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BEFORE THE COLORADO WATER CONSERVATION BOARD

STATE OF COLORADO

Rebuttal Statement of the Colorado Division of Parks and Wildlife and the U.S. Department of Interior, Bureau of Land Management

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IN THE MATTER OF AN INSTREAM FLOW APPROPRIATIONS ON THE SAN MIGUEL RIVER, in WATER DIVISION 4

Pursuant to Rule 5n(2) of the Rules Concerning the Colorado Instream Flow and Natural Lake Level, 2 CCR 408-2 ("ISF Rules"), the Colorado Division of Parks and Wildlife ("CPW"), (also known as the Colorado Division of Wildlife "CDOW"), and the U.S. Department of the Interior, Bureau of Land Management ("BLM") hereby submit their rebuttal statement in support of the Colorado Water Conservation Board ("CWCB") Staff's recommendation for an instream flow ("ISF") appropriation on the San Miguel River between the confluence with Calamity Draw and the confluence with the Dolores River and in the amounts set forth in CWCB staff recommendation (see CWCB staff recommendation at - http://cwcbweblink.state.co.us/WebLink/ElectronicFile.aspx?docid=146671&searchid=2810438f-b68f-467c-9147-7e13ef9f127a&dbid=0).

REBUTTAL TO OPPONENT'S FACTUAL CLAIMS

1. **Opponents question if the stream reach selected for the instream flow study is a "representative reach".**

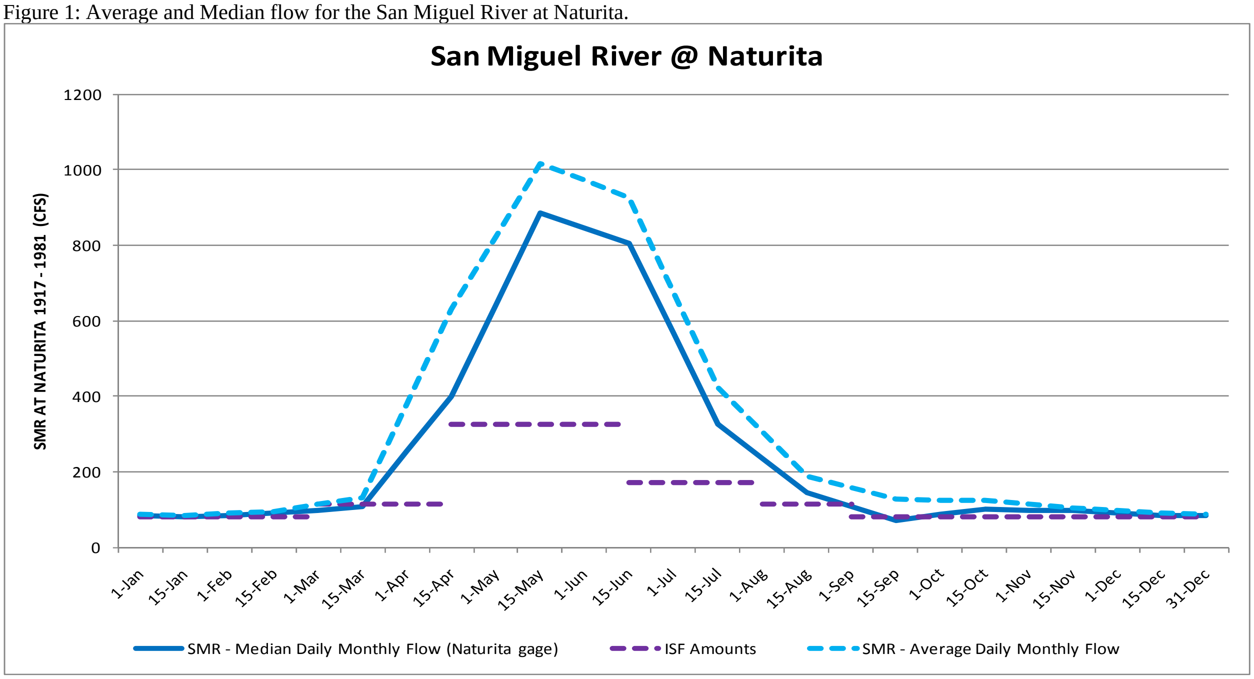
The BLM&CPW followed a criteria-driven process to select a representative reach for the instream flow study. Please see the attached Exhibit RS#1 for a memo describing the process.

2. **Opponents question whether the portion of the proposed instream flow reach between the confluence with Calamity Draw and the confluence with Coal Creek should be included in the proposed instream flow appropriation. Opponents state that the proposed instream flow amounts are not reflective of flows in this section, and that no data was collected in this stream section.**

2A. The proposed instream flow amounts are reflective of flows that are available within the reach between Calamity Draw and the Dolores River.

Dr. Wesche and others were concerned about the site location upstream of the USGS gage and that water availability might be over estimated. BLM&CPW considered this issue and looked at discharge records for the discontinued USGS gage, San Miguel River at Naturita (ID# 09175500), which is located approximately 4.0 miles upstream of Calamity Draw to confirm that water was historically available. The Naturita stream gage was operational for 53 years between 1917 – 1981, and the 53 year record indicates that the proposed instream flow amounts have been available at a location upstream of the upper terminus of the proposed instream flow reach (see Figure 1 below and attached Exhibit RS#2).

Figure 1: Average and Median flow for the San Miguel River at Naturita.



2B. Additional data collection is not necessary in the reach between Calamity Draw and the Dolores River, because river conditions are similar to the modeled reach.

BLM&CPW confirmed that the reach selected for modeling was representative of the proposed instream flow reach, as outlined in this rebuttal statement under number 1, above. Opponents present no information that would lead the CWCB to conclude that the reach between Calamity Draw and Coal Creek would possess significantly different channel dimensions, slope, or fish community than the reach selected for modeling purposes.

3. **Opponents argue that the biological justification, specifically the interpretation of PHABSIM modeling results, failed to consider; 1) the multiple life stages of bluehead sucker and flannelmouth sucker, 2) relative abundance of sampled species, 3) the habitat requirements of the roundtail chub, and 4) the suitability of using the habitat curves developed by Anderson and Stewart on the San Miguel River.**

3A. The BLM&CPW biological justification was broadly based to cover all elements of the water-dependent natural environment.

The BLM&CPW used the best data available to date to develop an instream flow recommendation for this reach of the San Miguel River. In addition to considering the habitat needs of the three native species (See Attached Exhibit RS#3), the BLM&CPW considered the needs of the entire natural environment including the macroinvertebrates present in the stream (see San Miguel River Executive Summary - Appendix D) and the plant community associated within the riparian corridor (see San Miguel River Executive Summary - Appendix B).

The riparian corridor of the San Miguel River contains an excellent occurrence of a plant community that is imperiled globally. In addition to the critically imperiled New Mexico privet riparian shrubland community, there are over 20 other targeted riparian communities within the corridor, including riparian forests dominated by both narrowleaf and Fremont cottonwoods (and their hybrids), and montane riparian shrublands dominated by river birch, skunkbrush, coyote willow or silver buffaloberry. There are several occurrences of rare plants including; Payson lupine and San Rafael milkvetch within the corridor.

The Opponents failed to consider the need for providing flows for these unique plant communities that are a part of the natural environment the CWCB is responsible to preserve to a reasonable degree. Flows exceeding bankfull conditions are arguably the minimum flows required to preserve these unique plant communities to a reasonable degree. In addition, studies conducted in this reach demonstrate that groundwater levels in the alluvial aquifer, which are critical to survival of the riparian community, are directly linked to flow levels in the river.

3B. BLM&CPW used the best information available to consider the habitat needs associated with multiple life stages of bluehead sucker and flannelmouth sucker.

Opponents argue that bluehead and flannelmouth sucker and roundtail chub habitat suitability curves for adult, juvenile, fry and spawning life stages should have been considered. The BLM&CPW reviewed existing literature and contacted fishery and instream flow experts (personal communications, CPW aquatic biologists Dan Kowalski, Jim White, Sherman Hebein, John Alves; Dr. Bill Miller (Miller Ecological) and Tom Annear (Author and Past President of the Instream Flow Council)) to determine if habitat suitability curves for juvenile, fry and spawning life stages had been developed for the three native species. Based on this review, the BLM&CPW determined that no juvenile, fry or spawning life stages habitat suitability curves existed for bluehead and flannelmouth sucker and no habitat suitability curves existed for any life stage of the roundtail chub. None of the Opponents in their Prehearing Statements have produced or referenced any evidence regarding the existence of any such curves.

All of the Opponents were concerned that the BLM&CPW did not consider flows for the spawning and fry life stages of the native fish species. BLM&CPW reviewed existing studies relating to native fish species, including studies completed by the San Juan River Recovery Implementation Program (SJRIP). The SJRIP was established to recover the Colorado pikeminnow and the razorback sucker while allowing water development and management activities to continue in the San Juan River Basin. The SJRIP Report "Flow Recommendations for the San Juan River" provides additional information relating to the life stages and stream flow requirements of the native fish community including the bluehead and flannelmouth sucker, roundtail chub and speckled dace. We have attached the Executive Summary of the SJRIP "Flow Recommendations for the San Juan River" (see Exhibit RS#4); the entire report can be found on the SJRIP website located at http://www.fws.gov/southwest/sjrip/index.cfm . This study indicates that the flows preferred by the native species mentioned above for spawning and increased reproductive success far exceed the amounts recommended by the BLM&CPW to protect "adult" habitat.

The native fish instream flow recommendations for the San Juan River were the result of a seven-year study that was designed and performed by the Biology Committee of the SJRIP. The Biology Committee of the SJRIP consisted of individuals representing a wide range of organizations and interests including the: Bureau of Indian Affairs, USFWS (Regions 2 & 6), Bureau of Reclamation, Jicarilla-Apache Tribe, Navajo Nation, Southern Ute Tribe, States of Colorado and New Mexico and Water Users. The SJRIP study was also peer reviewed by Drs. David Galat (University of Missouri), Ellen Wohl (Colorado State University), Clark Hubbs (University of Texas) and Ron Ryel (Independent Consultant). (see page P-1 SJRIP Executive Summary)

SJRIP study did not develop any specific habitat suitability curves for any life stages of the roundtail chub, speckled dace, bluehead sucker or flannelmouth sucker but it did provide specific observations regarding what flows provided these species with better reproductive success. The results of this seven-year study, indicated that:

"*the young of bluehead sucker and speckled dace, …, were found in greater numbers during* ***high flow years*** *(emphasis added) compared with low flow years*" (see 3rd paragraph, page S-3, SJRIP Executive Summary) and bluehead sucker and speckled dace reproductive success increased with increasing duration of flows equal to or exceeding bankfull conditions (see last paragraph, page S-6, SJRIP Executive Summary).

Bankfull discharge in the San Juan River was estimated to be approximately 8,000 cfs. Bankfull flows also fulfill other critical habitat functions, as Dr. Miller pointed out in his instream flow report regarding the Colorado River: *"Peak flows are most important for habitat creation and maintenance. Peak flows of bankfull and higher are required at regular frequency for proper ecosystem function."* (see 1st paragraph page iv) (Miller & Swaim 2011).

This information indicates that the spawning and fry life stages of the bluehead sucker and speckled dace (native species in the San Miguel River) require much higher flows than the BLM&CPW and Western Resource Advocates & Wilderness Society (WRA&WS) have recommended. If the recommendations of the SJRIP study to protect bankfull flows were followed in the San Miguel River, the BLM&CPW recommendation would be much higher. BLM&CPW have estimated that bankfull conditions on the San Miguel River at Uravan occur at a flow of approximately 2,520 cfs. The bankfull flow rate has a recurrence interval of approximately 1.5 years (see attached Exhibit RS#5).

In addition to consulting studies regarding native fish habitat and flow needs, the BLM&CPW also consulted with experts (personal communications, CPW aquatic biologists Dan Kowalski, Jim White, Sherman Hebein, John Alves; Rick Anderson (retired CPW aquatic research biologist) on the biology of these species. Those consultations revealed that one of the most important processes for preserving a thriving community of these species is the presence of a large adult population. A large adult population can spawn throughout the river channel when conditions are optimal for spawning and recruitment, which does not occur every year. If a thriving adult community is present, it indicates that fry and juvenile are successfully recruited into the adult community and that fry and juvenile are finding suitable habitat in a variety of flow rates.

Finally, the BLM&CPW flow recommendations are based upon the CPW management strategy for native species. First, CPW attempts to optimize habitat for native species and minimize habitat for non-native species. One of the threats identified in the attached native species Technical Conservation Assessments (see Exhibit RS#3) is that the introduction of non-native species increases predation on and competition with native suckers. Another threat to the native species is the hybridization with non-native species such as white suckers. Current sampling efforts indicate, that non-native white suckers are absent or present in only small numbers in the San Miguel River, presumably because of the relatively unaffected natural hydrograph. Second, CDOW's management strategy is focused on maintaining healthy adult populations. Healthy reproducing adult populations ensure that other life stages (Fry & Juvenile) are present within the natural system in a quantity to guarantee the survival of the species.

Based upon consulting existing studies, experts on species and biology, and CDOW's management strategy for native species, the BLM&CPW assert that protecting the identified optimum amount of habitat (WUA) for the adult life stages of bluehead and flannelmouth sucker is the minimum amount necessary to preserve the natural environment to a reasonable degree. However, if the Opponents and Proponents believe that the higher required spawning flows should be considered, the BLM&CPW are not opposed to modifying their existing instream flow recommendations to include the higher flows required for spawning and fry life stages, as recommended by Dr. Woodling in his July 13, 2011, Memorandum to Western Resource Advocates and The Wilderness Society (WRAWS) or as Rick Anderson has suggested in his attached letter (See Exhibit RS#6) to Roy Smith and Mark Uppendahl dated August 18, 2011. It should be noted, that Rick Anderson was hired by the BLM&CPW to give an independent review of the proposed San Miguel River instream flow recommendations and written comments received from Tom Wesche (HabiTech, inc.) and Don Conklin (GEI).

3C. Existing Studies Contradict the Assumptions and Hypothesis in the Conklin Report.

BLM&CPW conclude the results of the SJRIP study clearly contradict the hypothesis provided by Don Conklin in his report. Dr. Woodling in his (WRA&WS) Report also pointed out the flawed conclusions of Mr. Conklin. Dr. Woodling references a study done by Burdick in 1995 that indicated that "*high recruitment was documented in years with high spring snowmelt flows*" (see paragraph 3 page 8 Woodling Memorandum). Based upon the results of the SJRIP study, discussions with CPW biologist Dan Kowalski and retired CPW research aquatic biologist Rick Anderson's August 18, 2011 letter, BLM&CPW assert that Conklin's choice to model habitat for white sucker fry and longnose dace, both of which are common fish species on the east slope of

Colorado, is an erroneous application of science in the San Miguel River. His recommendation to use these species as surrogates for the native species of the San Miguel River is flawed.

Rick Anderson's attached letter provides a detailed explanation on why Mr. Conklin's hypothesis and conclusions are incorrect. BLM&CPW agree with Anderson's statement:

Speckled dace is not a species of special concern in the Colorado River watershed. Speckled dace are small-sized fish (about 4 inches) and occupy a niche as bottom dwellers in riffle habitats primarily with cobble substrates. Substrate velocities are much less compared to just a few inches above. Therefore cobble substrates are more critical than depths or velocities for habitat suitability. Speckled dace are common throughout the Colorado River system, have evolved with peak runoff conditions and have no apparent trouble persisting during high flow or flood conditions.

Mr. Don Conklin (July 8, 2011) presented WUA-discharge relationships for longnose dace as a surrogate for speckled dace to support his claim. Longnose dace habitat peaked at 200 cfs, a flow higher than those recommended except of the runoff period.

Miller et al. (2008) made speckled dace density and biomass estimates in the Colorado River in riffles that had suitable depths and velocities for adult bluehead sucker. It is safe to assume that speckled dace are currently common in the San Miguel. There does not appear to be any benefit to the speckled dace population given a lowered flow regime. Just because speckled dace can tolerate lowered flows far better than the 'three' native species is not a valid reason to recommend lowered instream flows, in my opinion.

(see Paragraphs 3 through 5, Page 10, Anderson Letter).

The San Miguel River fish population is distinctive from that of most west slope rivers in that non-native white sucker, carp and smallmouth bass are absent. As Anderson pointed out:

"*In rivers where white sucker are commonly collected, they are a highly problematic for native sucker. Hybridization (white and native sucker) has been documented in the Yampa, Colorado and Gunnison River. The native sucker population of the Yampa upstream of Lily Park has been severely threatened due to cross breeding with white sucker. White sucker are a pool-habitat fish and hybridization between native and white sucker appears to be more common when reduced flows decrease the availability of faster current habitats (Anderson and Stewart 2007).*"
(see Anderson Letter Paragraph 4 Page 5)

These are the conditions the BLM&CPW are specifically trying to avoid. Conklin's proposed lower instream flow recommendations, which were developed by using the non-native habitat suitability curves, would exacerbate these negative conditions and potentially threaten the native fish community of the San Miguel River. As Anderson pointed out:

"White sucker adult occupy pool habitat, they spawn later in the summer and fry are present during late summer (September) when flows are usually much less than earlier in the season."
(see Paragraph 7 Page 10 Anderson Letter).

Based on the information presented above the BLM&CPW assert that the use of white sucker fry and longnose dace curves as surrogates to recommend instream flows for roundtail chub, bluehead sucker and flannelmouth sucker is not suitable science.

3D. BLM&CPW utilized a complete set of information regarding life stages, spawning season and habitat requirements when developing the biological justification for the proposed instream flow rates.

Opponents have argued that the biological justification was limited and have requested additional information regarding life stages, spawning season and habitat requirements of the native species found in the San Miguel River. The original instream flow recommendation report provided a brief summary of the habitat needs of the three native species. Exhibit RS#3 provides a more detailed description of the life stages, spawning season, observations of flows required for spawning success and habitat needs of the native fish community.

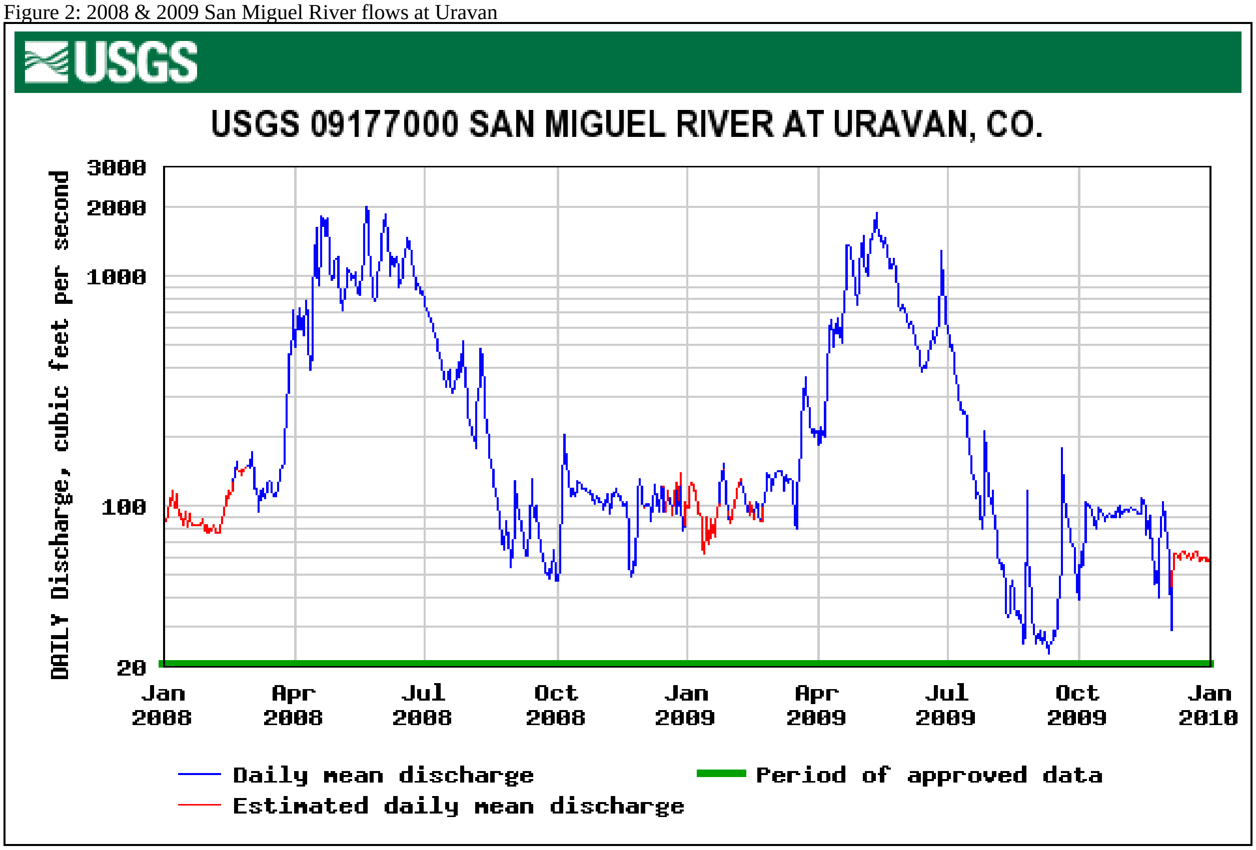
3E. Mimicry of the natural hydrograph is essential to maintenance of native fish species.

The Biology Committee of the SJRIP wrote that:

"*Mimicry of the natural hydrograph is the foundation of the flow recommendation process for the San Juan River. Scientists have recently recognized that temporal (intra- and interannual) flow variability is necessary to create and maintain habitat and to maintain a healthy biological community in the long term. Restoring a more-natural hydrograph by mimicking the variability in flow that existed before human intervention provides the best conditions to protect natural biological variability and health. The linkages between hydrology, geomorphology, habitat, and biology were used to define mimicry in terms of flow magnitude, duration, and frequency for the runoff and baseflow periods."(see Page S-1 SJRIP Executive Summary).*

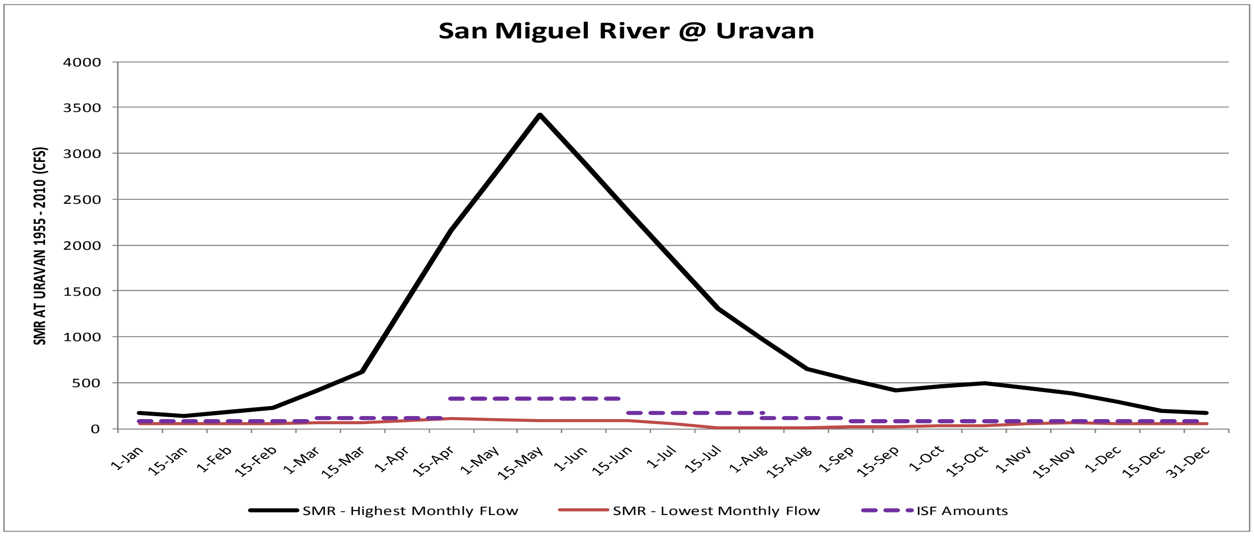
The BLM&CPW agree with the concept stated above. We assume that Dr. Wesche also agrees with this concept, since he was a member of the SJRIP Biology Committee. This same concept is implied by Mr. Conklin several times in his report where he states "*Recommended minimum flows that mimic current flows would preserve the existing healthy fish community*." (see last sentence page 4 Conklin July 8, 2011 letter) Mr. Conklin's own fish data seems to contradict his hypothesis that lower flows are needed to maintain habitat for fry, implying that fry habitat was limited at higher flows. Fish sampling by his own company, GEI, in 2008 and 2009 indicates that the existing flow regime of the San Miguel River, with an average daily flow of 1,050 cfs in May of 2008 and 1,237 cfs in May of 2009, has produced an abundant population of both sucker species. He states specifically that "*The fish populations in the river at present are being preserved with the **historical flow regime** (emphasis added) that has occurred over the years without designated minimum flows*." (see paragraph 3 page 1 Conklin letter) Figure 2 below shows the flows recorded at the Uravan gage for 2008 and 2009, the years of GEI's fish sampling effort. Flows clearly exceeded 1,625 cfs or 5 times the recommended instream flow of 325 cfs without any negative effects to the native fish community.

Figure 2: 2008 & 2009 San Miguel River flows at Uravan



The Figure 3 below shows the range of flows that created and has maintained the natural environment found in the San Miguel River near Uravan. The upper solid line represents the maximum average monthly flow and the lower solid line represents the minimum average monthly flow for the period of 1955 to 2010 for the Uravan gage. This relationship between the maximum and minimum average monthly flows is not unique to the San Miguel River and can be found on most streams within the state. Figure 3 demonstrates how the existing natural environment is able to adapt to wide ranges in stream flow. Every year may not be beneficial to the reproduction and survival of each specific species but it is important to provide each species with the conditions they require to survive and reproduce. The BLM&CPW assert that their instream flow recommendations are the minimum flows necessary to protect the natural environment of the San Miguel River based on the existing hydrologic record.

Figure 3: Range of Average Monthly Flows



3F. BLM&CPW considered the habitat needs of roundtail chub.

Dr. Wesche questioned if the roundtail chub habitat needs were considered by the BLM&CPW. The only information he provided in regards to this question was that:

"*… roundtail chub spawn on the declining limb of the spring runoff hydrograph, consideration of their habitat and flow requirements during the mid-June to July period may have strengthened the biological basis for this portion of the recommendation*" (see paragraph 1 page 3 Wesche June 29, 2011 letter) .

Roundtail chubs and bluehead suckers both spawn on the descending limb of the hydrograph. The proposed instream flow recommendations took this into consideration by attempting to provide some resemblance to a natural hydrograph in the recommendation. The recommendation clearly provides for minimal protection of the peak of the hydrograph, 325 cfs, (April 15 – June 14), and then slowly steps down with the declining limb of the hydrograph, 170 cfs (June 15 – July 31) and 115 cfs (August 1 – August 31). The instream flow recommendation of 170 cfs provides a specific flow amount for the time period Dr. Wesche is concerned about, the mid-June to July period.

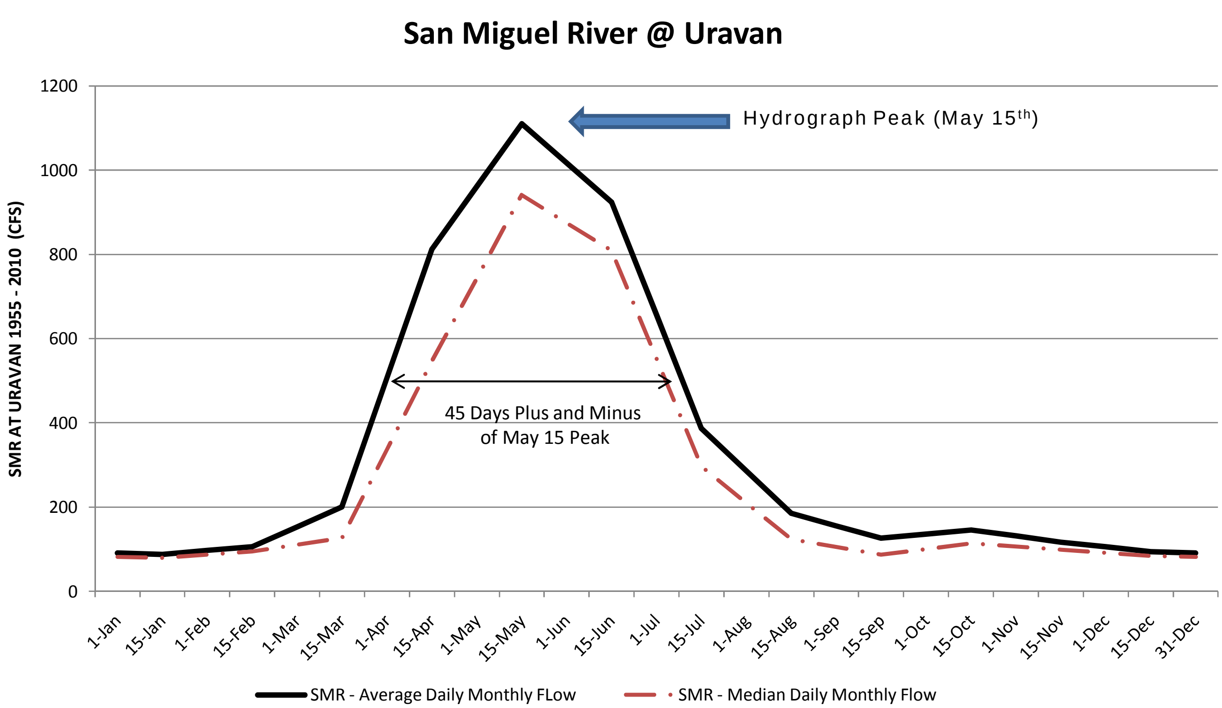
The specific recommendation of 170 cfs for a specific time period (June 15 – July 31 or the descending limb of the hydrograph) is a clear indication that the habitat needs of the native species that spawn on the descending limb of the hydrograph (bluehead & roundtail) were considered. The BLM&CPW provided information relating to when roundtail chub spawn in the San Miguel River Executive Summary (see page 4) and in the "Species Descriptions, Life Histories and Hybrids" section in the Species Conservation Agreement (see page 24 Appendix A, San Miguel River Executive Summary), further indicating that they took the flow and habitat needs of the roundtail chub into consideration.

It should be noted, that Dr. Wesche's alternative instream flow recommendation for the June 15 – July 31 time period is the same as proposed by the BLM&CPW. However, he does not provide a "peak flow," so his peak season recommendation is the same as his declining limb of the hydrograph flow recommendation. His proposed flow recommendations would not provide spawning cues to flannelmouths, that spawn on the ascending limb of the hydrograph, or to bluehead or roundtail, that spawn on descending limb the hydrograph.

3G. BLM&CPW's recommendation of peak flows is based upon a consideration of the spawning needs of the sensitive fish species.

Dr. Wesche has requested additional information be provided relating to the biological justification of the proposed instream flow recommendations. The literature review presented above clearly indicates that the native species spawn on the ascending or descending limb of the hydrograph, at flows equal to or greater than the recommended instream flows. Figure 4 below displays the average and median year hydrographs based on data from the USGS gage for the San Miguel River at Uravan. Figure 4 also shows a 90 day time period consisting of 45 days prior to the peak (flannelmouth spawning season) and 45 day after the peak (roundtail and bluehead spawning seasons).

Figure 4: Average and Median Monthly Flow



Flannelmouth Sucker - spawn in spring and early summer, typically during May and June, and on the ascending limb or **peak of the hydrograph**.
Bluehead Sucker - spawn in mid-June to mid-July, typically during the descending limb of the hydrograph.
Roaundail Chub - spawn in mid-June to mid July on the declining limb of the spring runoff hydrograph.

Table 1: Expected San Miguel River Flows at Uravan.

Expected Flows in CFS		
	Average	Median
April 1	506	339
April 15	810	550
May 1	965	747
May 15	1120	943
June 1	1024	882
June 15	927	820
July 1	660	561
July 15	392	301

Table 1 above indicates the average and median year flow amounts that could be expected in the San Miguel River at the time these species spawn. The average year hydrograph indicates that flows exceed 506 cfs for the 90 day spawning time period surrounding the 1,120 cfs average daily flow for the month of May. The median year hydrograph indicates that flows exceed 339 cfs for the 90 day spawning time period surrounding the 943 cfs median daily flow for the month of May. Extending the time period an additional 15 days to mid-July means flows exceeded 392 cfs and 301 cfs in average and median years respectively.

Additional information from the SJRIP study has also been presented that indicates that bankfull streamflows of nearly 2½ times the average year peak flow of 1,120 cfs could be ideal for two of the native species (bluehead and speckled dace). The above information clearly indicates that if the Opponents were truly interested in providing streamflows for spawning and fry life stages, as their pre-hearing statements indicate, they would be recommending that the BLM&CPW increase their instream flow recommendations to at least 339 cfs (the minimum flow during April 1 to July 1 time period for a median year hydrograph). Dr. Woodling has proposed the minimum flow be raised to at least 500 cfs (See 7/13/2011 Woodling Memorandum Page 10), which corresponds with the average year minimum flow during the April 1 through June 30 time period and Anderson has recommended a flow of 600 cfs (See Anderson Letter page 13).

Neither Dr. Wesche nor Mr. Conklin has provided any scientific evidence indicating how maintaining below average flows in perpetuity, would preserve the natural environment to a reasonable degree. A specific example of just such a case is the Dolores River below McPhee Reservoir. The natural environment and the existing fish community below McPhee Reservoir are severely affected by the lack of high flows associated with a natural hydrograph. Anderson and Stewart observed that:

"*The fish community of the Dolores River appeared to be highly stressed. Species composition of native fish was high, but most fish were small. Roundtail chub was the most common species and biomass was very low. These attributes appeared to be habitat and flow related. The lack of runoff flows in 2000 and 2001 may have negatively impacted productivity. Riffles and runs had large silt deposits and both forage and habitat potential seemed unnaturally low. If the Colorado River data can be used as an example of a high-quality habitat and fishery, the Dolores River data can be useful as an example of very poor quality habitat conditions.*"(Anderson & Stewart 2003)

In regard to the habitat and flow needs of the native fish found in the San Juan River, the SJRIP Report states:

"Habitat needs of the two endangered fishes in the San Juan River involve a complex mix of low velocity habitats such as eddies, pools, and backwaters adjacent to swifter run and riffle habitats. Habitat use changes with time of year and activity (e.g., spawning, feeding, nursery areas). A natural hydrograph, in terms of peak spring flows and late summer base flows, is important to not only provide the proper habitats at the correct time, but also to provide natural temperatures and productivity cycles for those habitats."(See SJRIP Paragraph 3, Page S-2)

The BLM&CPW assert these same habitat conditions apply to the native fish community found in the San Miguel River. Reducing the natural hydrograph of the San Miguel River to the flows proposed by Dr. Wesche and Mr. Conklin would have a very detrimental effect on the existing outstanding native fish community of the San Miguel River.

3H. Application of the Anderson & Stewart Habitat Curves to the San Miguel River is an appropriate habitat modeling technique.

The BLM&CPW reviewed the existing literature to determine what specific life stage curves have been developed for the native species of interest. In addition, BLM&CPW compared existing studies relating to the native species (Anderson and Stewart Studies and SJRIP Study) to determine if there were any river-related and site-specific factors identified in those studies that would indicate that existing curves should be modified if applied to different rivers.

The Anderson and Stewart Studies focused on specific habitat types found in all medium to large rivers. BLM&CPW assert that the San Miguel River is clearly a medium to large size river. Anderson and Stewart have identified 16 different mesohabitats, which covered varying depths and velocities. BLM&CPW identified 11 of 16 of those different mesohabitats over the range of flows modeled in our 815 foot San Miguel River study reach. Those mesohabitats identified by Anderson and Stewart are shown in the Table 2 below:

Table 2: Anderson & Stewart Mesohabitats.

Depth and velocity criteria used to define meso-habitat types.								
Habitat Types Depth Velocity								
	m	m	m/s	m/s	ft	ft	ft/s	ft/s
1 Wetted-pool 0.01 – 0.2 < 0.15	0.01	0.2	0	0.15	0.0328	0.656	0	0.492
2 Shoal-pool 0.2 - 0.5 < 0.15	0.2	0.5	0	0.15	0.656	1.64	0	0.492
3 Shallow-pool 0.5 - 1.0 < 0.15	0.5	1	0	0.15	1.64	3.28	0	0.492
4 Medi–pool 1.0 - 2.0 < 0.15	1	2	0	0.15	3.28	6.56	0	0.492
5 Deep-pool > 2.0 < 0.15	2		0	0.15	6.56		0	0.492
6 Wetted-run .01 - 0.2 0.15 - .6	0.01	0.2	0.15	0.6	0.0328	0.656	0.492	1.968
7 Shoal-run 0.2 - 0.5 0.15 - .6	0.2	0.5	0.15	0.6	0.656	1.64	0.492	1.968
8 Shallow-run 0.5 to 1.0 0.15 - .6	0.5	1	0.15	0.6	1.64	3.28	0.492	1.968
9 Medi-run 1.0 to 2.0 0.15 - .6	1	2	0.15	0.6	3.28	6.56	0.492	1.968
10 Deep-run > 2.0 0.15 - .6	2		0.15	0.6	6.56		0.492	1.968
11 Shallow-riffle < 0.2 0.6 - 1.5	0.2		0.6	1.5	0	0.656	1.968	4.92
12 Riffle 0.2 to 0.5 0.6 - 1.5	0.2	0.5	0.6	1.5	0.656	1.64	1.968	4.92
13 Deep-riffle 0.5 to 1.0 0.6 - 1.5	0.5	1	0.6	1.5	1.64	3.28	1.968	4.92
14 Very-deep-riffle > 1.0 0.6 - 1.5	1		0.6	1.5	3.28		1.968	4.92
15 Shallow-rapid < 0.5 > 1.5	0	0.5		1.5	0	1.64	0	4.92
16 Deep-rapid > 0.5 > 1.5	0.5			1.5	1.64		0	4.92

The highlighted habitat types were found within the BLM&CPW modeling effort.

BLM&CPW also compared the hydrological conditions used to develop the habitat availability for each of the four functional mesohabitat types (Optimal, Marginal, Unsuitable and Unusable) at each site in the Anderson and Stewart studies. Flows modeled at **Corn Lake** (Colorado River) ranged from 100 to 1800 cfs, flows modeled at **Clifton** (Colorado River) ranged from 100 to 2000 cfs, flows modeled at **Lily Park** (Yampa River) ranged from 40 to 600 cfs, flows modeled at **Sevens** (Yampa River) ranged from 40 to 880 cfs, flows modeled at **Duffy** (Yampa River) ranged from 40 to 600 cfs and flows modeled at **Big Gypsum** (Dolores River) ranged from 10 to 500 cfs (see Anderson Riverine Fish Flow Investigations Federal Aid Project F-289-R6**)**. We concluded that this range of hydrologic conditions was representative of the conditions we found and modeled in the San Miguel River. Specifically, BLM&CPW's model ranged from 40 cfs to 1125 cfs.

BLM&CPW also compared the mean slope of the sites modeled in the Anderson and Stewart studies and did not find them to be significantly different, from a modeling perspective, from the San Miguel River. The sites in the Anderson and Stewart Studies ranged from slopes of 0.05% to 0.20%, while the San Miguel River modeling location ranged of 0.40% to 0.50%. The sites in the Anderson and Stewart Studies and the San Miguel River would all be considered to be low-gradient sites on large river channels.

BLM&CPW also compared the relative composition of the native fish communities at the Anderson and Stewart study sites with the composition of the native fish community on the San Miguel River. BLM&CPW performed this comparison because habitat competition among species can cause differences in habitat preferences. The native fish composition of the reaches used to create the fish habitat curves and the fish composition of the San Miguel River are set forth below.

Percentage of Total Fish Population / Percentage of Native Fish Community

Modeling Location	Flannelmouth Sucker	Bluehead Sucker	Roundtail Chub
Corn Lake	39/49	36 /46	4/5
Clifton	33/42	41/53	5/6
Lily Park	48/84	9/16	.02/0
Sevens	47/65	20/28	5/7
Duffy	5/38	4/31	4/31
Big Gypsum	16/22	2/3	55/75
Average – All Anderson and Stewart Sites	37/50	19/30	12/21
San Miguel River	35/49	32/45	4/6

Based upon the comparison above, BLM&CPW determined that the native fish community on the San Miguel River was not substantially different from the fish communities on rivers used to develop the habitat curves. In the sites used to develop the habitat curves, flannelmouth sucker are typically the most common native species, with bluehead sucker as the second most abundant and roundtail chub comprising the smallest portion of the native fish community. The San Miguel River fits this general composition of native species. The only river that doesn't fit this general pattern is the Dolores River, where flow regimes are significantly altered by the operation of McPhee Reservoir.

Based on the above comparisons and subsequent discussions with Rick Anderson, author of the study that created the habitat curves, BLM&CPW conclude that the use of the Anderson & Stewart habitat criteria was appropriate to use on the San Miguel River and would be appropriate to use on most rivers in the Upper Colorado River Basin.

3I. BLM&CPW appropriately considered the relative abundance of the native species when developing instream flow recommendations.

Dr. Wesche criticizes BLM&CPW for not considering the relative abundance of the two species when selecting protective flow rates from the weighted usable curves produced by the PHABSIM model. Dr. Wesche then asserts that since the two species appear to be equally abundant in the proposed instream flow habitat, the proposed instream flow rate should provide equal amounts of habitat for both species. He proposed a flow rate of 170 cfs for the April 15 to July 31 period. According to the PHABSIM modeling, this flow rate would provide 25,000 square feet of habitat per 1000 feet of stream for bluehead suckers and 22,000 square feet of habitat per 1,000 feet of stream for flannelmouth sucker.

BLM&CPW conclude that this artificially imposed emphasis on having roughly equal weighted usable areas for both species is not protective of flannelmouth sucker and bluehead sucker for the following reasons:

- Such an approach assumes that the bluehead suckers, which have an ability to use a larger range of habitats, should be limited in habitat quantity by flannelmouth suckers, which have a more limited range of habitats;

- The SJRIP Study, indicated that bluehead sucker (a higher priority) preferred higher flows during the spawning season (the April 15 to June 14 time period) than flannelmouth sucker;
- 25,000 square feet of usable habitat per 1,000 feet of stream for bluehead suckers is only 57% of the weighted usable habitat that could potentially be available at higher flow rates. Spring runoff provides a very limited window of time in which usable habitat is available throughout a fully wetted stream channel. It would be detrimental to limit the fish population to less habitat during this critical spawning and growth period;
- During the remainder of the year, water availability limits the fish population to a much smaller usable habitat area. For example, BLM&CPW recommended 115 cfs from August 1 to August 31 based on water availability restrictions. This flow provides only 33.5% of the weighted usable area for bluehead suckers that could be available at higher flow rates. The limited habitat available during the non-runoff period increases the importance of weighted usable area during the runoff period;
- A flow rate of 325 cfs is the most efficient flow rate for balancing the needs of the two species. A flow rate of 325 cfs provides 100% of weighted usable area for flannelmouth sucker, while providing approximately 90% of weighted usable habitat for bluehead sucker. When two species have at least 90% of the weighted usable area available to them, such a proposal could hardly be called unbalanced because it would allow both species to thrive; and
- Anderson and Stewart noted that "*Among different species habitats, we found that bluehead sucker habitat was the most indicative for the habitat needs of the native fish assemblage overall*" (Anderson and Stewart 2007). Preserving a majority of the bluehead habitat increases the probability that all native species, including roundtail chub, habitat will be preserved.

4. **Opponents argue the depth and velocity criteria applied in the R2CROSS modeling were improperly applied. They also argue that the analysis of the flow at which maximum weighted usable area (WUA) for bluehead and flannelmouth sucker species is flawed.**

4A. BLM&CPW properly applied the depth and velocity criteria in the R2CROSS modeling.

Opponents believe that, because the standard criteria used by the BLM&CPW in their R2CROSS analysis were developed by Anderson and Stewart's observations in riffles, runs and pools, it is inappropriate to use them for riffles. BLM&CPW strongly disagree because:

- As stated in the San Miguel River report posted on the CWCB website, the BLM&CPW concluded that "*the best flow recommendation would come from using the results from a combination of methods*". The BLM&CPW used both the PHABSIM and R2CROSS results to make their recommendation.
- The whole premise of the R2CROSS Methodology used by the CPW and CWCB historically is that if adequate riffle habitat is protected, all other types of habitat should also be protected. R2CROSS is the most common methodology used by the CPW to develop instream flow recommendations and the most familiar to the CWCB. The

R2CROSS Methodology uses three instream flow hydraulic parameters (average depth, percent wetted perimeter, and average velocity) to develop biologic instream flow recommendations. The CPW has determined that maintaining these three hydraulic parameters at adequate levels across riffle habitat types also maintains aquatic habitat in pools and runs for most life stages of fish and aquatic invertebrates (Nehring 1979; Espegren 1996). The CPW's intent and basis for all its instream flow recommendations is the belief that preserving and protecting the entire fishery is the minimum requirement if your intent is to protect and preserve the entire natural environment of a segment to a reasonable degree.

- The BLM&CPW developed the standard 1.0 foot average depth and 1.3 ft/sec average velocity criteria used in the R2CROSS analysis from the Anderson and Stewart field studies. According to Anderson and Stewart, an average depth of 1.0 foot combined with average velocities exceeding 1.3 ft/sec were determined to be marginally suitable bluehead sucker habitat. Average riffle habitat as defined by Anderson & Stewart ranged from 0.65 ft to 1.6 ft in depth and 2.0 to 4.9 ft/sec velocity. Using the developed bluehead standard criteria of 1.0 ft depth and 1.3 ft/sec velocity in identified riffles results in maintaining average riffle depth but below average riffle velocity. However, protecting marginally suitable habitat in riffles translates to protection of marginal to optimal habitat being protected in pools and runs.

- BLM&CPW compared results from their PHABSIM study with their results using the R2CROSS Methodology with developed bluehead sucker standard criteria (1.0 foot average depth and 1.3 ft/sec average velocity). The BLM&CPW's original PHABSIM Study modeled flows of 50, 100, 175, 250, 325, 385, 420, 450, 500 and 600 cfs. The results of that study indicated that 325 cfs maximized weighted useable area or habitat for flannelmouth suckers and 450 cfs maximized weighted useable area or habitat for bluehead suckers (Note: the SMR Executive Summary Report erroneously indicated that 500 cfs maximized WUA for blueheads).

  The difference between the flow amounts recommended by the PHABSIM study and the R2CROSS study using the 1.0 foot depth and 1.3 foot/sec velocity criteria in riffles results in:

  R2CROSS overestimated flows needed for flannelmouth sucker habitat by 7% (350 cfs from R2CROSS vs. 325 cfs from PHABSIM)

  R2CROSS underestimated flows required for bluehead sucker habitat by 23% (350 cfs for R2CROSS vs. 450 cfs for PHABSIM).

  The results of the R2CROSS analysis falls between the two recommended flow amounts from PHABSIM modeling required to protect adult flannelmouth and bluehead sucker habitat. These results lead BLM&CPW to conclude that it may be possible to use R2CROSS alone, with the 1.0 foot depth and 1.3 foot/sec velocity criteria in riffles, to develop instream flow recommendations for the three native species in future studies.

3G. Flaws identified by the opponents in the weighted usable area analysis actually represent slightly different application of modeling techniques between the recommending agencies and the opponents.

Further modeling by the Opponents has indicated that the maximum WUA is produced at 310 cfs for flannelmouth suckers and 435 cfs for bluehead suckers. The BLM&CPW did not include 310 cfs and 435 cfs in their original model runs. Accordingly, we agree with the Opponents that the optimum amount of WUA for both adult bluehead and flannelmouth sucker falls somewhere between flows of 310 cfs and 450 cfs. The differences in the flow amounts identified by the opponents and BLM&CPW to protect the required adult bluehead and flannelmouth sucker habitat is less than 5%, well within any error associated with any discharge model.

Dr. Wesche also raised concern that the interpretation of the R2CROSS analysis appeared to be incorrect on p. 7 of the Executive Summary. The results displayed on page 7 of the Executive Summery are from the staging table generated using the standard R2CROSS Methodology on Site XS1, the critical-riffle cross-section. The cross section was run at the measured discharge of 325 cfs and 100 cfs, using a constant Mannings "n" value (standard R2CROSS Modeling Technique) to estimate discharges above and below the measured discharge (see Attached Exhibit RS#7 325 cfs & 100 cfs R2CROSS Runs).

The results of using the standard R2CROSS Method on standalone cross sections results in the following flows identified in the Executive Summary: a summer flow recommendation of approximately 650 cfs (or exactly 634 cfs) based on meeting the percent wetted perimeter criteria of 70% and a winter flow recommendation of 115 cfs (or exactly 111 cfs) based on the average depth criteria of 0.79 foot (1% of the measured top width).

REBUTTAL TO OPPONENTS' LEGAL ARGUMENTS

1. **Opponents argue the proposed instream flows fail to protect the natural environment to a reasonable degree.**

1A. The proposed instream flow recommendation protects only a portion of the very large range of natural hydrology that created the natural environment.

A review of the recorded gage data for the 1955 – 2010 time period (55 Years) for the San Miguel River at Uravan gage shows the existing "Natural Environment" of this segment of the San Miguel River (Calamity Draw to Dolores River confluence) has experienced and is the result of a wide range of flows. At the Uravan Gage, located in the middle of the reach, the highest average monthly flow during May was 3,420 cfs (1984) and the lowest average monthly flow during May was 87 cfs (1977), a difference of over 3,300 cfs. The average (mean) monthly flow at the Uravan Gage is 1,120 cfs for May (see Exhibit RS#8).

Figure 3 above (see page 8) shows the range of flows that have created the natural environment found in the San Miguel River near Uravan. The upper solid line represents the maximum average monthly flow and the lower dashed line represents the minimum average monthly flow. This relationship between the maximum and minimum average monthly flows is not unique to the Colorado River and can be found on all streams and rivers in the State of Colorado. Over the years, the CWCB has heard arguments for appropriating both ends of the spectrum.

Some people are concerned that the recommended instream flows that are required to protect a significant portion of the total useable area available to fish, as determined by the BLM&CPW study, are more than the minimum flow necessary to preserve the natural environment to a reasonable degree. However, as the Instream Flow Council (IFC) has pointed out "Instream flow is not just about fish habitat; it is transdisciplinary." (Annear, et all 2004). The IFC has identified 5 important riverine components: hydrology, geomorphology, biology, water quality, and connectivity. The IFC recommends protecting the inter and intra-annual flow regimes that ensure sustained biological diversity and dynamic ecosystem function.

To address all of these concerns, one must first compare the flows that created and maintained the natural environment of the San Miguel River to the recommended instream flows to maintain nearly **optimum** adult fish habitat. As shown in Figure 3 above (page 8), the natural hydrograph and the resulting natural environment of the San Miguel River is subject to wide swings in the quantity of water available. Figure 3 also displays how the BLM&CPW's proposed instream flow recommendations fall in relationship to the maximum and minimum average monthly flows that have produced the existing natural environment. As mentioned above, peak flows have exceeded 8,000 cfs and bankfull flows are estimated to occur at approximately 2,520 cfs. Peak flows are most important for habitat creation and maintenance. Peak flows of bankfull and higher are required at regular frequency for proper ecosystem functions (Miller & Swaim 2011).

The average year hydrograph indicates that flows exceed 506 cfs for the 90 day spawning time period surrounding the 1,120 cfs average year May 15th peak value. The median year hydrograph indicates that flows exceed 339 cfs for the 90 day spawning time period surrounding the 943 cfs median year May 15th peak value. Additional information from the SJRIP study has also been presented that indicates that bankfull streamflows of nearly 2½ times the average year flow could be ideal for the spawning success of two of the native species (bluehead sucker and speckled dace).

Asking the CWCB to base an instream flow appropriation exclusively upon the bare minimum flow to allow fish to survive does not seem appropriate or reasonable. Opponent's are implying that the CWCB should ignore other information about the water-dependent environment, including information about the relationship of the riparian community to flow rates. The goal of Colorado's instream flow program is to protect and maintain the existing fishery. The BLM&CPW's instream flow recommendations protect those flows. To balance the needs of mankind, it is assumed that the required higher peak flows will be available in sufficient quantity and quality to maintain the riverine components identified by the IFC above without specific instream flow protection.

1B. Appropriating an extremely limited subset of the natural hydrograph can result in an impoverished native fish community.

The Dolores River below McPhee Reservoir is a specific example of what can happen if the recommended or existing streamflows are too low. The natural environment and the existing fish community below McPhee Reservoir are severely affected by the lack of high flows associated with a natural hydrograph. Anderson and Stewert observed that:

"The fish community of the Dolores River appeared to be highly stressed. Species composition of native fish was high, but most fish were small. Roundtail chub was the most common species and biomass was very low. These attributes appeared to be habitat and flow related. The lack of

runoff flows in 2000 and 2001 may have negatively impacted productivity. Riffles and runs had large silt deposits and both forage and habitat potential seemed unnaturally low. If the Colorado River data can be used as an example of a high-quality habitat and fishery, the Dolores River data can be useful as an example of very poor quality habitat conditions."(Anderson and Stewart 2003)

The above information clearly shows the flows recommended by the BLM&CPW are the very minimum amounts necessary to preserve the natural environment to a reasonable degree.

2. **Opponents argue the CWCB must limit its consideration solely to the Subject Reach (i.e. Calamity Draw to the confluence with the Dolores River).**

2A. The BLM&CPW agree with this statement in regards to the determinations required for the subject reach by the CWCB in 37-92-102(3)(c):

Before initiating a water rights filing, the board shall determine that the natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made; that there is a natural environment that can be preserved to a reasonable degree with the board's water right, if granted; and that such environment can exist without material injury to water rights. The BLM&CPW assert that the CWCB has been presented evidence proving that the subject reach:

1) Has a natural environment that can be preserved to a reasonable degree with the board's water right;

2) The natural environment will be preserved to a reasonable degree by the water available for the appropriation to be made; and,

3) Such environment can exist without material injury to water rights.

2B. The BLM&CPW disagree with this statement in regards to the suggestion that the CWCB cannot consider information outside of the required three determinations mentioned above that may relate to Policies of the State of Colorado, the Department of Natural Resources or its sister agencies within the Department of Natural Resources.

The Opponents are concerned that the BLM&CPW presented evidence of a statewide effort to enhance the habitat of flows for the bluehead sucker, flannelmouth sucker and roundtail chub. The Director of the CPW is a member of the CWCB. It would seem illogical that the CWCB could not consider information from a member of the CWCB (Director of the CPW) or a sister agency within the Department of Natural Resources (CPW) regarding issues of statewide concern, existing state statutes, agency policies and strategic plans relating to such an agency.

2C. The Opponents also are concerned that BLM&CPW have identified efforts outside the subject reach to enhance flows and habitat in this and other documents.

The BLM&CPW are responsible for the management of lands and wildlife throughout the entire State of Colorado. The BLM&CPW must look at their management actions not only at the local level but also at the state, region and national levels. It would be impossible to not identify other segments, regions or watersheds in this or other documents if the affected species exist outside of a local area, watershed or region. The Opponents falsely believe that the BLM&CPW are making this instream flow recommendation solely to protect flows in the Dolores River. This is incorrect on two points:

1) the Dolores River upstream of the San Miguel River is already protected by an existing instream flow water right (Water Court Case No. 7-75W1346); and

2) The information presented to the CWCB in the Instream Flow Executive Summary regarding the instream flow recommendations only applies to the reach of the San Miguel River between Calamity Draw and the confluence with the Dolores River.

The San Miguel River, as stated before, supports an outstanding native fish community, has water available for appropriation (none of which comes from the Dolores Basin) and appropriating such water will not injure existing water rights. The BLM&CPW do not deny that the Dolores River below the confluence of the San Miguel River will benefit if the proposed instream flows are appropriated by the CWCB. However, such benefits would not be guaranteed without additional instream flow protection for that segment of the Dolores River, which is not a subject of this proceeding.

Respectfully submitted this 19th day of August 2011.

FOR THE COLORADO DIVISION OF PARKS AND WILDLIFE

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Respectfully submitted this 19th day of August 2011.

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Certificate of Service

I hereby certify that on the 19th day of August 2011, a true and correct copy of the foregoing Prehearing Statement of the Bureau of Land Management and Colorado Parks and Wildlife was served by electronic mail or mailed to the following:

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Exhibit RS#1

To: **Linda Bassi, Colorado Water Conservation Board**

From: **Roy Smith, Bureau of Land Management and Mark Uppendahl, Colorado Division of Wildlife**

Re: **San Miguel River Between Calamity Draw and Dolores River - Selection of Stream Reach for PHABSIM Modeling**

Date: **August 19, 2011**

This memo provides an overview of the process used by the Bureau of Land Management and the Colorado Division of Parks and Wildlife to select a location for PHABSIM modeling on the lower San Miguel River. The modeling was performed in support of our joint instream flow recommendation to the Colorado Water Conservation Board. The location that was selected is on property owned by the Nature Conservancy, approximately 1.5 miles upstream from the confluence of Tabeguache Creek with the San Miguel River.

<u>Personnel</u>

Professional judgment was critical in the selection of the modeling location. The location was selected by three individuals:

- Jay Skinner, who at the time was instream flow coordinator for the Colorado Division of Wildlife
- Dennis Murphy, who at the time was hydrologist in BLM's Uncompahgre Field Office
- Roy Smith, instream flow coordinator for BLM Colorado

This group has more than 75 years combined experience in evaluating streams and their characteristics, including hydraulics, channel dimensions, gradient, sinuousity, physical habitat availability, substrate and other morphological characteristics.

Mr. Skinner has worked for the Colorado Division of Parks and Wildlife since 1987, and worked for the Colorado Water Conservation Board from 1985 to 1987. During that time period, he has conducted instream flow assessments and modeling on multiple rivers within Colorado. Mr. Murphy has accumulated more than 30 years of stream assessment experience with the Bureau of Land Management. He has surveyed the reach between Calamity Draw and San Miguel River using ground surveys, float surveys, topographic maps, and aerial photographs. Mr. Smith has worked for the Bureau of Land Management for 19 years. During that period, he has selected representative stream reaches for modeling purposes on more than 120 streams in Colorado, including upper reaches of the San Miguel River. All of Mr. Smith's modeling data was ultimately accepted by the Colorado Water Conservation Board and resulted in instream flow water rights on those streams.

<u>Methodology</u>

Multiple criteria were used by the interagency team to select a reach for PHABSIM modeling. The first set of criteria included broad criteria to insure that the selected reach provided a snapshot of an unmodified stream channel with intact hydrologic processes. The second set of criteria included narrower scientific criteria to ensure that the reach was representative of the San Miguel River between Calamity Draw and the Doloreso River, in terms of hydrologic parameters and fish habitat parameters. Each of these criteria is discussed below.

Broad Criteria – Identification of Representative Natural Stream Channel

1. Confirmed presence of sensitive species in sampling performed at or close to the selected reach.

   The modeling location is approximately 1.5 miles upstream from an electrofishing raft survey conducted by Dan Kowalski, Colorado Division of Wildlife. The survey documented significant populations of flannelmouth sucker, bluehead sucker, and roundtail chub. This survey confirms earlier fish survey work that documented the three species in the subject reach. In addition, surveys conducted by GEI Associates in 2008 and 2009 (Exhibit A – Prehearing Statement of Montrose County) identified abundant flannelmouth suckers and bluehead suckers in portions of the river just upstream from the proposed instream flow reach. There are no known barriers to fish passage between the surveyed locations and the selected modeling location, so there would be no reason to expect that three species are not using the habitat at the modeling location.

2. Confirmed presence of native riparian communities, which would provide a confirmation of natural fluvial geomorphology processes at work.

   The selected location is property owned by the Nature Conservancy. The property was acquired specifically to protect outstanding examples of native riparian communities. Colorado Natural Heritage Program has verified the presence of high quality native riparian communities on the property. In addition, Dr. David Cooper, a well-known expert riparian ecology and hydrology, has performed research in this location to demonstrate the relationship between water surface elevations in the stream channel and water levels in alluvial aquifers that support the riparian community.

3. Minimal modification of the channel from human processes that would artificially change the hydrology and geomorphology of the channel.

   Much of the stream channel between Calamity Draw and the Dolores River has been modified by human activities:

   - The lower five miles of this reach were extensively modified by historic mining activities at Uravan. In much of these five miles, the channel was directly modified by mining activities, such as construction of access roads, processing facilities, and housing areas.
   - Downstream from the direct modification at Uravan, significant additional sediments were introduced to the stream channel. In addition, downstream from Uravan, the construction of a county road on the west side of the channel has limited channel migration and narrowed the active channel.

- The upper three miles of the proposed instream flow reach has been modified by agricultural activities and gravel pits. While these portions of the river are known to provide habitat for the sensitive fish species, the flood plain encroachment and changes in sediment availability are likely to change channel morphology in these areas. Such morphological changes may cause hydraulic and habitat modeling to show artificially high or artificially low flow numbers to meet instream flow parameters.

The nine miles in the middle of the reach, from approximately two miles upstream from Coal Creek to just upstream from Uravan, are the portions of the reach in the most natural condition. Even in this portion of the reach, there are parts of the river that are influenced by State Highway 141. The modeling location that was selected is away from State Highway 141 to minimize the impacts of the highway on natural channel migration.

4. Readily available public access, so that model data could be collected at a variety of flow rates on very short notice.

   The Nature Conservancy provided agency personnel with permission to access the property whenever needed to collect data, and the site can easily be accessed by walking in from State Highway 141. This allowed the modeling team to respond to quickly changing hydrology during the data collection effort.

Narrow Criteria – Hydrologic Parameters and Fish Habitat Parameters

5. Location in the upper half of the reach, which has slightly smaller channel size, so that identification of flow rates needed to provide various types of habitat would be conservative numbers.

   Although it is desirable to select a modeling location that is close to a stream gage, in this case a modeling location close to the Uravan gage was not selected for two reasons:

   - In some instream flow proceedings, the CWCB has been criticized for relying upon data collected in the lower portion of a long stream reach. The criticism flows from the fact that lower in a stream reach, the stream channel is typically larger, and therefore higher flow rates are required to meet the instream flow criteria. Tabeguache Creek is the largest tributary in this reach, and its flows result in a slightly larger channel downstream. Accordingly, the agencies selected a site upstream from this confluence.

   - The portion of the river between the Tabeguache Creek confluence and Uravan didn't meet several of the other criteria. Most importantly, this portion of the reach is influenced by roads on both sides of the river, and is influenced by housing, bridges, and an historic ball park. In addition, this portion of the reach doesn't provide the best examples of habitat types needed by the three sensitive fish species.

6. Contains a representation of the habitat types most critical for the various life stages of the three sensitive species.

   The habitat types that are most critical to the three sensitive species are listed below.

   - Cobble Bars/Shoals – flannelmouth sucker spawning habitat; bluehead sucker spawning habitat
   - Riffles/Runs - flannelmouth sucker spawning habitat
   - Pools – flannelmouth sucker adult habitat; roundtail chub adult habitat
   - Loose Gravel – bluehead sucker spawning habitat
   - Riffles / Cobbles – bluehead sucker Adult Habitat;
   - Eddies/Shoreline Eddies/Low velocity shoreline – Juvenile habitat for all three species
   - Flow-Through Backwaters – Juvenile habitat for all three species

   The selected modeling location was one of the few locations in the middle of the Calamity Draw to Dolores reach that contained all of these habitat types. Specifically, when the range of flows that were modeled is considered, the modeling location contains 11 of the 16 meso-habitat types used by the three sensitive fish species, as identified in the Anderson and Stewart studies. Other locations in the proposed instream flow reach between Calamity Draw and the Dolores River are often comprised of one predominant habitat type.

7. Channel gradient in the modeling location is in the middle of the range of gradients found in the reach between Calamity Draw and confluence with the Dolores River.

   Between Calamity Draw and the confluence with the Dolores River, a distance of 17.24 miles, the river drops from 5,272 feet to 4,836 feet, or a loss of 436 feet. This translates to an average gradient in the reach 0.0047. As illustrated in the attached graph, the river gradient remains very constant throughout the reach, so if a modeling reach were selected anywhere throughout the reach, it would be representative of the average gradient. The stream channel gradient in the modeling location ranges from 0.004 to 0.005, as measured on site. Accordingly, BLM and CDP&W believe that the modeling location is representative of the entire reach.

8. Channel widths in the modeling location duplicate the range of widths found in the reach between Calamity Draw and confluence with the Dolores River.

   BLM and CDP&W took ten channel measurements, dispersed throughout the proposed instream flow reach, to identify the range of channel widths. At each location listed below, the bankfull width was measured in a riffle habitat. The attached map shows the measured locations.

Stream Channel Measurement Site	Bankfull Width In Feet	Comments
Site #1	99	At Calamity Draw
Site #2	75	Between Calamity Draw and Coal Canyon
Site #3	87	Between Calamity Draw and Coal Canyon
Site #4	87	Between Calamity Draw and Coal Canyon
Site #5	75	Between Coal Canyon and Tabeguache Creek
Site #6	90	Between Coal Canyon And Tabeguache Creek
Site #7	75	At Uravan – Channel Narrowed by County Road Fill
Site #8	75	Below Uravan - Channel Narrowed by County Road Fill
Site #9	69	Below Uravan - Channel Narrowed by County Road Fill
Site #10	99	Near confluence with Dolores River
Average Stream Channel Width	83	

The following is a list of the top width of the channel within each of the modeled cross sections, in feet:

1 -- 79.29
2 -- 96.97
3 – 79.80
4 – 103.21
5 – 87.03
6 -- 84.32

BLM and CDP&W believe that the modeling location is optimal because it provides multiple bankfull widths, ranging from 79 to 103 feet. This variation in cross section widths comes very close to duplicating the range of bankfull widths found throughout the instream flow reach, if the sites above that have been affected by road fill are excluded. The modeled location has an average bankfull width of 88.4 feet, while the measurements taken above have an average bankfull width of 87.4 feet, if the three locations affected by county road fill are excluded.

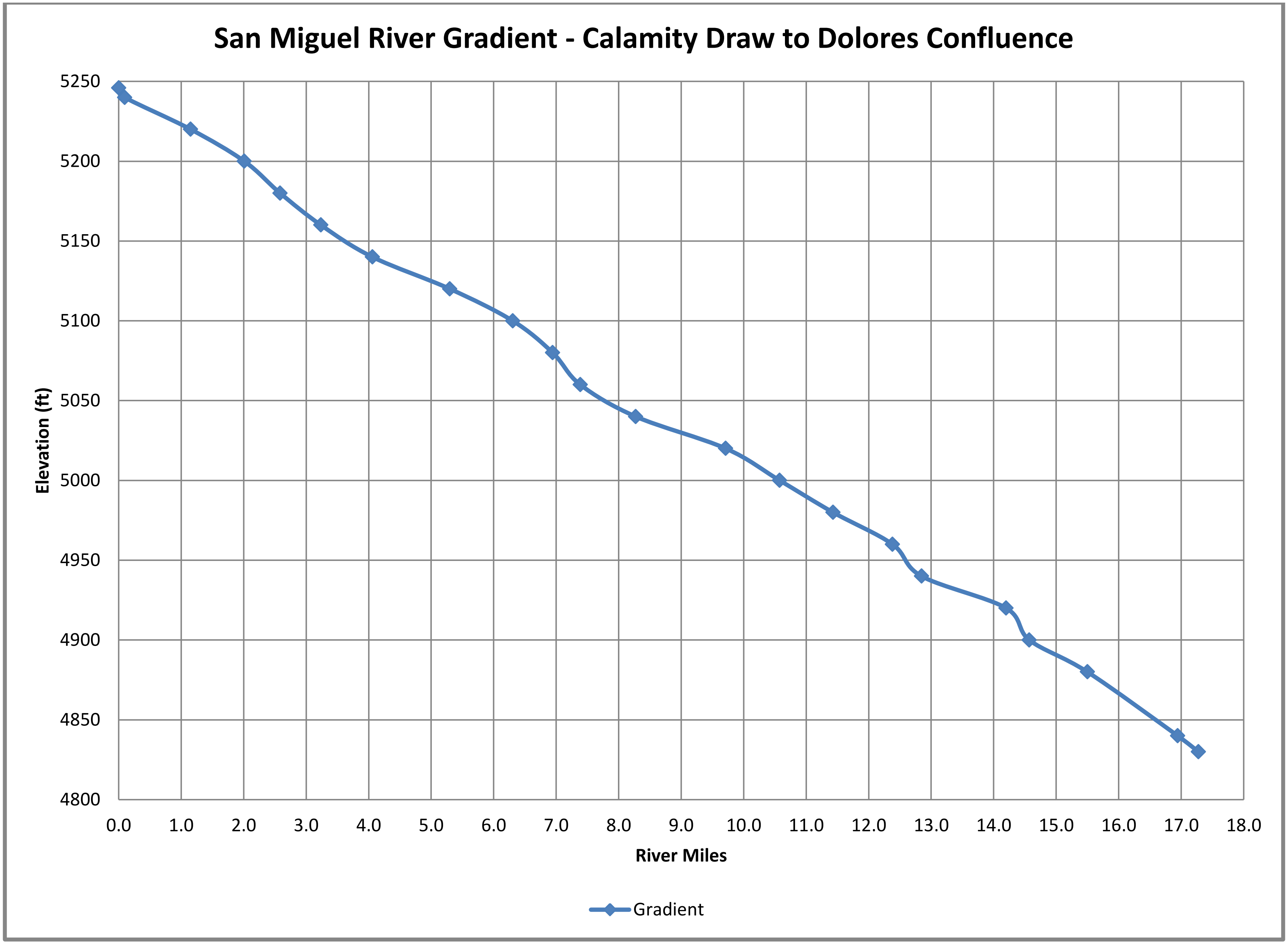
9. The reach is representative of typical channel migration.

The proposed instream flow reach is a broad and dynamic portion of the river, with significant erosional and depositional processes. The reach transports large sediments that are initially introduced to the river from large tributaries such as Horsefly Creek and it also transports finer sediments from upstream tributaries such as Dry Creek. Accordingly, the modeling team sought a reach that displayed active channel migration dynamics and a range of substrate types.

A review of aerial photographs of the portion of the proposed instream flow reach indicates that almost the entire instream flow reach has active channel migration, which the exception of the portion downstream from Uravan, which is constrained by narrow canyon walls and a county road. The modeled reach is typical of most of the proposed insteam flow reach, in which channel migration occurs and is influenced strongly by canyon walls that are from 500 to 1000 feet apart. In the modeling location, the active channel is redirected by canyon walls approximately every 0.3 mile to 0.5 mile.

Conclusion

BLM and CDP&W chose the Nature Conservancy location for PHABSIM modeling because it met qualitative criteria for a natural stream channel and fish habitat, and because it meets quantitative hydrologic parameters for a representative stream reach.


San Miguel River Gradient - Calamity Draw to Dolores Confluence
Elevation (ft)
5250
5200
5150
5100
5050
5000
4950
4900
4850
4800
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
9.0
10.0
11.0
12.0
13.0
14.0
15.0
16.0
17.0
18.0
River Miles
Gradient

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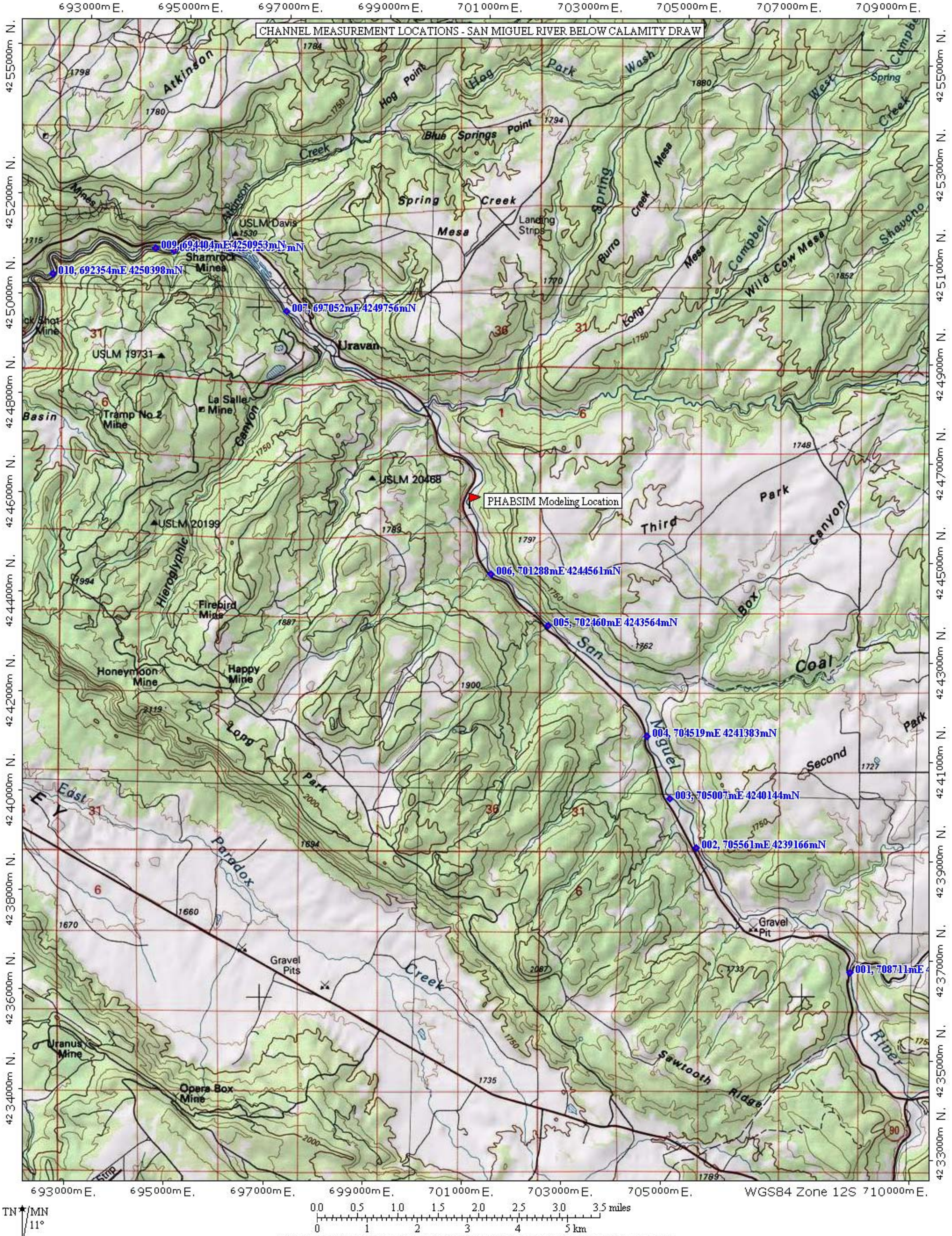

Map created with TOPO!® ©2003 National Geographic (www.nationalgeographic.com/topo)

Exhibit RS#2

Station: **SAN MIGUEL RIVER AT NATURITA, CO.**
Parameter: STREAM FLOW CFS
Year: 1917-1981
State: CO
County: MONTROSE

ID: 09175500
Statistic: Mean
Latitude: 38:13:04
Longitude: 108:33:57
Elevation: 5392.85
Drainage Area: 1069.00

Monthly Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
# Days	1643	1497	1643	1590	1643	1590	1643	1643	1590	1643	1590	1643	19358
Avg Day	84.45	95.05	132.1	629.3	1016	927.1	421.1	189.3	127.2	124.0	104.4	90.37	328.8
Max Day	240.0	646.0	1540	5270	6420	4160	2550	2070	1870	1720	499.0	350.0	6420
Min Day	19.00	23.00	15.00	22.00	17.00	11.00	1.60	3.40	5.80	6.00	8.30	20.00	1.60
# Months	53	53	53	53	53	53	53	53	53	53	53	53	53
SDev Month	20.03	26.59	58.44	462.8	635.7	469.5	280.2	134.7	142.5	95.15	45.07	24.78	149.6
Skew Month	0.868	0.941	1.63	2.51	0.854	0.662	1.08	1.36	2.96	3.76	2.82	1.12	0.710
Min Month	47.32	55.21	62.10	58.13	67.81	137.5	40.60	12.18	7.63	15.87	51.95	47.10	67.44
Max Month	149.7	181.2	337.3	2900	2656	2155	1306	591.1	817.3	664.5	334.8	168.3	789.2
Exceedences													
1%	165.3	260.3	551.1	3563	3231	2610	1500	859.1	905.2	625.7	340.0	179.6	2324
5%	125.0	150.0	270.9	2055	2497	1980	1060	505.0	431.0	262.0	179.0	145.0	1340
10%	115.0	127.0	210.7	1440	2000	1650	892.0	403.4	259.0	218.0	163.0	127.0	935.2
20%	100.0	110.0	163.0	947.0	1500	1330	655.0	277.0	155.0	162.0	130.0	110.0	488.0
50%	80.00	90.00	107.0	400.0	884.0	806.0	326.5	145.0	72.00	101.0	97.00	85.00	118.0
80%	65.00	70.00	78.00	161.0	420.0	458.0	150.0	66.00	37.00	67.00	73.00	70.00	75.00
90%	55.30	62.00	69.00	109.0	278.6	340.0	94.30	38.00	23.00	46.00	60.00	57.30	58.00
95%	50.00	55.00	60.00	86.00	165.3	250.0	66.00	21.00	14.00	19.00	47.00	50.00	42.00
99%	36.29	36.00	31.86	42.90	64.00	140.1	19.43	6.00	7.50	6.00	24.00	37.43	14.00

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USGS 09175500 SAN MIGUEL RIVER AT NATURITA, CO.

Available data for this site Time-series: Monthly statistics GO

Montrose County, Colorado Hydrologic Unit Code 14030003 Latitude 38°13'04", Longitude 108°33'57" NAD27 Drainage area 1,069 square miles Gage datum 5,392.85 feet above NGVD29	**Output formats** HTML table of all data Tab-separated data Reselect output format

00060, Discharge, cubic feet per second,												
YEAR	Monthly mean in cfs (Calculation Period: 1917-10-01 -> 1981-09-30)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1917										100.0	100.0	85.0
1918	90.0	95.0	125.0	250.0	512.6	926.7	294.0	102.7	133.3	48.8	60.8	84.4
1919	55.0	75.0	182.7	733.0	1,055	659.0	499.2	200.0	150.0	93.1	104.8	70.0
1920	92.8	135.3	135.3	387.7	2,402	1,737	689.1	259.5	120.6	116.8	108.8	85.5
1921	99.4	125.2	218.7	549.6	1,608	2,155	1,007	591.1	214.0	117.7	110.0	113.2
1922	59.6	97.5	131.3	739.1	1,824	1,305	388.8	182.1	59.3	59.1	74.3	110.0
1923	105.0	95.0	101.7	463.7	1,039	1,040	602.2	306.4	163.8	111.5	93.1	78.5
1924	70.5	112.3	83.8	948.1	1,338	868.9	230.8	89.3	54.8	81.4	73.1	70.0
1925	65.0	62.0	133.0	595.2	824.8	682.8	408.4	199.6	332.6	240.3	153.0	80.0

1926	75.0	108.5	145.0	763.4	1,260	1,225	527.8	152.4	63.9	140.4	107.1	105.0
1927	100.0	105.0	139.3	788.2	1,155	981.6	500.7	416.5	817.3	291.7	175.0	150.0
1928	125.0	125.0	200.0	400.0	1,273	981.9	439.7	160.1	77.6	170.4	176.7	110.0
1929	75.0	110.0	140.0	751.0	1,263	1,275	699.7	567.0	533.0			
1940										184.5	110.0	89.2
1941	93.0	102.4	167.3	1,025	2,656	1,697	1,023	412.4	292.6	664.5	334.8	168.3
1942	149.7	125.2	197.6	2,900	2,456	1,550	603.5	210.4	101.6	117.1	130.2	128.6
1943	129.5	116.0	123.8	808.8	691.6	667.8	309.8	368.1	149.2	92.1	101.0	86.2
1944	77.9	89.4	112.7	407.5	2,245	1,494	662.3	185.1	61.2	103.1	109.8	91.8
1945	79.5	93.6	100.0	457.6	1,463	814.5	443.1	273.1	70.9	119.8	106.8	79.2
1946	75.4	84.6	139.5	589.3	435.5	654.4	233.1	176.5	111.1	115.1	105.4	85.5
1947	84.1	90.0	118.9	321.8	742.3	783.8	530.9	303.9	290.5	218.2	154.1	116.6
1948	112.5	161.0	155.5	1,468	1,498	990.0	428.0	190.0	62.6	106.2	86.3	81.9
1949	90.1	114.2	114.6	662.1	847.6	1,269	669.1	179.2	57.9	95.8	91.0	83.1
1950	104.7	104.3	118.6	501.4	368.7	564.8	247.9	62.7	39.7	73.1	65.4	72.5
1951	71.0	64.8	68.4	58.1	230.4	442.4	156.0	124.0	57.6	59.9	64.6	62.0
1952	75.8	75.8	82.5	1,058	1,218	1,318	558.4	244.9	123.9	111.7	90.7	98.7
1953	103.1	85.3	101.3	283.4	428.0	810.1	252.9	133.5	38.4	60.5	85.5	81.0
1954	84.5	72.8	81.5	172.2	294.1	249.3	142.1	66.0	114.9	141.4	93.1	73.6
1955	75.8	76.4	141.7	489.2	535.8	584.7	172.3	135.7	30.6	42.9	62.2	72.8
1956	65.8	63.4	104.5	357.4	537.1	546.2	95.1	33.2	7.63	15.9	58.1	56.2
1957	65.7	92.4	83.5	574.4	1,291	1,998	1,306	537.9	273.4	177.5	174.0	124.4
1958	93.2	181.2	178.5	1,552	2,263	1,442	290.5	96.3	80.5	89.4	92.2	84.0
1959	88.7	96.1	101.5	248.2	296.2	492.6	87.9	117.9	31.8	95.6	90.2	75.1
1960	67.9	68.0	216.7	948.3	598.9	868.5	294.7	60.7	57.4	66.2	91.9	69.8
1961	62.5	65.8	105.8	593.3	962.3	727.9	146.1	142.6	200.6	189.0	138.4	92.2
1962	67.2	141.6	119.5	993.6	717.9	631.8	388.2	95.4	58.9	127.7	97.6	85.3
1963	83.7	120.9	290.6	266.1	378.7	236.7	95.2	117.5	93.7	48.4	93.6	59.6
1964	55.1	57.4	62.1	434.1	902.9	550.8	163.6	170.6	60.8	92.7	73.8	77.3
1965	83.7	78.8	80.7	1,054	1,044	978.0	869.8	366.5	224.4	207.4	149.2	147.7
1966	105.4	98.7	288.0	470.9	686.6	404.6	155.5	50.2	34.8	79.8	75.0	82.4
1967	63.8	68.1	117.0	91.9	361.8	367.4	184.8	160.6	82.3	84.7	64.8	74.3
1968	67.2	66.6	75.7	217.8	719.3	974.9	288.2	331.3	39.8	61.6	77.6	71.9
1969	80.3	80.4	84.9	654.0	691.1	483.3	386.6	126.6	119.3	184.6	133.5	112.7
1970	90.2	94.0	98.2	416.6	1,437	778.4	363.0	196.9	422.1	210.2	149.1	132.5
1971	118.2	126.0	337.3	521.9	592.2	795.7	327.2	119.4	85.7	143.4	116.1	119.8
1972	96.6	87.9	185.8	175.4	279.1	493.1	84.7	12.2	62.6	219.2	132.2	103.3

1973	93.6	95.9	121.5	750.6	2,043	1,779	864.9	225.8	85.9	91.9	83.1	105.5
1974	84.2	79.6	180.1	698.0	825.3	473.6	174.5	52.0	20.4	75.9	72.7	61.2
1975	63.9	76.3	88.9	382.1	1,277	1,195	986.1	212.4	78.7	101.4	83.2	72.1
1976	71.9	88.6	94.3	237.4	473.5	567.4	207.3	67.2	60.5	106.3	65.9	47.1
1977	47.3	55.2	62.8	98.2	67.8	137.5	40.6	52.0	29.3	67.8	52.0	67.8
1978	71.9	65.7	96.1	886.3	860.7	1,118	391.3	43.4	11.0	42.9	71.7	85.5
1979	91.9	93.1	112.8	1,250	1,423	1,508	674.1	166.3	31.0	57.4	85.5	83.9
1980	95.0	128.7	82.8	705.6	1,300	1,403	476.9	130.0	59.0	60.4	82.9	85.5
1981	81.9	64.9	74.1	200.6	153.2	459.0	257.5	57.3	105.5			
Mean of monthly Discharge	84	95	132	629	1,020	927	421	189	127	124	104	90
** No Incomplete data have been used for statistical calculation												

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Page Last Modified: 2011-08-17 12:45:57 EDT
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Exhibit RS#3

<u>Summary of Life Stages, Spawning Season, and Habitat Requirements – San Miguel River Sensitive Fish Species</u>

<u>Roundtail Chub</u> (***Gila robusta robusta***)
A detailed description of the physical and biological needs of the roundtail chub can be found in the attached "Technical Conservation Assessment" which was prepared for the USDA Forest Service, Rocky Mountain Region's Species Conservation Project (David E. Rees, Jonathan A. Ptacek, and William J. Miller, 2005) and "Flow Recommendations for the San Juan River" prepared by the Biology Committee of the San Juan River Basin Recovery Implementation Program (SJRIP) (Holden, et all, 1999).

As discussed in the Technical Conservation Assessment for Roundtail Chub- *Primary threats to the roundtail chub generally result from anthropogenic activities. Diversion of water has changed flow regimes in both mainstem rivers and tributary stream systems. Construction of diversion dams and reservoirs has degraded and fragmented habitats. Introduction of non-native fish species has increased the abundance of roundtail chub predators and competitors. Other threats to the species include modification of streambeds through channelization, landscape scale changes resulting from land misuse, and local disturbance of riparian zones that reduces the natural function of stream ecosystems.* (David E. Rees, Jonathan A. Ptacek, and William J. Miller, 2005).

Specific habitat suitability curves have not been developed for the roundtail chub because, as discussed in Anderson and Stewart, "The roundtail chub was another large-bodied native fish that we attempted to model by determining its meso-habitat suitability. Significant correlations were not found between roundtail chub biomass and a meso-habitat type that could be defined by depths and velocities." Other researchers determined that the "roundtail chub was a predator that occupied deep pools during the day and moved through several habitats to forage in the evening" (Byers 2001). Because the roundtail chub is a multi-habitat species it has been difficult to determine its specific preferences for depths and velocities.

<u>Bluehead Sucker</u> (*Catostomus discobolus*):
A detailed description of the physical and biological needs of the bluehead sucker can be found in the attached "Technical Conservation Assessment" which was prepared for the USDA Forest Service, Rocky Mountain Region's Species Conservation Project (David E. Rees, Jonathan A. Ptacek, and William J. Miller, 2005) and "Flow Recommendations for the San Juan River" prepared by the Biology Committee of the SJRIP (Holden, et all, 1999).

As discussed in the Technical Conservation Assessment for Bluehead Sucker – *The primary threats to the bluehead sucker generally result from anthropogenic activities. Diversion of water results in changes in flow regime for mainstem rivers and tributary streams. Construction of passage barriers (e.g., diversion dams and reservoirs) within many rivers and streams causes habitat degradation and fragmentation. Introduction of non-native species increases predation on and competition with bluehead suckers. Other threats to this species include channelization of streams, land use that changes the* *landscape, and local development of riparian zones that reduces the natural function of the stream ecosystem. Detailed information concerning the distribution, life history, population trends, and community ecology of this species is relatively limited…* **(**Jonathan A. Ptacek, David E. Rees, and William J. Miller, 2005)

As is discussed in the Flow Recommendations for the San Juan River - bluehead sucker inhabit the relatively cooler, clearer waters of the upper and middle portions of rivers and streams, preferring faster flowing water over rocky substrate (Holden and Stalnaker 1975a, McAda 1977, Woodling 1985). The high use of these habitats is probably largely related to feeding. Bluehead sucker in the Green River usually spawn in mid-June to mid-July, typically during the descending limb of the runoff period, at temperatures above 15 C (Holden 1973, McAda 1977).

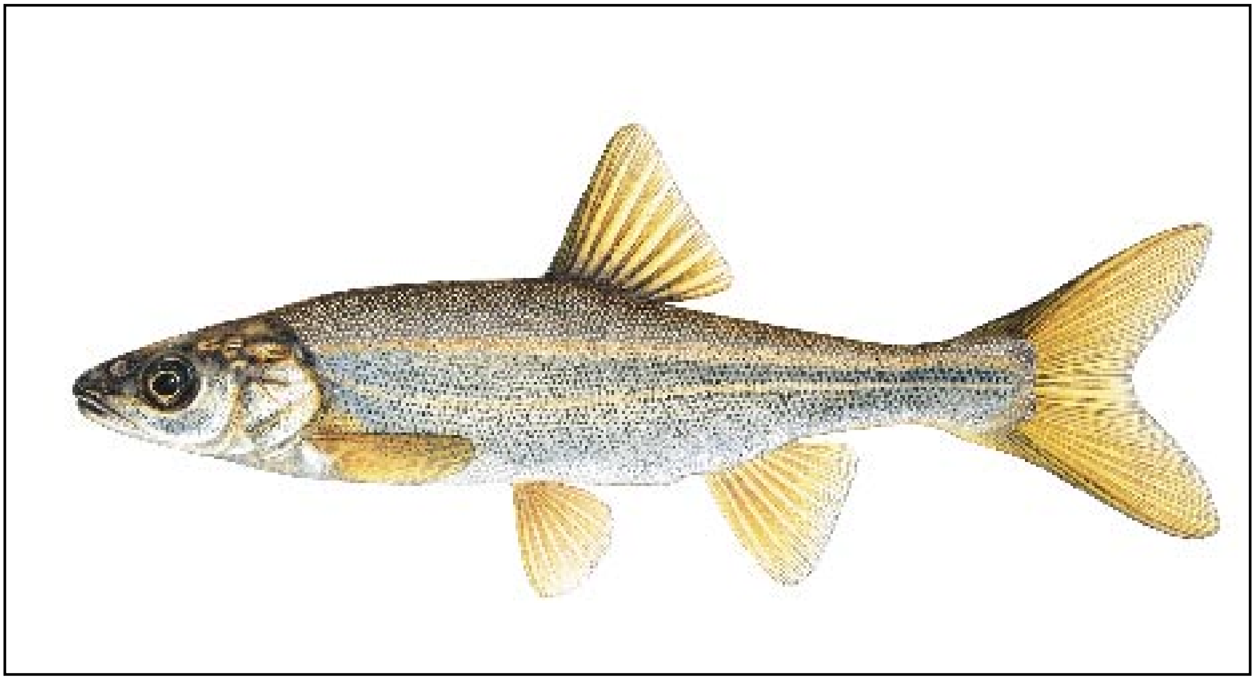
Flannelmouth Sucker (*Catostomus latipinnis*):
A detailed description of the physical and biological needs of the flannelmouth sucker can be found in the attached "Technical Conservation Assessment" which was prepared for the USDA Forest Service, Rocky Mountain Region's Species Conservation Project (David E. Rees, Jonathan A. Ptacek, Ryan J. Carr, and William J. Miller, 2005) and Flow Recommendations for the San Juan River prepared by the Biology Committee of the SJRIP (Holden, et all, 1999).

As discussed in the Technical Conservation Assessment for the Flannelmouth Sucker - *The primary threats to the flannelmouth sucker are generally human-induced activities that divert water and change the flow regime in both tributary and mainstem streams. Specific threats include (a) construction of passage barriers (e.g., diversion dams and reservoirs) that disconnect habitats and cause habitat fragmentation and (b) introduction of non-native species that are both predators on and competitors with the flannelmouth sucker. Other threats include modification of streambeds through channelization, landscape changes resulting from land use, and local degradation of riparian zones that reduces the natural function of the stream ecosystem. Detailed information concerning the distribution, life history, population trends, and community ecology for this species is relatively limited.* (David E. Rees, Jonathan A. Ptacek, Ryan J. Carr, and William J. Miller, 2005)

As is discussed in the Flow Recommendations for the San Juan River - Flannelmouth sucker spawn in spring and early summer, typically during May and June, and on the ascending limb or **peak of the hydrograph** (emphasis added)—although timing can vary spatially within and between river systems as hydrologic and temperature regimes vary (Valdez 1990). They are broadcast spawners, and there is no parental guarding of eggs. Eggs are demersal and initially adhesive (Muth and Nesler 1993). Ripe females were not captured past early June. Although spawning was not actually observed, "ripe male and female flannelmouth sucker were captured over the same gravel bars used by razorback suckers. . . ." The fish were collected in water about 3.0 ft deep and moving about 3.25 fps. Substrate ranged in size from 0.75 to 1.95 in. in diameter. Assuming spawning occurred at this exact location, such habitat approximately corresponds to riffle-run or run habitat in the San Juan River (Bliesner and Lamarra 1996).

The flannelmouth sucker spawning habitat discussed above can be found in the "reference reach" at X-Section Site #2 at flows between 300 and 400 cfs. Again, this is additional information relating to the spawning life stage of a native fish that indicates the flows proposed by the CDOW & BLM of 325 cfs are not only required but are the minimum amount.

Roundtail Chub (*Gila robusta robusta*): A Technical Conservation Assessment



Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

May 3, 2005

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Peer Review Administered by
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Rees, D.E., J.A. Ptacek, and W.J. Miller. (2005, May 3). Roundtail Chub (*Gila robusta robusta*): a technical conservation assessment. [Online]. USDA Forest Service, Rocky Mountain Region. Available: http://www.fs.fed.us/r2/projects/scp/assessments/roundtailchub.pdf [date of access].

Acknowledgments

We would like to thank those people who promoted, assisted, and supported this species assessment for the Region 2 USDA Forest Service. Ryan Carr and Kellie Richardson conducted preliminary literature reviews and were valuable in the determination of important or usable literature. Laura Hillger provided assistance with report preparation and dissemination.

Numerous individuals from Region 2 national forests were willing to discuss the status and management of this species. Thanks go to Greg Eaglin (Medicine Bow National Forest), Dave Gerhardt (San Juan National Forest), Kathy Foster (Routt National Forest), Clay Spease and Chris James (Grand Mesa, Uncompahgre, and Gunnison National Forest), Christine Hirsch (White River National Forest), as well as Gary Patton and Joy Bartlett from the Regional Office.

Dan Brauh, Lory Martin, Tom Nesler, Kevin Rogers, and Allen Zincush, all of the Colorado Division of Wildlife, provided information on species distribution, management, and current regulations.

Authors' Biographies

David E. Rees studied fishery biology, aquatic ecology, and ecotoxicology at Colorado State University where he received his B.S. and finally his M.S. in 1994. His specific areas of specialization include aquatic insect identification and ecology, and native fish movement and habitat use. He has been involved with and supervised extensive projects involving electrofishing and population studies on the native and nonnative fish in tributaries of the Colorado River Basin, and other various locations. He has supervised habitat use studies using radio telemetry to monitor Colorado pikeminnow and other native and nonnative fish in the Yampa River, San Juan River and Colorado River. He has worked on projects in Colorado, Utah, New Mexico, Nevada, Arizona, Wyoming, Montana, and Puerto Rico. David is currently conducting research on the relationship between physical and ecological processes in the Colorado River, and the implications of these interactions on native fish species.

Jonathan A. Ptacek received his bachelor's degree in Fishery Biology from Colorado State University in 1997. He has worked for Miller Ecological Consultants, Inc. since 1993. His work experience has focused primarily on native fish issues throughout the western United States. Currently, he is part of a team developing a mechanistic population model describing the aquatic environment of the San Juan River in Colorado, New Mexico and Utah.

Dr. William J. Miller has over 23 years experience in fisheries, instream flow, and aquatic ecology studies. He has worked extensively throughout the western U.S. and is a recognized expert in the areas of Colorado River basin endangered fish species, instream flow, water temperature modeling and habitat assessments. Dr. Miller's experience includes research and evaluations for several threatened, endangered, and candidate aquatic species in the Colorado River and Platte River basins. He has extensive experience in designing and conducting studies using the Instream Flow Incremental Methodology (IFIM), instream water temperature modeling and developing and implementing ecological models for aquatic systems. He has developed habitat suitability criteria for both anadromous and resident salmonids as well as warm-water game and forage species. Dr. Miller is a Certified Fisheries Scientist (No. 2008).

Cover Photo Credit

Summary of Key Components for Conservation of the Roundtail Chub

Status

The roundtail chub (*Gila robusta*) is considered a sensitive species within the USDA Forest Service (USFS) Rocky Mountain Region (Region 2). It has been estimated that this species, which is endemic to the Colorado River Basin, has been extirpated from 45 percent of its historical range, which includes medium to large tributaries of the Colorado River. Populations currently exist in western Colorado and south-central Wyoming. Distribution of this species on National Forest System lands is limited or unknown.

Primary Threats

Primary threats to the roundtail chub generally result from anthropogenic activities. Diversion of water has changed flow regimes in both mainstem rivers and tributary stream systems. Construction of diversion dams and reservoirs has degraded and fragmented habitats. Introduction of non-native fish species has increased the abundance of roundtail chub predators and competitors. Other threats to the species include modification of streambeds through channelization, landscape scale changes resulting from land misuse, and local disturbance of riparian zones that reduces the natural function of stream ecosystems.

Primary Conservation Elements, Management Implications and Considerations

Detailed information concerning the distribution, life history, population trends, and community ecology of roundtail chub is relatively limited. Specific local and regional information must be obtained to facilitate the development of management actions for this species. Initial research should include detailed surveys of every drainage on USFS land that could potentially hold populations of roundtail chub. Such efforts should be coordinated with other agencies (i.e., state game and fish departments, Bureau of Land Management, U.S. Fish and Wildlife Service) to obtain information from stream reaches that are off USFS land yet may be influenced by forest management activities. Like other fish species endemic to the Colorado River Basin, roundtail chub have not been well-studied until recent years. Most of the recent fishery studies in this basin have been directed toward the recovery of federally listed species. Consequently the information obtained for roundtail chub is often incidental to the primary study, but it could still be useful to USFS managers. Given the known threats to this and other native Colorado River fishes, conservation measures should concentrate on controlling non-native fishes, maintaining habitat diversity, and providing natural temperature and flow regimes in stream reaches with roundtail chub populations. These measures should contribute to the maintenance of current populations.

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INTRODUCTION

This assessment of the roundtail chub (*Gila robusta*) is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2), which considers the roundtail chub a sensitive species. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or in habitat quality that would reduce its distribution (FSM 2670.5 (19)). Due to concerns with population viability and abundance, a sensitive species requires special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology, ecology, conservation, and management of roundtail chub throughout its range, which is entirely within Region 2.

Goal

The purpose of this species assessment is to provide forest managers, research biologists, and the public with a thorough discussion of the current understanding of the biology, ecology, conservation status, and management of the roundtail chub. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope

This conservation assessment examines the biology, ecology, conservation status, and management of the roundtail chub with specific reference to the geographic and ecological characteristics in Region 2 and in the context of the current environment rather than under historical conditions. In producing this assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on the roundtail chub are referenced in the assessment, nor were all published materials considered equally reliable. This assessment emphasizes refereed literature because this is the accepted standard in science. We did use non-refereed literature in the assessments when other information was unavailable, but these sources were regarded with greater skepticism. Unpublished data (e.g., Natural Heritage Program records) were important in determining the species' status and in estimating its geographic distribution. These data required special attention because of the diversity of persons and methods used in their collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to science is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. The geologist, T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). In some ways, ecology is similar to geology because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide our understanding of the world (Hillborn and Mangel 1997). A problem with using the approach outlined in both Chamberlain (1897) and Platt (1964) is that there is a tendency among scientists to resist change from a common paradigm. Treatment of uncertainty necessitates that a wide variety of hypotheses or experiments by undertaken to test both the true or false nature of the uncertainties at hand (Vadas 1994). Confronting uncertainty, then, is not prescriptive. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

The synthesis of material for the roundtail chub included the use of the limited data sets that are available concerning the distribution, abundance, movements, habitat requirements, and life history requisites of the roundtail chub. This species, like many non-game native fish, has not been extensively studied throughout it's range. The limited data on key characteristics of the species and the lack of understanding concerning its resource needs create a great deal of uncertainty pertaining to the assessment for conservation of roundtail chub. For the purpose of this assessment, we have synthesized a wide range of available data throughout the Colorado River Basin including historical and current distribution, conservation strategies, habitat needs, and management requirements. The general lack of precise information regarding species distribution on National Forest land or near forest boundaries limits the actual data that can be used for this assessment. We have used a sound scientific approach to infer from available data an understanding of the current needs of this species.

Application and Interpretation Limits of This Assessment

Information used in this assessment was collected from studies that occurred throughout the geographical range of this species. The greatest emphasis for information regarding life histories and ecology was placed on studies and reports that were specific to Region 2. Although most information should apply broadly throughout the range of the species, it is likely that certain life history parameters (growth rate, longevity, spawning time, etc.) will differ along environmental gradients. Information regarding conservation strategies of the species pertains specifically to Region 2 and does not apply to other portions of the species range.

Publication of Assessment on the World Wide Web

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the American Fisheries Society, which chose two recognized experts on this or related taxa to provide critical input on the manuscript. Peer review was designed to improve the quality of communication and to increase the rigor and general management relevance of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The roundtail chub is not a federally listed species (i.e., threatened or endangered) (U.S. Fish and Wildlife Service; http://endangered.fws.gov/). In 1989, it was placed into Category 2 (a candidate species for federal listing), but this designation was discontinued in 1995 when the candidate list was re-evaluated. Its range is restricted to the Colorado River Basin, and populations currently exist in Wyoming, Colorado, Utah, New Mexico, and Arizona. The USFS considers the roundtail chub to be a sensitive species, as do the Bureau of Land Management (BLM) offices in Colorado and Wyoming. Criteria that apply to BLM sensitive species include the following: 1) species under status review by the U.S. Fish and Wildlife Service; or 2) species with numbers declining so rapidly that federal listing may become necessary; or 3) species with typically small and widely dispersed populations; or 4) species inhabiting ecological refugia or other specialized or unique habits.

The Colorado Division of Wildlife (CDOW) considers the roundtail chub a species of concern. The Wyoming Game and Fish Department (WGFD) has assigned a rank of NSS1 for the roundtail chub, defined as vulnerable with isolated populations. This species currently holds a Natural Heritage Program global rank of G3 (vulnerable) and a state rank of S2 (imperiled) in both Colorado and Wyoming (http://natureserve.org/explorer). In states outside of Region 2, the roundtail chub has the following designations: "imperiled" in Arizona, "endangered" in New Mexico, "threatened" in Utah, and extirpated from California (http://natureserve.org/explorer). These designations suggest that the roundtail chub is rare or restricted throughout its range and is vulnerable to extirpation.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

Ongoing recovery programs for federally listed fish in the Upper Colorado River Basin and the San Juan River drainage should provide benefits for all native fish species. Recovery efforts include flow recommendations, removal of migration barriers, removal of non-native species, and restoration of habitat. A conservation agreement specifically for roundtail chub, flannelmouth sucker (*Castostomus latipinnis*), and bluehead sucker (*C. discobulus*) has been prepared with the goal to ensure the persistence of these populations throughout their range (Utah Department of Natural Resources 2004). This agreement will incorporate cooperative efforts from states within the current and historic ranges of the roundtail chub (including Colorado and Wyoming from Region 2). Each state will develop an individual management plan for the conservation of these species. The CDOW intends to develop a conservation/management plan for roundtail chub by the year 2005. This plan will provide direction for research and management goals.

Currently, the CDOW has no regulations specifically designed to protect roundtail chub. However, several regulations are intended to protect native fish species and thus aid in the conservation of roundtail chub. Restrictions are in place in the Upper Colorado River Basin (in Colorado) regarding the live release of non-native fish species into rivers and lakes. Another regulation indirectly assisting the conservation of roundtail chub is a statewide statute prohibiting the seining, netting, trapping, or dipping of fish for bait in natural streams. The WGFD has mitigation objectives that permit projects in a manner that avoids alteration and degradation of roundtail chub habitat (Weitzel 2002).

The roundtail chub is not considered a gamefish in Region 2. However, it is probably incidentally caught by fishermen. There have been no studies that have determined mortality to roundtail chub by fishermen.

Biology and Ecology

Systematics and general species description

The Colorado River roundtail chub (*Gila robusta robusta*) is a medium-size fish (usually 200 to 300 mm [7.9 to 11.8 inches] total length [TL]) and one of several chubs native to the Colorado River Basin. In large rivers, adult roundtail chub may reach 500 to 600 mm (19.8 to 23.7 inches) in TL; adult size in the smaller tributaries can be less than 200 mm (7.9 inches) (Joseph et al. 1977). It is a member of the minnow family (Cyprinidae). Cyprinids are characterized by one to three rows of pharyngeal teeth, thin lips, large eyes, abdominal pelvic fins, and usually soft fin rays. Members of the genus *Gila* have soft fin rays and a fusiform body, but they vary considerably in other morphological characteristics. The roundtail chub is distinguished from other members of the genus *Gila* using the following characteristics described by Bezzerides and Bestgen (2002).

> *"Roundtail chub may have a somewhat flattened head, but are lacking the nuchal hump found in humpback chub (G. cypha) and, to some extent, bonytail (G. elegans). The mouth is large, sub-terminal, and associated with an acute snout. Eyes are small, low, and anteriorly placed on the head. Fins are generally large. Pectorals are pointed (fin rays[1] 14-15[12-17]); dorsal fin weakly falcate (rays 9[8-10]), originating slightly posterior to the pelvic fins (rays 8-9[7-9]); anal fin strongly falcate with fin rays 9[7-10]; caudal peduncle slender, but not approaching the pencil-thin narrowness of G. elegans; and caudal fin (rays 19[19-20]) deeply forked with somewhat rounded lobes.*
>
> *Other physical characteristics include a strongly decurved lateral line (scales 75-85[70-96]); a robust pharyngeal arch with teeth usually 2, 5-4,2; gill rakes 11-14 and 12-15 in the 1st and 2nd arches, respectively; and vertebrae 46[43-48]. Adults are usually dusky green to bluish gray dorsally and silver to white below, and may grow to 500 mm total length (TL). More commonly, adult roundtail chubs are 200-300 mm TL."*

The taxonomy of the genus *Gila* continues to evolve with recent changes in the status for several subspecies. In addition to *G. elegans* and *G. cypha*, other closely related chubs known only to exist in tributaries of the Lower Colorado River Basin include *G. seminuda* (Virgin River roundtail chub; previously *G. robusta seminuda*) in the Virgin River of Arizona, Nevada, and Utah; *G. nigra* (headwater chub) from tributaries of the Gila River in Arizona and New Mexico; and *G. r. jordani* (Pahranagat roundtail chub) from the White River in Nevada (Joseph et al. 1977, Minckley and DeMarais 2000, Bezzerides and Bestgen 2002).

[1]Counts (fin ray, vertebrae, dentition, etc.) are presented with the most commonly reported count outside the brackets and the range of values encountered in the literature inside the brackets.

Distribution and abundance

The roundtail chub is an endemic species to the Colorado River Basin in Colorado and Wyoming (Sublette et al. 1990). A map of USFS lands (**Figure 1**) can be compared to a map of watershed units that identifies where roundtail chub have been collected in Region 2 (**Figure 2**). Distribution of roundtail chub populations have been determined based on accounts by various researchers and distribution information provided by NatureServe (2003) at www.natureserve.org.

Historically, roundtail chub were known to commonly occur in most medium to large tributaries of the Upper Colorado River Basin (Vanicek 1967, Holden and Stalnaker 1975, Joseph et al. 1977). Roundtail chub historically occurred in lower elevation (below 2,300 m [7,546 ft.]) streams, including the Colorado, Dolores, Duchesne, Escalante, Green, Gunnison, Price, San Juan, San Rafael, White, and Yampa rivers (Bezzerides and Bestgen 2002). This distribution includes much of Region 2, but little is actually on USFS land.

Jordan (1891) described accounts of roundtail chub in several tributaries of the Upper Colorado River Basin and determined it was most common in transitional areas of streams between the mountains and low gradient reaches. Holden and Stalnaker (1975) reported that roundtail chub were abundant or common at all sites sampled on the Yampa River (including locations near Juniper Springs and Craig, Colorado), and at most sites in the Dolores River, Colorado. McNatt and Skates (1985) found roundtail chub to be common at most sites in the Green River and Yampa River in Dinosaur National Monument. Olson (1967) reported that roundtail chub were common in collections from Navajo Reservoir during 1965.

Roundtail chub are not restricted to large rivers within the Colorado River Basin. Miller and Rees (2000) described historical and recent accounts of roundtail chub in the mainstem of the San Juan River and various tributaries in the southwestern portion of Colorado and in New Mexico. These tributaries include the Animas, Florida, La Plata, and Mancos rivers as well as Navajo Wash (tributary to the Mancos River). Records of roundtail chub in these tributaries approach the boundary of the San Juan National Forest, but there is no evidence to suggest that this species ever commonly occurred within the boundary of that national forest.

Roundtail chub were once abundant in Wyoming in the Green River and the Blacks Fork River and were reportedly abundant in the Little Snake River drainage (Simon 1946, Baxter and Simon 1970). Currently, roundtail chub are found in the Blacks Fork River and the Green River drainage as well as the Big Sandy River, the Hams Fork River, Fontenelle Creek and Reservoir, and Halfmoon, Burnt, Boulder, Little Halfmoon, Willow and Fremont lakes. Roundtail chub were "widely distributed" in the Little Snake River from the lower stateline crossing upstream to the Highway 70 bridge at Dixon, Wyoming (Oberholtzer 1987). They were absent in collections from Dixon upstream. Fish surveys conducted on 131 streams in the Little Snake River drainage indicated the presence of roundtail chub in only one other stream, Muddy Creek (Oberholtzer 1987). Historically, roundtail chubs may have been found in parts of Savery Creek, a tributary to the Little Snake River, but records are not conclusive (Wyoming Game and Fish Department 1998). Recent investigations failed to find roundtail chub in the Savery Creek drainage (Wheeler 1997, Wyoming Game and Fish Department 1998). Roundtail chub continue to persist in the Region 2 portion of Wyoming in the Little Snake River and its tributary, Muddy Creek (Wheeler 1997, Weitzel 2002), but none of these accounts are within national forest boundaries.

The current distribution of roundtail chub on Region 2 USFS land appears to be very limited. However, comprehensive annual and seasonal distribution information is lacking for streams within Region 2. At the present time, only the San Juan National Forest contains a documented population of roundtail chubs (Gerhardt 2003 personal communication); this population occurs in the Dolores River, downstream from McPhee Reservoir, Colorado. Several roundtail chub populations exist in tributary streams immediately downstream of National Forest System lands. These tributary streams include Divide Creek and Rifle Creek (tributaries to the Colorado River), Elkhead Creek (tributary to the Yampa River), and Florida River, La Plata River, and Los Pinos River (San Juan River drainage).

Population trend

Roundtail chub have been extirpated from 45 percent of their total historical habitat, especially portions of the Price, San Juan, Gunnison, and Green rivers (Bezzerides and Bestgen 2002). A decline in populations has been observed in the Animas, Green,

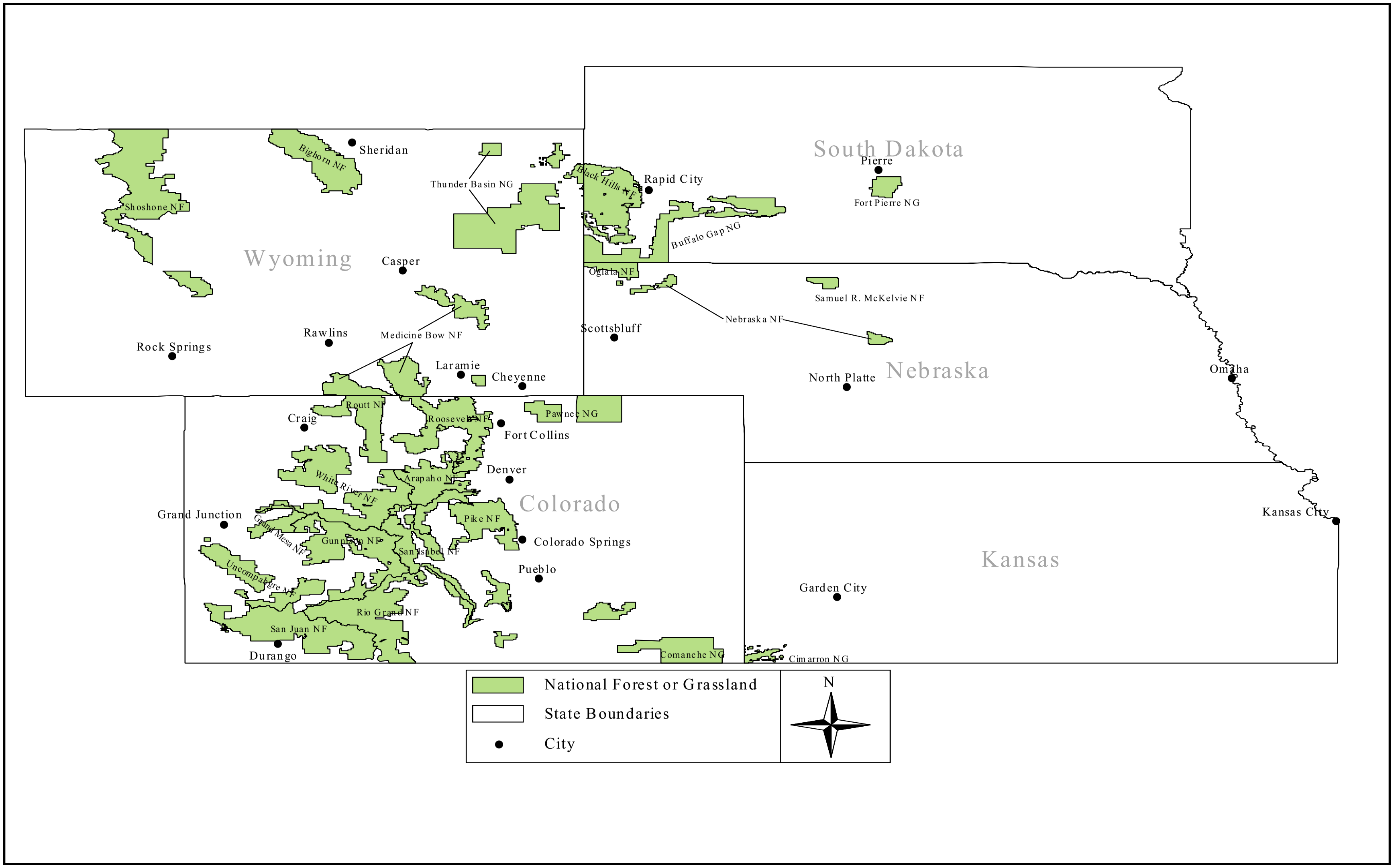

Figure 1. USDA Forest Service Region 2 national forests and grasslands.

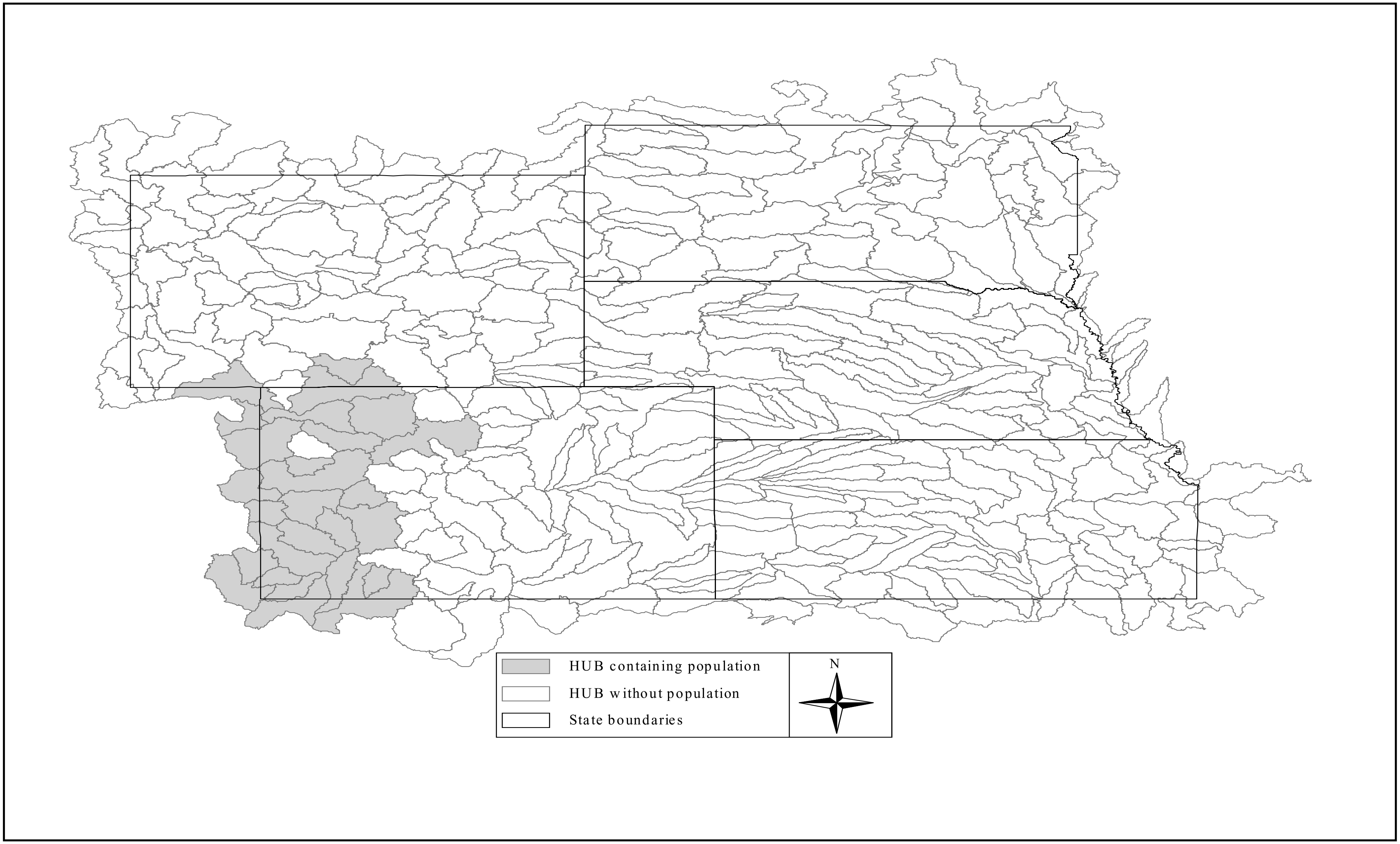

Figure 2. USDA Forest Service Region 2 hydrological unit boundaries (HUB) containing roundtail chub populations.

Gunnison, Salt, San Juan, White, and Yampa rivers (Minckley 1973, Platania 1990, Wheeler 1997, Lentsch et al. 1998, Propst and Hobbes 1999, Bestgen and Crist 2000, Miller and Rees 2000). The population trend for roundtail chub in Wyoming is unknown but thought to be declining (Wheeler 1997). Fish surveys in southwestern Wyoming in 1995 and 1996 indicated that this species no longer occurred in several drainages from which it was collected in 1965 (Wheeler 1997).

Roundtail chub populations have declined due to impacts of water development projects, land use management, and interactions with non-native species. Reductions of roundtail chub have been documented in the San Juan River downstream from Navajo Dam (Joseph et al. 1977) and in the Green River downstream from Flaming Gorge Dam (Vanicek and Kramer 1969, Karp and Tyus 1990). Hypolimnetic releases below impoundments cause changes in the thermal regime within the river downstream; temperatures are usually colder in the summer and warmer in the winter than historic conditions. Low numbers of roundtail chub in the San Juan River may also be attributed to the use of rotenone (fish toxicant) to eliminate all species from approximately 112 km (69.6 miles) of the river during 1961 (Olson 1962).

In 1962, 116 kilometers (72.1 miles) of the Green River and many of its tributaries upstream from the Colorado-Utah state line were treated with fish toxicant in an attempt to eliminate "coarse" fish prior to the construction of Flaming Gorge and Fontenelle Dams (Binns 1967). Pre-treatment surveys indicated that roundtail chub were common in the treatment area; however, populations post-treatment were completely eliminated. After the construction of Flaming Gorge Dam, the altered temperature and flow regimes downstream precluded effective recolonization of roundtail chub populations upstream in the Green River (Karp and Tyus 1990). Vanicek and Kramer (1969) provide evidence to suggest that the growth rate of roundtail chub has decreased in the Green River for approximately 74 km (46 miles) downstream of Flaming Gorge Dam due to the change in seasonal stream temperature. Absence of certain year classes suggests that successful spawning did not occur during some years in the Green River between Flaming Gorge Dam and the confluence of the Yampa River (Vanicek and Kramer 1969). Vanicek et al. (1970) also reported that roundtail chub were nearly absent in the Green River within 32 km (19.9 miles) of Flaming Gorge Dam.

Karp and Tyus (1990) acknowledge that the change in temperature and flow regime caused by Flaming Gorge Dam may be responsible for a decline in roundtail populations in the Green River upstream from its confluence with the Yampa River, but they additionally suggest that a negative interaction between roundtail chub and the non-native channel catfish (*Ictalurus punctatus*) is present in this reach. Competition for food and predation by channel catfish on young roundtail chub were cited as partial explanations for the decline of this species. It is likely that a combination of impacts from impoundments and competition with non-native fish has been responsible for reductions in roundtail chub populations. The cause of roundtail chub population declines in smaller tributaries has been poorly studied. However, Weitzel (2002) suggested that habitat degradation (e.g., bank erosion, sediment deposition, and poor riparian quality) from heavy grazing may contribute to population declines in Wyoming.

Activity pattern

Few studies have been specifically designed to describe the movements of roundtail chub. Available research indicates that, when movement occurs, it mostly depends on life-stage and location. Life-stage related movements include larval drift and spawning migrations. Carter et al. (1986) and Haines and Tyus (1990) reported capturing roundtail chub larvae in the drift after they emerged from spawning substrate in the upper Colorado and Yampa rivers.

Migration associated with spawning has not been studied throughout most of the range occupied by roundtail chub in Region 2. The limited information suggests that spawning related movement may depend on location and population, and may range from minimal localized movements to movement of more than 30 km (18.6 miles). In the Colorado River near Black Rocks, Kaeding et al. (1990) found roundtail chub moving in excess of 30 km during the reproductive season.

Miller et al. (1995) found roundtail chub in the La Plata River in Colorado and New Mexico to be relatively sedentary, with a maximum movement of 1.4 km (0.9 miles). Average movement (four sampling events in 11 months) was 0.42 km (0.3 miles) for 17 recaptures in this smaller tributary of the San Juan River. Bryan and Robinson (2000) reported sedentary behavior of roundtail chub in two Colorado River tributaries in the lower basin, as did Beyers et al. (2001) in a 3.2 km (2.0 miles) study area in the Colorado River during a fall survey. Beyers et al. (2001) did, however, document a significant difference in localized diel movement patterns for roundtail chub. Adults moved from shallow habitat at night to deeper habitat during the day.

Habitat

Roundtail chub evolved in the Colorado River Basin below an elevation of approximately 2,300 m (7,546 ft.). Most reaches of this system receive heavy sediment loads and high annual peak flows that contrast with low base flows. Little is known about the specific influence of these annual events, but healthy roundtail chub populations have persisted in habitats with a wide range of annual flows, sediment transport, and even sediment deposition, providing that these physical events are associated with a natural flow regime.

Studies documenting habitat use related to diel or seasonal changes are rare; however, several researchers have made general observations regarding habitat associations. Roundtail chub are often found in stream reaches that have a complexity of pool and riffle habitats (Bezzerides and Bestgen 2002). Juveniles and adults are typically found in relatively deep, low-velocity habitats that are often associated with woody debris or other types of cover (Vanicek and Kramer 1969, McAda et al. 1980, Miller et al. 1995, Beyers et al. 2001, Bezzerides and Bestgen 2002). Sigler and Sigler (1996) reported that substrate in roundtail chub habitat may range from rock and gravel to silt and sand. Seasonal or life stage associations with specific substrates were not identified. Beyers et al. (2001) determined that the mean depth of habitat used by roundtail chub was less at night than during the day in the Colorado River near Grand Junction, Colorado, suggesting that there may be a diel habitat preference. Larvae have been reported in low velocity areas associated with backwater habitats (Haines and Tyus 1990, Ruppert et al. 1993); however, there was no specific study to determine the importance or necessity of this habitat to larvae.

Temperature tolerance of roundtail chub has been reported up to 39 °C (102.2 °F), but temperature preference ranges between 22 °C (71.6 °F) and 24 °C (75.2 °F) (Weitzel 2002).

Food habits

The roundtail chub is an omnivorous species with "opportunistic" and "sporadic" feeding habits. The diet of juvenile roundtail chub (<200 mm TL) consists predominately of aquatic macroinvertebrates (Vanicek 1967, Vanicek and Kramer 1969, Joseph et al. 1977). Young roundtail chub in the Green River consumed primarily Chironomidae larvae and Ephemeroptera nymphs (Vanicek 1967, Vanicek and Kramer 1969).

Adult roundtail chub (>200 mm TL) have been documented feeding on filamentous algae, aquatic invertebrates, terrestrial invertebrates (especially grasshoppers and ants), fish, and plant debris (Vanicek and Kramer 1969, Joseph et al. 1977). The presence of crayfish in the diet of adult roundtail chub has been observed in the Colorado River near Grand Junction, Colorado (authors personal observations). Minckley (1973) indicates that adult roundtail chub may consume their own eggs as well as the eggs of other fish species. Olson (1967) reported that the diet of roundtail chub in Navajo Reservoir was similar to that of rainbow trout (*Onchorhynchus mykiss*), which was primarily composed of plankton and some aquatic insects.

Breeding biology

Roundtail chub in the Upper Colorado River Basin begin spawning when water temperatures reach about 18.3 °C (64.9 °C) (Vanicek and Kramer 1969, Joseph et al. 1977). In most Colorado River tributaries this increase in temperature coincides with a decrease in discharge after peak runoff (Bezzerides and Bestgen 2002). Karp and Tyus (1990) indicate that spawning of roundtail chub in the Yampa River at Dinosaur National Monument occurs between mid-May and early July. The time of spawning in other drainages and locations is probably similar but is influenced by water temperature and the hydrograph. Females typically produce 39,500 to 41,350 adhesive demersal eggs per kg of body weight (Muth et al. 1985). A review of fecundity by Bezzerides and Bestgen (2002) indicated that the number of eggs produced by a roundtail chub varies with female size, age, and location. Depending on water temperature, eggs usually hatch within four to 15 days after spawning. Young roundtail chub begin feeding approximately 10 days after they hatch (Minckley 1973). During the first 54 days after hatching, mean daily growth rate was 0.3 mm (0.01 inches) for cultured fish (Muth et al. 1985). Carter et al. (1986) suggested that roundtail chub actively drift during the mesolarval stage of development. Drifting occurs primarily after mid-July and appears to become more frequent as water temperatures initially increase. It was not determined whether the increase in drift was related to an increase in activity or an actual increase in larval abundance.

The drifting process provides a means of dispersal for roundtail chub and other members of the genus *Gila* in the Colorado River Basin.

Karp and Tyus (1990) collected ripe males ranging from 292 to 419 mm (11.6 to 16.5 inches) TL, and ripe females from 343 to 380 mm (13.5 to 15 inches) TL. Vanicek (1967) reports that most roundtail chub become sexually mature by age six. Muth et al. (1985) collected spawning females that ranged in age from five to seven years, and spawning males that ranged in age from five to eight years. Prior to spawning, male and female roundtail chub typically develop breeding tubercles. These tubercles are usually uniformly scattered over the surface of the male (although mostly restricted to the head) and caudal peduncle of the female. Both sexes develop an orange-red coloration on the ventral surface and ventral fins (Muth et al. 1985).

Little information is available concerning the specific spawning behaviors of roundtail chub. Due to the high turbidity commonly associated with the Colorado River and its tributaries, the exact spawning behaviors and habitat used by roundtail chub has not been observed. Vanicek and Kramer (1969) reported that while exact spawning sites or deposited eggs were never observed, all ripe fish were collected in eddies or shallow pools with boulder or cobble substrate. Although they had no direct observations indicating that eddy habitat was used for spawning, Karp and Tyus (1990) stressed the importance of this habitat during spawning whether it is used for spawning, feeding, or as a staging area.

Demography

The construction of impoundments in the Colorado River Basin has effectively separated roundtail chub populations. At this time there is no flow of genetic material between populations that are separated by impoundments. The potential loss of genetic heterogeneity and diversity is unknown at this time. It is logical that, as populations become more isolated, the impacts from catastrophic events become more severe.

There is some speculation that human-induced changes (e.g., regulated flows, altered temperature regimes) to the Colorado River Basin may be contributing to the breakdown of reproductive isolation mechanisms that have evolved between roundtail chub and other chub species (Kaeding et al. 1990). Reported hybrids between roundtail chub and other *Gila* species have been collected in the wild (Holden and Stalnaker 1970, Karp and Tyus 1990), and they have been cultured (Hamman 1981). Spawning of roundtail chub and bonytail chub is concurrent in time but thought to be spatially separated (Vanicek 1967). Kaeding et al. (1990) additionally suggests that the difference between roundtail chub and humpback chub micro-habitat selection is an important mechanism contributing to the reproductive isolation of each species. Because so little is known about specific spawning requirements of roundtail chub (and other chubs) in the Colorado River Basin, further research must be conducted to develop or confirm theories regarding spawning success of roundtail chub.

The development of a meaningful life cycle diagram for roundtail chub requires life stage-specific data regarding survival rates, fecundity, and sex ratio. Existing data on roundtail chub survival rates and other components necessary to construct a valid life cycle diagram are sparse (especially data specific to roundtail chub populations occurring in smaller tributary streams). We include the following life cycle description as an illustration of the data needed to refine the model (**Figure 3**).

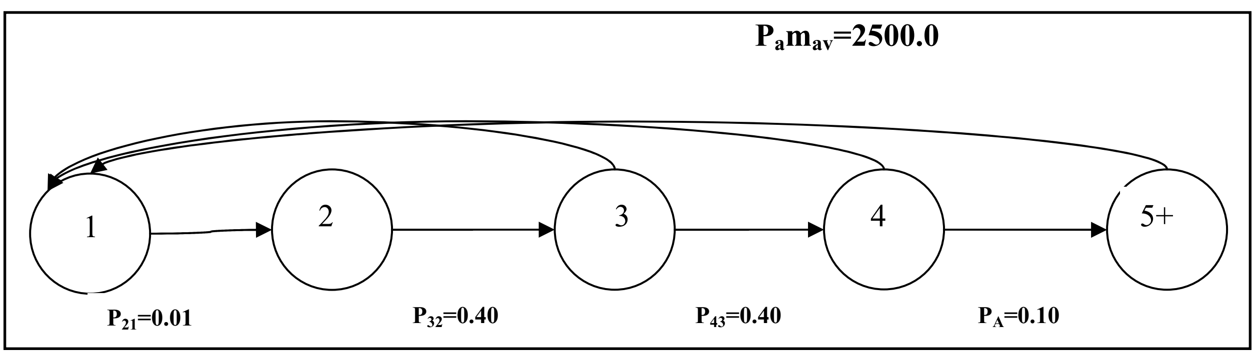

Figure 3. Life cycle graph for roundtail chub showing both the symbolic and numeric values for the vital rates. The circles denote the 5+ age classes in the life cycle, first year through adult females. Arrows denote survival rates. Survival and fertility rates provide the transition between age classes. Fertilities involve offspring production, mi, number of female eggs per female as well as survival of the female spawners.

Input data needed for a population projection matrix model consists of age-specific survival and fecundity rates. Very little data of this type is available for roundtail chub. Age at sexual maturity, length/age relationships, and fecundity depend on location (e.g., stream size, habitat) and can be highly variable (Bezzerides and Bestgen 2002). Therefore, we chose to use an average fecundity for all adult ages with sexual maturity beginning at age 3. The value for eggs per mature female (25,000) is an estimate for an approximately 250 mm (9.8 inches) TL female. We used roundtail chub data from Bezzerides and Bestgen (2002) and Muth et al. (1985) to provide average adult fecundity estimates. Information on survival rates, gender specific survival rates, or fertility rates of roundtail chub has not been reported. To provide some information on survival and population dynamics, we have used a general survival rate for both males and females. The annual survival rates (**Table 1**, **Figure 3**) provide longevity of the species to over age 10. Survival rates of roundtail chub populations likely depend on the flow regime and water quality characteristics at the time of spawning. Long-lived species such as roundtail chub would not require high recruitment success of individuals each year. Typical of many long-lived fish species, the roundtail chub likely has a high mortality rate from egg through age 1, followed by decreasing mortality rate with age and probably a fairly constant mortality rate for adult fish. This life history trait would provide large cohorts to infuse the population in years when conditions were optimal for spawning. This pulse of young roundtail chub would provide a strong cohort that would replenish or augment the adult population until the next period of favorable spawning conditions. Spawning and recruitment likely take place each year but with a very high rate of variability and overall success dependent on fluctuating environmental conditions.

Community ecology

Historically, roundtail chub may have been the most abundant carnivore in the Upper Colorado River Basin (Holden and Stalnaker 1975). Recently, a decrease in range and abundance has been documented at several locations (Vanicek et al. 1970, Joseph et al. 1977, Kaeding et al. 1990). Joseph et al. (1977) suggested that declines in roundtail chub populations are often correlated with the introduction and establishment of predatory non-native fish. They also suggested that prior to the introduction of non-native fish, roundtail chub were probably a major prey item for Colorado pikeminnow (*Ptychocheilus lucius*). Osmundson (1998) documented Colorado pikeminnow predation on roundtail chub in the Colorado River. It is very likely that roundtail chub are preyed upon by both native and non-native sympatric predators. Nesler (1995) documented northern pike (*Esox lucius*) utilization of roundtail chub as a significant prey item in the Yampa River, Colorado. Roundtail chub were the second most common prey item for northern pike in that system. Other introduced predators include rainbow trout, brown trout (*Salmo trutta*), smallmouth bass (*Micropterus dolomieui*), and channel catfish (Weitzel 2002). The red shiner (*Cyprinella lutrensis*), when present, may act as a predator on larvae as well as a competitor with juvenile roundtail chub (Ruppert et al. 1993).

Little is known about the influence of parasites on roundtail chub community ecology. A list of the known parasitic protozoan, trematodes, and nematodes can be found in the comprehensive report on roundtail chubs at www.natureserve.org. There is also concern that the introduction of non-native fish has resulted in the introduction of the Asian tapeworm (*Bothriocephalus acheilognathi*). This parasite can reduce growth and suppress swimming ability, especially in young roundtail chub (Weitzel 2002). The Asian tapeworm and anchor worm (*Lernia*) have been found in the system, but there is little evidence that roundtail chub are commonly used as hosts, despite their apparent susceptibility (Landye et al. 1999).

An envirogram for roundtail chub was developed to help elucidate the relationships between

Table 1. Parameter values for the component terms (P_i and m_i) that make up the vital rates in the projection matrix for roundtail chub. Available parameters were estimated from Muth et al. (1985) and Bezzerides and Bestgen (2002).

Parameter	Numeric value	Interpretation
P_{21}	0.001	First year survival rate
P_{32}	0.40	Survival from 2nd to 3rd year
P_{43}	0.40	Survival from 3rd to 4th year
P_a	0.10	Survival for adults
m_{av}	25000	Average fecundity for mature females

land use practices/management and roundtail chub population characteristics (**Figure 4**). Those elements that directly affect the roundtail chub are depicted in the envirogram by the centrum, which is further separated into resources, predators, and malentities. Resources elicit positive response in roundtail chub whereas predators and malentities produce either negative or neutral responses. Web levels illustrate factors that modify elements within the centrum or within the next lower web level. Andrewartha and Birch (1984) provide further detail into the specific description of all envirogram components. Relative importance of the linkages is poorly understood and warrants further study.

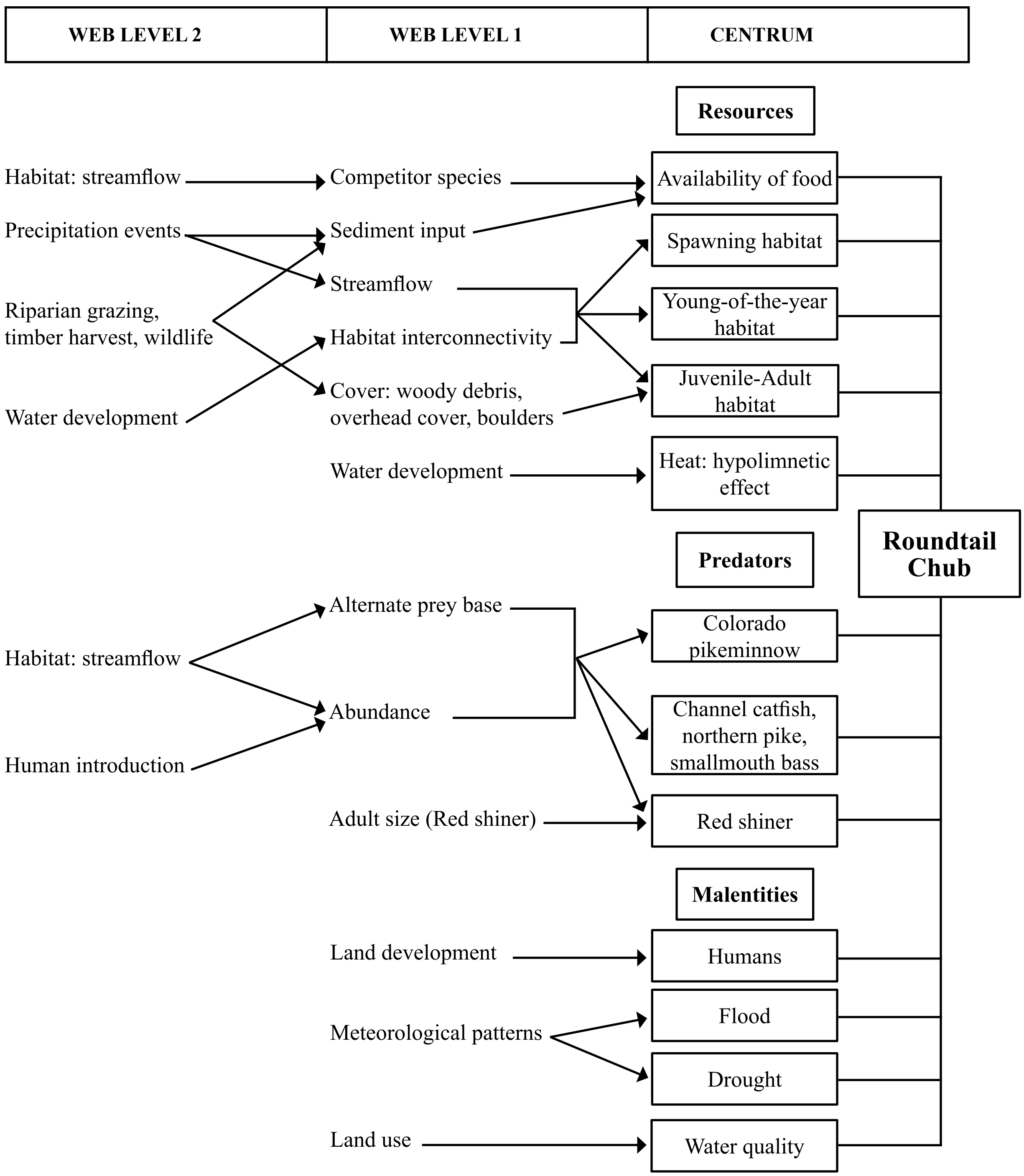

Figure 4. Envirogram for the roundtail chub.

CONSERVATION

Threats

The native fish community that evolved in the warm-water reaches of the Upper Colorado River Basin has been greatly reduced as a result of human activities during the last 100 years. Roundtail chub populations have suffered reductions in abundance and distribution from the same mechanisms that have caused the near extinction of other endemic fish species in this drainage. These mechanisms can be separated into two general categories that encompass the majority of the threats to the current and future survival of roundtail chub: 1) habitat degradation through loss, modification, and/or fragmentation and 2) interactions with non-native species (Tyus and Saunders 2000).

Both types of threats imperil the long-term persistence of roundtail chub. Each may work independently or in conjunction with the other to create an environment where populations may be reduced or eliminated. The relative importance of each category and the specific cause-effect relationship usually depend on location. The complexity of each requires further explanation.

Effects of habitat degradation may not be limited to localized areas but may cascade through the system. Therefore, activities or events occurring on National Forest System lands may have detrimental impacts on populations of roundtail chubs existing in rivers many kilometers downstream of USFS lands.

Habitat loss typically occurs when streams are dewatered or when reservoir construction inundates suitable roundtail chub habitat. Habitat modification occurs when the natural flow regime is altered, and when stream channels are modified due to channelization, scouring, or sedimentation from land use practices. Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, and overgrazing in riparian areas. These can all lead to an increased sediment load within the system and a subsequent change in stream channel geometry (e.g., widening, incision). These modifications alter width-depth ratios, pool-riffle ratios, and other aspects (e.g., pool depth) that affect the quality of habitat occupied by roundtail chub.

The effect of wildfire has little direct impact on habitat quality. However, post-fire conditions can affect downstream populations. Input of large quantities of sediment into streams frequently occurs during storm events at recently burned areas. The increased sediment load can diminish suitable spawning habitat, smother eggs and larvae, reduce habitat for prey, and cause direct mortality through suffocation at all life stages.

Habitat fragmentation is often a result of dewatering, but it can also be caused by the creation of barriers to fish passage such as dams and diversions. Even undersized (or improperly designed) culverts at road or trail crossings can act as barriers, especially at low flows. Large and small scale water development projects can have profound impacts on the persistence of roundtail chub. Irrigation diversions and small capacity irrigation reservoirs reduce streamflow, alter the natural hydrograph, and provide barriers to migration and normal population exchange. Barriers that preclude fish passage can cause population fragmentation and completely prevent or significantly reduce genetic exchange between populations. The fragmented populations in some areas remain viable and maintain population levels at the same density as they were before fragmentation occurred. This typically occurs in the larger mainstem river sections. In smaller rivers and tributaries to the mainstem, habitat fragmentation can eventually lead to habitat loss and extirpation of populations. As habitat is fragmented and populations are isolated, the probability that genetic "bottlenecks" will occur becomes more pronounced, and single catastrophic events may extirpate populations from entire drainages

Habitat modification includes aspects already discussed under fragmentation and degradation but also includes changes in temperature and flow regimes, as well as alterations to water chemistry related to pollution. Severely reduced streamflows may lead to increased water temperatures and reduced dissolved oxygen levels, especially in smaller tributary systems. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is reduced, roundtail chub fitness will also decline.

Water development, road construction, timber harvest, and grazing of riparian areas are likely to continue to impact roundtail chub habitat. While modification of land use management techniques to decrease the impact to roundtail chub habitat may lessen anthropogenic threats to this species, it is unlikely that all impacts or threats could be minimized or halted. Modifications of land use management techniques include:

- the specification of fish passage at new or existing low head diversions to eliminate or reduce habitat loss and fragmentation;

- the specification of minimum flow regimes to promote habitat connectivity;

- maintenance of baseflow habitat during summer or irrigation seasons;

- the specification for buffer zones for both road construction and timber harvest;

- the reduction of grazing in riparian areas to promote healthy riparian growth and reduce sedimentation from upland areas.

Competition with and predation by non-native species is another extensive threat to roundtail chub population health and viability. Many introduced species tend to be well-adapted to a variety of environmental conditions, giving them a competitive advantage on a spatial or temporal scale. Non-native species such as red shiner, fathead minnow (*Pimephales promelas*), redside shiner (*Richardsonius balteatus*), and young smallmouth bass compete with juvenile roundtail chubs for available macroinvertebrate food resources. Many of these species are prolific spawners and capable of successfully producing multiple broods each year.

A fusiform shape and lack of protecting spines makes the roundtail chub a desirable prey item for predatory non-native species. Large non-native predators, including northern pike, channel catfish, and smallmouth bass, occur in many of the drainages containing roundtail chub. In addition, red shiners have been reported to feed on native larval fish within the Upper Colorado River Basin (Ruppert et al. 1993). Preferred habitat for red shiners is slack water shoreline or backwater areas, which are also used by larval roundtail chub.

Hybridization with other *Gila* species is a minor threat to roundtail chub persistence. Currently, only small populations of bonytail and humpback chubs occur sympatrically with roundtail chub, but the future stocking of bonytail in the Upper Colorado River Basin is likely. Although these species historically co-existed, the alteration of natural temperature and flow regimes in some regulated stream reaches may reduce the reproductive isolation mechanisms that have evolved between species. Further treatment of hybridization can be found in the Demography section.

Given their proximity to USFS lands and the effects of some of the threats such as increased sedimentation from grazing, timber practices, and road construction, USFS activities could impact downstream roundtail chub populations. Fragmentation of populations or habitat loss could occur due to barriers to migrations that occur on occupied USFS lands at water diversions or impassable stream crossings. Both of those threats could be eliminated with inclusion of fish passages during construction of diversions, and proper sizing and construction of culverts to allow natural passage conditions at road crossings or bridges.

Conservation Status of the Roundtail Chub in Region 2

At present, there is concern regarding the status of roundtail chub in the Colorado River Basin. A decrease in roundtail chub populations has been documented or suggested throughout most of the basin. Existing research suggests that the decline in range and populations of this species is due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native species. Although the specific mechanisms of most threats to this species are poorly understood, it is imperiled throughout its range in the Upper Colorado River Basin.

Stable populations of roundtail chub still exist in various locations in the Upper Colorado River Basin (i.e., tributaries and sections of the Green, Colorado, and San Juan rivers). These locations are usually defined by adequate habitat (as specified in the habitat section of this report), and natural temperature and flow regimes. These areas often maintain healthy populations of other native fish species.

The roundtail chub evolved in a system with a high natural disturbance regime. This disturbance regime included a large contrast between annual peak flows and base flows, and considerable sediment transport. Life history attributes and population dynamics allowed this species to persist during (or to recolonize after) a disturbance event; however, modifications (loss of channel complexity, refugia) to the physical environment (e.g., loss of channel complexity and refugia) and the biological environment (e.g., increase in non-native species, predation, and competition) have reduced the species' ability to recover after such events. Habitat fragmentation through streamflow reduction, passage barriers, and habitat degradation disconnects metapopulations of roundtail chubs. Additional pressure from competition and predation can depress or extirpate roundtail chub populations.

Based on the impacts to roundtail chub abundance and distribution that have occurred in the last century, the potential for future declines is high. Unless alleviated, habitat degradation, habitat fragmentation, and non-native species interactions could intensify and jeopardize the existence of roundtail chub. While this species is not found on USFS lands, much of the water in rivers that currently support roundtail chub originates on those lands. Activities on USFS lands that impact streamflows and water quality could affect roundtail chub populations in downstream reaches.

Potential Management of the Roundtail Chub in Region 2

Implications and potential conservation elements

A brief description of threats is provided here to form a basis for the conservation elements; however, further discussion of threats to roundtail chub can be found in the Conservation Threats section of this document.

Management of roundtail chub should be based on an understanding of specific threats to the species. Habitat loss, degradation, and fragmentation due to land and water use practices are prime threats to roundtail chub persistence in the Upper Colorado River Basin. Reduction of streamflows and creation of barriers to fish passage can severely degrade habitat to the extent that roundtail chub populations are extirpated from the area. The degree of influence that population fragmentation has on roundtail chub populations is speculative but could impact the long-term persistence of this species. Creating isolated populations disrupts the natural exchange of genetic material between populations. Isolated populations are subject to extinction due to catastrophic events because of the impediment to recolonization from other nearby populations. Loss of genetic diversity can also lead to depression of fecundity and survival rates. The genetic exchange along a metapopulation framework within the roundtail chub distribution can provide the required demographic variability and viability.

Considerations for conservation elements should include:

- ❖ preservation of instream flows
- ❖ minimization of sediment input due to anthropogenic causes (e.g., road building, timber harvest)
- ❖ management of non-native fish species
- ❖ protection of riparian areas

Construction associated with road improvements or development, timber harvesting, grazing, and/or fire activity can result in a) increased sediment loads and b) loss of riparian vegetation along and adjacent to streams. Increased sediment can result in loss of habitat (e.g., pools), siltation of riffles and subsequent loss of food production, and changes in stream geometry (e.g., width:depth ratios). It is likely that increased sediment loads or sediment deposition could negatively impact roundtail chub populations. However, specific thresholds and mechanisms associated with this impact have not been studied well enough to make precise predictions. Impacts to riparian vegetation may result in channel in-stability (widening or incision), degraded water quality conditions (i.e. stream temperature), and loss of complex fish habitat.

The presence of non-native fish species threatens roundtail chub populations. Specifically, competition between roundtail chub and introduced species and predation by large non-native species represent the two most deleterious effects of non-native interaction. Implementation of management strategies should be designed to restrain further expansion of non-native fish distribution on USFS lands. These strategies should include strict enforcement of existing prohibitions regarding the release of non-native fish. Eradication programs for non-native fish (including game fish) in streams within the historical range of roundtail chub could also be considered.

Preservation of instream flows that are adequate to maintain complex habitat, interconnectivity of habitats, and instream cover should be a focal point of management policy or strategy. Conservation elements should address the function of the entire aquatic and riparian ecosystem, with particular attention to downstream populations. Any future plans for the conservation of roundtail chub should take into account the entire native fish assemblage in the Colorado River Basin. This assemblage of species evolved in a system with a high differential between peak spring runoff and fall base flows. Native fish species of the Colorado River all require similar management considerations related to channel maintenance and restoration of historical flow regimes.

Tools and practices

We are unaware of any management approaches implemented specifically for roundtail chub in Region 2. Because little information exists or is currently being collected regarding this species, this section will deal with techniques intended to gather information identified in the Information Needs section that follows.

The absence of distribution and abundance data for roundtail chub in Region 2 (with emphasis toward USFS land) should be a concern. The compilation of all available distribution data would provide a foundational database that further surveys could supplement. The initial priority should be a complete survey of all National Forest System streams that may contain roundtail chub. Because adult roundtail chub frequent areas with complex instream cover, the use of electrofishing as a means to determine distribution and abundance is warranted.

Once basic distribution information has been gathered, intensive population estimates would provide baseline information with which effectiveness of future management strategies could be evaluated. Focus should be on areas where future management strategies may include activities that could possibly impact roundtail chub populations. However, the long-term monitoring goal should be population estimates and population trend data on all streams containing roundtail chub populations on Region 2 lands. Consultation with agencies managing populations that are not on National Forest System lands but are affected by forest practices is imperative to allow forest managers to continually monitor the status of those populations. Several electrofishing techniques exist that would provide population estimates. These include mark/recapture and multiple pass removal estimates. Each has its advantages; however, due to the smaller size of many streams on National Forest System lands, estimating populations using a multiple pass removal technique should be a cost effective method to produce high quality data. Riley and Fausch (1992) recommended that a minimum of three passes be conducted when using the removal method. Use of a single pass method to develop a catch per unit of effort (CPUE) index is cost-effective on a time basis, but precision may be sacrificed and the introduction of bias is more likely, especially over long-term monitoring with significant researcher/technician turnover. With removal estimates, researchers are able to calculate confidence intervals, allowing insight into sampling quality, thereby allowing this approach to be comparable through time.

General stream reach habitat surveys should be conducted concurrently with distribution and abundance surveys. Winters and Gallagher (1997) developed a basinwide habitat inventory protocol that would be a cost-effective tool to collect general stream habitat data. This protocol includes characterization and quantities of habitat type, channel type, substrates, and bank stability. All of these parameters assist in describing habitat quality.

A large data gap exists in the knowledge of roundtail chub movement and use of streams on USFS lands. The implementation of a survey methodology to determine roundtail chub distribution and abundance can also provide insight into movement through the use of PIT (passive integrated transponder) tags. PIT tags are unobtrusive, long lasting (indefinitely), uniquely coded tags that allow for the efficient determination of movement with a minimum of disturbance. Establishment of a long-term monitoring program would be required. Even in areas considered to be strongholds for roundtail chub, the species is often rare; therefore, the time required to develop a robust data set is dependent upon sample size, recapture rates, and survey frequency.

Habitat selection and preference can be determined through the use a variety of techniques. The simplest technique involves correlating capture locations (during distribution surveys) to specific habitat types. Construction of habitat suitability curves is time intensive but could be used in conjunction with hydraulic modeling methodologies to estimate how habitat changes in relation to streamflow. This would allow land use managers to effectively compare the impacts of different altered flow regimes (due to water development projects) on roundtail chub habitat. Data obtained could also be used to justify the acquisition of adequate instream flows for roundtail chubs and other native fishes.

Defining the relationship between habitat alteration and roundtail chub population characteristics will be a difficult task. This process may require significant amounts of data including quantitative analysis of differences in prey base over time, changes in habitat quality/function, and some form of abundance estimates.

In addition to collecting data specifically related to the distribution and life history of roundtail chub, forest managers can implement techniques that will increase the quality of habitat for roundtail chub and other native fish (e.g., flannelmouth sucker, bluehead sucker). A healthy riparian corridor is important to overall aquatic ecosystem function. Forest managers can address minor riparian issues by altering the grazing rotation or by fencing riparian areas. In areas with severely degraded riparian growth, revegetation of the riparian area may also be warranted. Other tools and techniques to improve habitat condition and function could include physical habitat restoration. This technique can be costly and time intensive and may only be practical when previously mentioned techniques are unsuccessful.

Managers can also work to ensure that barriers do not fragment roundtail chub populations. In addition to properly designing future stream culverts (i.e., size and gradient to allow fish passage), managers should inventory and assess the threat of all potential barriers currently in place. Barriers located within roundtail chub range (as defined by distributional surveys) within Region 2 should receive priority and when possible, be removed.

The mechanical removal of non-native fish is currently conducted on lower mainstem rivers and pertinent stream systems occupied by roundtail chub within the Upper Colorado River Basin. The effectiveness of this technique to significantly reduce non-native fish populations is not clearly understood. Mechanical removal is likely most effective when utilized before non-native fish populations become well established and prolific.

In order to effectively gather data valuable for the conservation of this species, managers need to coordinate with federal and state agencies, academia, and private firms that are managing or studying portions of streams downstream of USFS lands. This is necessary to determine or verify the distribution and abundance of roundtail chub populations that exist off National Forest land, but that are still affected by USFS management policies and strategies.

Information Needs

Most of the available information regarding the roundtail chub has been collected as a byproduct of studies that were designed to learn more about federally listed fish in the Colorado River Basin. In order to attain the level of understanding that is necessary to properly manage this species at a localized level, specific threats must be identified by drainage. General information needs for roundtail chub include a wide range of information:

- ❖ distribution
- ❖ habitat requirements and associations
- ❖ general attributes of life history and ecology
- ❖ movement patterns
- ❖ influence of non-native fish
- ❖ genetic variation of populations
- ❖ effects of human-induced habitat modification.

The current distribution of roundtail chub on USFS lands in Region 2 is poorly understood. Specific knowledge of streams and watersheds containing roundtail chubs is essential prior to the development of any regional management strategies designed to preserve this species. The research priority should be to survey all streams with potential habitat for the presence of roundtail chub. Initial focus should be on streams with known populations downstream and adjacent to USFS lands. In addition to general distribution and abundance information, additional data on temporal and spatial changes in abundance and distribution is required. Roundtail chub may not establish resident populations in USFS-managed streams, but these tributaries may provide important spawning habitat.

During these surveys, information regarding the physical and chemical characteristics of the habitat should be obtained. Data collected should include elevation, water temperature, dissolved oxygen, dissolved solids (pollutants), discharge, depth, turbidity, substrate, and habitat type. This information will provide baseline data regarding habitat requirements and tolerances for each physical parameter. The available data on habitat use emphasizes large river systems, and few studies have been conducted on smaller tributary systems. Habitat requirements and preferences are poorly understood for most life stages and life history events. Specific studies need to be designed to provide information on spawning behavior and habitat, larval biology, and the importance of larval drift. Habitat requirements and feeding habits at each life stage should also be addressed.

Fish collected should be tagged with PIT tags to allow for studies of movement, migration, and growth rates. Continued monitoring of tagged fish will also provide an estimate of survival rate that is a necessary component for the creation of a life cycle diagram. Sex ratio and fecundity data should be collected to provide other components missing from the life cycle diagram. It may be important to collect data from several sub-basins because much of the specific life history information may vary by drainage. It is unknown whether roundtail chub life history traits are uniform between large river and small tributary systems.

In order to better understand the community ecology of roundtail chub, future studies should include inventory and monitoring of all fish (adult, juvenile, and larvae), macroinvertebrates, and periphyton taxa in the streams where the roundtail chub occurs. Stomach content analysis at various life stages will provide a better understanding of roundtail chub feeding habits. Feeding studies on sympatric fish populations need to be conducted as well, to determine potential competition and to further understand the impact of introduced and native predators on roundtail chub populations.

Genetic testing during future studies on roundtail chub populations is important. Tissue samples should be taken from fish for analysis of the genetic structure of mainstem and isolated populations. Genetic characterization would allow studies of population connectivity, migration, population diversity, viability of isolated populations, and the extent and effects of hybridization with other chub species.

In order to ensure the long-term conservation of this species, research must also examine how to minimize the impacts of human activities on roundtail chub populations. Studies specifically designed to evaluate the effects of riparian grazing, road construction, passage barriers, and non-native species interactions are imperative to preserving this species. Techniques to minimize the effects of impoundments on flow regime, temperature regime, and movement of native fish are particularly important. This research should focus on modifying existing impoundments, providing guidelines for construction of future impoundments, and exploring the use of off-channel impoundments. The development of a process-response model that portrays the biological response of a species to physical factors would further identify roundtail chub life history components that are not adequately understood.

DEFINITIONS

Centrum – any component that directly affects the central organism

Endemic – confined to a particular geographic region.

Habitat quality – the physical characteristics of the environment (e.g., soil characteristics for plans or channel morphology for fish) that influence the fitness of individuals. This is distinguished from habitat quantity, which refers to the spatial extent.

Hybridization – the production of offspring by crossing two individuals of unlike genetic constitution.

Lithophilic – associated with stony substrates.

Malentities – all components other than predators that directly affect the central organism and cause a negative response.

Metapopulation – one or more core populations that are fairly stable and several surrounding areas with fluctuating populations.

Process-response model – either a conceptual or mechanistic model to portray the biological response to physical factors.

Scale – the physical or temporal dimension of an object or process (e.g., size, duration, frequency). In this context, extent defines the overall area covered by a study or analysis and grain defines the size of individual units of observation (sample units).

Viability – a focus of the Species Conservation Project. Viability and persistence are used to represent the probability of continued existence rather than a binary variable (viable vs. not viable). We note this because of the difficulty in referring to 'probability of persistence' throughout the manuscript.

Web Level 1 – any component that affects the centrum.

Web Level 2 – any component that affects Web Level 1.

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Bluehead Sucker (*Catostomus discobolus*): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

April 25, 2005

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COVER PHOTO CREDIT

Bluehead Sucker (*Catostomus discobolus*). © Joseph Tomelleri.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE BLUEHEAD SUCKER

Status

The bluehead sucker (*Catostomus discobolus*) is considered a sensitive species in Region 2 of the USDA Forest Service (USFS). It is native to the Colorado River Basin and ancient Lake Bonneville in Idaho, Utah, and Wyoming. Within Region 2, populations exist in western Colorado and south-central Wyoming. However, the only populations known to occur on lands managed by USFS Region 2 are located on the San Juan National Forest in southwestern Colorado.

Primary Threats

The primary threats to the bluehead sucker generally result from anthropogenic activities. Diversion of water results in changes in flow regime for mainstem rivers and tributary streams. Construction of passage barriers (e.g., diversion dams and reservoirs) within many rivers and streams causes habitat degradation and fragmentation. Introduction of non-native species increases predation on and competition with bluehead suckers. Other threats to this species include channelization of streams, land use that changes the landscape, and local development of riparian zones that reduces the natural function of the stream ecosystem. Detailed information concerning the distribution, life history, population trends, and community ecology of this species is relatively limited, and it typically comes from non-National Forest System lands. More specific information is needed at the local and regional levels prior to the development of management plans or actions for the bluehead sucker.

Primary Conservation Elements, Management Implications and Considerations

The general lack of information for this species suggests that management should begin with a detailed survey of drainages on National Forest System land that could hold populations of bluehead suckers. Like other species native to the Colorado River Basin, the bluehead sucker has not been well-studied until recent years. Fish studies currently underway in the Colorado River Basin are in conjunction with recovery efforts for species that are federally listed as Endangered. The information collected for bluehead sucker is only incidental to those prime studies but could be useful in developing management plans. The USFS should coordinate with other agencies (e.g., state game and fish departments, Bureau of Land Management, U.S. Fish and Wildlife Service) to obtain information from adjacent, downstream reaches that may be influenced by activities on the National Forest System lands. Given the known threats to this species, conservation measures should concentrate on maintaining habitat diversity and managing for natural temperature and flow regimes in stream reaches that contain bluehead sucker populations.

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS) Rocky Mountain Region (Region 2) (**Figure 1**). The bluehead sucker is the focus of an assessment because it is considered a sensitive species in Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of significant current or predicted downward trends in abundance and/or habitat capability that would reduce its distribution (FSM 2670.5 (19)). Due to concerns with population viability and abundance, a sensitive species requires special management. Consequently, knowledge of its biology and ecology is critical. This assessment addresses the biology, ecology, conservation, and management of the bluehead sucker throughout its range in Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

The purpose of species conservation assessments produced as part of the Species Conservation Project is to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The goals of this assessment limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. This assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of changes in the environment that result from management (i.e., management implications). Furthermore, it cites management recommendations proposed elsewhere and examines the success of those that have been implemented.

Scope

This assessment examines the biology, ecology, conservation, and management of the bluehead sucker with specific reference to the geographic and ecological characteristics of the USFS Rocky Mountain Region. Although some of the literature originates from field investigations outside the region, this document places that literature in the ecological and social context of the central Rocky Mountains. Similarly, this assessment is concerned with the reproductive behavior, population dynamics, and other characteristics of bluehead sucker in the context of the current environment rather than under historical conditions. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing this assessment, we reviewed refereed literature, non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on bluehead sucker are referenced in the assessment, nor are all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. When information was unavailable elsewhere, we chose to use non-refereed publications and reports, but these were regarded with greater skepticism. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution of the species. These data required special attention because of the diversity of persons and methods used in collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to this uncertainty is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. Ecological science, however, is more similar to geology than physics because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide our understanding of the world (Hillborn and Mangel 1997). The geologist T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). A problem with using the approach outlined in both Chamberlain (1897) and Platt (1964) is that there is a tendency among scientists to resist change from a common paradigm. Treatment of uncertainty necessitates that a wide variety of hypotheses or experiments be undertaken to test both the true or false nature of the uncertainties at hand (Vadas 1994).

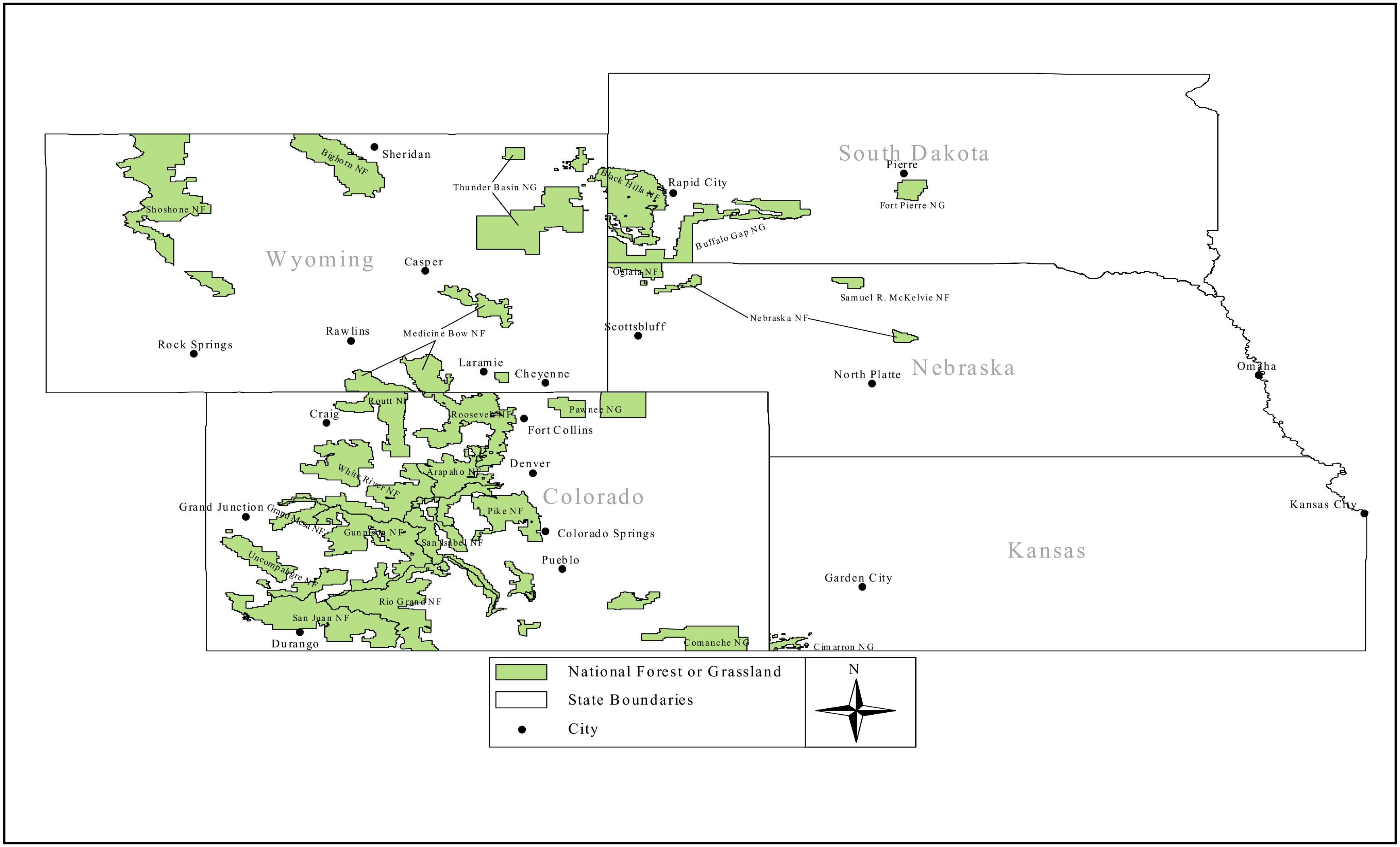

Figure 1. USDA Forest Service Region 2 national forests and grasslands.

Confronting uncertainty, then, is not prescriptive. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding and used in synthesis for this assessment. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

The synthesis of material for the bluehead sucker included the use of the limited data sets that are available regarding the distribution, abundance, movements, habitat requirements, and life history of the species. Like many non-game, native fish, this species has not been extensively studied within Region 2, nor has it been extensively studied for all the parameters needed for the species assessment. The limited amount of information on key characteristics for the species and our lack of understanding concerning its needs create a great deal of uncertainty pertaining to the assessment for conservation of bluehead sucker. This species assessment has synthesized a wide range of available data throughout the Colorado River Basin, including historical and current distribution, conservation strategies, habitat needs, and management requirements. The general lack of precise information regarding species distribution on or near National Forest System land limits the actual data that can be used for this assessment. Using a sound scientific approach, we have inferred from available data to present an understanding of the current needs of the species for the purpose of this assessment.

Application and Interpretation Limits of This Assessment

Information used in this assessment was collected from studies that occurred throughout the geographical range of this species. The greatest emphasis for information regarding life histories and ecology was placed on studies and reports that were specific to Region 2. Although most information should apply broadly throughout the range of the species, it is likely that certain life history parameters (e.g., growth rate, longevity, spawning time) will differ along environmental gradients. Information regarding conservation status of the species pertains specifically to Region 2 and does not apply to other portions of the species' range.

Publication of Assessment on the World Wide Web

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the American Fisheries Society, which chose two recognized experts (on this or related taxa) to provide critical input on the manuscript. Peer review was designed to improve the quality of communication and to increase the rigor of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The U.S. Fish and Wildlife Service does not list the bluehead sucker as federally threatened or endangered species, but other agencies have given it special status. The bluehead sucker currently has a Natural Heritage Program rank of G3G4 (globally vulnerable but apparently secure) and a state rank of S2 (imperiled) in Wyoming. The Bureau of Land Management (BLM) in Wyoming considers the bluehead sucker a sensitive species. Wyoming Game and Fish Department (WGFD) has assigned this species a state rank of NSS1, suggesting that its presence is extremely isolated and its habitats are declining or vulnerable. The Colorado Division of Wildlife (CDOW) has not given the bluehead sucker a special status, but the BLM in Colorado considers it a sensitive species. Bluehead suckers do not occur in Kansas, Nebraska, or South Dakota, but they do occur in several states outside of Region 2. The State of Utah considers the bluehead sucker to be a sensitive species, due to declining populations. In New Mexico, the species itself has no special status, but a subspecies, the

Zuni bluehead sucker (*Catostomus discobolus yarrowi*), is listed as endangered by the state and sensitive by the BLM in New Mexico. Idaho has not afforded the bluehead sucker special status.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

At this time there are no existing management strategies specific to the bluehead sucker. However, several states, including Colorado and Wyoming, have developed a "range-wide conservation agreement and strategy" to direct management for this species. By 2005, the CDOW intends to develop a "conservation/management plan" for bluehead sucker that will provide direction to research and management goals.

The CDOW has no regulations specifically designed to protect bluehead sucker, but several regulations are intended to protect native fish species and thus indirectly aid in the conservation of bluehead sucker. For example, live release of non-native fish species is prohibited in the Upper Colorado River Basin in Colorado. Another regulation that indirectly assists the conservation of bluehead sucker is a statewide statute that prohibits the seining, netting, trapping, or dipping of fish for bait in natural streams. Few, if any anglers specifically target bluehead suckers, but incidental take probably occurs as fisherman attempt to catch game fish species.

The WGFD has regulations regarding bluehead sucker habitat loss. The WGFD's objective is to permit projects in a manner that avoids altering or degrading the function of bluehead sucker habitat (Weitzel 2002). In addition, WGFD has regulations regarding baitfish that should assist in protecting bluehead suckers.

Ongoing recovery programs for federally-listed fish (e.g., Colorado pikeminnow [*Ptychocheilus lucius*], razorback sucker [*Xyrauchen texanus*]) in the Upper Colorado River Basin and San Juan River drainage should provide benefits for all native fish species. Recovery actions include recommendations to mimic a natural hydrograph (in-stream flow) and restrictions on non-native fish stocking within the basins.

Biology and Ecology

Systematics and general species description

The bluehead sucker belongs to the family Catostomidae, members of which are characterized by soft rays and a fleshy, subterminal, protractile mouth. This family is comprised of 12 genera and 60 species in the United States and Canada (Robins et al. 1991). Bluehead suckers are members of the genus *Catostomus* and subgenus *Pantosteus*. *Catostomus discobolus* has two recognized subspecies, *C. d. discobolus* and *C. d. yarrowi*. *Catostomus discobolus yarrowi* (Zuni bluehead sucker) occurs in small tributary streams in New Mexico and Arizona. *Catostomus discobolus discobolus* occurs throughout the remainder of the range of bluehead suckers. The focus of this document is on *C. d. discobolus*, and further reference will be made as *C. discobolus*.

The bluehead sucker can be differentiated from other Catostomids occurring sympatrically by several morphological characteristics. It possesses a cartilaginous scraping disc on the lip interior; this feature is lacking in both the white sucker (*Catostomus commersoni*) and the flannelmouth sucker (*C. latipinnis*). Bluehead suckers and mountain suckers (*C. platyrhynchus*) may occur sympatrically on the periphery of their distributions in smaller tributary streams. Both species possess a scraping disc, but the mountain sucker has an axillary process in the axil of the pelvic fin, which is lacking on the bluehead sucker. The reader should refer to Eddy and Underhill (1978) for identification and differentiation of bluehead suckers from other members of the genus *Catostomus*.

The following description of bluehead suckers is taken from Bezzerides and Bestgen (2002):

> "*Bluehead suckers have a short, broad head with a wide snout that overhangs a large mouth. Lips are large and the upper forms a fleshy hood over the mouth. The lower lip is shallowly notched at the midline. Small papillae are evenly scattered over the lower lip and oral face of the upper lip, but are absent from anterior face of upper lip. Both jaws have well-developed, cartilaginous scraping edges. The body is elongate and tapers to a caudal peduncle that varies in thickness. Fins are moderately sized, but the dorsal (rays 10-12[8-12]) may be enlarged and strongly falcate, or smaller and less concave (rays 9-10). Other fin ray counts are: pectorals 15-16[14-17]; pelvics 8-10[7-11], anal 7[7-8], and caudal 18.*
>
> *Other characteristics of bluehead suckers include: moderate- to small-sized scales, 90-110[78-122] in the lateral line series; predorsal scales usually more than 50-65[44-76]; gill rakers, 28 to 44 (usually more than 30) on the external*

row, with spines in two rows; the frontoparietal fontanelle is usually closed in adults, and reduced in immature specimens; and, a long intestine with 6 to 14 loops anterior to the liver.

In clear water, C. discobolus is typically dark olive to nearly black on the back and sides and yellowish on the belly, and in turbid water, silvery tan or lighter green above and dirty white below. The head is often bluish, thus the common name. Young fish are dusky above and white below."

Vanicek (1967) reports that young-of-the-year bluehead suckers in the Green River attain a total length of about 50 mm (2 inches) after one year. Juvenile bluehead suckers in the Green River reach a total length of about 90 mm (3.5 inches) after two years (Vanicek 1967). Age determination using scale analysis indicated that this species could achieve an age of at least 20 years in the Green River and other portions of the Colorado River Basin (Scoppettone 1988, Minckley 1991).

Distribution and abundance

Historically, bluehead suckers occurred in streams and rivers in the Colorado River Basin (Joseph et al. 1977, Bezzerides and Bestgen 2002) as well as in the drainages of the upper Snake, Weber, and Bear rivers (Sigler and Miller 1963, Sublette et al. 1990). However, only those populations found in the Colorado River Basin are within Region 2, and therefore, only those populations are discussed in this report. Within the Colorado River Basin, bluehead suckers are found in the Colorado, Dolores, Duchesne, Escalante, Fremont, Green, Gunnison, Price, San Juan, San Rafael, White, and Yampa rivers and numerous smaller tributaries (**Figure 2**; Vanicek et al. 1970, Bezzerides and Bestgen 2002). The bluehead sucker also occurs in the Little Colorado River drainage of the Lower Colorado River Basin (Minckley 1985). The range of the bluehead sucker often overlaps with that of other native suckers.

In the Colorado portion of Region 2, the bluehead sucker occupies most major tributaries associated with the Upper Colorado River Basin. Holden and Stalnaker (1975) found the bluehead sucker to be "common" to "abundant" at sample locations in the Yampa, Gunnison, middle to upper Green and Colorado rivers. Carlson et al. (1979) reported that the percent of bluehead suckers in fish collections ranged between 7.8 and 28.0 at six sites on the Yampa River between Dinosaur National Monument and the town of Hayden, Colorado. Miller and Rees (2000) indicated that the bluehead sucker was among the most common fish species collected in tributaries of the San Juan River. Most of these tributaries originate in the San Juan National Forest; however, the study area did not generally extend onto national forest property. Available data provided by Miller and Rees (2000) suggested that the range of bluehead suckers in the Piedra and San Juan rivers (and possibly other tributaries) included lower reaches in the San Juan National Forest.

In Wyoming, the range of bluehead suckers is smaller than historical reports indicate (Bezzerides and Bestgen 2002). It is known to occur in the Little Snake River and three tributaries, Savery Creek, Muddy Creek, and Littlefield Creek (Weitzel 2002). In a fish survey of 131 streams compiled by the Wyoming Game and Fish Department in 1987, bluehead suckers were collected in the Little Snake River beginning at the downstream most Stateline crossing, and extending upstream to the bridge on Highway 70 at Dixon, Wyoming (Oberholtzer 1987). They were also occasionally reported in collections upstream of Dixon and in Muddy Creek. Historical records indicate that bluehead suckers were widely distributed in Savery Creek in the mid-1950s. A follow-up study to assess the current distribution found a decline in most native species of fish, including the bluehead sucker (Wheeler 1997, Wyoming Game and Fish Department 1998).

Bluehead sucker populations exist in several tributary streams immediately downstream of lands managed by the Routt and San Juan national forests. These tributary streams include Divide Creek, Elkhead Creek, Florida River, La Plata River, Los Pinos River, and Rifle Creek. However, comprehensive annual and seasonal distribution information is lacking for these and other streams within Region 2.

Population trend

Recent work suggests that bluehead sucker populations are declining throughout their historic range (Wheeler 1997, Bezzerides and Bestgen 2002, Weitzel 2002). Currently, they are found in only 45 percent of their historic range in the Upper Colorado River Basin (Bezzerides and Bestgen 2002). The reasons for this decline are most likely due to the alteration of thermal and hydrologic regimes, degradation of habitat, and interactions with non-native species.

During the 1960s, two massive reductions in large river bluehead sucker populations occurred. In 1961, a non-game fish eradication program (using rotenone) was completed on a 112 km (69.6 miles) reach of the San Juan River (Olson 1962). In 1962,

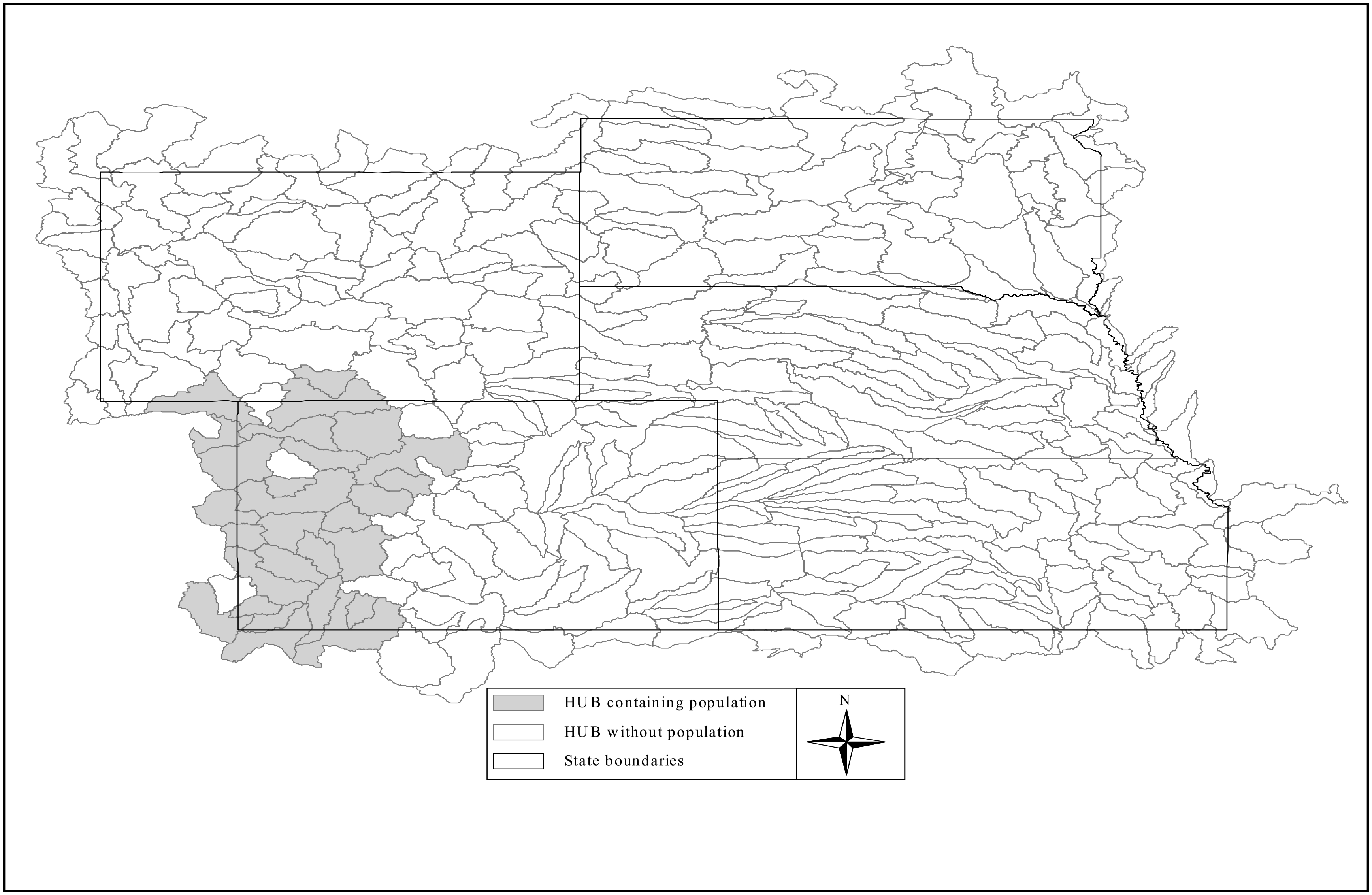

Figure 2. USDA Forest Service Region 2 hydrological unit boundaries (HUB) containing bluehead sucker populations.

a similar program was completed on 116 km (72.1 miles) of the Green River and many of its tributaries from the Colorado-Utah state line in an attempt to eliminate “coarse” fish prior to construction of Flaming Gorge and Fontenell dams (Binns 1967). Pre-treatment surveys indicated that bluehead suckers were abundant in the treatment area while post-treatment surveys showed that populations were completely eliminated. Bluehead suckers recolonized both rivers within a short time, but it is unknown what population-level impact each of these events had on this species.

Dam construction and the associated alterations of the thermal and hydrological regimes have reduced bluehead sucker populations in both the Lower and Upper Colorado River basins (Vanicek et al. 1970). Hypolimnetic releases below impoundments cause a change in the thermal regime in the river downstream, which is usually colder in the summer and warmer in the winter than historic conditions. Vanicek et al. (1970) found that the resulting change in temperature and flow regime created by Flaming Gorge Dam displaced bluehead suckers. Bluehead suckers were absent in the first 11 km (6.8 miles) downstream of Flaming Gorge Dam, but increased with distance downstream of the dam (Vanicek et al. 1970).

Activity pattern

Larvae of bluehead sucker are known to drift for various distances after emerging from the egg stage (Carter et al. 1986, Robinson et al. 1998). Information describing movement patterns of adult bluehead suckers is limited (Bezzerides and Bestgen 2002). Most studies have found this species to be relatively sedentary, moving only a few kilometers (Vanicek 1967, Holden and Crist 1981, Beyers et al. 2001, Rees and Miller 2001). However, Vanicek (1967) and Holden and Crist (1981) reported recapturing individuals more than 19 km (11.8 miles) from the original capture location, but these studies had relatively small sample sizes. Thus, bluehead sucker populations may exhibit both sedentary and mobile activity patterns; further study is warranted to define specific proclivities. Data on the timing and extent of spawning migrations of bluehead sucker are likewise limited. Weitzel (2002) reported bluehead suckers migrating into a creek to spawn in Wyoming.

Habitat

Although this species sometimes occupies areas of suitable habitat in larger, low elevation, mainstem streams, it is most commonly collected in small or mid-sized tributaries of the Upper Colorado River Basin. Most reaches of the basin receive heavy sediment loads, high annual peak flows, and low base flows. Little is known about the influence of these annual events, but healthy bluehead sucker populations have persisted in habitats with a wide range of annual flows, sediment transport and sediment deposition, providing that these physical events are associated with a natural flow regime.

Studies that determine specific habitat use related to diel or seasonal changes are rare; however, several researchers have made observations regarding habitat associations. Adult bluehead suckers exhibit a strong preference for specific habitat types (Holden and Stalnaker 1975). In-stream distribution is often related to the presence of rocky substrate which they prefer (Holden 1973). This species has been reported to typically be found in runs or riffles with rock or gravel substrate (Vanicek 1967, Holden and Stalnaker 1975, Carlson et al. 1979, Sublette et al. 1990). Juveniles have been collected from shallow riffles, backwaters, and eddies with silt or gravel substrate (Vanicek 1967).

Information concerning water quality requirements for bluehead suckers is lacking. Although the species generally inhabits streams with cool temperatures, bluehead suckers have been found inhabiting small creeks with water temperatures as high as 28 ^{o}C (82.4 ^{o}F) (Smith 1966). This species is found in a large variety of river systems ranging from large rivers with discharges of several hundred m^3 per sec to small creeks with less than a 0.05 m^3 per second (1.8 $ft.^3$ per sec) (Smith 1966).

Food habits

Bluehead suckers are omnivorous, benthic foragers with uniquely adapted chisel-like ridges that occur inside the upper and lower lips (Sigler and Miller 1963, Joseph et al. 1977). The ridges allow this fish to scrape algae, benthic insects, and other organic and inorganic material from the surface of rocks (Vanicek 1967, Joseph et al. 1977, Carlson et al. 1979). Although the diet of bluehead sucker changes with age and location, their feeding strategy remains relatively consistent throughout their range. Bluehead sucker larvae (<25 mm [1 inch] total length) drift to backwaters or areas of low velocity where they are known to feed on diatoms, zooplankton, and dipteran larvae (Carter et al. 1986, Muth and Snyder 1995). Juveniles and adults reportedly consume a variety of inorganic material, organic material, and benthic macroinvertebrates (Childs et al. 1998, Osmundson 1999, Brooks et al. 2000). Vanicek (1967) found that gut samples from bluehead suckers from the Green River contained mud, filamentous algae, and Chironomidae larvae. Carlson et al. (1979) reported that gut samples collected from bluehead suckers during August and September in the Yampa River contained mostly periphyton (algae) and a few invertebrates.

It is unknown if bluehead suckers demonstrate an active shift in diet preference due to seasonal or hydrologic regime changes.

Breeding biology

McAda and Wydoski (1983) determined that the majority of male and female bluehead suckers in the Upper Colorado River Basin were sexually mature at total lengths greater than 380 mm (15 inches). In smaller streams, bluehead suckers mature at smaller sizes. McAda and Wydoski (1983) reported that the smallest mature female was 313 mm (12.3 inches) total length; however, Smith (1966) reported mature females as small as 79 mm (3.1 inches) from a small tributary stream in Arizona.

Bluehead suckers spawn in the spring and early summer. Holden (1973) and Andreasen and Barnes (1975) reported spawning activity occurring during June and July in the Upper Colorado River Basin. Vanicek (1967) reported ripe bluehead suckers present in the Green River during June or July, depending on water temperature. All ripe fish that were collected occurred in pools or slow runs associated with large cobble or boulders. Spawning of bluehead suckers was observed by Maddux and Kepner (1988) in Kanab Creek, Arizona on 2 May 1985. They reported that spawning occurred during daylight hours over a "cleaned depression" in gravel substrate with a mean particle diameter of 6.6 mm (0.26 inches). Spawning occurred as one or two males positioned themselves laterally with the female and created a depression by fanning and shuddering of the body and fins, with the female subsequently releasing eggs into the depression. Spawning occurred when water temperatures ranged from 18.2 to 24.6 ^{o}C (64.8 to 76.3 ^{o}F), and water velocities at spawning sites were always between 0.34 and 0.35 m per sec (1.11 and 1.12 ft. per sec) (Maddux and Kepner 1988).

Bluehead suckers are a long-lived species with maximum ages reported over 20 years in the Upper Colorado River Basin (Scoppettone 1988, Minckley 1991). Similar to other sucker species, males comprise a higher proportion of the spawning population than do females. Maddux and Kepner (1988) and Otis (1994) report male to female sex ratios of approximately 2:1.

There is significant variability in the number of eggs produced by the same length reproductive females between rivers ($P = 0.001$) as well as between years in the same river ($P = 0.05$) (McAda 1977). McAda (1977) established relationships between total length and fecundity for the Colorado, Gunnison, and Yampa rivers. His estimates for a 319 mm (12.6 inches) fish ranged from 5,050 eggs for a fish in the Yampa River to 7,761 eggs for a fish in the Colorado River. Comparatively, Smith (1966) estimated that a 319 mm total length female in the Green River contained 8,500 eggs.

Demography

Hybridization between bluehead suckers and other sucker species occurs throughout the range of this species. Bluehead suckers are known to hybridize with the native flannelmouth sucker and mountain sucker, as well as the non-native white sucker (Bezzerides and Bestgen 2002).

In natural or minimally altered systems, certain undefined mechanisms (e.g., depth and velocity requirements, habitat selection, spawning timing) likely isolate spawning individuals of bluehead sucker and flannelmouth sucker; however, hybrids of these two species do occur (Hubbs and Hubbs 1947, Hubbs and Miller 1953, Whiteman 2000, authors' unpublished data). The most common instance of hybridization, and perhaps the most detrimental, occurs with the non-native white sucker. These two species have no natural mechanisms to isolate reproductive individuals, which can lead to an increased occurrence of hybridization. Where sympatric populations of bluehead and white suckers occur, hybridization is likely to occur. However, the reproductive viability of hybrids is unknown, and the overall impact is unclear. Contradictory reports on abundance of hybrids within the same system increase the uncertainty. Holden and Stalnaker (1975) found bluehead and white sucker hybrids to be common in the Yampa River; however, in a later survey Holden and Crist (1981) did not find any of these hybrids within the Yampa River system.

General life history characteristics are reviewed in the Breeding biology section of this document and are not repeated here. The development of a meaningful life cycle diagram for bluehead sucker requires life stage-specific data regarding survival rates, fecundity, and sex ratio. Existing data on bluehead sucker survival rates and fecundity components necessary to construct a life cycle diagram are sparse, especially data specific to bluehead populations occurring in smaller tributary streams. We include the following life cycle description as illustration of the data needed to refine the model (**Figure 3**).

Input data needed for a population projection matrix model consist of age-specific survival and fecundity rates, and very little data of this type are available for the bluehead sucker. We used bluehead sucker data from McAda (1977) to provide average adult fecundity estimates. Length at age is highly variable for bluehead suckers, and therefore we chose to use an average fecundity for all adult ages. We are unaware of age-specific survival rate information for bluehead suckers. We constructed a simple life table to provide estimates for survival rates. Gender specific survival rates or fertility rates of bluehead sucker have not been reported. To provide some information on survival and population dynamics, we have used a general survival rate for both males and females. The value for eggs per mature female is an estimate for an approximately 400 mm (15.7 inches) total length female. This data was calculated from regression equations presented in McAda (1977). The annual survival rates (**Figure 3**, **Table 1**) provide longevity of the species to over age 20. Bluehead sucker populations likely have variable survival rates, depending on the flow regime and water quality characteristics at the time of spawning. Long-lived species such as bluehead suckers would not require high recruitment success of individuals each year. Typical of many long-lived fish species, the bluehead sucker likely has a high mortality rate from egg through age 1, followed by decreasing mortality rate and probably fairly constant mortality rates for adult fish. This life history trait would provide large cohorts with which to infuse the population in years when conditions were optimal for spawning. This pulse of young bluehead suckers would provide a strong cohort that would replenish or augment the adult population until the next period of favorable spawning conditions. Spawning and recruitment likely takes place each year but with a very high rate of variability and overall success dependent on fluctuating environmental conditions.

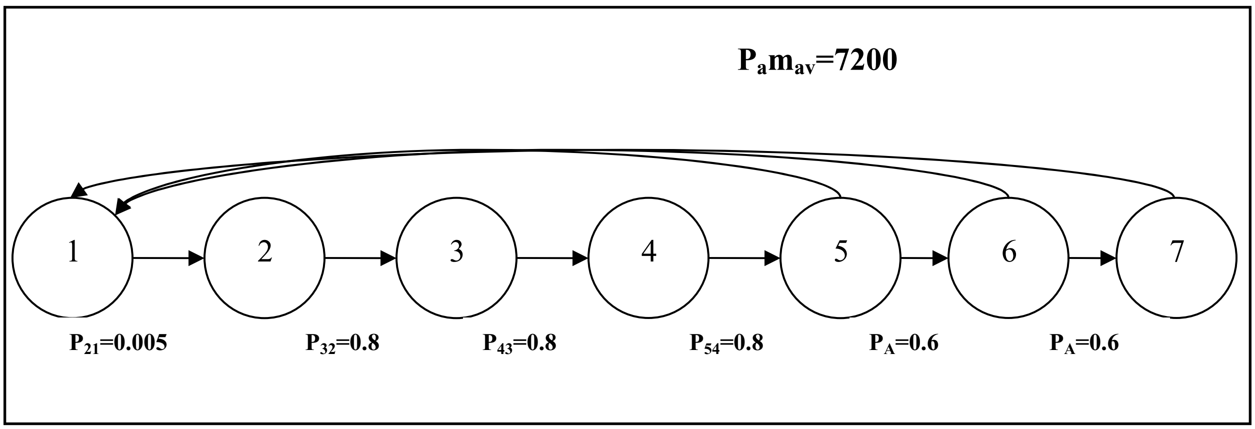

Figure 3. Life cycle graph for bluehead sucker showing both the symbolic and numeric values for the vital rates. The circles denote the 7+ age classes in the life cycle, first year through adult females. Arrows denote survival rates. Survival and fertility rates provide the transition between age classes. Fertilities involve offspring production, mi, number of female eggs per female as well as survival of the female spawners.

Table 1. Parameter values for the component terms (Pi and mi) that make up the vital rates in the projection matrix for bluehead sucker. Fecundity was estimated from data presented in McAda (1977).

Parameter	Numeric value	Interpretation
P_{21}	0.005	First year survival rate
P_{32}	0.80	Survival from 2nd to 3rd year
P_{43}	0.80	Survival from 3rd to 4th year
P_{54}	0.80	Survival from 4th to 5th year
P_a	0.60	Survival for adults
m_{av}	12000	Average fecundity for mature females

Community ecology

Historically, the bluehead, flannelmouth, and razorback suckers comprised the medium to large size Catostomid population in the Upper Colorado River Basin. Currently, distribution and abundance of bluehead suckers have diminished (Bezzerides and Bestgen 2002). Dams and diversions that isolate small populations in headwater reaches are the principal cause for reduction of the bluehead sucker's range. This species has been eliminated from areas inundated by reservoirs, and upstream migration has been blocked by dams. Fragmentation of populations may lead to a decrease in genetic diversity in isolated populations and a higher risk of extirpation of isolated populations due to catastrophic events. Reduction of bluehead sucker range and abundance has also been attributed in part to interactions with non-native species, changes in flow regime, increases in fine sediment loads, reductions in backwater and flooded habitats, and other types of habitat alteration (i.e., channelization).

The introduced white sucker and channel catfish (*Ictalurus punctatus*) have diets that partially overlap with bluehead sucker and are thus competitors for food resources. In addition to competing with bluehead suckers, several non-native and native fishes prey on bluehead suckers. Tyus and Beard (1990) and Nesler (1995) documented northern pike (*Esox lucius*) predation on bluehead sucker in the Yampa River, Colorado; however, the proportion of bluehead suckers in the diet of northern pike was relatively minor in both studies. It is also possible that bluehead suckers are taken as prey where they occur sympatrically with nonnative piscivors. These include brown trout (*Salmo trutta*), rainbow trout (*Oncorynchis mykiss*), red shiner (*Cyprinella lutrensis*), channel catfish, and smallmouth bass (*Micropterus dolomieu*). Predation on native suckers has been documented in the San Juan River, New Mexico and Yampa and Green rivers, Colorado (Brooks et al. 2000, Ruppert et al. 1993).

Young bluehead suckers are used as a forage fish by several native piscivorous species, including roundtail chub (*Gila robusta*) and Colorado pikeminnow. Populations of bluehead suckers often occur in smaller streams and at higher elevations than are inhabited by Colorado pikeminnow, which are restricted to larger river systems such as the Colorado, Green, Yampa, White, and Gunnison rivers. Consequently, in the small tributary streams, bluehead sucker populations are not a prey source for Colorado pikeminnow (Joseph et al. 1977); however, when these two species occur sympatrically, bluehead suckers are likely an important prey item.

Little is known about the impact of disease and parasites on bluehead sucker populations. Landye et al. (1999) surveyed the occurrence of parasites on bluehead suckers in the San Juan River from 1992 to 1999. Asian tapeworm (*Bothriocephalus acheilognathi*) and anchor worm (*Lernia*) were found in the system, but neither was found to infect bluehead suckers (Landye et al. 1999). Bluehead suckers were found to have a much lower rate of disease than flannelmouth suckers. The parasites, *Trichodina* and *Gyrodactylus*, were found to infect bluehead suckers in the San Juan River (Landye et al. 1999). Brienholt and Heckmann (1980) found that over 92 percent of the bluehead suckers from two Utah creeks were infected with parasites. Parasites and disease can adversely affect fish health; however, the extent of the impact and role in bluehead sucker mortality is unknown.

The bluehead sucker is an integral component of the aquatic ecosystem. Bluehead suckers provide an important link to the conversion of periphyton and algal communities into energy available to higher trophic levels. They possess a morphological adaptation (cartilaginous ridge) not found in other native and non-native sucker species within the majority of its range.

An envirogram for bluehead suckers was developed to help elucidate the relationships between land use practices/management and bluehead sucker population characteristics (**Figure 4**). In general, the usefulness of an envirogram is the visual representation of linkages between bluehead sucker life history parameters and environmental and biological factors affecting them. Those elements that directly affect the bluehead sucker are depicted in the envirogram by the centrum, which is further separated into resources, predators, and malentities. Resources elicit positive responses in bluehead suckers whereas predators and malentities produce either negative or neutral responses. Web levels illustrate factors that modify elements within the centrum or within the next lower web level. Andrewartha and Birch (1984) provide further detail into the specific description of all envirogram components. The relative importance of the linkages is poorly understood and warrants further study.

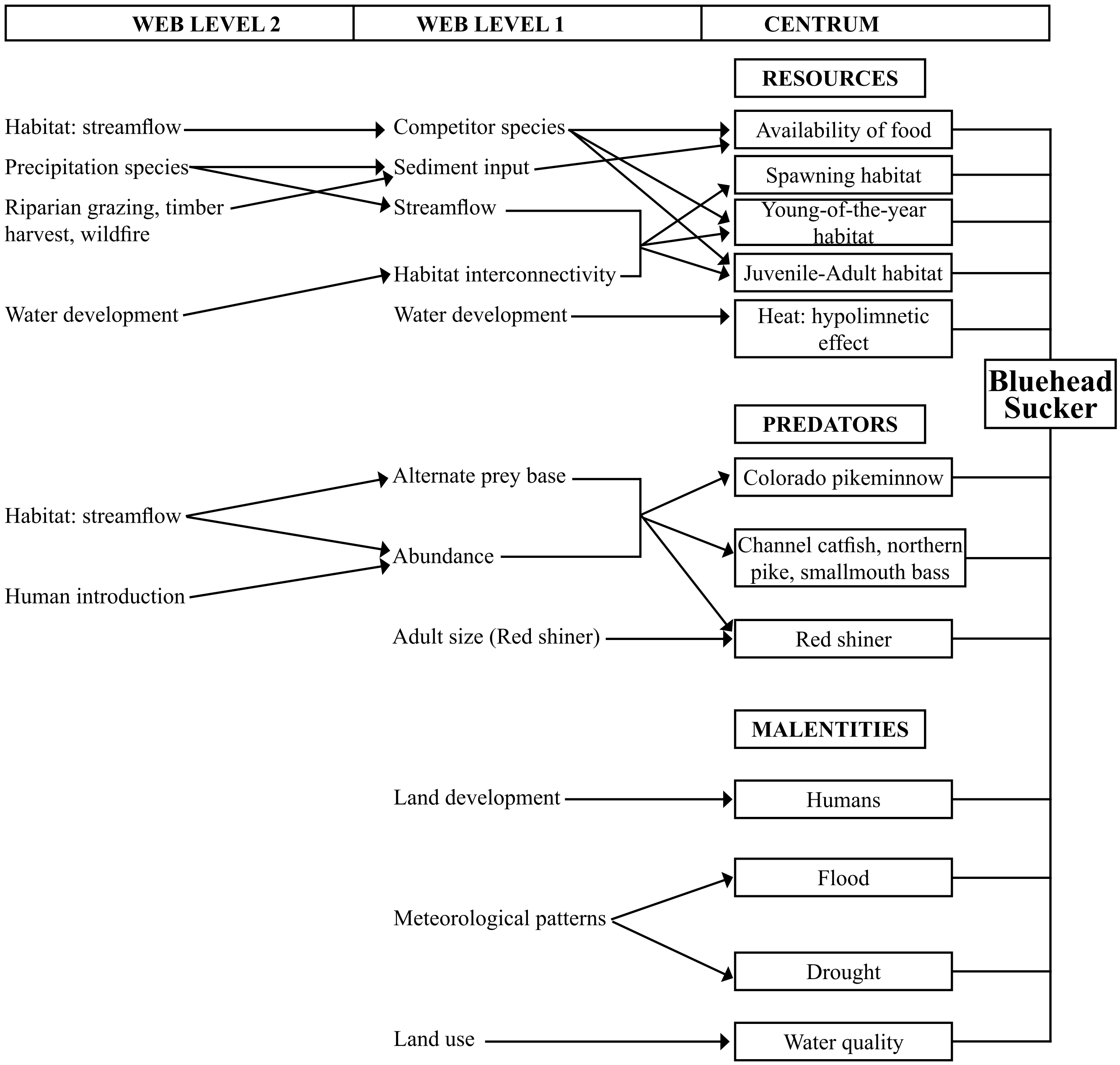

Figure 4. Envirogram for the bluehead sucker.

Conservation

Threats

The native fish community that evolved in the warm-water reaches of the Upper Colorado River Basin has been greatly reduced as a result of human activities during the last century. Bluehead sucker populations have suffered reductions in abundance and distribution from the same mechanisms that have caused the extirpation and near extinction of other endemic fish species in this drainage. These mechanisms can be separated into two general categories that encompass the majority of the threats to the current and future survival of bluehead sucker: 1) habitat degradation through loss, modification, and/or fragmentation and 2) interactions with non-native species.

Both of these threats imperil the long-term persistence of the bluehead sucker. Each may work independently or in conjunction with the other to create an environment where populations may be reduced or eliminated. The relative importance of each threat and the specific cause-effect relationship usually depend on location. The complexity of each threat requires further explanation.

Effects of habitat degradation may not be limited to localized areas but may cascade through the system. Therefore, activities or events occurring on forest lands may possibly have detrimental impacts on populations of bluehead suckers existing in rivers many kilometers downstream of National Forest System lands.

Habitat loss typically occurs when streams are dewatered or when reservoir construction inundates suitable bluehead sucker stream habitat. Habitat modification occurs when the natural flow regime is altered, and when stream channels are modified due to channelization, scouring, or sedimentation from land use practices. Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, and overgrazing of riparian areas. These can all lead to increased sediment load in the system and a subsequent change in stream channel geometry (e.g., widening, incision). These modifications alter width: depth ratios, pool:riffle ratios, and other aspects such as pool depth that affect the quality of habitat occupied by bluehead suckers.

The effect of wildfire has little direct impact on quality of habitat; however, post-fire conditions can affect downstream populations. Input of large quantities of sediment into streams frequently occurs during storm events at recently burned areas. The increased sediment load can diminish suitable spawning habitat, smother eggs and larvae, reduce fitness of juvenile and adults through reduction of the prey base, and cause direct mortality through suffocation of all life stages.

Habitat fragmentation is often a result of dewatering, but it also results from the creation of barriers to fish passage such as dams and diversions. Large and small-scale water development projects can profoundly impact the persistence of the bluehead sucker. Irrigation diversions and small capacity irrigation reservoirs reduce streamflow, alter the natural hydrograph, and provide barriers to migration and normal population exchange. Barriers that preclude fish passage can cause population fragmentation and completely prevent or significantly reduce genetic exchange between populations. The fragmented populations in some areas remain viable and maintain population levels at the same density as they were before fragmentation occurred. This typically occurs in the larger mainstem river sections. In smaller rivers and tributaries to the mainstem, habitat fragmentation can eventually lead to habitat loss and extirpation of populations. As habitat is fragmented and populations are isolated, the probability that "bottlenecks" will occur in the life history of the bluehead sucker become more pronounced, and single catastrophic events may extirpate populations from entire drainages.

Habitat modification contains aspects already discussed under fragmentation and degradation but also includes changes in temperature and flow regimes, as well as alterations to water chemistry related to pollution. Severely reduced streamflows may lead to increased water temperatures and reduced dissolved oxygen levels, especially in smaller tributaries, especially those with degraded riparian habitat. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is altered from the natural unimpacted range, bluehead sucker fitness also declines. During periods of elevated summer water temperatures and decreased baseflows, bluehead suckers were observed in stressed condition with evidence of increased adult mortality compared to periods of normal summer temperatures and baseflows (author's personal observation).

Water developments, road construction, timber harvest, and grazing of riparian areas are likely to continue to impact bluehead sucker habitat in the future. Modification of land use management techniques to decrease the impact to bluehead sucker habitat may lessen the anthropogenic threats to this species, however, it is unlikely that all impacts or threats could be minimized or halted. Modifications of land use management techniques include the specification of fish passage at new or existing low-head diversions to eliminate or reduce habitat loss and fragmentation, specification of minimum flow regimes to promote habitat connectivity, and maintenance of baseflow habitat during summer or irrigation seasons. Other practices include specifications for buffer zones for both road construction and timber harvest, and managing grazing practices in riparian areas to promote healthy vegetative development and to reduce sedimentation from upland areas.

Interaction with non-native species is another threat to bluehead sucker population health and viability. Non-native species prey upon, compete with, and hybridize with bluehead suckers when found sympatrically. Many introduced species tend to be well-adapted to a variety of environmental conditions, allowing a competitive advantage. Without fish passage barriers, the introduction of non-native fish into stream reaches that do not contain bluehead suckers often results in the uncontrollable dispersal of these fishes into stream reaches containing bluehead suckers.

All life stages of the introduced white sucker, due to similar life history traits, have a competitive impact on bluehead sucker populations. However, perhaps the most serious threat imposed by the introduction of white suckers is perhaps hybridization. These two species appear to lack any significant mechanism to isolate reproductive individuals, and distribution and abundance of white suckers are increasing within the Upper Colorado River Basin. Further treatment of hybridization can be found in the Demography section.

The bluehead sucker is likely a desirable prey item for some non-native species. Large, non-native predators (e.g., northern pike, channel catfish, smallmouth bass) occur in many of the drainages that contain bluehead suckers. In addition, red shiners have been reported to feed on native larval fish within the Upper Colorado River Basin. Preferred habitat for red shiners is slack water shoreline or backwater areas, which are the same habitats utilized by larval bluehead suckers (Holden 1999).

The current distribution and the historical range-wide distribution of bluehead sucker indicate that few populations occurred on USFS lands. In fact, many sucker populations in the mainstem rivers likely occurred downstream of current Region 2 lands. The proximity to Region 2 lands and the effects of some of the threats such as increased sedimentation from grazing, timber practices, and road construction could impact the downstream populations. Fragmentation of populations or habitat loss may exist as barriers to migration occurring on occupied USFS land stream reaches (i.e., impassable water diversion or road crossing structures). Both of those threats could be eliminated by designing fish passage inclusive with construction of diversions and proper sizing of road crossings for culverts or bridges to allow natural passage conditions.

Conservation Status of the Bluehead Sucker in Region 2

At present, there is concern regarding the status of bluehead suckers in the Colorado River Basin. Although the specific mechanisms of most threats to this species are poorly understood, the species appears to be vulnerable throughout its range in the Upper Colorado River Basin due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native species. A decrease in bluehead sucker populations has been documented or suggested throughout most of the basin (Bezzerides and Bestgen 2002).

Healthy populations of bluehead sucker still exist in various locations in the Upper Colorado River Basin (e.g., Colorado, Green, Yampa, San Juan rivers). These locations are usually defined by suitable habitat (as specified in the Habitat section of this report), and natural temperature and flow regimes. They often maintain healthy populations of other native fish species as well.

The bluehead sucker evolved in a system with a high natural disturbance regime. This disturbance regime included a large contrast between annual peak flows and base flows, and considerable sediment transport. Life history attributes and population dynamics allowed this species to persist during (or recolonize after) a disturbance event; however, modifications to the physical (habitat loss, fragmentation, refugia) and biological environment (non-native species) have reduced the ability to recover after such an event. Habitat fragmentation through streamflow reduction, passage barriers, and habitat degradation disconnects populations of bluehead suckers. Competition, predation, and hybridization associated with non-native species can depress bluehead sucker populations to precarious levels.

Based on the impacts to bluehead sucker populations and distribution that have occurred in the last century, the potential for future declines in distribution and abundance is high. Unless alleviated, habitat loss, habitat degradation, habitat fragmentation, and non-native species interactions will likely intensify and jeopardize the existence of the bluehead sucker.

Potential Management of the Bluehead Sucker in Region 2

Implications and potential conservation elements

Management of the bluehead sucker is based on an understanding of specific threats to the species. Habitat loss, degradation, and fragmentation due to land and water use practices are prime threats to bluehead sucker persistence in the Upper Colorado River Basin. Reduction of streamflows and creation of barriers to fish passage can severely degrade habitat to the extent that bluehead sucker populations are extirpated from the area. The degree of influence that population fragmentation has on bluehead sucker populations is speculative, but it could potentially impact the long-term persistence of this species. Creating isolated populations disrupts the natural exchange of genetic material between populations. Isolated populations are subject to extinction due to catastrophic events because of the impediment to recolonization from other nearby populations. Loss of genetic diversity can also lead to depression of fecundity and survival rates. The genetic exchange along a metapopulation framework within bluehead sucker distribution can provide the required demographic variability and viability.

Other considerations for conservation elements should include protection of riparian areas, minimization of sediment input due to anthropogenic causes (e.g., road building, timber harvest), and management of non-native fish species. Construction associated with road improvements or development, timber harvesting, grazing, and fire activity can result in increased sediment loads to adjacent streams. It is likely that increased sediment loads or sediment deposition could have a negative impact on bluehead sucker populations; however, specific thresholds and mechanisms associated with this impact have not been studied well enough to make precise predictions.

Management of non-native fish species requires strict adherence to existing regulations regarding live release of fish. Interactions between bluehead sucker and non-native fish species threaten bluehead sucker populations. Specifically, competition between bluehead sucker and introduced sucker species and predation by large non-native predatory species represent the two most deleterious effects of non-native interaction. Implementation of management strategies should be designed to restrain further expansion of nonnative fish distribution on National Forest System lands. These strategies should include strict enforcement of existing prohibitions regarding the release of non-native fish. Programs for the eradication of non-native fish in streams and within the historical range of bluehead sucker may also be considered.

The preservation of stream flows that are adequate to maintain complex habitat, interconnectivity of habitats, and instream cover should be a focal point of management policy or strategy. Conservation elements should address the function of the entire aquatic and riparian ecosystem, with particular attention to downstream populations. Any future plans for the conservation of bluehead suckers should take into account the entire native fish assemblage in the Colorado River Basin. This assemblage of species evolved in a system with a high differential between peak spring runoff and fall base flows. Native fish species of the Colorado River all require similar management considerations related to channel maintenance and restoration of historical flow regimes.

Tools and practices

The following review describes specific tools and techniques employed in the collection of bluehead sucker data. We are unaware of any management approaches implemented specifically for bluehead suckers in Region 2. Because little information exists or is being currently collected regarding this species, this portion will deal with techniques intended to gather the missing or needed information from the next section, Information Needs.

The absence of distribution and abundance data for bluehead sucker in Region 2 (with emphasis toward National Forest System land) should be a concern to forest managers. Because the bluehead sucker is a benthic fish often found in riffle areas, the use of electrofishing as a means to determine distribution and abundance is warranted. The initial priority should be a complete survey of National Forest System streams that possibly contain bluehead suckers. The compilation of all available (agency, academia, private) distribution data into a comprehensive database would provide a foundation to which further surveys could update and identify unknown populations. Concurrently with distribution surveys, general stream reach habitat surveys should be collected to provide additional information regarding the habitat use of bluehead suckers. Winters and Gallagher (1997) developed a basin-wide habitat inventory protocol that would be a cost-effective tool to collect general habitat data.

Once basic distribution information has been gathered, intensive population estimates would provide baseline information with which the effectiveness of future management strategies could be evaluated. Focus should be on areas where future management strategies may include activities that could possibly impact bluehead sucker populations. However, the long-term monitoring goal should be population estimates and population trend data on all streams containing bluehead sucker populations on Region 2 lands. Consultation with agencies managing populations off USFS lands but which are affected by forest practices is imperative to allow forest managers to continually monitor the status of those populations. Electrofishing techniques that would provide population estimates include mark/recapture and multiple pass removal estimates. Each has its advantages; however, due to the smaller size of many streams on National Forest System lands, estimating populations using a depletion/removal technique should be a cost effective method to produce high quality data. Riley and Fausch (1992) recommend that a minimum of three passes be conducted when using the removal method. Use of a single pass method to develop a catch per unit of effort (CPUE) index is cost-effective on a time basis, but precision may be sacrificed and the introduction of bias more likely, especially over long-term monitoring with significant researcher/technician turnover. With removal estimates, researchers are able to calculate confidence intervals, allowing insight into sampling quality.

A large data gap exists in the knowledge of bluehead sucker movement and stream use on National Forest System lands. The implementation of a survey methodology to determine bluehead sucker distribution and abundance can also provide insight into movement and growth through the use of passive integrated transponder (PIT) tags. PIT tags are unobtrusive, long lasting (indefinitely), uniquely coded tags that allow the efficient determination of movement with a minimum of disturbance. Other marking techniques (e.g., floy tags) lack the longevity of tag retention provided with a PIT tag. However, any marking technique used will require subsequent surveys to provide data. PIT tags are currently being used successfully in the San Juan River to determine growth and movement of native sucker species. Establishment of a long-term monitoring program would be required. The time required to develop a robust data set depends upon sample size, recapture rates, and survey frequency.

Habitat selection and preference can be determined through the use of a variety of techniques. The simplest technique involves correlating capture locations (during distribution surveys) to specific habitat types. Construction of habitat suitability curves is time intensive but could be used in conjunction with hydraulic modeling methodologies to estimate how habitat changes in relation to streamflow. This would allow land use managers to effectively compare the impacts of different altered flow regimes (due to water development projects) on bluehead sucker habitat. Data obtained could also be used to justify the acquisition of adequate instream flows for bluehead suckers and other native fishes.

Defining the relationship between habitat alteration and bluehead sucker population characteristics will be a difficult task. This process may require significant amounts of data, including:

- ❖ quantitative analysis of differences in prey base over time
- ❖ measurement of changes in habitat quality/function
- ❖ some form of abundance estimates.

In addition to collecting data specifically related to the distribution and life history of bluehead suckers, forest managers can implement techniques that will increase the quality of habitat and ensure that barriers do not fragment populations.

A healthy riparian corridor is important to overall aquatic ecosystem function. Forest managers can address minor riparian issues by altering the grazing rotation or by fencing riparian areas. In areas with severely degraded riparian growth, revegetation of the riparian area may also be prudent. Other tools and techniques to improve habitat condition and function could include physical habitat restoration. This technique can be costly and time-intensive and may only be practical when other options (i.e., preventing grazing, revegetation) fail or become infeasible.

In addition to proper future design of stream culverts that when improperly constructed can act as fish passage barriers, managers should inventory and assess the threat of all potential barriers currently in place. Barriers located within the bluehead sucker range (as defined by distributional surveys) on national forests should receive priority and, when possible, be removed.

The mechanical removal of non-native fish is currently being conducted in larger streams and rivers within the Upper Colorado River Basin, which contain bluehead sucker populations. The effectiveness of this technique to significantly reduce non-native populations is not clearly understood. Mechanical removal is likely most effectively utilized before non-native populations become well established.

In order to effectively gather data valuable to the conservation of this species, managers need to coordinate with federal and state agencies, academia, and private firms managing or studying portions of streams downstream of USFS lands to determine or verify the distribution and abundance of bluehead sucker populations existing elsewhere but that are still affected by USFS management policies and strategies.

Information Needs

Much of the information that has been collected regarding the bluehead sucker has been presented as a byproduct of studies that were designed to learn more about federally listed fish in the Colorado River Basin. In order to attain the level of understanding that is necessary to properly manage this species at a localized level, specific studies must be conducted by drainage. General information needs for bluehead sucker include a wide range of information:

- distribution
- habitat requirements and associations
- general attributes of life history and ecology
- movement patterns
- influence of non-native fish
- an understanding of human-induced habitat modification.

The current distribution of bluehead sucker on National Forest System lands in Region 2 is poorly understood. Specific knowledge of streams and watersheds containing bluehead sucker on USFS lands is essential prior to developing any regional management strategies designed to preserve this species. Basic knowledge regarding locations of specific bluehead sucker populations is inadequate or obsolete. A research priority should be to survey all streams with potential bluehead sucker habitat for the presence of this species. Initial focus should be on streams with suspected populations or known populations downstream of USFS lands. During these surveys, information regarding the physical and chemical characteristics of the habitat should be obtained. Data collected should include chemical (e.g., dissolved oxygen, pollutants, water temperature) and physical (e.g., elevation, discharge, depth, turbidity, substrate, habitat type) characteristics. This information will provide baseline data regarding habitat requirements and acceptable ranges for each physical parameter. Fish that are collected should be tagged with PIT tags to allow studies of movement, migration, and growth rates during continued monitoring.

In addition to general distribution and abundance information, additional data on seasonal distribution are required. Bluehead sucker may not establish resident populations in National Forest System streams, but these tributaries may in fact provide important spawning habitat. The available data on habitat use emphasizes large river systems, and few studies have been conducted on smaller tributary systems. It is unknown whether bluehead sucker life history traits are uniform between large river and small tributary systems. Temporal and spatial changes in abundance, distribution, and age structure should be documented prior to implementation of conservation strategies.

A data gap exists in basic life history information for the bluehead sucker. Habitat requirements and preferences are poorly understood for most life stages and life history events. Specific studies need to be designed to provide information on spawning behavior and habitat, larval biology, and the importance of larval drift. Habitat requirements and feeding habits at each life stage should also be addressed. Monitoring of tagged fish will also provide an estimate of survival rate that is a necessary component for the creation of a life cycle diagram. It may be important to collect data from several sub-basins because much of the specific life history information may vary by drainage.

In order to better understand the community ecology of the bluehead sucker, future studies should include inventory and monitoring of all fish (adult, juvenile, and larvae), macroinvertebrates, and periphyton taxa in the streams where the bluehead sucker occurs. Stomach content analysis at various life stages will allow for a better understanding of bluehead sucker feeding habits. Diet studies on sympatric fish populations need to be conducted to determine potential competition and to understand the impact of introduced and native predators on bluehead sucker populations.

Genetic testing during future studies on bluehead sucker populations is important. Tissue samples (e.g., plugs, fin clips) should be taken for analysis of genetic structure from fish from mainstem and isolated populations. Genetic characterization would allow long-term investigation of population connectivity, migration, population diversity, viability of isolated populations, and the extent and effects of hybridization with native or introduced sucker species.

In order to ensure the long-term conservation of this species, research must examine techniques to minimize the impact of impoundments on flow regimes, temperature regimes, and movement of native fish. This research should focus on the modification of existing impoundments, providing guidelines for construction of future impoundments, and exploring the use of off-channel impoundments. Specific scientific evidence relating the mechanisms in which habitat degradation links to bluehead sucker population attributes is missing. Investigating the impacts of land use management (e.g., grazing, road construction, culverts) on bluehead suckers is warranted. The development of a process-response model would further identify bluehead sucker life history components that are not adequately understood.

Essential to the long-term persistence of the bluehead sucker is the collection, analysis, and understanding of data relating to the distribution, life history, and impacts of threats to this species. Initially, determining the distribution and abundance of bluehead suckers on USFS lands is imperative to establishing baseline information from which future sampling can then be prioritized. Long-term monitoring of bluehead sucker abundance and distribution will establish a foundation of data to determine population and distributional trends. Short-term studies (e.g., diet analysis, habitat selection, movement) can be completed concurrently with long-term monitoring and will expand basic knowledge of bluehead sucker life history traits on USFS lands. Studies specifically designed to evaluate the impact of riparian grazing, road construction, passage barriers, and non-native species interactions are also imperative to preserving this species.

DEFINITIONS

Centrum – any component that directly affects the central organism.

Endemic – a species that is confined to a particular geographic region.

Habitat quality – the physical characteristics of the environment (e.g., soil characteristics for plans or channel morphology for fish) that influence the fitness of individuals. This is distinguished from habitat quantity which refers to spatial extent.

Hybridization – the production of offspring by crossing two individuals of unlike genetic constitution.

Malentities – all components other than predators that directly affect the central organism and cause a negative response.

Metapopulation – a fish population defined by its expansive presence in accessible habitat whereby its needs for sustainability are met through diversity of habitats, corridors for movement, and interconnection.

Process-response model – either a conceptual or mechanistic model used to portray the biological response of a species to physical factors.

Scale – the physical or temporal dimension of an object or process (e.g., size, duration, frequency). In this context, extent defines the overall area covered by a study or analysis and grain defines the size of individual units of observation (sample units).

Species viability – used in a most general way throughout the document and outlines. In general, the term refers to the probability of persistence for a species over some specified temporal scale. Throughout this document, the term ‘population’ could be substituted for ‘species’. Because biologists can identify (as in name) and define ‘species’ more easily than populations, that term is used here. However, the dynamics of persistence take place at the level of the population (Wells and Richmond 1995), and the National Forest Management Act focuses on populations. Therefore, our process targets species populations and species.

Viability – a focus of the Species Conservation Project. Viability and persistence are used to represent the probability of continued existence rather than a binary variable (viable vs. not viable). We note this because of the difficulty in referring to ‘probability of persistence’ throughout the manuscript.

Web Level 1 – any component that affects the centrum.

Web Level 2 – any component that affects Web Level 1.

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Flannelmouth Sucker (*Catostomus latipinnis*): A Technical Conservation Assessment

Prepared for the USDA Forest Service, Rocky Mountain Region, Species Conservation Project

April 6, 2005

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COVER PHOTO CREDIT

Flannelmouth sucker (*Catostomus latipinnis*). © Joseph Tomelleri.

SUMMARY OF KEY COMPONENTS FOR CONSERVATION OF THE FLANNELMOUTH SUCKER

Status

The flannelmouth sucker (*Catostomus latipinnis*) is considered a sensitive species in USDA Forest Service (USFS), Rocky Mountain Region (Region 2). Flannelmouth sucker are endemic to the Colorado River Basin. Within Region 2, there are populations in western Colorado and south-central Wyoming, but few of these populations are located on USFS lands.

Primary Threats

The primary threats to the flannelmouth sucker are generally human-induced activities that divert water and change the flow regime in both tributary and mainstem streams. Specific threats include (a) construction of passage barriers (e.g., diversion dams and reservoirs) that disconnect habitats and cause habitat fragmentation and (b) introduction of non-native species that are both predators on and competitors with the flannelmouth sucker. Other threats include modification of streambeds through channelization, landscape changes resulting from land use, and local degradation of riparian zones that reduces the natural function of the stream ecosystem. Detailed information concerning the distribution, life history, population trends, and community ecology for this species is relatively limited. Specific local and regional information must be obtained prior to the development of management actions. Currently, management implications can be based only on the limited information regarding this species, which typically originates from outside the National Forest System.

Primary Conservation Elements, Management Implications and Considerations

The general lack of information for this species suggests that management should begin with a detailed survey of each drainage on USFS land that could potentially hold populations of flannelmouth sucker. This effort should be coordinated with relevant agencies (i.e., state game and fish departments, Bureau of Land Management, U.S. Fish and Wildlife Service) to obtain information concerning stream reaches that are off National Forest System land, yet may be influenced by USFS management activities. Flannelmouth sucker, like other endemic species in the Colorado River Basin, have not been well-studied until recent years. Those studies currently being undertaken are in conjunction with recovery efforts for the listed endangered fish in the Colorado River Basin. The information for other native nongame species, like the flannelmouth sucker, is only incidental to those primary studies. The USFS could use this information on habitats and populations to coordinate management activities on National Forest System lands in Region 2. Given the known threats to this species, conservation measures should concentrate on maintaining aquatic habitat diversity and natural temperature and flow regimes in stream reaches with existing and adjacent flannelmouth sucker populations.

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EDITOR: Richard Vacirca, USDA Forest Service, Rocky Mountain Region

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INTRODUCTION

This assessment is one of many being produced to support the Species Conservation Project for the USDA Forest Service (USFS), Rocky Mountain Region (Region 2), which encompasses the national forests and grasslands in Wyoming, Colorado, Kansas, Nebraska, and South Dakota (**Figure 1**). The flannelmouth sucker is the focus of this assessment because it is a sensitive species in Region 2. Within the National Forest System, a sensitive species is a plant or animal whose population viability is identified as a concern by a Regional Forester because of substantial current or predicted downward trends in abundance and/or habitat capability that would reduce its distribution (FSM 2670.5 (19)). A sensitive species requires special management, so knowledge of its biology and ecology is critical. This assessment addresses the biology and ecology of flannelmouth sucker throughout its range in Region 2. This introduction defines the goal of the assessment, outlines its scope, and describes the process used in its production.

Goal

Species conservation assessments produced as part of the Species Conservation Project are designed to provide forest managers, research biologists, and the public with a thorough discussion of the biology, ecology, conservation status, and management of certain species based on available scientific knowledge. The assessment goals limit the scope of the work to critical summaries of scientific knowledge, discussion of broad implications of that knowledge, and outlines of information needs. The assessment does not seek to develop specific management recommendations. Rather, it provides the ecological background upon which management must be based and focuses on the consequences of environmental changes that result from management (i.e., management implications). Furthermore, this assessment cites management recommendations proposed elsewhere and examines the success of those recommendations that have been implemented.

Scope

This assessment examines the biology, ecology, conservation status, and management of the flannelmouth sucker with focus on the geography and ecology of USFS Region 2. Although some of the literature on the species originates from field investigations outside the region, this document places that literature in the ecological and social context of the central Rocky Mountains. This assessment is concerned with reproductive behavior, population dynamics, and other characteristics of flannelmouth sucker in the context of the current environment rather than under historical conditions 200, 2000, or 2 million years ago. The evolutionary environment of the species is considered in conducting the synthesis, but placed in a current context.

In producing the assessment, we reviewed refereed literature and non-refereed publications, research reports, and data accumulated by resource management agencies. Not all publications on flannelmouth sucker are referenced in the assessment, nor were all published materials considered equally reliable. The assessment emphasizes refereed literature because this is the accepted standard in science. However, when information was unavailable elsewhere, we chose to use grey literature, but this was regarded with greater skepticism than refereed literature. Unpublished data (e.g., Natural Heritage Program records) were important in estimating the geographic distribution of this species, but these data required special attention because of the diversity of persons and methods used in collection.

Treatment of Uncertainty

Science represents a rigorous, systematic approach to obtaining knowledge. Competing ideas regarding how the world works are measured against observations. However, because our descriptions of the world are always incomplete and our observations are limited, science focuses on approaches for dealing with uncertainty. A commonly accepted approach to this uncertainty is based on a progression of critical experiments to develop strong inference (Platt 1964). However, strong inference, as described by Platt, suggests that experiments will produce clean results (Hillborn and Mangel 1997), as may be observed in certain physical sciences. Ecological science, however, is more similar to geology than physics because of the difficulty in conducting critical experiments and the reliance on observation, inference, good thinking, and models to guide our understanding of the world (Hillborn and Mangel 1997). The geologist T. C. Chamberlain (1897) suggested an alternative approach to science where multiple competing hypotheses are confronted with observation and data. Sorting among alternatives may be accomplished using a variety of scientific tools (e.g., experiments, modeling, logical inference). A problem with using the approach outlined in both Chamberlain (1897) and Platt (1964) is that there is a tendency among scientists to resist change from a common paradigm. Treatment of uncertainty

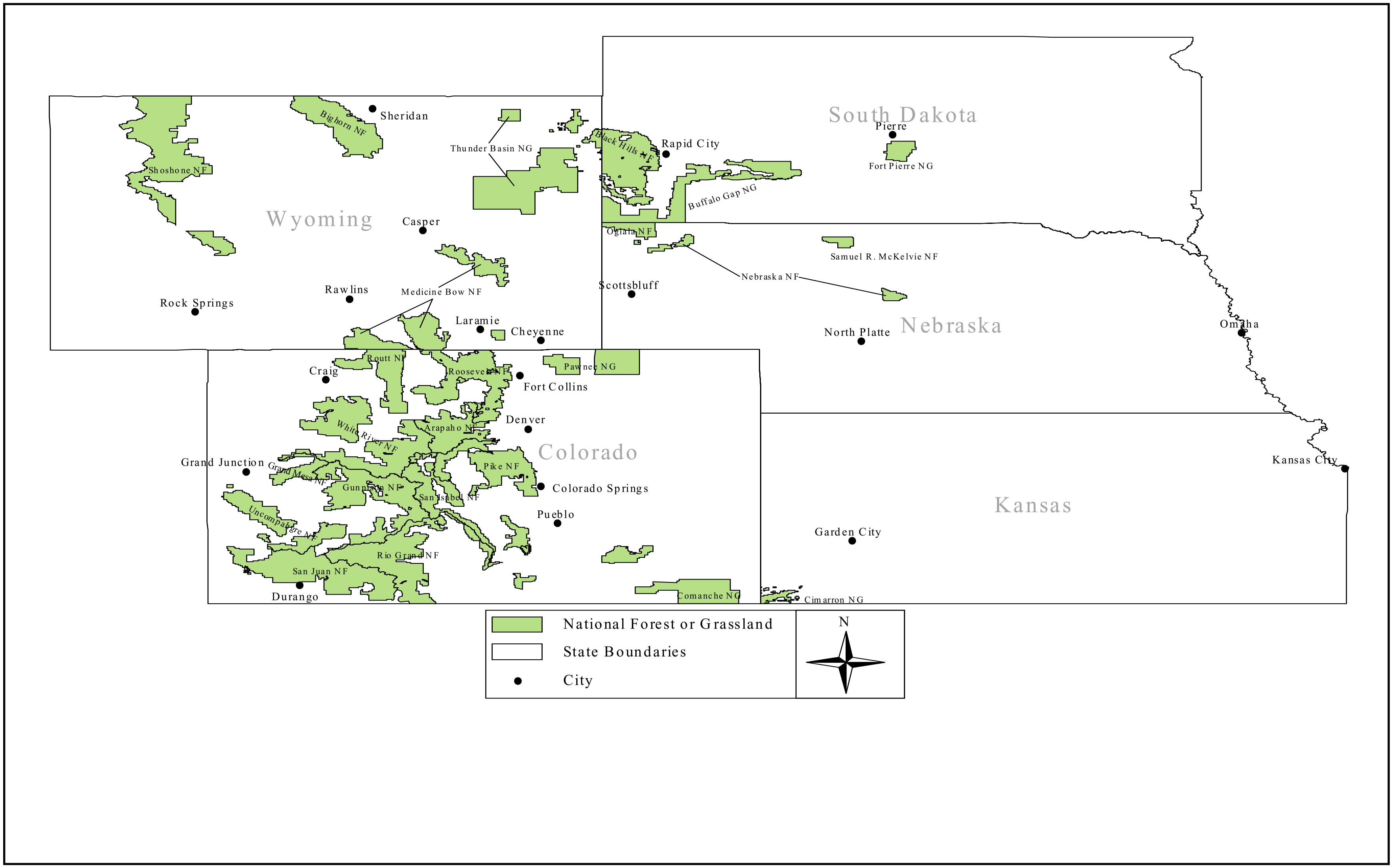

Figure 1. USDA Forest Service Region 2 national forests and grasslands.

necessitates that a wide variety of hypotheses or experiments be undertaken to test both the true or false nature of the uncertainties at hand (Vadas 1994).

Confronting uncertainty, then, is not prescriptive. While well-executed experiments represent a strong approach to developing knowledge, alternative approaches such as modeling, critical assessment of observations, and inference are accepted as sound approaches to understanding and used in synthesis for this assessment. In this assessment, the strength of evidence for particular ideas is noted, and alternative explanations are described when appropriate.

The synthesis of material for the flannelmouth sucker included the use of the limited data sets that are available for distribution, abundance, movements, habitat requirements, and life history requisites of the species. This species, like many non-game native fish, has not been extensively studied within Region 2. Furthermore, it has not been extensively studied for all the parameters needed for this assessment. The limited data on key characteristics for the species and the lack of understanding concerning its resource needs create a great deal of uncertainty pertaining to the assessment for conservation of flannelmouth sucker. This species assessment has synthesized a wide range of available data throughout the Colorado River basin, including historical and current distribution, conservation strategies, habitat needs, and management requirements. The general lack of precise information regarding species distribution on or near National Forest System land limits the actual data that can be used for this assessment. We have inferred from available data, using a sound scientific approach, to present an understanding of the current needs of the species for the purpose of this assessment.

Application and Interpretation Limits of This Assessment

Information used in this assessment was collected from studies that occurred throughout the geographical range of this species. The greatest emphasis for information regarding life histories and ecology was placed on studies and reports that were specific to Region 2. Although most information should apply broadly throughout the range of the species, it is likely that certain life history parameters (e.g., growth rate, longevity, spawning time) will differ along environmental gradients. Information regarding conservation strategies of the species pertains specifically to Region 2 and does not apply to other portions of the species' range.

Publication of Assessment on the World Wide Web

To facilitate the use of species assessments in the Species Conservation Project, they are being published on the Region 2 World Wide Web site (www.fs.fed.us/r2/projects/scp/assessments/index.shtml). Placing the documents on the Web makes them available to agency biologists and the public more rapidly than publishing them as reports. More important, it facilitates their revision, which will be accomplished based on guidelines established by Region 2.

Peer Review

Assessments developed for the Species Conservation Project have been peer reviewed prior to their release on the Web. This report was reviewed through a process administered by the American Fisheries Society, which chose two recognized experts on this or related taxa to provide critical input on the manuscript. Peer review was designed to improve the quality of communication and to increase the rigor and general management relevance of the assessment.

MANAGEMENT STATUS AND NATURAL HISTORY

Management Status

The flannelmouth sucker is not listed by Federal statute as threatened or endangered, but it has been given special status with other agencies. The flannelmouth sucker currently has Natural Heritage Program rank of G3G4 (globally vulnerable but apparently secure) and a state rank of S3 (vulnerable) in Colorado and Wyoming. In both of these states the Bureau of Land Management (BLM) considers the flannelmouth sucker a sensitive species. The Colorado Division of Wildlife (CDOW) additionally considers the flannelmouth sucker a species of concern, and Wyoming Fish and Game Department (WGFD) has assigned this species a state rank of NSS1, suggesting that its presence is extremely isolated and habitats are declining or vulnerable. This species does not occur in other states in Region 2 (Kansas, Nebraska or South Dakota).

In the remainder of its range, the BLM considers this species to be sensitive. In Arizona, the flannelmouth sucker has a state rank of S2 (rare). Utah considers flannelmouth sucker a species of concern due to declining populations. New Mexico gives this species no special status.

Existing Regulatory Mechanisms, Management Plans, and Conservation Strategies

The CDOW has no regulations specifically designed to protect flannelmouth sucker. However, several regulations are intended to protect native fish species and thus aid in the conservation of flannelmouth sucker. Restrictions regarding the live release of non-native fish species into rivers and lakes within the Upper Colorado River Basin are in place in Colorado. Another regulation indirectly assisting the conservation of flannelmouth sucker is Colorado's statute prohibiting the seining, netting, trapping, or dipping of fish for bait in natural streams. Flannelmouth sucker is largely unknown except to biologists (Bezzerides and Bestgen 2002).

The WGFD has regulations regarding flannelmouth sucker habitat loss. This agency's objective is to permit projects in a manner that avoids alteration and degradation of functioning flannelmouth sucker habitat (Weitzel 2002).

Ongoing recovery programs for federally listed fish (e.g., Colorado pikeminnow [*Ptychocheilus lucius*], razorback sucker [*Xyrauchen texanus*]) in the Upper Colorado River and San Juan River drainages should provide benefits for all native fish species. Recovery actions include flow recommendations to mimic a natural hydrograph and restriction on and recommendations of non-native fish stocking within the basins. Few, if any, anglers specifically target flannelmouth suckers, but incidental take probably does occur as fisherman attempt to catch gamefish species.

At this time, there are no existing management strategies that are specific to the flannelmouth sucker. Several states, including Colorado and Wyoming, are developing a "Range-wide conservation agreement and strategy" to direct management for this species. By 2005, the CDOW intends to develop a "Conservation/ management plan" for flannelmouth sucker. This plan will provide direction and goals for research and management projects. The range-wide conservation agreement and strategy has not currently been developed to a point where issues associated with this species have been identified. The success of management strategies and regulatory mechanisms will depend upon compliance by the public and the enforcement of management concerns, especially with habitat degradation and influence of non-native species interactions within the native range of the flannelmouth sucker.

Biology and Ecology

Systematics and general species description

The flannelmouth sucker belongs to the Family Catostomidae, the members of which are characterized by soft rays and a fleshy, subterminal protractile mouth. This family is comprised of 12 genera and 60 species in the United States and Canada (Robins et al. 1991). The flannelmouth sucker was described in 1853 by Baird and Girard from specimens taken from the San Pedro River in Arizona.

The following description follows that of Bezzerides and Bestgen (2002): "body streamlined; medium sized head; tapering body; narrow caudal peduncle; prominent snout; ventral mouth; large, well-developed lips, lower lip usually with one row papillae and deeply incised to jaw; upper lip with 5-8 rows of papillae; eyes small and high on head; fins large; pectoral fins (rays 16[14-18]) blunt tipped; origin of dorsal fin (rays 11- 13[10-14]) nearer snout than caudal peduncle and anterior to insertion of pelvic fins (rays 18[18-19]); trailing edge of dorsal fin concave; anal fin rays 7[7-8]; caudal fin deeply forked (rays 18[18-19]); fine scales (lateral line 90-116); vertebrae 44-50; pharyngeal teeth 36-37; adult coloration greenish brown to bluish gray dorsally to dorso-laterally, deep yellow to orange-red ventro-laterally, pale white ventrally, head may be pinkish ventrally; males in breeding season with tubercules from anal fin to lower lobe of caudal fin, females with tubercules only on ventral side of caudal peduncle."

Flannelmouth suckers are a large catostomid species with maximum total lengths upwards of 650 mm (25.6 inches). Average size of mature adult flannelmouth suckers is approximately 500 mm (19.7 inches). The relationship of length to weight during growth and development can be described by the following equation: log(weight gm) = 3.09((log total length) – 5.21) R2=0.99 (McAda 1977). Flannelmouth suckers are a long-lived species with a maximum life span of about 30 years (Scoppettone 1988, Minckley 1991, Weiss 1993).

The flannelmouth sucker can be distinguished from the native bluehead sucker (*Catostomus discobolus*) by the absence of a cartilaginous ridge on the upper lip. It can be distinguished from the introduced white sucker (*C. commersoni*) by finer scales along the lateral line that number 90 or more.

These are the only two species of *Catostomus* that occur sympatrically with flannelmouth sucker in Region 2. For a key to positively identify flannelmouth sucker, see Eddy and Underhill (1969). No analysis has been done to elucidate the phylogenetic relationships of species in the genus *Catostomus*.

Distribution and abundance

Historically, the flannelmouth sucker was commonly found in most, if not all, medium to large, lower elevation rivers of the Upper Colorado River drainage (upstream of Glen Canyon Dam). It was found in similar habitats of the Lower Colorado River drainage (downstream of Glen Canyon Dam), but in lesser numbers (Joseph et al. 1977). Although this species is typically associated with large rivers, it also occurs in smaller tributaries and occasionally in lakes and reservoirs (Bezzerides and Bestgen 2002).

The flannelmouth sucker is still widely distributed in medium to large streams in the Upper Colorado River Basin, which includes the mainstem of the Colorado River, numerous tributaries that drain a large portion of Colorado, Wyoming, and Utah, and the San Juan River drainage in New Mexico (**Figure 2**; Holden and Stalnaker 1975). However, in many areas of the upper basin populations are thought to be decreasing (Sigler and Sigler 1996). While the flannelmouth sucker is still found in most of its historical range in Colorado and Wyoming, it is less abundant and absent from its historical range in Nevada, Utah, Arizona, and California. Its distribution in the Lower Colorado River Basin is restricted to localized areas of suitable habitat (Sublette et al. 1990). It is believed that populations have become more restricted in the lower basin due to the severe impacts of dams and diversions on flow regimes, habitat availability, and habitat quality. In California this species is considered extirpated due to these impacts.

Within Region 2, flannelmouth sucker are currently present in streams and rivers of the Upper Colorado River drainage that are not heavily impacted by impoundments or other habitat degradation. Flannelmouth suckers have been reported from the San Juan River and the following tributaries that occur in the southern portion of Colorado: Animas, Florida, La Plata, Los Piños, Mancos, Navajo, and Piedra rivers, as well as McElmo Creek (Miller et al. 1995, Miller and Rees 2000, Whiteman 2000). Some of these tributaries are on San Juan National Forest lands. Flannelmouth sucker are also present in the Colorado River and numerous tributaries including the Gunnison River up to the Aspinall Unit reservoirs (Bezzerides and Bestgen 2002). Flannelmouth sucker are also present in the Yampa and White rivers in Colorado (Prewitt et al. 1976, Prewitt et al. 1978). They are considered common in the White River above and below Kenney Reservoir (Chart and Bergersen 1992). Flannelmouth suckers occur in the Uncompagre River and have been found in associated irrigation canals (Sigler and Miller 1963).

Flannelmouth suckers in Wyoming are known from the Green River and associated tributaries as well as streams within the Little Snake River drainage (Weitzel 2002). The only portion of this range that occurs in Region 2 in Wyoming is the Little Snake River drainage. Populations are present in the Little Snake River and the following tributaries: Muddy, Littlefield, and Savery creeks (Oberholtzer 1987). Flannelmouth suckers do not occur in the remaining Region 2 states (Kansas, Nebraska, or South Dakota).

Population trend

Flannelmouth sucker populations have declined in abundance and distribution throughout their historic range (Bezzerides and Bestgen 2002, Weitzel 2002). Most of the decline in the Lower Colorado River Basin has been attributed to flow manipulation and water development projects (Minckley 1973); however, Cross (1985) cited habitat loss, negative interaction with invasive species, and chemical pollution as the main reasons for the decline of flannelmouth sucker in the Virgin River in Arizona, Nevada, and Utah.

During the 1960s, two massive reductions occurred in large-river populations of flannelmouth sucker. In 1961, the San Juan River was poisoned with rotenone to eliminate non-game species from approximately 112 km (69.6 miles) of the river (Olson 1962). In 1962, 716 km (444.9 miles) of the Green River and many of its tributaries from the Colorado-Utah state line were poisoned in an attempt to eliminate "coarse" fish prior to the construction of Flaming Gorge and Fontenell dams (Binns 1967). Pre-treatment surveys indicated that flannelmouth suckers were abundant in the treatment areas; however, populations were completely eliminated following the treatments (Olsen 1962, Binns 1967). Flannelmouth suckers recolonized both rivers within a short time, but it is unknown what impact each of these events had on this species.

Dam construction and the associated alterations of the thermal and hydrological regimes have reduced flannelmouth sucker populations in both the Lower and Upper Colorado River Basins (Vanicek et al. 1970,

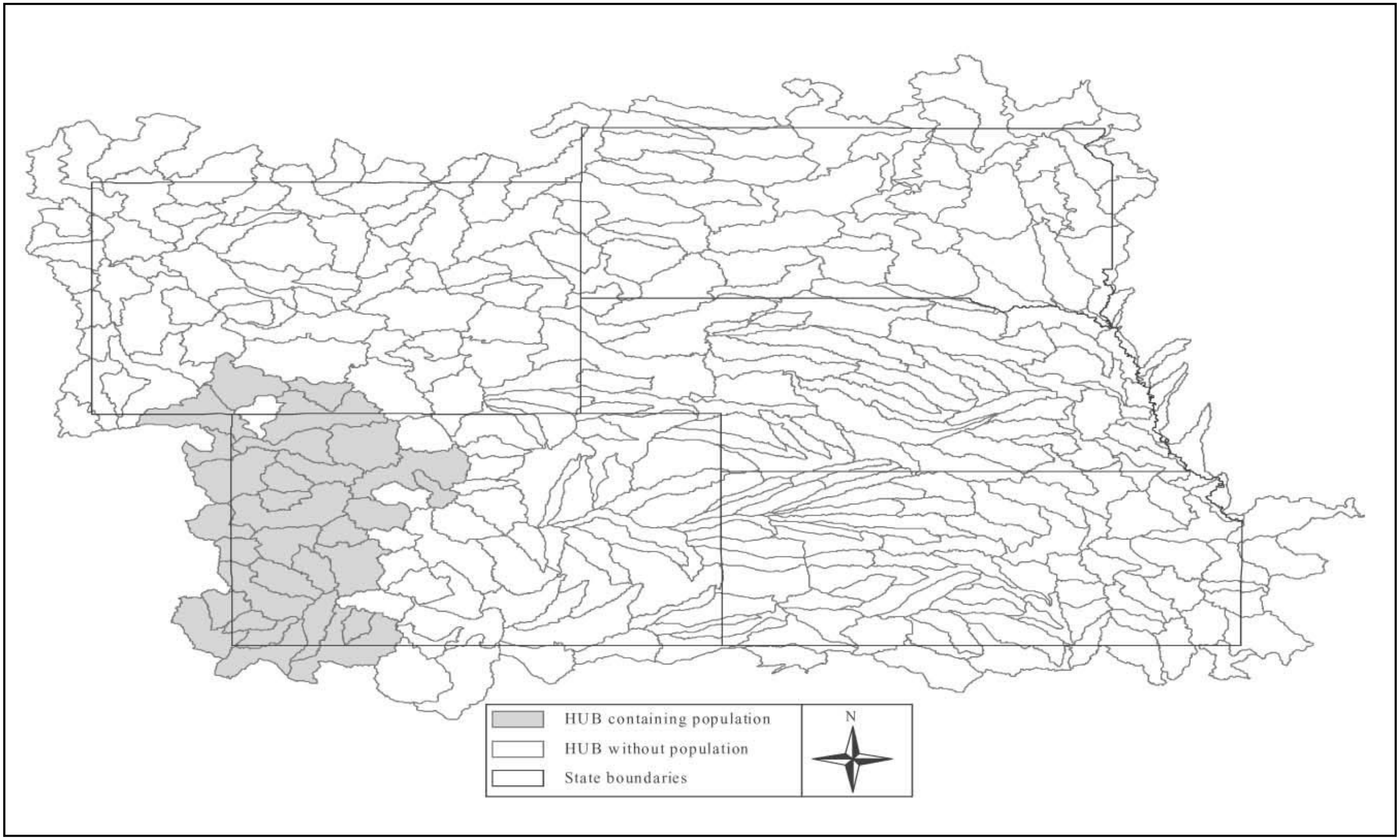

Figure 2. USDA Forest Service Region 2 hydrological unit boundaries (HUB) containing flannelmouth sucker populations.

Minckley 1991, Chart and Bergersen 1992, Robinson et al. 1998). Hypolimnetic releases below impoundments alter the thermal regime in the river downstream. The modified thermal regime is usually colder in the summer and warmer in the winter than historic conditions.

A variety of research has attempted to link the importance of flow regime to habitat requirements and survival of larval or young flannelmouth sucker (Haines and Tyus 1990, Weiss 1993, Robinson et al. 1998, Thieme et al. 2001). Weiss (1993) suggests that the altered hydrology of the Colorado River below Glen Canyon Dam may negatively impact young-of-the-year flannelmouth sucker. The poor representation of several year classes corresponded to the lack of turbid, flooded habitat in spring and early summer. Clarkson and Childs (2000) showed that lowered summer temperatures caused by hypolimnetic dam releases are responsible for slow growth, delayed transition to the juvenile stage, and possibly high larval mortality.

Flannelmouth suckers in the White River in Colorado were found to actively avoid newly created reservoir habitat and move upstream into the river (Chart and Bergersen 1992). Upon closure of the dam, adult fish moved upstream out of the reservoir and also avoided the area immediately below the dam. Vanicek et al. (1970) found that the resulting change in temperature and flow regime created by Flaming Gorge Dam displaced flannelmouth suckers to warmer locations during summer and reduced spawning success for more than 97 km (60.3 miles) downstream. However, some adults did tolerate the cold release regime at a location approximately 11 km (6.8 miles) downstream of Flaming Gorge Dam. Juvenile flannelmouth were collected 27 km (16.8 miles) downstream of the dam.

Activity pattern

Several researchers have reported on the movements of flannelmouth sucker and have found that most movement is associated with certain life stages (Bezzerides and Bestgen 2002). Flannelmouth sucker eggs are demersal and adhesive. After fertilization, they adhere to the substrate surface and hatch within several days of fertilization. After hatching, flannelmouth sucker larvae undergo a period where they drift with the current. Carter et al. (1986) and Robinson et al. (1998) suggest that larvae have the ability to actively enter and escape the drift. The drift mechanism likely accomplishes two separate objectives: population dispersal and location of suitable larval habitat.

Long distance movement has been detected in several flannelmouth sucker populations. However, portions of those populations were also classified as sedentary, remaining within the same general reach. Weiss (1993) reported flannelmouth sucker movement of over 200 km (124.3 miles) in the Colorado River and tributaries through the Grand Canyon. Chart and Bergersen (1992) detected highly mobile behavior in a portion of the flannelmouth sucker population in the White River in Colorado; however, a portion of this population was also classified as sedentary. In the Lee's Ferry section of the Colorado River, a portion of the flannelmouth sucker population was shown to be sedentary while other individuals were mobile, having a mean distance moved of 52 km (32.3 miles) and maximum of 231 km (143.5 miles) (McKinney et al. 1999). No correlation was observed between migration behavior in these fish and physical factors such as water chemistry, season, and flow regime. Both studies (Chart and Bergersen 1992, McKinney et al. 1999) were conducted over several years and therefore several spawning seasons. It is unclear if any of the documented movement was related to spawning migrations or as a mechanism of dispersal. Studies conducted from August through October on the Colorado River near Grand Junction, Colorado did not find substantial movement (maximum <3.2 km [2 miles]) of radio-tracked flannelmouth suckers (Beyers et al. 2001, Rees and Miller 2001). The consistency of migratory behavior and life stage relationships has not been studied.

Researchers have documented both diel and seasonal movement. Rees and Miller (2001) found that active movement and movement between major habitat types (e.g., riffle, pool, run) are most common at night. Chart and Bergersen (1992) suggest that long-distance seasonal migration for the flannelmouth sucker might be essential to the life history of this species. Bezzerides and Bestgen (2002) suggest that the occasional long-distance migration may be essential for maintenance of relatively isolated populations that occur in smaller tributaries at higher elevations. Further, upstream movement of juveniles and adults would be required to offset downstream drift of larvae.

Habitat

Flannelmouth suckers are typically found in slower, warmer rivers in plateau regions of the Colorado River drainage (Deacon and Mize 1997). They usually inhabit the mainstem of moderate to large rivers but are occasionally found in small streams. This species frequents pools and deep runs but can also be found in the mouths of tributaries, riffles, and backwaters. Flannelmouth suckers are occasionally found in lakes and reservoirs, but they generally react poorly to impounded habitats, or habitats influenced by impoundments (Minckley 1973, Chart and Bergersen 1992). Habitat association can be attributed to feeding strategies during specific life stages. Larval and young-of-the-year flannelmouth suckers are often associated with backwaters and shoreline areas of slow runs or pools (Holden and Stalnaker 1975, Joseph et al. 1977, Haines and Tyus 1990, Robinson et al. 1998). Larvae drift 8.6 km (5.3 miles) on average after hatching; during this time, they actively seek near-shore habitat (Robinson et al. 1998). Larvae then congregate in shallow pools and backwater areas. Haines and Tyus (1990) did not find a link between larval use and backwater temperature or size.

Juvenile (age 1 to adult) and adult flannelmouth suckers utilize most habitats and can be considered a habitat generalist. Juveniles and adults are most often found using run, pool, and eddy habitats (Joseph et al. 1977, McAda 1977, Tyus et al. 1982). This species appears to prefer temperatures around 25 °C (77 °F) (Sublette et al. 1990). Flannelmouth sucker are rare in cooler headwater streams. There has been no reported shift in habitat preference due to seasonal changes or changes in discharge cycles.

Studies have shown that flannelmouth suckers avoid cooler temperatures in headwater reaches and in the tailwaters of some dams. The effects of other physical parameters (e.g., dissolved oxygen, sediment, channel form) on the distribution and density of flannelmouth sucker have not been studied in detail and are not well understood.

Food habits

Flannelmouth suckers are omnivorous, benthic foragers that use their fleshy, protrusible lips to take in macroinvertebrates, algae, and debris. Like many native species within the Colorado River Basin, flannelmouth suckers demonstrate an ontogenetic shift in diet. Flannelmouth sucker diet shift parallels the previously discussed life stage specific habitat use. Larvae feed primarily on aquatic invertebrates, crustaceans, and organic/inorganic debris (Joseph et al. 1977, Maddux et al. 1987, Childs et al. 1998). Muth and Snyder (1995) found that young-of-the year flannelmouth suckers in backwater habitats feed on diptera larvae, crustaceans, algae, and organic/inorganic debris. As flannelmouth suckers become juvenile and adult fish, their diet shifts and becomes primarily composed of benthic matter including organic debris, algae, and aquatic invertebrates (Joseph et al. 1977, McAda 1977, Carothers and Minckley 1981, Brooks et al. 2000). The research to date reports no shift in food preference due to season, hydrological cycles, or migration, or between juvenile and adult stages.

Competition for food resources may exist between flannelmouth and bluehead suckers. The introduced white sucker may also compete with flannelmouth sucker in the many areas that they have invaded.

Breeding biology

Flannelmouth sucker typically spawn in the Upper Colorado River basin between April and June (McAda 1977, McAda and Wydoski 1980, Snyder and Muth 1990, Tyus and Karp 1990). Recently, Douglas and Douglas (2000) reported the occurrence of fall (October) spawning by flannelmouth sucker in Havasu Creek in Arizona. Robinson et al. (1998) reported evidence of year-round spawning by flannelmouth sucker in the Little Colorado River in Colorado.

Juvenile flannelmouth sucker may reach sexual maturity by age 4, but in most areas of the Upper Colorado River Basin, maturity is reached by age 5 or 6 (McAda and Wydoski 1985). By age 8, all individuals are mature (McAda 1977). Mature fish were 421 to 646 mm (16.6 to 25.4 inches) total length in the Colorado River in the Grand Canyon in Arizona (McKinney et al. 1999). Mature females tend to be slightly larger than mature males (McAda 1977).

Otis (1994) reports that spawning occurs at water temperatures ranging from 12 to 15 °C (53.6 °F to 59 °F), and that flannelmouth suckers in the lower Colorado River Basin spawn six to eight weeks earlier than those in the upper basin. McAda (1977) observed spawning in the upper basin at 6 to 12 °C (42.8 to 53.6 °F). In the Paria River in Arizona, Weiss (1993) found that timing of spawning was correlated with the receding limb of the hydrograph.

Flannelmouth spawning aggregations have been observed in tributaries of the Lower Colorado River in glides or slow riffles, over medium-coarse gravel substrate (Weiss 1993, Otis 1994). In the Grand Canyon, flannelmouth suckers were found to spawn in tributary creeks near the confluence with the Colorado River. In the Yampa and Colorado rivers (upper basin), McAda and Wydoski (1985) collected ripe (ready to spawn) females from areas with cobble substrate and an average velocity of 1 m per s (3.3 ft per s). Although actual spawning was not observed, it is likely that spawning occurred nearby.

Flannelmouth suckers are non-guarding, lithophilic breeders that leave their eggs on the surface of the substrate (Snyder and Muth 1990). Several fish congregate, closely spaced and in parallel. Eggs and sperm are released simultaneously in the water column, allowing fertilization of eggs while suspended. Once fertilized, the adhesive, demersal eggs sink and either adhere to gravel or fall into crevices (Snyder and Muth 1990, Sigler and Sigler 1996). Eggs typically incubate for six to seven days (Carlson et al. 1979). Fecundity depends on fish size and location. McAda (1977) reported a large difference in the number of eggs per female. Females typically lay from 4,000 to 40,000 eggs each spring, in the Colorado, Gunnison, Green, and Yampa rivers (McAda and Wydoski 1985). Sex ratios (male:female) are typically 2:1 or 3:1 (Weiss 1993, Otis 1994, McKinney et al. 1999).

Demography

Hybridization between flannelmouth suckers and other sucker species is a common occurrence throughout the range of this species. Flannelmouth sucker are known to hybridize with the following species of suckers: mountain (*Catostomus ardens*), bluehead, desert (*C. clarki*), razorback, and the introduced white suckers (Bezzerides and Bestgen 2002). Tyus and Karp (1990) observed flannelmouth sucker spawning on gravel beds near razorback sucker in the Yampa and Green rivers. Douglas and Marsh (1998) found that a small percentage of the fish taken in the Grand Canyon were hybrids of these two species, and most of the specimens were backcrosses to flannelmouth sucker. These fish were difficult to identify and were often repeatedly misidentified in a mark and recapture study (Douglas and Marsh 1998). In natural or minimally altered systems certain undefined mechanisms likely isolate spawning individuals of flannelmouth and bluehead suckers; however, hybrids between these two species do occur (Hubbs and Hubbs 1947, Hubbs and Miller 1953, Whiteman 2000, Authors' unpublished data).

The most common, and perhaps most detrimental, instance of hybridization occurs with the non-native white sucker. Hybrid specimens have been reported in the Animas, Colorado, Green, Gunnison, San Juan, Uncompagre, and Yampa river systems (Holden and Stalnaker 1975, Holden and Crist 1981, Anderson and Stewart 2000, Whiteman 2000, Authors' unpublished data). Wherever flannelmouth suckers and white suckers occur sympatrically, hybridization is likely to occur on some level. No information is available on the population-level genetics of flannelmouth sucker.

Natural flooding has been found to have a substantial influence on recruitment of juvenile flannelmouth suckers. Flooding in the Little Colorado River in Arizona caused a major decline in the larval flannelmouth sucker population in 1992 (Robinson et al. 1998). It is most likely that larvae were washed into the Colorado River where larval survival was probably low due to the cold summer temperature regime imposed by the Glen Canyon Dam (Robinson and Childs 2001). In contrast, pool formation and lack of flash-flooding led to higher larval populations and young-of-the-year (Age 0) recruitment in the Paria River during 1994 and 1996 (Thieme et al. 2001). Historically, ponding occurred in the mouths of tributaries of the Colorado River within the Grand Canyon when summer peak flows coincided with receding hydrographs in the tributaries (Robinson et al. 1998). The elimination of this process by reduction of summer flows might contribute to the loss of young-of-the-year recruitment.

General life history characteristics are reviewed in the Breeding biology section of this document and thus are not repeated here. The development of a meaningful lifecycle diagram for flannelmouth sucker requires life stage-specific data regarding survival rates, fecundity, and sex ratio. Existing data on flannelmouth sucker survival rates and fecundity (components necessary to construct a lifecycle diagram) are sparse and not validated in multiple studies. We include the following lifecycle description as illustration of data needed to refine the model (**Figure 3**).

Input data needed for a population projection matrix model consists of age-specific survival and fecundity rates. Very little data of this nature is available for flannelmouth sucker. We have used data from two studies, McAda (1977) and Douglas and Marsh (1998), to develop separate fecundity and survival rates for this species. The survival rate or fertility rate for specific gender of flannelmouth sucker has not been reported. To provide some information on survival and population dynamics, we have used the general survival rate for both males and females and the average number of eggs per mature female. The existing data presented in McAda (1977) show that the number of eggs per female ranges from approximately 10,000 for first-year maturity at age 5 to nearly 25,000 or higher for females age 8 and older. Age 8 was when all females collected show 100 percent maturity. The annual survival rates shown in **Table 1**

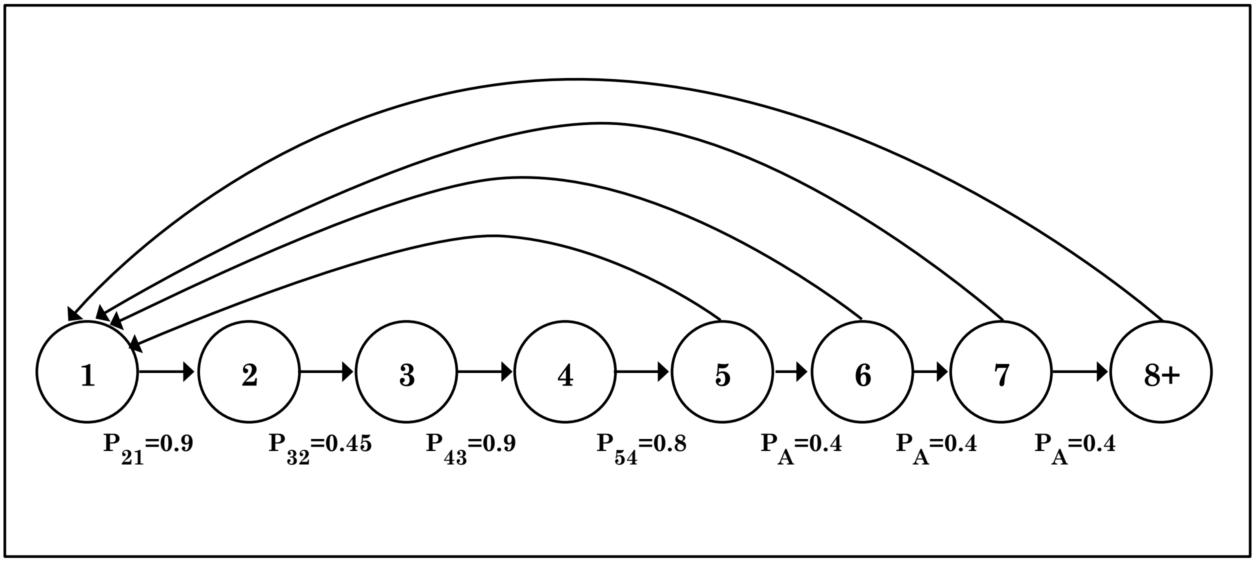

Figure 3. Lifecycle graph for flannelmouth sucker showing both the symbolic and numeric values for the vital rates. The circles denote the 8+ age classes in the life cycle, first year through adult females. Arrows denote survival rates. Survival and fertility rates provide the transition between age classes. Fertilities involve offspring production, mi, number of female eggs per female as well as survival of the female spawners.

Table 1. Parameter values for the component terms (Pi and mi) that make up the vital rates in the projection matrix for flannelmouth sucker. Parameters were estimated from data presented in McAda (1977) and Douglas and Marsh (1998).

Parameter	Numeric Value	Interpretation
P_{21}	0.9	First year survival rate
P_{32}	0.45	Survival from 2nd to 3rd year
P_{43}	0.9	Survival from 3rd to 4th year
P_{54}	0.8	Survival from 4th to 5th year
P_a	0.4	Survival for adults
m_{av}	17806	Average fecundity for mature females

and **Figure 3** provide longevity of the species to age 20 and higher, which has been noted in the literature as near the maximum age for flannelmouth sucker. Population dynamics of flannelmouth sucker likely have variable survival rates, depending on the flow regime and water quality characteristics at the time of spawning. Long-lived species, such as the flannelmouth sucker, would not recruit high numbers of individuals each year but likely have a high mortality rate from egg to surviving age 1 and then lower mortality rates and more constant mortality rates for the older age classes. This would provide large cohorts to infuse the population in years when flow conditions were optimal. It would also provide cohort strength that would carry over to the next period of favorable spawning conditions. Spawning and recruitment likely take place each year but with a very high rate of variability and success due to the variable conditions experienced in the widely fluctuating flows.

Community ecology

Historically, flannelmouth, bluehead, and razorback suckers comprised the medium to large river sucker population in the Upper Colorado River basin. It has been suggested that the flannelmouth sucker was the most abundant sucker species in the system (Holden and Stalnaker 1975, McAda 1977). Currently, distribution and abundance of flannelmouth suckers have diminished (Bezzerides and Bestgen 2002). Dams and diversions that isolate small populations in headwater reaches are the principal cause for the shrinking of the flannelmouth sucker's range. This species has been eliminated from areas inundated by reservoirs. Upstream migration is blocked by the dams. Fragmentation of populations in this way might lead to a decrease in genetic diversity in isolated populations and a higher risk of extirpation of isolated populations due to catastrophic events. Reduction of flannelmouth sucker range and abundance has been attributed in part to interactions with non-native species, changes in flow regime, sediment input, reduction in backwater and flooded habitats, habitat alteration, urban run-off, and various organic and inorganic pollutants.

Introduced white suckers compete with flannelmouth suckers for food resources. Both species have similar habitat associations and feeding habits. Channel catfish (*Ictalurus punctatus*) have a diet that partially overlaps with the diet of flannelmouth sucker, and this species should also be considered a competitor (Tyus and Nikirk 1990). In addition to competing with flannelmouth suckers, some non-native fishes prey on flannelmouth sucker. Tyus and Beard (1990) and Nesler (1995) documented northern pike (*Esox lucius*) predation on flannelmouth sucker in the Yampa River in Colorado, but the proportion of flannelmouth sucker in the diet of northern pike was relatively minor in both studies. It is also possible that flannelmouth suckers are taken as prey by brown trout (*Salmo trutta*), rainbow trout (*Oncorynchis mykiss*), red shiner (*Notropis lutrensis*), and smallmouth bass (*Micropterus dolomieu*).

In some river systems, flannelmouth suckers appear to have a high incidence of disease and abnormalities. Although flannelmouth sucker comprised 60 percent of the fish population in the San Juan River (Landye et al. 1999), they accounted for 80 percent of the abnormalities found in a fish health survey. Most of these abnormalities were common, unexplained lesions. The following parasites were counted among these abnormalities: Trichodina, Tetrahymena, Gyrodactylus, Hunterella, and Lernaea. Only opportunistic and secondarily infective bacteria were found (Landye et al. 1999). In the Fremont River and La Verkin Creek, both in Utah, all specimens of flannelmouth sucker collected were carrying parasites including protozoans, trematodes, cestodes, and hirudine (Brienholt and Heckmann 1980). Two of the trematodes and two of the cestodes were found in more than 75 percent of the fishes examined. No information is available on the effects of disease, parasites, or abnormalities on mortality. There are also no data on the effects of pollution on these maladies.

An envirogram for flannelmouth sucker was developed to help elucidate the relationships between land use practices/management and flannelmouth sucker population characteristics (**Figure 4**). The diagram provides a basic listing of variables affecting population structure with arrows depicting direct relationships between variables.

Conservation

Threats

The native fish community that evolved in the warm-water reaches of the Upper Colorado River basin has been greatly reduced as a result of human activities during the last 100 years. Flannelmouth sucker populations have suffered reductions in abundance and distribution from the same mechanisms that have caused the near extinction of other endemic fish species in this drainage. These mechanisms can be separated into two general categories: 1) habitat degradation through loss, modification, and/or fragmentation, and 2) interactions with non-native species (Tyus and Saunders 2000).

Both of these threats imperil the long-term persistence of flannelmouth sucker. Each may work independently or in conjunction with the other to create an environment where populations may be reduced or eliminated. The relative importance of each threat and the specific cause-effect relationship usually depend on location. The complexity of each threat requires further explanation.

Effects of habitat degradation may not be limited to localized areas but may cascade through the watershed. Therefore, activities or events occurring on National Forest System lands may have detrimental impacts on populations of flannelmouth suckers existing in rivers many kilometers downstream.

Habitat loss occurs when streams are dewatered or when dams block upstream migration for seasonal use or when currently occupied areas are inundated by reservoirs. Habitat modification occurs when the natural stream flow regime is changed or when stream channels are modified by channelization, scouring, or sedimentation from land use practices. Land use practices that can impact stream channels include construction of roads through highly erodible soils, improper timber harvest practices, and overgrazing in riparian areas that all lead to increased sediment load in the system and the subsequent change in stream channel

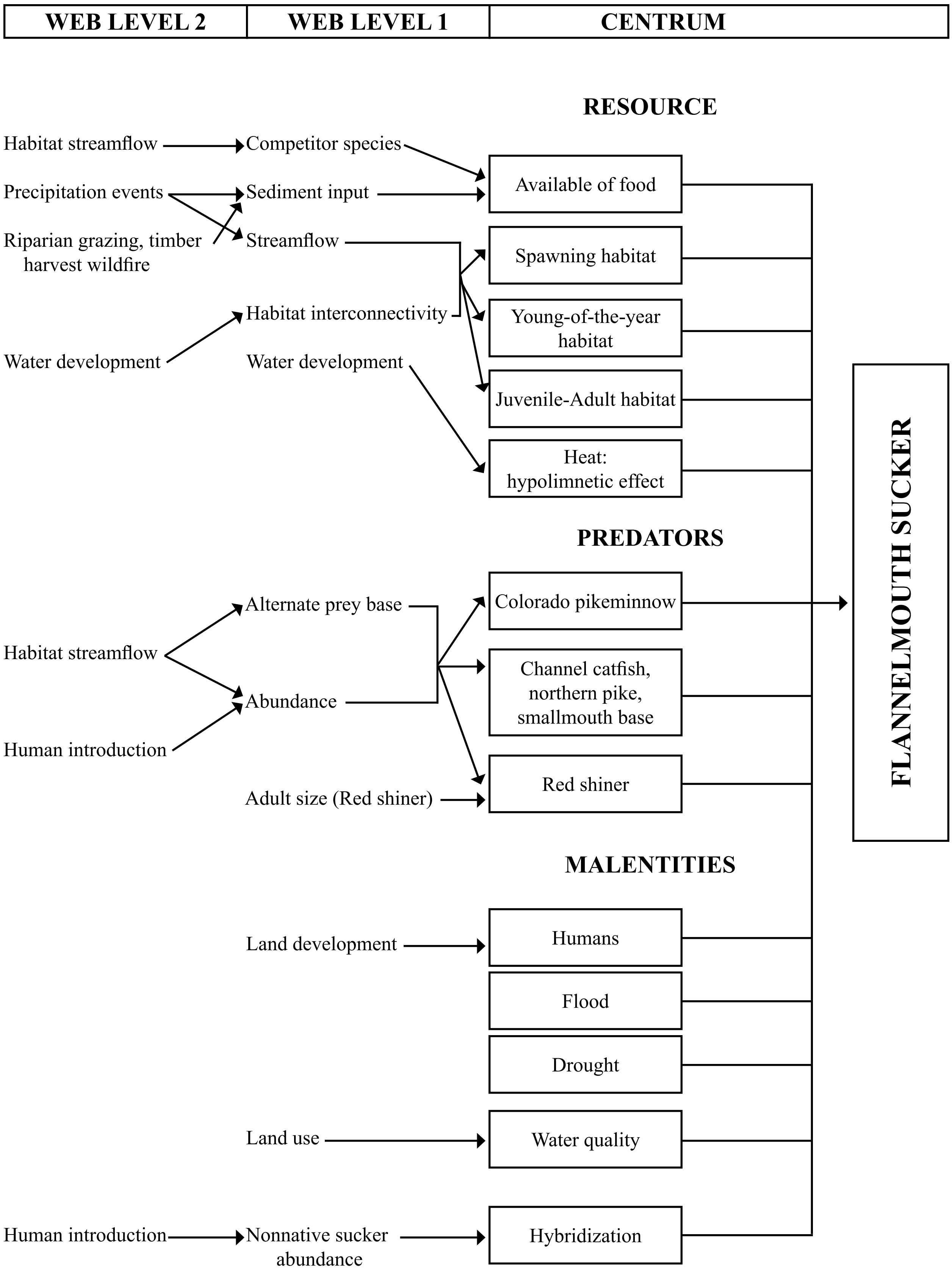

Figure 4. Flannelmouth sucker envirogram.

geometry (widening or incision). These modifications result in changes in width:depth ratios, pool:riffle ratios, pool depth, and other aspects that affect the quality of habitat occupied by flannelmouth suckers. Habitat fragmentation can be the result of dewatering of sections of river with populations occurring both upstream and downstream of the dewatered section, or reservoir or diversion construction that separates the exchange of individuals from separate populations throughout a river reach. The populations that become fragmented in some areas remain viable and reproduce and successfully recruit and maintain population levels at the same density or number as they were before the fragmentation occurred. This usually occurs in larger mainstem river sections. In smaller rivers and tributaries to a mainstem drainage, habitat fragmentation can eventually lead to habitat loss and extirpation of some of the populations.

Habitat fragmentation is often a result of dewatering, but it also results from the creation of barriers to fish passage such as dams and diversions. Large- and small-scale water development projects can profoundly impact the persistence of flannelmouth sucker populations. Irrigation diversions and small capacity irrigation reservoirs reduce streamflow, alter the natural hydrograph, and provide barriers to migration and normal population exchange. Barriers that preclude fish passage can cause population fragmentation and completely prevent or significantly reduce genetic exchange between populations. As habitat is fragmented and populations are isolated, the probability that "bottlenecks" will occur in the life history of the flannelmouth sucker become more pronounced and that single catastrophic events may extirpate populations from entire drainages.

Habitat modification contains aspects already discussed under fragmentation and degradation but also includes changes in temperature and flow regime, as well as alterations to water chemistry related to pollution. Severely reduced streamflows may lead to increased water temperatures and reduced dissolved oxygen levels, especially in smaller tributaries. Although specific tolerances to water quality parameters (i.e., temperature, dissolved oxygen, toxicants) are undefined for this species, it is likely that as water quality is reduced, flannelmouth sucker fitness also declines. For example, during periods of elevated summer water temperatures and decreased baseflows, flannelmouth sucker were observed in stressed conditions with evidence of adult mortality at higher levels than during times of normal summer temperatures and baseflows (Author's personal observation).

The effect of wildfire has little direct impact on quality of habitat. However, post-fire conditions can affect downstream populations. Input of large quantities of sediment into streams frequently occurs during storm events at recently burned areas. Once in the watershed, the increased sediment load can diminish suitable spawning habitat, reduce fitness through reduction of the prey base, and cause direct mortality through suffocation.

Water development, road construction, timber harvest, and grazing of riparian areas are likely to continue to impact flannelmouth sucker habitat in the future. Modification of land use management techniques to decrease the impact to flannelmouth sucker habitat may lessen the anthropogenic threats to this species. However, it is unlikely that all impacts or threats could be minimized or halted. Modifications of land use management techniques include the specification of fish passage at new or existing low head diversion to eliminate or reduce fragmentation of habitat and loss of habitat, and the specification of minimum flow regimes to promote connectivity of habitats and also maintenance of baseflow habitat during summer seasons or irrigation seasons. Other practices include specifications for buffer zones for road construction and timber harvest as well as grazing of riparian areas to promote healthy riparian growth and reduce sedimentation from upland areas.

Interaction with non-native species is another threat to flannelmouth sucker population health and viability. Non-native species prey upon, compete with, and hybridize with flannelmouth suckers when found sympatrically. Many introduced species tend to be well-adapted to a variety of environmental conditions, allowing a competitive advantage. Without fish passage barriers, the introduction of non-native fishes into stream reaches that do not contain flannelmouth sucker often results in the uncontrollable dispersal of these fishes into stream reaches containing flannelmouth suckers.

All life stages of the introduced white sucker have a competitive impact on flannelmouth sucker populations. However, the most serious threat imposed by the introduction of non-native suckers is perhaps hybridization. Distribution and abundance of white suckers is increasing within the Upper Colorado River Basin. These two species appear to lack any significant mechanism to isolate reproductive individuals. Further treatment of hybridization can be found in the Demography section.

The flannelmouth sucker is likely a desirable prey item for predatory non-native species. Large, non-native predators, including northern pike, channel catfish, and smallmouth bass, occur in many of the drainages containing flannelmouth sucker. In addition, red shiners have been reported to feed on native larval fish within the Upper Colorado River Basin. Preferred habitat for red shiners is slack water shoreline or backwater areas, which are the same habitats utilized by larval flannelmouth suckers.

The current distribution and the historical range-wide distribution of flannelmouth sucker indicate that few flannelmouth sucker populations occurred on National Forest System lands in Region 2. However, many sucker populations in the mainstem rivers likely occurred immediately downstream of adjacent National Forest System lands, and this proximity and the effects of some of the threats, such as increased sedimentation from grazing, timber practices, and road construction, could impact downstream populations. Fragmentation of populations or habitat loss could occur with barriers to migrations that occur on occupied National Forest System lands at water diversions without passage or impassable stream crossings. Both of those threats could be eliminated with inclusion of fish passage with construction of diversions and proper sizing of road crossings for culverts or bridges to allow natural passage conditions.

Conservation Status of the Species in Region 2

At present, there is concern regarding the status of flannelmouth sucker in the Colorado River drainage. Although the specific mechanisms of most threats to this species are poorly understood, the flannelmouth sucker appears to be vulnerable throughout its range in the Upper Colorado River Basin due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native species. A decrease in flannelmouth sucker populations has been documented or suggested throughout most of the basin.

Healthy populations of flannelmouth sucker, however, still exist in various locations in the Upper Colorado River Basin (e.g., San Juan, Green, Colorado rivers). These locations are usually defined by adequate habitat (as specified in the Habitat section of this report) and natural temperature and flow regimes. These areas often maintain healthy populations of other native fish species.

The flannelmouth sucker evolved in a system with a high natural disturbance regime. This disturbance regime included a large contrast between annual peak flows and base flows, and considerable sediment transport. Life history attributes and population dynamics allowed this species to persist during (or to recolonize after) a disturbance event. However, modifications to the physical and biological environment (e.g., loss of channel complexity, loss of refugia, introduction of non-native species, loss of benthic invertebrates) have reduced the species' ability to recover after such an event. Habitat fragmentation through streamflow reduction, passage barriers, and habitat degradation disconnects populations of flannelmouth suckers. Competition, predation, and hybridization associated with non-native species can depress or extirpate flannelmouth sucker populations.

Based on the impacts to flannelmouth sucker populations and distribution that have occurred in the last century, the potential for future declines in flannelmouth sucker distribution and abundance is high. Unless alleviated, habitat loss, habitat degradation, habitat fragmentation, and non-native species interactions will intensify and jeopardize the existence of flannelmouth sucker.

Potential Management of the Species in Region 2

Implications and potential conservation elements

Flannelmouth sucker populations are threatened due to the combined impacts of habitat loss, habitat degradation, habitat fragmentation, and interactions with non-native fish species. A brief description of threats is provided here to form a basis for the conservation elements; an in-depth discussion of threats to flannelmouth suckers can be found in the Conservation Threats section.

Management of flannelmouth sucker is based on an understanding of specific threats to the species. Habitat loss, degradation, and fragmentation due to land and water use practices are prime threats to flannelmouth sucker persistence in the Upper Colorado River Basin. Reduction of streamflows and creation of barriers to fish passage can severely degrade habitat to the extent that flannelmouth sucker populations are extirpated from the area. The degree of influence that population fragmentation has on flannelmouth sucker populations is speculative, but it could potentially impact the long-term persistence of this species. Creating isolated populations disrupts the natural exchange of genetic material between populations. Isolated populations are more vulnerable to extirpation from catastrophic events (e.g., lethal water quality conditions, extreme floods) because of the impediment to recolonization from other nearby populations. Loss of genetic diversity can also lead to the depression of fecundity and survival rates. The genetic exchange along a metapopulation framework within the flannelmouth sucker distribution can provide the required demographic variability and viability.

Other considerations for conservation elements should include:

- protection of riparian areas
- minimization of sediment input from anthropogenic causes (e.g., road building, timber harvest)
- management of non-native fish species.

Construction associated with road improvements or development, as well as timber harvesting, grazing, and fire activity, can cause increased sediment loads to adjacent streams. Increased sediment loads or sediment deposition could have a negative impact on flannelmouth sucker populations. Specific thresholds and mechanisms associated with this impact, however, have not been studied well enough to make precise predictions. In general, habitat loss or degradation from stream channel changes can reduce populations.

Management of non-native fish species requires strict adherence to existing regulations pertaining to the live release of fish. Interactions between flannelmouth suckers and non-native fish species threaten flannelmouth sucker populations. Specifically, competition and hybridization between flannelmouth sucker and introduced sucker species and predation by large non-native predatory species represent the two most deleterious effects of non-native interaction. Management strategies should limit further expansion of non-native fish on National Forest System lands in Region 2. These strategies should include strict enforcement of existing non-native stocking regulations and eradication programs for non-native fish in streams within the historical range of flannelmouth sucker.

The preservation of stream flows that are adequate to maintain complex habitat, interconnectivity of habitats, and instream cover should be a focal point of management policy or strategy. Conservation of flannelmouth sucker should address the function of the entire aquatic and riparian ecosystem, with particular attention to downstream populations. Any future plans for the conservation of flannelmouth sucker should take into account the entire native fish assemblage in the Colorado River Basin. This species assemblage evolved in and is adapted to a system with a high differential between peak spring runoff and fall baseflows. Native fish species of the Colorado River all require similar management considerations related to channel maintenance and restoration of historical flow regimes.

Tools and practices

The following review describes specific tools and techniques employed in the collection of flannelmouth sucker data. We are unaware of any management approaches implemented specifically for flannelmouth suckers in Region 2. Because little information exists or is being collected for this species, this portion will deal with techniques intended to gather the missing or needed information from the following Information Needs section.

The absence of distribution and abundance data for flannelmouth sucker on National Forest System lands in Region 2 is a concern. Because flannelmouth suckers are a benthic fish that is often found in riffle areas, electrofishing could be used to determine its distribution and abundance. The initial priority should be a complete survey of all streams on National Forest System lands that could contain flannelmouth suckers. General stream reach habitat surveys should be conducted concurrently with distribution surveys. Winters and Gallagher (1997) developed a basin-wide habitat inventory protocol that would be a cost-effective method to collect stream habitat characteristics. This protocol includes characterization of habitat type, quantity, channel type, substrates, and bank stability. All of these parameters assist in describing habitat quality.

Once basic distribution information has been gathered, intensive population estimates would provide baseline information to evaluate the effectiveness of future management strategies. Focus should be on areas where future management strategies could possibly impact flannelmouth sucker populations. However, the long-term monitoring goal should be population estimates and population trend data on all streams containing flannelmouth sucker populations on Region 2 lands. Several electrofishing techniques exist that would provide population estimates. These include mark/recapture and multiple-pass removal estimates. Each has its advantages, but due to the smaller size of many streams on Region 2 lands, estimating populations using depletion/removal techniques should be a cost-effective method to produce high quality data. Riley and Fausch (1992) recommend that a minimum of three passes be conducted when using the removal method. Use of a single pass method to develop a catch per unit of effort (CPUE) index is cost-effective on a time basis, but precision may be sacrificed and the introduction of bias is more likely, especially over long-term monitoring with researcher/technician turnover. With removal estimates, researchers are able to calculate confidence intervals, allowing insight into sampling quality and comparison over time.

A large data gap exists in the knowledge of flannelmouth sucker movement and use of streams on National Forest System lands. The implementation of a survey methodology such as the use of passive integrated transponder (PIT) tags to determine flannelmouth sucker distribution and abundance can also provide insight into movement. PIT tags are unobtrusive, long-lasting (indefinitely), uniquely coded tags that allow the efficient determination of movement with a minimum of disturbance. Establishment of a long-term monitoring program would be required. The time required to develop a robust data set depends on sample size, recapture rates, and survey frequency.

PIT tags could also be used for population estimates through mark and recapture over time to develop long-term population estimates on a broader basis for larger scale river areas. An alternate technique to develop habitat and movement information would be through the use of radio telemetry. Radio telemetry studies have been employed for flannelmouth sucker in the Colorado River and could be employed in other areas to develop more information on habitat. Radio telemetry would be limited mainly to larger juveniles, ages 3 and 4, and adults. PIT tags could be used for fish 120 mm (4.7 inches) total length and larger.

Habitat selection and preference can be determined through the use a variety of techniques. The simplest technique involves correlating capture locations to specific habitat types. Construction of habitat suitability curves is time intensive but could be used in conjunction with hydraulic modeling methodologies to estimate how habitat changes with streamflow. This would allow land managers to effectively compare the impacts of different flow regimes (due to water development projects) on flannelmouth sucker habitat. Data obtained could also be used to justify the acquisition of adequate instream flows for flannelmouth suckers and other native fishes.

Defining the relationship between habitat alteration and flannelmouth sucker population characteristics is a relatively difficult task. This process may require significant amounts of data, including research and quantitative analysis of temporal variation in prey base, habitat quality/function, abundance, and movement.

To effectively gather data valuable to the conservation of this species, managers need to coordinate with independent researchers and federal and state agencies that study or manage portions of streams downstream of Region 2 lands. This would help to determine or verify the distribution and abundance of flannelmouth sucker populations that exist downstream of Region 2 National Forest System land but are still affected by USFS management policies and strategies.

This coordinated effort could develop a regional knowledge base (i.e., interagency database) among biologists. This could be used to assess impacts from passage restrictions, barrier removal projects, and effects from water depletions. In addition, monitoring of physical attributes of streams downstream of Region 2 lands, in coordination with management practices on those federal lands, could develop cause and effect relationships over time to look at inputs of sediment or changes in discharge. Research and monitoring activities should enhance our understanding of these impacts on flannelmouth sucker populations (i.e., expansion or decline).

Information Needs

Most of the information that has been collected for flannelmouth sucker has been presented as a by-product of studies for federally listed fish in the Colorado River drainage. To attain adequate understanding to properly manage this species at a local level, specific studies must be conducted by drainage. General information needs for flannelmouth sucker include a wide range of information consisting of distribution, habitat requirements and associations, general attributes of life history and ecology, movement patterns, influence of non-native fish, and effects of human-induced habitat modification.

Specific knowledge of streams and watersheds containing flannelmouth sucker on National Forest System lands in Region 2 is essential for developing regional management strategies to preserve this species. Basic knowledge regarding locations of specific flannelmouth sucker populations is inadequate or obsolete. The research priority should be to survey all streams with potential habitat for the presence of flannelmouth sucker. Initial focus should be on streams with suspected populations or known populations downstream of National Forest System lands. During these surveys, information regarding the physical and chemical characteristics of the habitat should be obtained. Data collected should include:

- ❖ elevation
- ❖ water temperature
- ❖ dissolved oxygen
- ❖ dissolved solids (pollutants)
- ❖ discharge
- ❖ depth
- ❖ velocity
- ❖ turbidity
- ❖ substrate
- ❖ mesohabitat type.

This information will provide baseline data regarding habitat requirements and preferences for each physical parameter. Fish collected should be PIT-tagged to study movement, migration, and growth rates during continued monitoring.

In addition to general distribution and abundance information, additional data on seasonal distribution is required. Flannelmouth sucker may not establish resident populations in streams on National Forest System lands, but these tributaries may still provide important spawning habitat. The available data on habitat use emphasizes large river systems, and few studies have been conducted on smaller tributary systems. It is unknown whether flannelmouth sucker life history traits are uniform between large river and small tributary systems. Temporal and spatial changes in abundance, distribution, and age structure should be documented before implementing conservation strategies.

A data gap exists in basic life history information for the flannelmouth sucker. Habitat requirements and preferences are poorly understood for most life stages and life history events. Specific studies need to be designed to provide information on spawning behavior and habitat, larval biology, and the importance of larval drift. Habitat requirements and feeding habits at each life stage should also be addressed. Monitoring of tagged fish will also provide an estimate of survival rate that is a necessary component for refining the lifecycle diagram. Sex ratio and fecundity data should be collected to provide other components missing from the lifecycle diagram. It may be important to collect data from several sub-basins because much of the specific life history information may vary by drainage.

To better understand the community ecology of the flannelmouth sucker, future studies should include inventory and monitoring of all fish (adult, juvenile, and larvae), macroinvertebrates, and periphyton taxa in the streams where flannelmouth suckers occur. Gut content analyses at various life stages will allow a better understanding of flannelmouth sucker feeding habits. Feeding studies on sympatric fish populations need to be conducted to determine potential competition and the impact of introduced and native predators on flannelmouth sucker populations.

Genetic testing during future studies on flannelmouth sucker populations is important. Tissue samples should be taken from fish for analysis of genetic structure from mainstem and isolated populations. Genetic characterization would allow studies of population connectivity, migration, population diversity, richness, viability of isolated populations, and the extent and effects of hybridization with native or introduced sucker species.

To ensure the long-term conservation of this species, research must examine techniques to minimize the impact of impoundments and diversions on flow regimes, temperature regimes, and movement of native fish. This research should focus on ways to modify existing impoundments, provide conservation guidelines for construction of future impoundments, and explore the use of off-channel impoundments. Other land use actions that affect habitat, such as road construction, water crossing (culverts), timber harvest, and grazing, should be studied. Specific scientific evidence to understand how habitat degradation affects flannelmouth sucker population attributes is missing. The development of a process-response model that links physical process (e.g., stream channel, gradient, substrate, sediment) to biological response (e.g., primary, secondary, productivity, reproductive success, and recruitment) would further identify flannelmouth sucker life history components that are not adequately understood.

DEFINITIONS

Endemic species – a species that is confined to a particular geographic region.

Habitat quality – the physical characteristics of the environment (e.g., soil characteristics for plants or channel morphology for fish) that influence the fitness of individuals. This is distinguished from habitat quantity, which refers to spatial extent.

Hybridization – the production of offspring by crossing two individuals of unlike genetic constitution.

Lithophilic – associated with stony substrates.

Metapopulation – a genetically similar suite of populations defined by its expansive presence in accessible habitat, whereby its needs for sustainability are met through diversity of habitats, corridors for movement, and interconnection that allow adaptive straying.

Population viability – refers to the probability of species persistence over the temporal scale that defines a population or metapopulation. The dynamics of persistence take place at the level of the population (Wells and Richmond 1995), and the National Forest Management Act focuses on populations. Therefore, our process targets populations and species.

Process-response model – a conceptual or mechanistic model used to portray the biological response to physical factors.

Scale – the physical or temporal dimension of an object or process (e.g., size, duration, frequency). In this context, extent defines the overall area covered by a study or analysis and grain defines the size of individual units of observation (sample units).

Taxon – used in a broad sense to refer to a variety of taxonomic levels (i.e., genus, species, subspecies, variety).

Viability – a focus of the Species Conservation Project. Viability and persistence are used to represent the probability of continued existence rather than a binary variable (viable vs. not viable). We note this because of the difficulty in referring to 'probability of persistence' throughout the manuscript.

Web Level 1 – any component that affects the centrum.

Web Level 2 – any component that affects Web Level 1.

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Exhibit RS#4

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The "Mixer," a Colorado pikeminnow spawning area in the San Juan River.

Flow Recommendations for the San Juan River

May 1999

Prepared by:
The San Juan River Basin
Recovery Implementation Program
BIOLOGY COMMITTEE

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AUTHORS / ACKNOWLEDGMENTS

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Chapter 1: INTRODUCTION	Larry Crist, Bureau of Reclamation; Paul Holden, BIO/WEST, Inc.
Chapter 2: GEOMORPHOLOGY, HYDROLOGY, AND HABITAT OF THE SAN JUAN RIVER	
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HYDROLOGY	Ron Bliesner
HABITAT	Vince Lamarra, Ecosystems Research Institute
Chapter 3: LIFE HISTORY OF THE FISHES OF THE SAN JUAN RIVER	
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RAZORBACK SUCKER	Dale Ryden, U.S. Fish and Wildlife Service
FLANNELMOUTH SUCKER	Keith Lawrence, Ecosystems Research Institute
BLUEHEAD SUCKER	Keith Lawrence
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RED SHINER	Amber Hobbes
FATHEAD MINNOW	Amber Hobbes
CHANNEL CATFISH	Michael Buntjer, U.S. Fish and Wildlife Service
COMMON CARP	Michael Buntjer
Chapter 4: PHYSICAL AND BIOLOGICAL RESPONSE TO TEST FLOWS	
CHANNEL MORPHOLOGY	Ron Bliesner
COBBLE BAR MAINTENANCE	Ron Bliesner
BACKWATER MAINTENANCE	Ron Bliesner
HABITAT	Vince Lamarra
COLORADO PIKEMINNOW	Bill Miller; Utah Division of Wildlife Resources; Paul Holden
RAZORBACK SUCKER	Dale Ryden
FLANNELMOUTH SUCKER	Keith Lawrence
BLUEHEAD SUCKER	Keith Lawrence
SPECKLED DACE	David Propst and Amber Hobbes, New Mexico Department of Game and Fish; Keith Lawrence
CHANNEL CATFISH AND COMMON CARP	Michael Buntjer
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FATHEAD MINNOW	David Propst and Amber Hobbes; Keith Lawrence
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PREFACE

This report was prepared by the Biology Committee of the San Juan River Basin Recovery Implementation Program (SJRIP) and is based on all data available at the time it was prepared. Some field collections from 1997 and early 1998 had not been fully analyzed and, therefore, were not included in the report. Information collected on the San Juan River during the 7-year research period that is not pertinent to flow recommendations is also not included. Final research reports and a Synthesis Report that will compile and synthesize information on other aspects of recovery of the endangered fish in the San Juan River are scheduled to be completed in 1999.

SJRIP BIOLOGY COMMITTEE MEMBERS

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Ron Bliesner	Keller-Bliesner Engineering	Bureau of Indian Affairs
James Brooks	U.S. Fish and Wildlife Service	U.S. Fish and Wildlife Service, Region 2
Larry Crist	Bureau of Reclamation	Bureau of Reclamation
Paul Holden	BIO/WEST, Inc.	Jicarilla-Apache Tribe
Vince Lamarra	Ecosystems Research Institute	Navajo Nation
William Miller	Miller Ecological Consultants	Southern Ute Tribe
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Vacant	Bureau of Land Management	Bureau of Land Management, New Mexico

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Dr. Clark Hubbs	University of Texas
Dr. Ron Ryel	Independent Consultant

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EXECUTIVE SUMMARY

INTRODUCTION

This report presents the results of a process to develop flow recommendations for the native fish community, including the endangered Colorado pikeminnow (*Ptychocheilus lucius*) and razorback sucker (*Xyrauchen texanus*), in the San Juan River of New Mexico, Colorado, and Utah. Flow recommendations are a major milestone of the San Juan River Basin Recovery Implementation Program (SJRIP), which was initiated in 1992 with the following two goals:

1. To conserve populations of Colorado squawfish and razorback sucker in the basin, consistent with the recovery goals established under the Endangered Species Act, 16 U.S.C. 1531 et seq.

2. To proceed with water development in the basin in compliance with federal and state laws, interstate compacts, Supreme Court decrees, and federal trust responsibilities to the Southern Utes, Ute Mountain Utes, Jicarillas, and the Navajos.

Mimicry of the natural hydrograph is the foundation of the flow recommendation process for the San Juan River. Scientists have recently recognized that temporal (intra- and interannual) flow variability is necessary to create and maintain habitat and to maintain a healthy biological community in the long term. Restoring a more-natural hydrograph by mimicking the variability in flow that existed before human intervention provides the best conditions to protect natural biological variability and health. The linkages between hydrology, geomorphology, habitat, and biology were used to define mimicry in terms of flow magnitude, duration, and frequency for the runoff and base-flow periods. The flow characteristics of these linkages were compared with the statistics of the pre-Navajo Dam hydrology to assist in fine-tuning the flow recommendations. The flow recommendations require mimicry of statistical parameters of flow, based on the linkages developed and the statistical variability of the pre-dam hydrology rather than mimicry of each annual hydrograph. A 65-year-long period of record (1929 to 1993) was used to assess the relationship between water development scenarios and the ability to meet the flow recommendations.

Data were gathered and analyzed during a 7-year research period (1991 to 1997) to determine fish population and habitat responses to reregulation of Navajo Dam to mimic a natural hydrograph. The research involved quantification of several relationships, including flow/geomorphology, geomorphology/fish habitat, and flow/habitat availability relationships.

The SJRIP will use an adaptive management process, along with monitoring and continued research, to adjust the flow recommendations in the future. The ability to adaptively manage the system is

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important because flow recommendations can be refined in response to the emerging understanding of the mechanisms involved in recovery of the endangered species in the San Juan River.

This report is one of two reports that address the results of the 7-year research program. This report focuses on the analysis and integration of biological, hydrologic, and geomorphological data to determine flow needs of the endangered fish species. A companion report, to be produced in 1999, will compile and synthesize information on other aspects of recovery of the endangered fishes in the San Juan River. The companion report will specifically address issues such as contaminants, propagation, nonnative species control, and fish-passage needs.

RESULTS OF THE 7-YEAR RESEARCH PERIOD

The San Juan River is similar to other Upper Colorado River Basin (Upper Basin) streams, primarily the Green and Colorado rivers, in that they are all large rivers with high spring flows and low base flows, they are all fairly turbid most of the time, they typically have sand and cobble substrate, and they are all subject to late summer and fall thunderstorm activity. The San Juan River is also similar to other portions of the Upper Basin in that it once supported populations of Colorado pikeminnow and razorback sucker that have declined after the completion of major dams. However, the San Juan River is different than the Green and Colorado rivers primarily because it has a steeper overall slope, a higher overall sediment concentration, and more late summer and fall flood events. No wild razorback sucker were found in the San Juan River during the research period, and the Colorado pikeminnow population appears to be smaller than 100 individuals. Navajo Dam began affecting flows in the San Juan River in 1962, and post-dam flows had lower spring flows and higher late summer, fall, and winter flows than occurred during pre-dam periods. The advent of research flows in 1992 to 1997 produced flows more typical of the pre-dam era.

Habitat needs of the two endangered fishes in the San Juan River involve a complex mix of low-velocity habitats such as eddies, pools, and backwaters adjacent to swifter run and riffle habitats. Habitat use changes with time of year and activity (e.g., spawning, feeding, nursery areas). A natural hydrograph, in terms of peak spring flows and late summer base flows, is important to not only provide the proper habitats at the correct time, but also to provide natural temperatures and productivity cycles for those habitats.

Two key habitats important to Colorado pikeminnow and other native species that were used extensively in the flow recommendation process were cobble bars and backwaters. Cobble bars are spawning areas for Colorado pikeminnow, and the fish appear to have fidelity for a certain area of the San Juan River called “the Mixer” for spawning. In the Green River, similar fidelity to spawning areas is seen for both Colorado pikeminnow and razorback sucker. An important feature of Colorado pikeminnow spawning bars is that the cobbles are very clean with relatively little fine sediments between individual cobbles. Clean cobble bars are more rare in the San Juan River, as well as in other Upper Basin rivers, than just a typical cobble bar.

Backwaters are an important habitat for young native fishes, including Colorado pikeminnow. During studies of young stocked Colorado pikeminnow in the San Juan River, the fish were found in backwaters 60% of the time, but they were found in other low-velocity habitats (e.g. pools, pocket water) nearly 40% of the time. In the Green River, young Colorado pikeminnow are found in backwaters more often than fish in the San Juan River, and studies have shown that the San Juan River has relatively small amounts of backwaters compared with the Green and Colorado rivers. But the success of the stocked Colorado pikeminnow in the San Juan River has shown that this system has the habitats necessary for the survival and growth of these young fish.

Studies assessing the flows needed to build and maintain cobble bars and backwaters similar to those used by Colorado pikeminnow were an important part of the 7-year research effort. These studies showed that relatively high flows were needed to build and clean these habitats, but that lower flows were needed to make them more abundant at the proper time of the year.

During the 7-year research period, a number of responses to the reregulation of Navajo Dam were identified in the native fish community. Colorado pikeminnow young were found in very low numbers, or not at all, during low spring runoff years, and in larger numbers during higher flow years. The young of bluehead sucker and speckled dace, two other native species, were found in greater numbers during high flow years compared with low flow years. Flannelmouth sucker, another native species, tended to decline during the research period, but still remained the most abundant native species in the river. The change to a more-natural hydrograph during the research period resulted in more cobble and less sand habitats in the river, apparently favoring bluehead sucker and speckled dace rather than flannelmouth sucker.

Nonnative fishes in the San Juan River are potential predators and competitors with the native species and have been implicated in the decline of the native fishes throughout the Colorado River Basin. Populations of some nonnative fishes changed during the research period, but no major reduction in nonnative fish numbers were documented. Some authors have suggested that nonnative fishes may be reduced by high natural flows, but this was not the case in the San Juan River during the 7-year research period. Contaminants were also studied as a potential limiting factor for native fishes, but no pattern of contaminant concentrations and flow was found. Table S.1 summarizes the biological and habitat responses that were found during the research period and the flows that were important in producing those responses.

FLOW RECOMMENDATION

RiverWare, a generic hydrologic model, was used as the primary modeling tool for developing the flow recommendations. The model simulates the flow in the river at various gages at different points in time, including the past, present, and future. It does this by incorporating all past, present, and potentially future water development projects into the model. The 1929 to 1993 period of record was used in the model to simulate flows under the various development scenarios. Existing gaging stations were used to calibrate the model to ensure it was working properly for historic conditions.

Table S.1. Flow requirements needed to produce important biological responses and habitats in the San Juan River.

BIOLOGICAL RESPONSE/ HABITAT REQUIREMENT	FLOW CHARACTERISTIC
Reproductive success of Colorado pikeminnow lower in years with low spring runoff peaks, and higher in years with high and broad runoff peaks.	Mimicry of a natural hydrograph, especially during relatively high runoff years.
Decline in flannelmouth sucker abundance, increase in bluehead sucker abundance, and increased condition factor in both species.	Mimicry of natural hydrograph with higher spring flows and lower base flows.
Bluehead sucker reproductive success.	Increased number of days of spring runoff >5,000 and 8,000 cfs correlated with increased success.
Speckled dace reproductive success.	Increased number of days of spring runoff >5,000 and 8,000 cfs correlated with increased success.
Success of stocking YOY Colorado pikeminnow and subadult razorback sucker.	Mimicry of natural hydrograph has provided suitable habitat for these size-classes.
Eddies, pools, edge pools, other low-velocity habitats year round for adult Colorado pikeminnow and razorback sucker.	Mimicry of natural hydrograph has lowered base flows to provide more low-velocity habitats. Flows >10,000 cfs provide more channel complexity which provides for more habitat complexity.
Flows to cue razorback sucker and Colorado pikeminnow for migration and/or spawning.	Mimicry of natural hydrograph with higher spring flows.
Adult Colorado pikeminnow and razorback sucker use complex river areas.	Flows >10,000 cfs provide more channel complexity which provides for more habitat complexity, lower base flows add to amount of low-velocity habitats.
Clean cobble bars for spawning of all native species, especially Colorado pikeminnow.	Flows >8,000 cfs for 8 days to construct cobble bars, and >2,500 cfs for 10 days to clean cobble bars, during spring runoff.
Backwaters and other low-velocity habitats are important nursery habitats for Colorado pikeminnow and other native fishes.	High spring flows create conditions for backwater formation, low base flows allow them to appear in late summer and fall, flows >5,000 cfs for 3 weeks create and clean backwaters.
Flooded bottomlands appear to be important nursery areas for razorback sucker, but other habitats may be used in the San Juan River.	Overbank flows (> 8,000 cfs) increase flooded vegetation, and backwaters formed in association with edge features maximize on receding flows of 8,000 to 4,000 cfs.
Temperatures of 10 to 14 EC at peak runoff for razorback sucker spawning and near 18 to 20 EC at bottom of descending limb for Colorado pikeminnow spawning.	Proposed releases from Navajo Dam are too cool to replicate pre-dam temperature timing, but temperatures are above spawning threshold for Colorado pikeminnow during the correct period.
Reduction of nonnative fish abundance.	Most nonnative fishes did not decrease during research period, summer flow spikes reduce numbers of red shiner in secondary channels in the short term.

Note: cfs = cubic feet per second, YOY = young-of-the-year.

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The model was completed with input from the Bureau of Reclamation, Bureau of Indian Affairs, and the states of New Mexico and Colorado.

Mimicry of the natural hydrograph is the foundation of the flow recommendation process for the San Juan River. The flow recommendations require mimicry of statistical parameters of flow based on flow/geomorphology/habitat linkages and the statistical variability of the pre-dam hydrology rather than mimicry of each annual hydrograph. Therefore, the resulting flows will not mimic a natural hydrograph in all years, but will mimic the variation and dynamic nature of the 65-year record of the San Juan River.

The hydrograph recommendations are designed to meet the conditions required to develop and maintain habitat for Colorado pikeminnow and razorback sucker and provide the necessary hydrologic conditions for the various life stages of the endangered and other native fishes. The conditions are listed in terms of flow magnitude, duration, and frequency during the spring runoff period. Duration is determined as the number of days that the specified flow magnitude is equaled or exceeded during the spring runoff period of March 1 to July 31. Frequency is the average recurrence of the conditions specified (magnitude and duration), expressed as a percent of the 65 years of record analyzed (1929 to 1993). The underlying assumption in the flow conditions is that, over a long period of time, history will repeat itself: if the conditions were met during the past 65 years, they will also be met in the future. To the extent that the water supply is different in the future, then the natural condition would also be altered and the conditions of mimicry would be maintained, although the exact flow recommendation statistics may not be met.

To allow for gage and modeling error and the difference between the flows at the historical gage at Bluff, Utah, and the Four Corners gage, maximum allowable durations are computed for 97% of the target flow rate. In most cases, the primary recommendation is for a specified flow rate (i.e., 10,000 cubic feet per second (cfs)) of a minimum duration (i.e., 5 days) for a specific frequency of occurrence (i.e., 20% of the years). In addition to the primary recommendation, variability in duration is desirable to mimic a natural hydrograph. Therefore, a frequency table for a range of durations for each flow rate is recommended. A maximum duration between occurrences is also specified to avoid long periods when conditions are not met, since such long periods could be detrimental to the recovery of the species. The maximum period without reaching a specified condition was determined as twice the average required interval (except for the 80% recurrence of the 2,500 cfs condition, where 2 years is used). For example, if the average interval is 1 year in 3, then the maximum period between meeting conditions would be 6 years. The maximum periods were based on the collective judgement of Biology Committee members after review of historical pre-dam statistics. Following are the conditions specified:

A. Category: Flows > 10,000 cfs during runoff period (March 1 to July 31).

Duration: **A minimum of 5 days between March 1 and July 31**.

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Frequency: **Flows > 10,000 cfs for 5 days or more need to occur in 20% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 9,700 cfs (97% of 10,000 cfs) within the 65-year period of record is 10 years.

Purpose: Flows above 10,000 cfs provide significant out-of-bank flow, generate new cobble sources, change channel configuration providing for channel diversity, and provide nutrient loading to the system, thus improving habitat productivity. Such flows provide material to develop spawning habitat and maintain channel diversity and habitat complexity necessary for all life stages of the endangered fishes. The frequency and duration are based on mimicry of the natural hydrograph, which is important for Colorado pikeminnow reproductive success and maintenance of channel complexity, as evidenced by the increase in the number of islands following high flow conditions. Channel complexity is important to both Colorado pikeminnow and razorback sucker.

B. Category: Flow > 8,000 cfs during runoff period.

Duration: **A minimum of 10 days between March 1 and July 31**.

Frequency: **Flows > 8,000 cfs for 10 days or more need to occur in 33% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 7,760 cfs (97% of 8,000 cfs) within the 65-year period of record is 6 years.

Purpose: Bankfull discharge is generally between 7,000 and 10,500 cfs in the San Juan River below Farmington, New Mexico, with 8,000 cfs being representative of the bulk of the river. Bankfull discharge approximately 1 year in 3 on average is necessary to maintain channel cross-section. Flows at this level provide sufficient stream energy to move cobble and build cobble bars necessary for spawning Colorado pikeminnow. Duration of 8 days at this frequency is adequate for channel and spawning bar maintenance. However, research shows a positive response of bluehead sucker and speckled dace abundance with increasing duration of flows above 8,000 cfs from 0 to 19 days. Therefore, the minimum duration was increased from 8 to 10 days to account for this measured response. Flows above 8,000 cfs may be important for providing habitat for larval razorback sucker if flooded vegetation and other habitats formed during peak and receding flows are used by the species. This flow level also maintains mimicry of the natural hydrograph during higher flow years, an important feature for Colorado pikeminnow reproductive success.

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Category: Flow > 5,000 cfs during runoff period.

Duration: **A minimum of 21 days between March 1 and July 31**.

Frequency: **Flows > 5,000 cfs for 21 days or more need to occur in 50% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 4,850 cfs (97% of 5,000 cfs) within the 65-year period of record is 4 years.

Purpose: Flows of 5,000 cfs or greater for 21 days are necessary to clean backwaters and maintain low-velocity habitat in secondary channels in Reach 3, thereby maximizing nursery habitat for the system. The required frequency of these flows is dependent upon perturbating storm events in the previous period, requiring flushing in about 50% of the years on average. Backwaters in the upper portion of the nursery habitat range clean with less flow but may be too close to spawning sites for full utilization. Maintenance of Reach 3 is deemed critical at this time because of its location relative to the Colorado pikeminnow spawning area (RM 132) and its backwater habitat abundance.

3. Category: Flow >2,500 cfs during runoff period.

Duration: **A minimum of 10 days between March 1 and July 31**.

Frequency: **Flows > 2,500 cfs for 10 days or more need to occur in 80% of the years on average for the period of record 1929-1993**. Maximum number of consecutive years without meeting at least a flow of 2,425 cfs (97% of 2,500 cfs) within the 65-year period of record is 2 years.

Purpose: Flows above 2,500 cfs cause cobble movement in higher gradient areas on spawning bars. Flows above 2,500 cfs for 10 days provide sufficient movement to produce clean cobble for spawning. These conditions also provide sufficient peak flow to trigger spawning in Colorado pikeminnow. The frequency specified represents a need for frequent spawning conditions but recognizes that it is better to provide water for larger flow events than to force a release of this magnitude each year. The specified frequency represents these tradeoffs.

E. Category: Timing of the peak flows noted in A through D above must be similar to historical conditions, and the variability in timing of the peak flows that occurred historically must also be mimicked.

Timing: Mean date of peak flow in the habitat range (RM180 and below) for any future level of development when modeled for the period of 1929 to 1993 must be within 5 days ± of historical mean date of May 31 for the same period.

Variability: Standard deviation of date of peak to be 12 to 25 days from the mean date of May 31.

Purpose: Maintaining similar peak timing will provide ascending and descending hydrograph limbs timed similarly to the historical conditions that are suspected important for spawning of the endangered fishes.

F. Category: Target Base Flow (mean weekly nonspring runoff flow).

Level: 500 cfs from Farmington to Lake Powell, with 250 cfs minimum from Navajo Dam.

Purpose: Maintaining low, stable base flows enhances nursery habitat conditions. Flows between 500 and 1,000 cfs optimize backwater habitat. Selecting flows at the low end of the range increases the availability of water for development and spring releases. It also provides capacity for storm flows to increase flows and still maintain optimum backwater area. This level of flow balances provision of near-maximum low-velocity habitat and near-optimum flows in secondary channels, while allowing water availability to maintain the required frequency, magnitude, and duration of peak flows important for Colorado pikeminnow reproductive success.

G. Category: Flood Control Releases (incorporated in operating rule).

Control: Handle flood control releases as a spike (high magnitude, short duration) and release when flood control rules require, except that the release shall not occur earlier than September 1. If an earlier release is required, extend the duration of the peak of the release hydrograph. A ramp up and ramp down of 1,000 cfs per day should be used to a maximum release of 5,000 cfs. If the volume of water to release is less than that required to reach 5,000 cfs, adjust the magnitude of the peak accordingly, maintaining the ramp rates. Multiple releases may be made each year. These spike releases shall be used in place of adjustments to base flow.

Purpose: Historically, flood control releases were made by increasing fall and winter base flows. This elevates flows above the optimum range for nursery habitat. Periodic clean-water spike flows improve low-velocity habitat quality by flushing sediment and may suppress red shiner and fathead minnow abundance.

Operating rules for Navajo Dam were developed in cooperation with the Bureau of Reclamation to demonstrate how the dam may be operated to meet the flow recommendations. These suggested rules determine the timing and size of release flows to maximize the ability of the river to meet the flow recommendations. Releases to produce a peak spring flow are not made every year because saving water, (1) for human use, and (2) to make a larger peak in a future year, is incorporated into the rules. The flow recommendations, and use of the operating rules, will provide flows in the San Juan River that will promote the recovery of the two endangered fish species. As presently configured, the flow recommendations may also allow for a significant amount of future water development in the basin.

This report addresses the science of the development of flow recommendations for the San Juan River. It does not address the impact of the recommended flows on the holders of water rights in the San Juan River Basin. Legal and management factors to be considered by the U.S. Fish and Wildlife Service and affected parties will determine which holders of water rights will be affected by these flow recommendations. The SJRIP recognizes that the flow criteria and operating rules discussed herein are only recommendations that are subject to further refinement through the SJRIP adaptive management process and pursuant to the National Environmental Policy Act.

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Exhibit RS#5

San Miguel River @ Uravan Peak Flow

Date	q	rank (m) (m)	Exceed Prob (m/n+1)	% Exceed 100(m/n+1)	Return Int 1/P*100
9/6/1970	8910	1	0.0227	2	44.00
5/10/1983	8050	2	0.0455	5	22.00
4/19/1958	6690	3	0.0682	7	14.67
4/19/1979	6310	4	0.0909	9	11.00
5/11/1984	6260	5	0.1136	11	8.80
8/30/1957	5530	6	0.1364	14	7.33
4/18/1987	5470	7	0.1591	16	6.29
7/12/1975	4820	8	0.1818	18	5.50
8/23/1982	4540	9	0.2045	20	4.89
4/16/1985	4270	10	0.2273	23	4.40
4/11/1960	4210	11	0.2500	25	4.00
4/20/1997	4120	12	0.2727	27	3.67
4/24/1998	4120	13	0.2955	30	3.38
10/6/2006	3890	14	0.3182	32	3.14
4/28/1993	3870	15	0.3409	34	2.93
8/15/1956	3490	16	0.3636	36	2.75
4/26/1974	3460	17	0.3864	39	2.59
9/9/1976	3440	18	0.4091	41	2.44
8/20/1999	3380	19	0.4318	43	2.32
4/18/1962	3260	20	0.4545	45	2.20
4/23/1980	3220	21	0.4773	48	2.10
5/24/2005	3180	22	0.5000	50	2.00
8/18/1977	3140	23	0.5227	52	1.91
4/26/1955	3000	24	0.5455	55	1.83
4/8/1991	2740	25	0.5682	57	1.76
4/20/2008	2730	26	0.5909	59	1.69
4/27/1978	2690	27	0.6136	61	1.63
7/19/1986	2620	28	0.6364	64	1.57
9/7/2006	2520	29	0.6591	66	1.52
7/8/1990	2140	30	0.6818	68	1.47
9/10/2003	2130	31	0.7045	70	1.42
4/30/1961	2120	32	0.7273	73	1.38
5/9/2000	2090	33	0.7500	75	1.33
4/10/1992	1970	34	0.7727	77	1.29
9/8/1981	1780	35	0.7955	80	1.26
8/4/1959	1750	36	0.8182	82	1.22
4/19/2001	1490	37	0.8409	84	1.19
3/26/2004	1460	38	0.8636	86	1.16
6/1/1994	1390	39	0.8864	89	1.13
9/10/2002	1290	40	0.9091	91	1.10
4/8/1988	1240	41	0.9318	93	1.07
7/29/1989	1140	42	0.9545	95	1.05
9/25/1954	1040	43	0.9773	98	1.02

Peak Streamflow for Colorado

USGS 09177000 SAN MIGUEL RIVER AT URAVAN, CO.

Montrose County, Colorado
Hydrologic Unit Code 14030003
Latitude 38°21'26", Longitude 108°42'44" NAD27
Drainage area 1,499 square miles
Gage datum 5,000.00 feet above NGVD29

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1954	Sep. 25, 1954	6.21	1,040[5]
1955	Apr. 26, 1955	8.50[2]	3,000[5]
1956	Aug. 15, 1956	8.91	3,490[5]
1957	Aug. 30, 1957	10.78	5,530[5]
1958	Apr. 19, 1958	11.75	6,690[5]
1959	Aug. 04, 1959	6.58[6]	1,750[5]
1960	Apr. 11, 1960	9.08	4,210[5]
1961	Apr. 30, 1961	7.15	2,120[5]
1962	Apr. 18, 1962	7.83	3,260[5]

Water Year	Date	Gage Height (feet)	Stream-flow (cfs)
1986	Jul. 19, 1986	6.37	2,620[5]
1987	Apr. 18, 1987	8.77	5,470[5]
1988	Apr. 08, 1988	5.53[2]	1,240[5]
1989	Jul. 29, 1989	5.35	1,140[5]
1990	Jul. 08, 1990	6.40	2,140[5]
1991	Apr. 08, 1991	6.49	2,740[5]
1992	Apr. 10, 1992	5.72	1,970[5]
1993	Apr. 28, 1993	7.04	3,870[5]
1994	Jun. 01, 1994	5.42	1,390[5]

1970	Sep. 06, 1970	12.60	8,910[5,7]	1997	Apr. 20, 1997	7.33	4,120[5]
1974	Apr. 26, 1974	7.97	3,460[5]	1998	Apr. 24, 1998	7.24	4,120[5]
1975	Jul. 12, 1975	8.76	4,820[5]	1999	Aug. 20, 1999	6.71	3,380[5]
1976	Sep. 09, 1976	8.05	3,440[5]	2000	May 09, 2000	5.73[2]	2,090[5]
1977	Aug. 18, 1977	7.80	3,140[5]	2001	Apr. 19, 2001	5.27	1,490[5]
1978	Apr. 27, 1978	7.13	2,690[5]	2002	Sep. 10, 2002	4.99[2]	1,290[5]
1979	Apr. 19, 1979	8.95	6,310[5]	2003	Sep. 10, 2003	6.33	2,130[5]
1980	Apr. 23, 1980	7.80	3,220[5]	2004	Mar. 26, 2004	5.51	1,460[5]
1981	Sep. 08, 1981	6.35	1,780[5]	2005	May 24, 2005	6.72	3,180[5]
1982	Aug. 23, 1982	8.18	4,540[5]	2006	Sep. 07, 2006	6.20	2,520[5]
1983	May 10, 1983	10.14	8,050[5]	2007	Oct. 06, 2006	7.25	3,890[5]
1984	May 11, 1984	9.41	6,260[5]	2008	Apr. 20, 2008	6.46	2,730[5]
1985	Apr. 16, 1985	7.77	4,270[5]	2009	May 12, 2009	6.09	2,220[5]
				2010	Apr. 18, 2010	6.96	3,210[5]

Peak Gage-Height Qualification Codes.

- 2 -- Gage height not the maximum for the year
- 6 -- Gage datum changed during this year

Peak Streamflow Qualification Codes.

- 5 -- Discharge affected to unknown degree by Regulation or Diversion
- 7 -- Discharge is an Historic Peak

Exhibit RS#6

TO: Roy Smith (BLM) and Mark Uppendahl (CDOW)
From: Rick Anderson
Date: August 18, 2011

Subject: Requested Review with supplemental fishery data analysis concerning instream flow recommendation of the San Miguel River

Introduction

On July 25, 2011 Roy Smith, Mark Uppendahl and I met to discuss how my research regarding bluehead sucker, flannelmouth sucker and roundtail chub relates to the proposed San Miguel River instream flow recommendations. This instream flow recommendation is the subject of a contested hearing before the Colorado Water Conservation Board (CWCB) in September. Roy Smith and Mark Uppendahl hired me to give an independent review of the proposed San Miguel River instream flow recommendations and written comments received from Tom Wesche (HabiTech, inc.) and Don Conklin (GEI) concerning these flow recommendations.

I was the CDOW leader of a research project (CDOW Special Report Number 80) with the primary objective to determine habitat suitability criteria for the bluehead sucker, flannelmouth sucker and roundtail chub (Stewart and Anderson 2007, Anderson and Stewart 2007). This research provided data that were specifically meant to be applied to development of instream flow recommendations in the upper Colorado River basin.

The study sites of this project included 4 western Colorado Rivers: the Yampa River had three study sites, the Colorado River had 2 sites, the Gunnison River had 2 sites and there was 1 study site on the Dolores River. Bed topography (channel shape) of each site (8 total) was surveyed for use in computer modeling. 2 Dimensional (River 2D) flow models were used to calculate the area of different habitat types. Fish population density and biomass estimates were made in multiple years at each study site using mark and recapture methods. Fish distribution maps were made to determine habitat preference. Habitat suitability criteria for the 'three native species' were based on usage of meso-habitat (pools, runs, riffles, rapids) by the three species.

Tom Wesches' review suggested biological justifications for the San Miguel flow recommendations were lacking. Specifically: The PHABSIM modeling runs for native sucker were performed for adults, but not for fry and juvenile life stages; Roundtail chub WUA for adult and spawning were not modeled; Recent fish sampling data done by the Colorado Division of Wildlife (CDOW) was not integrated into the recommendation process; Also he felt there needed to be clarification on the habitat suitability curves used in the modeling process.

I was informed that generally these types of biological data are not part of a typical instream flow document. However, it is important to have these concerns addressed because of the San Miguel's relative importance for native fish management in Colorado. The Dr. Woodling memorandum (July 13, 2011) provides supporting background information concerning the status of the 'three native species', i.e. bluehead sucker, flannelmouth sucker, and roundtail chub.

The objectives of this review are:

1. Review and analyze the fishery information of the San Miguel River in regard to habitat and flow relationships for the 'three native species'. This includes reviewing the fish data, addressing the non-use of fry, juvenile life stages and Roundtail chub in the modeling, and providing logic for transferring bluehead and flannelmouth sucker habitat suitability criteria to the San Miguel River.

2. Provide an evaluation of whether the instream flow recommendations from the BLM and CPW sufficiently meet flow requirements of the existing native fish population. Provide revised flow recommendations given biological indications.

Fish Data for the San Miguel River (Kowalski, CDOW Fish sampling report)

The Kowalski (CDOW) fish survey made on July 15, 2008 documents the presence of a native fish population that meets requirements for an instream flow filing (Table 1a). This survey found 72 % of the fish caught were native species and indicates an abundant population of flannelmouth sucker, bluehead sucker and channel catfish. The number of roundtail chub captured indicates a low population size (Table 1a.).

Table 1a. Species composition by number caught and mean length (Kowalski report).

Species	# Caught	% Caught	Mean Length (in.)	Length Range (in.)
Flannelmouth Sucker	155	35	14.5	5.7 - 21.3
Bluehead Sucker	140	32	10.2	5.0 - 15.7
Roundtail chub	19	4	8.2	6.0 - 16.2
Channel Catfish	117	27	12.6	7.9 - 19.4

Flannelmouth sucker comprise 56% and bluehead sucker comprise 17% of the fish sample based on relative biomass (Table 1b). These data indicate flannelmouth sucker are much more common than bluehead sucker, suggesting higher habitat abundance for flannelmouth sucker. Relative biomass for channel catfish makes it the second most common species. Roundtail chub biomass composition is only 1% (Tables 1a and 1b).

Table 1b. Species composition by fish weight (calculated from length frequency data).

Species	# Caught	Total Weight (kg) & (% by weight)		Weight (gm) of mean length & (% weight)	
Flannelmouth Sucker	155	90.5	(56)	492	(47)
Bluehead Sucker	140	28.7	(18)	174	(17)
Roundtail chub	19	1.8	(1)	75	(7)
Channel Catfish	117	39.6	(25)	296	(28)

Comparison of San Miguel Fish Data to other Rivers in the basin.

The CDOW San Miguel fish data was evaluated by comparing it to other rivers in the upper Colorado basin (Table 2). Anderson and Stewart (2007) summarized several years of fish sampling data from the Dolores, Gunnison, Colorado and Yampa Rivers. These rivers are also tributaries of the Colorado River and have similar snowmelt hydrograph shapes and seasonal runoff periods. These rivers have the same native fish population. The primary differences for these rivers are in their annual flow volume and the degree of alterations to the pristine hydrograph.

The CDOW San Miguel fish survey represents a single pass boat electro-fishing effort. Equipment and methods for the San Miguel fish survey were otherwise similar to the sites listed in Table 2. Although density and biomass comparisons between the San Miguel River and the other rivers can not be done, this is not highly important. The San Miguel single pass data is likely representative of its species composition and length frequencies, so this fish data can be directly compared to other rivers in the basin.

Stewart and Anderson (2007) found that flannelmouth sucker and bluehead sucker abundance were significantly correlated to particular meso-habitat types. Bluehead sucker were highly associated with deep riffles and flannelmouth sucker with deep runs. The availability of preferred habitat largely explained biomass for these two species and inversely, bluehead and flannelmouth sucker abundance was found to be a good indicator of their habitat availability.

The general conclusions from the San Miguel River fish data are:

- The San Miguel Rivers' bluehead and flannelmouth sucker population structure was similar to the other rivers where habitat suitability criteria were identified.

- The number of non-native species in the San Miguel is comparatively low, making it an important conservation population for the Colorado River system.

- Roundtail chub numbers and percentage is lower in the San Miguel River, whereas channel catfish numbers are relatively higher. The use of roundtail chub habitat preferences will not assist in justifying instream flow recommendations.

In addition, the following discussion on habitat needs of native fish addresses many of the concerns raised by HabiTech and GEI about the use of more biological data.

<u>Population Structure</u>

The bluehead sucker and flannelmouth sucker composition is fairly typical of those in the Colorado and Gunnison rivers (Table 2). Bluehead sucker abundance is a very good indicator of riffle habitat availability (Anderson and Stewart 2007). Riffle habitat

Table 2. Species composition (% number and % weight) for the Yampa River, Colorado River, Gunnison River and Dolores River* and the San Miguel River**.

	Flannelmouth sucker		Bluehead sucker		Roundtail chub		White S. + Hybrids		Channel catfish		Other species***	
STUDY SITE	% number	% weight	% number	% weight	% number	% weight	% number	% weight	% number	% weight	% number	% weight
Yampa, Duffy	4	5	3	2	4	4	62	59	4	11	24	20
Yampa, Sevens	49	44	19	10	4	3	15	14	5	10	8	18
Yampa, Lily Park	56	49	8	7	0.1	0.1	0.6	0.04	29	29	8	14
Colorado, Corn Lake	36	42	33	19	4	3	7	3.7	6	12	13	21
Colorado, Clifton	36	35	31	13	6	3	5	2.4	7	17	15	30
Gunnison, Escalante	22	30	45	24	14	8	13	14	0	0	6	23
Gunnison, Delta	33	42	28	18	9	4	22	13	0	0	8	24
Dolores, Big Gypsum	33	13	2	1	36	11	0	0	9	37	19	38
San Miguel	**35**	**56**	**32**	**17**	**4**	**1**	**0**	**0**	**27**	**26**	**0**	**0**

*. These data obtained from Anderson and Stewart (2007) from Appendix Tables A2-1 (Duffy), A2-2 (sevens), A2-3 (Lily Park), A2-4 (Corn Lake), A2-5 (Clifton), A2-6 (Escalante), A2-7 (Delta) and A2-8 (Big Gypsum).

**. These data from Table 1a and 1b.

***. Other species in decreasing order of significance by biomass

Duffy - carp, smallmouth bass, northern pike, Colorado pikeminnow
Sevens - carp, smallmouth bass, northern pike
Lily Park – carp, smallmouth bass, northern pike
Corn Lake – carp, Colorado pikeminnow
Clifton – carp
Escalante – carp
Delta – carp
Big Gypsum – carp, black bullhead

availability appeared nearly optimal on the Colorado River and the bluehead species composition was 36% by number caught and 17% of the total biomass. The bluehead sucker composition from the San Miguel compared well to the much larger Colorado River. These fish data indicate that the San Miguel River retained a fairly high level of quality riffle habitats. Optimal bluehead sucker habitat availability is in the range of 30 to 50% of the surface area determined by 2D modeling (Anderson and Stewart 2007).

Flannelmouth sucker was the most common native fish collected in the San Miguel and also was the most common species in the sample at the sites Sevens, Lily Park, Corn Lake, Clifton, Escalante and Delta (Table 2.). Flannelmouth sucker was reduced at Duffy due to white sucker hybridization and degraded flows at Big Gypsum. Flannelmouth sucker occupy deep and semi-swift runs, habitats that are typically most prevalent given natural flow conditions. Flannelmouth sucker can achieve a large body size of 20 to 24 inches and the presence of these larger fish in the San Miguel River sample indicates an adequate flow regime is being maintained.

Non-Native Fish Species

The San Miguel River fish population differs from the other rivers in a highly positive aspect. That is non-native white sucker, carp and smallmouth bass were absent in the sample (Table 2). In addition white sucker, carp and smallmouth bass were also not collected in the Dolores River immediately downstream of the San Miguel confluence (Kowalski 2009), which tends to confirm absence or very low numbers of these non natives for both sections.

White sucker are a highly problematic for native sucker in rivers where they are commonly collected. Hybridization (white and native sucker) has been documented in the Yampa, Colorado and Gunnison River. The native sucker population of the Yampa upstream of Lily Park has been severely threatened due to cross breeding with white sucker. White sucker are a pool-habitat fish and hybridization between native and white sucker appears to be more common when reduced flows decrease the availability of faster current habitats (Anderson and Stewart 2007).

Carp are a major nuisance species. Carp are a large aggressive competitor fish that can tie up huge amounts of fish biomass. Smallmouth bass are another highly problematic species because they prey on small sized native fish which impacts native fishes independently of habitat conditions. The fact that white sucker, carp and smallmouth bass were absent elevates the status of the San Miguel River's fish community because minimal nonnative impacts will promote long term stability for the native fish community of this river. The San Miguel River is important native fish habitat to the western Colorado.

Roundtail Chub

The San Miguel River fish survey data indicates up to 3 year classes of roundtail chub were collected, documentation of continuing reproduction and recruitment. However, roundtail chub composition in the San Miguel was poor at 4% composition by number and 1% by weight. These results are a less than found at the other study sites except for

Lily Park (Table 2). A hypothesis presented in Anderson and Stewart (2007) was that the very large channel catfish population at Lily Park was likely impacting the roundtail chub in that section of the Yampa River. In contrast channel catfish were absent in the Gunnison River samples but roundtail chub number and composition was strongest there (Table 2). These data plus the San Miguel data suggest that channel catfish probably have a negative relationship on roundtail chub abundance.

Stewart and Anderson (2007) found that roundtail chub abundance and habitat data were not highly informative for making instream flow recommendations. Roundtail chub are a multi-habitat species occupying pools during the day and foraging in runs and riffle at night. Anderson and Stewart (2007) suggested that roundtail chub are more likely limited by forage availability than by habitat availability. If availability of pool habitats is used to represent roundtail chub instream flow needs, then several misrepresentations could result. Since pool habitat availability generally increases with decreasing flows, it could be concluded that lower flows benefit this species, but this is false reasoning. Roundtail chub use pools for resting and hiding cover and deeper habitats are generally much more beneficial. Quality riffles provide insects and small fish for their prey.

San Miguel channel catfish numbers were higher than most sites but in the range for Lily Park on the Yampa River (Table 2). Channel catfish prefer deep pool habitats with cover and usually select slow current velocities for foraging. Channel catfish have a large overlap in preferred habitats with the roundtail chub, but much less habitat overlap with bluehead and flannelmouth sucker.

Specific concerns that were raised about use of biological data for the instream flow recommendations

The primary concerns raised by Habitech and GEI were:

Concern 1: Overall, the biological justification for the recommendations was limited:

a. Flow recommendations should be inclusive for multiple species and life stages.
b. Roundtail chub habitat for adult and spawning were not modeled.
c. Either conduct field studies to develop roundtail chub habitat criteria or provide literature reviews and professional judgments for roundtail chub habitat needs.
d. Integrate the CDOW fish data into the recommendation process.

Concern 1 evaluation:

a) The request for an instream flow document typically provides fishery data as ancillary information meant to show the existence of a viable fish community. This basic criterion was met by the Kowalski (DOW) data collected in 2008.

Data (habitat and abundance) on bluehead sucker provide the best information for justifying instream flows needed to maintain the native fish assemblage (Anderson and Stewart 2007). The next most important data is for adult flannelmouth sucker. These two species were 67% of the catch and 74% of the biomass in the San Miguel fish data and would certainly be higher in the absence of channel catfish.

The bluehead sucker is a riffle obligate species, which is the reason it is nearly ideal for modeling the flow needs of the entire community. The R2Cross method identifies riffles as first limiting habitat and therefore the most critical habitat to protect. The prime importance of riffle habitat availability was also confirmed by the 2D modeling study of meso-habitat availability (Stewart and Anderson 2003).

Modeling fry/juvenile habitat for bluehead sucker, flannelmouth sucker and roundtail chub is not going to provide conclusive justifications for summer flow recommendations. First, the fish survey data did not indicate concerns with native sucker recruitment since juvenile fish were represented in the sample. This further suggests fry and juvenile habitat availability are a lower concern. Second, the goals of the flow recommendations are to maintain a healthy adult native fish population. As a general principle increasing fry and juvenile habitat availability in order to increase fry and juvenile numbers is not a sound management strategy for species with a long life span and low adult mortality rates. Third, preferred fry and juvenile habitat is considered associated with shallower and lower velocities located on the margins of the river bank. Habitat availability maps made by 2D modeling demonstrated that fry/juvenile habitats were available at flows regimes prioritized by adult bluehead and flannelmouth sucker (Stewart and Anderson 2007, CD Appendix- Habitat 2D modeling).

I disagree with the Dr. Wesche conclusion that spring flow recommendations require biological justifications based on spawning WUA habitat curves. Flows during the spawning period (spring) are very important and should not be ignored. However using WUA curves are probably not the best way to justify spring flow recommendations. Suitable spawning habitats are considered to be cobble substrates flushed of fine sediment. PHABSIM models spawning habitat using depth and velocity suitability curves, without the consideration for clean substrate. Therefore WUA curves may not clearly identify flows that are most suitable for the spawning activity of these native species

It is highly desirable to account for suitable spawning habitats for native fish (bluehead sucker, flannelmouth sucker and roundtail chub) in the instream flow recommendations. The three native species spawn in the spring and presumably select clean substrates for spawning sites. Spawning adults are typically larger fish that select spawning habitats deep enough to not to be dewatered by naturally declining runoff flows. The spring flow recommendation of 325 cfs appears to address the minimum depth requirement for adult bluehead and flannelmouth sucker.

Clean substrates used for spawning by native fish are maintained by annual spring flushing flows. Flushing flows or channel maintenance flows also have been used to make spring instream flow recommendations for T & E native species of the Colorado River system. A spring flow that mimics the shape of the runoff hydrograph was not included in the instream flow recommendation, but could be addressed by CDOW staff.

I have proposed the minimum flow for the runoff period to be the lowest flow that will fill the channel to the base of the bank. This 'bank-bottom' flow might approach 99% wetted perimeter in runs/pools (defined bank) and 90% of the wetted perimeter in riffles (tapered bank). The 'bank-bottom' flow appears to provide near maximum habitat diversity and habitat abundance for adult native fish at the time of staging for pre- or post- spawning. Based on observations of the rivers in Anderson and Stewart (2007) the 'bank-bottom flow' inundates shoreline habitat occupied by fry and juvenile fish, and provides preferred depths and velocities in riffles, runs and pools. Although a statistical analysis of 'bank-bottom flow' was not completed, I suggest it has potential as a spring flow recommendation.

The 'bank-bottom flow' appears to be about 500 to 900 cfs based on data from the PHABSIM cross sections. If the CDOW staff wants to consider the use of the 'bank-bottom' flow here, it could be justified based on promoting maximum habitat diversity.

b and c) Modeling adult habitat for roundtail chub is inordinately difficult to interpret and provides little biological justification for instream flows since it is a multi-habitat species. The use of generalized suitability curves (usually pools) for roundtail chub has not been validated with biological data. Stewart and Anderson (2007) could not correlate habitat abundance to adult roundtail chub abundance in their study partly due to negative impacts of non-native species like channel catfish on the abundance of roundtail chub, impacts independent of habitat. Anderson and Stewart (2007) concluded that availability of quality riffle and runs habitats (based on bluehead and flannelmouth suckers) were justified for representing the native fish community including roundtail chub. Roundtail chub occupy deep runs/riffles for feeding and deep pools for cover, and although riffles are not primary habitat, they are important for forage production

d) The biological component in the PHABSIM model is the depth and velocity probabilities for describing habitat suitability. PHABSIM has been commonly used to establish a relationship between habitat and discharge for certain species. The proper use of this model is when depth and velocity suitability curves and other assumptions have been validated. Stewart and Anderson (2207) validated the use of depth and velocities habitat variables for bluehead and flannelmouth suckers. I conclude that the San Miguel instream flow recommendation have properly integrated these biological information.

The fish data from CDOW sampling was presented above. These data provide a context for the recommended instream flow recommendations.

Concern 2: Justify the use of bluehead and flannelmouth sucker habitat suitability criteria developed from the Yampa, Colorado, Gunnison and Dolores Rivers for use on the San Miguel River.

Concern 2 evaluation:

The reason Stewart and Anderson (2007) were able to correlate meso habitat use to bluehead and flannelmouth sucker biomass (abundance) was that habitat preferences did not highly vary between rivers. The native fish communities in the Colorado River system has adapted to a dynamic riverine environment characterized by seasonal variations (discharge and temperature) and longitudinal variations (channel geomorphology, gradient and substrate composition). Also this is a fairly small and simple native fish community. Each species of the native fish community is associated with a habitat or niche. The bluehead sucker occupy the deeper riffles, speckled dace occupy shallower riffles, flannelmouth sucker occupy runs and roundtail chub the pools. There is some overlap between species, but habitat use for these species does not seem to be highly variable between rivers.

Based on my professional judgment, this portion of the San Miguel River appears to be typical for both its geomorphic properties and for its fish community compared to the other Western Colorado rivers I studied.

Although I do not have fish/habitat data collected from the San Miguel River, utilization of suitability criteria from neighboring tributaries appears reasonable. The geomorphic properties (slope, width depth ratio, substrates) and therefore habitat qualities of this section of the San Miguel are similar to the other rivers used in Anderson and Stewart (2007). The species composition and size structure are similar between in the San Miguel as in the other rivers.

Concern 3: Is it appropriate to use the bluehead sucker depth and velocity criteria used in PHABSIM modeling as the criteria for the R2Cross?

Concern 3 evaluation:

As has been pointed out several times the native fish assemblage of the San Miguel (between its confluence with the Dolores River and Calamity Creek) is comprised of three large bodied species. Providing adequate stream flow and habitat is highly desirable for large adult roundtail chub, bluehead sucker and flannelmouth sucker.

The R2Cross criteria evaluated by Nehring (1979) were for use in headwater trout streams. Headwater sections have several different channel/geomorphic properties than downstream reaches. A generalized trout population has different biological properties compared with the fish community in the section of the San Miguel under consideration.

Characteristics of river channels typically change downstream (Pitlick and Cress 2000). Headwaters are typically higher gradient, have lower annual volume, lower bankfull flow and a narrower channel. In headwaters a common mean depth would provide higher velocities and percent wetted perimeter than downstream reaches. Depth, velocity and wetted perimeter criteria were appropriately chosen, in my opinion, by CDOW and BLM staff who are thoroughly familiar with the R2Cross model and fluvial geomorphology. The larger bluehead sucker occupies riffle habitats and it is correct to use habitat needs for this species for R2Cross criteria.

The specific depth and velocity criteria of 1.0 ft depth and 1.3 ft/sec velocity were extracted from Anderson and Stewart (2003). These numbers represented minimum values for habitat defined as marginally suited for adult bluehead sucker. Therefore the criteria used in R2Cross minimal in this regard (adult bluehead sucker habitat).

Instream flow recommendations and PHABSIM WUA curves

I have reviewed the suitability curves used in the PHABSIM modeling and do not have any issues.

Evaluation of Don Conklin comments

Don Conklin (July 8, 2011) stated that when habitat for speckled dace and the fry life stage of suckers are considered, instream flow recommendations would be lower than those being proposed. Don Conklin further concluded that recommended flows are more than what is necessary because the purpose of instream flows is to preserve the existing aquatic environment. These claims were not clearly validated for the San Miguel River instream flow recommendations.

Speckled dace is not a species of special concern in the Colorado River watershed. Speckled dace are small-sized fish (about 4 inches) and occupy a niche as bottom dwellers in riffle habitats primarily with cobble substrates. Substrate velocities are much less compared to just a few inches above. Therefore cobble substrates are more critical than depths or velocities for habitat suitability. Speckled dace are common throughout the Colorado River system, have evolved with peak runoff conditions and have no apparent trouble persisting during high flow or flood conditions.

Mr. Don Conklin (July 8, 2011) presented WUA-discharge relationships for longnose dace as a surrogate for speckled dace to support his claim. Longnose dace habitat peaked at 200 cfs, a flow higher than those recommended except of the runoff period.

Miller et al. (2008) made speckled dace density and biomass estimates in the Colorado River in riffles that had suitable depths and velocities for adult bluehead sucker. It is safe to assume that speckled dace are currently common in the San Miguel. There does not appear to be any benefit to the speckled dace population given a lowered flow regime. Just because speckled dace can tolerate lowered flows far better than the 'three' native species is not a valid reason to recommend lowered instream flows, in my opinion.

Another criticism was that native fish fry life-stages were not considered in the analysis. If these data were available, the issue would become how to interpret it. It is prudent to evaluate computer generated data given their biological context. When biological reality does not indicate a problem with recruitment or fry survival at current flows, then the inclusion of fry-life stage data is not informative. Even if WUA fry curves indicate lowered spring/summer flow regimes provide increases in fry habitat, the habitat would be relocated from the rivers' margin to the interior sections. Increases in WUA at lowered flow could be offset with increased predation rates and lowered overall fry survival.

Mr. Conklin substituted data for white sucker, since habitat suitability curves bluehead sucker fry and flannelmouth sucker fry were not available,. Any conclusions made from white sucker fry WUA curves are of no value for this process. White sucker adult occupy pool habitat, they spawn later in the summer and fry are present during late summer (September) when flows are usually much less than earlier in the season. The white sucker fry curves peaked at 5 or 10 cfs (Conklin memo July 8, 2011). Flows in this range are unreasonable for instream flows for the San Miguel River.

In my opinion the proposed flow recommendations are correct to focus on the life stages (adult) that provide the clearest information concerning flow needs that will perpetuate the entire community. The critics are suggesting that current flow recommendations could be reduced without being problematic to speckled dace (reasonable) and to the fry life stages (inconclusive), but did not identify the trade off for the adult life stage.

Another claim by Mr. Conklin was the existing aquatic environment can be maintained at flows less than recommended. My studies (Anderson and Stewart 2007) have found that native fish are able to 'ride out' short term periods of drought (several months) and will recover when normal flows return. The Dolores and Yampa rivers native fish data document where long term reduced minimum flows have severely altered native fish biomass and community composition relative to rivers with high base flows. The existing fish community in the San Miguel is considered healthy and therefore flows at or near average (not minimum) are important to maintain.

Opinions on Instream Flow Recommendations

The current Recommendations:

Period		**ISF Recommendation**	**Bluehead WUA**	**Flannelmouth WUA**
April 15	- June 14	**325***	24000	40000
June 15	- July 31	**170****	25000	22000
August 1	– August 31	**115**	12000	12000
September 1	– February 29	**80**	7500	7500
March 1	– April 14	**115**	12000	12000

Comments by HabiTech (Wesche)
* Spring flow is not related to adult and spawning habitat for the sucker species.
** 170 has a nearly equal amount of habitat for bluehead and flannelmouth sucker.

It is highly appropriate to make seasonal instream flow recommendations. The hydrograph and biological activities vary greatly by season. Spring runoff is important for channel maintenance flows and native fish spawn in the spring during the ascending and descending limb of the hydrograph. Summer is the period for high rates of fish growth, primary (algae) and secondary (invertebrates) productively. Fish activity slows with cooler fall temperatures and fish are generally inactive in the winter.

The suitability curves derived from Stewart and Anderson (2003) used in the PHABSIM modeling were derived from fish surveys made in the late summer (July to early October). It was assumed that fish populations were at or near 'carrying capacity' at that time. Habitat use is likely different for winter conditions when fish are inactive and for spring spawning fish.

Summer Period, June 15 to September 30.

The 170 cfs instream flow recommendation seems to be the bare minimum for bluehead and flannelmouth sucker for the summer period. In most years flows have exceed 170 cfs in June, July and August (Table 2, San Miguel River ISF request). Maintaining habitat abundance and habitat diversity in the summer is key to maintaining a healthy and persistent native fish community in the San Miguel River. The most suitable minimum flow of the summer period is 300 cfs. However, in my opinion the flow recommendation of 170 cfs from June 15 to September 30 is marginally adequate as long as the frequency of flows less than 170 cfs does not increase compared to existing conditions. I prefer a higher minimum flow recommendation of 300 cfs.

The current recommendation drops the flow to 115 cfs from August 1 to August 31 and drops further to 80 cfs at September 1. In my opinion these flows are marginally acceptable for the native fish community. Lower flows in August and September (115 to 80 cfs) can be advantageous to non-native fish species that are competitors and predators on native fish. Channel catfish share habitat with roundtail chub and lower flows in the summer increase competitive and predatory interactions mostly to the detriment of roundtail chub. Low summer flows are also highly likely to increase white sucker habitat at the expense of native sucker.

I suggest the flow recommendation be revised to:

June 15 to August 15: 300 cfs
August 16 to September 15: 115 CFS

Fall/Winter flow recommendations:

Current recommendation: September 1 to February 29; 80 cfs

The winter flow of 80 cfs seems reasonable to me based on the fact that large adult fish were observed to persist in the community given flows during the years prior of the fish survey. My recommendation is to begin the winter period on September 16, instead of September 1.

I suggest the flow recommendation be revised to:

September 16 to February 29: 80 cfs

Early-Spring flows

I am in agreement with the current recommendation of:

March 1 to April 14: 115 cfs

Runoff Period, April 15 to June 15.

Current recommendation: April 16 to June 15: 325 cfs

Habitat suitability curves (the biological component of PHABSIM) are usually not the basis for instream flow recommendations for the spring period. Typically the need for frequent channel maintenance flows (flushing or bankfull flow) is used to justify recommendations for the runoff period. Habitats that are scoured during the runoff become the deep pool habitats required during the winter. The Dolores River is an example of a river that went several years without flushing flows to the detriment of the native fish community (Anderson and Stewart 2006 and Richard and Anderson 2007).

The instream recommendation for the runoff season is only 325 cfs. This is much less than bankfull flow (approximately 2,500 cfs) and therefore is not a flow related to channel geomorphology. Flushing flows are usually cited as important for cleaning sediment from cobble substrates used for spawning by native species. Perhaps their reasoning is that near bankfull flows are likely to continue to reoccur naturally at intervals frequent enough to perform geomorphic maintenance.

The 325 cfs flow recommendation was justified based on maximizing the available adult bluehead sucker and flannelmouth sucker habitat during the runoff period. The recommendation 325 cfs was not based on spawning habitat availability because spawning suitability curves were not used. If such spawning suitability curves were available it would likely indicate a higher flow recommendation for the runoff period. The 325 cfs flow recommendation was justified by maximizing available adult bluehead sucker and flannelmouth sucker habitat during the runoff season. During the winter period fish are confined to pools and deeper habitat. This is appropriate since fish are less active due to cold water temperatures. But in the spring native fish, initiate spawning behavior, are very active and occupy all available habitats.

In my opinion the flow that will maximize meso-habitat diversity (described in Anderson and Stewart 2007) offers biological justification for spring flow recommendations. I have suggested identification of a ‘bank-bottom’ flow (described above) as the minimum spring flow. This appears to be near 500 to 900 cfs and should mimic the timing of the peak, from May 15 to June 15.

Maintenance of large bodied native fish, the adult flannelmouth sucker, bluehead sucker and roundtail chub are absolutely requisite to maintaining a healthy native fish community. Since water is available during this period a recommendation of 600* cfs (or the more precise determination of a ‘bank-bottom flow’) might have more biological functionality than the recommended 325 cfs in the current recommendations.

I suggest the flow recommendation be revised to:

April 15 to May 14: 325 cfs
May 16 to June 15: 600* cfs (base on cross section analysis)

Literature Cited

Anderson, R. M and G. Stewart. 2003 Riverine fish-flow investigation: Using 2D modeling to determine relationship between flow and habitat availability for warm-water riverine fish in Colorado. Annual Progress Report to Colorado Division of Wildlife, F-289. Fort Collins, CO 106 pp.

Anderson R. M and G. Stewart. 2006, riverine fish-flow investigations: Quantification of habitat availability and instream flows on the Gunnison River and impacts of long term drought on native fish populations in the Dolores River. Annual progress Report to Colorado Division of Wildlife, F-289-R. Fort Collins, CO 89 pp.

Anderson, R. M. and G. Stewart (2007). Impacts of stream flow alterations on the native fish assemblage and their habit5at availability as determined by 2D modeling and the sue of fish population data to support instream flow recommendations for section of the Yampa, Colorado. Gunnison, and Dolores Rivers in Colorado. In: CDOW special report Number 80. Fort Collins, CO.

Miller Ecological (Rees, D.E., Miller, W. J., Ptacek, J. A.) and Mussetter Engineering (Harvey, M. D., Mussetter, R. A., Morid, C, E.) 2008. Ecological and physical process during spring peak flow and summer base flows in the 15-Mile Reach of the Colorado River. Final Report to the Colorado River Conservation District, Glenwood CO.

Pitlick, J.M. and R. Cress. 2000. Longitudinal trends in channel characteristics of the Colorado River and implications for food web dynamics. Final Report, University of Colorado Boulder.

Stewart G. and R. M. Anderson (2007). Two-dimensional modeling for predicting fish biomass in western Colorado. In: CDOW Special Report Number 80. Fort Collins, CO

Conklin, Wesche, and Woodling are included as attachment in the current documentation package.

Exhibit RS#7

COLORADO WATER CONSERVATION BOARD
INSTREAM FLOW / NATURAL LAKE LEVEL PROGRAM
STREAM CROSS-SECTION AND FLOW ANALYSIS

LOCATION INFORMATION

STREAM NAME:	San Miguel River - TNC #1 - Q = 325
XS LOCATION:	TNC
XS NUMBER:	1 - REVISED
DATE:	0-Jan-00
OBSERVERS:	CDOW + BLM
1/4 SEC:	0
SECTION:	0
TWP:	0
RANGE:	0
PM:	0
COUNTY:	0
WATERSHED:	0
DIVISION:	0
DOW CODE:	0
USGS MAP:	0
USFS MAP:	0

SUPPLEMENTAL DATA

*** NOTE ***
Leave TAPE WT and TENSION
at defaults for data collected
with a survey level and rod

TAPE WT:	0.0106
TENSION:	99999

CHANNEL PROFILE DATA

SLOPE: 0.004

INPUT DATA CHECKED BY: ....DATE....................

ASSIGNED TO: ....DATE....................

STREAM NAME: San Miguel River - TNC #1 - Q = 325
XS LOCATION: TNC
XS NUMBER: 1 - REVISED

DATA POINTS= 36

VALUES COMPUTED FROM RAW FIELD DATA

FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	WETTED PERIM.	WATER DEPTH	AREA (Am)	Q (Qm)	% Q CELL
Pin	-1.00	3.63			0.00		0.00	0.00	0.0%
	4.00	4.53			0.00		0.00	0.00	0.0%
	7.00	5.42			0.00		0.00	0.00	0.0%
	14.00	6.07			0.00		0.00	0.00	0.0%
1 GL	40.00	7.18			0.00		0.00	0.00	0.0%
	49.00	8.10			0.00		0.00	0.00	0.0%
	58.00	8.00			0.00		0.00	0.00	0.0%
	64.00	9.88	0.00	0.00	0.00		0.00	0.00	0.0%
	66.00	10.03	0.15	5.35	2.01	0.15	0.22	1.20	0.4%
	67.00	10.33	0.45	5.35	1.04	0.45	0.67	3.61	1.1%
	69.00	10.53	0.65	5.35	2.01	0.65	1.46	7.82	2.4%
	71.50	10.73	0.85	5.35	2.51	0.85	2.13	11.37	3.5%
	74.00	10.93	1.05	5.35	2.51	1.05	2.63	14.04	4.3%
	76.50	11.18	1.30	5.35	2.51	1.30	3.25	17.39	5.3%
	79.00	11.33	1.45	5.35	2.50	1.45	3.63	19.39	6.0%
	81.50	11.43	1.55	5.35	2.50	1.55	3.88	20.73	6.4%
	84.00	11.33	1.45	5.35	2.50	1.45	3.63	19.39	6.0%
	86.50	11.33	1.45	5.35	2.50	1.45	3.63	19.39	6.0%
	89.00	11.63	1.75	5.35	2.52	1.75	4.38	23.41	7.2%
	91.50	11.53	1.65	5.35	2.50	1.65	4.13	22.07	6.8%
	94.00	11.33	1.45	5.35	2.51	1.45	3.63	19.39	6.0%
	96.50	11.43	1.55	5.35	2.50	1.55	3.88	20.73	6.4%
	99.00	11.23	1.35	5.35	2.51	1.35	3.38	18.06	5.6%
	101.50	11.08	1.20	5.35	2.50	1.20	3.00	16.05	4.9%
	104.00	10.83	0.95	5.35	2.51	0.95	2.38	12.71	3.9%
	106.50	10.93	1.05	5.35	2.50	1.05	2.63	14.04	4.3%
	109.00	10.93	1.05	5.35	2.50	1.05	2.63	14.04	4.3%
	111.50	10.78	0.90	5.35	2.50	0.90	2.25	12.04	3.7%
	114.00	10.73	0.85	5.35	2.50	0.85	2.13	11.37	3.5%
	116.50	10.43	0.55	5.35	2.52	0.55	0.91	4.86	1.5%
	117.30	10.33	0.45	5.35	0.81	0.45	0.29	1.56	0.5%
	117.80	10.03	0.15	5.35	0.58	0.15	0.10	0.56	0.2%
	118.70	9.88	0.00	0.00	0.91		0.00	0.00	0.0%
1 gl	119.60	6.59			0.00		0.00	0.00	0.0%
	120.00	4.33			0.00		0.00	0.00	0.0%
Pin	121.50	3.98			0.00		0.00	0.00	0.0%
TOTALS ----------------------					54.98	1.75 (Max.)	60.79	325.24	100.0%

Manning's n = 0.0188
Hydraulic Radius= 1.10575847

STREAM NAME: San Miguel River - TNC #1 - Q = 325
XS LOCATION: TNC
XS NUMBER: 1 - REVISED

WATER LINE COMPARISON TABLE

WATER LINE	MEAS AREA	COMP AREA	AREA ERROR
	60.79	60.79	0.0%
9.63	60.79	74.58	22.7%
9.65	60.79	73.47	20.8%
9.67	60.79	72.36	19.0%
9.69	60.79	71.25	17.2%
9.71	60.79	70.14	15.4%
9.73	60.79	69.04	13.6%
9.75	60.79	67.93	11.7%
9.77	60.79	66.83	9.9%
9.79	60.79	65.73	8.1%
9.81	60.79	64.63	6.3%
9.83	60.79	63.53	4.5%
9.84	60.79	62.98	3.6%
9.85	60.79	62.44	2.7%
9.86	60.79	61.89	1.8%
9.87	60.79	61.34	0.9%
9.88	60.79	60.79	0.0%
9.89	60.79	60.25	-0.9%
9.90	60.79	59.70	-1.8%
9.91	60.79	59.16	-2.7%
9.92	60.79	58.62	-3.6%
9.93	60.79	58.08	-4.5%
9.95	60.79	57.01	-6.2%
9.97	60.79	55.95	-8.0%
9.99	60.79	54.89	-9.7%
10.01	60.79	53.85	-11.4%
10.03	60.79	52.81	-13.1%
10.05	60.79	51.77	-14.8%
10.07	60.79	50.74	-16.5%
10.09	60.79	49.71	-18.2%
10.11	60.79	48.68	-19.9%
10.13	60.79	47.65	-21.6%

WATERLINE AT ZERO
AREA ERROR = 9.880

STREAM NAME: San Miguel River - TNC #1 - Q = 325
XS LOCATION: TNC
XS NUMBER: 1 - REVISED

Constant Manning's n

STAGING TABLE

GL = lowest Grassline elevation corrected for sag
WL = Waterline corrected for variations in field measured water surface elevations and sag

	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	7.18	79.44	2.92	4.45	232.01	82.11	100.0%	2.83	2320.02	10.00
	8.88	58.17	2.02	2.75	117.23	59.36	72.3%	1.97	923.20	7.88
	8.93	57.99	1.97	2.70	114.32	59.14	72.0%	1.93	887.59	7.76
	8.98	57.82	1.93	2.65	111.43	58.92	71.8%	1.89	852.55	7.65
	9.03	57.65	1.88	2.60	108.54	58.70	71.5%	1.85	818.08	7.54
	9.08	57.47	1.84	2.55	105.66	58.48	71.2%	1.81	784.20	7.42
	9.13	57.30	1.79	2.50	102.79	58.26	71.0%	1.76	750.91	7.31
	9.18	57.13	1.75	2.45	99.93	58.05	70.7%	1.72	718.20	7.19
	9.23	56.95	1.70	2.40	97.08	57.83	70.4%	1.68	686.09	7.07
	9.28	56.78	1.66	2.35	94.24	57.61	70.2%	1.64	654.59	6.95
	9.33	56.61	1.61	2.30	91.40	57.39	69.9%	1.59	623.68	6.82
	9.38	56.43	1.57	2.25	88.58	57.17	69.6%	1.55	593.39	6.70
	9.43	56.26	1.52	2.20	85.76	56.95	69.4%	1.51	563.70	6.57
	9.48	56.09	1.48	2.15	82.95	56.73	69.1%	1.46	534.64	6.45
	9.53	55.91	1.43	2.10	80.15	56.51	68.8%	1.42	506.21	6.32
	9.58	55.74	1.39	2.05	77.36	56.29	68.6%	1.37	478.41	6.18
	9.63	55.57	1.34	2.00	74.58	56.07	68.3%	1.33	451.24	6.05
	9.68	55.39	1.30	1.95	71.80	55.85	68.0%	1.29	424.72	5.92
	9.73	55.22	1.25	1.90	69.04	55.64	67.8%	1.24	398.85	5.78
	9.78	55.05	1.20	1.85	66.28	55.42	67.5%	1.20	373.64	5.64
	9.83	54.87	1.16	1.80	63.53	55.20	67.2%	1.15	349.10	5.49
WL	9.88	54.70	1.11	1.75	60.79	54.98	67.0%	1.11	325.24	5.35
	9.93	53.73	1.08	1.70	58.08	54.01	65.8%	1.08	305.04	5.25
	9.98	52.77	1.05	1.65	55.42	53.03	64.6%	1.04	285.53	5.15
	10.03	51.80	1.02	1.60	52.80	52.06	63.4%	1.01	266.71	5.05
	10.08	51.55	0.97	1.55	50.22	51.79	63.1%	0.97	246.17	4.90
	10.13	51.30	0.93	1.50	47.65	51.52	62.7%	0.92	226.31	4.75
	10.18	51.05	0.88	1.45	45.09	51.25	62.4%	0.88	207.15	4.59
	10.23	50.80	0.84	1.40	42.54	50.98	62.1%	0.83	188.69	4.44
	10.28	50.55	0.79	1.35	40.01	50.70	61.7%	0.79	170.94	4.27
	10.33	50.30	0.75	1.30	37.49	50.43	61.4%	0.74	153.92	4.11
	10.38	49.40	0.71	1.25	35.00	49.53	60.3%	0.71	138.91	3.97
	10.43	48.50	0.67	1.20	32.55	48.62	59.2%	0.67	124.63	3.83
	10.48	47.58	0.63	1.15	30.15	47.70	58.1%	0.63	111.09	3.68
	10.53	46.67	0.60	1.10	27.79	46.78	57.0%	0.59	98.27	3.54
	10.58	45.62	0.56	1.05	25.48	45.73	55.7%	0.56	86.34	3.39
	10.63	44.58	0.52	1.00	23.23	44.68	54.4%	0.52	75.14	3.23
	10.68	43.54	0.48	0.95	21.03	43.64	53.1%	0.48	64.65	3.07
	10.73	42.50	0.44	0.90	18.88	42.59	51.9%	0.44	54.89	2.91
	10.78	39.37	0.43	0.85	16.83	39.46	48.1%	0.43	47.70	2.83
	10.83	37.91	0.39	0.80	14.90	38.00	46.3%	0.39	39.92	2.68
	10.88	34.71	0.38	0.75	13.08	34.78	42.4%	0.38	34.09	2.61
	10.93	29.00	0.39	0.70	11.43	29.07	35.4%	0.39	30.67	2.68
	10.98	28.00	0.36	0.65	10.00	28.07	34.2%	0.36	25.15	2.51
	11.03	27.00	0.32	0.60	8.63	27.06	33.0%	0.32	20.14	2.33
	11.08	26.00	0.28	0.55	7.30	26.06	31.7%	0.28	15.64	2.14
	11.13	24.67	0.24	0.50	6.03	24.72	30.1%	0.24	11.79	1.95
	11.18	23.33	0.21	0.45	4.83	23.38	28.5%	0.21	8.46	1.75
	11.23	21.67	0.17	0.40	3.71	21.71	26.4%	0.17	5.71	1.54
	11.28	20.21	0.13	0.35	2.66	20.25	24.7%	0.13	3.44	1.29
	11.33	16.25	0.10	0.30	1.69	16.29	19.8%	0.10	1.86	1.10
	11.38	10.84	0.09	0.25	1.01	10.86	13.2%	0.09	1.04	1.03
	11.43	5.42	0.11	0.20	0.60	5.43	6.6%	0.11	0.70	1.16
	11.48	4.38	0.08	0.15	0.36	4.39	5.3%	0.08	0.34	0.94
	11.53	3.33	0.05	0.10	0.17	3.34	4.1%	0.05	0.11	0.68
	11.58	1.67	0.03	0.05	0.04	1.67	2.0%	0.02	0.02	0.43
	11.63	0.00	#DIV/0!	0.00	0.00	0.00	0.0%	#DIV/0!	#DIV/0!	#DIV/0!

STREAM NAME: San Miguel River - TNC #1 - Q = 325
XS LOCATION: TNC
XS NUMBER: 1 - REVISED

SUMMARY SHEET

MEASURED FLOW (Qm)=	325.24	cfs
CALCULATED FLOW (Qc)=	325.24	cfs
(Qm-Qc)/Qm * 100 =	0.0	%
MEASURED WATERLINE (WLm)=	9.88	ft
CALCULATED WATERLINE (WLc)=	9.88	ft
(WLm-WLc)/WLm * 100 =	0.0	%
MAX MEASURED DEPTH (Dm)=	1.75	ft
MAX CALCULATED DEPTH (Dc)=	1.75	ft
(Dm-Dc)/Dm * 100	0.0	%
MEAN VELOCITY=	5.35	ft/sec
MANNING'S N=	0.019	
SLOPE=	0.004	ft/ft
.4 * Qm =	130.1	cfs
2.5 * Qm=	813.1	cfs

RECOMMENDED INSTREAM FLOW:
===========================

FLOW (CFS)	PERIOD
___________	___________
___________	___________
___________	___________
___________	___________

RATIONALE FOR RECOMMENDATION:
============================

RECOMMENDATION BY: .... AGENCY.. DATE:..........................

CWCB REVIEW BY: .... DATE:..........................

COLORADO WATER CONSERVATION BOARD
INSTREAM FLOW / NATURAL LAKE LEVEL PROGRAM
STREAM CROSS-SECTION AND FLOW ANALYSIS

LOCATION INFORMATION

STREAM NAME:	SMR #1 - RIFFLE
XS LOCATION:	0
XS NUMBER:	100 CFS
DATE:	0-Jan-00
OBSERVERS:	0
1/4 SEC:	0
SECTION:	0
TWP:	0
RANGE:	0
PM:	0
COUNTY:	0
WATERSHED:	0
DIVISION:	0
DOW CODE:	0
USGS MAP:	0
USFS MAP:	0

SUPPLEMENTAL DATA

*** NOTE ***
Leave TAPE WT and TENSION at defaults for data collected with a survey level and rod

TAPE WT:	0.0106
TENSION:	99999

CHANNEL PROFILE DATA

SLOPE: 0.004

INPUT DATA CHECKED BY: ....DATE....................

ASSIGNED TO: ....DATE....................

STREAM NAME: SMR #1 - RIFFLE
XS LOCATION: 0
XS NUMBER: 100 CFS

DATA POINTS= 36

VALUES COMPUTED FROM RAW FIELD DATA

FEATURE	DIST	VERT DEPTH	WATER DEPTH	VEL	WETTED PERIM.	WATER DEPTH	AREA (Am)	Q (Qm)	% Q CELL
Pin	-1.00	3.63			0.00		0.00	0.00	0.0%
	4.00	4.53			0.00		0.00	0.00	0.0%
	7.00	5.42			0.00		0.00	0.00	0.0%
	14.00	6.07			0.00		0.00	0.00	0.0%
1 GL	40.00	7.18			0.00		0.00	0.00	0.0%
	49.00	8.10			0.00		0.00	0.00	0.0%
	58.00	8.00			0.00		0.00	0.00	0.0%
	64.00	9.88			0.00		0.00	0.00	0.0%
	66.00	10.03			0.00		0.00	0.00	0.0%
	67.00	10.33	0.00	0.00	0.00		0.00	0.00	0.0%
	69.00	10.53	0.20	2.67	2.01	0.20	0.45	1.20	1.2%
	71.50	10.73	0.40	2.67	2.51	0.40	1.00	2.67	2.7%
	74.00	10.93	0.60	2.67	2.51	0.60	1.50	4.01	4.0%
	76.50	11.18	0.85	2.67	2.51	0.85	2.13	5.67	5.7%
	79.00	11.33	1.00	2.67	2.50	1.00	2.50	6.68	6.7%
	81.50	11.43	1.10	2.67	2.50	1.10	2.75	7.34	7.3%
	84.00	11.33	1.00	2.67	2.50	1.00	2.50	6.68	6.7%
	86.50	11.33	1.00	2.67	2.50	1.00	2.50	6.68	6.7%
	89.00	11.63	1.30	2.67	2.52	1.30	3.25	8.68	8.7%
	91.50	11.53	1.20	2.67	2.50	1.20	3.00	8.01	8.0%
	94.00	11.33	1.00	2.67	2.51	1.00	2.50	6.68	6.7%
	96.50	11.43	1.10	2.67	2.50	1.10	2.75	7.34	7.3%
	99.00	11.23	0.90	2.67	2.51	0.90	2.25	6.01	6.0%
	101.50	11.08	0.75	2.67	2.50	0.75	1.88	5.01	5.0%
	104.00	10.83	0.50	2.67	2.51	0.50	1.25	3.34	3.3%
	106.50	10.93	0.60	2.67	2.50	0.60	1.50	4.01	4.0%
	109.00	10.93	0.60	2.67	2.50	0.60	1.50	4.01	4.0%
	111.50	10.78	0.45	2.67	2.50	0.45	1.13	3.00	3.0%
	114.00	10.73	0.40	2.67	2.50	0.40	1.00	2.67	2.7%
	116.50	10.43	0.10	2.67	2.52	0.10	0.16	0.44	0.4%
	117.30	10.33	0.00	0.00	0.81		0.00	0.00	0.0%
	117.80	10.03			0.00		0.00	0.00	0.0%
	118.70	9.88			0.00		0.00	0.00	0.0%
1 gl	119.60	6.59			0.00		0.00	0.00	0.0%
	120.00	4.33			0.00		0.00	0.00	0.0%
Pin	121.50	3.98			0.00		0.00	0.00	0.0%
TOTALS ----------------------					50.43	1.3 (Max.)	37.49	100.10	100.0%

Manning's n = 0.0289
Hydraulic Radius= 0.74336332

STREAM NAME: SMR #1 - RIFFLE
XS LOCATION: 0
XS NUMBER: 100 CFS

WATER LINE COMPARISON TABLE

WATER LINE	MEAS AREA	COMP AREA	AREA ERROR
	37.49	37.49	0.0%
10.08	37.49	50.22	34.0%
10.10	37.49	49.19	31.2%
10.12	37.49	48.16	28.5%
10.14	37.49	47.14	25.7%
10.16	37.49	46.11	23.0%
10.18	37.49	45.09	20.3%
10.20	37.49	44.07	17.6%
10.22	37.49	43.05	14.8%
10.24	37.49	42.04	12.1%
10.26	37.49	41.02	9.4%
10.28	37.49	40.01	6.7%
10.29	37.49	39.51	5.4%
10.30	37.49	39.00	4.0%
10.31	37.49	38.50	2.7%
10.32	37.49	37.99	1.3%
10.33	37.49	37.49	0.0%
10.34	37.49	36.99	-1.3%
10.35	37.49	36.49	-2.7%
10.36	37.49	35.99	-4.0%
10.37	37.49	35.49	-5.3%
10.38	37.49	35.00	-6.6%
10.40	37.49	34.01	-9.3%
10.42	37.49	33.04	-11.9%
10.44	37.49	32.07	-14.5%
10.46	37.49	31.10	-17.0%
10.48	37.49	30.15	-19.6%
10.50	37.49	29.20	-22.1%
10.52	37.49	28.26	-24.6%
10.54	37.49	27.33	-27.1%
10.56	37.49	26.40	-29.6%
10.58	37.49	25.49	-32.0%

WATERLINE AT ZERO
AREA ERROR = 10.330

STREAM NAME: SMR #1 - RIFFLE
XS LOCATION: 0
XS NUMBER: 100 CFS

Constant Manning's n

STAGING TABLE

GL = lowest Grassline elevation corrected for sag
WL = Waterline corrected for variations in field measured water surface elevations and sag

	DIST TO WATER (FT)	TOP WIDTH (FT)	AVG. DEPTH (FT)	MAX. DEPTH (FT)	AREA (SQ FT)	WETTED PERIM. (FT)	PERCENT WET PERIM (%)	HYDR RADIUS (FT)	FLOW (CFS)	AVG. VELOCITY (FT/SEC)
GL	7.18	79.44	2.92	4.45	232.01	82.11	100.0%	2.83	1508.79	6.50
	9.33	56.61	1.61	2.30	91.40	57.39	69.9%	1.59	405.60	4.44
	9.38	56.43	1.57	2.25	88.58	57.17	69.6%	1.55	385.90	4.36
	9.43	56.26	1.52	2.20	85.76	56.95	69.4%	1.51	366.60	4.27
	9.48	56.09	1.48	2.15	82.95	56.73	69.1%	1.46	347.70	4.19
	9.53	55.91	1.43	2.10	80.15	56.51	68.8%	1.42	329.20	4.11
	9.58	55.74	1.39	2.05	77.36	56.29	68.6%	1.37	311.12	4.02
	9.63	55.57	1.34	2.00	74.58	56.07	68.3%	1.33	293.46	3.94
	9.68	55.39	1.30	1.95	71.80	55.85	68.0%	1.29	276.21	3.85
	9.73	55.22	1.25	1.90	69.04	55.64	67.8%	1.24	259.39	3.76
	9.78	55.05	1.20	1.85	66.28	55.42	67.5%	1.20	242.99	3.67
	9.83	54.87	1.16	1.80	63.53	55.20	67.2%	1.15	227.03	3.57
	9.88	54.70	1.11	1.75	60.79	54.98	67.0%	1.11	211.51	3.48
	9.93	53.73	1.08	1.70	58.08	54.01	65.8%	1.08	198.38	3.42
	9.98	52.77	1.05	1.65	55.42	53.03	64.6%	1.04	185.69	3.35
	10.03	51.80	1.02	1.60	52.81	52.06	63.4%	1.01	173.45	3.28
	10.08	51.55	0.97	1.55	50.22	51.79	63.1%	0.97	160.09	3.19
	10.13	51.30	0.93	1.50	47.65	51.52	62.7%	0.92	147.18	3.09
	10.18	51.05	0.88	1.45	45.09	51.25	62.4%	0.88	134.72	2.99
	10.23	50.80	0.84	1.40	42.55	50.98	62.1%	0.83	122.71	2.88
	10.28	50.55	0.79	1.35	40.01	50.70	61.7%	0.79	111.17	2.78
WL	10.33	50.30	0.75	1.30	37.49	50.43	61.4%	0.74	100.10	2.67
	10.38	49.40	0.71	1.25	35.00	49.53	60.3%	0.71	90.34	2.58
	10.43	48.50	0.67	1.20	32.55	48.62	59.2%	0.67	81.05	2.49
	10.48	47.58	0.63	1.15	30.15	47.70	58.1%	0.63	72.24	2.40
	10.53	46.67	0.60	1.10	27.79	46.78	57.0%	0.59	63.91	2.30
	10.58	45.62	0.56	1.05	25.48	45.73	55.7%	0.56	56.15	2.20
	10.63	44.58	0.52	1.00	23.23	44.68	54.4%	0.52	48.86	2.10
	10.68	43.54	0.48	0.95	21.03	43.64	53.1%	0.48	42.05	2.00
	10.73	42.50	0.44	0.90	18.88	42.59	51.9%	0.44	35.70	1.89
	10.78	39.37	0.43	0.85	16.83	39.46	48.1%	0.43	31.02	1.84
	10.83	37.91	0.39	0.80	14.90	38.00	46.3%	0.39	25.96	1.74
	10.88	34.71	0.38	0.75	13.08	34.78	42.4%	0.38	22.17	1.70
	10.93	29.00	0.39	0.70	11.43	29.07	35.4%	0.39	19.95	1.75
	10.98	28.00	0.36	0.65	10.00	28.07	34.2%	0.36	16.35	1.64
	11.03	27.00	0.32	0.60	8.63	27.06	33.0%	0.32	13.10	1.52
	11.08	26.00	0.28	0.55	7.30	26.06	31.7%	0.28	10.17	1.39
	11.13	24.67	0.24	0.50	6.03	24.72	30.1%	0.24	7.67	1.27
	11.18	23.33	0.21	0.45	4.83	23.38	28.5%	0.21	5.50	1.14
	11.23	21.67	0.17	0.40	3.71	21.71	26.4%	0.17	3.71	1.00
	11.28	20.21	0.13	0.35	2.66	20.25	24.7%	0.13	2.24	0.84
	11.33	16.25	0.10	0.30	1.69	16.29	19.8%	0.10	1.21	0.72
	11.38	10.84	0.09	0.25	1.01	10.86	13.2%	0.09	0.68	0.67
	11.43	5.42	0.11	0.20	0.60	5.43	6.6%	0.11	0.45	0.75
	11.48	4.38	0.08	0.15	0.36	4.39	5.3%	0.08	0.22	0.61
	11.53	3.33	0.05	0.10	0.17	3.34	4.1%	0.05	0.07	0.44
	11.58	1.67	0.03	0.05	0.04	1.67	2.0%	0.02	0.01	0.28
	11.63	0.00	#DIV/0!	0.00	0.00	0.00	0.0%	#DIV/0!	#DIV/0!	#DIV/0!

STREAM NAME: SMR #1 - RIFFLE
XS LOCATION: 0
XS NUMBER: 100 CFS

SUMMARY SHEET

MEASURED FLOW (Qm)=	100.10	cfs
CALCULATED FLOW (Qc)=	100.10	cfs
(Qm-Qc)/Qm * 100 =	0.0	%
MEASURED WATERLINE (WLm)=	10.33	ft
CALCULATED WATERLINE (WLc)=	10.33	ft
(WLm-WLc)/WLm * 100 =	0.0	%
MAX MEASURED DEPTH (Dm)=	1.30	ft
MAX CALCULATED DEPTH (Dc)=	1.30	ft
(Dm-Dc)/Dm * 100	0.0	%
MEAN VELOCITY=	2.67	ft/sec
MANNING'S N=	0.029	
SLOPE=	0.004	ft/ft
.4 * Qm =	40.0	cfs
2.5 * Qm=	250.2	cfs

RECOMMENDED INSTREAM FLOW:
============================

FLOW (CFS)	PERIOD

RATIONALE FOR RECOMMENDATION:
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RECOMMENDATION BY: .... AGENCY.. DATE:..........................

CWCB REVIEW BY: .... DATE:..........................

Exhibit RS#8

YEAR	00060, Discharge, cubic feet per second, Uravan											
	Monthly mean in cfs (Calculation Period: 1955-01-01 -> 2010-01-30) Period-of-record for statistical calculation restricted by user											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1955	80.3	94	211.8	519.2	701.3	618.2	184	157.9	43.7	49.1	60.9	73.5
1956	64	64.1	106.9	400.8	592.1	558.7	107.5	66	16.8	30.6	64.3	58
1957	80.4	114.3	81.6	612.7	1,478	2,361	1,306	591.7	269.6	207	190.3	144.4
1958	104.5	225.5	200.8	1,777	2,546	1,612	299.7	104	90.5	94.3	101.4	88.5
1959	95.1	99.3	101.2	265	320.9	493.7	103	148	45.6	126.7	100.3	79
1960	75.5	76.7	459	1,097	712.8	884.1	299.9	70.1	62.3	80	105.4	74.7
1961	65.1	68.3	114	602.8	1,046	755.4	164.8	160.8	251.4	214.3	140.5	94.9
1962	78.3	176.7	129.5	1,176	832.1	654.1	406.5	120.1	98.1			
1973										121.4	101.1	114.1
1974	87.3	83.5	260.5	767.7	908	481.1	192.6	58.6	24.2	78.1	78.8	64.5
1975	65.8	80.8	106.5	419.1	1,451	1,244	991	238.9	104.1	104.5	84.1	71.5
1976	72.4	97.5	98.7	304.3	617.3	598.3	234.9	85.1	105.9	111.9	67.3	49.6
1977	49.9	59	66.8	109.5	86.6	177.4	107.6	128.3	56.4	89.3	65.9	59
1978	70.3	66.2	104.5	981.5	1,133	1,156	415.8	59	29.1	53.5	83.3	103.5
1979	115.2	113.9	169.2	1,396	1,728	1,564	643.1	196.8	51.8	72.6	84.3	72.2
1980	104.6	129.1	87.1	758.3	1,727	1,490	525.1	150.5	91	84.7	91.8	88.8
1981	69.8	62.4	77.6	262	226.9	465.8	292.2	107.7	159.8	153.1	118.6	93.6
1982	74.9	78	119.7	818.8	1,155	1,027	616.5	463.4	416.3	246.9	169.1	131.5
1983	128.5	151.6	185	1,051	2,507	2,343	1,306	603.5	181.7	189.5	147.2	146
1984	124	132	217.1	1,506	3,420	1,758	801.8	436.1	202.2	270.8	193.5	161
1985	139.4	153.6	394	2,154	2,060	1,522	627.7	203.2	215	246.9	169.2	125.5
1986	103	134.6	442.5	942.6	1,414	1,336	743.8	231.2	320.7	333.3	384.8	187.6
1987	133.9	185.4	294	2,049	1,936	1,298	584.5	312.5	129.8	136.7	162.6	111.3
1988	91.9	157	202.3	456	476.2	692.9	263	144.1	170	119.1	92.6	72.7
1989	66.3	89.5	322.7	465.8	344.9	322.4	141.9	106.4	29.4	60.9	62.9	58.5
1990	51.5	54.1	67.5	152.5	378.9	517.3	165.5	44.3	70	155.9	82.7	75.2
1991	81.5	90.4	98.3	764.8	803.8	716.3	238.4	112.7	115.5	84.3	88.6	71.2
1992	71.9	69	117.9	943	918.7	736.9	350.5	123.7	51.7	93.7	96.5	64.3
1993	105.9	119	262.7	1,235	2,020	1,456	526.2	170.2	120.7	91	81.4	75.9
1994	70.5	70.6	173.6	593.3	832.5	776.2	121.2	37.2	91.4			
1996									73.7	240	153	133.2
1997	121	120.2	611.8	1,464	1,793	1,552	578.9	406.8	279.9	244.8	170.2	145.1
1998	130.8	128.9	358.8	1,092	1,557	853.1	467.9	145.9	93.1	141.5	162.7	124.4
1999	97	94.8	194.2	455	1,135	1,049	632.2	646.3	350.7	170.4	108.2	108.1
2000	113.8	113.2	141.8	894.8	880.7	439	87.4	54.6	71	116.9	100.2	80.7
2001	68.6	88.6	114.8	489.8	810.4	531.7	220.1	176.6	43.5	82.1	72.2	68.8
2002	57.3	81.4	85.1	177.3	113	87.2	9.15	11.2	99.7	102.4	84.6	53.6
2003	64.6	70.1	119	460.5	604.8	505.4	76.6	78.9	196.5	104.7	91.5	71
2004	49.1	103.1	315.7	592.1	696.5	466.4	139.5	43.5	125.5	142.5	125.4	111.9
2005	131.8	121	175	942.2	1,435	996	398.5	170.3	109.7	199.9	118.6	105.9
2006	78.5	91.6	123	540.8	503.8	342.5	161.4	203.3	137.6	496.5	160.6	81.9
2007	78.6	125.4	611.5	687.1	841	736.2	243.7	231.4	145.2	180.7	119.6	128.7
2008	90.3	112.1	194.6	986.8	1,050	1,177	451.5	175.6	75	113.8	97.4	104
2009	98.5	107.9	174	660	1,237	598.3	241.4	49.5	50.4			59.6
2010	73.3											
Mean of monthly Discharge	88	106	202	810	1,120	927	392	186	127	147	118	95

Station: **SAN MIGUEL RIVER AT URAVAN, CO.**
Parameter: STREAM FLOW CFS
Year: 1954-2005
State: CO
County: MONTROSE

ID: 09177000
Statistic: Mean
Latitude: 38:21:26
Longitude: 108:42:44
Elevation: 5000.00
Drainage Area: 1499.00

Monthly Statistics

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann
# Days	1178	1073	1178	1140	1178	1140	1178	1211	1200	1178	1140	1178	13972
Avg Day	88.31	105.7	194.5	819.7	1142	949.8	404.5	185.5	129.9	137.3	116.5	94.27	363.0
Max Day	260.0	530.0	1830	4900	5440	3800	2380	2110	1170	1100	1040	350.0	5440
Min Day	15.00	29.00	29.00	35.00	37.00	13.00	3.50	3.20	4.10	20.00	20.00	25.00	3.20
# Months	38	38	38	38	38	38	38	39	40	38	38	38	38
SDev Month	26.22	38.89	126.8	507.0	740.8	550.8	318.4	162.9	95.34	70.46	58.68	33.62	186.4
Skew Month	0.455	1.09	1.50	0.929	0.997	0.857	1.32	1.65	1.29	0.924	2.78	0.925	0.561
Min Month	49.13	54.11	66.77	109.5	86.65	87.23	9.15	11.17	16.80	30.65	60.90	49.65	78.35
Max Month	139.4	225.5	611.8	2154	3420	2361	1306	646.3	416.3	333.3	384.8	187.6	758.4
Exceedences													
1%	162.9	351.0	1044	3750	4123	2808	1770	958.5	612.0	432.0	370.6	217.8	2620
5%	140.0	186.1	578.2	2610	2700	2240	1102	597.2	371.0	292.1	212.0	160.0	1460
10%	130.0	155.7	383.2	1900	2220	1770	868.0	424.7	301.0	252.0	182.0	148.0	1010
20%	120.0	130.0	252.0	1260	1724	1380	633.4	265.6	201.0	199.0	152.0	121.0	536.6
50%	80.00	97.00	128.0	550.0	943.0	820.0	301.0	125.5	88.00	116.0	100.0	85.00	131.0
80%	62.00	70.00	83.00	233.0	484.0	437.0	112.0	51.20	42.00	76.60	73.00	65.00	74.00
90%	55.00	61.00	70.80	130.0	271.0	298.0	61.00	27.00	29.00	53.80	61.00	57.00	57.00
95%	48.00	55.00	62.00	96.00	140.9	215.0	34.00	20.55	23.00	33.00	52.00	50.00	40.00
99%	40.00	40.73	47.00	55.00	61.90	38.00	6.63	5.91	14.00	20.00	32.00	36.00	20.00

Exhibit RS#9

Literature Cited

Anderson, R. M and G. Stewart. 2003 Riverine fish-flow investigation: Using 2D modeling to determine relationship between flow and habitat availability for warm-water riverine fish in Colorado. Annual Progress Report to Colorado Division of Wildlife, F-289. Fort Collins, CO 106 pp.

Anderson R. M and G. Stewart. 2006, riverine fish-flow investigations: Quantification of habitat availability and instream flows on the Gunnison River and impacts of long term drought on native fish populations in the Dolores River. Annual progress Report to Colorado Division of Wildlife, F-289-R. Fort Collins, CO 89 pp.

Anderson, R. M. and G. Stewart (2007). Impacts of stream flow alterations on the native fish assemblage and their habit5at availability as determined by 2D modeling and the sue of fish population data to support instream flow recommendations for section of the Yampa, Colorado. Gunnison, and Dolores Rivers in Colorado. In: CDOW special report Number 80. Fort Collins, CO.

Holden, P.B. (Ed.). 1999. Flow recommendations for the San Juan River. San Juan River Basin Recovery Implementation Program, USFWS, Albuquerque, NM.

Miller Ecological Consultants (Miller, W. J., Swaim, K.M.) 2011. Instream Flow Report for the Colorado River from Kremmling Colorado downstream to Dotsero, Colorado

Miller Ecological Consultants (Rees, D. E., Ptacek, J. A., and Miller, W. J.) 2005. Roundtail Chub Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region's Species Conservation Project

Miller Ecological Consultants (Rees, D. E., Ptacek, J. A., and Miller, W. J.) 2005. Bluehead Sucker Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region's Species Conservation Project

Miller Ecological Consultants (Rees, D. E., Ptacek, J. A., Carr, R.J. and Miller, W. J.) 2005. Flannelmouth Sucker Technical Conservation Assessment. USDA Forest Service, Rocky Mountain Region's Species Conservation Project

Stewart G. and R. M. Anderson (2007). Two-dimensional modeling for predicting fish biomass in western Colorado. In: CDOW Special Report Number 80. Fort Collins, CO

Hearing Exhibits Cited

Don Conklin, July 8, 2011 Letter – Montrose County Prehearing Statement - Exhibit A
Dr, Tom Wesche, June 29, 2011 Letter – SWCD Prehearing Statement - Exhibit A
Dr. John Woodling, July 13, 2011 Letter – WRAWS Prehearing Statement - Exhibit 1
Rick Anderson, August 18, 2011 Letter – BLM&CPW Rebuttal Statement – Exhibit RS#6