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## Overview

### Water Issues along the U.S. Mexican Border

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Sustainable rural and urban prosperity along the border between the United States and Mexico depends on the availability of suitable water supplies. Agricultural irrigation requires large volumes of water during certain periods of the year, and the salt content must be low enough ( $< 1,000$  mg/L) to prevent damage to plant roots. Industrial manufacturers, such as offshore assembly industries (maquiladoras), need water for commercial applications (e.g., cleaning, processing, and cooling water). Many border communities are experiencing rapid population growth, which will provide labor for intensive agriculture, maquiladora industries, and cross-border work, increasing the demand for industrial water resources. Unplanned urban settlements (colonias) are growing quickly and do not have adequate infrastructure or safe domestic water supplies. Increased population growth, irrigation return flows, and industrial/domestic wastewater flows impact downstream water users and ecosystems on both sides of the border. This monograph comprises summaries of five studies of the U.S. Mexican border region that aid in understanding border water issues and pose potential strategies for sustainable border development.

#### POPULATION GROWTH

Development in the border region has occurred primarily near areas with surface water supplies. The border region comprises an area that extends approximately 100 km on either side of the border. Figure 1 illustrates the U.S. Mexican border region and its river sys-



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and Nogales, Sonora, rivers rarely flow due to the over-pumping of groundwater wells (e.g., Santa Cruz River). Such ephemeral rivers flow only during sustained winter rains or intense summer monsoons.

Tables 1 and 2 show the population and rate of population growth for U.S. counties and Mexican municipios along the border, respectively. In 1995, approximately 10 million people lived along the border, with 55% in the United States and 45% in Mexico (Infomexus 1996). If the current rates of population growth continue, the border population will double in 25 years. A portion of the population of Mexico is

Table 1: Total Population (1995) and Growth Rate (1990-1995) for U.S. Counties along the U.S. Mexican Border

| State/Country           | Population*      | Growth Rate (%)      |
|-------------------------|------------------|----------------------|
| <b>California</b>       |                  |                      |
| San Diego               | 2,644,132        | 1.1                  |
| Imperial                | 158,852          | 4.8                  |
| <b>Arizona</b>          |                  |                      |
| Yuma                    | 152,863          | 4.4                  |
| Pima                    | 780,158          | 3.2                  |
| Santa Cruz              | 96,878           | 4.8                  |
| Cochise                 | 110,862          | 2.4                  |
| <b>New Mexico</b>       |                  |                      |
| Hidalgo                 | 6,354            | 8.7                  |
| Lea                     | 23,922           | 5.8                  |
| Dona Ana                | 158,849          | 3.2                  |
| <b>Texas</b>            |                  |                      |
| El Paso                 | 678,819          | 2.8                  |
| Hudspeth                | 3,194            | 1.2                  |
| Culberson               | 3,245            | -8.9                 |
| Jeff Davis              | 2,122            | 1.8                  |
| Pecos                   | 7,656            | 2.9                  |
| Blanco                  | 9,128            | 1.1                  |
| Terrell                 | 1,299            | -1.7                 |
| Val Verde               | 43,698           | 2.4                  |
| Kinney                  | 3,289            | 1.8                  |
| Morick                  | 43,766           | 4.5                  |
| Dimock                  | 10,502           | 8.1                  |
| Webb                    | 170,865          | 4.9                  |
| Zapata                  | 11,875           | 3.2                  |
| Starr                   | 51,442           | 4.9                  |
| Hidalgo                 | 479,783          | 4.6                  |
| Cameron                 | 589,378          | 3.5                  |
| <b>Total Population</b> | <b>5,861,431</b> | <b>2.6 (Average)</b> |

Sources: Infomexus (1996); \*U.S. Census Bureau (1995)

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Table 2: Total Population (1995) and Growth Rate (1990-1995) for Mexican Municipios along the U.S. Mexican Border

| State/Municipio         | Population <sup>a</sup> | Growth Rate(%)       |
|-------------------------|-------------------------|----------------------|
| <b>Baja California</b>  |                         |                      |
| Tijuana                 | 991,392                 | 5.8                  |
| Tecate                  | 62,617                  | 5.5                  |
| Mexicali                | 696,054                 | 2.6                  |
| <b>Sonora</b>           |                         |                      |
| San Luis Rio Colorado   | 132,781                 | 5.4                  |
| Puerto Peñasco          | 27,160                  | 8.96                 |
| Caborca                 | 64,617                  | 1.6                  |
| Altar                   | 7,116                   | 1.8                  |
| Sonora                  | 2,286                   | 1.4                  |
| Nogales                 | 139,491                 | 5.8                  |
| Santa Cruz              | 1,487                   | -0.8                 |
| Casa Grande             | 29,158                  | 1.8                  |
| Naco                    | 4,911                   | 1.0                  |
| Gen. P.E. Callan        | 18,334                  | N/A                  |
| Agua Prieta             | 56,288                  | 6.7                  |
| <b>Chihuahua</b>        |                         |                      |
| Janet                   | 18,784                  | -0.2                 |
| Arriola                 | 19,657                  | 5.3                  |
| Juchitán                | 1,811,786               | 4.3                  |
| Guadalupe               | 9,611                   | 1.1                  |
| Francisco G. Guerrero   | 8,928                   | 1.1                  |
| Olinda                  | 25,585                  | -0.2                 |
| Masculi Interlomas      | 2,591                   | -5.1                 |
| <b>Cochila</b>          |                         |                      |
| Chimicu                 | 9,670                   | 9.9                  |
| Acuña                   | 81,577                  | 6.8                  |
| Juchitán                | 8,342                   | 2.2                  |
| Progreso Negro          | 116,148                 | 5.0                  |
| Nuevo                   | 28,497                  | 5.5                  |
| Guaraca                 | 2,179                   | -1.8                 |
| Hidalgo                 | 1,273                   | 0.7                  |
| <b>Nuevo León</b>       |                         |                      |
| Andrés                  | 18,278                  | 6.96                 |
| <b>Tamaulipas</b>       |                         |                      |
| Nuevo Laredo            | 275,060                 | 4.1                  |
| Guerrero                | 4,087                   | 2.0                  |
| Mier                    | 6,270                   | 8.87                 |
| Miguel Alemán           | 22,369                  | 0.88                 |
| Camargo                 | 15,389                  | 0.51                 |
| Gustavo Díaz Ordaz      | 15,685                  | -2.12                |
| Rayón                   | 997,053                 | 5.1                  |
| Río Bravo               | 108,376                 | 1.1                  |
| Valle Hermoso           | 55,274                  | 1.9                  |
| Matamoros               | 563,487                 | 5.3                  |
| <b>Total Population</b> | <b>4,759,488</b>        | <b>2.1 (Average)</b> |

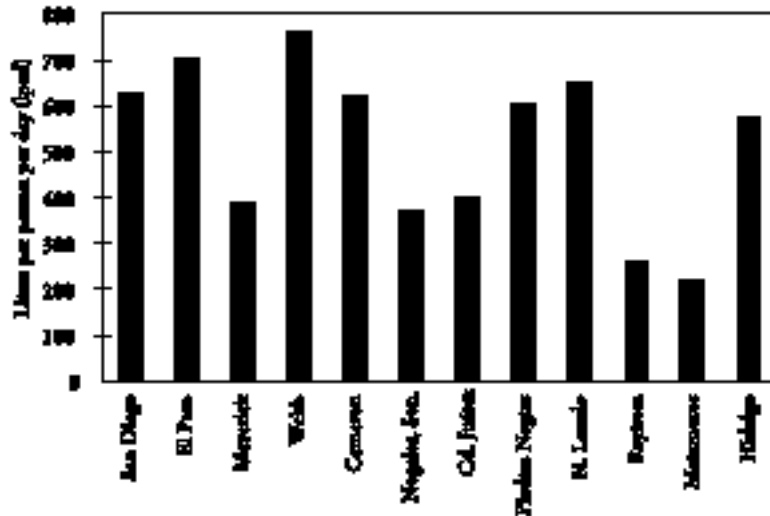
Sources: Informex (1996); \*C onteo de Poblaci n y Vivienda (1995),

employed in maquiladora industries, but many more people have also moved into colonias along the border. Growing populations can have a detrimental impact on water quality, yet require a sustainable supply of safe drinking water.

### WATER CONSUMPTION PATTERNS

The increase in population along the border may result in a shift in current water use from agricultural irrigation to domestic and industrial applications. Currently, irrigation water use is significantly larger than domestic requirements; however, the demand for municipal water treated for domestic and industrial applications is increasing (see Chapter 2). Furthermore, domestic drinking water requires higher water quality standards than does irrigation applications. The amount of water treated to provide for domestic, public, and commercial uses is generally reported in liters per capita (person) per day (lpcd). Figure 3 illustrates per capita water use for U.S. counties and Mexican municipios along the border. The average water consumption along the border in the United States (615 lpcd) is 41% greater than that in Mexican border municipios (435 lpcd). Water consumption is correlated with the standard of living, and as the standard of

Figure 3: Per Capita Water Use for U.S. Counties and Mexican Municipios along the Border



Source: adapted from Infomexus (1996).

living increases in Mexico, water consumption will increase as well. Applying the U.S. and Mexican water consumption rates to the total border population in 1995 would result in an annual water consumption rate (non-irrigation) of  $1.3 \times 10^9 \text{ m}^3/\text{yr}$  (1.1 million acre-feet/yr) and  $0.76 \times 10^9 \text{ m}^3/\text{yr}$  (0.61 million acre-feet/yr), respectively.

## DOMESTIC WASTEWATER

Approximately one-half of all water treated for domestic and industrial applications is conveyed through sewage treatment plants. Sewage contains high concentrations of pathogens (virus, protozoan), organic matter (BOD material), and nutrients (nitrogen and phosphorous). Both sides of the border suffer from inadequate civil infrastructures with which to convey wastewater from households and industries to a centralized location for treatment. Where insufficient infrastructure exists, inadequate on-site wastewater treatment (e.g., surface disposal or septic tanks) can lead to surface or ground water contamination. In some border communities where sewage is collected, wastewater treatment occurs with low-tech, low-cost systems such as lagoons or wetlands. In other communities, sewage pipe infrastructure does not exist and sewage enters surface water supplies as runoff, impairing downstream water quality. With appropriate planning, treated wastewater from these systems can be safely used to irrigate nonconsumptive crops (Chapter 5) or used to augment depleted groundwater aquifers (Chapter 6). Therefore, treated wastewater should be considered a valuable commodity in the U.S. Mexican border region.

## AGRICULTURE

In addition to the maquiladora industries, agricultural water demand dominates the annual water usage, especially along the Rio Grande River (Chapters 2 and 3). As water is applied to crops, plants directly utilize approximately 50% to 70% of the water through evapotranspiration or biomass production. While some nutrients are taken up by the plants, most of the dissolved solids in the water (e.g., sodium, calcium, chloride, sulfate) are concentrated in the remaining 30-50% of the water not utilized by the plants, and dissolved solid salts concentrate in the pore water beneath agricultural fields. Salts will migrate into the groundwater, precipitate in the soils, or leach into surface waters as irrigation return flows (Chapter 3). Irrigation practices therefore contribute significantly to increasing salinity, or total dissolved solids (TDS), in downstream groundwater and surface water

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aquifers. Many types of plant roots can not tolerate high salinity levels. Salinity guidelines also exist for salt concentrations in domestic and industrial source waters due to health effects (e.g., sulfate causes diarrhea), taste, and distribution issues (salts precipitate and clog pipes and equipment). Long-term salinity management will be an increasingly significant issue in the border region.

## WATER QUALITY

While the availability of water for various uses along the border is a major issue for sustainability, and salinity-related water quality deterioration is a key concern for agriculture, water quality emerges as the most significant environmental health issue in colonias in the border region. Both chemical and microbial water quality issues pose health concerns. The World Health Organization has guidelines regarding a large suite of inorganic (e.g., nitrate, arsenic, mercury, fluoride, lead, copper, radionuclides) and organic (e.g., pesticides, fertilizers, petroleum products) contaminants. Guidelines have also been developed to protect against microbial pathogenic waterborne diseases (e.g., typhoid fever, hepatitis A, giardiasis, cryptosporidiosis, cholera) due to pathogenic virus and protozoa (Chapters 5 and 6). The frequency of waterborne disease outbreaks associated with microbial contaminants increases during warm weather conditions (Craun 1988), thus placing surface waters in the border region at a high risk during many months of the year. In many arid regions, pumping groundwater in close proximity to surface waters creates a direct connection between groundwater and surface water supplies. Chemical and microbial contaminants can readily move through such connections and present significant health risks associated with drinking groundwater. Many of the chemical contaminants pose long-term, chronic health risks whereas microbial pathogens pose significant short-term, acute health risks. Thus, management of risk from water quality contamination must include protection against both chemical and microbial contaminants.

In summary, many regions along the border have historically relied upon both groundwater and surface water supplies for drinking water. Some water supplies have become contaminated by a high salt content or other chemical contamination. Other aquifers are being pumped at rates greater than natural groundwater recharge, resulting in nonsustainable mining of groundwater, and ultimately impacting riparian ecosystems. Therefore, some communities are shifting from groundwater to surface water supplies. During periods of prolonged

drought, regional surface water supplies will have to be balanced between irrigation requirements and domestic/industrial needs.

## SUMMARY

The following chapters address in more detail general issues regarding the quantity and quality of water in the U.S. Mexican border region. Most of the chapters address the status of water quality in the border region as it relates to the availability of water for various uses. The following is a summary of the focus of each of the chapters in this monograph:

- Chapter 2 addresses the availability of water along the Rio Grande and the impact of upstream reservoir operation on downstream water quality (predominantly salinity).
- Chapter 3 establishes a linkage among surface water flows, water uses, and regional aquifer water quality in the El Paso Ciudad Juárez region.
- Chapter 4 presents results from a study of rainfall runoff that enters surface waters in the Tijuana River watershed and its impact on microbial contamination based upon land usage.
- Chapter 5 considers water quality, and details an innovative, low-cost system capable of safely discharging and reusing domestic wastewater in Ojinaga, Mexico, for irrigation of fast-growing trees that can provide fiber and energy.
- Chapter 6 describes a sustainable, low-cost natural treatment process for wastewater that protects human health from water quality contamination and minimizes detrimental impacts to riparian stream ecosystems.

Without considerable research, planning, and management of water along the border, serious conflicts regarding water resources and water quality will develop. It is especially important to understand the issues related to the availability of water in the border region, including the potential to reuse irrigation return flows and treated wastewater, as well as the impact of urban development on water quality.

## REFERENCES

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