*	X	E	
Bluntnose Shiner	*Notropis simus*		T	
Shovelnose Sturgeon	*Scaphirhynchus platorynchus*	T	E	
Texas Pipefish	*Syngnathus affinis*	WL		
Turtles				
Loggerhead	*Caretta caretta*	T	E	T
Atlantic Green Turtle	*Chelonia mydas*	T	T	T
Leatherback	*Dermochelys coriacea*	E	E	E
Atlantic Hawksbill	*Eretmochelys imbricata*	E	E	E
Texas Tortoise	*Gopherus berlandieri*	T	T	
Atlantic Ridley	*Lepidochelys kempi*	E	E	E
Lizards				
Reticulated Collared Lizard	*Crotaphytus reticulatus*	T	T	C2
Keeled Earless Lizard	*Holbrookia propinqua*			
Texas Horned Lizard	*Phrynosoma cornutum*	T	T	C2
Snakes				
Scarlet Snake	*Cemophora coccinea*	WL	T	
Black-striped Snake	*Coniophanes imperialis*	WL	T	
Indigo Snake	*Drymarchon corais*		T	
Speckled Racer	*Drymobius margaritiferus*	WL	T	
Northern Cat-eyed Snake	*Leptodeira septentrionalis*	T	T	
Salamanders				
Black Spotted Newt	*Notophalmus meridionalis*	E	T	C2
Rio Grande Lesser Siren	*Siren intermedia texana*	E	T	C2
Frogs and Toads				
Giant Toad	*Bufo marinus*	WL		
Sheep Frog	*Hypopachus variolosus*	T	T	
White-lipped Frog	*Leptodactylus labialis*	E	T	
Mexican Burrowing Toad	*Rhinophrynus dorsalis*	T	T	
Mexican Treefrog	*Smilisca baudinii*	T	T	
Rio Grande Chirping Frog	*Syrrhophus guttilatus*	WL		
Vasey's Adelia	*Adelia vaseyi*			
South Texas Ambrosia	*Ambrosia cheiranthifolia*	WL	E	E
Yellowshow	*Amoreuxia wrightii*	WL		
Prostrate Milkweed	*Asclepias prostrata*		T	
Star Cactus	*Astrophytum asterias*		E	E
Kleyber's Saltbrush	*Atriplex klebergorum*	WL		
Texas Ayenia	*Ayenia limitaris*		E	E

Common Name	Scientific Name	Conservation Status		
Plants		**TOES**	**TPWD**	**USFWS**
Chihuahua Balloon-vine	*Cardiospermum dissectum*	WL		
Texas Windmillgrass	*Chloris texensis*	WL		
Mission Fiddlewood	*Citharexylum spathulatum*	WL		
Runyon's Corycactus	*Coryphantha macromeris var. runyonii*		T	
Lila De Los Llanos	*Echeandia chandleri*	WL		
Small Yellow Alicoche	*Echinocereus berlandieri var. angusticeps*		T	
Gregg's Wild-buckwheat	*Eriogonum greggii*	WL		
Jopoy	*Esenbeckia runyonii*	WL		
Johnston's Frankenia	*Frankenia johnstonii*			E
Plains Gumweed	*Grindelia oolepis*	WL		
Runyon's Waterwillow	*Justicia runyonii*	WL		
Zapata Bladderpod	*Lesquerella thamnophila*		T	
Runyon's Huaco	*Manfreda longiflora*		T	
Walker's Manioc	*Manihot walkerae*		E	E
Falfurrias Milkvine	*Matelea radiara*		E	
Few-spine Prickly-pear	*Opuntia engelmannii*		T	
Texas Palmetto	*Sabal mexicana*		T	
Montezuma Baldcypress	*Taxodium mucronatum*		E	
Straw-spine Glory of Texas	*Thelocactus bicolor var. flavidispinus*		T	
Ashy Dogweed	*Thymoophylla tephroleuca*			E
Bailey's Ballmoss	*Tillandsia baileyi*	WL		

APPENDIX I

Selected Marsh Plants (freshwater and salt water) Indigenous to Hidalgo and/or Cameron Counties Suitable for Wetland Creation and Restoration Projects

Selected Freshwater (salinity <0.5 ppt) Marsh Plants (Categorized by Maximum Water-Depth Tolerances)

Transitional – seasonally flooded

GRASSES

Andropogon glomeratus (bushy bluestem)
Distichlis spicata (coastal saltgrass)
Echinochloa crus-pavonis (Gulf cockspur)
Echinochloa muricata
Echinochloa polystachya
Eragrostis reptans (creeping lovegrass)
Eriochloa punctata (Louisiana cupgrass)
Leersia hexandra (clubhead cutgrass)
Leptochloa fascicularis (bearded sprangletop)
Leptochloa nealleyi (Neally sprangletop)
Leptochloa panicoides (Amazon sprangletop)
Leptochloa uninervia (Mexican sprangletop)
Panicum hians (gaping panicum)
Panicum hirsutum (hairy panicum)
Panicum virgatum (switchgrass)
Paspalum hartwegianum (Hartweg paspalum)
Paspalum lividum (longtom)
Paspalum pubiflorum (hairyseed paspalum)
Paspalum virgatum (talquezal)
Phalaris caroliniana (Carolina canarygrass)
Setaria parvifolia (knotroot bristlegrass)
Sporobolus buckleyi (Buckley dropseed)

FORBS

Amaranthus australis (southern water hemp)
Amaranthus rudis (Nuttall's water hemp)
Bidens laevis (beggarticks)
Bidens odorata (beggarticks)
Callitriche nuttallii (water starwort)
Callitriche terrestris (water starwort)
Echinodorus berteroi (= E. rostratus; burhead)
Echinodorus cordifolius (burhead)
Eustoma evaltatum (bluebell gentian)
Hydrocotyle bonariensis (water pennywort; sombrerillo)
Justicia runyonii (Runyon's waterwillow)
Polygonum lapathifolium (pale smartweed)
Rumex chrysocarpus (= R. berlandieri; dock)
Rumex crispus (curly-leaf dock)
Rumex pulcher (dock)

SHRUBS

Cephalanthus salicifolius (Mexican buttonbush)
Hydrolea spinosa (spiny hydrolea)

Shallow – seasonally flooded to permanently flooded to 15 cm

Bacopa monnieri (water hyssop)
Bacopa rotundifolia (disc water hyssop)
Carex brittoniana (sedge)
Callitriche nuttallii (water starwort)
Callitriche terrestris (water starwort)
Cyperus articulatus (joint-stem umbrella sedge)
Cyperus digitatus (finger umbrellasedge)
Cyperus elegans (umbrellasedge)
Cyperus macrocephalus (largehead umbrellasedge)
Cyperus ochraceus (umbrellasedge)
Cyperus odoratus (umbrellasedge)
Cyperus oxylepis (umbrellasedge)
Cyperus virens (umbrellasedge)
Eleocharis minima (spikerush)
Eleocharis parvula (spikerush)
Eurystemon mexicanum
Heteranthera dubia (mud plantain)
Heteranthera Liebmannii (water stargrass)
Heteranthera limosa (mud plantain)
Heteranthera reniformis (mud plantain)
Ludwigia octovalvis (water primrose)
Ludwigia peploides (water primrose)
Ludwigia repens (water primrose)
Marsilea macropoda (water clover)
Marsilea vestita (water clover)
Pluchea purpurascens (salt marsh fleabane)
Polygonum densiflorum (stout smartweed)
Polygonum pennsylvanicum (pink smartweed)
Polygonum persicaria (smartweed)
Polygonum punctatum (smartweed)
Polygonum setaceum (smartweed)
Schoenoplectus saximontanus (= Scirpus supinus; bulrush)

Mid-Depths – 15 to 50 cm water depths

Eleocharis acicularis (spikerush)
Eleocharis albida (spikerush)
Eleocharis austrotexana (spikerush)
Eleocharis cellulose (spikerush)
Eleocharis interstincta (spikerush)
Eleocharis montevidensis (spikerush)
Eleocharis palustris (syn. E. macrostachya; large spikerush)
Phragmites australis (common reed)
Sagittaria longiloba (flecha de agua)
Schoenoplectus americanus (=Scirpus olneyi; Olney bulrush)
Schoenoplectus californicus (=Scirpus californicus; giant bulrush, tule)
Schoenoplectus pungens (=Scirpus americanus; cronquist, American bulrush)
Schoenoplectus tabernaemontani (=Scirpus validis; soft-stem bulrush)
Typha domingensis (narrow-leaf cattail)

Deep – 50 to 100 cm water depths

ROOTED FLOATING

Eichornia crassipes (water hyacinth)
Nelumbo lutea (yellow lotus)
Nymphaea elegans (blue water lilly)
Nymphaea mexicana (yellow water lilly)

SUBMERGENT

Ceratophyllum demersum (coontail)
Najas guadalupensis (southern naiad)
Najas marina (naiad)
Potamogeton nodosus (pondweed)
Utricularia biflora (bladderwort)

Free-Floating

Azolla caroliniana (water fern)
Azolla mexicana (water fern)
Lemna valdiviana (small duckweed)
Spirodela polyrhiza (giant duckweed)
Wolffia columbiana (water meal)
Wolffiella floridana (mud midget)
Wolffiella gladiata (mud midget)

Selected Salt and Brackish Marsh Plants

Salinity key: S – tolerates salinity > 17.0 ppt; B – tolerates salinity between 0.5 and 17.0 ppt; and E – tolerates either saline or brackish waters

Transitional – seasonally flooded

GRASSES

Andropogon glomeratus (bushy bluestem) **B**
Distichlis spicata (coastal saltgrass) **E**
Eriochloa punctata (Louisiana cupgrass) **E**
Leptochloa fusca **B**
Leptochloa uninervia (Mexican sprangletop) **S**
Monanthochloë littoralis (shoregrass) **E**
Panicum hirsutum (hairy panicum) **B**
Paspalum denticulatum **B**
Paspalum vaginatum (seashore paspalum) **E**
Setaria parvifolia (knotroot bristlegrass) **S**
Spartina alterniflora (smooth cordgrass) **E**
Spartina patens (wiregrass) **S**
Spartina spartinae (Gulf cordgrass) **E**
Sporobolus virginicus (seashore dropseed) **E**
Sporobolus wrightii **E**

FORBS

Amaranthus australis (Gulf Coast water hemp) **B**
Aster subulatus (saltmarsh aster) **B**
Echinodorus berteroi (= E. rostratus; burhead) **B**
Eclipta prostrata (hierba de tago) **B**
Eustoma evaltatum (bluebell gentian) **B**
Hydrocotyle bonariensis (water pennywort; sombrerillo) **E**
Rumex chrysocarpus (= R. berlandieri; dock) **B**

Shallow – seasonally flooded to permanently flooded to 15 cm

Bacopa monnieri (water hyssop) **B**
Bacopa rotundifolia (disc water hyssop) **B**
Cyperus articulatus (joint-stem umbrella sedge) **E**
Cyperus ochraceus (umbrellasedge) **B**
Heteranthera dubia (mud plantain) **B**
Marsilea vestita (water clover) **B**
Pluchea purpurascens (salt marsh fleabane) **E**

Mid-Depths – 15 to 50 cm water depths

Eleocharis austrotexana (spikerush) **B**
Eleocharis interstincta (spikerush) **B**
Schoenoplectus californicus (=Scirpus californicus; giant bulrush, tule) **B**
Schoenoplectus pungens (=Scirpus americanus; cronquist, American bulrush) **B**
Schoenoplectus tabernaemontani (=Scirpus validis; soft-stem bulrush) **B**
Scirpus robustus (= S. maritimus; saltmarsh bulrush) **B**
Typha domingensis (narrow-leaf cattail) **E**

Deep – 50 to 100 cm water depths

ROOTED FLOATING

Nymphaea mexicana (yellow water lilly) **B**

SUBMERGENT

Ruppia maritime (widgeon grass) **E**

Source: Compiled by Chris Hathcock from Correll and Johnston (1979), Hammer (1997), Hatch et al. (1999), Judd and Lonard (2002, 2004), Richardson (1995), Stutzenbaker (1999) and Turner et al. (2003).

APPENDIX J

Historical Fish Kills in Segment 2201 (Arroyo Colorado Tidal)

Date	Location	Fish Killed	Suspected Cause
07/06/1994	Canal 5 miles north of U.S. 83 on Bass Blvd. In Harlingen	100	Low Dissolved Oxygen
10/13/1994	Arroyo Colorado, intake canal at shrimp farm, back part of canal on private property	500	Low Dissolved Oxygen
09/16/1995	Arroyo Colorado turning basin east of Harlingen	2,000,000	Low Dissolved Oxygen
11/04/1996	Arroyo Colorado, from water tower in Arroyo City, upstream to Circle X	1,000	Disease
06/18/1997	Arroyo Colorado, Port of Harlingen to Camp Perry	1,000,000	Low Dissolved Oxygen
08/04/1997	Arroyo Colorado at Rio Hondo near port of Harlingen	1,000,000	Low Dissolved Oxygen
09/13/1997	Irrigation Canal off FM 803	300	Low Dissolved Oxygen
07/13/1998	On the west bank of the Arroyo Colorado from the Port of Harlingen to the N of the Rio Hondo swing bridge	100,000	Low Dissolved Oxygen
07/30/1998	Arroyo Colorado at the Rio Hondo bridge	100,000	Low Dissolved Oxygen
08/17/1998	Arroyo Colorado approximately 0.5 miles N of Rio Hondo bridge	2,000,000	Low Dissolved Oxygen
07/26/1999	Arroyo Colorado T Pt of Harlingen	16,804	Low Dissolved Oxygen
08/03/1999	Arroyo Colorado Low water bridge to Pt of Harlingen	4,160	Low Dissolved Oxygen
08/06/1999	Arroyo Colorado Tidal	19,840,000	Low Dissolved Oxygen
09/08/1999	Pt of Harlingen downstream 1 mile	2,000	Low Dissolved Oxygen
01/06/2000	Arroyo Colorado near Arroyo City	unknown	unknown
09/19/2001	Cameron County Airport 6	unknown	unknown
09/24/2001	Arroyo Colorado	16,159	Low Dissolved Oxygen
02/24/2002	Arroyo Colorado in Arroyo City	unknown	Low Dissolved Oxygen
12/02/2003	Arroyo Colorado	20	Low Dissolved Oxygen
03/20/2004	San Juan Holding Ponds and Drainage Ditch	172,713	Pollutant
02/10/2005	San Benito	2	Pollutant

Source: Texas Parks and Wildlife Department – Fish Kill and Pollution Complaint Database

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