CONSERVING NATIVE RIO GRANDE FISHES IN SOUTHERN NEW MEXICO AND WEST TEXAS: A CONCEPTUAL APPROACH

Funded by the U.S. Bureau of Reclamation, through the Paso del Norte Watershed Council and Texas A&M University

September 2018

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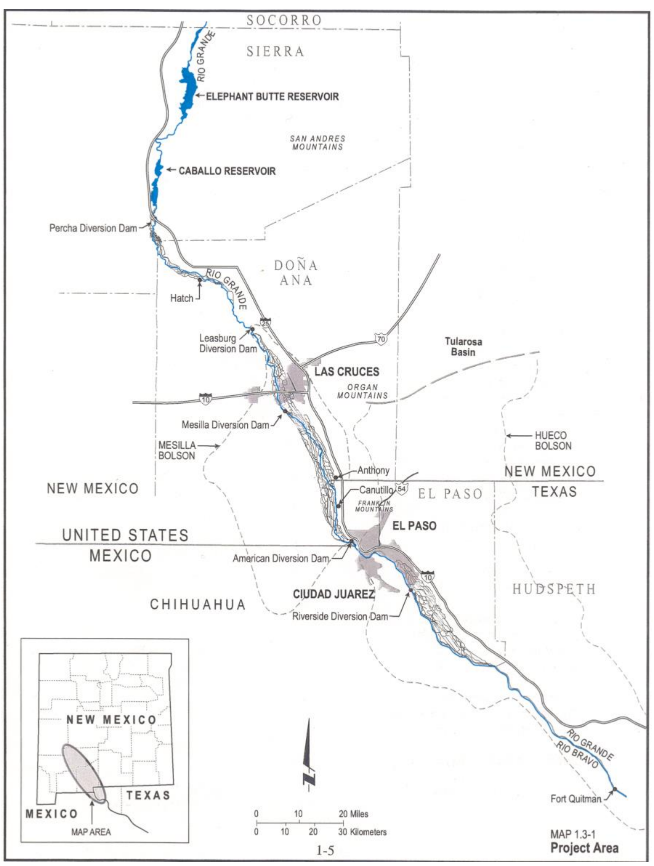

MAP 1. Rio Grande between Elephant Butte Reservoir (NM) and Fort Quitman (TX).

Introduction

The Rio Grande in Southern New Mexico and West Texas has been heavily modified to meet human needs for irrigation and flood control, beginning with the completion of Elephant Butte Dam in 1916 as part of the federal Rio Grande Project. The ecological price of this development has been high. More than a century of dam building, channelization, and dewatering have taken a heavy toll on the river ecosystem.

The near total elimination of riparian woodlands (bosques), wetlands, and other floodplain habitats is readily apparent to anyone with a passing knowledge of historical conditions. The changes to aquatic habitats and native fish populations are less visible, but no less significant.

Virtually all of the pre-dam diversity of aquatic habitats in the river has been lost. The result, predictably, has been the disappearance from this reach of an estimated one-half to two-thirds of the original complement of native fish species. (Exact numbers of historic native species are hard to determine due to the scarcity of documented collections. See discussion in following section.)

Many other western rivers have endured similar changes, but the Rio Grande has suffered longer than most. The Rio Grande Project, authorized by Congress in 1904, was one of the first major federal water projects in the country. Unlike many multi-purpose projects that came later, it was authorized for a single purpose—irrigation—thus, setting in motion the gradual transformation of a living river into the conveyance channel it has become today.

Biologists consider fish to be good indicators of the health of aquatic ecosystems for several reasons: they are sensitive to environmental change, widely distributed, and relatively well-known (Minckley et al, 1997). The fact that so many native fishes have disappeared from this section of the Rio Grande is a strong signal that the river itself is in trouble.

Conversely, any improvements in the status of native fish populations would suggest progress towards improving ecological conditions in the river itself; hence the focus of this report on restoring native Rio Grande fish, both for its own sake and as a means for advancing river restoration.

Some observers believe that restoring this segment of the Rio Grande is a lost cause, that the changes have been too profound and longstanding, and the system, under which it is managed, too complex and rigid to allow restoration efforts to succeed without a massive application of resources and political capital.

The Southwest Environmental Center takes a different view. We recognize the enormous challenges to meaningful restoration, but we also see opportunity. From our perspective, this section of the river is an ideal laboratory for testing restoration approaches in highly modified river systems precisely because of its long history of modification and degradation. If restoration efforts can succeed here, it is likely they can succeed on similarly modified rivers elsewhere.

This paper proposes an approach to restoring native fish based on habitat enhancements that can potentially be undertaken without major changes to current river management. It focuses on finding and taking advantage of the "wet" spots in the system, where locations in the river channel, or off-channel in the irrigation system or floodplain, can be enhanced to create perennial aquatic habitats where certain fish species can survive during times of low river flows during the non-irrigation season (typically November through February). These sites would be physically connected to the river so that fish would be able to move back into the river channel during the irrigation season. A similar approach has been advocated for conserving fish in the middle Rio Grande of New Mexico (Cowley 2003). If there were enough of these refugial habitats, the small fish populations they supported could, in theory, collectively form a larger, self-sustaining metapopulation.

This approach, admittedly, has its limitations. Only certain native fishes could survive in the refugial habitats, and perhaps not in great enough numbers to be self-sustaining. We understand that full ecological restoration will necessitate reestablishment of the river's pre-dam flow patterns and habitats over a larger scale. Doing so, however, will require major changes to the current delicate, and contested, system of water allocation to human users in New Mexico, Texas, and Mexico, something that could take many years to accomplish. Our proposal is intended to make incremental progress in the interim.

We hope that this report will spur further interest in the recovery and conservation of native Rio Grande fish. In particular, we hope it will spark implementation of a recommendation made by the Good Neighbor Environmental Board (2014) to the President and Congress for ecological restoration along the U.S.-Mexico border:

> *Include development of a science-based recovery plan for native Rio Grande fish from Caballo Reservoir (New Mexico) to Presidio (Texas) that balances the restoration of native fish and their habitats with the continued best management practices of the Rio Grande for all domestic and international obligations and requirements. (p. 52)*

It should be emphasized that the purpose of this report is to suggest conceptual approaches to native fish restoration that may be worth further consideration in the Caballo Dam (NM) to Fort Quitman (TX) reach, a mostly channelized segment which shares a flow regime that is largely determined by operation of the Rio Grande Project to meet irrigation demands. Some of the approaches we suggest may prove impractical or infeasible upon closer investigation, while others might require modification to be practical.

We have not made any attempt to address water rights issues, which are beyond the scope of this report.

Section 1: Literature Review

The first collection of fishes from the Rio Grande between Truth or Consequences, New Mexico and Fort Quitman, Texas was near El Paso in 1891 when five species were captured by seining a shallow, rocky “ripple” (Woolman 1894). The earliest Rio Grande collection in New Mexico was in 1938 when the Hubbs family sampled the river west of Las Cruces (University of Michigan, Museum of Zoology Fish Collection). In addition to seven native species, they collected nonnative common carp.

The next collecting effort occurred about 26 kilometers north of Las Cruces in 1942 followed by a fourth effort in 1944 near the U.S./Mexico border (University of New Mexico, Museum of Southwestern Biology). Collectively, these collections indicated that the historical native fish fauna of the Truth or Consequences-Fort Quitman reach consisted of 17 species (Table 1).

Although collected in 1944 near the U.S./Mexico border, largemouth bass was not considered native by most workers. In addition to vouchered specimens, Woolman (1894) reported gray redhorse in the Rio Grande at El Paso/Juarez. Based on several lines of evidence, six more species were added to the list of native fishes that likely occurred in the Truth or Consequences-Fort Quitman reach. Cope and Yarrow (1875), reported American eel and shovelnose sturgeon in Rio Grande in the vicinity of Santa Fe and Albuquerque, respectively, and if neither was resident in the Truth or Consequences-Fort Quitman reach, both likely traversed it during their migrations.

Based on a comment in Cope and Yarrow (1875) and archaeological evidence, Sublette et al. (1990) proposed that longnose gar was native to the Rio Grande in New Mexico. Archaeological evidence was also cited by Sublette et al (1990) as evidence for the native New Mexico occurrence of blue sucker, smallmouth buffalo, and gray redhorse in the Rio Grande. Without explanation, Stotz (2000) reported largemouth bass native to the El Paso-Fort Quitman reach of the Rio Grande.

In summary, between 14 and 24 fish species were native to the Rio Grande in the Truth or Consequences-Fort Quitman reach, depending upon reference (Table 2). This paper accepts a liberal interpretation of native fishes in the Truth or Consequences-Fort Quitman reach. Each species listed as native in Table 2 for which a reference does not exist is/was a native to the Rio Grande downstream of the Pecos River confluence in Texas, and most were also native to the Pecos River of New Mexico and Texas (Smith and Miller 1986).

The Rio Grande in the Truth or Consequences-Fort Quitman reach has undergone tremendous modification in the past century. These changes (e.g., flow cessation, aseasonal high flows, canalization, and water quality) in addition to species range fragmentation by irrigation diversion dams and species introductions have diminished native species richness and abundance of most, if not all, persisting native fishes. Based on inventories since 1970, 10 native fishes persist in the New Mexico portion of the Truth or Consequence-Fort Quitman reach and seven in the Texas portion of the reach (Table 3). Five species were common to all six inventories and each was generally distributed. Among the persisting native fishes, red shiner and western mosquitofish were the most common. Large-bodied native fishes (e.g., smallmouth buffalo and largemouth bass) were rare or uncommon. Sixteen nonnative fishes have been collected in the Truth or Consequences-Fort Quitman reach, but only four (common carp, bullhead minnow, white bass, and green sunfish) were widespread (Table 4). Each of these was comparatively common in at least one inventory.

TABLE 1. Native fishes of the Rio Grande between Truth or Consequences, New Mexico and Fort Quitman, Texas based upon museum specimens.

SPECIES	NM	LOCATION	RECORD	TX	LOCATION	RECORD
gizzard shad *Dorosoma cepedianum*	1942	16 mi N Las Cruces	MSB	1959	3 mi E El Paso	TCWC
red shiner *Cyprinella lutrensis*	1942	16 mi N Las Cruces	MSB	--		
Rio Grande chub *Gila pandora*	1938	W Las Cruces	UMMZ	--		
Rio Grande silvery minnow *Hybognathus amarus*	1938	W Las Cruces	UMMZ	--		
speckled chub *Macrhybopsis aestivalis*	1938	W Las Cruces	UMMZ	1891	El Paso	UMMZ
Rio Grande shiner *Notropis jemezanus*	1942	16 mi N Las Cruces	MSB	--		
phantom shiner *Notropis orca*	--			1891	El Paso/Juarez	UMMZ
Rio Grande bluntnose shiner *Notropsis simus simus*	1938	Las Cruces	UMMZ	1891	El Paso/Juarez	UMMZ
fathead minnow *Pimephales promelas*	1958	Truth or Consequences	MSB	--		
longnose dace *Rhinichthys cataractae*	1944	Leasburg Dam	MSB	--		
river carpsucker *Carpiodes carpio*	1938	W Las Cruces	UMMZ	--		
Mexican tetra *Astyanas mexicanus*	1944	Leasburg Dam	MSB	1959	3 mi E Ysleta	TCWC
blue catfish *Ictalurus furcatus*	--			1892	El Paso	UMMZ
channel catfish *Ictalurus punctatus*	1944	US/MX border	MSB			
flathead catfish *Pylodictus olivaris*	1938	W Las Cruces	UMMZ	--		
western mosquitofish *Gambusia affinis*	1938	W Las Cruces	UMMZ	--		
bluegill *Lepomis macrochirus*	1944	US/MX border	MSB	--		
largemouth bass *Micropterus salmoides*	1944	US/MX border	MSB	--		

MSB=University of New Mexico, Museum of Southwestern Biology
TCWC=Texas Cooperative Wildlife Collections
UMMZ=University of Michigan Museum of Zoology

TABLE 2. Presumed native fishes of the Rio Grande between Truth or Consequences, New Mexico and Fort Quitman, Texas.

Species	New Mexico			Texas		NM & TX
	Sublette et al. 1990	Stotz 2000	Carrasco 2009	Stotz 2000	Hendrickson & Cohen 2015	Smith & Miller 1986[1]
freshwater eel *Anguilla rostrata*	X	X	X	X	X	X
shovelnose sturgeon *Scapharhynchus platyrhynchus*	X	X	X	X	X	X
longnose gar *Lepisosteus osseus*	X		X			--[2]
gizzard shad *Dorosoma cepedianum*	X	X	X	X	X	--[2]
red shiner *Cyprinella lutrensis*	X	X	X	X	X	X
speckled chub *Macrhybopsis aestivalis*	X	X	X	X	X	X
Rio Grande chub *Gila pandora*	X	X	X			X
Rio Grande silvery minnow *Hybognathus amarus*	X	X	X	X		X
Rio Grande shiner *Notropis jemezanus*	X	X	X			X
Rio Grande bluntnose shiner *Notropis simus simus*	X	X	X	X	X	X
phantom shiner *Notropis orca*	X	X	X		X	X
fathead minnow	X	X	X			X
longnose dace *Rhinichthys cataractae*	X	X	X	X	X	X
river carpsucker *Carpiodes carpio*	X	X	X	X	X	X
Rio Grande blue sucker *Cycleptus sp*	X	X	X			X
smallmouth buffalo *Ictiobus bubalus*	X	X	X	X	X	--[2]
gray redhorse *Moxostoma congestum*	X		X	X	X	--[2]
Mexican tetra *Astyanax mexicanus*	X	X	X			--[2]
blue catfish *Ictalurus furcatus*	X		X		X	--[2]
channel catfish *Ictalurus punctatus* (?)						--[2]
flathead catfish *Pylodictus olivaris*	X	X	X		X	--[2]
western mosquitofish *Gambusia affinis*	X		X	X	X	--[2]
bluegill *Lepomis macrochirus*	X	X	X			--[2]
largemouth bass *Micropterus salmoides*				X	X	--[2]
Total # species	22	18	22	13	15	13

[1]Smith and Miller (1986) reported fish as native to lower and/or upper Rio Grande, with the upper Rio Grande the entire river upstream of Del Rio, Texas (just downstream of historical Devils River confluence, now inundated by Amistad Reservoir) and the lower reach extended from Del Rio to Gulf of Mexico.
[2]Species native to lower Rio Grande per Smith and Miller (1986).

TABLE 3. Current native fish assemblage of the Rio Grande between Truth or Consequences, New Mexico and Fort Quitman, Texas.

Species	**New Mexico**				**Texas**	
	Propst et al 1986	Buntjer 2001	Davenport et al. 2003	Carrasco 2009[1]	Hubbs et al. 1977	Bestgen & Platania 1988
gizzard shad	X	X	X	X	X	X
red shiner	X	X	X	X	X	X
fathead minnow	X	X	X		X	
longnose dace				X		
river carpsucker	X	X	X	X	X	X
smallmouth buffalo	X			X		
channel catfish (?)	X	X	X	X	X	X
flathead catfish		X	X	X		
western mosquitofish	X	X	X	X	X	X
bluegill	X	X	X	X		
largemouth bass	X	X	X	X		X
Total # species	9	9	9	9	6	6

[1]Species from both irrigation canals and Rio Grande included

The life histories of native Rio Grande fishes are intimately linked to natural cycles and changes in the river's flow and thermal regimes. Spawning occurs in response to various environmental cues. For some species, the rising waters caused by spring snowmelt triggers spawning. For others, it might be a flow pulse associated with a summer storm. The eggs of some species passively drift downstream in the main channel as they develop. Others are deposited on aquatic vegetation in low velocity habitats, while some develop among the gravel and cobble of rapid-velocity riffle habitats, and others in nests excavated in deep, low-velocity runs. After hatching, young fish seek low-velocity shoreline and backwater habitats rich in nutrients and food (zoo- and phytoplankton). Fish grow rapidly through their first year with small-bodied, short-lived species, such as red shiner and fathead minnow, often attaining adult size by the end of their first year. Large-bodied, long-lived species, such as smallmouth buffalo and river carpsucker, typically attain adult size by their third or fourth year. Food habitats of native Rio Grande fishes include species persisting mainly on aquatic insects found in riffles (e.g., longnose dace), mosquito larvae (e.g., western mosquitofish), fine bottom sediments and detritus (e.g., river carpsucker), and fishes (e.g., flathead catfish).

As adults, fishes are distributed over a variety of habitats; some species are habitat specialists occurring only in specific habitats while other species range over a variety of habitats. Over the course of a day, habitats occupied change as individuals seek cover from predators, food, or shelter from high-velocity flows, or to escape desiccating reaches. Habitats occupied also change with the seasons. During periods of elevated flows, individuals attempt to avoid displacement by sheltering where flows are less forceful. As the metabolism of fishes is slowed during cold seasons, individuals move less and are found mainly where water is comparatively deep and slow.

TABLE 4. Current nonnative fish assemblage of the Truth or Consequences--Fort Quitman reach of the Rio Grande.

Species	**New Mexico**				**Texas**	
	Propst et al 1986	Buntjer 2001	Davenport et al. 2003	Carrasco 2009	Hubbs et al. 1977	Bestgen & Platania 1988
threadfin shad *Dorosoma petenense*	X	X		X		
rainbow trout *Oncorhynchus mykiss*	X					
brown trout *Salmo trutta*	X					
common carp *Cyprinus carpio*	X	X	X	X	X	X
golden shiner *Notemigonus crysoleucas*		X				
bullhead minnow *Pimephales vigilax*	X	X	X	X	X	X
black bullhead *Ameiurus melas*		X				
yellow bullhead *Ameiurus natalis*	X			X		
plains killifish *Fundulus zebrinus*	X					
sailfin molly *Poecilia latipinna*	X					
white bass *Morone chrysops*	X	X	X	X	X	X
green sunfish *Lepomis cyanellus*		X	X	X	X	X
warmouth *Lepomis gulosus*			X			
longear sunfish *Lepomis megalotis*		X	X	X	X	X
spotted bass *Micropsterus punctatus*		X	X			
white crappie *Pomoxis annularis*	X	X				
black crappie *Pomoxis nigromaculatus*				X		
yellow perch *Perca flavescens*	X		X			
walleye *Sander vitreus*	X	X		X		
Total # Species	12	11	8	9	5	5

In summary, the historical native fish assemblage of the Truth or Consequences to Fort Quitman reach of the Rio Grande required a broad variety of habitats—shallow vegetated shorelines, backwaters, rapid velocity gravel and cobble riffles, shaded debris choked pools, and moderate-velocity runs--that changed within a day, across seasons, and over years. Habitats were dynamic and changed with flow. Most of these historic habitats have been lost. Currently, there are basically two habitats in the river channel—deep and rapid-velocity run during the irrigation season and dry channel bed in the non-irrigation season. The low number of native species and the paucity of individuals in this river reach are largely, if not entirely, a consequence of habitat loss and degradation.

Section 2: Conceptual Approaches to the Restoration of Native Rio Grande Fishes

The current fish fauna, native and nonnative, of the Truth or Consequences-Fort Quitman reach is comprised largely of species having comparatively high tolerances to modified and degraded environments. During no-flow periods, tolerant species may persist in scattered pools and/or irrigation canals and drains (Carrasco 2009). When surface flows are restored, desiccated reaches may be repopulated by fish moving from persistent in-channel habitats, irrigation system habitats, or downstream from perennial upstream habitats.

This paper presents concepts for four refuge habitats for native fishes in the Rio Grande between Percha Dam and Mesilla Dam (Figure 1) in Doña Ana County, New Mexico. Our study was limited to this reach due to time and budgetary constraints, but our findings should be applicable to downstream portions of the river that share similar flow and channel conditions.

The species that might use each refuge depends upon temporal availability of water, potential physical features of each refuge, proximity/availability of potential colonizers (natural or human-assisted), and life history attributes of potential colonizers. Special consideration was given to designing each refuge to enhance its potential to support native species extirpated from the lower Rio Grande in New Mexico. Target species are identified in the discussion of proposed enhancements for each refuge site.

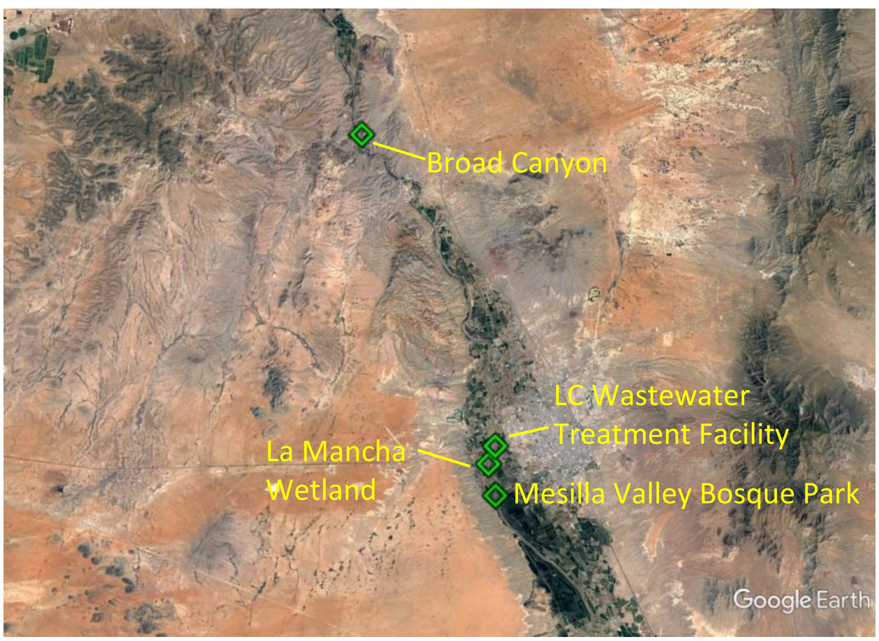

FIGURE 1. Location of four potential native fish refuge habitats on Rio Grande, Doña Ana County, New Mexico.

Fish habitat restoration/enhancement concepts for each location were designed to be accomplished within the existing legal and management framework. Each seeks to use existing opportunities and with minor adjustments make aquatic habitats at each location more conducive to sustaining a native fish assemblage. Because nonnative fishes, especially those that consume native fishes, are partially responsible for loss of native fishes, barriers to their entering restored habitats are proposed, where feasible.

Broad Canyon Habitat Enhancement

The first study location is where Broad Canyon Arroyo joins the Rio Grande about 23 kilometers downstream of Hatch, New Mexico in Selden Canyon. The project site is owned by USIBWC and New Mexico State Park Division. The federal Natural Resources Conservation Service constructed a sediment control dam on Broad Canyon Arroyo, about 400 meters west of US Highway 185. From the dam downstream for about 1300 meters a narrow, slightly incised channel conducts water during rain events to a point where the waterway broadens into a narrow floodplain (Figure 2). When Rio Grande flows are elevated, water backs into the arroyo and inundates about 100 meters of the lower-most reach of the channel. The seasonally wetted portion of the channel is bordered by willow (*Salix spp*), cattail (*Typha spp*) and bulrushes (*Scirpus spp*). Willows have been planted in the floodplain's wet soils by USIBWC and U.S. Fish and Wildlife Service (USIBWC 2016).

FIGURE 2. Broad Canyon Arroyo near its mouth.

The alignment of Broad Canyon Arroyo from the highway to the river is directed by earthen berms built by unknown parties prior to construction of the sediment dam. Prior to construction of the berms, it is likely Broad Canyon's historical connection to the Rio Grande was perpendicular rather than oblique and upstream of the current connection. Based upon Elephant Butte Irrigation District's (EBID) stream gage at Hayner's Bridge (about 10 kilometers upstream of Broad Canyon), surface flow is year-round in some years, but intermittent in others (Figure 3). Although the Hayner's Bridge gage recorded zero flow on that date, a 15 April 2013 Google Earth image of the Broad Canyon confluence area showed a string of disconnected surface pools (Figure 4).

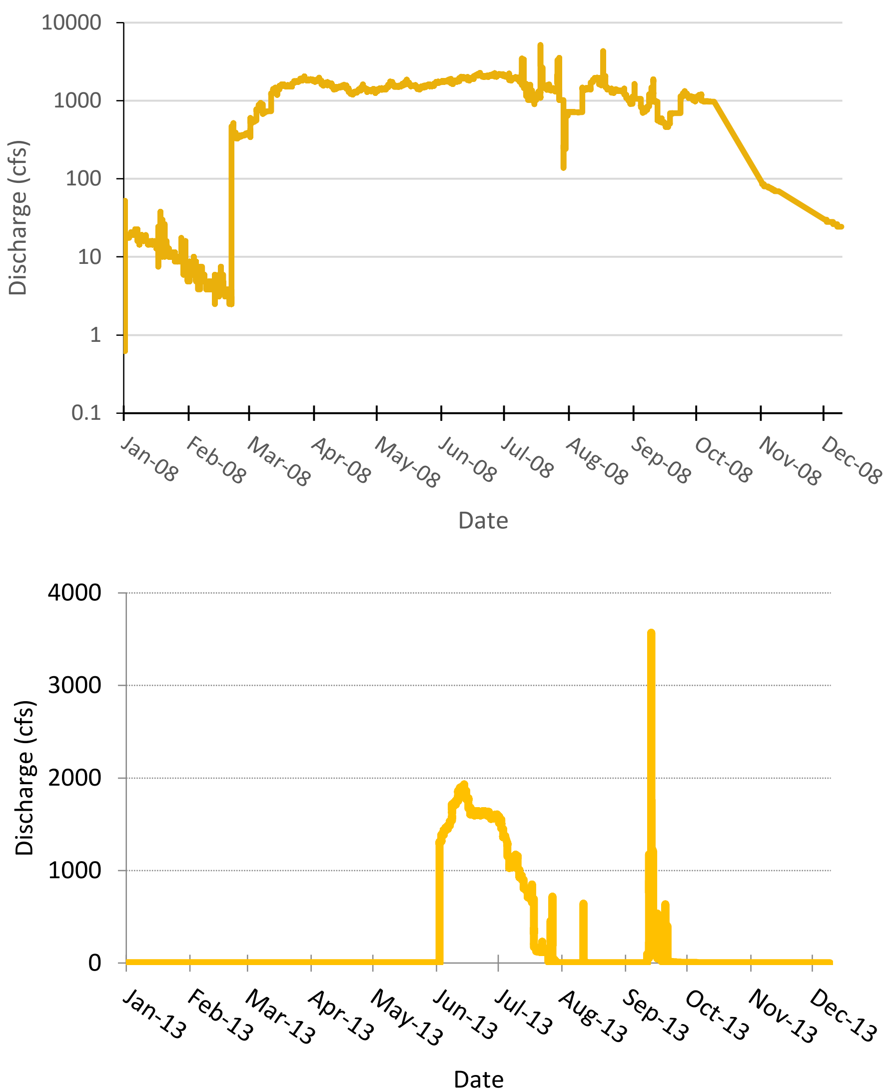

FIGURE 3. Discharge of Rio Grande at EBID's Hayner's Bridge gage in 2008 (upper panel) and 2013 (lower panel).

Three options were considered for enhancement of Broad Canyon Arroyo mouth for native fishes.

<u>Option 1</u>

The overall goal of this option is to replicate a spring-fed tributary to the river. This option involves diverting water from the Rio Grande via a small diversion gate set in line of main flow direction at a point where the active river channel is along the west river bank and conducting diverted water through a buried 8" PVC pipe (green line in Figure 4) for about 350 meters to an constructed artificial spring in the Broad Canyon channel. Cobble and boulders (20-50 cm diameter) would be placed in the excavated spring to enhance structural complexity of the spring and serve to stabilize spring banks. Water would well up through the constructed spring head and flow through the existing arroyo (yellow line in Figure 4) for about 300 meters to a backwater created by excavating the arroyo at its confluence with the Rio Grande (turquoise polygon in Figure 4). At gradient breaks in the spring run, riffle habitat will be constructed by laying cobble (approximately 15 centimeter diameter) and gravel (2-5 cm diameter) across width of channel for 3-5 meters at each break.

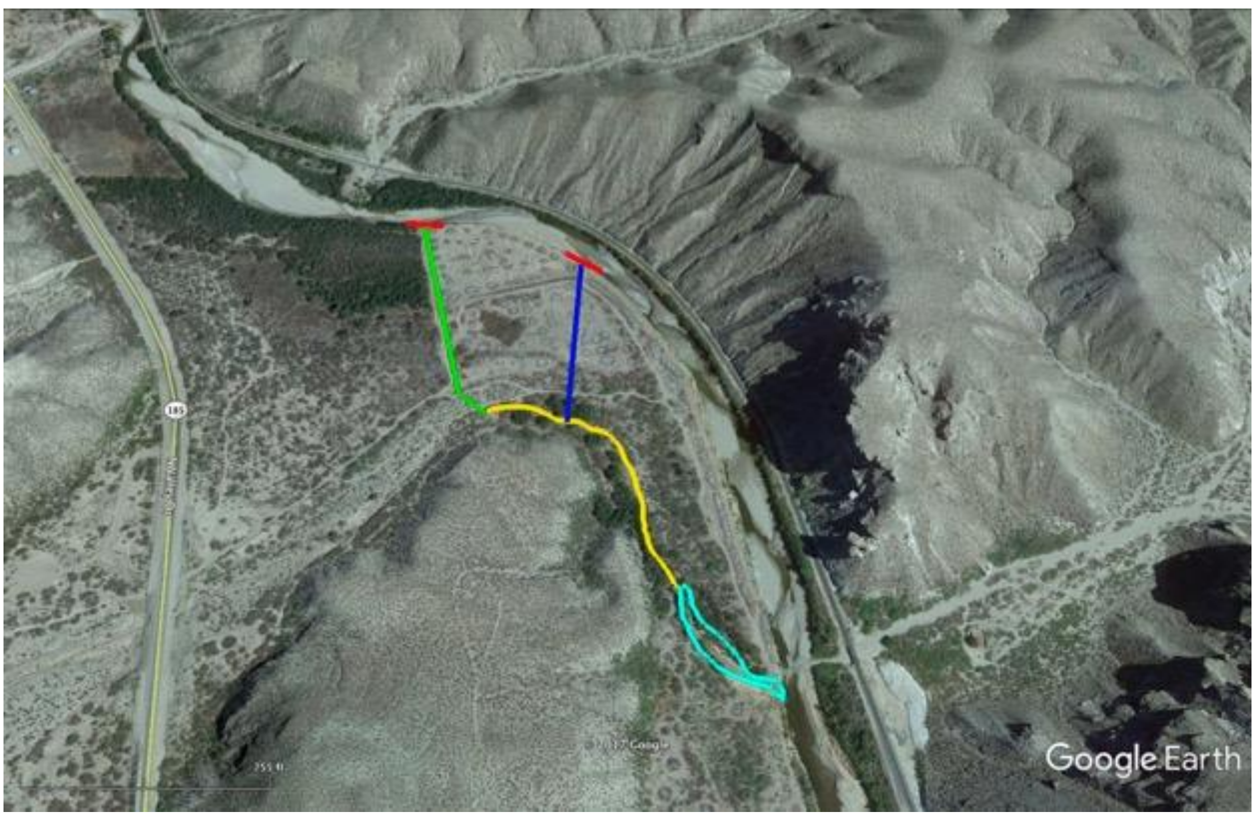

FIGURE 4. Schematic of 3 options to provide surface water to Broad Canyon. Google Earth image dated April 15, 2013.

The lower portion of Broad Canyon Arroyo (turquoise in Figure 4) would be excavated to provide a depth gradient from shallow at its head to at least 0.5 meter at its mouth. Along the southwestern margins of the embayment several deeper (1.5-2.0 meters) excavations would be dug. In each of these, large cobble and boulders (0.25-1.5 meters diameter) would be placed in a manner to provide structural heterogeneity and bank stability. Large cottonwood (Populus spp) root masses would be placed adjacent to excavated holes. Width of the excavation would vary from narrow at embayment head to 5-6 meters in mid-length to about 2 meters at mouth. Sediments from Buckle Bar Canyon opposite Broad Canyon will likely periodically berm the mouth of Broad Canyon and necessitate its removal.

Fish movement into and from the constructed habitats would not be controlled. The diversion gate at the river would be screened to prevent large debris and fish from entering and clogging the PVC pipe. An intake screen with a mesh of about 20 millimeters (mm) in size would likely prevent fishes greater than 150 mm in total length from entering the pipe and would trap larger debris. Fishes less than 100 mm in total length could access the pipe and emerge in the springhead.

If the intake is only open during non-irrigation season when surface water is limited to scattered pools, debris build-up on the screen should be minimal. Nonetheless, weekly hand cleaning of the screen would be appropriate.

Option 2

The goal of this option is the same as that of Option 1 except that this option differs mainly in placement of the gated diversion, buried PVC pipe location (blue line in Figure 4), and length of spring run. All habitat enhancements described under Option 1 would be implemented in Option 2.

Option 3

This option omits diversion of river water to replicate a spring-fed stream in case a surface diversion is not feasible. The benefits to fish would be less, but still substantial. This option would consist only of the excavated embayment (turquoise polygon in Figure 4). All embayment habitat enhancements described under Option 1 would be implemented in Option 3.

Potential Fish Species

During their 4-year study to characterize fish use of habitat enhancement structures in Rio Grande between Percha Dam and a site about 10 kilometers downstream of Hatch, Davenport et al (2001) collected 10 native fish species. At their most downstream site (Reed Arroyo), about 16 kilometers upstream of Broad Canyon, they collected seven native and five nonnative fish species. All fishes, native and nonnative species, were uncommon. Western mosquitofish and red shiner were the most common native species and bullhead minnow the most common nonnative. Because there are no barriers to fish movement, other than seasonally dry reaches, each native species found by Davenport et al. (2001) is a potential occupant of Broad Canyon. Some, however, by virtue of their habitat preferences and life histories are more likely to use Broad Canyon restored habitats than others. Each native fish recently documented in the vicinity of Broad Canyon is widely distributed and often common in suitable habitats. These species are:

Gizzard shad—In lotic (i.e. moving water) environments this species frequents low to moderate velocity and deeper waters of streams it inhabits. Gizzard shad are filter feeders, gaining sustenance from plankton and bottom sediments.

Red shiner—This species is commonly found in moderate velocity and depth habitats. It is tolerant of a comparatively broad range of physiochemical conditions. It feeds upon small aquatic macroinvertebrates. Spawning typically occurs amongst gravel and small cobble bottomed riffles.

Fathead minnow—Structurally diverse, vertical shorelines in low velocity water are commonly frequented by fathead minnow. The minnow feeds on algae and small aquatic insects. Males guard the fertilized eggs that attach to stems of emergent plants, exposed roots, and woody debris.

Longnose dace—The species is found mainly in riffles having moderate to rapid velocity water where it feeds on small aquatic macroinvertebrates. Spawning occurs among the interstitial spaces of gravel and small cobble.

River carpsucker—River carpsucker commonly occur in larger streams where it feeds on bottom detritus, incidentally consuming small aquatic invertebrates and algae.

Channel catfish—This popular sportfish is most common in low to moderate gradient streams where it feeds, largely at night, on larger aquatic macroinvertebrates and fishes.

Flathead catfish—Flathead catfish are typically found in deep, low velocity streams and rivers. It is highly piscivorous, but also consumes aquatic macroinvertebrates.

Western mosquitofish—Low-velocity shorelines and off-channel pools with dense stands of emergent vegetation are optimal habitats for western mosquitofish. This live-bearing species feeds voraciously on small aquatic insects and has been widely distributed for mosquito control.

Bluegill—Bluegill most commonly occur along vegetated shorelines of low-velocity streams where they feed on aquatic insects and small fish. Fertilized eggs are deposited in shallow depressions and guarded by the male.

If Option 1 or 2 were implemented and spring run and pool habitat provided, fathead minnow, longnose dace, western mosquitofish, and bluegill would be the most likely beneficiaries. If these habitats were maintained year-round, Broad Canyon would conceivably provide important refuge habitat for several native fishes. Improving aquatic habitats at Broad Canyon, however, likely would not be sufficient to warrant repatriation of native fishes not currently present in the area. If, however, the spring head pool is perennial, a small population of Mexican tetra might persist there.

<u>Uncertainties/Risks</u>

- Sufficient gradient for gravity water transmission through pipes to spring head; Broad Canyon bed is perched (i.e., above that of adjacent Rio Grande)
- Water availability, especially during base- and no-flow periods
- Substrate porosity
- Spring run flow persistence
- Water persistence in embayment during no-flow periods
- Impact of nonnative fishes
- Construction costs
- Legal/water rights issues

<u>Needs</u>

- Fish surveys (at base flows and <100 cubic feet per second)
- Topographic surveys
- Groundwater depth
- Substrate porosity
- Water use/loss and associated legal issues

Las Cruces Wastewater Habitat Enhancement

The Las Cruces Wastewater Treatment Facility (LCWTF), located about 0.5 kilometers east of the Rio Grande, discharges its treated water to the river just north of Interstate 10. Discharge of treated water is about 5 cubic feet per second (cfs), and is year-round, resulting in a rare perennial reach of the Rio Grande for about 4.3 kilometers downstream of its confluence with the river.

FIGURE 5. Las Cruces wastewater drain and Rio Grande floodplain.

The active channel of the Rio Grande in this reach is within levees that tightly constrain the river. The levees and floodway between them are owned by USIBWC. The narrow floodplain on either side of the river varies in width but averages about 100 meters and is maintained as open space by USIBWC (Figure 5). Within the levees in vicinity of the LCWTF drain, grasses and scattered planted cottonwoods are the primary vegetation. Surface water in the adjacent Rio Grande is generally limited to the irrigation season (March-October, Figure 6 upper panel) and that is variable, depending on water availability; the active channel is usually dry when water is not being released from upstream Caballo Reservoir (lower panel Figure 6). On the same date, about 2.3 kilometers downstream, discharge from the LCWTF provided a thin ribbon of water to the Rio Grande (Figure 7).

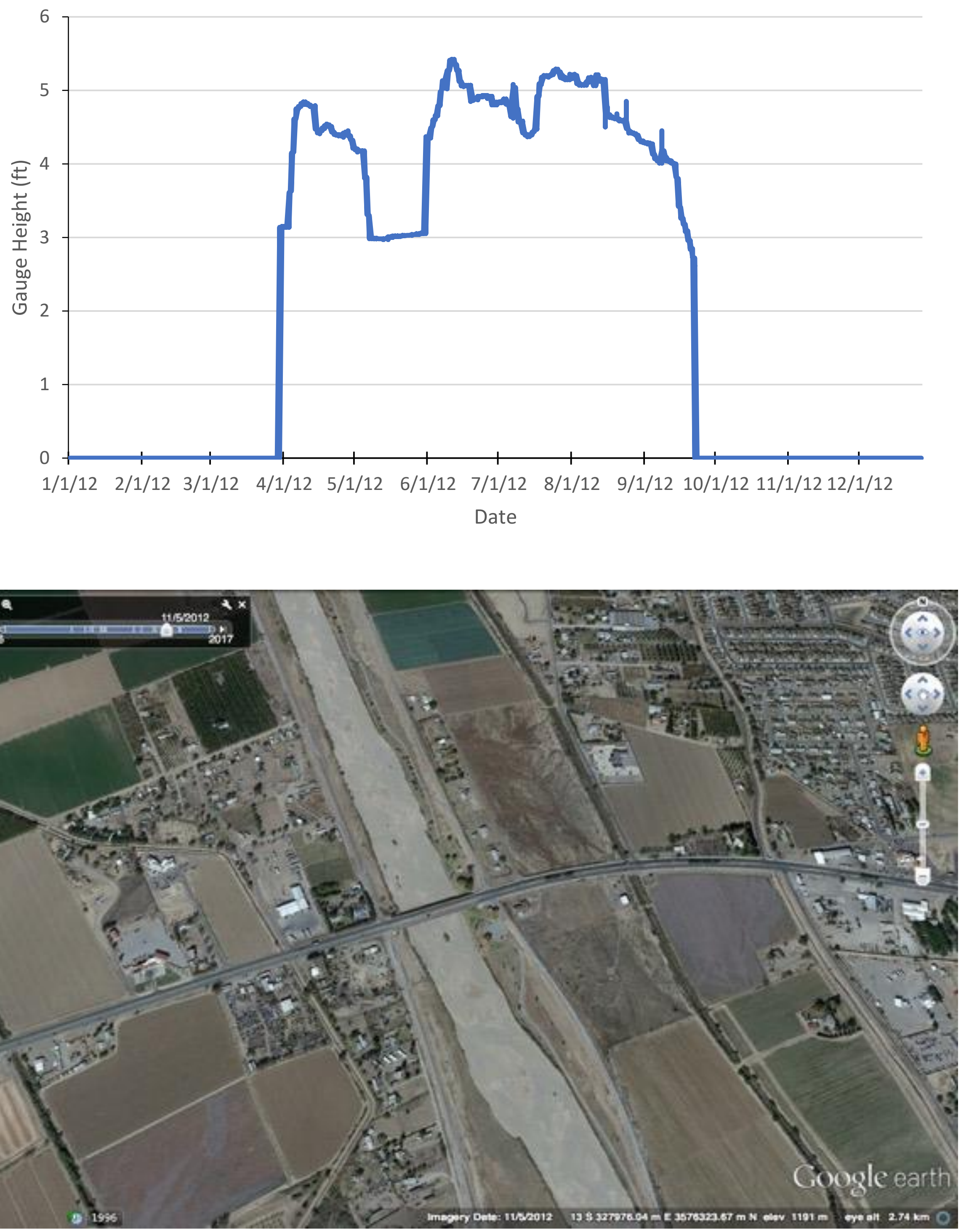

FIGURE 6. Water depth at Elephant Butte Irrigation District Picacho Bridge gauge during 2012 (upper panel) and Google Earth imagery of Rio Grande at Picacho Bridge on 5 November 2012 showing a dry river bed (lower panel). The Picacho Bridge is about 2.3 km upstream of the LCWTF discharge.

FIGURE 7. Google Earth imagery of Rio Grande at Interstate 10 Bridge and Las Cruces Wastewater Treatment Facility discharge on 5 November 2012.

When sampled in 1938, seven native fishes and one nonnative species (common carp) were collected from the Rio Grande in the vicinity of this site. Seventy years later, Carrasco (2008) reported three of the species collected in 1938 in the Rio Grande and associated canals and drains near Las Cruces; river carpsucker, western mosquitofish, and common carp. Among all sites sampled in his study, Carrasco reported 10 native species (Table 3), but three (longnose dace, blue catfish, and bluegill) were represented by a single specimen. At his Rio Grande site near Picacho Bridge he reported only two native fishes, gizzard shad and largemouth bass.

This site presents the opportunity to construct a perennial stream with a variety of habitats that historically were present but no longer exist or are extremely rare in this reach of the Rio Grande. Besides benefitting native species that are still extant in the reach, this project presents an opportunity to restore several native fishes that have not occurred in this area since the early 20th century.

Option 1

The goal of this option is to realign the existing LCWTF discharge channel to replicate a perennial tributary with a variety of habitats used by multiple native fish species at various life stages.

Fish habitat enhancement at the Las Cruces Wastewater Treatment Facility area consists of constructing a sinuous artificial channel to carry treated water to the Rio Grande (Figure 8). This approach allows a variety of habitat features including spring pool, shaded pools, shoals (shallow, low velocity), runs, and riffles (rapid velocity water over gravel-cobble substrate) to maximize the number of native species that might use the constructed channel.

FIGURE 8. Schematic illustration of constructed channel to provide perennial habitat for native fishes using water discharged from the Las Cruces Wastewater Treatment Facility.

(Habitat complexity and diversity equates to increased number of species able to occupy a given area.) The length of the constructed channel will be dictated, aside from costs, by evapotranspiration water losses in the channel's course to the river. At a fixed discharge, as is the case here, the longer the channel, the greater the evapotranspiration losses. At an as yet undetermined point, there would be insufficient water in the channel to provide suitable habitat for resident fishes. Channel width will vary from about 1 to 3 meters (schematic in Figure 11 not to scale). Depths will vary depending on mesohabitat; riffles will be 10-25 cm, runs 20-30 cm, and pools will be 40-150 cm deep. Substrates will vary from gravel and cobble (3-20 cm diameter) in riffles to sand and pebble (<3 cm diameter) in pools. Generally, riffles and runs will be straight or slightly curving reaches while pools will be on outside bend of curves with shallow shoals on inside bends (Figure 9). A two-gate control structure will be

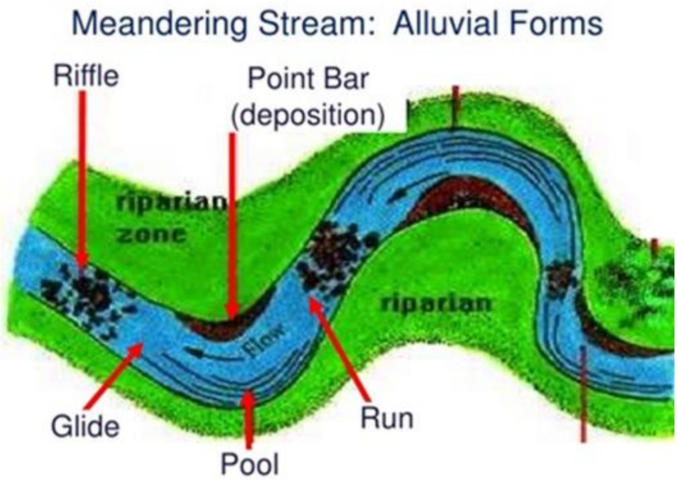

FIGURE 9. Sequence and general location of mesohabitats in a meandering stream in a low gradient setting. (Source: https://www.slideshare.net/jennings8332/jennings-tdec-stream-small.)

placed in the current wastewater channel to divert water into the constructed channel (Figure 10). Gates will enable diversion of all or a part of the LCWTF discharge into the constructed channel. Gates will also allow altering flow within the constructed channel to simulate storm flows and to flush accumulated fine sediments. The head of the constructed channel will be a small pool mimicking a spring pool. The spring pool will be lined with cobble and boulder (30-100 cm diameter) to provide habitat complexity and bank stability. Willows will be planted around the spring pool.

FIGURE 10. Control structure splitting flow between channels. (Source: http://us.123rf.com/450wm/pancaketom/pancaketom1406/pancaketom140600016/29073241-water-diversion-structures-to-control-the-flow-of-water-from-an-irrigation-canal-in-the-owens-valley.jpg?ver=6)

The constructed meander is intended to provide a diversity of habitats suitable for multiple species year-round. During the irrigation season, habitat in the river channel is monotonous—rapid velocity run. The meandering water course maintained by effluent flows persists for several months each year and is then eliminated each year when the irrigation season begins. This on-off of desirable habitat is not conducive to maintenance of healthy fish populations. The concept presented in the report could be expanded to extend downstream to at least the La Mancha wetland—aside for natural flow diminution, the length would be dependent upon funds to construct and maintain a constructed channel.

The typical sequence of mesohabitats in a meandering stream is pool-run-riffle, and that pattern would be generally followed in the constructed channel. From the spring pool downstream, the stream will meander to its confluence with the Rio Grande. The specific configuration of the channel will depend upon an array of physical factors; manuals such as the USDA Natural Resources Conservation Service National Engineering Handbook 654 – Stream Restoration Design should be used in designing and constructing the channel (https://www.nrcs.usda.gov/wps/portal/nrcs/detail/national/ndcsmc/?cid=nrcs143_009158).

Figure 11 provides additional insight to the elements that must be considered in designing a channel. A meandering stream is dynamic and will likely move at each curve apex. To slow this natural process, consideration needs to be given hardening concave banks with cobble. Planting cottonwood and willow will impede bank erosion and exposed roots will provide cover for fish.

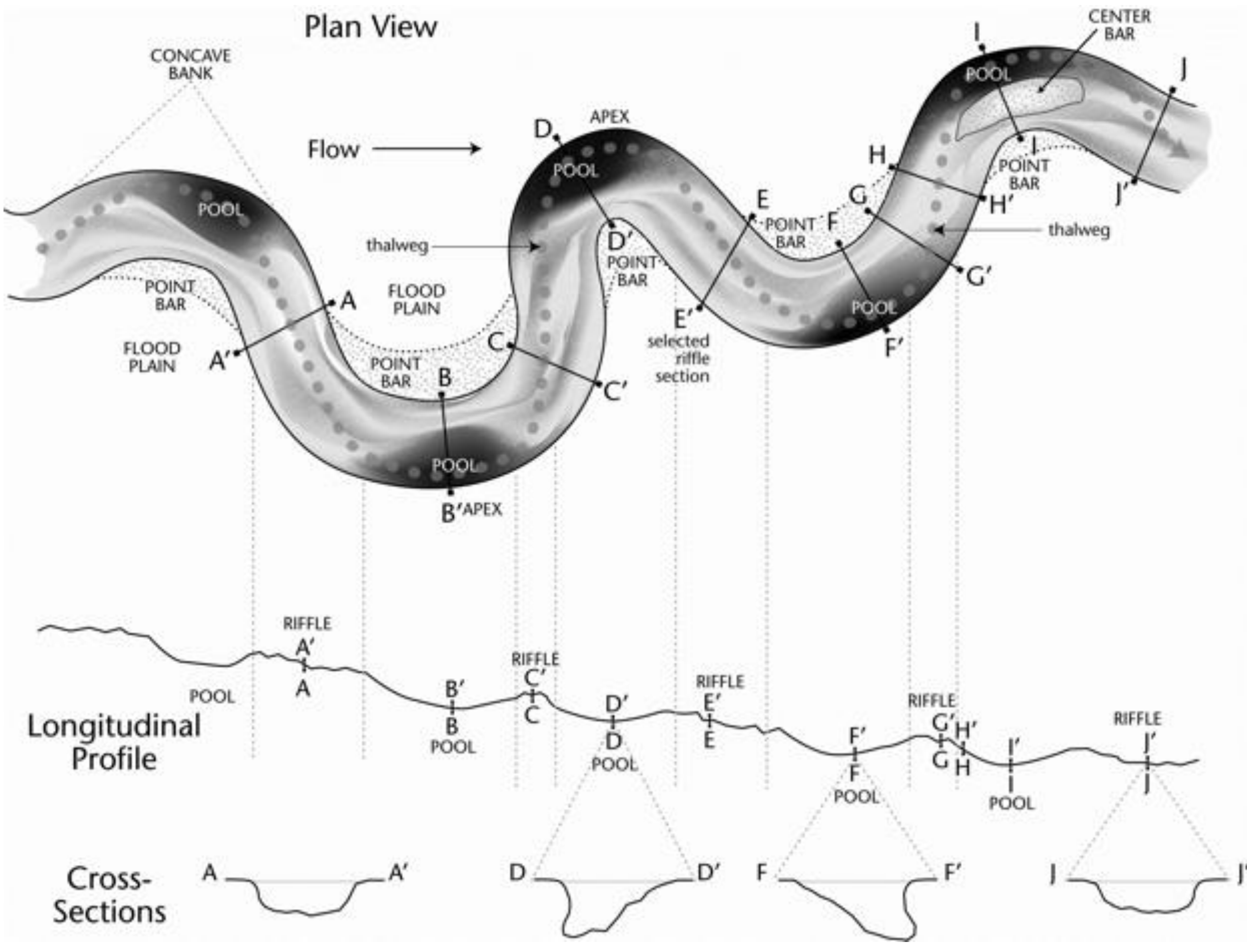

FIGURE 11. Schematic of idealized meandering stream in a moderate gradient setting, which greater than the gradient at LCWTF habitat restoration site. (Sources: Top image--http://www.theelevatormuseum.org/images/h-1-1.gif. Bottom image http://i2.wp.com/www.hiddenhydrology.org/wp-content/uploads/2017/01/fluvial.jpg?resize=640%2C480)

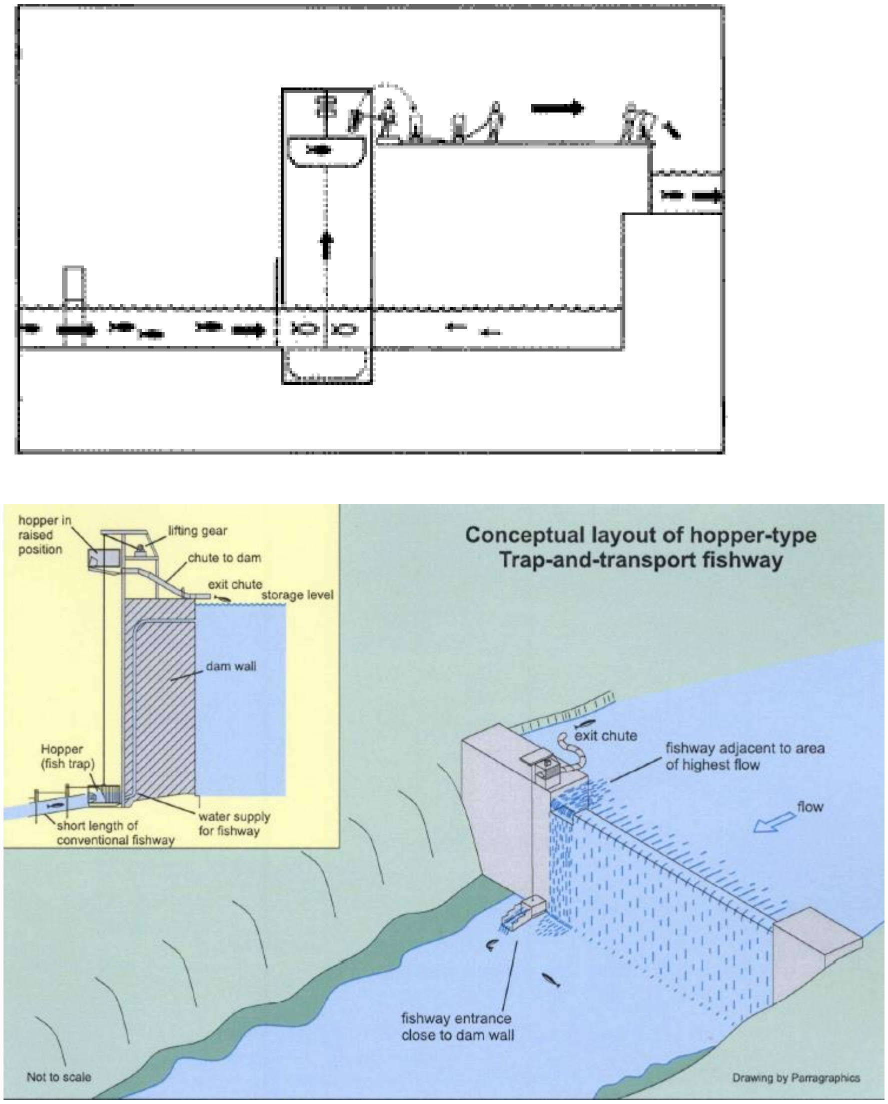

FIGURE 12. Illustration of general concept of selective fish passage structure for LCWTF habitat restoration constructed channel. (Source: http://cwenvironment.erdc.dren.mil/restore/fishpassage/images/natureelevator1.jpg)

A fish movement barrier with selective fish passage structure will be constructed near the downstream terminus of the realigned stream (Figure 12). As flows recede in the Rio Grande with cessation of irrigation deliveries, rheophilic fishes (i.e., fishes that prefer or are found exclusively in moving water) will be attracted to the outflow of the LCWTF channel. As the illustration indicates, fish will be captured in a cage that can be elevated to a sorting table; native fishes will be released into LCWTF and nonnative fishes released back into the Rio Grande. The frequency of operation would depend upon fish capture rate. A movable screen is dropped when the fish basket is full and being lifted to sorting table. When fish are not being transferred from the Rio Grande to the restoration channel, the screen is up.

It is unlikely that a fish movement barrier with over-topping flow would be sufficiently high to preclude fish jumping over it. Consequently, a low-profile barrier about one meter or less in height will be constructed, similar to that illustrated in Figure 13. Water from the constructed channel flows through a grated slot in a concrete platform over the channel downstream of a dam. The platform blocks fish from jumping the dam and provides a working space to sort native and nonnative fishes. Because the barrier cannot be higher due to the gradient, the slot for water passage is grated to prevent fish from jumping over the concrete barrier. The structure would not obstruct flood flows on the floodplain.

This type of selective fish passage structure is used on the San Juan River in northern New Mexico and Gunnison River in Colorado. The conceptual plan in this document is a variation of the basic approach.

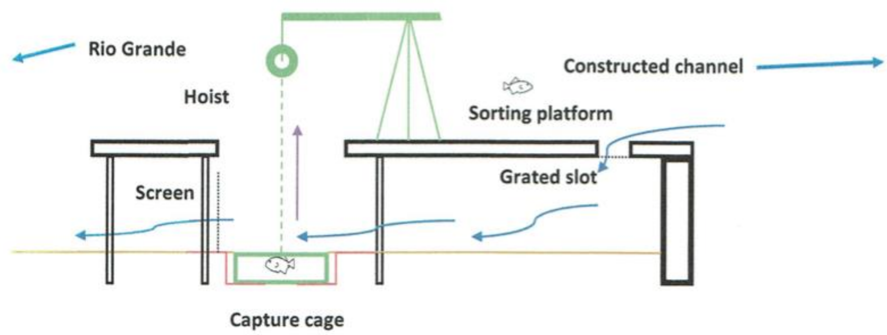

FIGURE 13. Schematic of low-profile fish passage structure for LCWTF restoration channel. (D. Propst.)

Option 2

A second approach to providing perennial habitat for native fishes using LCWTF discharge is considerably simpler than Option 1. The benefits it would provide to native fishes are less than in Option 1 because it has less habitat diversity and consists only of standing water habitat. Rather than constructing an artificial stream, water would be diverted from the existing drain through a concrete lined ditch to small constructed oxbow lake (Figure 14). The head gate structure to divert water would be similar to or the same as that for Option 1 and the barrier at the river terminus of the discharge ditch would be the same as that in Option 1 or it could be a simple gated culvert. Type of fish movement barrier would depend, in part, on whether water continuously flows through the oxbow lake or lake is filled and recharged as needed to maintain the desired depth. Continuous movement of water through the oxbow is preferable because potential for water quality problems (e.g., depleted dissolved oxygen levels) is diminished. Simply maintaining a specific depth would require periodic checking of depth.

Maximum depth of the oxbow lake would be between 1 and 2 meters, and be somewhat dependent upon depth to groundwater. From the west shore, the oxbow bottom would slope to maximum depth along the eastern shore. Submerged, cottonwood root wads would provide cover in deeper portions of the backwater. Several cottonwoods would be planted around the oxbow.

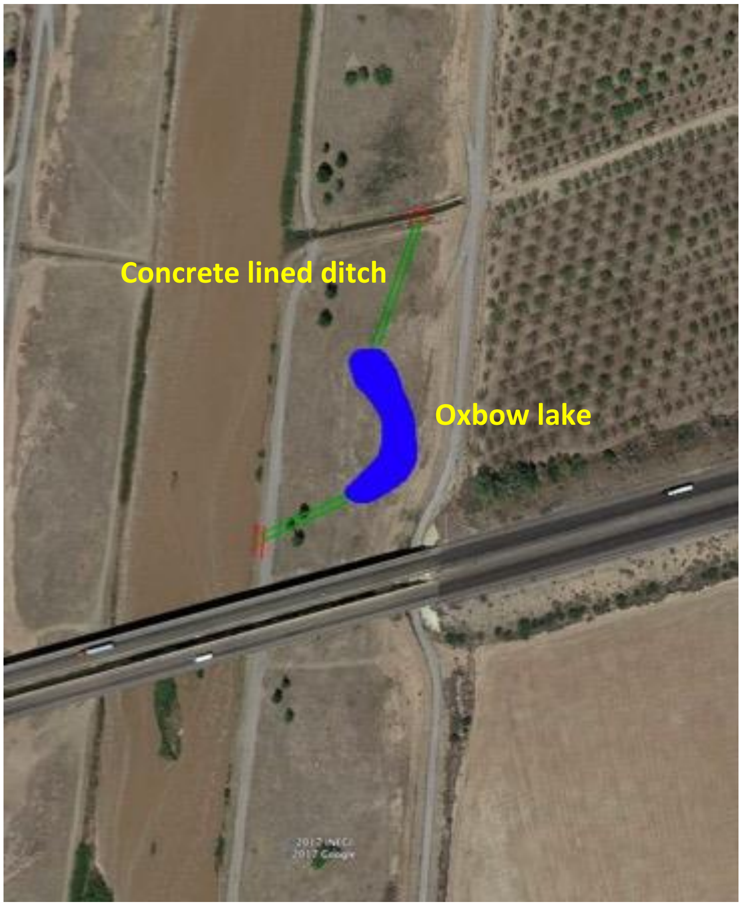

FIGURE 14. Schematic illustration of oxbow lake constructed to provide perennial habitat for native fishes using LCWTF discharge water.

Potential Fish Species

Historically, about 18 fish species regularly occurred in the Rio Grande in the vicinity of Las Cruces (Tables 1 and 2), but fewer than 10 currently occur in this reach. Between the Rio Grande and irrigation canals and drains, Carrasco (2008) reported only 10 native fishes and several were represented by single specimens. Overall abundance of native fishes in aquatic habitats in the vicinity of Las Cruces was low.

Given the low abundance of native fishes, the need for a selective fish passage barrier on the discharge channel is uncertain. Of the native fishes reported in the vicinity of Las Cruces, gizzard shad, red shiner, longnose dace, channel catfish, and western mosquitofish, would likely use the constructed stream. The oxbow lake would not likely provide suitable habitat for red shiner and longnose dace, but likely would for gizzard shad, channel catfish, western mosquitofish and largemouth bass. The oxbow lake might support river carpsucker, but because stream habitats would be comparatively small in scale, its establishment in LCWTF stream would be more problematic. Because so few fish occur naturally in the river under current operations, natural colonization of the constructed habitat, regardless of option, would likely be insufficient to establish populations of any species. Consequently, fish would need to be captured from elsewhere in the Rio Grande drainage and periodically stocked.

In addition to the native species currently occurring in the vicinity of Las Cruces, as many as 13 other species potentially occurred historically at least periodically in this reach of the Rio Grande. Major alterations of the Rio Grande downstream of Caballo Dam, however, make this reach unsuitable for all except, perhaps, longnose gar, fathead minnow, and Mexican tetra. Of the these, restoration of fathead minnow would most likely succeed, especially if the restored habitat is a mimicked stream channel. If an artificial spring-pool is constructed at the head of the channel, a small population of Mexican tetra might be established as it prefers such habitats. If an adequate prey base could be established in an oxbow lake, a small population of longnose gar might be established.

Regardless of option or species targeted for population establishment, regular augmentation of each species selected would likely be necessary for several years to establish sustaining populations. Regular monitoring of the fish assemblage also would be necessary to determine if adjustments were necessary in physical configuration and habitat features of the channel or oxbow to influence relative abundance of each species present.

Uncertainties/Risks

- Sufficient gradient for constructed stream to provide riffle habitats.
- Soil porosity (both options)
- Depth to groundwater (both options)
- Security (both options)
- Construction costs (both options)
- Legal/water rights questions. The City of Las Cruces has a Subfile Order LRG-430 for its water rights to its treated effluent with the New Mexico Office of State Engineer.

Needs

- Fish surveys (at flows <100 cfs)
- Topographic survey
- Groundwater depth
- Hydrologist/geomorphologist evaluation and design

La Mancha Wetland Project

The Southwest Environmental Center's (SWEC) La Mancha Wetland Project, on the west bank of the Rio Grande about 1.3 kilometers south of the Interstate 10 Rio Grande bridge, consists of a 0.6 acre constructed pond and associated wetland (Figure 15). The pond and wetlands are on property owned by SWEC. They were designed to provide a variety of habitats for native fishes (Parametrix 2010). Water in the pond is sustained by groundwater. Shallow portions of the pond support cattails, and willow and cottonwood border the northern pond shore.

FIGURE 15. La Mancha Wetland (upper panel) and constructed pond (lower panel).

Surface water in the nearby Rio Grande is largely dependent on irrigation releases from Caballo Reservoir, but discharge from the LCWTF (about 1.6 km upstream) maintains surface water during the non-irrigation season (1 November-1 March in most years) as well as during the irrigation season during drought years (Figure 16).

FIGURE 16. Rio Grande near Las Cruces on 26 November 2011 during non-irrigation season.

Given the proximity of La Mancha Wetland to the LCWTF site, the historical and current native fish assemblages of each site were very similar, if not identical. Currently, native western mosquitofish, largemouth bass, and bluegill, and nonnative white crappie occur in the La Mancha pond.

The goal of this project is to construct a perennial pond that is seasonally connected to the river, per the La Mancha Wetland Design and Analysis Report (LMWDA; Parametrix 2010). Under this approach the pond would be filled when Rio Grande flows exceeded 1200 cfs. After filling, supplemental watering would occur only to maintain a total surface area of 2.2 acres. Rather than depending upon fishes to move from the river to the pond during diversion, target species would be stocked, at least initially. With uncontrolled access, nonnative species would need to be mechanically removed.

Currently, La Mancha pond is isolated from the Rio Grande and cannot be accessed by Rio Grande fishes. A gated culvert was installed to allow movement of water and fish from the Rio Grande to La Mancha pond when discharge in the Rio Grande is greater than 1200 cfs. When operational, fishes could move back and forth from the Rio Grande to the pond when flows were elevated, but would not be able to return to the river when flows receded.

To complete the project, a connecting channel needs to be excavated across the USIBWC-owned floodway between the river and the culvert. This will require obtaining approval for a change in point of diversion for SWEC's Rio Grande Project water rights associated with its property on which the pond is currently located. It will also require gaining approval to use Rio Grande Project water for purposes other than irrigation, and approval from USIBWC to construct the channel.

Potential Fish Species

The constructed La Mancha pond currently has native western mosquitofish, bluegill, and largemouth bass. If habitat restoration is limited to seasonally filling the pond, fathead minnow, and channel catfish might be added to the current assemblage. The addition of a constructed stream makes possible the addition of red shiner. Because the stream will not be perennial, it is unlikely species such as longnose dace would naturally persist once introduced. The presence of the highly piscivorous largemouth bass limits opportunities to include other apex predators, such as longnose gar, and species especially susceptible to predation, such as Rio Grande chub.

Natural colonization of the constructed habitats will likely be limited. Consequently, stocking of selected species will be necessary to establish a native fish assemblage in La Mancha aquatic habitats. The particular mix of species will ultimately be determined through adaptive management.

Uncertainties/Risks

- Security
- Operational needs (e.g., screen maintenance and gate control)
- Nonnative fish control/elimination
- Permits required for constructing connecting channel to complete project

Mesilla Valley Bosque State Park

Mesilla Valley Bosque State Park (MBSP) is located on the west bank of the Rio Grande, about 2.4 kilometers southwest of Mesilla. The park is composed of parcels owned by New Mexico State Parks (NMSP), New Mexico State Game Commission (NMSGC), USIBWC, Harris Farm LLC, with several small private inholdings (Figure 18). Park headquarters are on the NMSP parcel.

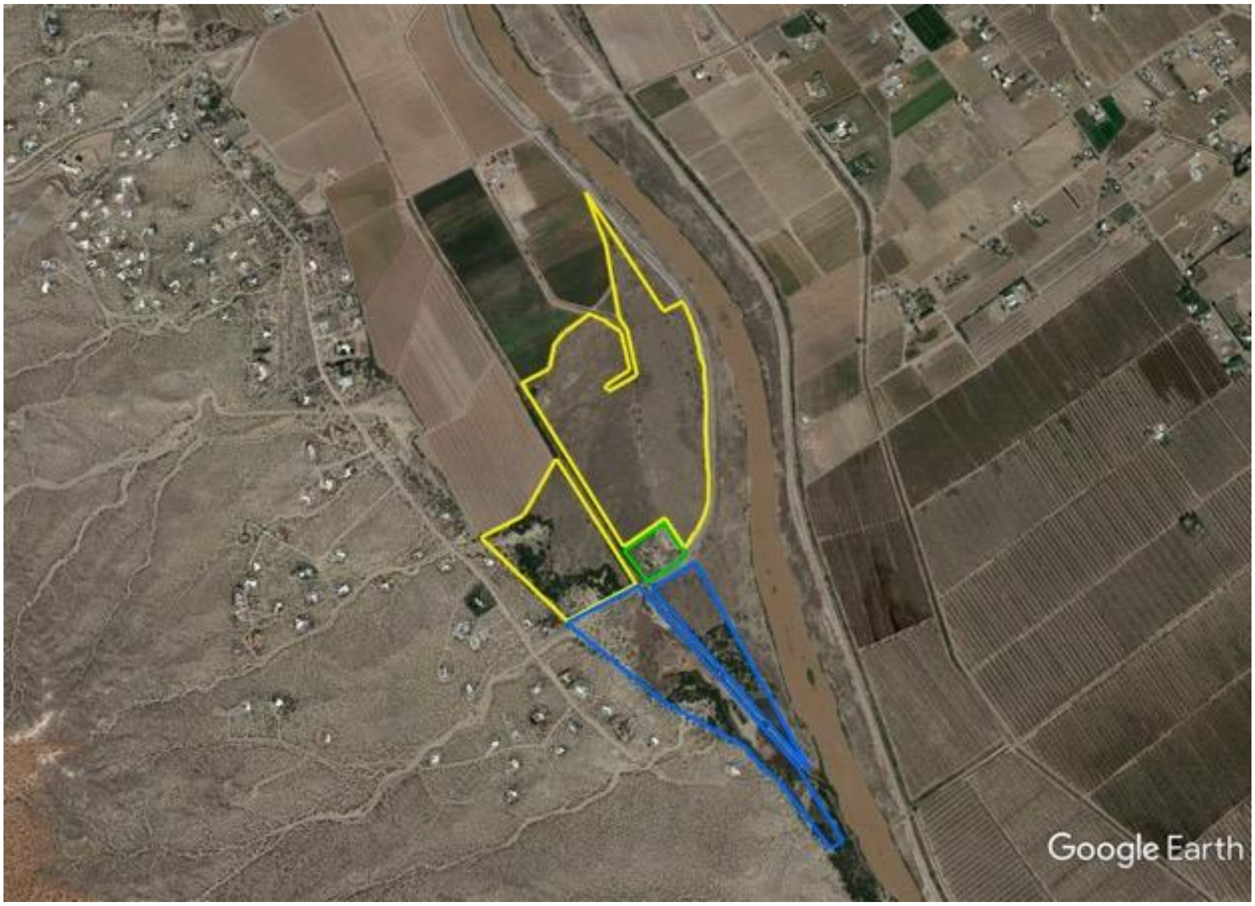

FIGURE 18. Mesilla Valley Bosque State Park. Yellow demarks Harris Farm LLC property, green NM State Parks property, and blue NM State Game Commission property. The USIBWC owns lands between park boundaries and the river.

Surface water in the adjacent Rio Grande is almost entirely dependent upon irrigation releases from Caballo Reservoir. During the non-irrigation season, discharge by LCWTF extends downstream to the park but typically submerges upstream of the parks southern extent (Figure 19). In addition to the Rio Grande, aquatic habitats within and adjacent to the park consist of the Picacho Drain, ponds, and a constructed wetland. The potential riverine fish assemblage is likely the same as that for the LCWTF and La Mancha sites, but few species have been captured in the river in the vicinity of the park. During its survey, USIBWC (2003: 3-42) found only bullhead minnow and western mosquitofish in the river near the park. Subsequently, Blue

Earth Ecological Consultants (2008: 3.5.2) reported black bullhead, western mosquitofish, bluegill, largemouth bass, and bigscale logperch in park Resaca habitat.

Following its formal designation as a state park, a resource management plan was drafted and adopted for the park (Blue Earth Ecological Consultants 2008). The plan offered several options or concepts for increasing and enhancing aquatic habitats in and adjacent to the park. The following includes several proposed in the resource management plan with some modifications as well as others.

This location provides the opportunity to create comparatively large oxbow habitat that would be more likely to support several large-bodied fishes than would either the LCWTF or La Mancha Wetland locations. Specifically, these species are longnose gar, river carpsucker, and smallmouth buffalo.

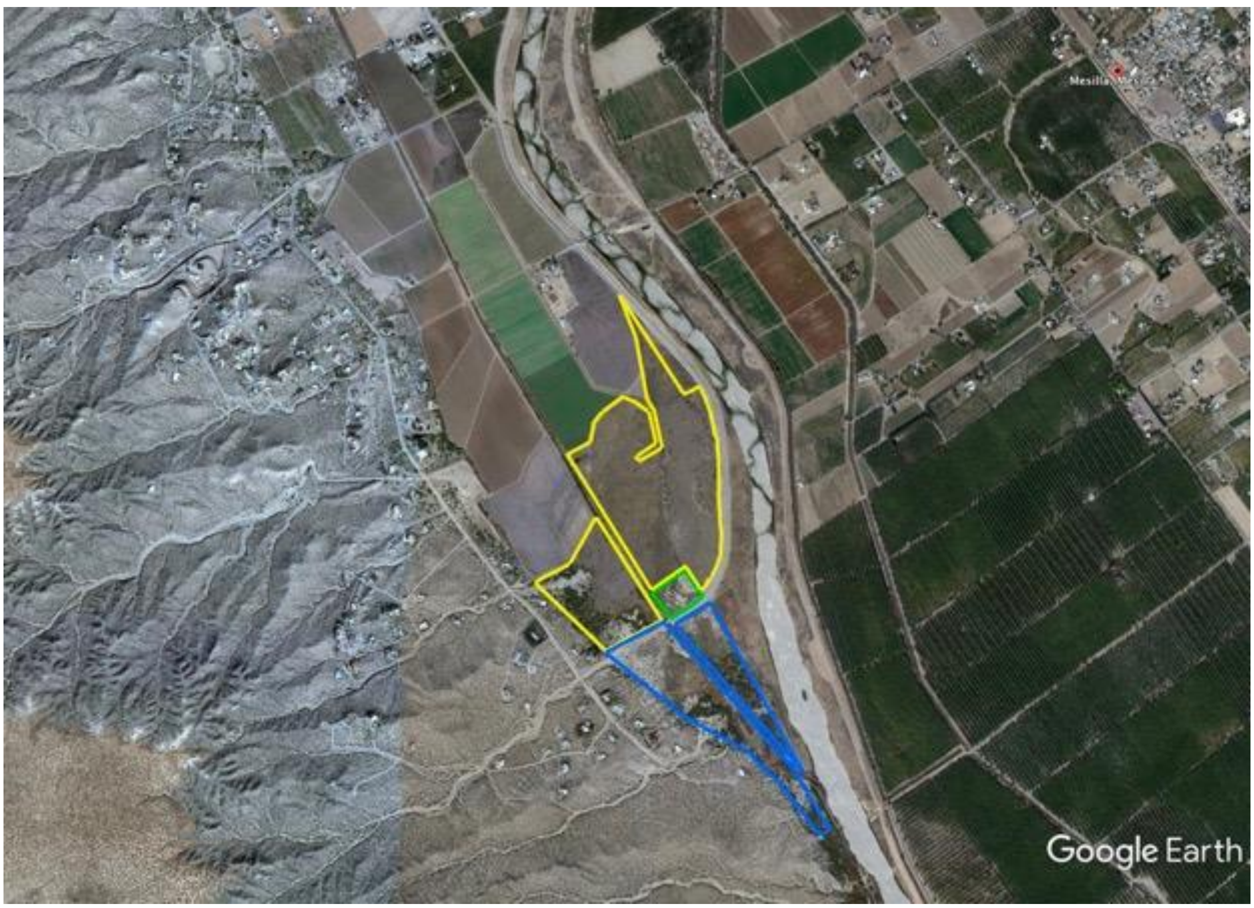

FIGURE 19. Rio Grande near Mesilla Valley Bosque State Park on 26 November 2011 during non-irrigation season. Discharge from LCWTF submerges in the vicinity of the Park.

Option 1

The goal of this option is to deepen pool habitats in the Picacho drain and associated resaca ponds, so that they mimic an oxbow habitat.

The Picacho Drain, owned and operated by Elephant Butte Irrigation District (EBID), essentially bisects the park from north to south and is confluent with the Rio Grande near the southern terminus of the park. A gated culvert at the road crossing of the drain near park headquarters controls flow in the lower portion of the drain (Figure 20). Sediment deposition in the drain mouth and river channel has rendered the drain ineffective and EBID currently does not use the drain to return water to the river. Groundwater seepage, however, maintains water in the drain. Dense cattail stands choke the drain and there is no water movement. In its current condition, the drain between the headquarters gated culvert and the river would only support the most environmentally tolerant species, such as western mosquitofish.

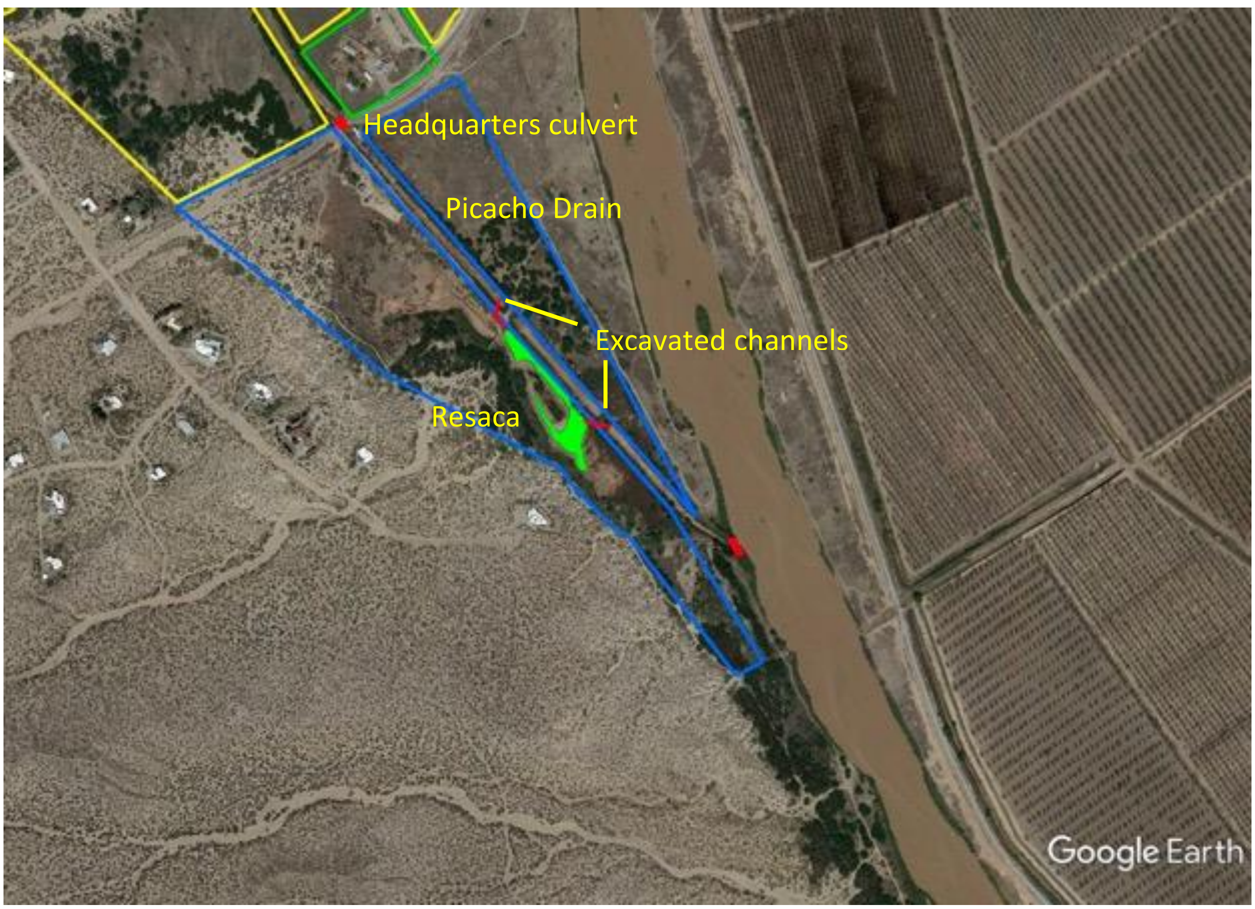

FIGURE 20. Lower Picacho Drain, headquarters culvert gate, stop-log structure (gated culvert that uses log or boards to control water passage), Resaca (oxbow lake), and connecting channels.

If EBID does not intend to use Picacho Drain to return water to the river it could be managed as an oxbow lake or resaca, albeit an unnaturally linearly shaped one. Cattails should be removed and the lower reach deepened in a manner that provides a variety of standing water habitats. If a stop-log structure (typically a concrete square weir with slots to place boards that can be removed to increase volume of water transmitted) was installed at the drain's mouth, as suggested by Blue Earth Ecological Consulting (2008), and the headquarters culvert gate periodically opened to release water into the drain, the number of fish species potentially able to inhabit the drain would be greater than without water flow. The existing resaca should be excavated to provide pool habitat with depths of 4-5 feet.

With deep habitats and structural complexity, Picacho Drain and resaca would likely support western mosquitofish, fathead minnow, bluegill, largemouth bass, longnose gar and Mexican tetra.

FIGURE 21. Existing resaca on west side of Picacho Drain, Mesilla Valley Bosque State Park.

Option 2

The purpose of this option is to provide backwater habitat seasonally for fishes currently occurring in this reach of the Rio Grande.

During the irrigation season, the Rio Grande typically has bank-to-bank flow, but during the non-irrigation season the river channel is normally dry, except for that watered by discharge from LCWTF. Water from LCWTF typically submerges before reaching the southern park boundary.

This option proposes two backwaters near the northern boundary of the park and on USIBWC administered lands (Figure 22). Backwaters would be located where there is greatest likelihood of surface water during the non-irrigation season. A challenge for this option is determining precisely where surface water will be present from one year to the next during the non-irrigation season. Each backwater would be within the levees but not in the active channel. If flows are not out-of-bank during irrigation season, there should not be an issue of backwaters headcutting. The alignment and size of each backwater would be such as to minimize erosion issues.

Regardless of location, each backwater will likely require annual sediment excavation, especially at their mouths. Because of vagaries in non-irrigation season downstream extent of LCWTF discharge, it is likely one or both backwaters periodically will be non-functional as refuge habitat. During the early irrigation release season, both backwaters will potentially provide nursery habitat for Rio Grande fishes.

FIGURE 22. Potential locations for constructed Rio Grande backwater habitat (outlined in red) on IWBC administered lands adjacent to Mesilla Valley Bosque State Park. Imagery date is 5 November 2012.

Among the limited number of native fishes occurring in the Rio Grande in the vicinity of Mesilla Valley Bosque State Park, western mosquitofish and bluegill are most likely to use the constructed backwaters because shallow portions provide preferred western mosquitofish habitat and deeper, zero velocity areas are occupied by bluegill. Given the likely ephemeral nature of these constructed backwaters, stocking native fishes is not a viable action.

Option 3

The goal of this option is to provide side-channel habitat seasonally for fishes that inhabit this reach of the Rio Grande.

Based on pre-channelization river configuration, the Mesilla Valley Bosque Park Resource Management Plan considered three locations for restoring side-channel habitat in the vicinity of the park on federal land. Of the three locations considered, that near the southern extent of the park downstream of the Picacho Drain confluence with the river was considered the most practical because it most closely aligned with a historical channel (Figure 23). (USIBWC owns a narrow strip along the river in this location, while the Bureau of Land Management owns the rest.) In its approximately 1,430 feet course, the channel has a gradient of 0.07 percent.

Because LCWTF non-irrigation season discharge rarely extends downstream to the proposed side channel, this option will not provide year-round habitat for fishes. It will, however, provide habitat not normally available during the irrigation season. With sufficient complexity, the side channel would likely provide seasonal habitat for any large-bodied native fishes, such as smallmouth buffalo, river carpsucker, channel catfish, and flathead catfish that persist in this reach of the Rio Grande. In addition, small-bodied red shiner, fathead minnow, and western mosquitofish would likely use the side-channel.

FIGURE 23. Restored Rio Grande side-channel. Location is approximately the same as that portrayed in the Mesilla Valley Bosque State Park Resource Management Plan.

Uncertainties/Risks

- Concurrence of EBID in Picacho Drain modifications (Option 1)
- Concurrence of USIBWC in backwater and side channel restoration (Options 2 & 3)
- Nonnative fish control or elimination (dependent upon option)
- Construction costs
- Maintenance costs
- Environmental compliance
- Legal/water rights issues
- Security

Needs

- Topographic surveys
- Hydrologist/geomorphologist design and evaluation

Conclusions

Certainly, the most critical issue facing native fishes in the Truth or Consequences to Fort Quitman reach of the Rio Grande is the annual drying of practically the entire river during the non-irrigation season. What surface water there is during the non-irrigation season is limited to scattered pools in a few reaches (e.g., Selden Canyon) and that discharged by the Las Cruces Wastewater Treatment Facility. Even if refuge habitats were constructed/provided through the reach, the abrupt cessation of flow when the irrigation season ends means that few fish have adequate warning or time to retreat to them. Under this operational approach, practically the only fish that might use a refuge are those present in it when flows cease. With a few exceptions, persistence of fishes in each constructed/restored habitat will depend upon stocking. Overall, year-round flowing water with a mix of mesohabitats (e.g., pools, riffles, and runs) is the most critical need to support a more diverse and numerous fish assemblage in the Rio Grande in the Truth or Consequences to Fort Quitman reach.

Constructed in-channel refuges are most likely to provide some relief to native fishes where some surface water persists after releases from Caballo Reservoir cease. Among the four locations considered in this report, Broad Canyon provides the best opportunity to increase non-irrigation persistence of native fishes in the main channel.

The lower three locations (LCWTF, La Mancha, and Mesilla Valley Bosque State Park) could collectively provide a complex of habitats; each location has specific attributes that make it best suited to provide specific habitats that are largely, if not completely, absent in the Truth or Consequences to Fort Quitman reach of the Rio Grande. Thus, LCWTF has the potential to support species preferring clear water springs (e.g., Mexican tetra), debris pools adjacent to flowing water (e.g., Rio Grande chub), riffles (e.g., longnose dace and red shiner), pool-run habitats with undercut banks (e.g., flathead catfish) and vegetated shorelines (e.g., fathead minnow and western mosquitofish). Largemouth bass and bluegill currently occupy the off-channel pond at La Mancha Wetland Project and improvements to habitat there (including establishing native prey species such as fathead minnow) helps secure their persistence. With excavation of the lower Picacho Drain and the adjacent pond and increasing the structural heterogeneity of each, the Mesilla Valley Bosque State Park has the potential to support populations of fish that naturally occupied oxbow habitats associated with low-gradient meandering rivers. In addition to largemouth bass and bluegill, longnose gar, fathead minnow, western mosquitofish are potential inhabitants of the park's aquatic habitats.

Movement of individuals among the lower three locations will be precluded during the non-irrigation season and limited by main channel flow regime when surface water is present. While access to La Mancha Wetland Project would be unrestricted that at LCWTF would be controlled.

In time, the knowledge gained from restoration efforts at each location can be used to design additional refuges and improve upon efforts at these initial locations, including Broad Canyon. Unless there are changes in river operations to slowly attenuate discharge when the irrigation season is over, the proposed refuges (except Broad Canyon) will have to function as self-contained fish assemblages.

Although aquatic habitats have been dramatically altered in the Truth or Consequences to Fort Quitman reach of the Rio Grande to the point that most observers would doubt the existence of a single fish, several species persist. The tenacity of these species suggests that with provision of an array of perennial aquatic habitats, ranging from mimicked tributaries to ponds and oxbow lakes, the abundance of each could be increased and sustaining populations maintained.

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Section 3: Stakeholders

The following is a list of stakeholders who are generally involved in Rio Grande issues in the region and would potentially be interested in efforts to restore native Rio Grande fishes.

Stakeholders (U.S.)

Federal agencies:

- International Boundary and Water Commission—U.S. Section
- U.S. Fish and Wildlife Service
- U.S. Bureau of Reclamation, El Paso Field Office

State agencies:

- New Mexico Department of Environment
- New Mexico Department of Energy, Minerals and Natural Resources (State Parks Division)
- New Mexico Office of State Engineer
- New Mexico Department of Game and Fish
- Texas Parks and Wildlife Department
- Texas Water Development Board

Local governmental entities:

- Elephant Butte Irrigation District
- El Paso County Water Improvement District No. 1
- Hudspeth County Irrigation District
- City of El Paso
- City of Las Cruces

Academic Institutions:

- New Mexico State University
- University of Texas at El Paso (Rio Bosque Wetlands Park)
- Texas A&M University

Non-governmental organizations:

- Southwest Environmental Center
- Paso del Norte Watershed Council
- Audubon New Mexico

Stakeholders (Mexico)

- La Comisión Internacional de Límites y Aguas—Sección Mexicana
- Comisión Nacional del Agua
- Secretaria del Medio Ambiente y Recursos Naturales
- Universidad Autónoma De Ciudad Juárez

Tribal governments:

- Ysleta del Sur Pueblo

Section 4: Potential Funding Sources for Fish Habitat Restoration

The following is a list of potential funding sources for projects to benefit native fishes conservation. Note: some of these funding sources are not available to federal agencies or for use on federal property. Since most of the projects described in this report include USIBWC property and involvement, these sources may not be available.

National Fish and Wildlife Foundation: Bring Back the Natives:
The Bring Back the Natives program invests in conservation activities that restore, protect and enhance native populations of sensitive or listed fish species across the United States, especially in areas on or adjacent to federal agency lands. Priority species include native desert fishes in the arid southwest.

National Fish and Wildlife Foundation: Five Star and Urban Waters Restoration Grant Program:
The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country. Its goal is to meet the conservation needs of important species and habitats, providing measurable and meaningful conservation and educational outcomes.

New Mexico River Stewardship Program:
State funding administered by the NM Environment Department—Surface water Quality Bureau. The goal of the River Stewardship Program is to fund projects that enhance the health of rivers by addressing the root causes of poor water quality and stream habitat. The River Stewardship Program will fund projects that improve habitat for fish and wildlife and provide safe water for swimming and other recreational activities.

U.S. Army Corps of Engineers: Beneficial Uses of Dredged Material (CAP Section 204)
Work under this authority provides for the use of dredged material from new or existing Federal projects to protect, restore, or create aquatic and ecologically related habitats, including wetlands. The cost share is 75% Federal and 25% non-Federal of the incremental cost above the least cost method of dredged material disposal consistent with engineering and environmental criteria. The Federal share of planning, design, and construction cannot exceed $10,000,000.

U.S. Army Corps of Engineers: Aquatic Ecosystem Restoration (CAP Section 206)
Work under this authority may carry out aquatic ecosystem restoration projects that will improve the quality of the environment, are in the public interest, and are cost-effective. There is no requirement that an existing Corps project be involved.

U.S. Environmental Protection Agency/State of New Mexico: Nonpoint Source Implementation Grants (319 Program)
Nonpoint source pollution projects can be used for a wide range of activities including agriculture, forestry, construction, and urban challenges. Most states (including New Mexico) provide opportunities for 3rd parties to apply for funds under a state request for proposal.

U.S. Fish and Wildlife Service: *State Wildlife Grant Program (Non-Tribal and Non-Competitive)*
The SWG program provides funds to help develop and implement programs that benefit wildlife and their habitat, including species that are not hunted or fished. Although not directly eligible for these grants, third parties such as nonprofit organizations may benefit from these funds by working directly with their states to see if either grants or partnering opportunities are available.

U.S. Fish and Wildlife Service: *Partners for Fish and Wildlife Program*
The Partners for Fish and Wildlife Program provides technical and financial assistance to private landowners to restore fish and wildlife habitats on their lands via cooperative agreements. In addition, the program restores stream habitat for fish and other aquatic species by removing barriers to passage.

U.S. Fish and Wildlife Service: *North American Wetlands Conservation Act Grants Program*
Federal funding to carry out wetlands and associated uplands conservation projects in the United States, Canada, and Mexico. Grant requests must be matched by a partnership with nonfederal funds at a minimum 1:1 ratio. Conservation activities supported by the Act in the United States and Canada include habitat protection, restoration, and enhancement. Although intended to benefit birds, some projects are likely to benefit fishes as well.

U.S. Fish and Wildlife Service: Desert Fish Habitat Partnerships:
The purpose of DFHP is to conserve aquatic habitat for desert fishes by protecting, restoring and enhancing these unique habitats in cooperation with, and in support of, state fish and wildlife agencies, federal agencies, tribes, conservation organizations, local partners, and other stakeholders.