FINANCING WASTEWATER COLLECTION AND TREATMENT ON THE U.S. – MEXICO BORDER

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ABSTRACT

Bilateral negotiations between the United States (U.S.) and Mexico over the scale, location, and financing of water treatment facilities serving border twin cities frequently break down, leaving water pollution and supply uncertainty problems unresolved. Agreements reached have been reactive to immediate health emergencies, limited in scope, and have failed to address market failures that contributed to the environmental problems in the first place. New institutions created to address environmental concerns over North American Free Trade Agreement (NAFTA) have helped both nations plan, build, and finance new facilities in a more coordinated and proactive manner. Yet, the goal of developing locally self-financing municipal water systems on both sides of the border has remained elusive. To illustrate, we use a case study of negotiations over water resources shared by Nogales, Arizona, and Nogales, Sonora.

INTRODUCTION: THE UNITED STATES - MEXICO BORDER REGION

Rapid population growth along the United States (U.S.)-Mexico border, combined with large disparities in the two countries' incomes and financial resources, has presented challenges to management of transboundary water pollution. In 1980, about 4 million people lived within 100 km of the U.S.-Mexico Border. The border population grew to 10.5 million by 1997 and is projected to double over the next 20 years. Over 90 percent of the border population are clustered in 14 pairs of sister cities. The border region's most serious public health problems are lack of access to safe drinking water, sewage treatment, and solid and hazardous waste disposal. Of 16.1 million people residing in Mexican border municipalities and U.S. border counties, 12 percent do not have direct access to potable water, 18 percent of the Mexican population, and 3 percent of the U.S. population (Table 1). 30 percent lack access to wastewater treatment facilities, 33 percent of to the Mexican population and 27 percent of the U.S. population. Another 25 percent of Mexico's border municipalities lacked solid waste disposal facilities. In 1997, only 69 percent of the Mexican border population lived in residences connected to sewage collection systems and only 34 percent of the collected wastewater was treated. As of 1997, less than half of Mexican households along the border had solid waste collected and deposited in sanitary landfills, while 14 percent had no access to solid waste collection services whatsoever. As Table 1 shows, problems are not confined to the Mexican side of the border. U.S. problems are most acute in *colonias* – low income, unincorporated subdivisions lacking basic public services (Texas A&M University). Over 400,000 people live in colonias, primarily in Texas and New Mexico. A study of colonias residents in Texas estimated that half of the state's *colonia* population of 350,000 did not have direct access to potable water (Texas A&M University).

Untreated wastewater is a major transboundary externality, as polluted water flows in many instances, northward from Mexican to American cities (See Frisvold and Caswell for references to transboundary water pollution incidents).[1] Raw or partially treated wastewater flows into drinking water sources on both sides of the border. Ciudad Juarez, adjacent to El Paso, Texas, has a population of over one million and its first wastewater treatment plant is only now nearing completion. The cities of Chihuahua and Matamoros, Mexico also lack wastewater treatment systems. The *maquiladora* program, that allows duty-free imports into Mexico of materials from foreign suppliers to produce goods for reexport, has spurred rapid industrialization in the region, and with it, production of hazardous wastes. While Mexican law requires hazardous wastes produced by maquiladoras to be either treated in Mexico or returned to the country of origin (usually the United States), studies have noted problems with Mexico's hazardous waste disposal system (Johnstone, Hinojosa-Ojeda; U.S. GAO). Industrial wastes, such as volatile organic compounds, mercury and cyanide at levels exceeding U.S. Environmental Protection Agency (EPA) standards have been found in U.S. water supplies along the border (Igram & White, Johnstone, Sprouse et al., Varady & Mack).

Table 1. Lack of Access to Water Infrastructure and Services in Border Region

	Population (millions)	Population lacking services (millions)	Percent lacking services
Mexico border municipalities	9.6		
PoTable water		1.72	18
Wastewater treatment		3.17	33
Solid waste disposal		4.04	42
U.S. border counties	6.5		
PoTable water		0.21	3
Wastewater treatment		1.72	27
Solid waste disposal		N/A	N/A
Total	16.1		
PoTable water		1.93	12
Wastewater treatment		4.89	30
Solid waste disposal		>4.04	>25

Source: U.S. General Accounting Office, 2000. Figures for 1999.

Bilateral negotiations between the United States and Mexico over the scale, location, and financing of water treatment facilities serving border twin cities frequently break down, leaving water pollution and supply uncertainty problems unresolved. Agreements reached have been reactive to immediate health emergencies, limited in scope, and have failed to address market failures contributing to the environmental problems in the first place. We present a case study of negotiations over water resources shared by Nogales, Arizona and Nogales, Sonora, known collectively as "Ambos Nogales" to illustrate our points. Many of the problems faced by these cities are common to many other U.S.-Mexico border cities. We begin by providing some background about the population, economy, and water resources in the region. Next, we sketch out a brief history of water conflicts and negotiations. A historical perspective is useful because there is a path dependence to how water conflicts have arisen and been addressed in Ambos Nogales. Earlier attempts to address particular problems, pre-condition the form subsequent negotiations and solutions can take.

New institutions created to address environmental concerns over NAFTA have helped both nations plan, build, and finance new facilities in a more coordinated and proactive manner. The goal of developing locally self-financing municipal water systems on both sides of the border has remained elusive, however. Recent U.S. government recommendations to enhance public and private investment in border water infrastructure call for greater strategic planning. Yet, these policy discussions of both problems and solutions to border water pollution continue to consider water quality issues separately from critical, unresolved water quantity issues between the United States and Mexico. The example of Ambos Nogales highlights the need to consider border water sanitation problems in conjunction with surface and ground water supply and demand.

AMBOS NOGALES: POPULATION AND ECONOMY

Ambos Nogales refers to the twin border cities of Nogales, Arizona and Nogales, Sonora. "Ambos" means "both" in Spanish and more than 80 percent of Nogales, Arizona residents speak Spanish (Ingram et al., 1994). The population of Nogales, Sonora is much larger and growing much more rapidly than Nogales, Arizona. The population of Nogales, Arizona is roughly 21,000, projected to increase to 27,000 by 2018. Nogales, Sonora's population exceeds 206,000, nearly double its 1990 population, and is projected to reach 345,000 by 2018 (Morehouse et al., 2000).

Increased trade with the United States has driven the population boom on the Mexican side of the border. In 1965, Mexico established the Border Industrialization Program that allowed foreign (predominantly U.S.) firms located in Mexico to import production inputs duty-free to assemble manufactured goods for re-export. These assembly plants, or *maquiladoras*, were originally required to operate within 12 miles of the U.S. border and allowed U.S. firms access to low-cost Mexi-

can labor. Critics have also argued that they allow U.S. firms to avoid environmental regulations and taxes to support local infrastructure (e.g., Johnstone). Maquiladoras employ 43 percent of Nogales, Sonora's workforce (Ingram et al., 1994).

The economies of both cities are highly integrated. Residents shop and conduct business across both sides of the border. Police, firefighters, and paramedics frequently cross the border to respond to emergencies. Nogales is a major port of entry for Mexican exports to the United States. Nearly half of Mexico's winter vegetable exports to the United States pass through Nogales. Visitors from Mexico account for about two-thirds of retail sales receipts in Santa Cruz County's (Nogales, Arizona, is the county seat). Sales taxes, in turn, account for over half of the revenues of the city of Nogales, Arizona (Ingram et al., 1994).

WATER SUPPLIES

Ambos Nogales lies in a valley that runs north to south and is bisected by the border. At the southern, Mexican side of the valley, the hills are higher and quite steep. Both cities rely on ground water supplies that are replenished by the Santa Cruz River and its tributary, the Nogales Wash. The Santa Cruz originates in Arizona, 20 miles east of Nogales. It flows south into Mexico, then loops west and north back in the United States, five miles east of Nogales (Figure 1). The Nogales Wash originates in Sonora, flows north through the very center of Ambos Nogales and runs into the Santa Cruz, just upstream of the International Waste Water Treatment Plant 9 miles north of the border. Average rainfall in the area is about 14 inches, with more than half occurring during monsoon rains in July and August. While the Santa Cruz is mostly perennial in Mexico, it is ephemeral on the U.S. side of the border. Except during storms, the stream channel is usually dry two miles north of the border. Treated effluent from the International Treatment Plant creates a perennial stream flow for a 12-mile stretch of the Santa Cruz.

Nogales, Sonora, obtains 45 percent of its water from shallow well fields east and southeast of the city. These wells can run dry in drought years, leaving residents vulnerable to water shortages (Ingram and White, 1993). Additional water is now piped in from ground water wells in the Los Alisos basin 20 miles south of the city. The Los Alisos well fields currently supply 40 percent of the city's water, but this source may not be renewable. There is evidence that this aquifer is not being significantly recharged by rainfall (Morehouse et al. 2000). The remaining 15 percent of the city's water supply come from urban wells near the Nogales Wash. This water is treated as a reserve supply because of its poor quality. Leaks and breaks in sewage and potable water pipes feed the Wash. Monitor wells on the Nogales Wash were found to have elevated levels of trycloroethylene (TCE), tetrocholoroethylene (PCE), and fecal coliform (Arizona Department of Public Health, 1993; Morehouse et al., 2000; Sprouse et al., 1996).

Provision of water infrastructure and other public services has not kept pace with population growth in Nogales, Sonora. Many residents live in *colonias*, undeveloped settlements generally lacking the most basic services. These settlements have grown up steep hillsides. Only 39 percent of the population receives water 24 hours a day, while 15 percent are not connected to the system at all. Residents outside the system either tap into it illegally or purchase water from tank trucks (Liverman et al,1997; Morehouse et al.,2000; Ingram et al.,1994). The poorest residents, who often live higher up on the hillsides, must make frequent purchases of small quantities of water, even purchasing it by the gallon in U.S. grocery stores. Per capita water consumption in Nogales, Sonora is roughly 40 gallons per person per day, one-fifth of per capita water consumption in Nogales, Arizona.

Arizona's major source of water is a well field between the border and the International Treatment Plant. The storage capacity in this well field is limited and the water table can drop quickly in drought years; but unlike the Sonora wells, these have never actually run dry. A second well field northwest of the city has deeper wells that are less sensitive to changes in rainfall. A cone of depression has recently formed around these wells, however, indicating that overdrafting is occurring (Morehouse, et al., 2000).

Nogales, Arizona, lies within the larger Santa Cruz Active Management Area (AMA) that surrounds the Santa Cruz river basin and runs from the U.S. - Mexico border in the south to just beyond the border of Santa Cruz and Pima Counties to the North. Arizona's Ground Water Code requires the establishment of AMAs in areas with high potential for ground water overdrafting. The Santa Cruz AMA (SCAMA) is administered by the Arizona Department of Water Resources (ADWR) office in Nogales. ADWR is tasked with maintaining a “safe-yield condition” (i.e. no secular decline in the water table). ADWR has authority to regulate well operators and water providers and may prohibit new irrigated agricultural use, license new wells, establish well spacing rules, and impose mandatory conservation requirements. The Ground Water Code also gives the SCAMA office authority to require subdivision developers to demonstrate the availability of drinking-quality water supplies for 100 years for any new developments.

The treated effluent from the International Treatment Plant plays an increasingly important role in ADWR's plans to maintain safe-yield conditions in the SCAMA. From 1992-1995, treated effluent from the plant accounted for 38 percent of the total inflow into the SCAMA and 47 percent of renewable supply (total inflow minus uncaptured underflow leaving SCAMA) (Morehouse, et al.). The treated effluent, placed back in the Santa Cruz River streambed, has also created a riparian habitat that supports local and migratory bird populations. The U.S. Fish and Wildlife Service is currently investigating whether the yellow-billed cuckoo that resides in the riparian area should be considered for designation as a threatened or endangered species under the Endangered Species Act. Likewise, populations of Gila topminnow are under consideration for endangered species listing. From 1992-95, maintenance of stream flow for the riparian area accounted for 57 percent of water use in the SCAMA.

The International Treatment Plant treats wastewater from both Nogales, Sonora, and from Nogales, Mexico. About 70 percent of the untreated wastewater comes from Mexico, and by treaty, Mexico has the right to retain or recapture the effluent. If Mexico were to retain its effluent, it would become more difficult to maintain the riparian habitat in Arizona in dry years. Thus far, it has proven prohibitively expensive for Mexico to construct a system to pipe the effluent uphill back to Sonora. Mexico has expressed a desire to construct a new treatment plant on its side of the border in order to capture the effluent for irrigation or industrial use. The United States has opposed this idea, expressing concern that Mexico would not construct a large enough facility or maintain it sufficiently to prevent deterioration of U.S. water supplies. Maintaining continued access to the Mexico's share of the treated effluent is also an important U.S. consideration (ADWR; GUAC).

WATER QUALITY

On the Mexican side of the border, thousands of residents live without sewer connections or garbage removal services. Roughly 20 percent are not connected to the municipal sewer system. Out of this percentage, half use septic tanks, a third use simple latrines, and the remainder dispose of waste into the streets or open environment (Ingram et al., 1994). During the heavy monsoon rains of July-August, raw sewage flows down hilly terrain into the Nogales Wash through the center of Ambos Nogales and through neighborhoods on both sides of the border (Ingram & White, 1993; Varady et al., 1995).

Aside from imposing obvious health risks to Sonoran residents, untreated flows from leaking pipes and storms impose externalities on residents of Nogales, Arizona. In July of 1990, flooding and broken sewer lines led to fecal coliform levels in the Santa Cruz River and Nogales Wash reaching from 8 thousand CFU / 100 ml, double the Arizona regulatory standard of 4 thousand CFU / 100 ml. In August, readings shot up to 1.6 *million* CFU / 100 ml after a Sonoran sewer line ruptured. In 1991, levels of cyanide and mercury, exceeding EPA limits were detected in the Wash (Ingram and White, 1993). Giardia, cryptosporidium, parasites, petroleum, and heavy metals have also been detected in the Wash (Varady & Mack, 1995). Following heavy rains in 1990, VOC levels were found to be so high that the county government declared a health emergency (Sprouse et al., 1996). In 1994, 2,000 residents had to be evacuated from the downtown because the dumping of petroleum products into the Nogales Wash produced potentially explosive fumes (Varady et al., 1995).

Some of these contaminants have also shown up in the ground water of the underlying Santa Cruz Basin aquifer, the primary source of drinking water in the area. All but one of the public water systems serving Santa Cruz County, Arizona, is either classified as small (serving 1,000 – 3,300 persons) or very small (serving fewer than 1,000 persons) (Sprouse et al., 1996). The rapid growth of population and pollution just south of the border has stressed these small systems' abilities to meet requirements of the Safe Drinking Water Act (SDWA). Seven of the water systems have been found in non-compliance with the SDWA because of bacterial contamination and one was found in non-compliance because of nitrate contamination (Sprouse et al., 1996). Ground water samples have also found levels of VOCs in excess of SDWA standards (Hayes, 1996).

HISTORY OF WATER CONFLICTS AND NEGOTIATIONS

There are five salient features of water resource management in and around Ambos Nogales that frame the debate over the future of water use in the area. The first is the importance of transboundary externalities, namely water pollution flowing from Sonora into Arizona. Second, is the large difference in incomes and economic resources available to the United States and Mexico to address water availability and pollution problems. Third, while representatives and citizens of both cities have historically expressed interest in developing a joint municipal water system, this has been hampered by a lack of agreement on broader border water issues between the U.S. and Mexico at the federal level. These issues include apportionment of surface flows of the Santa Cruz River and transboundary aquifer management. Fourth, the U.S. federal appropriations have funded and continue to fund the major part of municipal wastewater collection and treatment for both Nogales,

Arizona and Sonora. Residents and industry on both sides of the border have avoided paying the full costs of municipal wastewater collection and treatment. Fifth, wastewater has been transformed from being just an environmental "bad" to being an important good. Treated effluent from the international treatment plant has become an increasingly valuable resource as population and water demand grows on both sides of the border. The contribution of the treated effluent to riparian ecosystem function has also received increasing recognition in water policy debates.

1930s and 1940s

Active involvement in water management of Ambos Nogales by the U.S. and Mexican federal governments began in the 1930s in response to flooding. The International Boundary Commission (IBC), a joint U.S.-Mexico water engineering commission, recommended a series of flood control conduits and channels. Federal funds were provided jointly by the United States and Mexico for flood control infrastructure on both sides of the border. These flood control measures also increased the flow of water and pollution over the border into Arizona.

In 1944, a Water Treaty between the United States and Mexico that apportioned the Colorado and Rio Grade Rivers also established the International Boundary and Water Commission (IBWC) as the successor of the IBC. The IBWC is made up of U.S. and Mexican Sections. The jurisdiction of the IBWC is specific and narrow, extending only to water management problems that are binational. The Commission is primarily a technical agency staffed by engineers, and focuses on scientific appraisals and engineering solutions to water management problems. Initially, the Commission focused on surface water supply and infrastructure issues. But growing population pressure and pollution in Ambos Nogales and elsewhere on the border has drawn the Commission's attention increasingly toward water sanitation problems (Frisvold & Caswell, 2000).

A 1946 Arizona State Engineer's report to the IBWC chronicles the beginnings of water pollution problems in Ambos Nogales (Ingram & White, 1993). The report stated that the two cities should be considered a single community from a public health perspective. The main source of water to both towns was the Nogales, Arizona, water plant that served the entire Arizona side as well as downtown businesses and some residences on the Sonora side. Many of the Sonora customers were also connected to a wastewater treatment plant on the Arizona side. The engineer noted that sewage from Sonoran households without connections were draining directly into the Nogales, Arizona, and warned that expansion of ground water pumping and delivery systems in Sonora would increase the flow of liquid wastes with negative consequences for public health. Cases of typhoid and dysentery had already been reported in Santa Cruz County, Arizona. The report also noted that the Arizona Department of Health had advocated "a single sewerage system and disposal plant (for the entire town) which would efficiently and economically handle the situation (Ingram & White, 1993)." Here, the "entire town" meant both Nogales, Arizona and Sonora.

City officials in Nogales, Arizona, went straight to the Arizona Congressional Delegation and the IBWC to obtain federal funds for expanding sewage collection and treatment capacity in Ambos Nogales. The result was an IBWC designed project to extend more sewage collecting lines into Mexico that would feed, along with lines on the Arizona side, into a new treatment plant located two miles north of the border. Because the slope of the topography went from Sonora to Arizona, it would be cheaper and more effective to have the collection system drain northward. The construction costs were to be borne equally between the U.S. and Mexican Sections of the IBWC, funded through federal appropriations by each government. The new plant was completed in 1951. Originally the cities were to split the costs of plant operation and maintenance in proportion to each city's share of effluent produced. Senator Carl Hayden of Arizona, however, was able to pass legislation providing partial federal funding for Nogales, Arizona's obligation.

1950s to 1990s

In the 1950s, Nogales, Arizona, residents became concerned about the potential impact of ground water pumping and diversions of the Santa Cruz by Mexico on the future of their own water supplies. Both cities expressed interest in a treaty that would allow for a common ground water withdrawal and distribution system for residents and business on both sides of the border. There are a number of advantages for both cities in developing a common system. Arizona has ground water wells that are deeper, less sensitive to drought, and less vulnerable to contamination from sewer pipe leaks and raw sewage flows. Flood control and pollution prevention measures (such as improved sewerage or pretreatment of industrial wastewater) can be more effectively taken upstream in Mexico.

While the two cities may have desired broader binational cooperation, the U.S. Section of the IBWC was less enthusiastic. There has yet been no agreement between the two nations over the apportionment of the waters of the Santa Cruz River. In the 1950s the United States was using over half the water in the Santa Cruz

River watershed, even though a third of water came from the United States. The U.S. Section recommended against negotiating with Mexico over water supply, instead suggesting either the construction of a pipeline to divert the waters of the Santa Cruz before they entered Mexico or building a dam near Nogales, Arizona to capture and store flood waters. At that time, the IBWC dealt primarily with surface water projects. The Commission was not given authority to negotiate over transboundary ground water management until 1973, with the signature of Minute 242. Even now, the Commission has yet to begin such negotiations (Mumme, 1993).

Without support at the federal level, the two cities did not proceed with more comprehensive water resource planning. Nogales, Arizona had also grown accustomed to the IBWC providing engineering expertise and financial support for the continued operation of the treatment plant. Mexico's legal system limits the ability of local governments to issue bonds against user fees or real estate taxes. Financing of such projects was decided at the federal level in Mexico City (Liverman et al., 1999).

Growth in population, ground water pumping, and water pollution in Sonora led to a series of public health crises and to expansion of treatment facilities on the Arizona side. By 1958, the capacity of the international treatment plant was regularly exceeded, with raw sewage flowing into the Nogales Wash. In 1963, the U.S. Section finally recommended construction of a new treatment plant. The U.S. wanted to construct a new plant, located nine miles north of the border to treat both U.S. and Mexican wastewater. Mexico preferred a more modest expansion of the current plant closer to the border. The two countries did not agree on the plan and cost apportionment of the project until 1967 and the plant was not operational until 1971. Mexico was in less of a hurry to deal with external costs affecting the United States, particularly as they had their own concerns about the salinity of Colorado River water flowing into Mexico. The plant was eventually constructed nine miles north of the border just downstream from the confluence of the Santa Cruz and the Nogales Wash. About 54 percent of construction funds came from U.S. federal appropriations (from the IBWC and the EPA). Mexico paid 29 percent, an amount equal to the cost of the plant expansion at the existing site. Nogales, Arizona paid for the remaining 17 percent (Ingram & White, 1993).

By 1976, plant capacity was again exceeded, leading to another round of public health concerns and protracted negotiations. The U.S. Section of the IBWC wanted to expand the existing facility. The Mexican Section wanted to build a facility on its side of the border. The Mexican Section was coming to appreciate the value of effluent leaving the treatment plant. The U.S. Section was concerned that a plant constructed on more hilly terrain at the wider part of the valley in Sonora would not be of sufficient scale and operated and maintained adequately to prevent continued sewage spills in the United States. These concerns were well founded. At the time, San Diego, California, was suffering from uncontrolled sewage flows emanating from Tijuana, Mexico (Frisvold & Caswell, 2000). The U.S. IBWC engineers recommended a gravity flow collection system with a large, main treatment plant located downstream in San Diego. The United States insisted that Mexico pay half the cost of the $730 million project that would primarily benefit San Diego. Instead Mexico acted unilaterally, building a smaller system on its side of the border. The capacity of this plant was soon exceeded and both sides eventually agreed on a larger design.

From the U.S. perspective, a plant in Nogales, Sonora, would capture effluent that could otherwise be used by the United States in dry periods, but would be overrun with sewage during wet periods. They did not want to see a repetition of the Tijuana-San Diego debacle. From Mexico's perspective, they had (and still have) a legal right to retain or reclaim their share of the effluent coming out of the International Treatment Plant. But the plant's location, nine miles downhill from the border makes pumping it back prohibitively expensive. An agreement was finally reached in 1988 with U.S. EPA and U.S. Section of the IBWC contributing 66 percent to construction costs; Nogales, Arizona, 26 percent; and Mexico, 8 percent (Ingram & White, 1993).

Sewage crises have continued throughout the 1990s, with greater attention also paid to levels of hazardous industrial wastes entering the U.S. water supply. In each case, the response has been reactive, limited engineering solutions. These have included a temporary dam to store contaminated water, placing chlorine granules in the Nogales Wash, and successive expansions of the International Treatment Plant.

Economic and Environmental Significance of Effluent

As noted at the outset, both Mexico and the United States have a growing appreciation of the economic and environmental benefits of the treated effluent from the International Treatment Plant. Water supplies in Arizona's Santa Cruz Active Management Area (SCAMA) are vulnerable to drought. ADWR has determined that SCAMA is currently under "safe-yield conditions" - conditions are not generating a secular decline in the water table. Yet, the storage capacity in the aquifers is limited, so the water table drops significantly in drought years, and recharge and draw down are asymmetric. If

wet years follow in succession, the aquifers may not be able to absorb much additional water in the second year. Unlike other areas of the state (notably Tucson and Phoenix), the area does not have infrastructure to deliver surface water from the Colorado or other rivers to the area.

Currently the largest demand on the system is maintenance of the riparian area. If Mexico were able to retain or reclaim their share of the treated effluent from the International Treatment Plant, maintaining current streamflow in the Santa Cruz River would require drastic cut backs in agricultural, industrial, or municipal consumption to prevent overdrafting in drier years. Drawing down the water table in dry years needn't imply a secular decline in the water table. The ADWR is currently developing a dynamic hydrologic model to assess the impacts of changes in these flow variables (including loss of Mexican effluent) on the long-term stock of ground water. Planning and modeling to date, however, have not included much explicit consideration of water supplies and use on the Sonoran side of the border.

A number of interest groups in Santa Cruz County, Arizona, are interested in acquiring more permanent property rights over Mexico's share of the effluent. Environmental groups such as the Friends of the Santa Cruz River want assured streamflow to maintain the riparian habitat (Morehouse et al., Ilich and Varady). Currently, because Mexico owns 70 percent of the effluent, this water cannot be used in calculations of 100-year assured water supplies. Thus, the fact that SCAMA doesn't own the water constrains the amount of development that will be permitted in the area. Developers and ADWR anticipate growth in the retirement community of Rio Rico (located between Nogales and Tucson) to grow from 9,000 in 2000 to over 23,000 by 2025 (ADWR). Other current water users in the SCAMA would like to avoid loss of the Mexican effluent because this would likely induce ADWR to impose conservation requirements. As in the past, local interests in Santa Cruz County are looking to the federal government. This time they would like the federal government to provide funds to acquire the water from Mexico (GUAC).

Mexico has in fact discussed options for retaining the effluent. Options include constructing a new treatment plant in Sonora and diverting the effluent for irrigated agriculture and industrial use. Another proposed project would allow the current amount of effluent to flow to the International Treatment Plant, but construct a plant to capture effluent from future water use in Nogales, Sonora. Nogales, Sonora's population is projected to grow by another 139,000 by 2018. Water users in Arizona have an interest in not only the existing flow into the International Treatment Plant, but would also like acquiring the rights to this additional effluent. This is seen as a means to address the competing demands of preserving the riparian area and providing water for development. Mexico has discussed the possibility of building an electricity generating plant that would make use of wastewater that would otherwise flow to Arizona. Some business interests have floated plans to build the electricity plant on the Arizona side, keeping the effluent and selling electricity primarily to Sonora (GUAC). Mexico has also proposed doubling its current ground water pumping, which could have additional impacts on the aquifers in Arizona (Liverman, et al., 1997).

The current state of affairs is this: Mexico owns its share of the effluent, but doesn't control it. The United States controls the effluent but doesn't own Mexico's share of it. At the local level, both sides are waiting to see if U.S. federal appropriations might create incentives for some sort of permanent sale. In the meantime, environmental groups see the current impasse, blocking the speed of development and diversion of stream flow, as a good thing. Yet they worry about the environmental consequences of Mexican proposals to retain the effluent.

PROJECT PLANNING AND FINANCING IN THE POST-NAFTA ERA

In response to objections by environmental groups to the U.S.-Mexico North American Free Trade Agreement (NAFTA), both nations established the Border Environmental Cooperation Commission (BECC) and the North American Development Bank (NADBank). The NADBank arranges financing of water and municipal solid waste projects within 100 km of the international border. These projects must be certified by the BECC based on environmental, technical feasibility, and financial criteria.

The IBWC has responded to border sanitation problems after they arise. As a scientific-engineering agency, they have focused on engineering, structural solutions. The agency has neither the mandate nor the expertise to address problems of market failures or incentive problems that lead to water pollution crises in the first place. Firms located on the border have not had to pay the full social costs of their production and release of industrial wastes into water bodies. A second problem is the lack of financing for water infrastructure to support the rapidly growing workforce on the Mexican side of the border. Historically, firms have not paid by way of user fees or taxes to finance safe drinking water or sewer systems for the growing workforce. Labor continues to flock to the border despite the lack of public services because wages in the border region are much higher than in Mexico on the whole. Mexico's legal system does not allow local municipalities to issue bonds against user fees or property taxes. Even on the U.S. side of the border, local mu-

nicipalities pay only a fraction of the cost for local water treatment infrastructure. Instead, as in the case of Nogales, San Diego, and other border cities, they have relied on periodic federal bailouts to deal with public health emergencies. As a consequence, because cities and businesses on both sides of the border are not paying the social costs of border growth, population and sewage growth has outstripped local infrastructure.

NADBank's purpose is to help border communities with long-term funding of water and solid waste projects. Border cities are limited in their abilities to self-finance water infrastructure. Because of risks associated with these investments, it is difficult to obtain long-term financing through international markets. Capitalized by both the Mexican and U.S. governments, NADBank can secure financing at lower commercial rates than border communities could otherwise obtain for commercial loans. NADBank also uses funds to leverage other private loans and grants that communities may not otherwise be able to secure. The NADBank is a bank, not a grant agency. Water projects must be able to repay loans, raising funds through user fees or other mechanisms.

BECC must certify projects before the NADBank may finance them. The BECC certification criteria include project impacts on human health and the environment, technical and financial feasibility, project management, community participation, and sustainable development. The BECC also provides technical assistance for local entities developing proposals, analyzes environmental and financial aspects of projects, and helps arrange public financing for projects.

In the first two years of BECC-NADBANK operation, no BECC certified projects secured NADBank funding, primarily because projects were not meeting NADBank's financial criteria. NADBank found projects lacking in five areas: (a) insufficient community resources for high cost projects; (b) lack of master plans and inadequate proposal preparation; (c) limited financial, administrative, and commercial capabilities of local water agencies; (d) inadequate revenue for the sound operation of existing systems and resistance to charging / raising user fees; and (e) lack of private sector involvement in environmental projects.

Given the history of financing of border water projects, these problems should be of little surprise. The level of growth and development on the border has been fostered by a no or low-user fee environment for several years. The pace of growth is much greater than it would have been had projects been funded on a "pay as you go" basis. Internalizing externalities after high population densities and pollution problems have been reached entails high adjustment costs. In addition, communities on both sides of the border have grown accustomed to receiving federal funding for federally planned water projects, albeit sporadically and in response to crises.

To address the problems of transitioning to a more locally self-financing system, the U.S. EPA and NADBank established the Border Environmental Infrastructure Fund (NADBank, 1998). The fund receives and administers grants that may be combined with loans or loan guarantees. Grants may support municipal infrastructure, drinking water treatment plants, and treated water distribution systems. Funds may be used to allow user fees to be phased in over time.

Since 1995, the BECC has certified 40 projects receiving funding or commitments of funding of more than $1 billion. The BECC has earmarked more than $20 million dollars in grants for technical assistance to aid communities move projects through certification. Water project development throughout the border area is now proceeding in a more coordinated and proactive manner. Investments are being made before crises emerge and projects are being developed with more considerations of long-term needs in mind.

Yet, the goal of developing locally self-financing municipal water systems on both sides of the border has remained elusive. The United States and Mexican governments have contributed $152 million each in paid-in capital to the NADBank. Combined with callable capital, this adds up to a lending capacity of roughly $2 billion (Reed, 2000). NADBank has approved financing for 29 projects, but loans account for a small fraction of project financing. While NADBank has approved $265 million in loans and grants, $253 million, over 95 percent, of this has been BEIF grants. Actual loans account for less than 5 percent of financing (Reed, 2000). While U.S. borrowers could obtain loans at rates lower than taxable municipal bonds, NADBank rates are higher than rates available through the State Revolving Fund or tax-exempt municipal bonds, which are subsidized. (For additional discussion of interest rate charges and demand for NADBank loans, see U.S. GAO, 2000). Since 1994, the U.S. federal government has provided $2.02 million for border infrastructure spending, 65 percent of the total. Mexico has provided $0.65 million (21 percent) and U.S. border states $0.45 million (14 percent) (U.S. GAO). The EPA accounts for more than half of U.S. federal appropriations. In short, EPA (via BEIF) continues to be the major source of funding for water projects on both sides of the border.

Problems of instituting local self-financing of projects continue in Ambos Nogales as well as elsewhere along the border. A new BECC-NADBank approved project to upgrade the International Treatment Plant is projected to cost $46.1 million. Over 85 percent of the funds will come from EPA, via BEIF grants. Arizona users have

accepted proposed fee increases. Yet, given population and per capita water use projections, the increase in fees, even after being fully phased in, would bring in less than $2 million per year.

In 1996, the BECC received substantial criticism when it provisionally certified the Acuaférico project for Nogales, Sonora, without requiring specifics about the user fee structure planned to finance the project (Milich & Varady, 1999). The ambitious $39 million project claims to provide "uninterrupted service to 100 percent of the population." The project would upgrade the existing water distribution system that has over 7,000 leaks per year and connect households to both the delivery and wastewater treatment system. The project would also establish a metering and billing system to charge for water services. Various NGOs complained that certification was premature for equity and environmental reasons. One concern was that the poor would bear an undo share of the project's costs. Some groups advocated a block-pricing scheme that would shift a higher proportion of the costs to maquiladoras and other high volume users. Environmental groups expressed concern over the potential impact of further ground water pumping and potential loss of effluent on the riparian area in Arizona. The latest version of the project announces "micro-scale" metering for medium and high volume users. The project would rely on additional ground water supplies from interbasin transfers rather than tapping further into the Santa Cruz Basin aquifer. By reducing leaks, the plan would improve capture in Sonora and reduce the amount of wastewater flowing to the International Treatment Plant. A contract for the operation and maintenance of the system has been awarded, but contract negotiations are ongoing. It remains to be seen what the user fee structure will look like, what public reaction will be, and if the system can operate in a self-financing manner. As with other projects, direct grants are providing a substantial share of the project funds.

CONCLUSIONS

New institutions created to address environmental concerns over NAFTA have helped both nations plan, build, and finance new facilities in a more coordinated and proactive manner. The BECC certification process has allowed discussion of border water problems to expand beyond simple engineering responses to sanitation crises to broader consideration of incentives and long-term investment needs. In Ambos Nogales as elsewhere along the border, project development is more forward-looking than 10 years ago.

The goal of developing locally self-financing municipal water systems on both sides of the border has remained elusive, however. Grants from EPA's Border Environmental Infrastructure Fund (BEIF) (and other U.S. federal agencies) continue to be the primary vehicle financing new investments. The sustainability of this practice may be in doubt as enthusiasm by the U.S. Congress for BEIF funding is declining, despite continued rapid growth in the region (GAO).

Recent U.S. government proposals, embodied in the recent U.S. GAO Report and EPA, U.S. State Department and Treasury Department responses (U.S. GAO), to enhance public and private investment in border water infrastructure call for "a strategic plan" and setting of "milestones" to monitor accomplishments. Yet much data has already been assembled documenting shortfalls in wastewater collection and treatment infrastructure.

Ongoing policy discussions, at least among U.S. government agencies, continue to treat border water problems as primarily infrastructure and engineering problems. Noticeably absent is any consideration of linkages between water quality and quantity. The historical example of Ambos Nogales demonstrates that questions of water quality and quantity cannot be easily separated. Indeed, pervasive disagreements of over quantity issues remain a key impediment to resolving water quality problems. Important missing considerations are relationships between water quantity and quality and management of transboundary aquifers. Brown and Mumme (2000) have recommended establishing Binational Water Councils that would negotiate and plan water management on a local watershed basis. To date, however, U.S. agencies have remained wary of linking negotiations over border water sanitation to broader water quantity and allocation issues.

The United States has financed border water projects to mitigate transboundary externalities. The historical example of Ambos Nogales and other border metropolitan areas reveals that this has created perverse incentives. By financing water distribution and wastewater collection and treatment infrastructure in Mexico, the United States has improved public services, albeit unevenly, for the local workforce. By doing so, it has subsidized the location of industrial plants and the accompanying workforce, near the border. This subsidization has spurred further growth that has led to further spending on sanitation infrastructure, and further growth. The controversy over the Acuaférico project in Nogales, Sonora, demonstrates that breaking this cycle will be difficult. If projects are to be locally self-financing, what are appropriate user fees to charge households versus maquiladoras? To what extent will local municipalities in Mexico be given authority to retain locally the fees that are charged? Recent political changes in Mexico point to greater decentralization of decision-

making, but the question of who in Mexico can or will pay for future investments in water infrastructure remains uncertain.

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ENDNOTES

[1] Transboundary externalities are bi-directional. For example, U.S. practices affect the level and salinity of Colorado River water received by Mexico. U.S. proposals to line the All-American Canal in California would affect ground water availability in Mexico's Mexicali Va lley.

FIGURE 1. The upper Santa Cruz and Los Alisos watersheds.