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Cleaning up the United State-Mexico Border: North American Development Bank's Efforts to Close the Wastewater Infrastructure Gap

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Abstract

The North American Development Bank (NADBank) was established in 1994 to "cleanup" the border region, which was characterized at the time as an open sewer. This research examines NADBank's cleanup efforts to date by analyzing data from published reports, articles, and archival records using descriptive statistics and geospatial analysis. Overall, NADBank has provided almost $760 million in loans and grants to support the implementation of 133 wastewater infrastructure projects that have a total construction cost of $1.9 billion. Although a substantial investment, these projects have not fully addressed the wastewater infrastructure needs of the border, estimated in 1993 to be between $4.3 and $6 billion. However, these infrastructure projects have resulted in some tangible improvements in water quality in major transboundary rivers. Unfortunately, the border region continues to be plagued by discharges of raw sewage and additional investment in infrastructure and institutional capacity is needed to fully resolve the problems.

Introduction

In 1990, the American Medical Association characterized the United States (U.S.) - Mexico border region as a "virtual cesspool and breeding ground for infectious diseases", due in large part to the lack of adequate systems to collect and treat sewage in communities on both sides of the border (American Medical Association, 1991, p. 3320). The lack of infrastructure at that time, most border communities in Mexico as well as colonias in the U.S. Border States discharged untreated sewage to nearby surface or ground waters, which were often also used as sources for drinking water (Inadequate Water Supply, 1988). At the same time, the border region experienced higher rates of gastrointestinal diseases than in non-border regions (Inadequate Water Supply, 1988). Although the presence of untreated sewage is one of several factors that contributed to these poor public health outcomes, it was frequently cited as the dominant factor and by the early 1990s, there were increasing demands to remedy the deplorable border conditions as they were widely publicized at the national level.

Historically, the U.S. and Mexico had struggled to address the dire environmental and public health conditions in the border region due to a lack of funding, weak binational institutions, and low prioritization by each country (Mumme & Collins, 2017; Gilbreath Rich, 1991; Liverman et al., 1999). That all changed, however, in the early 1990s when the North American Free Trade Agreement (NAFTA) was proposed and cleaning up the border region became a political imperative to ensure passage of the agreement. Out of political necessity, the U.S. and Mexico created two binational agencies, the Border Environment Cooperation Commission (BECC) and North American Development Bank (NADBank), to develop and fund wastewater systems, as well as drinking water systems and municipal landfills, in the border region. It was estimated at that time the investment needed to attain internationally acceptable standards for wastewater infrastructure alone was $4.3 to $6 billion for the 10-year time period from 1993 to 2003, by far the largest investment needed by any infrastructure sector (United States-Mexican Border Environment Agreement, 1993; U.S. General Accounting Office, 2000).

As of 2019, BECC had certified 133 wastewater infrastructure projects that had a total value of around $1.9 billion and NADBank provided or committed to provide around $760 million in grants and loans to support implementation of these projects. Although this is a considerable investment, it falls far short of meeting the full investment needs in wastewater infrastructure identified in the early 1990s for the border region and at present, untreated sewage continues to impact the environmental and public health of the border communities (Dougherty, 2018a, 2018b; Bravo, 2019; Stone, 2019; Caballero, 2019). The severity of the situation was elevated to the national political stage again in 2019 and the U.S. was compelled to approve additional funds for NADBank as part of the approval of the U.S.-Mexico-Canada Agreement, NAFTA's successor (Stecker, 2019). Despite the continued interest in cleaning up the border region, and in particular addressing the inadequate wastewater infrastructure, the work of the BECC and NADBank has received surprisingly little scrutiny over the years (hereinafter both institutions are referred to as NADBank, since BECC was subsumed by NADBank in 2018).

To address this gap in the literature, this article examines the performance of NADBank to date in fostering investment in wastewater collection and treatment systems in the border region as well as the available data on tangible environmental improvements that have resulted from this investment for a few areas along the border. Overall, based on this review, it appears that the wastewater infrastructure projects supported by NADBank have had a measurable impact on environmental health in the border region in some locations, but the benefits of the improvements will not be fully realized if the infrastructure is not adequately operated and maintained. This article is organized as follows: background on the general environmental and public health conditions in the border region is provided first, followed by a review of the wastewater infrastructure projects developed and funded by the NADBank, then a review of available data on changes in environmental conditions that might be attributed to these infrastructure projects in a few locales, and lastly, the conclusions drawn from the analysis and review.

Background on the U.S.-Mexico Border Region

The U.S.-Mexico border region, typically defined as an area within 100-kilometers (km) on each side of the U.S.-Mexico international boundary (La Paz Agreement, 1983) (see Figure 1), has for many years faced a myriad of environmental and public health challenges (U.S. Trade Representative, 1992; American Medical Association, 1991). The region experienced rapid economic development and urbanization from the 1940s onwards. However, this development was not accompanied by investment in basic urban infrastructure. There was a general lack of investment in drinking water and wastewater treatment plants, and municipal solid waste landfill in most municipalities in Mexico as well as colonias in the U.S. (Lorey, 1999; U.S. General Accounting Office, 1996). Other problems that plagued border communities were the improper disposal of hazardous waste from industries, extensive air pollution from unpaved roads, motor vehicles, smelters, brick and cement kilns, power plants, open burning of waste, and residential burning of non-traditional fuels (U.S. Trade Representative, 1992; Liverman et al., 1999; Sánchez, 1990).

Figure 1: U.S.-Mexico Border Region with Major Sister Cities

Map Source: Developed by author using ArcGIS

These various sources of pollution, many transboundary in nature, coupled with the low socio-economic status of many residents and limited access to healthcare, contributed to numerous public health risks in the border region (U.S. Trade Representative, 1992; USM BHC, 2020, AMA, 1990). Diseases such as Hepatitis A, cholera, shigellosis, salmonellosis, tuberculosis and amebiasis were notably higher than in non-border regions at the time (U.S. Trade Representative, 1992; Liverman et al., 1999; Inadequate Water Supply 1988; American Medical Association, 1990; Federal Reserve Bank of Dallas, 1996). Some of these diseases are waterborne and the most frequently cited route of exposure was consumption or use of water that had been contaminated with raw or partially treated sewage (U.S. EPA, 1996). In general, the linkages between untreated sewage and infectious diseases are well-established and the prevalence of waterborne diseases in the border region underscored the drastic need to improve the systems for collection and treatment of sewage in municipalities in Mexico and colonias in the U.S.

In Mexico in the early 1990s, most municipalities or cities had some level of wastewater collection, but almost all of these communities lacked adequate treatment systems. Wastewater collection coverage ranged from a low of about 40% in Ciudad Acuna and 47% in Matamoros to about 80% in Nogales and Mexicali (Liverman et al., 1999, p. 612). A few of the larger cities, such as Tijuana, Nogales, and Mexicali, had some wastewater treatment capacity, but not enough to treat all sewage collected, which was often only a portion of that generated in the cities (BECC, 1997a; International Boundary and Water Commission, n.d.1; U.S. Trade Representative, 1992), and often times the treatment systems that did exist were poorly maintained and operated (U.S. EPA, 1996). Many communities completely lacked wastewater treatment, such as Ciudad Juárez, the largest border city in Mexico in 1990 with about 850,000 residents, which did not have any wastewater treatment capacity at that time (U.S.EPA, 1996). As a result, about 22 million gallons per day (mgd) of raw sewage from the city was "collected and discharged to an open ditch without treatment", where it was mixed with irrigation water and used to irrigate field crops or discharged directly to the Rio Grande, a waterbody shared with the U.S. (U.S. EPA & SEDUE, 1991). Nuevo Laredo likewise completely lacked a wastewater treatment system and discharged 24 mgd of raw sewage per day into the lower Rio Grande (Inadequate Water Supply 1988) and similar situations existed as well in other border communities in Mexico (U.S. Trade Representative, 1992; U.S. EPA, 1996). Thus, on the Mexican side of the border, there was a well-established need for rehabilitation, expansion, and construction of wastewater collection and treatment systems.

In the U.S., hundreds of colonias, which are unincorporated, informal developments, similarly lacked adequate wastewater infrastructure. Estimates of the number of colonias in the border region and their resident populations are incomplete for the late 1980s or early 1990s, but limited surveys provide some indication of their extent and size, as well as available wastewater infrastructure. One early survey of colonias in Texas in 1987 assessed infrastructure needs in three counties (Hidalgo, Cameron, and Willacy) in the lower Rio Grande valley; this survey identified 435 colonias with a total population of about 71,000 persons (Texas Water Development Board, 1987, p. ii). All of these colonias disposed of sewage using on-site latrines or septic tanks, and in virtually all cases, the disposal method was considered inadequate (Texas Water Development Board, 1987, p. ii). Around the same time, a survey in the El Paso area identified around 68,000 persons living in 350 colonias in 1987, of which 78% disposed of their sewage onsite using septic tanks, outhouses, or illegal cesspools (Inadequate Water Supply, 1988). By the early 1990s, it was estimated that around 280,000 persons lived in 1,200 colonias in Texas, most of which were located in border counties (Schoolmaster, 1993, p. 325). Only about 1% of these colonias had adequate wastewater collection and treatment systems; most residents relied on cesspools or septic systems for sewage disposal (U.S. Trade Representative, 1992, p. 108). At that time, the investment needs for wastewater systems in Texas colonias was an estimated $500 million (Schoolmaster, 1993). In New Mexico in the early 1990s, an estimated 42,000 persons lived in colonias (USEPA, 1996). Although there were no studies of colonias in the border states of Arizona and California, colonias were present at the time and overall, there was a dire need for improved wastewater systems in all these communities.

The discharge of raw or partially treated sewage in Mexican municipalities and U.S. colonias along the border significantly impacted the quality of many surface or ground waters. These impacts were most apparent in the transboundary rivers, such as the Tijuana, Santa Cruz, New Rivers, and Rio Grande, which are major water sources and more extensively monitored (U.S. Trade Representative, 1992). High levels of fecal coliform or E. coli, indicating possible human fecal contamination, were frequently observed in these water bodies (Rio Grande Basin Assessment, 2002; Sanders et al., 2012; Setmire, 1984; ADEQ, 2018; Medoza et al., 2004). Raw sewage, however, was not the only source of pollution in many areas; other sources of pollution to these water bodies, such as the New River, included untreated industrial wastewater, drainage from solid waste landfills, and runoff from agricultural lands and animal feedlots (U.S. Trade Representative, 1992, p. 109; see also ADEQ, 2018). In addition to contaminated surface waters, however, ground waters were also impacted by the on-site discharge of sewage to cesspools or latrines (Inadequate Water Supply, 1988).

Although there is clear evidence that the discharge of raw or partially treated sewage adversely impacted water quality and that there was a higher prevalence of waterborne diseases in the border region, there is a lack of baseline data on the levels of waterborne diseases directly associated with this fecal contamination in the early 1990s. Anecdotal data indicates that the raw or partially treated sewage contributed to "chronic and acute infectious health problems such as gastroenteritis, dysentery, and cholera" on both sides of the border; health surveys in the U.S. showed that rates of infectious diseases and infant morbidity due to gastrointestinal diseases in the U.S. border region were significantly higher than in non-border regions (Liverman et al, 1999, p. 612; Doyle & Bryan, 2000, p. 1503; Inadequate Water Supply, 1988, p. 134). For example, in one community in Texas, a 1987 health survey revealed that two-thirds of the residents who were tested had been infected with Hepatitis A at some time in their lives (Inadequate Water Supply, 1988, p. 200). Border counties in Texas overall had a rate of infection for Hepatitis A that was three times the state average (FRBD, 1996, p. 12). Thus, it is not surprising that the American Medical Association (1990) characterized the border region as a cesspool and breeding ground for infectious diseases, which in turn gave rise to demands to clean-up the border region.

To date, there has been very limited research to assess the linkages between the projects developed and funded by NADBank and on-the-ground improvements in environmental and public health (see e.g., Giner, Vazquez, Vazquez, Balarezo, & Cordova, 2017; NADBank, 2016, 2019). This gap in the literature is due in large part to a dearth of geospatial data on environmental and public health conditions that can be correlated with wastewater infrastructure improvements. In general, there are some water quality data available for the border region, but historically, the U.S. and Mexico do not have binational efforts to monitor public health issues in the border region (U.S. Trade Representative, 1992; U.S.-México Border Health Commission, 2010). As such, this research only examines impacts to environmental conditions.

Methods

This research provides a compilation and review of the wastewater infrastructure projects developed and funded by NADBank within the U.S.-Mexico border region to assess the extent to which this investment has closed the gap in wastewater infrastructure over the past 25 years. The research also examines readily available data on improvements in environmental health, in particular ambient water quality that might be attributed to this investment in wastewater infrastructure. Data sources are primarily published reports, articles, and archival records, including project certification documentation from NADBank, and the data are analyzed using descriptive statistics and geospatial analysis.

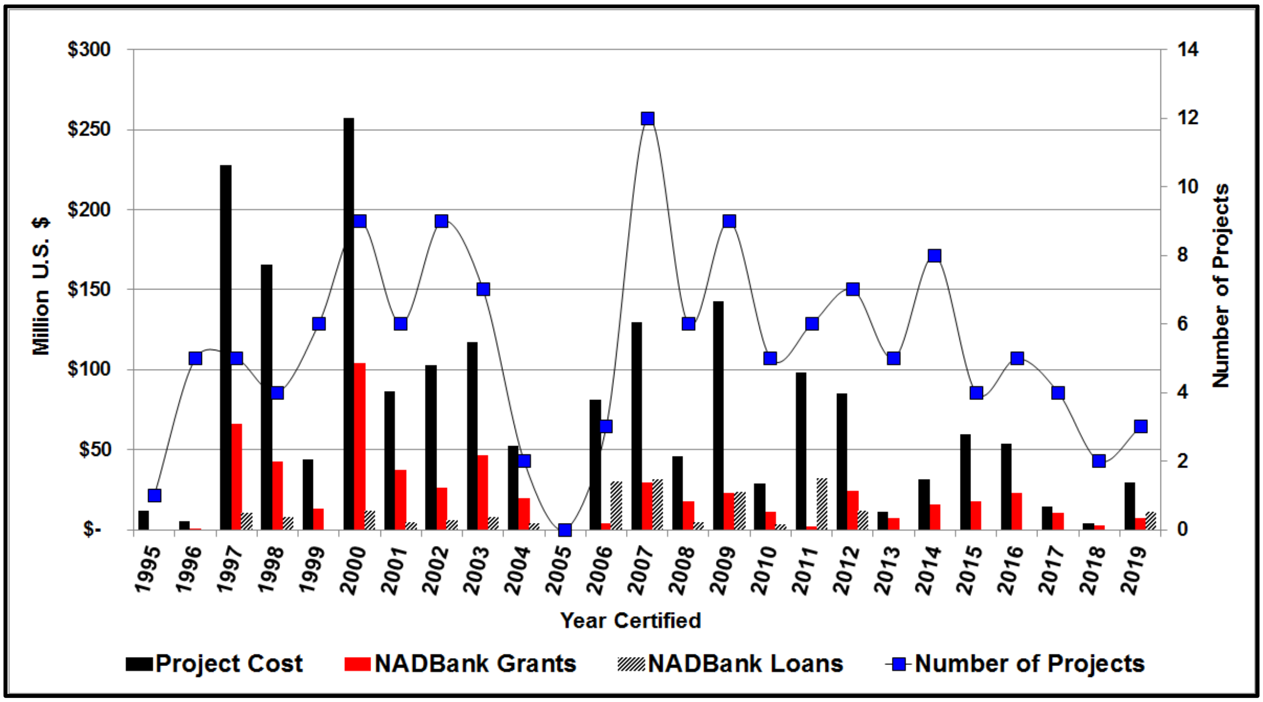
NADBank Supported Wastewater Projects

Between 1994 and 2019, NADBank certified 133 wastewater infrastructure projects within the border region, which for NADBank is defined as the area within 100 km on the U.S. side of the international boundary and 300 km on the Mexican side of the boundary (Agreement Between, 2004). Of these projects, 117 have been completed while 16 are still being implemented; the total estimated construction cost for the 133 projects is around $1.9 billion (NADBank, n.d.). To support implementation of these projects, NADBank has provided or committed to provide around $760 million in grants and loans; the remaining funding is provided by the local, state, and federal governments or private concessionaires that operate the wastewater systems (NADBank, n.d.). Overall, the number of projects and associated total project costs and levels of NADBank financial assistance have varied over time as well as across states. The following discusses the temporal and geospatial variations in more detail, as well as an overview of the improvements from all wastewater projects collectively and a detailed discussion of improvements in a few communities along the border.

Temporal Analysis

On average, NADBank has certified five wastewater infrastructure projects per year with the actual number of projects certified ranging from zero in 2005 to 12 in 2007 (see Figure 2). There have been a few periods of time when the annual number of projects certified has been low, including in 1995 shortly after NADBank was set up, and from 2004 to 2006 and 2018 to 2019, when major institutional reforms were being implemented by NADBank. Aside from these few time periods, NADBank has consistently supported wastewater infrastructure projects over the years. However, these wastewater projects vary in terms of their size and complexity. In general, project scopes can vary from a relatively small project that entails the rehabilitation or expansion of a wastewater collection system in a small community to a very large project that consists of the construction of an entirely new wastewater collection and treatment systems in a major city. As such, the construction costs of these projects and the levels of financial assistance provided by NADBank have varied notably over time depending on the composition of the project portfolio for a particular year (see Figure 2).

Figure 2: Number of Wastewater Projects, Project Costs, and Financial Assistance by Year Certified (n=133)



Source: Data from NADBank. (n.d).

Comparing the distribution of the number of projects over time to the project costs and levels of financial assistance from NADBank reveals that more costly projects were certified and funded during the early years of NADBank operation; the total project costs have generally been lower since about 2000 and steadily decreasing since about 2010. At the same time, the grant funds provided to these projects have been decreasing since the mid-2000s. Almost every wastewater project has received grant funds from NADBank's Border Environment Infrastructure Fund (BEIF) since it was established in 1997 (NADBank, n.d.). The BEIF grant funds have been provided by the U.S. government for wastewater (and water) projects; up through 2019, around $720 million had been provided to NADBank, however, the level of this funding has decreased precipitously since the mid-2000s (Allen, forthcoming). In general, this grant funding has been critical for wastewater projects because most of the border communities are low-income and require subsidized funding for their projects; very few communities can afford loans from

NADBank, even on concessional terms. Thus, it is likely that as the level of BEIF grant funds has decreased, so have the size and cost of the wastewater projects certified and supported by NADBank.

Geospatial Analysis

At the country-level, 77 wastewater projects (58%) were located in Mexico while 56 projects (42%) were located in the U.S. The total cost for the wastewater projects in Mexico was about $1.15 billion (61%) while the total cost for the U.S. projects was about $740 million (39%); the total NADBank financial assistance for projects in Mexico was about $500 million (65%) and for the U.S. projects, the total financial assistance was about $260 million (35%). At the state-level, the number of projects varied notably across the states, ranging from a high of 26 projects in Baja California to one project in Nuevo Leon (see Figure 3; Figure 4 for project locations). However, the total number of projects per state is somewhat misleading, as there may be multiple projects for a single community over time. For example, for Baja California, 12 out the 26 projects were for Tijuana, all focused on the same overall wastewater system, but addressing different components at different times. The total project costs varied across states as well, from a high of $352 million for wastewater projects in Texas to a low of $59 million for projects in New Mexico (see Figure 3; Figure 5 for geospatial distribution of project costs and financial assistance). Similarly, the levels of financial assistance varied across states, from a high of $144 million for Tamaulipas to a low of $27 million for Nuevo Leon. In general, it is not surprising that the number of projects and associated costs and levels of financial assistance would vary across the states because the territorial area, total population, and levels of urbanization within the 100 km and 300 km border regions vary for each state in the U.S. and Mexico, respectively. Total population and levels of urbanization are likely correlated with demand for wastewater infrastructure. Thus, the number, size, and type of infrastructure projects certified within a state would vary based on these factors.

Figure 3: Number of Wastewater Projects, Project Costs, and Financial Assistance by State (n=133). Source: Data from NADBank.(n.d).

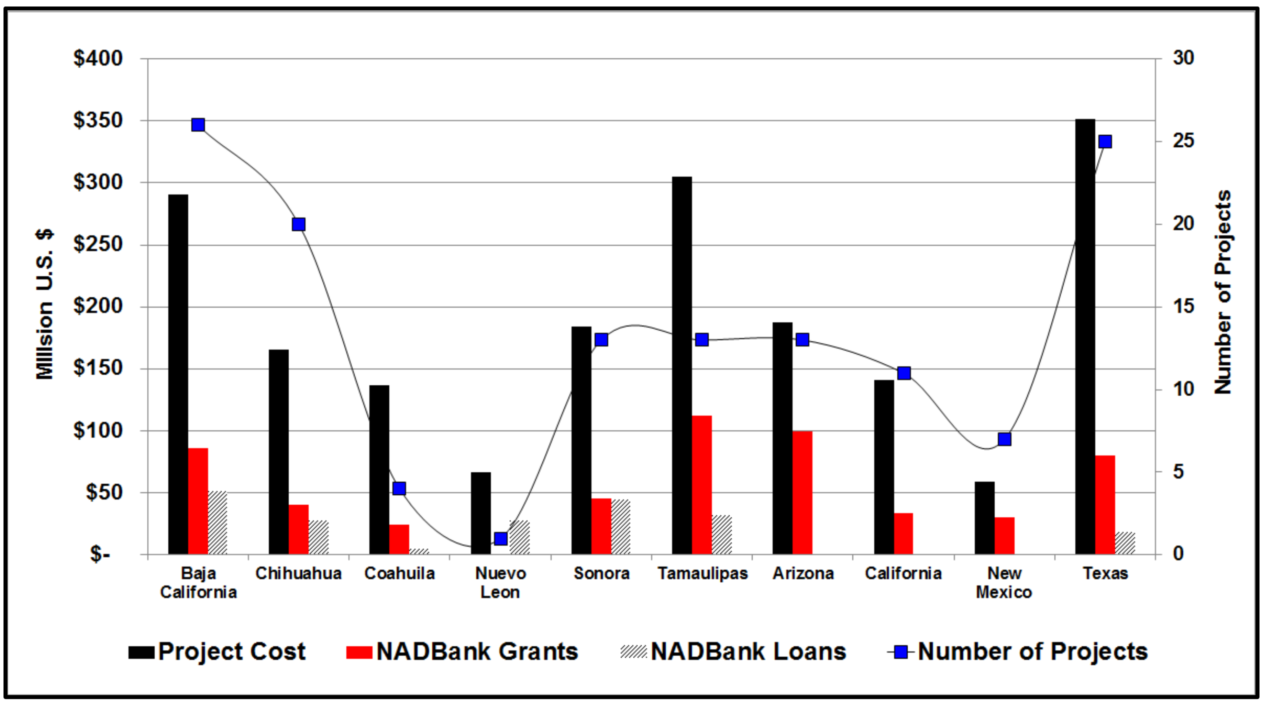
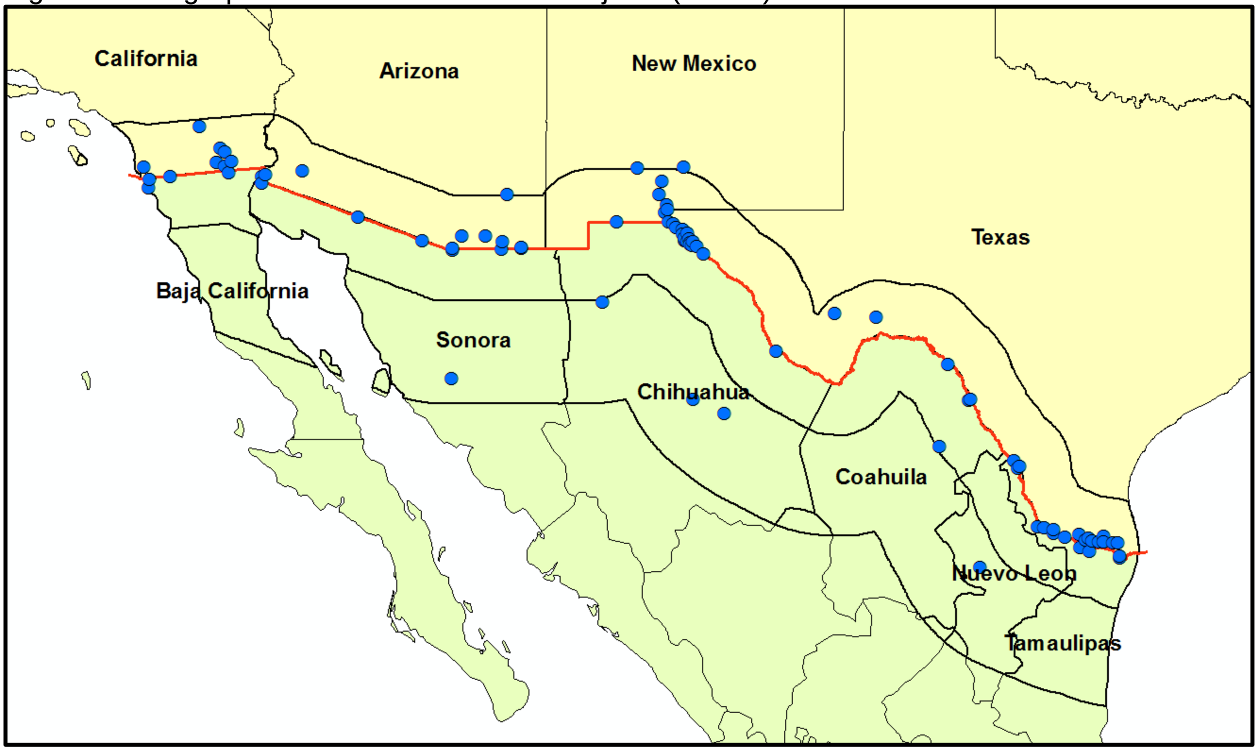
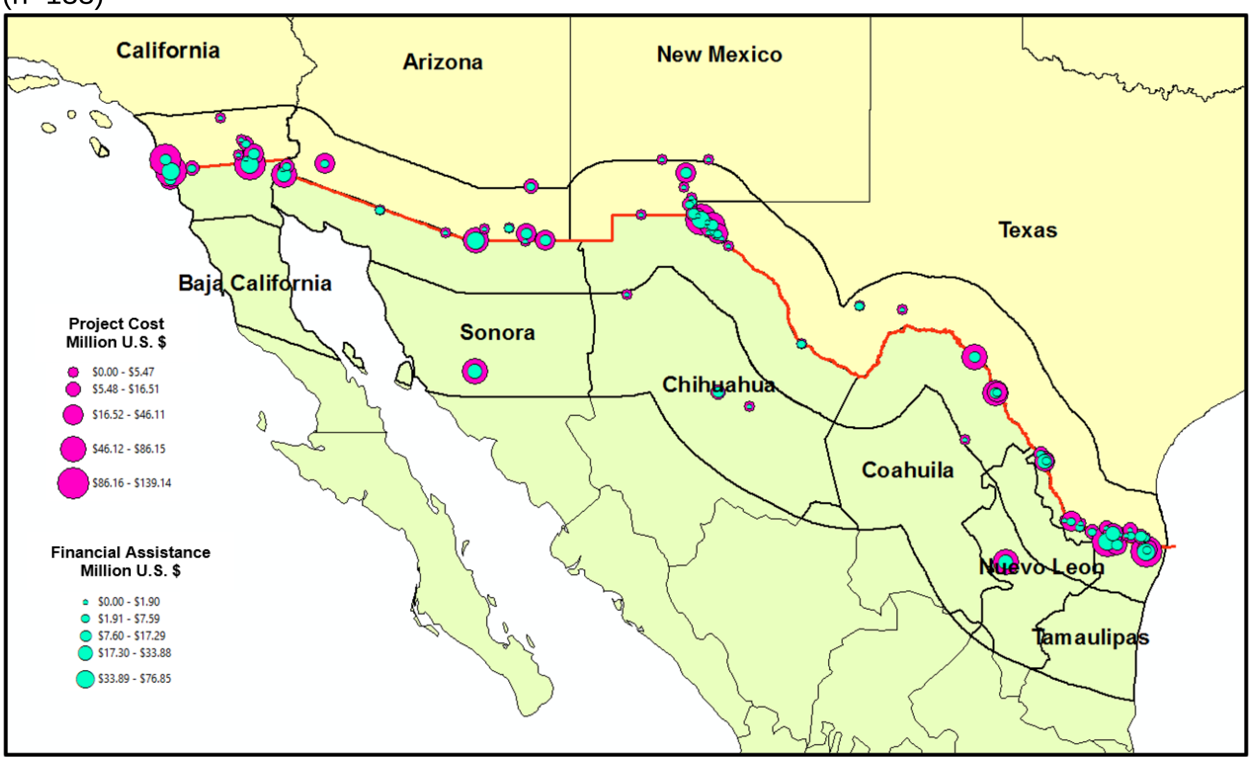


Figure 4: Geographic Location of Certified Projects (n=133)



Source: Data from NADBank. (n.d).

Figure 5: Geographic Location of Total Project Costs and Financial Assistance by Community (n=133)



Source: Data from NADBank. (n.d).

Total Wastewater Infrastructure Improvements

In general, the wastewater projects supported by NADBank consisted of the expansion or rehabilitation of existing wastewater collection and treatment systems, the construction of completely new collection and treatment systems, or the connection of private residences that previously used on-site systems to a new or existing centralized wastewater system. Each infrastructure project had a unique scope, but collectively the 133 wastewater projects have resulted, or will result once completed, in new treatment capacity of 415 mgd and rehabilitated or upgraded treatment capacity of about 110 mgd, for a total improved treatment capacity of almost 525 mgd (NADBank, n.d.). In addition, these projects collectively added or will add around 1,600 miles of sewer lines and interceptors, rehabilitated around 360 miles of sewer lines, constructed 115 new pump stations, and added at least 110,000 new service connections based on project information publicly available (NADBank, n.d.). These estimated wastewater improvements compare favorably with metrics reported by NADBank based on post-construction closeout reviews, which indicate that 60 completed NADBank wastewater projects had resulted in 265 mgd in treatment capacity and 945 miles of collection lines installed (NADBank, 2018).

Financial Assistance

NADBank has provided or committed to provide around $760 million in grants and loans to support implementation of the 133 wastewater projects; this financial assistance represents around 40% of the total project costs of $1.9 billion. Thus, NADBank has leveraged over one dollar for every dollar it invested in these infrastructure projects. Breaking the NADBank financial assistance down, 73% percent of the assistance was grant funding while 27% was loans, provided at either market interest rates or on concessional terms (see Table 1 for financial assistance by state) (NADBank, n.d.). The vast majority of the grant funds were from the BEIF, only a limited amount of grant funds for these projects was from NADBank's retained earnings. The BEIF grants could be used to support construction of water and wastewater projects in the U.S. as well as projects in Mexico that had direct water quality benefits for the U.S., such as reducing transboundary water pollution. Given that the most of the projects in Mexico were in border communities that discharged sewage to transboundary water bodies, these projects received considerable BEIF funds from NADBank.

Table 1: Total Wastewater Project Costs and NADBank Financial Assistance by State (n=133)

State	Number of Projects	Project Costs (million US $)	NADBank Loans (million US $)	NADBank Grants (million US $)
Baja California	26	$ 291	$ 53	$ 86
Chihuahua	20	$ 165	$ 27	$ 40
Coahuila	4	$ 136	$ 4	$ 25
Nuevo Leon	1	$ 66	$ 27	$ -
Sonora	13	$ 184	$ 44	$ 46
Tamaulipas	13	$ 305	$ 32	$ 112
Arizona	13	$ 187	$ -	$ 100
California	11	$ 141	$ 1	$ 34
New Mexico	7	$ 59	$ -	$ 30
Texas	25	$ 352	$ 18	$ 80
Totals	133	$ 1,887	$ 205	$ 552

Source: Data from NADBank. (n.d).

Although NADBank provided a considerable amount of funding to support the construction of these 133 wastewater projects, the remaining 60%, or $1.13 billion of the project costs was funded from a variety of other sources. These sources included grants and loans from the state and federal governments in each country, user fee revenue from utilities or general taxes from municipalities, and private equity from concessionaires for build operate transfer projects (only in Mexico) (NADBank, n.d.). Overall, grants from state and federal governments constituted around 57% of the non-NADBank funding, while loans from state and federal governments were about 11% of the funding, local utility or government contributions were about 23% of the funding, and private equity was around 10% of the funding (NADBank, n.d.). Taking into consideration the NADBank financial assistance, the $1.9 billion in construction costs were funded with around 63% grants from all sources, 17% loans from all sources, 14% from local utility or municipality contributions, and 6% from private equity, however all the loans are also eventually funded by revenue from the utility when the debt is repaid. In general, the composition of the funding indicates that the wastewater projects in the border region are heavily subsidized by state and federal governments and a variety of sources are typically used to fund individual projects.

Community-Level Analysis

In general, the temporal and geospatial analysis provide a high-level view of the wastewater infrastructure improvements supported by NADBank in the border region, but as a practical matter, an analysis at the community-level would provide the best indication of tangible impacts due to the implementation of the wastewater projects. Unfortunately, a detailed community-level analysis is beyond the scope of this article (Appendix A provides a list of individual projects by state and community). In lieu, however, a few communities will be examined in detail to illustrate the types of impacts that may have been achieved due to the projects. In the U.S., the colonias will be examined collectively, while in Mexico, the large border cities of Ciudad Juárez, Mexicali, and Tijuana will be examined. In general, the colonias and large border cities represent a major portion of the NADBank wastewater project portfolio. The colonias had the highest need of any border communities in the U.S. and collectively around 50% of the total project costs for the U.S. are associated with these communities. At the same time, the three border cities in Mexico represent around 33% of the total project costs for all wastewater projects in Mexico. Given the support the colonias and large cities have received, it is anticipated that these areas would likely realize tangible benefits from the wastewater projects.

Ciudad Juárez

In 1990, Ciudad Juárez was the largest city in the border region, with a population of around 850,000 residents. At that time, its wastewater collection system covered about 80% of the city but there was no wastewater treatment capacity and approximately 22 mgd of raw wastewater was discharged into an irrigation canal and used to irrigate field crops or ultimately discharged directly to the Rio Grande (U.S. EPA & SEDUE, 1991; NADBank, 1998). Today Ciudad Juárez has a population of 1.3 million and its collection system covers about 93% of the city and all of the sewage collected from these areas is treated at five wastewater treatment plants with a total capacity of around 96 mgd (NADBank, 2015). Much of this increase in wastewater infrastructure has been supported by NADBank, which certified and provided funding for four major wastewater projects for the city between 1997 and 2009. These projects included the construction of four treatment plants, subsequent expansion of one treatment plant, and rehabilitation and expansion of the collection and conveyance system for the city (BECC, 1997, 2006, 2009a, 2009b). NADBank also certified a project in 2015 to construct a cogeneration facility and improve sludge management at one treatment plant, which although associated with the wastewater system does not directly impact the collection or treatment of sewage (NADBank, 2015). The total construction cost for these projects was around $120 million, and NADBank provided around $47 million in grants and loans to support their implementation. Two treatment plants, North and South, began operation in 2000 while the Anapra and South-South plants began operation in 2010 and 2013, respectively (BECC, 2006, ConAgua, 2016). Effluent from the three largest plants, North, South, and South-South, is discharged to nearby irrigation canals while the Anapra effluent is reused within that community (BECC, 2006, 2009a, 2009b; ATSDR, 2005).

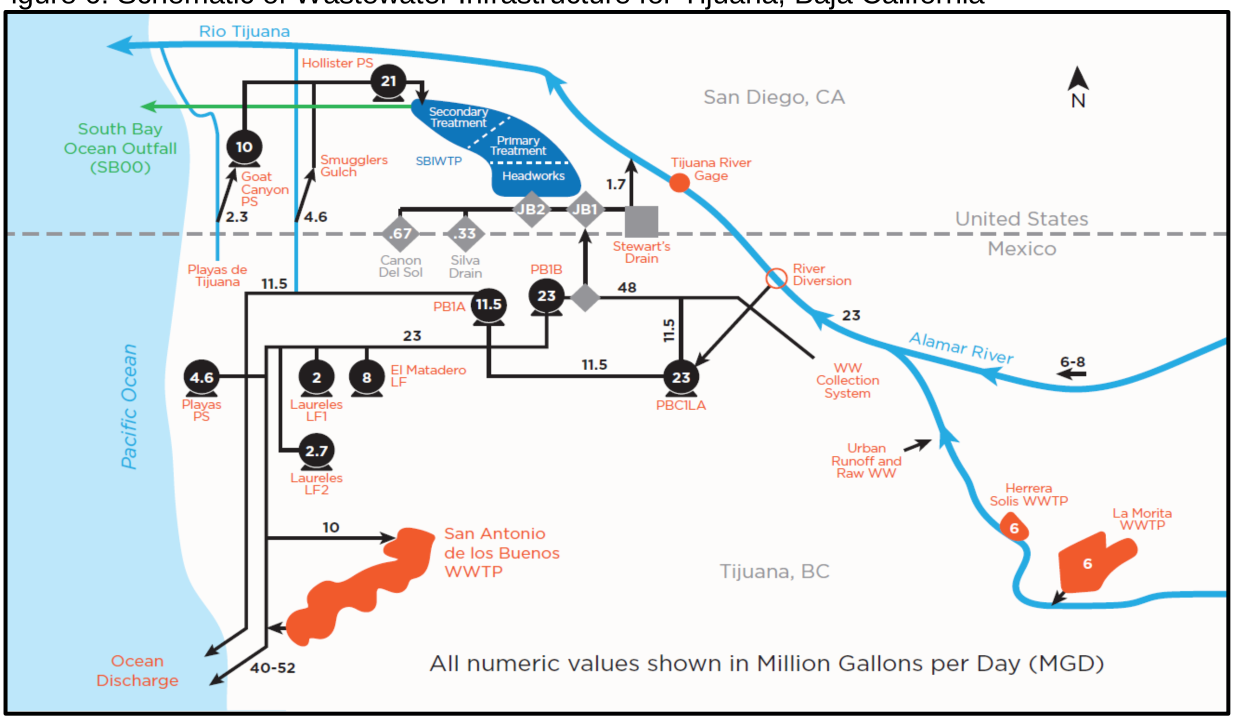
Mexicali

Mexicali is another major border city that historically had a collection system that covered part of the city but lacked adequate wastewater treatment capacity. With a population of about 600,000 in 1990, the city's collection system covered about 90% of the city at that time. There were two existing treatment plants, Zaragoza, with a capacity of around 22 mgd, and Gonzalez-Ortega, with a capacity of about 2 mgd, but both plants were operating poorly and discharged partially treated sewage into drains that ultimately flowed into the New River. (IBWC, 1980). At the same time, around 8 mgd of raw sewage collected from other areas of the city were likewise discharged into the New River, which flows northward into the U.S. Although the U.S. and Mexico had sought to improve the wastewater collection and treatment capacity of Mexicali for many years under the auspices of the International Boundary and Water Commission (see e.g. IBWC, 1980, 1987, 1992), it wasn't until the mid-1990s with support from NADBank that major system improvements were made. A comprehensive facilities plan was developed in 1996 that envisioned improvements to the wastewater facilities in several phases to serve the entire city (International Boundary and Water Commission, 1995; U.S. General Accounting Office, 1999). Between 1997 and 2014, NADBank certified four projects to rehabilitate and expand the Zaragoza plant, close the Gonzalez-Ortega plant, and construct and then expand a new treatment plant, Las Arenitas, as well as rehabilitate and expand the collection and conveyance systems (NADBank, 1997, 1999, 2003, 2007, 2014, 2016). The total cost for these projects was around $129 million and NADBank provided or committed to provide around $50 million to support their implementation. All of the work was completed except for the expansion of the Las Arenitas plant, which was never undertaken (Baja California, et al., 2017). At present, the capacity of the two existing treatment plants is about 50 mgd and the collection system covers 100% of the residents (NADBank, 2016); treated effluent from one plant, Zaragoza, is discharged to an irrigation canal that ultimately flows into the New River while the effluent of the other plant is discharged to a wetlands and reused for irrigation south of the city (Conagua, 2016; NADBank, 2003, 2007; Sonoran Institute, n.d.).

Tijuana

Similar to the other large border cities, Tijuana collected sewage from a portion of the city but it historically had limited treatment capacity and untreated sewage was discharged that directly impacted Tijuana as well as communities in the U.S. for many years (IBWC, n.d., 1967; Schoenherr, n.d.). The U.S. and Mexico have sought to address these transboundary sewage flows since the 1930s, but even by the early 1990s, the wastewater system in Tijuana was woefully inadequate. In 1990, the city had a population of about 750,000; its collection system covered about 65% of the residents and it had only one treatment plant, San Antonio de los Buenos, with a capacity of 17 mgd, which was not sufficient to treat all the sewage collected. Partially treated sewage from the plant as well as from other areas of the city were discharged to either to the Pacific Ocean or Tijuana River (U.S. EPA, 2003; IBWC, 1985, 1990). Between 1997 and 2019, NADBank certified 12 wastewater projects that involved the rehabilitation as well as expansion of the wastewater collection, conveyance, and treatment system in Tijuana, including the construction of two new treatment plants, La Morita and Tecolote-La Gloria (NADBank, 2011). These projects had a total cost of about $142 million and NADBank provided or committed to provide around $79 million in loans and grants to support their implementation. By 2019, most of these projects had been completed except for construction of one treatment plant, Tecolote-La Gloria, which was started but never finished. Today, with a population of 1.7 million, Tijuana collects sewage from about 90% of the city and has four major treatment plants with a total capacity of 66 mgd; the construction of two treatment plants, South Bay International, located in the U.S. and Arturo Herrera Solis, located in Mexico, were not certified or supported by NADBank. Treated sewage from the four plants is discharged into either the Pacific Ocean or Tijuana River. In addition, base flow from the Tijuana River, which includes treated effluent, groundwater seepage, and untreated sewage, is collected at a river diversion structure and conveyed to the Pacific Ocean as well (see Figure 6).

Figure 6: Schematic of Wastewater Infrastructure for Tijuana, Baja California



Source: County of San Diego, 2020.

Colonias in U.S.

In the early 1990s, the border communities in the U.S. with the most significant need for wastewater infrastructure were the colonias, located predominantly in Texas. As was noted previously, it was estimated that around 280,000 persons lived in 1,200 colonias in Texas alone in the early 1990s (Schoolmaster, 1993, p. 325) and only about 1% of these colonias had adequate wastewater collection and treatment systems (U.S. Trade Representative, 1992, p. 108). However, colonias exist in the other U.S. Border States and a more recent border-wide assessment indicated that there were about 2,200 colonias in the four border states with a total population of about 840,000 persons (Rural Community Assistance Program, et al, 2015). Around 43% lived in Texas, 33% lived in Arizona, 19% lived in New Mexico, and 5% lived in California (Rural Community Assistance Program, et al., 2015). Not all of these colonias were located within the 100 km border region and the level of infrastructure needs varied widely between the colonias. In general, efforts to address the needs of colonias have evolved over time, but between 1996 and 2016, NADBank certified 34 projects that were associated in whole or in part with improving wastewater systems in colonias. Collectively, these projects had a total project cost of $400 million, which is 54% of the total costs for wastewater projects certified by NADBank in the U.S. In addition, NADBank provided around $110 million in grants and loans to support implementation of these projects, which is 43% of the financial assistance provided to U.S. wastewater projects. Nineteen projects were located in Texas, while seven projects were located each in Arizona and New Mexico, and one project in California. In general, the colonia projects in Texas were located in the upper Rio Grande valley near the El Paso area or in the lower Rio Grande valley near Brownsville and McAllen while the New Mexico colonia projects were located just north of El Paso in the Rio Grande valley (see Figure 4).

Wastewater Infrastructure Gap

The preceding analyses and discussion of wastewater infrastructure in the U.S.-Mexico border region improvements indicates that NADBank has invested considerable funds in wastewater collection and treatment systems in this region. Overall, NADBank has provided around $760 million in grants and loans to support implementation of around $1.9 billion in wastewater projects over the past 25 years. When NADBank was created, the estimated investment needed for wastewater infrastructure in the border region, which at the time was only defined as 100 km on either side of the international boundary, was $4.3 to $6 billion for the 10-year time period from 1993 to 2003. A simple comparison between the investment gap at that time and projects supported by NADBank over the past 25 years indicates that the gap has not been fully addressed even taking into consideration that NADBank investment occurred over a much longer time horizon. However, this simple comparison does not provide the complete picture of the possible extent of the shortfall for several reasons.

First, NADBank is only one institution supporting the implementation of wastewater projects in the border region; projects have also been implemented by communities without any NADBank support. The federal and state governments in both countries have financed wastewater projects that did not involve NADBank (see e.g. U.S. General Accounting Office, 2000, 2009; Texas Water Development Board, 2019; New Mexico Colonia Infrastructure Board, 2019). Texas, for example, has provided over $1 billion in grants and loans to support water and wastewater projects in colonias since 1989 through its Economically Distressed Areas Program, which is a mix of state and federal funds (Texas Water Development Board, 1999, 2019); some of this funding was used to co-fund NADBank wastewater projects).

Second, the investment gap for wastewater infrastructure has not been static, it is constantly changing as the population in the border region has increased and existing infrastructure reaches the end of its useful life. For example, the population of the border region (100 km on each side of the border) in 1990 was around 8.3 million but increased to 14 million by 2010, an increase of about 70% in ten years (U.S.EPA, 1996; U.S.EPA & SEMARNAT, 2016). Thus, the investment gap for wastewater infrastructure is a moving target that needs to be continuously reassessed in light of these dynamics and the contributions of NADBank to addressing this gap need to be assessed against this moving baseline.

Lastly, the investment gap refers strictly to the capital costs for the physical infrastructure and does not consider whether the infrastructure is being properly maintained and operated. As a practical matter, the mere presence of physical infrastructure is insufficient to ensure that the sewage will be adequately collected and treated and the associated environmental and public health risks will be abated. Institutional capacity and effective governance by the operating utilities is essential to reducing these risks and some operating utilities lack the capacity and resources to properly maintain and operate their wastewater systems. When this occurs and the wastewater collection and treatment facilities fall into disrepair, as has occurred, for example, with some facilities supported by NADBank in Mexicali and Tijuana (ConAgua, 2016), the environmental and public health risks from the discharge of untreated sewage remain.

Considering all these factors, it is not possible to definitively assess NADBank's contribution to addressing the investment gap in wastewater infrastructure in the border region. However, anecdotal data indicate that there is still a significant need for investment in wastewater infrastructure on both sides of the border. In Mexico, for example, raw or partially treated sewage continues to be discharged from Tijuana into the Tijuana River and Pacific Ocean despite considerable planning and investment by both countries to improve the wastewater infrastructure in that city for decades (NADBank, 2019a; Bravo, 2019; Stone, 2019; Vanderpool, 2018; International Boundary and Water Commission, 1965, 1985, 1990, 1997; US EPA, 2003). Likewise in Nogales, Nuevo Laredo, and Naco, raw or partially treated sewage continues to plague communities on both sides of the border (Caballero, 2019; NADBank, 2018; Dougherty, 2018a, 2018b). In the U.S., progress has been made in improving infrastructure in colonias, yet a recent survey identified around 600 high-priority colonias that face significant health risks due to lack of adequate water or wastewater services (Rural Community Assistance Program, et al., 2015). Additionally, the continuing need for significant investment in wastewater infrastructure in the border region was highlighted by the recent authorization by the U.S. Congress of $300 million in new grant funds for wastewater projects in the Tijuana and San Diego area as well as another $3 billion in capital for NADBank when it approved the United States-Mexico-Canada Agreement (which replaced the North American Free Trade Agreement) in 2020 (Stecker, 2019). Lastly, various estimates indicate the need for further investment in wastewater infrastructure, such as from the IBWC (2019a), which estimated $700 million was needed to address transboundary sewage flows along the border.

Environmental Impacts of Wastewater Infrastructure Projects

For decades, the U.S.-Mexico border region has been plagued with discharges of raw or partially treated sewage that have impacted environmental and public health conditions in many border communities. High levels of fecal coliform or E. coli have been observed in many surface and ground waters and a higher prevalence of water-borne diseases has been found in border communities compared to non-border communities. Improvements to wastewater systems in the border region should reduce both the fecal contamination of the water bodies and rates of waterborne diseases. While the implementation of these infrastructure projects is often assumed to improve environmental and public health conditions prima facie, additional analyses of environmental or public health data can independently corroborate the impacts of these projects. In general, completing these types of analyses require comprehensive time series data which unfortunately are not available for the border region. Nonetheless, the following review of limited data on water quality for a few transboundary rivers provides some indication of the impacts of the wastewater projects for the border region.

Ambient Water Quality Data

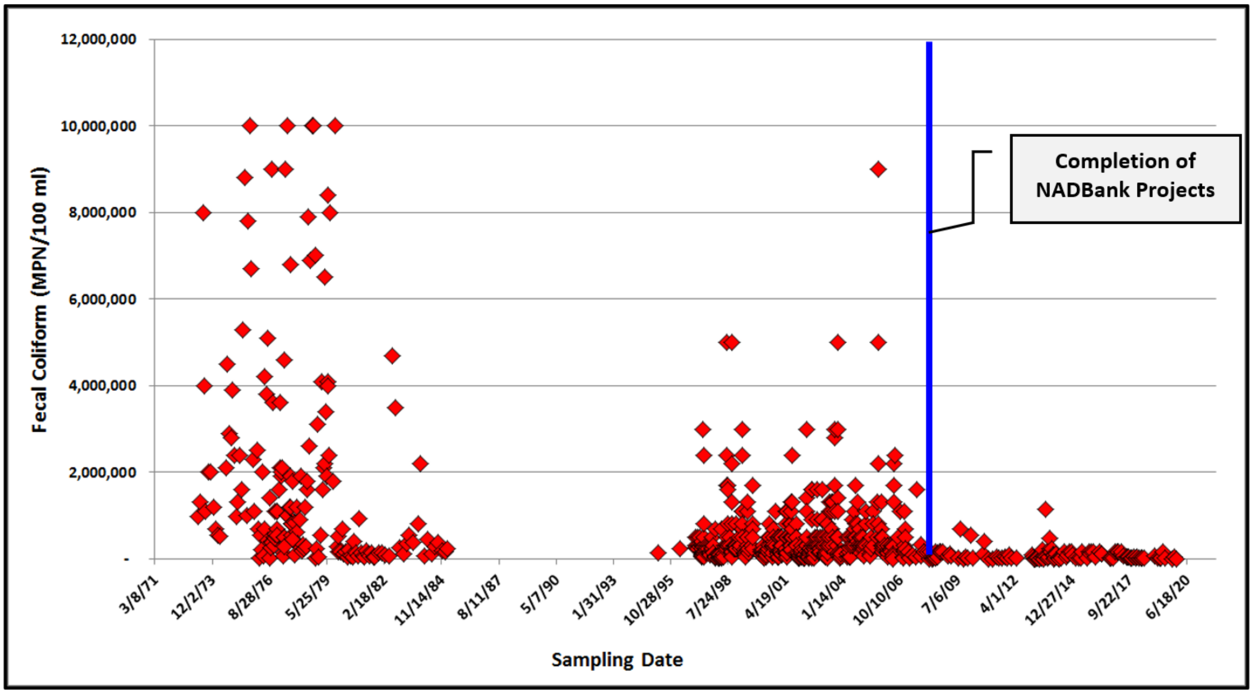
Historically, the discharge of raw sewage from border communities in both the U.S. and Mexico significantly impacted the ambient water quality in major transboundary rivers such as the Tijuana, New, and Santa Cruz Rivers, and Rio Grande. Prior to the establishment of NADBank, the U.S. and Mexico made some improvements to wastewater systems in few border communities, such as the construction of a binational treatment plant in Nogales in the 1950s, and construction of treatment lagoons in Mexicali and Tijuana in the 1970s and 1980s respectively. However, since the mid-1990s, considerable investment has been made in wastewater infrastructure in border communities with NADBank financial and technical support and ambient water quality data for the Tijuana and New Rivers, and Rio Grande provide some indication of the impacts of these wastewater system improvements that have occurred since the NADBank projects were completed.

Data for the New River, which flows north from Mexicali, Baja California into the U.S. Imperial Valley, are probably the most comprehensive and cover a relatively long time period albeit with some gaps. Overall, about one third of the flow in the New River originates in Mexico and this flow is mostly a mix of treated and untreated municipal and industrial sewage and agricultural runoff (U.S. EPA & SEDUE, 1991; U.S. General Accounting Office, 1999). In the 1970s and 1980s, the state-run operating utility, Comisión Estatal de Servicios Públicos de Mexicali, constructed some infrastructure to collect and treat sewage in Mexicali, in particular a lagoon treatment system, Zaragoza, and pump stations and interceptors to convey the sewage flows to the treatment system (California Water Boards, n.d.2; U.S. EPA & SEDUE, 1991; IBWC, 1987, 1992). Some facilities fell into disrepair over the years and emergency repairs were made in the late 1990s to reduce transboundary flows of raw sewage while more long-term improvements were being planned (International Boundary and Water Commission, 1997, 2011).

NADBank supported several major wastewater projects in Mexicali from 1997 to 2004, which included the rehabilitation of existing wastewater facilities, construction of a new treatment plant, Las Arenitas, and expansion of the collection and conveyance system, all completed by 2007 (NADBank, 1997, 2003, 2016; International Boundary and Water Commission, 2011). NADBank certified another project in 2007 to expand the Las Arenitas plant and the collection and conveyance system for the east side of the city (NADBank, 2007), however, the plant expansion has not been completed and is currently in the state long-term water plan (Baja California, et al., 2017). A project to rehabilitate collection lines on the west side of the city was certified in 2014 and completed in 2016 (NADBank, 2019b). Since that time, some of the wastewater facilities, in particular pump stations, have experienced operational problems or failures, which resulted in discharges of raw sewage to the New River (CA RWQCB, n.d.).

Overall, the water quality data for the New River indicate that in the early 1970s there were very high levels of fecal contamination in the river (see Figure 7), giving rise to its characterization as the most polluted river in the U.S. (International Boundary and Water Commission, 2011). However, by the late 1990s, the levels of fecal contamination had decreased somewhat due to construction of wastewater infrastructure in the 1970s and 1980s, but even so, conditions in the New River remained dire as the population of the city continued to increase and existing facilities were not properly operated and maintained (Setmire, 1984; California Water Boards, 2019). The rehabilitation of existing wastewater facilities and construction of the new Las Arenitas plant in 2007, however, resulted in a measurable improvement in the levels of fecal contamination in the New River from sources originating in Mexicali (California Water Boards, 2019, see Figure 7, vertical line indicates completion date for treatment plant). The few spikes in levels of fecal coliform in 2013 and 2014 likely correspond to the discharges of raw sewage due to equipment failures in Mexicali. Notwithstanding these spikes, overall, the levels of fecal contamination from Mexicali have been significantly reduced compared to historical levels.

Figure 7: Fecal Coliform Sample Results at International Boundary, Calexico, CA (1973-2019)*

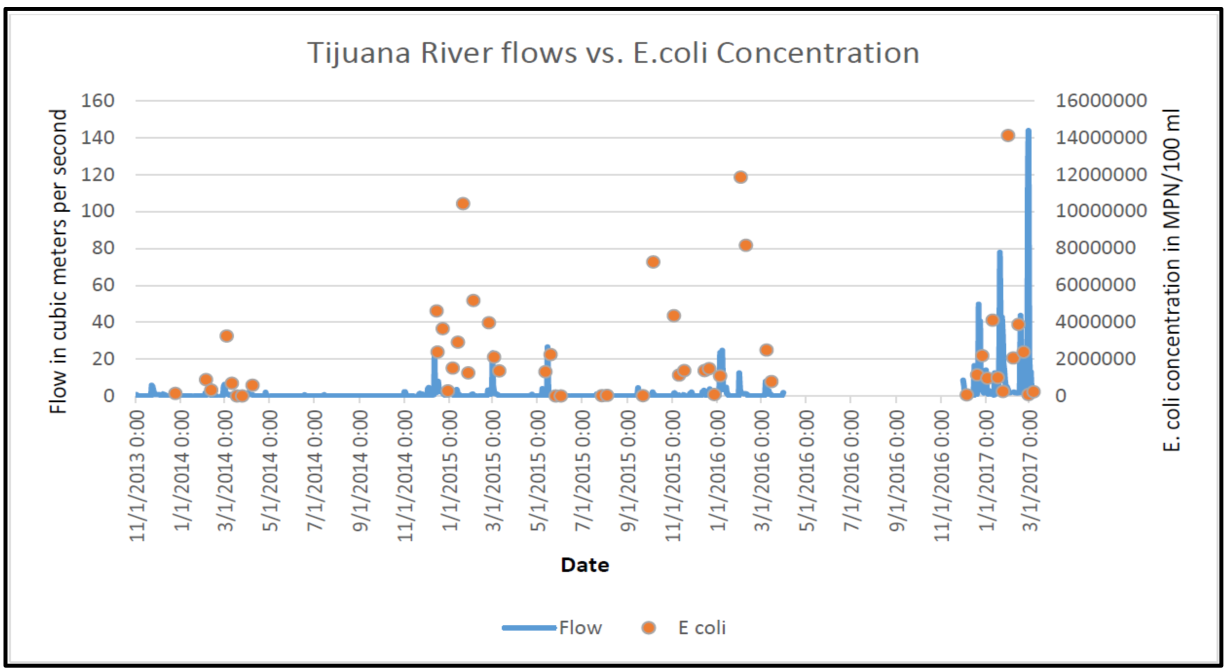


*Source: Data from California Water Boards. (n.d).1; National Water Quality Monitoring Council, n.d.; International Boundary and Water Commission, 2003a. Some sample results for 2007, 2008, 2014, and 2015 reflect a reporting maximum of 160,000 MPN/100 ml. Fecal concentrations are influenced by overall flow levels in the river and a more appropriate metric for evaluating contamination is the total fecal load, which requires data on flow but these data do not exist for all years from 1971 to 2020.

Water quality data for the other major transboundary rivers examined in this study, the Tijuana River and Rio Grande, are not as comprehensive as for the New River but still provide an indication of tangible improvements due to NADBank wastewater infrastructure projects. For the Tijuana River, transboundary sewage flows from Tijuana, Baja California northward into southern San Diego County, California, have been occurring since the 1930s (International Boundary and Water Commission, n.d.). For decades, the U.S. and Mexico implemented numerous short-term fixes to reduce the impacts of these transboundary flows, but it wasn't until the 1980s that the two countries agreed to long-term solutions, which included the construction of two large treatment plants; one in Mexico, San Antonio de los Buenos, and one in the U.S., South Bay International, which began operation in 1987 and 1999, respectively (International Boundary and Water Commission, n.d., 1985, 1990).

Building on these investments in infrastructure, NADBank has supported the construction of one major new treatment plant, La Morita, in Tijuana as well as the rehabilitation and expansion of the existing treatment plant, San Antonio de los Buenos, and the collection and conveyance system throughout Tijuana, from 1997 to 2017. In addition, the state operating utility, Comisión Estatal de Servicios Públicos de Tijuana, and the Mexican national government, have invested in wastewater infrastructure independent of NADBank, including the construction of several small treatment plants. Despite this investment, however, raw or partially treated sewage continues to be discharged into the Tijuana River or Pacific Ocean when there are major failures of existing infrastructure due to disrepair or end of useful life, or when infrastructure is operated beyond its design capacity (International Boundary and Water Commission, 2017, 2019a, 2019b; NADBank, 2019a; CESPT, 2018; County of San Diego, 2020; California Water Boards, n.d.3). In addition, areas of the city not currently tied into the centralized collection system continue to discharge raw sewage into the river, although there is a separate system to collect the baseflow in the river during dry weather and discharge it to the Pacific Ocean (NADBank, 2019a). Nonetheless, limited data indicates that high levels of fecal contamination continue to occur in the Tijuana River (see e.g. U.S. Customs and Border Protection, 2018), although these occurrences appear to be episodic and likely associated with equipment failures or overcapacity issues (see Figure 8) (California Water Boards, 2020; U.S. EPA, 2014; Weston Solutions, 2012; International Boundary and Water Commission, 2017). At the same time, base flows in the Tijuana River, which are collected and conveyed to the Pacific Ocean during dry weather, contain raw sewage from unsewered areas, and raw sewage also flows into the U.S from small drainage basins along the border, such as Goat Canyon, Canon del Sol, Silva Drain, and Smugglers Gulch (NADBank, 2019a; County of San Diego, 2020, see Figure 6). As such, the water quality data for the Tijuana River should not be used as the only indicator for assessing improvements in wastewater infrastructure in Tijuana.

Figure 8: E. coli Concentrations in Tijuana River (Dairy Mart Road Bridge) (2013-2017)

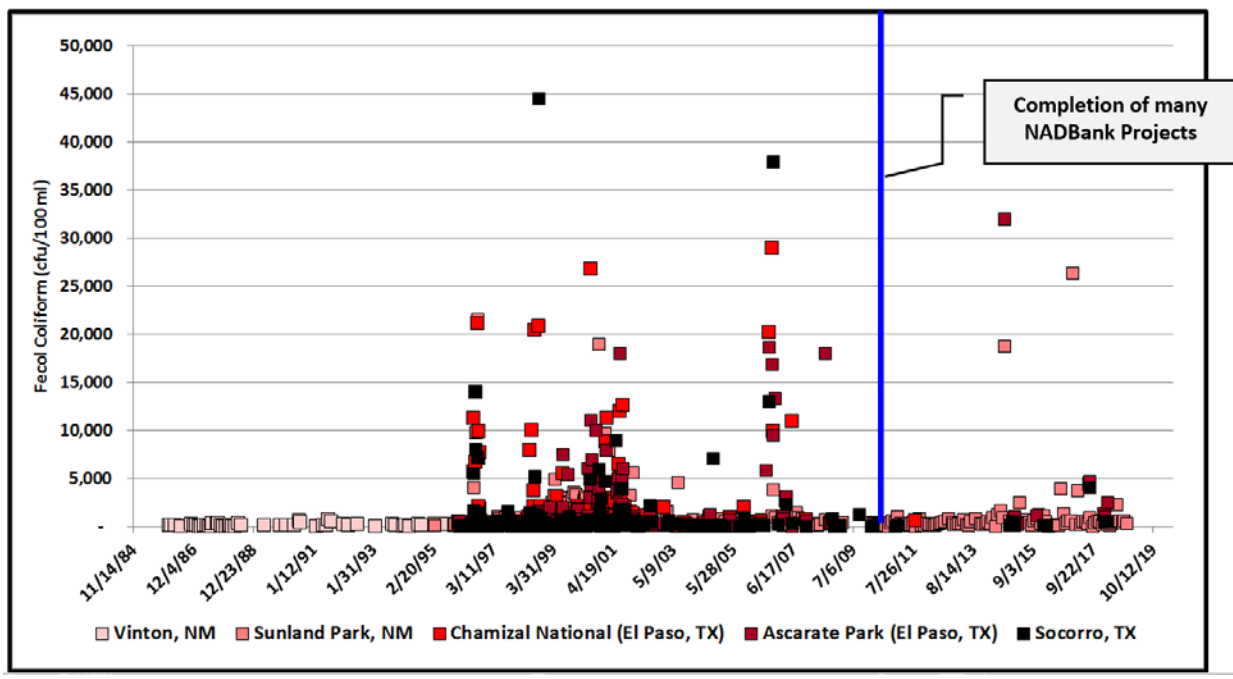


Source: International Boundary and Water Commission (2017).

The Rio Grande, with its headwaters in Colorado, passes through New Mexico and then serves as the international boundary between Mexico and Texas for over 1,200 miles, from El Paso to the Gulf of Mexico. The river is a major source of water for municipal and agricultural users but numerous reaches have historically been impaired by discharges of raw sewage, in particular the reaches that pass through the urbanized areas of sister cities, Las Cruces-El Paso-Ciudad Juárez, Del Rio-Ciudad Acuna, Eagle Pass-Piedras Negras, Laredo-Nuevo Laredo, McAllen-Reynosa, and Brownsville-Matamoros (International Boundary and Water Commission, 2003b, 2010; Texas Commission on Environmental Quality, n.d.). Since 1995, NADBank has supported 60 projects located in communities adjacent to the Rio Grande in both countries and many of these projects are concentrated in the Las Cruces-El Paso-Ciudad Juárez area and the lower Rio Grande valley (see Figure 4). In general, the NADBank wastewater projects on the Mexican side focused on the larger urban areas while the projects in the U.S. were focused on areas with colonias, and collectively these investments should have reduced the discharge of raw sewage into the Rio Grande. A majority of these projects (36) were certified in the time frame from 1995 to 2007, and most of these earlier projects were completed by 2010 or 2011 (NADBank, 2014).

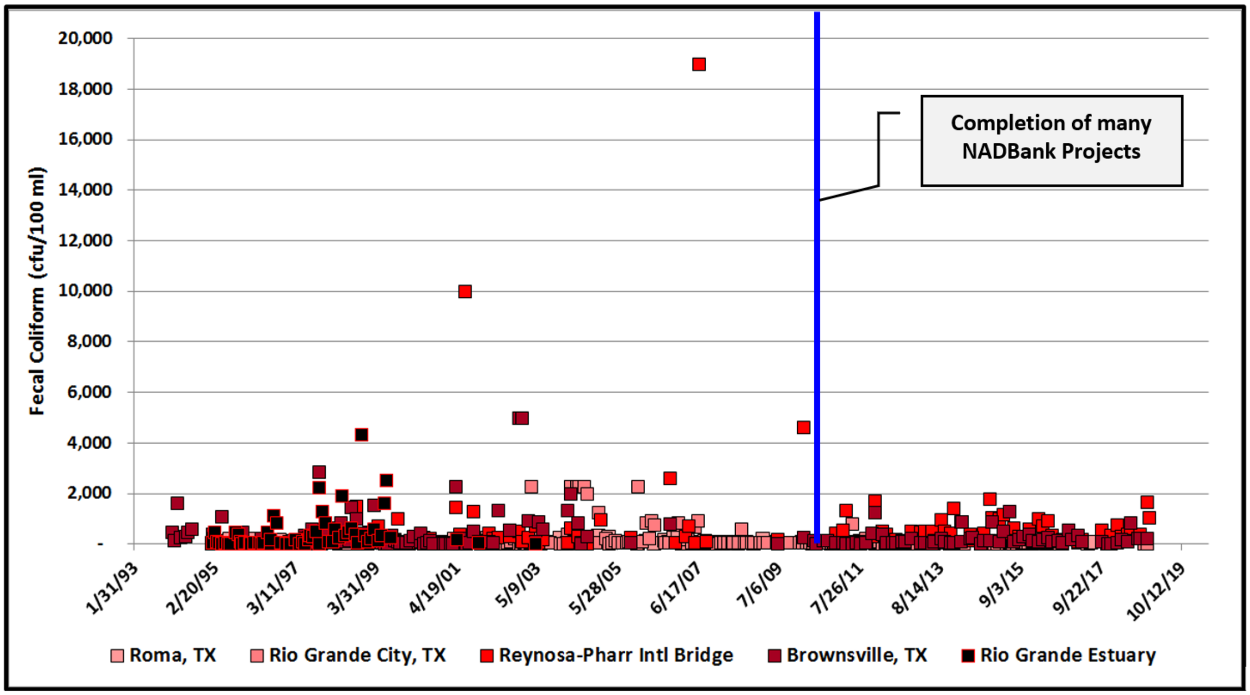
Data on ambient water quality of the Rio Grande or nearby tributaries have been collected at about 140 sampling points along the river, but the overall time periods and frequency of sampling at the individual sampling points has varied as have the parameters monitored (International Boundary and Water Commission, n.d.2). Nonetheless, the available data for the El Paso-Ciudad Juárez area and lower Rio Grande valley from below the Falcon Dam to the Rio Grande estuary at Brownsville, TX provide some indication of changes in water quality (see Figures 9 and 10, presenting data for five sampling points moving from upstream to downstream in each reach of the river). The dataset for the El Paso-Ciudad Juárez area does not have data for the downstream sites prior to 1995 but the available data clearly indicates that fecal contamination was present in the Rio Grande starting around Sunland Park in the mid-1990s. This fecal contamination persisted until around the 2010 to 2011 timeframe, when numerous NADBank projects in the area were completed, although a few high fecal counts have been observed since that time (see Figure 9). The dataset for the lower Rio Grande similarly has some gaps but likewise indicates that the observed high fecal counts in the river decreased somewhat by 2010 (see Figure 10).

Figure 9: Fecal Coliform Concentrations in Rio Grande (El Paso-Ciudad Juárez) (1986-2018)



Source: Data from International Boundary and Water Commission (n.d.1). Some sample results reflect reporting maximums.

Figure 10: Fecal Coliform Concentrations in Lower Rio Grande (1994-2018)



Source: Data from International Boundary and Water Commission (n.d.1). Some sample results reflect reporting maximums.

Overall, the ambient water quality data for fecal contamination in the three transboundary rivers in the U.S.-Mexico border region indicates the improvements associated with NADBank infrastructure projects. In general, the water quality improvements were most apparent in the New River, where a measurable reduction in fecal coliform levels was observed after completion of numerous large wastewater infrastructure projects in Mexicali. Although the river continues to be impaired by sources of pollution on both sides of the border, the infrastructure projects in Mexicali were instrumental in reducing pollution at the time of their completion. Unfortunately, failing or overcapacity infrastructure in Mexicali has led to periodic discharges of raw sewage. The water quality data for the Tijuana River were more limited and based on secondary sources, which limit the ability to assess the impacts of the NADBank wastewater infrastructure projects. In general, there continues to be discharges of raw sewage in Tijuana due to inadequate or failing wastewater infrastructure despite the fact that NADBank contributed to tangible improvements in the city's infrastructure. Lastly, the ambient water quality data for the Rio Grande is more comprehensive, but the total number of sources of sewage pollution and their location along the entire reach of the river make it difficult to ascertain distinct improvements in water quality. However, there appears to be some trend towards reducing fecal contamination in some locations in the Rio Grande near El Paso as well as the lower Rio Grande basin.

Conclusions

Thirty years ago, the U.S.-Mexico border region was characterized as an open sewer and breeding ground for diseases, due in large part to the discharge of untreated sewage from communities that lacked adequate wastewater infrastructure on both sides of the border. In 1993, NADBank was established to address this lack of infrastructure and over the past 25 years, it has certified 133 wastewater infrastructure projects, with a total project cost of about

$1.9 billion, and provided or committed to provide about $760 million in loans and grants to support the project implementation. Overall, these projects did not fully address the wastewater infrastructure gap that existed when NADBank was established, which was estimated to be between $4.3 and $6 billion over a ten-year period from 1993 to 2003. However, NADBank has not been the only institution to fund wastewater infrastructure projects in the border, so more work has likely been done than reflected by these numbers. Nonetheless, although NADBank has provided considerable assistance in constructing wastewater infrastructure in the border region, its efforts overall fall far short of addressing the full infrastructure gap. The provision of substantial grant funding from the BEIF was critical to the completion of almost all of the NADBank wastewater infrastructure projects, however, the availability of grant funding has declined significantly since the mid-2000s. This decline in BEIF funds coincides with a decline in the number and size of wastewater projects that have been supported by NADBank over the past decade, which further limits its ability to close the infrastructure gap.

Without a doubt, NADBank has supported considerable improvements in wastewater infrastructure in the border region, however, the extent to which this infrastructure has actually resulted in on-the-ground improvements in environmental and public health conditions have not been examined in detail. As a practical matter, undertaking such a review requires extensive and detailed time series data on environmental and public health outcomes, which are not readily available or simply do not exist. This research was an initial effort to address this gap in the literature by reviewing the infrastructure projects completed by NADBank as well as examining ambient water quality data for waterbodies potentially impacted by some of these projects. Water quality data for three water bodies were reviewed and overall, it appears that some tangible improvements have occurred due to the infrastructure projects.

The improvements were most apparent for the New River, which historically had received discharges of raw sewage from Mexicali. The rehabilitation, construction, and expansion of about $129 million in wastewater infrastructure in Mexicali, which NADBank supported with around $50 million in financial assistance, appears to have tangibly improved water quality in the New River. The results for the Tijuana River are more mixed. Overall, NADBank supported numerous infrastructure projects, with a total cost of $142 million, in Tijuana that should have reduced the discharge of raw sewage to the Tijuana River and Pacific Ocean. Unfortunately, these projects, as well as other projects not supported by NADBank, clearly did not address all of the infrastructure needs and discharges of raw sewage from Tijuana. The sheer size of the city coupled with its continued growth and the complexity of the wastewater system present unique challenges that both countries have struggled to overcome for close to 80 years. The Rio Grande has also historically been impacted by discharges of raw sewage from communities on both sides of the border at numerous locations along its nearly 1,200 mile length. Almost half of NADBank's wastewater infrastructure projects were located in communities adjacent to the Rio Grande, and two reaches of the river that should have realized some benefit were in the El Paso-Ciudad Juárez area and in the lower river basin. Overall, the ambient water quality data indicate that some improvements in water quality may have occurred after implementation of NADBank projects in these two reaches.

Based on this research, it appears that the wastewater infrastructure projects supported by NADBank (as well as non-NADBank supported projects) have resulted in some measurable improvements in major water bodies in the border region. Nonetheless, many of these water bodies remain impaired by discharges of raw sewage, which are likely occurring for several reasons. First, the infrastructure gap that existed when NADBank was established has never been fully addressed, even after 25 years. The wastewater infrastructure projects supported by NADBank represented somewhere between 30% and 45% of the wastewater infrastructure needs that existed in the early 1990s ($4.3 to $6 billion), so less than half of the gap identified at the time was ever addressed. The percent of the gap addressed would be even smaller because NADBank support occurred over a 25-year time period, not a 10-year time period as originally envisioned. Even considering projects funded independent of NADBank, the simple fact is that all the infrastructure that needed to be built never was built.

Second, the population of the border region has continued to increase, so new infrastructure is continuously being needed, which if not provided, likely contributes to the continued discharges of raw sewage, exacerbating an already bad situation. Lastly, the infrastructure improvements that were made did not necessarily result in tangible benefits or benefits that will last indefinitely. The tangible environmental benefits of the completed wastewater projects depend considerably on the proper operation and maintenance of the collection and treatment systems as well as their eventual upgrade or replacement at the end of their useful life. Anecdotal evidence indicates that some of the NADBank funded infrastructure has fallen into disrepair or is operating at overcapacity, resulting in equipment failures or inefficient operations (see e.g. NADBank, 2019a), which is essentially the same as having no infrastructure. In Tijuana, for example, the operating annual budget for operations and maintenance of the city's wastewater system is approximately one-third of the amount requested, "and preventive maintenance of the system appears to be minimal" (NADBank, 2019a, p. ES-5). The poor condition of the critical infrastructure has resulted in "frequent pump failures and line breaks causing raw sewage to flow into the Tijuana River and adjacent canyons" (NADBank, 2019a, p. ES-11). Although NADBank has provided some support to build the institutional capacity of the operating utilities, effectively closing the infrastructure gap will depend considerably not just on building the physical infrastructure but also the institutional capacity to properly operate and maintain it.

Overall, the need for wastewater infrastructure in the U.S.-Mexico border region remains, as clearly evidenced by the continuing discharge of raw or partially treated sewage in many border communities. The recent approval of $300 million to address infrastructure needs in the Tijuana River valley alone is just one indication of the magnitude of the level of investment needed for wastewater infrastructure, but even that level of funding is likely to be insufficient given the complexity of the transboundary sewage flows in the Tijuana River valley. Wastewater infrastructure needs elsewhere along the border, however, are unlikely to be addressed without a similar infusion of substantial grant funding to NADBank, comparable to the levels provided by the U.S. government for the BEIF during the early years of NADBank operation. The proposed increase of $3 billion in capitalization of NADBank will be of little use for addressing the wastewater infrastructure gap because, as has been demonstrated over the past 25 years, border communities simply cannot afford NADBank loans. Generally, substantially new grant funding and extensive institutional capacity building are essential for addressing the wastewater infrastructure gap in the U.S.-Mexico border region.

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Appendix A – Wastewater Infrastructure Projects Certified by NADBank

Date Certified	Community	State
12/1/1995	El Paso	Texas
1/18/1996	Douglas	Arizona
1/18/1996	Matamoros (FINSA)	Tamaulipas
4/30/1996	Naco	Sonora
7/18/1996	El Paso County (EPISO)	Texas
11/9/1996	Mercedes	Texas
6/18/1997	Tijuana	Baja California
6/18/1997	San Diego	California
6/18/1997	Alton	Texas
9/30/1997	Ciudad Juárez	Chihuahua
12/5/1997	Mexicali I	Baja California
3/31/1998	Reynosa	Tamaulipas
6/24/1998	Donna	Texas
6/24/1998	Lower Valley Water District	Texas
12/3/1998	Berino (Dona Ana Co.)	New Mexico
3/26/1999	Heber	California
9/11/1999	Westmorland	California
9/30/1999	Brawley	California
9/30/1999	Heber	California
9/30/1999	Roma	Texas
12/2/1999	Cameron, Hidalgo, Val Verde Counties (7 colonias)	Texas
1/27/2000	Patagonia	Arizona
3/24/2000	Ciudad Acuna	Coahuila
3/24/2000	Piedras Negras	Coahuila
3/24/2000	Sanderson (Terrell Co)	Texas
6/22/2000	Tecate	Baja California
6/22/2000	San Luis Rio Colorado	Sonora
6/22/2000	Nogales	Arizona
9/14/2000	Laredo	Texas
12/7/2000	Puerto Palomas	Chihuahua
3/27/2001	Sasabe	Sonora
6/20/2001	Douglas	Arizona
6/20/2001	Doña Ana Co. (Vado, Del Cerro, et al)	New Mexico
6/20/2001	Salem-Ogaz (Dona Ana Co.)	New Mexico
10/16/2001	Tijuana	Baja California
12/6/2001	La Unión (Dona Ana County)	New Mexico
3/20/2002	Eagle Pass	Texas
3/20/2002	Fabens	Texas
6/26/2002	Desert Shores	California
6/26/2002	San Pablo	New Mexico
9/25/2002	San Benito	Texas
9/25/2002	Santa Rosa	Texas
9/25/2002	Ojinaga	Chihuahua
9/25/2002	Tornillo	Texas
12/6/2002	Gadsden	Arizona
4/3/2003	La Feria	Texas

6/18/2003	Marathon	Texas
6/18/2003	Somerton	Arizona
6/19/2003	Matamoros	Tamaulipas
6/19/2003	Seeley	California
9/25/2003	Mexicali II	Baja California
9/25/2003	Bisbee	Arizona
7/30/2004	Nuevo Laredo	Tamaulipas
7/30/2004	Nogales	Sonora
6/21/2006	Monterrey	Nuevo Leon
10/26/2006	Playas de Rosarito	Baja California
10/26/2006	Ciudad Juárez (Anapra)	Chihuahua
3/27/2007	Pharr	Texas
7/30/2007	San Isidro	Chihuahua
7/30/2007	Guadalupe	Chihuahua
7/30/2007	Porfirio Parra	Chihuahua
7/30/2007	SLRC	Sonora
9/28/2007	Colonia Esperanza	Chihuahua
9/28/2007	El Porvenir	Chihuahua
9/28/2007	Praxedis G. Guerrero	Chihuahua
10/30/2007	Tecate	Baja California
10/30/2007	Mexicali	Baja California
10/30/2007	Agua Prieta	Sonora
10/30/2007	Miguel Alemán	Tamaulipas
5/29/2008	Rio Bravo/Nuevo Progreso	Tamaulipas
11/26/2008	Ciudad Mier	Tamaulipas
12/1/2008	Barreales and Juárez y Reforma	Chihuahua
12/16/2008	Tijuana (coastal)	Baja California
12/16/2008	Tijuana (river)	Baja California
12/16/2008	Sonoyta	Sonora
7/21/2009	Tijuana & Playas de Rosarito	Baja California
7/21/2009	Playas de Rosarito (Aztlan)	Baja California
7/21/2009	Playas de Rosarito (Independencia)	Baja California
7/21/2009	Playas de Rosarito (Lomas)	Baja California
7/21/2009	Playas de Rosarito (Rosarito 1)	Baja California
12/10/2009	Ciudad Juárez	Chihuahua
12/10/2009	Ciudad Juárez (South-South)	Chihuahua
12/10/2009	Yuma Co.	Arizona
12/10/2009	Lower Valley Water District (Clint)	Texas
4/14/2010	San Luis Rio Colorado	Sonora
5/4/2010	El Millon	Chihuahua
5/4/2010	Jesús Carranza	Chihuahua
5/4/2010	Tres Jacales	Chihuahua
10/1/2010	Nogales	Sonora
2/1/2011	Tijuana (La Morita)	Baja California
4/1/2011	Tijuana (Tecolote)	Baja California
4/1/2011	Hermosillo	Sonora
5/20/2011	Tijuana (Alcatraces)	Baja California
5/20/2011	Playas de Rosarito	Baja California

6/30/2011	Rio Grande City	Texas
5/21/2012	Playas de Rosarito	Baja California
7/17/2012	Matamoros	Tamaulipas
7/17/2012	Miguel Alemán	Tamaulipas
7/17/2012	Nuevo Laredo	Tamaulipas
10/26/2012	Tijuana	Baja California
11/8/2012	San Agustín	Chihuahua
11/8/2012	Bisbee	Arizona
3/13/2013	Brawley	California
4/13/2013	Sierra Vista	Arizona
5/9/2013	Holtville	California
5/9/2013	Holtville	California
7/22/2013	Nuevo Casas Grandes	Chihuahua
2/24/2014	Holtville	California
5/8/2014	Piedras Negras	Coahuila
5/8/2014	San Luis Rio Colorado	Sonora
8/28/2014	Tornillo	Texas
12/3/2014	Tecate	Baja California
12/3/2014	Mexicali	Baja California
12/3/2014	Tijuana	Baja California
12/3/2014	Socorro (Lower Valley Water District, Cotton Valley)	Texas
4/23/2015	Sunland Park	New Mexico
5/14/2015	Willcox	Arizona
11/6/2015	Sabinas	Coahuila
11/24/2015	Brownsville	Texas
5/6/2016	Reynosa	Tamaulipas
5/6/2016	Anthony	New Mexico
6/16/2016	N. Alamo (Hidalgo County)	Texas
11/17/2016	Nogales	Sonora
11/17/2016	Douglas	Arizona
11/9/2017	San Luis Rio Colorado	Sonora
11/9/2017	Tijuana	Baja California
11/9/2017	Loma Blanca	Chihuahua
11/9/2017	Marathon	Texas
6/19/2018	Camargo	Tamaulipas
11/8/2018	Nogales	Arizona
5/30/2019	Tijuana	Baja California
5/30/2019	Gustavo Diaz Ordaz	Tamaulipas
11/14/2019	Chihuahua	Chihuahua

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