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Regina M. Buono

Gabriel Eckstein

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Chapter 19

Current challenges in the Rio Grande/Río Bravo Basin: old disputes in a new century

Regina M. Buono[1] and Gabriel Eckstein[2]

[1]Non-resident Scholar, Center for Energy Studies, Baker Institute for Public Policy, Rice University; and Principal, Aither, USA
[2]Professor of Law and Director of the Energy, Environmental & Natural Resources Systems Law Program, Texas A&M University School of Law, USA

ABSTRACT

The Rio Grande River traverses 2000 kilometres of the international border between Mexico and the United States. The river and its tributaries are governed by a series of border treaties and institutions, as well as under the domestic laws of each nation. Often lauded for enabling innovative and collaborative governance, in recent years the complicated regime has come under pressure as domestic and international water governance institutions struggle under the strain of climate change, population growth, and other stressors on water supply and demand in the region. This chapter considers three of the major challenges currently facing the Rio Grande River Basin and its riparians: (1) groundwater and ground–surface interactions and related practical and policy implications; (2) engagement with local and regional stakeholders; and (3) Mexico's latest water debt under the 1944 Treaty. It also identifies shortcomings in the regime to address these concerns, as well as innovative responses and solutions that have been crafted at various levels of governance.

Keywords: 1944 Treaty, groundwater, Rio Grande River Basin, stakeholders, transboundary governance

19.1 INTRODUCTION

For over 170 years, the peoples of Mexico and the United States have shared the Rio Grande River Basin (known as the Río Bravo in Mexico). Though the basin traverses over 2000 kilometres of the international border between the two countries, it also ties the two nations together through shared natural resources and wildlife habitats, socio-economic systems, and cultural and historic bonds. Management of the Rio Grande and its tributaries has been governed by a series of border treaties and institutions, the most recent of which is the 1944 *Treaty on the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande*. Often lauded for enabling innovative and collaborative governance of the three named rivers, in recent years the treaty regime has nonetheless come under intense pressure in the Rio Grande Basin. Domestic and international water governance institutions are struggling under the strain of climate change impacts, population growth, and the attendant impacts to water supply and demand in the region.

This chapter considers some of the major challenges the Rio Grande River Basin faces currently, as the two riparians seek to adjust and adapt long-established systems to accommodate changing conditions and needs. We review the current situation in the region and focus on three areas of importance: (1) groundwater and ground–surface interactions and the related practical and policy implications; (2) engagement with local and regional stakeholders; and (3) Mexico's latest water debt under the 1944 Treaty.

19.2 BACKGROUND

19.2.1 Geology and geography of the region

The Rio Grande River rises in Colorado and flows south and east to the Gulf of Mexico, along the way passing through New Mexico and then forming the border between Texas and the Mexican states of Chihuahua, Coahuila, Nuevo León, and Tamaulipas (Figure 19.1). The streamflow of the river is

Figure 19.1 Map of the Rio Grande River Basin with its principal tributaries (Wikipedia). Source: https://en.wikipedia.org/wiki/Rio_Grande

highly variable but tightly controlled, particularly south of Otowi Bridge in Santa Fe, New Mexico, where diversions and inflows from tributaries are significant.

In the region north of El Paso, releases from Elephant Butte and Caballo reservoirs in New Mexico determine the river flow up to the Mexico–U.S. border (Nava *et al.*, 2016), while confluences with return flows downstream near Fort Quitman, the Rio Conchos, and the Pecos River, again replenish the river downstream. Along its route, the river supports more than two million acres of irrigated agriculture on both sides of the border, and more than six million residents in both countries.

19.2.2 Legal structures and governance at the binational level

Governance of the river at the international level is the responsibility of a binational body created by the *1944 Treaty on the Utilization of Waters of the Colorado and Tijuana Rivers and of the Rio Grande* (1944 Treaty) known as the International Boundary and Water Commission. The Commission is responsible for applying boundary and water treaties between Mexico and the United States and for settling differences that may arise in their interpretation and implementation. It operates through two sections: the Comisión Internacional de Límites y Aguas, based in Ciudad Juárez, Mexico, and the International Boundary and Water Commission, based in El Paso, Texas, in the United States (collectively IBWC/CILA). This is primarily a technocratic organization as each section's leadership team is comprised of a commissioner, who must be a trained engineer; two principal engineers; a legal advisor; and a foreign affairs secretary (Carter *et al.*, 2017).

In addition to creating the IBWC/CILA, Article 4 of the 1944 Treaty allocates the waters of the Rio Grande between Mexico and the United States from Fort Quitman, Texas, to the Gulf of Mexico (Figure 19.2). Under the treaty, Mexico is entitled to all waters reaching the main channel of the Rio Grande from the San Juan and Alamo rivers; half of unallocated flows from the main channel of the Rio Grande below the southernmost international dam; two-thirds of flows reaching the main channel of the Rio Grande from named tributaries in Mexico; and half of all other Rio Grande main channel flows not otherwise allotted by the treaty. The U.S. is allocated all Rio Grande water reaching the main channel of the river from named, smaller tributaries originating in Texas; one-half of unallocated flows in the main channel below the lowest major international storage dam; one-third of the flow reaching the main channel from named tributaries originating in Mexico; and one-half of unallotted flows between Fort Quitman and the lowest major international storage dam. The 1944 Treaty also provides that the one-third of the flow reaching the main channel of the river from the specified Mexican tributaries 'shall not be less, as an average amount in cycles of five consecutive years, than 350 000 acre-feet annually'. It allows Mexico, in the event of 'extraordinary drought or serious accident to the hydraulic systems' on its tributaries, to make up any deficiencies at the end of a 5-year cycle during the following 5-year cycle.

In addition, Article 25 of the 1944 Treaty includes an innovative mechanism – known as the minute system – that authorizes the IBWC to conduct ongoing negotiations to interpret and implement treaty terms. This mechanism has made the 1944 Treaty among the most flexible and adaptive binational treaties globally as it provides a way for the two countries, through their representatives in IBWC/CILA, to adapt management of the border's rivers in response to changing environmental and technical conditions and evolving stakeholder needs. When the 1944 Treaty lacks a clear directive regarding the outcome of an issue, IBWC/CILA Commissioners are able to negotiate an agreement (a 'minute') regarding how to address it. A minute is not an amendment to the treaty, but rather is treated as an interpretation of the 1944 Treaty, and does not require formal approval by the parties' legislatures. If neither government objects to a decision of IBWC/CILA within 30 days of the minute's pronouncement, the minute becomes a binding agreement between the countries.

One other treaty that is especially relevant to the Rio Grande is the *1906 Convention Between the United States and Mexico, Equitable Distribution of the Waters of the Rio Grande*. The treaty governs distribution of the upper portion of the basin before it reaches the Mexico–U.S. border. The agreement requires the U.S. to deliver to Mexico 60 000 acre-feet of water annually in the Rio Grande at a point

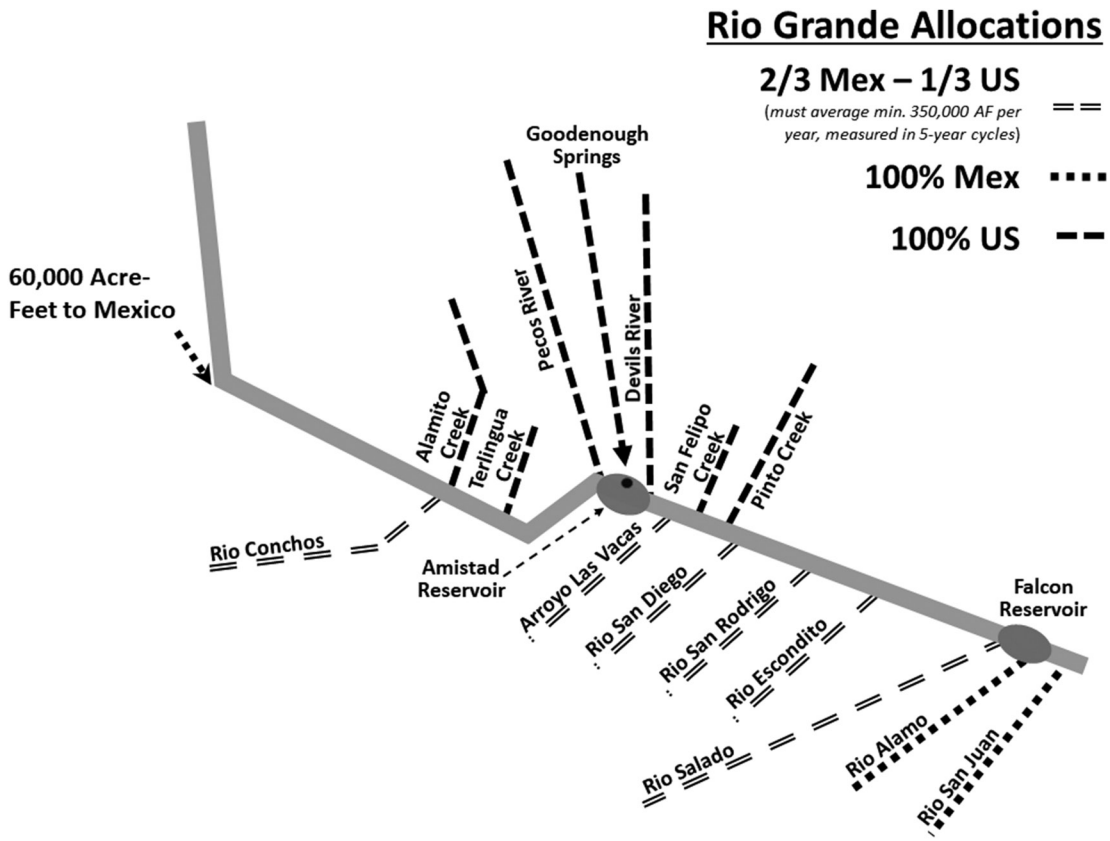

Figure 19.2 Schematic of the lower Rio Grande River basin, its main tributaries and reservoirs, and allocation of water under the 1944 Treaty.

just above the city of Juárez, Mexico. That volume, however, can be proportionally reduced during drought conditions and the U.S. is not required to make up deficits incurred by reduced deliveries. In fact, deliveries to Mexico under this treaty have been reduced in nearly one-third of the years between 1939 and 2015 (Carter *et al.*, 2017). Within Mexico, the water is transported to the Juárez Valley of Chihuahua where it is used primarily for irrigating agriculture.

19.2.3 Legal structures and governance at the national level

19.2.3.1 Surface water

While the 1944 Treaty distributes specific volumes and tributaries from the Rio Grande to both parties, within each country, domestic laws govern the internal allocation and uses of the river's water. Within the United States, the administration of water management and allocation is considerably more devolved and decentralized than in Mexico. In the U.S., inter-state compacts determine the allocation of inter-state surface water to each U.S. riparian state. Thus, the Rio Grande has been apportioned among Colorado, New Mexico, and Texas in accordance with the 1938 Rio Grande Compact. Under Article III of the Compact, while Colorado is entitled to use the river's water within its territory, it is required to deliver a specific volume of water at the Colorado–New Mexico border based on a formula that considers current flows of the Rio Grande and its tributaries at designated gauging stations.

Likewise, New Mexico has similar benefits and obligations regulated by formula under Article IV, however, its obligatory delivery location is not the New Mexico–Texas state line, but rather at a point close to San Marcial in New Mexico, just before the Rio Grande flows into Elephant Butte Reservoir. This delivery point was selected because the U.S. Bureau of Reclamation has managed the reservoir since 1906 and, thereby, controls water flow in the river below the dam as it courses toward the New Mexico–Texas border. Much of the water in the reservoir is reserved for Mexico (60 000 acre-feet noted above) under the Rio Grande Convention of 1906, as well as for the Elephant Butte Irrigation District in New Mexico and the El Paso County Water Improvement District in Texas under the federal 1905 Rio Grande Project Act. Any remaining flows are allotted for use by Texas.

While determinations at the international and national level can impact lower-level allocations, they do so only through a trickle-down process. Thus, water rights and uses by individuals, companies, municipalities, and other users, as well as any reductions in their allocations, are determined exclusively according to each country's domestic laws.

On the U.S. side, after bulk allocations are conducted under the 1906 and 1944 treaties, the three U.S. states of Colorado, New Mexico and Texas allocate the U.S. allotment in accordance with the 1938 Rio Grande Compact. Thereafter, each state can only distribute water in the Rio Grande that has been allotted to it in accordance with the compact. In Texas, according to its Water Code, surface water is owned by the state and held in trust for the public. Individuals and entities who wish to use surface water in Texas must obtain a water right and permit from the Texas Commission on Environmental Quality. Water rights are apportioned based on the doctrine of prior appropriation, which provides that the first person to take a quantity of water from a water source for 'beneficial use' has the right to continue to use that quantity of water for that purpose. The right is perpetual so long as it continues to be used fully in accordance with the permit and can be lost for non-use and other permit violations. Those who likewise take surface water for beneficial use at a later date are junior to those who establish their rights earlier in time, and those rights may be curtailed during low flows.

Both Colorado's and New Mexico's water law regimes, based on their respective state constitutions, are relatively similar to that of Texas in that surface waters are held by the state on behalf of the public, and both embrace the doctrine of prior appropriation (Constitution of the State of Colorado; Constitution of the State of New Mexico). The main difference is that in Colorado, most of the administrative functions of permitting water rights are managed by water courts rather than a state agency (Water Right Determination and Administration Act, 1969); in New Mexico, the State Engineer is charged with administering water rights for the state (New Mexico Statutes, 2016).

In sharp contrast, authority to regulate all water resources in Mexico is explicitly reserved by the federal government under the national constitution (Mexican Constitution, 1917). Surface water allocations are federally granted as concessions or assignments through the National Water Commission (Comisión Nacional del Agua, or CONAGUA) in accordance with the National Waters Law (Ley de Aguas Nacionales, 1992). Concessions are water rights granted for a fee to private parties for terms of 5 to 30 years, but which can be extended upon application. Assignments comprise the transfer of the right to manage, allocate, and charge for water resource uses from CONAGUA to sub-national governmental entities. Mexico uses basin agencies (Organismos de Cuenca) and Basin Councils (Consejos de Cuenca) in order to implement CONAGUA's mandate at the regional and local levels; however, these bodies have little authority or opportunity to engage in decision-making that affects regional or local allocations. For the most part, they function as liaisons between the federal government and local stakeholders (Foster, 2018).

19.2.3.2 Groundwater

With regard to groundwater, national regulations also vary between the two countries, as well as domestically among the individual U.S. states. Like surface water, groundwater in the U.S. is controlled by state law. In Texas, per the state's Water Code, groundwater is privately owned by the overlying landowner as real property. While its use is subject to some regulation by local groundwater conservation districts and the state, the government's ability to regulate groundwater is limited by constitutional provisions prohibiting the taking or overregulation of private property (Constitution of the State of Texas).

In contrast, under New Mexico's Water Code, groundwater is held by the state, but belongs to the public. It is subject to the doctrine of prior appropriation and managed by the state's Water Resources Allocation Program in the Office of the State Engineer. Permits are required for new groundwater appropriations, alterations to existing uses, and drilling of supplemental or replacement wells; however, a water right can be forfeited to the extent that any of the appropriated water is not fully applied to the designated beneficial use within a statutorily-defined time period.

Like in New Mexico, groundwater under Colorado's Water Code is owned by the state on behalf of the public. With the exception of groundwater rights in the Denver Basin, the state employs a modified prior appropriation system based on the type of groundwater at issue. Tributary groundwater (groundwater hydraulically connected to surface streams) is treated as surface water and subject to the state's surface prior appropriation system; non-tributary groundwater rights are subject to prior appropriation in relation to the total amount of recoverable water beneath the overlying land and the aquifer's life expectancy; groundwater rights in designated basins are adjudicated by the Colorado Ground Water Commission under a modified prior appropriation system 'to permit full economic development of designated ground water resources'. Groundwater rights in the Denver Basin aquifer are governed by statutory rules and are appurtenant to ownership of the overlying land.

Just as it does for surface waters, Mexican law vests the Mexican federal government with authority over the management and regulation of groundwater. A permit is required to extract groundwater or discharge wastewater into an aquifer. CONAGUA has jurisdiction nationwide to administer permits and monitor Mexican aquifers; the agency exercises its authority through various sub-agencies organized at the level of hydrologic-administrative regions based on surface hydrogeology. In recent years, Mexico has sought to decentralize water management authority in the country but has not conveyed sufficient resources and authority to local and regional entities to allow them to achieve desired objectives, such as the protection of aquifers and ecosystems and sufficient water quality in drinking water systems (Foster, 2018).

19.3 CURRENT CHALLENGES AT THE BORDER

The treaty regime described above has been lauded by some scholars for enabling innovative and collaborative governance of the named rivers (Mumme, 1993), but circumstances on the border have nonetheless come under pressure in the Rio Grande basin in the decades since 1944 and, in particular, in recent years. Domestic and international water governance institutions are struggling under the strain of climate change impacts, population growth, and the attendant impacts to water supply and demand in the region. The remainder of this chapter focuses on three policy areas where tension is surfacing: (1) groundwater and ground–surface interactions and related practical and policy implications; (2) engagement with local and regional stakeholders; and (3) Mexico's water debt under the 1944 Treaty.

19.3.1 Groundwater

Groundwater has long been treated as the neglected stepchild of the transboundary water regime along the Mexico–US border. Transboundary aquifers are excluded from the existing treaty regime, have rarely been placed on the IBWC/CILA's agenda, and until recently, have only sporadically been studied. Yet, groundwater on the border plays a significant role in agricultural production, economic development, and even the social fabric of the region.

As many as 72 transboundary aquifers and hydrogeological units are surmised to underlay large segments of the 3000-kilometre-long frontier (Sanchez & Rodriguez, 2021). Along Mexico's border with Texas alone, 53 domestic and transboundary hydrogeological formations have been identified, of which nearly 30% have good to moderate aquifer potential (Sanchez *et al.*, 2018). Numerous wells dot the landscape, and millions of people on both sides of the international border rely heavily on these subsurface resources. The Hueco Bolson and Conejos Medanos aquifers, for example, provide all of

the freshwater used by Ciudad Juárez's 1.54 million residents, while the Hueco Bolson and Mesilla Bolson aquifers supply approximately one-half of that used by El Paso's 963 000 residents (Far West Texas Water Planning Group, 2021).

The region's transboundary aquifers, however, do not exist in isolation. Many aquifers along the Mexico–Texas border are hydrologically connected to the Rio Grande. For example, the Rio Grande provides significant recharge to the Mesilla Basin aquifer system in the El Paso/Ciudad Juárez area, especially to the upper hydrogeologic unit (the Rio Grande alluvium) (Teeple, 2017). Likewise, groundwater flow in the Allende–Piedras Negras Aquifer, which historically discharged into the Rio Grande, may have recently shifted due to extensive groundwater pumping in the region, which now causes the Rio Grande to seep into the aquifer (Rodriguez *et al.*, 2020). In yet another distinct example, Goodenough Springs (also called Hinojosa Springs) are a series of freshwater springs that now lie submerged below and discharge into the binational Amistad Reservoir, effectively supporting the flow of the Rio Grande. The springs originate in the Edwards Trinity Aquifer emerging from the top of limestone deposits on the extreme western edge of Maverick Basin. Between inundation of the reservoir in 1967–68 and 2005, spring discharge was calculated to decline from a historical mean of 4.03 to 2.03 m^3/s, possibly due to hydrostatic backpressure from Amistad Reservoir (Flores *et al.*, 2021).

In addition, the region's aquifers represent a critical source of freshwater for the border region's distinct environment and ecosystems. For example, groundwater flowing from Cretaceous limestone aquifers into the Rio Grande helps sustain aquatic habitats along the river during dry years, as well as mitigate impairment to water quality (Bennett, 2011). In addition, during low flow conditions, groundwater is estimated to account for as much as two-thirds of the flow in the Rio Grande at the Foster's Weir gage and the point where the river enters the Amistad National Recreation Area (Bennett, 2011). Moreover, flows and aquatic habitats in the river segment above and including Amistad Reservoir have been found to be highly susceptible to groundwater extraction in nearby Terrell County and Val Verde County in Texas (Cutillo *et al.*, n.d.).

Notwithstanding the relevance of groundwater to the Rio Grande and its critical importance to various ecosystems along the frontier, none of the existing treaties between Mexico and the United States address the region's groundwater resources (Eckstein, 2013). The only direct reference to the region's transboundary aquifers is found in Minute 242 from 1973, which limits groundwater withdrawals on both sides of the Sonora–Arizona border near San Luis, Arizona, to specifically enumerated withdrawal targets, and mandates consultation between the parties prior to the development, by either nation, of any groundwater resources along the border that could adversely impact the other country. The two groundwater provisions were intended as temporary measures 'pending the conclusion … of a comprehensive agreement on groundwater in the border region' (IBWC, 1973, Para. 5). However, internal divisions among the stakeholders, especially on the American side, made agreement unachievable. Five decades later, the temporary provisions of Minute 242 have yet to be realized (Eckstein, 2013).

One other reference to groundwater on the Mexico–U.S. border, albeit very indirect, is found in Minute 289 from 1992, which addresses water quality problems along the border. Hidden among provisions that mostly address the Rio Grande and Colorado rivers, the minute refers to the Integrated Border Environmental Plan, which was adopted by the two countries in the same year. That plan calls for the creation of a water-monitoring program and database to observe both groundwater and surface water quality along the frontier (IBWC, 1992, Para. 4).

Aside from these two instruments, the region's groundwater resources are regulated independently by each country, exclusively under their respective domestic regime.

Missing from the existing treaty regime are mechanisms to address the hydrologic relationship that the Rio Grande has with the various aquifers that flow alongside and below the river. It is easy to imagine a scenario in which extensive groundwater extraction on one or both sides of the river could diminish flows in hydrologically linked segments of the Rio Grande. As noted above, that is already

happening with the Rio Grande River losing water to both the Mesilla Basin aquifer system and the Allende–Piedras Negras Aquifer. Under the existing treaty system, however, withdrawals from these aquifers, which are likely exacerbating the leakage, are likely to fall outside the rights and obligations created by the treaty regime. In a similar vein, the contamination of an aquifer (e.g., from sewage overflows, industrial spills, misuse of agricultural products, etc.) that is adjacent to and interrelated with a section of the Rio Grande that receives inflows from the aquifer could cause the pollutants to migrate into the river and affect downstream water uses and users. That scenario also may fall outside the scope of the treaties governing the river.

What is needed are provisions and mechanisms developed through IBWC/CILA that take hydrologically related groundwater into account in the overall management and allocation regime of the Rio Grande. As a first step, this would require compiling the existing information on such groundwater–surface water relationships in the basin, as well as conducting additional research to fill in the significant knowledge gaps that currently exist. At the very least, Mexico and the U.S. should expand their existing system for data and information sharing to include groundwater resources on the frontier.

The two nations also should explore whether groundwater withdrawals can offset allocation rights from the main stem of the Rio Grande or its various tributaries. Likewise, they should consider whether to incorporate a prioritization mechanism into the governance regime to determine when and under what circumstances groundwater or surface water allocations should prevail in times of shortages. In addition, Mexico and the U.S. should assess the impact that shortages in surface water have on groundwater exploitation, even in hydrologically unrelated aquifers.

Lastly, the two nations also should facilitate more opportunities for public participation. The management and governance of transboundary aquifers should not end at the frontier, but rather should be pursued collaboratively by local and regional stakeholders on both sides of the border.

19.3.2 Stakeholder involvement and transparency

IBWC/CILA's role under the 1944 Treaty is primarily carried out with a strong focus on technical issues, which are often analyzed and addressed from an engineering perspective. The organization's current approach to managing the Rio Grande under the 1944 Treaty offers limited stakeholder involvement. This approach has been criticized by scholars, one of whom asserted even nearly 30 years ago that the IBWC is merely 'a social artifact, imperfect at best, and captive to the vicissitudes of time' (Mumme, 1993; Mumme & Collins, 2014).

In response to the criticism, both national sections have established citizens' fora to engage with locals on their side of the border regarding issues in the region. On the U.S. side, the Rio Grande Citizens Forum, established in 1999, addresses the upper stretches of the river to Fort Quitman. The Lower Rio Grande Citizens Forum, established in 2003, offers a venue for residents of the lower reaches of the river (IBWC, 2017). CILA has also created citizens' fora in Ciudad Juárez, Ciudad Acuña, Nuevo Laredo, and Reynosa, Mexico, to facilitate the exchange of information between the Rio Grande Basin border community and CILA (CILA, 2014). The fora in both countries, however, have no formal role in negotiations over the river's management or operations. The U.S. fora have tended to focus primarily on circumscribed, smaller-scale challenges such as saltcedar control, endangered species, and levee remediation, while the Mexican groups appear to have met infrequently, with their agendas determined by CILA.

Stakeholder participation and transparency beyond the citizens' fora vary between the parties, though neither side evidences the extensive stakeholder engagement enjoyed by both nations in managing the Colorado River under the same treaty. In the U.S., stakeholder participation and transparency are, in part, a function of that country's decentralized approach to water management, which requires local participation to operate effectively. Stakeholder engagement in the U.S. also benefits from the greater availability of resources for state-level administrations and agencies that support the development and administration of local and regional water plans, as well as from

efforts by private and civil society groups. For instance, in New Mexico, the Nature Conservancy is leading a group of over 90 entities – including federal and state agencies, local governments, health systems, landowner groups, environmental consultancies, irrigation districts, water utilities, and non-governmental organizations (NGOs) – in the creation of the Rio Grande Water Fund (RGWF), which seeks to protect and improve the storage, delivery, and quality of Rio Grande water through landscape-scale forest restoration in the Rio Grande watershed (The Nature Conservancy, 2020). Since it began in 2014, the RGWF has treated 140 000 acres of forest, and continues to generate sustainable funding to support a 20-year program to restore 600 000 acres of forests and Rio Grande headwaters in New Mexico and Colorado. The fund also supports efforts to restore streams and wetlands by installing water sources for cattle and wildlife away from riparian areas and investing in local organizations that reduce wildfire risk through the use of prescribed fire.

In contrast, stakeholder participation and transparency on the Mexican side is largely absent because of the country's centralized approach to water management. Since the vast majority of domestic water-management decisions are made by CONAGUA at the national level, local communities have little to no real opportunity to be involved in meaningful decision-making. Efforts at decentralization proposed by the government over the past two decades have largely been ineffective because they failed to include funding and resources, as well as legal authority to create and enforce laws, for local and regional water-management entities (Foster, 2018). There have been some efforts – including in collaboration with cross-border partners – by environmental and other civic groups in Mexico to implement better conservation and agricultural practices in parts of the region (Borders, 2015). In general, local communities and institutions in Mexico lack adequate information about water availability, how allocation decisions are made, or Mexico's treaty relations with and obligations to the U.S.

The eventual effects of these enduring conditions became apparent in 2020 during Mexico's latest water debt, when violent conflicts erupted between Chihuahua farmers and the Mexican government. The protests were a poignant symptom of the disenfranchisement of local Mexican water stakeholders, and are another example in which decisions on water allocations to farmers, municipalities, and industry in Mexico continue to be made at the highest levels, in Mexico City. Interviews conducted by the media suggested that a lack of transparency by the central government was one of the chief reasons for the protests (Yucatan Times, 2020). Payan (2020) has argued that the conflict in Chihuahua is representative of Mexico's greater governance crisis.

19.3.3 Mexico's recurring water debt

Since the implementation of the 1944 Treaty, Mexico has twice fallen short on its treaty obligations to deliver to the U.S. an average annual 350 000 acre-feet of water down the Rio Conchos and into the Rio Grande. Under the treaty, Mexico is allowed to carry over any incomplete balances of water from one 5-year cycle to the subsequent 5-year cycle in the event of an 'extraordinary drought'. The two countries, however, have disagreed over two critical points. The first is what exactly constitutes an extraordinary drought. The second is whether repayment of a debt from the first 5-year cycle made during the second 5-year cycle must be made concurrently with any debt incurred during the second 5-year cycle, or whether that second shortfall can be postponed and carried over to a third 5-year cycle (Carter *et al.*, 2017).

Between 1944 and the drought that extended from 1994 to 2003, Mexico met its deliveries within each successive 5-year cycle (Carter *et al.*, 2017). Due to intensive expansion of agricultural production in the Rio Conchos basin during the 1980s and 1990s, as well as a number of intermittent droughts, the 1994–2003 drought was especially difficult for farmers in Northern Mexico. As a result, Mexico was unable to deliver the requisite water volumes into the Rio Grande. That water debt was eventually resolved by transferring some of Mexico's water rights in the two international reservoirs to the United States (see IBWC, 2002), as well as by the advent of hurricane-related rains in 2005 (Carter *et al.*, 2017).

The recent water shortfall dispute between Mexico and the United States began during the delivery cycle that began in October 2010 and ended in October 2015. A final accounting for that cycle showed a deficit of 216 250 acre-feet (Carter *et al.*, 2017). That deficit was carried over into the 2016–2020 cycle and threatened to continue into a third 5-year cycle, ratcheting up tension over both the debt and interpretation of the deficit provision as the two countries have long disagreed whether the treaty allows such water debts to be carried over into a third cycle.

The situation led to protests in the summer and fall of 2020 when farmers in Chihuahua learned that their national government planned to pay off the country's water shortfall by increasing Rio Concho flows into the Rio Grande (Mumme, 2020). In violent confrontations that resulted in the death of one female protester, the farmers forcibly took control of three dams on the Rio Conchos to prevent water from being released into the Rio Grande for the United States.

On October 21, 2020, three days before Mexico would have violated its delivery obligations under the 1944 Treaty, IBWC/CILA signed an agreement to resolve the issue. Under Minute 325, Mexico fulfilled its delivery obligations by transferring the entirety of its water in the Amistad and Falcon reservoirs to the United States. The transfer nearly depleted all of Northern Mexico's stored water in the reservoirs, thereby depriving Tamaulipas farmers downstream on the Rio Concho from their winter water supplies. However, by doing so, Mexico abided by the 1944 Treaty and ended the 2016–2020 cycle debt free (Helfgott, 2021). The minute also resolved the long-standing disagreement over Mexico's ability to end two back-to-back cycles, referencing Minute 234 and stating that two subsequent cycles 'may not end in a deficiency'.

In addition, as a long-term measure to improve water management in the basin, Minute 325 officially recognized two pre-existing working groups. The first is the Rio Grande Hydrology Work Group tasked with 'enhance[ing] information exchange, develop[ing] a binational Rio Grande model, and us[ing] the model as a tool to analyze water management scenarios, including scenarios related to future water conservation projects'. The second is the Rio Grande Policy Work Group, which would oversee the Hydrology Work Group and 'consider water management policies in the basin'. The two working groups have been collaborating since 2017 with binational participation to advance modeling capabilities in the basin (IBWC, 2017). Per the minute, the working groups are now tasked with developing a new minute by December 2023 to provide 'increased reliability and predictability in Rio Grande water deliveries to water users in the United States and Mexico' (IBWC 2020, Para. 4).

19.4 CONCLUSIONS

While long-standing and still functionally operational, the 1944 Treaty does suffer from some shortcomings. Most notably, the treaty offers no guidance or direction for dealing with modern circumstances that are beginning to overwhelm the instrument's capacity to generate effective and meaningful responses. Climate change, for example, threatens to make the Rio Grande basin even more arid. Likewise, population growth, as well as economic and agricultural activities, are taxing the regime's existing allocation system and its ability to balance water supply and demand. In addition, the 1944 Treaty provides no references to ecological purposes or to the region's hydraulically linked binational aquifers (Helfgott, 2021). While the treaty could probably continue operating in its current format for a few additional decades, these limitations will only amplify the growing water challenges on the Mexico–U.S. border.

That said, the 1944 Treaty's mechanisms – and, in particular, the minute system – have shown themselves able to facilitate and support innovations in water management. Recent evidence of this includes the work of the two working groups established by Minute 325 currently tasked with the development of a new minute to increase reliability and predictability in Rio Grande water deliveries. Additional lessons may be drawn for the Rio Grande from the experience of minutes developed to advance collaborative governance, stakeholder engagement, conservation, and environmental flows for the Colorado River (Buono *et al.*, 2021). Other initiatives, such as the Permanent Forum of

Binational Waters formed in 2020, will strengthen collaborative efforts across a wider set of scientists, government officials, NGOs, and citizens interested in the sustainability of the Rio Grande Basin. Finally, over the past few years, substantial academic research has been conducted on the region's transboundary aquifers and their relationship to the Rio Grande, contributing to the IBWC/CILA decision to formally to recognize the critical nature of groundwater in the border area and organize its first ever conference focusing on shared aquifers in April 2019. While independent of each other, these three efforts offer hope that human ingenuity and cooperation can move the basin toward better management of shared resources that bind the two nations and achieve long-term sustainability.

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