WATER SCARCITY IN THE RIO GRANDE/BRAVO WATERSHED: CHALLENGES AND SOLUTIONS

Results of Binational Rio Grande/Bravo Water Forum (November 7-8, 2017)

Prepared by the Rio Grande Water Forum Organizing Committee

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Rio Grande/Bravo Water Forum Organizing Committee

Co-Chairs

Genevieve Johnson, Desert Landscape Conservation Cooperative
Karin Krchnak, World Wildlife Fund*

Members

Ismael Aguilar Barajas, Instituto Tecnológico y de Estudios Superiores de Monterrey
Eugenio Barrios, World Wildlife Fund
Mark Briggs, World Wildlife Fund
Matthew Grabau, Desert Landscape Conservation Cooperative
Bruce Karas, The Coca-Cola Company
Mike Langston, South Central Climate Science Center, U.S. Geological Survey
Jurgen Mahlknecht, Instituto Tecnológico de Monterrey
Mario López Pérez, Instituto Mexicano de Tecnología del Agua
Jon Radtke, The Coca-Cola Company
Aimee Roberson, Rio Grande Joint Venture
J. Alfredo Rodriguez-Pineda, World Wildlife
Fund Judy A. Takats, World Wildlife Fund
Kim Winton, South Central Climate Science Center, U.S. Geological Survey

Cover Photograph: Sunrise along the Rio Grande/Bravo in the binational region of Big Bend (photo by Day's Edge).

* Karin joined the World Bank in early 2018 and is now head of the 2030 Water Resources Group in the World Bank Water Practice.

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Index

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I.- INTRODUCTION

Hot, dry, binational, critically important, yet overallocated. These descriptors are commonly used to describe the Rio Grande/Bravo basin that stretches across the southern United States and northern Mexico. 'Hot, dry' refers particularly to the arid portion of the basin that overlaps with the Chihuahuan Desert where average annual precipitation is often less than 30 cm (12 inches) with great majority occurring during the warm season months in a typical year. 'Binational' refers to an almost even split of the basin between Mexico and the U.S., with about 48% of the basin's total area of 355,500 sq miles (920,740 km^2)* lying in Mexico, and 52% in the U.S. The river, itself, forms about 1,250 miles (2,011 km) of the international border between the United States and Mexico from El Paso/Ciudad Juarez to the Gulf of Mexico (Fig. 1).

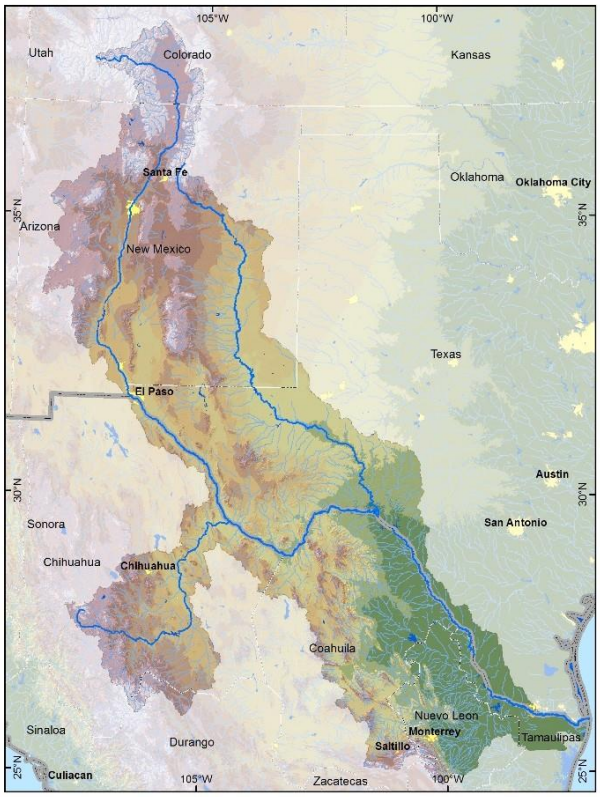


Figure 1. Enhanced satellite image of Rio Grande/Bravo basin showing the river, the international border, and selected cities.

* Source: Bureau of Reclamation 2013. Note: There is great variability in the calculated surface area of the RGB basin depending on (i) the source of information; and (ii) whether closed basins are included in the calculation of the total area (approximately 176,000 square miles (455,838 sq km) of the basin area contributes to the Rio Grande/Bravo, with the remainder of the basin area comprised of internal closed sub-basins (Bureau of Reclamation 2013)).

'Critically important' describes how essential water resources are to support the basin's 13 million people. The basin's rapidly growing cities, thriving economies, vital agriculture, and an incredible range of biodiversity all depend on one precious ingredient—water. And, finally, 'overallocated' brings to light the growing gap between water supply and demand, which is reaching crisis proportions in many parts of the basin.

Fortunately, the RGB's water challenges are fostering innovation. Throughout the river basin, collaborative and creative initiatives are underway to conserve water and riverine ecosystems while supporting human needs. These success stories are not widely known and need to be shared and considered for implementation throughout the Rio Grande/Río Bravo Basin. What can we learn from what is working in one place in the basin, or even another river basin, to help address issues at a larger scale? How can we apply lessons learned from these projects to other areas to help address current and future water demands?

> *We want more from the river than it can deliver. We want the water to grow pecans in the desert, maintain cottonwood bosques, support endemic species, and not flood our cities.*
>
> - Colin McDonald (Policy Analyst, Texas Comptroller of Public Accounts and RGB Water Forum participant)

To address these questions, The Rio Grande/Bravo Water Forum ('RGB Water Forum' or simply 'Forum') of November 7-8, 2017 in El Paso, Texas, brought together a diversity of stakeholders to discuss the basin's main water-related challenges, specifically with how the growing gap between water supply and demand is affecting fresh water resources and underserved communities, and potential solutions to those challenges (Fig. 2). Two main assumptions underlined the importance of the RGB Water Forum. First, the water issues that face the basin are complex, and while many decision-makers, managers, scientists and conservationists are aware of the challenges, there is a need to better understand the political, social, economic and ecological conditions that affect water quantity and quality. And, second, a basin wide response consisting of a diversity of stakeholders is needed to foster a resilient water management framework that provides for continuing economic and social benefits, fresh water ecosystems, and underserved communities.

The deep commitment to making this a truly binational event distinguished the RGB Water Forum from other efforts. Speakers presented in their native languages, with translators interpreting. Participants from both sides of the international border and representing a variety of different sectors sat at round tables designed to promote meeting new people and hearing diverse perspectives.

During the two days, participants heard from nearly three dozen speakers, who shared the issues they face and the work they do to overcome them. These speakers represented diverse organizations. The RGB Water Forum balanced the presentation of information with opportunities for discussion as means to not only identify water-related challenges and solutions, but to initiate and deepen personal relationships.

Figure 2. Over 180 basin experts representing 35 different agencies, organizations, institutes, businesses, municipalities, irrigation districts, and communities from both sides of the international border participated in the RGB Water Forum.

Organizations represented at the RGB Water Forum, included:

- Black & Veatch
- Centro de Investigaciones en Materiales Avanzados, S.C. (CIMAV),
- Centro de Investigaciones en Materiales Avanzados, Unidad Durango
- Chihuahua State Government
- Colegio de Postgraduados
- Comisión Nacional de Áreas Naturales Protegidas (CONANP)
- El Paso Water Utility
- Fundacion para la Conservación del Río Conchos
- Fundación Coca-Cola México
- GeoSystems Analysis, Inc.
- Hidalgo County Irrigation District No. 2
- Instituto Mexicano de Tecnología del Agua
- International Boundary and Water Commission
- Irrigation District 005 Delicias (Farmers)
- Junta Central de Aguas Saneamiento de Chihuahua
- Middle Rio Grande Conservancy District
- New Mexico Audubon Society
- Pronatura Noreste
- Río Bravo Basin Council

- Rio Grande Headwaters Restoration Project
- Texas Comptroller of Public Accounts
- Texas Parks and Wildlife Department
- The Coca-Cola Company
- U.S. Forest Service
- Instituto Tecnológico y de Estudios Superiores de Monterrey
- The Nature Conservancy
- Universidad de las Américas
- Universidad Autónoma de Chihuahua
- Universidad Autónoma de Ciudad Juárez
- University of California–Davis
- University of New Mexico, Utton Transboundary Resources Center
- University of Oklahoma
- Utah State University
- Water Utility of Monterrey
- World Wildlife Fund

The main objective of this report is to summarize the main water-related challenges and solutions that were discussed during the RGB Water Forum. To accomplish this, the report is divided into two main sections: Section II reviews some of the main water related challenges discussed at the Forum and Section III reviews some of the potential solutions to those challenges that were discussed. In the solution section, emphasis is placed on strategies that offer answers to how the flexibility and resilience of the basin's water management systems can be improved to ensure that there is enough water for people and nature, which was identified as a common goal at the Forum. Where appropriate, citations are provided to allow readers to track down documentation on points made during the Forum. The report concludes with a synopsis of potential next steps.

It is important to emphasize that the water-related challenges and solutions that are summarized in this report do not equate to any obligation of continuance by the RGB Forum Organizing Committee (RGB Water Forum OC). The main obligation of the RGB Water Forum OC, which is fulfilled here, is to provide a summary of the main topics discussed by participants during the Forum. The themes and topics that are ultimately selected by the RGB Water Forum OC as next step priorities will be determined based on input from basin partners and Forum participants, funding availability, trends of water-related issues and priorities in the basin, amongst other factors.

II.-CHALLENGES TO ADDRESSING WATER SCARCITY IN RGB BASIN

During the RGB Water Forum, challenges related to water security were highlighted through formal presentations as well as during small group discussions. Challenges that were discussed at the Forum are highlighted below.

A) The Basin is Already Overallocated

The amount of surface of water that is typically available in the system (available supply) is roughly half of demand. Rapidly growing thirsty cities and impacts of climate change will further widen the supply-demand gap. For example, just for the eight-county water planning region M in Texas, an annual water deficit of 592,000 acre-ft (730.2 Mm^3) is forecast by 2060 (BOR 2013). On the Mexican side of the basin, the annual deficit has been estimated at 1,874.5 Mm^3, amounting to a mean annual discrepancy of over 163,000 acre-ft (202 Mm^3) to meet Mexico's annual water obligations under the Mexico-US Water treaty of 1944 (CONAGUA 2013).

The predicted gap between water availability and demand in the basin constitutes a challenge for all Forum participants in the search for effective solutions that balance the water needs of growing urban areas, agriculture, industry, fresh water ecosystems, and underserved populations. The growing gap between water availability and demand in the basin is the overarching water-related issue that constitutes the background challenge for the entire Forum and one that needs to placed up front and center as we search for effective solutions.

B) Water Management in the RGB Basin is Complex

On numerous occasions, RGB Water Forum participants emphasized that water management is not holistically implemented at the watershed scale but subjugated by a variety of artificially imposed political boundaries that pose challenges to increasing the temporal and spatial flexibility of water management. The management of water in the basin is inherently complex with RGB's surface waters uniquely apportioned by a series of both international treaties and interstate compacts, including:

- The Convention of 1906
- The Rio Grande Compact of 1938
- The Water Treaty of 1944
- The Pecos River Compact of 1948

To meet obligations stipulated in the above treaties, the agencies and institutions that hold greatest sway over how RGB surface waters are managed varies by region. From Southern Colorado through New Mexico to El Paso, Texas, the Rio Grande Compact of 1938 holds sway with distribution, timing and magnitude of releases considered important in the adaptive management of several endangered species, most notably the federally endangered Rio Grande Silvery Minnow (in practice, the river still dries up along the middle Rio Grande, NM, with surviving fish being maintained at hatcheries and re-released when flow returns). At the international level, the IBWC/CILA oversees river water allocation from El Paso/ Cd. Juárez to the gaging station at Fort Quitman, Texas. From the Rio Conchos to Amistad Reservoir, the

federal water management agency, CONAGUA, oversees all of Mexico's surface waters, and IBWC/CILA oversee releases from the Rio Conchos to the mainstem of the river in accordance with the Water Treaty of 1944. At the US federal level, the Bureau of Reclamation is responsible for surface water management from Elephant Butte reservoir to the international border. From the Big Bend to the Gulf of Mexico, waters are tracked on the Texas side of the lower Rio Grande Valley by the Rio Grande Water Master Program working with local irrigation districts and the IBWC.

In general, there is a distinct difference between the way water is managed in the U.S. side versus the Mexican side of the basin. In the U.S., water is managed bottom-up, with state and local water agencies overseeing different parts of the basin. Agricultural water users in New Mexico, Texas, Chihuahua, Coahuila and Tamaulipas are organized in irrigation districts. Municipal water use is overseen by the city water utilities and Ysleta del Sur Pueblo (YDSP), 8 miles (13 km) south of El Paso, represents the interests of the main native tribes in the U.S. side of the basin. In comparison, water management in Mexico is very much top-down, beginning and ending with CONAGUA, which is the lead water agency at the federal level.

This layered complexity does not preclude the development of solutions to the basin's water challenges that potentially can be applied basin-wide. However, emphasis needs to be placed on developing targeted solutions at sub-basin scale that are tailored to the management frameworks that are in place in the parts of the basin where they are applied. When it comes to solutions to the basin's water crisis, one size does not fit all.

C) On-Going Political Water-Related Disputes

At the RGB Water Forum, two on-going water-related disputes were noted. Participants noted that these (and other) disputes needed to be understood and taken into account in order to effectively weave potential solutions into the basin's current water fabric. Participants also noted that solutions to the basin's water crisis can be discussed and even implemented before resolution of these and other on-going water disputes occurs. A brief background on the two on-going water-related disputes noted at the Forum are provided below.

U.S. – Mexico Water Sharing**:** Per the Water Treaty of 1944, the United States provides Mexico with 1.5 million acre-ft (1,850 Mm^3) per year from the Colorado River and 60,000 acre-ft (74 Mm^3) of Rio Grande, and Mexico provides the United States with an average of 350,000 acre-ft (431 Mm^3) per year from six tributaries emanating from the Mexican side of the RGB basin. Declaration of extraordinary drought by either country affects deliveries but agreeing on what exactly constitutes extraordinary drought has been a challenge. For example, in 1999, a dispute between US and Mexican delegations over what constitutes extraordinary drought in the RGB basin led to strained relations that were not rectified until 2002 at the presidential level (Vina 2005). Particularly with climate change research forecasting droughts of greater frequency, duration and intensity, such disputes are likely to continue in the future with the potential of compromising binational collaboration on a variety of water and river issues.

Texas – New Mexico Law Suit Over Rio Grande Compact: Texas sued New Mexico claiming that New Mexico had breached the Rio Grande Compact, and the United States agreed, alleging that New Mexico's breaches harmed the United States' interests on the Rio Grande River as well. For now, the dispute over the Rio Grande goes back before the special master for further proceedings on the merits. At stake are billions of gallons of water for agricultural use and international agreements.

D) Deterioration in Water Quality

Deteriorating water quality has become an issue in many parts of the basin; one that is not frequently highlighted given its importance to human well-being and fresh water ecosystem health. Unfortunately, water quality issues do not confine themselves to surface waters. As aquifers are overexploited, pumping at deeper depths is removing ancient sediments with high concentrations of arsenic, fluoride, lead and other resident pollutants of geographic origin. This has become a key issue for cities reliant almost solely on ground water. Ciudad Juarez and several urban centers located in the Rio Conchos basin are good examples. In addition, the potential that fracking – the injection of liquid at high pressure into subterranean rocks in order to extract oil or gas – could contaminate basin aquifers critical to drinking supplies has become a concern in many parts of the basin.

E) Variety of Issues Related to Current Water Law

At the RGB Water Forum, participants from mostly the U.S. side of the basin noted that current water law is entrenched, often fixed on historical water rights, not litigated, and does not reflect environmental needs, all of which leads to inflexible management that limits opportunities for creative and beneficial solutions for all. Some Forum participants acknowledged that although river ecology is affected greatly by water management (timing, quality, quantity), the needs of native freshwater ecosystems are not prioritized alongside other objectives related to human use. Along a similar thematic vein, several participants also mentioned that enforcement of existing water laws is not adequate, which has led to ineffective management and overuse.

The disconnect between surface water and ground water law was mentioned by participants on numerous occasions. In general, times of enhanced water stress (e.g., during periods of drought) tend to increase the use of ground water resources. Surface water resources dry and the pumps are turned on. Yet, surface and ground water resources are interconnected and have a great bearing on the overall hydroecological condition of the river. 0ver-pumping of our aquifers is extensive in southern NM, Texas, and Mexico. Ground water pumping is not metered or consistently quantified and ground water laws vary with state and region. In addition, the on-going dispute between Texas and New Mexico (see 'C. On-Going Political Water-Related Disputes) over ground water use and its impacts on surface water raises the concern that a Texas win could lead to surface waters along the Middle Rio Grande of New Mexico being taken to satisfy future Compact delivery requirements. The lack of interstate or international groundwater agreements sets the stage for rash responses in times of shortage and stress.

F) Disincentive for Water Conservation in the Irrigated Agriculture Sector

When considering water use in the basin as a whole, irrigated agriculture is by far the largest water user at over 85%. Given this, agricultural water conservation has to be an important part of providing sufficient water for native fresh water ecosystems and underserved communities. Several RGB Water Forum participants representing irrigation districts in New Mexico, Texas, and Rio Conchos noted two challenges to implementing actions to conserve water: (i) lack of funding, technical capacity, and general support to improve infrastructure; and (ii) the way that water is managed in the basin with water rights (or water concessions in Mexico) allocated to irrigation districts rather than individual farmers. As such, there is often no direct economic (or pricing) incentives for producers to conserve water with individual irrigation applications (Schmandt et al. 2018). However, recent adoption by some irrigation districts of metering at field outlets shows promise for charging water deliveries on a per-unit basis. Future water conservation efforts will need to address both of these challenges.

G) The Condition of the River is Dramatically Altered

Improving the condition of the river for benefit of both humans and native species was one of the central themes of the RGB Water Forum with the underlying question being, where can we get the water and/or how can we improve water management to accomplish this? River impoundment, diversion, pollution, invasive species and a host of other impacts have altered the river's hydroecologic condition dramatically, making efforts to bring back the river to a higher functioning level difficult and expensive. Simply put, the greater the deterioration of a river system, the more challenging it will be to bring back to a desirable condition, assuming there is even an agreement on what the desired condition is. To have significant impact, river conservation initiatives - which are typically underfunded - need to be planned strategically (e.g., protect parts of the basin that remain hydroecologically intact versus trying to bring back areas that are substantially deteriorated) and with a diversity of collaborators. Despite the challenge of improving river conditions, several participants of the RGB Water Forum noted that there exist several on-going efforts in the basin that are having positive impact. We need to learn from these efforts as part of the solution (see "J" in Solution section).

H) Climate Change

Climate change means change in water balance. Climate change is upon us and is occurring rapidly (Fig. 3). For example, average temperatures in the greater Big Bend region are expected to rise 3°F to 5°F by the middle of the 21st century (Nielsen-Gammon 2011). When considering interannual variability, even cool years during the middle of the 21st century will be normal or above normal relative to current temperatures. The situation is eye-opening because the majority of precipitation in this part of the basin falls during the warm season. Therefore, the availability of water will depend more and more on cool season precipitation, which is normally sparse in this region (McRoberts and Nielsen-Gammon 2010).

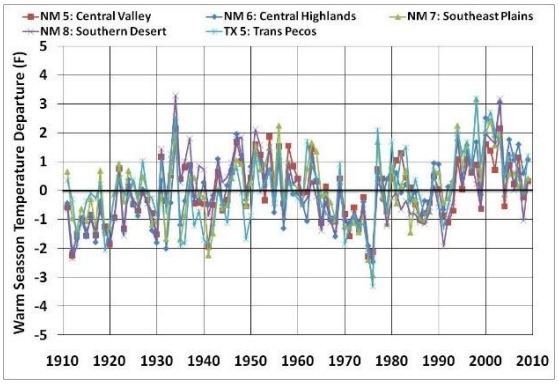


Figure 3. Time series of warm season temperature departures (from the period of record mean) for the five climate divisions in the transboundary region near Big Bend (McRoberts and Nielsen-Gammon 2010).

How such rapid changes in climate will impact water availability throughout the basin was on the minds of many Forum participants. Certainly, periods of drought have occurred on multiple occasions, impacting both streamflow and reservoir storage (Schmandt et al. [in press]). For example, the RGB experienced drought conditions in the 1950s, 1970s, and 1980s. Most recently, the region has been under drought conditions since 2010. The current drought has brought Elephant Butte within storage levels that resemble those of the drought of record in the 1950s. In 2013, the reservoir was at just 3% of its capacity (from Schmandt et al. [in press]). Such is the new norm. To be effective, solutions to the basin's growing water crisis will need to be adapted to the basin's rapidly changing climate.

I) Municipalities are Growing Rapidly but Irrigated Agriculture has the Majority of the Water

While agricultural water use has remained relatively stable since the middle of the 20th century, it still represents by far the largest user of surface water in the Rio Grande Basin (Texas Water Development Board). However, rapidly growing municipalities are seeking to meet their growing water demand via a diversity of solutions that include leasing and/or purchasing water from the agricultural sector. Although water transactions between municipality and agricultural sectors are occurring more frequently, they have inherent cultural, socioeconomic, political and legal challenges that need to be recognized and addressed.

J) Antiquated Water Delivery Infrastructure

RGB Water Forum participants representing several irrigation districts noted the importance of improving antiquated water delivery infrastructure and irrigation systems. They expressed the need for assistance to identify funding sources to help them in this endeavor. The value of return flows was also noted in this context, particularly in regard to how reduced transmission losses from improved infrastructure could impact downstream users. The challenge is one of supporting farmers while being cognizant that improved infrastructure will not be the end all to solving water scarcity issues.

K) Outdated Hydrologic Models

Regulatory bodies tend to rely on outdated allocation values that do not account for external impacts. This is troubling, as sedimentation, climate change and related evaporation are expected to increase water losses. In addition, increases in population and demand for irrigation water will exacerbate pressures on the water supply (Schmandt et al. [in press]). Given the importance that hydrologic models have on how water is managed in the basin, the need to update modeling was mentioned by several participants at the Forum as a key challenge that has to be addressed as part of an informed, thoughtful response to the basin's water challenges.

L) The Border Wall

Although discussion of the proposed border wall between the U.S. and Mexico was outside the theme of the RGB Water Forum, participants nonetheless noted during the Forum that, if constructed, the wall will affect binational relations between the U.S. and Mexico and, therefore, poses challenge to cross-border collaboration on water issues. It is an issue that everyone will keep an eye on with hope for improved relations between the two countries.

M) Lack of Basin Wide Cooperation Amongst Stakeholders

Participants noted several challenges regarding communication and improving collaboration basin wide, participants noted several challenges, including:

- Lack of cooperation amongst stakeholders (unwillingness to see mutual benefit);
- Inability of different groups to communicate - their focus can be narrow to the extent of losing the big picture (even if working on the same issue)
- Lack of understanding of who is doing what, tools used, effectiveness, results, lessons learned, etc.;
- Lack of consensus on what the water-related challenges are and the solutions to them;
- Lack of innovative response and a general hesitancy to think outside the box;
- The need and importance of enhancing collaboration between the 3-legged stool of government, public organizations (NGOs) and industry.

N) Lack of Funding in Support of Water-Related Issues and Natural Resource Conservation

An overarching challenge associated with improving water management to meet future demands is that costs (e.g., to cover infrastructure improvements, change water policies, etc.) need to be covered by current users for the benefit of future generations. In addition, RGB Water Forum participants noted the great discrepancy in funding between groups and/or countries. Funding for natural resource conservation and for efforts to address water-related challenges are scattered, uncoordinated, and typically short-term.

O) Significant Needs Related to Research, Monitoring and Data Management

Notes from breakout sessions highlighted research, monitoring and data management needs related to water management and natural resource conservation. Selected highlights in this context include the need to:

- Improve measurement standards and address data sharing challenges;
- Thoughtfully assess results of efforts to address water-related issues and/or natural resource conservation (i.e., how effective were these efforts in accomplishing their stated objectives?);
- Address knowledge gaps relating to the socioeconomic value of the ecosystem services that rivers provide and what is lost when river conditions deteriorate;
- Quantify flow targets related to environmental flow; and
- Better understand ground water – surface water interactions.

III.- SOLUTIONS TO WATER SCARCITY IN THE RIO GRANDE/BRAVO BASIN

Solutions to water scarcity in the RGB Basin that are outlined below are ones highlighted during the RGB Water Forum, either as part of formal presentations and/or during breakout and side discussions. Depending on a range of factors, including funding, input from the Forum Organizing Committee, and comments from participants and other basin leaders, a subset of these solutions may become the focus of the next Forum that is provisionally planned to take place in the Mexican side of the basin in 2020 (see IV. Next Steps).

Regardless of the action that is being implemented to address a challenge, RGB Water Forum participants noted the benefits of testing projects a small scale. It is unrealistic and even counterproductive to tackle big issues all at once, and it is often more effective to begin at a reasonable spatial scale and expand from there. In addition, several Forum participants noted that some solutions may be appropriate to specific geographies or parts of the basin, but not in others (one size does not fit all).

A) Improve Water Policy

Enhancing water security and restoring flows for nature is not just about water volume. Forum participants emphasize the importance of finding flexible and fair ways to allocate water supplies amongst uses, particularly during times of shortage. Water policy is key in this regard. Policies need to be promoted that support environmental flows and water security. Forum participants noted specific water policies that will allow farmers and ranchers to dedicate conserved water to rivers, fostering opportunities to restore streams throughout the basin. Policies that allow saved water to be legally stored, credited, and protected from depletion upstream or downstream would also be useful. To bring about such policy changes, strong and diverse collaboration and successful local demonstration projects are needed. In this context, it is important to emphasize that water policy discussion is well advanced (i.e., we are not starting from scratch). For example, The Utton Transboundary Resources Center started a broad dialogue on water policy reform when they convened over forty experienced water managers,

lawyers, scientists, engineers, academics, and students in October 2014 to explore water law and policy options (Oglesby 2016).

B) Improve Water Management

Improving water management practices is critical to advancing freshwater conservation in the basin, particularly in the agricultural water sector, which is responsible for about 85% of the basin's consumptive use of water. Addressing agricultural water management is central to assuring that available water is shared by farms, cities, and rivers; flow needs for native fresh water ecosystems are met; and aquifers are sustainably managed. Central to realizing this goal, improvements to water management will need to directly address sources of water stress, whether depletion or diversion, to minimize flow alteration, either by leaving more water in the river or by increasing return flow to the river. Improvements to conveyance infrastructure and the use of water markets to improve hydrologic resiliency and provide economic incentives to farmers are specifically discussed below. Water management priorities highlighted during the Forum and summarized, below.

C) Learn from On-Going and Past Irrigated Agriculture Water Conservation Efforts

Irrigated agriculture water conservation has a long history in the RGB basin and can generally be placed into one of two categories:

1) On-Farm Water Conservation Efforts

There are many different avenues available to farmers who consider water sustainability to be a worthwhile goal. History suggests that farmers tend to pursue three main options for dealing with water scarcity and agriculture: (i) crop choice, (ii) irrigation techniques, and/or (iii) abandonment of agriculture.

The first two options are closely related and can produce significant water savings. However, for a variety of reasons, much of what is saved does not equate to increased river flow. For example, depending on the situation, water savings may simply give farmers reason to expand their planting footprint and/or extend their irrigation season to allow an increased number of crops per year. For similar reasons, going from flood irrigation to drip irrigation may actually increase water consumption as well as reduce agricultural return flows critical to downstream users. As part of improving water efficiency in the irrigated agriculture sector, these and other challenges will need to be addressed to provide and/or safe guard waters for native ecosystems and downstream users (Fig. 4).

Figure 4. In the Rio Conchos basin, collaborative efforts between the Irrigation Unit of San Pedro, WWF, and CONAGUA have helped to improve irrigation efficiencies, allowing more water flow in the San Pedro for native species.

Concerning the third option, several RGB Water Forum participants noted that abandoning agriculture completely in the basin is considerably less popular. While a reduction in agriculture may be feasible, even this possibility comes with many downsides for the RGB basin binational community. If the region were to reduce or abandon agriculture, significant job losses would occur, and food cost could rise. Nonetheless, a reduction in agricultural production seems a likely scenario given the future water availability outlook and the ability of cities to pay more for water. However, many people struggle to imagine a future where agriculture in the basin is significantly reduced (Schmandt et al. [in press]).

2) Reduce Evapotranspiration Losses from Open Water Surfaces:

Reducing evapotranspiration losses in the basin (from reservoirs and conveyance infrastructure) is not a panacea solution yet could produce water savings that could potentially be applied to the environment and/or underserved communities.

To understand how water can be delivered more efficiently, Forum participants noted the importance of working with agricultural producers to understand the nature of the water supply and the location and timing of water needs in the system. There are a variety of potential options available. Conveyance efficiency can be improved by installing check structures or re-grading the irrigation canals. Diversion structures can be constructed in a manner that enables irrigators to adjust diversion amounts to better meet needs, allowing greater amounts of unneeded water to be returned to the river.

Regardless of the method, both on-farm and conveyance efficiency measures can be implemented without compromising crop production. Participants noted the importance of learning from results of water conservation efforts in the irrigated agricultural sector that have already been completed. For example, a collaborative effort involving irrigation districts, North American Development Bank, the U.S. Bureau of Reclamation, the Texas Water Development Board, Texas AgriLife Research, and Texas AgriLife Extension Service that was initiated in 2002 saved an estimated 58,250 acre-ft (71.8 Mm^3) of raw irrigation water at an "annualized" cost of $12/acre-ft to $427/acre-ft (Harrington and Lacewell 2015). Forum participants noted that similar rehabilitation projects have also been conducted with irrigation districts in Colorado, New Mexico, and Chihuahua. It would be interesting to learn how much water has been saved by these efforts, how the saved water was used, and what can be done to save additional water. Addressing such important questions could be a central part of the next RGB Water Forum (see Section III. Next Steps).

In addition, Forum participants also noted the importance of fostering policy and/or economic incentives that will promote more water conservation efforts as well as a broader application of the water that is ultimately saved. In this light, it is critical to pair discussions of water conservation in the irrigated agricultural sector with discussions of water markets and transactions (see both of these topics, below) as well as with funding incentives for on-farm and conveyance improvements, including public grants (e.g., in Mexico, assistance through

CONAGUA; in U.S., Farm Bill program such as the Regional Conservation Partnership Program and the Environmental Quality Incentives Program, and the Bureau of Reclamation's WaterSMART program), as well as private donations and investments.

D) Learn from On-Going and Past Urban Water Conservation Efforts

In cities like El Paso, Ciudad Juarez, Albuquerque and others, a host of water initiatives have been implemented to help them meet growing demands with limited supplies. These water initiatives include rain water harvesting, ground water desalination, re-use of waste water, repair of urban delivery systems, incentives for low water-use appliances, amongst others. We need to learn more about the effectiveness and pros and cons of these initiatives to be better informed on how to best address the growing demand-supply gap.

E) Develop Water Markets and Water Transaction Programs

Water markets can support resilience by moving water to higher value uses and encourage conservation. Coupling the use of water markets with agricultural infrastructure improvements can enhance the resiliency of water supplies to hydrologic variation and, by so doing, provide greater security to farmers. Water transfers conducted as part of a water market can provide revenue for farmers and be carried out in a flexible, voluntary way that will also benefit the environment (NMSU and Udall 2012). There are different types of water transfers: point of diversion, place of use, purpose of use, or any combination of the three. On the U.S. side of the RGB basin, market-based water transfers from farms to cities has been common for many years and is seen as critical tool to meet growing urban demand. The larger value of water in urban areas than for irrigated agriculture signals water trading could benefit both cities and farmers.

There are four established water market mechanisms in New Mexico that were noted by Forum participants: the Middle Rio Grande Conservancy District Water Bank, a private water bank – Waterbank.com; the Pecos River Acquisition, and the New Mexico Strategic Water Reserve (GeoSystems Analysis 2017). A recent success story involves a novel approach implemented in 2016 by Audubon New Mexico. Audubon representatives worked with four Middle Rio Grande Pueblos (Cochiti, Santa Ana, Sandia and Isleta) on a conservation demonstration project that resulted in each of the four Pueblos donating 100 acre-ft (.12 Mm^3) of San Juan-Chama water provided to the Pueblos by the City of Santa Fe and Reclamation for cooperation in utilization of designated Prior and Paramount space in El Vado to supplement Middle Rio Grande instream flows. These and other on-going water markets should be assessed to understand the best path forward.

In West Texas, Schmandt (2002) noted that many farmers have found it more profitable to sell or rent their water rights than farm. That said, several RGB Water Forum participants representing irrigation districts expressed concern on part of the agricultural community that water transfers and markets will destabilize rural agricultural communities. This concern is also reflected in the literature (The Nature Conservancy 2018; New Mexico State University and New Mexico First 2017; New Mexico State University Udall 2012). One potential answer to this concern is for water transfers to be carried out temporarily in order to protect agricultural

water rights. In this context, experts on water markets emphasize the importance of designing water transactions in a manner that benefits native fresh water species and, at the same time, provides direct economic benefits to farmers while protecting water rights and supporting farming communities (Ward et al. 2005).

F) Develop International Ground Water Agreements

Transboundary aquifers, such as the Hueco Bolson, are being pumped at dangerously high, unsustainable rates. Both El Paso and Ciudad Juarez depend on the Hueco Bolson for at least some of their water supply. Ciudad Juarez is almost 100% dependent on this water source and some experts have estimated that pumping from this important transboundary aquifer will no longer be possible in less than a decade due to diminished water quality and higher pumping costs associated with pumping at ever greater depths. CONAGUA has identified several aquifers in the transboundary region that are over-exploited (i.e., annual pumping exceeds annual recharge) and is assisting cities to implement conservation measures and/or find new groundwater or surface water supplies. As noted by Forum participants, the U.S.-Mexico 1944 Water Treaty does not address binational allocation of transboundary ground water reserves. The current lack of any pre-existing international (as well as interstate) groundwater agreements sets the stage for rash responses in times of shortage and stress. As the over-exploitation of transboundary aquifers becomes an ever more serious issue, the need for developing a transboundary aquifer agreement becomes more pressing. Some organizations (e.g., Utton Transboundary Resources Center, University of New Mexico) have already taken up the cause, conducting necessary research and even developing draft transboundary ground water agreements to provide a useful foundation for future efforts.

G) Improve/Update Estimates of Evapotranspiration Losses

As temperatures have increased and precipitation has declined, irrigation requirements and subsequent evapotranspiration rates have increased. Recent research reveals methodology shortcomings in how the Bureau of Reclamation and other management institutions determine water allocation and delivery. Equations used to allocate water in the RGB basin need to be updated, taking into account data more recent than the 1951-1978 data range on which allocation decisions are based (Schmandt et al. 2018). Several Forum participants noted the importance of communicating directly with federal water management agencies, as well as municipal and irrigation districts, to assess how they are determining water losses. The need to update methodologies may present an opportunity for new collaborative public-private partnerships that could help to not only update water gains and losses in the system, and potentially other priorities, as well (e.g., formation of water banks, addressing specific water policy issues, improving conveyance infrastructure, etc.).

H) Learn from Creative Solutions to Water Scarcity that are Already Being Conducted

Creative solutions will be needed to secure water for the future. Forum participants noted several water conservation efforts from which we can learn, including:

- WATER 2120: A plan completed by The Albuquerque Bernalillo County Water Utility Authority that uses aquifer storage and recovery, waste water reuse and storm water capture as primary strategies to address water security;
- Water Sharing Strategies: 'Water Sharing' strategies allow cities to manage the risk of water shortage through targeted investment in agricultural efficiency improvements and/or fallowing agreements. A great benefit of "water sharing" approaches is that they encourage rural agricultural communities to create programs that establish a market for conserved water that cities and other downstream water users can buy into (The Nature Conservancy et al., 2018). Such water-sharing agreements can be designed to restore and protect river ecosystems by providing mechanisms and incentives for transactions that reduce river diversions or increase return flows, thereby enhancing flows; and
- Creative efforts being employed in other basins: There are a variety of efforts in Mexico and U.S. that are conserving water and use conserved water to support native fresh water ecosystems. Forum participants noted, for example, the System Conservation Pilot Program (SCPP), which is administered by the Upper Colorado River Commission, www.usbr.gov/lc/region/programs/PilotSysConsProg/pilotsystem.html, as one example of how cities can support environmental flows (see The Nature Conservancy (2018) for other great examples.

I) Optimize Water Storage

The time is ripe for water management agencies to review their project operation rules and consider alternative operating regimes and involve the public in the process (Geosystems Analysis 2017; Benson 2016). Certainly, options exist to better integrate reservoir management across the large systems that make up the Basin and Range Province. For example, the current system stores large volumes of water in low-elevation reservoirs with high rates of evaporative loss. Alternatives to this management practice include networked multi-reservoir storage that shifts water to higher elevations (where evaporative losses are lower) and aquifer storage and recovery (ASR). Such practices will not only decrease evaporative losses but can also help sustain late-summer base flows (The Nature Conservancy et al., 2018). Numerous solutions have been identified and need to be tested (Oglesby 2016) and Forum participants noted that meetings such as the Forum are well positioned and could be used to communicate with and support water management agencies to improve their operating procedures.

J) Learn from On-Going and Past On-the-Ground Stream Restoration Efforts

The good news coming out of RGB basin as it relates to the conservation of water and freshwater ecosystems is that there is a lot of innovative, collaborative work being carried out by a myriad of organizations, agencies, foundations, communities, businesses, irrigation districts, ranchers, and others on both sides of the international border. Although the grand majority of these efforts are at reach scale (or smaller), some are having significant impact on water supply and environmental conditions. As longer-term issues related to water management and policy are being addressed, on-the-ground stream restoration efforts show great promise for stemming deterioration and even improving the condition of our fresh water resources. Forum participants noted several on-going stream restoration efforts that can serve

as models from which we can all learn and consider how they can best be expanded for greater impact. Some of the on-going stream restoration efforts mentioned at the Forum, include:

- Colorado farmers coordinating their water deliveries to sustain trout fisheries
- Upland restoration efforts in the middle and upper Rio Grande basin being carried out as part of The Nature Conservancy-led Rio Grande Water Fund, with more than 70 partners (Fig. 5);
- Floodplain and river habitat rehabilitation efforts along the Middle Rio Grande, NM conducted by various federal, state, and tribal entities (Fig. 6);
- Environmental flow experiments supported by a broad group of federal, state, regional governments and non-profit organizations on the Wild and Scenic stretch of the Rio Chama in northern New Mexico;
- Population enhancement and reintroduction of the Rio Grande Silvery Minnow in the Middle Rio Grande of New Mexico and the Big Bend of Texas/Mexico by U.S. Fish and Wildlife Service and others;
- International Boundary Water Commission effort to purchase water rights to restore riparian forests;
- El Paso and Presidio using their treated sewage to create wetlands;
- Historic and collaborative effort between Audubon New Mexico, four Middle Rio Grande Pueblos – Sandia, Isleta, Santa Ana, and Cochiti – and the Club at Las Campanas marked the first time in the history of New Mexico that a conservation organization stored water in a reservoir for environmental purposes (Fig 7);
- Grassland and riparian restoration and enhancement in Rio Grande/Bravo tributaries on both sides of the border in the binational region of Big Bend being conducted by World Wildlife Fund, Comisión Nacional de Áreas Naturales Protegidas (CONANP), Texas Parks and Wildlife Department (via TPWD's Landowner Initiative Program), Pronatura Noreste, Rio Grande Joint Venture, Big Bend National Park, local ranches and communities, others;
- On-the-ground restoration actions along the reach of the mainstem of the Rio Grande/Bravo, itself, from Ojinaga toward Amistad being carried out by World Wildlife Fund, CONANP, Big Bend National Park, Profauna, Texas Parks and Wildlife Department, riverside communities, and others (Fig. 8);
- Forest, soil and vegetation recovery efforts along tributaries in the upper portion of the Rio Conchos by World Wildlife Fund, Chihuahuan State Government, Comisión Nacional Forestal (CONAFOR), local communities, and others (Fig. 9);
- Community-based rainwater harvesting work in the upper Conchos by World Wildlife Fund and others (Fig. 10);
- Aquatic habitat restoration work along the Bitter Lakes reach of the Pecos River by U.S. Fish and Wildlife Service, Weber State University, others;
- Farming governance implementation and water use reduction efforts with farmers from the Irrigation Units at the Rio San Pedro and Rio Conchos in collaboration with WWF;

- Urban aquifer recharge studies and pilot projects carried by the University of Chihuahua and WWF that include new Ramsar wetlands for their international importance as well as community-based efforts to treat raw sewage via biological methods;
- A range of innovative public-private partnerships that have formed to accomplish many of the above efforts show great promise for future expansion for greater impact (Fig. 11).

Figure 5. Following the 2014 Conchas wildfire, proactive forest restoration actions taking place in the upper parts of the Santa Fe implemented by the Rio Grande Water Fund coalition are protecting source water for Santa Fe and Albuquerque (photo by Craig Allen, USGS).

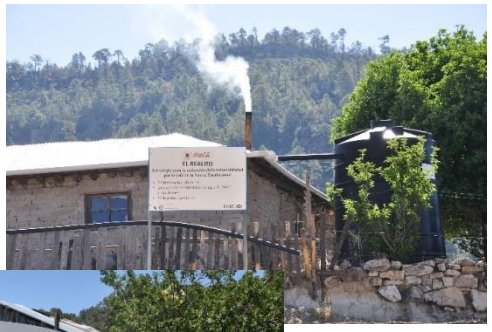
Figure 6. Floodplain restoration conducted by GeoSystems Analysis and Corps of Engineers along middle Rio Grande, NM, promoted over 120-acres of floodplain inundation during snowmelt runoff events in 2016-2017 (photo by Todd Caplan, GeoSystems Analysis, Inc.).

Figure 7. For the first time in the history of NM, a conservation organization is storing water in a reservoir for environmental purposes (photo by Paul Tashijan, Audubon NM).

Figure 8. As part of an on-going binational effort to restore floodplain habitat, a prescribed burn of dense stands of giant cane along the Black Gap reach of the Rio Grande/Bravo during the spring of 2018 marks rehabilitation of over 100 km of this binational river (photo by Mark Briggs, WWF).

Figure 9. Thousands of gabion and check dam structures have been installed along upper tributaries of the Rio Conchos to slow runoff, capture sediment and encourage ground water recharge (photo by Alfredo Rodriguez, WWF).

Figure 10. More than 300 families benefited from a rain water capture system pilot project to serve basic access to water. Now, the Chihuahua state government develops a similar program to provide water for hundreds of indigenous communities (photos by Alfredo Rodriguez, WWF).



K) Improve Basin Wide Communication and Collaboration on Water Issues

On numerous occasions, RGB Water Forum participants emphasized that fair and equitable water governance will only occur if the resources and the political will are mobilized. A diverse coalition is needed to address the basin's water management challenges with win-win solutions. The RGB Water Forum of 2017 was a good start to building such a coalition, but additional steps are needed. One obvious suggestion that was made at the Forum was to convene a subsequent Forum in the near future (see "Next Steps").

Another suggestion that was made at the Forum was to work closely with on-going initiatives (or revive past initiatives) that bring diverse groups together to discuss water-related issues. Examples of such efforts include:

- Revive the 'Paseo del Norte Water Taskforce,' that would facilitate effective, diverse and frequent participation from all basin geographies;
- Collaborate with IBWC/CILA to expand participation in their semi-annual binational meetings;

- Collaborate with the Consejo de Cuenca Rio Bravo and Comités Técnicos de Aguas Subterráneas (COTAS);
- Take advantage of and expand on innovative collaborative public-private partnerships that have already formed in response to water-related and natural resource conservation priorities (Fig. 11).

Figure 11. A photo of a portion of the binational public-private collaboration that is working to restore the binational reach of the Rio Grande/Bravo downstream of Rio Conchos confluence, includes Big Bend National Park, RGSSS consulting, The Coca-Cola Company, World Wildlife Fund, Comisión Nacional de Áreas Naturales Protegidas, and Profauna. These and similar public private partnerships in the basin (e.g., like the Rio Grande Water Fund coalition, which has over 70 signatories) need to be the future model for addressing key water-related issues in the basin (photo by Audra Melton).

Targeted public outreach is essential to fostering solutions to water scarcity. We need to do better at bringing people from all walks of life together to jointly discover the intersections between current river management practices and the failing ecological health of the streams and aquifers that are vital for agriculture, municipalities and wildlife. Visiting with acequias, irrigation districts and agricultural producers is vital to understanding on-the-ground problems, such as water delivery during times of shortage. Conversely, getting water consumers and other stakeholders on the river to see river conditions first hand is also important.

Several groups in attendance at the RGB Water Forum have dedicated missions on public outreach on water issues (e.g., Rio Grande International Study Center). More public outreach is needed on the importance of water, how water is used, and water scarcity. Basin wide collaboration on public outreach is needed such that water-related messages becomes more unified. In this context, solutions identified during the RGB Forum include:

- Engaging stakeholders across all levels, from communities to decision-makers to different cultures;
- Reinforce inherent linkages between water scarcity and the deterioration of river conditions to public health and economic well-being;
- Emphasize ecosystem services that the river provides so that water remaining in the river is seen as valuable and the river, itself, is seen and treated as something other than an irrigation ditch;
- Emphasis on incorporating green infrastructure into development plans for our growing municipalities;
- Develop greater consensus on what the best priority uses for water should be.

Forum participants noted the potential of collaborating with several on-going and new public outreach efforts on water and natural resource conservation. The public outreach efforts noted at the Forum, include:

- Connecting People with Rivers (CPR) – this effort, which is part of the Rio Chama Flow Project, offers annual tours of the river to water managers and users, the individual and institutional "stakeholders" of the Rio Grande Basin. CPR trips not only assures that managers and principals have a close acquaintance with the resource for which they are responsible, but have the added benefit of solidifying personal working relationships among the diverse institutions who are responsible for the range of desired outcomes for the river;
- A variety of public outreach efforts offered through the Rio Grande International Study Center, focusing mostly in the Lower Rio Grande Valley;
- The Rio San Pedro Bird Festival - a day long community celebration of the Ramsar site Rio San Pedro, with technical conferences, bird watching, food, music, and some other recreational activities to strengthen social awareness of river importance; and
- The El Camino Bravo - a destination hike in development on par with the Wonderland Trail or Appalachian Trail that will raise public awareness of the beautiful landscape along the U.S. – Mexico border and build support for its long-term protection and sustainable development.

L) Quantifying Ecosystem Services

Several of the presentations during the Forum on water management underscored the importance of integrating the value of ecosystem services into scenario analyses and optimization models as part of improving water management. Public willingness to pay for river restoration in order to enhance the quality of the ecosystem services that the river provides has become an important area of research. For example, a team of physical and social scientists developed a set of ecological endpoints for the middle Rio Grande in New Mexico and used these ecological endpoints to assess the willingness to pay for restoration alternatives. Results indicate that a public informed about the benefits of a restored river will be willing to pay for them (Broadbent et al. 2015).

M) Address Key Gaps of Knowledge Related to Water Scarcity and Conservation of Native Fresh Water Ecosystems

Forum participants noted the importance of documenting priorities related to addressing water scarcity and the conservation of fresh water ecosystems. Six priorities are put forth, below:

1) Improve water accounting: Lack of accurate accounting for water used and water available makes it almost impossible to effectively dedicate water to the environment, while also providing for other uses;
2) Water policy: Development and integration of policies in U.S. and Mexico (as well as state policies for the seven basin states) into water management to improve sustainability and resiliency of water management;
3) Stream restoration: There are a variety of restoration actions taking place in the basin (Section II. J). What has worked/been effective? What has not? How can the current suite of on-the-ground stream restoration actions that are most effective and realistically expanded for greater impact?
4) Water Conservation Efforts: Significant water conservation efforts in the basin have been undertaken by cities, municipalities, businesses (e.g., Coca-Cola's 2020 zero water footprint goal), and agriculture sectors. How much water has been conserved? How has conserved water been used? Can a portion of water saved from conservation efforts be used in support of native fresh water ecosystems and underserved human communities?
5) Protecting basin ecosystems that remain in relatively good condition: Where in the RGB basin are areas that remain in relatively good hydroecological condition and still support significant fresh water biodiversity? Identifying these areas is key to focusing resources on protecting these remaining areas before they are impacted by human activities;
6) Water Markets: As noted earlier in this document, a variety of water markets have already been developed in parts of the basin. Learning from these efforts will be critical to enhancing these on-going initiatives as well as starting additional water markets in other parts of the basin;
7) Monitoring sediment and water input from side drainages: Several participants noted the hydrologic importance of small side drainages that feed into the RGB. Along some reaches of the RGB, increased flooding from side drainages appears to be occurring (e.g., along the middle Rio Grande, New Mexico, and along the Big Bend reach of the RGB), which could in some cases provide benefit for both people and wildlife. The challenge is that many of these side drainages are not monitored in a manner that allows accurate quantification of water and sediment inputs;
8) Public and private investment: All of the solutions reviewed in this report will carry a price tag. In order to cover these costs, we need to move beyond traditional investment. An overview is needed that would address how we can:
    - Protect and expand existing public funding sources;
    - Develop and test innovative public-private financing mechanisms (e.g, payment for ecosystem services, pooling of financial resources from multiple stakeholders, payments for switching to low water-use crops, creation of new public funding sources); and

- Document and share case studies with agriculture and municipal water users and philanthropic and investment communities.

9) Public Outreach: Enhance public outreach is needed on the importance of water, water governance, the growing disparity between water supply and demand, and how the public can become involved in fostering solutions.

IV.- NEXT STEPS

RGB Water Forum participants identified several specific next steps to keep momentum going following the Forum's conclusion. These suggested next steps are summarized, below. With exception of the completion of this technical report and the binational database of RGB stakeholders, whose development is being led by USGS with funding secured through the Desert LCC, all the next steps listed below are provisional. In order for the Forum Organizing committee to act on these next steps, the Organizing Committee needs to formally approve them as well as secure necessary funding for their implementation before they can be moved from the provision column to the definitive. Of course, the Forum Organizing Committee is not the only entity with a desire to address water scarcity in the RGB basin. The objective of this report is to continue the discussion begun during the 2017 Forum and spark action, regardless of whether you were a participant of the 2017 RGB or not.

The potential next steps that are summarized below are in no particular order, beginning with two steps that are currently underway and ending with the next RGB Water Forum that is provisionally scheduled for 2020.

Completion and Distribution of RGB Water Forum Technical Report

The English version of the technical report summarizing Forum results (i.e., this report) was completed by mid- September 2018. It is now distributed electronically to all RGB Forum participants and it is available to all interested parties via WWF's website (as well as websites of those partnering organizations involved in the RGB Forum that are also interested in distributing the report). The report was translated into Spanish and distributed in a similar manner.

Geodatabase of Conservation Activities in the RGB Basin

The US Geological Survey and the South Central Climate Science Center are developing a binational geodatabase of conservation activities in the Rio Grande Basin. The database will serve as a comprehensive resource that will help improve how resource managers coordinate conservation projects. The database will be provided on both ScienceBase.gov and DataBasin.org. Partners can use data loaders to load additional data into the database after project completion. The final database is expected to be completed in 2020, but early database development will focus on the Dos Rios Landscape Conservation Design pilot area in 2019, which encompasses more than 9 million acres (3.6 M ha) split between Texas and Chihuahua centered around the confluence of the Rio Conchos and Rio Grande.

Formation of Targeted Subcommittees

During the final wrap-up session of the Forum, a number of Forum participants recommended the formation of subcommittees that would focus on moving forward on priority issues or actions. In this light, a subcommittee may focus on one or more of the solutions identified in this report. In addition, forming a subcommittee to assist the Forum Organizing Committee to convene the next binational Forum on water scarcity in the RGB watershed may be helpful (e.g., a subcommittee that would work in tandem with the current Organizing Committee on specific planning tasks ahead of the next Forum (e.g., such as fundraising, narrowing focus, agenda, etc.)). In addition, a variety of water-related issues in the RGB may be pressing and require a more immediate response and formation of a subcommittee in connection with the 2017 Water Forum may help to organize a collective response.

Public Communication Splashes

To maintain momentum on water scarcity moving forward, several participants noted the importance of getting targeted communication pieces in the public arena (i.e., articles, interviews, etc.). As a non-governmental entity, WWF is well-suited to do this and should be able to prepare something for public consumption that uses the 2017 RGB Water Forum as a pretext. But, other ideas and strategies are needed to not only keep the dialog moving forward but to involve others in this critical discussion.

Fundraising

Several participants proposed the idea of forming a task force of basin businesses that would be focused completely on the topic of enhancing awareness and financial support for initiatives to address basin water scarcity.

Keep the Conversation Going

The RGB Water Forum of 2017 was, in its basic form, a profound discussion on challenges and solutions to water scarcity in the RGB basin. The challenge is how to keep the conversation moving forward on a variety of water-related topics, ranging from next steps proposed here to others not yet contemplated. A variety of social media platforms can potentially help (e.g., establish a RGB Water Communication platform) but leads need to be identified.

Plan and Convene the Next RGB Water Forum

The 2017 RGB Water Forum was a success from many angles, foremost being a secure platform on which to convene critical binational discussions on challenges and solutions to water scarcity. The ever-growing disparity between available water supplies and water demand will only make the issue of water scarcity more critical. Although current funding levels limit us to the 2017 RGB Water Forum, the long-term idea is to continue to collaborate and fundraise in order to convene another binational forum on water in the near future. This aim was echoed by many participants at the 2017 RGB Water Forum. Provisionally, a 2020 RGB Water Forum in Monterrey, Nuevo Leon has been discussed, but much needs to happen before such a provisional plan becomes definitive.

LITERATURE CITED

Broadbent, C.D., D.S. Brookshire, D. Goodrich, M.D. Dixon, L.A. Brand, J. Thacher and S. Stewart. 2015. Valuing preservation and restoration alternatives for ecosystem services in the southwestern USA. Ecohydrology 8:851-862,

Bureau of Reclamation. 2013. Lower Rio Grande Basin Study. U.S. Department of the Interior, Bureau of Reclamation, Denver, Colorado.

CONAGUA-Diario Oficial de la Federación. 2013. ACUERDO por el que se actualiza la disponibilidad media anual de las aguas superficiales en las cuencas hidrológicas Río Bravo 1, y otras regiones, Segunda Sección del reporte, p.31: www.dof.gob.mx/nota_detalle_popup.php?codigo=5312175.

GeoSystems Analysis. 2017. Assessment of water conservation opportunities and constraints on irrigated lands of the Middle Rio Grande Conservancy District. Prepared for The World Wildlife Fund. Report can be obtained from GeoSystems Analysis, Albuquerque, NM or World Wildlife Fund, Tucson, Arizona (mark.briggs@wwfus.org).

Harrington, P. and R. Lacewell. 2015. Impacts of institutions on water conservation incentives in the Texas Rio Grande Valley. Texas Water Resources Institute and Texas A&M AgriLife Office of Federal Relations. Texas Water Resources Institute Technical Report TR-481, College Station, Texas.

McRoberts and Nielsen-Gammon. 2010. Historic and future droughts in the Big Bend region of the Chihuahuan Desert. World Wildlife Fund Final Report. Office of the State Climatologist, Texas @ Texas A&M University, College Station, Texas. Report can also be obtained from World Wildlife Fund (mark.briggs@wwfus.org)

NM First and New Mexico Interstate Stream Commission. 2017. Advancing New Mexico's Water Future. State Water Planning Town Hall. Available at www.nmfirst.org

NM State University & United States Senator Tom Udall. 2012. Conference Report: Policy options form the New Mexico Water Resources Research Institute's 57th Annual New Mexico Water Conference. Hard choices: adapting policy and management to water scarcity.

Nielsen-Gammon, J. 2011. The Changing Climate of Texas. In: Schmandt J., North G., & Clarkson J. (Eds.), The Impact of Global Warming on Texas (pp. 39-68). University of Texas Press.

Oglesby, A. 2016. Water resilience in a time of uncertainty – How can our water laws and policies better support water resilience? WRRI Technical Completion Report No. 370.

Schmandt, J. 2002. Bi-national water issues in the Rio Grande/Rio Bravo basin. Water Policy 4:137-155.

Schmandt, J., S.M. Thomas, C. Stolp, and R. Buono. [in press] Recommendations for sustainable management of the Rio Grande/Bravo: improving operations, engaging stakeholders, and activating governance. University of Texas.

The Nature Conservancy, Trout Unlimited, Audubon New Mexico, Rio Grande Restoration, Utton Transboundary Resources Center, University of New Mexico. 2018. Campaign for New Mexico Rivers: a roadmap to conserve New Mexico Rivers. The Nature Conservancy, 212 East Marcy Street, Suite 200, Santa Fe, NM 85701.

Ward, F., A. Michelsen, and L. DeMouche. 2005. Institutional barriers to water conservation in the Rio Grande Basin: challenges and opportunities. New Mexico Water Resources Research Institute. October 2005.