Rio Grande Basin Study, NGO Sectoral Committee Environmental Flow Hypotheses Process

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Rio Grande Basin Study

- A planning effort to develop climate resilient strategies for the Rio Grande in New Mexico.
- WaterSMART project led by the USBOR and MRGCD
- Divided into "sectoral" committees: Agriculture, Community Organizations, Local Governments, NGO, Tribal
- Water needs of all sectors will be modeled and analyzed to help develop strategies for resiliency.
- The NGO Sectoral Committee is defining environmental flow needs for the Basin as a primary mission.
- WWF Report Card provided important tools for the Basin Study: environmental flow information, systems model.

Primary Questions

- "How much water does the river ecosystem need?" in 6 reaches of the Upper Rio Grande in New Mexico.
- What are the primary ecologic water deficits? (based on current and projected future conditions)
- What activities lessen these deficits?
  - Within current constraints
  - Future outside-the-box ideas

NGO SC Eflow Hypotheses Process

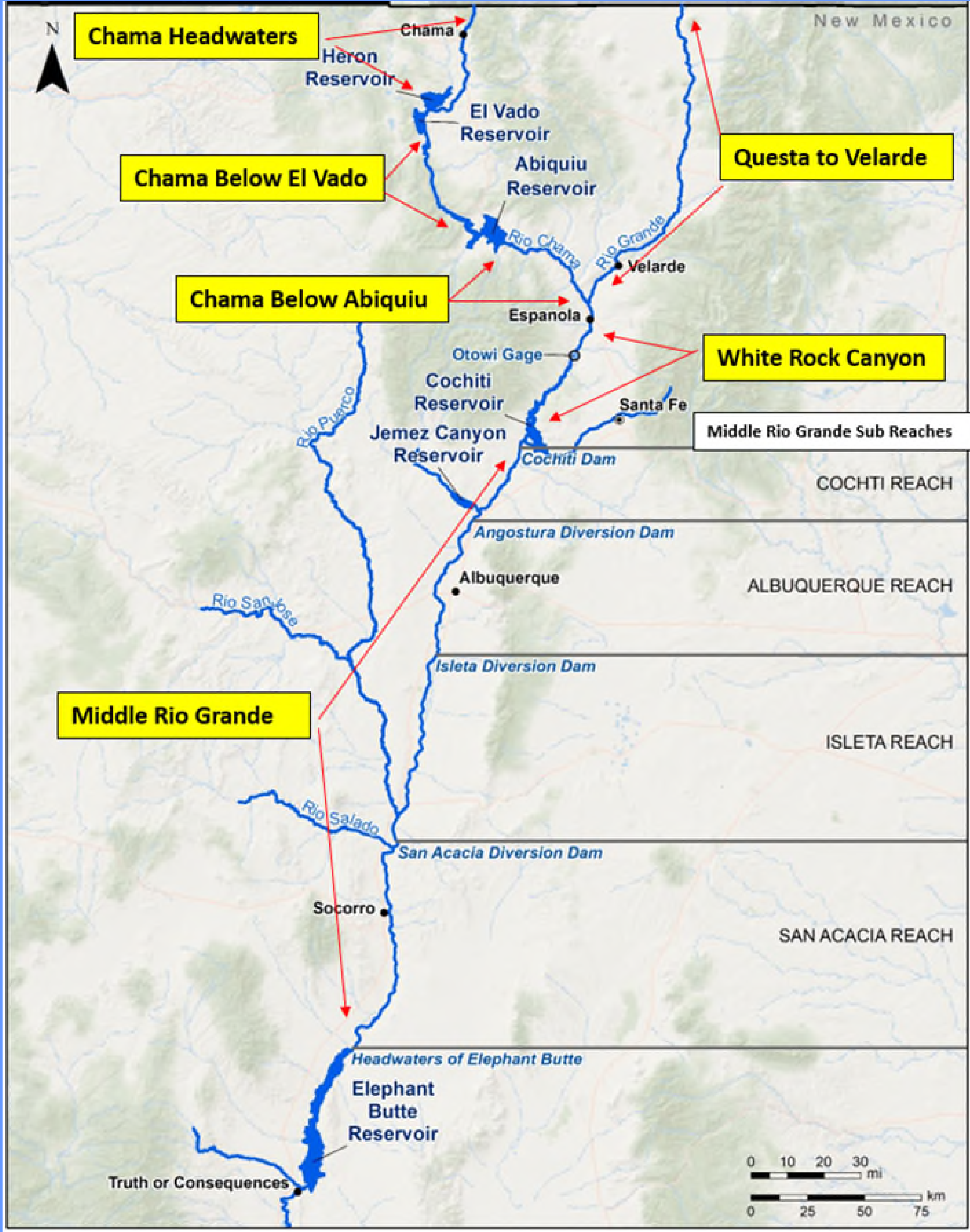
- Based on structure of Rio Chama e-flow hypothesis
  - Hypotheses tied to USGS gage within reach
- Utilize all available resources: hydrologic information, geomorphic information, ecologic information
  - citations and expert opinions.
- Sectoral Committee teams develop initial hypotheses (summer 2023- spring 2024)
  - Compile citations
  - Identify uncertainties
- Mark Briggs (contractor/ hydrologist) is compiling hypotheses and citations and placing into a draft report (June 2024)
- Peer review workshop (summer 2024)
  - Draft document circulated for comments to attendees and other experts
- E-flow document finalized: early fall of 2024

Environmental Flow Document

I.	Study Objectives and Background
II.	Methods
III.	Environmental Flow – A Brief Primer
IV.	The Basin
V.	The River
VI.	The Indicator Species
VII.	The Six Study Reaches
	Each Reach
	Location Climate and Geology
	Surface and Ground Water Conditions, Trends and Management
	Biophysical Changes
	E-Flow Recommendations
	Constraints
VIII.	Constraints, Challenges and Opportunities to E-Flow Recommendations
IX.	Next Steps

A Team Effort

- Steering Committee
  - Paul Tashjian, Mark Briggs, Tricia Snyder, Enrique Prunes, Brian Richter
- Author for compilation: Mark Briggs
  - Funded by BLM and Turner Foundation
- Reach Team Leads
  - Paul Tashjian (Audubon), Steven Fry (Amigos Bravos), Toner Mitchell (TU), Anjali Bean (WRA), Martha Cooper (TNC), Rachel Ellis (American Rivers)
- Expert input
  - Steve Harris, Dagmar Llewelyn, Mike Harvey, Keith Sauter, Sage Dunn, Shinya Burck, Ed MacKerrow, Cecil Rich, Mickey Porter, Joel Lusk, Kim Eichorst, Rich Wagner, Garret Hanks, Julia Bernal, Tucker Davidson, Aidan Manning, etc (still growing!)
- Expert review
  - The larger Rio Grande expert community including you!



New Mexico
N
Chama Headwaters
Chama
Heron Reservoir
El Vado Reservoir
Chama Below El Vado
Abiquiu Reservoir
Questa to Velarde
Rio Chama
Rio Grande
Velarde
Chama Below Abiquiu
Espanola
Otowi Gage
White Rock Canyon
Cochiti Reservoir
Santa Fe
Middle Rio Grande Sub Reaches
Rio Puerco
Jemez Canyon Reservoir
Cochiti Dam
COCHTI REACH
Angostura Diversion Dam
Albuquerque
ALBUQUERQUE REACH
Rio San Jose
Isleta Diversion Dam
Middle Rio Grande
ISLETA REACH
Rio Salado
San Acacia Diversion Dam
Socorro
SAN ACACIA REACH
Headwaters of Elephant Butte
Elephant Butte Reservoir
Truth or Consequences
0 10 20 30 mi
0 25 50 75 km

ADAPTED ECO-FLOW RECOMMENDATIONS

IDEALIZED RIO CHAMA NON-CONSUMPTIVE FLOW REGIME TO MEET ECOLOGICAL OBJECTIVES					
(Annual total flow ~ 400,000 AF)					
FLOWS				ECOLOGICAL OBJECTIVES	
Magnitude (cfs)	Recurrence Interva (yrs)	Duration (days)	Season	Canyon ("Wild" Reach)	Lower Reach ("Scenic" Reach, or Monastary Reach)
6000*	10	2 (peak)	Spring	Redistribution of tributary debris-flow sediments	Floodplain and low terrace inundation
(63,000 AF)		(21 total)	(April-June)	Mobilization of bed and bank material	Accelerate lateral migration and point-bar formation in alluvial reaches
				New bar formation and fossilized bar dissection	Creation of off-channel habitat for amphibian and avian species
				Inundation of limited floodplain segments	Recruitment of large woody debris
4000	5	2 (peak)	Spring	Redistribution of tributary debris flow sediments	Floodplain inundation
(30,000AF)		21 (total)	(April-June)	Mobilization of bed and bank material	Accelerate lateral migration and point bar formation in alluvial reaches
				New bar formation and fossilized bar dissection	Riparian plant recruitment
				Creation of fish spawning habitat	Maintenance of off-channel habitat for amphibian and avian species
				Inundation of limited floodplain segments	Recruitment of large woody debris
2500**	2	2 (peak)	Spring	Bed material mobilization & gravel flushing	Bed material mobilization and gravel flushing
(18,000 AF)		21 (total)	(April-June)	Maintenance of in-channel habitats	Riparian vegetation maintenance
700-1000***	na	3/event	Summer	Monsoon-season riffle flushing for macro-invertebrates	Monsoon season riffle flushing for macro-invertebrates
			(May-Oct)		
150****	na	60-90	Fall	Spawning redd inundation	In-channel habitat maintenance
			(Oct-Dec)		
100	na	90	Winter	Redd maintenance	In-channel habitat maintenance
			(Jan-March)	Pool habitat for fish over-wintering	Pool habitat for fish over-wintering

* Maximum controlled release from El Vado Dam
** Bankfull discharge
*** Weekend Boating Flows
**** Brown trout spawning period

Study Reach	Indicator Species
Questa to Velarde	Brown Trout, Cottonwood, Southwestern Willow Flycatcher, River Otter, American Dipper
Chama Headwaters	Cottonwood, Stonefly, Brown Trout
Chama below El Vado to Abiquiu	Cottonwood, Stonefly, Brown Trout
Chama – Abiquiu to confluence	SWFL, Stonefly, Brown Trout, Coyote Willow
White Rock Canyon	Summer Tanager, Rio Grande Chub/ Rio Grande Sucker, River Otter, Coyote Willow
Middle Rio Grande	Rio Grande Silvery Minnow, Cottonwood, Southwestern Willow Flycatcher, Sandhill Crane

MRG: Indicator Species and Environmental Hydrograph

- Cottonwood
  - Large spring pulse/ disturbance event: recurrence?
  - Low flows for survival/ charging shallow groundwater
- Rio Grande Silvery Minnow
  - Spring pulse; medium and low, at least every 2 and 5 years
  - Low flows for survival
- Southwestern Willow Flycatcher
  - Spring pulse for wet floodplain soils
  - Low flows
- Sandhill Crane
  - Fall and winter low flows for roost habitat- not too high

Middle Rio Grande: Albuquerque Gage; San Acacia Floodway Gage
Environmental Flow Hypothesis
DRAFT PROPOSAL FOR DISCUSSION: January 2024

Flow Target Minimal Magnitude (cfs) Albuquerque Gage	**Minimal flow event recurrence or baseflow percent of time (signpost/ threshold)**	**Minimum Duration of Flow Target (days)**	**Season/ timing**	**Ecologic Objectives (include all supporting citations, interviews etc.)** Indicator species: Cottonwood, RGSM, SWFL, wetland species	**Evidence of Transformation**	**Potential opportunities and limitations to implement environmental flow hypothesis**
7,000 to 10,000 cfs Occasional high volume disturbance	10-20 yr recurrence Need to tie down	5 days at or above peak; recessional tail of 500 cfs/ day Use BEMP numbers for descending limb (use gage rating table for discharge-elevation relationship).	April 15- June 15	Regeneration of cottonwood (BEMP; Bhattacharjee et al 2006) Breakdown of organic material on floodplain RGSM spawn SWFL moist soils Wetland plants	Dying, older cottonwood trees; no younger recruits on floodplain; mistletoe infestation October RGSM population numbers are below a threshold.	Limitations: Flood control; 2023 maximum flood capacity for MRG = 6000 cfs; Los Lunas levees. Opportunities: High flow impact could be received through bank lowering, swails
5000 Wet year flow event	5 yr recurrence	5 days at or above peak; recessional tail of 500 cfs/ day	April 15- June 15	*Isleta Reach:* Inundation of older floodplain allowing for decomposition of organic material; disturbance of bar and island habitat with new recruits of native veg SWFL nesting on bars and islands *Other reaches:* inundation of bare-soil bar and island habitat with new recruits of native veg RGSM spawn	No cottonwood recruitment on bars and islands October RGSM population numbers are below a threshold. SWFL: nesting pairs limited (#?) from Rio Grande corridor	Opportunity: Use upstream reservoirs to store snow melt run off and re-regulate to improve peak and timing.

Flow Target Minimal Magnitude (cfs) Albuquerque, Bosque Farms and San Acacia gages	Minimal low-flow percent of time (signpost/ threshold)	Minimum Duration of Flow Target (days)	Season/ timing	Ecologic Objectives (include all supporting citations, interviews etc.) Indicator species: Cottonwood, RGSM, SWFL, wetland species tbd	Evidence of Transformation	Potential opportunities and limitations to implement environmental flow hypothesis
2500 Average year flow event	2 yr recurrence	2 days at or above peak; recessional tail of 300 cfs/ day	April 15- June 15	RGSM recruitment, songbird nesting on bars and islands (SWFL etc)	October RGSM population numbers are below a threshold.	Opportunity: Use upstream reservoirs to store snow melt run off and re-regulate to improve peak and timing.
1200 flow event	2 yr recurrence	At least 3 events within a monsoon season	July 1- Oct 1 (monsoon season disturbance events)	Wetted songbird habitat (insect base), freshening events for RGSM survivability		
200 cfs Minimum base flow		Minimum mean daily flow	Irrigation season low flows (April 1- Sep 30)	shallow riparian aquifer- water for cottonwood, (BEMP numbers) RGSM survival (Dudley and Platania), SWFL wetted soils, wetland plant survivability	RGSM CPUE numbers below threshold Cottonwood: young trees dying on bars and islands; older trees stressed on older floodplain (mistletoe?)	Opportunities: Dynamic leasing programs from agriculture, USBOR SJC water leases Limitations: water supply, drought
300 cfs Minimum base flow not to exceed 1200 cfs Nov 1 through Feb 28		Minimum mean daily flow	Fall-Winter low flows (Oct 1- March 31)	RGSM survival, migratory bird habitat (crane roosting, duck habitat etc.) Charge the shallow groundwater- riparian health Nov 1 through Feb 28 limit for crane roost habitat		

A	B
Author	Title
Michael Porter and Audrey Harris	Environmental Flow Analysis for Rio Grande Silvery Minnow recruitment
Mark Stone, Colin Byrne, and Ryan Morrison	Evaluating the Impacts of Hydrologic and Geomorphic Alterations on Floodplain Connectivity
Andrea Everett	Impacts of Environmental Changes to the Middle Rio Grande Landscape on Ysleta del Sur Pueblo Ceremonial Sustainability
Hugo Magaña	Flood pulse trophic dynamics of larval fishes in a restored arid-land, river-floodplain, Middle Rio Gr NM
Joydeep Bhattacharjee, John Taylor Jr, and Loren Smith	Controlled Flooding and Staged Drawdowns for Restoration of Native Cottonwoods in the MIddle R Valley, NM, USA
Paula Makar and Jonathan AuBuchon	Channel Changes on the MRG
Timothy Walsworth and Phaedra Budy	Examining Alternative Water Management Strategies to Support Rio Grande Silvery Minnow Cons and across Years
Hamilton, Sarah G.	Effect of Hydrologic, Geomorphic, and Vegetative Conditions on Avian Communities in the Middle Rio Grande of New Mexico
Muldavin, E., Milford, E, Brunau, L., Rondeau, R.	Middle Rio Grande Conservation Action P{lan
Siegle and Moore	Southwestern Willow Flycatcher Breeding Habitat Suitability, 2021: Middle Ri Grande, Upper Color
Patterson, Sandoval	Upper Rio Grande Functional Flows Assesment
Blythe, T. L., and J. C. Schmidt. 2018	Estimating the Natural Flow Regime of Rivers With Long Standing Development: The Northern Bra
Sandoval-Solis, S., Paladino, S., Garza-Diaz, L.E., Nava, L.F	Environmental Flows in the Rio Grande - Rio Bravo Basin
Fullerton and Batts	Hope for a Living River
Crawford et al	1993 Bosque Biological Managment Plan
Richter	Summary of Initial Environmental Flow Recommendatiosn for the Rio Grande
Thomas P. Archdeacon, Eric J. Gonzales, Lyle I. Thoı	Effects of flow recession regime on stranding of Rio Grande silvery minnow suggests that cons
Archdecon	Reduction in Spring Flow Threatens Rio Grande Silvery Minnow: Trends in Abundance during R
Archdecon and Reale, 2020	No quarter: Lack of refuge during flow intermittency results in catastrophic mortality of an im
Cowley	Water requiremetns for native species- Rio Grande silvery minow
Dudley, R. K., & Platania, S. P. (2007).	Flow regulation and fragmentation imperil pelagic-spawning riverine fishes.

PROPOSED E-FLOWS FOR COTTONWOOD-WILLOW BOTTOMLAND FORESTS

[although cottonwood-willow bottomland forests have been put forward as an indicator species for MRG, the numbers put forward, below, are based solely on *P. deltoides* (versus *P. deltoides* and *S. nigra* and *S. gooddingii*)]

What we know (or at least have a good handle on) regarding flows required for cottonwood-willow propagation and long-term viability, in general, and the occurrence of such flows along the MRG

- Timing of Propagation Flow: Recruitment flows need to occur in the Spring during C-W seedfall. According to several experts, the heart of cottonwood seed fall along the MRG is late May to early June. For now, we set dates for this seed fall period as May 21 to June 10 (for purposes of setting e-flow duration).
- General Description of Cottonwood-Willow Propagation Flow: Flows need to be of sufficient magnitude and duration to perform sufficient channel work that establishes surfaces that are free of vegetation, wet and not prone to rapid desiccation after the peak flow has receded, nor to flood scour by frequent relatively low magnitude flow events (Shafroth et al., 2010; Stromberg et al., 2006; many others).
- MRG Flows that Fomented Strong Propagation: In the recent past (last two decades), strong cottonwood recruitment was experienced in 2016, …. In addition, last year (2023) Spring flow was of sufficient magnitude and duration to do significant channel work conducive to cottonwood recruitment, but we do not know the actual vegetative response.
- Average, Peak, and Std Deviation of MRG Cottonwood Propagation Flows: Assuming 2023 Spring flows were conducive to strong cottonwood recruitment, the average flow (as measured at Albuquerque gauge 8330000) during the period of May 21, 2023 to June 10, 2023 was 4,494 ft^3s^{-1} (w std deviation of 226 ft^3s^{-1}). For the same period in 2016, average flow as 2,878 ft^3s^{-1} (w std deviation of 478 ft^3s^{-1} and peak flow of 3,950ft^3s^{-1}). Provisionally, these two flows are put forward as e-flow needed for strong and moderate propagation, respectively.
- Recession Limb: The recession limb of a strong cottonwood propagation flow event is an important consideration given that high *Populus* spp. seedling death can occur if the slope of the recession limb is steep with such precipitating a dramatic decline in elevation of saturated soils that exceeds 4 cm per day (Mahoney and Rood 1992; Shafroth et al. 1998; Amlin and Rood 2002). The recession limbs for targeted recent cottonwood recruitment flow events (e.g., 2023, 2016…..) can be calculated/modeled.
- Summer Low Flow: For summer low-flow period, we know that threshold groundwater decline for establishing obligate riparian trees cannot be greater than 1.3 m below the elevation of the recruitment surface ((Mahoney and Rood 1992; Shafroth et al. 1998; Amlin and Rood 2002). The rollout of the Mikeshe model may help to tie surface flow to shallow groundwater elevations.

PROPOSED E-FLOWS FOR COTTONWOOD-WILLOW BOTTOMLAND FORESTS (continued)

What we do not Know:

- Peak Flow Duration for Strong Propagation: The ideal peak flow duration needed for recruitment of C-W likely varies (potentially significantly) at sub reach scale, though such can likely be estimated from gauge data. For 2023 propagation flow, the maximum discharge during the seed fall window was 5,020 ft^3s^{-1} with duration of discharges within 5% of the maximum discharge lasting 1.9 days. For 2016, the maximum for the recruitment window was 3,950 ft^3s^{-1} with duration of discharges within 5% of the maximum discharge lasting 5.5 hours (0.2 days).
- Total Duration of Propagation Flow: For cottonwood propagation, we provisionally are using one week duration that would (if used) encompass the ascending limb, peak, and descending limb of a strong cottonwood recruitment flow event.
- Monsoon Pulse Flow: Past studies have documented the importance of monsoon pulse flows for native riparian trees (e.g., Smith and Finch 2016), but nothing put forward for MRG as yet.
- Summer and Winter Low-Flow: Currently, it appears that data are not currently available to quantify low-flow needed to maintain shallow groundwater elevations at thresholds for both summer and winter months. Provisionally, we are using the median flow for RGSM monitoring years (2010-2020) that experienced the lowest minnow numbers during this period (Best and Bullard 2020).

Middle Rio Grande Reach: Summary of e-flow needs for the Rio Grande Cottonwood (*Populus deltoides* ssp. *wislizeni*))

Peak Discharge	Recurrence Interval	Duration and (Timing)	Average Flow and Variance	Reasoning and Source Information
High Spring Pulse Flow (associated with strong propagation)				
10,000 ft^3s^{-1}	~ 15 year	One week (May 21-June 10)	$\mu =$ $\sigma^2 =$	Based on riparian ecology and geomorphology expert assessment of disturbance magnitude for cottonwood recruitment in the Middle Rio Grande.
Medium Spring Pulse Flow (associated with intermediate propagation)				
3630 ft^3s^{-1} ($82\ m^3s^{-1}$)	5 year	One week (May 21-June 10)	$\mu =$ $\sigma^2 =$	Discharge that occurred during height of cottonwood seed fall in 2016 that produced strong cottonwood recruitment
Low Spring Pulse Flow (associated with weak propagation)				
2,470 ft^3s^{-1} ($70\ m^3s^{-1}$)	2 year	One week (May 21-June 10)	$\mu =$ $\sigma^2 =$	Flow identified by Slaugh (2003) as minimum needed to inundate floodplain habitat near Las Lunas
Monsoon Flush Flow				
Not Well Understood	Not Well Understood	Not Well Understood	Not Well Understood	Not Well Understood
Spring-Summer Low Flow				
253 ft^3s^{-1} ($7.2\ m^3s^{-1}$)	Minimum flow	183 days (April 1 – Sept 30)	$\mu =$ $\sigma^2 =$	Based on median flow for RGSM monitoring years (2010-2020) w lowest minnow numbers during this period (Best and Bullard 2020)
Fall-Winter Low Flow				
300 cfs	Minimum flow	182 days Oct 1- March 31	$\mu =$ $\sigma^2 =$	Based on riparian ecology and hydrology expert assessment of low flow needs for charging riparian groundwater levels in the Middle Rio Grande.

PROPOSED E-FLOWS FOR RIO GRANDE SILVERY MINNOW

What we know (or at least have a good handle on) regarding flows required for RGSM propagation and long-term viability, in general, and the occurrence of such flows along the MRG:

- Peak Flow Discharge Needed for Strong Propagation: The peak discharge of 6,992 ft^3s^{-1}, which occurred during May 2005, has been documented as what is needed to inundate a variety of floodplain and backwater areas to foster significant propagation response of RGSM (Magaña 2012). Provisionally, this flow is put forward as what is needed for strong Spring propagation.
- Minimum Flow Needed to Inundate Floodplain Habitat: Although two decades old, Slough (2003) identified a discharge of 2,470 ft^3s^{-1} as the minimum needed to begin inundating floodplain habitat
- Duration: Ten days has been documented as the minimum duration needed for robust propagation to take place (Magaña 2012). Therefore, all propagation flows (strong, med, and minimal) are currently put forth with ten-day duration.
- Timing of Propagation Flows: Study of minnow fecundity along the MRG during the 2005 high flow (Magaña 2012) as well as USFWS monitoring of minnow (Best and Bullard 2020) support other studies that demonstrate that the breeding period for minnow occurs in May.
- Summer Low Flow: A low flow averaging 300 ft^3s^{-1} equates well with low flows during May and June when intermediate numbers of minnow were captured as part of the USFWS monitoring program (Best and Bullard 2020). However, low flow per se is but one of many variables that impact the minnow population.

What we don't know:

- Viable Population: What constitutes a viable population of the minnow? This question is underscored particularly as we relate flow to minnow monitoring results (per Best and Bullard 2020).
- Winter Low Flow: We don't know this, per se, but could quantify it based on USFWS monitoring results (per Best and Bullard 2020).
- Monsoon Flush: Literature on monsoonal pulse flow needs for RGSM have not been identified. That noted, there may be flows that can be put forward as important for establishing additional floodplain habitat for the minnow.

Middle Rio Grande Reach: Summary of e-flow needs for the Rio Grande Silvery Minnow (*Hybognathus amarus*)

Peak Discharge	Recurrence Interval	Duration and (Timing)	Average Flow and Variance	Reasoning and Source Information
High Spring Pulse Flow (associated with strong propagation)				
6,992 ft^3s^{-1} (198 m^3s^{-1})	tbd	10 days (May – June)	$\mu =$ $\sigma^2 =$	Discharge capable of inundating significant floodplain habitat, which is critical for strong spawning response (Magaña 2012)
Medium Spring Pulse Flow (associated with intermediate propagation)				
4,730 ft^3s^{-1} (134 m^3s^{-1})	tbd	10 days (May – June)	$\mu =$ $\sigma^2 =$	Discharge mid-way between May 24, 2005 peak discharge (per Magaña 2012) and discharge needed to begin inundating floodplain habitat (per Slaugh 2003).
Low Spring Pulse Flow (associated with weak propagation)				
4,730 ft^3s^{-1} (134 m^3s^{-1})	tbd	10 days (May – June)	$\mu =$ $\sigma^2 =$	Flow identified by Slaugh (2003) as minimum needed to inundate floodplain habitat near Las Lunas[1]
Monsoon Flush Flow				
Not Well Understood	Not Well Understood	Not Well Understood	Not Well Understood	Not Well Understood
Spring-Summer Low Flow				
253 ft^3s^{-1} (7.2 m^3s^{-1})	Minimum flow	183 days (April 1 – Sept 30)	$\mu = 250\ ft^3s^{-1}$ (7.1 m^3s^{-1}) $\sigma^2 =$	Based on median flow for RGSM monitoring years (2010-2020) w lowest minnow numbers during monitoring period (Best and Bullard 2020)
Fall-Winter Low Flow				
88.9 ft^3s^{-1} (2.5 m^3s^{-1})	Minimum flow	182 days (Oct 1 – Mar 31)	$\mu = 80\ ft^3s^{-1}$ (2.3 m^3s^{-1}) $\sigma^2 =$	Based on lowest flow during RGSM monitoring period 2010-2020 that sustained the minnow (Best and Bullard 2020)

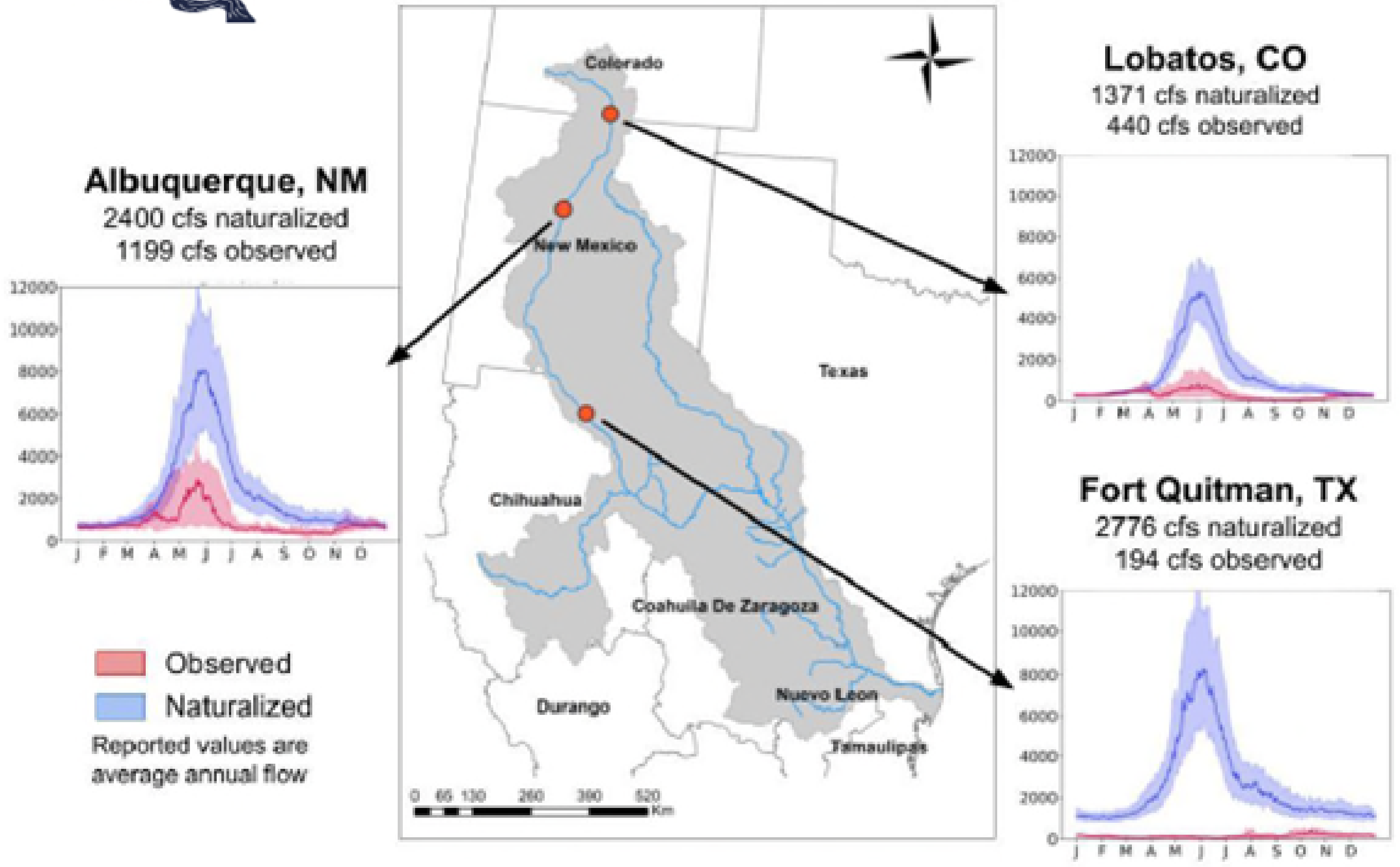


Figure 11. Selected study sites in the Upper Rio Grande illustrate the range of natural and observed conditions occurring across the subbasin.

Modeled pre human conditions

1900 - 2010

Naturalized	units	tenth	twenty-fifth	fiftieth	seventy-fifth	ninetieth
Spring flood median magnitude	cfs	1710.1	2166.91	3383.25	4932.99	5563.56
Spring flood peak magnitude	cfs	4480.85	5171.08	7058.5	9335.25	11820.7
Spring flood timing	date	77.9	89	98	104.75	110
Spring flood duration	days	79.9	90.5	100	109	120
Spring recession rate of change	percent	0.03965	0.04566	0.05237	0.05951	0.06555
Monsoon median magnitude	cfs	488.05	659.563	809.3	1007.5	1301.76
Monsoon magnitude 90th	cfs	805.273	1107.49	1615.15	2368.69	2644.53
Monsoon timing	date	182.9	189	196.5	205	210
Monsoon duration	days	89.9	98.25	110	140.75	155.2
Dry season median magnitude	cfs	370.4	436.5	512.5	586.787	649.65
Dry season magnitude 90th	cfs	489.092	610.225	731.3	902.25	1023.5
Dry season timing	date	296	296	303	336.75	346.2
Dry season duration	days	115.5	127.75	151.5	171.25	176.3
Average annual flow	cfs	984.611	1145.83	1550.98	1973.01	2300.46
Coefficient of variation	percent	0.87662	0.94469	1.08565	1.19044	1.27485

1990-2020

Observed	units	tenth	twenty-fifth	fiftieth	seventy-fifth	ninetieth
Spring flood median magnitude	cfs	502.8	608	986	1610	1987
Spring flood peak magnitude	cfs	657	1045	2055	3255	4362
Spring flood timing	date	28.2	39	55	79	103.8
Spring flood duration	days	74.6	87	120	134	153.2
Spring recession rate of change	percent	0.04186	0.05474	0.06226	0.0721	0.08251
Monsoon median magnitude	cfs	229.6	267.25	338	440.5	536.4
Monsoon magnitude 90th	cfs	317.88	507.15	590.9	683.25	1206.8
Monsoon timing	date	110.4	170	191	199.5	208
Monsoon duration	days	84.6	99.5	108	161	171.8
Dry season median magnitude	cfs	358	459.5	507	542.5	593
Dry season magnitude 90th	cfs	456	513.1	635.4	702.4	747.7
Dry season timing	date	296	296	299	339.5	345.8
Dry season duration	days	60	79	111	138	145
Average annual flow	cfs	349.546	444.963	634.709	885.401	976.984
Coefficient of variation	percent	0.37673	0.43406	0.58913	0.81508	0.96528

Reach	Safe channel capacity (cfs)	Spring Mag Rare Distubance flow (cfs) 10-20 year recurrence Apr-May-June	Spring Mag High flow (cfs; 5 year recurrence) April, May June	Spring Mag Average (cfs; 2 year recurrence) Apr-May-June	Monsoon Flush (cfs) 2 year with 3 events	Spring-summer Low Flow (cfs) April 1- Sep 30	Fall- winter Low Flows (cfs) Oct 1- March 31
Chama Headwaters La Puente Gage		4k					
Chama Below ElVado Below El Vado Gage	6000	6,000 w/ recessional limb of xx	4,000	2500	700	100	150
Chama Below Abiquiu Below Abiquiu Gage	1800						
Rio Grande SL to Chama Taos Junction Bridge Gage							
Rio Grande White Rock Otowi Gage	5000	7500	3000	2000	?	350	550
Middle Rio Grande Albuquerque Gage San Acacia	5000	10,000 w/ 2 weeks at or above 4k w/ recessional limb of 500 cfs	5,000 w/ 2 weeks at or above 3k w/recessional limb of 500	2500 w/ 2 weeks at or above 2k w/recessional limb of 500 cfs	1200?	250	300

ALL NUMBERS ARE DRAFT HYPOTHESES

Rio Grande Basin Study Environmental Flow Quantification Process

- Environmental Flow Recommendations represent our best current scientific hypotheses, based on available data/ analyses, as to what the river needs for ecologic viability in the 6 reaches.
- This information will identify primary environmental flow deficits within each reach (current).
- Basin Study modeling will help us understand how these deficits are likely to change in the future with no action or with potential resiliency actions.
- Workshop and ensuing Basin Study process will compile and develop resiliency actions to help close the environmental flow deficits where feasible.
- Some Environmental Flow Recommendations will not be achievable.
- **These recommendations are not a threat to water right holders or bankside landowners.**