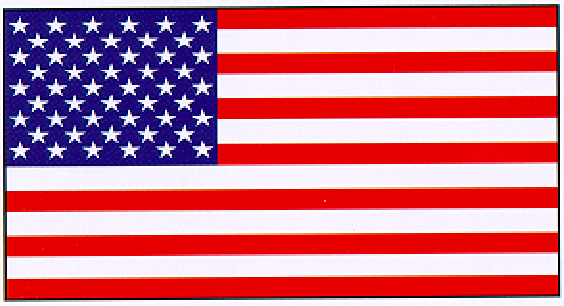
Second Phase of the Binational Study Regarding the Presence of Toxic Substances in the Rio Grande/Rio Bravo and its Tributaries Along the Boundary Portion Between the United States and Mexico

Segunda Fase del Estudio Binacional Sobre la Presencia de Sustancias Tóxicas en el Río Bravo/Río Grande y sus Afluentes, en su Porción Fronteriza Entre México y Estados Unidos



Volume I of II

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AUTHORITY

This study and report were undertaken by the United States and Mexico pursuant to the International Boundary and Water Commission Minute No. 289 entitled "Observation of the Quality of the Waters Along the United States and Mexico Border," dated November 13, 1992, and the "Joint Report of the Principal Engineers Relative to the Second Phase of the Program to Observe for the Presence of Toxic Substances in the Rio Grande/Rio Bravo in its International Reach," dated May 12, 1995.

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FOREWORD

This report is issued by the Governments of the United States and Mexico through their respective Sections of the International Boundary and Water Commission, the National Water Commission of Mexico, and the United States Environmental Protection Agency. The governments of both countries thank the State of Texas, specifically the Texas Natural Resource Conservation Commission, for their efforts in the study.

Copies of this report in English may be obtained by writing to the International Boundary and Water Commission, 4171 North Mesa Street, Suite C-310, El Paso, Texas 79902-1422, or by calling (915)832-4150. Electronic copies of Volume I and Volume II of the report are available on the World Wide Web via http://www.epa.gov/earth1r6/6wq/ecopro.

Copies of this report in Spanish may be obtained from the Comisión Internacional de Límites y Aguas, Ave. Universidad No. 2180, Zona Chamizal, C.P. 32310, Cd. Juárez, Chihuahua, or from the following agencies of the Comisión Nacional del Agua: Gerencia Regional Norte, Subgerencia de Administración del Agua, Comisión Nacional del Agua, Boulevard Revolución No. 2343 Ote., C.P. 27000, Torreón, Coahuila, Telephone No. 18-9939, 18-9945; Gerencia de Saneamiento y Calidad del Agua, Ave. San Bernabé No. 549, Col. San Gerónimo Lídice, México, D.F., C.P. 10200, Telephone No. 595-2344, 683-1740, and on the Internet at the address: sglabmon@re.redint.com.

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1.0 INTRODUCTION

In February 1992, the United States and Mexico issued the first stage of the Integrated Environmental Plan for the United States-Mexican Border Area (1992-1994; the subsequent plan is now called United States-Mexico Border XXI Program). This plan set the stage for the two countries to work jointly in identifying and solving environmental problems along the international border. On November 13, 1992, the United States Section International Boundary and Water Commission (IBWC) and the Mexican Section International Boundary and Water Commission (MxIBWC) approved Minute No. 289, titled "Observation of the Quality of the Waters Along the United States-México Border." This agreement resulted in the multi-phase Rio Grande/Río Bravo Toxic Substance Studies. These studies have been a binational and multi-agency effort to characterize the extent of toxic contamination of the Rio Grande/Río Bravo and its tributaries along the international reach.

The Phase 1 study (1992-1993) was prompted by a widely held belief that the river was being contaminated by toxic substances originating from municipal, industrial and agricultural sources near the border. This concern has intensified in recent years with the increasing number of industrial facilities within the border region. Review of prior studies yielded limited information. While revealing some evidence of contamination from toxic substances, these studies did not provide sufficient data on environmental effects.

The overall objective of the multi-phase studies was to assess if the suspected contamination of the Rio Grande/Río Bravo by toxic substances was, in fact, present. This objective was accomplished by the analysis of a full spectrum of chemical analytes in order to detect their presence and evaluate their impact on human health, fish and other aquatic organisms living in the river.

Due to the variety of activities occurring along the international reach of the Rio Grande/Río Bravo and in the Rio Grande/Río Bravo Basin, it is difficult to pinpoint exact sources of a particular contaminant. The Toxic Substance Studies should be considered a starting point and not an answer to all of the water quality issues facing the Rio Grande/Río Bravo. Concerns identified in the multiple phases of this study help focus resources on those sites and those contaminants most likely to impair water quality.

Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study was done from May to December 1995. The Phase 2 report consists of two Volumes (Volume I and II). Volume I is a summary report which consolidates the findings reported by both countries. Volume II contains technical assessment reports based on samples collected jointly by representatives of Mexico and the United States. Volume II contains the complete Phase 2 data set.

1.1 STUDY AREA

The Rio Grande/Río Bravo originates in the headwaters of the San Juan Mountains of southern Colorado, flows southward through New Mexico and enters Texas about 32 km (20 miles) northwest of El Paso/Ciudad Juárez Downstream of this area, the Rio Grande/Río Bravo forms the international boundary between the United States and Mexico. The total river reach extends for approximately 3,059 km (1,901 miles), with the international reach being about 2,053 km (1,276 miles) in length. The watershed (hydrologic region) encompasses approximately 924,300 square kilometers (335,500 square miles). Of this total, approximately 231,317 square kilometers (88,968 square miles) in the United States and 227,149 square kilometers (87,365 square miles) in Mexico drain into the Rio Grande /Río Bravo. The remaining hydrologic region

FIGURE 1

Rio Grande/Río Bravo River Basin

LEGEND

- Rio Grande & Arroyo Colorado Watersheds
- River/stream reach
- Cities

This map was generated by the Water Planning and Assessment Division of the Texas Natural Resource Conservation Commission (TNRCC). No claims are made to the accuracy or completeness of the data, or to its suitability for a particular use. The scale and compilation of all information shown herein are approximate.

TEXAS NATURAL RESOURCE CONSERVATION COMMISSION
"Protecting Texas by Reducing and Preventing Pollution"

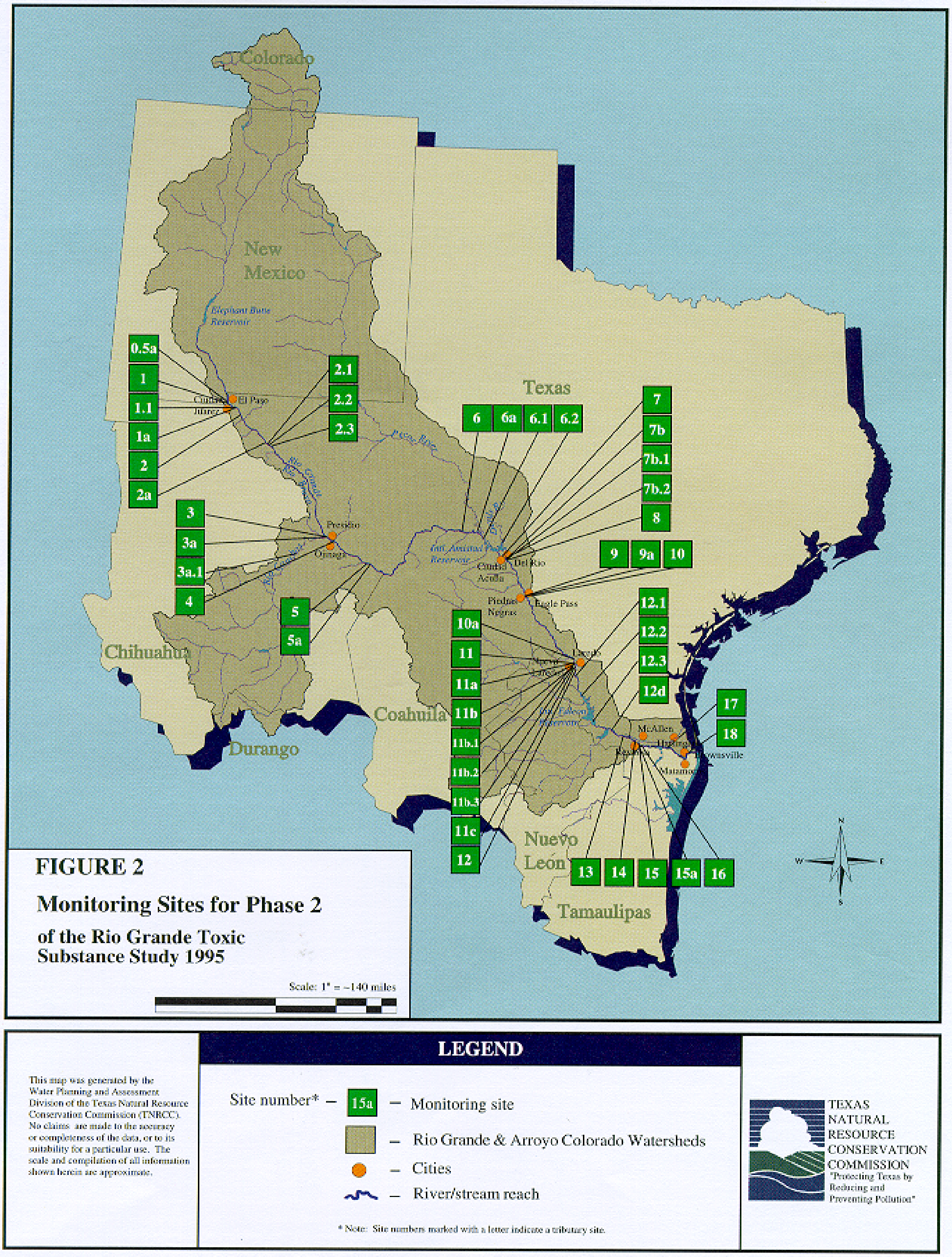

FIGURE 2

Monitoring Sites for Phase 2
of the Rio Grande Toxic Substance Study 1995

drains into closed (endorheic) watersheds.

The study was conducted within the international reach of the Rio Grande/Río Bravo, that portion extending from the New Mexico/Texas/Chihuahua border (El Paso/Ciudad Juárez area) to the Gulf of Mexico (Brownsville/Matamoros area), which forms the boundary between Mexico and the United States (Figure 1). Population along this river reach is concentrated in the following transborder metropolitan areas: El Paso/Ciudad Juárez, Presidio/Ojinaga, Del Rio/Ciudad Acuña, Eagle Pass/Piedras Negras, Laredo/Nuevo Laredo, McAllen/Edinburg/Mission/Reynosa and Brownsville/Matamoros. The economy of the area is based on wholesale and retail trade, oil and gas production, agriculture, manufacturing, tourism and international trade.

The Rio Grande/Río Bravo serves as an important natural resource for industry, agriculture, domestic water supply, recreation and aesthetic enjoyment, and as aquatic and wildlife habitat for both countries.

1.2 STUDY DESCRIPTION

The study was designed based on cooperative planning from agencies representing both the United States and Mexico. Agencies with principal involvement in the project planning included:

- United States-Texas Natural Resource Conservation Commission (TNRCC)
- United States Environmental Protection Agency (USEPA) - Region 6
- United States S ction, International Boundary and Water Commission (USIBWC)
- Mexico - Mexican Section, International Boundary and Water Commission (MxIBWC)
- Mexico - National Water Commission (CNA)

The binational field sampling team was comprised of representatives from the TNRCC, USEPA - Region 6, USIBWC, MxIBWC and CNA. Agencies involved in sampling, field and laboratory analyses, and data evaluation were responsible for meeting the quality assurance requirements as established by their respective country.

The Phase 2 study provides an assessment of both conventional and toxic pollutants. Conventional pollutant assessment was performed using a Water Quality Index (WQI) developed and used by Mexico. The WQI is a support tool for the evaluation of water quality which integrates the combined effects of all applicable conventional pollutants. Toxic pollutant assessment was performed similarly to Phase 1 with some modifications. The basic toxic substance assessment was performed using various screening levels and/or criteria for human health and aquatic life. In addition, water/sediment toxicity and biological community data were also used in the assessment. Consequently, the sites of concern were determined using data collected jointly by both countries but assessed independently using two assessment classifications. These two assessment classifications have been labeled:

- Potential for Conventional Pollutant Effects (i.e. Water Quality Index)
- Potential for Toxic Substance Effects (i.e. Toxic Pollutant Screening)

1.3 SAMPLING SITES

Phase 1 of the Rio Grande/Río Bravo Toxic Substance Study identified sites of greatest concern for toxic contamination. During the second phase of the intensive monitoring, samples were collected at 46 stations, consisting of 27 mainstem sites and 19 tributary sites from El Paso/Ciudad Juárez to Brownsville/Matamoros (Figure 2). Sites from Phase 1 which showed a low potential for impact were excluded from Phase 2. Sixteen new sites were added to Phase 2 to include areas not covered in Phase 1. Four of these new sites were located in International Falcon and Amistad Reservoirs. Additional work was performed in areas where toxic effects where found in Phase 1 to develop a better understanding of contamination and associated effects.

Sampling consisted of:

- toxic substances, conventional pollutants and toxicity testing in water at 37 sites and sediment at 33 sites
- toxic substances in fish tissue samples at 24 sites
- bioassessment of benthic macroinvertebrate communities at 16 sites
- bioassessment of fish communities at 24 sites

Of the 48 sites originally scheduled, 46 were sampled. One site was dry (Station 5a Terlingua Creek in Big Bend National Park), and a second site, at Station 5b Lozier Canyon was inaccessible during this phase of the study. Twenty-seven of the sites were on the mainstem and 19 were on tributaries (8 in Mexico and 11 in the United States)(Tables 1 to 5).

This study classified tributaries as any non-mainstem waterbody that flows or discharges to the Rio Grande/Río Bravo. This broad categorization includes wastewater treatment plant (WWTP) point source discharges and/or conveyance drains and streams.

The river was divided into five "reaches." For this study a reach is a defined length or unit that may be based on natural or artificial criteria. In this instance, the five river reaches were based on sister cities along the international reach of the Rio Grande/Río Bravo.

- El Paso/Ciudad Juárez
- Presidio/Ojinaga-Big Bend National Park/Cañón Santa Elena/Maderas del Carmen (protected areas in Mexico)
- International Amistad Reservoir-Eagle Pass/Piedras Negras
- Laredo/Nuevo Laredo-International Falcon Reservoir
- Below International Falcon Reservoir-Brownsville/Matamoros

1.4 TYPES OF ANALYSES

Toxic substance and conventional pollutant analyses consisted of all compounds recognized as priority pollutants in the United States Code of Federal Regulations, Title 40, Part 423, Appendix A, with the exception of dioxin and asbestos. Supplementary toxic substance parameters consisted of 11 pesticides with numerical criteria established by the State of Texas, 19 pesticides recommended for inclusion by the United States Environmental Protection Agency (USEPA) Region 6, three additional toxicants with potential to affect water quality (aluminum, styrene, xylene) and those conventional pollutants as found in Criterios Ecológicos de Calidad del Agua (CECA) (Ecological Water Quality Criteria), established by Mexico. All toxic substances and conventional pollutants analyzed in the study are listed in Table 6.

TABLE 1
Sampling Stations and Types of Samples Collected During
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study
EL PASO/CIUDAD JUAREZ REACH
December 2-3, 1995

Binational Station Descriptions	Station No.	Conventionals in Water	Toxic Chemicals in Water	Toxic Chemicals in Sediment	Toxic Chemicals in Fish Tissue	Toxicity Testing, Water & Sediment	Benthics (B) Fish (F)
Montoya Drain 0.4 km upstream of mouth at Frontera Road near Texas/New Mexico state line	(new) 0.5a	X	X	X		X	
Rio Grande/Río Bravo at Courchesne Bridge in El Paso/Ciudad Juárez, 2.7 km upstream of American Dam (river km 2,021)	1	X	X	X	X (metals)	X	B
Rio Grande/Río Bravo upstream of El Paso Haskell Street WWTP	(new) 1.1	X	X	X		X	
El Paso Haskell Street Wastewater Treatment Plant Discharge	1a	X	X			X(water)	
Rio Grande/Río Bravo at Zaragosa International Bridge in El Paso/Ciudad Juárez (river km 1,992.8)	2	X	X	X	X	X	B
Ciudad Juárez Wastewater Discharge Canal	2a	X	X	X		X	
Rio Grande/Río Bravo upstream of Fort Hancock International Bridge	(new) 2.1	X	salinity only				
Rio Grande/Río Bravo at Fort Hancock/Porvenir International Bridge	(new) 2.2	X	salinity only				
Rio Grande/Río Bravo downstream of Fort Hancock downstream of International Bridge	(new) 2.3	X	salinity only				

TABLE 2
Sampling Stations and Types of Samples Collected During
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study
PRESIDIO/OJINAGA-BIG BEND NATIONAL PARK REACH
December 4-5, 1995

Binational Station Descriptions	Station No.	Conventionals in Water	Toxic Chemicals in Water	Toxic Chemicals in Sediment	Toxic Chemicals in Fish Tissue	Toxicity Testing, Water & Sediment	Benthics (B) Fish (F)
Rio Grande/Río Bravo 5 km upstream of Río Conchos confluence near Presidio/ Ojinaga (river km 1,552.2)	3	X	X	X	X	X	B
Río Conchos 0.2 km upstream of mouth, 4.8 km northwest of Ojinaga	3a	X	X	X	X	X	B
Río Conchos 20-25 km upstream of mouth near Ojinaga	(new) 3a.1	X	X	X		X	B
Rio Grande/Río Bravo 14.4 km downstream of Río Conchos confluence near Presidio/ Ojinaga (river km 1,528.5)	4	X	X	X	X	X	B
Rio Grande/Río Bravo at mouth of Santa Elena Canyon (river km 1,424.7)	5	X	X	X	X	X	B
Terlingua Creek 0.2 km upstream of mouth, 13.7 km south of Terlingua-NOT SAMPLED	5a	X					
Rio Grande/Río Bravo at downstream of mouth of Lozier Canyon-NOT SAMPLED	5b	X					
Rio Grande/Río Bravo at IBWC weir on Foster Ranch near Langtry (river km 1,058.2)	6	X	salinity only				
Pecos River at Shumla Bend gaging station, 19.2 km east of Langtry, 62.4 km upstream of Rio Grande confluence	6a	X	salinity only				

TABLE 3
Sampling Stations and Types of Samples Collected During
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study
INTERNATIONAL AMISTAD RESERVOIR-
EAGLE PASS/PIEDRAS NEGRAS REACH
May 15-17, 1995

Binational Station Descriptions	Station No.	Conventionals in Water	Toxic Chemicals in Water	Toxic Chemicals in Sediment	Toxic Chemicals in Fish Tissue	Toxicity Testing, Water & Sediment	Benthics (B) Fish (F)
International Amistad Reservoir in Rio Grande Arm at Buoy #17	(new) 6.1	X	X	X	X	X	
International Amistad Reservoir in Devils River Arm	(new) 6.2	X	X	X	X	X	
Rio Grande/Río Bravo upstream of Del Rio/Ciudad Acuña International Bridge (river km 903.2)	7	X			X		F
San Felipe Creek 1.8 km upstream of mouth in Del Rio	7b	X	X	X	X	X	B
San Felipe Creek at US 277 in Del Rio	(new) 7b.1	X	X	X		X	B
San Felipe Creek 6.0 km upstream of mouth in Del Rio	(new) 7b.2	X	X	X		X	B
Rio Grande/Río Bravo downstream of Del Rio/ Ciudad Acuña International Bridge (river km 896.8)	8	X			X		B & F
Rio Grande/Río Bravo at Eagle Pass/Piedras Negras (river km 799.8)	9	X			X		B & F
Arroyo El Tornillo in Piedras Negras	9a	X	X	X		X	
Rio Grande/Río Bravo 14 km downstream of Eagle Pass/Piedras Negras (river km 785.8)	10	X	X	X	X	X	B

TABLE 4
Sampling Stations and Types of Samples Collected During
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study
LAREDO/NUEVO LAREDO-INTERNATIONAL FALCON RESERVOIR REACH
June 5-8, 1995

Binational Station Descriptions	Station No.	Conventionals in Water	Toxic Chemicals in Water	Toxic Chemicals in Sediment	Toxic Chemicals in Fish Tissue	Toxicity Testing, Water & Sediment	Benthics (B) Fish (F)
Manadas Creek 0.8 km upstream of mouth near Laredo	10a	X	X	X		X	
Rio Grande/Río Bravo near the Laredo Water Treatment Plant Intake, Laredo/Nuevo Laredo (river km 585.9)	11	X			X		B & F
Zacate Creek 0.1 km upstream of mouth near Laredo	11a	X	X	X		X	
Chacon Creek 0.1 km upstream of mouth in Laredo	11b	X	X	X		X	
Laredo Zacate Creek Wastewater Treatment Plant discharge	(new) 11b.1	X	X			X(water)	
Laredo Southside Wastewater Treatment Plant discharge	(new) 11b.2	X	X			X(water)	
Manhole 115 of Riverside III, Stage I collection system, in Nuevo Laredo	(new) 11b.3	X	X			X(water)	
Arroyo El Coyote 0.1 km upstream of mouth in Nuevo Laredo	11c	X	X	X		X	
Rio Grande/Río Bravo 13.2 km downstream of Laredo/Nuevo Laredo (river km 567.6)	12	X	X	X	X	X	B
Rio Grande/Río Bravo 25 km downstream of Laredo/Nuevo Laredo (river km 555.8)	(new) 12.1	X	X	X	X	X	B
International Falcon Reservoir, headwaters at Monument 14	(new) 12.2	X	X	X	X	X	B & F
International Falcon Reservoir, at Monumet 1, near the dam	(new) 12.3	X	X	X	X	X	B & F

TABLE 5
Sampling Stations and Types of Samples Collected During
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study
BELOW INTERNATIONAL FALCON RESERVOIR-BROWNSVILLE/MATAMOROS
July 10-13, 1995

Binational Station Descriptions	Station No.	Conventionals in Water	Toxic Chemicals in Water	Toxic Chemicals in Sediment	Toxic Chemicals in Fish Tissue	Toxicity Testing, Water & Sediment	Benthic (B) Fish (F)
Arroyo Los Olmos upstream of mouth near Rio Grande City	12d	X	X	X		X	
Rio Grande/Río Bravo near Los Ebanos (river km 328.8)	13	X	X	X	X	X	B & F
Rio Grande/Río Bravo 0.8 km downstream of Anzalduas Dam (river km 273.3)	14	X	X	X	X	X	B
Rio Grande/Río Bravo at the Hidalgo/Reynosa International Bridge (river km 256.7)	15	X	X	X	X (metals)	X	B & F
El Anhelo Drain 0.1 km upstream of mouth, 3.2 km east of Reynosa	15a	X	X	X		X	
Rio Grande/Río Bravo downstream of el Anhelo Drain south of Las Milpas (river km 244.1)	16	X	X	X	X	X	B
Rio Grande/Río Bravo 6.3 km downstream of San Benito (river km 155.8)	17	X	X	X	X (metals)	X	B & F
Rio Grande/Río Bravo 11.2 km downstream of Brownsville/ Matamoros (river km 78.3)	18	X	X	X	X	X	B

TABLE 6
Parameters Analyzed
Phase 2 of the Rio Grande/Río Bravo Toxic Substance Study

WATER
Water sample analyses for Phase 2 included the following parameters:

Inorganics
- Total Organic Carbon (TOC)
- Total Hardness
- Total Alkalinity
- Ammonia Nitrogen (NH_3-N)
- Nitrite Nitrogen (NO_2-N)
- Nitrate Nitrogen (NO_3-N)
- Total Phosphorus (T-P)
- Orthophosphorus (O-P)
- Chloride (Cl^-)
- Sulfate (SO_4)
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Cyanide (CN^-)
- Biochemical Oxygen Demand (5-Day)
- Oil and Grease
- Detergents (MBAS)
- Dissolved Metals

Organics
- Phenols and Cresols
- Pesticides
- Ethers
- Halogenated Aliphatics
- Nitrosamines and Other N Compounds
- Polycyclic Aromatic Hydrocarbons (PAH)
- Monocyclic Aromatics
- PCBs and Related Compounds
- Phthalate Esters

Biological
- Toxicity

SEDIMENT
Sediment sample analyses for Phase 2 included the following parameters:

Conventionals
- Total Organic Carbon
- Particle Size Composition
- Acid Volatile Sulfides

Inorganics
- Metals

Organics
- Phenols and Cresols
- Pesticides
- Ethers
- Halogenated Aliphatics
- Nitrosamines and Other N Compounds
- Polycyclic Aromatic Hydrocarbons (PAH)
- Monocyclic Aromatics
- PCBs and Related Compounds
- Phthalate Esters

Biological
- Toxicity

FISH TISSUE
Fish tissue sample analyses for Phase 2 included the following parameters:

Conventionals
- Percent Lipid Content

Inorganics
- Metals

Organics
- Phenols and Cresols
- Pesticides
- Ethers
- Halogenated Aliphatics
- Nitrosamines and Other N Compounds
- Polycyclic Aromatic Hydrocarbons (PAH)
- Monocyclic Aromatics
- PCBs and Related Compounds
- Phthalate Esters

2.0 STUDY METHODS

2.1 FIELD AND LABORATORY METHODS

All sampling, data collection and sample preservation procedures were performed in accordance with standardized TNRCC surface water quality monitoring field procedures. Laboratory analyses were performed in accordance with each country's applicable analytical methods and protocols. The United States samples were analyzed according to USEPA and American Public Health Association (APHA) guidelines. All water, sediment and tissue samples, for chemical analysis, were analyzed by the Texas Department of Health Environmental Chemistry Laboratory in Austin, Texas. Water and sediment toxicity samples were analyzed at the USEPA Laboratory located in Houston, Texas. Physicochemical samples collected by Mexico were analyzed at the State laboratories of the Comisiôn Nacional del Agua in Chihuahua and Nuevo Leon. Analyses for metals were conducted at the Regional Northern Laboratory and Central Laboratory of the Wastewater Management and Water Quality Office.

An attempt was made to collect all samples under the lowest flow conditions possible. Sampling under low flow conditions gives a better indication of impact from industrial /municipal discharges. Higher flows tend to have a dilution effect, reducing the ability to assess pollutant impacts.

2.2 DATA EVALUATION

The effects of any single chemical can vary in each type of sample (water, sediment or fish tissue). It is important to note that the criteria/screening levels used to evaluate the toxics data will differ depending on the problem being evaluated. For example, a chemical concentration necessary to protect human health from the consumption of contaminated fish is likely to be very different from the concentration to protect a drinking water source or that required to protect aquatic life.

In contrast, the procedure used to assess conventional pollutants, using the Water Quality Index (WQI), provides a defined unit for measuring water quality that varies when changes occur in water quality. This method, given its function of combining the parameter concentrations, reflects a net value of water quality that can be significantly interpreted. This is different from using water quality standards, such as the Ecological Water Quality Criteria (CECA), established by Mexico, where parameters are analyzed individually, and for which individual concentration limits have been established. Consequently, two assessment methods were used in the Phase 2 study to provide an overall site ranking for both toxic and conventional pollutants. While these assessment methods are complex, overviews of both assessment methods are provided.

2.2.1 Toxic Substances Overall Site Ranking

The Toxic Pollutant Site Ranking procedures are outlined in Table 7. These rankings were based on water, sediment, fish tissue, toxicity and biological community data. This method is a modified version of the system used in Phase 1. This site ranking system was developed as an assessment tool and has no regulatory significance.

2.2.2 Conventional Pollutants-Water Quality Index

The WQI is defined as the degree of contamination of water existing at the time of a sampling event, expressed as a percentage of pure water. Water which is highly contaminated will have an index near or equal to 0%, while water of excellent quality will have an index near or equal to 100%. The WQI is an average of the effect caused by varying levels of each parameter measured in a waterbody. The WQI is applicable to flowing waters (lotic) only. Therefore, WQI values were calculated for mainstem, tributary and wastewater point source stations. Reservoir stations were excluded since such waters are considered non-moving (lentic).

2.2.2.1 Factors of Contamination

The factors of contamination are grouped into four categories:

Amount of Organic Matter	dissolved oxygen (% saturation) and biochemical oxygen demand
Amount of Coliform Bacteria	coliform and *Escherichia coli* (bacterial samples were not collected during any of the multi-phase studies)
Amount of Ionic Matter	alkalinity, hardness, chlorides, conductivity, pH, oil and grease, suspended solids, dissolved solids, nutrients and detergents
Physical Characteristics	color and turbidity

2.2.2.2 Water Uses

Measurement of water quality degradation is very complex due to the numerous criteria needed for this WQI. The different water uses and the relative importance of each use was established for the WQI. The WQI represents water quality at a point in time and expresses the level of contamination. The different water quality uses considered in the WQI and the classification scale are presented in Table 8.

2.2.2.3 Method of Calculation of WQI

The first phase for establishing the Water Quality Index methodology consists of creating a qualifying scale based on the different water uses. The second phase involved the development of a qualifying scale for each parameter, in such a manner that a correlation would be established between the different parameters and their influence on the degree of contamination. After these scales were developed, a mathematical model was prepared for each parameter which would convert the physical data to an index "I_x." These individual "I_x's" are averaged to produce a composite "I" for the water sample. Since some of the parameters have a greater influence on water quality than others, each parameter was assigned a "weight" according to its order of importance. The weight assigned is "W," characterized by a subscript which designates the parameter involved. In this manner, the following formula was developed to calculate the WQI:

$$I = \frac{\sum_{i=1}^{n} I_i W_i}{\sum_{i=1}^{n} W_i}$$

where:

- **I** = Water Quality Index
- **I_i** = Quality Index for the parameter i
- **W_i** = Weight assigned according to the importance of the parameter i
- **n** = Number of parameters

The purpose of the qualifying scale is to provide a standardized criterion which allows the transformation of the individual measurements into a single unit of comparison.

TABLE 7
OVERALL SITE RANKING FOR TOXIC SUBSTANCES
PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

The following method was used to rank sites according to level of concern. The rankings were based on water, sediment, fish tissue, toxicity, and biological community data.

INITIAL SITE SCORES for level of concern were calculated using five categories; water, sediment, fish tissue and toxicity (water and sediment). Each category consists of three individual components.

CATEGORIES		COMPONENTS		SCORES
1	**WATER CHEMISTRY**	1	# of Toxic Substances Detected	1+2+3 = **WATER SCORE**
		2	# of Toxic Substances > Criteria/Screening Levels	
		3	Mean Factor for Values > Criteria/Screening Levels	
2	**SEDIMENT CHEMISTRY**	4	# of Toxic Substances Detected	4+5+6 = **SEDIMENT SCORE**
		5	# of Toxic Substances > Screening Levels	
		6	Mean Factor for Values > Screening Levels	
3	**FISH TISSUE CHEMISTRY**	7	# of Toxic Substances Detected	7+8+9= **FISH TISSUE SCORE**
		8	# of Toxic Substances > Screening Levels	
		9	Mean Factor for Values > Screening Levels	
4	**TOXICITY IN WATER**	10	Water Flea Mortality, Percent > Control	10+11+12= **TOXICITY IN WATER SCORE**
		11	Water Flea Reproduction, Percent < Control	
		12	Fathead Minnow Mortality, Percent > Control	
5	**TOXICITY IN SEDIMENT**	13	Water Flea Mortality, Percent > Control	13+14+15= **TOXICITY IN SEDIMENT SCORE**
		14	Water Flea Reproduction, Percent < Control	
		15	Fathead Minnow Mortality, Percent > Control	

INITIAL SITE SCORE **=THE SUM OF THE FIRST FIVE CATEGORY SCORES or**
WATER + SEDIMENT + FISH TISSUE + TOXICITY IN WATER + TOXICITY IN SEDIMENT

An ***Exceedance Factor*** is defined as the number of times a specific concentration exceeded a criterion or screening level. ***Mean Factor*** is the average of all exceedance factors for a given site. Information on exceedance factors for toxic substances found at each station is located in Appendix J of Volume II.

"Criteria" refers to specific numerical based concentrations for the protection of human health and aquatic life.

"Screening Levels" are based on historical data sets. Statistics are used to determine the 85th percentile for a given compound. An 85th percentile is a screening value for a given compound that is higher than 85% of the values for a similar area.

TABLE 7 (cont)
OVERALL SITE RANKING FOR TOXIC SUBSTANCES
PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

CATEGORIES		COMPONENTS		SCORES
HUMAN HEALTH AND AQUATIC LIFE COMPONENTS In order to add weight to the exceedance of human health and/or aquatic life criteria, additional factors were added to the initial overall site score.				
6	**Aquatic Life**	**16**	2.5 Points for each value > aquatic life water criterion	**SUM OF ALL POINTS FOR A SITE**
7	**Human Health**	**17**	5.0 Points for each value > human health water criterion	
		18	10 Points for each value > human health edible tissue criterion	
BIOLOGICAL COMMUNITY COMPONENTS At sites where biological community data was also collected another factor was added to the total site score. The level of concern for biological communities was calculated separately from the overall ranking with a different set of criteria.				
8	**Benthic Community**	**19**	0.0 Points for No Concern	**INDIVIDUAL SCORE FOR A SITE** (based on Biological Community Ranking)
			2.5 Points for Potential Concern	
			5.0 Points for Concern	
9	**Fish Community**	**20**	0.0 Points for No Concern	**INDIVIDUAL SCORE FOR A SITE** (based on Biological Community Ranking)
			2.5 Points for Potential Concern	
			5.0 Points for Concern	
TOTAL SITE SCORE **= SUM OF SCORES FOR ALL CATEGORIES USED FOR A SITE**				
RANK SCORE **= TOTAL SITE SCORE DIVIDED BY NUMBER OF COMPONENTS USED TO DERIVE THE TOTAL SITE SCORE**				
RANK SCORES The final step was to divide the total site score by the number of individual components used in the calculation. Due to some variation between stations in the types of samples collected, dividing by the number of individual components used to calculate the total site score was necessary to balance the sites. The resulting number is called the "Rank Score". This score is used to determine a level of concern for the sites based on data collected during this study. The rank scores for mainstem and tributary sites were calculated separately due to variations in the types of samples collected.				
CATEGORIES OF CONCERN Based on these rank scores sites were placed in categories of concern, HIGH, MODERATE, LOW and SLIGHT. It should be noted that this site ranking system was developed as an assessment tool and does not have any regulatory significance.				
Additional information on site ranking and numbers used in calculations is located in Appendix K of Volume II.				

TABLE 8
MEXICO'S WATER QUALITY INDEX CLASSIFICATION SCALE
(Numbers in bold represent ranges for classification of WQI scores)

WATER QUALITY USES					
Public Water	Direct Contact Recreation	Fishing and Aquatic Life	Industry and Agriculture	Navigation	Transportation of Treated Wastes
No Purification Required **90-100**	Acceptable for Any Aquatic Recreation **70-100**	Acceptable for All Organisms **70-100**	No Purification Required **90-100**	Acceptable **30-100**	Acceptable **10-100**
Light Purification **80-90**	Acceptable Not Recommended **50-70**	Acceptable for Very Sensitive Species **60-70**	Light Purification for Some Processes **70-90**	Contaminated **20-30**	Unacceptable **0-10**
Needs Greater Level of Treatment **50-80**	Doubtful for Contact Recreation **40-50**	Doubtful for Sensitive Species **50-60**	Without Treatment for Industry **50-70**	Unacceptable **0-20**	
Doubtful **40-50**	No Contact with Water **30-40**	Only Very Tolerant Organisms **30-50**	With Treatment for Greater Number of Industries **30-50**		
Unacceptable **0-40**	Obvious Indication of Contamination **20-30**	Unacceptable **0-30**	Very Restricted Use **20-30**		
	Unacceptable **0-20**		Unacceptable **0-20**		

3.1 BACKGROUND

The Rio Grande/Río Bravo, the fifth longest river in North America and among the top 20 in the world, was once a formidable river. The river extends 3,059 km (1,901 miles) from the San Juan Mountains in Colorado to the Gulf of Mexico. From El Paso/Ciudad Juárez to the Gulf of Mexico, approximately two-thirds of the total length of the river forms the 2,053 km (1,276 mile) international boundary between United States and Mexico.

The Rio Grande/Río Bravo has been significantly modified in order to support the lives of millions of inhabitants along the river. Diversion for agricultural and domestic/ industrial water supplies, and receipt of treated and untreated domestic/industrial wastewaters and agricultural runoff, have reduced the quantity and quality of the Río Grande/Río Bravo. Diversion structures and dams impounding water on the Rio Grande/Río Bravo have changed the regime of flow in the mainstem. As a result, the Rio Grande/Río Bravo is a very complex hydrologic system.

The entire Rio Grande/Río Bravo Basin drains a 335,500 square mile area in the United States (Colorado, New Mexico and Texas), and Mexico (Chihuahua, Coahuila, Durango, Nuevo Leon and Tamaulipas). Not all of the basin drains to the Rio Grande/Río Bravo. Half of the total area lies within closed basins (153,285 square miles) where water either evaporates or soaks into the ground, never making it to the Rio Grande/Río Bravo. The actual drainage area of the Rio Grande/Río Bravo is 182,215 square miles. Approximately half is in the United States (88,968 square miles) and the remaining half in Mexico (93,250 square miles).

3.2 FLOW

3.2.1 El Paso/Ciudad Juárez to International Amistad Reservoir

Flow in the Rio Grande/Río Bravo, originating in the mountains of Colorado and New Mexico, is stored in Elephant Butte Reservoir. This reservoir was designed to retain all flow on the Rio Grande/Río Bravo. Flow to El Paso /Ciudad Juárez is controlled by irrigation releases from Elephant Butte Dam. Most of this flow is diverted for irrigation in New Mexico's Mesilla Valley. The remainder is diverted at the American Dam (United States) and International Dam (Mexico) in El Paso/Ciudad Juárez for municipal use, and in the El Paso and Juárez Valleys for irrigation. This causes the Rio Grande/Río Bravo flow to be intermittent from downstream of El Paso/Ciudad Juárez to Presidio/Ojinaga. This section of the river receives occasional stormwater runoff, treated municipal wastewater from El Paso, untreated wastewater from Ciudad Juárez, irrigation return flows, and occasional unscheduled releases from Elephant Butte Dam due to high runoff.

The majority of surface water flow into the international reach of the Rio Grande/Río Bravo originates in Mexico. A main source of flow comes from the Río Conchos near Presidio/Ojinaga 454 km (284 miles) downstream of El Paso, which replenishes the Rio Grande/Río Bravo by providing three quarters of the flow to the Big Bend area (Table 9). In the past few years, flow in the Río Conchos has been reduced by a severe drought in the state of Chihuahua, located in northern Mexico.

Flow continues to International Amistad

TABLE 9
RIO GRANDE/RIO BRAVO TRIBUTARIES AND DIVERSIONS

Mexico side		Reach		U.S. side
		El Paso/Ciudad Juárez		
Acequia Madre	←	↓	→	American Canal
Río Conchos	→	↓	←	Alamito Creek
Carima Springs and Other Springs	→	↓	←	Terlingua Creek
		↓	←	Pecos River
		↓	←	Devils River
		International Amistad Reservoir		
Creeks near Ciudad Acuña	→	↓	←	San Felipe Creek, Creeks near Del Rio
Río San Diego	→	↓	→	Maverick Canal
Río San Rodrigo	→	↓	←	Maverick Canal Return Flow
Río Escondido	→	↓		
Río Salado	→	↓		
		International Falcon Reservoir		
Río Alamo	→	↓	→	Numerous diversions Falcon Dam to Brownsville
Río San Juan	→	↓		
Anzalduas Canal	←	↓		
Irrigation Return Flows	→	↓		
		Brownsville/Matamoros		
		↓		
		Gulf of Mexico		

Reservoir, 500 km (312 miles) downstream of El Paso/Ciudad Juárez. Two major United States tributaries, the Pecos and Devils Rivers, flow into International Amistad Reservoir. Most of the smaller tributaries are intermittent, having defined channels but ceasing to flow during dry periods.

3.2.2 International Amistad Reservoir to International Falcon Reservoir

Seventy-two percent of the flow in the next 481 km (281 miles) of river between International Amistad and Falcon Reservoirs originates in Mexico. Major Mexican tributaries in this section are the Río San Diego and Río San Rodrigo which enter the Rio Grande/Río Bravo between Amistad and Laredo/Nuevo Laredo. San Felipe Creek, a spring fed stream, is located on the United States side in Del Rio, and is that city's source of drinking water. The Río Salado is a major tributary of International Falcon Reservoir (Table 9).

Major diversions in the middle basin are the sister cities of Del Rio/Ciudad Acuña, Eagle Pass/Piedras Negras and Laredo/Nuevo Laredo. Treated and untreated domestic wastewater is discharged from both sides of the Rio Grande/Río Bravo at Laredo/Nuevo Laredo. The largest portion of irrigated lands (approximately 80%) along the Texas/Mexico border lies between International Amistad and Falcon Reservoirs.

3.2.3 International Falcon Reservoir to Brownsville/Matamoros

The remaining 442 km (275 miles) of the Rio Grande/Río Bravo extend from International Falcon Dam to the Gulf of Mexico. Releases from International Falcon Reservoir are the main source of water for domestic and industrial uses and irrigation in the Lower Rio Grande Valley. Flow into this section of the river is from the Mexican tributaries, Río Alamo and Río San Juan, and irrigation return flows (Table 9).

The major use of Rio Grande/Río Bravo water in the Lower Rio Grande Valley is for agriculture. Overall, 88% of the United States and 96% of Mexican border territory is irrigated by the Rio Grande/Río Bravo.

3.3 CLIMATE

The upper portion of the Rio Grande/Río Bravo flows through the northern Chihuahuan Desert and has an arid/semi-arid climate. As the river flows south, it becomes less arid and more tropical as it reaches the Gulf of Mexico. The Rio Grande/Río Bravo region tends to be hot, warm and windy, and averages more 38°C+ (100° F) days from May to September than any part of Texas. Temperatures tend to be warmer in the lower portion of the basin than in the north. Rainfall averages 19.8 cm (7.8 inches) at El Paso/Ciudad Juárez, 30.5 cm (12 inches) at Amistad, 51 cm (20.1 inches) at Laredo/Nuevo Laredo, and 64.5 cm (25.4 inches) at Brownsville/Matamoros.

3.4 BORDER POPULATION

According to data from the 1990 census, there are approximately 9.5 million residents living along the United States/Mexico border. This figure represents a growth of over 60% in the past 10 years. Of the total, approximately 82% (7.9 million) live in 12 sister cities (United States/Mexican paired order cities). The remaining 28% of United States and Mexican border residents live in rural areas. Of the 12 sister cities, seven are located along the Texas/Mexico border. The population of these seven sister cities represents 43.5% of the total United States/Mexico metropolitan border population (Table 10).

3.5 Potential Sources of Toxic Substances in the Rio Grande/Río Bravo and Tributaries

Due to the variety of activities occurring in the Rio Grande/Río Bravo Basin, it is difficult to pinpoint exact sources of a particular contaminant. This study should be considered a starting point, and not the answer to all of the water quality issues facing the Rio Grande/Río Bravo. Concerns identified in the multiple phases of this study help focus resources on those sites, and those contaminants most likely to impair water quality. A discussion of contaminant sources in relation to sample stations is located in Table 11. Potential sources of individual toxic substances and potential adverse effects are outlined in Table 12.

TABLE 10
POPULATION OF MAJOR SISTER CITIES ALONG THE UNITED STATES/MEXICO BORDER

SISTER CITIES	POPULATION	% OF TOTAL
San Diego/Tijuana	3,240,702	41.2
Imperial County/Mexicali	711,693	9.0
Yuma/San Luis Colorado	218,403	2.8
Nogales/Nogales	136,795	1.7
Douglas/Agua Prieta	136,669	1.7
El Paso/Ciudad Juárez	1,389,289	17.7
Presidio/Ojinaga	30,584	0.39
Del Rio/Ciudad Acuña	195,471	2.5
Eagle Pass/Piedras Negras	134,555	1.7
Laredo/Nuevo Laredo	352,707	4.5
Mc Allen/Reynosa	760,221	9.7
Brownsville/Matamoros	563,512	7.2
TOTAL	**7,870,601**	**100**
Total-Texas/Mexico Border area	**3,426,339**	**44**
Total-California, Arizona, New Mexico/Mexico Border area	4,444,262	56

TABLE 11
POTENTIAL SOURCES OF CONTAMINANTS BY STATION FROM PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

STATION	POTENTIAL SOURCES OF CONTAMINATION AT STUDY SITES
Station 0.5a - Montoya Drain, near Texas/New Mexico state line	Originates in New Mexico. A horse race track facility is located upstream of the site, and El Paso Electric is located downstream. The area is influenced by urban and agricultural runoff.
Station 1 - Rio Grande/Río Bravo at Courchesne Bridge in El Paso	No potential sources were located immediately adjacent to this site but it was surrounded by disturbed urban setting. This site is influenced by flows coming from Elephant Butte Dam in New Mexico. The use of water for irrigation upstream contributes large volumes of irrigation return flow and agricultural runoff. The Rio Grande/Río Bravo also receives urban runoff and wastewater discharges from the Cities of Anthony, Canutillo and El Paso.
Station 1.1 -Rio Grande/Río Bravo Upstream of El Paso Haskell Street WWTP	Vehicle traffic is heavy in the surrounding area. The El Paso/Ciudad Juárez border crossings are the most heavily used on the Texas/Mexico border. In 1994, 15,747,393 passenger vehicles and 580,200 trucks crossed the border at El Paso/Ciudad Juárez, second only to San Ysidro/Otay Mesa, California. The area is also affected by urban runoff.
Station 2 -Rio Grande/Río Bravo at Zaragosa International Bridge in El Paso/Ciudad Juárez	This area is influenced by urban runoff, wastewater discharges from the El Paso Haskell Street WWTP and runoff from industrial facilities on both sides of the border.
Station 2a - Ciudad Juárez Wastewater Canal	Receives large amounts of wastewater from domestic and industrial sources. Although future plans include wastewater treatment plants for the Mexican border cities, the Ciudad Juárez Wastewater Canal carried untreated wastewater during this phase of the study.
Station 3- Rio Grande/Río Bravo Upstream of Presidio/Ojinaga	This area is mostly influenced by agricultural activities, predominantly rangeland with some irrigated croplands. Mining and industry occur in the area.
Station 3a- Río Conchos Near Mouth.	Located near Presidio/Ojinaga. Surrounding area is predominantly rangeland with some irrigated cropland. Might also be affected by runoff from Ojinaga.
Station 3a.1-Río Conchos 25 km Upstream of Mouth near Ojinaga.	Area is outside of Ojinaga. Surrounding area is predominantly rangeland with some irrigated cropland.
Station 4-Rio Grande/Río Bravo Upstream of Presidio/Ojinaga	The area is also predominantly rangeland but is also influenced by urban runoff and wastewater discharges. Some mining in the area.
Station 5- Rio Grande/Río Bravo at Santa Elena Canyon in Big Bend National Park	Area is predominantly used for recreation with some rangeland activities upstream. Some mining may occur outside of Big Bend National Park. One of the least impacted areas in the study.
Note: The stations from El Paso/Ciudad Juárez to Big Bend National Park were sampled under low flow conditions; however, high flows dominated this reach for months before flows returned to normal. High flows were due to large releases from Elephant Butte Reservoir. This may have had an impact on what was found in water and sediment samples.	
Station 6.1-International Amistad Reservoir in the Rio Grande Arm	Influenced by inflow from Rio Grande/Río Bravo. Area is mostly used as rangeland and for recreation. Air deposition from industry may have a long-term impact on the reservoir.

TABLE 11 (cont)
POTENTIAL SOURCES OF CONTAMINANTS BY STATION FROM PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

STATION	POTENTIAL SOURCES OF CONTAMINATION AT STUDY SITES
Station 6.2-International Amistad Reservoir in the Devils River Arm	Influenced by inflow from Devils River. Area is mostly used as rangeland and for recreation. Air deposition from industry may have a long-term impact on the reservoir.
Station 7-Rio Grande/Río Bravo Upstream Del Rio/Ciudad Acuña	Heavily influenced by releases from International Amistad Reservoir. Upstream of wastewater discharges.
Station 7b-San Felipe Creek Lower	Located in a more rural part of Del Rio. Surrounding land use is rangeland.
Station 7b.1-San Felipe Creek Mid	Located in an urban residential section of Del Rio. Main impact urban/stormwater runoff.
Station 7b.2-San Felipe Upper	Located next to major highway in Del Rio. Influenced by urban/stormwater runoff. No wastewater discharged to this creek. Wastewater was discharged to the creek prior to 1990's.
Station 8-Rio Grande/Río Bravo Upstream of Del Rio/Ciudad Acuña	Located downstream of the wastewater discharges and urban runoff from Del Rio/Ciudad Acuña. Acuña has 50 maquiladoras located upstream of the site, primarily textiles, electronics, leather and plastics.
Station 9-Rio Grande/Río Bravo at US 57 in Eagle Pass/Piedras Negras	Located upstream of Eagle Pass/Piedras Negras wastewater discharges. Surrounding land is primarily used for rangeland and some irrigated crops.
Station 9a-Arroyo El Tornillo in Piedras Negras	Used to carry untreated wastewater from Piedras Negras wastewater lagoons.
Sttion 10-Rio Grande/Río Bravo Downstream of Eagle Pass/Piedras Negras	Located downstream of Eagle Pass/Piedras Negras wastewater discharges. Piedras Negras has 43 maquiladoras, primarily transportation equipment and food processing.
Station 10a - Manadas Creek in Laredo	Carries stormwater and urban runoff from a heavily industrialized area of Laredo.
Station 11-Rio Grande/Río Bravo Upstream of Laredo/Nuevo Laredo	Located upstream of Laredo/Nuevo Laredo and above wastewater discharges.
Station 11a- Zacate Creek in Laredo	Located in Laredo. Influenced by WWTP discharges and urban/stormwater runoff.
Station 11b -Chacon Creek in Laredo	Located in Laredo. Influenced by urban/stormwater runoff.
Station 11b.1-Laredo Zacate Creek WWTP	WWTP located in Laredo. Discharges to Zacate Creek upstream of Station 11a.
Station 11b.2-Laredo Southside WWTP	WWTP located downstream of Laredo. Discharges upstream of Station 12.
Station 11b.3-Manhole 115 of the Nuevo Laredo Wastewater Collection System	Untreated wastewater discharge point for Nuevo Laredo. Located upstream of Stations 12 and 12.1.

TABLE 11 (cont)
POTENTIAL SOURCES OF CONTAMINANTS BY STATION FROM PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

STATION	POTENTIAL SOURCES OF CONTAMINATION AT STUDY SITES
Station 11c- Arroyo El Coyote in Nuevo Laredo	Untreated wastewater discharge point for Nuevo Laredo. Located upstream of Stations 12 and 12.1.
UStation 12 -Rio Grande/Río Bravo 13.2 km downstream of Laredo/ Nuevo Laredo	Located downstream of Laredo/Nuevo Laredo. Laredo discharges 29 MGD (treated wastewater), and Nuevo Laredo 25-30 MGD (untreated wastewater-at the time of the study) upstream of this site.
Station 12.1 -Rio Grande/Río Bravo 25 km downstream of Laredo/Nuevo Laredo	Located further downstream of Station 12. Same impacts.
Station 12.2-International Falcon Reservoir Headwaters	Influenced by inflow from Laredo/Nuevo Laredo. Area primarily used as rangeland and for recreation.
Station 12.3-International Falcon Reservoir near Dam	Influenced by inflow from Texas/Mexico. Area primarily used as rangeland and for recreation.
Station 12d-Arroyo Los Olmos near Rio Grande City	Located near Rio Grande City. Influenced by urban/stormwater runoff. Area rural, residential development, and rangeland.
Station 13-Rio Grande/Río Bravo at SH 886 near Los Ebanos	Influenced by releases from Falcon Reservoir. Surrounding area primarily agricultural.
Station 14-Rio Grande/Río Bravo Downstream of Anzalduas Dam	Located upstream of McAllen/Reynosa and upstream of wastewater discharges from these cities. Surrounding area primarily agricultural.
Station 15-Rio Grande US 281 at Hidalgo/Reynosa	Located at border crossing. Influenced by urban/stormwater runoff.
Station 15a -El Anhelo Drain in Reynosa	Carries partially treated and untreated wastewater from Reynosa.
Station 16-Rio Grande/Río Bravo Downstream of El Anhelo Drain	Located downstream of El Anhelo Drain discharge. Reynosa has 78 maquiladoras. Also influenced by urban/stormwater runoff and agricultural runoff.
Station 17-Rio Grande/Río Bravo Downstream of San Benito	Land is primarily irrigated cropland. Influenced by irrigation return flows and urban/stormwater runoff from Harlingen/San Benito area.
Station 18-Rio Grande/Río Bravo Downstream of Brownsville/ Matamoros	Located downstream of Brownsville/Matamoros. Influenced by urban/stormwater runoff. Matamoros has 111 maquiladoras but most of the wastewater flows toward the Gulf of Mexico. May also be influenced by irrigation return flows.

TABLE 12
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 12/95

Parameter	Sources/Uses	Environment/Health Effects
Aluminum	*Sources* Occurs naturally, one of most abundant metals. Found in combination with other rocks and minerals; mined from bauxite. *Uses*: Cooking utensils, containers, appliances, airplanes and building materials; in paints, fireworks, and production of glass, rubber, and ceramics; in combination with other chemicals, used in antacids (aluminum hydroxide), deodorants (aluminum chlorohydrate), and to treat drinking water (aluminum sulfate), baking powder, fireproofing, tanning, dyes, catalysts, and medicines.	May be present in the aquatic environment due to erosion, mining, and industrial/municipal wastewater treatment plant (WWTP) effluent; common in point and nonpoint source discharges; solubility in lakes, streams, and rivers depends on pH; moderate acute effect on aquatic life and high acute toxicity to birds; high chronic toxicity to aquatic life; very persistent in water; does not bioaccumulate in fish tissue.
Antimony	*Sources*: Element occurs naturally as a component of certain minerals; little mined in the United States; brought in from other countries for processing; some companies in the United States produce antimony as a by-product of smelting lead and other metals. *Uses*: Used as a flame retarding agent; used t form metal alloys with lead, bismuth, tin, copper, nickel iron, and cobalt; used in the manufacture of bearings, ammunition, sheet and pipe metal, castings, pewter and batteries; manufacture of fireworks and matches; used in paints, ceramics, plastics, metal and glass.	Enters the aquatic environment from weathering of rocks, runoff from soils and effluents from mining and manufacturing operations, municipal and industrial WWTP effluent; high acute and chronic toxicity in aquatic life.
Arsenic	*Sources*: Naturally occurring element; common in areas with volcanic activity; *Uses*: Mainly used to preserve wood; used in insecticides and weed killers; veterinary uses; used to make glass, cloth, and electrical semiconductors.	Carcinogen; dissolves in water; changes from one form to another; persistent in water; can bioaccumulate in fish and shellfish tissue; enters environment mainly from use as a pesticide, industrial/municipal WWTP effluent, and emissions from coal fired power plants; erosion; certain forms have a high acute and chronic toxicity in aquatic life
Beryllium	*Sources*: Found in mineral rocks, coal, and soil; beryllium compounds are commercially mined *Uses*: Purified form used in electrical parts, machine parts, ceramics, aircraft parts, nuclear weapons, and mirrors.	Carcinogen; enters water from weathering of rocks, runoff from soils and industry; mainly settles to the bottom in water; does not bioaccumulate in fish tissue.

TABLE 2 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 2/95

Parameter	Sources/Uses	Environment/Health Effects
Cadmium	*Sources:* Natural element in the earth's crust; usually found as a mineral combined with other elements; all soils and rocks, including coal and mineral fertilizers contain some cadmium *Uses*: Cadmium does not corrode easily and has many uses in industry and consumer products; batteries, pigments, photoelectric cells, process engraving, electroplating, metal alloys, metal coatings, and plastics.	Carcinogen; enters the air from mining, industry and the burning of coal and household waste; enters water from metal plating industry effluent and municipal WWTP effluent; doesn't break down in the environment, very persistent in water; bioaccumulates in tissue; high acute and chronic toxicity to aquatic life.
Chromium	*Sources*: Naturally occurring element in rocks, plants, animals, volcanic dust, and gases; manufacturing, disposal of products or chemicals containing chromium or burning of fossil fuels release chromium to the air, soil, and water *Uses*: Making steel and other alloys, bricks in furnaces, dyes and pigments, chrome plating, leather tanning, and wood preserving.	Carcinogen and Mutagen; a small amount dissolves in water; rest settles to the bottom; chromium does not accumulate in fish tissue; very persistent in water; more toxic in soft water than hard; chromium (III) has a moderate acute toxicity and high chronic toxicity to aquatic life and chromium (VI) has high acute and chronic toxicity to aquatic life.
Copper	*Sources:* Extremely common in rocks and soil; corrosion of brass and copper pipes and tubes, industrial/municipal WWTP discharges, the use of copper compounds as aquatic algicides *Uses*: Smelting and refining industries, copper wire mills, coal burning industries, and iron and steel production.	One of the most common contaminants of urban runoff; enters natural waters by runoff, industrial/municipal WWTP effluent or by atmospheric fallout from industry; rainfall may be a significant source of copper to the aquatic environment in industrial and mining areas; industrial and municipal discharges.
Lead	*Sources:* Lead is a major constituent of > 200 identified minerals. Only three are found in sufficient abundance to form mineral deposits *Uses*: Lead pipe, lead lined containers for corrosive gases and liquids, paint, pigments, alloys used in metallurgy, storage batteries, ceramics, electronic devices, and plastics.	Teratogen; reaches the aquatic environment through rainfall, fallout of lead dust, urban runoff and both industrial and municipal WWTP discharges.
Mercury	*Sources*: Occurs naturally, runoff from urban and industrial sources, municipal and industrial discharges *Uses*: Major use is as a cathode in the preparation of chlorine and caustic soda, electrical components, industrial control instruments (switches, thermometers, and barometers), pulp and paper manufacture, mining, pharmaceuticals, and general laboratory uses.	Several forms, ranging from elemental to dissolved organic and inorganic, occur in the environment; Certain microorganisms have the ability to convert the organic and inorganic forms to highly toxic methyl and dimethyl mercury has made all forms of mercury highly hazardous to the environment.

TABLE 2 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 2/95

Parameter	Sources/Uses	Environment/Health Effects
Nickel	*Sources:* Weathering of rocks, rainfall and runoff; 24th most abundant mineral and can be found in all soils; *Uses*: Nickel is combined with other metals to form alloys; the most common alloy is nickel-iron used to make stainless steel; other alloys are used to make coins, jewelry, plumbing, and heating equipment, gas-turbine engines and electrodes; nickel compounds are also used in plating, to color ceramics, and to make some batteries.	Carcinogen; one of the most common metals in surface water; burning of coal and other fossil fuels; discharges from industry (electroplating and smelting); does not bioaccumulate in fish tissue; nickel common in air and is washed out by rain or snow; most ends up attached to soil or sediment particles; high acute and chronic toxicity in aquatic life.
Selenium	*Sources*: Major source is the weathering of rocks and soil, abundant in the drier soils for North America from the Great Plains to the Pacific Ocean; human activities contribute approx. 3,500 metric tons/year; mining or smelting of certain ores; present in coal, and fuel oil *Uses*: Photocopying, the manufacture of glass, electronic devices, pigments, dyes, and insecticides.	Runoff; natural weathering of soils and rocks; industrial/municipal WWTP effluent; trace amounts essential for plants and animals; high acute and chronic toxicity in aquatic life.
Silver	*Sources*: Occurs in pure form or in ores; *Uses*: Photographic material, electroplating, as a conductor, in dental alloys, solder and brazing alloys, paints, jewelry, silverware, coinage, and mirror production.	Usually found in low concentrations in the aquatic environment; sorption and precipitation processes reduce dissolved silver concentrations in water which result in higher concentrations in sediments; high chronic toxicity to aquatic life; toxicity depends on the hardness of the water.
Thallium	*Sources:* Found in trace amounts in the earth's crust; once obtained as a by-product from smelting of other metals but has not been produced in the United States since 1984; all thallium is currently obtained from imports and thallium reserves *Uses*: Manufacturing electronic devices mainly for the semiconductor industry; limited use in the manufacture of special glas and some medical procedures.	Enters the environment mainly from coal burning and smelting; usually a trace contaminant; persists in air, water and soil for long periods of time; absorbed by plants and enters the food chain; builds up in fish and shellfish; high acute and chronic toxicity to aquatic life.
Zinc	*Sources:* One of the earth's most common elements; found in air, soil, and water and is present in all foods *Uses*: Many commercial uses; as coating to prevent rust, in dry cell batteries, mixed with other metals to make alloys like brass and bronze; zinc compounds are widely used to make paint, rubber, dye, wood preservatives, and ointments.	Enters the environment by natural processes in addition to activities like mining, steel production, coal burning and waste burning; builds up in fish and other organisms; readily transported in most natural waters-groundwater, lakes, streams and rivers.

TABLE 2 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 2/95

Parameter	Sources/Uses	Environment/Health Effects
Cyanide	*Sources:* Most cyanides come from industrial processes; small amounts of cyanide occur naturally in almonds, lima beans, cassava, and in the pits of apricots and peaches; certain bacteria, fungi, and algae also produce cyanide. *Uses*: Used extensively in the chemical industry to make nylon and other chemicals; metal cyanides are used in electroplating and metallurgy.	Cyanide does not bioaccumulate in fish tissue; small organisms in water and soil convert some cyanides to less harmful chemicals.
Toluene	*Sources:* Formed during the production of gasoline and other fuels from crude oil; making coke from coal and a by-product in the manufacture of styrene *Uses*: Making paints, paint thinners, fingernail polish, lacquers, adhesives, and rubber; used in some printing and leather tanning processes.	Enters the environment mainly from industrial discharges; does not persist in the environment; readily broken down by microorganisms; evaporates quickly from soil and surface water; moderate acute and chronic toxicity to aquatic life.
Phenol	*Sources:* Common component of oil refinery wastes; produced in the conversion of coal into gaseous or liquid fuels and in the production of metallurgical coke from coal; produced in large volumes; *Uses*: Mostly used as an intermediate in the production of other chemicals.	Enters the environment from oil refinery discharges, coal conversion plants, industrial/municipal WWTP effluent and spills.
Chloroform	*Sources:* Naturally occurring but most of the chloroform that gets into the environment is manufactured *Uses*: Used to make other compounds; small amounts are formed when chlorine is added to water (chlorine is used as a disinfectant at wastewater and water treatment plants, swimming pools and spas); used as a solvent, an anesthetic, a cleansing agent, and in fire extinguishers, in making dyes, drugs and pesticides.	Carcinogen; numerous ways for chloroform to get into the environment; enters air and water from industry, leaky storage containers and waste disposal; evaporates quickly (mostly in the air); dissolves easily in water; does not persist in water; does not bioaccumulate in plants and animals; moderate acute and chronic toxicity.
Bromo-dichloro-methane	*Sources:* Manmade *Uses*: Used as a chemical intermediate, solvent, and fire extinguisher fluid ingredient.	Carcinogen; highly soluble in water; does not persist in water; most ends up in the air; can bioaccumulate in tissue, concentrations in fish tissue higher than in the surrounding water; enters the environment through industrial discharges and spills; moderate acute and chronic toxicity to aquatic life.

TABLE 2 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 2/95

Parameter	Sources/Uses	Environment/Health Effects
N-Nitrosodi-n-Propylamine	*Sources*: Manmade. *Uses*: Used for research purposes, as a synthetic intermediate or as a solvent in chemical manufacture	A carcinogen; enters the environment through industrial discharges and spills; does not persist in water; about 54 % will end up in air, 45 % in water and the rest in terrestrial soils and aquatic sediments; insufficient data to assess acute and chronic effects to aquatic life, plants, birds, or land animals; can bioaccumulate in tissue.
Benzene	*Sources:* Volcanoes and forest fires are examples of natural sources that release small amounts of benzene to the environment; found in crude oil and gasoline. *Uses*: Used in industry to make chemicals for styrofoam, plastics, resins, nylon, and synthetic fibers; also used to make some types of rubber, lubricants, dyes, detergents, drugs, and pesticides.	Carcinogen and Mutagen; enters the environment from human and natural activities; liquid form mixes easily with air and water; benzene in water changes quickly to vapor; breaks down more slowly in water than air; plants and animals do not store high concentrations; high acute and chronic toxicity to aquatic life.
Xylene	*Sources*: mixture of three isomers of xylene (ortho,meta and para) with possible trace amounts of ethyl benzene. *Uses*: Used as a solvent; in the production of organic chemicals used to make polyester fibers and to make dyes; sterilizing catgut and microscopy; used in making drugs, insecticides, and gasoline.	Enters the environment from industrial discharges municipal wastewater treatment plant discharges or spills; high chronic toxicity to aquatic life; xylene does not persist in water; the concentration of xylene in fish tissue is expected to be somewhat higher than the average concentration of the surrounding water.
1,4-Dichloro-benzene	*Sources*: Manufactured chemical *Uses*: used to control moths, molds, and mildew; to deodorize restrooms and waste containers; when exposed to air the solid turns to a vapor, and the vapor deodorizes or kills insects.	Most comes from the use as moth repellent products and toilet deodorizer blocks; breaks down to harmless product in about a month; does not dissolve easily in water; mostly found in the air; bioaccumulates in plants and fish; moderate acute toxicity and high chronic toxicity to aquatic life.
Alpha Benzene Hexachloride (Lindane)	*Sources*: Manmade-organochlorine insecticide. Alpha BHC is one of five isomers of hexachlorocyclohexane *Uses*: Broad spectrum insecticide; Lindane is the most common isomer.	Enters the environment through runoff. Does not readily bioaccumulate.
Chlordane	*Sources* : Manmade, polycyclic chlorinated hydrocarbon group of pesticides *Uses*: Broad spectrum pesticide; used extensively over the past 30 years for termite control, home and garden insecticide and the control of soil insects during crop production; EPA banned the use chlordane for all but termite control in 1983; in 1988 EPA banned all use of chlordane.	Carcinogen; enters the aquatic environment from urban and agricultural runoff, can remain in the soil for over 20 years; breaks down very slowly; doesn't dissolve readily in water; bioaccumulates in fish, birds and animals; high acute and chronic toxicity to aquatic life.

TABLE 2 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 2/95

Parameter	Sources/Uses	Environment/Health Effects
DDT **DDE** **DDD**	*Sources*: Manufactured chemical, (DDT=1,1,1-trichloro-2,2-bis (p-chlorophenyl) ethane) does not occur naturally in the environment; *Uses*: Widely used to control insects on agricultural crops and diseas carrying insects (malaria, typhus); due to damage to wildlife and potential harm to human health DDT was banned in the U.S in 1972, except for public health emergencies; DDT is still used in other countries. DDE and DDD are similar to DDT; DDD was also used to kill pests but has also been banned in the U.S.; DDE has no commercial use.	Levels of DDT build up in plants and in the fatty tissues of fish, birds, and animals; DDT breaks down to form DDE and DDD; DDT in surface water can evaporate from surface water and can be broken down by sunlight and microorganisms; lasts a long time in soil.
Diazinon	*Sources*: Manmade organophosphorus compound *Uses*: Used extensively by commercial and home applicators to control flies, lice on sheep, insect pests of ornamental plants, food crops (corn, rice, onions, and sweet potatoes), forage crops (alfalfa); also control of nematodes and soil insects in lawns and agricultural land.	In water, diazinon breaks down to relatively nontoxic compounds with little known hazard potential to aquatic life but the degradation rate is highly dependent on pH; birds are more sensitive than mammals.
Dieldrin	*Sources:* Manmade, does not occur naturally in the environment. *Uses*: Insecticide. From 1950 to 1970, aldrin and dieldrin were used for crops (ex:corn and cotton). Due to concerns about environmental damage and potential harm to human health, the U.S. banned all uses of aldrin and dieldrin in 1974 except for termite control. The U.S. banned all uses in 1987.	Dieldrin breaks down very slowly; binds tightly to soil; plants accumulate dieldrin from the soil; dieldrin accumulates in fat and leaves the body very slowly; aldrin quickly breaks down to dieldrin in the body and environment.
Endosulfan Alpha	*Sources:* Manufactured chemical *Uses*: Endosulfan is a mixture of alpha and beta endosulfan; it has not been produced in the US since 1982; it is still used here to produce other chemicals; used as an insecticide to control insects on grain, tea, fruits, vegetables, tobacco, and cotton; in the S it is mainly applied to tobacco and fruit crops; it is also a wood preservative.	Enters the environment primarily through spraying on farm crops; does not dissolve easily in water; stays in the soil for years before it breaks down; bioaccumulates in the bodies of fish and other organisms.
Endrin	*Sources*: Manmade member of the chlorinated hydrocarbon group of pesticides; *Uses*: Known uses in the US are as an avicide, rodenticide, and insecticide, the latter being the most common. The largest single use of endrin is to control Lepidopteran (butterflies and moths) larvae attacking cotton crops in the Mississippi delta states; broad spectrum pesticide.	Enters the environment primarily as a result of direct application to soil and crops; waste material discharge from endrin manufacturing and container disposal are significant contributors to the environment; persists in the soil; has a high acute toxicity to aquatic organisms and mammals; insoluble in water.

TABLE 12 (cont)
SOURCES/USES FOR TOXIC SUBSTANCES DETECTED IN THE RIO GRANDE/RIO BRAVO DURING PHASE 2 OF TOXIC SUBSTANCE STUDY
5/95 to 12/95

Parameter	Sources/Uses	Environment/Health Effects
PCBs (Polychlorinated Biphenyls)	*Sources:* A group of common industrial chemicals that share the same structure; do not occur naturally; aroclor is a popular trade name *Uses*: Coolants, insulating materials and lubricants in electrical equipment. U.S. stopped manufacturing them in 1977 because of health effects. Pre-1977 products still contain PCBs-old fluorescent lighting fixtures, electrical devices or appliances with PCB capacitors, old microscope oil, and hydraulic fluids.	Carcinogen and Teratogen; enter the environment leaking industrial and electrical equipment, industrial discharges, spills, leaching from landfills and previously contaminated sediments; contained in rain or snow runoff; adhere tightly to soil; small amounts dissolve in water; high acute and chronic toxicity to aquatic life; bioaccumulate in fish and other seafood; levels in fish can be 1000's of times higher than in water.
Bis (2-ethylhexyl) Phthalate	*Sources*: Manmade *Uses*: Widely used in plastics; component of many products found in homes and automobiles and in the medical and packaging industries.	Carcinogen and Teratogen; wide use and distribution; commonly found in water, sediment and tissue; persists in the environment.

4.0 STATUS OF THE RIO GRANDE/RIO BRAVO AND ITS TRIBUTARIES

4.1 PHASE 2 TOXIC SUBSTANCE STUDY RESULTS

During the Phase 1 Study, a total of 48 toxic chemicals were detected, 30 of which exceeded screening levels at some sites. The 30 chemicals that exceeded screening levels were considered to be of potential concern and were assigned a level of importance based on occurrences.

A total of 38 toxic chemicals were detected during the Phase 2 Study (in water, sediment and fish tissue), 28 of which exceeded criteria/screening levels at some sites. These chemicals were divided into three groups: High (Figure 3) Medium (Figure 4) and Low Priority (Figure 5).

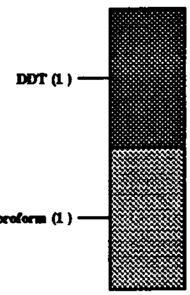

Figure 4 Phase 2 Medium Priority Group Chemicals Exceeding Screening Levels
Includes 2 chemicals that exceeded criteria/screening levels at multiple tributary sites. ( ) indicates number of times criteria/screening level was exceeded.

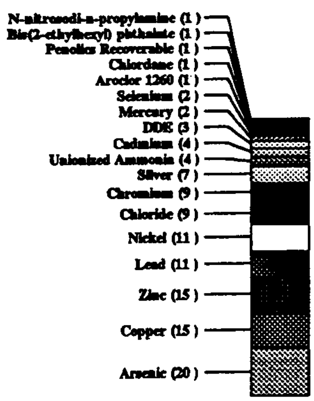

Figure 3 Phase 2 High Priority Group Chemicals Exceeding Screening Levels
Includes 18 chemicals that exceeded criteria/screening levels in the mainstem if the Rio Grande/Río Bravo.Thirteen chemicals occurring at multiple tributary sites were included in the High Priority Group; all listed metals, DDE, unionized ammonia and chloride. ( ) indicates number of times criteria/screening level was exceeded.

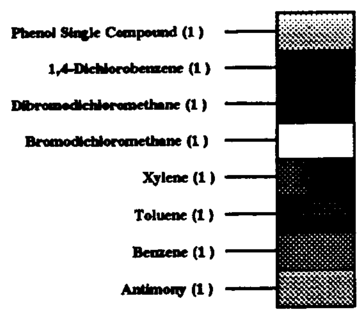

Figure 5 Phase 2 Low Priority Group Chemical Exceeding Screening Levels
Includes 8 chemicals that exceeded criteria/screening levels at a single tributary site, and not included in the High or Medium Priority Groups. ( ) indicates number of times criteria/screening level was exceeded.

4.2 PHASE 2 SITES OF CONCERN FOR TOXIC EFFECTS

The sites of concern were determined using data collected jointly by both countries but assessed independently using two different classification methods.

The **Potential for Toxic Substance Effects** classification system was developed by the United States to synthesize water, sediment, fish tissue, toxicity and biological data.

The **Potential for Conventional Pollutant Effects** classification is based on the Water Quality Index (WQI) used by Mexico to evaluate water quality which considers the combined effects of various conventional water pollutants.

TABLE 13
POTENTIAL SUBCATEGORIES

Potential for Toxic Substance Effects	Potential for Conventional Pollutant Effects	
Site Ranking (%)		Potential
75~100	0~50	High
74~50	51~70	Moderate
49~25	71~80	Low
24~0	81~100	Slight

The sites were ranked according to potential effects of toxic and conventional pollutants found in Phase 2. The ranking was used as a data analysis tool used to provide a general idea of conditions at the sample sites (Table 13). It also allowed prioritization of areas where further investigation may be warranted. All of the Phase 2 data was considered together to identify sites of potential concern. The individual pollutant scores for each station are located in Tables 14 and 16. Based on the analysis of water, sediment, fish tissue and biological data, Table 15 summarizes those stations exhibiting either high, moderate or low potential for effects.

TABLE 14
MAINSTEM POLLUTANT SCORES

Station Location	Toxic Substance Score	Water Quality Index Score
1	47.4	67.46
1.1	36.1	69.54
2	100	61.77
2.1	Note ①	71.88
2.2	Note ①	68.01
2.3	Note ①	67.56
3	84.2	64.39
4	89.5	63.13
5	73.7	62.76
6	Note ①	80.24
6.1	79.0	Note ②
6.2	63.2	Note ②
7	Note ③	Note ②
8	Note ③	Note ③
9	Note ③	Note ③
10	68.4	73.59
11	Note ③	Note ③
12	10.5	62.13
12.1	94.7	68.48
12.2	52.6	Note ②
12.3	5.3	Note ②
13	15.8	72.31
14	21.1	71.70
15	36.8	77.61
16	57.9	76.17
17	26.3	72.05
18	42.1	67.04

Notes:
①Salinity only collected at these stations
②WQI not applicable to reservoirs (lentic waters)
③Fish tissue only collected at these stations

TABLE 15
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
0.5a-Montoya Drain Near the Texas/New Mexico State Line	Conventionals	Chloride		NO DATA	No Toxicity
	Metals	Arsenic, Copper, Nickel	Cadmium, Copper, Lead, Nickel, Zinc		NO DATA
MODERATE	Level of Concern	LOW	HIGH		
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
1-Rio Grande at Courchesne Bridge in El Paso	Conventionals	Chloride			No Toxicity
	Metals	Arsenic, Copper	Cadmium, Copper, Lead, Nickel, Zinc	Cadmium, Copper	Benthics-POTENTIAL CONCERN
LOW	Level of Concern	LOW	MODERATE	LOW	Fish-CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
1.1-Rio Grande/Río Bravo Upstream of El Paso Haskell Street WWTP	Conventionals	Chloride			No Toxicity
	Metals	Arsenic, Copper	Arsenic, Copper, Lead, Nickel, Zinc	NO DATA	
	Organics	Phenolics Recoverable		NO DATA	
LOW	Level of Concern	SLIGHT	LOW		NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
1a- El Paso Haskell Street WWTP	Conventionals	Unionized Ammonia, Chloride	NO DATA	NO DATA	Toxicity -Water Water Fleas Fathead Minnows
	Metals	Arsenic	NO DATA	NO DATA	
	Level of Concern	HIGH			NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
2-Rio Grande/Río Bravo at Zaragosa Bridge in El Paso/Ciudad Juárez	Conventionals	Unionized Ammonia, Chloride			Toxicity-Sediment Fathead Minnows
	Metals	Arsenic	Arsenic, Copper, Lead, Nickel, Zinc	Cadmium, Copper, Zinc	Benthics-POTENTIAL CONCERN
HIGH	Level of Concern	LOW	HIGH	MODERATE	Fish-CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
2.1-Rio Grande/Río Bravo Upstream of Fort Hancock International Bridge	Conventionals	Unionized Ammonia	NO DATA	NO DATA	NO DATA
Mexico's WQI Score	Slight Potential for Conventional Pollutant Effect				

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
2.2-Rio Grande/Río Bravo at Fort Hancock International Bridge	Conventionals	Unionized Ammonia	NO DATA	NO DATA	NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
2.3-Rio Grande/Río Bravo Downstream of Fort Hancock International Bridge	Conventionals	Unionized Ammonia	NO DATA	NO DATA	NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
2a-Ciudad Juárez Wastewater Canal	Conventionals	Unionized Ammonia, Chloride		NO DATA	Toxicity-Water Water Fleas & Fathead Minnows
	Metals	Arsenic, Nickel	Arsenic, Silver	NO DATA	
	Organics	Phenol		NO DATA	
HIGH	Level of Concern	HIGH	HIGH		NO DATA
Mexico's WQI Score	High Potential for Conventional Pollutant Effect				
3-Rio Grande/Rio Bravo Upstream of Presidio/Ojinaga	Conventionals	Chloride			No Toxicity
	Metals	Arsenic	Copper, Lead, Nickel, Zinc	Selenium	
	Organics	Bis (2-ethyl hexyl) Phthalate			Benthics-CONCERN
HIGH	Level of Concern	HIGH	MODERATE	HIGH	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
3a-Río Conchos Near the Mouth	Conventionals	Chloride			No Toxicity
	Metals		Zinc	Cadmium, Selenium, Zinc	
	Organics	Bis (2-ethylhexyl) Phthalate			Benthics-CONCERN
SLIGHT	Level of Concern	SLIGHT	SLIGHT	HIGH	Fish-CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
3a.1-Río Conchos 25 km Upstream from Mouth	Metals	Arsenic	Copper, Lead, Nickel, Zinc	NO DATA	No Toxicity
LOW	Level of Concern	MODERATE	LOW		Fish-NO CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
4-Rio Grande/Río Bravo Downstream of Presidio/Ojinaga	Conventionals	Chloride			Toxicity-Water Water Fleas
	Metals	Arsenic	Cadmium, Copper, Lead, Nickel, Zinc	Selenium, Zinc	
	Pesticides			DDE	Benthics-POTENTIAL CONCERN
HIGH	Level of Concern	HIGH	MODERATE	HIGH	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effect				
5-Rio Grande/Río Bravo at Santa Elena Canyon in Big Bend National Park	Conventionals	Chloride			Toxicity-Water Water Fleas
	Metals	Arsenic		Cadmium, Copper, Zinc	Benthics-POTENTIAL CONCERN
MODERATE	Level of Concern	HIGH	SLIGHT	MODERATE	Fish- CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
6.1-International Amistad Reservoir in Rio Grande Arm	Metals	Arsenic	Arsenic, Chromium, Copper, Lead, Nickel, Zinc	Mercury	No Toxicity
HIGH	Level of Concern	MODERATE	HIGH	MODERATE	NO DATA
6.2-International Amistad Reservoir in Devils River Arm	Metals	Arsenic		Arsenic	No Toxicity
MODERATE	Level of Concern	LOW	HIGH	LOW	NO DATA
7-Rio Grande/Río Bravo Upstream of Del Rio	Metals	NO DATA	NO DATA	Copper	NO DATA
	Level of Concern			HIGH	
7b-San Felipe Creek 1.8 km Upstream of Mouth	Metals		Zinc	Copper, Zinc	No Toxicity
	Organics			Chloroform, Benzene	Benthics-POTENTIAL CONCERN
SLIGHT	Level of Concern	SLIGHT	LOW	HIGH	Fish-NO CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
7b.1-San Felipe Creek at US 277 in Del Rio	Metals			NO DATA	No Toxicity
	Pesticides		Chlordane	NO DATA	
SLIGHT	Level of Concern	SLIGHT	LOW		Benthics-NO CONCERN

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
7b.2-San Felipe Creek 6.0 km Upstream of Mouth	Metals			NO DATA	No Toxicity
	Pesticides		Chlordane	NO DATA	
SLIGHT	Level of Concern	SLIGHT	SLIGHT		Benthics-NO CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effect				
8-Rio Grande/Rio Bravo 6.4 km Downstream of Del Rio	Metals	NO DATA	NO DATA	Copper, Zinc	NO DATA
	Level of Concern			LOW	Fish-INCONCLUSIVE
9a-Arroyo el Tornillo in Piedras Negras	Conventionals	Unionized Ammonia, Chloride		NO DATA	Toxicity-Sediment Fathead Minnows
	Metals	Arsenic		NO DATA	
MODERATE	Level of Concern	LOW	HIGH		NO DATA
Mexico's WQI Score	High Potential for Conventional Pollutant Effect				
10- Rio Grande/Rio Bravo Downstream of Eagle Pass/Piedras Negras	Metals	Arsenic		Arsenic	No Toxicity Benthics-NO CONCERN
MODERATE	Level of Concern	SLIGHT	LOW	HIGH	Fish-NO CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
10a-Manadas Creek in Laredo	Conventionals	Chloride		NO DATA	Toxicity-Water Fathead Minnow
	Metals	Arsenic	Antimony	NO DATA	
	Pesticides		DDT	NO DATA	
HIGH	Level of Concern	MODERATE	MODERATE		NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
11-Rio Grande/Rio Bravo Upstream of Laredo/Nuevo Laredo	Metals	NO DATA	NO DATA	Arsenic, Copper, Mercury, Zinc	NO DATA
	Level of Concern			HIGH	
11a-Zacate Creek in Laredo	Metals	Arsenic		NO DATA	No Toxicity
LOW	Level of Concern	LOW	LOW		NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
11b-Chacon Creek in Laredo	Conventionals	Chloride		NO DATA	Toxicity-Water Water Fleas
	Metals	Arsenic		NO DATA	
	Pesticides		DDT	NO DATA	
MODERATE	Level of Concern	MODERATE	MODERATE		NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
11b.1-Laredo Zacate Creek WWTP	Metals	Arsenic	NO DATA	NO DATA	Toxicity-Water Water Fleas
	Level of Concern	MODERATE			NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
11b.2-Laredo Southside WWTP	Metals	Arsenic, Zinc	NO DATA	NO DATA	No Toxicity
	Organics	Bromodi-chloromethane, Chloroform, Dibromodi-chloromethane	NO DATA	NO DATA	
	Level of Concern	LOW			NO DATA
Mexico's WQI Score	Moderae Potential for Conventional Pollutant Effects				
11b.3-Manhole 115 of Riverside Collection System, Nuevo Laredo	Conventionals	Unionized Ammonia, Chloride	NO DATA	NO DATA	Toxicity-Water Water Fleas
	Metals	Arsenic	NO DATA	NO DATA	
	Organics	Toluene, Xylene, 1,4-dichlorobenzene	NO DATA	NO DATA	
	Level of Concern	HIGH			NO DATA
Mexico's WQI Score	High Potential for Conventional Pollutant Effects				
11c-Arroyo el Coyote in Nuevo Laredo	Conventionals	Unionized Ammonia, Chloride		NO DATA	Toxicity-Water Water Fleas & Fathead Minnows
	Metals	Arsenic	Silver	NO DATA	
	Organics	Chloroform		NO DATA	
HIGH	Level of Concern	HIGH	HIGH		NO DATA
Mexico's WQI Score	High Potential for Conventional Pollutant Effects				

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
12-Rio Grande/Río Bravo 13.2 km Downstream of Laredo/ Nuevo Laredo	Metals	Arsenic	Silver		No Toxicity Benthics-POTENTIAL CONCERN
SLIGHT	Level of Concern	LOW	LOW	SLIGHT	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
12.1-Rio Grande/Río Bravo 25 km Downstream of Laredo/ Nuevo Laredo	Metals	Arsenic	Copper, Lead, Nickel, Zinc		No Toxicity
	Organics	N-nitrosodi-n-propylamine			Benthics-POTENTIAL CONCERN
HIGH	Level of Concern	HIGH	MODERATE	SLIGHT	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
12.2-International Falcon Reservoir-Headwaters	Metals	Arsenic	Copper, Lead, Nickel, Zinc	Lead, Zinc	No Toxicity
MODERATE	Level of Concern	SLIGHT	HIGH	MODERATE	NO DATA
12.3-International Falcon Reservoir-Near Dam	Metals	Arsenic			No Toxicity
SLIGHT	Level of Concern	MODERATE	SLIGHT	SLIGHT	NO DATA
12d-Arroyo los Olmos Near Rio Grande City	Conventionals	Chloride		NO DATA	No Toxicity
	Metals	Arsenic		NO DATA	
	Pesticides		DDE	NO DATA	
MODERATE	Level of Concern	MODERATE	MODERATE		NO DATA
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				
13-Rio Grande/Rio Bravo at SH 886 Near Los Ebanos	Metals	Arsenic	Silver		No Toxicity
SLIGHT	Level of Concern	MODERATE	LOW	SLIGHT	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				

TABLE 15 (cont)
SUMMARY OF DATA FOR MAINSTEM AND TRIBUTARY STATIONS SAMPLED DURING PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCES STUDY

STATION / OVERALL LEVEL OF CONCERN	TYPE	WATER	SEDIMENT	FISH TISSUE	TOXICITY & BIOLOGICAL LEVEL OF CONCERN
14-Rio Grande/Río Bravo Downstream of Anzalduas Dam	Metals	Arsenic	Copper, Lead, Nickel, Silver, Zinc		No Toxicity; Benthics-POTENTIAL CONCERN
SLIGHT	Level of Concern	MODERATE	MODERATE	SLIGHT	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
15-Rio Grande/Río Bravo at US 281 in Hidalgo/Reynosa	Metals	Arsenic	Silver	Lead	No Toxicity
LOW	Level of Concern	HIGH	SLIGHT	LOW	Fish- CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
15a-El Anhelo Drain in Reynosa	Conventionals	Unionized Ammonia, Chloride		NO DATA	Toxicity-Water Water Fleas & Toxicity-Water and Sediment Fathead Minnows
	Metals	Arsenic	Silver	NO DATA	
HIGH	Level of Concern	HIGH	MODERATE		NO DATA
Mexico's WQI Score	High Potential for Conventional Pollutant Effects				
16-Rio Grande/Río Bravo Downstream of el Anhelo Drain	Metals	Arsenic	Copper, Nickel, Silver, Zinc	Copper, Zinc	No Toxicity
	Pesticides			Chlordane	Benthics-NO CONCERN
MODERATE	Level of Concern	LOW	HIGH	LOW	Fish-NO CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effects				
17-Rio Grande/Río Bravo Downstream of San Benito	Metals	Arsenic	Lead, Nickel, Silver, Zinc	Copper	No Toxicity
LOW	Level of Concern	MODERATE	MODERATE	LOW	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Low Potential for Conventional Pollutant Effect				
18-Rio Grande/Río Bravo Downstream of US 83/77 Brownsville/ Matamoros	Metals	Arsenic	Silver, Zinc		No Toxicity
	Organics			Aroclor 1260	Benthics-CONCERN
LOW	Level of Concern	SLIGHT	LOW	MODERATE	Fish-POTENTIAL CONCERN
Mexico's WQI Score	Moderate Potential for Conventional Pollutant Effects				

TABLE 16
TRIBUTARY POLLUTANT SCORES

Station Location	Toxic Substance Score	Water Quality Index Score
0.5a	57.1	72.78
1a	100 ①	58.61
2a	92.9	33.79
3a	21.4	63.10
3a.1	42.9	69.21
7b	35.7	79.68
7b.1	14.3	83.71
7b.2	7.1	77.96
9a	64.3	45.67
10a	78.6	53.84
11a	28.6	65.37
11b	71.4	54.30
11b.1	66.7 ①	57.20
11b.2	44.4 ①	67.17
11b.3	77.8 ①	33.64
11c	100	31.34
12d	50.0	68.20
15a	85.7	34.07

Note:
① Water only collected at these stations

4.3 RANKING SITES FOR POTENTIAL EFFECTS FROM TOXIC SUBSTANCES

4.3.1 Mainstem Sites-High Concern

Mainstem sites of highest concern for potential impairment by toxic substances were located downstream of El Paso/Ciudad Juárez and Laredo/Nuevo Laredo, upstream and downstream of Presidio/Ojinaga and in the Rio Grande/Río Bravo arm of International Amistad Reservoir. Stations 2 and 12.1 were both below two of the largest Rio Grande/Río Bravo border cities, and previously were identified as areas of high concern in Phase 1. Station 2, located on the downstream side of El Paso /Ciudad Juárez, and downstream of the El Paso Haskell Street WWTP, is ranked number two (1=highest concern; 19=lowest concern). In addition to urban/industrial runoff and heavy vehicle traffic, the site was affected by the Haskell Street WWTP effluent. Although the WWTP discharge was not included in the overall site ranking, it ranked number one (1=highest concern) when compared to other tributaries for water quality. This station had the highest unionized ammonia value of any tributary or mainstem station. The unionized ammonia concentration exceeded both acute and chronic aquatic life criteria. The effluent also caused toxicity to water fleas and fathead minnows.

Station 12.1 was the second of two stations located downstream of Laredo/Nuevo Laredo. The station ranked number one while Station 12, the downstream site closest to Laredo/ Nuevo Laredo ranked eighteenth, reflecting a slight potential for impairment. In contrast, Station 12 ranked number one in Phase 1, having the highest potential for negative effects by toxic substances. This variation was likely due to flow dynamics in the Rio Grande/Río Bravo. Station 12, downstream of all major point source discharges and tributary inflows from Laredo/Nuevo Laredo, would seem to be the most likely place to detect any effects from these discharges and inflows. However, the site may not be representative of water quality in the area. It may take many miles for the discharges from Laredo/Nuevo Laredo to completely mix with river water.

It is more difficult to explain the presence of Stations 3, 4 and, 6.1 in the high concern group. Stations 3 and 4 are located above and below Presidio/Ojinaga. The area is primarily influenced by agriculture, industry in Presidio/Ojinaga and inflow from the Río

Conchos. Station 4 was one of two mainstem sites where water had a significant toxic effect on water fleas (reduced number of young per female). The cause appeared to be elevated chloride. Chloride exceeded the aquatic life chronic criterion at Stations 1, 2, 3, 4, and 5, with Stations 3, 4, and 5 having the highest chloride concentrations. Elevated salinity is a known problem in the Rio Grande/Río Bravo and Pecos River.

Station 6.1, the Rio Grande/Río Bravo arm of International Amistad Reservoir, was also in the high concern group. This was primarily due to numerous metals in sediment, arsenic in water and mercury in whole fish. It should also be noted that the reservoir stations were ranked along with the river stations, which represent two very different systems. International Amistad and Falcon Reservoirs can act as a sink for contaminants flowing in from the Rio Grande/Río Bravo. Reservoirs are depositional environments. The significance of the contamination is different from the river stations. In particular, lake sediment tends to concentrate contaminants with the water column free of elevated contaminant concentrations. Aquatic organisms would be more likely to come in contact with contaminants in a river system than in a reservoir.

4.3.2 Mainstem Sites-Moderate Concern

Sites with a moderate potential for effects by toxic chemicals were located downstream of Santa Elena Canyon in Big Bend National Park (Station 5), downstream of Eagle Pass/Piedras Negras (Station 10), the Devils River Arm of International Amistad Reservoir (Stations 6.2), downstream of El Anhelo Drain near Reynosa (Station 16), and at the headwaters of International Falcon Reservoir (Station 12.2). Stations 6.2 and 16 ranked high for sediment concerns. Station 10 ranked high for fish tissue concerns.

Station 5 at Santa Elena Canyon was the second mainstem station where water had a significant toxic effect on water fleas (reduced number of young per female). Similar to Station 4, the cause was also thought to be elevated chlorides. As previously stated, chloride concentrations exceeded the aquatic life criterion at Stations 1, 2, 3, 4 and 5. Stations 3, 4 and 5 had the highest exceedance of chloride criteria.

In the past, *Prymnesium parvum* has been cited as a cause of fish kills on the Pecos River. Blooms of this toxic algae are closely associated with salinity concentrations. Chloride concentrations at Station 6a (Pecos River east of Langtry), sampled due to salinity concerns, exceeded both the acute and chronic aquatic life criteria. According to Mexico's Ecological Water Quality Criteria (CECA), concentrations for total dissolved solids and chloride are not in compliance for any of the designated uses. According to CECA criteria, use of this water is restricted to crops with high resistance to salt, in highly permeable soils.

Station 12.2, at the headwaters of International Falcon Reservoir, appeared to be heavily influenced by Laredo/Nuevo Laredo. Contaminants found in sediment downstream of Laredo/Nuevo Laredo (Station 12.1) were similar to those found at the headwaters of Falcon Reservoir. Station 12.3, near the Falcon Dam, ranked nineteenth (slight concern). The most likely causes for ranking as a moderate concern are urban/agricultural runoff, municipal wastewater discharges and industry.

The remaining stations were ranked as low to slight concern. With the exception of Station 12, these rankings reflected lesser industrial influence. Included in the group are stations above and below Brownsville/Matamoros (Stations 17 and 18), International Falcon Reservoir at the dam (Station 12.3), upstream of El Paso/Ciudad Juárez (Station 1), upstream of the El Paso Haskell Street WWTP (Station 1.1), downstream of Anzalduas Dam (Station 14), downstream of San Benito (Station 13), and at Hidalgo/Reynosa (Station 15).

4.3.3 Tributaries Sites-High Concern

The four tributary sites of highest concern were the Arroyo El Coyote near Nuevo Laredo (11c), Ciudad Juárez wastewater canal (2a), El Anhelo Drain near Reynosa (Station 15a) and Manadas Creek in Laredo (Station 10a). The three Mexican tributaries carry wastewater from municipal/industrial areas, but Manadas Creek does not. Manadas Creek is located in an area of Laredo containing warehouses which store a variety of hazardous materials.

4.3.4 Tributaries Sites-Moderate Concern

Tributaries of moderate concern for potential impact were Chacon Creek in Laredo, Arroyo El Tornillo in Piedras Negras (Station 9a), Montoya Drain (Station 0.5a), and Arroyo Los Olmos near Rio Grande City (Station 12d). Chacon Creek (Sation 11b), like Manadas Creek, has adjacent warehouses storing a variety of hazardous materials. Arroyo El Tornillo transports partially treated wastewater from the treatment ponds in Piedras Negras. Arroyo Los Olmos drains a rural residential area near Rio Grande City and is probably influenced by urban and agricultural runoff. Montoya Drain is located downstream of a horse race track in an urbanized area. It may also be influenced by agricultural runoff.

The remaining stations, Zacate Creek in Laredo (Station 11a), San Felipe Creek in Del Rio (Stations 7b, 7b.1 and 7b.2), the Río Conchos near the mouth and 25 km upstream of the mouth (Stations 3a and 3a.1), were all placed in the low to slight concern group.

4.4 SUMMARY OF TOXIC SUBSTANCES FOUND IN PHASE 2

4.4.1 WATER QUALITY

Water samples were analyzed for 161 toxic chemicals at 37 mainstem and tributary sites on the Rio Grande/Río Bravo. Of the 161 chemicals, 21 were above detection limits. Of the 21 detected, 14 exceeded a criterion or screening level. Twelve of the 14 were found in tributaries: arsenic, copper, nickel, zinc, phenols, bromodichloromethane, chloroform, dibromochloromethane, toluene, xylene, 1,4-dichlorobenzene, and bis (2-ethylhexyl) phthalate. Five of the 14 were found in the Rio Grande/Río Bravo. These included arsenic, copper, phenolics recoverable, bis (2-ethylhexyl) phthalate, and n-nitrosodi-n-propylamine (Table 17). All of the contaminants, with the exception of arsenic, were detected in less than five samples, and exceeded criteria/screening levels a maximum of three times. Arsenic was detected in 33 of the 37 samples analyzed, and exceeded criteria/ screening levels in all 33.

4.4.1.1 Organics

The largest number of organics in water were found in the Laredo/Nuevo Laredo area (8 of the 10 detected in the study). Six of the eight were found in two wastewater discharges, the Laredo Southside Wastewater Treatment Plant (WWTP) (Station 11b.2), and Manhole 115 of the Nuevo Laredo wastewater collection system (Station 11b.3). Chloroform was also found in the Arro o El Coyote in Nuevo Laredo (Station 11c). N-nitrosodi-n-propylamine was the only organic in water found at the mainstem site downstream of Laredo (Station 12.1). Laredo /Nuevo Laredo is a heavily industrialized area with numerous treated, partially treated and untreated wastewater discharges influencing water quality. All of these manmade compounds, commonly used in various manufacturing processes, were found in wastewater discharges, suggesting industrial sources. None of the organics found in tributaries was detected in the mainstem of this reach. Phenols and phenolics recoverable were found in the El Paso/Ciudad Juárez area, one at Station 1.1 downstream of the El Paso Haskell Street WWTP, and the other at the Ciudad Juárez wastewater canal (Station 2a). Both sites are heavily influenced by urban/industrial activities. The remaining organic, bis (2-ethylhexyl) phthalate, was found in the Presidio/Ojinaga area in the mainstem upstream of the Río Conchos confluence, and in the Río Conchos near the mouth (Stations 3 and 3a). Both stations are located near Presidio/ Ojinaga and have the potential to be impacted by some industrial activities. Bis (2-ethylhexyl) phthalate, a manmade chemical widely used in plastics, is commonly found in water, sediment and tissue and is known to persist in the environment.

TABLE 17
CONTAMINANTS DETECTED IN WATER
El Paso/Ciudad Juárez to Brownsville/Matamoros

Contaminant	Mainstem		Tributary	
Aluminum	X		X	
Antimony	X		X	
Arsenic	X	●	X	●
Cadmium	X		X	
Chromium			X	
Copper	X	●	X	●
Lead	X			
Nickel			X	●
Selenium	X		X	
Thallium	X		X	
Zinc	X		X	●
Phenols			X	●
Phenolics Recoverable	X	●	X	
1,4-Dichlorobenzene			X	●
Bis (2-ethylhexyl) phthalate	X	●	X	●
Bromodichloromethane			X	●
Chloroform			X	●
Dibromochloromethane			X	●
N-nitrosodi-n-propylamine	X	●		
Toluene			X	●
Xylene			X	●

X=detected; ●=exceeded screening level

4.4.1.2 Pesticides

Pesticides were not detected in water at any of the sites.

4.4.1.3 Metals

Arsenic was the most common of the metals found in the Rio Grande/Río Bravo and tributaries. As stated earlier, arsenic was detected in, and exceeded criteria/screening levels in 33 of 37 samples. Arsenic is a naturally occurring element, and is found in association with areas of past volcanic activity. Arsenic enters the environment from soil erosion, pesticide application, industrial/ municipal wastewater effluent, and coal fired power plant emissions. The widespread occurrence of arsenic would suggest a combination of natural and manmade sources. The other metals found in water, copper, nickel, and zinc, all occurred in the El Paso/Ciudad Juárez reach. Copper and nickel exceeded screening levels at Station 0.5a (Montoya Drain). Copper and zinc also exceeded screening levels at Station 1, Rio Grande/Río Bravo at Courchesne Bridge. Both of these stations are located near the Texas/New Mexico state line, and are influenced by agricultural runoff and some urban activities. Copper is very common in rocks, soils, and municipal/industrial wastewater discharges. Zinc is one of earth's most common elements, and has numerous commercial uses. Elevated zinc was also found in the discharge from the Haskell Street WWTP.

4.4.2 SEDIMENT QUALITY

Sediment samples were also analyzed for the same 161 toxic chemicals at 33 mainstem and tributary sites on the Rio Grande/Río Bravo. Of the 161 chemicals, 17 were found above detection limits. Of the 17 detected, 12 exceeded a screening level. All 12 contaminants were found at tributary sites, including antimony, arsenic, cadmium, chromium, copper, lead, nickel, silver, zinc, chlordane, DDT, and DDE. Eight of the 12 were found at mainstem stations, including arsenic, cadmium, chromium, copper, lead, nickel, silver, and zinc (Table 18).

4.4.2.1 Organics

Only one organic was detected in sediment, bis (2-ethylhexyl) phthalate at Stations 2 (Zaragosa Bridge downstream of El Paso/ Ciudad Juárez) and 2a (Ciudad Juárez wastewater canal), but did not exceed screening levels.

4.4.2.2 Pesticides

Four pesticides were detected in sediment: alpha benzene hexachloride (BHC), chlordane, DDT, and DDE. Chlordane was found in San Felipe Creek sediment at the upper station (7b.1). This station is located in an urban residential area of Del Rio adjacent to a city park. DDT was found in two urban tributaries, Manadas and Chacon Creeks in Laredo. Warehouses storing industrial materials, both products and raw, are located along Manadas and Chacon Creeks. Both creeks have golf courses located nearby. DDE was found in sediments of the Río Conchos near the mouth (3a), downstream of Presidio/ Ojinaga (4), Arroyo El Coyote in Nuevo Laredo (11c), at the headwaters of International Falcon Reservoir (12.2), Arroyo Los Olmos near Rio Grande City (12d), and El Anhelo Drain near Reynosa (15a). These areas receive a mixture of agricultural and urban runoff. The USEPA banned the use of DDT in 1972 and chlordane in 1983. DDT and its breakdown products, DDE and DDD, along with chlordane are known to persist in the environment for many years.

4.4.2.3 Metals

Metals were the most common of the contaminants found in sediment. Nickel, arsenic, chromium, copper, lead, and zinc were the most commonly occurring metals, and were detected in all 33 samples. Copper, lead, nickel, and zinc exceeded screening levels in 8 of 16 samples. Arsenic was found slightly above the screening level at two stations. Chromium did not exceed sediment screening levels. Silver was detected in 12 samples and exceeded screening levels at 10 sites. Cadmium was also detected in all 33 samples but exceeded screening levels at three sites.

TABLE 18
CONTAMINANTS DETECTED IN SEDIMENT
El Paso/Ciudad Juárez to Brownsville/Matamoros

Contaminant	Mainstem		Tributary	
Aluminum	X		X	
Antimony	X		X	●
Arsenic	X	●	X	●
Cadmium	X	●	X	●
Chromium	X	●	X	●
Copper	X	●	X	●
Lead	X	●	X	●
Mercury	X			
Nickel	X	●	X	●
Selenium	X			
Silver	X	●	X	●
Thallium	X			
Zinc	X	●	X	●
Alpha BHC (lindane)	X			
Chlordane	X		X	●
DDT	X		X	●
DDE	X		X	●
X=detected; ●=exceeded screening level				

Mercury was detected in 23 of 33 samples but did not exceed screening levels. Selenium, found in 31 of 33 samples, did not exceed screening level concentrations. Most metals are common in rocks and soils in addition to being common components of numerous industrial manufacturing processes. Arsenic enters the environment from soil erosion, pesticide application, and coal fired power plant emissions. Nickel can be found in all soils, is the 24th most abundant metal on earth, and is a component of many commonly used products. Chromium, also a naturally occurring element, can be a by-product of the burning of fossil fuels, and of many manufacturing processes. Copper is extremely common in rocks and soils and is a common component of industrial and municipal wastewater discharges. Lead, a common component of numerous minerals, has many industrial uses. Zinc, one of the earth's most common elements has many commercial uses.

All of these metals can enter the aquatic environment through stormwater/urban runoff, soil erosion, air emissions and wastewater discharges. The widespread occurrence of these metals in the Rio Grande/Río Bravo system suggests a combination of natural and manmade sources.

4.4.3 FISH TISSUE

Fish tissue samples were collected from 24 mainstem sites and two tributary sites; San Felipe Creek and the Río Conchos. Fish tissue samples were analyzed for the same parameters analyzed in water and sediment. Twenty-seven toxic contaminants were detected in 68 samples (33 edible tissue and 35 whole tissue samples). Four of the 68 samples were analyzed for metals only. Of the 27, 13 exceeded criteria/screening concentrations. Eleven of the 13 contaminants were found at mainstem stations: arsenic, cadmium, chromium, copper, lead, mercury, selenium, zinc, chlordane, DDE and aroclor 1260. Six of the 13 were found at tributary stations: cadmium, chromium, selenium, zinc, chloroform and benzene (Table 19).

4.4.3.1 Organics

Six of the 27 contaminants detected were organics. Three of the six exceeded criteria /screening levels: chloroform, benzene, and aroclor 1260. Chloroform and benzene were found in San Felipe Creek (7b.1) in Del Rio. There was no obvious source for these compounds. Neither of these compounds has the tendency to bioaccumulate in tissue. Chloroform and benzene were found in whole and edible tissue samples. Toluene was also detected at this station but no exceedances were noted. Aroclor 1260, a PCB, was detected in a whole snook sample from Station 18 just south of Brownsville/ Matamoros. Aroclor 1260 exceeded the United States Fish and Wildlife Service predator protection limit. Aroclor 1248 and 1260 were detected once each in fish tissue but not in water or sediment.

4.4.3.2 Pesticides

Seven pesticides were detected in fish tissue but only two exceeded criteria/screening level concentrations: chlordane and DDE. Chlordane was detected in six of 62 samples, and exceeded criteria /screening level concentrations in one carp edible tissue sample from Station 16 (downstream of El Anhelo Drain near Reynosa). The reach below International Falcon Reservoir is heavily influenced by agricultural runoff and irrigation return flows. The edible tissue criterion for DDE was exceeded in carp and carpsucker samples from Station 3 and Station 4, upstream and downstream of Presidio /Ojinaga. This breakdown product of DDT is known to persist in the environment for years, and to bioaccumulate in fish tissue. It should be noted that although DDE exceeded criteria/screening levels at only two stations, it was detected in 57 of 62 samples. DDT and DDD were detected four and seven times, respectively, but there were no exceedances. Other pesticides detected were endosulfan alpha, diazinon, dieldrin and endrin, which were found in only one or two of the 62 samples.

4.4.3.3 Metals

Seven of 13 metals detected exceeded criteria/screening levels: arsenic, cadmium, copper, lead, mercury, selenium and zinc. The two most common metals were copper and zinc in whole body samples, primarily carp. In the El Paso/Ciudad Juárez area, cadmium, copper, and zinc were found in whole body carp samples. In the Presidio/Ojinaga-Big Bend National Park area, cadmium, copper, selenium, and zinc were found in whole body carp and one smallmouth buffalo samples, and one carp edible tissue sample. Selenium was found only at sites immediately upstream and downstream of the Río Conchos confluence, and in the Río Conchos itself. Arsenic, cadmium, lead and mercury were found in two to four samples. Arsenic, chromium and mercury were found from International Amistad Reservoir to Laredo /Nuevo Laredo, mainly in whole fish samples (although arsenic and mercury were also found in one edible tissue sample each). Other metals detected were antimony, aluminum, nickel, silver and thallium. Reviewing the water and sediment data, it is not surprising that metals were also common in fish tissue samples. The widespread occurrence of metals in the study area suggests a combination of natural and manmade sources.

4.4.4 TOXICITY

4.4.4.1 Water

Of 37 stations from which water samples were tested, toxicity was found in 12 instances. Affected sites included two mainstem stations between Presidio/Ojinaga and Big Bend National Park, and ten tributary stations. One hundred percent mortality of water fleas and fathead minnows at Stations 1a, 2a, 11c and 15a (treated and untreated wastewater discharges from El Paso, Ciudad Juárez, Nuevo Laredo and Reynosa) was an effect of elevated unionized ammonia and chloride concentrations,both of which exceeded aquatic life criteria. Stations 1a, 11c and 15a had levels of unionized ammonia that exceeded acute and chronic aquatic life criteria; at Station 2a, only the chronic aquatic life criterion was exceeded. Chloride exceeded the chronic aquatic life criterion at all four stations. Arsenic was also present but did not exceed aquatic life criteria. Nickel and phenol

TABLE 19
CONTAMINANTS DETECTED IN FISH TISSUE
El Paso/Ciudad Juárez to Brownsville/Matamoros

Contaminant	Mainstem		Tributary	
Aluminum	X		X	
Antimony	X		X	
Arsenic	X	●	X	
Cadmium	X	●	X	●
Chromium	X	●	X	
Copper	X	●	X	●
Lead	X	●	X	
Mercury	X	●	X	
Nickel	X			
Selenium	X	●	X	●
Silver	X		X	
Thallium	X			
Zinc	X	●	X	●
Cyanide	X			
Phenolics Recoverable	X			
Chloroform			X	●
Benzene			X	●
Toluene	X			
Chlordane	X	●		
Diazinon	X			
Dieldrin	X			
DDT	X		X	
DDE	X	●	X	
DDD	X			
Endosulfan Alpha	X			
Endrin	X			
Aroclor 1248	X			
Aroclor 1260	X	●		
X = detected; ● = exceeded screening levels				

exceeded state 85th percentiles at Station 2a, and may have contributed to the overall toxic effect on fathead minnows and water fleas.

Only water fleas were affected at Stations 4, 5, 10a, 11b, 11b.1, and 11b.3. At Stations 4 (downstream of Presidio) and 5 (in Big Bend National Park), water fleas exhibited a reduction in the number of young per female. These were the only stations where a significant effect other than mortality was observed. The elevated chloride and total dissolved solids concentrations. Elevated TDS and chloride levels are a common problem in the Rio Grande/Río Bravo. Use and reuse of river water for irrigation, oil and gas wells, industrial and municipal wastewater discharges, and the natural occurrence of salts in surrounding soils contribute to this problem.

One hundred percent mortality of water fleas was found for Stations 10a, 11b, 11b.1 and 11b.3. Stations 10a and 11b are urban creeks within Laredo (Manadas and Chacon). Stations 11b.1 (Laredo Zacate Creek WWTP) and 11b.3 (Manhole 115, Nuevo Laredo) were treated wastewater discharges from Laredo and untreated discharges from Nuevo Laredo, respectively.

Elevated chloride and TDS were the probable cause of toxicity to water fleas. Excessive chloride concentrations in freshwater can adversely affect aquatic organisms. Freshwater invertebrates tend to be more sensitive to chloride than vertebrates. Arsenic was elevated in water but did not exceed aquatic life criteria. Unionized ammonia was not a factor at Stations 10a, 11b and 11b.1, but was at Station 11b.3. Unionized ammonia and chloride were present at other stations but did not exert significant effects on the test organisms. Industrial and municipal wastewater can contain thousands of chemicals with only a few causing aquatic toxicity. Many parameters in water including total organic carbon (TOC), total suspended solids (TSS), pH, and hardness can have a strong effect on toxicity.

Toxic effect is dependent upon the synergistic (total effect > sum of the individual effects), and antagonistic (interaction of two or more substances) activities of the toxicants present. Although unionized ammonia was elevated at Station 2 (downstream of the El Paso Haskell Street WWTP), toxic effects were not observed in water. Wastewaters containing toxicants are influenced by mixing, by effluent characteristics, and by receiving stream characteristics, all of which can produce toxicity levels different from pure compounds. In this case, undiluted effluent from the El Paso Haskell Street WWTP had a greater effect on test organisms than did the mixture of effluent and river water downstream.

4.4.4.2 Sediment

In sediment elutriate tests, significant effects occurred to fathead minnows in samples from Stations 2, 2a, 9a, 11c and 15a. All but Station 2 were partially treated and untreated wastewater discharges from Ciudad Juárez, Piedras Negras, Nuevo Laredo and Reynosa, respectively. Station 2, located downstream of El Paso at Zaragosa Bridge, was the only mainstem station where significant effects occurred in sediment. Copper, lead, nickel and zinc were elevated in sediment at Station 2, which is influenced by wastewater discharges and urban stormwater runoff. Copper, silver and DDE were elevated at Station 2a. Any one metal and/or combination of metals found could have caused a toxic effect. Arsenic and nickel have high acute and chronic toxicity to aquatic life, while silver has high chronic toxicity which is dependent on pH. Metals at Stations 9a, 11c and 15a were not elevated.

4.5 ASSESSMENT OF CONVENTIONAL POLLUTANTS AND METALS USING MEXICO'S ECOLOGICAL WATER QUALITY CRITERIA AND THE WATER QUALITY INDEX

4.5.1 MEXICO'S WATER QUALITY INDEX (WQI)

The Water Quality Index (WQI) is a support tool that encompasses all conventional water quality parameters. The index uses a scale from 0 to 100, in which zero corresponds to water that is highly contaminated, and 100 to water with excellent quality. In the reach from El Paso/Ciudad Juárez to Santa Elena Canyon, the average WQI was 66.28, which corresponds to water with little contamination from conventional pollutants. Downstream of Laredo/Nuevo Laredo (Station 12.1) the WQI dropped to 62.13, possibly due to the discharges from the Laredo Wastewater Treatment Plants (average WQI of 51) and from Arroyo El Coyote (WQI of 31.34). Downstream from International Falcon Dam (Station 12.3), water quality in the Rio Grande/Río Bravo improves, and at its terminus the average WQI is 71.24. In general terms, it is concluded that the quality of water is acceptable for the designated uses.

4.5.2 MEXICO'S ECOLOGICAL WATER QUALITY CRITERIA (Criterios Ecológicos de Calidad del Agua)

In order to put the ecological policies regarding water into practice, it is necessary to define the ecological water quality criteria. With this frame of reference, in which the permissible levels of parameters and substances found in water or other water characteristics such as color, odor, taste, pH, etc. are defined, the regulating agencies are able to designate water bodies as usable for drinking water supply, primary contact recreation, agricultural irrigation, aquaculture, etc. These parameters define the minimum required quality for the different uses.

In establishing the permissible levels of parameters and substances in water, consideration is given to the wide variations in water quality and quality of natural water bodies and to their present degree of contamination. Also, consideration is given to the different water uses and to the necessary environmental conditions for the normal development of organisms in an ecosystem, and the effects caused by variations of the physical, chemical and biological water characteristics on different species.

4.5.2.1 CONVENTIONAL PARAMETERS

4.5.2.1.1 Mainstem

In general terms, the stations with the highest number of parameters exceeding Mexico's Ecological Water Quality Criteria (CECA) were those downstream of Ojinaga/Presidio (Station 4) and Laredo/Nuevo Laredo (Station 12.1) with 12 at each site. These two sites also ranked as having a high potential concern for toxic substance effects.

The assessment for conventional pollutant effects indicates that most of the Rio Grande/Río Bravo stations had high conductivity, total dissolved solids, phosphates and oil/grease. These would need to be removed through treatment if this water is to be used as a public drinking water supply. Also, increasing concentrations of these parameters could make the water unsuitable for agricultural irrigation and even less suitable for the protection of aquatic life.

4.5.2.1.2 Tributaries

Tributaries were evaluated using the same method applied to the mainstem stations. It was observed that levels of certain parameters caused water in some tributaries to be unsuitable for agricultural irrigation (conductivity and dissolved solids), protection of aquatic life (chloride, ammonia-nitrogen, phosphates and detergents) and public water supply source (dissolved solids, chloride, sulfate, phosphate, color and oil/grease).

4.5.3 METALS IN WATER

4.5.3.1 Mainstem

In general terms, the concentrations of metals in the Rio Grande/Río Bravo were below the concentrations established by the CECA criteria. It was concluded that there was no contamination threat to aquatic life or other water uses from the presence of metals.

4.5.3.2 Tributaries

The tributaries which may have water quality problems due to metals are Manadas Creek (Station 10a) with chromium and manganese concentrations above CECA criteria for public water supply source. Río Conchos (Station 3a), Arroyo El Tornillo (9a), Chacon (11b), El Coyote (11c), and the municipal discharge from Ciudad Juárez (2a) all had high manganese concentrations. Manganese does not constitute a toxicity problem, but rather an undesirable aesthetic situation.

4.6 POTENTIAL CONCERNS TO HUMAN HEALTH AND THE AQUATIC ENVIRONMENT

4.6.1 HUMAN HEALTH

4.6.1.1 Water

Human health criteria relate to potential effects of regular long-term consumption of fish and/or untreated drinking water. Five toxic substances were found at levels exceeding human health criteria: arsenic, bromodichloromethane, dibromochloromethane, bis (2-ethylhexyl) phthalate, and n-nitrosodi-n-propylamine.

Only arsenic and n-nitrosodi-n-propylamine were found in the mainstem. N-nitrosodi-n-propylamine, found at one station downstream of Laredo, exceeded the criterion for the consumption of fish and water (Table 20). N-nitrosodi-n-propylamine is a manmade chemical, which may have originated from an unauthorized discharge, or in one of the wastewater treatment plant discharges, although it was not detected in any of the Laredo/Nuevo Laredo tributaries. N-nitrosodi-n-propylamine does not persist in water suggesting a recent release or discharge.

TABLE 20
CONTAMINANTS IN WATER THAT EXCEEDED HUMAN HEALTH CRITERIA IN PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

Contaminant	Human Health Criteria Exceeded (# of Times)
•Arsenic	•Water and Fish (33) •Fish Only (33)
•Bromodichloromethane	•Water and Fish (1)
•Dibromochloromethane	•Water and Fish (1)
•Bis (2-ethylhexyl)phthalate	•Water and Fish (1)
•N-nitrosodi-n-propylamine	•Water and Fish (1)

Bis (2-ethylhexyl) phthalate exceeded the human health criteria for water and fish at the Rio Conchos Station (3a) just upstream of the Rio Grande/Rio Bravo confluence. Bromodichloromethane and dibromochloromethane were both detected in the Laredo Southside WWTP effluent. Both concentrations exceeded the human health criteria for water and fish.

Arsenic exceeded both human health criteria at 33 of the 37 stations sampled. Low levels of arsenic are found in water, soil, food, and air because it occurs naturally in the environment. Its presence in the aquatic environment is primarily due to its use as a pesticide/herbicide, and from coal burning power plant emissions, smelters, mine tailing runoff, industrial/ municipal wastewater, and erosion. Arsenic is not broken down or destroyed in the environment but is converted to various forms by natural chemical or bacteriological action. There are many forms of arsenic, but it was not possible to determine what forms were present at the time Phase 2 samples were collected. Arsenic is a carcinogen that persists in water and tends to bioaccumulate in fish tissue.

4.6.1.2 Fish

A concentrated effort was made to include a predatory species, and a bottom-feeding species for each site. The number of fish used in each composite sample ranged from one to four. The number of target species was limited, and varied widely in size at some locations. A decision was made to use fewer fish of similar size rather than more of varying size. In the mainstem, edible tissue criteria were exceeded for arsenic, mercury, chlordane, and DDE (Table 21). These contaminants were found at elevated levels in only one or two of the 33 samples. These exceedances indicate only the potential for possible human health effects. Pesticides were detected in samples containing only one fish each. The fish analyzed were carp and a carp sucker. Mercury and arsenic were also detected in samples with only one fish each but were found in largemouth bass.

TABLE 21
CONTAMINANTS IN WATER THAT EXCEEDED EDIBLE FISH TISSUE CRITERIA IN PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

Contaminant	Edible Tissue Criteria Exceeded (# of Times)
•Arsenic	•USEPA Edible Tissue (2)
•Mercury	•USFDA Action Level (1)
•Chlordane	•USEPA Edible Tissue (1)
•DDE	•USEPA Edible Tissue (2)

4.6.2 AQUATIC ENVIRONMENT

4.6.2.1 Water

Chloride and unionized ammonia were the only substances found in the Rio Grande/Río Bravo that exceeded criteria for the protection of aquatic life.

TABLE 22
CONTAMINANTS IN WATER THAT EXCEEDED AQUATIC LIFE CRITERIA IN PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

Contaminant	Aquatic Life Criteria Exceeded (# of Times)
•Unionized Ammonia	•Aquatic Life Acute (4) •Aquatic Life Chronic (10)
•Chloride	•Aquatic Life Acute (3) •Aquatic Life Chronic (17)

Both occurred at concentrations that exceeded acute and chronic aquatic life criteria, and were commonly associated with ambient water toxicity to fathead minnows and water fleas (Table 22). The majority of toxic effects by unionized ammonia and chloride were seen in samples from tributaries that were associated with treated, partially treated or untreated wastewater. A number of factors affect the toxicity of unionized ammonia to aquatic life: pH, DO, temperature, salinity, presence of other toxicants, chronic exposure to sublethal concentrations, and consistency of exposure. Ammonia can be toxic to fish under certain conditions and impact can be related to the ability of a stream to eliminate ammonia from water.

Toxic effects of water on fathead minnows were observed in one treated wastewater discharge (El Paso Haskell Street WWTP), which contained the highest ammonia nitrogen concentration recorded in the survey, and three Mexican tributaries (Ciudad Juárez Wastewater Canal, Arroyo El Coyote, and El Anhelo Drain). All four sites had unionized ammonia concentrations that exceeded aquatic life criteria.

Toxic effects of water from mainstem sites were observed at Stations 4 and 5. These stations located downstream of Presidio/Ojinaga in Big Bend National Park were mainly affected by elevated total dissolved solids (TDS) and chloride concentrations. The highest salinity observed in the study was in the Rio Grande/Río Bravo between El Paso/Ciudad Juárez and Presidio/ Ojinaga. Under normal circumstances inflow from the Río Conchos contributes enough fresh water to reduce salinity downstream of Presidio/Ojinaga. When samples were collected in August and December 1995, however, there was little inflow from the Río Conchos. Salinity, TDS, and chloride tend to increase during the non-irrigation season, September through March, when upstream reservoir releases are at a minimum. Irrigation return flows and wastewater containing elevated chloride and TDS are the main source of flow from September to March.

No metals, organics, or pesticides in water exceeded acute or chronic aquatic life criteria. Concentrations of several parameters were greater than state and/or national 85th percentiles at only one to three stations. These contaminants generally were found at stations dominated by untreated wastewater. Arsenic, on the other hand, exceeded state and/or national 85th percentiles 29 of the 33 times it was detected. Although arsenic may have contributed to the toxicity of water to fathead minnows and water fleas, it did not appear to be the main factor.

4.6.2.2 Sediment

Many of the contaminants, natural and/or manmade (metals, pesticides, organics, and inorganics), introduced to surface waters will eventually accumulate in sediment. Information suggests that even in areas where surface water quality criteria are met, organisms in or on sediment can be adversely impacted by contaminants in sediment. Surface water quality criteria, developed to protect organisms inhabiting the water column, were not derived to protect benthic organisms. The bioavailablity of organic contaminants in sediment is thought to be dependent upon the amount of organic carbon present and metals dependent on the presence of acid volatile sulfides; increases in organic carbon and acid volatile sulfides concentrations cause bioavailability of a contaminant to decrease.

Metals were the most common contaminant found in sediment (Table 23). The most frequently occurring were arsenic, chromium, copper, lead, nickel, and zinc. Arsenic, chromium and nickel are highly toxic to aquatic life. Although these metals were found at numerous stations, toxic effects of sediment were seen at only one mainstem station (Station 2) and four tributary stations (Stations 2a, 9a, 11c, and 15a). There were no obvious causes of sediment toxicity.

TABLE 23
CONTAMINANTS IN SEDIMENT THAT EXCEEDED SCREENING LEVELS IN PHASE 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

Contaminant	Sediment Screening Level Exceeded (# of Times)
•Antimony	•85th Percentile (1)
•Arsenic	•85th percentile (1)
•Copper	•Molar SEM/AVS Ratio (12) •85th percentile (1)
•Lead	•Molar SEM/AVS Ratio (12)
•Nickel	•Molar SEM/AVS Ratio (13) •85th percentile (1)
•Silver	•85th percentile (10)
•Zinc	•Molar SEM/AVS Ratio (16)
•Chlordane	•Sediment Quality Criteria (1)
•DDE	•Sediment Quality Criteria (8)
•DDT	•Sediment Quality Criteria (2)

4.7 COMPARISON OF DATA FROM PHASES 1 AND 2 OF THE RIO GRANDE/RIO BRAVO TOXIC SUBSTANCE STUDY

Metals were the most common contaminant found in water and sediment (mainstem and tributaries). PCBs were found in fish tissue in the Del Rio/Ciudad Acuña area in Phase 1, but only at Station 18 near Brownsville/Matamoros in a single fish tissue sample during Phase 2. The majority of organics were found in tributaries in both studies. DDE, DDT, and chlordane were the only pesticides to exceed screening/ criteria levels in Phase 2 (in both mainstem and tributary sites). In Phase 1 DDE, DDT, lindane, dieldrin, and chlordane exceeded screening levels.

The differences in the types and concentrations of toxic substances found in Phases 1 and 2 are not surprising. Water samples, unless collected as a composite over time, give only a relative indication of what water quality was at the time of collection. Sediment and tissue samples are better indicators of existing conditions. Toxic substances tend to accumulate in sediment and tissue over time, while concentrations in flowing water are dynamic and constantly changing. Therefore, sediment and fish tissue data should be regarded as the most meaningful basis for comparing conditions during the two phases of the study.

5.0 RECOMMENDATIONS

It is recommended that further assessment be performed along the mainstem reach extending from El Paso/Ciudad Juárez (Station 1) to Santa Elena Canyon, Big Bend National Park (Station 5). The results of the Phase 1 and 2 data indicate a gradual increase in downstream concentrations of conventional and metal pollutants in this reach. Similar results were observed in the mainstem reach extending from Las Milpas (Station 16) to Brownsville /Matamoros (Station 18). It was also noted that increases in concentrations of physicochemical parameters in the Rio Grande/Río Bravo, mainly salinity, are strongly influenced by the contributions of the tributaries and the discharges of wastewater from several drains. It was determined that the tributaries Manadas (Station 10a), Chacon (Station 11b), El Coyote (Station 11c), Los Olmos (Station 12d), the municipal discharge from Ciudad Juárez (Station 2a), the discharge from El Anhelo Drain (Station 15a), and to a lesser extent the Pecos River (Station 6a) and the discharge from Manhole 115 of Riverside III, Nuevo Laredo (Station 11b.3) constitute sources of pollution for the Rio Grande/Río Bravo. These sites need further assessment to identify and implement appropriate actions to improve the water quality of these tributaries and drains. Such assessment should focus on the stressors that have the greatest effects on aquatic communities and human health.

5.1 ROUTINE SURFACE WATER QUALITY MONITORING ALONG THE INTERNATIONAL REACH OF THE RIO GRANDE/RÍO BRAVO

Each year state and federal agencies in the United States and Mexico spend enormous amounts of resources to monitor the quality of the surface waters along the international reach of the Rio Grande/Río Bravo. These programs are conducted to monitor the quality and trends in water quality, to identify and rank existing and emerging problems, to design and implement resource-management programs and to determine compliance with regulatory programs. In consideration of the good results obtained from the *synoptic* studies of the multiphase Binational Toxic Substances Study (1992-present) as performed within the framework of IBWC Minute No. 289, it is proposed that a Binational Workgroup be created for the routine monitoring of the Rio Grande/Río Bravo. Participants in the workgroup would be for Mexico: Mexican Section, International Boundary and Water Commission, National Water Commission; for the United States: United States Section, International Boundary and Water Commission, United States Environmental Protection Agency - Region 6, United States Geological Survey and the Texas Natural Resource Conservation Commission.

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