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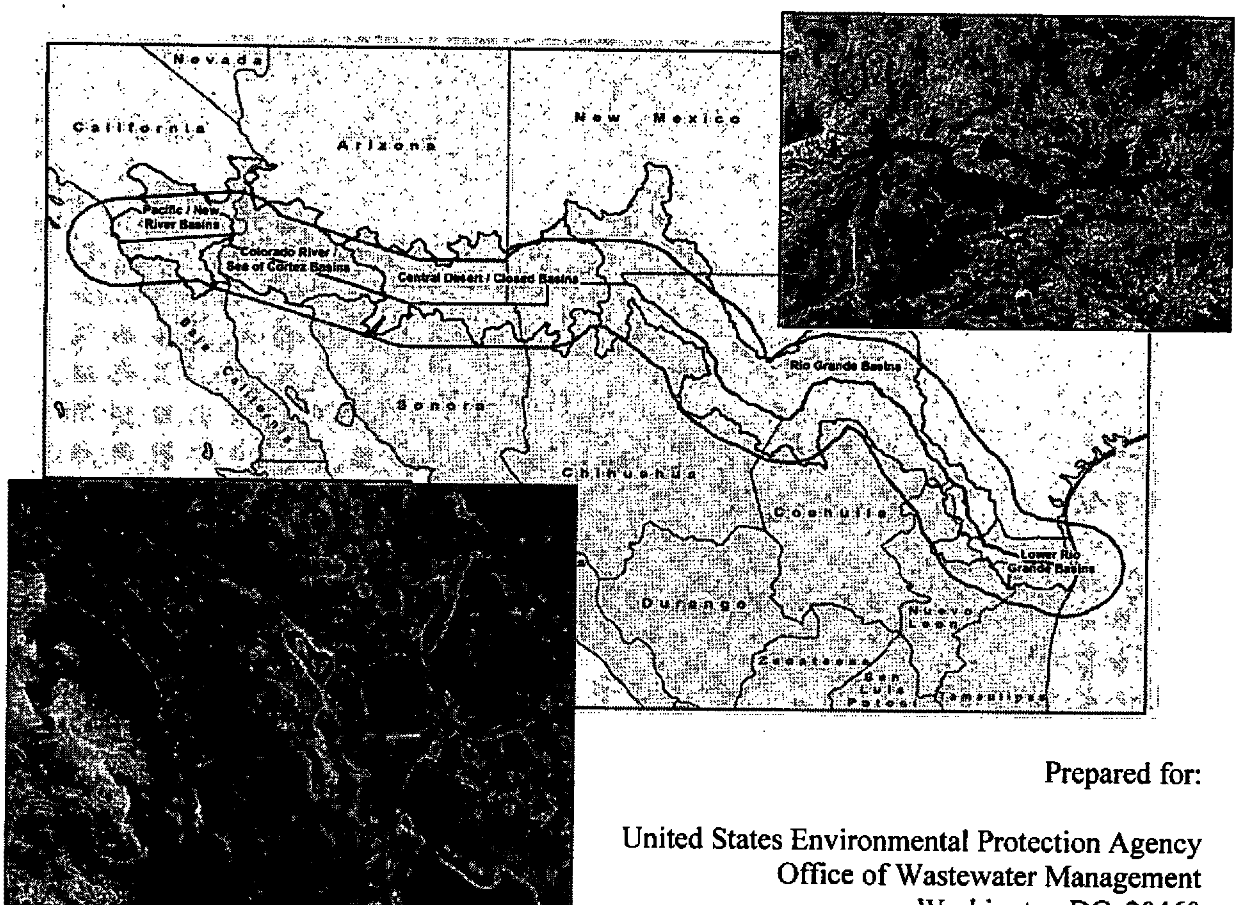
Development of Water Quality Analyses for the Shared Waters of the United States and Mexico



Prepared for:

United States Environmental Protection Agency
Office of Wastewater Management
Washington DC, 20460

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[1] RTI International is a trade name of Research Triangle Institute.

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Acknowledgments

The U.S.-Mexico Shared Waters project represents a unique effort to bring together organizations and individuals from both sides of the U.S.-Mexico border to help with the design and creation of the first prototype version of the U.S.-Mexico Border Waters Repository and the Mexico Border Reach File (MBRF). This effort has developed a baseline of what water quality information is available on both sides of the U.S.-Mexico border, generated useful products based on this information, and identified ways to build up on what has been done so far towards developing a binational water quality dataset that can be used to establish baseline border water quality conditions and measure future progress towards improving water quality conditions for this important resource.

One of the most important accomplishments of this project has been to identify current and future key players involved with U.S.-Mexico border environmental issues and to gain their cooperation towards establishing a baseline data set. Many of these organizations have been working for years on important environmental problems in the region and have vast experience dealing with water resources and water quality issues along the U.S.-Mexico border. The following organizations contributed data, comments, and recommendations to this project; their expertise and guidance on border issues was fundamental to completing this report:

- U.S. Environmental Protection Agency (EPA) Region 6 and Region 9
- Comisión Nacional del Agua (CNA), México Distrito Federal, México
- Comisión Internacional de Límites y Aguas (CILA), Juárez, México
- International Boundary and Water Commission (IBWC), El Paso, TX
- Southwest Consortium for Environmental Research and Policy (SCERP), San Diego, CA
- University of Texas at Austin (UTA)
- U.S. Geological Survey (USGS), Austin, TX.

Future cooperation and coordination with these entities must be included in planning for subsequent phases of this project and will be critical towards the continuing success of the border water data collection efforts.

In addition, this report builds upon earlier work on this project conducted by Parsons Engineering Science, Inc. (A Unit of Parsons Infrastructure & Technology Group Inc.). In particular, that work contributed significantly to the description of the study area in Section 2 and Appendix A of this report.

This work was led and directed by Alfonso Blanco, Office of Wastewater Management, U.S. EPA Office of Water. The work was done under task order contract by RTI International. Eric Solano was the RTI technical lead and Robert Truesdale was the RTI task order leader.

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List of Acronyms and Abbreviations

BASINS	Better Assessment Science Integrating Point and Nonpoint Sources
BECC	Border Environment Cooperation Commission
BFCC	U.S.-Mexico Border Field Coordinating Committee
BITF	Border Indicators Task Force
BOD	biological oxygen demand
CILA	Comisión Internacional de Límites y Aguas
CNA	Comisión Nacional del Agua
COD	chemical oxygen demand
CU	cataloging unit
DO	dissolved oxygen
DOI	U.S. Department of the Interior
DPSIR	driving forces-pressure-state-impact-response
EPA	U.S. Environmental Protection Agency
ESAR	Environmental Sampling, Analysis, and Results
GIS	geographic information systems
GNEB	Good Neighbor Environmental Board
GNIS	Geographic Names Information System
GPS	global positioning system
IBWC	International Boundary and Water Commission
ITFM	Interagency Task Force on Monitoring
MBRF	Mexico Border Reach File
NAD	National Assessment Database
NADB	North American Development Bank
NAFTA	North American Free Trade Agreement
NHD	National Hydrography Dataset
NWIS	National Water Information System
OMB	Office of Management and Budget
PSR	pressure-state-response
QA/QC	Quality Assurance/Quality Control
RIT	Reach Indexing Tool
RTI	RTI International
SCERP	Southwest Consortium for Environmental Research and Policy
SEMARNAT	Secretariat of Environment and Natural Resources
SNICA	Sistema Nacional de Información de la Calidad del Agua
SQL	structured query language
STORET	EPA's STOrage and RETrieval data repository
TCEQ	Texas Commission on Environmental Quality
TDS	total dissolved solids
TN	total nitrogen
TSS	total suspended solids
U.S.	United States
USGS	U.S. Geological Survey
UTA	University of Texas at Austin

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1.0 Introduction

The U.S. Environmental Protection Agency's (EPA's) Office of Wastewater Management initiated this project, entitled *Development of Integrated Water Quality Analyses for the Shared Waters of the United States and Mexico* (U.S.-Mexico Shared Waters), to support specific objectives of the Border 2012: U.S.-Mexico Environmental Program (Border 2012) that require assessment and management of water quality data along the U.S.-Mexico border. In support of these objectives, the U.S.-Mexico Shared Waters project

- Assembled, centralized, and standardized in one repository existing water quality data from both sides of the border
- Developed a watershed approach that can be used to analyze water quality issues on the U.S.-Mexico border
- Created a prototype of a hydrographic data set, the Mexico Border Reach File (MBRF), and described its potential use for assessing and managing water quality data towards improving water conditions in the border region.

The U.S.-Mexico Shared Waters project created a U.S.-Mexico Border Waters Data Repository, populated this Repository with U.S. and Mexican data, and reviewed the assembled data to identify data gaps. Additionally, common water quality analysis methodologies, such as water quality status and trends analysis, were investigated as examples of potential uses of the repository.

1.1 Background

The *Agreement between the United States of America and the United Mexican States on Cooperation for the Protection and Improvement of the Environment in the Border Area,* also known as the La Paz Agreement, was signed by the United States and Mexico at La Paz, Baja California, in August 1983 and entered in force in February 1984 (U.S. EPA, 2004). The La Paz Agreement is the legal basis for the creation of Border 2012.

Border 2012—a 10-year, results-oriented environmental program that serves as the main legal framework within which the United States and Mexico can pursue solutions for improving the environmental conditions along the border—is the latest multiyear, binational planning effort to be implemented under the La Paz Agreement. It succeeds Border XXI, a 5-year program that ended in 2000 (U.S. EPA, 2005a). Border 2012 was designed to empower the federal environmental authorities in the United States and Mexico to undertake cooperative initiatives. The U.S. EPA and Mexico's Secretariat of Environment and Natural Resources (SEMARNAT) serve as national coordinators for these initiatives.

One of the goals of Border 2012 is to reduce water contamination by building on infrastructure projects initiated by the Border Environment Cooperation Commission (BECC) and the North American Development Bank (NADB). Since 1995, BECC and NADB, both created by North American Free Trade Agreement (NAFTA), have had the primary role of working with communities to develop and construct infrastructure projects. The main objectives of Border 2012, which build on those early projects, are as follows:

- **Objective 1.** By 2012, promote a 25 percent increase in the number of homes connected to potable water supply and wastewater collection and treatment systems.
- **Objective 2.** By 2012, assess significant shared and transboundary surface waters and achieve most of the water quality standards currently being exceeded in those waters.
- **Objective 3.** By 2006, implement a monitoring system for evaluating coastal water quality at the international border beaches. By the end of 2006, establish a 2012 objective toward meeting both countries' coastal water quality standards.
- **Objective 4.** By 2005, promote the assessment of water system conditions in 10 percent of the existing water systems in the border cities to identify opportunities for improvement in overall water system efficiencies.

In support of these objectives, in particular objectives 2 and 3, EPA initiated the U.S.-Mexico Shared Waters project to provide the information and tools needed to help determine indicators for measuring program progress and assessing environmental and health changes in the region.

The U.S.-Mexico Shared Waters project is consistent with observations and recommendations presented in the Good Neighbor Environmental Board's (GNEB) recent report on water quality for the border region (U.S. EPA, 2005b). This eighth report by GNEB to the President and Congress reiterates GNEB's 1995 recommendation that environmental data gaps and data accessibility be addressed as a high priority. Specifically, GNEB's Recommendation 2 in the report is

> "Develop and sign formal U.S.-Mexico border-region water resources data agreements. Such agreements should support the collection, analysis, and sharing of compatible data across a wise range of uses so that the border region water resources can be more effectively managed."

To support this recommendation, the GNEB report goes on to describe that border water data are needed by water resource managers to help them understand "overarching forces that continue to affect the fate of the regions water resources (such as current and projected land use) in managing water quantity, quality, and use. The 2005 GNEB report also references the 2003 report of the U.S.-Mexico Binational Council as stating that "...an accurate and harmonious system of data collection would serve as a fundamental starting point for cross-border management."

The GNEB report identifies several remaining barriers to adequate border water quality data, which this project has helped to overcome:

- **Barrier 1. Data gaps on water quantity and quality.** The U.S.-Mexico Shared Waters project has identified surface water data gaps (Section 3.2.2) and provides recommended next steps to fill them (Section 6).
- **Barrier 2. Different methods, inability to compare.** As described in Section 3.1, the project has brought data from both sides of the border into

a common format to promote and inform ongoing binational discussions towards developing and applying standardized, comparable measures and protocols.

- **Barrier 3. Inaccessibility of data.** The U.S.-Mexico Border Waters Data Repository provides a standardized format and database structure that can be interfaced with Web-based systems that (1) enable data-providing organizations to upload, review, and maintain data and (2) access data through map-based and tabular queries. Because the Repository was designed and built as a cooperative effort between U.S. and Mexican agencies and organizations (Section 1.2), the project has built the capacity and trust needed for prompt availability and access of data collected on both sides of the border.

- **Barrier 4. Limited, ad hoc data exchange systems.** In recommending next steps for establishing an annual U.S.-Mexico water quality data exchange, page 27 of the GNEB report specifically endorses this project and its subsequent phases as a collaborative, cross-border effort that should be strongly supported.

As described in Section 3.1, the U.S.-Mexico Border Waters Data Repository is designed to efficiently assemble data from existing U.S. and Mexican data systems into a common system to enable cross-border sharing and comparison of data, and through the cooperation of Mexican and U.S. agencies and organization, has been populated with most of the readily available water quality data in the border region.

1.2 Stakeholder Workgroup

The U.S.-Mexico Shared Waters project has provided a unique opportunity to bring together organizations and individuals from both sides of the U.S.-Mexico border to help with the design and creation of the first version of the U.S.-Mexico Border Waters Repository and the MBRF prototype. When planning this project, EPA and RTI recognized that the expertise and guidance of stakeholders and experts on both sides of the border would be essential to accomplishing the objectives of this project, from designing a robust and maintainable data repository to populating it with U.S. and Mexican data. To meet this need, we worked with the following key players involved with U.S.-Mexico border environmental issues:

- Angel Kosfizer, U.S. EPA Region 6
- Eugenia McNaughton, U.S. EPA Region 9
- Eric Gutiérrez López, Carolina Molina Segura, Comisión Nacional del Agua (CNA), México Distrito Federal, México
- Antonio Rascón, Comisión Internacional de Límites y Aguas (CILA), Juárez, México
- Carlos Peña, International Boundary and Water Commission (IBWC), El Paso, TX
- Rick Van Schoik, Southwest Consortium for Environmental Research and Policy (SCERP), San Diego, CA

- Daene McKinney and Carlos Patiño, University of Texas at Austin (UTA), Austin, TX
- Jean Parcher, U.S. Geological Survey (USGS), Dallas, TX.

These individuals and others in their organizations represent vast experience dealing with water resources and water quality issues along the U.S.-Mexico border. Many of them have been working for years on important environmental problems on the border region. Through meetings, conference calls, and e-mail, the stakeholders contributed data, comments, and recommendations at every stage of this project. Specific input was solicited and used for the following aspects of the project:

- Selection of the study area basins (Section 2)
- Agreement on the water quality parameters to be addressed in the project (Section 3)
- Design of the data repository (Section 3)
- Collection of the data to be incorporated in the Repository, especially for the Mexican side of the border (Section 3)
- Review of the draft final report
- Recommendations for activities to be included in the next phase of the study (Section 6).

Building this work group was critical to the completion of this report, and EPA thanks each individual and organization for their valuable contributions to the project.

The future cooperation of these stakeholders will be essential in planning the subsequent phases of this project. For example, recent (November and December 2005) meetings have confirmed the value of this effort to all parties and their commitment and desire to continue the work. The next meeting of the group, to be held in February 2006, will focus on developing common, standardized binational measures and benchmarks that can be used to focus future data collection efforts and allow regular assessment of water conditions in the border region. Topics will include finalizing system requirements (e.g., for data sharing and updates) and identifying resources for continuing the effort.

1.3 Document Content and Organization

This report documents the following activities that RTI performed in support of this project:

- Collected and centralized in one repository a significant amount of existing water quality data on both sides of the U.S.-Mexico border
- Standardized the format in which water quality data on both sides of the border are collected and stored
- Facilitated the integration of existing and future water quality data with other repositories, such as EPA's STOrage and RETrieval system (STORET) and the National Water Information System (NWIS)

- Identified data gaps in the water quality indicators for which data are being collected at the monitoring stations along the border
- Provided a watershed approach to analyzing water quality issues on the U.S.-Mexico border
- Developed a prototype of the MBRF and described its potential benefits for water quality analysis.

The rest of this document is organized as follows:

- **Section 2, Study Area**, defines the study area and provides a brief overview of the major basins in the transboundary region.
- **Section 3, Data Repository**, describes the methodology used to develop the data repository and the findings from the data collected so far.
- **Section 4, Developing Effective 2012 Water Quality Indicators for the U.S.-Mexico Border**, provides background and recommendations for developing an effective set of indicators that can be used to assess the quality of the shared waters of the United States and Mexico.
- **Section 5, Mexico Border Reach File**, describes the prototype reach file developed for the U.S.-Mexico border region.
- **Section 6, Future Work**, describes future enhancements or analyses that could build upon the work described here.
- **Section 7, References**, lists the works cited in this report.

2.0 Study Area

The border region was defined in the La Paz agreement (Article 4) as the area located within 100 km on either side of the inland border between the United States and Mexico. Figure 1 shows the border region with this 100-km buffer (outlined in red). The border region includes territory in four U.S. states (California, Arizona, New Mexico, and Texas) and six Mexican states (Baja California, Sonora, Chihuahua, Coahuila, Nuevo Leon, and Tamaulipas).

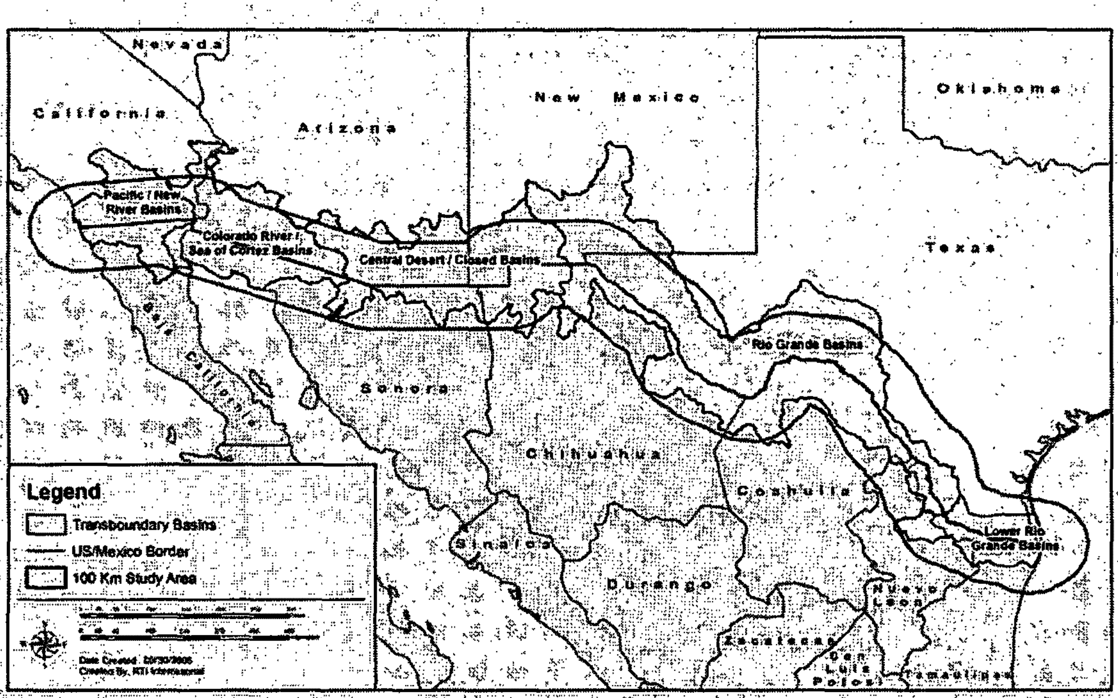


Figure 1. U.S.-Mexico border study area.

The 100-km buffer encompasses eight basins that were defined in the mid-1990s by a U.S. Department of the Interior (DOI) committee—the U.S.-Mexico Border Field Coordinating Committee (BFCC)—that was created to promote and facilitate coordination among the DOI bureaus and the U.S.-Mexico border organizations. The BFCC, which is no longer active, proposed a new definition for the U.S.-Mexico border, using hydrologic and hydrogeologic criteria to delineate the extent of the border area (Woodward and Durall, 1996).

These basins do not, of course, coincide perfectly with the 100-km buffer, nor do state and international lines coincide with the basins. Consequently, it makes sense to discuss the border waters and their status and trends from a shared-waters perspective. This report is organized around such a shared-waters perspective. For simplicity, we combined some of the eight DOI basins that had similar hydrologic and physiographic characteristics to define five "transboundary regions" (shown outlined in black in Figure 1):

- Pacific/Salton Sea Basins (DOI Basin 1)

- Colorado River/Sea of Cortez Basin (DOI Basin 2)
- Central Desert/Closed Basins:
  - Mexican Highlands Basin (DOI Basin 3)
  - Mimbres/Animas Basin (DOI Basin 4)
- Upper Rio Grande Basin:
  - Rio Grande I—Elephant Butte Reservoir to above Rio Conchos Basin (DOI Basin 5)
  - Rio Grande II—Rio Conchos to Amistad Reservoir Basin (DOI Basin 6)
  - Rio Grande III—Below Amistad Reservoir to Falcon Reservoir Basin (DOI Basin 7)
- Lower Rio Grande Basin (Basin 8).

Table 1 summarizes the characteristics of each of these transboundary regions, including the DOI basins of which they are composed. The remainder of this section provides a brief description and a more detailed map for each of the transboundary regions. Appendix A describes the geography and hydrology of each of the transboundary regions in more detail.

Table 1. Transboundary Basin Characteristics

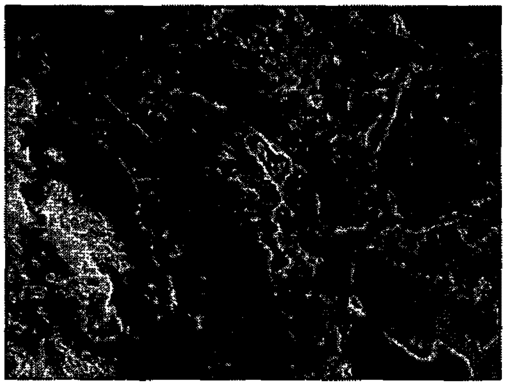
Transboundary Region	DOI Basin	DOI Basin Name	Total Area		Area in Mexico		Area in U.S.	
			sq. mi.	km²	sq. mi.	km²	sq. mi.	km²
Pacific/Salton Sea Basins	1	Pacific Basins/Salton Sea	14,000	36,000	4,870	13,000	9,130	24,000
Colorado R./Sea of Cortez Basin	2	Colorado R./Sea of Cortez	22,590	59,000	8,370	22,000	14,220	37,000
Central Desert/ Closed Basins	3	Mexican Highlands	21,840	57,000	5,395	14,000	16,445	43,000
	4	Mimbres/ Animas	12,450	32,000	6,185	16,000	6,265	16,000
Upper Rio Grande Basin	5	Rio Grande I	28,940	75,000	5,760	15,000	23,180	60,000
	6	Rio Grande II	34,630	90,000	13,910	36,000	20,720	54,000
	7	Rio Grande III	12,910	33,000	7,840	20,000	5,070	13,000
Lower Rio Grande Basin	8	Lower Rio Grande	10,240	27,000	6,155	16,000	4,085	11,000
Total U.S.-Mexico Border area			157,600	408,000	58,485	151,000	99,115	257,000

Source: Woodward and Durall (1996)

2.1 Pacific/Salton Sea Transboundary Basins

The Pacific/Salton Sea Basins drain an area of 14,000 square miles (36,000 km^2), to either the Pacific Ocean or inland seas. These basins have a very dry, semiarid climate with few fresh water resources. The most important watersheds are the San Diego, Cottonwood-Tijuana, and Salton Sea. Except for the Salton Sea watershed, flow is primarily from east to west, with stream flows originating from precipitation in the mountains flowing toward the Pacific Ocean. The flow in these streams is controlled through a series of hydraulic structures, including reservoirs. Land use varies considerably, ranging from urbanized to agricultural to wilderness. The Salton Sea watershed includes the fertile Imperial Valley and the manufacturing center of Mexicali.

From MODIS-TERRA Satellite/Sensor System, NASA



Pacific/Salton Sea Basins.

The Tijuana River is one of the main streams in the basin and one of the City of Tijuana's major natural resources. The river flows northwest through the city of Tijuana before crossing into California near San Ysidro and then flowing into the Pacific Ocean. Figure 2 shows the Pacific/Salton Sea Basins and their most important characteristics.

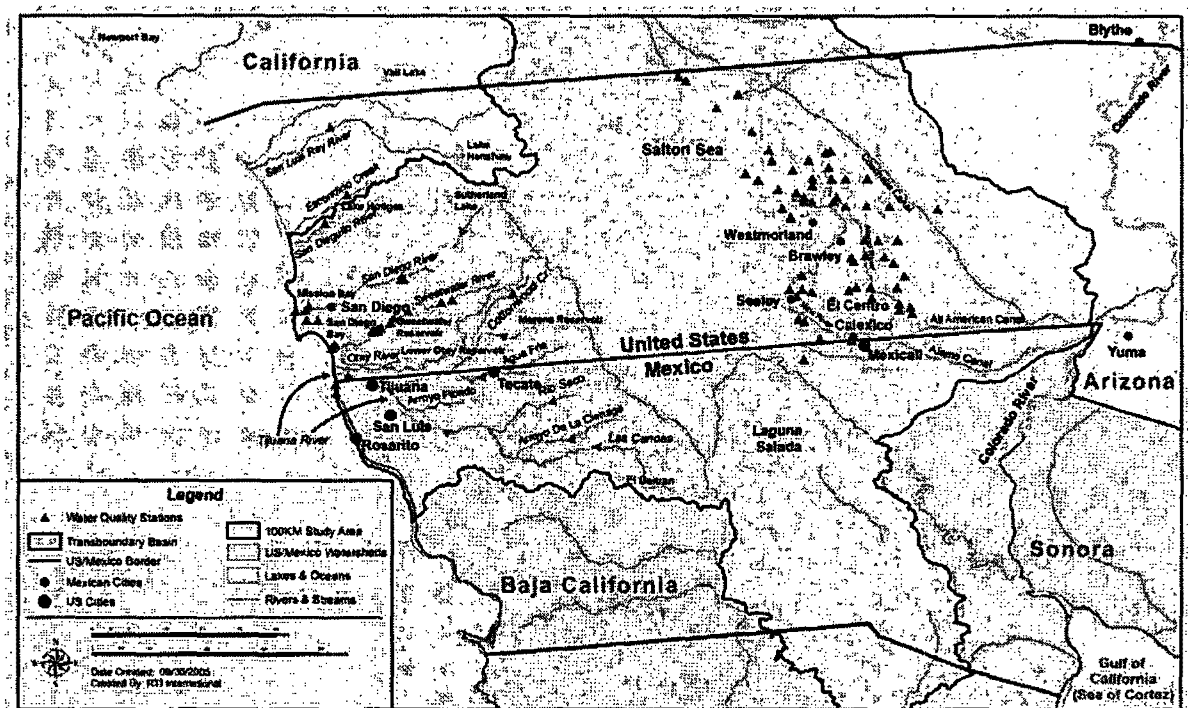


Figure 2. Pacific/Salton Sea Basins.

2.2 Colorado River/Sea of Cortez Transboundary Basins

The Colorado River/Sea of Cortez Basins contain watersheds that drain either to the Colorado and Gila Rivers, or directly to the Gulf of California (Sea of Cortez). These basins drain 22,590 square miles (59,000 km^2) and cover portions of the states of Arizona and Sonora. Land use is primarily agricultural and grazing, although there are important wildlife refuges and wilderness areas, along with urban areas such as Yuma and San Luis Rio Colorado.

Photo courtesy Bureau of Reclamation

Lower Colorado River.

The Colorado River flows into the basin through heavily urbanized areas near Yuma and San Luis Rio Colorado and then through wetlands before flowing into the Sea of Cortez. Currently, most of the water flowing into the delta comes from agricultural drainage and periodic flood flow from the United States and Mexico, with little perennial flow in the lower Colorado River. This has significantly altered the delta's once extensive estuaries and salt flats. Figure 3 shows the Colorado River/Sea of Cortez Basins and their most important characteristics.

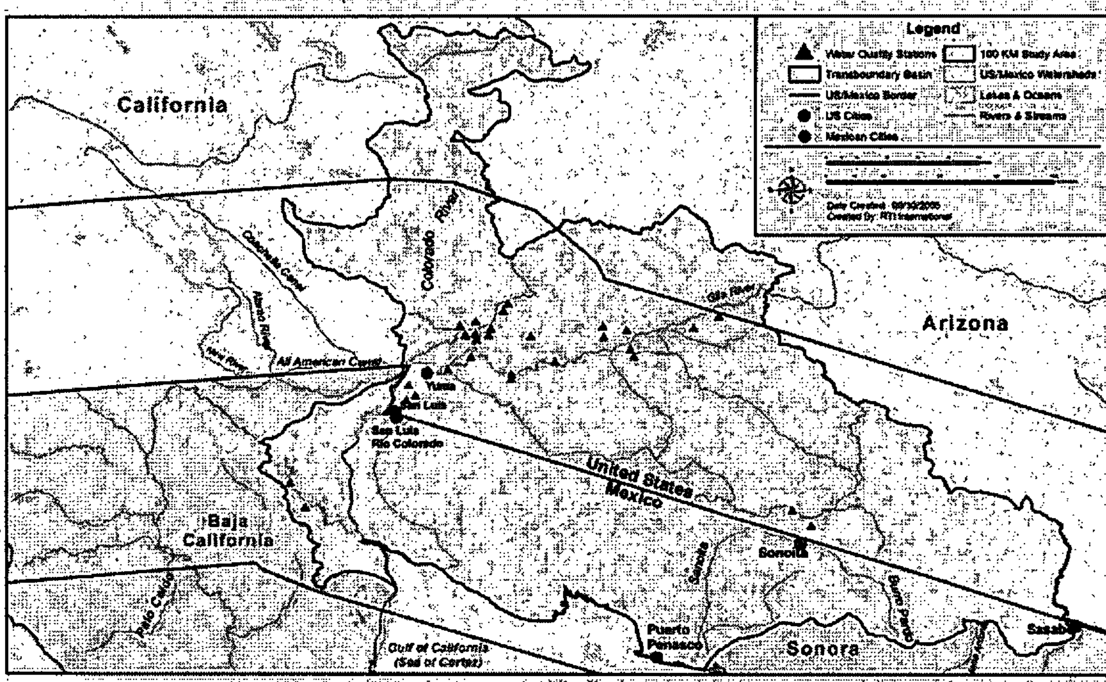
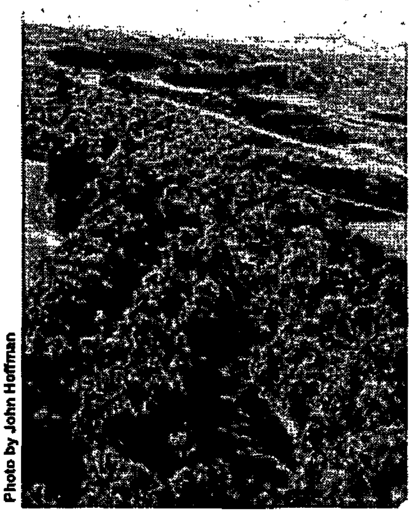


Figure 3. Colorado River/Sea of Cortez Basins.

2.3 Central Desert/Closed Transboundary Basins

The Central Desert/Closed Basins include the Mexican Highlands basins and the Mimbres and Animas basins. Figure 4 shows the Central Desert/Closed Basins and their most important characteristics. The Mexican Highlands Basin contains watersheds that drain to rivers in southern Arizona (e.g., the San Pedro and Santa Cruz Rivers), southwestern New Mexico, northern Sonora (e.g., Aqua Prieta), or the extreme northwestern tip of Chihuahua. The Mimbres/Animas Basin contains watersheds that drain internally in southern New Mexico and northern Chihuahua. Together, these watersheds drain 34,290 square miles (89,000 km^2) (Woodward and Durall, 1996). Water resources are scarce and competition for this limited resource is a major water resource management theme in the region.



Santa Cruz River between Nogales and Tumacácori.

The Mexican Highland basins are broad valleys separated by steep mountain ranges, with each basin a mostly closed, independent hydrologic system. Although classified as a desert, the region is renowned for relatively lush vegetation and diverse aquatic habitats. All streams are ephemeral, except in the valleys of Animas Creek. The Central Closed Basin (which includes the Mimbres, Playa, and Marmel watersheds) ranges from sub-humid in the north to arid in the south (Papoulias et al., 1997).

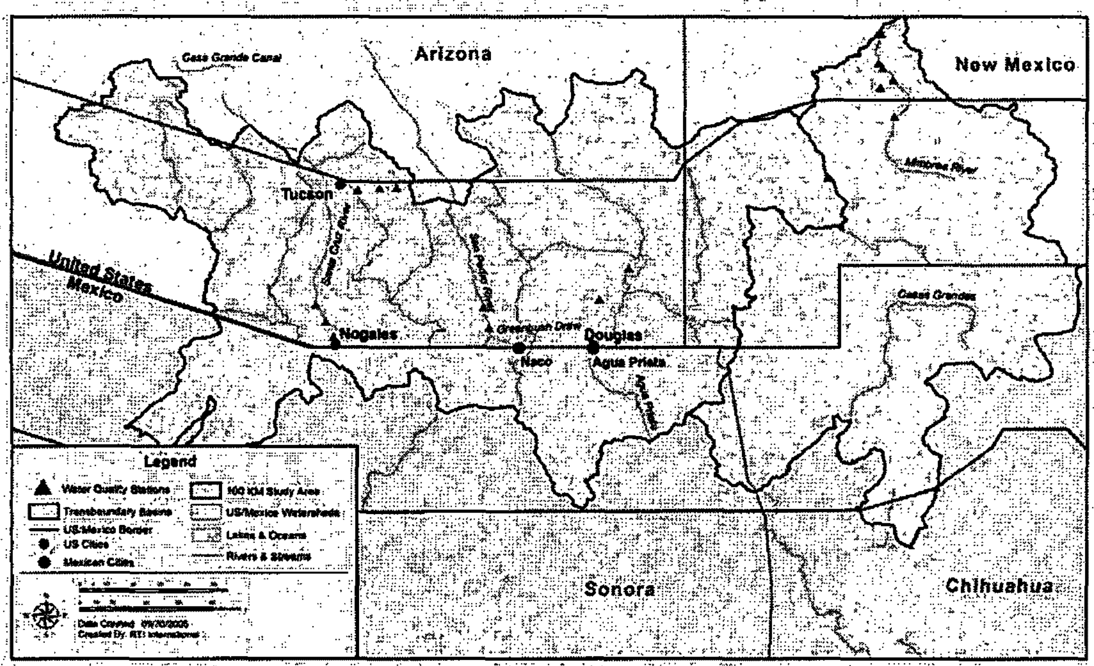
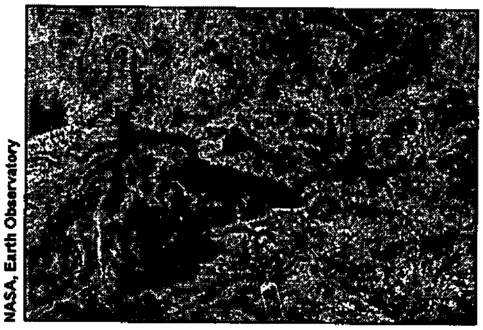


Figure 4. Central Desert/Closed Basins.

2.4 Upper Rio Grande Transboundary Basins



NASA, Earth Observatory

International Amistad Reservoir.

The Upper Rio Grande/Rio Bravo Basin is defined as the area from the Elephant Butte Reservoir in New Mexico to the Falcon Reservoir on the U.S.-Mexico Border. The Rio Grande Basin drains 76,480 square miles (200,000 km^2) (Woodward and Durall, 1996). Figure 5 shows the Upper Rio Grande Basins and their most important characteristics. The basins are divided into three segments: (1) from Elephant Butte Reservoir to Rio Conchos, (2) from Rio Conchos to the Amistad Reservoir, and (3) below the Amistad Reservoir to the Falcon Reservoir. For most of this length the river defines the U.S.-Mexico border and is the major source of surface water for the area (Blackstun et al., 1996)

The climate of the Upper Rio Grande basins is semi-arid to arid, and the availability of water in the river greatly affects water quality in the river. Flows are controlled largely by the series of reservoirs along the river, and the availability of water determines almost all land use within the basin. Land use is varied, including rangeland, agriculture, light industrial uses, mining, and urban areas (five pairs of sister cities on either side of the border). Where reservoirs and other water storage devices are available, urban population and industries can be sustained. Where canals are available to transport water, rangeland, ranches, and agriculture can be supported. Colonias, communities on the U.S. side of the border without basic infrastructure, have a significant impact of water quality and other water issues, and upgrading their infrastructure is one focus for managing water quality in the region.

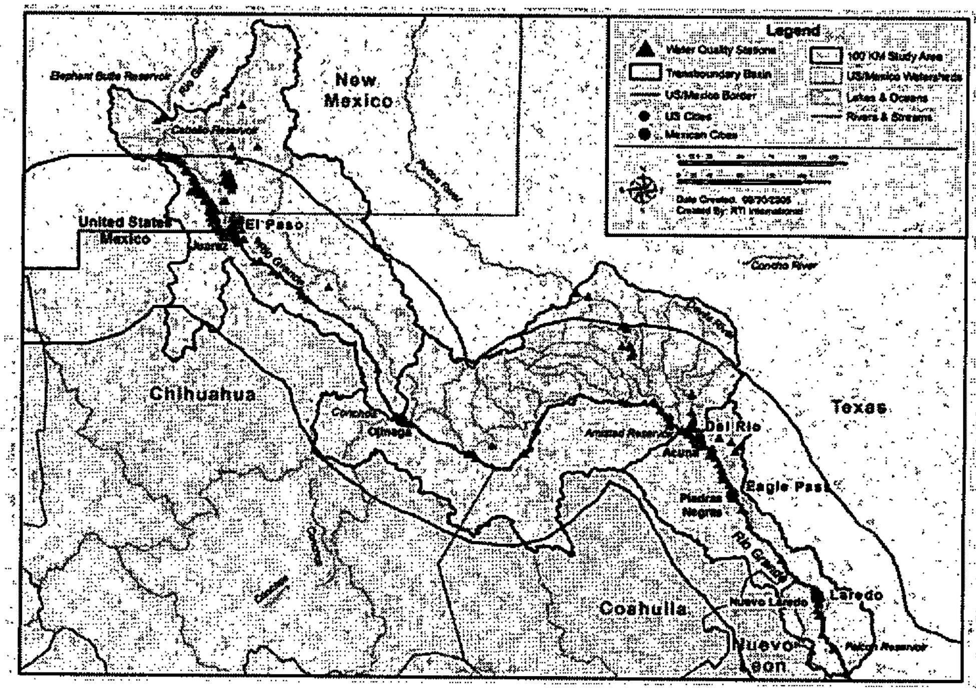
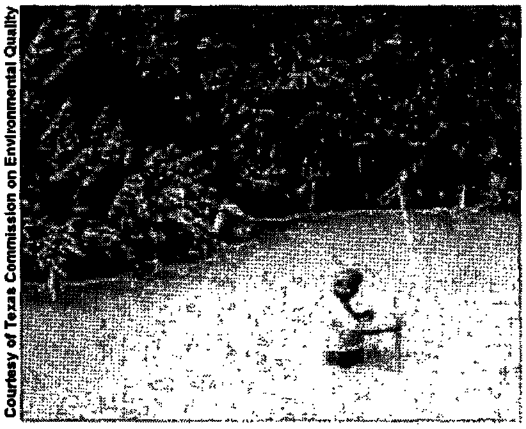


Figure 5. Upper Rio Grande Basins.

2.5 Lower Rio Grande Transboundary Basin

The Lower Rio Grande Valley—below Falcon Reservoir to the Gulf of Mexico—contains watersheds that drain either to the Rio Grande, to the lower reach of the Rio San Juan below the gaging station at Santa Rosalia, or to Arroyo Colorado in southern Texas. It drains an area of 10,240 square miles (27,000 km²) of the Gulf Coastal Plain. Figure 6 shows the Lower Rio Grande Basin and its most important features.



Courtesy of Texas Commission on Environmental Quality

Collecting water quality and flow data at Arroyo Colorado.

The climate for lower Rio Grande basin becomes more humid downstream, with vegetation ranging from semiarid scrub land near the Falcon Reservoir, to oak forests, and then to marshes and wetlands near the gulf. Urban areas represent a significant proportion of land use within the basin, along with irrigated cropland for vegetables, sorghum, and cotton. Water supplies in the lower Rio Grande are limited and largely controlled by releases from the Falcon Resevoir. Increasing demands from both sides of the border create a water management challenge. Surface water has been and will continue to be the major source of water supply in the basin, and increasing municipal and agricultural demands have significantly decreased the amount of water available for refuge wetlands in the delta region near the Gulf, with negative impacts on plants and wildlife in the estuaries and marshes near the mouth of the river (Buckler et al., 1997).

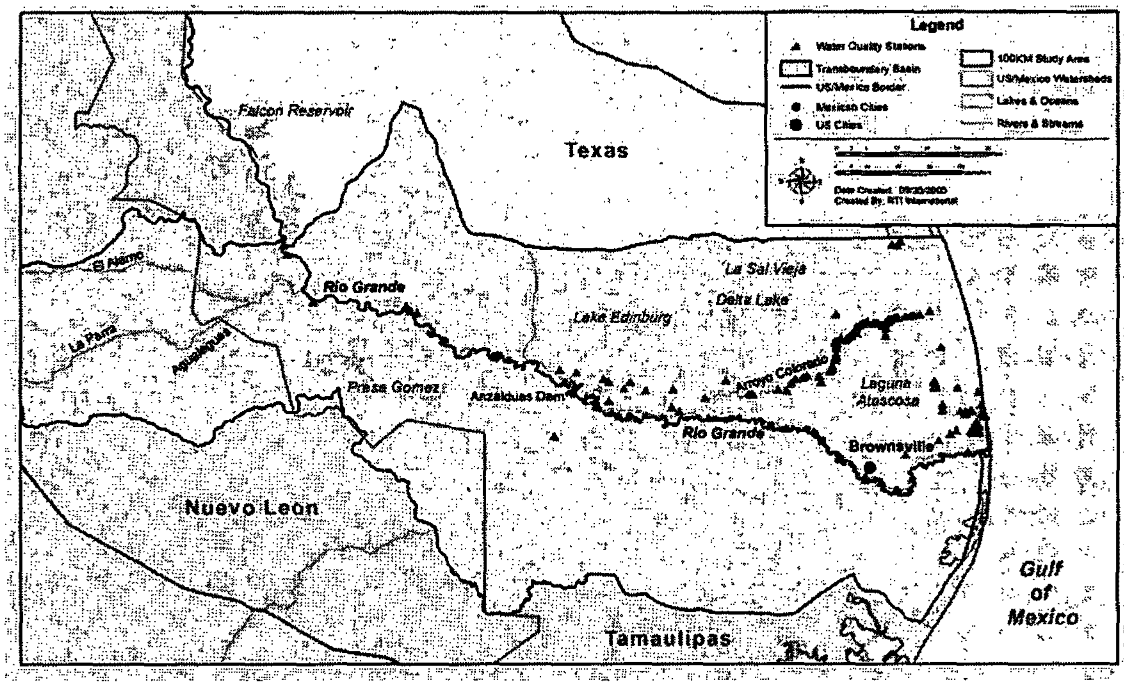


Figure 6. Lower Rio Grande Basin.

3.0 U.S.-Mexico Border Waters Data Repository

The U.S.-Mexico Border Waters Data Repository was developed to compile water quality data from both sides of the U.S.-Mexico border. It was designed to be compatible with and receive data from both U.S. and Mexican water quality data sources and to allow retrieval of comparable data to compare and assess water quality conditions in the border region over time. By establishing baseline water quality conditions on both sides of the border and tracking changes over time, the Repository will help measure progress towards the effective management of the border region's shared water resources.

The Repository contains secondary data of known quality, and it is not intended to replace or supplant the water quality data systems that U.S. and Mexican agencies have established to assess and manage their surface water resources. Instead, it is designed to hold data migrated from these sources to enable easy access to the combined data on the shared water resources of the border region. Data quality procedures were followed to ensure the accurate transfer and processing of the data from the original data sources, but the Repository depends on the primary data systems for ensuring adequate data quality.

This section discusses the Border Waters Data Repository that was built and populated during this project. Section 3.1 describes the methodology used to build the Repository and to collect and process the initial data set from U.S. and Mexican data sources. Section 3.2 describes significant findings from this initial data set, including data content and data gaps.

3.1 Methodology

The main objective of the U.S.-Mexico Border Waters Repository is to provide a means to store and retrieve water quality information for the U.S.-Mexico border areas. Important aspects of the methodology used to build the Repository include its design, data sources, parameters collected, data processing steps, and quality assurance and quality control (QA/QC) measures used to populate the Repository. These aspects are described in the following sections.

3.1.1 Repository Design

The U.S.-Mexico Border Waters Repository is comprehensive but also simple: a repository that can store and maintain data but that is also compatible with other existing systems. The Repository was designed to be easily enhanced, because many data standards are still under development and water quality collection activities seem to be increasing along the Border.

The Repository is a flexible tool designed to allow the easy importation of water quality data from a variety of sources from both sides of the border. In this initial effort, the Repository was populated with data from both U.S. and Mexican sources. For the U.S. side, both recent and historic (legacy) data were included to enable analysis of current and past water quality conditions.

We designed the U.S.-Mexico Border Waters Repository to be

- Easy to maintain, update, and expand

- Easily integrated with EPA's STORET
- Easy to use
- Compliant with EPA Environmental Sampling and Results (ESAR) standards and Latitude/Longitude standards
- Flexible enough to accommodate future changes that may be caused by data standard protocols currently under development by EPA.
- Robust enough to allow for storage of non–water-quality information, such as water flow data
- Able to store maps, text files, diagrams, and other information files.

To achieve those goals, we used

- A simple database structure based largely on STORET
- Best practices in database design to ensure integrity of the links between tables
- Numerous lookup tables, which make aid in navigation and querying and are easy to add or modify as needed
- Binary object storage techniques (to store maps, etc).

In addition, we incorporated many data elements from the EPA ESAR and Latitude/Longitude data standards. The Repository complies with EPA's Latitude and Longitude data standards in that every monitoring station for which data are stored is referenced with geographic coordinates and additional geographic information. This is an important condition for linking water quality data to a georeferenced system that holds hydrological and physiographic information about a region.

The Repository structure is compatible with existing systems (most importantly the U.S. STORET system) but has been simplified to facilitate data entry, maintenance, and access. Appendix B explains in detail the technical design objectives considered when building the data structure for the Repository. Appendix B also shows the data dictionary and entity relational diagrams for the Repository.

The Repository is currently stored as a Microsoft Access database. Microsoft Access 2000 or later is required to use the Repository. However, the Repository was designed so that it could be migrated to another relational database software system, such as open-source MySQL, Oracle, SQL Server, or open-source PostGRESQL.

The Repository does not yet have a user interface; therefore, a basic knowledge of relational databases and structured query language (SQL) is needed to review Appendix B and write queries to extract data summaries from the Repository. In the next phase of the project, we can develop standard queries and include them in the Repository to produce reports and output tables that can be viewed as text files or in standard spreadsheet software, such as Microsoft Excel.

3.1.2 Water Quality Data Sources

We identified and accessed water quality data sources for the project through collaboration with the U.S.-Mexico stakeholder work group. The current Repository includes water quality data extracted from the following sources:

- U.S. EPA (modernized and legacy STORET)
- USGS (NWIS)
- Texas Commission on Environmental Quality (TCEQ)
- International Border Waters Commission (IBWC)
- Southwest Consortium for Environmental Research and Policy (SCERP)
- Comisión Nacional del Agua (CNA)
- Comisión Internacional de Límites y Aguas (CILA).

Some of the water quality data collected during this project were not included in the current Repository because the data sources did not have location coordinates for water quality sampling points:

- Certain CILA data in PDF, jpg and Excel formats (example: data from the wastewater treatment plant in Ciudad Acuña, Coahuila)
- Data from the Beach and Bay Status Report from the Department of Environmental Health, County of San Diego.

Finally, data from several other sources were received near the end of the project. These sources were not included in the current Repository, but may contain useful water quality data:

- *City of San Diego.* Dry weather bio-assessment and chemical monitoring of creeks and rivers.
- *City of San Diego Metropolitan Wastewater Department.* Sampling and analysis of Tijuana wastewater.
- *San Diego County Water Authority.* Regional Colorado River Conveyance Feasibility Study Final Report, which compares Colorado River quality to recommended water quality standards.
- *State of California.* Data report on discontinued water quality stations. Southern Great Basin from Mexican Border to Mono Lake Basin, and Pacific Slope Basins from Tijuana River to Maria River.
- *San Diego State University.* Monitoring and Modeling of Water Quality in the Tijuana River Watershed.
- *San Diego State University.* An overview of the existing literature of the water quality and quantity of the Tijuana River Watershed.
- *City of San Diego Water Department.* Water quality monitoring at Barrett and Morena Reservoirs.

- *Tijuana State Commission of Public Services.* Drinking Water and Wastewater Master Plan for Tijuana and Playas de Rosarito. Water quality data.
- *Tijuana State Commission of Public Services.* Information about Flow, Water Quality, and Efficiency at the wastewater treatment plants.

Data from these sources can be explored during the next phase of this project.

3.1.3 Water Quality Parameters Collected

The stakeholder group selected 12 water quality parameters for data collection and entry in the U.S-Mexico Border Waters Repository. This selection was based on the importance of these parameters in evaluating how water resources are impaired in the border region and their availability in data sources for both sides of the border. The 12 water quality parameters are

- Dissolved Oxygen (DO)
- Nutrients (nitrogen compounds, phosphorus compounds)
- Chlorophyll/biomass
- Conductivity/total dissolved solids/salinity
- Chlorides
- Sulfates
- Acidity/pH/alkalinity
- Chemical oxygen demand (COD)
- Biochemical oxygen demand (BOD)
- Total suspended solids, total solids
- Fecal bacteria (fecal coliform, fecal streptococci)
- Temperature.

These water quality parameters are consistent with the water quality parameters listed on EPA's Border 2012 Web site (http://www.epa.gov/usmexicoborder/indicators.htm) as part of the effort to define water quality environmental indicators. EPA plans to refine these indicators and use them as base-forming measures that should contribute to the development of more complex, integral integrators. (Section 4.0 of this report provides suggestions and recommendations for this further development.)

3.1.4 Flow Data

Flow data are an important component of the Repository both because water supply is a critical issue in the border region and because flow data are needed to accurately calculate and assess water quality status and trends, especially in arid and semiarid areas where seasonal flow can vary greatly. The Repository was designed to hold flow data, and some flow data were collected for the current Repository. Because stations that collect water quality data do not always collect flow information and flow gaging stations do not necessarily collect water quality data, adding flow data to the Repository often requires adding additional station information and locations. Potential sources of water flow data for the border region include:

- IBWC Web site
- STORET
- USGS NWIS gage stations
- San Diego Water Department.

3.1.5 Data Processing

The original sources of water quality data vary both in the methods used to measure the parameters of interest and in how these parameters are named in the databases. For all data sources, data are stored in the Repository in the same format as the original data source, preserving the original water quality indicator name and units, as well as the original water quality indicator ID. However, the Repository needed to have a consistent set of names to enable comparable queries from different data sources, so we created lookup tables in the Repository to link the source-specific indicator names to a standardized name (e.g., chlorophyll a) so that the data can be extracted and analyzed for a particular indicator regardless of the different source-specific names. As we import additional data sources into the Repository, we can easily modify these lookup tables to match new source-specific names to the standardized names. These standardized (or "generic") names can then be used to query the Repository database. Thirty-six generic water quality parameters are included in the Repository database to represent the 12 selected water quality parameters listed in Section 3.1.3:

1. Fecal coliform
2. Fecal streptococci
3. Chlorophyll a
4. Biomass, periphyton
5. Chlorophyll c
6. Chlorphyll (a+b+c)
7. Chlorophyll b
8. Sulfate
9. Total dissolved solids (TDS)
10. Chloride
11. Dissolved oxygen (DO)
12. Flow rate
13. Conductivity, specific conductance
14. Alkalinity
15. Acidity
16. Hardness
17. Salinity
18. Sodium Adsorption Ratio
19. Turbidity
20. Chemical Oxygen Demand (COD)

21. Total Oxygen Demand
22. Inorganic nitrogen
23. Total phosphorus
24. Organic nitrogen
25. Nitrogen ion
26. Total nitrogen (TN)
27. Nitrite
28. Phosphate
29. Nitrate
30. Ammonia
31. Nitrite plus nitrate
32. Biological oxygen demand (BOD)
33. pH
34. Temperature
35. Total Suspended Solids (TSS)
36. Dissolved solids.

Appendix C of this report lists each standard variable name that has multiple designations in the source data and describes how the variable was assigned in the Repository in terms of its description and units. The Repository data table TL_CHARACTERISTIC, described in Appendix B, is a lookup table that contains information about all water quality indicators for which data were collected in the Repository, and relates the name and indicator ID in the original data source to the generic water quality parameters listed above.

Data were extracted from the original data sources by a specific methodology for each source, as described in Appendix C. In summary, we downloaded the data from the data source Web site (or obtained the data files from the responsible organization). Most of the data files were in text format. We imported each text file into a temporary database with the same structure as the Repository. The text file was also placed in a separate Access data table with the same structure as the original data source. Data were checked for completeness and cleaned and converted as needed to bring it into the Repository format. These steps are described in Appendix C for each data source.

3.1.5 Quality Assurance/Quality Control

Several QA/QC measures were used to ensure accurate transfer of data from the original data sources into the Repository. The first QA/QC step was to count the number of records transferred from the downloaded file into the temporary Access database to ensure that all records from the downloaded file were properly transferred.

The next QA/QC step was to compare the two Access databases (one with the data in the original file structure and one with the data in the Repository structure). A portion of the records stored in these databases were checked to ensure that all information was carried from the original downloaded file to the temporary Access database. This check was done by querying the original data against the restructured data and by visual comparison. We checked 3 to 10 percent of all records for the tables containing results, sample data, location data, and station data. We checked 100 percent of records for the tables containing organization data, analytical methods data, and characteristic data. The rest of the tables are lookup tables that were reviewed for accuracy as they were created or obtained from another data source (i.e., STORET).

3.2 Findings and Recommendations

Different analyses were performed on the collected data to provide examples of the type of analyses that could be done with the data stored in the Repository. These analyses are presented in Appendices D and E. Section 3.2.1 summarizes the data collected and Section 3.2.2 describes the gaps identified in these data. Sections 3.2.3 to 3.2.6 describe the major findings from the Repository and the recommendations that follow from those findings.

Appendix F is a summary of water quality status for a limited number of U.S. watersheds along the border. These summaries are taken from the National Assessment Database (NAD) and represent state assessments of water quality conditions (impaired or not) with respect to specific designated uses (e.g., swimming, drinking water, fish consumption). Because they represent regulatory assessment, data from the NAD can provide a solid baseline for water quality conditions on the U.S. side of the border.

3.2.1 Data Summary

The U.S.-Mexico Waters Repository holds close to 200,000 data points for many different water quality indicators at stations along the border. For each water quality indicator, data frequency is defined as the number of stations with measured values of that indicator. Data frequency of data collected on the U.S.-Mexico Repository was summarized by generic water quality indicator for each basin.

Tables 2 through 5 summarize the number of stations sampling, generating, or reporting data by geographic location (country, state, or transboundary region) in summary (Tables 2 and 3) and by water quality parameter (Tables 4 and 5). Table 2 shows the number of stations by country and state. Table 3 shows the number of stations by transboundary region. Table 4 shows the number of stations by country and water quality indicator. Table 5 shows the number of stations by transboundary region and water quality indicator.

Table 2. Number of Stations Sampling, Generating, or Reporting Data, by State[a]

State	Total Number of Stations	Number of Stations with Flow Data
United States		
California	114	7
Arizona	12	0
New Mexico	30	0
Texas	276	146
U.S. Total	*432*	*16*
Mexico		
Baja California	7	0
Sonora	1	0
Chihuahua	2	0
Coahuila	2	0
Nuevo León	1	1
Tamaulipas	4	0
Mexico Total	*17*	*1*

[a] Some monitoring stations were not assigned to a country or state because of inconsistencies between the station description and the reported latitude and longitude (e.g., coordinates that were not in the state in the description or in the study area at all).

Table 3. Number of Stations Sampling, Generating, or Reporting Data, by Transboundary Region[a]

Transboundary Region	Total Number of Stations
Pacific/Salton Sea	119
Colorado River/Sea of Cortez	5
Central Desert/Closed	18
Rio Grande	147
Lower Rio Grande	160
Total	449

[a] Some monitoring stations were not assigned to a region because of inconsistencies between the station description and the reported latitude and longitude.

Table 4. Number of Stations Sampling, Generating, or Reporting Data on a Water Quality Parameter, by Country[a]

Water Quality Parameter	U.S	Mexico
Fecal coliform	203	16
Fecal streptococci	5	5
Chlorophyll a	214	3
Sulfate	270	9
TDS	27	11
Chloride	279	10
DO	305	12
Conductivity	280	13
COD	51	12
Inorganic Nitrogen	21	0
Phosphorus	276	2
Organic Nitrogen	37	7
Nitrogen	269	5
Nitrite	224	7
Orthophosphate	268	11
Nitrate	150	5
Ammonia	321	9
Nitrite and Nitrate	286	2
BOD	108	13
pH	376	14
Temperature	399	13
TSS	22	13
Total Solids	10	9

[a] Totals do not add to stations totals in Table 3 because each station may sample multiple parameters.

Table 5. Number of Stations Sampling, Generating, or Reporting Data on a Water Quality Parameter, by Transboundary Region

Water Quality Indicator	Transboundary Region				
	Pacific/Salton Sea	Colorado River/Sea of Cortez	Central Desert/Closed	Rio Grande	Lower Rio Grande
Fecal coliform	10	4	7	122	103
Fecal streptococci	1	4	0	6	1
Chlorophyll a	12	1	4	115	112
Sulfate	53	6	15	134	106
TDS	12	4	1	17	6
Chloride	51	6	18	139	110
DO	57	6	16	132	139

(continued)

Table 5. (continued)

Water Quality Indicator	Transboundary Region				
	Pacific/Salton Sea	Colorado River/Sea of Cortez	Central Desert/Closed	Rio Grande	Lower Rio Grande
Conductivity	78	6	10	107	119
COD	1	4	0	17	43
Inorganic Nitrogen	0	0	7	14	0
Phosphorus	43	0	18	133	113
Organic Nitrogen	12	4	7	21	2
Nitrogen	37	1	18	134	112
Nitrite	80	4	8	84	76
Orthophosphate	51	4	9	129	117
Nitrate	21	3	0	79	72
Ammonia	82	4	18	142	115
Nitrite and Nitrate	61	2	18	128	106
BOD	7	4	1	43	73
pH	109	6	18	150	141
Temperature	108	6	17	154	164
TSS	13	4	2	14	4
Total Solids	2	4	1	10	4

3.2.2 Data Gaps

Although some water quality indicators have been measured consistently at many stations for years, important data gaps occur in all regions. For the purposes of this project, a data gap may be defined as the lack of values for some parameter at a given monitoring station at a given point in time, provided that the monitoring station was supposed to collect data for that parameter at that time. A data gap can be of three types:

- **Temporal:** data for a given parameter were expected at a monitoring station or location at a specific point in time. The station might have collected data at other times for that same parameter.
- **Spatial:** data for a given parameter were expected at different times at a location or locations. These locations may or may not have monitoring stations. Other nearby monitoring locations might have collected data for that same parameter at the same period of time.
- **Combination of spatial and temporal:** a data set with a parameter that is monitored on a given segment of a river does not have any data records for different points of the river at different points in time.

Temporal gaps affect trends analyses. In general, the fewer temporal gaps we have for a given parameter at a given monitoring station, the better the trends analyses. Appendix G documents the temporal data gaps found for the water quality parameters of interest.

Spatial gaps can be important when determining water quality status for a particular river segment. Recent data are preferable for establishing water quality status based on water quality standards, water designated use, and stream flow level; therefore, it is important to address spatial and temporal data gaps within five years of a water quality status study.

Spatial gaps can be determined for each transboundary region based on simple observation of water quality monitoring station locations on the maps of each region presented in Section 2:

- In the ***Pacific/Salton Sea Transboundary Basins***, a few water quality stations are located in the Tijuana Watershed, on the Tijuana River on the U.S. side, but there are no stations on the Mexico side. Water quality monitoring stations could be added to the Repository for rivers such as Arroyo Florido, Rio de Las Palmas, or Arroyo Seco to fill in spatial gaps. Many monitors are located near the Sweetwater River, Sweetwater Reservoir, and the San Diego Bay. Some stations are located near other important rivers and waterbodies such as the Mission Bay, San Diego River, and San Dieguito River. To the east, many stations are located at the Salton Sea and its tributaries, the Alamo River, and the New River. In Mexico, no stations are found in the Repository for Laguna Salada.
- For the ***Colorado River/Sea of Cortez Basin***, the Repository does not include many stations for the Colorado River and just a few for the Gila River. The Repository has no stations from the Mexico side mainly because these are desert areas. Spatial data gaps also exist along the Lower Colorado River and Lower Gila River.
- For the ***Central Desert/Closed Basins***, the repository includes data from many stations for the most important rivers: the Santa Cruz River and the San Pedro River. Data are sparse for the Mimbres River and there are no stations on the Mexico side stored on the Repository.
- The ***Upper Rio Grande Basin*** has plenty of monitoring stations on the Rio Grande from the Elephant Butte Reservoir to El Paso/Juarez, but just a few on the segment of Rio Grande from El Paso/Juarez to Amistad Reservoir. There are also a few stations at the Pecos River and a few stations downstream of Amistad Reservoir. More data from stations on the Rio Conchos and other Rio Grande Mexican tributaries could be added to the Repository if they exist. Additionally, more sampling points could be used along the Rio Grande above International Falcon Reservoir.
- The ***Lower Rio Grande Basin*** has just a few stations below International Falcon Reservoir and above Anzalduas Dam. On the Mexico side, there are a couple of stations on the Rio San Juan and Rio El Alamo, both tributaries of Rio Grande. There are plenty of stations on the Arroyo Colorado, Laguna Madre, and South Bay. More data from stations on the Rio Grande from Anzalduas Dam to the South Bay estuary are needed if they exist.

One additional kind of spatial gap is the case when a river or segment of a river has a number of monitoring stations, but those stations do not all collect data for the same water quality parameters. If an analysis requires evenly located data on a river segment for a given parameter, this can pose a data gap for that particular analysis. For example, stations TCEQ-15561, TCEQ-15562, TCEQ-15563 and TCEQ-15561 are located on the Arroyo Colorado at the Lower Rio Grande Basin with a maximum distance of 4 km between the stations. Dissolved oxygen, pH, and turbidity are monitored at all four stations, but chlorophyll a, chloride, and sulfate are monitored only at stations TCEQ-15561 and TCEQ-15562.

Data gaps can also be caused by missing data elements in the source data. These records cannot be entered into the Repository because necessary data fields, such as locational information (latitude and longitude), are missing from the data set.

3.2.3 Finding 1: The Variability of the Study Area Makes It Difficult to Draw General Conclusions

The border region reflects great diversity in geography, physiography, and hydrology. This diversity affects how monitoring stations collect information and what kind of information monitoring stations collect. For example, a station on the Salton Sea will be very different from a station on the Rio Grande, and there are differences between the upper Rio Grande, which has been dramatically altered by reservoirs and irrigation infrastructure, and the lower Rio Grande, which is a delta/estuary. As a result, it is difficult to draw general conclusions about water quality status along the border. However, conclusions can be drawn about individual border segments of similar character.

Water quality comparisons can be done for specific data points, but standards vary by state, and variability is so great that it can be difficult to draw general conclusions about water quality even for a single watershed. We can select specific monitoring stations located along a given river segment or lake/reservoir and use recorded water quality data to reach some conclusions about that river segment status. As shown in the examples included in Appendix D, the analyst first selects a benchmark value from existing water quality standards assigned to that river segment for a particular use category. Next, the analyst compares each water quality reading from the monitoring stations with the benchmark. The analyst will then determine the percentage of data points exceeding the benchmark. For example, the analyst can find out that 50 percent of the data points recorded on a station for a particular parameter (e.g., nitrates) are exceeding the established water quality standard for that segment.

Recommendations: Because of the diversity of the study area, water quality conditions should be analyzed and assessed in smaller segments or watersheds along the border. The development of indicators (see Section 4) should also consider the complex framework of water management and use that impacts water quality in the border region.

3.2.4 Finding 2: The Lack of Unified Water Quality Standards Leads to Ambiguity in Assessing the Status of Waterbodies that Cross the Border

Water quality standards in the four U.S. border states have been established for different waterbodies and rivers, for many pollutants, and for different use categories. As in the United States, Mexico has also adopted surface water quality standards for some pollutants based on use categories. In most cases, water quality standards differ between the two countries. Even within the United States, water quality standards vary from state to state, and in some cases, water quality standards may vary from one river segment to another, depending on use and other waterbody characteristics. The lack of unified water quality standards leads to ambiguity in determining the status of a stream or waterbody that crosses a national or state border.

Recommendation: While acknowledging the many difficulties inherent in reaching a binational consensus on border water quality issues, the stakeholders have expressed their desire to work towards the creation of a unified body of water quality benchmarks. A unified set of benchmarks would help with the implementation of equivalent sampling and analytical methods on both sides of the border, which would improve the comparability of the data in the Repository and enable the use of these data to assess water quality for the shared waters in the border area. A unified set of benchmarks is therefore an important first step in developing and implementing a measurement program for effective indicators of water quality in the border region. (Section 4 provides suggestions for developing and applying such indicators.)

3.2.5 Finding 3: The Repository Contains Far Less Data for Mexico than the United States, Making Balanced, Binational Analysis Difficult

The Repository contains surface water quality data for a number of monitoring stations on the U.S. side of the border, located on rivers and streams, springs, lakes and reservoirs, and canals, as well as at facilities. However, there are far less data in the Repository from the Mexico side of the border, with data points from a very limited number of locations. These locations identified latitude and longitude; the date when the reading was made; and the parameter name, value, and units, but do not include metadata about sampling or analytical methods used to obtain the value. This disparity in quantity and completeness of data makes it difficult to conduct balanced, binational analysis.

Recommendations: We identified additional sources of Mexico water quality data late in this study. These sources should be explored and considered for inclusion in the next phase of the project. In addition, the Mexico stakeholders have expressed a desire to continue efforts to identify additional data sources that may contain metadata for existing stations, but have requested a Web-based system to facilitate review of the data they have contributed and input of new data to the Repository as available. The next steps on the project should include implementation of a simple Web site to allow secure data uploads and downloads to facilitate this data exchange. Finally, Phase 2 of the project could support field work in Mexico to position new monitoring points to fill spatial data. Global positioning system (GPS) technology can be used to accurately position such points and locate important sources of water pollution, such as discharges from industrial facilities and wastewater treatment plants.

3.2.6 Finding 4: The Lack of Flow Data in the Repository Hinders Analysis

The Repository currently includes only a small amount of flow data from STORET and NWIS. Flow data are needed for the following kinds of analyses:

- Water quality status analyses where standards are established based on flow levels
- Water supply/demand studies, water budget analyses, and general watershed hydrology studies that can complement water quality analyses
- Detailed pollutant modeling on a given watershed.

Recommendation: To enable such analyses, additional flow data can be added to the Repository for targeted waterbodies or (as available) for the entire border area. We are aware of the availability of large records of flow data collected by IBWC (and available on their Web site) for the Rio Grande/Rio Bravo. In addition, data from the USGS NWIS system should be fully accessed and included in the repository.

4.0 Developing Water Quality Indicators for the U.S.-Mexico Border

The Border 2012 program mandates that water quality indicators be developed and used to demonstrate real, meaningful, and measurable results in meeting the goals of Border 2012. To ensure that these goals are met and to increase overall capacity to respond to environmental and health problems at the border, the Border Indicators Task Force (BITF) was established in December 2003. The role of BITF is to coordinate with all Border 2012 groups and stakeholders to define a set of indicators and develop protocols for the collection, analysis, and quality control of the data necessary for the calculation and interpretation of those indicators.

Indicators are useful, informative tools when they are related to a conceptual framework that holistically describes the interactions within a system. The Pressure-State-Response (PSR) conceptual framework has been used as a starting point to help define needed border area indicators. This model follows a linear logic where a pressure causes a change in state, which then evokes a response. More recently, the Driving Forces-Pressure-State-Impact-Response (DPSIR) conceptual framework, an extension of the PSR model, has been applied in developing a conceptual framework more suitable for Border 2012 needs. DPSIR seems well suited to the Border 2012 program because it allows for the identification and analysis of relationships between border-specific development actions and the effects produced on the environment and human health. The enhanced understanding of these relationships would allow policy makers to develop the region in a sustainable manner, aware of potential environmental and human health consequences. Additional information on the emerging Border 2012 Program's *Strategy for Indicator Development* is available at http://www.epa.gov/usmexicoborder/pdf/indicator_strat.pdf.

Indicators can be used on either an ongoing basis or for a finite period of time. Regardless of the length of data collection or indicator usage, a review process is necessary to evaluate the performance of the indicator. What may be a useful indicator now may change with time, given the development of technology, further improvements along the border, changing needs of the public, or increased insights in policy or science. The BITF proposes that a review occur two years after an indicator is first implemented and then every five years thereafter. At a minimum, the review should answer the following questions:

- **Purpose**—Why was the indicator developed?
- **Data collection and management**—What protocol was followed?
- **Data reliability**—Is the source reliable?
- **Quality assurance**—How accurate and precise are the data?

- **Information**—What does the indicator convey? Is it true to its purpose? How does the information compare to the standard?
- **Limitations**—What are the outstanding gaps or limitations of the indicator?
- **Conclusion**—Are the data useful and should the indicator continue to be used?

Parameters that could be applied in the development of water quality indicators are included in recommendations for a *Binational Set of Indicators for the Border 2012 Program* (available at http://www.epa.gov/usmexicoborder/pdf/indicators_set.pdf). These materials cover several types of proposed environmental indicators, with the aim of stimulating discussion and consideration among the various workgroups regarding the appropriateness of the indicators for measuring program progress and assessing environmental and health changes in the region's conditions.

This list of potential indicators, given further refinement, will eventually become the official *Binational Set of Indicators for the Border 2012 Program*. Environmental indicators to support Goal 1 (Reduce Water Contamination) include the set of 12 physical, chemical, and biological parameters related to surface water quality conditions that were selected for data collection and entry in the U.S-Mexico Border Waters Repository (see Section 3.1.3). The Repository has assembled all readily available ambient monitoring data related to this set of parameters. As described in Section 3, the Repository provides a good platform to investigate different alternatives for developing the needed 2012 water quality state indicators. As illustrated in Figure 7, this development process would lead to indicators that are consistent with the overall Border 2012 conceptual framework.

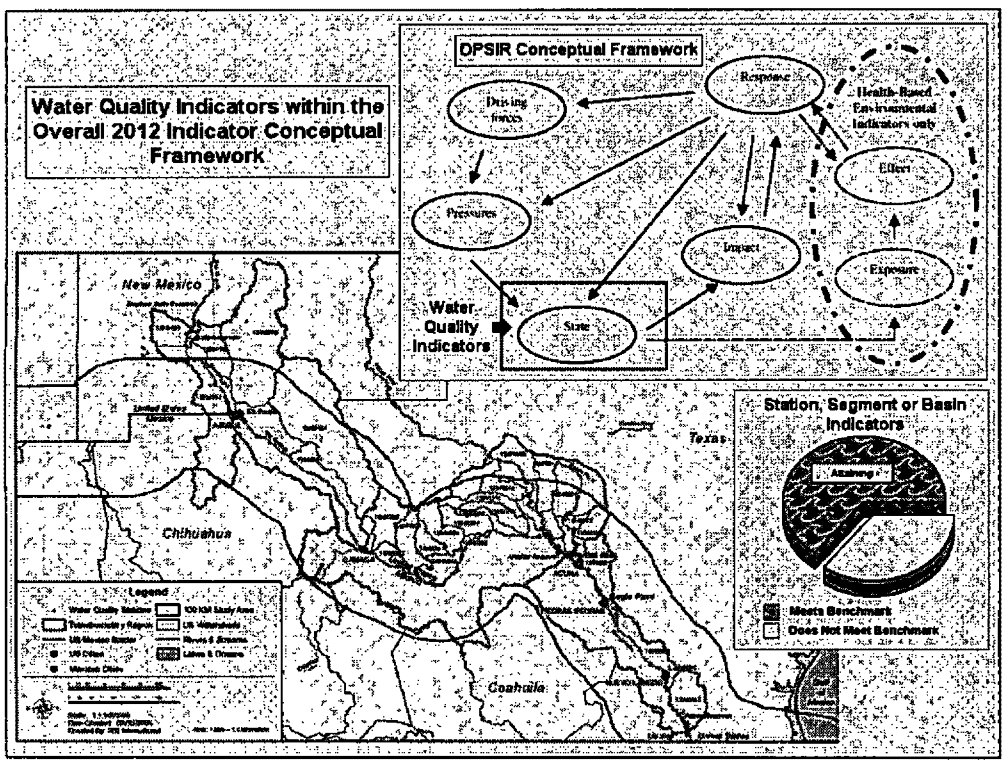


Figure 7. Process for developing water quality indicators within the Border 2012 conceptual framework.

The parameters in the Repository include measures commonly applied directly in water quality standards criteria and measures, such as COD and BOD, commonly used in permits to achieve pollutant discharge reductions needed to safeguard the standards for receiving waters. The proposed indicators include parameters related to the protection of aquatic-life designated uses and other parameters (e.g., fecal coliform) related to human-health–oriented body contact recreation uses. Microbial parameters are also used as indicators to safeguard drinking water uses, as are parameters such as chlorides and sulfates as applied to inland fresh waters (river and lakes). Table 6 summarizes these considerations for the different Border 2012 parameters collected in the Repository.

Table 6. Repository Parameters Related to Aquatic Life or Public Health Uses and Typical Applicability as Ambient Water Standards or for Use in Permitting

Water Quality Indicator	Aquatic Life Support Uses	Public Health Uses	Ambient Water	Permitting
Fecal coliform		•	•	•
Chlorophyll a	•		•	
Sulfate[a]		•	•	•
TDS[a]		•	•	•
Chloride[a]		•	•	•
DO	•		•	
Conductivity[a]		•	•	•
COD	•			•
Orthophosphate	•		•	
Nitrate	•		•	
Ammonia	•		•	•
BOD	•			•
pH	•		•	•
Temperature	•		•	•
TSS	•		•	•

[a] Applied mainly to inland fresh waters.

Water quality indicators for major uses of water resources can be related to the water quality standards developed under both U.S. and Mexican water quality management programs. The parameter criteria from these water quality standards can be combined with appropriate benchmarks (or norms) to define indicators of the environmental state or condition of individual monitoring standards or associated assessment segments. The site-specific indicator information can then be aggregated over larger geographical units such as basins. The Interagency Task Force on Monitoring (ITFM), a joint EPA and USGS initiative, helped establish a framework for applying available water quality monitoring information to establish water quality indicators for the status and trends tracking of environmental conditions. The ITFM work showed how broad categories of environmental indicators—for instance, ecological health or human health concerns—can be related to major types of water uses that can represent specific management objectives. These management objectives are analogous to the designated uses that U.S. states set in their water-quality standards and report to the U.S. EPA as part of the Clean Water Act's Section 305(b) Integrated Reporting process.

The work of ITFM continues through the USGS-sponsored interagency Water Information Coordination Program and the Advisory Committee on Water Information (http://water.usgs .gov/wicp/). These interagency initiatives are based on directives in the Office of Management and Budget (OMB) Memorandum No. 92-01, which designates DOI, through USGS, as the lead agency. Other U.S. federal organizations (including the EPA) that fund, collect, or use water resources information work with USGS to implement program recommendations. Documents stemming from the work of ITFM can be found at http://water.usgs.gov/wicp/itfm.html. The work of ITFM has been very influential for EPA in the design and ongoing enhancement of the performance measures used in EPA programs as part of the Government Performance and Results Act or the related OMB Program Assessment Rating Tool systems.

Outcome indicators similar to the water quality indicators recommended for development by the Border 2012 initiative are found in performance measures EPA is developing (http://www.epa.gov/ water/waterplan/) for programs operating within the United States and for special measures under development dealing with water quality standards attainment for waters in the U.S.-Mexico border area. These proposed outcome measures related to the evaluation of programs in the United States under the Clean Water Act can be developed in ways that compliment the Border 2012 indicator initiatives, thus achieving significant efficiencies in creating and maintaining the data infrastructures needed for operational status and trends outcome measures. Further information on EPA reporting measures relevant to the development of Border 2012 water quality indicators can be found in the *National Water Program Guidance: FY 05 Midyear Reporting on Final Measures and Commitments* (available at http://www.epa.gov/water/waterplan/documents/ FY05measuremidyeardata.pdf).

The major actions needed to apply information in the Repository are to select appropriate benchmarks (or norms) to help interpret the parameter information relative to concepts of designated use attainment or non-attainment. Benchmark information can be taken for either implemented water quality standards criteria or from the national criteria guidelines developed by EPA or corresponding Mexican government agencies that guide management programs delegated to states and other water resource agencies. These benchmarks are typically applied according to major waterbody types (e.g., rivers, lakes, and estuaries/near coastal waters). The benchmarks can also be organized according to major designated use categories (e.g., aquatic life support and public health uses).

To facilitate checks on data adequacy and help pinpoint areas where there may be apparent data gaps, the indicators would be developed parameter by parameter for assessment segments in the vicinity of the primary ambient monitoring sites. This site-specific information could then be analyzed for its suitability in creating indicators for larger geographic units, such as border area basins (e.g., the Rio Grande Basin). Such basin-level indicators could be organized by waterbody type, major designated use category (aquatic life or public health), and parameter. Because data gaps are likely to exist for some parameters within a basin, the organization in terms of designated use categories will be helpful in taking available parameter information to develop indicators of use attainment. This development approach would be consistent with practices followed in Clean Water Act assessment programs in the United States and would help provide indicators of immediate value to ongoing management activities in the border area.

5.0 Mexico Border Reach File

The MBRF is a prototype product created using a method similar to the one used to create the U.S. National Hydrography Dataset (NHD), which is a comprehensive set of digital spatial data that contains information about such surface water features as lakes, ponds, streams, rivers, springs, and wells. Within the NHD, surface water features are combined to form "reaches," which provide the framework for linking water-related data to the NHD surface water drainage network.

5.1 Methodology

The MBRF prototype was created to showcase the potential of an NHD-like hydrographic network in Mexico in which all waterbody and river reaches are uniquely identified and linked in a network. RTI then reach indexed the water quality monitoring stations to the MBRF so that each station was uniquely identified by a river or lake reach in the network. The reach indexing, or pinpointing, of stations onto the MBRF was possible because of the MBRF's unique networking features and the existence of latitude/longitude information for a given station. The reach indexing itself was made possible by the existence of tools such as EPA's Reach Indexing Tool (RIT). Because each station was indexed to the MBRF network, all the water quality data related to the stations can be also related to a unique point in the MBRF network. This prototype shows the potential of what a future official Mexican reach file can do to perform water quality modeling and assessments in the entire Mexican territory.

The MBRF was derived from several initial shapefiles[2] received from CNA. CNA had already appended the linework into a large national-scale file comprising the northern portion of Mexico. There were no cataloging unit (CU) boundaries, and no NHD data existed that could be conflated (transferred) onto the Mexican linework. Despite these differences, it was possible to alter the attribute information stored on the nodes, lines, and polygons of the Mexican linework so that the NHD Create software could operate on it. To create an NHD-style data set, RTI used NHD Create to append the linework and conflated existing reach codes from the NHD data onto the linework.

CNA also provided point name data, which could be converted to something that emulates the U.S. Geographic Names Information System (GNIS). This was not done because the linework from CNA did not include name data and the level of effort to manually assign point names to linear features (and thereby name) a relatively small number of reaches using tools in NHD Create was deemed excessive.

Appendix H explains the process of creating the MBRF in detail.

The prototype MBRF can be used to showcase the functionality of reach indexing water-quality–related information to a hydrography network. The monitoring stations on the Mexico side, and therefore all the water quality data contained within the stations, were reach indexed using

[2] A shapefile is an editable spatial database format generated in the desktop software application ArcView that stores the location, shape, and attribute information of geographic features.

EPA's RIT to illustrate how different tools can be combined to provide more valuable information for water quality analyses and modeling.

5.2 Findings and Recommendations

The MBRF represents an initial step to creating a NHD-like geographic information system (GIS) hydrography layer for the Mexican side of the border. Another attempt to create a binational hydrography was made by the University of Texas at Austin (UTA). UTA has created a hydrologic geodatabase for the Rio Grande/Rio Bravo Basin using ArcHydro and available data from either side of the border. Some important findings relating these efforts include the following:

- The raw linework obtained from CNA to create the MBRF was acceptable, although some connectivity and arc direction issues surfaced that will need to be corrected in the next version. The final MBRF network is functional, but it requires further editing to ensure proper connectivity and flow direction.
- Additional editing is required to include reach names.
- The Rio Grande is depicted as it was in the original linework. Considerable effort will be required to integrate the U.S. side into the Mexican data set. Because of scale and CU delineation issues, a complete integration of the U.S. and Mexican systems many not be feasible.
- UTA's Rio Grande basin geodatabase has some advantages over the MBRF: it is built in a modern, flexible geodatabase format called ArcHydro, and the hydrography linework has been edited to obtain good flow characteristics. UTA's geodatabase also contains higher quality linework for the Rio Grande/Rio Bravo basin than does the MBRF.

Based on a review of these two efforts, the U.S.-Mexico Border Waters stakeholders group has come to the conclusion that the ArcHydro model developed by UTA provides the best option for developing a GIS hydrography layer for the Mexico side of the border because the ArcHydro data model is more flexible and does not require strict definition of hydrologic units as part of the feature-naming conventions. The NHD-based hydrography developed for this project can be easily imported into ArcHydro. Future enhancements should include completing the ArcHydro hydrographic dataset for the entire border, using the available NHD creation tools as appropriate and importing the resulting coverages into ArcHydro. This development could include development of metadata standards similar to those established for the NHD. Additional study and collaboration between U.S. and Mexico stakeholders is needed to develop a detailed approach for developing the Mexican GIS ArcHydro hydrography coverage for the border area and developing options for linking that network to the NHD coverage on the U.S. side.

6.0 Future Work

The U.S.-Mexico Border Waters project represents a very important first step towards the creation of a multidisciplinary and multiorganizational team that will identify needs on water resources management along the border. It is important to identify funding sources and obtain resources to build on this effort by performing studies and improving these tools to help reach the goals set forth by EPA's Border 2012 program and other programs pursuing the improvement of the quality of the shared waters in the border area.

Future phases of this project need to build on the extensive expertise of organizations that have worked on environmentally related issues in the border area, such as SCERP, UTA, University of Texas at El Paso, San Diego State University, New Mexico State University, Arizona State University, University of Utah, Universidad Autónoma de Baja California, Universidad Autónoma de Sonora, and other universities in Mexico and the United States. CNA, CILA, and IBWC have also built on their own expertise working on border water resources issues. SCERP is currently developing a Transborder Watershed Research Program that focuses on land use practices in the San Pedro and Tijuana watersheds. Other organizations are currently working on a variety of projects with the goal of improving the human condition on the U.S.-Mexico Border.

Many different future activities have been identified during the development of this project, to be proposed and prioritized for completion on subsequent phases. The completion of this report in particular has shed light on how the U.S-Mexico Border Waters Repository can be enhanced and improved as new benchmarks are developed and information become available, and on how robust indicators can be developed to measure improvements in water quality conditions for the shared waters along the border.

The implementation of more sophisticated analytical methodologies will become possible as more water quality data are stored and maintained in the Repository and benchmarks and indicators are further developed. The addition of GIS-based tools and the georeferencing of water-quality related data will also provide us with the opportunity to perform more statistically sound and realistic analyses to support the border water assessment efforts. The creation of the MBRF prototype and the georeferencing of stations show the potential of combining water quality data with GIS-based tools.

6.1 Maintaining and Enhancing the Repository

The U.S.-Mexico Border Waters Repository can be enhanced by adding new data standards as they become available. These standards, such as EPA's ESAR standards, try to create uniformity among the different existing repositories such as STORET and other surrogate systems. CNA may consider the benefits of including some of these data standards into its own water quality system (Sistema Nacional de Información de la Calidad del Agua [SNICA]) and by transferring the water data already collected and stored in the Repository.

The Repository should be migrated to a more robust relational database management system, such as the commercial ORACLE or SQL Server systems or open source systems such as MySQL or PostGRESQL. This migration would ensure referential integrity of data and provide enhanced security and user management tools. A graphical user interface can be built on top of the Repository to facilitate data entry and maintenance. The Repository could also be enhanced with additional lookup tables to provide more thematic information related to water resources and to allow for simpler and more powerful querying of the stored data.

An important next step is a Web-based system to provide tools to enable the Mexico data providers to review and verify Repository data, edit data already in the Repository, and upload additional water quality data into the system.[3] Such a data verification and input tool would help automate the review and update processes for a distributed client network making use of modern Internet-based techniques, and is especially critical as a way to fill the data gaps on the Mexico side of the border. This data verification tool would query the underlying relational database tables to produce data formats that would be convenient for end users to examine and verify their water quality information. Similarly the tool could provide table formats to enable data providers to conveniently upload data to the Repository.

Future Repository enhancements could include

- Mechanisms to allow uploads of additional water quality (or flow) data for established stations
- Tools to provide basic locational information for both established and new stations (a streamlined locational tool to help in verifying lat/long station locations)
- Analytical programs to provide basic summary statistics on data availability for individual stations, and for groups of station over defined watershed basins, to help identify where sufficient data are available to move forward to develop Border 2012 indicators and where there are still data gaps.

As end users provide additions or corrections to the Repository, the Web-enabled system could be periodically refreshed with updates to these basic summary statistics.

6.2 Water Quality Analysis

Water quality analyses and modeling can be scaled up to accommodate more variables and scenarios as more data and tools are incorporated into the Repository. The Repository can become a key component within a decision support system that includes GIS-based analysis tools, mapping tools, and Web interfaces for downloading additional information. Water quality analysis and modeling would then be able to better simulate the complex universe behind water resources and uses on the U.S.-Mexico border.

One of the key ideas stemming from this project is to create a decision support tool for Mexico that incorporates some components of SNICA, the Repository, the MBRF prototype, and analysis tools from EPA's BASINS (Better Assessment Science Integrating Point and Nonpoint Sources). This decision support tool should be tested for a watershed on the border, most likely on the Rio Grande/Rio Bravo watershed because an important project has already been developed there by UTA. This effort would require, among other activities, the collection of flow data for the most important rivers on the border watersheds, the georeferencing of industrial discharge points in Mexico, and the acquisition and storage of industrial discharge data from Mexico. CNA has expressed its interest in pursuing this effort to enhance SNICA and to build upon its current system by incorporating publicly available tools such as BASINS.

[3] Because Repository data for the U.S. side of the border is extracted directly from existing EPA and USGS systems (STORET and NWIS) that have extensive data quality measures in place, a data upload and verification system is not needed for the U.S. data.

6.3 Mexico Border Reach File

The completion, demonstration, and use of an MBRF is needed at the next stage of this project to relate water quality information to an ArcHydro-based network of the Mexican hydrographic system and to convey the advantages of having reach-indexed water quality data for future water quality analyses and modeling. This could also be a first step towards creating an official national Mexico hydrography network. Training of officials from CNA, CILA, and other Mexican agencies on the MBRF and BASINS are also proposed activities for subsequent phases.

During the stakeholders meeting in Juarez in November 2004, two resource intensive activities were identified as future needs for subsequent phases. One of these activities is the geopositioning of all wastewater and industrial discharges on both sides of the border using global positioning system (GPS) equipment. It was proposed that SCERP could help with students from the different universities in their Consortium to assist in getting this information.

The other identified activity was the use of remote sensing techniques to identify water quality indicators, with emphasis on the Rio Grande. Mexican and U.S. agencies are very much interested in implementing this technology because it can identify pollution sources and measure indicators via satellite imagery, reducing considerably the costs of sampling and monitoring necessary to measure progress towards improving water quality conditions for the shared waters of U.S. and Mexico.

7.0 References

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Appendix A

Detailed Study Area Descriptions

This Appendix provides more detailed descriptions of the geography and hydrology of the five transboundary regions that make up the study area. These summaries draw heavily on previous work on the U.S.-Mexico border project conducted by Parsons Engineering Science, Inc. (U.S. EPA, 2000), as well as USGS factsheets for three of the basins (Central Desert/Closed Basins: Papoulias et al., 1997; Rio Grande Basin: Blackstun et al., 1996; and Lower Rio Grande Basin: Buckler et al. 1997).

A.1 Pacific/Salton Sea Transboundary Basins

The Pacific/Salton Sea Basins contain watersheds that drain either to the Pacific Ocean or to inland seas. The basins drain an area of 14,000 square miles (36,000 km^2). These basins have a very dry, semiarid climate with few fresh water resources. Flow is primarily from east to west, with stream flows originating from precipitation in the mountains flowing toward the Pacific Ocean. The flow in these streams is controlled through a series of hydraulic structures, including reservoirs. The Tijuana River is one of the main streams in the basin and one of the City of Tijuana's major natural resources. The river flows northwest through the city of Tijuana before crossing into California near San Ysidro and then flowing into the Pacific Ocean. Figure A-1 shows the Pacific/Salton Sea Basins and their most important characteristics.

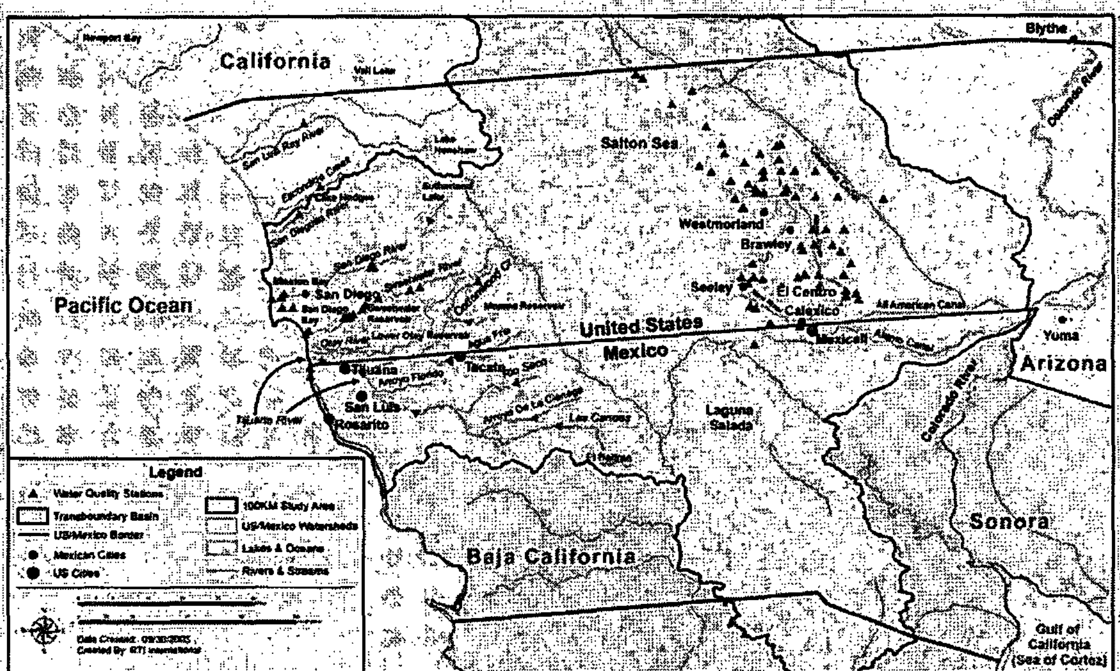

Figure A-1. Pacific/Salton Sea Basins.

A.1.1 Geography of the Pacific/Salton Sea Basins

The San Diego, Cottonwood-Tijuana, and Salton Sea watersheds are the most important watersheds within the Pacific/Salton Sea Basins. They also cover part of the North-East Baja California basin in Mexico.

The San Diego watershed encompasses San Diego County, parts of southwestern Riverside County, and southwestern Orange County. It comprises three distinct areas: the coastal plain, the central mountain valley area, and the eastern mountain valley area. The coastal plain ranges from sea level to about 1,200 feet (370 m) above sea level and extends for 10 miles (16 km) inland from the coast. The central mountain valley area is characterized by ridges and basins, which extend from the coastal plain northeast to the Elsinore fault zone. The basins range in elevation from 500 to 5,000 feet (150 to 1,500 m) above sea level, with the exception of the El Cajon area, where the mountain elevation reaches only 1,500 feet (1,500 m). To the northeast of the Elsinore fault zone, in the area known as the eastern mountain valley area, the valleys range from 1,000 to 3,500 feet (300 to 1,100 m) above sea level, while the surrounding peaks reach elevations of 4,000 to 7,500 feet (1,200 to 2,300 m).

South of San Diego, the Tijuana watershed is separated from the San Diego watershed by the San Isidro and San Miguel Mountain range at the southern end of the San Diego County, and by the Sierra Juarez in Mexico. The highest mountain elevation is Sierra Juarez at 6,500 feet (2,000 m) above sea level.

Land use varies considerably and ranges from urbanized areas to wilderness such as the Cleveland National Forest. Major cities include San Diego in California and Tijuana, Tecate, Rosarito, and Ensenada in Baja California. Smaller cities and towns include Descanso in California; various suburbs of San Diego; and Valle Bonito, San Luis, and La Joya in Baja California.

There are also numerous Indian lands on the U.S. side of the border, including the Campo, La Posta, Manzanita, Cuyapaipe, Barona Ranch, Capitan Grande, Cahuilla, Santa Rosa, Pechanga, Mission, Pala, Rincon, La Jolla, San Pasqual, Los Coyotes, Santa Ysabel, and Mesa Grande Reservations. The northern part of the basin encompasses the Camp Pendleton Marine Corps base, and further down along the coast are many scenic beach areas, on both the Mexican and U.S. sides of the border.

The Tijuana watershed serves as habitat for coastal shrubs and a chaparral ecosystem that extends from Baja California into California near the Pacific Ocean. This chaparral ecosystem gives way to pine forests and coastal vegetation along valleys and intermittent streams. Among the more serious threats to this ecosystem are erosion and slope instability. Increased sedimentation from urbanization and unregulated road development has negatively affected the flora and fauna and has also significantly affected other resources in the area. In addition to erosion and sedimentation concerns, estuarine and wetland areas have been reduced significantly in this basin, to the point where only 20 to 40 percent of the original wetland area remains intact. The watershed also contains several environmentally sensitive areas, such as the Tijuana River Estuary, which straddles the U.S.-Mexico border. The estuary is approximately 2,000 acres (800 hectares) of salt water marsh with several stretches of open water. The estuary is generally open to the ocean, and its water quality generally is the same as that of the shoreline open ocean waters. However, during periods of excess runoff, a variety of wastes originating upstream in the Tijuana River in Mexico can be carried into the estuary. Tidal flushing is considered to be crucial to the estuary's health, and thus a program to control erosion, manage sediment, and strategically dredge parts of the estuary has been initiated.

In the North East Baja California basin, the major surface water is Laguna Salada. The Sierra Juarez range discharges surface runoff to the Laguna Salada. As the range slopes towards the Sea of Cortez, the mountains give way to sand dunes and wetlands. Of these dune areas, one of the most important is Constitution National Park, located south of Laguna Salada, which has been designated as a protected area by the Mexican government.

The Salton Sea watershed stretches north from the northeast section of Baja California in Mexico into the southeast portion of California in the United States. The watershed has a gross contributing drainage area of 7,500 square miles (19,000 km^2), most of which is in the United States. The western boundaries of the watershed are contiguous with the western boundaries of the Imperial Valley and the eastern side of the Anza Borrego area in California. To the north, the basin is bounded by the Salton Sea along California Route 10 from the San Bernardino National Forest through the Joshua Tree National Monument and to the Colorado River, which forms the eastern side of the boundary. The southern boundary of the watershed is formed as the Imperial Valley lowlands drop to the Sea of Cortez.

The watershed's central feature is the flat, fertile Imperial Valley. The Imperial Valley consists primarily of farming communities, although there are several larger cities in the basin, including the border city of Mexicali in Baja California, a thriving manufacturing center. The main communities in the watershed on the U.S. side of the border are Calexico, El Centro, and Brawley, which are all located along California Route 86 east of the New River. Other communities within the basin area on the California side of the border include Blythe, Indio, Palo Verde, Salton Sea, Seeley, and Westmorland.

A.1.2 Hydrology of the Pacific/Salton Sea Basins

The mountain ranges running along the coasts of California and Baja California divide the precipitation falling there: precipitation that falls on the western slopes flows toward the Pacific Ocean, and precipitation that falls on the eastern slopes flows east into the Imperial Valley and the lands below Mexicali and on into the Sea of Cortez. In California, a series of stream systems originating in the highlands flow west to the Pacific Ocean. These streams include the Aliso, San Juan, San Mateo, San Onofre, San Marcos, and Escondido Creeks, and the Santa Margarita, San Luis Rey, San Dieguito, San Diego, Sweetwater, Otay, and Tijuana Rivers. Most of these streams and creeks consist of both perennial and ephemeral segments, primarily because of man-made controls and impoundments throughout the watersheds. This has created a series of reservoirs and lakes, which include Vail, O'Neill, Henshaw, Hodges, and Sutherland Lakes, and the Lower Otay, Sweetwater, and San Dieguito Reservoirs. Further south, major streams in Mexico include the Santo Tomas Pino, Las Palmas, Las Cabaza, Agua Caliente, and El Baron.

Little rain falls within the basin, which is semi-arid. On the U.S. side of the border, 70 to 90 percent of the region's water has to be imported from northern California and the Colorado River. The basin is served by the Metropolitan Water District of Southern California (MWD), which serves more than 16 million people in the California coastal plain. The MWD manages the importation and distribution of water from the Colorado River and the California State Water Project. Small amounts of water are also available from the regional impoundments described above.

Despite the fact that most of the rivers flowing through this basin are not used for human water consumption, they are very important as natural systems that can carry pollutant loads and polluted runoff downstream. Of particular concern in this respect is the Tijuana River. The Tijuana River originates east of the city of Tijuana, Mexico, then flows west through the center of Tijuana, where it is heavily channelized. In Tijuana, the river is joined by the Alamar, another highly channelized watercourse. As the river flows west through Tijuana, it also bends north and flows near San Ysidro, California. The Tijuana River drains approximately 1,286 square miles (3,300 km^2), approximately two-thirds in Baja California and one-third in California. The river flows into the Pacific through the Tijuana Estuary, which is designated as a federal reserve by the U.S. government.

The primary hydrologic features of the Salton Sea watershed are the New River and Alamo rivers, which both flow north into the Salton Sea. The New River originates in Mexico near Mexicali, while the Alamo River intersects and receives flow from the All American Canal near Bond's Corner, California. Most of the west side of the Salton Sea basin drains to several individual internal sinks or playas, while the southern area generally drains to the Salton Sea.

The Salton Sea is the largest salt waterbody in the basin. The sea, which is located on the site of a prehistoric lake, was created in 1905 when the Colorado River breached an irrigation canal during a large flood and filled a natural depression between the Imperial and Coachella valleys in Riverside and Imperial Counties, California. The sea serves as a drainage reserve for irrigation return water and stormwater from the Coachella, Imperial, and Borrego valleys. It also receives water from the Mexicali Valley in Mexico. Replenishment of the Salton Sea comes predominantly from farm drainage and seepage, with occasional storm runoff from the Coachella Valley, Imperial Valley, and the Anza Borrego areas on the U.S. side of the border and from the Mexicali Valley on the Mexican side.

The Salton Sea is an extension of the Sea of Cortez drainage area and is 30 miles (48 km) long, about 10 to 15 miles (16 to 24 km) wide, and is 30 feet (9 m) deep on average. It has an area of approximately 360 square miles (930 km^2) and its surface elevation, although variable, is approximately 227 feet (69 m) below mean sea level. This basin has an average annual precipitation of about 2.6 inches (6.6 cm); however, in the Coyote Mountains west of the Salton Sea near Mountain Spring, California, average annual precipitation can reach 8 inches (20 cm).

The New River and Alamo River convey agricultural irrigation water from the farmlands in the Imperial Valley, surface runoff, and smaller flows from treated municipal and industrial wastewaters from the Imperial Valley.

The flow in the New River also contains agricultural drainage, treated and untreated sewage, and industrial waste discharges from Mexicali, Mexico. Surface waters mostly drain toward the Salton Sea and enter a series of canals, creeks, and washes in the Imperial Valley south of the Salton Sea. These waters are diverted on the north by the Little San Bernardino Mountains and Orocopia Mountains, on the west by the Anza Borrego Park (Vallecito and Santa Rosa Mountains), and on the east by the Chocolate Mountains.

The Colorado River is the most important waterway in the region because it supplies water for use within and outside the region. Regional drainage comes from an area of 280 square miles (730 km^2) on the west side of the Colorado River. Surface water is diverted by several dams (including the Parker, Palo Verde, and Imperial dams) into several canals and valleys. The Colorado is also the primary water source for irrigation, industrial, and domestic water via the All American Canal.

A.2 Colorado River/Sea of Cortez Transboundary Basins

The Colorado River/Sea of Cortez Basins contain watersheds that drain either to the Colorado River below the gaging station at Parker Dam, or to the Sea of Cortez (which is also known as the Sea of Cortez). These basins drain 22,590 square miles (59,000 km^2) and cover portions of the states of Arizona and Sonora.

The major surface waters in these basins are the lower Colorado River delta. From the north, the Colorado River flows into the basin through heavily urbanized areas near Yuma, Arizona, and San Luis Rio Colorado, Sonora, and then through wetlands before flowing into the Sea of Cortez. Presently, most of the water that the delta receives comes from agricultural drainage from the United States and Mexico, with little perennial flow in the lower Colorado River. Figure A-2 shows the Colorado River/Sea of Cortez Basins and their most important characteristics.

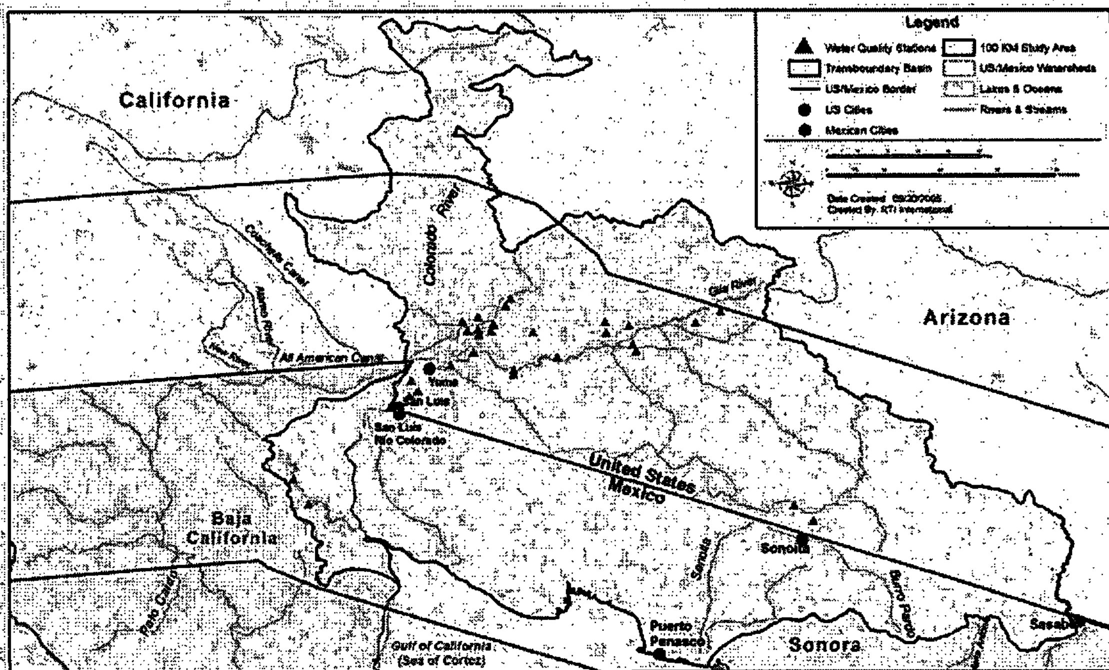

Figure A-2. Colorado River/Sea of Cortez Basins.

A.2.1 Geography of the Colorado/Sea of Cortez Basins

The Lower Gila, Gulf of California, and Colorado River watersheds are the most important watersheds within this transboundary region.

The Gulf of California watershed consists of horseshoe-shaped lowlands ringed by the Sierra Juarez and the Sierra San Pedro Martir mountain ranges to the west, and the Desierto de Altar (Sonoran Desert) and the Northwest Chihuahua highlands to the east. To the north, the Colorado River flows into the basin through a heavily urbanized area, and then through a series of swampy lowlands before ending in the Sea of Cortez. The watershed encompasses the eastern part of the Mexican State of Baja California and northwestern and northern parts of the State of Sonora.

Reaching heights of up to 6,500 feet (2,000 meters), the Sierra Juarez mountain range is part of the coastal range of California and Baja California that extends from the tip of Baja California north well into central California. In the border area, the Sierra Juarez extend approximately 31 miles (50 km) west and 93 miles (150 km) south of Mexicali, Baja California. The range discharges surface runoff to the Lower Colorado River delta and the Sea of Cortez to the east. As the range slopes towards the Sea of Cortez, the mountains give way to sand dunes and wetlands.

The most important features of the basin are the Colorado River and the Desierto de Altar. The Colorado River begins in the United States and flows for more than 1,200 miles

(1,900 km) to the international border, where it enters Mexico on the east side of Mexicali and continues for 100 miles (160 km) before ending in the Sea of Cortez. At one time, the Colorado delta at the Sea of Cortez was a vast area of wetlands and salt flats that covered more than 3,800 square miles (9,800 km^2) of Sonora Desert. Historically, the delta was an important estuary that supported coastal vegetation and fresh, brackish, and intertidal wetlands. However, the delta has been significantly altered by human activity, principally through the development and diversion of water for upstream use. Perennial flow from the Colorado is minimal, and most of the water that the delta receives is from agricultural drainage from the United States and Mexico, as well as periodic flood flow.

The Sonora Desert includes parts of south-central and southwestern Arizona as well as southeastern California, and extends into Sonora to the shores of the Sea of Cortez. The desert has an extremely rough topography and supports diverse flora and fauna communities. There are a series of lands in the basin managed and protected by federal and state agencies, including the Alto Golfo de California, the Delta del Rio Colorado, La Purica National Forest, El Pinacate, Sierra de los Ajos, Sierra Buenos Aires, Sierra San Antonio, and others.

The Colorado River drains approximately 246,000 square miles (640,000 km^2) in Wyoming, Utah, Colorado, Nevada, California, New Mexico, and Arizona in the United States and is important economically, ecologically, and culturally to the western U.S. As the river flows southwest through northern Arizona, it flows through Lake Mead and then turns south to form the borders between Nevada, California, and Arizona. The Colorado enters the border area as it flows past Blythe, California, and then continues south through Yuma, Arizona. As it crosses the border to Mexico, the Colorado becomes the International Boundary between Baja California in Mexico and Arizona in the United States. The river then flows through the Morelos Diversion Structure near San Luis Rio Colorado, Baja California, Mexico and into the Sea of Cortez near Golfo de Santa Clara, Mexico. At this point, the Colorado forms the boundary between the Mexican states of Baja California and Sonora.

In the border area, the Colorado River basin ranges from the eastern part of California east of the Chocolate, Chuckwalla, and McCoy Mountains, and extends east into New Mexico at the headwaters of the Gila River in the Gila National Forest. To the south, the basin is defined by the mesas and plateaus of the New Mexico and Arizona highlands. As the Colorado crosses the border below Yuma, it empties into the wide, low Sea of Cortez delta.

Land use in the Lower Colorado River basin in the border area consists primarily of agricultural and grazing tracts, although large parcels of land belong both to the U.S. government (including several military ranges and four National Wildlife Refuges [the Cibola, the Imperial, the Kofa, and the Cabeza Prieta refuges]). The Colorado River, Yuma, and Cocopah Indian Reservations are also located along the reaches of the Lower Colorado. As the river flows across the border into Mexico, the land becomes much more urbanized between Mexicali, Baja California, to the west, and San Luis Rio Colorado, Sonora, to the east. Further to the east, in the Santa Cruz and San Pedro subbasins, most of the privately-owned land is devoted to grazing, although there are also a variety of mine operations in the area. However, as with the land around Yuma, much of the land in these subbasins is owned by the U.S. government or by Indian tribes. Reservations in the Santa Cruz subbasin include the Papago, the San Xavier, the Ak-Chin Maricopa, and the Gila River, while the San Carlos Indian Reservation lies along the northern part of the San Pedro River where it joins the Gila River. Wilderness areas in the subbasins include the Coronado National Forest and several other designated wilderness areas.

The Lower Colorado River basin and its subbasins contain several major U.S. and Mexican cities, including Yuma, Arizona; the suburbs of Tucson, Arizona, in Pima County; San Luis Rio Colorado, Sonora, Mexico; and the cities of Agua Prieta and Cananea in the San Pedro subbasin, and Nogales in the Santa Cruz subbasin, Sonora. The primary communities in the Sea of Cortez basin are the Sonoran cities of Altar, Arizpe, Bavispe, Caborca, Imuris, Magdalena de Kino (Magdalena), Puerto Penasco, Santa Ana, Sasabe, and Sonoyta, and the Arizona city of Lukeville, which is located at the border within Organ Pipe Cactus National Monument. Several of these cities, including Sasabe and Sonoyta, are border cities, while Caborca and Altar are located further within Sonora. Only one of these cities, Puerto Penasco, lies on the Sea of Cortez.

A.2.2 Hydrology of the Colorado/Sea of Cortez Basins

Flow in the Sea of Cortez occurs as smaller streams drain from the higher areas to the east and west of the basin and flow directly into the Sea of Cortez, while flow from the northern plateaus is directed into the Colorado River, and then into the Sea of Cortez. The major surface waters in the basin are the Colorado River and its delta. The lower Colorado River in turn supports the Cienaga de Santa Clara; Sonoita Creek; and the Santa Cruz, Magdalena, San Pedro, and Yaqui Rivers. Perennial flow from the Colorado is minimal, with most of the flow resulting from agricultural drainage from the United States and Mexico, as well as periodic flood flow. Residual flows from the Colorado River into Mexico, irrigation return flows, and highly concentrated briny waters have negatively affected the ecology of the upper Sea of Cortez and the Cienaga de Santa Clara.

Drainage into the Sea of Cortez also comes from the higher lands to the east. Some surface water drainage flows southwest from elevations of up to 8,300 feet (2,500 meters) from the areas between Nogales and Agua Prieta. This flow forms smaller tributaries among the different mountain ranges and eventually discharges through several creek systems into the Sea of Cortez.

The Lower Colorado River basin in the border area consists of the Lower Colorado and many smaller streams and washes, some perennial and some ephemeral, that flow across the border. These include the Nogales Wash near Nogales, Arizona; the Greenbush Draw near Naco, Arizona; and the Whitewater Draw near Douglas, Arizona. The basic flow regimes in the basin occur as the Santa Cruz and San Pedro Rivers (which both originate in the highland areas of the northern Sonora Desert, Mexico) flow north across the border and into the Gila River, which itself originated in the Gila National Forest and flows from east to west across the southern part of Arizona. The Gila empties into the Lower Colorado near Yuma, Arizona.

The Lower Colorado River and its tributaries are the main source of water for the entire lower southwest United States. The Lower Colorado proper supports 700,000 acres (280,000 hectares) of farmland in the Imperial, Coachella, Bard, and Palo Verde Valleys of California. The river supplies water to 25 million people throughout its watershed, and almost all of the river's flow is allocated for use to specific consumers. Current river usage agreements guarantee 8.5 million acre-feet (10.5 billion m^3) per year of water to the Lower Colorado Basin and 1.5

million acre-feet (1.9 billion m^3) per year to Mexico. A series of dams and reservoirs store water for consumer use, but the use is such that, in periods of low flow, the flow of the river can be reduced significantly. The river is diverted and controlled by a series of drains and irrigation canals, including the East and West Main Canals, the Main Drain, the A Canal, and the Mohawk Canal. These canals distribute water, as necessary, to agricultural operations in the surrounding areas. Return flows from these canals re-establish flows in the river; however, in conjunction with agricultural runoff, these return flows are thought to contribute to salinity problems in the river.

A.3 Central Desert/Closed Transboundary Basins

The Central Desert and Closed Basins consist of the Mexican Highlands watersheds and the Mimbres and Animas watersheds. Figure A-3 shows the Central Desert and Closed Basins and their most important characteristics. The Mexican Highlands Basin contains watersheds that drain to rivers in southern Arizona, southwestern New Mexico, northern Sonora, or the extreme northwestern tip of Chihuahua. The Mimbres/Animas Basin contains watersheds that drain internally in southern New Mexico and northern Chihuahua. Together, these watersheds drain 34,290 square miles (89,000 km^2) (Woodward and Durall, 1996).

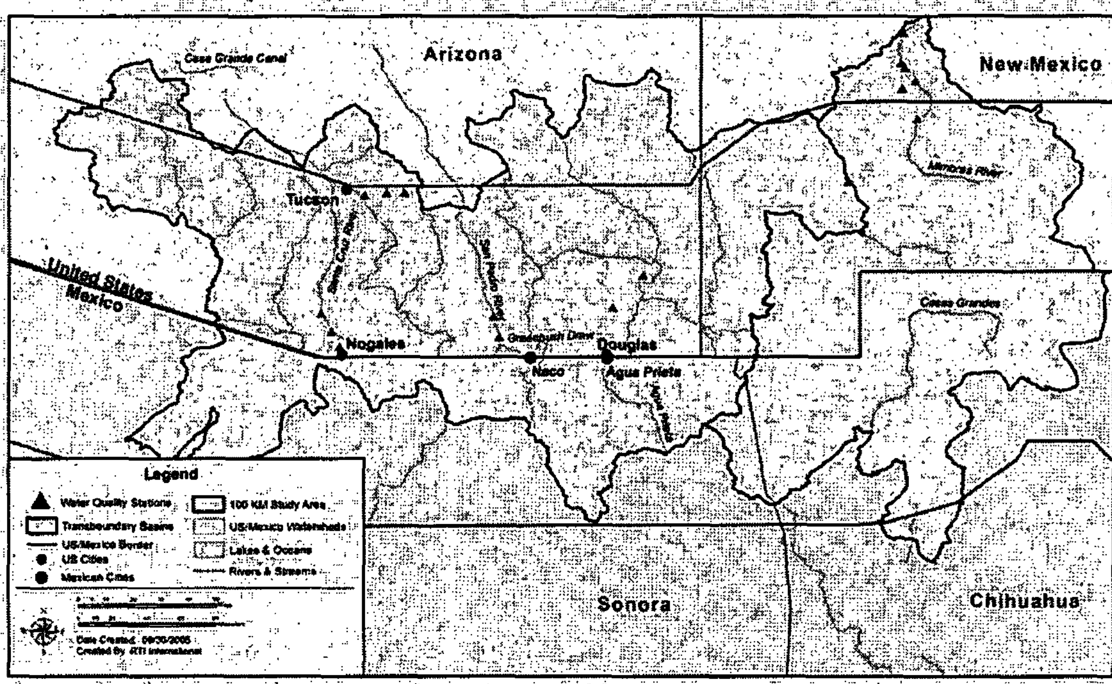

Figure A-3. Central Desert/Closed Basins.

A.3.1 Geography of the Central Desert/Closed Basins

The Mexican Highlands watersheds are characterized by broad valleys or basins separated by steeply rising mountain ranges. Each basin is essentially an independent hydrologic system. The watersheds drain to rivers in southern Arizona, southwestern New Mexico, northern Sonora, and the northwestern tip of Chihuahua.

The Mexican Highlands watersheds are classified as desert. However, this desert area, unlike many others, is renowned for its lush vegetation and diverse aquatic habitats, remnants from a time when the area was wetter. The uniqueness of this desert has attracted humans since early history. The U.S. and Mexican 1990 censuses estimated the population of the area to be about 935,000. Selected regions in the Mexican Highlands area have experienced intense human pressure with subsequent effects on its water resources and associated plant, fish, and wildlife species. (Papoulias et al., 1997)

The Mimbres and Animas watersheds consist mostly of topographically closed basins with piedmont and basin-floor alluvial surfaces grading to central playa (ephemeral lake) depressions that are designated "bolsons." All stream systems are ephemeral, except in the valleys of Animas Creek (New Mexico Environment Department, 2002).

The area is further subdivided into the Mimbres, Playas, and Marmel watersheds. The eastern part of the area is contiguous with the Upper Rio Grande basin area. This area is known as the Central Closed Basin area. Most flows in the Central Closed Basin area are intermittent, and all of the surface flows within the basin's boundaries are self-contained. The Central Closed Basin consists of several subbasins. The Rio Grande-Mimbres subbasin extends from the Elephant Butte Reservoir to the junction of Mexico, New Mexico, and Texas at the International Boundary, and includes parts of the Jornada del Muerto highlands, the Mimbres River, Playas, and other closed areas west of the Rio Grande. The Rio Grande-Caballo area includes the Caballo Mountains; the southern reaches of the Jornada del Muerto highlands; and the cities of Las Cruces, New Mexico, and El Paso, Texas. On the Mexican side of the border, the basin encompasses the northwestern part of the state of Chihuahua. This area is defined to the west by the Sierra Madre Occidental Mountain Range, which begins almost from the Sonora-Chihuahua Border and extends south. Within the Sierra Madre Occidental are several smaller mountain ranges, including the Sierra Boca Grande, the El Fresnal, the Gapulin, the Encendida, the America, the La Catarina, the Las Tunas, the El Nido, and the Los Arados ranges.

The basin area is a topographically closed, high plateau area with few ephemeral streams that drain internally and do not contribute flow to any of the surrounding basins. Its boundaries are formed by the Continental Divide on the west, the Rio Grande Basin to the north and east, and the Chihuahua Highlands and Route 45 from Ciudad Juarez to the city of Chihuahua to the south. The northern part of the basin area consists of wooded areas with elevations from 6,500 to 10,000 feet (2,000 to 3,000 m); moving further south, the topography changes to desert and semi-arid plains. To the east of the basin, in the northern section of Chihuahua, are several wetland areas called El Barreal. Climatologically, the basin ranges from sub-humid in the north to dry and arid in the south. Annual rainfall ranges from 25 inches (64 cm) in the northern wooded areas to 8 to 10 inches (20 to 25 cm) in the southern elevations.

Land in the basin area is primarily desert, and urbanized areas make up the majority of developed and utilized land. However, range and open land also make up a significant portion of the basin.

The principal cities within this region in the United States are Columbus and Sunland Park, New Mexico. In Mexico, the principal cities are Las Palomas, Ascension, and Janos Nuevo Casas Grandes, and General Rodrigo M. Quevedo, Chihuahua.

A.3.2 Hydrology of the Central Desert/Closed Basins

The most important major rivers include the Gila, Santa Cruz, and San Pedro Rivers. In addition, many smaller streams and washes, some perennial and some ephemeral, flow across the border. These include the Nogales Wash near Nogales, Arizona; the Greenbush Draw near Naco, Arizona; and the Whitewater Draw near Douglas, Arizona. The basic flow regimes in the basin occur as the Santa Cruz and San Pedro Rivers, which both originate in the highland areas of the northern Sonora Desert, Mexico, flow north across the border and into the Gila River, which itself originates in the Gila National Forest and flows from east to west across the southern part of Arizona. The Gila empties into the Lower Colorado near Yuma, Arizona.

The Santa Cruz River originates in the Coronado National Forest west of Nogales, Arizona, and flows south into Mexico before looping back towards the United States near Nogales, Sonora, Mexico. At Nogales, the river flows north through the city, across the border, and into the United States. The river's drainage area is approximately 8,200 square miles (21,000 km^2), with populations concentrated in the Pima County suburbs of Tucson and in the cross-border community of Nogales. Because of the extensive use of groundwater throughout the basin, most parts of the river flow only as a result of runoff or wastewater discharge. However, some tributary streams remain perennial. Of the tributary streams and washes, one of particular concern is the Nogales Wash, which is often composed of raw wastewater and sewage discharged from Nogales on the Mexican side of the border.

The San Pedro River originates in Mexico in a ranching, agriculture, and mining area, and flows into the United States near Palominas, Arizona. The San Pedro River then flows north for almost 100 miles (160 km) before reaching the Gila River. The basin encompasses approximately 3,740 square miles (9,700 km^2), with most of the land owned by the State of Arizona. The population centers in the San Pedro subbasin are primarily small towns, and include Naco, Bisbee, Tombstone, Willcox, and Douglas, Arizona, and the larger communities of Agua Prieta, Cananea, and Naco, Sonora, Mexico. As with the Santa Cruz subbasin, there are several smaller waterbodies of concern in the San Pedro subbasin, including the Whitewater Draw, which drains the town of Douglas, Arizona, and flows into Mexico where it discharges into the Agua Prieta River; and the Greenbush Draw, which drains the Bisbee-Naco area into the San Pedro River.

During the early part of the 20th century, surface water in the basin was almost fully appropriated; thus, further augmentation of water supplies has had to depend almost entirely on groundwater resources. Extensive development of groundwater depletes stream flow, captures natural discharge, and decreases water levels in the aquifer, resulting in reduced stream flows and spring flows and decreased riparian habitat. The Santa Cruz and San Pedro Rivers are the dominant streams in the basin. Their flows largely depend on precipitation in the mountains in Arizona and Mexico. Near their headwaters, certain reaches of these rivers flow continuously, but their flows decrease dramatically as the rivers travel northward. For example, the Santa Cruz River near Nogales, Sonora, generally flows continuously. However, the natural flow in the river typically does not reach the Nogales International Wastewater Treatment Plant (located along the river about 6 miles [10 km] north of Nogales, Arizona). Flow downstream from the treatment plant is composed entirely of effluent return, and this water rarely flows past the Santa Cruz County line (located about 12 miles [19 km] downstream from the treatment plant) before it completely seeps into the subsurface. (Papoulias et al., 1997)

An important perennial river in this basin is the Mimbres River, which flows only in the upper reaches outside of the border area. The Bear Canyon Reservoir, which is fed by the Mimbres River at Bear Canyon, lies in the northern part of the basin; it is capable of impounding 700 acre-feet (860,000 m^3) of water for conservation storage and recreation. The principal rivers in Northwest Chihuahua are the Rio Casa Grandes, the Rio Santa Maria, and the Rio Santa Clara. There are also several lakes in this region, including Laguna Colorado, Laguna Victorio, Laguna de Santa Maria, Laguna de la Ascension, Laguna de Guzman, Laguna Fierro, Laguna Redonda, Laguna la Vieja, Laguna Seca, Laguna Encinitas, and Laguna San Rafael. The Ochenta y Nueve irrigation district also lies in the basin.

Unlike the other major basins straddling the U.S.-Mexico border region, no perennial streams flow across the border in this basin. While some ephemeral streams, such as the Wamels Draw and other unnamed streams, flow across the border during runoff events, few streams flow perennially in the entire basin.

Groundwater is the major source of water within the basin. Four underground basins (the Mimbres, the Animas Valley, the Playas Valley, and the Nutt-Hockett Aquifers) have been identified on the U.S. side of the border. Of these aquifers, the Animas Valley, the Playas Valley, and the Nutt-Hockett aquifers lie in the border region. The Animas Valley aquifer encompasses approximately 426 square miles (1,100 km^2) underneath Hidalgo County and parts of Arizona in the Colorado River basin; the Playas Valley aquifer underlies 515 square miles (1,300 km^2) in Hidalgo County; and the Nutt-Hockett underlies approximately 133 square miles (340 km^2) in portions of Luna, Sierra, and Dona Ana Counties. Because of the lack of reliable alternative water sources, safeguarding groundwater from pollution is a critical issue within this basin.

The conflicts resulting from competition for the region's limited water resources are well illustrated in the Santa Cruz River Basin. Competing water needs and uses include municipal, domestic, industrial, and agricultural uses; irrigation; and support of riparian habitat and fish and wildlife. The withdrawal of groundwater, the basin's principal source of supply for municipal, industrial, and agricultural uses, is greater than natural basin recharge. The two largest population centers occur in the Santa Cruz River Basin: Tucson (about 579,000 people) and the sister cities of Nogales-Nogales (about 137,000 people). As a result, more than 75 percent of the people in the subarea live in the Santa Cruz River Basin. The Nogales-Nogales area also supports one of the largest maquiladora clusters along the U.S.-Mexico border. About 26,000 acres (11,000 hectares) of agricultural lands are irrigated in the basin upstream from Tucson, including about 2,300 acres (930 hectares) in Mexico. (Papoulias et al., 1997)

Overdraft of groundwater supplies is a major concern to the basin because of the rapid growth rates in this region of the border. Increased groundwater withdrawal from the Tucson Basin has resulted in increased well pumping costs, reduced groundwater quality, decreased well capacities due to the consolidation of sand in the aquifer, and the potential for land surface subsidence. Groundwater-surface water interactions in the area are poorly understood, but as groundwater withdrawals exceed natural recharge, greater volumes of surface flows from the Santa Cruz River will be drawn into the aquifer and eventually the river will run dry. Subsidence and aquifer overdraft also concern federal land managers, and the results on wetlands and springs could directly affect the ability to protect ecological resources. (Papoulias et al., 1997)

Water in the San Pedro River is supplied by flow from Mexico and by discharge from the adjacent aquifer. The San Pedro Riparian National Conservation Area is a narrow corridor of riparian habitat hosting a wide variety of plant and animal species. The water requirements of the San Pedro Riparian National Conservation Area, municipalities, industry, the military, and agriculture in the San Pedro Basin must all be met from the same, limited resource. The issues of the San Pedro Basin include (1) maintenance of sufficient river flows for the protection of the riparian environment, (2) resolution of conflicting water-use interests and the legal determination of water rights, and (3) identification of the effects of water-resource development in the basin within the upper reaches in Mexico. (Papoulias et al., 1997)

These water quantity issues are exacerbated by problems associated with insufficient data for the San Pedro River System. At present, there is a poor understanding of the origin of surface flows, groundwater-surface water interaction, and the importance of the riparian system. We are only beginning to understand the significance of large riparian cottonwood and willow forests to the biological health of the river system. (Papoulias et al., 1997)

The area contains two National Wildlife Refuges, each dependent on a sustaining water supply. The fish and wildlife resources of San Bernardino National Wildlife Refuge are inextricably tied to the water resources of the San Bernardino artesian basin, more than half of which is in Mexico. Another system of great importance to wildlife, particularly to migratory birds, is the Arivaca Oenega (a type of wetland) of Arivaca Creek within the Buenos Aires National Wildlife Refuge. In addition, springs and intermittent drainages support approximately 30 acres (12 hectares) of riparian habitat at the Fort Bowie National Historic Site, 180 acres (73 hectares) within the Chiricahua National Monument, and more than 300 acres (120 hectares) of riparian wetland habitat, including 101 acres (41 hectares) of Oak Riparian Forest in the Coronado National Memorial. (Papoulias et al., 1997)

Federal (United States) bureaus are participating in the Arizona adjudication of water rights, particularly as it addresses the issues of allocation and ground- and surface-water interaction in the Mexican Highlands. Under Arizona law, uses of surface water must adhere to the doctrine of prior appropriation (the rule of "first in time, first in right"), and most groundwater uses are limited by the doctrine of reasonable use. The reasonable-use doctrine provides no limits on the quantity and timing of withdrawal. The U.S. Bureau of Land Management, U.S. Fish and Wildlife Service, and U.S. National Park Service have submitted claims in adjudications to protect water rights for surface- and groundwater uses, including uses that maintain riparian habitat. The U.S. Bureau of Indian Affairs has supported Gila River Indian Community claims, and the U.S. Bureau of Reclamation has Central Arizona Project authority on the San Pedro River. This adjudication, referred to as the Gila River Adjudication, will resolve several issues that are significant to management of the San Pedro Riparian National Conservation Area. (Papoulias et al., 1997)

A.4 Upper Rio Grande Transboundary Basins

The Rio Grande/Rio Bravo Basin on the U.S.-Mexico Border is defined as the area from the Elephant Butte Reservoir to the Falcon Reservoir. The Rio Grande Basin drains 76,480 square miles (200,000 km^2) (Woodward and Durall, 1996). Figure A-4 shows the Rio Grande Basins and their most important characteristics.

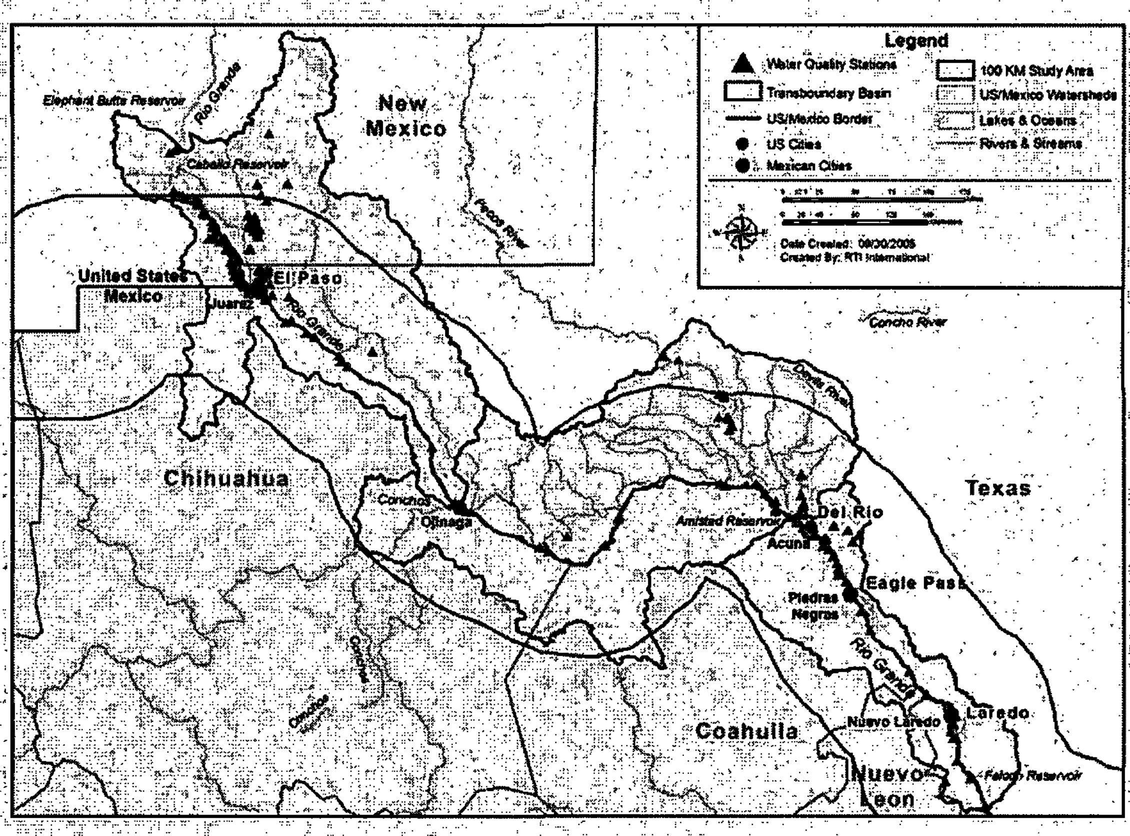

Figure A-4. Upper Rio Grande Basins.

A.4.1 Geography of the Upper Rio Grande Basins

The Rio Grande basin extends from the Rio Grande's headwaters in the San Juan Mountains of southern Colorado all the way to its end in the Gulf of Mexico in the Mexican state of Tamaulipas and the U.S. state of Texas. The Rio Grande is approximately 1,900 miles (3,100 km) long and drains an area of 182,215 square miles (470,000 km^2) in three U.S. states (Colorado, New Mexico, and Texas) and five Mexican states (Chihuahua, Coahuila, Durango, Nuevo Leon, and Tamaulipas). As the river flows through El Paso, Texas, it begins to define the International Boundary between Mexico and the United States, and does so until its mouth at the Gulf of Mexico. In this area along the International Boundary, the river is also known by its Mexican name, the Rio Bravo.

In the border area, the Rio Grande/Rio Bravo basin stretches from New Mexico to the International Falcon Reservoir, which lies in the northwestern portions of Tamaulipas, Mexico, and the southwestern part of Texas, near Zapata and Falcon, Texas, and Nuevo Ciudad Guerrero, Tamaulipàs. Below the International Falcon Reservoir, the hydrography of the Rio Grande basin changes, and thus this area of the basin has been defined as a separate basin, designated the Lower Rio Grande Basin. The Lower Rio Grande Basin is discussed fully in Section A.5.

The Rio Grande basin as defined in the border area is bounded by the official 100-km border designation about 65 miles (105 km) north of the border, below the elephant Butte Reservoir near the towns of Salem and Hatch, New Mexico. Near this northern boundary, the Río Grande flows through the Mesilla Valley, at an approximate elevation of 3,700 feet (1,100 m) above sea level. As the Rio Grande flows south, it becomes the border between New Mexico and Texas, and then, at El Paso, Texas, it becomes the International Boundary between Mexico and the United States. As it flows to the Gulf of Mexico, the Rio Grande/Rio Bravo basin encompasses all or part of 31 western Texas counties. The Rio Grande/Rio Bravo valley encompasses a narrow strip of land bordered by the Guadalupe, Davis, and Santiago mountain ranges in western Texas, and a series of ranges along the eastern reaches of Chihuahua, including the Sierra La Armagosa, Sierra San Jose del Prisco, Sierra La Lagrima, Sierra Pilares, Sierra, Sierra La Esperanza, and the Sierra El Peguis. As the river flows south past the International Amistad Reservoir, its floodplain widens as the valleys between the Sierra Madre Occidental and the Serranias del Burro of Coahuila, Nuevo Leon, and Tamaulipas give way to lower valleys supporting the tributaries of the river. On the U.S. side of the border, the Rio Grande river valley widens below the Edwards Plateau of northwestern Texàs. Below the Reservoir, the lower lands and valleys become wide enough to support more agricultural uses.

The Rio Grande section from Rio Conchos to Amistad Reservoir area is hot, and the climate varies from semiarid to arid. Average annual rainfall (1961–90) ranged from about 11 inches (28 cm) per year at Presidio, Texas., to about 19 inches (48 cm) per year at the upper elevations of the Chisos Mountains in Big Bend National Park. This sparsely populated area (1990 U.S. population less than 40,000) is predominantly open range and is divided between the Basin and Range and Great Plains physiographic provinces. The Basin and Range province, from Big Bend National Park westward, is characterized by isolated mountain ranges separated by desert basins characteristic of the northern Chihuahua Desert. (Blackstun et al., 1996)

Both sides of the international border have protected areas. The Maderas del Carmen and Cañon de Santa Elena in Mexico contain nearly 1.2 million acres (490,000 hectares). Although much of this land is privately held, the Mexican government has given these areas special environmental status. Although much of the land in Texas is privately owned, the U.S. National Park Service (NPS) and the Texas Parks and Wildlife Department (TPWD) protect significant areas along the border including Big Bend National Park (NPS), the Rio Grande Wild and Scenic River (NPS), and Amistad National Recreation Area and Big Bend Ranch State Park (TPWD). (Blackstun et al., 1996)

In the northern reaches of the basin in New Mexico, the Rio Grande flows through portions of the Chihuahua Desert, where precipitation is less than 8 inches (20 cm) per year and annual evaporation may be more than 1,000 percent of this annual input. As the river flows southeast, rainfall increases, ranging from approximately 12 inches (30 cm) per year at Fort

Stockton to 20 inches (51 cm) at Laredo to over 25 inches (64 cm) at Brownsville. As described above, most of the Rio Grande is semi-arid desert scrub land with vegetation consisting of shrubs, short grasses, and cacti. At the higher elevations along some isolated peaks, small forests of oak, juniper, and pine can be supported. The basin supports several biotic communities in both the scrub desert ecosystems, as well as in the riparian corridor of the river itself. The river is also an important ecosystem and is home to as many as 80 species of northern Chihuahua desert fish species. The Rio Grande/Rio Bravo basin also contains many protected lands, including the Canon de Santa Elena Reserve in Chihuahua, the Maderas del Carmen area in Coahuila, and Big Bend National Park and the Big Bend Natural Ranch Area in Texas.

Land use in this area of the Rio Grande/Rio Bravo basin is primarily devoted to rangeland, agriculture, light industrial uses, mining, and urban areas. As discussed above, the availability of water determines almost all of the land uses in the basin. In areas where water control devices allow the regulation and storage of water, larger human populations can be sustained and industries can flourish. In other areas, the use of canals to transport water supports ranching, rangeland, and agricultural practices. Areas with no water control most likely remain as scrub desert.

Major cities in the Rio Grande basin are primarily composed of five pairs of sister cities (El Paso/Ciudad Juarez, Presido/Ojinaga, Del Rio/Ciudad Acuna, Eagle Pass/Piedras Negras, and Laredo/Nuevo Laredo) located along the Rio Grande/Rio Bravo. These pairs of sister cities account for the largest population segments in the basin. In addition, because of their proximity to each other and their location on the International Boundary, these communities represent the interrelated natures of the cross-border economies, populations, and environmental issues characteristic of the border area

In addition to these incorporated communities, unincorporated "colonias" play a significant role in water issues and infrastructure planning in the Rio Grande/Rio Bravo basin. Colonias are permanent communities that have been built for the most part without basic infrastructure, including water and wastewater systems. Colonia communities are located throughout New Mexico and Texas, and are estimated to have a population of over 300,000. While most colonias are located in Hidalgo, Starr, Cameron, and Willacy Counties in southeastern Texas, 25 percent lie along the Rio Grande/Rio Bravo basin in the border area. Most of the colonias in this area lie in Maverick County near Eagle Pass. Because of their proximity to the Rio Grande, and their lack of basic infrastructure to ensure safe drinking water and adequate disposal of wastes, the colonias can have a major effect on water quality and other water issues. Some Texas cities have already begun to incorporate the colonias into their strategic planning, and a number of entities, including EPA, the U.S. Department of Agriculture, the U.S. Department of Housing and Urban Development, and the States of New Mexico and Texas have already initiated various programs to upgrade infrastructure in the colonias.

A.4.2 Hydrology of the Upper Rio Grande Basins

The primary waterbodies in the Rio Grande basin are the Rio Grande/Rio Bravo River and its major tributaries, including the Rio Concho, the Rio Salado, and the Rio San Rodrigo in Mexico, and the Pecos and Devils Rivers in Texas. Pecos River and Devils River contribute flow directly to Amistad Reservoir. Other surface water features include springs, ephemeral and intermittent streams, and tinajas (water pockets often below small waterfalls). The Rio Grande flows through deep, steep-walled canyons of limestone, forming a ribbonlike oasis of riverine and riparian environment sand providing a stark comparison to the adjacent desert landscape. The Rio Conchos watershed in its entirety contains almost half the entire Rio Grande drainage area in Mexico. (Blackstun et al., 1996)

The Rio Grande/Rio Bravo has also been dammed in several places to create reservoirs, including the International Amistad Reservoir and the International Falcon Reservoir. Two reservoirs, the Centenario and the San Miguel Reservoirs, are also located west of the Rio Grande/Rio Bravo, below the International Amistad Reservoir between Ciudad Acuna and Piedras Negras, Coahuila, Mexico.

The hydrography of the Rio Grande/Rio Bravo basin has been substantially altered by humans. The entire basin area is semi-arid, and human populations can only be supported in areas with reliable water supplies. The extremely high demand for water throughout the basin has resulted in a complex series of dams, reservoirs, canals, diversions, and other man-made structures that control, divert, and store water for human use, including drinking water supplies, agricultural irrigation water supply, and other uses. These control structures are located throughout the basin, and in fact begin outside of the border area in the upper reaches of the Rio Grande. The increasingly competitive natures of water interests have made the hydrography of the Rio Grande/Rio Bravo a matter of increasing concern, both economically and ecologically, with many regional planning decisions affected by both the quantity and quality of water available.

Flow in the Rio Grande/Rio Bravo has historically been the result of spring snowmelts in the upper reaches of the river, as well as localized inputs from summer thunderstorms. With the exception of the major rivers, many of the tributaries flowing into the Rio Grande are intermittent streams that flow only during the wet period of the year. As a result of this water balance, most flow in each segment of the basin is basically controlled by man-made diversions in the segment upstream. Thus, flow through El Paso is controlled by releases from the Elephant Butte Reservoir in New Mexico, flow through Ciudad Acuna and Del Rio is controlled by the International Amistad Reservoir upstream, and flow to the lower Rio Grande/Rio Bravo is controlled by the International Falcon Reservoir. Between these water storage structures are a series of water diversion structures that divert the water to localized uses. Water is diverted in the El Paso/Ciudad Juarez area by the American Canal and the Acequia Madre; flow around Del Rio is diverted by the Maverick Canal; and flow below the International Falcon Reservoir is diverted by the Anzalduas and other canals.

The related processes of controlled flows from dams and reservoirs, outflows into canals, and inflows from tributaries and canal return flows, make the flows of the Rio Grande/Rio Bravo inconsistent from location to location and over time. Between El Paso and the International Amistad Reservoir, the Acequia Madre and American Canals remove 322,000 acre-feet (397 million m^3), while various creeks and rivers add 1,354,000 acre-feet (1.67 billion m^3) to the flows, creating a net gain in flow of 1,032,000 to 1,426,000 acre-feet (1.27 billion to 1.76 billion m^3) per year into the International Amistad Reservoir. In a similar fashion, between the International Amistad and International Falcon Reservoirs, outflows are 1,050,000 acre-feet

(1.3 billion m^3) per year, and inflows are 1,649,000 acre-feet (2.0 billion m^3) per year, nearly half of which are Maverick Canal return flows.

The construction of dams and implementation of flood-control practices, channelization, increased water diversions, and displacement of native cottonwood and willow with tamarisk (salt cedar) have resulted in the Rio Grande becoming seasonally intermittent between Fort Quitman, about 70 miles (110 km) southeast of El Paso/Ciudad Juarez, and Presidio. On the Rio Grande upstream from the area, Elephant Butte and Caballo Reservoirs (in southern New Mexico), impound and release virtually all Rio Grande flows for urban, industrial, and agricultural uses in the El Paso/Ciudad Juarez region. Existing water rights, international treaties, and operational policies administered by the Rio Grande Compact Commission limit Rio Grande flow from this region. The limited return flows to the Rio Grande from these uses have significantly degraded water quality. Those return flows are significantly reduced between Fort Quitman and Presidio as they pass through a reach overgrown with tamarisk and are evapotranspired. This often results in little or no surface flow from the Rio Grande entering the subarea from above the Rio Conchos. (Blackston et al., 1996)

Water quantity, water quality, and aquatic-biological characteristics within the Rio Conchos area are heavily influenced by the Rio Conchos. In the Rio Conchos watershed, upstream from the area, expanding agricultural, mining, and timber harvesting activities as well as urban and industrial development affect both the quantity and quality of Rio Grande flows through the area. (Blackston et al., 1996)

The Pecos and Devils Rivers are tributaries at Amistad Reservoir. The natural discharge of saline groundwater into the Pecos River in New Mexico also affects the water quality of Amistad Reservoir. (Blackston et al., 1996)

The availability of streamflows sufficient in variability, magnitude, and duration to protect natural resources that are dependent on these flows is the most serious water quantity issue in this subarea. If sufficient streamflow is not available to fully support and satisfy all competing water needs, the issue of water quality becomes academic. Before 1915, the Rio Grande flowed unimpeded through relatively undisturbed lands in the sparsely populated subarea. At Presidio/Ojinaga, a dramatic change in the river is visible due to the dominating influence of inflow from the Rio Conchos. The Rio Conchos typically supplies the largest percentage of Rio Grande flows allocated by Mexico in accordance with the 1944 Treaty between the United States and Mexico. The total annual flow of the Rio Conchos averaged 737,000 acre-feet (909 million m^3) through the 1980s, more than five times the flow of the Rio Grande measured just above its confluence with the Rio Conchos. Also, the flood-peak histories of the Rio Grande and Rio Conchos are dramatically different, even though both rivers are heavily regulated. (Blackston et al., 1996).

Dams on the Rio Conchos are operated primarily for water storage. Consequently, the Rio Conchos sometimes experiences high peak flows—71,300 cubic feet per second (cfs) (2,020 m^3/sec) in 1978 and 45,900 cfs (1,300 m^3/sec) in 1991. As flood control becomes an issue in the developing Rio Conchos watershed, changes in the annual volume and peak levels of streamflow entering the Rio Grande could affect the long-term maintenance of existing aquatic and riparian habitats and further affect the variability of the flow regime downstream. (Blackston et al., 1996)

Flow from the Pecos and Devils Rivers' watersheds directly enters Amistad Reservoir. The Rio Grande, which was impounded at Amistad Dam in 1969, has a drainage area of 123,142 square miles (320,000 km^2) at the IBWC streamflow gage located 2.2 miles (3.5 km) downstream from the dam. Relative contributions of flow to the reservoir for the period 1968–1993 are as follows: the Rio Grande above the Pecos River, about 66 percent (1,836 cfs, or 52 m^3/sec), the Pecos River, about 11 percent (298 cfs, or 8.4 m^3/sec), and the Devils River, about 23 percent (656 cfs, or 19 m^3/sec). Mean annual flow from Amistad Reservoir is 2,454 cfs (69 m^3/sec). Although the Devils River watershed is only about 12 percent of the size of the Pecos River watershed, its mean annual flow is more than twice that of the Pecos. Reasons for significant differences in water yields from the two watersheds are as follows: (1) the Pecos River watershed is mostly arid, whereas the Devils River watershed is mostly semiarid; (2) along much of its length, the Pecos River contains alluvial deposits which allow recharge to groundwater by seepage from the river, whereas the Devils River lies almost entirely within incised limestone canyons, resulting in less groundwater recharge; (3) spring discharge accounts for a higher baseflow for the Devils River, and water diversions for irrigation are greater along the Pecos River. (Blackston et al., 1996)

Groundwater is a source of baseflow for streams in the subarea, and its interaction with surface water accounts for differences in water yields between watersheds. The Edwards-Trinity aquifer system is the principal source of water for domestic, livestock, and public supply east of Big Bend National Park. Although surface water is fully developed, use of water from the Edwards-Trinity aquifer system for irrigation over the subarea is limited due to the poor soils and the generally rocky terrain. In the Big Bend area, groundwater occurs in alluvial deposits along the Rio Grande and intermittent streams. These areas provide important sources of water for wildlife and habitat for the endangered Big Bend Gambusia. (Blackstun et al., 1996)

In some areas sufficient yields can be obtained for domestic, stock, and public water supply uses. Geothermal springs are also a local tourist attraction in Big Bend National Park. River rafting and other forms of recreation are popular along the Rio Grande; contact recreation occurs both in the river and at hot springs along the river's edge in the subarea. (Blackstun et al., 1996)

A.5 Lower Rio Grande Transboundary Basin

The Lower Rio Grande Valley—below Falcon Reservoir to the Gulf of Mexico basin contains watersheds that drain either to that reach of the Rio Grande, to the lower reach of the Rio San Juan below the gaging station at Santa Rosalia, or to Arroyo Colorado in southern Texas. It drains an area of 10,240 square miles (27,000 km^2). Figure A-5 shows the Lower Rio Grande Basin and its most important characteristics.

A.5.1 Geography of the Lower Rio Grande Basin

The Lower Rio Grande Basin is physiographically characterized as Gulf Coastal Plain. This basin encompasses a total of 10,240 square miles (27,000 km^2), of which 6,155 square miles (16,000 km^2) are in Mexico and 4,085 square miles (11,000 km^2) are in the United States. A small portion (approximately 174 square miles, or 450 km^2) of this area is under the ownership or administration of the U.S. Federal Government. Federally owned or managed areas include the Santa Ana, Lower Rio Grande Valley, and Laguna Atascosa National Wildlife Refuges administered by the U.S. Fish and Wildlife Service, and the Palo Alto Battlefield National Historic Site administrated by the U.S. National Park Service. (Buckler et al., 1997)

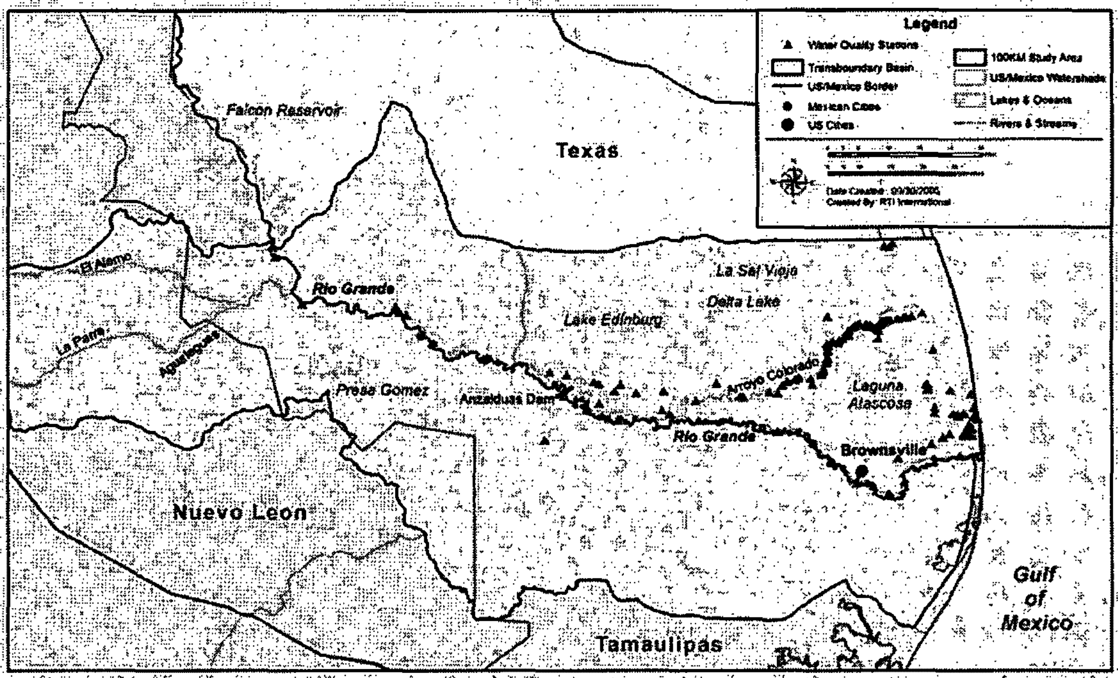

Figure A-5. Lower Rio Grande Basin.

From Falcon Reservoir, the Rio Grande/Rio Bravo flows southeastward approximately 275 river miles (440 km), terminating in the coastal wetlands and marshes of the Gulf of Mexico, including the Laguna Madre off the coasts of Texas and Tamaulipas. Among the unique habitats of this segment of the U.S.-Mexico border are the resacas (oxbow lakes) of the Lower Rio Grande Valley. The basin is classified as Tamaulipan brushland, which is characterized by dense, woody, and thorny vegetation and a high degree of biological diversity. Vegetation is taller and more lush in riparian areas than in the drier uplands and provides not only important nesting and feeding habitat, but also serves as corridors for more rainfall than most other basins of the border, with an average annual rainfall of about 26 inches (66 cm) at the mouth of the river and about 16 inches (41 cm) at Falcon Dam. As in other border basins, the water resources and associated plant, fish, and wildlife communities of the Lower Rio Grande Valley are increasingly subject to the pressures of human activities. (Buckler et al., 1997)

Vegetation, climate, and temperatures are similar on both sides of the border. Along the coastal area, marshes and wetlands dominate the landscape; moving up the watershed, these wet areas give way to oak forests, and then to arid scrub areas near the Falcon Reservoir. The basin supports a unique biotic community that includes several rare plant communities and numerous species of mammals, snakes, lizards, and tortoises. Annual rainfall averages about 26 inches (66 cm) in the lower Rio Grande Valley.

Land use in this area of the Lower Rio Grande ranges from semi-arid open scrub lands below the Falcon Reservoir to agricultural lands and then wetlands and other protected areas. Urban areas also represent a large proportion of the land in this basin. Alluvial soils along the upper reaches of this basin are ideal for irrigated crops, and the region is a major producer of vegetables, sorghum, and cotton. Traveling further downstream in the basin, the land becomes marsh and wetland and has been left primarily undeveloped. However, these wetland areas are widely used for recreation, including fishing. The Lower Rio Grande also contains several wildlife refuges, including the Santa Ana National Wildlife Refuge between McAllen and Brownsville, and the Laguna Atascosa National Wildlife Refuge north of the Rio Grande delta on the Gulf of Mexico.

Major cities in the Lower Rio Grande Basin include Mier, Ciudad Miguel Aleman, Ciudad Camargo, Gustavo Diaz Ordaz, Reynosa, and Matamoros in Tamaulipas. In Texas, the primary population centers are Roma, Rio Grande City, McAllen, Harlingen, and Brownsville. The total 2000 population of these cities is estimated to be in excess of 1,500,000.

A.5.2 Hydrology of the Lower Rio Grande Basin

Water supplies in the Lower Rio Grande are very limited, and increasing demands for water from both sides of the border put a heavy burden on the river, as well as on the water managers that must both protect and utilize the river's resources. Use of groundwater to meet usage demands will also likely increase, making it imperative that water quality in the Rio Grande, its tributaries, estuaries, bays, resacas, and also groundwater aquifers below the Gulf of Mexico basin be protected.

In the upper part of the basin, just below the Falcon Reservoir in northwestern Starr County, the Lower Rio Grande is confined to a narrow course and the flood plain is less than a mile (1.6 km) wide. However, as the river flows southeast, it widens, with the flood plain reaching a width of 6 miles (10 km) in the middle reaches in Hidalgo County. Near its mouth on the Gulf of Mexico, the river enters a broad delta characterized by wetlands, salt marshes, and open waters and lakes.

Other major rivers in this basin are the Rio Alamo and the Rio San Juan, which discharge into the Rio Grande/Rio Bravo near Mier and near Ciudad Camargo, respectively. One of the major tributaries to the Rio Grande is the Arroyo Colorado, which is the major drainage way in the lower Rio Grande Valley and it is separated into two segments, the above tidal reach and the tidal reach. Originally this was a tributary to the Rio Grande/Rio Bravo, but it was dredged in the lower reach and channels built in several places. The flow in the above tidal section is mainly for irrigation return flows and domestic waste effluent. The creek drains into the Laguna Madre and becomes the estuary for the Rio Grande.

The Rio Grande discharges directly into the Gulf of Mexico, except during high flows, when much of the water is diverted into flood channels throughout the Reynosa/Matamoros corridor and then directly into the Laguna Madre. This canal system serves a dual purpose;

besides providing flood control, the canal system also distributes water throughout the region. These canals play a major role in the hydrology and water balance of the Lower Rio Grande and the Gulf of Mexico basin.

Flow in the Lower Rio Grande through the Gulf of Mexico basin is controlled through releases from the International Falcon Reservoir. Throughout the basin on both sides of the border, other water structures, such as reservoirs and dams, control and store flow to meet the region's water needs. In addition to their functions as storage facilities, these structures are used for flood control, irrigation, water supply, and power generation. As noted above, these water diversion structures play a major role in the hydrography of the region. Below the Falcon Reservoir, various diversions remove approximately 994,000 acre-feet (1.2 billion m^3) of water annually from the Rio Grande on the U.S. side of the border, while approximately 987,000 acre-feet (1.2 billion m^3) of water are diverted annually to the Anzalduas Canal in Mexico. Even with the approximately 500,000 acre-feet (620 million m^3) of inflow from the Rio Alamo, Rio San Juan, and irrigation return flows from the Mexican side of the border, this still leaves a deficit of 1.5 million acre-feet (1.9 billion m^3) of water in the Lower Rio Grande.

Mexico's Rio Conchos and Rio San Juan have been the primary sources of water for this section of the Lower Rio Grande for several decades. Flow in these rivers is being rapidly diminished by increasing demands in their upper watersheds. The Rio Conchos supplies many cities in northwestern Mexico, while Monterrey (Mexico's second largest city) is drawing much of the Rio San Juan's water. (Buckler et al., 1997)

Within the basin, the rapidly growing cities of Reynosa, McAllen, Brownsville, and Matamoros are placing increasing demands on the Rio Grande for freshwater. Groundwater is usually not a suitable alternative water source for these urban areas due to high salinity, and elsewhere in the basin there is concern that increased future water demands could exacerbate the problem due to saltwater encroachment into the aquifer. Within the basin, a high percentage of the surface water supply is currently allocated to agriculture, and increased municipal and industrial demands are raising concerns as to whether sufficient water supplies will be available during dry periods. (Buckler et al., 1997)

Surface flow in the Rio Grande below Falcon Reservoir is highly controlled. Falcon Reservoir, which is the most downstream of the major international storage reservoirs, was authorized for construction by the U.S.-Mexico Water Treaty of 1944. The reservoir has a storage capacity of about 2.7 million acre-feet (3.3 billion m^3) and a maximum storage capacity of about 4 million acre-feet (4.9 billion m^3). Much of the water released from the reservoir is diverted during April, May, and June to satisfy irrigation needs. Average diversions during January through June exceed the total annual flow in the Rio Grande at Brownsville. (Buckler et al., 1997)

Water for use in the United States is diverted along the river by local irrigation districts and stored in holding ponds. Most of the water for use in Mexico is diverted at Anzalduas Dam. The most downstream tributary to the river is located 10 miles (16 km) west of Mission, Texas. A low ridge extends from the southern edge of the upland plain near Mission in Hidalgo County preventing runoff in the area north of the ridge from flowing to the river. Much of the eastern part of the valley is drained by small coastal streams, the Arroyo Colorado, resacas, and drainage ditches that flow into the Laguna Madre. Two floodways, constructed by IBWC to receive excess floodwater, dissect the valley. A small portion (less than 10 percent) of the water withdrawn for irrigation is returned to the Rio Grande. (Buckler et al., 1997)

The Arroyo Colorado carries much of the natural drainage and irrigation return flows to the Laguna Madre just north of the Laguna Atascosa. Much of the drainage from the northeastern parts of the study area is carried to the Laguna Madre by the Raymondville Drain. As a result of these diversions, the Rio Grande itself delivers only a portion of the water in the basin to the Gulf of Mexico. (Buckler et al., 1997)

The principal flow to the Laguna Atascosa National Wildlife Refuge is through the Cayo Atascoso. The Cayo Atascoso flows into Laguna Atascosa, which is the largest lake on the refuge. The Cayo Atascoso continues past the northern side of the refuge and ultimately discharges into the Arroyo Colorado. Although the Cayo Atascoso continues past Laguna Atascosa, sediment has been deposited near the outlet of the laguna to such an extent that it can no longer be completely drained. The refuge also receives agricultural drainwater through the Resaca de los Cuates. (Buckler et al., 1997)

Groundwater in the area is obtained from the Gulf Coast aquifer system of Texas and is produced in small volumes from Eocene-age strata and the Miocene-age Oakville Sandstone. Moderate to large volumes come from the Evangeline and Chicot aquifers (part of the Gulf Coast aquifer system) in Cameron, Hidalgo, and Willacy Counties. These aquifers are hydraulically connected and function as a unit. (Buckler et al., 1997)

Water levels in the area have declined dramatically since the 1950s due to irrigation pumpage and severe drought. In 1985, the total pumpage of groundwater in the Lower Rio Grande Valley was 17,268 acre-feet (21.3 million m^3). Total surface water use was 824,250 acre-feet (1.0 billion m^3). Surface water has been, and will continue to be, the most important source of water supply for the basin. (Buckler et al., 1997)

The four southernmost counties of Texas have one of the highest diversities of plants and animals in the continental United States, which sustains ecotourism in south Texas and northeastern Mexico. Seven of the eleven biotic communities in these counties are riparian or partially riparian. Additionally, the extreme lower section of the river supports a very diverse estuarine community and serves as a valuable nursery area for sport and commercial species of shrimp, crabs, and fish. (Buckler et al., 1997)

The Santa Ana, Lower Rio Grande Valley, and Laguna Atascosa National Wildlife Refuge in this basin provide habitat to a wide variety of species and serve as important wintering and production habitat for migratory waterfowl and neotropical birds. (Buckler et al., 1997)

The natural resources under protection in the Lower Rio Grande Valley are closely associated with both the coastal estuary systems and the flows of the Rio Grande and its associated floodplain wetland systems. Maintenance of many of these wetland resources, in particular the resacas, requires a natural cycling of flood events, which no longer regularly occurs in the system due to water management practices. (Buckler et al., 1997)

Increased municipal and agricultural demands for water have significantly decreased the quantity of water available for refuge wetlands. Additionally, agricultural systems and water control structures now intercept overland flow that historically inundated much of the river floodplain. Annual average flow in the lower part of the Rio Grande has been reduced by 30 to 50 percent by water diversions, and over the past decades, several fish species have disappeared from the river. Additionally, river-dependent natural stands of plants, such as the Sabal Palm and the Montezuma Bald Cypress, have been reduced to remnant numbers. (Buckler et al., 1997)

A.6 References

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Appendix B

U.S.-Mexico Border Waters Repository Data Dictionary

B.1 Introduction

This Appendix provides the data dictionary for the U.S-Mexico Waters Repository, which describes each table in the database. Each table consists of a number of fields or columns. Field information includes field name, type, size, whether the field value is required, and a field description. Each table has a primary key, indicated with a "PK" next to the field. The primary key is the column or columns that uniquely identify a row in a table.

B.2 Design Objectives

RTI's design team sought to satisfy the following objectives in designing the repository:

- Provide a database structure that is compatible with existing systems (most importantly STORET) but simple enough to facilitate data entry and maintenance.
- Include data elements that comply with EPA's data-standardization efforts.
- Include data elements that add value to the water quality information in the context of this project. These data elements must provide additional information that is not contained in existing systems such as STORET. Examples of these data elements are ecoregions and transboundary regions.

To meet these objectives, RTI based the Repository design primarily on EPA's STORET data dictionary and business rules. STORET is a repository for water quality, biological, and physical data and is used by state environmental agencies, EPA, and other U.S. federal agencies, as well as by universities, private citizens, and many others. RTI simplified STORET's design and incorporated the most important data elements into the U.S.-Mexico Border Waters Repository design (U.S. EPA, 2005).

Figure B-1 shows a high-level representation of the U.S.-Mexico Border Waters Repository. The boxes reflect major categories of data that characterize the data collection process. As part of the data collection process, organizations carry out station visits to sampling stations. At the sampling stations, they conduct monitoring activities that then generate results (U.S. EPA, 2003). The repository contains a variety of data tables for each element in this process.

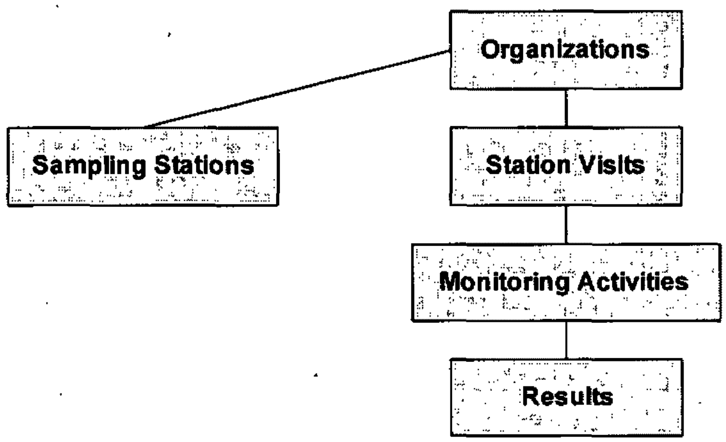

Figure B-1. High-level components of the U.S.-Mexico Border Waters Repository.

Similarly to STORET—as stated in STORET's business rules (U.S. EPA, 2003)—the U.S.-Mexico Border Waters Repository may contain many organizations. Each organization is at the top of its own data and information pyramid, which includes not only its own description, but also the descriptions of its stations, visits, monitoring activities, and associated results.

B.2.1 Environmental Sampling, Analysis, and Results Standard

The U.S.-Mexico Border Waters Repository design incorporated many of the standards described in EPA's Environmental Sampling, Analysis, and Results (ESAR) protocol. The ESAR standard is still under development and is applicable to cataloging and exchanging information about projects, sampling stations/locations, sample collection activities, analyses, and results. This standard defines the data elements that describe projects, sampling stations/locations, sample collection activities, analytical processes and results, and any ancillary information needed to accompany environmental data (U.S. EPA, 2004).

Examples of data elements from ESAR are as follows:

- **Organization Description**—organization identifier, name, description, etc.
- **Organization Electronic Address**—electronic address text and type
- **Organization Physical Address**—address type, location address, state, country, etc.
- **Monitoring Location Identity**—identifier, name, type, description, etc.
- **Monitoring Activity**—identifier, type, media, media subdivision, end date, end time, depth/altitude measure, etc.
- **Sample**—collection method, collection equipment, holding container material, holding container color, preservation thermal code, etc.

- **Result**—detection condition, characteristic name, sample fraction, value measure, units, statistical base, value type, weight basis, time basis, temperature basis, particle size, comments, etc.

B.2.2 Latitude/Longitude Standard

The U.S.-Mexico Border Waters Repository design incorporated many of the data elements listed in EPA's final version of the Latitude/Longitude standard. Latitude and longitude information is provided for the monitoring stations. The Latitude/Longitude standard represents a clarification and update of the EPA locational data policy originally outlined in the Method Accuracy Description (MAD) documentation. The MAD codes were developed by the Locational Data Policy (LDP) Sub-Work Group to meet EPA's needs to standardize the coding of geographic coordinates and associated attributes for method, accuracy, and description codes for all environmental measurements (U.S. EPA, 2004).

Data elements included in the repository are as follows:

- Latitude measure
- Longitude measure
- Source map scale number
- Horizontal accuracy measure
- Horizontal collection method
- Horizontal reference datum.

B.3 Data Dictionary

B.3.1 Table: T_ORGANIZATION

Description: An organization is a state, federal, local, academic, commercial, or other group united for a particular purpose. An organization may establish sampling stations where readings for a characteristic are taken.

Field Name	**Type**	**Size**	**Required**	**Description**
T_ORGANIZATION_ID (PK)	Long Integer	4	Yes	A system-generated value used to uniquely identify an occurrence of this table.
ORGANIZATION_TYPE	Text	30		Text that describes the type of organization.
ORGANIZATION_NAME	Text	60	Yes	The formal full length of the Organization.
SHORT_NAME	Text	20		The short name or abbreviation for the organization.

(continued)

Field Name	Type	Size	Required	Description
DESCRIPTION_TEXT	Text	254		The text describing details of the organization that users may wish to provide. For example, this field may be used to describe the purpose, mission, or goals of the Organization.
CONTACT_NAME	Text	30		The name of the person who is the contact for this Organization
CONTACT_ADDRESS_TYPE	Text	8		Address Type: 'Location', 'Mailing', or 'Shipping'.
CONTACT_ADDRESS	Text	50		The contact mail address of the Organization
CONTACT_PHONE	Text	50		The telephone number for the contact person on this Organization
CONTACT_LOCALITY_NAME	Text	30		The name of a city, town, village or other locality where the contact person is located.
TL_STATE_ID	Text	8		The foreign key to TL_STATE implements: "A state can have many organizations."
TL_TRIBAL_GROUP_ID	Text	3		The foreign key to TL_TRIBAL_GROUP implements: "The organization may be a tribal group."
ELECTRONIC_ADDRESS	Text	120		A resource address, usually consisting of the access protocol, the domain name, and optionally, the path to a file or location.
ELECTRONIC_ADDRESS_TYPE	Text	8		The name that describes the electronic address type.
LAST_UPDATE	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.2 Table: T_STATION

Description: Information about the monitoring site where data were collected. In this version, each station can only have one latitude/longitude point.

Field Name	Type	Size	Required	Description
T_STATION_ID (PK)	Text	30	Yes	A system-generated value used to uniquely identify an occurrence of this table.
T_ORGANIZATION_ID	Long Integer	4	Yes	The foreign key to T_ORGANIZATION implements: "One Organization may have many Stations."
TL_COUNTRY_ID	Text	2	Yes	The foreign key to TL_COUNTRY implements "One Country may have many Stations."
TL_STATE_ID	Text	8	Yes	The foreign key to TL_STATE implements "One State may have many Stations."
TL_USCOUNTY_ID	Long Integer	4		The foreign key to TL_USCOUNTY implements "One County in the United States may have many Stations."
TL_USGS_CU_ID	Text	8		The foreign key to TL_USGS_CU implements "One US Cataloging Unit in the United States may have many Stations."
TL_MEX_BASIN_ID	Integer	2		The foreign key to TL_MEX_BASIN implements "One Mexican basin may have many Stations."
TL_BINATIONAL_REGION_ID	Long Integer	4		The foreign key to TL_BINATIONAL_REGION_ID implements "One trans-boundary watershed may have many Stations."
TL_LEVEL_II_ECOREGION_ID	Text	4		The foreign key to TL_LEVEL_II_REGION implements "One Level II Region in North America may have many Stations."
IDENTIFICATION_CODE	Text	15		The alpha-numeric code assigned by the owning Organization which uniquely identifies the Station within the Organization.
STATION_NAME	Text	60		The name by which an Organization refers to a Station.
STATION_TYPE	Text	20		The word describing the station type. Permitted values are stored in table TL_PERMITTED_VALUE.
ESTABLISHMENT_DATE	Date	8		The date the Station was established.
DESCRIPTION_TEXT	Memo	0		The Organization user-defined description of a Station. May include distance to left shore or right shore to the Station.
STATION_BINARY_OBJECT	Long Binary	0		The actual binary object representing the station.

(continued)

Field Name	Type	Size	Required	Description
STATION_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
STATION_OBJECT_FILETYPE	Text	6		File type associated with the attached file.
LAST_UPDATE	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.3 Table: T_ABSLOCATION

Description: The latitude and longitude of points associated with a station where a sample is taken.

Field Name	Type	Size	Required	Description
T_STATION_ID (PK)	Text	30	Yes	The foreign key to T_STATION implements "One Station have only one Absolute Location Points."
LAT_DIRECTION	Text	1	Yes	The direction of the latitude measurement. "N" denotes a positive value of the latitude. "S" denotes a negative value of the latitude.
LAT_DEC_DEG_MSR	Double	8	Yes	The measure of latitude in decimal degrees (-90.0000 to 90.0000) indicating angular distance North or South of the Equator.
LONG_DIRECTION	Text	1	Yes	The direction of the longitude measurement. "E" denotes a positive value of the latitude." W" denotes a negative value of the latitude.
LONG_DEC_DEG_MSR	Double	8	Yes	The measure of longitude in decimal degrees (-180.0000 to 180.0000) indicating angular distance East or West of the prime meridian.
SOURCEMAP_SCALE_NUMBER	Long Integer	4		The number that represents the proportional distance on the ground for one unit of measure on the map or photo.
DIST_TO_US_MEX_BORDER	Double	8		Shortest distance from station to US-Mexico border in meters.
HORZTL_ACCURACY_MSR	Double	8		The measure of the accuracy (in meters) of the latitude and longitude coordinates.
HORZTL_COLLECT_METHOD	Text	60		The text that describes the method used to determine the latitude and longitude coordinates for a point on the Earth. Permitted values are stored in table TL_PERMITTED_VALUE.
HORZTL_REF_DATUM	Text	60		The name that describes the reference datum used in determining latitude and longitude coordinates. Permitted values are stored in table TL_PERMITTED_VALUE.

(continued)

Field Name	Type	Size	Required	Description
LOCATION_BINARY_OBJECT	Long Binary	0		The actual binary object representing the absolute location.
LOCATION_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
LOCATION_OBJECT_FILETYPE	Text	6		File type associated with the attached file.
LAST_UPDATED	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.4 Table: T_STATION_VISIT

Description: This table represents a period of time spent at a station during which measurements, observations, and/or sampling activities may take place.

Field Name	Type	Size	Required	Description
T_STATION_VISIT_ID (PK)	Text	50	Yes	T_Station_ID&VisitID number
T_STATION_ID	Text	50	Yes	The foreign key to T_STATION implements: "One Station may receive many Station Visits."
ARRIVAL_DATE	Date	8	Yes	Date that the Station Visit commenced.
ARRIVAL_TIME	Date	8		Time at which the Station Visit commenced.
ARRIVAL_TIME_ZONE	Text	50		Time zone in which the visit arrival time is reported. Permitted values are stored in table TL_PERMITTED_VALUE.
DEPARTURE_DATE	Date	8		Date that the Station Visit is concluded.
DEPARTURE_TIME	Date	8		Time at which the Station Visit ended.
DEPARTURE_TIME_ZONE	Text	50		Time zone in which the visit Departure time is reported. Permitted values are stored in table TL_PERMITTED_VALUE.
COMMENT_TEXT	Memo	0		Free text attribute where field notes may be recorded.
LAST_UPDATE	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.5 Table: T_SAMPLE

Description: Samples are quantities of material (e.g., water, sediment, biota) presumed to be representative of the environment. May be collected in the field or created from other samples for the purpose of analyses to identify constituents or pollutants.

Field Name	Type	Size	Required	Description
T_SAMPLE_ID (PK)	Text	60	Yes	T_station_ID&T_STATION_VISIT_ID&T_SAMPLE_ID
T_STATION_VISIT_ID	Text	50	Yes	The foreign key to T_STATION_VISIT implements: "Many Samples may be taken during one Station Visit."
LAB_NAME	Text	60		The name of the laboratory where the sample is analyzed.
SAMPLING_LAB_COMMENT	Text	150		Free text for any comments from the lab on this Sample.
SAMPLING_METHOD	Text	60		The sampling method used when collecting this Sample. Permitted values are stored in table TL_PERMITTED_VALUE.
SAMPLING_METHOD_COMMENT	Text	150		Free text for adding comments on the sampling method.
SAMPLING_CONDITION	Text	30		Weather condition when Sample was taking. Permitted values are stored in table TL_PERMITTED_VALUE.
SAMPLE_COLLECTION_EQUIPMENT	Text	40		The equipment used in collecting the sample. Permitted values are stored in table TL_PERMITTED_VALUE.
SAMPLE_HOLDING_CONTAINER_MATERIAL	Text	35		The material from which the sample container is made. Permitted values are stored in table TL_PERMITTED_VALUE.
SAMPLE_HOLDING_CONTAINER_COLOR	Text	15		The color of the sample container. Permitted values are stored in table TL_PERMITTED_VALUE.
MEDIUM_TYPE_NAME	Text	20		The name of the medium or matrix where the activity occurred during the Station Visit. Examples: Air, Sediment, Water. Permitted values are stored in table TL_PERMITTED_VALUE.

(continued)

Field Name	Type	Size	Required	Description
MEDIUM_SUB_DIVISION	Text	20		Name or code indicating the environmental matrix as a subdivision of the sample media. Permitted values are stored in table TL_PERMITTED_VALUE.
RELTV_DEPTH_NAME	Text	15		The name that indicates the approximate location within the water column at which the activity occurred. Permitted values are stored in table TL_PERMITTED_VALUE.
DEPTH_REF_POINT	Text	30		The text that describes the reference point from which the depth is measured, typically "Surface." Permitted values are stored in table TL_PERMITTED_VALUE.
DEPTH_TO_ACTIVITY	Double	8		Distance in meters from the reference point to the point in the water column at which the activity is conducted.
TEMP_PRESERV_TYPE	Text	25		A default for the name of the type of temperature based physical preservation. Permitted values are stored in table TL_PERMITTED_VALUE.
SAMPLE_OBJECT	Long Binary	0		The binary object with information about the sample.
SAMPLE_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
SAMPLE_OBJECT_FILETYPE	Text	6		File type associated with the attached file.
LAST_UPDATE	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.6 Table: T_RESULT

Description: Information about an environmental characteristic determined as a result of either field measurements, observations or analytical procedures performed on samples. This will be the largest table in the database..

Field Name	Type	Size	Required	Description
T_RESULT_ID (PK)	Text	70	Yes	Source&ID number
T_CHARACTERISTIC_ID	Long Integer	4	Yes	The foreign key to T_CHARACTERISTIC implements "One Characteristic may be the thing measured or reported for many Results."
T_DATA_SOURCE_ID	Long Integer	4	Yes	The foreign key to T_DATA_SOURCE implements "One Data Source may be the source of many Results.
T_SAMPLE_ID	Text	60	Yes	The foreign key to T_SAMPLE implements "One Sample may produce many Results.
T_ANALYTICAL_METHOD_ID	Text	50		The foreign key to T_ANALYTICAL_METHOD implements: "An Analytical Method may have been used to obtain many Results."
VALUE_TEXT	Text	30	Yes	The alpha-numeric representation of the result of analyzing, measuring, or observing a Characteristic.
VALUE_MEASURE	Double	8	Yes	The numeric representation of the result of analyzing a Characteristic with an analytical procedure.
T_UNIT_MEASURE_ID	Long Integer	4	Yes	The foreign key to T_UNIT_MEASURE implements "One Unit of Measure may be the unit of measure for many Results.
DESCRIPTION_TEXT	Memo	0		Long free text associated with a Result in this database.
DETECTION_CONDITION	Text	40		The textual descriptor of a result. Permitted values are stored in table TL_PERMITTED_VALUE.
DETECTION_QUANT_LEVEL_TYPE	Text	35		Text describing the type of detection or quantitation level used in the analysis of a characteristic. Permitted values are stored in table TL_PERMITTED_VALUE.
WEIGHT_BASIS_TYPE	Text	15		The name that represents the form of the sample or portion of the sample which is associated with the result value (e.g., wet weight, dry weight, ash-free dry weight).

(continued)

Field Name	Type	Size	Required	Description
TEMPERATURE_BASIS_TYPE	Text	12		The name that represents the controlled temperature at which the sample was maintained during analysis, e.g. 25 deg BOD analysis.
PARTICLE_SIZE_BASIS_TYPE	Text	15		User defined free text describing the particle size class for which the associated result is defined.
DUR_BASIS_TYPE	Integer	2		The period of time (in days) over which a measurement was made. For example, BOD can be measured as 5 day or 20 day BOD.
SAMPLE_FRAC_TYPE	Text	15		The text name of the portion of the sample associated with results obtained from a physically partitioned sample. Examples: dissolved, suspended, total. Permitted values are stored in table TL_PERMITTED_VALUE.
STATISTIC_TYPE	Text	20		A statistic or calculation type which described the reported result (e.g. average, mode). Permitted values are stored in table TL_PERMITTED_VALUE.
VALUE_TYPE_NAME	Text	10		A name that represents the process which was used in the determination of the result value (e.g., actual, estimated, calculated). Permitted values are stored in table TL_PERMITTED_VALUE.
ANALYSIS_DATE	Date	8		The date on which laboratory analysis of the sample for this particular result was performed.
RESULT_OBJECT	Long Binary	0		The binary object with information about the methodology used to extract data from this source.
RESULT_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
RESULT_OBJECT_FILETYPE	Text	6		File type associated with the attached file.
LAST_UPDATE	Date	8	Yes	System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8	Yes	The foreign key to TL_USER implements: "This table can be modified by many Users."

B.3.7 Table: T_ANALYTICAL_METHOD

Description: Allows for the optional association of an analytical method employed either in the lab or in the field with any result.

Field Name	Type	Size	Required	Description
T_ANALYTICAL_METHOD_ID (PK)	Text	50	Yes	ID Code, unique within Context, which identifies the formally documented method used to obtain the result. Methods may have been used either in the Field or in the Lab. These are methods or procedures which yield results.
ANALYTICAL_METHOD_ORGANIZATION	Text	120		Name of the organization which published the method used to obtain the result. Methods may have been used either in the Field or in the Lab.
ANALYTICAL_METHOD_NAME	Text	150		Free text name of the method used to obtain the result. Methods may have been used either in the Field or in the Lab.
ANALYTICAL_METHOD_OBJECT	Long Binary	0		The binary object with information about the analytical method used to obtain the result.
ANALYTICAL_METHOD_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
ANALYTICAL_METHOD_OBJECT_FILETYPE	Text	6		File type associated with the attached file.

B.3.8 Table: T_DATA_SOURCE

Description: This table holds information about the source (non-primary sources) where data come from. Sources could be existing databases such as STORET, the (U.S.) National Water Information System (NWIS), or the (Mexico) Comisión Nacional del Agua (CNA) data repositories.

Field Name	Type	Size	Required	Description
DATA_SOURCE_ID (PK)	Long Integer	4		A system-generated value used to uniquely identify an ocurrence of this table.
SOURCE_NAME	Text	50		The name and type of the source for data. Example: STORET, NWIS, etc. Source types are: database, organization, etc. Permitted values are stored in table TL_PERMITTED_VALUE.

(continued)

Field Name	Type	Size	Required	Description
EXTRACT_DATE	Date	8		Date when data was extracted from secondary source.
EXTRACT_USER_ID	Text	8		A code that identifies the specific person extracting the data. A foreign key to TL_USER implements: "Data from an existing source can be extracted by many Users"
LAST_UPDATED	Date	8		System generated value that represents the calendar date and time on which this information was posted to the database or when a subsequent modification was made.
TL_USER_ID	Text	8		A foreign key to TL_USER implements: "This table can be modified by many Users." The person who extracts the data from an existing database does not necessarily enter the data in this database.
EXTRACT_METHODOLOGY	Long Binary	0		The binary object with information about the methodology used to extract data from this source. It could be stored in text or PDF format.
EXTRACT_METHOD_OBJECT_FILENAME	Text	255		Name of the attached binary object (file), including file extension.
EXTRACT_METHOD_OBJECT_FILETYPE	Text	6		File type associated with the attached file.

B.3.9 Table: TL_CHARACTERISTIC

Description: A lookup table imported from STORET. Characteristic is the name of the "thing" being investigated. For example, in an analysis for phosphorus, the name of the characteristic is phosphorus.

Field Name	Type	Size	Required	Description
T_CHARACTERISTIC_ID (PK)	Long Integer	4	Yes	A system-generated value used to uniquely identify an ocurrence of this table.
TL_GEN_CHAR_ID	Long Integer	4	Yes	The foreign key to TL_GENERIC_CHARACTERISTIC implements: "One Generic Characteristic may group together many Characteristics."
ORIGINAL_CHAR_ID	Text	20	Yes	Original characteristic ID from the originating database.
ORIGINAL_SOURCE	Text	20	Yes	Original database name where characteristic name is taken from.

(continued)

Field Name	Type	Size	Required	Description
UNIT_TYPE	Text	5	Yes	The category that represents the braod class of a related set of units. Examples: Volume, Concentration, Mass, Area, Velocity, Flow.
SEARCH_NAME	Text	110	Yes	The standardized form of the name as determined by EPA for use in searching the list of environmental characteristics. All caps for consistent search reports.
DISPLAY_NAME	Text	110	Yes	The name of the environmental characteristic as it is to be displayed on windows and reports.
D_SCR_TYPE_CD	Text	4		The code that represents the type of data to be displayed. See STORET data dictionary for Domain/Permitted Values.
PROC_REQ_IND_CD	Text	1		A code indicating whether an analytical procedure is required for a result for this Characteristic.
VALID_FOR_QC_IND	Text	1		A code indicating whether this Characteristic is a valid report for QC samples.
SAMP_FRAC_REQ_CD	Text	1		A code indicating whether a sample fraction is required for this Characteristic. This will be used primarily for Chemical Characteristics.

B.3.10 Table: TL_GENERIC_CHARACTERISTIC

Description: A lookup table with the generic characteristics to group the characteristics in TL_characteristics.

Field Name	Type	Size	Required	Description
TL_GEN_CHAR_ID (PK)	Long Integer	4	Yes	Automatic generated identification code for each Generic Characteristic.
GEN_CHAR_NAME	Text	50	Yes	Name of the generic characteristic grouping more than one Characteristic of similar nature.
GEN_CHAR_DESC	Text	70	Yes	Description of the Generic Characteristic

B.3.11 Table: TL_BINATIONAL_REGION

Description: The 8 transboundary watersheds as defined by the Department of the Interior's U.S.-Mexico Field Coordinating Committee in 1996. Surface-water drainage basins were used as the primary basis for defining and delineating the extent of the border area.

Field Name	Type	Size	Required	Description
TL_BINATIONAL_REGION_ID (PK)	Long Integer	4	Yes	Identification code for the binational subareas
BINATIONAL_REGION_NAME	Text	70	Yes	Binational subareas that have similar hydrologic and physiographic features and defined by the United States Department of the Interior U.S.-Mexico Border Field Coordinating Committee.
BINATIONAL_REGION_DESC	Text	100	Yes	Description of the binational subarea

B.3.12 Table: TL_COUNTRY

Description: A lookup table with list of country names and the ISO 3166-1-alpha-2 code elements.

Field Name	Type	Size	Required	Description
TL_COUNTRY_ID (PK)	Text	2	Yes	ISO 3166-1-alpha-2 code elements given in ISO 3166-1.
COUNTRY_NAME	Text	50	Yes	Country name in English

B.3.13 Table: TL_LEVEL_II_ECOREGION

Description: The 52 level II ecological regions provide a more detailed description of the large ecological areas nested within the level I regions. These are useful for national and subcontinental overviews of physiography, wildlife, and land use.

Field Name	Type	Size	Required	Description
TL_LEVEL_II_ECOREGION_ID (PK)	Text	4	Yes	The North American Commission for Environmental Cooperation classification code of ecological regions.
ECOREGION_NAME_ENG	Text	60	Yes	Ecological region in English
ECOREGION_NAME_SP	Text	60	Yes	Ecological region in Spanish

B.3.14 Table: TL_MEX_BASIN

Description: A lookup table with information on the Mexican Hydrologic Units.

Field Name	Type	Size	Required	Description
TL_MEX_BASIN_ID (PK)	Integer	2	Yes	Unique identifier for a Mexican Hydrologic Unit
BASIN_NAME	Text	50	Yes	Text for basin name.

B.3.15 Table: TL_PERMITTED_VALUE

Description: A lookup table with permitted values for specific fields in some tables of this database. The TABLE_NAME and COLUMN_NAME fields of this table are used to cross reference the field to which given permitted values will apply.

Field Name	Type	Size	Required	Description
TL_PERMITTED_VALUE_ID (PK)	Long Integer	4	Yes	A system-generated value used to uniquely identify an occurrence of this table.
TABLE_NAME	Text	30	Yes	Table name where permitted value is required.
COLUMN_NAME	Text	30	Yes	Column name where permitted value is required.
SEQUENCE_NUMBER	Integer	2	Yes	A sequence number used for ordering the display of a list of permitted values for a specific table and field as referenced.
PERMITTED_VALUE	Text	255	Yes	The text that describes the permitted value to be entered in a given table for a given field on this database.
VALUE_DESC	Text	255		Text description or definition for the term held in the PERMITTED_VALUE column.

B.3.16 Table: TL_STATE

Description: A lookup table that stores information about states in the United States and Mexico.

Field Name	Type	Size	Required	Description
TL_STATE_ID (PK)	Text	8	Yes	State abbreviation (two-letter abbreviation in the US)
TL_STATE_NAME	Text	30	Yes	US state name
TL_COUNTRY_ID	Text	2	Yes	The foreign key to TL_COUNTRY implements "One Country has many States."
US_REGION	Text	2		US Region where US state is located.
US_STATE_FIPS_CODE	Text	2		Federal Information Processing Standards (FIPS) Code in the US for a state.

B.3.17 Table: TL_TRIBAL _GROUP

Description: A lookup table with tribal group codes that represent the American Indian tribe or Alaskan Native entity.

Field Name	Type	Size	Required	Description
TL_TRIBAL_GROUP_ID (PK)	Text	3	Yes	Unique code to represent the American Indian tribe or the Alaskan native entity.
TRIBAL_GROUP_NAME	Text	255	Yes	Text description for the tribal group.

B.3.18 Table: TL_UNIT_MEASURE

Description: A lookup table imported from STORET. This table defines the domain of valid values for units of measure.

Field Name	Type	Size	Required	Description
TL_UNIT_MEASURE_ID (PK)	Long Integer	4	Yes	A system-generated value used to uniquely identify an occurrence of this table.
UNIT_TYPE	Text	10	Yes	The category that represents the broad class of a related set of units. Examples: Volume, Concentration, Mass, Area, Velocity, Flow.
SHORT_NAME	Text	50	Yes	The abbreviation for the name of the unit of measure.
DESCRIPTION_TEXT	Text	50		The full name of the unit of measure.

B.3.19 Table: TL_US_COUNTY

Description: A lookup table with U.S. county information.

Field Name	Type	Size	Required	Description
TL_USCOUNTY_ID (PK)	Long Integer	4	Yes	A system-generated value used to uniquely identify an occurrence of this table.
TL_STATE_ID	Text	8	Yes	The foreign key to TL_STATE implements "One State in the United States has many Counties."
FIPS_COUNTY_CODE	Text	3	Yes	Federal Information Processing Standards (FIPS) Code in the US for this county.
COUNTY_NAME	Text	70	Yes	County name

B.3.20 Table: TL_USER

Description: A lookup table with user information. Users are allowed to view, enter, and/or modify data depending on the privileges given on this table.

Field Name	Type	Size	Required	Description
TL_USER_ID (PK)	Text	8	Yes	Unique text identifier for a user of this database
USER_NAME	Text	40	Yes	Full name of user of this database
VIEW_DATA	Boolean	1	Yes	User can view data
ENTER_DATA	Boolean	1	Yes	User can insert new data
UPADTE_DATA	Boolean	1	Yes	User can update existing data

B.3.21 Table: TL_USGS_CU

Description: A lookup table with USGS 8-digit HUCs identifying the hydrologic units in the United States. The United States is divided and subdivided into successively smaller hydrologic units: regions, subregions, accounting units, and cataloging units.

Field Name	Type	Size	Required	Description
TL_USGS_CU_ID (PK)	Text	8	Yes	First 2 digits: regional area defined by the U.S. WRC; second 2 digits are subregions defined by IHRC; third 2 digits are NWDN Accounting Units and last 2 digits are cataloging units maintained by OWDC.
DESCRIPTION	Text	255	Yes	Text description for this cataloging unit.
AREA	Double	8		Area in sq. miles for this cataloging unit.
STATES	Text	255		States in the US where cataloging unit is located.

B.3.22 Table: TL_METADATA _TABLE

Description: A lookup table to include all tables that are part of this database and their descriptions. This lookup table will support future graphical user interfaces for this database.

Field Name	Type	Size	Required	Description
TABLE_NAME (PK)	Text	50	Yes	Unique table name of table in this database
TABLE_DESCRIPTION	Memo	0	Yes	Text describing table functionality in this database
IS_LOOKUP	Boolean	1		Whether or not this table is a lookup table
IS_CROSSWALK	Boolean	1		Whether or not this table is a cross-walk table
IS_PARENT	Boolean	1		Whether or not this table is a parent table
HAS_PARENT	Boolean	1		Whether or not this table has a parent table
PARENT_NAME	Text	50		Parent table name if this table has a parent table

B.3.23 Table: TL_METADATA _COLUMN

Description: A lookup table to include all columns from all tables that are part of this database and their descriptions. This lookup table will support future graphical user interfaces for this database.

Field Name	Type	Size	Required	Description
TABLE_NAME (PK)	Text	50	Yes	Unique table name of table in this database
COLUMN_NAME	Text	100	Yes	Column name of column within table in this database
COLUMN_DESCRIPTION	Memo	0	Yes	Text describing column functionality within table in this database
IS_PRIMARY_KEY	Boolean	1		Whether or not this column is part of the primary key of table
IS_UNIQUE_KEY	Boolean	1		Whether or not this column is part of a unique key in table
DISPLAY_ORDER	Integer	2		Order in which column is located within column

B.4 Repository Structure

Figure B-2 shows a more detailed diagram of the U.S.-Mexico Border Waters Repository structure. This is an Entity Relational Diagram that includes only the most important tables.

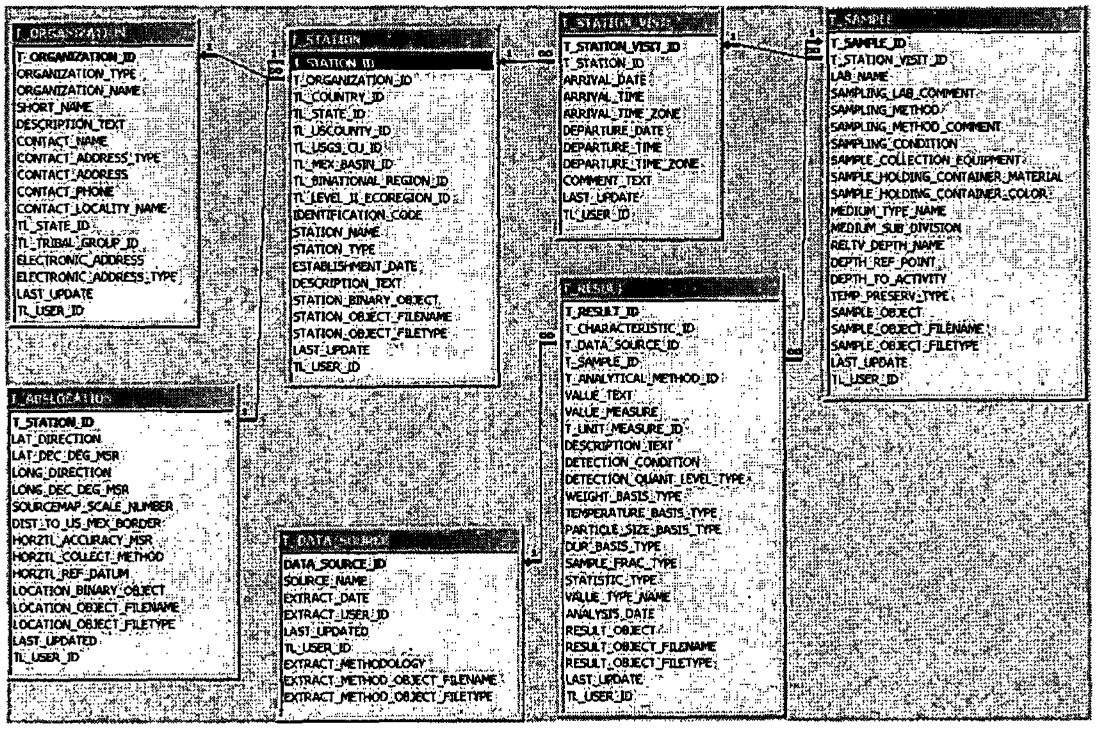

Figure B-2. U.S.-Mexico Border Waters Repository entity relationship diagram.

B.5 References

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Appendix C

Water Quality Indicators Included in the U.S.-Mexico Border Waters Repository

This Appendix includes a list of all "generic water quality indicators" included in a lookup table within the U.S.-Mexico Border Waters Repository. Each one of these generic water quality indicators points to a group of water quality indicators found in the original data sources. For some of these generic indicators, this Appendix includes tables with the corresponding original indicators as found in the data sources.

C.1 Data Collection Process

RTI included surface water data on the parameters of interest in the Repository if they met the following criteria:

- Collected in 1992 or later
- Collected from stations located within 100 km of the U.S.-Mexico border
- Included latitude and longitude coordinates.

This section explains the methods used to download data from the most important online data sources. All data were subject to the QA/QC procedures described in Section 3.1.5.

C.1.1 STORET Modernized

STORET is the U.S. Environmental Protection Agency's (EPA's) largest computerized environmental data system. It is a repository for water quality, biological, and physical data collected by federal, state, and local agencies; Native American tribes; volunteer groups; academics; and others. STORET contains data collected beginning in 1999, along with older data that have been properly documented and migrated from the STORET Legacy Data Center. For the area near the U.S.-Mexico border, STORET contains no data from Texas, very little data from New Mexico and California, and a significant amount of data from Arizona.

RTI performed the following steps to download Modernized STORET data:

1. Opened "http://www.epa.gov/STORET/dw_home.html."
2. Under "STORET Regular Results," clicked on "Regular Results by Geographic Location."
3. For California and New Mexico, downloaded data for each state. For Arizona, conducted separate downloads for each county along the border because the data sets were large.

4. Downloaded data from 1992 to 2004 for the selected parameters.

5. Imported the data sets for California and New Mexico into a processing database and filtered them to select only stations that were located in counties along the border.

6. Further refined the stations list by using ArcView to map all the stations that were in counties of interest and that had data for the parameters of concern during the years of concern. Dropped from the data set any station that was not within the 100 km buffer.

C.1.2 Legacy STORET

The STORET Legacy Data Center is the world's largest repository of ambient water quality data. The database holds more than 200 million water sample observations from about 700,000 sampling sites for both surface water and groundwater. However, the data in Legacy STORET are of undocumented quality. Further, the data in this system are static and only include data from 1999 and earlier. All newer data are stored in STORET Modernized.

To collect data from Legacy STORET, RTI performed the following steps:

1. Opened "http://www.epa.gov/storpubl/legacy/gateway.htm."

2. At the bottom of this Web page, clicked on "Download" by STATE, ALL STORET Legacy DATA for each state, via a compressed self-extracting tab-delimited flat file. This option directed RTI to U.S. EPA's FTP (file transfer protocol) site, where there were executable files available for download for all 50 U.S. states.

3. Downloaded executable files for Texas, California, New Mexico, and Arizona.

4. Unzipped executable files to RTI's server. Organized text files by county, with separate files in each county for station information and water quality data.

5. Imported text files for the counties along the border into a processing database.

6. After all the separate text files were appended into a single stations table, filtered out stations that did not contain data for the period of concern (1992 to present).

7. Checked the remaining stations to determine whether they contained data for a number of parameters.

8. Further refined the stations list by using ArcView to map all stations that were in counties of interest and that had data for the parameters of concern during the years of concern. Dropped from the data set any station that was not within the 100 km buffer.

C.1.3 National Water Information System (NWIS)

The United States Geological Survey (USGS) has collected water resources data at approximately 1.5 million sites in the United States, Puerto Rico, and Guam. Water quality data are available for both surface water and groundwater. Flow data are also available but were not downloaded at this time. NWIS-Web makes available current and historical data. Other programs within USGS, such as the National Water Quality Assessment Program (NAWQA) and the National Stream Quality Accounting Network (NASQAN), make their data available through NWIS-Web. Users can retrieve data by category—such as surface water, groundwater, or water quality—and by geographic area. On subsequent pages, users can further refine their searches by selecting specific information and defining the output desired.

RTI's procedure for acquiring NWIS data was as follows:

9. Opened the NWIS Web site "http://waterdata.usgs.gov/nwis."
10. Clicked on "Water Quality," and then clicked on "Samples."
11. For the site-selection criteria, checked the "Latitude-Longitude" box.
12. Used the following coordinates to create a latitude-longitude box for the area of interest: North latitude = 33.8; East longitude = -96.0; South latitude = 24.7; West longitude = -118.3.
13. Entered the years of interest, 1992 to 2004.
14. Because the data set created was too large to download, downloaded smaller data sets separately by adding the border state into the query criteria.
15. Imported downloadable tab-delimited text files created by NWIS-Web into a processing database.
16. Removed stations that are not in the U.S. counties that fall within the 100 km buffer.
17. Included stations that had data for selected parameters.
18. Further refined the stations list by using ArcView to map the all the stations that were in counties of interest and that had data for the parameters of concern during the years of concern. Dropped from the data set any station that was not within the 100 km buffer.

C.1.4 Texas Commission on Environmental Quality

The Texas Council on Environmental Quality (TCEQ) contracts out its monitoring requirements from the Clean Water Act to various smaller organizations, such as the International Boundary and Water Commission (IBWC). As part of these contract requirements, IBWC must make its data available to the public, and it does so by posting Excel files on the Clean Rivers Program Web site. The IBWC also must submit its data to TCEQ, which must make the data publicly available on its Web site. Therefore, the TCEQ and IBWC Clean Rivers Program should have overlapping data, with the TCEQ Web site containing more data, because it includes organizations other than the IBWC, such as USGS. Therefore, a download of TCEQ data retrieves all the data for the IBWC Clean Rivers Program in addition to the TCEQ data.

The IBWC-originated results are differentiated by having "IBWC" in the T_SAMPLE.LAB_NAME field in this database.

RTI downloaded TCEQ data for the following Level III ecoregions of Texas: regions 21, 22, 23, 24, and 25, which border Mexico.

C.1.5 Southwest Consortium for Environmental Research and Policy (SCERP) Data

SCERP provided two data sets in Microsoft Excel format, one for the New River and one for wastewater. We imported these files directly into Microsoft Access.

C.1.6 Comisión Nacional del Agua (CNA) Data

CNA provided its data to us in Microsoft Excel format. We imported the data directly into Microsoft Access.

C.1.7 Comisión Internacional de Límites y Aguas (CILA) Data

CILA provided some of its data to us in Microsoft Excel format. We imported those data into Microsoft Access using a tab-delimited format. We also downloaded additional data from CILA's Web site. RTI's procedure for acquiring CILA data from the Web site was as follows:

1. Opened the CILA Web site "http://cila.sre.gob.mx."
2. Clicked on "Calidad del Agua" [Water Quality]
3. Clicked on "Estudio Binacional sobre el Monitoreo Intensivo de la Calidad de las Aguas del Rio Bravo en el Tramo de Nuevo Laredo, Tamaulipas-Laredo Texas, entre Mexicoico Estados Unidos del 6 al 16 de noviembre de 2000 (Informe Completo)" (the first link). [Binational Study on the Intensive Monitoring of the Water Quality of the Rio Grande in Laredo, Tamaulipas/Laredo Texas between Mexico and the United States, November 6–16, 2000 (Complete Report)] This Nuevo Laredo/Laredo area report was the only report containing data that met all the criteria noted above.
4. Saved the PDF (Adobe portable document format) file for the above report.
5. Scanned tables containing analysis results from U.S. laboratories (Tables 9, 11, 13, 15, and 17). All data in these tables met the date, location, and location coordinates criteria, so no data were filtered out.
6. Processed the scanned data using OCR (optical character reader) software and performed a 100 percent QC check of the resulting file against the hardcopy, correcting any OCR errors.
7. Added station location coordinates from Table 3 of the downloaded PDF file.

C.2 Generic Water Quality Indicators

The original sources of water quality data vary both in the methods used and the means by which they name the analyses in the data. Data were stored in the same format as the original data source, preserving the water quality indicator name and units, as well as the original water quality indicator ID. We created lookup tables in the database to link the source-specific indicator names to a standardized name (e.g., chlorophyll a) so that we could analyze data for a particular indicator regardless of the different source-specific names. These lookup tables can be easily modified to add new source-specific names as needed.

Table C-1 lists the 23 generic indicator designations associated with the 12 parameters we collected for the Repository. The 12 parameters are shown in bold. Where more than one generic indicator was associated with a parameter, those are listed indented under the bolded parameter name. If only one generic indicator was associated with the parameter, it had the same name as the parameter and only the bolded parameter is listed.

Most of the 23 generic indicators had multiple designations in the source data. Table C-1 also identifies the indicators with multiple designations and provides a cross reference to the more detailed table (Tables C-2 through C-22) listing the multiple designations. For each indicator with multiple designations, Tables C-2 to C-22 (one table per indicator) describe how the variable was assigned in the border waters database in terms of its description and units.

C.3 References

Nelson, R. 2004. "Texas monitoring data." Personal communication from Ryan Nelson, International Boundary and Water Commission (IBWC), to Eric Solano, RTI. October 27.

Table C-1. Generic Indicators by Parameter

Parameter Generic Indicator Name	Detail Table for Indicators with Multiple Designations
Fecal coliform	
Fecal coliform	Table C-2
Fecal streptococci	Table C-3
Chlorophyll a	Table C-4
Sulfate	Table C-5
Conductivity/TDS	
TDS	Table C-6
Conductivity	Table C-7
Chloride	Table C-8
DO	Table C-9
COD	Did not have multiple designations
Nutrients	
Inorganic Nitrogen	Table C-10
Phosphorus	Table C-11
Organic Nitrogen	Table C-12
Nitrogen	Table C-13
Nitrite	Table C-14
Orthophosphate	Table C-15
Nitrate	Table C-16
Ammonia	Table C-17
Nitrite+Nitrate	Table C-18
BOD	Table C-19
pH	Table C-20
Temperature	Table C-21
Total suspended solids	
TSS	Did not have multiple designations
Total Solids	Table C-22

Table C-2. Water Quality Indicators in Repository Related to "Fecal Coliform"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1042	Fecal coliform, M-FC MF (0.7 micron) method, water	NWIS	cfu/100ml
1090	Escherichia coli	STORET	cfu/100ml
1090	Escherichia coli	STORET	MPN/100ml
1090	Escherichia coli	STORET	none
1091	Fecal Coliform	STORET	#/100ml
1091	Fecal Coliform	STORET	cfu/100ml
1091	Fecal Coliform	STORET	cpu/100ml
1091	Fecal Coliform	STORET	MPN/100ml
1091	Fecal Coliform	STORET	none
1164	E. COLI, GEOMETRIC MEAN (#/100ML)	LegSTORET	#/100ml
1165	FECAL COLIFORM GEOMETRIC MEAN (COLONIES/100ML)	LegSTORET	#/100ml
1166	FECAL COLIFORM,MEMBR FILTER,M-FC BROTH, #/100ML	LegSTORET	#/100ml
1167	E. COLI, MTEC, MF, #/100 ML	LegSTORET	#/100ml
1170	E. COLI, COLILERT, IDEXX METHOD, MPN/100ML	LegSTORET	MPN/100ml
1181	FECAL COLIFORM MPN/100ML 5/2,3 DIL FERMENT METHO	LegSTORET	MPN/100ml
1274	COLIFORM,TOT,MEMBRANE FILTER,IMMED.M-ENDO MED,35C	LegSTORET	m-Endo agar LES/100 Ml
1277	COLIFORM,TOT,MPN,CONFIRMED TEST,35C (TUBE 31506)	LegSTORET	MPN/100ml
1283	FECAL COLIFORM,MEMBR FILTER,M-FC AGAR,44.5C,24HR	LegSTORET	m-FC agar/100ml
1285	FECAL COLIFORM,MPN,EC MED,44.5C (TUBE 31614)	LegSTORET	MPN
1288	FECAL COLIFORM,MPN,BORIC ACID LACTOSE BR,43C,48HR	LegSTORET	MPN
1291	FECAL COLIFORM, MF,M-FC, 0.7 UM	LegSTORET	m-FC agar/100ml
1363	FECAL COLIFORM, GENERAL (PERMIT)	LegSTORET	none
1434	Fecal Coliform (CPU/100 ml)	SCERP-New River	cpu/100ml
1440	Fecals	SCERP-Wastewater	Fecals
1457	COLIFORM, TOTAL	CNA	cpu/100ml
1457	COLIFORM, TOTAL	CNA	MPN/100ml
1475	Coliform F	CILA	cfu/100ml

Table C-3. Water Quality Indicators in Repository Related to "Fecal Streptococci"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1043	Fecal streptococci, KF streptococcus MF method, water	NWIS	cfu/100ml
1169	FECAL STREPTOCOCCI, MBR FILT,KF AGAR,35C,48HR	LegSTORET	#/100ml
1459	Fecal streptococci	CNA	MPN/100ml

Table C-4. Water Quality Parameters in U.S.-Mexico Waters Repository Related to "Chlorophyll a"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
227	Chlorophyll a, uncorrected for pheophytin	STORET	none
227	Chlorophyll a, uncorrected for pheophytin	STORET	ug/l [a]
1044	Chlorophyll a, periphyton, chromatographic-fluorometric method	NWIS	mg/m^2
1172	Chlorophyll a ug/l spectrophotometric acid. method	Legacy STORET	ug/l
1179	Chlorophyll a, phytoplankton ug/l, chromo-flouro	Legacy STORET	ug/l
1296	Chlorophyll a ug/l fluorometric corrected	Legacy STORET	ug/l
1297	Chlorophyll a ug/l trichromatic uncorrected	Legacy STORET	ug/l
1303	Chlorophyll a,% of(pheophytin a+chl a),spec-acid.	Legacy STORET	%
1309	Chlorophyll a (mg/l)	Legacy STORET	mg/l
1473	Chlorophyll a	CILA	ug/l

[a] Micrograms per liter.

Table C-5. Water Quality Indicators in Repository Related to "Sulfate"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1047	Sulfate, water, filtered	NWIS	mg/l
1161	SULFATE (MG/L AS SO4)	LegSTORET	mg/l
1186	SULFATE, SO4, SED, DRY WT, WTR EXTRACT, (MG/KG)	LegSTORET	mg/kg
1207	SULFATE (AS S) WHOLE WATER, MG/L	LegSTORET	mg/l
1265	SULFATE, DISSOLVED (MG/L AS SO4)	LegSTORET	mg/l
1429	Sulfate (SO4)	SCERP-New River	mg/l
1444	sulfate	SCERP-Wastewater	mg/l
1471	Dissolved Sulfate	CNA	mg/l

Table C-6. Water Quality Indicators in Repository Related to "TDS"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
553	Dissolved Solids	STORET	mg/l
1176	SOLIDS,TOTAL, DISS, ELECTRICAL-CONDUCTIVITY,MG/L	LegSTORET	mg/l
1177	SOLIDS, DISSOLVED-SUM OF CONSTITUENTS (MG/L)	LegSTORET	mg/l
1431	Total Filter Residue (TDS)	SCERP-New River	mg/l
1445	TDS	SCERP-Wastewater	mg/l

Table C-7. Water Quality Indicators in Repository Related to "Conductivity"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
266	Specific conductance	STORET	none
266	Specific conductance	STORET	umho/cm
266	Specific conductance	STORET	uS/cm
1072	Specific conductance, water, unfiltered	NWIS	uS/cm
1081	Specific conductance, water, unfiltered, laboratory	NWIS	uS/cm
1110	SPECIFIC CONDUCTANCE,FIELD (UMHOS/CM @ 25C)	LegSTORET	umho/cm
1111	SPECIFIC CONDUCTANCE (UMHOS/CM @ 25C)	LegSTORET	umho/cm
1115	SPECIFIC CONDUCTANCE, UMHOS/CM, FIELD, 24HR AVG	LegSTORET	umho/cm
1116	SPECIFIC CONDUCTANCE, UMHOS/CM, FIELD, 24HR MAX	LegSTORET	umho/cm
1117	SPECIFIC CONDUCTANCE, UMHOS/CM, FIELD, 24HR MIN	LegSTORET	umho/cm
1417	Conductivity (uohms/cm)	SCERP-New River	umho/cm

Table C-8. Water Quality Indicators in Repository Related to "Chloride"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1046	Chloride, water, filtered	NWIS	mg/l
1087	Chloride	STORET	mg/l
1087	Chloride	STORET	none
1159	CHLORIDE (MG/L AS CL)	LegSTORET	mg/l
1264	CHLORIDE, DISSOLVED IN WATER MG/L	LegSTORET	mg/l
1425	Chloride (Cl)	SCERP-New River	mg/l
1437	Cl	SCERP-Wastewater	mg/l

Table C-9. Water Quality Indicators in Repository Related to "DO"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
502	Oxygen, (O2)	STORET	mg/l
502	Oxygen, (O2)	STORET	none
1073	Dissolved oxygen, water, unfiltered	NWIS	mg/l
1074	Dissolved oxygen, water, unfiltered	NWIS	%
1089	Dissolved oxygen (DO)	STORET	%
1089	Dissolved oxygen (DO)	STORET	mg/l
1089	Dissolved oxygen (DO)	STORET	none
1127	OXYGEN, DISSOLVED (MG/L)	LegSTORET	mg/l
1128	OXYGEN, DISSOLVED (PERCENT OF SATURATION)	LegSTORET	%
1189	DISSOLVED OXYGEN, 24-HOUR MIN. (MG/L) MIN. 4 MEA	LegSTORET	mg/l
1190	DISSOLVED OXYGEN, 24-HOUR MAX. (MG/L) MIN. 4 MEA	LegSTORET	mg/l
1191	DISSOLVED OXYGEN, 24-HOUR AVG. (MG/L) MIN. 4 MEA	LegSTORET	mg/l
1211	OXYGEN ,DISSOLVED, ANALYSIS BY PROBE MG/L	LegSTORET	mg/l
1418	Dissolved Oxygen (mg/l)	SCERP-New River	mg/l

Table C-10. Water Quality Indicators in Repository Related to "Inorganic Nitrogen"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1249	NITROGEN, INORGANIC, TOTAL (MG/L AS N)	LegSTORET	mg/l

Table C-11. Water Quality Indicators in Repository Related to "Phosphorus"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1063	Phosphorus, water, unfiltered	NWIS	mg/l
1064	Phosphorus, water, filtered	NWIS	mg/l
1101	Phosphorus	STORET	mg/kg
1101	Phosphorus	STORET	mg/l
1101	Phosphorus	STORET	none
1102	Phosphorus as P	STORET	mg/l
1102	Phosphorus as P	STORET	none
1154	PHOSPHORUS, TOTAL, WET METHOD (MG/L AS P)	LegSTORET	mg/l
1155	PHOSPHORUS, DISSOLVED (MG/L AS P)	LegSTORET	mg/l
1252	PHOSPHOROUS DISSOLVED TOTAL WHATMAN GF/F MG/L P	LegSTORET	mg/l
1443	P	SCERP-Wastewater	mg/l
1477	Total Phosphorus	CILA-south/north	mg/l

Table C-12. Water Quality Indicators in Repository Related to "Organic Nitrogen"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1239	NITROGEN, ORGANIC, TOTAL (MG/L AS N)	LegSTORET	mg/l
1241	NITROGEN, ORGANIC, DISSOLVED (MG/L AS N)	LegSTORET	mg/l
1462	NITROGEN, ORGANIC	CNA	mg/l

Table C-13. Water Quality Indicators in Repository Related to "Nitrogen"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
554	Nitrogen ion (N)	STORET	mg/l
1058	Ammonia plus organic nitrogen, water, filtered	NWIS	mg/l
1059	Ammonia plus organic nitrogen, water, unfiltered	NWIS	mg/l
1094	Nitrogen, Kjeldahl	STORET	mg/kg
1094	Nitrogen, Kjeldahl	STORET	mg/l
1094	Nitrogen, Kjeldahl	STORET	none
1147	NITROGEN, KJELDAHL, DISSOLVED (MG/L AS N)	LegSTORET	mg/l
1148	NITROGEN, KJELDAHL, TOTAL (MG/L AS N)	LegSTORET	mg/l
1235	NITROGEN, TOTAL (MG/L AS N)	LegSTORET	mg/l
1432	Total Nitrogen (TN)	SCERP-New River	mg/l
1447	TKN	SCERP-Wastewater	mg/l

Table C-14. Water Quality Indicators in Repository Related to "Nitrite"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1054	Nitrite, water, filtered	NWIS	mg/l
1055	Nitrite, water, unfiltered	NWIS	mg/l
1098	Nitrogen, Nitrite (NO2) as N	STORET	mg/l
1098	Nitrogen, Nitrite (NO2) as N	STORET	none
1099	Nitrogen, Nitrite (NO2) as NO2	STORET	mg/l
1099	Nitrogen, Nitrite (NO2) as NO2	STORET	none
1099	Nitrogen, Nitrite (NO2) as NO2	STORET	ug/l
1144	NITRITE, DISSOLVED (MG/L AS N)	LegSTORET	mg/l
1145	NITRITE NITROGEN, TOTAL (MG/L AS N)	LegSTORET	mg/l
1356	NITRITE NITROGEN,TOTAL (MG/L AS NO2)	LegSTORET	mg/l
1427	Nitrite-Nitrogen (NO2-N)	SCERP-New River	mg/l

Table C-15. Water Quality Indicators in Repository Related to "Orthophosphate"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1065	Orthophosphate, water, filtered	NWIS	mg/l
1066	Orthophosphate, water, unfiltered	NWIS	mg/l
1100	Phosphate	STORET	mg/l
1100	Phosphate	STORET	none
1103	Phosphorus, orthophosphate as P	STORET	mg/l
1103	Phosphorus, orthophosphate as P	STORET	none
1104	Phosphorus, orthophosphate as PO4	STORET	mg/l
1104	Phosphorus, orthophosphate as PO4	STORET	none
1104	Phosphorus, orthophosphate as PO4	STORET	ug/l
1157	ORTHPHOSPHATE PHOSPHORUS,DISS,MG/L,FLDFILT<15MIN	LegSTORET	mg/l
1178	ORTHPHOSPHATE PHOSPHORUS,DISS,MG/L,FILTER >15MIN	LegSTORET	mg/l
1255	PHOSPHATE, ORTHO (MG/L AS PO4)	LegSTORET	mg/l
1269	PHOSPHATE, TOTAL, LAND MG/KG	LegSTORET	mg/kg
1271	ORTHOPHOSPHATE,DRY WEIGHT,LAND MG/KG	LegSTORET	mg/kg
1272	PHOSPHATE HYDROLYZED, DRY WEIGHT, LAND MG/KG	LegSTORET	mg/kg
1327	ORTHOPHOSPHORUS AS P, WATER MG/L	LegSTORET	mg/l
1328	ORTHOPHOSPHATE AS P, WATER MG/L	LegSTORET	mg/l
1329	PHOSPHATE, TOTAL AS P, WATER MG/L	LegSTORET	mg/l
1343	PHOSPHATE,TOTAL,COLORIMETRIC METHOD (MG/L AS P)	LegSTORET	mg/l
1428	Phosphate (PO4-P)	SCERP-New River	mg/l
1460	PHOSPHATE, SOLUBLE	CNA	mg/l
1461	PHOSPHATE, TOTAL	CNA	mg/l
1463	Orthophosphate	CNA	mg/l

Table C-16. Water Quality Indicators in Repository Related to "Nitrate"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1056	Nitrate, water, filtered	NWIS	mg/l
1095	Nitrogen, Nitrate (NO3) as N	STORET	mg/l
1095	Nitrogen, Nitrate (NO3) as N	STORET	none
1096	Nitrogen, Nitrate (NO3) as NO3	STORET	mg/l
1096	Nitrogen, Nitrate (NO3) as NO3	STORET	none
1096	Nitrogen, Nitrate (NO3) as NO3	STORET	ug/l
1146	NITRATE NITROGEN, TOTAL (MG/L AS N)	LegSTORET	mg/l
1244	NITRATE NITROGEN, DISSOLVED (MG/L AS N)	LegSTORET	mg/l
1354	NITRATE NITROGEN,TOTAL (MG/L AS NO3)	LegSTORET	mg/l
1355	NITRATE NITROGEN, DISSOLVED (MG/L AS NO3)	LegSTORET	mg/l
1426	Nitrate-Nitrogen (NO3-N)	SCERP-New River	mg/l

Table C-17. Water Quality Indicators in Repository Related to "Ammonia"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
446	Nitrogen, ammonium (NH4) as NH4	STORET	ug/l
1052	Ammonia, water, filtered	NWIS	mg/l
1053	Ammonia, water, unfiltered	NWIS	mg/l
1086	Ammonia, unionized	STORET	mg/l
1086	Ammonia, unionized	STORET	none
1092	Nitrogen, ammonia (NH3) + ammonium (NH4)	STORET	mg/l
1092	Nitrogen, ammonia (NH3) + ammonium (NH4)	STORET	none
1093	Nitrogen, ammonia as N	STORET	mg/kg
1093	Nitrogen, ammonia as N	STORET	mg/l
1093	Nitrogen, ammonia as N	STORET	none
1141	NITROGEN, AMMONIA, DISSOLVED (MG/L AS N)	LegSTORET	mg/l
1142	NITROGEN, AMMONIA, TOTAL (MG/L AS N)	LegSTORET	mg/l
1143	AMMONIA, UNIONIZED (MG/L AS N)	LegSTORET	mg/l
1267	NITROGEN-NITRATE IN WATER PERCENT	LegSTORET	%
1352	NITROGEN, AMMONIA, TOTAL (MG/L AS NH4)	LegSTORET	mg/l
1422	Ammonia Nitrogen (NH3-N)	SCERP-New River	mg/l
1448	Total NH4-N	SCERP-Wastewater	mg/l

Table C-18. Water Quality Indicators in Repository Related to "Nitrite+Nitrate"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
1060	Nitrite plus nitrate, water, unfiltered	NWIS	mg/l
1061	Nitrite plus nitrate, water, filtered	NWIS	mg/l
1097	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	STORET	mg/kg
1097	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	STORET	mg/l
1097	Nitrogen, Nitrite (NO2) + Nitrate (NO3) as N	STORET	none
1140	NO2 PLUS NO3-N, TOTAL, WHATMAN GF/F FILT (MG/L)	LegSTORET	mg/l
1151	NITRITE PLUS NITRATE, TOTAL 1 DET. (MG/L AS N)	LegSTORET	mg/l
1152	NITRITE PLUS NITRATE, DISS 1 DET. (MG/L AS N)	LegSTORET	mg/l
1270	NITRATE + NITRITE,DRY WT,LAND MG/KG	LegSTORET	mg/kg
1442	NO2-N and NO3 -N	SCERP-Wastewater	mg/l
1474	Nitrite plus nitrate	CILA	mg/l

Table C-19. Water Quality Indicators in Repository Related to "BOD"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
85	BOD, Biochemical oxygen demand	STORET	mg/l
85	BOD, Biochemical oxygen demand	STORET	none
1129	BIOCHEM OXY DEM,INHIB, DISS(MG/L,5DAY-20C, CBOD)	LegSTORET	mg/l
1130	BIOCHEM OXY DEM,NIT INHIB,TOT (MG/L,20 DAY-20C)	LegSTORET	mg/l
1131	BIOCHEM OXY DEM,NIT INHIB DISS(MG/L,20 DAY-20C)	LegSTORET	mg/l
1132	BIOCHEMICAL OXYGEN DEMAND (MG/L, 5 DAY - 20DEG C	LegSTORET	mg/l
1133	BIOCHEM OXY DEM NIT INHIB, TOT (MG/L, 5 DAY-20C)	LegSTORET	mg/l
1182	BOD, CARBONACEOUS, 5 DAY, 20 DEG C	LegSTORET	mg/l
1423	Biological Oxygen Demand (BOD)	SCERP-New River	mg/l
1436	BOD	SCERP-Wastewater	mg/l

Table C-20. Water Quality Indicators in Repository Related to "pH"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
29	pH	STORET	none
1076	pH, water, unfiltered, field	NWIS	none
1077	pH, water, unfiltered, laboratory	NWIS	none
1118	PH, S.U., 24HR MAXIMUM VALUE	LegSTORET	none
1119	PH, S.U., 24HR, MINIMUM VALUE	LegSTORET	none
1135	PH (STANDARD UNITS)	LegSTORET	none
1136	PH (STANDARD UNITS) LAB	LegSTORET	none
1233	PH, FIELD, STANDARD UNITS SU	LegSTORET	none

Table C-21. Water Quality Indicators in Repository Related to "Temperature"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
257	Temperature, water	STORET	deg C
257	Temperature, water	STORET	deg F
257	Temperature, water	STORET	none
480	Temperature, air	STORET	deg C
480	Temperature, air	STORET	none
1067	Temperature, water	NWIS	deg C
1068	Temperature, air	NWIS	deg C
1105	TEMPERATURE, WATER (DEGREES CENTIGRADE)	LegSTORET	deg C
1106	TEMPERATURE, AIR (DEGREES CENTIGRADE)	LegSTORET	deg C
1112	TEMPERATURE, WATER (DEGREES CENTIGRADE, 24HR AVG	LegSTORET	deg C
1113	WATER TEMPERATURE, DEGREES CENTIGRADE, 24HR MAX	LegSTORET	deg C
1114	TEMPERATURE, WATER (DEGREES CENTIGRADE) 24HR MIN	LegSTORET	deg C
1420	Temperature (deg C)	SCERP-New River	deg C
1446	Temp	SCERP-Wastewater	deg C

Table C-22. Water Quality Indicators in Repository Related to "Total Solids"

Water Quality Indicator ID	Indicator Display Name	Original Source	Units
216	Total Solids	STORET	mg/l
216	Total Solids	STORET	none

Appendix D

Water Quality Comparisons against Benchmarks

This Appendix summarizes the water quality standards in each U.S. border state and Mexico and shows the comparisons of some water quality indicators from the U.S.-Mexico Waters Repository to those standards.

D.1 Water Quality Standards and Comparisons for the United States

For the U.S. side of the border, water quality standards vary by state. We reviewed published regulations in Arizona, California, New Mexico, and Texas on surface water quality standards. All four states established standards based on specific water quality objectives. Texas establishes water quality standards specific to river segments-specific. Water quality standards may differ for waterbodies with recreational purposes and waterbodies used for consumption purposes.

Table D-1 shows the water quality indicators for which the four U.S. states have established water quality standards. A single bullet in this table may represent a series of standards for a state for a water quality indicator. For more detailed information on all specific standards refer to the documents published by the States (ADEQ, 2003; CSWRCB, 1994a and 1994b; NMED, 2002; TNRCC, 2000). Tribes in the United States also issue their own water quality standards subject to EPA oversight and approval. Tribal water quality regulations may be considered in future assessments of water quality status using the Repository.

Table D-1. List of Water Quality Parameters with Legal Standards in U.S. Border States

Water Quality Parameter	State			
	Arizona	California[a]	New Mexico	Texas
Ammonia	•		•	
BOD_5		•		
Chloride (Cl)		•	•	•
COD		•		
Conductivity			•	
DO	•	•	•	•
Escherichia coli (*E. coli*)	•	•		•
Fecal Coliform Organisms	•	•	•	•
Hardness ($CaCO_3$)				•
Nutrients	•	•	•	
pH	•	•	•	•
Phosphorus	•	•		•

(continued)

Table D-1. (continued)

Water Quality Parameter	State			
	Arizona	California[a]	New Mexico	Texas
Sulfate (SO_4)			•	•
Temperature	•	•	•	•
Total dissolved solids	•	•	•	•
Toxic Materials	•	•	•	•
Turbidity	•		•	
Others	•	•	•	•

[a] Standards for the California border basins only.

In addition to state water quality standards in the United States, U.S. EPA has published recommended nutrients standards for rivers, streams, lakes, and reservoirs in the *National Strategy for the Development of Regional Nutrient Criteria* (U.S. EPA, 1998). EPA divided the United States into nutrient regions and proposed standards for each region. The border states fall in three of the Nutrient Regions:

- **Nutrient Region III** includes Arizona, California, New Mexico, and Southwest Texas to the Amistad Reservoir. Stations in the Pacific/Salton Sea, Colorado River/Sea of Cortez, and Central Desert transboundary regions and some stations in the Rio Grande transboundary region are located in Nutrients Region III.

- **Nutrient Region IV** includes Texas from the Amistad Reservoir to the Falcon Reservoir. Some stations in the Rio Grande transboundary region are located in Nutrients Region IV.

- **Nutrient Region X** includes the Texas-Louisiana Coastal and Mississippi Alluvial Plains and Texas from the Falcon Reservoir to the Gulf of Mexico. Stations on the Lower Rio Grande transboundary region are located in Nutrient Region X.

For those three regions, Table D-2 shows the nutrients criteria for rivers and streams and Table D-3 shows the nutrients criteria for lakes and reservoirs.

Table D-2. Nutrient Criteria for Rivers and Streams by Nutrient Region

Parameter	Region III	Region IV	Region X
Chlorophyll a (μg/L)	1.8	2.4	2.1
Secchi disc depth (m)	-	-	-
Total Nitrogen (mg/L)	0.38	0.56	0.76
Total Phosphorus (μg/L)	22	23	-
Turbidity (Nephelometric Turbidity Units)	2.34	4.21	17.50

Table D-3. Nutrient Criteria for Lakes and Reservoirs by Nutrient Region

Parameter	Region III	Region IV	Region X
Chlorophyll a (µg/L)	3.4	2.0	5.5
Secchi disc depth (m)	2.7	2.0	0.8
Total Nitrogen (mg/L)	0.40	0.44	0.57
Total Phosphorus (µg/L)	17	20	60
Turbidity (Nephelometric Turbidity Units)	-	-	-

D.1.1 Water Quality Comparisons for Arizona

The Arizona Department of Environmental Quality (ADEQ) reviews and approves on a triennial basis the Arizona Surface and Groundwater Quality Standards (ADEQ, 2003). Currently, ADEQ is preparing for its 2006 triennial review. Arizona establishes water quality standards for nontoxics, toxics, and radiochemicals based on designated uses. Arizona's regulations also include surface water quality nutrient standards, aquifer water quality standards, and groundwater standards for organic chemicals, pesticides, etc. Table D-4 shows some of the surface water quality standards approved by Arizona in 2003.

Table D-4. Water Quality Standards for Arizona

Parameter	Criteria	Comment
DO (mg/L)	≥ 7.0	Aquatic and wildlife uses
E. coli (CFU/100 ml)	≤ 580	Single sample maximum
Fecal coliform (CFU/100 ml)	≤ 800	Single sample maximum
Nitrate as nitrogen (NO_3 as N) (mg/L)	≤ 224	Water contact recreation
Nitrite as nitrogen (NO_2 as N) (mg/L)	≤ 14	Water contact recreation
pH	6.5–9.0	Aquatic and wildlife uses, water contact recreation
Total dissolved solids (mg/L)	≤ 1,000	U.S. EPA criteria—more sensitive crops
Turbidity (Nephelometric Turbidity Units)	≤ 50 NTU	Aquatic and wildlife uses, streams and lakes

Tables D-5 to D-7 compare Repository data on chlorophyll a, dissolved oxygen, and pH, respectively, to these standards.

Table D-5. Water Quality Comparisons for Arizona: Chlorophyll-a (Water Quality Indicator ID: 227)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-100183	SCROS-A	6	5	83%
ModSTORET-100000	SCARI-A	4	4	100%
ModSTORET-100035	SCLAK-B	1	1	100%
ModSTORET-100034	SCLAK-A	1	1	100%

Table D-6. Water Quality Comparisons for Arizona: Dissolved Oxygen (Water Quality Indicator IDs: 1073, 1089, 1127 and 1211)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-100000	SCARI-A	33	16	48%
ModSTORET-100183	SCROS-A	22	19	86%
ModSTORET-100035	SCLAK-B	6	2	33%
ModSTORET-101177	SCCIE010.20	4	1	25%
ModSTORET-101080	SCRED002.17	4	1	25%
ModSTORET-101176	SCCIE014.39	4	2	50%
ModSTORET-101178	SCCIE002.66	4	2	50%
ModSTORET-101179	SCCIE001.49	4	2	50%
ModSTORET-101152	SCSAB004.39	4	1	25%
NWIS_321836111064800	BARREL SPRINGS STOCK TANK	3	2	67%
ModSTORET-100938	RMRUC005.63	3	1	33%
ModSTORET-100653	SPSPR095.71	3	1	33%
ModSTORET-100639	UGSCV002.26	3	2	67%
ModSTORET-100281	SPSPR077.66	3	2	67%
ModSTORET-100275	SPSPR113.55	3	1	33%
NWIS_321227110331201	D-14-17 13DDA	3	3	100%
NWIS_321344110320601	D-14-18 07DAB	3	3	100%
NWIS_320842109252401	D-15-28 12ACC1	2	2	100%
ModSTORET-100937	UGCAV006.55	2	1	50%
NWIS_313144111271501	CARPENTER TANK AT BUENOS AIRES NWR	1	1	100%
NWIS_313530109302701	POOL AT LESLIE CREEK AT LESLIE CANYON NWR	1	1	100%
NWIS_321156110420001	LOMA VERDE WASH AT SAGUARO NP	1	1	100%
NWIS_321157110362901	CHIMENEA CREEK AT SAGUARO NP	1	1	100%

Table D-7. Water Quality Comparisons for Arizona: pH (Water Quality Indicator IDs: 29, 1076, 1077, 1135 and 1136)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-100000	SCARI-A	39	8	21%
ModSTORET-100183	SCROS-A	34	15	44%
ModSTORET-100872	SCTHC004.01	1	1	100%
ModSTORET-59761	GARRETT RANCH	2	1	50%
NWIS_312250110041901	GREENBUSH DRAW PRECIP	10	2	20%
NWIS_313756110240801	UPPER BABOCOMARI PRECIP	12	4	33%
NWIS_321344110320601	D-14-18 07DAB	6	2	33%

D.1.2 Water Quality Comparisons for California

California has adopted water quality criteria on a regional basis. The *Water Quality Control Plan for the Colorado River Basin* (CSWRCB, 1994a) and the *Water Quality Control Plan for the San Diego Basin* (CSWRCB, 1994b) were used as references for water quality criteria in the border area of California. General water quality objectives for the Colorado River Basin apply for all waters of the region. These include aesthetic, toxicity, temperature, pH, bacteria, and other general standards. Specific surface waters objectives are also enforced for the Colorado River above and below the Imperial Dam and for the New River. The designated water quality control plan for the San Diego Basin includes different water quality objectives: temperature control, agricultural supply beneficial use, ammonia control, contact and noncontact recreation, shellfish harvesting, etc. Table D-8 shows the water quality standards for the Colorado River Basin, Table D-9 for the New River at the International Boundary, and Table D-10 for the San Diego Basin.

Table D-8. Water Quality Standards for the Colorado River Basin

Parameter	Criteria	Comment
Dissolved oxygen (mg/L)	≥ 8.0	For Warm uses and Cold uses
Escherichia coli (*E. coli*) (#/100 mL)	≤ 400	For water contact recreation (for noncontact water recreation the value is 2,000)
Fecal coliform (#/100 mL)	≤ 200	For water contact recreation
pH	6.0–9.0	Regional waters are somewhat alkaline
Total dissolved solids (mg/L)	≤ 4,500	Maximum at Imperial Valley Drains and New River

Table D-9. Water Quality Standards for the New River at the International Boundary

Parameter	New River at Boundary	Lagoon Discharge Canal	New River Upstream of Discharge Canal
BOD5	-	30 mg/L filtered (monthly grab sample)	30 mg/L unfiltered (monthly 12-hr composite sample)
COD	-	70 mg/L filtered	100 mg/L unfiltered (monthly 12-hr composite sample)
DO	5.0 mg/L (daily grab sample)	-	-
Fecal coliform organisms	-	-	30,000 colonies per 100 ml, with no single sample to exceed 60,000 colonies per 100mL
pH	6.0–9.0	-	-

Table D-10. Water Quality Standards for the San Diego Basin

Parameter	Criteria	Comment
Ammonia (mg/L)	≤ 0.025	Nonionized
Dissolved oxygen (mg/L)	≥ 5.0	For warm uses (for cold uses it must be ≥ 6)
E. coli (MPN/100 mL)	≤ 235	For water contact recreation (designated beach)
Fecal coliform (MPN/100 mL)	≤ 400	For water contact recreation (for noncontact water recreation the value is 4,000)
pH	6.5 to 8.5	Inland surface waters

Tables D-11 to D-17 compare Repository data on total phosphorus, total nitrogen, chlorophyll a, pH, dissolved oxygen, fecal coliform, and ammonia, respectively, to these standards.

Table D-11. Water Quality Comparisons for California: Total Phosphorus (Water Quality Indicator ID: 1154)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21CAL-4-LL-SD-06	LINDO LAKE PARK WEST BASIN NE-BANK / CALIFORNIA / SAN DIEGO	3	3	100%
11NPSWRD-JOTR_NPS_BOSP	BOLSTER CANYON SPRING / COLORADO RIVER / DEAD BASIN	2	2	100%
21CAL-4-LL-SD-01	LINDO LAKE PARK EAST BASIN SE-BANK / CALIFORNIA / SAN DIEGO	2	2	100%
21CAL-4-LL-SD-07	LINDO LAKE PARK WEST BASIN N-BANK / CALIFORNIA / SAN DIEGO C	2	2	100%
21CAL-4-LL-SD-10	LINDO LAKE PARK WEST BASIN NW-BANK / CALIFORNIA / SAN DIEGO	2	2	100%
21CAL-4-LL-SD-13	LINDO LAKE PARK WEST BASIN S-BANK / CALIFORNIA / SAN DIEGO C	2	2	100%
11NPSWRD-JOTR_NPS_SSPL	STUBBE SPRING LOWER / COLORADO RIVER / DEAD BASIN	1	1	100%
21CAL-4G-LL-WW-01	LINDO LAKE PARK EAST BASIN SE-BANK / CALIFORNIA / SAN DIEGO	1	1	100%
21CAL-4-LL-LW-01	LINDO LAKE PARK EAST BASIN SE-CENTER / CALIFORNIA / SAN DIEG	1	1	100%
21CAL-4-LL-LW-02	LINDO LAKE PARK EAST BASIN NW-CENTER / CALIFORNIA / SAN DIEG	1	1	100%
21CAL-4-LL-LW-03	LINDO LAKE PARK WEST BASIN E-CENTER / CALIFORNIA / SAN DIEGO	1	1	100%
21CAL-4-LL-LW-04	LINDO LAKE PARK WEST BASIN W-CENTER / CALIFORNIA / SAN DIEGO	1	1	100%
21CAL-4-LL-LW-05	LINDO LAKE PARK WEST BASIN SW-CENTER / CALIFORNIA / SAN DIEG	1	1	100%

Table D-12. Water Quality Comparisons for California: Total Nitrogen (Water Quality Indicator ID: 1148)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
11NPSWRD-JOTR_NPS_BOSP	BOLSTER CANYON SPRING / COLORADO RIVER / DEAD BASIN	2	2	100%
11NPSWRD-JOTR_NPS_SSPL	STUBBE SPRING LOWER / COLORADO RIVER / DEAD BASIN	1	1	100%
21CAL-4-LL-SD-01	LINDO LAKE PARK EAST BASIN SE-BANK / CALIFORNIA / SAN DIEGO	4	4	100%
21CAL-4-LL-SD-06	LINDO LAKE PARK WEST BASIN NE-BANK / CALIFORNIA / SAN DIEGO	6	6	100%
21CAL-4-LL-SD-07	LINDO LAKE PARK WEST BASIN N-BANK / CALIFORNIA / SAN DIEGO C	4	4	100%
21CAL-4-LL-SD-10	LINDO LAKE PARK WEST BASIN NW-BANK / CALIFORNIA / SAN DIEGO	4	4	100%
21CAL-4-LL-SD-13	LINDO LAKE PARK WEST BASIN S-BANK / CALIFORNIA / SAN DIEGO C	4	4	100%

Table D-13. Water Quality Comparisons for California: Chlorophyll-a (Water Quality Indicator ID: 227)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-CA99-0047	San Diego Bay	3	1	33%
ModSTORET-CA99-0048	San Diego Bay	3	2	67%
ModSTORET-CA99-0044	Mission Bay	2	2	100%
ModSTORET-CA99-0045	San Diego River	1	1	100%

Table D-14. Water Quality Comparisons for California: pH (Water Quality Indicator IDs: 29, 1076, 1077, 1135 and 1136)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_324114115551801	017S010E11H PRECIP	4	1	25%
NWIS_324130117002501	SWEETWATER RES NR PUMP TOWER UPPER	178	7	4%
NWIS_324131117000101	SWEETWATER RES CTR OF MIN POOL UPPER	174	10	6%
NWIS_324209116585001	SWEETWATER RES E END RES FILL BNDRY UPPER	35	5	14%
NWIS_324703116473101	LOVELAND RES NR DAM SITE 1 UPPER	298	27	9%
NWIS_325428114282601	014S022W32Q PRECIP	3	2	67%
NWIS_331259116214501	011S006E16N PRECIP	4	1	25%

Table D-15. Water Quality Comparisons for California: Dissolved Oxygen (Water Quality Indicator IDs: 1073, 1089, 1127 and 1211)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_324703116473101	LOVELAND RES NR DAM SITE 1 UPPER	265	210	79%
NWIS_324130117002501	SWEETWATER RES NR PUMP TOWER UPPER	161	126	78%
NWIS_324131117000101	SWEETWATER RES CTR OF MIN POOL UPPER	159	128	81%
NWIS_324209116585001	SWEETWATER RES E END RES FILL BNDRY UPPER	33	11	33%
NWIS_324311116565901	SWEETWATER R A LOW FLOW BARRIER A SWEETWATER RES	9	5	56%

Table D-16. Water Quality Comparisons for California: Fecal Coliform (Water Quality Indicator ID: 1042)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_10254670	ALAMO R AT DROP 3 NR CALIPATRIA CA	11	11	100%
NWIS_11022200	LOS COCHES C NR LAKESIDE CA	1	1	100%
NWIS_11022480	SAN DIEGO R A MAST RD NR SANTEE CA	1	1	100%

Table D-17. Water Quality Comparisons for California: Ammonia (Water Quality Indicator IDs: 1052, 1058, 1059)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_10254005	SALTON SEA NR WESTMORLAND CA	4	4	100%
NWIS_10254670	ALAMO R AT DROP 3 NR CALIPATRIA CA	22	22	100%
NWIS_324018115355201	BROCKMAN DR NO 2 AB CONF NR CALEXICO CA	1	1	100%
NWIS_324320115260401	SOUTH CENTRAL DR A FAWCETT RD NR CALEXICO CA	1	1	100%
NWIS_324324115384601	WISTARIA DR NO 7 NR GREESON DR NR MT SIGNAL CA	1	1	100%
NWIS_324350115395000	GREESON DR NR NEW R CA	2	2	100%
NWIS_324504115182201	VERDE DR A CHELL RD NR HOLTVILLE CA	1	1	100%
NWIS_324531115260401	SOUTH CENTRAL DR A HILFIKER RD NR HOLTVILLE CA	1	1	100%
NWIS_324545115204800	VERDE DR NR CONFLUENCE W ALAMO R CA	2	2	100%
NWIS_324611115182101	WARREN DR NO. 2 ON HUNT RD NR HOLTVILLE CA	1	1	100%
NWIS_324650115205200	WARREN DR NR ALAMO R	2	2	100%
NWIS_324752115260200	SOUTH CENTRAL DRAIN NR ALAMO R	2	2	100%
NWIS_324818115401701	ELDER 14 DR S OF EL CENTRO NAVAL STA NR SEELEY CA	1	1	100%
NWIS_324904115372401	CENTRAL DR NO 10 AB CONF NR EL CENTRO CA	1	1	100%
NWIS_324923115302601	CENTRAL DR BETWEEN CENTRAL DR 6&7 NR EL CENTRO CA	1	1	100%
NWIS_324930115413101	ELDER 14 DRAIN NR NEW R NR SEELEY CA	2	2	100%
NWIS_324931115391301	RICE DRAIN NO. 5 A ATEN RD NR SEELEY CA	1	1	100%
NWIS_324956115211401	PALMETTO DR A BRIDENSTEIN RD NR HOLTVILLE CA	1	1	100%
NWIS_324956115261701	CENTRAL DR/ROSITAS WASTE NR HOLTVILLE CA	2	2	100%
NWIS_324958115290101	MESQUITE DR NO 6 AB CONF NR HOLTVILLE CA	1	1	100%
NWIS_324959115255201	PALMETTO C ON MORRISN RD NR ALAMO R NR HOLTVILLE C	2	2	100%

(continued)

Table D-17. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_325207115195201	HOLTVILLE DR NO. 1 ON WRIGHT RD NR HOLTVILLE CA	1	1	100%
NWIS_325210115391601	RICE DRAIN NO. 5 NR NEW R NR SEELEY CA	2	2	100%
NWIS_325354115310001	014S014E27N01SLYS S-154 AT 19 FT	2	2	100%
NWIS_325354115310002	014S014E27N02SLYS S-154 AT 14 FT	2	1	50%
NWIS_325354115310003	014S014E27N03SLYS S-154 AT 9 FT	2	1	50%
NWIS_325434115215501	HOLTVILLE MAIN DRAIN A COOPER RD NR HOLTVILLE CA	1	1	100%
NWIS_325449115293001	MESQUITE DR NR HWY S27 NR ALAMORIO CA	1	1	100%
NWIS_325538115294800	ROSE DRAIN A PUMP STA CA	2	2	100%
NWIS_325548115233301	HOLTVILLE DR NO. 8 A ADAMS RD NR ALAMORIO CA	1	1	100%
NWIS_325552115270900	HOLTVILLE DR NR ALAMO CA	2	2	100%
NWIS_325853115245101	OSAGE DR W OF HASTIAN RD NR ALAMORIO CA	1	1	100%
NWIS_325854115272601	OSAGE DR NR ALAMO R NR ALAMORIO CA	2	2	100%
NWIS_325855115211301	OSAGE DR ON SILLIMAN RD NR HOLTVILLE CA	2	2	100%
NWIS_325855115211302	OSAGE CANAL ON SILLIMAN RD NR HOLTVILLE CA	2	2	100%
NWIS_330307115412101	TRIFOLIUM DR NO. 2 A BANNISTER RD NR CALIPATRIA CA	1	1	100%
NWIS_330454115413301	TRIFOLIUM DRAIN NO. 2 A BAKER RD NR WESTMORLAND CA	1	1	100%
NWIS_330459115430101	TRIFOLIUM NO1 DRAIN AT OUTLET TO SALTON SEA, CA	2	2	100%
NWIS_330520115305901	NETTLE DRAIN NR ALAMO R NR CALIPATRIA CA	2	2	100%
NWIS_330521115265901	NETTLE DRAIN A HWY 115 NR CALIPATRIA CA	1	1	100%
NWIS_330522115223701	NETTLE DR W OF E HIGHLINE CANAL NR CALIPATRIA CA	1	1	100%
NWIS_330615115331101	VAIL DRAIN ON VAIL RD NR WESTMORLAND CA	1	1	100%
NWIS_330616115361701	VAIL DR ON VAIL RD E OF GENTRY RD NR CALIPATRIA CA	1	1	100%
NWIS_330617115385201	VAIL DRAIN A LACK RD NR CALIPATRIA CA	2	2	100%

(continued)

Table D-17. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
NWIS_330703115324001	C DR NR ALAMO R NR CALIPATRIA CA	1	1	100%
NWIS_330706115385201	VAIL 6 DRAIN A BOWLES RD NR CALIPATRIA CA	1	1	100%
NWIS_330758115392601	VAIL CUT OFF DR AT YOUNG RD OUTLET TO SALTON SEA	4	4	100%
NWIS_330835115434501	SALTON SEA IN NEW R DELTA CA	2	2	100%
NWIS_330915115361701	VAIL 3-A DRAIN A KUNS RD NR NILAND CA	1	1	100%
NWIS_331023115473701	SALTON SEA IN SAN FELIPE C DELTA CA	2	2	100%
NWIS_331034115334501	K DRAIN A BRANDT RD NR ALAMO R NR NILAND CA	2	2	100%
NWIS_331034115371800	PUMICE DRAIN NR SALTON SEA CA	2	2	100%
NWIS_331036115265801	K DRAIN A WIEST RD NR NILAND CA	1	1	100%
NWIS_331036115310501	K DRAIN A HWY 111 NR NILAND CA	1	1	100%
NWIS_331215115410001	SALTON SEA BETWEEN S BASIN AND NEW ALAMO R DELTA	2	2	100%
NWIS_331246115341301	P DR 0.5 MI E OF CONF WITH P LATERAL NR NILAND CA	1	1	100%
NWIS_331400115380001	SALTON SEA IN ALAMO R DELTA CA	2	2	100%
NWIS_331400115450001	SALTON SEA NR CENTER OF S BASIN CA	2	2	100%
NWIS_331532115344401	WASH AT DAVIS RD NR W DRAIN NR NILAND CA	1	1	100%
NWIS_331600115453001	SALTON SEA A CENTER OF S BASIN CA	2	2	100%
NWIS_331930115484001	SALTON SEA NR CENTER OF LAKE BETWEEN N AND S BASIN	2	2	100%
NWIS_332400115553001	SALTON SEA A CENTER OF N BASIN CA	2	2	100%
NWIS_332637115512001	SALTON SEA IN SALT C DELTA CA	2	2	100%
NWIS_332908116011501	SALTON SEA BETWEEN N BASIN AND WHITEWATER RIVER	11	11	100%
NWIS_332958116023501	SALTON SEA IN WHITEWATER R DELTA CA	2	2	100%

D.3 Water Quality Comparisons for New Mexico

The New Mexico Water Quality Control Commission established surface water quality standards for interstate and intrastate surface waters (NMED, 2002). General standards are established to sustain and protect existing or attainable uses of surface waters of the state. These general standards apply to all surface waters of the state at all times, unless a specified standard is provided elsewhere on a river segment. Specific standards for a river segment depend on the designated use and flow level. Table D-18 shows the highest standards across the state.

Table D-18. Water Quality Standards for New Mexico

Parameter	Criteria	Comment
Chloride (mg/L) (1)	≤ 25	Highest standard across the state
Dissolved oxygen (mg/L)	≥ 5.0	Most uses
Fecal coliform (CFU/100 ml)	≤ 200	Highest standard across the state
pH	6.6–8.8	In most reaches of Rio Grande Basin
Sulfate (mg/L) (1)	≤ 150	Highest standard across the state
Total dissolved solids (mg/L) [a]	≤ 500	Highest standard across the state
Turbidity (Nephelometric Turbidity Units)	≤ 10 NTU	Fisheries

[a] Rio Grande Basin—The main stem of the Rio Grande, from Taos Junction bridge upstream to the New Mexico-Colorado State line.

Tables D-19 to D-27 compare Repository data on total phosphorus, total nitrogen, chlorophyll a, dissolved oxygen, fecal coliform, sulfate, chloride, pH, and total dissolved solids, respectively, to these standards.

Table D-19. Water Quality Comparisons for New Mexico: Total Phosphorus (Water Quality Indicator ID: 1154)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-LRG101.000110	RIO GRANDE NEAR ANTHONY ON NM HIGHWAY 225 BRIDGE / WESTERN G	19	19	100%
21NMEX-LRG046	RIO GRANDE AT PICACHO AVE IN LAS CRUCES / WESTERN GULF / UPP	19	19	100%
21NMEX-LRG053	RIO GRANDE AT NM HIGHWAY 226 NEAR BERINO / WESTERN GULF / UP	17	17	100%
21NMEX-LRG101.000101	RIO GRANDE BELOW SUNLAND PARK / /	16	16	100%
21NMEX-LRG101.000125	RIO GRANDE NEAR MESQUITE ON HIGHWAY 192 BRIDGE / WESTERN GUL	16	16	100%
21NMEX-LRG046.5	RIO GRANDE AT BRIDGE NEAR LA MESILLA / WESTERN GULF / UPPER	15	15	100%
21NMEX-LRG101.000109	RIO GRANDE AT SANTA TERESA / /	14	14	100%
21NMEX-LRG047	RIO GRANDE AT MESILLA DIVERSION DAM / WESTERN GULF / UPPER R	14	14	100%
21NMEX-LRG045.5	RIO GRANDE AT NM HWY 430 NEAR DONA ANA / WESTERN GULF / UPPE	13	13	100%
21NMEX-SWC804.006048	MIMBRES RIVER AT COONEY CAMPGROUND CROSSING 150A / WESTERN G	13	13	100%
21NMEX-LRG046.3	LAS CRUCES WWTP EFFLUENT DITCH AT RIO GRANDE / WESTERN GULF	12	12	100%
21NMEX-LRG101.000107	SUNLAND PARK WWTF EFFLUENT / /	12	12	100%
21NMEX-SWC803.002530	MIMBRES RIVER UPSTREAM OF HWY 90 BRIDGE / WESTERN GULF / UPP	9	9	100%
21NMEX-SWC803.002501	MIMBRES RIVER ABOVE CONFLUENCE WITH GALLINAS CR. / WESTERN G	9	9	100%
21NMEX-SWC804.003035	MIMBRES RIVER ABOVE MIMBRES GAGE / WESTERN GULF / UPPER RIO	9	9	100%
21NMEX-LRG103.002030	RIO GRANDE BELOW E. BUTTE DAM AT USGS GAGE / /	7	7	100%
21NMEX-SWC803.002001	GALLINAS CREEK ABOVE MIMBRES RIVER / WESTERN GULF / UPPER RI	6	6	100%
21NMEX-SWC803.000105	MIMBRES RIVER FOUR MILES S. OF DWYER / WESTERN GULF / UPPER	5	5	100%
21NMEX-LRG101000109.5	RIO GRANDE AT BORDERLAND ROAD BRIDGE / WESTERN GULF / UPPER	5	5	100%

(continued)

Table D-19. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-LRG101000107.5	RIO GRANDE ABV SUNLAND PARK WWTF OUTFALL / WESTERN GULF / UP	5	5	100%
21NMEX-LRG058	RIO GRANDE AT AMERICAN DAM / RIO GRANDE /	5	5	100%
21NMEX-LRG101.000103	10 M ABOVE EL PASO ELECTRIC OUTFALLS 001 003 / WESTERN GULF	4	4	100%
21NMEX-LRG101000108	RIO GRANDE BELOW WEST DRAIN / WESTERN GULF / UPPER RIO ABOVE	4	4	100%
21NMEX-LRG101000109.7	RIO GRANDE AT VINTON ROAD BELOW ANTHONY / WESTERN GULF / UPP	4	4	100%
21NMEX-LRG101000139	RIO GRANDE BELOW I-10 BRIDGE NEAR LAS CRUCES / WESTERN GULF	4	4	100%
21NMEX-LRG103.002020	RIO GRANDE BELOW WILLIAMS / /	4	4	100%
21NMEX-LRG101.000102	100 M BELOW EL PASO ELECTRIC 001 003 / WESTERN GULF / UPPER	4	4	100%
21NMEX-BEARCANYONDAM	SLIGHTLY E. OF DAM CENTER 1/8 DISTANCE FROM DAM / COLORADO R	3	3	100%
21NMEX-OT01AP.STINKY	LAKE STINKY / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS RI	1	1	100%
21NMEX-DA01AN.S-LUCERO	SAMPLE STATION ON WEST END OF LAKE VIA MISSLE RA / WESTERN G	1	1	100%
21NMEX-DA02AO.N-LUCERO	SAMPLE STATION NEXT TO RANGE RD 10 ON MISSLE RNG / WESTERN G	1	1	100%
21NMEX-DA03BI.DAVIES	STATION ON W END OF TANK 1/4 MI E. OF ROAD. / WESTERN GULF M	1	1	100%
21NMEX-HI01AK.SACATONP	PLAYA LAKE DUE N FROM DUNES OF N LORDSBURG PLAYA / COLORADO	1	1	100%
21NMEX-HI02AL.NLORD	N LORDSBURG PLAYA / COLORADO RIVER /	1	1	100%
21NMEX-LCRSSC.TSCC05	SKELETON CANYON CREEK / /	1	1	100%
21NMEX-SWCANC.TCLD20	CLANTON DRAW AT GRAY RANCH HEADQUARTERS / /	1	1	100%
21NMEX-SWCANC.TCDC30	CLOVERDALE CREEK / /	1	1	100%
21NMEX-SWCANC.TDAC10	DOUBLE ADOBE CREEK / /	1	1	100%
21NMEX-OT02BJ.MALPAISP	STATION APPROX. 100 YDS S OF SPRING IN POOL AREA / WESTERN G	1	1	100%

Table D-20. Water Quality Comparisons for New Mexico: Total Nitrogen (Water Quality Indicator ID: 1148, 1235)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO002	1529 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO003	1705 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO019	Calle Ruiz #215-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	3	2	67%
21NMBHO-BHO022	417 Koenig--Mesquite / WESTERN GULF / UPPER RIO GRANDE ABOVE	2	1	50%
21NMBHO-BHO024	428 Moonlight--San Miguel / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO026	1198 Wanabe Road #3--Mesquite 88048 / WESTERN GULF / UPPER	2	1	50%
21NMBHO-BHO050	1313 W Main St--La Union / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO061	1095 Sierra Vista--Berino / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO092	5405 Santa Teresita--Santa Teresa 88008 / WESTERN GULF / UP	1	1	100%
21NMBHO-BHO094	643 Pinabetes--Las Cruces 88001 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO095	388 Meadow Park--Fair Acres / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO098	7335 Harvey Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO105	17835 N Hwy 85--Radium Springs 88005 / WESTERN GULF / UPPER	1	1	100%
21NMBHO-BHO106	2268 Alta Mira--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO111	Hwy 28--San Miguel / WESTERN GULF / UPPER RIO GRANDE ABOVE P	1	1	100%
21NMBHO-BHO119	2601 W O'Hara Rd--Anthony 88021 / WESTERN GULF / UPPER RIO	2	1	50%
21NMBHO-BHO124	441 Minter Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO125	11859 Jarmen Dr.--Mesquite 88048 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO126	456 Wannabe Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	2	1	50%
21NMBHO-BHO133	110 Ashtray Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%

(continued)

Table D-20. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO135	1660 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO137	2460 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO138	1060 Road Runner Rd--Las Cruces 88005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO140	711 Long River Lane--Fair Acres / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO141	730 Tamaris --Rio Grande Estates / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-M004	DEMING,NM / /	1	1	100%
21NMEX-BEARCANYONDAM .	SLIGHTLY E. OF DAM CENTER 1/8 DISTANCE FROM DAM / COLORADO R	6	6	100%
21NMEX-DA01AN.S-LUCERO	SAMPLE STATION ON WEST END OF LAKE VIA MISSLE RA / WESTERN G	2	2	100%
21NMEX-DA02AO.N-LUCERO	SAMPLE STATION NEXT TO RANGE RD 10 ON MISSLE RNG / WESTERN G	2	2	100%
21NMEX-DA03BI.DAVIES	STATION ON W END OF TANK 1/4 MI E. OF ROAD. / WESTERN GULF M	2	2	100%
21NMEX-HI01AK.SACATONP	PLAYA LAKE DUE N FROM DUNES OF N LORDSBURG PLAYA / COLORADO	2	2	100%
21NMEX-HI02AL.NLORD	N LORDSBURG PLAYA / COLORADO RIVER /	2	2	100%
21NMEX-HI03AM.SLORD	S LORDSBURG PLAYA / COLORADO RIVER /	2	2	100%
21NMEX-LRG045.5	RIO GRANDE AT NM HWY 430 NEAR DONA ANA / WESTERN GULF / UPPE	26	26	100%
21NMEX-LRG046	RIO GRANDE AT PICACHO AVE IN LAS CRUCES / WESTERN GULF / UPP	36	31	86%
21NMEX-LRG046.3	LAS CRUCES WWTP EFFLUENT DITCH AT RIO GRANDE / WESTERN GULF	24	24	100%
21NMEX-LRG046.5	RIO GRANDE AT BRIDGE NEAR LA MESILLA / WESTERN GULF / UPPER	28	28	100%
21NMEX-LRG047	RIO GRANDE AT MESILLA DIVERSION DAM / WESTERN GULF / UPPER R	28	28	100%
21NMEX-LRG053	RIO GRANDE AT NM HIGHWAY 226 NEAR BERINO / WESTERN GULF / UP	34	34	100%
21NMEX-LRG058	RIO GRANDE AT AMERICAN DAM / RIO GRANDE /	10	10	100%
21NMEX-LRG101.000101	RIO GRANDE BELOW SUNLAND PARK / /	32	32	100%

(continued)

Table D-20. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-LRG101.000102	100 M BELOW EL PASO ELECTRIC 001 003 / WESTERN GULF / UPPER	8	8	100%
21NMEX-LRG101.000103	10 M ABOVE EL PASO ELECTRIC OUTFALLS 001 003 / WESTERN GULF	8	8	100%
21NMEX-LRG101.000107	SUNLAND PARK WWTF EFFLUENT / /	24	24	100%
21NMEX-LRG101.000109	RIO GRANDE AT SANTA TERESA / /	27	27	100%
21NMEX-LRG101.000110	RIO GRANDE NEAR ANTHONY ON NM HIGHWAY 225 BRIDGE / WESTERN G	37	36	97%
21NMEX-LRG101.000125	RIO GRANDE NEAR MESQUITE ON HIGHWAY 192 BRIDGE / WESTERN GUL	32	32	100%
21NMEX-LRG101000107.5	RIO GRANDE ABV SUNLAND PARK WWTF OUTFALL / WESTERN GULF / UP	10	10	100%
21NMEX-LRG101000108	RIO GRANDE BELOW WEST DRAIN / WESTERN GULF / UPPER RIO ABOVE	8	8	100%
21NMEX-LRG101000109.5	RIO GRANDE AT BORDERLAND ROAD BRIDGE / WESTERN GULF / UPPER	10	10	100%
21NMEX-LRG101000109.7	RIO GRANDE AT VINTON ROAD BELOW ANTHONY / WESTERN GULF / UPP	8	8	100%
21NMEX-LRG101000139	RIO GRANDE BELOW I-10 BRIDGE NEAR LAS CRUCES / WESTERN GULF	8	8	100%
21NMEX-LRG103.002020	RIO GRANDE BELOW WILLIAMS / /	4	3	75%
21NMEX-LRG103.002030	RIO GRANDE BELOW E. BUTTE DAM AT USGS GAGE / /	8	6	75%
21NMEX-OT01AP.STINKY	LAKE STINKY / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS RI	2	2	100%
21NMEX-OT02BJ.MALPAISP	STATION APPROX. 100 YDS S OF SPRING IN POOL AREA / WESTERN G	2	2	100%
21NMEX-SWC803.000105	MIMBRES RIVER FOUR MILES S. OF DWYER / WESTERN GULF / UPPER	10	6	60%
21NMEX-SWC803.002001	GALLINAS CREEK ABOVE MIMBRES RIVER / WESTERN GULF / UPPER RI	12	5	42%
21NMEX-SWC803.002501	MIMBRES RIVER ABOVE CONFLUENCE WITH GALLINAS CR. / WESTERN G	18	7	39%
21NMEX-SWC803.002530	MIMBRES RIVER UPSTREAM OF HWY 90 BRIDGE / WESTERN GULF / UPP	18	13	72%
21NMEX-SWC804.003035	MIMBRES RIVER ABOVE MIMBRES GAGE / WESTERN GULF / UPPER RIO	18	4	22%
21NMEX-SWC804.006048	MIMBRES RIVER AT COONEY CAMPGROUND CROSSING 150A / WESTERN G	26	7	27%
21NMEX-SWCANC.TCLD20	CLANTON DRAW AT GRAY RANCH HEADQUARTERS / /	2	2	100%

Table D-21. Water Quality Comparisons for New Mexico: Chlorophyll-a (Water Quality Indicator IDs: 1172, 1297)

Data Points	Values Exceeding	Station ID	Station Name	Indicator ID
21NMEX-BEARCANYONDAM	SLIGHTLY E. OF DAM CENTER 1/8 DISTANCE FROM DAM / COLORADO R	4	4	100%
21NMEX-DA03BI.DAVIES	STATION ON W END OF TANK 1/4 MI E. OF ROAD. / WESTERN GULF M	2	2	100%
21NMEX-HI01AK.SACATONP	PLAYA LAKE DUE N FROM DUNES OF N LORDSBURG PLAYA / COLORADO	2	2	100%
21NMEX-LRG101.000102	100 M BELOW EL PASO ELECTRIC 001 003 / WESTERN GULF / UPPER	2	2	100%
21NMEX-LRG101.000110	RIO GRANDE NEAR ANTHONY ON NM HIGHWAY 225 BRIDGE / WESTERN G	2	2	100%
21NMEX-LRG101.000125	RIO GRANDE NEAR MESQUITE ON HIGHWAY 192 BRIDGE / WESTERN GUL	2	2	100%
21NMEX-LRG101000107.5	RIO GRANDE ABV SUNLAND PARK WWTF OUTFALL / WESTERN GULF / UP	2	2	100%
21NMEX-LRG101000109.5	RIO GRANDE AT BORDERLAND ROAD BRIDGE / WESTERN GULF / UPPER	2	2	100%
21NMEX-OT01AP.STINKY	LAKE STINKY / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS RI	2	2	100%

Table D-22. Water Quality Comparisons for New Mexico: Dissolved Oxygen (Water Quality Indicator ID: 1127, 1211, 1191, 1089, 1073, 1189, 1190)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-BEARCANYONDAM	SLIGHTLY E. OF DAM CENTER 1/8 DISTANCE FROM DAM / COLORADO R	26	17	65%
21NMEX-SWC804.006048	MIMBRES RIVER AT COONEY CAMPGROUND CROSSING 150A / WESTERN G	9	3	33%
21NMEX-LRG103.002030	RIO GRANDE BELOW E. BUTTE DAM AT USGS GAGE / /	3	1	33%
21NMBHO-BHO043	301 Mendez--La Union 88021 / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO051	398 Alvarez--La Union / WESTERN GULF / UPPER RIO GRANDE ABOV	1	1	100%
21NMBHO-BHO050	1313 W Main St--La Union / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO049	125 N. Alvarez--La Union / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO048	125 N. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO047	105 N. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO046	412 S. Virginia--La Union / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO052	1626 Paloma--La Union / WESTERN GULF / UPPER RIO GRANDE ABOV	1	1	100%
21NMBHO-BHO044	324 S. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO055	1400 Main St--La Union 88021 / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO042	1526 Amador--La Union 88021 / WESTERN GULF / UPPER RIO GRAN	1	1	100%
21NMBHO-BHO041	272 South Virginia--La Union 88021 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO040	413 Mendez--La Union 88021 / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO045	412 S. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO066	124 Miranda St--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO054	immediately west of BHO053--La Union / WESTERN GULF / UPPER	1	1	100%
21NMBHO-BHO037	Mustang Dr--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE PEC	1	1	100%

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Table D-22. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO056	701 Lopez Rd--Chamberino 88027 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO057	601 Medina--Chamberino 88027 / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO058	201 Lopez --Chamberino 88027 / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO059	4372 S Hwy 28--San Pablo 88005 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO060	4169 Sauco Ln.--San Pablo 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO061	1095 Sierra Vista--Berino / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO062	near valley view dairy-- / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO063	946 Lechuga--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	1	1	100%
21NMBHO-BHO064	733 Lechuga Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO065	795 Lechuga Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO053	1201 Main --La Union / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO019	Calle Ruiz #215-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	1	1	100%
21NMBHO-BHO003	1705 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO004	1400 Burke Road--Las Cruces 80005 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO005	1230 Burke Rd--Las Cruces 80005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO006	1120 Burke Rd--Las Cruces 80005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO007	231 Boggy Lane--Mesilla Park 88047 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO008	201 Boggy Lane--Mesilla Park 88047 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO009	320 Boggy Lane--Mesilla Park 88047 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO010	330 Boggy Lane--Mesilla Park 88047 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO011	4633 Lamar Rd--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%

(continued)

Table D-22. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO012	4597 Lamar Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO013	near Lamar Rd--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO014	El Farro St. #4443-- / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO039	304 Provencio Rd.--Chamberino / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO018	Ashtray Road-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO038	216 Lopez St--Chamberino / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO020	Ashtray Road-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO021	Ashtray Road-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO023	(Moonlight) Rt 1 Box 479--La Mesa / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO024	428 Moonlight--San Miguel / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO025	538 Costilla Pl-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	1	1	100%
21NMBHO-BHO028	Vistosos Loop #2--Berino / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO029	Calle Vistoso Loop #35--Berino / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO030	1093 Sierra Vista--Berino / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO032	6821 Portilla Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABO	1	1	100%
21NMBHO-BHO035	810 Lechuga Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO036	7524 Mustang--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE P	1	1	100%
21NMBHO-BHO071	133 Boone Circle--Anthony 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO016	846 Pajara Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO133	110 Ashtray Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO116	1800 Overcast Rd--Anthony / WESTERN GULF / UPPER RIO GRANDE	1	1	100%

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Table D-22. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO119	2601 W O'Hara Rd--Anthony 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO120	2510 W O'Hara Rd--Anthony / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO121	2500 O'Hara Rd--Anthony 88021 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO122	7717 Hwy 28-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO123	Hwy 28 & O'Hara-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	1	1	100%
21NMBHO-BHO124	441 Minter Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO126	456 Wannabe Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO128	11816 Hatheway--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO129	11781 Jarmen Dr--Mesquite 88048 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO130	Hwy 192/County Rd B43--Mesquite 88048 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO067	1045 Miranda Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOV	1	1	100%
21NMBHO-BHO132	216 W. San Miguel--Mesquite 88048 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO111	Hwy 28--San Miguel / WESTERN GULF / UPPER RIO GRANDE ABOVE P	1	1	100%
21NMBHO-BHO134	1530 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO135	1660 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO136	3719 Bales Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO137	2460 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO138	1060 Road Runner Rd--Las Cruces 88005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO139	1240 Burke Road--Las Cruces 88005 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO140	711 Long River Lane--Fair Acres / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO141	730 Tamaris --Rio Grande Estates / WESTERN GULF / UPPER RIO	1	1	100%

(continued)

Table D-22. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO142	3500 West View --Las Cruces / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO143	553 Fairpark Rd--Fair Acres / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO144	11836 Jarmon --Mesquite 88048 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMEX-DA03BI.DAVIES	STATION ON W END OF TANK 1/4 MI E. OF ROAD. / WESTERN GULF M	1	1	100%
21NMBHO-BHO131	12409 Railroad Dr--Mesquite 88048 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO088	Iglesias Rd--Mesilla Park / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO068	Lara Rd--Chamberino / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO072	150 Boone Circle--Anthony 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO073	138 Boone Circle--Anthony 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO074	2001 Washington--Anthony 88021 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO075	1508 W. Washington--Anthony 88021 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO076	1509 W. Washington--Anthony 88021 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO077	1505 W. Washington--Anthony 88021 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO079	1401 W. Washington--Anthony 88021 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO080	Pancho Place-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO081	6040 Pancho Place-- / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO083	6090 Mariachi Place--Mesilla Park / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO085	3810 Mariachi Place--Mesilla Park 88047 / WESTERN GULF / UP	1	1	100%
21NMBHO-BHO114	Hwy 28--1/2 mi south of Dairy--Santa Teresa / WESTERN GULF /	1	1	100%
21NMBHO-BHO087	6009 South Main--Mesilla Park / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO113	McNutt and Borderland--Santa Teresa / WESTERN GULF / UPPER R	1	1	100%

(continued)

Table D-22. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO089	2292 Old Hwy (Las Palmaras)-- / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO092	5405 Santa Teresita--Santa Teresa 88008 / WESTERN GULF / UP	1	1	100%
21NMBHO-BHO094	643 Pinabetes--Las Cruces 88001 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO095	388 Meadow Park--Fair Acres / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO096	837 Clark Lane--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO097	705 Clark Lane--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO098	7335 Harvey Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO102	13140 N Hwy 85--Radium Springs / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO106	2268 Alta Mira--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO108	18924 S. Hwy 28--San Miguel 88058 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO110	Hwy 28--San Miguel / WESTERN GULF / UPPER RIO GRANDE ABOVE P	1	1	100%
21NMBHO-BHO001	1205 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO086	Opal Rd-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%

Table D-23. Water Quality Comparisons for New Mexico: Fecal Coliform (Water Quality Indicator IDs: 1166, 1091)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-NM0020010	Hatch WWTP	2	2	100%
ModSTORET-NM0020109	Silver City WWTP	2	1	50%
ModSTORET-NM0023311	Las Cruces WWTP	2	2	100%

Table D-24. Water Quality Comparisons for New Mexico: Sulfate (Water Quality Indicator ID: 1161)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-LRG046.5	RIO GRANDE AT BRIDGE NEAR LA MESILLA / WESTERN GULF / UPPER	7	3	43%
21NMEX-LRG101.000109	RIO GRANDE AT SANTA TERESA / /	6	6	100%
21NMEX-LRG046	RIO GRANDE AT PICACHO AVE IN LAS CRUCES / WESTERN GULF / UPP	6	3	50%
21NMEX-LRG101.000110	RIO GRANDE NEAR ANTHONY ON NM HIGHWAY 225 BRIDGE / WESTERN G	6	6	100%
21NMEX-LRG053	RIO GRANDE AT NM HIGHWAY 226 NEAR BERINO / WESTERN GULF / UP	5	4	80%
21NMEX-LRG101.000101	RIO GRANDE BELOW SUNLAND PARK / /	5	5	100%
21NMEX-LRG101.000125	RIO GRANDE NEAR MESQUITE ON HIGHWAY 192 BRIDGE / WESTERN GUL	4	2	50%
21NMEX-LRG045.5	RIO GRANDE AT NM HWY 430 NEAR DONA ANA / WESTERN GULF / UPPE	4	2	50%
21NMEX-LRG103.002020	RIO GRANDE BELOW WILLIAMS / /	4	1	25%
21NMEX-LRG047	RIO GRANDE AT MESILLA DIVERSION DAM / WESTERN GULF / UPPER R	4	2	50%
21NMEX-LRG046.3	LAS CRUCES WWTP EFFLUENT DITCH AT RIO GRANDE / WESTERN GULF	4	1	25%
21NMEX-LRG101.000107	SUNLAND PARK WWTF EFFLUENT / /	4	4	100%
21NMBHO-BHO019	Calle Ruiz #215-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PE	3	3	100%
21NMBHO-BHO126	456 Wannabe Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	2	2	100%
21NMBHO-BHO106	2268 Alta Mira--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	2	2	100%
21NMBHO-BHO047	105 N. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	2	2	100%
21NMBHO-BHO026	1198 Wanabe Road #3--Mesquite 88048 / WESTERN GULF / UPPER	2	2	100%
21NMBHO-BHO093	McNutt-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	2	2	100%
21NMBHO-BHO035	810 Lechuga Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	2	2	100%
21NMBHO-BHO022	417 Koenig--Mesquite / WESTERN GULF / UPPER RIO GRANDE ABOVE	2	2	100%
21NMBHO-BHO054	immediately west of BHO053--La Union / WESTERN GULF / UPPER	1	1	100%

(continued)

Table D-24. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO085	3810 Mariachi Place--Mesilla Park 88047 / WESTERN GULF / UP	1	1	100%
21NMBHO-BHO056	701 Lopez Rd--Chamberino 88027 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO057	601 Medina--Chamberino 88027 / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO058	201 Lopez --Chamberino 88027 / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO081	6040 Pancho Place-- / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO060	4169 Sauco Ln.--San Pablo 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO061	1095 Sierra Vista--Berino / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO062	near valley view dairy-- / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO064	733 Lechuga Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO067	1045 Miranda Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABOV	1	1	100%
21NMBHO-BHO079	1401 W. Washington--Anthony 88021 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO059	4372 S Hwy 28--San Pablo 88005 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO099	6900 N Hwy 85--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO003	1705 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO005	1230 Burke Rd--Las Cruces 80005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO023	(Moonlight) Rt 1 Box 479--La Mesa / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO028	Vistosos Loop #2--Berino / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO029	Calle Vistoso Loop #35--Berino / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO030	1093 Sierra Vista--Berino / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO038	216 Lopez St--Chamberino / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%
21NMBHO-BHO032	6821 Portilla Rd--Vado / WESTERN GULF / UPPER RIO GRANDE ABO	1	1	100%
21NMBHO-BHO050	1313 W Main St--La Union / WESTERN GULF / UPPER RIO GRANDE A	1	1	100%

(continued)

Table D-24. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMBHO-BHO037	Mustang Dr--Vado / WESTERN GULF / UPPER RIO GRANDE ABOVE PEC	1	1	100%
21NMBHO-BHO088	Iglesias Rd--Mesilla Park / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO040	413 Mendez--La Union 88021 / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO041	272 South Virginia--La Union 88021 / WESTERN GULF / UPPER R	1	1	100%
21NMBHO-BHO043	301 Mendez--La Union 88021 / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO048	125 N. Virginia--La Union 88021 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO031	121 Warthem--Berino / WESTERN GULF / UPPER RIO GRANDE ABOVE	1	1	100%
21NMBHO-BHO142	3500 West View --Las Cruces / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO096	837 Clark Lane--Las Cruces / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO135	1660 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO136	3719 Bales Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO137	2460 Burke Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO138	1060 Road Runner Rd--Las Cruces 88005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO139	1240 Burke Road--Las Cruces 88005 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO132	216 W. San Miguel--Mesquite 88048 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO141	730 Tamaris --Rio Grande Estates / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO130	Hwy 192/County Rd B43--Mesquite 88048 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO143	553 Fairpark Rd--Fair Acres / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO144	11836 Jarmon --Mesquite 88048 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMEX-DA01AN.S-LUCERO	SAMPLE STATION ON WEST END OF LAKE VIA MISSLE RA / WESTERN G	1	1	100%
21NMEX-DA02AO.N-LUCERO	SAMPLE STATION NEXT TO RANGE RD 10 ON MISSLE RNG / WESTERN G	1	1	100%
21NMEX-OT01AP.STINKY	LAKE STINKY / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS RI	1	1	100%

(continued)

Table D-24. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
21NMEX-OT02BJ.MALPAISP	STATION APPROX. 100 YDS S OF SPRING IN POOL AREA / WESTERN G	1	1	100%
21NMEX-SWC000.000050	APPROX 400 FT BELOW NM0027375 RIODEARENAS MHP / SOUTHWESTERN	1	1	100%
21NMBHO-BHO140	711 Long River Lane--Fair Acres / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO103	13633 N Hwy 85--Radium Springs / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO090	1023 Grace-- / WESTERN GULF / UPPER RIO GRANDE ABOVE PECOS	1	1	100%
21NMBHO-BHO092	5405 Santa Teresita--Santa Teresa 88008 / WESTERN GULF / UP	1	1	100%
21NMBHO-BHO094	643 Pinabetes--Las Cruces 88001 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO095	388 Meadow Park--Fair Acres / WESTERN GULF / UPPER RIO GRAND	1	1	100%
21NMBHO-BHO002	1529 Road Runner Ln--Las Cruces 80005 / WESTERN GULF / UPPE	1	1	100%
21NMBHO-BHO098	7335 Harvey Rd--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO133	110 Ashtray Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO100	6335 N Hwy 85--Las Cruces 88005 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO089	2292 Old Hwy (Las Palmaras)-- / WESTERN GULF / UPPER RIO GRA	1	1	100%
21NMBHO-BHO105	17835 N Hwy 85--Radium Springs 88005 / WESTERN GULF / UPPER	1	1	100%
21NMBHO-BHO108	18924 S. Hwy 28--San Miguel 88058 / WESTERN GULF / UPPER RI	1	1	100%
21NMBHO-BHO116	1800 Overcast Rd--Anthony / WESTERN GULF / UPPER RIO GRANDE	1	1	100%
21NMBHO-BHO124	441 Minter Rd--Mesquite 88048 / WESTERN GULF / UPPER RIO GR	1	1	100%
21NMBHO-BHO125	11859 Jarmen Dr.--Mesquite 88048 / WESTERN GULF / UPPER RIO	1	1	100%
21NMBHO-BHO128	11816 Hatheway--Mesquite 88048 / WESTERN GULF / UPPER RIO G	1	1	100%
21NMBHO-BHO129	11781 Jarmen Dr--Mesquite 88048 / WESTERN GULF / UPPER RIO	1	1	100%
21NMEX-SWC000.000055	APPROX 20 FT ABOVE NM0027375 RIODEARENAS MHP / SOUTHWESTERN	1	1	100%

Table D-25. Water Quality Comparisons for New Mexico: Chloride (Water Quality Indicator IDs: 1087, 1159)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
ModSTORET-NM0020681	Truth or Consequences WWTP	3	3	100%
ModSTORET-NM0023311	Las Cruces WWTP	1	1	100%
ModSTORET-NM0020109	Silver City WWTP	1	1	100%
ModSTORET-NM0020010	Hatch WWTP	1	1	100%

Table D-26. Water Quality Comparisons for New Mexico: pH (Water Quality Indicator IDs: 29, 1076, 1077, 1135, 1136)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
SCERP-West Mesa WWTF	West Mesa Wastewater Treatment Facility	8	6	75%

Table D-27. Water Quality Comparisons for New Mexico: Total Dissolved Solids (Water Quality Indicator ID: 1445)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
SCERP-West Mesa WWTF	West Mesa Wastewater Treatment Facility	31	31	100%

D.1.4 Water Quality Comparisons for Texas

The Texas Commission on Environmental Quality, formerly known as the Texas Natural Resource Conservation Commission has issued detailed surface water quality standards for the State of Texas (TNRCC, 2000). General criteria apply to surface water in the state and specifically apply to substances attributed to waste discharges or the activities of humans. General criteria are superseded by specific exemptions. Specific toxic materials must meet criteria for protecting aquatic life and human health. Site-specific uses and criteria exist for contact and noncontact recreation for both freshwater and saltwater. Criteria exist for the domestic water supply. Application of standards depends also on low flow conditions, mixing zones, minimum analytical levels, etc. The regulations also include definitions of low flow for each river segment in Texas. The standards corresponding to the International Amistad Reservoir are shown in Table D-28. These standards are the strictest among all river segments on the Rio Grande Basin.

Table D-28. Water Quality Standards for Texas

Parameter	**Criteria**	**Comment**
Chloride (mg/L) (1)	≤ 150	International Amistad Reservoir
Dissolved oxygen (mg/L)	≥ 5.0	International Amistad Reservoir
E. coli (CFU/100 ml)	≤ 126	International Amistad Reservoir
Fecal Coliform (CFU/100 ml)	≤ 200	International Amistad Reservoir
pH	6.5–9.0	International Amistad Reservoir
Sulfate (mg/L) (1)	≤ 270	International Amistad Reservoir
Total Dissolved Solids (mg/L)	≤ 800	International Amistad Reservoir

Tables D-29 to D-35 compare Repository data on chlorophyll a, fecal coliform, sulfate, chloride, dissolved oxygen, *e. coli*, and total dissolved solids, respectively, to these standards.

Table D-29. Water Quality Comparisons for Texas: Chlorophyll-a (Water Quality Indicator ID: 1172)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	59	55	93%
TCEQ-15817	RIO GRANDE AT WEBB/ZAPATA CO	57	49	86%
TCEQ-13560	RIO GRANDE AT MOODY RANCH	45	29	64%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	44	32	73%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	43	40	93%
TCEQ-13181	RIO GRANDE AT US 281	42	31	74%
TCEQ-13228	RIO GRANDE AT SANTA ELENA CNY	41	37	90%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	41	30	73%
TCEQ-13072		38	34	89%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	38	35	92%
TCEQ-13073		38	34	89%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	37	33	89%
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	35	34	97%
TCEQ-15528	RIO GRANDE 1.3KM DWNSTRM WWTP	31	24	77%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	26	24	92%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	25	20	80%
TCEQ-13446	LAGUNA MADRE GIWW CM 129	25	11	44%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	24	24	100%
TCEQ-13185		23	23	100%
TCEQ-13086		21	19	90%
TCEQ-13079		21	21	100%
TCEQ-13082		21	18	86%
TCEQ-16445	ARROYO COLORADO AT DILWORTH R	21	18	86%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	20	19	95%
TCEQ-13071	ARROYO COLORADO AT CM 22	20	14	70%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	19	16	84%
TCEQ-13257	PECOS RIVER AT US 67	19	14	74%
TCEQ-15114	PECOS R. ABOVE US 290	19	16	84%
TCEQ-13039		19	17	89%
TCEQ-13246	PECOS R. NR. VAL VERDE CO. LN	18	14	78%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	18	12	67%
TCEQ-13782	ARROYO COLORADO CM 16	18	14	78%
TCEQ-13056		18	10	56%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	18	17	94%
TCEQ-13225	RIO GRANDE AT FM 2627	17	11	65%
TCEQ-13559	ARROYO COLORADO AT CM27, MI 1	17	15	88%

(continued)

Table D-29. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13184		17	17	100%
TCEQ-13084		17	14	82%
TCEQ-17113	DRAINAGE DITCH HARDING RANCH	17	8	47%
TCEQ-13459	SOUTH BAY NEAR SHIP CM 17	17	5	29%
TCEQ-13460	BROWNSVILLE SHIP CHANNEL CM 3	17	7	41%
TCEQ-14875	BROWNSVILLE SHIP CHANNEL	17	15	88%
TCEQ-13448	LAGUNA MADRE AT GIWW	16	10	63%
TCEQ-15892	AMISTAD RESERV RIO GRANDE ARM	15	8	53%
TCEQ-15814	RIO GRANDE AT INTL BRIDGE #2	15	11	73%
TCEQ-15893	AMISTAD RESERV DEVILS R ARM	14	7	50%
TCEQ-13285	PORT ISABEL AT SH 100	14	5	36%
TCEQ-15820	SAN FELIPE CK AT WEST SPRINGS	14	5	36%
TCEQ-13206	RIO GRANDE AT US 277	14	9	64%
TCEQ-15529	RIO GRANDE UPSTR HASKELL WWTP	13	13	100%
TCEQ-13202	RIO GRANDE LAREDO WTP PUMP	13	7	54%
TCEQ-14942	DOLAN SPRGS AT DEVILS R CONFL	13	1	8%
TCEQ-13835		12	4	33%
TCEQ-13103		10	8	80%
TCEQ-13270	SAN FELIPE CK AT GUYLER CONFL	10	3	30%
TCEQ-17407	RIO GRANDE UPSTRM OF CANDELAR	10	10	100%
TCEQ-17596	RIO GRANDE AT APACHE RANCH	10	10	100%
TCEQ-17114	HIDALGO POTW OUTFALL	9	9	100%
TCEQ-17115	MISSION POTW DISCHARGE DITCH	9	6	67%
TCEQ-17247	RIO GRANDE UPSTRM OF FM 1015	9	5	56%
TCEQ-17111	DONNA POTW DISCHARGE DITCH	9	2	22%
TCEQ-16379	PECOS RIVER BELOW US90W BRIDG	9	7	78%
TCEQ-13223	RIO GRNADE AT FOSTER RANCH	9	2	22%
TCEQ-17112	MERCEDES POTW DISCHARGE DITC	8	7	88%
TCEQ-15818	FALCON RES AT SAN YGNACIO WTP	8	6	75%
TCEQ-15274	RIO GRANDE AT IBWC WEIR DAM	8	1	13%
TCEQ-15821	SAN FELIPE CK AT BLUEHOLE GAT	7	2	29%
TCEQ-13189		7	7	100%
TCEQ-13179	RIO GRANDE AT RIVER BEND	5	4	80%
TCEQ-13116		4	4	100%
TCEQ-14870	LAGUNA MADRE NEAR LAGUNA VIST	4	2	50%
TCEQ-16288	RIO GRANDE AT SABAL PALM	3	2	67%
TCEQ-14871	BROWNSVILLE SHIP CHANNEL	3	2	67%
TCEQ-14865	SOUTH BAY	3	2	67%
TCEQ-13255	PECOS RIVER AT FM 1901	1	1	100%

Table D-30. Water Quality Comparisons for Texas: Fecal Coliform (Water Quality Indicator IDs: 1091, 1166, 1181)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
CNA-PSRB-02	Km 0+000, PUENTE INTERNACIONAL CD. JUÁREZ	1	1	100%
CNA-PSRB-04	PUENTE INTERNACIONAL FORT-HANKOK	1	1	100%
CNA-PSRB-23	PUENTE INTERNACIONAL 1. NUEVO LAREDO	8	8	100%
CNA-PSRB-24	R. BRAVO-PARQUE INDUSTRIAL ACUÑA	9	2	22%
CNA-SSRB-25	PUENTE INTERNACIONAL REYNOSA	6	1	17%
CNA-SSRB-36	PUENTE INT. CAMARGO	4	1	25%
TCEQ-13039		6	5	83%
TCEQ-13056		6	5	83%
TCEQ-13072		25	9	36%
TCEQ-13073		21	7	33%
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	26	21	81%
TCEQ-13079		16	12	75%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	26	25	96%
TCEQ-13082		17	17	100%
TCEQ-13084		8	5	63%
TCEQ-13086		17	16	94%
TCEQ-13103		6	4	67%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	35	14	40%
TCEQ-13181	RIO GRANDE AT US 281	34	13	38%
TCEQ-13185		22	2	9%
TCEQ-13196	RIO GRANDE BELOW LAREDO	30	24	80%
TCEQ-13201		29	24	83%
TCEQ-13202	RIO GRANDE LAREDO WTP PUMP	44	12	27%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	43	24	56%
TCEQ-13206	RIO GRANDE AT US 277	14	2	14%
TCEQ-13225	RIO GRANDE AT FM 2627	11	3	27%
TCEQ-13228	RIO GRANDE AT SANTA ELENA CNY	26	8	31%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	35	27	77%
TCEQ-13270	SAN FELIPE CK AT GUYLER CONFL	6	4	67%
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	109	95	87%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	11	6	55%
TCEQ-13285	PORT ISABEL AT SH 100	7	1	14%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	22	1	5%
TCEQ-13559	ARROYO COLORADO AT CM27, MI 1	10	2	20%
TCEQ-13560	RIO GRANDE AT MOODY RANCH	44	23	52%

(continued)

Table D-30. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13782	ARROYO COLORADO CM 16	10	1	10%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	79	32	41%
TCEQ-15528	RIO GRANDE 1.3KM DWNSTRM WWTP	110	73	66%
TCEQ-15529	RIO GRANDE UPSTR HASKELL WWTP	94	65	69%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	1	1	100%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	28	16	57%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	35	15	43%
TCEQ-15813	RIO GRANDE AT CP&L POWER PLAN	17	2	12%
TCEQ-15814	RIO GRANDE AT INTL BRIDGE #2	45	37	82%
TCEQ-15815	RIO GRANDE AT MASTERSON RD	31	26	84%
TCEQ-15817	RIO GRANDE AT WEBB/ZAPATA CO	38	13	34%
TCEQ-15818	FALCON RES AT SAN YGNACIO WTP	6	3	50%
TCEQ-15820	SAN FELIPE CK AT WEST SPRINGS	1	1	100%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	12	10	83%
TCEQ-16445	ARROYO COLORADO AT DILWORTH R	17	15	88%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	11	2	18%
TCEQ-17000	RIO GRANDE PRESIDIO RR BRIDGE	21	20	95%
TCEQ-17001	RIO GRANDE PRESIDIO/OJINAGA	20	4	20%
TCEQ-17111	DONNA POTW DISCHARGE DITCH	9	8	89%
TCEQ-17112	MERCEDES POTW DISCHARGE DITC	9	9	100%
TCEQ-17113	DRAINAGE DITCH HARDING RANCH	8	6	75%
TCEQ-17114	HIDALGO POTW OUTFALL	9	9	100%
TCEQ-17115	MISSION POTW DISCHARGE DITCH	9	8	89%

Table D-31. Water Quality Comparisons for Texas: Sulfate (Water Quality Indicator ID: 1161)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	118	38	32%
TCEQ-15528	RIO GRANDE 1.3KM DWNSTRM WWTP	113	47	42%
TCEQ-15529	RIO GRANDE UPSTR HASKELL WWTP	94	34	36%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	81	24	30%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	59	57	97%
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	59	57	97%
TCEQ-15817	RIO GRANDE AT WEBB/ZAPATA CO	57	1	2%
TCEQ-13560	RIO GRANDE AT MOODY RANCH	51	1	2%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	51	6	12%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	46	2	4%
TCEQ-13079		46	43	93%
TCEQ-13181	RIO GRANDE AT US 281	45	3	7%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	45	2	4%
TCEQ-13228	RIO GRANDE AT SANTA ELENA CNY	43	41	95%
TCEQ-13073		38	37	97%
TCEQ-13072		38	36	95%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	38	31	82%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	38	37	97%
TCEQ-13185		33	1	3%
TCEQ-13223	RIO GRNADE AT FOSTER RANCH	30	21	70%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	26	22	85%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	25	25	100%
TCEQ-13446	LAGUNA MADRE GIWW CM 129	25	25	100%
TCEQ-13184		24	2	8%
TCEQ-16445	ARROYO COLORADO AT DILWORTH R	21	20	95%
TCEQ-13086		21	20	95%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	21	21	100%
TCEQ-13082		21	21	100%
TCEQ-13071	ARROYO COLORADO AT CM 22	20	18	90%
TCEQ-13240	PECOS RIVER NEAR LANGTRY	20	19	95%
TCEQ-15114	PECOS R. ABOVE US 290	19	19	100%
TCEQ-13257	PECOS RIVER AT US 67	19	19	100%
TCEQ-13039		19	16	84%
TCEQ-13056		19	11	58%

(continued)

Table D-31. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13782	ARROYO COLORADO CM 16	18	18	100%
TCEQ-13246	PECOS R. NR. VAL VERDE CO. LN	18	18	100%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	18	10	56%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	18	4	22%
TCEQ-13084		17	17	100%
TCEQ-13225	RIO GRANDE AT FM 2627	17	15	88%
TCEQ-14875	BROWNSVILLE SHIP CHANNEL	17	17	100%
TCEQ-13459	SOUTH BAY NEAR SHIP CM 17	17	17	100%
TCEQ-13448	LAGUNA MADRE AT GIWW	17	17	100%
TCEQ-13460	BROWNSVILLE SHIP CHANNEL CM 3	17	17	100%
TCEQ-13559	ARROYO COLORADO AT CM27, MI 1	17	17	100%
TCEQ-17113	DRAINAGE DITCH HARDING RANCH	17	17	100%
TCEQ-13285	PORT ISABEL AT SH 100	14	14	100%
TCEQ-17407	RIO GRANDE UPSTRM OF CANDELAR	10	10	100%
TCEQ-13103		10	6	60%
TCEQ-17596	RIO GRANDE AT APACHE RANCH	10	1	10%
TCEQ-17247	RIO GRANDE UPSTRM OF FM 1015	10	2	20%
TCEQ-17115	MISSION POTW DISCHARGE DITCH	9	8	89%
TCEQ-17114	HIDALGO POTW OUTFALL	9	3	33%
TCEQ-16379	PECOS RIVER BELOW US90W BRIDG	9	6	67%
TCEQ-17111	DONNA POTW DISCHARGE DITCH	9	8	89%
TCEQ-17112	MERCEDES POTW DISCHARGE DITC	9	9	100%
TCEQ-18196	UNNAMED DITCH SOUTH OF FM 510	5	4	80%
TCEQ-13116		4	3	75%
TCEQ-14870	LAGUNA MADRE NEAR LAGUNA VIST	4	4	100%
TCEQ-14871	BROWNSVILLE SHIP CHANNEL	3	3	100%
TCEQ-14865	SOUTH BAY	3	3	100%
TCEQ-16288	RIO GRANDE AT SABAL PALM	3	2	67%
TCEQ-13255	PECOS RIVER AT FM 1901	1	1	100%

Table D-32. Water Quality Comparisons for Texas: Chloride (Water Quality Indicator ID: 1159, 1046, 1087)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	117	40	34%
TCEQ-15528	RIO GRANDE 1.3KM DWNSTRM WWTP	107	41	38%
TCEQ-15529	RIO GRANDE UPSTR HASKELL WWTP	88	32	36%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	77	27	35%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	59	54	92%
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	59	57	97%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	51	36	71%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	46	1	2%
TCEQ-13079		46	44	96%
TCEQ-13181	RIO GRANDE AT US 281	45	19	42%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	45	18	40%
TCEQ-13228	RIO GRANDE AT SANTA ELENA CNY	43	36	84%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	38	38	100%
TCEQ-13073		38	38	100%
TCEQ-13072		38	38	100%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	36	34	94%
TCEQ-13185		33	3	9%
TCEQ-13223	RIO GRNADE AT FOSTER RANCH	30	11	37%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	26	17	65%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	25	25	100%
TCEQ-13196	RIO GRANDE BELOW LAREDO	25	1	4%
TCEQ-13446	LAGUNA MADRE GIWW CM 129	25	25	100%
TCEQ-13184		24	6	25%
TCEQ-13082		21	21	100%
TCEQ-16445	ARROYO COLORADO AT DILWORTH R	21	20	95%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	21	21	100%
TCEQ-13086		21	21	100%
TCEQ-13071	ARROYO COLORADO AT CM 22	20	19	95%
TCEQ-13240	PECOS RIVER NEAR LANGTRY	20	20	100%
TCEQ-15114	PECOS R. ABOVE US 290	19	19	100%
TCEQ-13056		19	18	95%
TCEQ-13039		19	18	95%
TCEQ-13257	PECOS RIVER AT US 67	19	19	100%
TCEQ-13246	PECOS R. NR. VAL VERDE CO. LN	18	18	100%

(continued)

Table D-32. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13782	ARROYO COLORADO CM 16	18	18	100%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	18	3	17%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	18	18	100%
TCEQ-13448	LAGUNA MADRE AT GIWW	17	17	100%
TCEQ-13459	SOUTH BAY NEAR SHIP CM 17	17	17	100%
TCEQ-13460	BROWNSVILLE SHIP CHANNEL CM 3	17	17	100%
TCEQ-13559	ARROYO COLORADO AT CM27, MI 1	17	17	100%
TCEQ-13225	RIO GRANDE AT FM 2627	17	8	47%
TCEQ-13084		17	17	100%
TCEQ-14875	BROWNSVILLE SHIP CHANNEL	17	17	100%
TCEQ-17113	DRAINAGE DITCH HARDING RANCH	17	17	100%
TCEQ-15892	AMISTAD RESERV RIO GRANDE ARM	16	4	25%
CNA-PSRB-04	PUENTE INTERNACIONAL FORT-HANKOK	14	10	71%
TCEQ-13285	PORT ISABEL AT SH 100	14	14	100%
CNA-PSRB-02	Km 0+000, PUENTE INTERNACIONAL CD. JUÁREZ	14	4	29%
TCEQ-17247	RIO GRANDE UPSTRM OF FM 1015	10	4	40%
TCEQ-17596	RIO GRANDE AT APACHE RANCH	10	1	10%
TCEQ-17407	RIO GRANDE UPSTRM OF CANDELAR	10	10	100%
TCEQ-13103		10	9	90%
TCEQ-16379	PECOS RIVER BELOW US90W BRIDG	9	9	100%
TCEQ-17111	DONNA POTW DISCHARGE DITCH	9	9	100%
TCEQ-17112	MERCEDES POTW DISCHARGE DITC	9	9	100%
TCEQ-17114	HIDALGO POTW OUTFALL	9	9	100%
TCEQ-17115	MISSION POTW DISCHARGE DITCH	9	9	100%
CNA-SSRB-36	PUENTE INT. CAMARGO	6	6	100%
TCEQ-13179	RIO GRANDE AT RIVER BEND	5	4	80%
TCEQ-18196	UNNAMED DITCH SOUTH OF FM 510	5	5	100%
TCEQ-14870	LAGUNA MADRE NEAR LAGUNA VIST	4	4	100%
TCEQ-13116		4	3	75%
TCEQ-16288	RIO GRANDE AT SABAL PALM	3	3	100%
TCEQ-14871	BROWNSVILLE SHIP CHANNEL	3	3	100%
TCEQ-14865	SOUTH BAY	3	3	100%

Table D-33. Water Quality Comparisons for Texas: Dissolved Oxygen (Water Quality Indicator IDs: 1211, 1127, 1089, 1073)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
CNA-PSRB-02	Km 0+000, PUENTE INTERNACIONAL CD. JUÁREZ	10	4	40%
CNA-PSRB-04	PUENTE INTERNACIONAL FORT-HANKOK	10	3	30%
TCEQ-13039		19	2	11%
TCEQ-13056		18	9	50%
TCEQ-13071	ARROYO COLORADO AT CM 22	55	17	31%
TCEQ-13072		232	161	69%
TCEQ-13073		153	98	64%
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	40	6	15%
TCEQ-13079		44	2	5%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	39	1	3%
TCEQ-13082		20	3	15%
TCEQ-13084		15	4	27%
TCEQ-13086		20	2	10%
TCEQ-13103		9	1	11%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	55	12	22%
TCEQ-13179	RIO GRANDE AT RIVER BEND	5	1	20%
TCEQ-13181	RIO GRANDE AT US 281	47	1	2%
TCEQ-13185		24	1	4%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	60	1	2%
TCEQ-13209	RIO GRANDE BELOW AMISTAD DAM	18	6	33%
TCEQ-13223	RIO GRNADE AT FOSTER RANCH	28	1	4%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	66	2	3%
TCEQ-13257	PECOS RIVER AT US 67	19	4	21%
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	130	1	1%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	14	1	7%
TCEQ-13285	PORT ISABEL AT SH 100	36	1	3%
TCEQ-13446	LAGUNA MADRE GIWW CM 129	57	1	2%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	50	8	16%
TCEQ-13448	LAGUNA MADRE AT GIWW	44	5	11%
TCEQ-13460	BROWNSVILLE SHIP CHANNEL CM 3	96	2	2%
TCEQ-13559	ARROYO COLORADO AT CM27, MI 1	55	27	49%
TCEQ-13560	RIO GRANDE AT MOODY RANCH	56	2	4%
TCEQ-13782	ARROYO COLORADO CM 16	55	13	24%
TCEQ-13835		197	41	21%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	89	7	8%

(continued)

Table D-33. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-14871	BROWNSVILLE SHIP CHANNEL	28	9	32%
TCEQ-14875	BROWNSVILLE SHIP CHANNEL	64	7	11%
TCEQ-15114	PECOS R. ABOVE US 290	19	1	5%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	13	1	8%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	62	9	15%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	47	1	2%
TCEQ-15892	AMISTAD RESERV RIO GRANDE ARM	171	16	9%
TCEQ-15893	AMISTAD RESERV DEVILS R ARM	120	18	15%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	21	1	5%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	31	1	3%
TCEQ-17111	DONNA POTW DISCHARGE DITCH	8	6	75%
TCEQ-17113	DRAINAGE DITCH HARDING RANCH	17	9	53%
TCEQ-17114	HIDALGO POTW OUTFALL	8	3	38%
TCEQ-17115	MISSION POTW DISCHARGE DITCH	8	4	50%
TCEQ-17247	RIO GRANDE UPSTRM OF FM 1015	10	2	20%
TCEQ-17621	RIO GRANDE 5 MI. DS OF SANTA	4	1	25%
TCEQ-17643	DRAINAGE DITCH AT FM 1846	13	2	15%
TCEQ-17644	DRAINAGE DITCH AT FM 2062	12	1	8%
TCEQ-17650	ARROYO COLORADO TIDAL P OF HA	40	25	63%
TCEQ-18196	UNNAMED DITCH SOUTH OF FM 510	5	1	20%

Table D-34. Water Quality Comparisons for Texas: E. coli (Water Quality Indicator IDs: 1167, 1170, 1090)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-13272	RIO GRANDE AT COURCHESNE BRDG	39	37	95%
TCEQ-15814	RIO GRANDE AT INTL BRIDGE #2	31	23	74%
TCEQ-15528	RIO GRANDE 1.3KM DWNSTRM WWTP	32	21	66%
TCEQ-15815	RIO GRANDE AT MASTERSON RD	23	18	78%
TCEQ-13177	RIO GRANDE AT EL JARDIN PUMP	28	17	61%
TCEQ-13201		21	17	81%
TCEQ-13205	RIO GRANDE NR US277/EAGLE PAS	26	17	65%
TCEQ-15795	RIO GRANDE AT ALAMO CTRL STRU	20	17	85%
TCEQ-13560	RIO GRANDE AT MOODY RANCH	26	16	62%
TCEQ-15529	RIO GRANDE UPSTR HASKELL WWTP	24	15	63%
TCEQ-13196	RIO GRANDE BELOW LAREDO	22	14	64%
TCEQ-13081	ARROYO COLORADO MAIN FLOODWAY	19	13	68%
TCEQ-14465	RIO GRANDE AT RIVERSIDE CANAL	19	12	63%
TCEQ-15808	RIO GRANDE ABOVE PHARR BRIDGE	23	10	43%
TCEQ-13181	RIO GRANDE AT US 281	24	8	33%
TCEQ-17000	RIO GRANDE PRESIDIO RR BRIDGE	14	8	57%
CILA_Monitoreo_Laredo-2	Rio Bravo en Masterson Road	7	7	100%
CILA_Monitoreo_Laredo-5	Rio Bravo 1.6 Km (1 milla) abajo del Arroyo Coyotes (PIT ARN	7	7	100%
TCEQ-13084		10	6	60%
TCEQ-13086		7	6	86%
TCEQ-15704	RIO GRANDE AT TORNILLO-CASETA	7	6	86%
TCEQ-13074	ARROYO COLORADO /PT.HARLINGEN	15	5	33%
TCEQ-13228	RIO GRANDE AT SANTA ELENA CNY	24	5	21%
TCEQ-13229	RIO GRANDE BELOW RIO CONCHOS	18	5	28%
TCEQ-13276	RIO GRANDE ABOVE ANTHONY DRAI	12	5	42%
TCEQ-13072		8	4	50%
TCEQ-13079		5	4	80%
TCEQ-13082		7	4	57%
TCEQ-13185		24	4	17%
TCEQ-13202	RIO GRANDE LAREDO WTP PUMP	28	4	14%
TCEQ-13071	ARROYO COLORADO AT CM 22	4	3	75%
TCEQ-13103		6	3	50%
TCEQ-16141	ARROYO COLORADO & COMMERCE ST	4	3	75%

(continued)

Table D-34. (continued)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
TCEQ-16445	ARROYO COLORADO AT DILWORTH R	7	3	43%
TCEQ-16730	RIO GRANDE VILLAGE BOAT RAMP	19	3	16%
TCEQ-13073		2	2	100%
TCEQ-13246	PECOS R. NR. VAL VERDE CO. LN	13	2	15%
TCEQ-13270	SAN FELIPE CK AT GUYLER CONFL	4	2	50%
TCEQ-13116		1	1	100%
TCEQ-13225	RIO GRANDE AT FM 2627	6	1	17%
TCEQ-13447	LAGUNA MADRE GIWW AND ARROYO	1	1	100%
TCEQ-13782	ARROYO COLORADO CM 16	1	1	100%
TCEQ-15114	PECOS R. ABOVE US 290	8	1	13%
TCEQ-15817	RIO GRANDE AT WEBB/ZAPATA CO	17	1	6%
TCEQ-16288	RIO GRANDE AT SABAL PALM	2	1	50%
TCEQ-17001	RIO GRANDE PRESIDIO/OJINAGA	14	1	7%
TCEQ-17247	RIO GRANDE UPSTRM OF FM 1015	10	1	10%
TCEQ-17596	RIO GRANDE AT APACHE RANCH	10	1	10%

Table D-35. Water Quality Comparisons for Texas: Total Dissolved Solids (Water Quality Indicator ID: 1445)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
CNA-PSRB-02	Km 0+000, PUENTE INTERNACIONAL CD. JUÁREZ	14	5	36%
CNA-PSRB-04	PUENTE INTERNACIONAL FORT-HANKOK	14	14	100%
CNA-SSRB-36	PUENTE INT. CAMARGO	6	6	100%

D.2 Water Quality Standards and Comparisons for Mexico

Table D-36 shows Mexico's ecological criteria for water quality (Norm 13) for various water types/uses.

Table D-36. Water Quality Standards for Mexico: Ecological Criteria[a]

Parameter	Drinking water supply source	Recreation with direct contact	Agri-cultural irrigation	Livestock	Fresh water	Marine waters (coastal areas)
Chlorides (as Cl-)	250.0	-	147.5	-	250.0	-
Dissolved solids	500.0	-	500.0 [b]	1,000.0	-	-
Dissolved Oxygen[c]	4.0	-	-	-	5.0	5.0
Electrical conductivity (mmhos/cm)	-	-	1.0[d]	-	-	-
Elementary phosphorus	-	-	-	-	0.0001	0.0001
Fecal coliform	1,000.0	[e]	1,000.0	-	[e]	[e]
Fluorides (as F-)	1.5	-	1.0	2.0	1.0	0.5
Nitrates (NO3 as N)	5.0	-	-	90.0	-	0.04
Nitrites (NO2 as N)	0.05	-	-	10.0	-	0.002
pH[f]	5.0 – 9.0	-	4.5 – 9.0	-	[g]	[g]
Phosphates (as PO4)	0.1	-	-	-	[h]	0.002
Sulfates (SO4)	500.0	-	130.0	-	0.005	-
Suspended solids	500.0	-	50.0	-	[i]	[i]
Temperature (C)	Natural Conditions + 2.5	-	-	-	Natural Conditions + 1.5	Natural Conditions + 1.5
Total Solids	1,000.0	-	-	-	-	-

[a] Maximum levels in mg/L except when another unit is indicated

[b] The concentration of dissolved solids that have no harmful effect on any cultivation is from 500 mg/l, in sensitive cultivation it is from between 500 and 1000 mg/l in many harvests that require special handling it is between 1000 and 2000 mg/l and for cultivation of tolerant plants in permeable soils it is between 2000 and 5000 mg/l required by special handling.

[c] For dissolved oxygen, the established levels shall be considered minimums.

[d] The level takes into consideration the use of water under average conditions of soil texture, speed of infiltration, drainage, irrigation-plate used, climate and the tolerance of cultivation to salts. Considerable deviance from the average value of these variables may make use of this water unsafe.

e Organisms shall not exceed 200 as the most probable number in 100 milliliters (NMP/100ml) in fresh or marine water, and no more than 10% of the monthly samples may exceed 400 NMP/100ml.

[f] For Hydrogen potential (pH), the established level shall be considered minimums and maximums.

[g] There can be no variations greater than 0.2 pH units, using the normal seasonal value as a base.

[h] The total phosphates, measured as phosphorus, shall not exceed 0.005 mg/l in tributaries to lakes or reservoirs or 0.025 mg/l inside the lake or reservoir, in order to prevent the development of undesirable biological species and control accelerated eutrophication; in the case of rivers and streams, concentrations of up to 0.1 mg/l are permitted.

[i] Suspended solids (including sediments) along with color shall not reduce the depth of the level of light compensation for photosynthetic activity more than 10% over the normal value.

Tables D-37 to D-38 compare Repository data on pH and dissolved oxygen, respectively, to these standards.

Table D-37. Water Quality Comparisons for Mexico: pH (Water Quality Indicator ID: 29, 1076, 1135, 1118, 1119, 1233, 1136, 1077)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
CILA-WWTP-Planta Sur		35	1	3%
CNA-PSBC-17	RÍO COLORADO-YURIMURY	72	1	1%
CNA-PSBC-20	CANAL ALIMENTADOR DEL AC. RÍO COLORADO-TIJUANA	96	1	1%
SCERP-New River-CD-04	Dren Tula Oeste	8	1	13%

Table D-38. Water Quality Comparisons for Mexico: Dissolved Oxygen (Water Quality Indicator ID: 1211, 1127, 1089, 1073)

Station ID	Station Name	Data Points	Values Exceeding	Percentage values exceeding
CNA-SSBC-09	DESC. RÍO ARDÍ (RÍO COLORADO)	49	2	4%
CNA-PSBC-20	CANAL ALIMENTADOR DEL AC. RÍO COLORADO-TIJUANA	48	2	4%
CNA-PSRB-18	PUENTE INTERNACIONAL VIEJO MATAMOROS	18	1	6%
CNA-SSRB-26	RÍO BRAVO a.a. DE CD. ACUÑA, POBLADO BALCONES	2	1	50%

D.3 References

ADEQ (Arizona Department of Environmental Quality). 2003. *Arizona's Surface and Groundwater Quality Standards.* Available at http://www.azdeq.gov/environ/water/assessment/ download/305-02/acstand.pdf (accessed October 26, 2005).

CSWRCB (California State Water Resources Control Board). 1994a. *Water Quality Control Plan for the Colorado River Basin.* September.

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NMED (New Mexico Environment Department). 2002. *State of New Mexico Standards for Interstate and Intrastate Surface Waters.* Available at http://www.nmenv.state.nm.us/NMED_regs/ swqb/20_6_4_nmac.html (accessed October 26, 2005).

TNRCC (Texas Natural Resource Conservation Commission). 2000. *Chapter 307: Texas Surface Water Quality Standards*. Numerals 307.1-307.10.

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Appendix E

Water Quality Trends Scenarios

E.1 Introduction

This Appendix presents water quality trends analyses for twelve case studies organized by transboundary region. The purpose of these case studies is to illustrate a very basic approach to identifying water quality trends and the effects of seasonality on measured values for a given parameter. The U.S.-Mexico Border Waters Repository shows an important increase in the number of monitoring stations reporting values along the U.S-Mexico Border in the last 5 to 6 years. Given its robust and flexible structure, the Repository is the most appropriate tool to store, maintain, and retrieve this information for future years. More detailed and statistically sound trends analyses can be performed in the future if data continue to be collected at the same rate as in the last 5 or 6 years. At this time, there is not enough data to draw conclusions on water quality trends for each transboundary region as a whole.

The analyses presented in this Appendix are grouped by transboundary region rather than by state because waterbodies within the same region share common characteristics and it makes more sense to select groups of rivers and waterbodies by hydrologic unit rather than by state for analysis.

The remainder of this Appendix is organized as follows:

- Section E.2 explains the methodology used to identify water quality trends
- Section E.3 includes two case scenarios for the Pacific/Salton Sea Region
- Section E.4 includes two case studies for the Colorado River/Sea of Cortez Region
- Section E.5 includes two case studies for the Central Desert/Closed Basins Region
- Section E.6 includes four case studies for the Rio Grande Region
- Section E.7 includes two case studies for the Lower Rio Grande Region.

Table E-1 shows how the case studies within this entire section are organized by transboundary regions. The case studies were selected based on data availability in the U.S.-Mexico Border Waters Repository. Those stations with most data points for a given water quality indicator were chosen for the case studies.

Table E-1. Case Studies for Water Quality Trends Analyses

Case Study	Water Quality Indicator	Station
Pacific/Salton Sea (Section E.3)		
1	Specific Conductance	NWIS-3247-0311-6473-101
2	DO	NWIS-3247-0311-6473-101
Colorado/Sea of Cortez (Section E.4)		
3	Total Hardness as $CaCO_3$	CNA-PSBC-14
4	DO	CNA-PSBC-14
Central Desert/Closed Basins (Section E.5)		
5	DO	ModSTORET-100034
6	DO	ModSTORET-100035
Rio Grande (Section E.6)		
7	DO	TCEQ-13272
8	Sulfate	TCEQ-13272
9	Specific Conductance	TCEQ-15892
10	Specific Conductance	TCEQ-13205
Lower Rio Grande (Section E.7)		
11	Specific Conductance	TCEQ-13072
12	DO	TCEQ-13072

E.2 Methodology

Water quality trends analyses are important for detecting change in water quality status for a given waterbody over time. Water quality trends may help decision makers determine the appropriate actions to prevent the future impairment of specific waterbodies.

Water quality trends analyses require large data sets comprising data points that have been consistently recorded over time in a given river point or segment. Furthermore, water quality on a river segment may be affected by a number of factors, including precipitation intensity, discharges, flow peaks, and many other climatic events. Seasonality certainly must be included in water quality status and trends analyses, because water quality is affected by seasonal events.

Quantitative trends analyses require appropriate methodologies and algorithms to capture effects of seasonality, account for missing data, accommodate measurements below detection limits, and resolve other data problems. For example, the Tau-Kendall methodology is often used to perform trends analyses. However, applying that technique is time consuming and computationally intensive, and it may not be the best technique for initial analyses where data are somewhat limited (as in this project). For these reasons, complex quantitative trends measures were not used.

Instead, initial water quality trends analyses were limited to visual inspection of plots of all values for each indicator between 1993 and 2003 (Figure E-1 provides an example). For a given water quality indicator at a specific station, all values were plotted, and outliers were identified and eliminated. Stations with at least 50 data points for a given water quality indicator in the study period were selected for the scenarios. Basic statistics were calculated for the data set after removing outliers. Given the importance of seasonality effecting water quality values, univariate statistics were calculated for data points measured at different times of the year during the study period. Box and whisker diagrams were used to show the differences in the data point distributions at different times of the year.

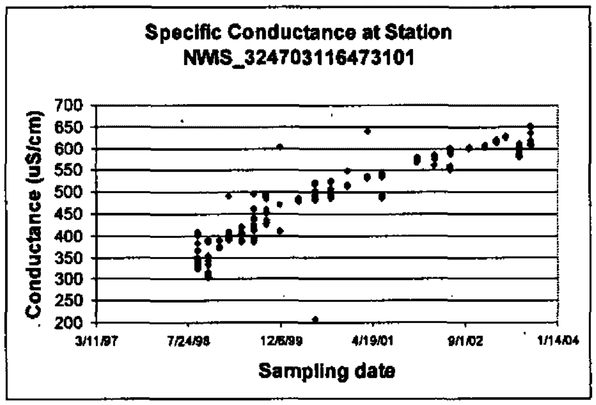


Figure E-1. Example of a simple plot

E.3 Case Studies for the Pacific/Salton Sea Transboundary Region

Two case studies were included for this region. Each case study is defined by a water quality indicator measured at a given station. Water quality trends and seasonality were assessed for both scenarios and are summarized in Figures E-2 through E-7 and Tables E-2 and E-3. Additional trends were assessed for other stations and are summarized in Tables E-4 and E-5.

E.3.1 General Characteristics

The Pacific/Salton Trough Region contains seven basins that drain either to the Pacific Ocean or to inland seas. It drains 14,000 square miles (36,000 km^2). The basin has a very dry, semiarid climate with few fresh water resources. Flow in the basin is primarily from east to west, with stream flows originating from precipitation in the mountains flowing toward the Pacific Ocean. The flow in these streams is controlled through a series of hydraulic structures, including reservoirs. The Tijuana River is one of the main streams in the basin and one of the City of Tijuana's major natural resources. The river flows northwest through the city of Tijuana before crossing into California near San Ysidro and flowing into the Pacific Ocean.

Case Study 1: Specific Conductance at Station NWIS_324703116473101

Case Study 1 is defined by the following attributes:

- Water Quality Indicator: Specific Conductance, water, unfiltered. Indicator ID: 1072. Measured in microsiemens per centimeter (μS/cm).
- Station ID: NWIS_324703116473101
- Station Location: Latitude: 32.78422009 N; Longitude: 116.79279994 E
- Station Name: LOVELAND RES NR DAM SITE 1 UPPER
- Owning Organization: Arizona Department of Environmental Quality's Legacy & Modernized STORET data.

Figure E-2 shows the plot of values measured within the study period, once the outliers have been removed from the data set. A slight increasing trend can be observed on this plot.

Figure E-3 shows the cumulative normal distribution for this data set indicating about an 80 percent probability of measuring a specific conductance value of 400 μS/cm or greater at this station. As a reference, the specific conductance of distilled water is about 1 μS/cm, which is low, and that of seawater is about 50,000 μS/cm.

Table E-2 shows an average value of 493 μS/cm and a standard deviation of 95 μS/cm.

Table E-2 also shows the differences in the statistics for the seasonal values measured at this station. Averages are similar for both seasons but the distribution of values is a little spread out in March. Figure E-4 shows the March and September seasonal distributions for this water quality indicator.

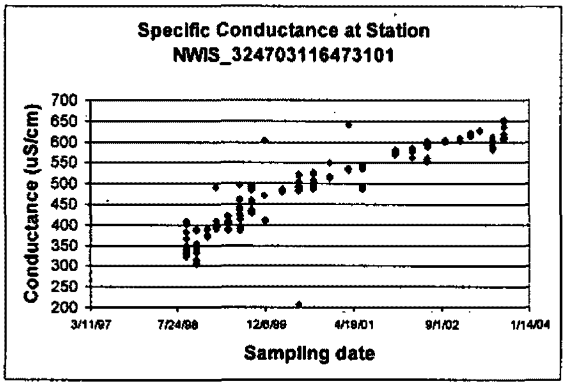


Figure E-2. Specific conductance values during the study period.

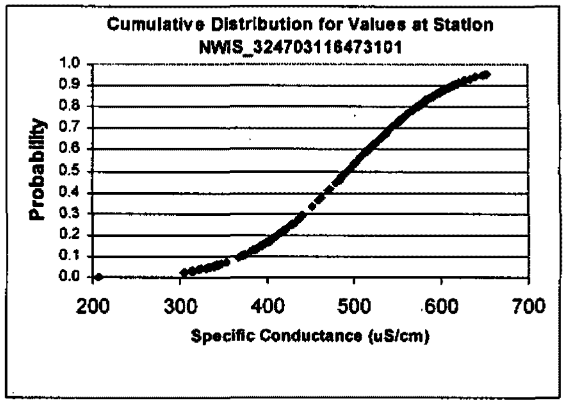
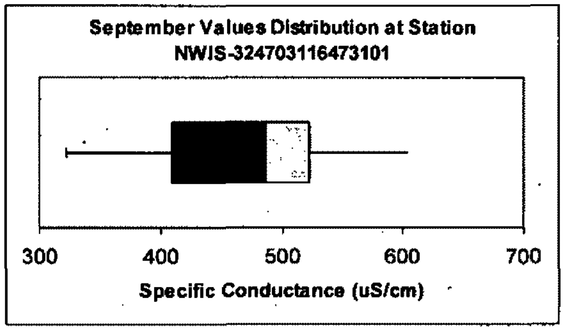


Figure E-3. Cumulative normal distribution for specific conductance values during the study period.

Table E-2. Statistics for Specific Conductance Values Measured at Station NWIS_324703116473101

Statistic	All Values	March Values	September Values
Count	468	90	90
Average	493	495	469
Median	492	487	488
Mode	608	481	602
Standard Deviation	95	72	91
Min	207	390	322
Quartile 1	403	403	409
Quartile 2	492	487	488
Quartile 3	584	537	523
Max	653	640	604
First Reading	10-Sep-98	02-Mar-99	10-Sep-98
Last Reading	20-Aug-03	19-Mar-02	18-Sep-02



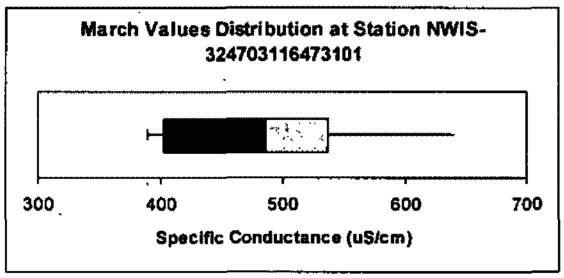


Figure E-4. Seasonal distributions for specific conductance values during the study period.

Case Study 2: DO at Station NWIS_324703116473101

Case Study 2 is defined by the following attributes:

- Water Quality Indicator: DO, water, unfiltered. Indicator ID: 1073. Measured in mg/L.
- Station ID: NWIS_324703116473101
- Station Location: Latitude: 32.78422009 N; Longitude: -116.79279994 E
- Station Name: LOVELAND RES NR DAM SITE 1 UPPER
- Organization Name: U.S. Geological Survey
- Data Source: Arizona Department of Environmental Quality's Legacy & Modernized STORET data.

Figure E-5 shows the plot of values measured within the study period once the outliers have been removed from the data set. No trend can be identified on this plot.

Figure E-6 shows the cumulative normal distribution for this data set indicating a 56 percent probability of measuring a DO value of about 5.0 mg/L or below at this station.

Table E-3 shows an average value of 4.4 mg/L and a standard deviation of 3.7 mg/L.

Table E-3 also shows the differences in the statistics for the seasonal values measured at this station. DO concentrations are greater in average in March than in September for this station. Figure E-7 shows the March and September seasonal distributions for this water quality indicator.

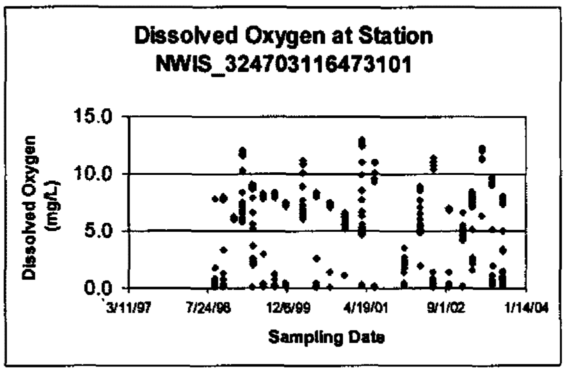


Figure E-5. DO values during the study period.

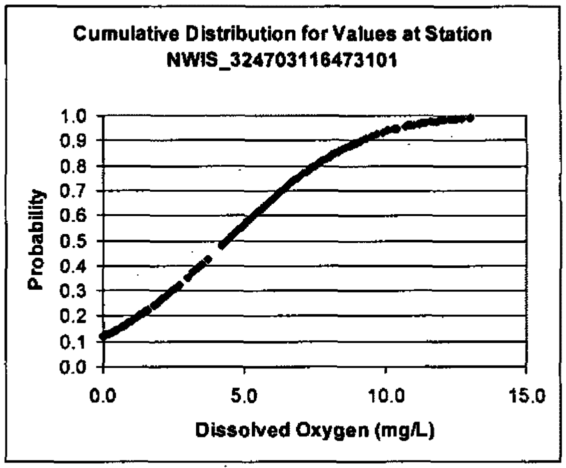
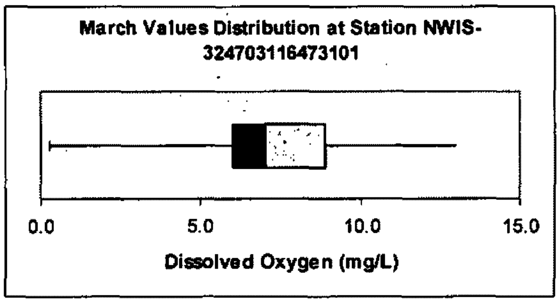


Figure E-6. Cumulative normal distribution for dissolved oxygen values during the study period.

Table E-3. Statistics for DO Values Measured at Station NWIS_324703116473101

Statistic	All Values	March Values	September Values
Count	462	90	86
Average	4.4	7.6	2.5
Median	5.1	7.1	0.4
Mode	0.1	8.9	0.1
Standard Deviation	3.7	2.5	3.3
Min	0.0	0.3	0.1
Quartile 1	0.3	6.0	0.1
Quartile 2	5.1	7.1	0.4
Quartile 3	7.3	8.9	6.8
Max	13.0	13.0	8.3
First Reading	10-Sep-98	02-Mar-99	10-Sep-98
Last Reading	20-Aug-03	19-Mar-02	18-Sep-02



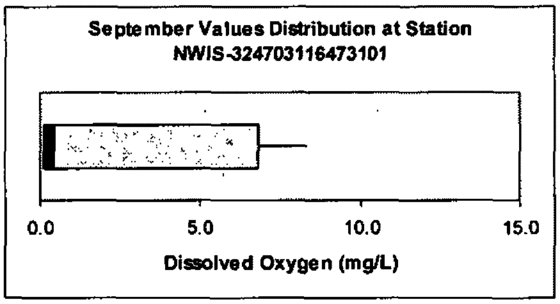


Figure E-7. Distributions for dissolved oxygen seasonal values during the study period.

Table E-4. Statistics for Water Quality Indicator Values Measured at Different Stations in Pacific/Salton Sea Transboundary Region

Statistic	Temp. (°C) at Station NWIS-3247-0311-6473-101	Conductance (µS/cm) at Station NWIS-3241-3111-7000-101	DO (mg/L) at Station NWIS-3241-3111-7000-101	Conductance (µS/cm) at Station NWIS-3241-2611-6595-701	DO (mg/L) at Station NWIS-3241-3011-7002-501
	Statistics Values				
Count	493	283	282	87	258
Average	14.5	916	5.5	791	5.7
Median	12.7	921	6.4	787	6.5
Mode	11.3	1040	0.2	795	0.1
Standard Deviation	4.2	114	3.2	37	3.3
Min	10.4	740	0.1	736	0.1
Quartile 1	11.5	796	2.8	766	3.2
Quartile 2	12.7	921	6.4	787	6.5
Quartile 3	15.7	1030	7.6	796	7.8
Max	27.0	1120	12.0	875	15.1
First Reading	10-Sep-98	09-Sep-98	09-Sep-98	10-Sep-98	09-Sep-98
Last Reading	20-Aug-03	19-Aug-03	19-Aug-03	12-Jul-99	19-Aug-03
Trend	Increasing	Increasing	Not identifiable	Increasing	Not identifiable

Table E-5. Location of Additional Stations in the Pacific/Salton Sea Region

Station ID	Location	Name	State	Owning Organization
NWIS-3241-3111-7000-101	Lat: 32.69199773, Lon: -117.00113737	SWEETWATER RES CTR OF MIN POOL UPPER	California	U.S. Geological Survey
NWIS-3241-2611-6595-701	Lat: 32.69060889, Lon: -117.0000262	SWEETWATER RES NR RECREATION AREA UPPER	California	U.S. Geological Survey
NWIS-3241-3011-7002-501	Lat: 32.69171991, Lon: -117.0078043	SWEETWATER RES NR PUMP TOWER UPPER	California	U.S. Geological Survey

E.4 Case Studies for the Colorado River/Sea of Cortez Transboundary Region

Two case studies were included for this region. Each case study is defined by a water quality indicator measured at a given station in this region. Water quality trends and seasonality were assessed for both scenarios and are summarized in Figures E-8 through E-13 and Tables E-6 and E-7. Additional trends were assessed for other stations and are summarized in Table E-8.

E.4.1 General Characteristics

The Colorado River/Sea of Cortez Region contains 11 basins that drain either to the Colorado River below the gaging station at Parker Dam or to the Sea of Cortez. The region drains 22,590 square miles (58,500 km^2). It covers portions of the states of Arizona, Sonora, and Chihuahua and consists of lowlands flanked by the Sierra Juarez and the Sierra San Pedro Martir mountain ranges to the west and the Desierto de Altar (Sonoran Desert) and the Northwest Chihuahua highlands to the east.

The major surface waters in the region are the lower Colorado River delta and the Laguna Salada. From the north, the Colorado River flows into the basin through heavily urbanized areas near Yuma, Arizona, and San Luis Rio, Colorado, Sonora, and then through wetlands before flowing into the Sea of Cortez.. Most of the water that the delta receives comes from agricultural drainage from the United States and Mexico, with little perennial flow in the lower Colorado River.

Case Study 3: Total Hardness at Station CNA-PSBC-14

Case Study 3 is defined by the following attributes:

- Water Quality Indicator: Hardness, Total (as $CaCO_3$), measured in mg/L. Indicator ID: 1158
- Station ID: CNA-PSBC-14
- Station Location: Latitude: 32.5 N; Longitude: -114.8167 E
- Station Name: Canal Sánchez Taboada
- Country: Mexico
- Owning Organization: Comisión Nacional del Agua.

Figure E-8 shows the plot of values measured within the study period once the outliers have been removed from the data set. A slight decreasing trend can be spotted on this plot.

Figure E-9 shows the cumulative normal distribution for this data set indicating a 100 percent probability of measuring a total hardness value greater than 120 mg/L, which is considered very hard water.

Table E-6 shows an average value of 723 mg/L and a standard deviation of 60 mg/L.

Table E-6 also shows the differences in the statistics for the seasonal values measured at this station. Total Hardness values are greater in average in June through August than in December through February for this station. Values in December through February are more spread out. Figure E-10 shows the December–February and the June–August seasonal distributions for total hardness at Station CNA-PSBC-14.

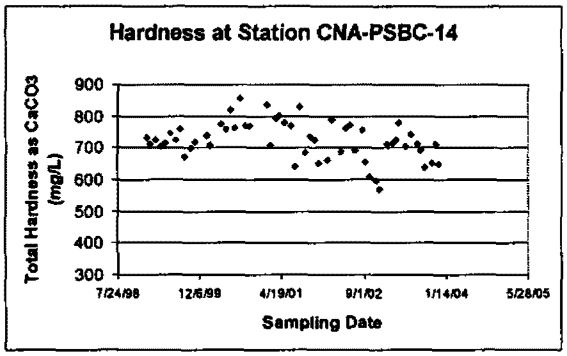


Figure E-8. Total hardness values during study period.

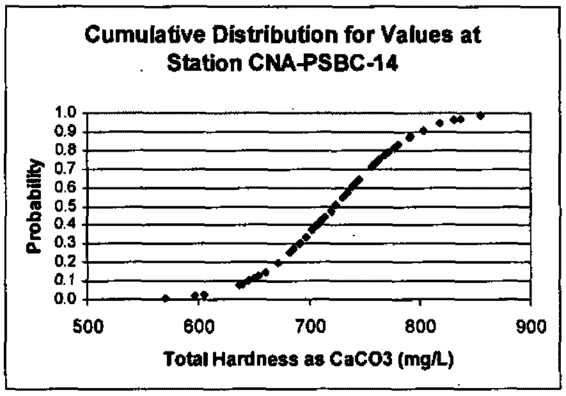


Figure E-9. Cumulative normal distribution for total hardness values during study period.

Table E-6. Statistics for Total Hardness Values Measured at Station CAN-PSBC-14

Statistic	All Values	Dec–Feb Values	Jun–Aug Values
Count	55	13	13
Average	723	706	754
Median	724	710	760
Mode	724	-	-
Standard Deviation	60	67	60
Min	571	571	640
Quartile 1	692	660	711
Quartile 2	724	710	760
Quartile 3	766	730	771
Max	855	837	855
First Reading	19-Jan-99	19-Jan-99	08-Aug-00
Last Reading	02-Dec-03	02-Dec-03	12-Aug-03

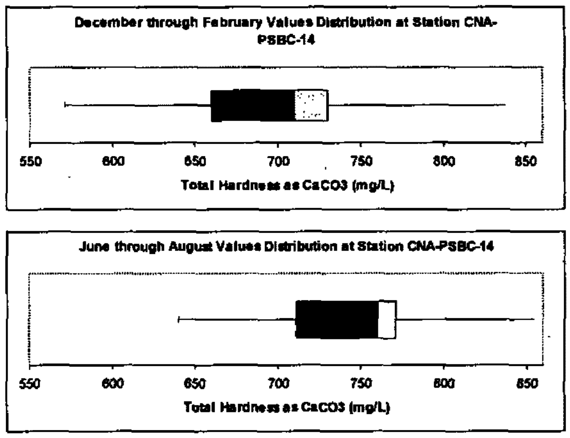


Figure E-10. Seasonal distributions for total hardness values during the study period.

Case Study 4: DO at Station CNA-PSBC-14

Case Study 4 is defined by the following attributes:

- Water Quality Indicator: DO, measured in mg/L. Indicator ID: 1089
- Station ID: CNA-PSBC-14
- Station Location: Latitude: 32.5 N; Longitude: -114.8167 E
- Station Name: Canal Sánchez Taboada
- Country: Mexico
- Owning Organization: Comisión Nacional del Agua.

Figure E-11 shows the plot of values measured within the study period once the outliers have been removed from the data set. A slight declining trend can be spotted on this plot.

Figure E-12 shows the cumulative normal distribution for this data set indicating a 100 percent probability of getting a value higher than 5 mg/L and a 73 percent probability of getting a value higher than 8 mg/L.

Table E-7 shows an average value of 8.4 mg/L and a standard deviation of 1.2 mg/L.

Table E-7 also shows the differences in the statistics for the seasonal values measured at this station. DO values are greater on average in the December–February season. Figure E-13 shows the December–February and the June–August seasonal distributions for this water quality indicator.

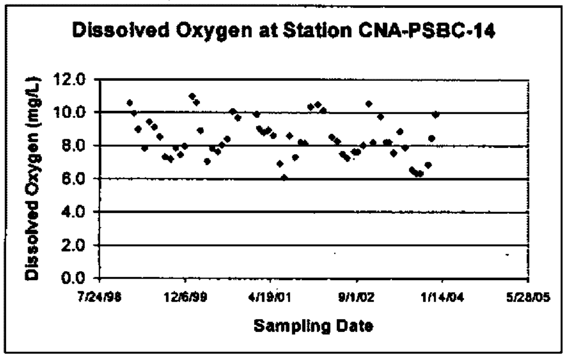


Figure E-11. Dissolved oxygen values during study period.

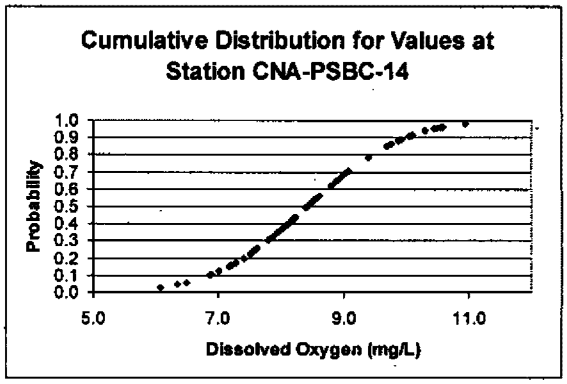


Figure E-12. Cumulative normal distribution for dissolved oxygen values during the study period.

Table E-7. Statistics for Dissolved Oxygen Values Measured at Station CNA-PSBC-14

Statistic	All Values	Dec–Feb Values	Jun–Aug Values
Count	57	14	15
Average	8.4	9.7	7.6
Median	8.2	9.9	7.6
Mode	7.8	-	-
Standard Deviation	1.2	1.0	0.9
Min	6.1	8.0	6.1
Quartile 1	7.6	9.2	7.0
Quartile 2	8.2	9.9	7.6
Quartile 3	9.1	10.4	8.2
Max	11.0	11.0	9.1
First Reading	19-Jan-99	19-Jan-99	08-Jun-99
Last Reading	02-Dec-03	02-Dec-03	12-Aug-03

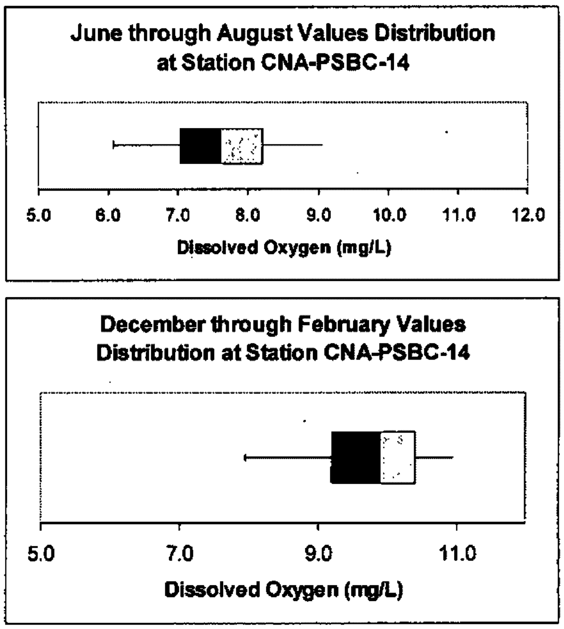


Figure E-13. Distributions for suspended volatile solids seasonal values during the study period.

Table E-8. Statistics for Water Quality Indicator Values Measured at Different Stations in the Colorado River/Sea of Cortez Transboundary Region

Statistic	Total Solids (mg/L) at Station CNA-PSBC-14	Conductance (µS/cm) at Station CNA-PSBC-14	Chloride (mg/L) at Station CNA-PSBC-14	BOD[a] (mg/L) at Station CNA-PSBC-14	COD[b] (mg/L) at Station CNA-PSBC 14
	Statistics Values				
Count	57	57	54	57	57
Average	2,675	3,824	561	2.0	50
Median	2,744	3,880	627	1.4	50
Mode	2,847	4,210	637	1.1	50
Standard Deviation	339	484	212	1.7	21
Min	1,256	1,999	3	0.5	9
Quartile 1	2,607	3,590	574	1.1	39
Quartile 2	2,744	3,880	627	1.4	50
Quartile 3	2,862	4,195	670	2.3	60
Max	3,114	4,650	808	9.4	118
First Reading	19-Jan-99	19-Jan-99	19-Jan-99	19-Jan-99	19-Jan-99
Last Reading	02-Dec-03	02-Dec-03	02-Dec-03	02-Dec-03	02-Dec-03
Trend	Decreasing	Decreasing	Decreasing	Decreasing	Not identifiable

[a] BOD: Biochemical Oxygen Demand
[b] COD: Chemical Oxygen Demand

E.5 Case Studies for the Central Desert/Closed Basins Transboundary Region

Two case studies were included for this region. Each case study is defined by a water quality indicator measured at a given station in this region. Water quality trends and seasonality were assessed for both scenarios and are summarized in Figures E-14 through E-19 and Tables E-9 and E-10. Additional trends were assessed for other stations and are summarized in Tables E-11 and E-12. Both case studies fall in the Mexican Highlands portion of the region; there was inadequate data to conduct a case study in the Mimbres/Animas basins.

E.5.1 General Characteristics

The Mexican Highlands basins contain 14 basins that drain to rivers in southern Arizona, southwestern New Mexico, northern Sonora, or the extreme northwestern tip of Chihuahua. The Mimbres/Animas basins contain 5 basins that drain internally in southern New Mexico and northern Chihuahua. The Mexican Highlands region drains 21,840 square miles (56,600 km^2) and the Mimbres/Animas region drains 12,450 square miles (32,200 km^2) (Woodward and Durall, 1996).

The Mexican Highland Region, although is classified as desert, contains vegetation and diverse aquatic habitats. The Santa Cruz and San Pedro Rivers are the dominant streams in the region. Their flows largely depend on precipitation in the mountains in Arizona and Mexico. Near their headwaters, certain reaches of these rivers flow continuously, but their flows decrease dramatically as the rivers travel northward. The Santa Cruz river near Nogales, Sonora, generally flows continuously, but the natural flow in the river does not reach the Nogales International Wastewater Treatment Plant (located along the river about 6 miles north of Nogales, Arizona). Flow downstream from the treatment plant is composed of effluent return, and this water rarely flows past the Santa Cruz County line (Papoulias et al, 1997).

The Mimbres and Animas basin system consists mostly of topographically closed basins with piedmont and basin-floor alluvial surfaces grading to central playa (ephemeral-lake) depressions that are designated "bolsons." All stream systems in the basins are ephemeral, except in the valleys of Animas Creek (NMED, 2002).

Case Study 5: DO at Station ModSTORET-100034

Case Study 5 is defined by the following attributes:

- Water Quality Indicator: DO, measured in mg/L. Indicator ID: 1089
- Station ID: ModSTORET-10034
- Station Location: Latitude: 32.1862411 N; Longitude: -110.81672 E
- Station Name: SCLAK-A
- Owning Organization: Arizona Department of Environmental Quality.

Figure E-14 shows the plot of values measured within the study period once the outliers have been removed from the data set. No trend can be spotted on this plot.

Figure E-15 shows the cumulative normal distribution for this data set indicating a 40 percent probability of measuring a DO value of 5.0 mg/L or less at this station.

Table E-9 shows an average value of 5.8 mg/L and a standard deviation of 3.3 mg/L.

Table E-9 also shows the differences in the statistics for the seasonal values measured at this station. Although values for July and August were available only for 1998, one can see that the average values in December–February are much larger than in June–August. Figure E-16 shows the December–February and the June–August seasonal distributions for DO at Station ModSTORET-100034.

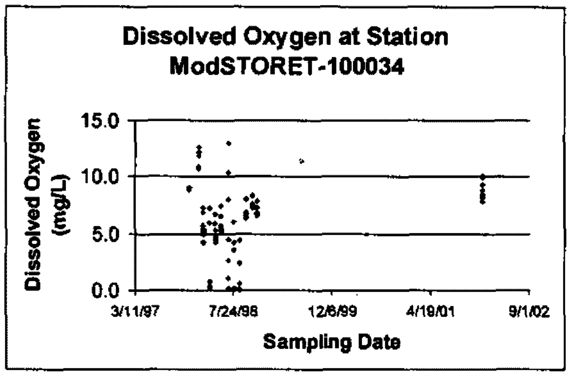


Figure E-14. Dissolved oxygen values during the study period.

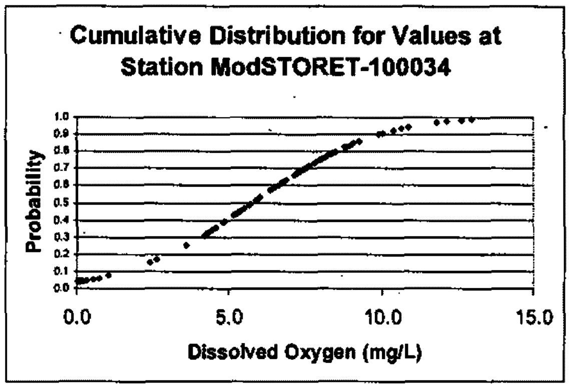


Figure E-15. Cumulative normal distribution for dissolved oxygen values during the study period.

Table E-9. Statistics for Dissolved Oxygen Values Measured at Station ModSTORET-100034

Statistic	Value	Dec–Feb Values	Jun–Aug Values
Count	108	29	26
Average	5.8	8.3	2.4
Median	6.7	8.5	0.2
Mode	0.0	-	0.0
Standard Deviation	3.3	2.3	3.5
Min	0.0	4.2	0.0
Quartile 1	4.3	6.8	0.1
Quartile 2	6.7	8.5	0.2
Quartile 3	7.6	9.3	4.1
Max	13.0	12.6	13.0
First Reading	12-Dec-97	12-Dec-97	01-Jul-98
Last Reading	9-Jan-02	09-Jan-02	27-Aug-98

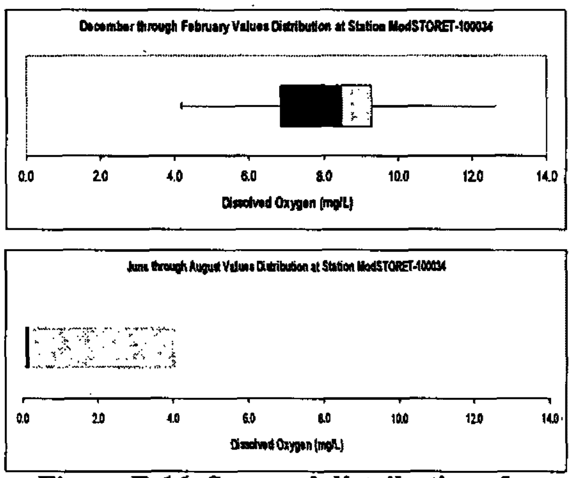


Figure E-16. Seasonal distributions for dissolved oxygen values during study period.

Case Study 6: DO at Station ModSTORET-100035

Case Study 6 is defined by the following attributes:

- Water Quality Indicator: DO, measured in mg/L. Indicator ID: 1089
- Station ID: ModSTORET-10035
- Station Location: Latitude: 32.1862411 N; Longitude: -110.81672 E
- Station Name: SCLAK-B
- Owning Organization: Arizona Department of Environmental Quality.

Figure E-17 shows the plot of values measured within the study period once the outliers have been removed from the data set. No trend can be spotted on this plot.

Figure E-18 shows the cumulative normal distribution for this data set indicating a 25 percent probability of measuring a DO value of 5.0 mg/L or less at this station.

Table E-10 shows an average value of 6.6 mg/L and a standard deviation of 2.5 mg/L.

Table E-10 also shows the differences in the statistics for the seasonal values measured at this station. Values in December–February are also larger in average than the values in June–August. Figure E-19 shows the December–February and June–August seasonal distributions for DO at Station ModSTORET-100035.

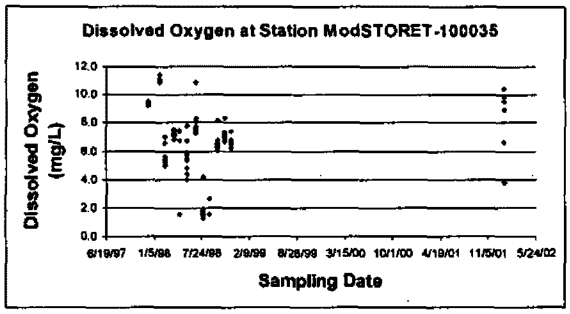


Figure E-17. Dissolved oxygen values during the study period.

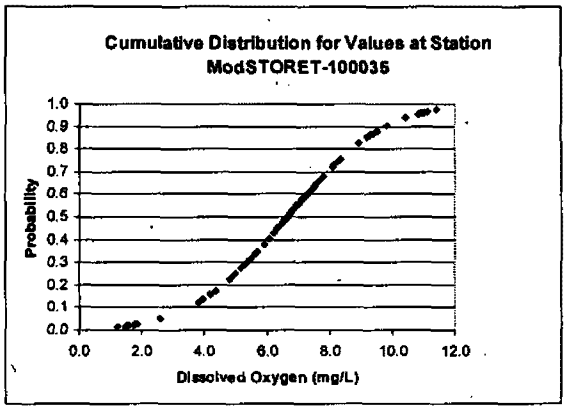


Figure E-18. Cumulative normal distribution for dissolved oxygen values during the study period.

Table E-10. Statistics for Dissolved Oxygen Values Measured at Station ModSTORET-100035

Statistic	Value	Dec–Feb Values	Jun–Aug Values
Count	88	25	18
Average	6.6	8.3	4.7
Median	6.8	9.3	3.4
Mode	7.1	-	-
Standard Deviation	2.5	2.4	3.3
Min	1.2	3.8	1.2
Quartile 1	5.6	5.6	1.6
Quartile 2	6.8	9.3	3.4
Quartile 3	7.7	10.4	7.6
Max	11.4	11.4	10.8
First Reading	12-Dec-97	12-Dec-97	01-Jul-98
Last Reading	09-Jan-02	09-Jan-02	27-Aug-98

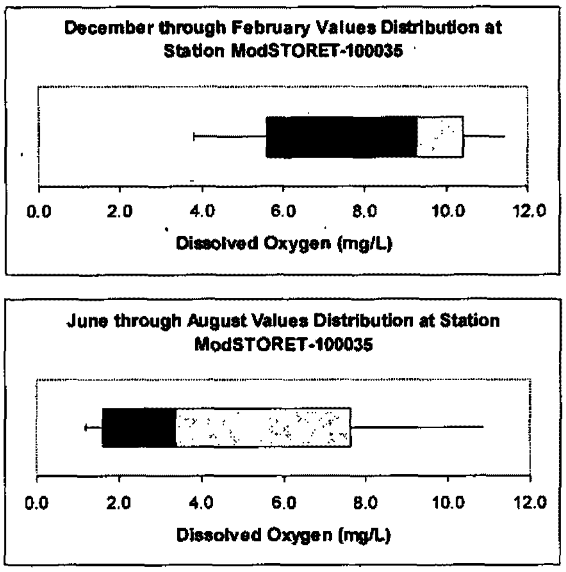


Figure E-19. Seasonal distributions for dissolved oxygen values during study period.

Table E-11. Statistics for Water Quality Indicator Values Measured at Different Stations in the Central Desert/Closed Basins Transboundary Region[a]

Statistic	DO (mg/L) at Station ModSTORET-100000	pH at Station ModSTORET-100034	Conductance (µS/cm) at Station ModSTORET-100034	DO (mg/L) at Station ModSTORET-100028	Conductance (µS/cm) at Station ModSTORET-100035
	Statistics Values				
Count	63	122	122	64	105
Average	5.5	8.4	450	7.8	451
Median	6.9	8.4	488	8.7	493
Mode	0.1	9.0	277	8.8	277
Standard Deviation	4.4	0.6	141	3.2	136
Min	0.1	6.9	274	0.1	274
Quartile 1	0.2	8.1	307	7.4	307
Quartile 2	6.9	8.4	488	8.7	493
Quartile 3	9.1	8.9	534	9.4	527
Max	12.9	9.8	715	14.9	717
First Reading	03-Dec-97	13-Aug-93	13-Aug-93	13-Aug-93	13-Aug-93
Last Reading	28-Aug-01	09-Jan-02	09-Jan-02	25-Nov-98	09-Jan-02
Trend	Not identifiable	Not identifiable	Increasing	Not identifiable	Increasing

[a] These stations are all in the Mexican Highlands basins; there were not enough data points for the Mimbres/Animas basins in the Repository for analysis.

Table E-12. Location of Additional Stations in the Central Desert/Closed Basins Transboundary Region

Station ID	Location	Name	State	Owning Organization
ModSTORET-100000	Lat: 31.53289, Lon: -111.25345	SCARI-A	Arizona	Arizona Department of Environmental Quality
ModSTORET-100028	Lat: 32.180138, Lon: -111.00752	SCKEN-A	Arizona	Arizona Department of Environmental Quality

E.6 Case Studies for the Rio Grande Transboundary Region

Four case studies were included for this region. Each case study is defined by a water quality indicator measured at a given station in this region. Water quality trends and seasonality were assessed for all four scenarios and are summarized in Figures E-20 through E-31 and Tables E-13 through E-16. Additional trends were assessed for other stations and are summarized in Tables E-17 through E-20.

E.6.1 General Characteristics

The Rio Grande/Rio Bravo Basin is subdivided into three regions. The Rio Grande-Elephant Butte Reservoir to above Rio Conchos Region contains 14 basins that drain to that reach of the Rio Grande below the gaging station at Elephant Butte dam. The Rio Grande-Rio Conchos to Amistad Reservoir Region contains 32 basins that drain either to that reach of the Rio Grande, to the lower reach of the Rio Conchos below the now suspended Falomir gaging station (near the Luis Leon Dam), or to the lower reach of the Pecos River below the gaging station at Girvin. The Rio Grande below Amistad Reservoir to Falcon Reservoir Region contains 13 basins that drain either to that reach of the Rio Grande or to the lower reach of the Rio Salado below the gaging station at Las Tortillas. The Rio Grande-Elephant Butte Reservoir to above Rio Conchos Region includes 28,940 square miles (75,000 km^2); the Rio Grande-Rio Conchos to Amistad Reservoir Region includes 34,630 square miles (89,700 km^2); and the Rio Grande below Amistad Reservoir to Falcon Reservoir Region includes 12,910 square miles (33,400 km^2) (Woodward and Durall, 1996).

The entire Rio Grande Basin extends 1,896 miles (3,051 km) from the river's headwaters in the San Juan Mountains of southern Colorado to near its mouth in the Gulf of Mexico. The Rio Grande/Rio Bravo drains an area of approximately 182,215 square miles (471,937 km^2) in the three U.S. states of Colorado, New Mexico, and Texas and the five Mexican states of Chihuahua, Coahuila, Durango, Nuevo Leon, and Tamaulipas. Major cities along the Rio Grande within the transboundary region include five sister city pairs: El Paso, TX/Juarez, Chihuahua; Presidio, TX/Ojinaga, Chihuahua; Del Rio, TX/Acuña, Coahuila; Eagle Pass, TX/Piedras Negras, Coahuila; and Laredo, TX/Nuevo Laredo, Tamaulipas.

The primary water courses in these regions are the Rio Grande/Rio Bravo and its tributaries, including the Rios Conchos, Salado, San Juan, and San Rodrigo in Mexico, and the Pecos and Devil's Rivers in Texas. On the main stream are the Amistad and the Falcon Reservoirs. A feature of this region is the extent of control on the natural flow of the river including dams, reservoirs, canals, and diversions for water supply and flow control. Flow in the lower Rio Grande has become dependent on controlled releases and "return flows" back to the river from agricultural and other commercial water uses (U.S. EPA, 2001).

Case Study 7: DO at Station TCEQ13272 (Rio Grande-Elephant Butte Reservoir to above Rio Conchos Region)

Case Study 7 is defined by the following attributes:

- Water Quality Indicator: DO, measured in mg/L. Indicator ID: 1127
- Station ID: TCEQ-13272
- Station Location: Latitude: 31.802778 N; Longitude: -106.540276 E
- Station Name: RIO GRANDE AT COURCHESNE BRDG
- Owning Organization: Texas Commission on Environmental Quality.

Figure E-20 shows the plot of values measured within the study period once the outliers have been removed from the data set. A stable tendency around the average value of 8.0 mg/L can be seen on this plot.

Figure E-21 shows the cumulative normal distribution for this data set indicating only a 1 percent probability of measuring a DO value of 5.0 mg/L or less at this station.

Table E-13 shows an average value of 8.0 mg/L and a standard deviation of 1.5 mg/L.

Table E-13 also shows the differences in the statistics for the seasonal values measured at this station. Values measured in March are larger in average than the values measured in September. Figure E-22 shows the March and September seasonal distributions for DO at Station TCEQ-13272.

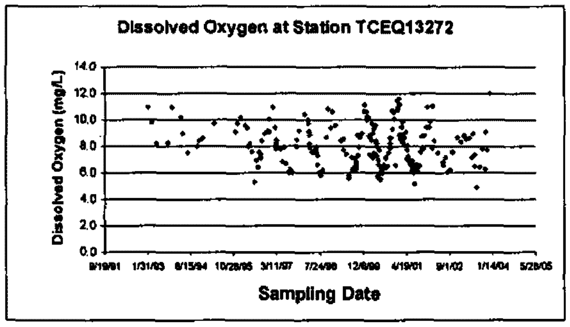


Figure E-20. Dissolved oxygen values during the study period.

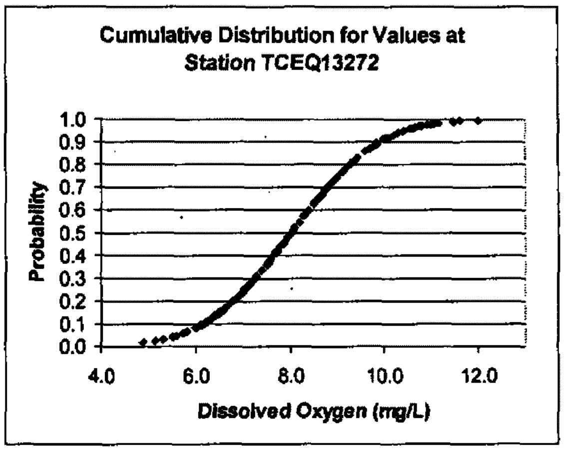


Figure E-21. Cumulative normal distribution for dissolved oxygen values during the study period.

Table E-13. Statistics for Dissolved Oxygen Values Measured at Station TCEQ13272

Statistic	All Value	March Values	September Values
Count	252	36	43
Average	8.0	8.7	7.0
Median	7.9	8.6	7.2
Mode	7.2	8.5	7.2
Standard Deviation	1.5	0.6	0.6
Min	4.9	7.8	6.0
Quartile 1	6.9	8.4	6.5
Quartile 2	7.9	8.6	7.2
Quartile 3	8.9	9.0	7.2
Max	12.0	10.0	8.8
First Reading	27-Jan-93	09-Mar-93	28-Sep-93
Last Reading	16-Dec-03	18-Mar-03	23-Sep-03

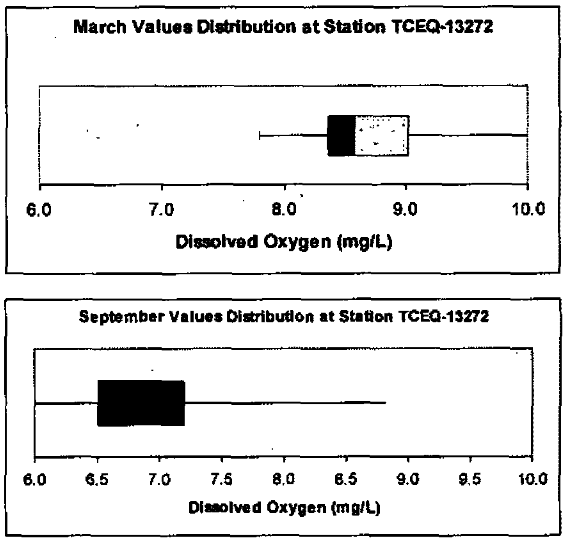


Figure E-22. Seasonal distributions for dissolved oxygen values during the study period.

Case Study 8: Sulfate at Station TCEQ13272 (Rio Grande-Elephant Butte Reservoir to above Rio Conchos Region)

Case Study 8 is defined by the following attributes:

- Water Quality Indicator: Sulfate as SO4, measured in mg/L. Indicator ID: 1161
- Station ID: TCEQ-13272
- Station Location: Latitude: 31.802778 N; Longitude: -106.540276 E
- Station Name: RIO GRANDE AT COURCHESNE BRDG
- Owning Organization: Texas Commission on Environmental Quality.

Figure E-23 shows the plot of values measured within the study period once the outliers have been removed from the data set. No trend can be spotted on this plot.

Figure E-24 shows the cumulative normal distribution for this data set indicating an 87 percent probability of measuring a Sulfate value of 150 mg/L or greater at this station.

Table E-14 shows an average value of 275 mg/L and a standard deviation of 114 mg/L.

Table E-14 also shows the differences in the statistics for the seasonal values measured at this station. Values measured in February are slightly larger in average and more spread out than the values measured in September. Figure E-25 shows the February and September seasonal distributions for Sulfate at Station TCEQ-13272.

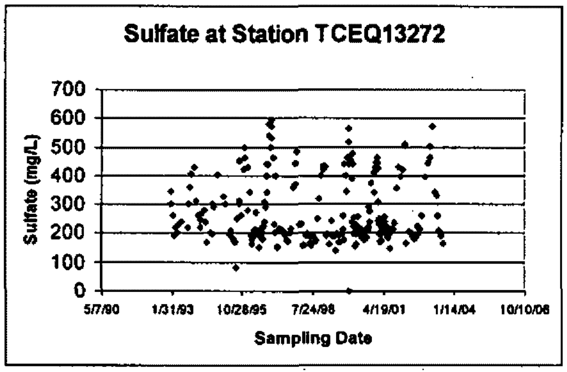


Figure E-23. Sulfate values during the study period.

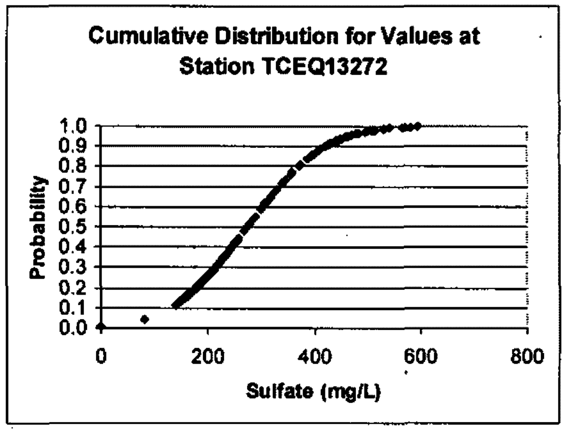


Figure E-24. Cumulative normal distribution for sulfate values during the study period.

Table E-14. Statistics for Sulfate Values Measured at Station TCEQ13272

Statistic	All Value	February Values	September Values
Count	249	24	21
Average	275	326	259
Median	223	284	240
Mode	210	260	300
Standard Deviation	114	113	62
Min	1	189	173
Quartile 1	197	231	217
Quartile 2	223	284	240
Quartile 3	346	430	300
Max	594	511	452
First Reading	21-Jan-93	18-Feb-93	16-Sep-93
Last Reading	19-Aug-03	18-Feb-03	17-Sep-02

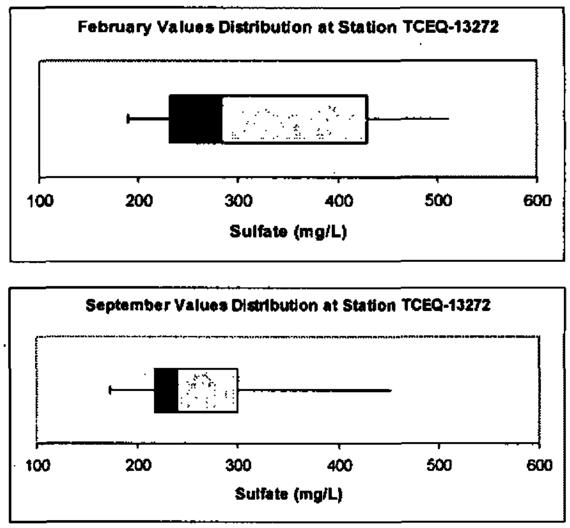


Figure E-25. Distributions for sulfate seasonal values during the study period

Case Study 9: Specific Conductance at Station TCEQ-15892 (Rio Grande-Rio Conchos to Amistad Reservoir Region)

Case Study 9 is defined by the following attributes:

- Water Quality Indicator: Specific Conductance, field (UMHOS/CM @ 25C). Indicator ID: 1110
- Station ID: TCEQ-15892
- Station Location: Latitude: 29.625278 N; Longitude: -101.251114 E
- Station Name: AMISTAD RESERV RIO GRANDE ARM
- Owning Organization: Texas Commission on Environmental Quality.

Figure E-26 shows the plot of values measured within the study period once the outliers have been removed from the data set. A slight decreasing trend can be seen on this plot.

Figure E-27 shows the cumulative normal distribution for this data set indicating a 95 percent probability of measuring a specific conductance value of about 1,000 µS/cm or greater at this station.

Table E-15 shows an average value of 1,125 µS/cm and a standard deviation of 79 µS/cm.

Table E-15 also shows the differences in the statistics for the seasonal values measured at this station. Values measured in March are larger in average and more spread out than the values measured in October. Figure E-28 shows the March and October seasonal distributions for Conductance at Station TCEQ-15892.

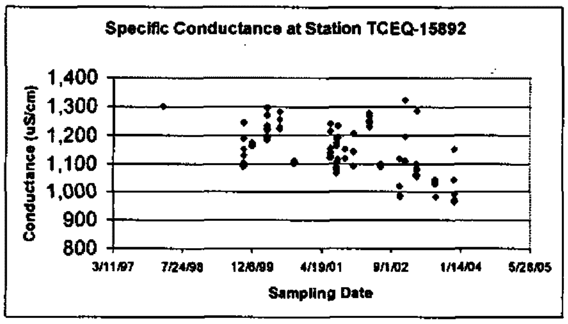


Figure E-26. Specific conductance values during the study period.

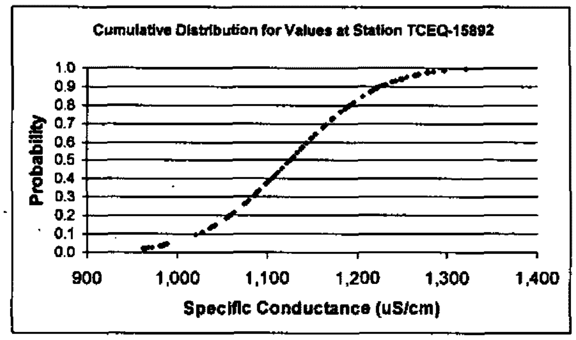


Figure E-27. Cumulative normal distribution for specific conductance values during the study period.

Table E-15. Statistics for Specific Conductance Values Measured at Station TCEQ15892

Statistic	All Values	March Values	October Values
Count	187	35	44
Average	1,125	1,195	1,089
Median	1,109	1,219	1,100
Mode	1,117	1,219	1,117
Standard Deviation	79	82	58
Min	963	1,055	983
Max	1,087	1,141	1,089
Quartile 1	1,109	1,219	1,100
Quartile 2	1,173	1,257	1,117
Quartile 3	1,321	1,298	1,242
First Reading	05-Mar-98	05-Mar-98	06-Oct-99
Last Reading	02-Dec-03	05-Mar-03	29-Oct-02

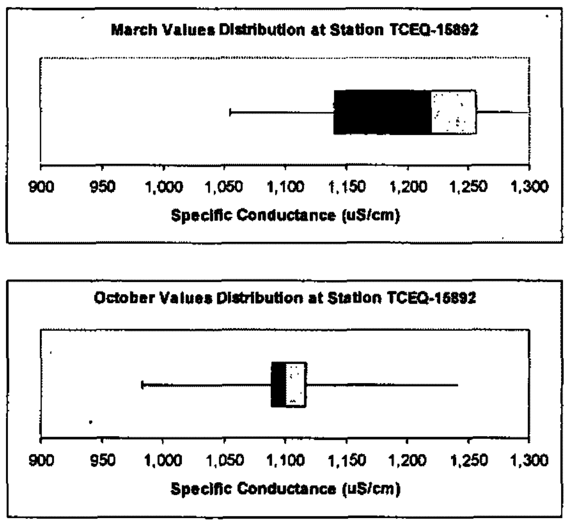


Figure E-28. Seasonal distributions for specific conductance values during the study period.

Case Study 10: Specific Conductance at Station TCEQ-13205 (Rio Grande—below Amistad Reservoir to Falcon Reservoir Region)

Case Study 10 is defined by the following attributes:

- Water Quality Indicator: Specific Conductance, field (UMHOS/CM @ 25C). Indicator ID: 1110
- Station ID: TCEQ-13205
- Station Location: Latitude: 28.663334 N; Longitude: -100.5 E
- Station Name: RIO GRANDE NR US277/EAGLE PASS
- Owning Organization: Texas Commission on Environmental Quality.

Figure E-29 shows the plot of values measured within the study period once the outliers have been removed from the data set. A slight decreasing trend can be spotted on this plot.

Figure E-30 shows the cumulative normal distribution for this data set indicating a 60 percent probability of measuring a Specific conductance value of about 1,000 µS/cm or greater at this station.

Table E-16 shows an average value of 1,023 µS/cm and a standard deviation of 97 µS/cm.

Table E-16 also shows the differences in the statistics for the seasonal values measured at this station. Values measured in June–August are larger in average and less spread out than the values measured in December–February. Figure E-31 shows the December–February and June–August seasonal distributions for Conductance at Station TCEQ-13205.

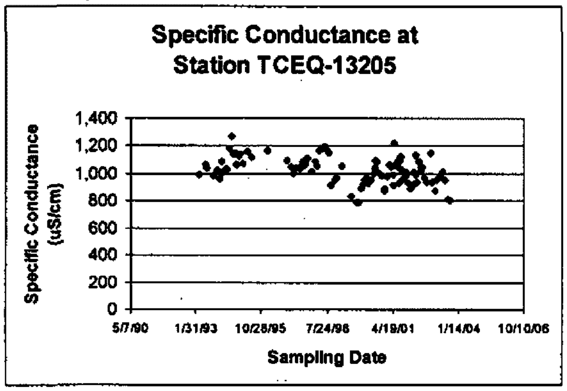


Figure E-29. Specific conductance values during the study period.

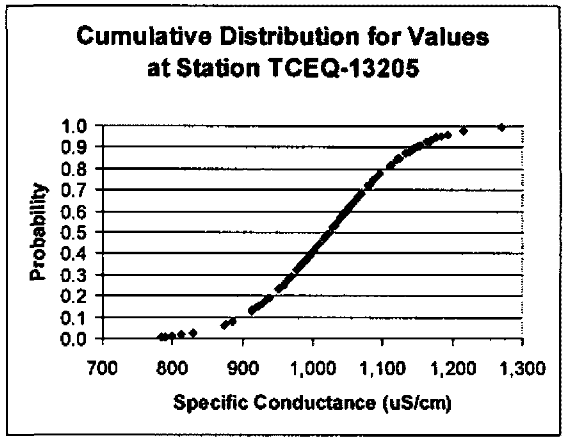


Figure E-30. Cumulative normal distribution for specific conductance values during the study period.

Table E-16. Statistics for Specific Conductance Values Measured at Station TCEQ-13205

Statistic	All Values	Dec–Feb Values	Jun–Aug Values
Count	108	33	32
Average	1,023	988	1,064
Median	1,026	996	1,065
Mode	954	1,009	1,177
Standard Deviation	97	78	96
Min	784	874	813
Max	957	923	1,035
Quartile 1	1,026	996	1,065
Quartile 2	1,087	1,053	1,121
Quartile 3	1,270	1,138	1,270
First Reading	23-Mar-93	01-Dec-93	17-Jun-93
Last Reading	10-Sep-03	12-Feb-03	13-Aug-03

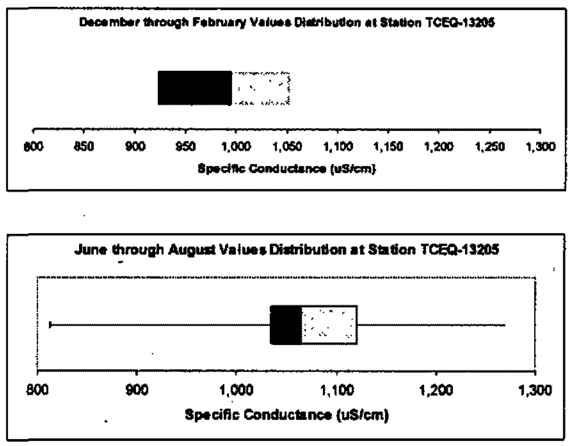


Figure E-31. Seasonal distributions for specific conductance values during study period.

Table E-17. Statistics for Water Quality Indicator Values Measured at Different Stations in the Rio Grande-Elephant Butte Reservoir to above Rio Conchos Region

Statistic	Chloride (mg/L) at Station TCEQ-13272	Conductance (µS/cm) at Station TCEQ-13272	Total Nitrogen (mg/L) at Station TCEQ-13272	Fecal Coliform (#/100 ml) at Station TCEQ-13272	pH at Station TCEQ-15528
	Statistics Values				
Count	251	175	155	151	146
Average	157.5	1,469	0.2	1,236	8.3
Median	119.0	1,190	0.1	567	8.3
Mode	110.0	1,170	0.1	300	8.2
Standard Deviation	99.9	765	0.3	1,649	0.4
Min	1.0	288	0.0	1	6.5
Quartile 1	94.0	1,058	0.1	219	8.1
Quartile 2	119.0	1,190	0.1	567	8.3
Quartile 3	190.0	1,760	0.2	1,535	8.5
Max	752.0	8,490	1.9	9,700	9.7
First Reading	21-Jan-93	27-Jan-93	27-Jan-93	27-Jan-93	20-Nov-97
Last Reading	18-Nov-03	16-Dec-03	16-Dec-03	16-Dec-03	16-Dec-03
Trend	Stable	Increasing	Increasing	Not identifiable	Increasing

Table E-18. Statistics for Water Quality Indicator Values Measured at Different Stations in the Rio Grande-Rio Conchos to Amistad Reservoir Region

Statistic	DO (mg/L) at Station TCEQ-15892	pH at Station TCEQ-15892	Conductance (µS/cm) at Station TCEQ-13835	DO (mg/L) at Station TCEQ-13835	Conductance (µS/cm) at Station TCEQ-15893
	Statistics Values				
Count	197	197	197	197	141
Average	7.9	8.1	1,001	7.0	553
Median	8.0	8.1	1,019	7.8	534
Mode	7.8	8.1	1,030	8.0	435
Standard Deviation	1.9	0.2	74	2.8	160
Min	0.3	7.5	820	0.1	327
Quartile 1	7.2	8.0	965	6.1	416
Quartile 2	8.0	8.1	1,019	7.8	534
Quartile 3	9.1	8.3	1,059	8.9	691
Max	11.1	8.5	1,171	11.7	932
First Reading	05-Mar-98	05-Mar-98	21-Jun-00	21-Jun-00	06-Oct-99
Last Reading	02-Dec-03	02-Dec-03	02-Dec-03	02-Dec-03	02-Dec-03
Trend	Stable	Not identifiable	Decreasing	Not identifiable	Not identifiable

Table E-19. Statistics for Water Quality Indicator Values Measured at Different Stations in the Rio Grande below Amistad Reservoir to Falcon Reservoir Region

Statistic	DO (mg/L) at Station TCEQ-13205	pH at Station TCEQ-13205	Conductance (µS/cm) at Station TCEQ-13560	DO (mg/L) at Station TCEQ-13560	Chloride (mg/L) at Station TCEQ-13209
	Statistics Values				
Count	114	113	107	106	102
Average	8.5	8.1	998	9.1	151.8
Median	8.3	8.0	1,010	9.2	150.0
Mode	10.7	8.0	1,013	9.0	160.0
Standard Deviation	2.0	0.7	140	2.4	20.8
Min	3.9	6.9	94	2.1	60.9
Quartile 1	7.1	7.7	946	7.3	138.4
Quartile 2	8.3	8.0	1,010	9.2	150.0
Quartile 3	9.7	8.2	1,056	10.9	160.0
Max	15.4	10.5	1,312	15.2	200.0
First Reading	23-Mar-93	23-Mar-93	16-Mar-93	16-Mar-93	20-Jan-93
Last Reading	11-Dec-03	11-Dec-03	13-Nov-03	13-Nov-03	12-Sep-02
Trend	Stable	Stable	Decreasing	Stable	Decreasing

Table E-20. Location of Additional Stations in the Rio Grande Transboundary Region

Station ID	Location	Name	State	Owning Organization
TCEQ-15528	Lat: 31.752777, Lon: -106.418892	RIO GRANDE 1.3KM DWNSTRM WWTP	Texas	Texas Commission on Environmental Quality
TCEQ-13835	Lat: 29.458334, Lon: -101.05722	AMISTAD RESERVOIR AT BUOY #1. Ambient monitoring station.	Texas	Texas Commission on Environmental Quality
TCEQ-15893	Lat: 29.601389, Lon: -100.976112	AMISTAD RESERV DEVILS R ARM	Texas	Texas Commission on Environmental Quality
TCEQ-13560	Lat: 29.291945, Lon: -100.876114	RIO GRANDE AT MOODY RANCH	Texas	Texas Commission on Environmental Quality
TCEQ-13209	Lat: 29.416666, Lon: -101.033333	RIO GRANDE BELOW AMISTAD DAM	Texas	Texas Commission on Environmental Quality

E.7 Case Studies for the Lower Rio Grande Transboundary Region

Two case studies were included for this region. Each one is defined by a water quality indicator measured at a given station in the region. Water quality trends and seasonality were assessed for the scenario and are summarized in Figures E-32 through E-37 and Tables E-21 and E-22. Additional trends were assessed for other stations and summarized in Tables E-23 and E-24.

E.7.1 General Characteristics

The Lower Rio Grande Valley Region (below Falcon Reservoir to the Gulf of Mexico) contains 11 basins that drain either to that reach of the Rio Grande, to the lower reach of the Rio San Juan below the gaging station at Santa Rosalia, or to Arroyo Colorado in southern Texas. It drains an area of 10,240 square miles (26,500 km^2).

This region is physiographically characterized as Gulf Coastal Plain. From Falcon Reservoir, the Rio Grande/Rio Bravo flows southeastward approximately 275 river miles (443 km), ending in the coastal wetlands and marshes of the Gulf of Mexico, including the Laguna Madre off the coasts of Texas and Tamaulipas. Among the unique habitats of this segment of the U.S.-Mexico border are the "resacas" (oxbow lakes) of the Lower Rio Grande Valley. Surface water flow entering the Lower Rio Grande Valley Region via the Rio Grande mainstream is greatly influenced by water management practices and upstream control structures. Mexico's Rio Conchos and Rio San Juan have been the primary sources of water for this section of the Lower Rio Grande for several decades (Buckler et al., 1997).

Plates

U.S.-Mexico Transboundary Basins

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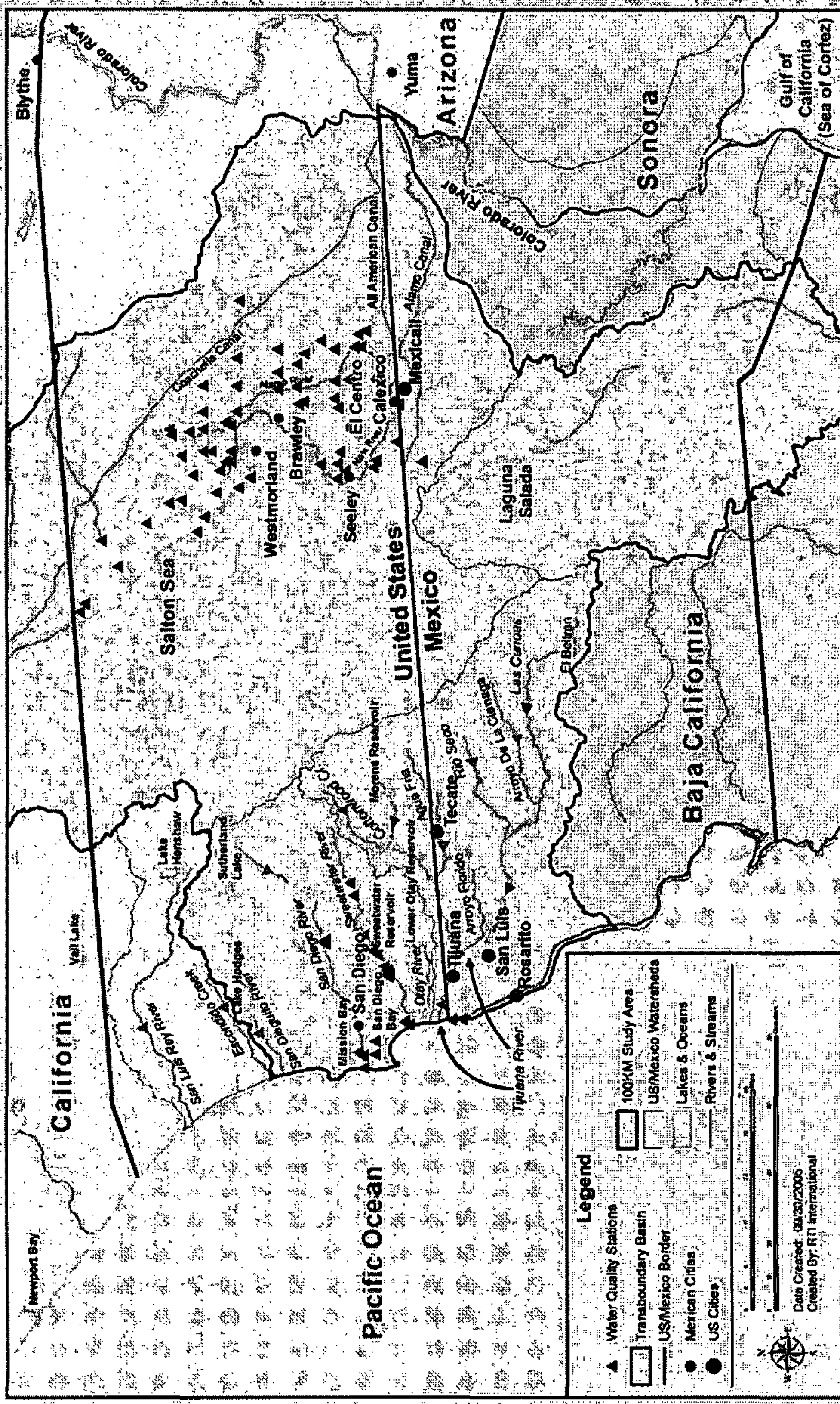

Plate 1. Pacific/Salton Sea Transboundary Basins

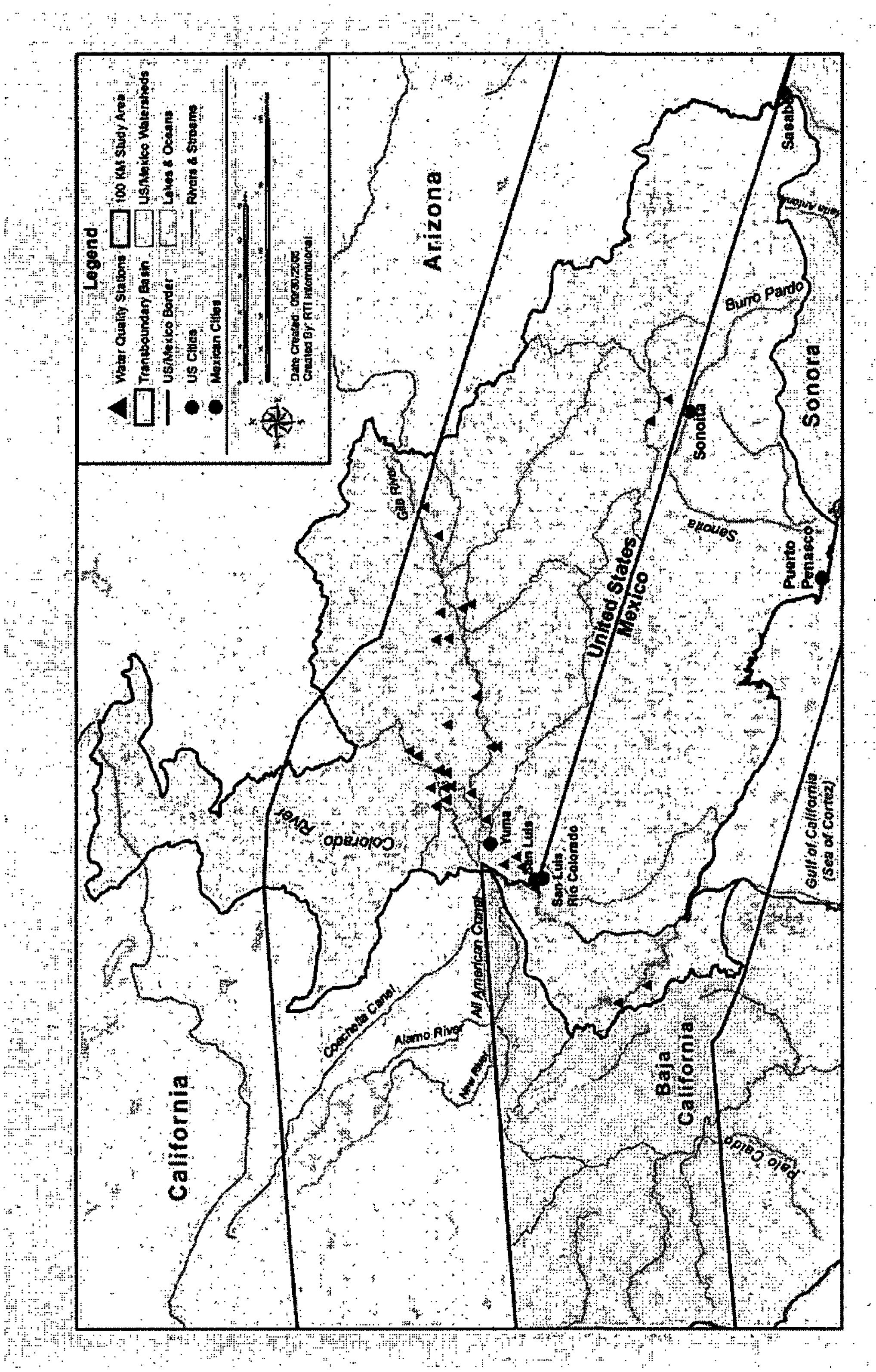

Plate 2. Colorado River/Sea of Cortez Transboundary Basins

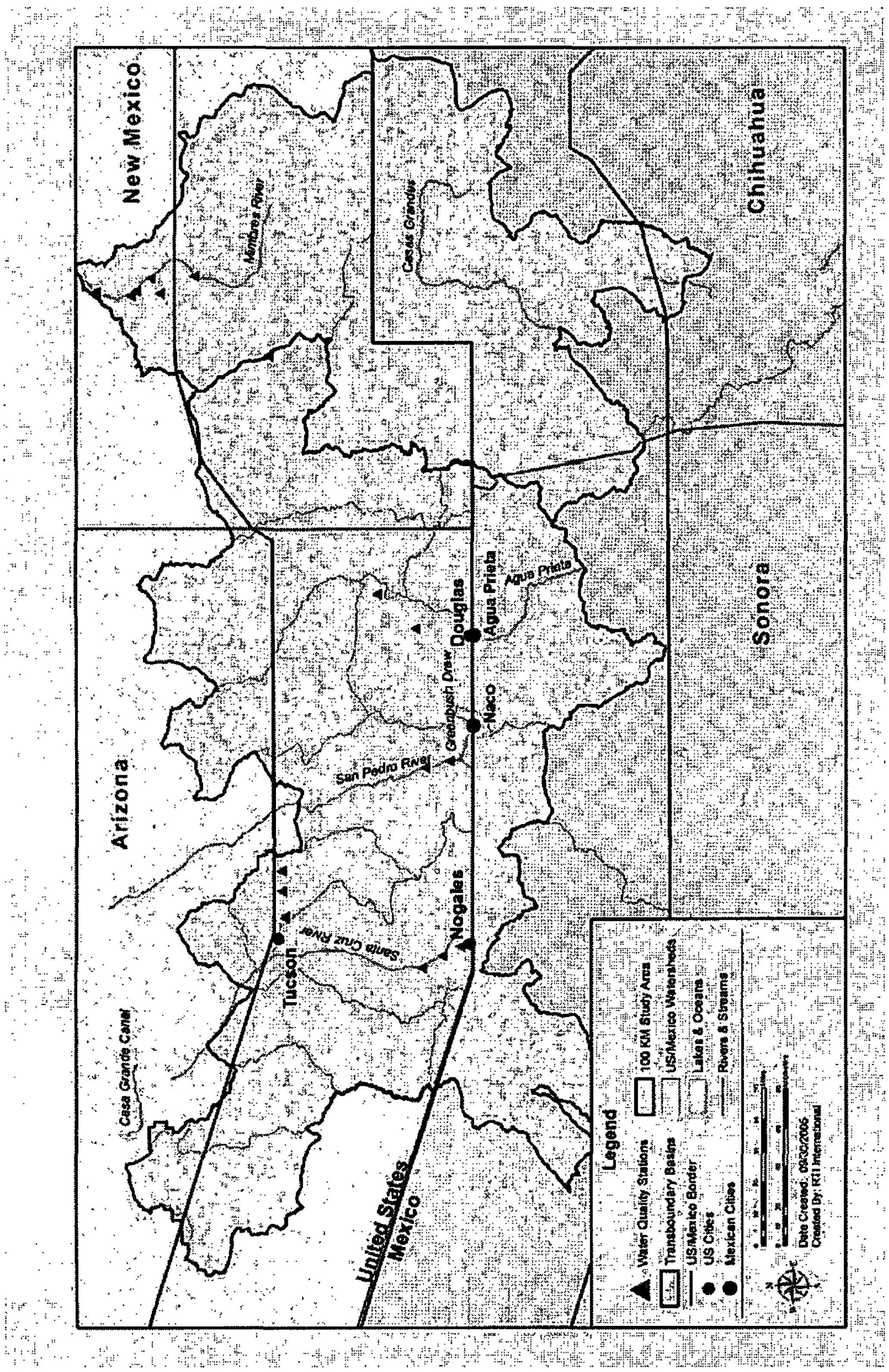

Plate 3. Central Desert/Closed Transboundary Basins

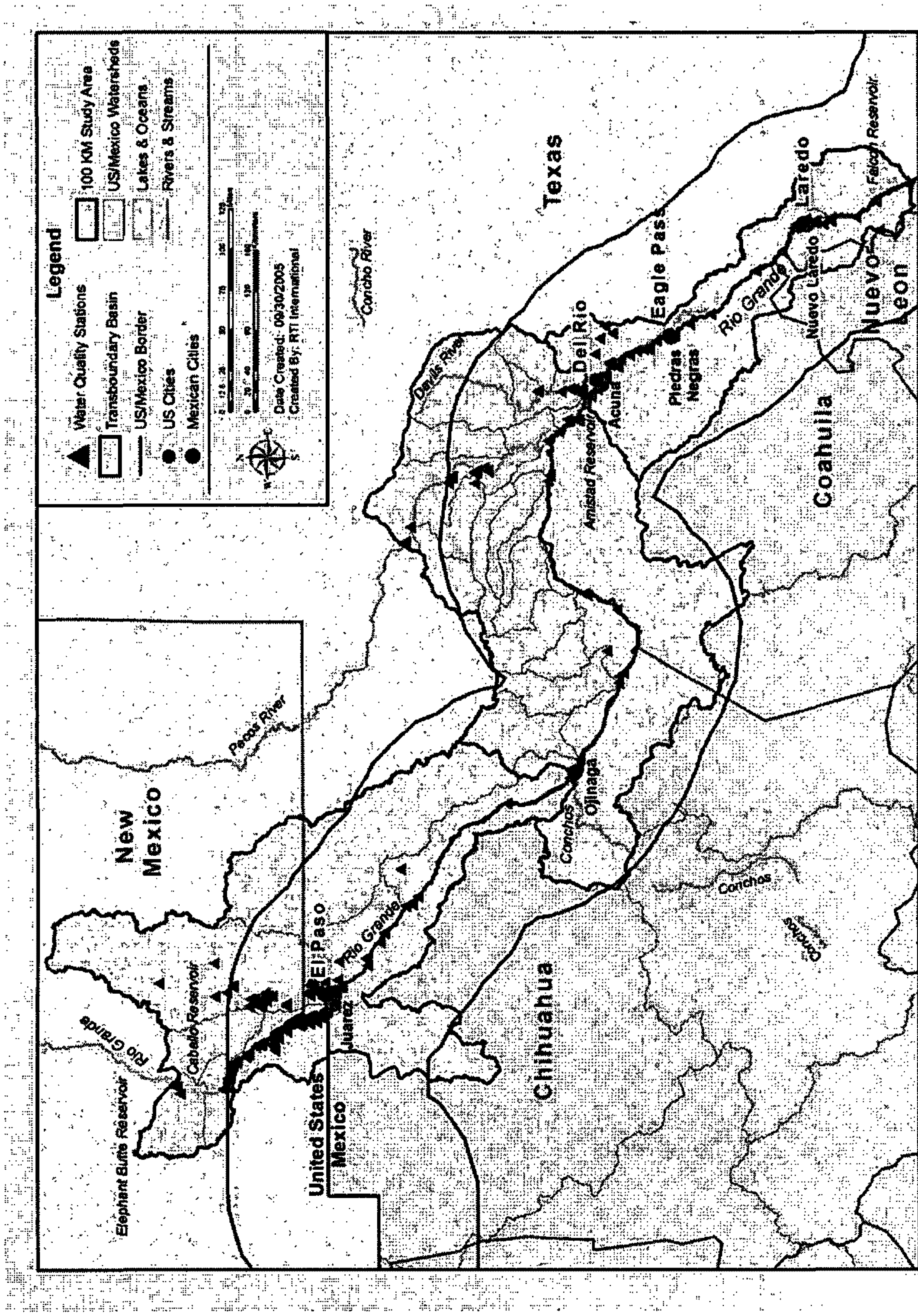

Plate 4. Upper Rio Grande Transboundary Basins

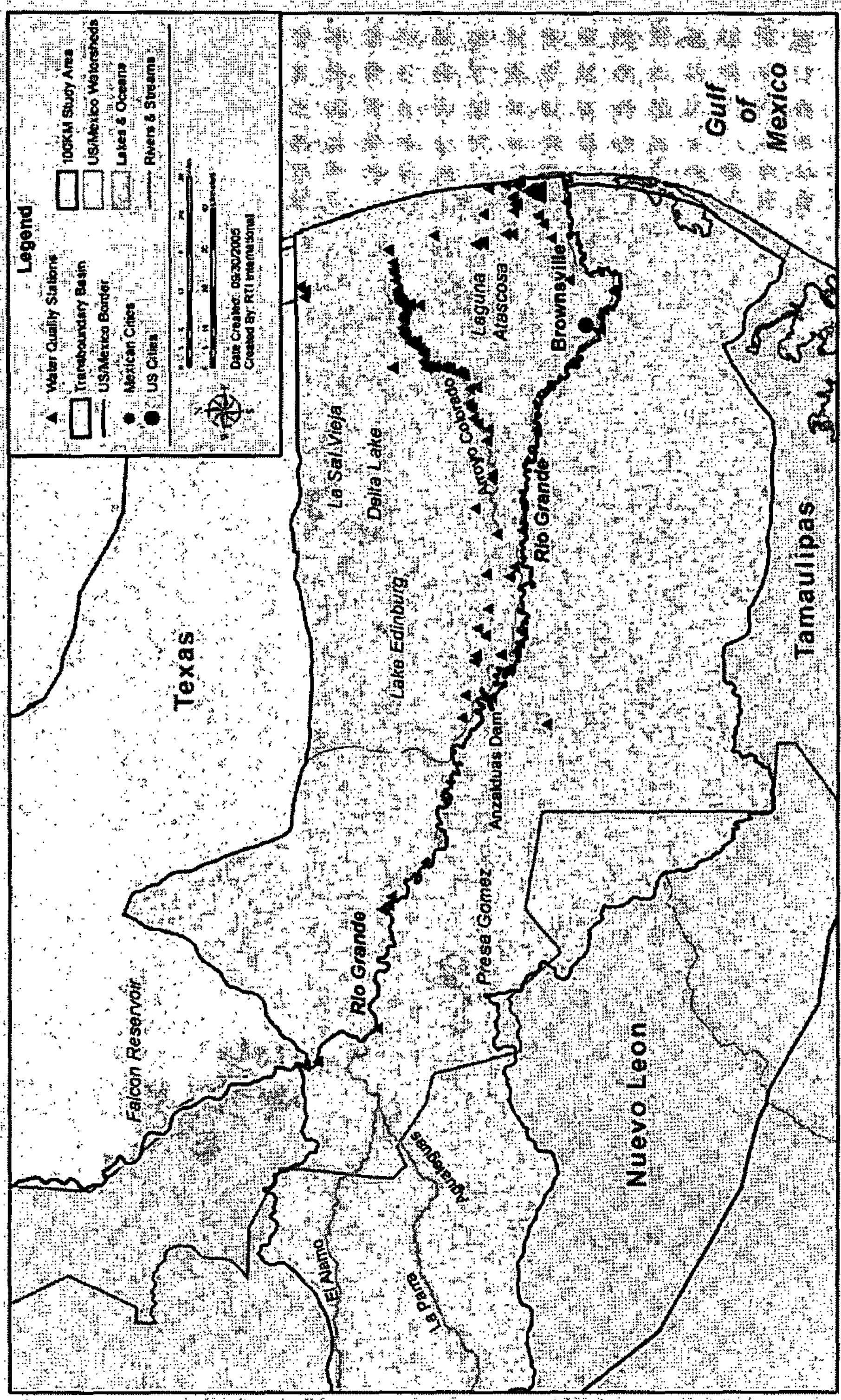

Plate 5. Lower Rio Grande Transboundary Basin