RECLAMATION

Managing Water in the West

Joint Biological Assessment

Bureau of Reclamation and Non-Federal Water Management and Maintenance Activities on the Middle Rio Grande, New Mexico

Part I – Water Management Appendices

Middle Rio Grande Project, New Mexico
Upper Colorado Region

U.S. Department of the Interior
Bureau of Reclamation

July 2012

Mission Statements

The U.S. Department of the Interior protects America's natural resources and heritage, honors our cultures and tribal communities, and supplies the energy to power our future.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

Joint Biological Assessment

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Part I – Water Management Appendices

Middle Rio Grande Project, New Mexico
Upper Colorado Region

Submitted to the U.S. Fish and Wildlife Service

Rio Grande Silvery Minnow	**Southwestern Willow Flycatcher**
Pecos Sunflower	**Interior Least Tern**

U.S. Department of the Interior
Bureau of Reclamation

July 2012

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APPENDIX 1

SELECTION OF FIVE SYNTHETIC FLOW SEQUENCES FOR DETAILED ANALYSIS WITH THE UPPER RIO GRANDE WATER OPERATIONS PLANNING MODEL, PAGES 1–21

Selection of Five Synthetic Flow Sequences for Detailed Analysis with the Upper Rio Grande Water Operations Planning Model.

Prepared by

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January 19, 2009

Abstract:

This document describes the methods utilized to select five, ten-year climate sequences to drive the Upper Rio Grande Water Operations Model (URGWOM) Planning Model. 1000 synthetic climate sequences each 100 years in length, made up by historic years from 1950-2004 inclusive, were generated based on 604 years of tree ring data. From these sequences, 91,000 possible ten year sequences were evaluated according to the average Otowi Index Supply (OIS) for each, and the five sequences comprised of historic years from1975 forward only, closest to 10%, 30%, 50%, 70%, and 90% exceedance were selected for analysis with the daily timestep URGWOM Planning Model.

Introduction:

Managing water resources in New Mexico's Rio Grande basin as efficiently as possible requires an understanding of the uncertainties associated with water supply, as well as the operational flexibilities of storage and conveyance facilities in the basin. URGWOM has been developed to analyze the operational flexibilities of storage and conveyance facilities, however due to the computational restrictions of this daily timestep, basin scale model, it is not practical to run the model with the large numbers of long climate sequences that would be necessary to generate understanding of the range of system impacts associated with supply uncertainties. To get around this problem, the distribution of potential climate sequences based on over 600 years of tree ring data was evaluated, and five climate sequences, each ten years long were selected as representative of a wide range of hydrologic conditions in the basin. This process occurred in two steps, first synthetic sequences were generated, and second, representative, ten-year sequences were selected from within the synthetic climate sequences.

Generation of Synthetic Sequences:

The first step was generation of synthetic sequences of flow years from the observed record whose overall statistics were based on longer term climatic trends from available tree ring records. This work was done by AMEC Earth and Environmental in Boulder Colorado (AMEC) and is summarized briefly here. A 2½ degree gridded Palmer Drought Severity Index (PDSI) was reconstructed from tree ring data by Cook et al (2004). From this data set, AMEC chose a single grid cell in which the reconstructed

* Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under Contract DE-AC04-94AL85000.

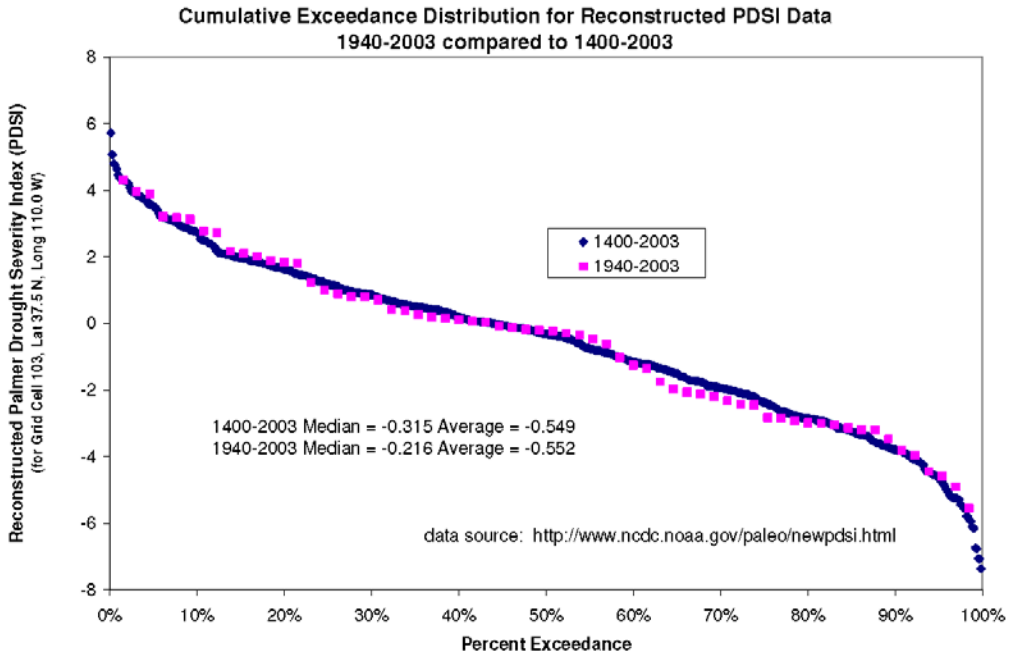
PDSI correlated most closely to the OIS for the period 1940-2003 which is the period of overlap for the two data sets. This grid cell is centered at latitude 37.5N, and longitude 110.0W, and encompasses area in Utah, Colorado, Arizona, and New Mexico. 604 years (1400-2003) of this reconstructed PDSI timeseries were then classified as either wet or dry, with the definition of wet and dry selected so that approximately half of the years fell in each class. Next, the observed state of the system (wet or dry) through time was used to generate a transient two state transition probability matrix. A two state transition probability matrix gives the likelihood of moving from a wet year to a dry year, a wet year to a wet year, a dry year to a dry year, or a dry year to a wet year from one year to the next. A transient transition probability matrix then changes through time. So, for example, a dry year was less likely to be followed by a dry year early in the 19th century than later that same century. This approach is used so that climate cycles may be captured in the synthetic sequences, rather than relying on long term averages alone. Once the transient transition probability matrix was developed, 1000, 100 year long synthetic climate sequences were generated by selecting at random an initial state (wet or dry), and moving through a randomly selected 100 year window of the transient transition probability matrix one year at a time, randomly generating either a wet or a dry climatic state based on the previous year state and the transition probability matrix that year.

The next step was to replace wet and dry climatic years with wet and dry years from the observed record, effectively going from a synthetic climatic sequence to a synthetic hydrologic sequence. This was accomplished by specifying the smallest 50% of the 1940-2007 annual Otowi Index Supply (OIS) values as occurring in "dry" years, and the rest as occurring in "wet" years, implicitly assuming that climate during the period from 1940-2007 was representative of the long term statistics derived for the 1400-2003 climate. This assumption was not listed or checked by AMEC, but was checked independently, and found to be reasonable as seen in Figure 1.

The final step was to substitute each "wet" or "dry" year in the synthetic climate sequence with a "wet" or "dry" historic year using a process called "conditional K-nearest neighbor bootstrap" selection. In transitioning from one historic year to another, transitions from similar years in the observed record were favored, thus retaining some of the year to year transition properties that have been observed historically. So if the year 1977 ("dry", 297 kAF OIS) was the last year selected, and the climate sequence called for another dry year, then "dry" years that followed a year similar to 1977 would be the most likely selections for the next year in the sequence. This selection process is referred to as a conditional K-nearest neighbor (K-nn) bootstrap selection, and is designed to maintain historically observed transition magnitudes. As a result of the K-nn bootstrap approach, in many of the sequences, historic years appear in sequential order. The combination of a transient transition probability matrix and a K-nn bootstrap approach was introduced by Prairie et al (2008) for stochastic analysis of the Colorado River at Lees Ferry, and is designed to take advantage of the strengths of both long term paleoreconstructed data, and the observed hydrologic records to generate synthetic sequences. Using this approach AMEC Earth and Environmental delivered 1000, 100 year sequences of historic years between 1950 and 2004 as synthetic sequences representative of long term climate variability in New Mexico's Rio Grande Basin. The reader is referred to the technical

memo from AMEC to Dr. Nabil Shafike of the New Mexico Interstate Stream Commission dated June 24, 2008 (Gangopadhyay and Harding, 2008) for additional details on the methods used to generate the synthetic sequences.

Figure 1: Comparison of 1940-2003 Palmer Drought Severity Index (PDSI) to 1400-2003 PDSI. The close overlap of the exceedance distribution curves suggests that 1940-2003 conditions are representative of 1400-2003 conditions, and thus median Otowi Index Supply 1940-2007 can be used as the cutoff between wet and dry years.



Selection of Representative 10 Year Sequences:

Due to the computational restrictions of the daily timestep URGWOM planning model, model runs are limited to 10 year sequences and analysis of more than five potential climatic sequences is not desired. In addition, the synthetic sequences were generated with observed years from 1950-2004 so that they could be run with a monthly timestep version of the URGWOM planning model developed in the software Powersim Studio 2005 by Sandia National Laboratories (SNL), which can run any combination of historic years from 1950-2004 as input data for scenario analysis. However, the data necessary to drive the daily timestep URGWOM planning model currently extends back only to 1975. Therefore, from the 1000, 100 year synthetic sequences developed by AMEC, it was necessary to select three to five sequences of ten year duration, made up of historic years from 1975 forward only. This was accomplished as follows. There are 91 ten year sequences in each 100 year synthetic sequence (years 1..10, 2..11, …, 90-99, 91..100), thus 91,000 total sequences in the 1000, 100 year sequences. First, the average OIS for the 91,000 ten year sequences was calculated. Next, the 91,000 values for average 10 year OIS were sorted in ascending order, and ranked according to Equation 1 below.

$$\%rank = \frac{r}{n+1} \qquad (1)$$

where r is the absolute rank (1 for the smallest value, 91,000 for the largest value), and n is the number of total records (91,000). In hydrology, distributions such as this are often described with exceedance, meaning how many of the records exceed the value of the individual record in question. Percent exceedance was calculated by subtracting the percent rank from 1 as shown in Equation 2 below.

$$\%exceedance = 1 - \%rank \qquad (2)$$

Table 1 demonstrates the calculation of percent exceedance for the 12 sequences with exceedance closest to 50%. The entire table contains 91,000 data rows.

Table 1: Portion of 91,000 data row table showing ranked 10 year sequences close to 50% exceedance compared to all 91,000 sequences.

Sequence (1-1000)	10 Year Sequence Start Year (1-91)	10 yr ave Otowi Index Flow Volume [kAF/yr]	Rank r	%Rank r/(n+1)	%Exceedance 1- (r/(n+1))
532	19	883.82	45495	49.994%	50.006%
615	26	883.84	45496	49.995%	50.005%
659	53	883.84	45497	49.996%	50.004%
17	85	883.85	45498	49.997%	50.003%
380	22	883.85	45499	49.998%	50.002%
726	31	883.86	45500	49.999%	50.001%
808	37	883.86	45501	50.001%	49.999%
753	24	883.87	45502	50.002%	49.998%
800	62	883.88	45503	50.003%	49.997%
433	85	883.88	45504	50.004%	49.996%
246	27	883.89	45505	50.005%	49.995%
742	62	883.91	45506	50.006%	49.994%

Plotting the 10 year average OIS (column 3 in Table 1) against % exceedance (column 6 in Table 1) for all 91,000 ten year sequence points yields the exceedance curve shown in Figure 2. Also shown for perspective in Figure 2, are the four, ten year sequences that were used to drive the URGWOM Planning Model for the Upper Rio Grande Water Operations (URGWOPS) Environmental Impact Study (EIS).

Next, of the 91,000 10-year sequences, 1088 sequences contained years from 1975 forward only. Of these, the five sequences closest to 10%, 30%, 50%, 70%, and 90% exceedance were selected as drivers for the URGWOM Planning Model. Table A-1 in Appendix A lists alternate sequences that were the next closest sequences to the 10%, 30%, 50%, 70%, and 90% exceedance targets.

Figure 2: Exceedance distribution curve for 10-year average Otowi Index Flow for 91,000 synthetic 10-year sequences generated based on 604 years of tree ring data.

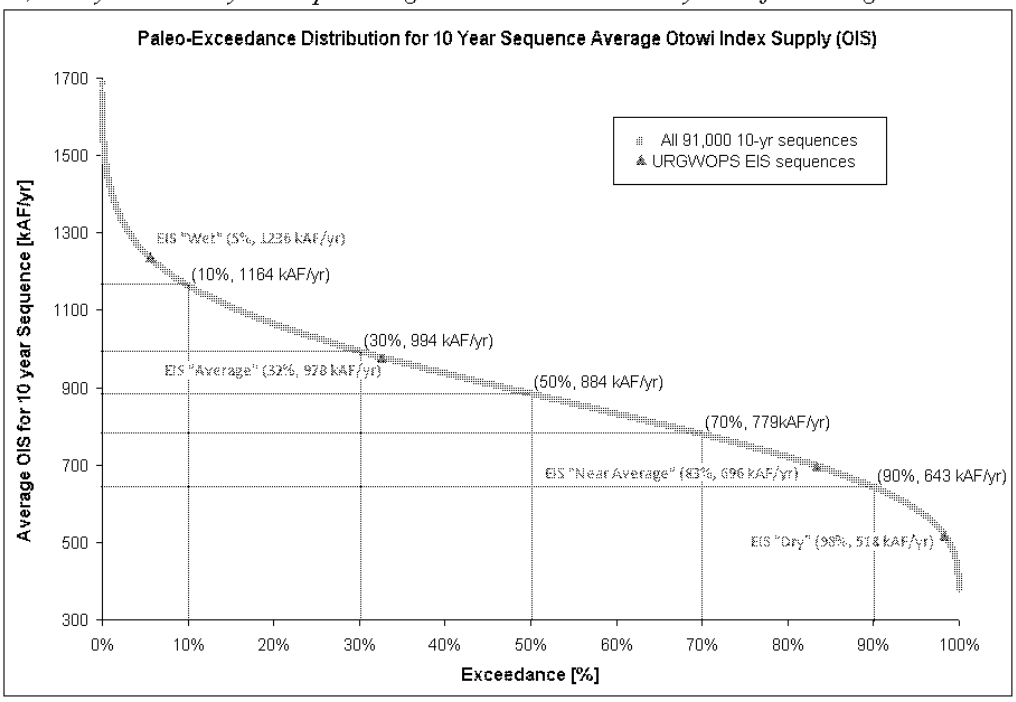


Figure 3 shows the 1088 1975 and forward sequences and the five chosen sequences in relation to the overall exceedance curve. Note that because 1975-2004 was wetter than average, sequences comprised of these years only tend to lie on the wetter (left) side of the exceedance curve distribution. Of the sequences made up only of years from 1975 forward, there were two with exactly 1164.75 kAF/yr average 10-year Otowi Index Supply. Of these, the one with the larger variation, as measured by the standard deviation of the annual Otowi Index Supply values was selected for use. This decision was based on group discussion and consensus that the high variability sequence would test the system and model more, and thus be of more use to planning efforts. Figure A-1 in Appendix A shows these two sequences in relation to one another.

The historic years making up the five selected sequences are shown in Table 2. Figures 3-7 show the individual Otowi Index Supply for the years that make up the sequences. Figure 9 compares the Otowi Index Supply for all sequence years sorted by the magnitude of annual Otowi Index Supply of each year.

Figure 3: Distribution of sequences made up of years 1975 and greater only as compared to overall exceedance curve. Note that because 1975-2004 was wetter than average, sequences comprised of these years only tend to lie on the wetter (left) side of the exceedance curve distribution. Also shown are the five sequences selected for further analysis with the daily timestep URGWOM Planning Model.

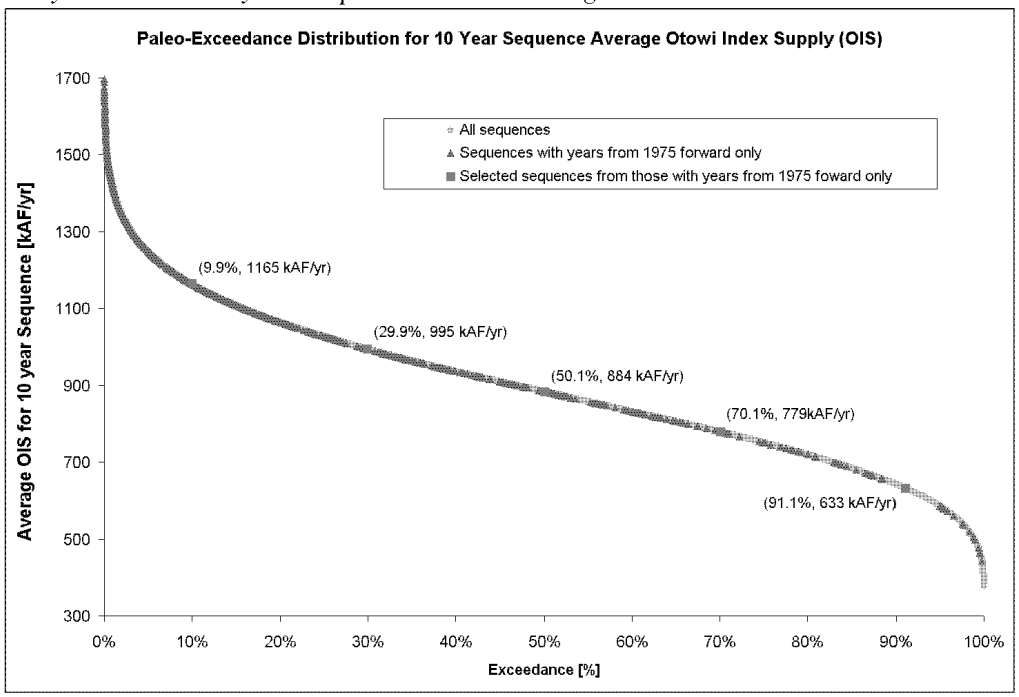


Table 2: Historic years making up each of the 5 selected sequences.

		Historic Year Used				
		Sequence Name				
		10% paleo-exceedance	30% paleo-exceedance	50% paleo-exceedance	70% paleo-exceedance	90% paleo-exceedance
Sequence Year	1	1985	1976	2004	1989	2000
	2	1996	1977	1991	1990	1990
	3	2004	1982	1992	1977	1977
	4	1977	1995	2000	2004	2003
	5	1978	1987	1977	1990	2004
	6	1979	1994	1978	1977	1991
	7	1980	1992	1990	1978	2002
	8	1992	1999	1991	1991	2003
	9	1986	1988	1976	1992	1982
	10	1994	1977	1979	1993	1976

Figure 4: Otowi Index Supply for individual years in 10% exceedance sequence selected for further analysis with the daily timestep URGWOM Planning Model.

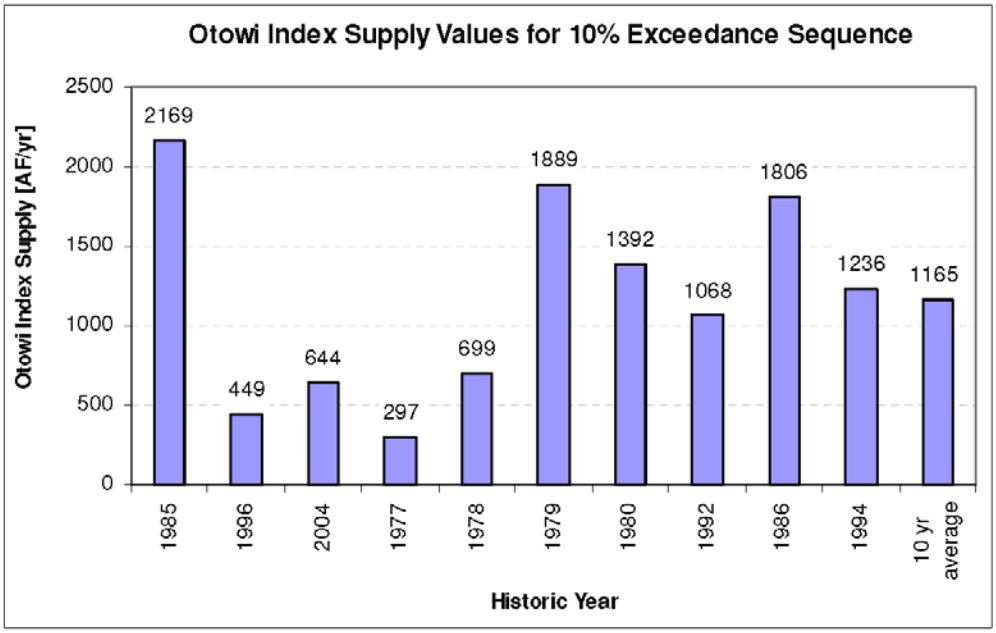


Figure 5: Otowi Index Supply for individual years in 30% exceedance sequence selected for further analysis with the daily timestep URGWOM Planning Model.

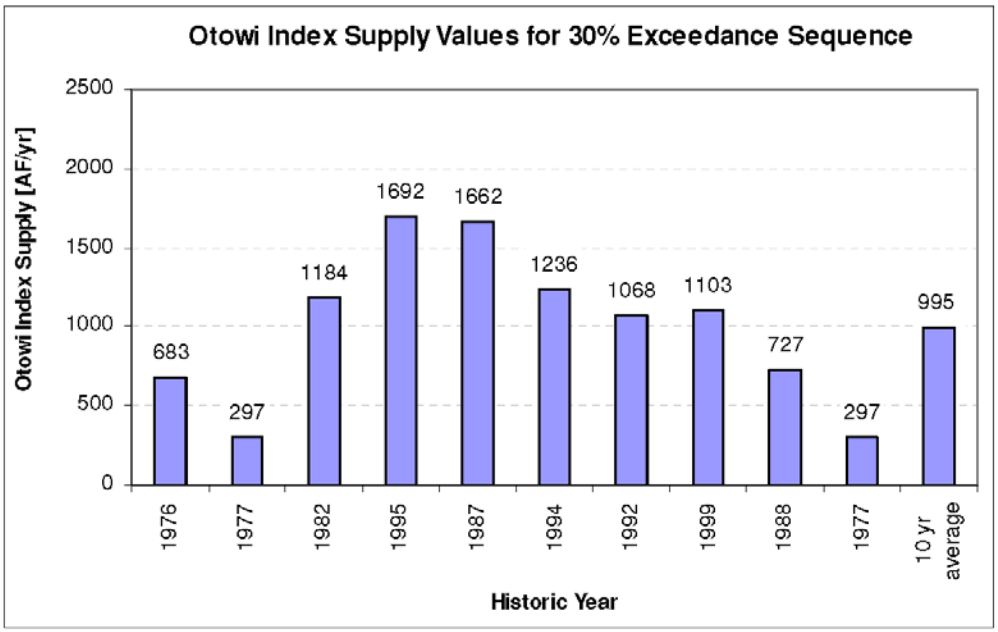


Figure 6: Otowi Index Supply for individual years in 50% exceedance sequence selected for further analysis with the daily timestep URGWOM Planning Model.

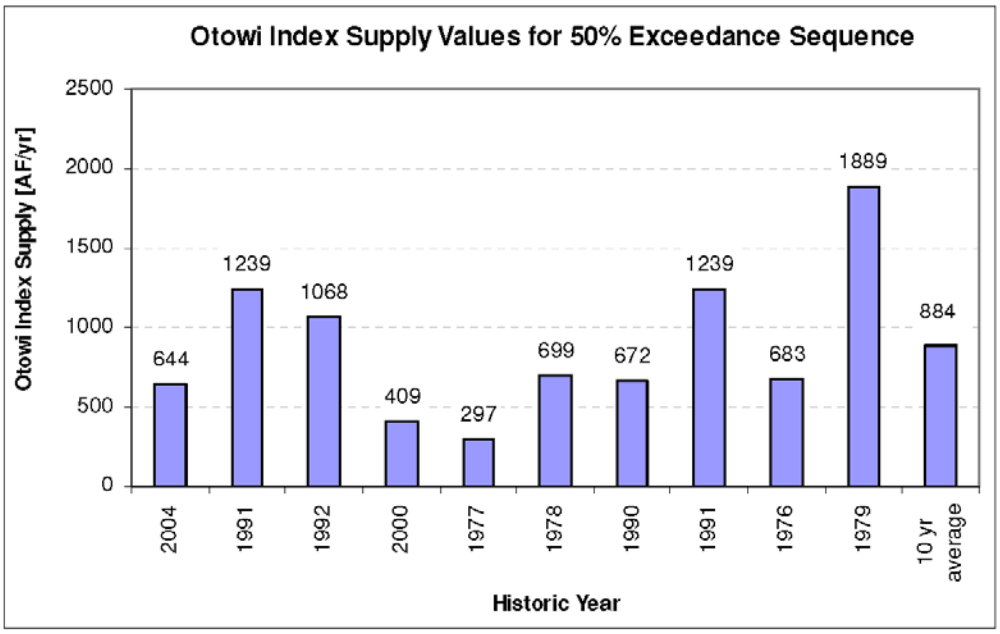


Figure 7: Otowi Index Supply for individual years in 70% exceedance sequence selected for further analysis with the daily timestep URGWOM Planning Model.

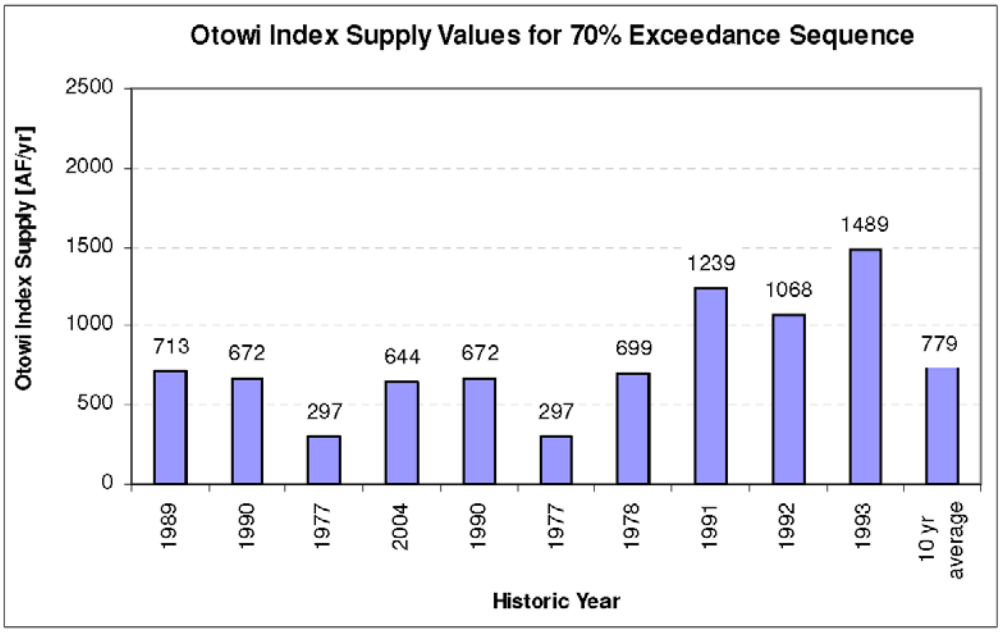


Figure 8: Otowi Index Supply for individual years in 90% exceedance sequence selected for further analysis with the daily timestep URGWOM Planning Model.

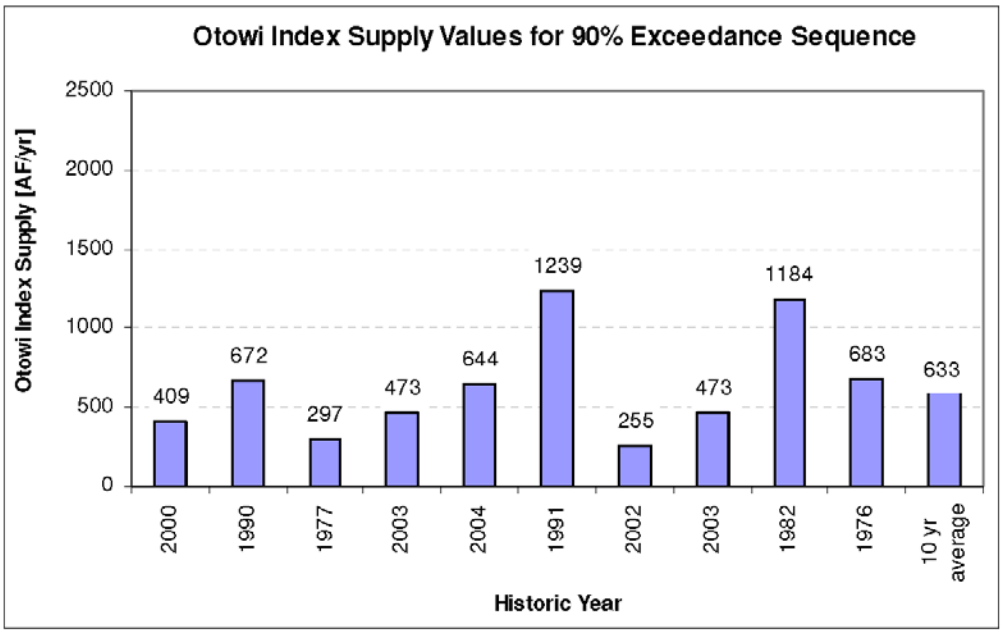
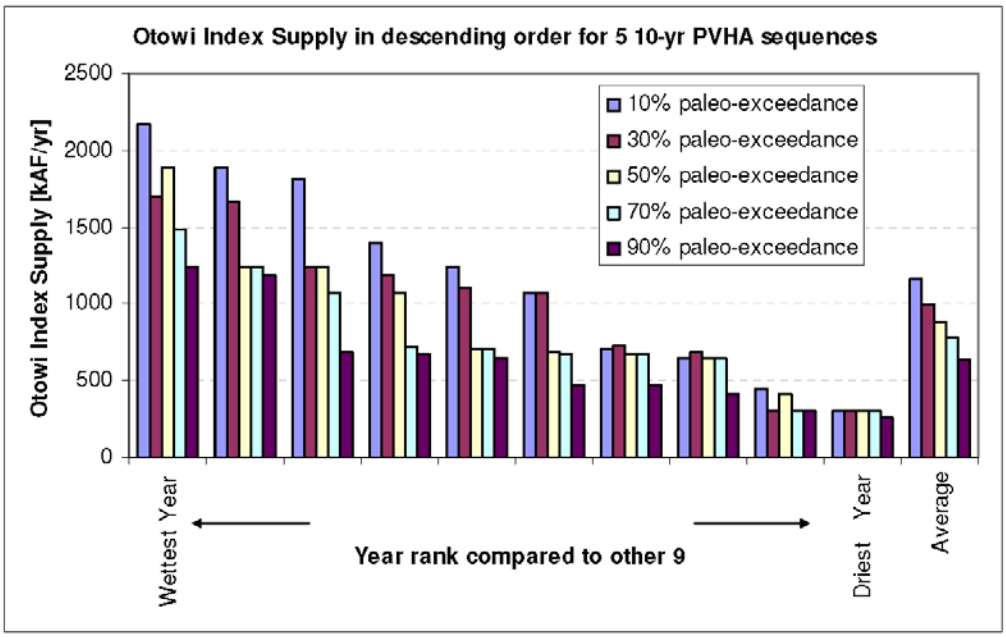


Figure 9: Otowi Index Supply for individual years in all five sequences selected for further analysis with the daily timestep URGWOM Planning Model.



Relative Monsoon Strength of Selected Sequences:

One of the most significant challenges currently facing Rio Grande water operators is in providing sufficient water to maintain established agricultural rights, growing municipal and industrial demands, and in-stream flows necessary to support endangered species habitat. Late summer can represent a bottleneck in this balance, when demands are at a peak, and supply is past the spring snowmelt generated peak. Summer monsoon based precipitation can provide an important supply during this time. Of interest to water planners is the total water that enters the surface water system below Otowi from July through September from all gaged and ungaged tributary inflows. To evaluate the relative strength of the summer monsoon, a "representative monsoon volume" was defined as the sum of gaged tributary inflows to URGWOM between Otowi and Elephant Butte Reservoirs from July through September of each year. Formally:

$$RMV^{y} = Q_{SantaFe}^{July_y - Sept_y} + Q_{Galisteo}^{July_y - Sept_y} + Q_{Jemez}^{July_y - Sept_y} + Q_{Northflood}^{July_y - Sept_y} + Q_{Southdiv}^{July_y - Sept_y} + Q_{Tijeras}^{July_y - Sept_y} + Q_{Puerco}^{July_y - Sept_y}$$

Where RMV^{y} is the annual representative monsoon volume in year y, $Q_{SantaFe}^{July_y - Sept_y}$ is the total gaged volume in the Santa Fe River above Cochiti (United States Geological Survey (USGS) gage number 8317200) for July, August, and September in year y. Similarly for Galisteo Creek below Galisteo Dam (USGS-8317950), the Jemez River near Jemez (USGS-8324000), the North Floodway Channel near Alameda (USGS-8329900), the South Diversion Channel above Tijeras Arroyo (USGS-8330775), Tijeras Arroyo near Albuquerque (USGS-8330600), and the Rio Puerco near Bernardo (USGS-8353000). The RMV was calculated for each year from 1950 through 2004. Synthetic gage data generated by the USGS was used in place of any missing data (Engdahl, et al 2008).

RMV for each year from 1950-2007 were calculated, and compared to the corresponding OIS values to get a sense of the relationship between flow at Otowi, and summer tributary inflows. Interestingly, as shown in Figure 10, with the exception of an unusual year in 1957, large summer RMV values are rarely associated with large annual OIS values, meaning that strong monsoon events almost never follow winters with heavy precipitation. The physical mechanism for this might be that monsoons are driven by land mass heating in the summer, which is reduced in summers that follow a wet winter. Average annual RMV for each ten year sequence was also calculated. Figure 11 shows RMV plotted against OIS for all 91,000 ten year sequences. The effect of the 1957outlier is lost to the 10 year average, and the pattern of no strong monsoon sequences occurring with large spring runoff sequences emerges clearly. Also plotted in Figure 11 are the five selected sequences, none of which can be classified as an outlier by visual inspection of this particular plot.

Next, RMV exceedance probabilities were calculated for all 91,000 runs according to Equations 1 and 2 above as described previously for Otowi Index Supply values. The exceedance distribution for all sequences is shown in Figure 12. Also shown in Figure 12, are the RMV values for the five selected sequences. Consistent with the preceding discussion, the 10% OIS exceedance, which is wet in terms of Otowi Volume, is dry with respect to RMV.

Figure 10: Otowi Index Supply (OIS) compared to Representative Monsoon Volume (RMV) for individual years from 1950-2007. Historic years 1950-2004 drive the 91,000 sequences considered here. Note that with the exception of 1957, strong monsoon signals as estimated by RMV almost never coincide with high annual Otowi flows.

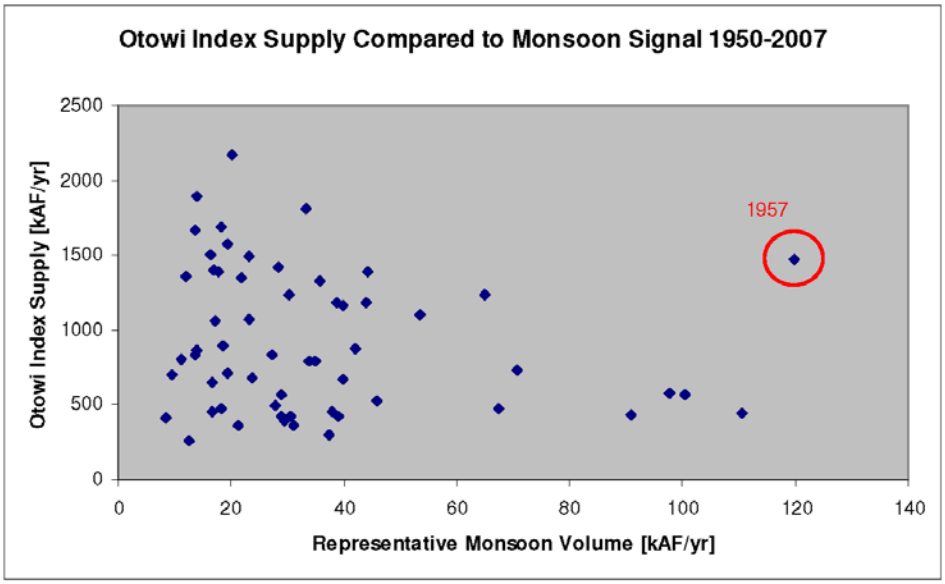


Figure 11: Ten year average Otowi Index Supply (OIS) compared to ten year average Representative Monsoon Volume (RMV) for all 91,000 ten year sequences considered here as well as the five selected sequences.

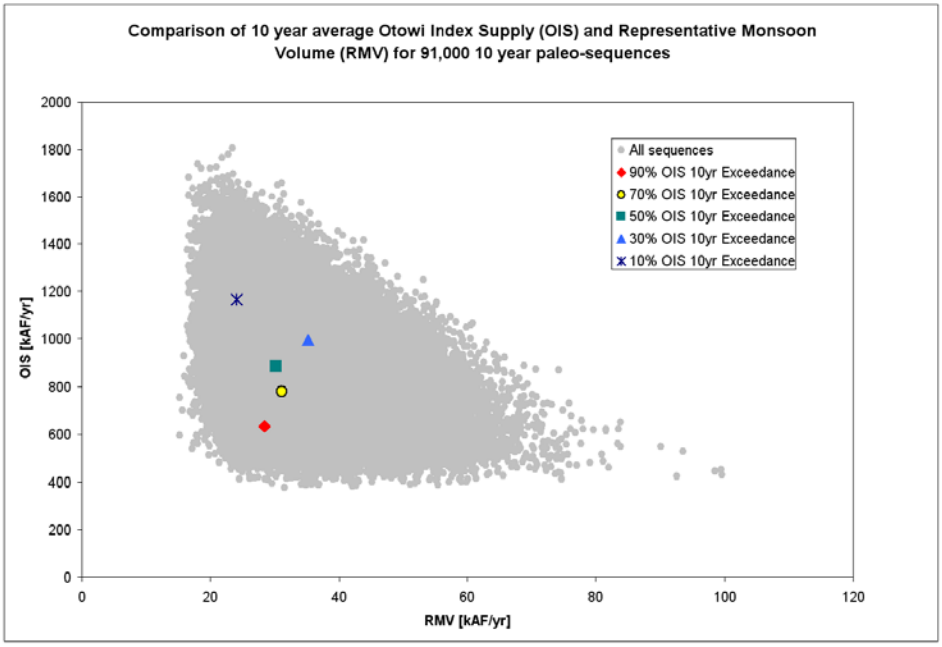
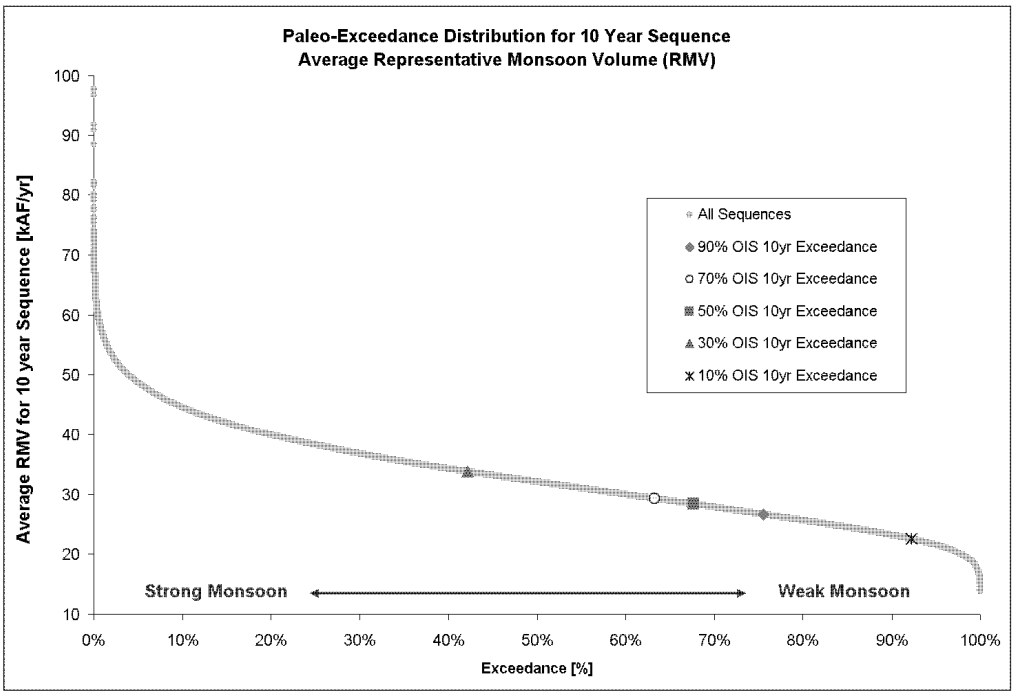


Figure 12: Exceedance distribution curve for 10-year average Representative Monsoon Volume for 91,000 synthetic 10-year sequences generated based on 604 years of tree ring data.



RMV values and their exceedance probabilities for the five selected sequences are shown in Table 3 below.

Table 3: 10 year average Representative Monsoon Volumes (RMV) and associated exceedance probabilities for the five selected sequences.

Sequence Name	10yr ave RMV [kAF/yr]	10yr RMV % Exceedence
90% OIS	26.6	76%
70% OIS	29.3	63%
50% OIS	28.3	68%
30% OIS	33.8	42%
10% OIS	22.5	92%

Figures 13-17 show the annual Representative Monsoon Volumes for all individual years in each of the five selected sequences.

Figure 13: Representative Monsoon Volume (RMV) for individual years in 10% exceedance sequence selected for further analysis with URGWOM.

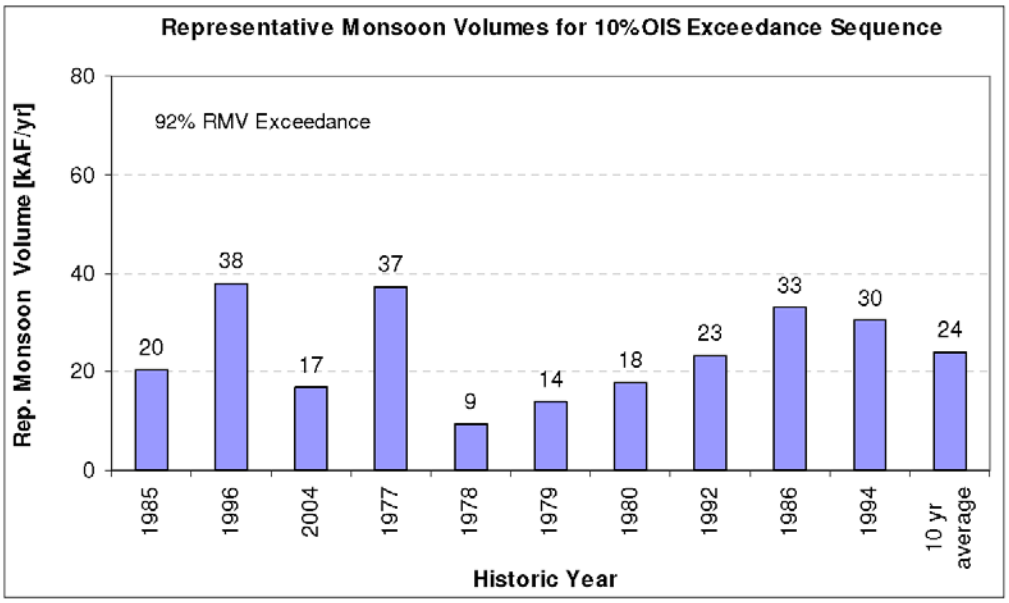


Figure 14: Representative Monsoon Volume (RMV) for individual years in 30% exceedance sequence selected for further analysis with URGWOM.

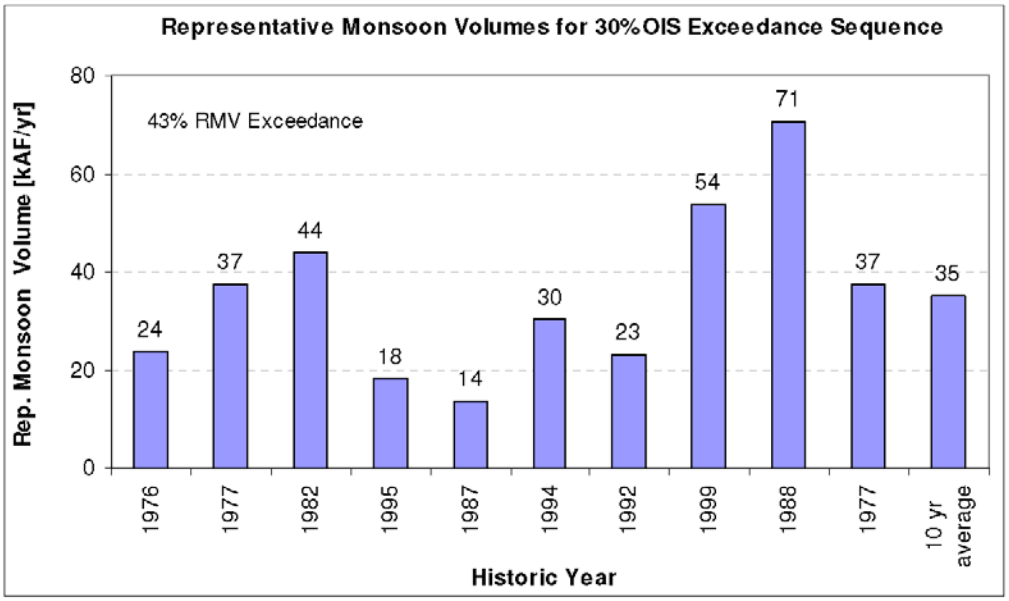


Figure 15: Representative Monsoon Volume (RMV) for individual years in 50% exceedance sequence selected for further analysis with URGWOM.

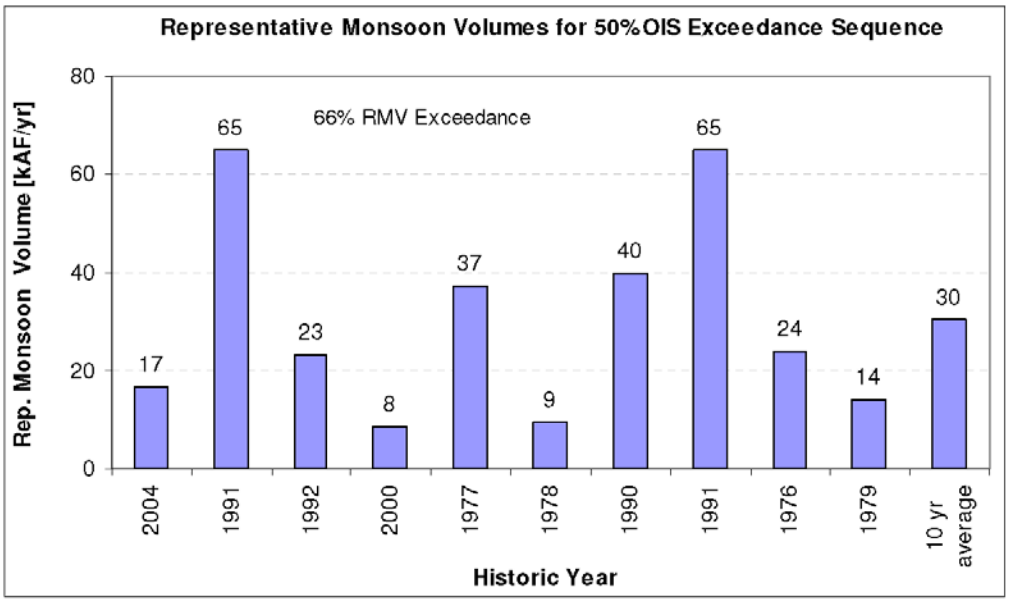


Figure 16: Representative Monsoon Volume (RMV) for individual years in 70% exceedance sequence selected for further analysis with URGWOM.

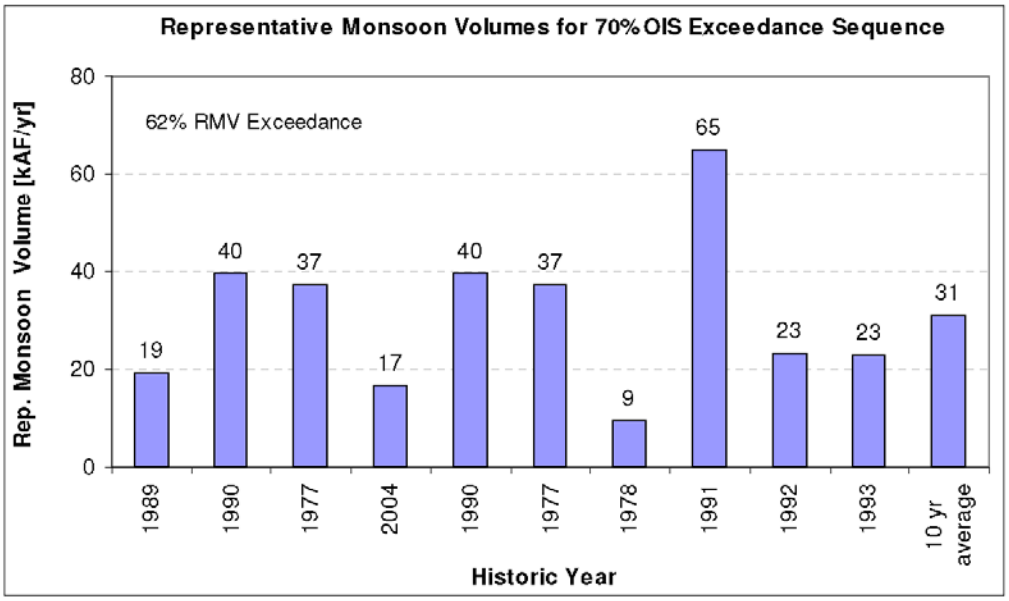
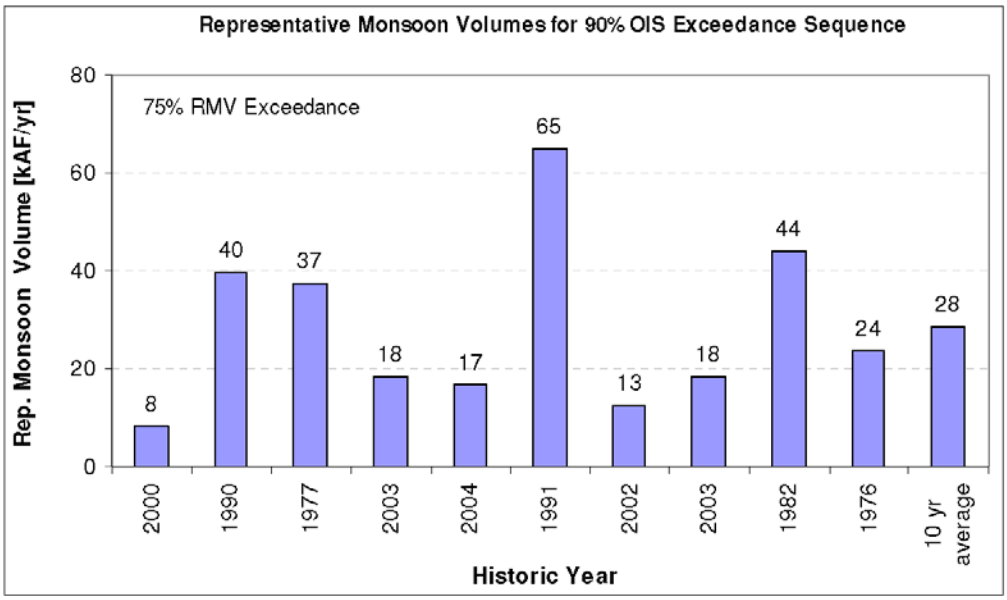


Figure 17: Representative Monsoon Volume (RMV) for individual years in 90% exceedance sequence selected for further analysis with URGWOM.



Finally, in order to compare relative Otowi flow and monsoon signal for each year of the selected sequences, OIS and RMV values were normalized by dividing by the annual average value for each from all years in the paleo based synthetic sequences. These values are 895,000 AF/year and 34,700 AF/summer for OIS and RMV respectively. The result is unitless OIS and RMV values representing a fraction of average. Figures 18-22 show year by year relative comparisons of unitless OIS and RMV values for the five selected sequences.

Figure 18: Normalized Otowi Index Supply and Representative Monsoon Volumes in each year of the 10% Exceedance Sequence. Values are normalized to annual average value of all years in the paleo based synthetic sequences.

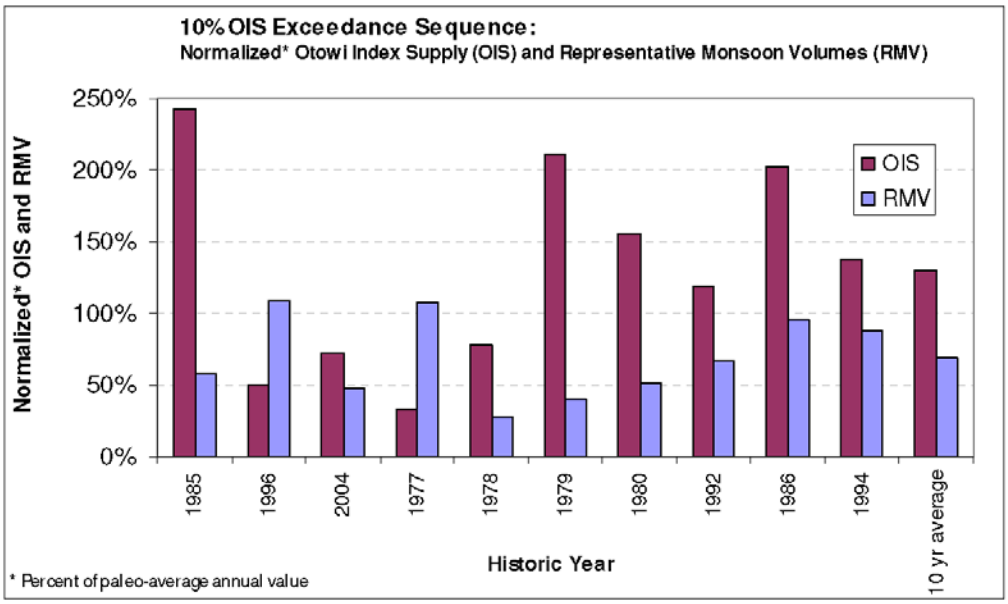


Figure 19: Normalized Otowi Index Supply and Representative Monsoon Volumes in each year of the 30% Exceedance Sequence. Values are normalized to annual average value of all years in the paleo based synthetic sequences.

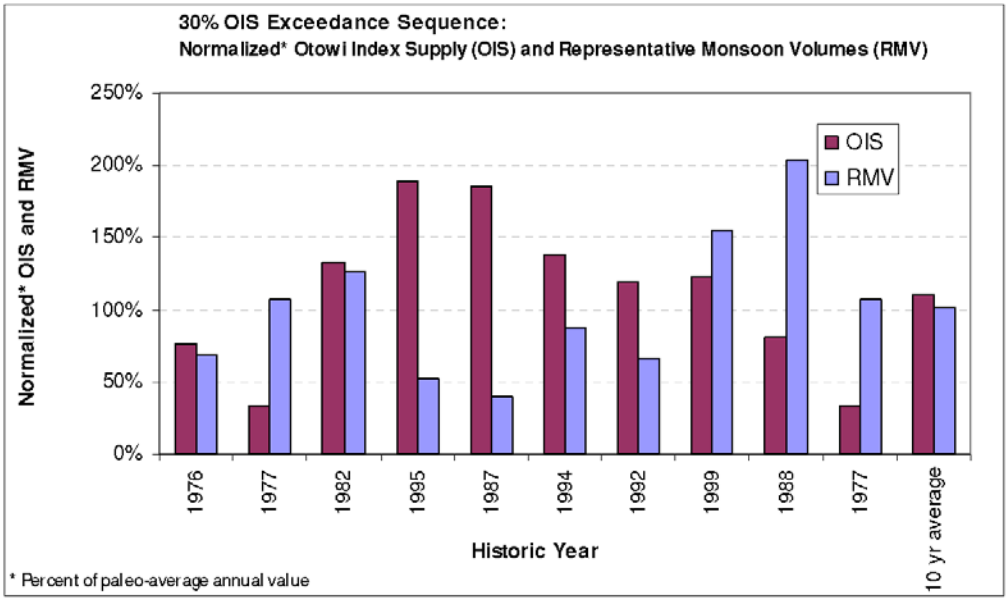


Figure 20: Normalized Otowi Index Supply and Representative Monsoon Volumes in each year of the 50% Exceedance Sequence. Values are normalized to annual average value of all years in the paleo based synthetic sequences.

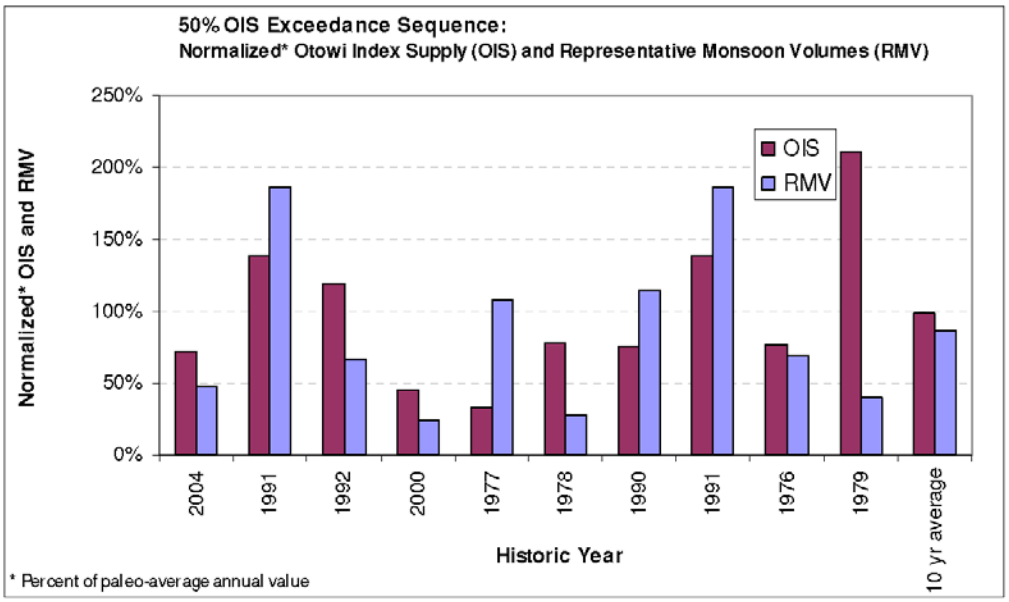


Figure 21: Normalized Otowi Index Supply and Representative Monsoon Volumes in each year of the 70% Exceedance Sequence. Values are normalized to annual average value of all years in the paleo based synthetic sequences.

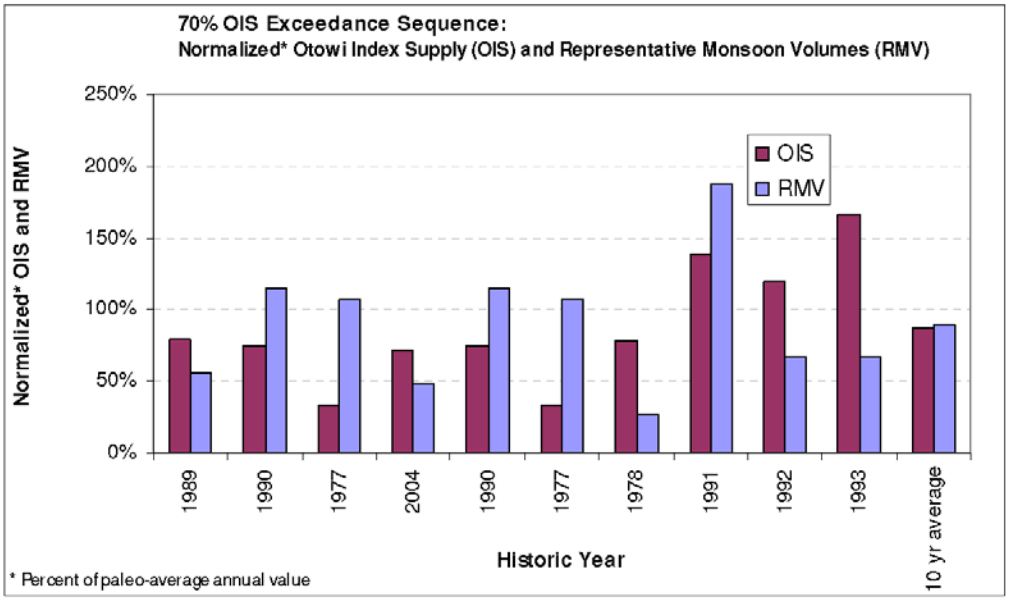
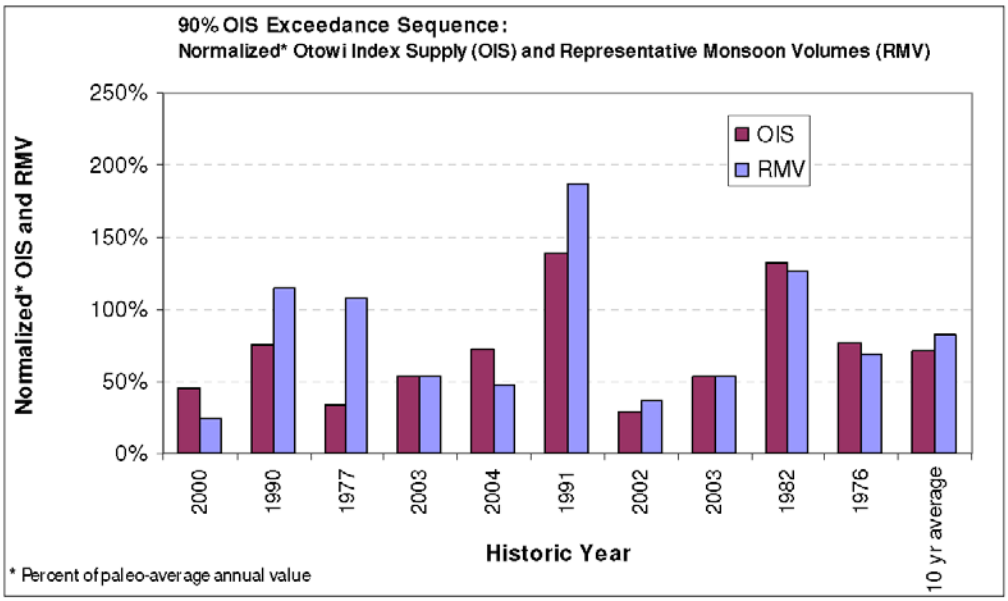


Figure 22: Normalized Otowi Index Supply and Representative Monsoon Volumes in each year of the 90% Exceedance Sequence. Values are normalized to annual average value of all years in the paleo based synthetic sequences.



Reference:

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Prairie, J, K. Novak, B. Rajagopalan, U Lall, and T. Fulp, 2008. A Stochastic Nonparametric Approach for Streamflow Generation Combining Observational and Paleo Reconstructed Data. *Water Resources Research*, Vol.44, W06423, doi:10.1029/2007WR006684, 2008
http://www.agu.org/pubs/crossref/2008/2007WR006684.shtml

Acknowledgment:

Thanks to Craig Boroughs for significant help in this analysis.

Appendix A:

Figure A-1: Otowi Index Supply for individual years in two sequences with identical 10-year average Otowi Index Supply. The sequence (in blue) beginning with 1985 was chosen for further analysis with the daily timestep URGWOM Planning Model because of a larger OIS standard deviation (647 kAF/yr) than that of the sequence (in red) beginning with historic year 1994 (385 kAF/yr).

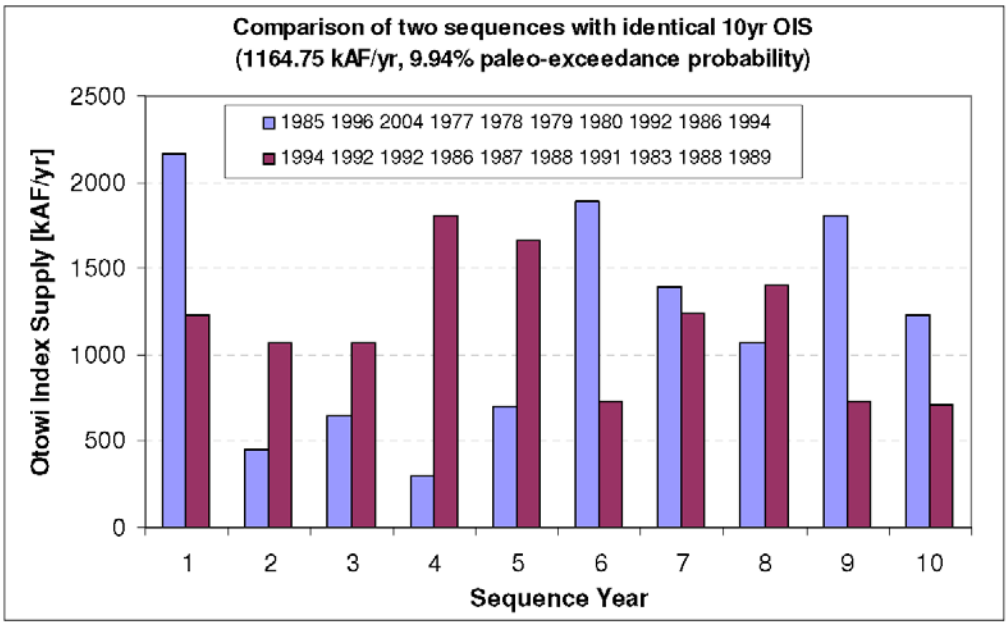

Table A-1: This table shows the sequences chosen for further analysis (named 10%, 30%, 50%, 70%, and 90%), along with two alternate sequences for each. This table is included in case additional analysis on a similar sequence is desired, or in case one of the selected sequences is discarded after additional analysis.

Sequence Name	10 yr ave OIS [kAF/yr]	% Exceed	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10
10%	633	91.1%	2000	1990	1977	2003	2004	1991	2002	2003	1982	1976
10% alt1	632	91.2%	2004	1978	1989	1977	1978	1990	1977	2004	1991	1981
10% alt2	655	88.6%	2002	1989	1990	1977	2004	1990	1977	1978	1991	1992
30%	778.81	70.09%	1989	1990	1977	2004	1990	1977	1978	1991	1992	1993
30% alt1	778.76	70.10%	1981	1982	2000	2003	1997	1992	1983	1981	2001	2002
30% alt2	778.65	70.11%	1982	2000	1977	2001	1981	1997	1976	1989	1991	1976
50%	884	50.05%	2004	1991	1992	2000	1977	1978	1990	1991	1976	1979
50% alt1	886	49.64%	1998	1992	1983	1984	1984	1976	1989	1977	2003	2004
50% alt2	882	50.42%	1982	2002	2001	1993	1994	1983	2002	1982	1976	1977
70%	995	29.93%	1976	1977	1982	1995	1987	1994	1992	1999	1988	1977
70% alt1	993	30.23%	1982	1976	1991	1992	1983	1994	1998	1992	1976	2003
70% alt2	997	29.60%	1980	1981	2001	2002	1978	1979	1980	1981	1982	1993
90%	1164.75	9.938%	1985	1996	2004	1977	1978	1979	1980	1992	1986	1994
90% alt1	1164.75	9.939%	1994	1992	1992	1986	1987	1988	1991	1983	1988	1989
90% alt2	1165.2	9.90%	1980	2000	1982	1994	1993	1994	1995	1994	1996	1997

Table A-2: Historic Annual Otowi Index Supply Values. Values provided by Dr. Nabil Shafike, New Mexico Interstate Stream Commission, personal communication August 2008. To read table, add year number to decade. For example, the Annual Otowi Index Supply Value for 1944 was 1363.2 kAF/yr.

Annual Otowi Index Supply [kAF/yr]											
		Year									
		0	1	2	3	4	5	6	7	8	9
Decade	1940	590	2686.8	2079.9	693.6	1363.2	1137.9	474.2	754.4	1370.9	1344.7
	1950	492.2	358.3	1423.2	522.3	431.3	438.7	359.8	1473.2	1507.1	424.8
	1960	798.8	788.6	1056.2	416.7	394.7	1387.5	793.8	567.6	870.6	1167.2
	1970	832.2	566.1	474.3	1576.3	450.4	1185.8	682.5	296.5	699	1888.7
	1980	1392.2	416.9	1183.5	1402.5	1343.1	2169.1	1805.9	1662.4	726.5	713.4
	1990	671.5	1239	1067.8	1489.4	1235.7	1692	449.1	1329.3	892.5	1103.2
	2000	409.2	833.7	254.8	473	643.5	1353	574.3	859.9	-	-

APPENDIX 2

AMEC MEMORANDUM
SUBJECT: STOCHASTIC STREAMFLOW SIMULATIONS FOR THE OTOWI GAGE

MEMORANDUM

TO: Dr. Nabil Shafike, P.E., New Mexico Instream Commission

FROM: Subhrendu Gangopadhyay and Ben Harding
AMEC Earth & Environmental

SUBJECT: Stochastic Streamflow Simulations for the Otowi gage

DATE: June 24, 2008

In this memorandum we present the results of stochastic simulation of Otowi ensemble flows developed using two approaches. The first set of simulations is based on the non-homogeneous Markov Chain (NHMC) algorithm of *Prairie et al* [2008]. The second set is based on the homogeneous Markov Chain (HMC) algorithm [*Haan*, 1977] using transition probability matrix developed by *Ward* [2008] for the Otowi gage.

Non-homogeneous Markov Chain Simulations

The non-homogeneous Markov Chain algorithm with an application to the Lees Ferry gage (Colorado River, AZ) ensemble streamflow simulation is described in the paper by *Prairie et al.* [2008]. Conceptually, this approach provides a method to combine transient state information (wet/dry) from paleo reconstructions of hydrologic markers (e.g., streamflow, Palmer Drought Severity Index – PDSI) with observed streamflow records to generate streamflow ensembles. Please refer to *Prairie et al* [2008] paper for the detailed description of this algorithm.

The starting point to apply this algorithm for the Otowi simulations was to study the correlation between the gridded paleo PDSI [*Cook et al*, 2004] for grid points in the vicinity of the Otowi gage and the natural streamflow of the Otowi gage. Naturalized streamflow for the Otowi gage is presently available for the period 1940-2007. The gridded PDSI data is available from the NCDC (National Climate Data Center) website, http://www.ncdc.noaa.gov/paleo/newpdsi.html. Results of the correlation analysis are shown in Figure 1. The grid point (longitude, 110.0W; latitude, 37.5N; number, 103) was found to have the highest correlation with the Otowi naturalized flow. Paleo reconstructed PDSI [*Cook et al*, 2004] for this grid point (number, 103) was used to define the flow states of the Otowi gage – 604 years of PDSI values for the period 1400-2003. Two states (dry – 0, wet – 1) were assigned to each of the 604 years of the PDSI time series. The mean and median PDSI for the 604 year period was found to be, -0.5490 and -0.3150 respectively. Consequently, positive PDSI values (PDSI > 0.0) were assigned to state wet, and PDSI values less than and equal to zero were assigned to state dry. This resulted in a binary [0, 1] time series of length 604.

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This binary time series was used to develop the transient transition probability matrix corresponding to four transitions, dd (dry-dry); dw (dry-wet); wd (wet-dry); and wet-wet (ww). The transient transition probability plot is given in Figure 2. The transient transitions were developed using a non-parametric kernel smoothing algorithm following *Prairie et al.* [2008]. It should be noted in Figure 2 that certain epochs have a higher (lower) probability of transitioning from dry (wet) to wet (dry) states. The NHMC algorithm then randomly selects an epoch of given length (100 in this case), randomly selects the initial state (dry or wet), and marches through the transitions [*Haan,* 1977] to get the simulated 100 year state time series. In addition, the historical Otowi naturalized flow time series is also classified into two states. Median flow over the 1940-2007 period, 833 kaf, was used to assign dry and wet states to each of the 68 years. If annual flow for a given year was greater than 833 kaf that year was identified to be wet, else the year was in dry state. Using the above simulated states from the paleo PDSI, the flow state from the observed period and flow magnitudes of the observed period, a conditional K-nearest neighbor (K-nn) bootstrap was performed [*Prairie et al.,* 2008] to generate an ensemble member of years and hence flow. The step of randomly selecting an epoch and conditional K-nn was repeated to generate a 1000 member ensemble of traces, each of length 100. The simulated years and flows are available in files *NM_paleo.txt* and *NM_paleo_flow.txt* respectively (the files are in matrix format, 100 rows x 1000 columns) in directory *NHMC*.

To test the simulated flows a suite of basic distributional statistics were computed from the flow ensemble including the ensemble member (i) mean, (ii) standard deviation, (iii) coefficient of skew, (iv) maximum, (v) minimum, and (vi) lag-1 autocorrelation. Drought statistics include, (i) average deficit, (ii) maximum deficit, (iii) average drought run intensity, and (iv) maximum drought run length. The drought statistics were derived using the respective median values as the threshold (drought – below median flows).

The results are displayed as boxplots in Figures 3 and 4, where the box represents the interquartile range (IQR) and whiskers approximate the 5th and 95th percentile of the simulations and outliers are shown as open circles beyond the whiskers. The statistics of the observed record are represented as a filled red triangle. Performance on a given statistic is considered good when the observed statistic of interest falls within the box (i.e., IQR) of the boxplots, while increased variability is indicated by a wider boxplot.

Generally, in all cases the observed record (red triangle) falls within the IQR of the boxplots except the drought statistic, maximum run length. The maximum drought run length in the observed flow record is 4 years (1953-1956), the maximum drought length from the PDSI record is 14 years (1870-1883). The NHMC is able to generate flows that span extended drought periods not experienced in the observed period. This we believe is valuable to the ISC in using these simulated flows in the URGWOM model.

In the next section we present the results from the homogeneous Markov Chain simulations using transition probability matrix from *Ward* [2008].

Homogeneous Markov Chain Simulations

Markov chain simulation using a single (hence the notion of homogeneity) transition probability matrix is given in *Haan* [1977]. The transition probability matrix (four state - very dry, dry, wet, very wet) used in simulating the Otowi flows is based on the matrix derived using 2000-year paleo record (Table 4, *Ward*, 2008). The transition probability matrix is given in Table 1. The flows for the observed, 1940-2007 period were assigned the four states based on thresholds defined in Table 6 of *Ward* [2008] (2000-year record upper bounding flows – very dry (444.5 kaf); dry (843.1 kaf); wet (1463.2 kaf); very wet (maximum)).

The simulated years and flows (1000 simulations each of length 100) are available in files *Ward_SimYear.out* and *Ward_SimFlow.out* respectively (the files are in matrix format, 100 rows x 1000 columns) in directory *Ward*. Similar to the NHMC simulations, basic distributional statistics and drought statistics were calculated from the simulated flows and the results are presented as boxplots in Figures 5 and 6. Generally, the observed statistic (red triangle) is within the IQR of the boxplots, except for the statistic maximum drought run length. Using the homogeneous Markov Chain model we were able to generate flow traces with longer drought lengths (median length of 7 to 8 years) than the observed maximum of 4 years (1953-1956). This again, we believe is of value to ISC in using these simulated flows in the URGWOM model.

Transition Probability Comparison

As part of the above analyses we also compared the transition probability matrix (four state – very dry, dry, wet, very wet) of *Ward* [2008] derived using 2000 year of paleo record with the one we developed (four state) using the 604 years (1400-2003) PDSI values for grid 103 (longitude, 110.0W; latitude, 37.5N; *Cook et al.,* 2004). This may not be the case for the Otowi gage, but from our experience on working with tree-ring chronologies on the Colorado River for the Lees Ferry gage (e.g., *Gangopadhyay et al.,* 2008), limited tree-ring chronologies are available prior to c. 1400, and we believe any hydrologic reconstruction prior to this time will likely have large uncertainties. This was the motivation for using the PDSI time series starting in 1400.

The definition of the four states for the above PDSI data as used in this comparison is given in Table 2. We believe these state definitions to be objective as it is based on the standard PDSI state classification system [e.g., http://weather.nmsu.edu/drought/053102/drought6.pdf]. Using the PDSI classification from Table 2, each of the 604 years (1400-2003) were assigned a state – very dry, dry, wet and very wet. The four state transition probability matrix is given in Table 3. Overall the transitions in Table 3 compare well with the transitions in Table 1 [*Ward,* 2008] except that we found no transition in the 604 year record and based on our state definition (Table 2) from very dry to very wet state. It is intuitive that for the semi-arid Rio Grande valley to move from a very dry state (very low soil moisture) to a very wet state (very high soil moisture) within a year is mostly unlikely. From a steady state transition probability estimation analysis (alternatively, Table 2 column labeled – *Count Pct)* we found that the system will be in very dry, dry, wet and very wet states 17%, 39%, 36%, and 8% of the time respectively. *Ward* [2008, Table 5] estimated these states to be 17% (very dry), 35% (dry), 33% (wet), and 15% (very wet). Again these state percentages compare well, except for the very wet state, where we get

nearly half (8%) as compared to 15% by *Ward* [2008]. No flow simulations were carried out using our transition probability matrix (Table 3) at this time.

Future Work

The following additional work is proposed to be carried out on this project.

(1) Use the transition probability matrix (Table 3) to generate flow ensembles using the homogeneous Markov Chain (HMC) algorithm.

(2) Derive two state homogeneous transition probability matrix (e.g., average of the NHMC transient transition probability matrix) and generate flow ensembles using the *Prairie et al.*[2008] conditional bootstrap algorithm.

(3) Repeat (2) above using alternative PDSI thresholds corresponding to mean and median flows from the observed period. The current transition probability matrix is derived using PDSI value of zero as the dry/wet transition threshold.

(4) Perform NHMC simulations using the additional two state transition probability matrix derived in (3) above.

(5) Perform HMC simulations using a three state (based on observed Otowi flow terciles) transition probability matrix with unconditional and possibly conditional resampling of flows. Current conditional resampling codes are based on a two state system, will need additional development for extending it to more states.

(6) Evaluate cross-validation statistics for selected Markov Chain simulations.

References

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Table 1. Transition probability matrix used in homogeneous Markov Chain simulations.

	Very Dry	*Dry*	*Wet*	*Very Wet*	**Steady State**
Very Dry	0.22	0.42	0.29	0.07	17%
Dry	0.20	0.41	0.29	0.10	35%
Wet	0.16	0.31	0.35	0.19	33%
Very Wet	0.07	0.25	0.40	0.29	15%

Source: Ward [2008].

Table 2. Definition of four states for the Cook et al. [2004] PDSI data.

State	*Description*	*Definition*	*Count*	*Count Pct*
1	Very Dry	PDSI ≤ -3.00	105	17%
2	Dry	-2.99 ≤ PDSI ≤ 0.00	233	39%
3	Wet	0.01 ≤ PDSI ≤ 2.99	220	36%
4	Very Wet	PDSI ≥ 3.00	46	8%

Table 3. Four state transition probability matrix using state definition from Table 2 and Cook et al. [2004] PDSI time series for grid 103 for the period 1400-2003.

	Very Dry	*Dry*	*Wet*	*Very Wet*
Very Dry	0.27	0.52	0.21	0.00
Dry	0.20	0.42	0.33	0.05
Wet	0.13	0.30	0.46	0.10
Very Wet	0.02	0.33	0.39	0.26

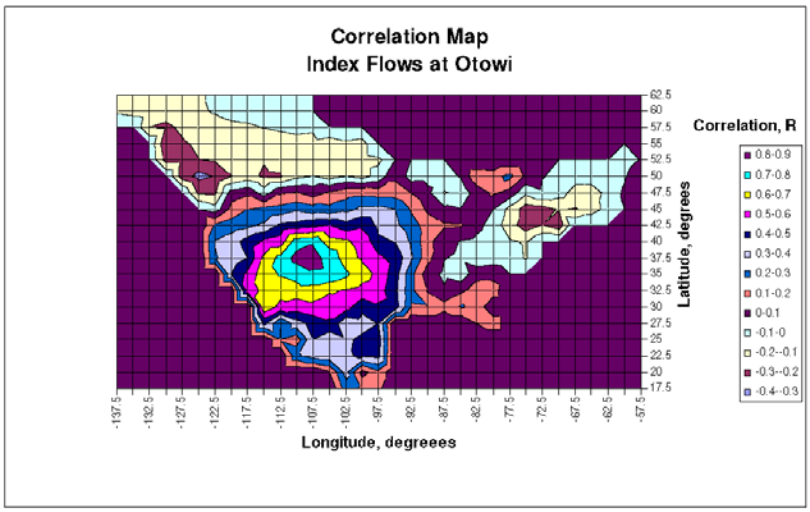

Figure 1. Correlation of gridded PDSI to Otowi index flows.

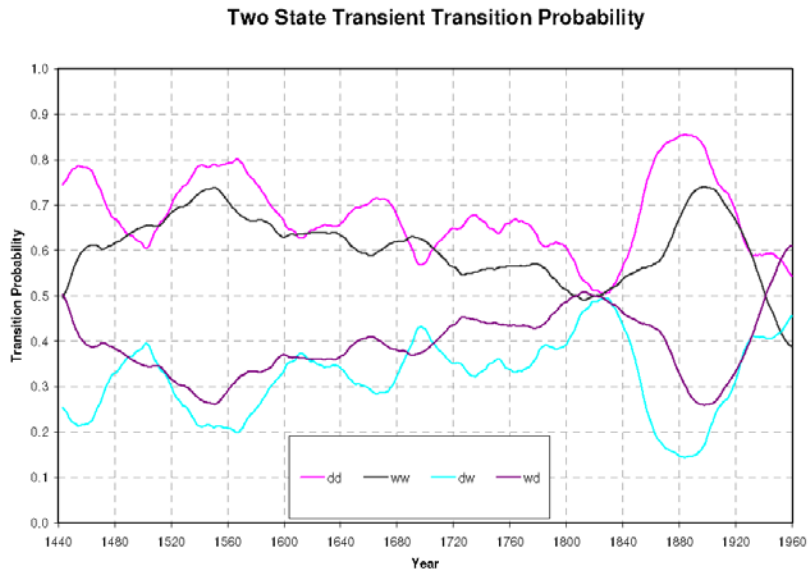

Figure 2. Two state – four transitions (dd, dw, wd, ww) transient transition probability based on the binary dry/wet time series of length 604 (1400-2003).

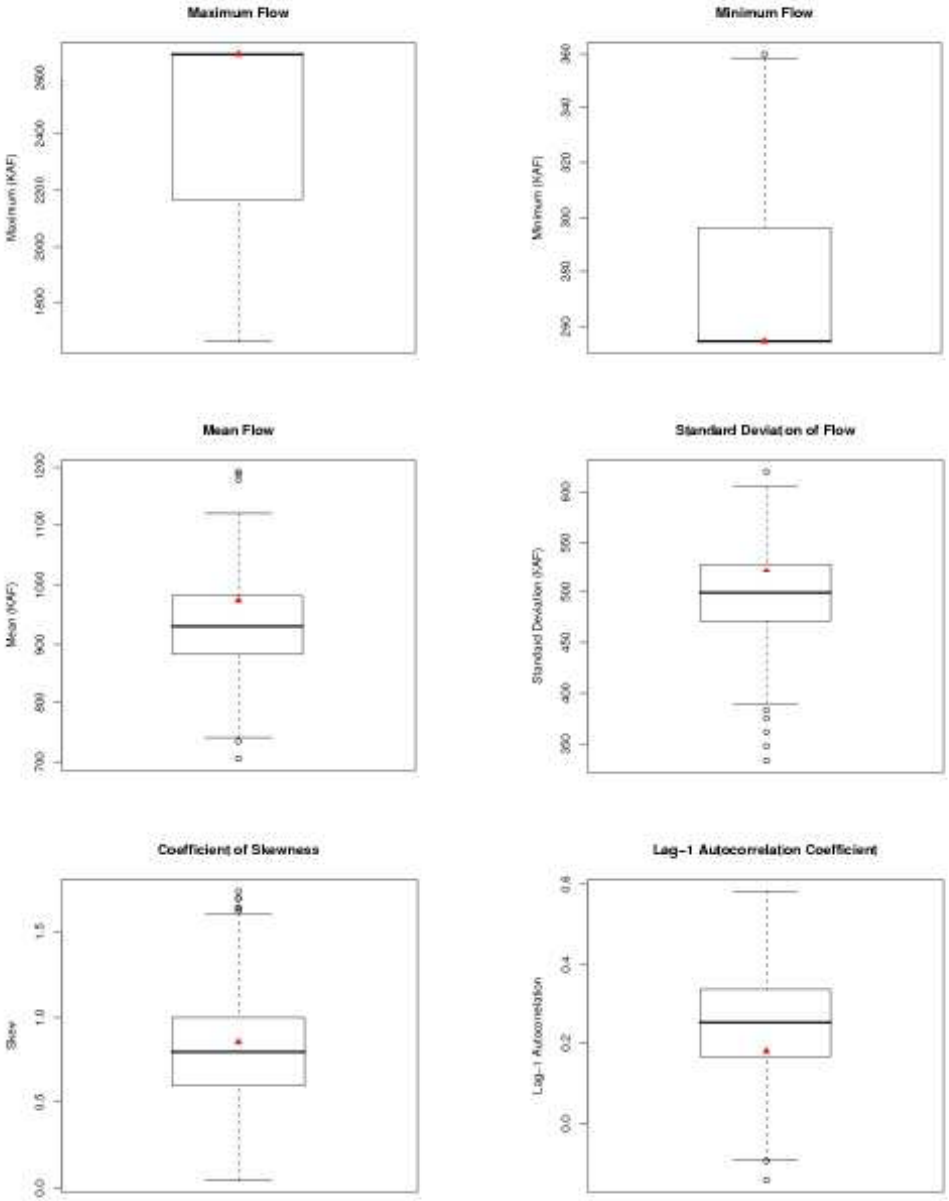

Figure 3. Distributions of statistics of annual flows for the traces generated by the NHMC.

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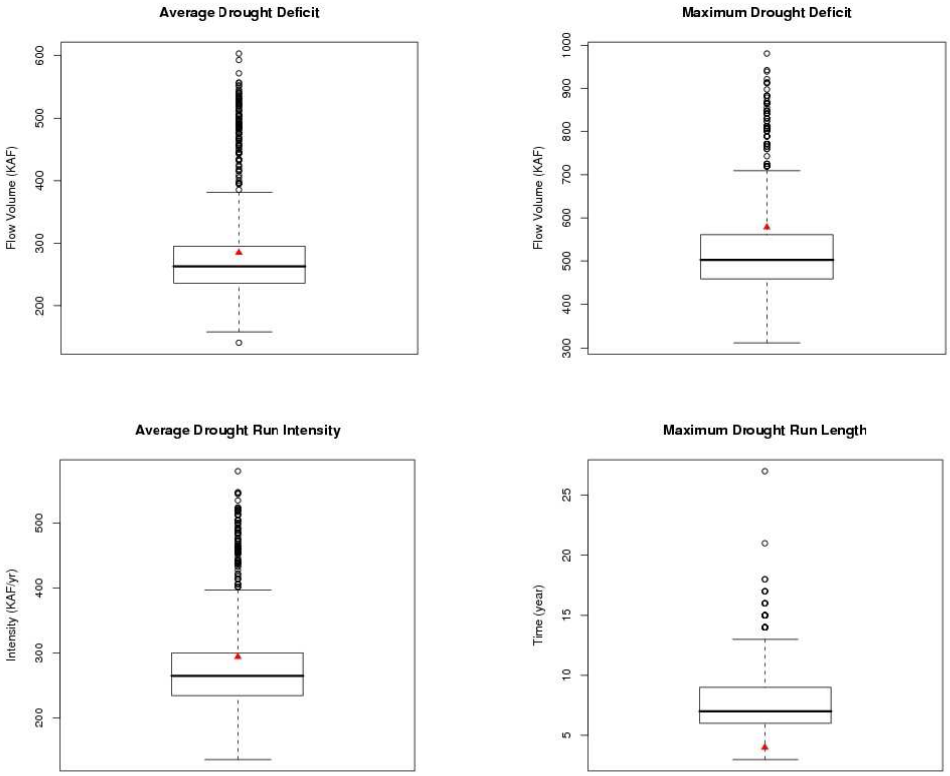

Figure 4. Distributions of statistics of drought for the traces generated by the NHMC

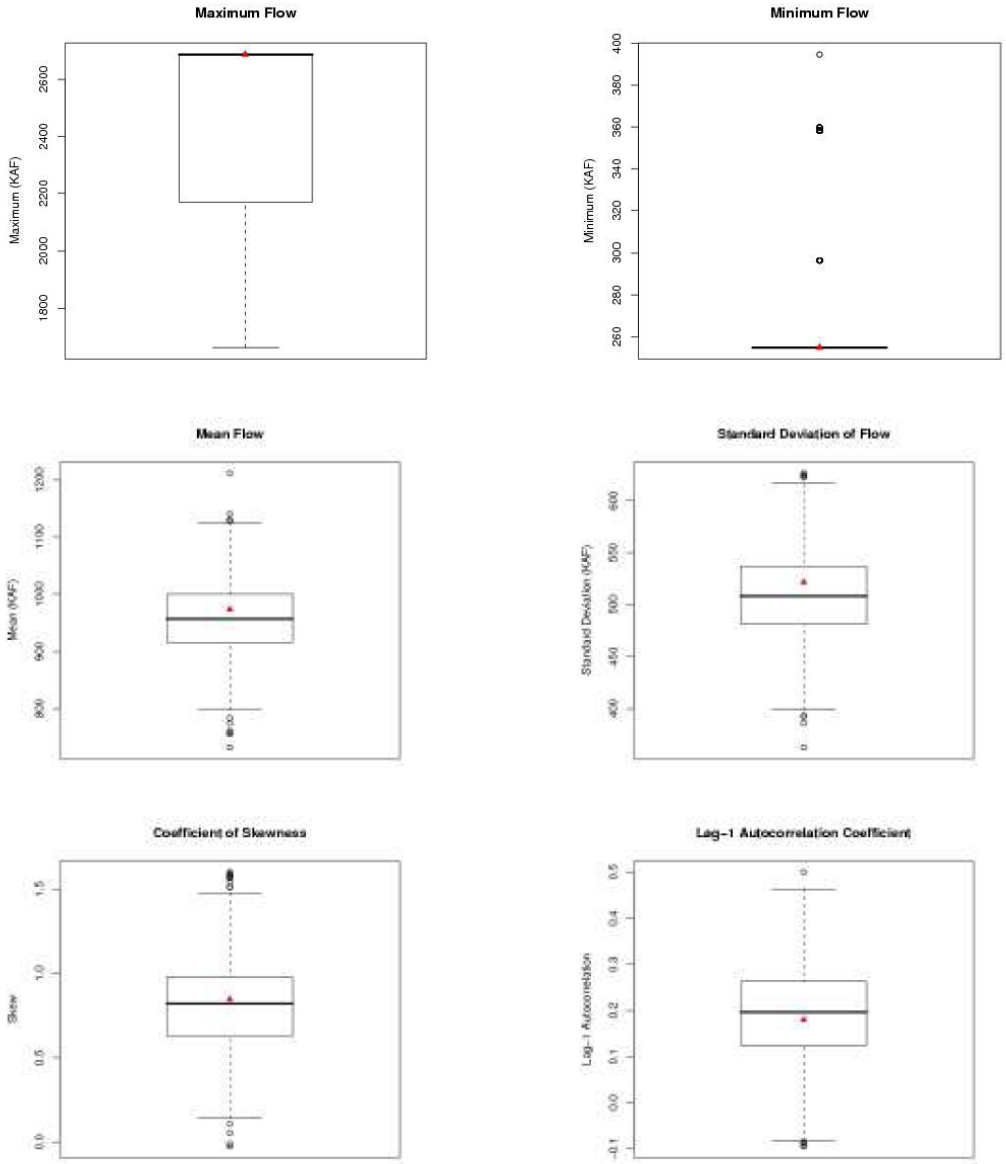

Figure 5. Distributions of statistics of annual flows for the traces generated by the HMC.

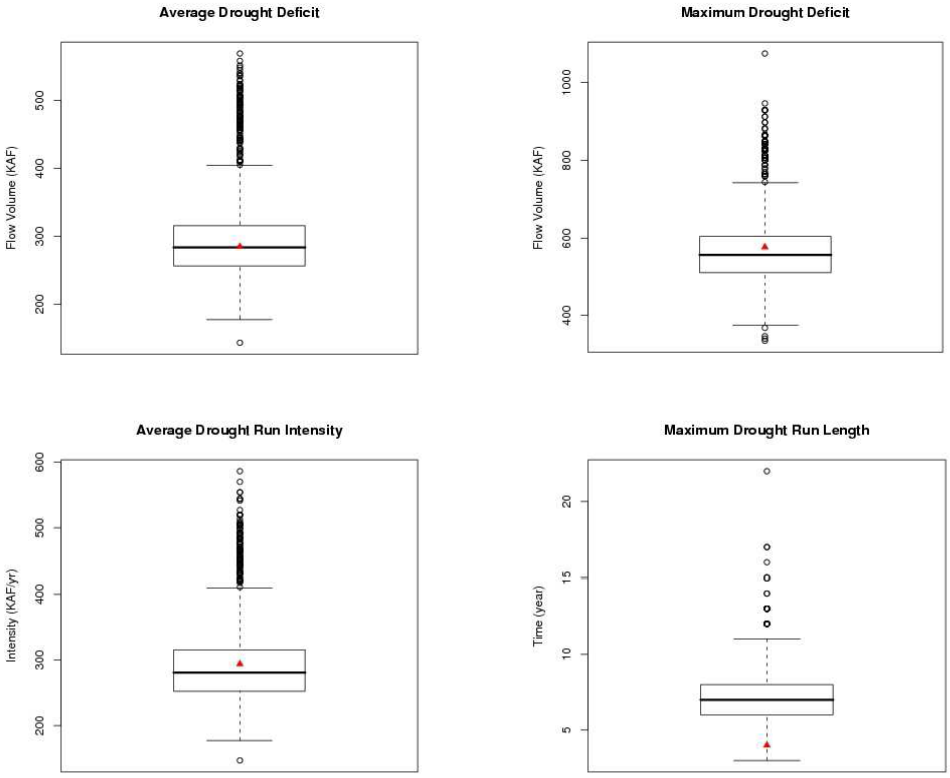

Figure 6. Distributions of statistics of drought for the traces generated by the HMC

APPENDIX 3

HABITAT RESTORATION TECHNIQUES COMMONLY USED IN THE MIDDLE RIO GRANDE

Appendix 3 – Habitat Restoration Techniques Commonly Used in the Middle Rio Grande

Method	Geomorphic Response	Habitat Characteristics	Biological Response
Riparian vegetation establishment	Can cause sediment deposition in overbank areas due to increased flow resistance. Sediment deposition in the overbank can increase main channel sediment transport capacity by raising the bank height.	Directly adds to the amount of riparian vegetation.	Increased growth of riparian vegetation in overbank areas can enhance habitat conditions for both the flycatcher and the silvery minnow. Encroachment of mature vegetation may eventually lead to a narrower and more confined channe,l which is negative for silvery minnow habitat.
Longitudinal bank and bar/island lowering	Lowered bank line can promote a wider channel width and decreases in main channel velocity, depth, shear stress, and sediment transport capacity reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels. Increases overbank flooding, creating variable depth and velocity habitat. During subsequent years, sediment may deposit in the lowered bank line area occupied by vegetation, which may reduce overbank conveyance capacity.	Promotes overbank flooding favorable for establishment of riparian vegetation as well as creating variable depth and velocity habitat. Reduces potential for channel degradation, thereby maintaining a higher water table and more connectivity with backwaters and side channels.	Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff. Increased overbank flooding maintains moist soil conditions during flycatcher territory establishment. Growth of native riparian vegetation can enhance habitat conditions for the flycatcher.
Bankline embayments (willow swales and backwater areas)	Historical channel slow water velocity and shallow depth bank line habitat is restored/rehabilitated. Bank line embayments are zones of sediment deposition and have a finite lifespan without periodic re-excavation.	Slow water velocity and shallow depth bank line habitat.	Increase in egg retention and availability of nursery larval habitat during high flow. Increases probability of native vegetation growth and potential for flycatcher habitat.
large woody debris (LWD)/ perennial pools	Creates pools, generates scour and substrate sorting, and increases depth and velocity complexity. Can promote side channel formation and maintenance. LWD in the Middle Rio Grande can lead to sediment deposition, including formation of islands, in reaches with large sand loads. Prone to sedimentation after inundation. Short life span for LWD using cottonwood trees on Middle Rio Grande.	Adds complexity to the system. Sediment deposition can create areas where new riparian vegetation becomes established. Can create variable depth and velocity habitat. Can provide structure and habitat for fish.	May provide for habitat diversity in areas with monotypic flow patterns and refugia habitat during low flows. These habitats may also provide refuge for predatory fishes. Increased areas of moist or flooded soil conditions could assist in flycatcher territory establishment and native vegetation recruitment.

Exotic vegetation removal	Exotic vegetation removal may result in channel widening and increased flood plain connectivity. Channel widening could reduce channel flow depth and velocity. Degree of change is dependent on degree of connection between the main channel and the surface upon which the exotic vegetation is being removed. In removal areas that are currently disconnected from the river, there is a negligible effect on the fluvial geomorphology of the river channel. The degree of influence exotic vegetation removal has on the geomorphology is also influenced by the timing of peak flows in relation to the period when exotic vegetation removal occurred. May also have an influence on the geomorphology of disconnected, historical flood plain areas as the removal of trees may allow for a higher groundwater table.	Could result in channel widening, increased flood plain connectivity, allow for a higher groundwater table and increase chances of native vegetation outcompeting exotics.	Dependant on site-specific details, the removal of exotic vegetation could temporarily remove flycatcher habitat as species such as saltcedar do provide the structural composition required for nesting. Over the long term, if replaced with native vegetation and a wider channel and increased flood plain connectivity, could re-establish better nesting habitat over time. The temporary removal of vegetation may allow for a more active channel with connectivity to the flood plain creating silvery minnow habitat.
Island and bank destabilization	Promotes a wider channel with greater flood plain connectivity and balances sediment. Reduces further degradation of the channel and lowering of the local water table. Sediments from destabilized areas may deposit new bars suitable for vegetation growth. Can locally increase sediment supply for a temporary period of time if erosion occurs. New sediment balance may be temporary unless incoming loads also increase. Can provide increased flood carrying capacity. Cleared and lowered bankline or island areas can become zones of sediment deposition and may need to be re-cleared and re-excavated for benefits to continue. Degree of change is dependent on degree of connection between the main channel and flood plain and the timing of peak flows in relation to the period when destabilization occurred	Reduces further degradation of the channel and lowering of the water table. Sediments from destabilized areas may deposit new bars suitable for vegetation. Clearing and destabilization would result in the temporary loss of this habitat. Islands/bars that are more connected to the main channel can provide RGSM with a greater variety of depth and velocity habitat types.	Provides low velocity habitat during high flows for adult fish. Increased overbank flooding creates variable depth and velocity habitat types including silvery minnow nursery habitat during spring runoff and aids in increasing egg and larval entrainment. Loss of habitat may be temporarily negative depending on site-specific details and proximity to flycatcher territories; however, sediment accumulation forming new bars or islands could promote new seed source establishment and potentially young native successional stands to develop into flycatcher habitat. By reducing further degradation of the channel and lowering of the water table, the flood plain has a better chance of connectivity, which is better overall for the flycatcher.

Side channel (high flow and oxbow reconnection)	Important to natural systems for passage of peak flows. Maintains higher water surface elevation and ground water table. Can reconnect the flood plain to the channel. Sediment tends to fill in high flow side channels over time. Can decrease peak flow water surface elevation and may decrease sediment transport capacity until sediment blocks the side channel. Method provides for reduced main channel sediment transport capacity. Sediment tends to deposit at the inlets and outlets. Periodic inlets and outlets sediment removal may be needed to maintain project benefits.	Side channels result in raising the ground water table and surface flows to developing riparian areas. Maintains higher water surface elevation and ground water table, adding to the health of the riparian zone. Can reconnect the flood plain to the channel, creating nursery habitat for the Rio Grande shiny minnow (RGSM) with variable depth and velocity habitats.	Provides low velocity habitat during high flows for adult fish and developing larvae. Increase in retention of eggs and larvae during high flows. Raising the ground water table to provide water to developing riparian areas increases vegetation health. Periods of increased surface flows, particularly during mid-May to mid-June, increases probability of flycatcher territory establishment in areas with suitable habitat.
GRF/sill	Grade controls can reduce the gradient upstream by controlling the bed elevation and dissipating energy in discrete steps. At least during low flows, the upstream water surface is raised, depending on structure height above bed. Upstream velocity is reduced. For low head structures (1 to 2 feet), the amount of upstream sediment storage is low and usually does not cause downstream bed level lowering as a result of upstream sediment storage. In sediment supply-limited reaches, channel degradation downstream of the structure will continue as a result of excessive sediment transport capacity. For gradient restoration facilities (GRF), the bed is fixed; for a rock sill, the rock launches into the downstream scour hole.	Reduces channel degradation upstream of this feature and can promote overbank flooding and raise the water table. This provides more opportunity for riparian zone establishment and development. Backwater areas could develop upstream, which would raise the water table. If downstream degradation continued, then the water table would be lowered, reducing water availability to the riparian forest.	Increased overbank flooding upstream creates variable depth and velocity habitat types including potential spring runoff silvery minnow nursery habitat. Steeper apron slopes may restrict fish movement, while lower slopes can meet flow velocity requirements for fish passage. A reduction in channel degradation and increase in overbank flooding and water table levels would likely increase vegetative health and could attract flycatchers, particularly if overbank flooding conditions occurred during territory establishment. However, the opposite effect likely would occur downstream.

Bendway weirs	The location of the thalweg is shifted away from the outer bank line. Local scour at the tip occurs because of the three-dimensional flow patterns. Secondary currents are interrupted, and flows are redirected away from the bank. The outer bank can become a zone of lower velocity. The combined effect of the tip scour and lower velocity along the bank line creates a flow condition of variable depth and velocity. Scalloping also can occur along the bank line, or sediment deposition between structures depending upon local conditions and bendway weir geometry. Can reduce local sediment supplied from bank erosion, because the current river alignment is maintained.	Sediment deposition between structures may allow establishment of riparian vegetation and backwater areas. Channel deepening and tip scour could locally lower the riverbed and lower the ground water table.	Depending on site-specific details, bendway weirs would allow for overbank flooding conditions for flycatchers. However, depending on the location and the degree of lowering the ground water table, construction efforts could impact flycatcher suitable habitat. Silvery minnows could be stranded in pools that would form between weirs as flow receeded. However, it could provide habitat diversity and deep habitat during low flow conditions.
Rootwads	Creates local scour pools and variable depth and velocity habitat Increases flow resistance along the bank line, which dissipates energy, traps and retains sediments, and creates turbulence that can move the main current away from the bank line. Cottonwood tree rootwads have a design span of about 5 years; therefore, this method has been used with many other methods to create habitat.	Adds complexity to the system. Variable depth and velocity conditions can be created. Some potential for creating areas of sediment deposition (depending on specific placement), which is generally beneficial to the establishment and development of riparian vegetation.	Can provide structure and habitat for silvery minnow. Isolated pools are often maintained in scour pools caused by debris, including rootwads. This can serve as refugia habitat for silvery minnow during low flow periods. Similar to LWD. Could trap sediment and encourage new native vegetative growth.
Jetty removal	Jetty removal may result in channel widening and increased flood plain connectivity. However, vegetation often promotes more bank stability than jetties, thus removal may not result in channel widening and increased flood plain connectivity. Channel widening could reduce channel flow depth and velocity.	The habitat may not change if the existing vegetation has more effect on bank stability than the jetties themselves. Otherwise, channel widening could reduce channel flow depth and velocity and create more bank line habitat.	If banks are destabilized, there can be an increased availability of shallower and lower velocity habitat for the silvery minnow. By destabilizing the bank, could encourage lateral migration of the river providing more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.

Removal of lateral constraints	Can encourage current geomorphic processes to continue, such as lateral migration, and the creation of new flood plain and riparian areas. This may increase opportunities for the river to connect with historical channels and oxbows. For incised channels, may provide an opportunity to establish new inset flood plain and riparian zone. Lateral river movement creates broader flood plain. Lateral bank movement should result in deposition of sediment downstream. The river may establish bars and low surfaces as lateral migration continues to occur. Longer meander bends may establish greater pool depth and eroding banks providing additional complexity.	Lateral river movement creates broader flood plain and more favorable riparian zone habitat. Lateral bank movement should result in deposition of sediment downstream. The river will establish bars and low surfaces, where vegetation can become established. Longer meander bends may establish greater pool depth and eroding banks with vegetation falling into the channel, providing fish cover and habitat complexity.	Inset flood plain and riparian zones increase overbank flooding and create variable depth and velocity habitat types including potential spring runoff for silvery minnow nursery habitat. The lateral migration of the river provides more opportunity for successional age classes of potentially native vegetation for flycatcher habitat.
Longitudinal stone toe with bioengineering	Studies about longer reach response are contradictory. Maintains the local current river alignment, and the point bar remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Can be susceptible to flanking if upstream channel migration occurs. Eliminates sediment supplied from bank erosion. Bank line vegetation is established.	Prevents lateral migration and the establishment of new depositional zones where vegetation could become established. Eliminates sediment supplied from bank erosion. The steep bank angle on the outside of the bend limits fish cover, except for the riprap interstitial spaces. The point bar remains connected to the main channel and remains static. The flow velocity and depth are greater than typically found in natural channels along the outside bank of a river bend. Bioengineering provides very minimal benefits to riparian community.	

APPENDIX 4

CRAIG BOROUGH'S MEMORANDUM SUBJECT: ESTIMATION OF DECEMBER 31, 2011, CONDITIONS TO USE AS INITIAL CONDITIONS FOR UPDATED URGWOM SIMULATIONS FOR RECLAMATION'S WATER OPERATIONS BIOLOGICAL ASSESSMENT DATED DECEMBER 15, 2011

Memorandum

To: Warren Sharp Reclamation –Albuquerque

CC: URGWOM Technical Team

From: Craig Boroughs

Date: December 15, 2011

Re: Estimation of December 31, 2011 Conditions to Use as Initial Conditions for Updated URGWOM Simulations for Reclamation's Water Operations Biological Assessment

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Introduction

Initial condition information is needed for modeling of river system operations for development of the Bureau of Reclamation's (Reclamation) Middle Rio Grande Water Operations Biological Assessment (BA) using an updated planning module of the Upper Rio Grande Water Operations Model (URGWOM). Initial conditions were developed to reflect expected conditions on December 31, 2011 to represent the latest and best information on starting conditions for the 10-year planning model runs. Estimated initial conditions are based on recent information regarding the current status of storage in the reservoirs in the basin and the account status as reflected in the Accounting Model maintained by Reclamation. The December 31, 2011 conditions were developed based on several basic assumptions for the movement of water and accounting adjustments expected before the end of the year as documented below. It is emphasized that the resulting estimated storage levels for December 31, 2011 will not match the actual storage levels on that date but represent reasonable and clean starting conditions that are adequate for planning model runs.

Approach for Estimating December 31, 2011 Conditions

Initial conditions needed to complete URGWOM runs include initial values for numerous series such as reservoir storage levels and the storage for all the individual storage accounts at each reservoir including the Compact credit at Elephant Butte Reservoir. Initial values are also needed for incidental content, carryover storage, and reservoir sedimentation at Abiquiu Reservoir, Cochiti Lake, and Jemez Reservoir. Values are needed for initial reach flows, total reservoir releases, and releases of native Rio Grande flow; although, it should be emphasized that initial river flows needed to start calculations in the model actually have little impact on the model results as long as the values are reasonable.

Storage conditions on December 31, 2011 were estimated starting with actual values for total reservoir storage and account storage on November 21, 2011. Refer to Table 1 for the actual November 21, 2011 values which include storage for the different accounts for San Juan-Chama Project water at Heron Reservoir along with the common pool for San Juan-Chama Project water

(Note that data errors for the gaged flows in the Low Flow Conveyance Channel at San Marcial and the pool elevation at Elephant Butte Reservoir on October 25th were corrected in the provided Accounting Model prior to evaluating conditions at Elephant Butte Reservoir). Storage of San Juan-Chama Project water in allocated space at El Vado and Abiquiu Reservoirs for Albuquerque, MRGCD, and the Combined account is also needed where the Combined account includes storage for all contractors other than Albuquerque, MRGCD, or the Cochiti Recreation Pool. Storage of Reclamation's leased San Juan-Chama Project water is included. Storage must also be input for the NMISC and Jemez Sediment Pool accounts which are not used. Storage of native Rio Grande water at each reservoir is included along with storage of Emergency Drought water from relinquished Compact credits as represented with the MRGCD Drought and Supplemental ESA accounts at El Vado Reservoir. Storage of Prior and Paramount (P&P) water at El Vado is represented by the Indian Storage account. Conservation storage at Abiquiu, Cochiti, or Jemez Reservoirs is set to zero. An initial estimate for the Compact credit at Elephant Butte Reservoir is also included. Storage of Albuquerque and Santa Fe San Juan-Chama Project water at Elephant Butte Reservoir along with Colorado credit water is input as an initial condition to assure initial account storage adds up correctly at Elephant Butte Reservoir.

Table 1. Actual November 21, 2011 Total and Account Storage Levels and Incidental, Carryover, and Sediment Contents

Account	Heron	El Vado	Abiquiu	Cochiti	Jemez	Elephant Butte
TOTAL	237,132	97,834	180,042	51,748	0	226,557
San Juan-Chama Project Water:						
Federal Pool	150,682	---	---	---	---	---
Albuquerque	48,200	0	166,735	---	---	30,787
MRGCD	13,966	65,360	1100	---	---	---
Combined	20,601	0	2386	---	---	19,103
Cochiti Rec Pool	2783	---	---	45,319	---	---
Reclamation	0	111	6198	---	---	---
NMISC	---	---	0	---	---	---
Jemez Sediment Pool	---	---	---	---	0	---
Native Rio Grande Water:						
Rio Grande	900	0	-125	540	-1114	52,356
Indian Storage	---	13,168	---	---	---	---
MRGCD Drought	---	0	---	---	---	---
Supplemental ESA	---	19,196	---	---	---	---
Rio Grande Conservation	---	---	0	0	0	---
NM Credit	---	---	---	---	---	123,151*
CO Credit	---	---	---	---	---	1160*
Incidental Content	---	---	-125	540	-1114	---
Carryover Content	---	---	0	0	0	---
Sed Deposition	---	---	3748	5889	1114	---
Total storage at Caballo Reservoir is 11,093 acre-ft.						

* Compact credits prior to the end of the year for New Mexico and Colorado are actually 164,700 and 1600 acre-ft, respectively, but the reported values in the Accounting Model for November 21, 2011 reflect daily evaporation losses for the year based on the accounting method in the model.

Adjustments were made to the November 21, 2011 storage levels to reflect expected movement of water and accounting adjustments to be completed by December 31, 2011. Adjustments were made for all the assumed remaining actions listed in Table 2 and discussed further in the separate sections below. All other potential reservoir inflows and outflows were neglected for the remainder of the year as these inflows and outflows are expected to be smaller and partially offsetting. Evaporation, precipitation, and sedimentation effects at the reservoirs for the remainder of the year were also neglected.

Table 2. Assumptions for Actions before December 31, 2011 Reflected by Adjustments to the November 21, 2011 Conditions to Estimate December 31, 2011 Conditions

#	Assumed Actions
1	Movement of MRGCD Water from Heron Reservoir to El Vado Reservoir
2	Movement of Cochiti Rec Pool Water at Heron Reservoir to Cochiti Lake
3	End-of-year Rio Grande Adjustment at Heron Reservoir for Evaporation and Recreation
4	P&P Storage Evacuated from El Vado Reservoir
5	Movement of Reclamation's Leased Water at El Vado Reservoir to Abiquiu Reservoir
6	Reclamation Lease of Albuquerque Water at Abiquiu Reservoir
7	Delivery of Albuquerque Water to Surface Water Diversion
8	Delivery of Combined Account Water to the Buckman Direct Diversion
9	Delivery of Albuquerque Account Letter Water
10	Rio Grande Storage at Abiquiu and Cochiti Returned to Zero
11	End-of-Year Compact Credit Adjustment at Elephant Butte Reservoir
12	Additional Storage of Rio Grande Inflows to Elephant Butte Reservoir

1. Movement of MRGCD Water from Heron Reservoir to El Vado Reservoir

It is assumed that MRGCD San Juan-Chama Project water at Heron Reservoir on November 21st would be moved to El Vado Reservoir prior to December 31st, so estimated storage of MRGCD San Juan-Chama Project water at Heron Reservoir on December 31st is set to zero (with the total reservoir storage adjusted accordingly) and storage in the MRGCD San Juan-Chama account at El Vado is set to 79,326 acre-ft to include the additional 13,966 acre-ft of water in Heron. Total storage at El Vado Reservoir is also adjusted accordingly. The San Juan-Chama loss rate between Heron Reservoir and El Vado Reservoir is zero, so no loss is applied for this transfer.

2. Movement of Cochiti Rec Pool Water at Heron Reservoir to Cochiti Lake

It is assumed the 2783 acre-ft of Cochiti Rec Pool water at Heron Reservoir on November 21st would be moved to Cochiti Lake by the end of the year, so the estimated storage of Cochiti Rec Pool water at Heron Reservoir on December 31, 2011 was set to zero (with the total storage at Heron Reservoir adjusted accordingly), and the amount of Cochiti Rec Pool water at Cochiti Lake was increased from 45,319 acre-ft to 48,037 for the additional water from Heron minus a loss based on the 2.33 percent San Juan-Chama loss rate between Heron Reservoir and Cochiti Lake.

3. End-of-year Rio Grande Adjustment at Heron Reservoir for Evaporation and Recreation

An end-of-year accounting adjustment is made to transfer Rio Grande water to the Federal pool to offset for the impacts of Rio Grande storage on evaporation losses of San Juan-Chama Project water along with recreation considerations. This adjustment entails a transfer of 350 acre-ft from the Rio Grande account to the Federal pool, so implementing this adjustment entails adjusting the November 21, 2011 Rio Grande storage to zero and increasing the Federal San Juan account storage by 350 acre-ft. Note that it is also assumed that additional Rio Grande water in storage on November 21 would be evacuated from Heron Reservoir and also bypassed at El Vado Dam due to Article VII being in effect.

4. P&P Storage Evacuated from El Vado Reservoir

It is assumed that water remaining in the Indian Storage account, representing remaining P&P storage, will be fully evacuated from El Vado Reservoir by December 31, 2011, so the storage in the Indian Storage account was set to zero. Since P&P water was stored when storage restrictions per Article VII of the Compact were in effect, the water is evacuated as opposed to being transferred to the Rio Grande account.

5. Movement of Reclamation's Leased Water at El Vado Reservoir to Abiquiu Reservoir

It is assumed that Reclamation's 111 acre-ft of leased San Juan-Chama Project water in storage at El Vado Reservoir would be moved to Abiquiu Reservoir by the end of the year as this water would be moved when convenient and as space at Abiquiu Reservoir becomes available, so the storage in the Reclamation account at El Vado Reservoir was decreased to zero (with the total El Vado Reservoir storage adjusted accordingly), and the storage in the Reclamation account at Abiquiu Reservoir was increased accordingly, considering San Juan-Chama losses between El Vado Reservoir and Abiquiu Reservoir.

6. Reclamation Lease of Albuquerque Water at Abiquiu Reservoir

It is assumed that a Reclamation lease of 10,000 acre-ft from Albuquerque will occur before the end of the year and is reflected as a transfer from the Albuquerque account to the Reclamation account at Abiquiu Reservoir (Donnelly, 2011). Albuquerque storage at Abiquiu on November 21st is decreased by 10,000 acre-ft for this transaction, and Reclamation's account storage is increased by 10,000 acre-ft. Note that the pending leases of approximately 12,000 acre-ft by Reclamation of contractor water in storage at Heron Reservoir, known as an initial condition, will actually be modeled during the first year of simulation.

7. Delivery of Albuquerque Water to Surface Water Diversion

It is assumed that water will continue to be delivered to the Albuquerque surface water diversion for the remainder of the calendar year. The daily release of Albuquerque San Juan-Chama Project water from Abiquiu on November 21, 2011 was 32 cfs, and this release rate is assumed for the remainder of the year (Kandl, 2011). The storage in the Albuquerque account at Abiquiu

Reservoir is thus reduced by the resulting release volume of 2539 acre-ft to estimate a December 31, 2011 storage level.

8. Delivery of Combined Account Water to the Buckman Direct Diversion

It is assumed that Santa Fe water will continue to be delivered to the Buckman Direct Diversion at a rate of 5.59 cfs for the remainder of the calendar year (Kandl, 2011). The storage in the Combined account at Abiquiu Reservoir is reduced by the resulting release volume of 444 acre-ft for estimating the December 31, 2011 storage level.

9. Delivery of Albuquerque Account Letter Water

It is estimated that a letter water delivery prior to the end of the year will occur at Elephant Butte Reservoir as a transfer of 1300 acre-ft of San Juan-Chama Project water from the Albuquerque account to the Rio Grande account. To reflect this pending transfer, the storage in the Albuquerque account was decreased by 1300 acre-ft. Note that a final estimated storage for the Rio Grande account at Elephant Butte Reservoir was set to an estimated value that also reflects an end-of-year Compact credit adjustment and estimated inflows for the remainder of 2011.

10. Rio Grande Storage at Abiquiu and Cochiti Returned to Zero

Storage levels of Rio Grande water at Abiquiu Reservoir and Cochiti Lake were reset from -125 and 540 acre-ft, respectively, to zero. It is assumed that operations would be conducted to correct for the incidental content apparent on November 21, 2011 to return to zero Rio Grande storage at both Abiquiu and Cochiti on December 31, 2011. Total storage at each reservoir was adjusted accordingly.

11. End-of-Year Compact Credit Adjustment at Elephant Butte Reservoir

The Compact credit as tracked with the NMCredit account at Elephant Butte Reservoir was adjusted for the end-of-year annual Compact calculations and the impacts of evaporation resulting in a new estimated total Compact credit of 65,000 acre-ft. The Colorado credit was also adjusted to 2000 acre-ft.

12. Additional Storage of Rio Grande Inflows to Elephant Butte Reservoir

It is assumed that additional storage of native Rio Grande inflows to Elephant Butte Reservoir plus the end-of-year Compact credit adjustment and the letter water transfer from the Albuquerque account will yield a storage of 164,410 acre-ft of native Rio Grande water at the end of the year resulting in a total Elephant Butte Reservoir storage of 280,000 acre-ft.

Resulting Estimated December 31, 2011 Conditions

Reservoir and Account Storage Levels

Resulting estimated conditions for December 31, 2011 are presented in Table 3. Areas with gray shading are unchanged from the referenced November 21, 2011 conditions. Values in blue bold font were increased as a result of the aforementioned adjustments, and values in the red italics font were reduced with the changes.

Note that initial allocations for storage of Emergency Drought water for MRGCD and ESA include water already in storage of 0 and 19,196 acre-ft, respectively, plus additional unused allocations from previous Relinquished Compact credits. The estimated unused allocations for December 31, 2011 are 50,500 acre-ft for MRGCD and 19,500 acre-ft for ESA. Additional Emergency Drought water will be stored during the Planning Model runs up to the unused allocation amount. The resulting total initial allocations will be set in the model to 50,500 acre-ft and 38,696 acre-ft to include both Emergency Drought water already in storage and the unused allocations.

Initial values for all Account Accruals and Gain Losses are all set to zero. The initial tallies for the cumulative Cochiti Rec Pool release from Heron Dam and account fill releases as needed to start calculations are set to zero. Heron waiver balances are set on January 1st during the simulation to the input storage values for the individual accounts at Heron Reservoir for December 31st.

Table 3. Estimated December 31, 2011 Total and Account Storage Levels and Incidental, Carryover, and Sediment Contents

Account	Heron	El Vado	Abiquiu	Cochiti	Jemez	Elephant Butte
TOTAL	*219,833*	**98,522**	*177,294*	**53,926**	0	**280,000**
San Juan-Chama Project Water:						
Federal Pool	**151,032**	---	---	---	---	---
Albuquerque	48,200	0	*154,196*	---	---	*29,487*
MRGCD	*0*	**79,326**	1100	---	---	---
Combined	20601	0	*1942*	---	---	19,103
Cochiti Rec Pool	*0*	---	---	**48,037**	---	---
Reclamation	0	*0*	**16308**	---	---	---
NMISC	---	---	0	---	---	---
Jemez Sediment Pool	---	---	---	---	0	---
Native Rio Grande Water:						
Rio Grande	*0*	0	**0**	*0*	-1114	**164,410**
Indian Storage	---	*0*	---	---	---	---
MRGCD Drought	---	0	---	---	---	---
Supplemental ESA	---	19,196	---	---	---	---
Rio Grande Conservation	---	---	0	0	0	---
NM Credit	---	---	---	---	---	**65,000**
CO Credit	---	---	---	---	---	**2000**
Incidental Content	---	---	**0**	*0*	-1114	---
Carryover Content	---	---	0	0	0	---
Sed Deposition	---	---	3748	5889	1114	---
Total storage at Caballo Reservoir is 11,093 acre-ft.						

Initial River Flows

Initial total reservoir outflows are required for each dam along with the outflow of native Rio Grande water at El Vado, Abiquiu, and Cochiti dams (Refer to Table 4 for the estimated initial reservoir outflows). Initial flows at gage sites and reach inflows are also required. Estimated values for December 31, 2011 are presented in Table 5. All assumed initial flows are typical values for December 31st and based on the historical average for December 31st for most locations. The initial flow values have little impact on the Planning Model results but are simply required to start a simulation.

Initial values for the accounting supplies for the release of water from the Indian Storage, MRGCD Drought, and Supplemental ESA accounts at El Vado Reservoir downstream are set to zero. Initial inflows needed for the following locations within MRGCD's system or on the Low Flow Conveyance Channel are all set to zero: Central East Side Lag, Isleta to Bernardo East Side Lag, Isleta to Bernardo West Side Lag, Drain Unit 7 Return, San Acacia to San Marcial Low Flow Time Lag, and San Acacia to San Marcial Canal Time Lag.

Table 4. Estimated Initial Reservoir Outflows

Reservoir	Rio Grande Outflow (cfs)	Total Outflow (cfs)
Heron	---	---
El Vado	100	100
Abiquiu	110	148
Cochiti	600	600
Jemez	---	27
Elephant Butte [1]	---	17
Caballo [2]	---	2

[1] Same total outflow from Elephant Butte Dam for December 30th and 31st.
[2] Same total outflow from Caballo Dam for December 24th through 31st.

Table 5. Estimated Initial Gage and Reach Inflows

Reach (or Gage)	Inflow (cfs)
Lobatos	200
Cerro to Taos[1]	297
Embudo to Confluence	512
Below Abiquiu to Chamita	210
Otowi to Cochiti	828
Cochiti to Central	821
Central to Bernardo	895
Bernardo to San Marcial	712
San Marcial to Elephant Butte	884
Leasburg to Mesilla	2
Mesilla to El Paso	2

[1] Value needed for 12/30 for the Cerro to Taos reach also set to 293 cfs

Initial Values for Shallow Aquifer Groundwater Levels

Initial groundwater storage levels for all the groundwater objects in the Middle Valley portion of the model were identified separately by the URGWOM Technical Team based on equilibrium conditions from completed calibration runs. The initial values are unchanged from the initial conditions used for other previous simulations completed with the planning module of URGWOM.

References

Donnelly, Carolyn. 2011. Personal Communication. Bureau of Reclamation. Albuquerque, New Mexico.

Kandl, Ed. 2011. Personal Communication. Bureau of Reclamation. Albuquerque, New Mexico.

APPENDIX 5

MRGCD DEMAND CURVES USED IN URGWOM PLANNING MODE

MRGCD Demand Curves Used in URGWOM Planning Model[1]

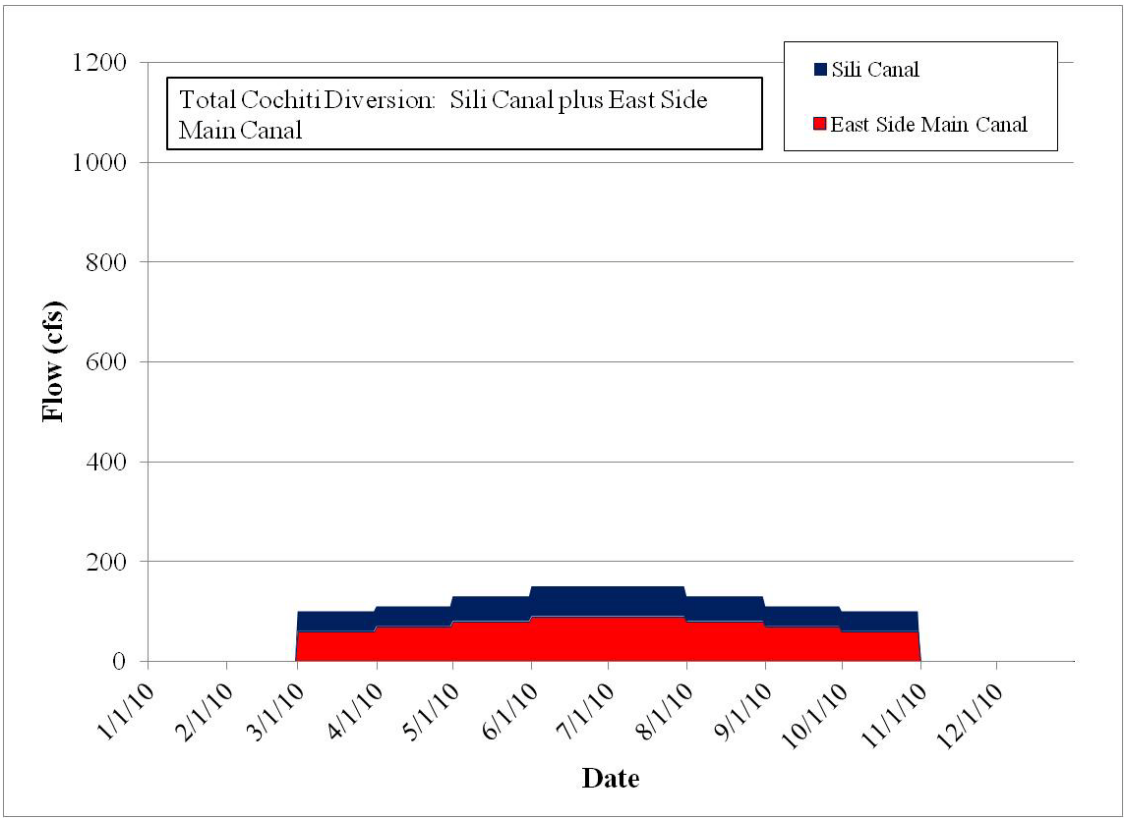

Figure 1. MRGCD Demand at Diversions to the Cochiti Division.

1 MRGCD = Middle Rio Grande Conservancy District; URGWOM = Middle Rio Grande Conservancy District (MRGCD) Demand Curves Used in Upper Rio Grande Water Operations Model (URGWOM) Planning Model.

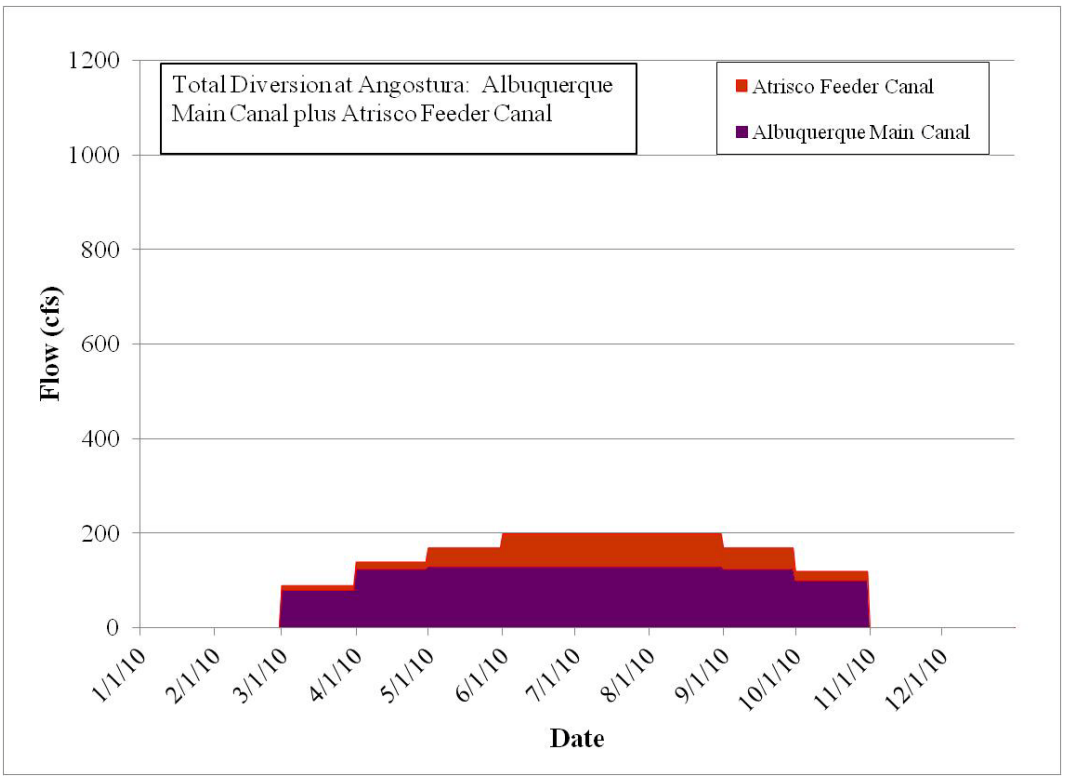

Figure 2: MRGCD Demand at Diversions to the Albuquerque Division.

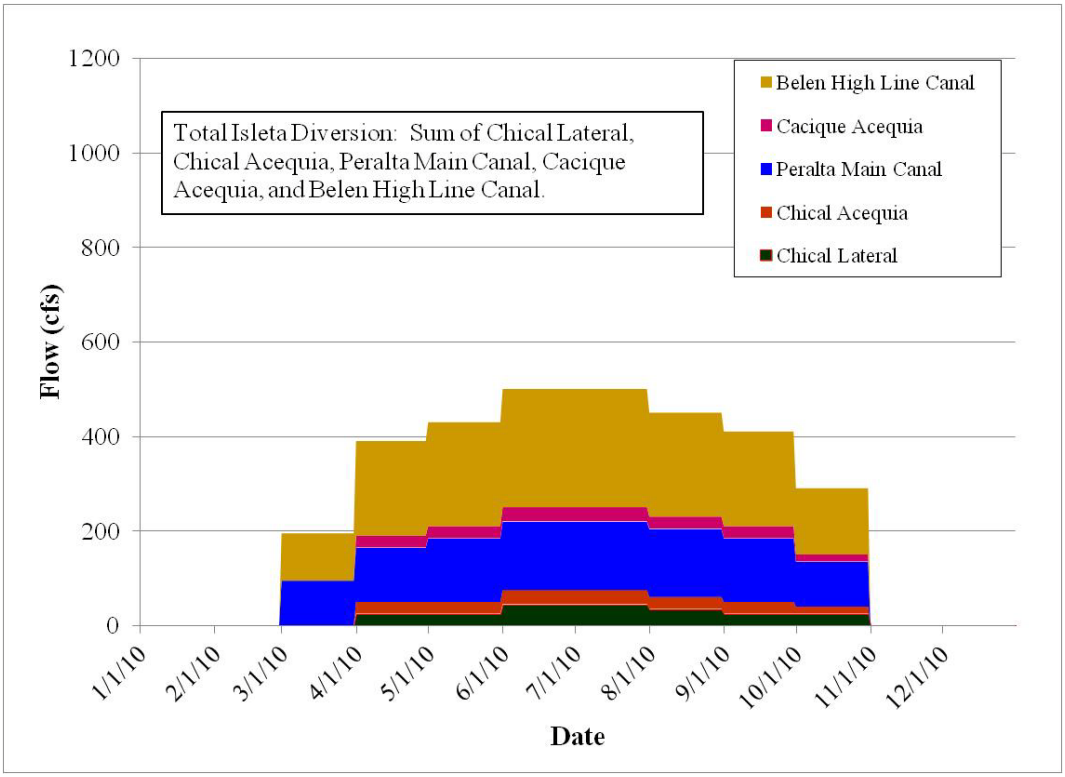

Figure 3. Total MRGCD Demand at Diversions to the Isleta Division.

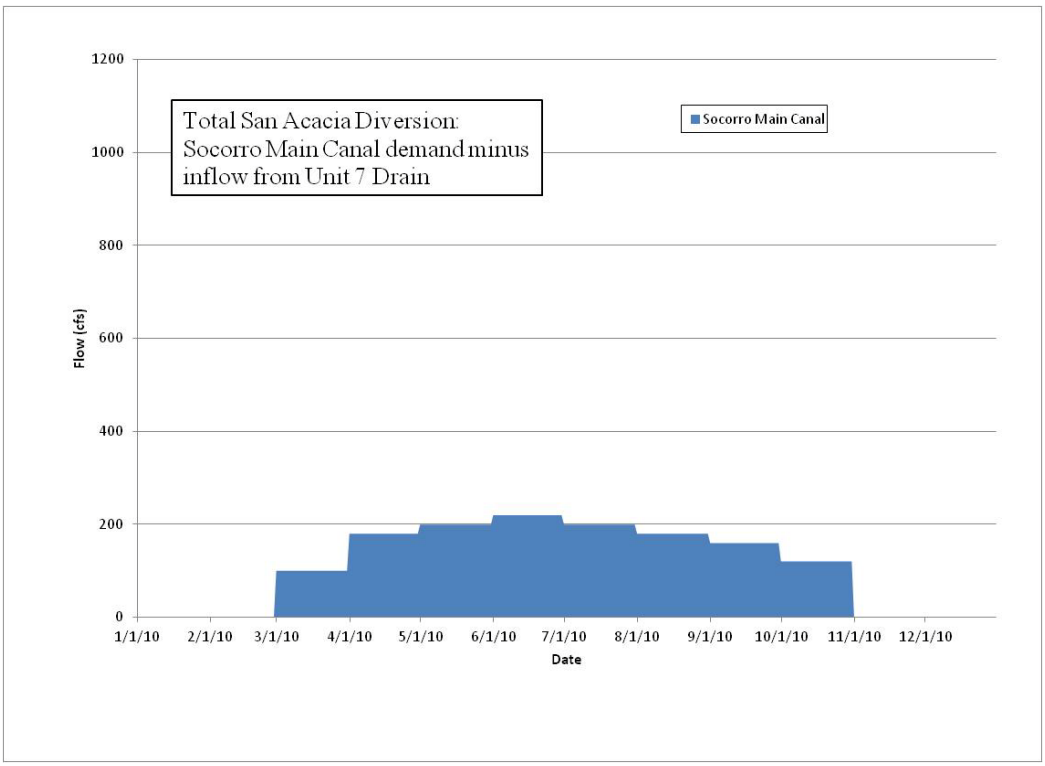

Figure 4. Total MRGCD Demand at Diversions to the San Acacia Division.

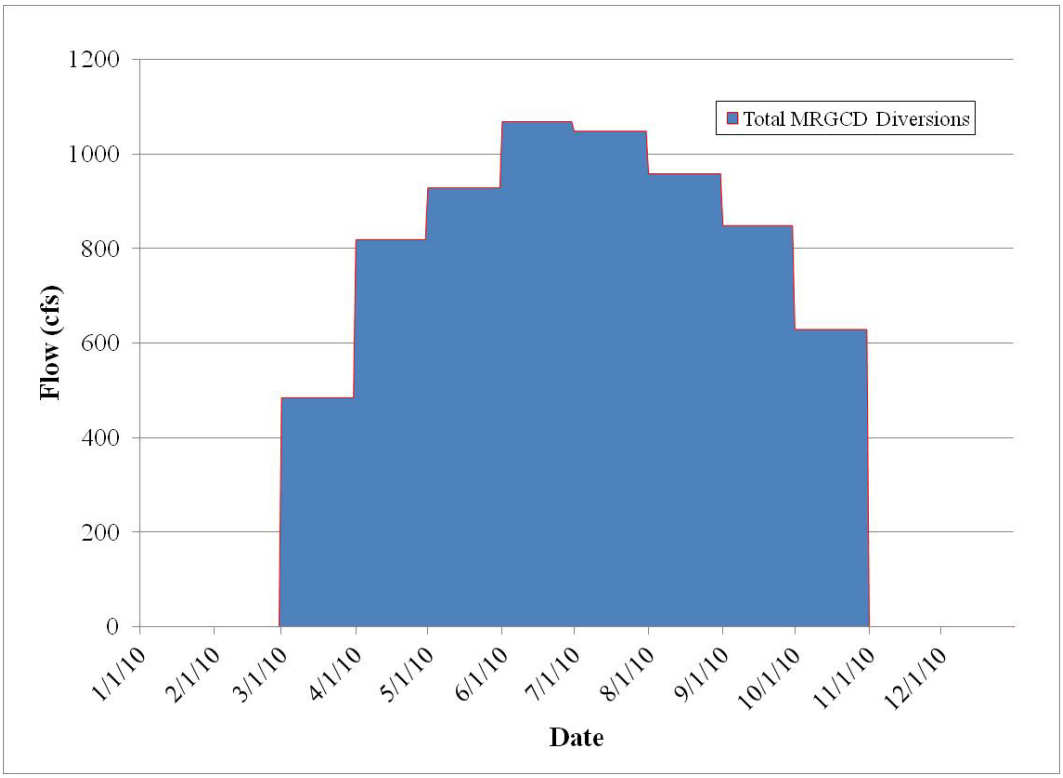

Figure 5. Total of MRGCD Demand Curves.

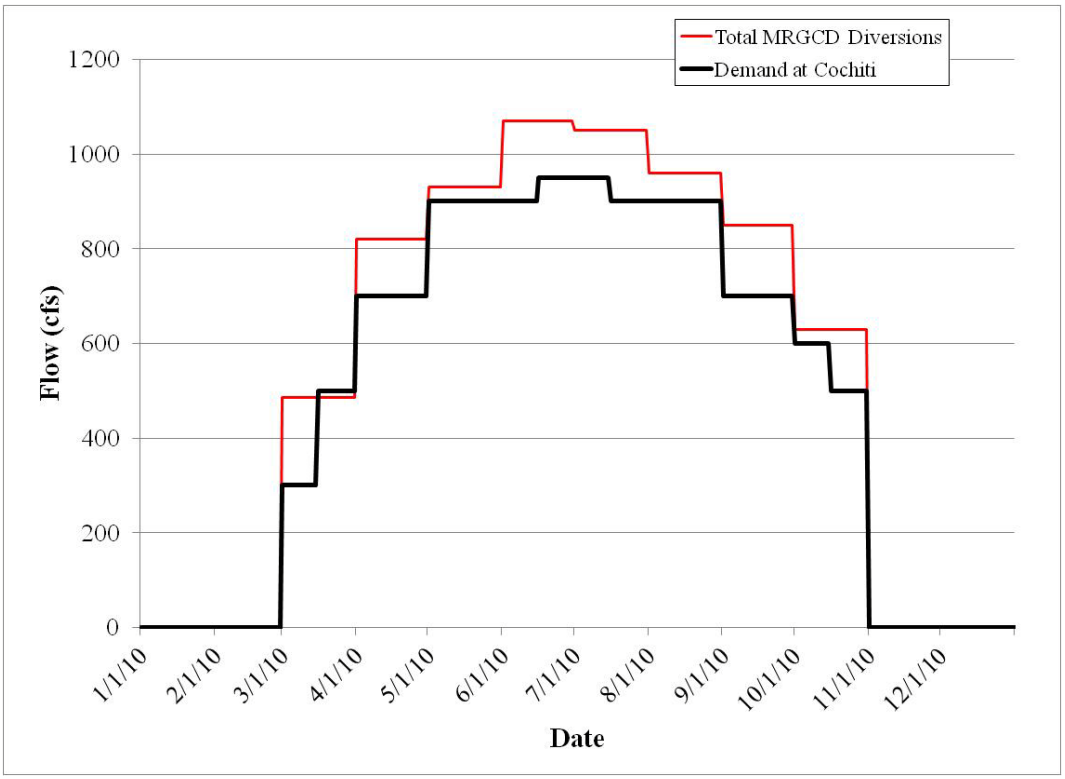

Figure 6. Comparison of Total MRGCD Demand at Cochiti to Total of Demand at All Diversions (difference is due to return flows).

APPENDIX 6

RECLAMATION AND CORPS COMPLETED CONSULTATIONS

10.0 Bureau of Reclamation's Water and River Maintenance Operations, U.S. Army Corps of Engineers' Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande

On February 19, 2003, a biological assessment (BA) was submitted to the U.S. Fish and Wildlife Service (Service) requesting formal consultation pursuant to Section 7 of the Endangered Species Act (ESA) for the proposed actions associated with water operations, river maintenance, and flood control on the Middle Rio Grande (MRG). The BA and subsequent biological opinion (BO) (Consultation #2-22-03-F-0129), issued March 17, 2003, addressed Federal and non-Federal entities actions related to typical operations, including net depletions and withdrawals, water and river management activities, operation of the Middle Rio Grande Project, flood control, and other management actions on the Middle Rio Grande, as well as their effects on the endangered silvery minnow and its designated critical habitat, the endangered flycatcher, threatened bald eagle, and endangered interior least tern.

The Bureau of Reclamation (Reclamation) and the U.S. Army Corps of Engineers (Corps) determined that the proposed action "may affect, is not likely to adversely affect" the bald eagle and the least tern and "may affect, is likely to adversely affect" the silvery minnow and flycatcher and "may adversely modify" designated critical habitat of the minnow. The Service concurred with the determinations for the eagle and tern. The Service also concluded that water operations and river maintenance of the Middle Rio Grande, as proposed in the February 2003 BA, are likely to jeopardize the continued existence of the silvery minnow and the flycatcher and adversely modify critical habitat of the silvery minnow.

In April 2006, Reclamation and the Corps subsequently reinitiated consultation (Consultation #2-22-03-F-0129-R1) requesting amendment to the 2003 BO evaluating effects on flycatcher designated critical habitat, amending Term and Condition 1.1 of RPM 1, and evaluating the effects of recent river drying on the minnow. The Service transmitted a letter amending the 2003 BO, determining that the proposed action did not destroy or adversely modify flycatcher designated critical habitat and also determined that all other determinations included in the 2003 BO regarding the silvery minnow and its critical habitat and the flycatcher remained unchanged.

Environmental commitments associated with the 2003 BO included Reasonable and Prudent Alternatives (RPAs) addressing water operations elements, habitat restoration elements, salvage and captive propagation elements, water quality

elements, and reporting elements. Additional terms and conditions affiliated with RPMs included commitments to 1) minimize silvery minnow take within the Rio Grande while performing water operations activities, flood control activities, and river maintenance activities and 2) minimizing loss of river drying and reduction of flycatcher reproductive success.

Improvements in operations that have occurred since the March 17, 2003, Biological Opinion (2003 BiOp) include a reduction in Middle Rio Grande Conservancy District (MRGCD) river diversions, improvements in water operations (daily coordination conference calls, etc.), Rio Grande Compact (Compact) relinquishment of credit water in 2003 and 2008, implementation of habitat restoration work, levee and Low Flow Conveyance Channel (LFCC) setback work in the San Acacia Reach, implementation of the Rio Grande silvery minnow (RGSM) augmentation program, Cochiti deviation to create spawning and recruitment flow, and various efforts to slow river degradation.

10.1 Corps of Engineers Actions with Early or Completed Consultation

10.1.1 Rio Grande Nature Center Habitat Restoration Project

In September 2006, the Corps submitted a biological assessment to the Service for the proposed Rio Grande Nature Center Habitat Restoration Project for the Albuquerque Reach of the Rio Grande and requested formal Section 7 consultation (Consultation #22420-2006-F-161). This project rehabilitated flood plain areas, reconnected the old channel to the river to create habitat for the minnow, and facilitated the regeneration of native vegetation suitable for the flycatcher while meeting priorities of the MRG ESA Collaborative Program to complete restoration projects in the Albuquerque Reach. The Service concurred with the Corps determination that the proposed project “may affect, is not likely to adversely affect” the bald eagle, flycatcher and critical habitat for the minnow. The Service determined that the proposed project is not likely to jeopardize the continued existence of the minnow; and although it may minimally adversely affect individual minnows in the 15-acre project area, the proposed project is anticipated to have a long-term positive impact on the species through improvements to quality and availability of suitable habitat.

Environmental commitments associated with the proposed Rio Grande Nature Center Habitat Restoration Project included development of protocols to monitor minnows in the ephemeral channel following high flows and to determine whether channel maintenance is warranted, reporting injured or dead minnows to the Service, and providing a final restoration monitoring report outlining results and effectiveness of the side channel restoration and embayments to the Service. Additional commitments were to monitor and report on water quality before,

during, and after construction activity and scheduling, to the extent possible, embayment construction during dry or frozen soil conditions.

10.1.2 Bosque Revitalization at Route 66 Project

In March 2008, the Corps submitted a biological assessment to the Service for the proposed Bosque Revitalization at Route 66 project for the Albuquerque Reach of the Rio Grande and requested formal Section 7 consultation (Consultation #22420-2008-F-0125). This project entails jetty jack removal, non-native shrub removal, native woody plantings, and creation of willow swales throughout a 121-acre area adjacent to the Central Avenue and Bridge Boulevard Bridges in Albuquerque. These riparian features would improve habitat conditions for the flycatcher and minnow. Three high flow side channels are expected to establish diverse mesohabitats that support the silvery minnow. Such habitat benefits the species through improved egg and larval retention, increased recruitment rates, and increased survival of both young-of-year (YOY) and adult minnows.

The Service concurred with the Corps' determination that the proposed project "may affect, is not likely to adversely affect" the flycatcher and designated critical habitat for the silvery minnow. The Service determined that the proposed project is not likely to jeopardize the continued existence of the minnow; and although it may minimally adversely affect individual minnows when constructing channel embayment areas, the project is anticipated to have a long-term positive impact on the species through improvements to quality and availability of suitable habitat.

The attendant Incidental Take Statement included Reasonable and Prudent measures to minimize take of silvery minnow due to habitat restoration activities; manage for the protection of water quality from activities associated with the restoration project; and to continue to work collaboratively with the Service on the Middle Rio Grande Endangered Species Act Collaborative Program.

10.2 Reclamation Actions with Early or Completed Consultation and General Commitments

10.2.1 Middle Rio Grande Riverine Habitat Restoration Project for the Albuquerque Reach of the Rio Grande in Bernalillo County, New Mexico (New Mexico Interstate Stream Commission)

In September 2005, Reclamation submitted a biological assessment to the Service on behalf of the New Mexico Interstate Stream Commission (ISC), addressing potential impacts of a proposed habitat restoration project within the Albuquerque Reach on the endangered silvery minnow, the endangered flycatcher, and the

threatened bald eagle (Consultation #22420-2006-F-02). The Service concurred with Reclamation's determination of "may affect, not likely to adversely affect" for the willow flycatcher and bald eagle, provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow, that the proposed action "may affect is likely to adversely affect" minnows in the short-term with long-term "positive impact on the species," and that the proposed action is "not likely to destroy or adversely modify designated critical habitat" for the minnow.

Environmental commitments for the Albuquerque Reach Habitat Restoration Project required the ISC to monitor minnows at construction sites, use adaptive management as appropriate, develop and submit a Restoration Monitoring Plan to the Service, and report dead or injured minnows to the Service. Additional commitments were to schedule crossings during dry or frozen soil conditions, measure and report water quality parameters before, during, and after construction, as well as to report any hazardous materials spills (i.e., fuels, hydraulic fluids) to the Service.

10.2.2 Sandia Priority Site Project

In June 2006, Reclamation submitted a biological assessment to the Service of the proposed action on the endangered silvery minnow, the endangered flycatcher, and the threatened bald eagle. The proposed project included the protection of the east levee and canal system along the Albuquerque Reach between U.S. Highway 550 and into the Sandia Pueblo by creating secondary channels, realigning the main river channel, and installing bendway weirs and rootwad revetments to reduce bank erosion threatening the levee. The Service concurred (Consultation #22420-2006-F-039) with Reclamation's determination of "may affect, not likely to adversely affect" the flycatcher and eagle, also determined that the project "may affect, is not likely to adversely affect" minnow critical habitat, and that long-term effects would be beneficial. The Service concluded that the Sandia Priority Site Project was "not likely to jeopardize the continued existence of the silvery minnow," and that impacts on the population would be minimal because of the small area within occupied habitat.

Environmental commitments for the Sandia Priority Site Project required Reclamation to monitor minnows at construction sites, use adaptive management to modify construction activities, partial dewatering and habitat improvement activities, as appropriate, and to report dead or injured minnows to the Service. Additional commitments were to schedule crossings during dry or frozen soil conditions, measure and report water quality parameters before, during, and after construction, to report water quality measurements per conditions of Reclamation's Clean Water Act 401 certification to the Service and the Sandia

Pueblo, as well as to report any exceedance of pueblo water quality standards or spills (i.e., fuels, hydraulic fluids) to the Service and the Sandia Pueblo, and immediately remediate those conditions.

10.2.3 Middle Rio Grande Riverine Habitat Restoration Phase II Project for the Albuquerque Reach (ISC)

In August 2006, Reclamation submitted a biological assessment to the Service on behalf of the ISC, addressing potential impacts of Phase II of a proposed habitat restoration project within the Albuquerque Reach on the endangered silvery minnow, the endangered flycatcher, and the threatened bald eagle. This phase of the proposed project was to create or improve habitat for minnows, including promoting egg-retention, larval rearing, young-of-year and overwintering habitat for silvery minnow within four subreaches of the Albuquerque Reach in support of Element S of the RPA in the 2003 BiOp. Habitat restoration techniques included island modifications, bank scouring, and installation of woody debris to improve aquatic habitats. The Service concurred (Consultation #22420-2006-F-160) with Reclamation's determination of "may affect, not likely to adversely affect" for the bald eagle and the flycatcher and its critical habitat, and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely modify designated critical habitat. The Service also determined that the proposed action may adversely affect individual minnows in the short term, but that the proposed action was likely to have a long-term positive impact on the species.

Environmental commitments for the Albuquerque Reach Habitat Restoration Project required the ISC to monitor minnows at construction sites, use adaptive management as appropriate, develop protocol to monitor for minnows in ephemeral channels following high flows, and determine whether channel maintenance is warranted in coordination with the Service, report effectiveness of all treatments to the Service in a timely manner, and report dead or injured minnows to the Service. Additional commitments were to schedule crossings during dry or frozen soil conditions, measure and report water quality parameters before, during, and after construction, as well as report water quality measurements per conditions of Reclamation's Clean Water Act 401 certification to the Service and the Sandia Pueblo.

10.2.4 Santo Domingo Pueblo Restoration Project Phase II

Reclamation submitted a BA to the Service in April 2007, requesting concurrence for proposed activities associated with the Santo Domingo Pueblo Restoration Project Phase II, entailing three excavation sites on the east side of the Rio Grande beginning 1.5 miles south of SP88 and Bridge No. M102, during winter and placement of large woody debris in the Rio Grande to reduce water

velocity and enhance sediment deposition as a means for improving habitat for the minnow in the Cochiti Reach. Reclamation determined that the proposed action "may affect, is not likely to adversely affect" the endangered silvery minnow and the threatened bald eagle. The Service concurred with Reclamation's determinations by letter dated April 19, 2007, provided that general environmental commitments for the bald eagle were followed, and excavation would take place during winter low flows or dry periods, no equipment would enter the river, silt fences and sand bags would be used to isolate the excavation area from the river and minimize transport of sediment from the work area into the river, standard best management practices (BMPs) would be used, and that the Santo Domingo Pueblo would be responsible for monitoring and notifying the Service if silvery minnows were to use ephemeral channels or other isolated habitats forming in the channel.

10.2.5 Proposed Installation of Crump Weir and Passive Integrated Transponder Tag Readers in the Albuquerque Drinking Water Project Fishway

Reclamation submitted a biological assessment to the Service on May 1, 2007, the proposed installation of crump weir and passive integrated transponder tag readers in the Albuquerque Drinking Water Project Fishway. Reclamation determined that the proposed action "may affect, is not likely to adversely affect" the minnow or its designated critical habitat. The Service concurred with Reclamation's determinations by letter dated June 21, 2007, provided that the following conditions were followed: 1) block nets would be used to exclude minnows from the work area and installation would occur by hand.

10.2.6 Perennial Rio Grande Silvery Minnow Refugia at Drain Outfalls

Reclamation submitted a biological assessment to the Service on October 4, 2006, for the proposed Perennial Rio Grande Silvery Minnow Refugia at Drain Outfalls Project (Perennial Outfalls Project), located in the Isleta Reach of the MRG. The project partners will create habitat structures for minnows using large woody debris in three drain outfalls: Los Chavez and Peralta Wasteways and the Lower Peralta Drain #1. Reclamation determined that the proposed action "may affect, is not likely to adversely affect" the flycatcher or its designated critical habitat, or the bald eagle. The Service (Consultation #22420-2007-F-0021) concurred with Reclamation's determinations and also found that the project would have temporary adverse effects to the minnow and its designated critical habitat; the project would benefit the minnow during dry conditions by creating refugial habitat.

Environmental commitments for the Perennial Outfalls Project required Reclamation to minimize take of silvery minnow during construction; manage for water quality protection from activities associated with construction by avoiding the wetted river channel with heavy equipment during high flows; and by monitoring water quality before, during, and after construction activities. Additional commitments included monitoring of piscivores in newly created habitats and reporting monitoring results to the Service; coordinating with the Service if poor water quality, potential for stranding, high predation levels, or occurrence of disease were observed in the pools created by the project; and to determine if a decrease in habitat suitability or value occurred due to the project, and if observed, required removal of the structures.

10.2.7 Corrales Siphon River Maintenance Project

In September 2007, Reclamation submitted a biological assessment to the Service of the proposed action on the endangered silvery minnow and the endangered flycatcher and their respective designated critical habitats. The proposed project would protect the inverted siphon and associated infrastructure from damage caused by potential westward migration of the Rio Grande by moving the river eastward using a bioengineering technique designed to create and improve habitat for the minnow. Reclamation determined that the proposed project "may affect, but is not likely to adversely affect" the flycatcher or its designated habitat. The Service concurred with this determination (Consultation #22420-2007-F-0056) and also determined that the proposed project was not likely to jeopardize the continued existence of the minnow or result in adverse modification of its designated critical habitat. The project also was anticipated to be of long-term benefit to silvery minnow habitat quality.

Environmental commitments for the Corrales Siphon Project included monitoring for minnows prior to, and at least four times during, and after construction, reporting findings and results to the Service, transporting fill materials with heavy equipment across the Rio Grande as few times as possible to minimize destabilization of sediments, avoidance (to the extent possible) of crossing the wetted channel of the river at flows exceeding 900 cubic feet per second (cfs), and monitoring water quality during and after equipment operating in the river.

10.2.8 Proposed Pueblo of San Felipe Bosque Restoration Project

In September 2007, Reclamation submitted a biological assessment to the Service on behalf of the Pueblo of San Felipe, addressing potential impacts of a bosque restoration project under Section 7 of the Endangered Species Act of 1973, as amended. The proposed project would remove about 10 acres of non-native vegetation in the abandoned riparian flood plain of the bosque and subsequent replanting of Goodding's willow (*Salix gooddingii*) and Rio Grande cottonwood

(*Populus deltoides* var. *wislizeni*) poles. Reclamation determined that the proposed action "may affect, is not likely to adversely affect" the minnow or its designated critical habitat or the flycatcher and its designated critical habitat. The Service concurred with these determinations (Consultation # 22420-2008-IC-0010) provided that no vegetation would be removed within 20 feet of the Rio Grande; bankline would not be disturbed; and the construction would take place outside normal breeding and nesting seasons for the flycatcher.

10.2.9 Elephant Butte Reservoir Temporary Channel Maintenance Project

In October 2007, Reclamation submitted a BA addressing the effects of the proposed project on the endangered flycatcher and the minnow and the designated critical habitat for each. The proposed action was described by reaches and by activities, and includes maintenance of the temporary channel, which facilitates delivery of water and sediment from RM 57.8 to Elephant Butte Reservoir, for a period of 5½ years. Activities included ongoing non-channel enhancement features, maintenance operations, future temporary channel construction, and widening and realignment of the existing temporary channel. The Service determined (Consultation # 22420-2008-F-0017) that the project was not likely to jeopardize the continued existence of the minnow or flycatcher or result in adverse modification of designated critical habitat. In April 2008, the Service transmitted a letter amending the January 2008 BO, pursuant to communication among the Service and Reclamation in February and March.

In order to fulfill environmental commitments for this project, Reclamation will: 1) to the extent possible, operate airboats in the middle of the channel; 2) avoid pumping directly from the channel to minimize minnow egg and larvae entrainment, and use sumps adjacent to the channel whenever feasible; 3) in coordination with the Service, fund a program to monitor minnows in the temporary channel; 4) support CP efforts to prioritize and implement habitat restoration projects in the San Acacia Reach pursuant to the Long-Term Plan (MRGESCP 2006); 5) excavate an area as few times as possible; and when excavating within the wetted channel, minimize movement of excavator tracks and bucket contact with the bed of the channel to minimize sediment disturbance; 6) monitor water quality before, during, and after the project, which may include visual observations or direct sampling; 7) use current flycatcher monitoring data and avoid working within 0.25 mile of an active nest; 8) monitor vegetation health, incorporating vegetation mapping; 9) monitor ground water levels from the north boundary of the Bosque del Apache (BDA) refuge, along the temporary channel and the west side of the reservoir, as needed; 10) monitor the riverbed and movement of the headcut; and 11) work with the Service to plan and

implement a specific restoration project to establish flycatcher habitat on the Rio Grande, outside the San Marcial Reach, by January 2009, and implemented by July 2013.

10.2.10 Rio Grande Restoration Project at Santa Ana Pueblo

In June 2007, Reclamation submitted a biological assessment to the Service on behalf of the Santa Ana Pueblo, to perform a project to protect existing levees and associated infrastructure using bioengineering and other techniques, including installation of 13 bendway weirs to protect a threatened bankline by moving the river westward and relocating sediment to the west bank of the river, and to provide habitat for listed species, the endangered silvery minnow and Southwestern willow flycatcher. No critical habitat exists for either species and, therefore, will not be affected. Reclamation determined that the project "may affect, is not likely to adversely affect" the flycatcher. The Service concurred (Consultation # 22420-1998-F-0168-R002) and also determined that the Santa Ana Restoration Project is not likely to jeopardize the continued existence of the silvery minnow or result in adverse modification of designated critical habitat. The minnow and its food base will be adversely affected by the use of heavy equipment and placement of fill in the wetted channel of the river.

Environmental commitments for the Santa Ana Restoration Project include limiting equipment crossing speeds to 5 miles per hour (mph) for the first three crossings per day and, to the extent feasible, limit all crossing speeds to 5 mph, reporting of dead or injured minnows to the Service, and immediately cease construction activity until the Service determines it is safe to resume. Additionally, Reclamation would transport fill materials across the Rio Grande as few times as possible, avoid crossing the wetted channel of the river at greater than (>) 900-cfs flows, monitor water quality before, during, and after construction activities.

10.2.11 River Mile 111 Priority Site Project

In March 2008, Reclamation submitted a biological assessment to the Service evaluating the effects of relocation of the Low Flow Conveyance Channel (LFCC) and the associated levee to allow the Rio Grande more freedom to move within its historic flood plain on the endangered flycatcher and minnow and its designated critical habitat. Reclamation determined that the project "may affect, is not likely to adversely affect" the minnow and its designated habitat. The Service concurred with this determination (Consultation #22420-2008-I-0067), provided the following conditions were met: All construction of woody debris piles would occur under dry working conditions or during low flow conditions, recent surveys of the LFCC downstream of the proposed construction area did not find any minnows, the Lemitar radial gate structure would be closed during the

construction operations, cottonwood root wads would be placed on the bank near RM 111 and would cascade into the river as it migrates west, the Mitigation Plan described in the BA would be fully implemented, and the Conservation Measures described in the BA would also be fully implemented by Reclamation.

10.2.12 Drain Unit 7 Extension River Maintenance Priority Site Project

On June 13, 2008, Reclamation submitted a biological assessment, along with a letter formally requesting consultation re-initiation, to the Service for the proposed Drain Unit 7 (DU7) Extension River Maintenance Priority Site Project. The project will reinforce the bankline and protect the adjacent access road and drain by placing riprap along the bank within the active river channel. Reclamation determined that the proposed action may affect, and is likely to adversely affect, the endangered minnow during construction and may affect, and is not likely to adversely affect designated minnow critical habitat. The Service concluded that the proposed action is not likely to jeopardize the continued existence of the minnow and that there is likely to be short-term adverse effects on a very small portion of designated critical habitat at the construction site.

Environmental commitments associated with the proposed DU7 Project include implementing construction BMPs and dust abatement during construction and revegetating the site, along with performing construction outside minnow spawning periods (construction exclusion period of April 15–July 1).

10.2.13 Rio Grande Sediment Plug Removal Project at Bosque del Apache National Wildlife Refuge

In August 2008, Reclamation submitted a biological assessment to the Service addressing potential impacts of removal of a sediment plug that formed within the Rio Grande at the BDA during spring runoff 2008, on the endangered minnow and its designated critical habitat, and on the endangered flycatcher proposed habitat restoration project within the Albuquerque Reach on the endangered silvery minnow, the endangered flycatcher, and the threatened bald eagle (Consultation #22420-2006-F-160). This phase of the proposed project was to create or improve habitat for minnows, including promoting egg-retention, larval rearing, young-of-year, and overwintering habitat for silvery minnow within four subreaches of the Albuquerque Reach in support of Element S of the RPAs in the 2003 BiOp. Habitat restoration techniques included island modifications, bank scouring, and installation of woody debris to improve aquatic habitats. The Service concurred with Reclamation's determination of "may affect, not likely to adversely affect" for the bald eagle and the flycatcher and its critical habitat and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely

modify designated critical habitat. The Service also determined that the proposed action may adversely affect individual minnows in the short term, but that the proposed action was likely to have a long-term positive impact on the species.

Reclamation's environmental commitments for the Sediment Plug Removal Project include: 1) construction of at least four embayments (approximately 30–50 feet in width and 50–70 feet in length, each) on the west side of the pilot channel to promote channel widening to be completed during Phase I(b); 2) collection of data for 4 years following excavation of the pilot channel to monitor channel degradation/aggradation and overbanking patterns—including cross-section data of the river channel from the north boundary of BDA to the San Marcial Railroad Bridge, at least two inspections of the river channel by boat when overbanking begins during runoff, and at least once during the 4 years, cross-section data of the river channel and flood plains will extend between endpoints for these rangelines; 3) Data collected as above will be analyzed and compared to 2002 and 2005 cross-section data to assess changes to the riverbed thalweg and channel geometry including width/depth ratio, and data and analysis will be provided to the Service (NMESFO and the BDA); and 4) indepth analysis of alternatives to pilot channel construction within the aforementioned reach of river will be initiated within 6 months of completion of Phase I(b) of the project and will include at least three strategies to address sediment transport through the reach, maintenance of connected unvegetated river bars, opportunities for river realignment following sand plug formation, river connectivity during low flows, river/flood plain surface connectivity, surface water supplies to adjacent wetlands, and effects on threatened, endangered, or candidate species. This analysis must be conducted in coordination with the Service, and the final report must be completed within 3 years and will be used in all future sediment plug removal or maintenance activities within the BDA.

10.2.14 Middle Rio Grande Isleta Reach Riverine Habitat Restoration Project

In October 2008, Reclamation submitted a biological assessment to the Service on behalf of the ISC, addressing potential impacts of a proposed riverine habitat restoration project within the Isleta Reach on the endangered silvery minnow and the endangered flycatcher. The proposed project was to create or improve habitat for minnows, including promoting egg-retention, larval rearing, and young-of-year habitat for silvery minnow within the Isleta Reach in support of Element S of the RPA in the March 2003 BO. Habitat restoration techniques included creation of bankline embayments, ephemeral channels, island modifications, bank scouring, placement of woody debris, removal of lateral constraints, as well as flood plain vegetation management. The Service concurred (Consultation #22420-2009-F-0002) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher and its critical habitat and

provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely modify designated critical habitat.

Environmental commitments for the Isleta Reach Riverine Habitat Restoration Project required Reclamation to monitor minnows at construction sites, report site-specific monitoring protocol availability and effectiveness of all treatments to the Service in a timely manner, and report dead or injured minnows to the Service. Additional commitments were to encourage adaptive management of flows and conservation of water to benefit listed species, and to measure and report water quality parameters before, during, and after construction, as well as report water quality measurements per conditions of Reclamation's Clean Water Act 401 certification to the Service.

10.2.15 Middle Rio Grande Isleta Reach Riverine Habitat Phase IIa Restoration Project

In November 2008, Reclamation submitted a biological assessment to the Service on behalf of the ISC, addressing potential impacts of a proposed riverine habitat restoration project within the Angostura Reach on the endangered silvery minnow and the endangered flycatcher. The proposed project was to create or improve habitat for minnows, including promoting egg-retention, larval rearing and young-of-year habitat for silvery minnow, as well as to facilitate evaluation of habitat restoration techniques. The project supported Element S of the RPA in the 2003 BiOp. Habitat restoration techniques included island, bar, and bankline modifications. The Service concurred (Consultation #22420-2009-F-0016) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher and its critical habitat and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely modify designated critical habitat.

Environmental commitments for the Isleta Reach Riverine Habitat Restoration Phase IIa Project required Reclamation to monitor minnows at construction sites, ensure post-construction monitoring protocol for silvery minnow entrapment is implemented, report effectiveness of all treatments to the Service in a timely manner, and report dead or injured minnows to the Service. Additional commitments were to encourage adaptive management of flows and conservation of water to benefit listed species and to measure and report water quality parameters before, during, and after construction, as well as report water quality measurements per conditions of Reclamation's Clean Water Act 401 certification to the Service.

10.2.16 Pueblo of Sandia Bosque Rehabilitation Project

In December 2008, Reclamation submitted a biological assessment to the Service on behalf of the Pueblo of Sandia, addressing potential impacts of a proposed habitat restoration project within the Pueblo of Sandia on the endangered silvery minnow and the endangered flycatcher. The proposed project was to design and implement techniques to restore and enhance riverine and riparian habitat for the benefit of the silvery minnow, including promoting egg-retention, larval rearing, and young-of-year habitat for silvery minnow, as well as creating suitable habitat for future use by flycatchers. Habitat restoration techniques included the renovation of a side channel, placement of woody debris within the renovated channel, and planting approximately 5 acres of native woody vegetation. The Service concurred (Consultation #22420-2009-F-0022) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher and its critical habitat and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely modify designated critical habitat. The Service also determined that the proposed action may be anticipated to have long-term beneficial effects on silvery minnows by restoring and enhancing riverine and riparian habitat.

Environmental commitments for the Pueblo of Sandia Bosque Rehabilitation Project required Reclamation and the Pueblo of Sandia to ensure that restoration treatment occurs between September 1 and April 15, to monitor minnows at construction sites, to use adaptive management as appropriate, to monitor for minnows in ephemeral channels following high flows, to report effectiveness of all treatments and dead or injured minnows to the Service in a timely manner. Additional commitments were to measure and report water quality parameters before, during, and after construction as well as report water quality measurements.

10.2.17 Pueblo de San Felipe Priority Sites Phase I Project

In September 2009, Reclamation submitted a biological assessment to the Service addressing potential impacts of proposed river channel maintenance activities, at four priority sites within the Pueblo of San Felipe on the endangered silvery minnow and its designated critical habitat. The proposed project was to eliminate bank erosion and migration through bankline improvements. Techniques included removal of vegetation and jetty jacks, vegetation planting, bar removal, lining banks with riprap, and installation of bioengineered bankline stabilization. The Service concurred (Consultation #22420-2009-F-0089) with Reclamation's determination of "may affect, not likely to adversely affect" for the minnow and its critical habitat and is not likely to adversely modify designated critical habitat.

Environmental commitments for the Pueblo de San Felipe Priority Sites Phase I Project required Reclamation to ensure that in water work not be conducted

during spring runoff, monitor minnows at construction sites, report site-specific monitoring results, and report dead or injured minnows to the Service. Additional commitments were to encourage adaptive management of flows and conservation of water to benefit listed species and to pursue population surveys for silvery minnow in the Cochiti Reach.

10.2.18 Two Rivers and Three Falls Flycatcher Habitat Expansion Project

In October 2009, Reclamation submitted a memorandum requesting concurrence for proposed activities to enhance, create, and expand flycatcher habitat at Ohkay Owingeh in Sandoval County, New Mexico. The proposed project was to improve the quality of riparian habitat by excavating a filled-in secondary channel and reconnect it to the river. The Service concurred (Consultation #22420-2010-I-0005) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher and its critical habitat and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow and is not likely to destroy or adversely modify designated critical habitat.

10.2.19 Middle Rio Grande Isleta Reach Phase II Riverine Habitat Restoration Project

In April 2010, Reclamation submitted a biological assessment to the Service on behalf of the ISC, addressing potential impacts of a proposed riverine habitat restoration project within the Isleta Reach on the endangered silvery minnow and the endangered flycatcher and respective designated critical habitats. The purpose of the proposed project was to create or improve habitat and provide benefits for the silvery minnow, the flycatcher, and the Middle Rio Grande ecosystem as a whole. Long-term goals included diversifying mesohabitat types to promote egg-retention, larval rearing and young-of-year habitat, create habitat adjacent to perennial water sources for silvery minnow, increase the extent of overbank inundation, and encourage fluvial process and river dynamics in four subreaches within the Isleta Reach. Habitat restoration techniques included creation of bankline benches, backwater embayments, ephemeral channels, and island/bar modifications. The Service concurred (Consultation #22420-2010-F-0060) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher or its critical habitat, and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow, and is not likely to destroy or adversely modify designated critical habitat.

Environmental commitments for the Isleta Reach Phase II Riverine Habitat Restoration Project required Reclamation to monitor minnows at construction sites, implement *Protocol for Monitoring Silvery Minnow Entrapment*, and report effectiveness of all treatments, as well as dead or injured minnows to the Service

in a timely manner. Additional commitments were to encourage adaptive management of flows and conservation of water to benefit listed species, and to measure and report water quality parameters before, during, and after construction as well as report water quality measurements.

10.2.20 Pueblo of Sandia Riverine Habitat Restoration Project

In May 2010, Reclamation submitted a biological assessment to the Service on behalf of the Pueblo of Sandia, addressing potential impacts of a proposed riverine habitat restoration project within the Sandia subreach of the Angostura (or Albuquerque) Reach on the endangered silvery minnow and the endangered flycatcher. The purpose of the proposed project was to create or improve habitat and provide benefits for the silvery minnow, the flycatcher, and the Middle Rio Grande ecosystem as a whole. Long-term goals included diversifying mesohabitat types to promote egg-retention, larval rearing and young-of-year habitat, create habitat adjacent to perennial water sources for silvery minnow, increase the extent of overbank inundation, and encourage fluvial process and river dynamics in support of Element S of the RPA in the 2003 BiOp. Habitat restoration techniques included creation of bankline benches, backwater embayments, ephemeral channels, and island/bar modifications. The Service concurred (Consultation #22420-2010-F-0083) with Reclamation's determination of "may affect, not likely to adversely affect" for the flycatcher and provided an opinion that the proposed action is not likely to jeopardize the continued existence of the minnow.

Environmental commitments for the Pueblo of Sandia Riverine Habitat Restoration Project required Reclamation to monitor minnows at construction sites, implement *Protocol for Monitoring Silvery Minnow Entrapment,* and report effectiveness of all treatments, as well as dead or injured minnows to the Service in a timely manner. Additional commitments were to encourage adaptive management of flows and conservation of water to benefit listed species and to measure and report water quality parameters before, during, and after construction, as well as report water quality measurements.

10.3 General Environmental Commitments from Early or Completed Consultations

The following are general environmental commitments from the aforementioned consultations pertaining to listed species and their habitats.

10.3.1 Southwestern Willow Flycatcher

Construction disturbance will be avoided near occupied and known flycatcher territories from April 15–August 15. A predetermined, standard-setting buffer distance around willow flycatcher territories has not been established; instead, such buffer zones will be defined on a case-by-case basis (Reclamation, 2001).

Future project sites with occupied or suitable habitat shall be surveyed for at least one breeding season prior to the start of any project activities. If flycatchers are detected within the boundaries of proposed projects, consultations will be initiated with the Service. It is Reclamation's intent to use the principles of adaptive management and monitor project sites sufficiently to accumulate the necessary data and information for future decisionmaking (Reclamation, 2001).

Reclamation will minimize the number of new transects that are cleared in conjunction with river surveying activities. As referenced in the 2001 BA, the collection and use of hydrographic data from transects provide better management of the Middle Rio Grande flood plain and river channel. Transect clearing or maintenance will not occur in occupied habitat. Out-of-use transects will be allowed to revegetate. Brushing will occur only when necessary for project purposes. If transect brushing is necessary, brushing or surveys during the breeding period (April 15–August 15) shall be avoided to minimize disturbance. Suitable or potential flycatcher habitat also can be avoided in certain cases by limiting brushing to the river's edge and not clearing beyond that point. All sites proposed for transect clearing will be reviewed by Reclamation biologists. If it is determined that the site is not suitable or potential willow flycatcher habitat, transect clearing will proceed under the above conditions (Reclamation, 2001).

10.3.2 Rio Grande Silvery Minnow

Reclamation will continue to conduct fish population monitoring at established locations in the Middle Rio Grande between Angostura Diversion Dam and the headwaters of Elephant Butte Reservoir. Pre- and post-construction monitoring for fish species will continue at constructed and proposed river maintenance sites through the Middle Rio Grande (Reclamation, 2001).

If it is necessary to redirect flows away from a construction site, steps will be taken to allow flows to recede from the area gradually so silvery minnow can avoid entrapment. Any disconnected aquatic habitat, e.g., isolated pools, associated with a river maintenance site will be sampled for silvery minnow which, if found, will be relocated into adjacent areas of flowing water (Reclamation, 2001).

Construction activities requiring the movement of equipment within the river channel will avoid potential silvery minnow habitat to the extent possible. When

feasible, xeric conditions will be sought to minimize direct impacts of construction activities to silvery minnow. While many of the proposed habitat enhancement activities involve extensive construction activity in or near the river channel, disturbance to the aquatic environment will be minimized (Reclamation, 2001).

10.3.3 Additional General Commitments

- Reclamation will carry out its actions to encourage seasonal overbank flooding and associated low velocity aquatic habitats in or near suitable willow flycatcher habitat within the bounds of the expected natural hydrograph.

- Reclamation will review the Southwestern Willow Flycatcher Recovery Plan and update the environmental commitments related to the willow flycatcher as appropriate.

- Reclamation will work with the MRGCD to: 1) facilitate fish passage at the three main diversion dams to allow upstream movement of the silvery minnow, 2) investigate the effects of fish, eggs, and larvae passage over the structures, and 3) alleviate the entrainment of silvery minnow into the irrigation system. Reclamation is currently conducting a planning study that focuses on some of these issues at San Acacia Diversion Dam.

- Reclamation will pursue habitat restoration along the Middle Rio Grande, in coordination with other parties, which includes the restoration of the river channel to create and enhance aquatic habitat for the silvery minnow and native riparian habitat for the willow flycatcher and bald eagle. The principles of adaptive resource management will be incorporated into habitat restoration. Reclamation, as a component of the river maintenance program, will perform two river restoration projects annually.

- Increase the number and distribution of overbank flooding sites and sites with shallow, low velocity water conditions to enhance silvery minnow habitat, assist in regeneration of native vegetation, and provide for flooding in suitable habitat for the willow flycatcher during the breeding season. Monitoring will be conducted to quantify the extent of overbank flooding.

- Eliminate mowing of native riparian vegetation unless it contributes to habitat restoration or is required for safe conveyance of flood flows.

- In areas where impacts to mature cottonwoods cannot be avoided, Reclamation will replace the trees at a 10:1 ratio.

- Reclamation will continue to work with the MRGCD to improve gaging and real-time monitoring of water operations.

  Reclamation will initiate efforts to define a suite of characteristics important for flycatcher habitat occupancy and nesting success. Conduct a preliminary examination and assessment of habitat parameters of occupied habitat within the delta of Elephant Butte Reservoir (near the LFCC) to determine features that characterize optimal habitat selected by flycatchers.

APPENDIX 7

REPORT ON URGWOM DEVELOPTMENT SIMULATIONS AND FINAL RESULTS FOR PREPARATION OF BIOLOGICAL ASSESSMENT ON WATER MANAGEMENT ACTIONS ON THE MIDDLE RIO GRANDE, FEBRUARY 2012

Report on

URGWOM Development, Simulations, and Final Results for Preparation of a Biological Assessment on Water Management Actions on the Middle Rio Grande

Prepared by

Craig Boroughs, Ph.D., P.E.

February 2012

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Acknowledgments

Numerous individuals and representatives from different agencies and organizations must be acknowledged for contributing toward the completion of all aspects of the work documented in this report for preparation of a Biological Assessment (BA) of Water Management Actions on Middle Rio Grande. Enhancements and development of the Upper Rio Grande Water Operations Model (URGWOM) for meeting specific needs for this study were completed through coordination with the interagency Population and Habitat Viability Assessment/Hydrology ad hoc Work Group (PHVA Work Group) of the Middle Rio Grande Endangered Species Collaborative Program with model runs completed throughout the process leading to the final simulations and results presented in this report. Several agency representatives were involved with the PHVA work group efforts since the inception of the work group in December of 2007 and the subsequent work on the BA write-up.

Leann Towne with the U.S. Bureau of Reclamation (Reclamation) was instrumental in overseeing and assuring all aspects of the analyses and modeling were completed as co-leader of the PHVA work group along with the support from April Fitzner and Stephen Kissock as co-leaders from the U.S. Army Corps of Engineers (Corps). The significant support from the following other agency representatives throughout the entire process was also essential for successful completion of all work: Dagmar Llewellyn, Jim Wilber, Josh Mann, Valda Terauds, and Jeanne Dye-Porto with Reclamation; Rolf Schmidt Peterson with the Interstate Stream Commission (ISC); David Gensler with the Middle Rio Grande Conservancy District (MRGCD); John Stomp and Andrew Lieuwen with the Albuquerque Bernalillo County Water Utility Authority (ABCWUA); Randy Shaw (previously with the Bureau of Indian Affairs (BIA)) and Chris Banet from BIA; Paul Tashjian, Lori Robertson, and Jennifer Bachus with the U.S. Fish and Wildlife Service (Service); and Tim Ward (previously with the University of New Mexico). Collaborative Program Management Team (PMT) liaisons Terina Perez and Kathy Dickinson were also imperative to the overall effort along with the oversight from Collaborative Program Managers, Yvette McKenna and Lisa Croft.

Significant appreciation must also be expressed to the URGWOM Technical Team (Tech Team) contributors for the work on model development, completed simulations, and post-processing and analyses including the close involvement from Tech Team members, Warren Sharp with Reclamation, Marc Sidlow with the Corps, and Nabil Shafike with ISC. Their efforts were vital for assuring the PHVA work group's analyses were a priority and for assuring a quality modeling study was completed. Other Tech Team members contributing to the study include Don Gallegos and Amy Louise with the Corps, Steve Bowser and Michelle Estrada-Lopez with Reclamation, Jesse Roach with Sandia National Laboratories, Mike Roark with the U.S. Geological Survey (USGS), and contractors Tomas Stockton and Bill Miller.

Executive Summary

The Upper Rio Grande Water Operations Model (URGWOM) was selected as the tool for completing model runs for providing needed hydrologic information for the U.S. Bureau of Reclamation (Reclamation) and U.S. Army Corps of Engineers (Corps) to prepare water operations Biological Assessments (BAs) for use in consultation with the U.S. Fish and Wildlife Service (Service). The model was used by the Population and Habitat Viability Assessment/Hydrology ad hoc work group (PHVA work group) of the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) for analyzing scenarios for managing reservoirs and diversions in the Rio Grande basin. Numerous model enhancements and updates were completed throughout the modeling process to meet the needs for the PHVA work group analyses and BA preparation that included the following:

- adjusting the physical layout of the Middle Rio Grande in the model, incorporating groundwater-surface water interaction, and updating the URGWOM database and data management interface (DMIs) accordingly;
- completing a review of the calibration with a low flow calibration enhancement to improve model performance at simulating low flows and the timing and extent of river drying;
- enhancing the representation of the calibration and inflows for the reach from San Marcial to Elephant Butte Reservoir – important for accurately representing Compact deliveries;
- setting up policy for flow tools including Cochiti deviations and pumping from the Low Flow Conveyance Channel;
- updating model policy for Prior and Paramount (P&P) storage for the six Middle Rio Grande Pueblos to occur at El Vado Reservoir up to the minimum starting on January 5th and with calls for P&P releases from El Vado Reservoir computed with reference to URGWOM loss rates and usable flow factors of 1.0,
- updating policy for Albuquerque Bernalillo County Water Utility Authority (ABCWUA) diversions, and representing increased diversions at Angostura during shortage operations;
- updating policy for the use of Reclamation's leased San Juan-Chama Project water including step downs in target flows for representing Reclamation's discretionary operations to use supplemental water to manage the recession after the runoff, but
  - with no use of supplemental water to control the rate of drying after any river rewetting in final model runs;
- incorporating the Buckman Direct Diversion;
- updating calculations for usable storage available at Elephant Butte Reservoir,
- updating assumed initial conditions throughout the modeling process with estimated values for December 31, 2011 used in final model runs; and
- representing deep aquifer heads accurately for scenarios including different heads for modeling with no Heron Dam operations for the San Juan-Chama Project where ABCWUA would rely on groundwater pumping to meet needs.

This report provides additional background information on the items listed above as completed to meet the needs for the PHVA work group analyses for BA preparation, specific details about flow tools defined by the PHVA work group, and scenarios evaluated throughout the modeling process. Results from final simulations are also presented. Notes on the communication and coordination of the analyses with the PVA work group of the Collaborative Program are also included.

Model runs were set up as part of a process that ultimately led to a defined Proposed Action for Reclamation's BA and other final scenarios to be modeled. The Proposed Action entails meeting the 2003 Biological Opinion (2003 BO) flow requirements as possible utilizing an initial supply of supplemental water and assumed future Reclamation leases of San Juan-Chama Project water (12,000 acre-ft/year for the first five years and 8000 acre-ft/year for the following five years). Pumping from the Low Flow Conveyance Channel (LFCC) is also included to manage the recession after the continuous flow requirement (or after the runoff). It was determined that flow requirements under the 2003 BO cannot be fully met under the Proposed Action. Flow targets cannot always be met with the projected available supply of supplemental water, and more river drying would occur. Results from the modeling indicate the total annual amount of supplemental water needed to meet the 2003 BO flow requirements over the next ten years may average from 32,000 acre-ft/year to 49,000 acre-ft/year depending on the hydrology for the next ten years. The additional supplemental water needed beyond the amount provided under the Proposed Action may average from 17,800 acre-ft/year to 35,900 acre-ft/year.

A review was also completed of the impact of Reclamation's actions including Heron Dam operations for the San Juan-Chama Project and El Vado Dam operations along with the Supplemental Water Program included under the Proposed Action. It was determined that Heron Dam operations help to augment flows in the Middle Rio Grande as a result of providing San Juan-Chama Project water to the Middle Rio Grande Conservancy District (MRGCD) and ABCWUA. El Vado Dam operations also help to augment flows in the Middle Rio Grande. Water stored at El Vado Reservoir during the runoff as not needed to meet the daily irrigation demand, and when storage restrictions per Article VII of the Compact are not in effect, is released to meet irrigation needs later in the summer and helps to provide additional flows in the Middle Rio Grande. Reclamation's Supplemental Water Program consisting of leases of San Juan-Chama water and pumping from the Low Flow Conveyance Channel (LFCC) to the river further helps to augment flows in the Middle Rio Grande. It was also determined that Middle Rio Grande Conservancy District (MRGCD) diversions adversely impact flows as river flows are diverted.

1.0. Introduction

In April 2008, the Upper Rio Grande Water Operations Model (URGWOM) was selected by the Population and Habitat Viability Assessment/Hydrology ad hoc work group (PHVA work group) of the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) to use as the primary tool for analyzing scenarios for managing reservoirs and diversions in the Rio Grande basin and evaluate impacts of potential operational scenarios on the long-term viability of the Rio Grande silvery minnow (*Hybognathus amarus*) and the southwestern willow flycatcher (*Empidonax trailii extimus*). Results from the model runs were referenced for providing needed hydrologic information for the U.S. Bureau of Reclamation (Reclamation) and U.S. Army Corps of Engineers (Corps) to prepare water operations Biological Assessments (BAs) for use in consultation with the U.S. Fish and Wildlife Service (Service).

This report provides background information on all the model development and preparatory work since the inception of the PHVA work group in December 2007. Numerous enhancements and updates to URGWOM were completed to meet the needs for the PHVA work group analyses that included incorporating a representation of the groundwater-surface water interaction in the

Middle Rio Grande, completing a detailed review of the model calibration and a low flow calibration enhancement, and reviewing the model policy and incorporating numerous rule changes and updates to meet the needs for the study. Several flow tools as defined by the PHVA work group were set up in URGWOM for analysis as potential solutions for meeting flow needs that included Cochiti deviations, relinquished Compact credits/storage of Emergency Drought Water, Reclamation leases of contractor San Juan-Chama Project water, Low Flow Conveyance Channel (LFCC) pumping, and alternate letter water delivery schedules.

The process for ultimately defining the final water management scenarios for modeling is discussed which started with an initial screening of water management scenarios and eventually led to a single defined scenario for the Proposed Action in Reclamation's BA. A detailed analysis of the Proposed Action was completed, and all simulation results as referenced for preparation of Reclamation's BA are presented. Results are also presented for a scenario that includes all the flow tools defined by the PHVA work group. This documentation serves as the last three deliverables under the PHVA work group charter (2010) and documentation of all model development, completed simulations, and final results for BA preparation. Work was completed through the PHVA work group and with contributions from the URGWOM Technical Team (Tech Team).

1.1. URGWOM

Operations of facilities in the Rio Grande basin from the Colorado-New Mexico state-line to below Elephant Butte Reservoir including the Rio Chama are modeled with URGWOM. URGWOM is a daily timestep computational model developed through an interagency effort and is used to simulate processes and operations of facilities and complete accounting calculations for tracking the delivery of water allocated to specific users. Policy for setting dam releases along with diversions and other demands are represented in coded rules in an URGWOM ruleset. Various methods are included to represent physical processes such as floodwave travel times; reservoir evaporation and seepage; conveyance losses to deep percolation, open water evaporation, and evapotranspiration (ET); surface water-groundwater interaction; and irrigation return flows.

URGWOM was developed using the RiverWare software application developed by the Center for Advanced Decision Support for Water and Environmental Systems (CADSWES) at the University of Colorado at Boulder. RiverWare is a generalized river basin modeling environment that can be used to develop an operations model for any configuration and to simulate operations to meet needs for flood control, water supply, recreation, etc. Numerous methods are available for representing the key physical processes in a basin. RiverWare is designed to provide river basin managers with a tool for scheduling, forecasting, and planning reservoir operations and includes extensive capabilities for rulebased simulations and water accounting. A key benefit of RiverWare is that software development is ongoing and new methods and capabilities can be added to RiverWare by the software developers to meet evolving needs. The rule policy language (RPL) editor in RiverWare is used to code various aspects of policy for operations for flood control, ecological benefits, recreation, and deliveries to irrigation districts, municipalities, and other water users.

Separate modules of URGWOM are used by agencies involved with Rio Grande operations in New Mexico. The Accounting Model is used to track the status of accounts under actual

operations. A Forecast Model is used to develop forecasted inputs for Water Operations Model runs which simulate operations under a provided forecast for preparing Annual Operating Plans (AOP). All the work for the PHVA work group was completed with the planning module of URGWOM (Boroughs, 2010a). The Planning Model uses the same single URGWOM ruleset used with the Water Operations Model but the Planning Model uses a Combined account to represent water for all contractors for San Juan-Chama Project water other than the Albuquerque Bernalillo County Water Utility Authority (ABCWUA), Middle Rio Grande Conservancy District (MRGCD), and water for the Cochiti Recreation Pool. Using a Combined account allows for longer model runs to be completed more efficiently.

Several other aspects of URGWOM that are key for the analyses are discussed in this document, but more information can be obtained at the URGWOM website: (http://www.spa.usace.army.mil/urgwom/default.asp). The set up for URGWOM simulations includes initial conditions, an assumed hydrology, and details on operational policy for setting demands and releases from reservoirs in the system as represented in the URGWOM ruleset, and the related assumptions for the model runs for the PHVA work group are discussed further in this report. Slight adjustments to model parameters or the rules are implemented to represent proposed changes to operations. Resulting flows are analyzed to identify the timing of river drying and the occurrence of recruitment and overbank flows where a comparison of the results between two model runs indicates the impact of a change on the river flows.

2.0. Model and Ruleset Changes

To assure the needs for the PHVA work group analyses could be met, several adjustments were made to different aspects of URGWOM and the ruleset used to represent policy for operations. Changes included overseeing work by the URGWOM Technical Team to incorporate a new configuration for representing groundwater-surface water interaction in the Middle Rio Grande. Following this work, a detailed review of the model calibration was completed with specific focus on the model performance at simulating lower flows and predicting the timing and extent of river drying. Model policy for standard operations was reviewed, and several aspects of the URGWOM rules were edited to assure policy is represented accurately as needed for the PHVA work group analyses. Work on the rules included changes for representing ABCWUA diversions and deliveries of ABCWUA's San Juan-Chama Project water from Abiquiu Reservoir to the diversion, policy for increased diversions at Angostura Dam when MRGCD is in a shortage situation, and El Vado Dam releases that may be set per Article VIII of the Compact. The model and ruleset were adjusted to incorporate or make changes for flow tools analyzed as potential solutions for meeting water needs for Endangered Species Act (ESA) needs including Cochiti deviations, relinquished Compact credits/storage of Emergency Drought Water, Reclamation leases of contractor San Juan-Chama Project water, LFCC pumping, and alternate letter water delivery schedules. The model approach for representing the use of supplemental water to meet flow requirements was also reviewed.

2.1. Middle Valley Rework

Work included an update to the representation of the physical system and processes in the Middle Rio Grande for including groundwater-surface water interaction between the shallow aquifer and the river, drains, and canals (URGWOM Technical Team, 2010). The shallow groundwater system throughout the Middle Rio Grande is set up as a grid of 57 groundwater areas. The groundwater areas are established in a 3 x 19 grid with three columns of groundwater areas for the area under the river and on each side of the river for 19 separate subreaches between Cochiti Dam and San Marcial. Seepage between the surface water and shallow aquifer is head based and computed daily. The subreaches represent river lengths of 5 to 15 miles with the boundaries defined by gage locations or other key benchmarks along the river. Modeled inflows to each of these subreaches are referenced for identifying modeled river drying.

Crop consumption is computed based on irrigated areas and crop evapotranspiration (ET) rates, and canal seepage is included. Open water evaporation from the river and riparian ET losses are also represented. Deep percolation is computed daily as a head based loss, and wasteway returns are simulated. Refer to Figure 2.1 for a screen capture of the workspace from URGWOM for the top portion of the Middle Rio Grande system.

Numerous new model inputs are needed as a result of the Middle Valley Rework, so incorporating the changes required significant work by the Tech Team to the data management interface (DMIs) and URGWOM database as maintained in files that have the format of the Corps' Hydrologic Engineering Center Data Storage System (DSS).

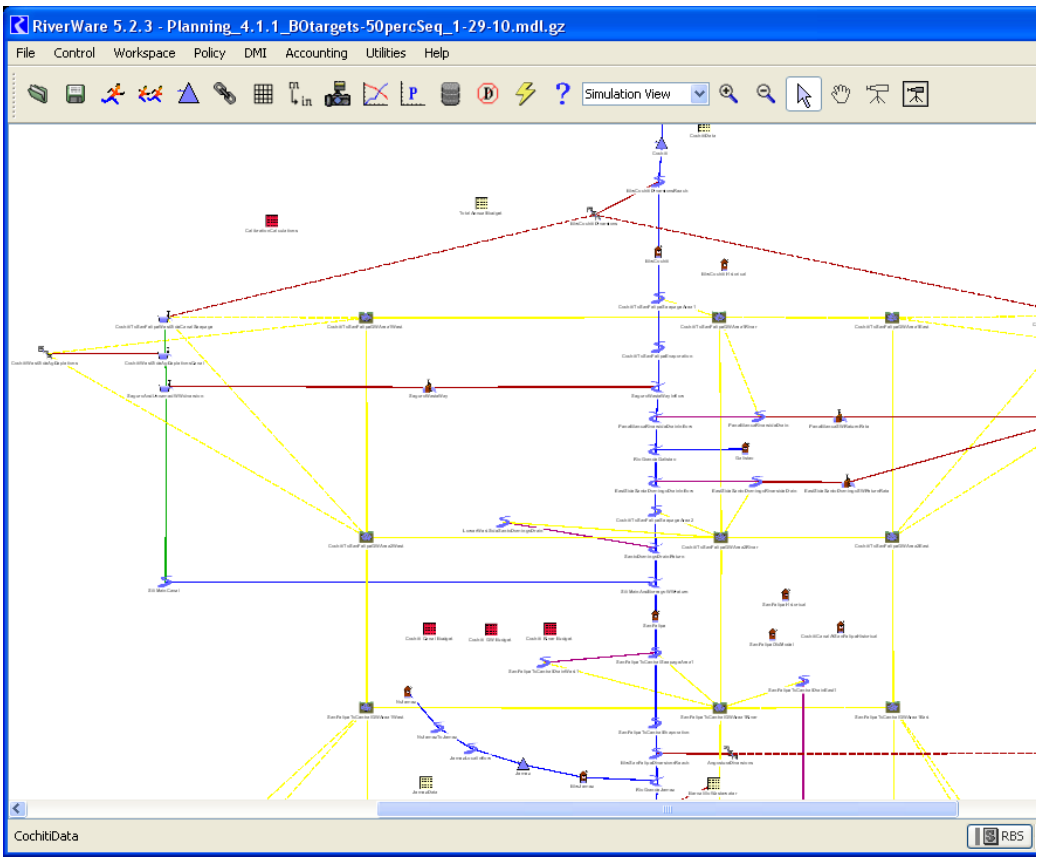

Figure 2.1. Screen Capture of the Representation of the Top Portion of the Middle Rio Grande System in URGWOM

2.2. Calibration Review

After the Middle Valley Rework was implemented in the Planning Model, an updated review of the model calibration was completed with specific focus on the model results at low flows and simulated river drying, of specific interest to the PHVA work group and for BA preparation. Adjustments were incorporated for a few model parameters used for setting canal seepage, return flows at wasteways, and stream seepage. The model calibration entailed reviewing model results with the historical hydrology and historical operations from 1990 through 2007 versus historical gaged flows at key gage location along the Middle Rio Grande for the same period. The difference in the model flows and historical gage flows represent model residuals which were evaluated to assure the model is simulating river flows accurately and there are no trends toward over-predicting or under-predicting flows. The distribution of the residuals was reviewed at the key gage locations. Refer to Figure 2.2 for a sample plot of the distribution of the daily residuals at the location of the USGS gage Rio Grande at Albuquerque, NM (ID#08330000) (herein after referred to as Central).

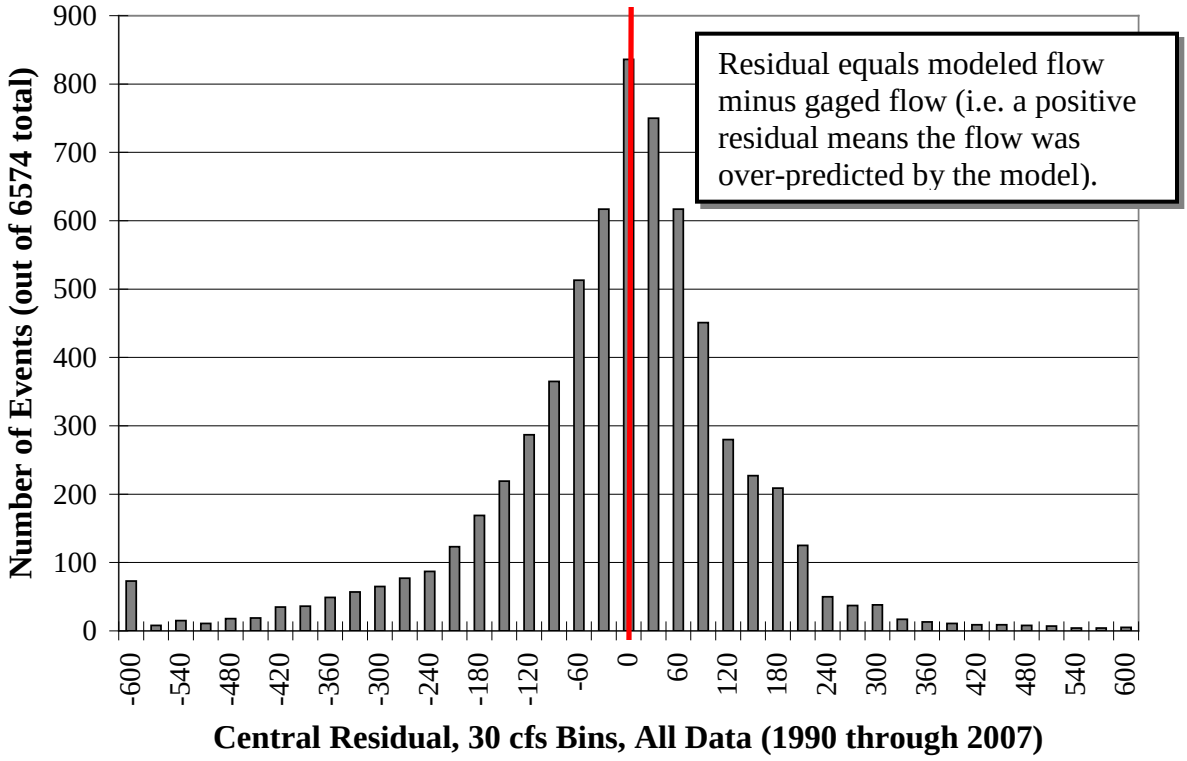

Figure 2.2. Sample Plot of Distribution of Residuals – Central

The review of the model calibration also included a check of the timing for simulated river drying under historical operations versus available RiverEyes data for when river drying actually occurred based on field observations. Refer to Figure 2.3 for a sample plot of the modeled flow at a model node below the Isleta diversion using the 2007 hydrology and operations versus the historical data for when river drying occurred at the corresponding location based on the RiverEyes data. In preparation for post-processing model output from URGWOM runs and providing key information on simulated river drying, trigger flows were defined for each subreach in URGWOM for when river drying would be expected.

As a separate side exercise to update the model calibration, the approach for representing inflows to the reach between the location of the USGS gage Rio Grande Floodway at San Marcial, NM (ID# 08358400) (herein after referred to as San Marcial) and Elephant Butte Reservoir was refined to assure simulated inflows to the reservoir are accurate and computed Compact credits are correct in the model simulations. The new approach was calibrated such that the modeled inflows to Elephant Butte Reservoir match actual inflows computed using a mass balance on the reservoir with recent historical data.

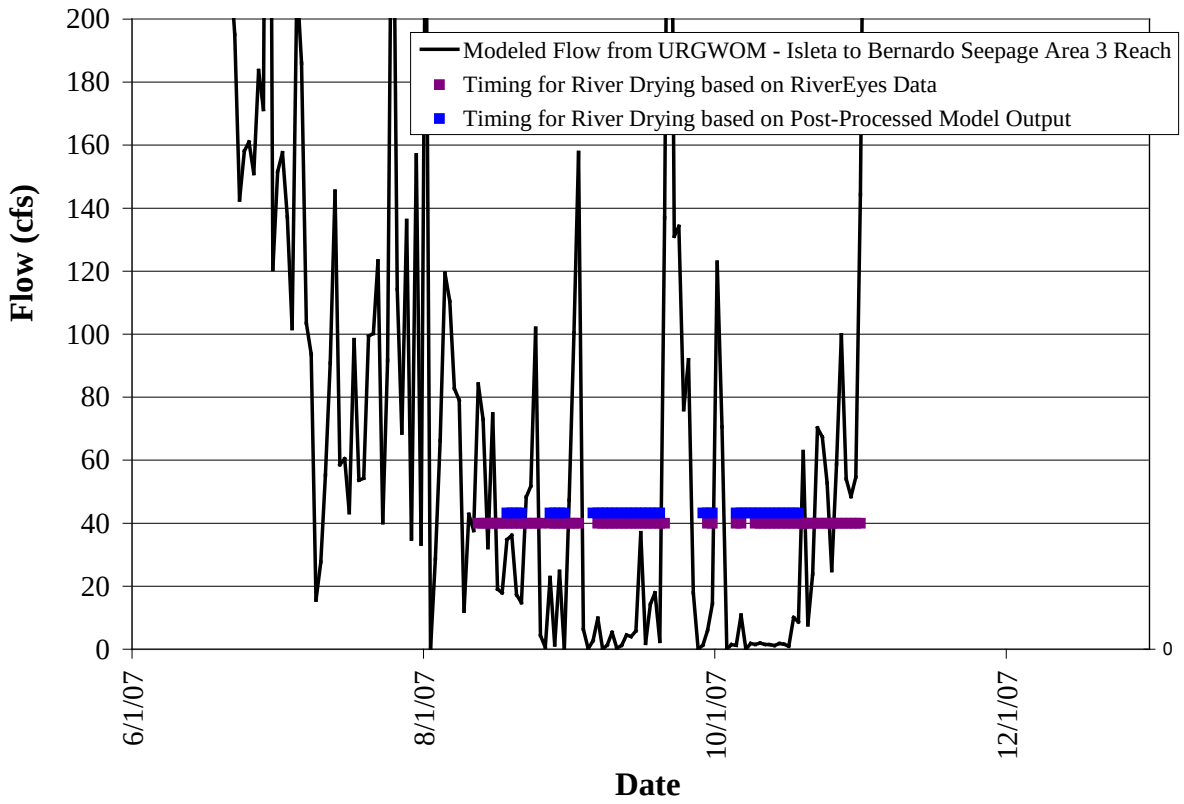

Figure 2.3. Sample Plot of Simulation Results for River Drying versus RiverEyes Data

2.3. Model Policy for Standard Operations

The URGWOM rules for representing standard operations have been refined over years of model development. In addition to the policy for flood control operations, the URGWOM rules include policy for moving San Juan-Chama Project allocated to contractors, deliveries to meet water uses in the Middle Rio Grande, and standard policy for potential storage, releases, or bypasses of native Rio Grande water at dams in the basin in New Mexico. A summary of policy for standard operations as represented in URGWOM is presented in section 2.3.1 below. Further review of the policy was completed by the PHVA work group as a result of the work group's review of several iterations of test model runs before final simulations were completed, and a few additional enhancements were incorporated to assure the needs for BA preparation are met as discussed in section 2.3.2.

2.3.1. Summary of Standard Operations

San Juan water is diverted from the San Juan basin to Heron Reservoir to allow for New Mexico to use its portion of San Juan water under the Upper Colorado River Compact. Diversions occur up to the capacity of the San Juan-Chama Project infrastructure and to assure minimum bypass flows are maintained on the San Juan river tributaries and such that the total diversion volume does not exceed 270,000 acre-ft/year or 1,350,000 acre-ft over any 10-year period. Diversions are also curtailed as needed based on lack of space at Heron Reservoir below the maximum pool elevation.

San Juan-Chama Project water at Heron Reservoir is allocated to contractors each year up to the total firm yield of 96,200 acre-ft. A Cochiti recreation pool is maintained with San Juan-Chama Project water where this water is generally delivered from Heron Reservoir to Cochiti Lake in the late fall and winter to enhance fish and wildlife habitat at the upper end of Cochiti Lake. Allocated San Juan-Chama Project water may be kept in storage at Heron Reservoir until the end of the calendar year. Any remaining contractor water is reverted back to the Project pool on December 31st; although, Reclamation may issue waivers to allow contractors to continue storing allocated water until September 30th of the year following the year the water was allocated if there is a benefit to Reclamation. MRGCD has allocated storage space for San Juan-Chama Project water at El Vado Reservoir where the water will remain in storage until needed to meet the demand for their diversions in the Middle Rio Grande after native water supplies are exhausted. ABCWUA and other contractors have allocated storage space at Abiquiu Reservoir.

ABCWUA San Juan-Chama Project water is delivered to their surface water diversion in Albuquerque and will also be released as letter water deliveries to payback MRGCD or the Compact deliveries for depletions to the surface water supplies caused by groundwater pumping. These deliveries are set based on schedules provided by the Office of the State Engineer. Actual paybacks are determined by the Office of the State Engineer and the deliveries are requested as letters from the State to Reclamation, hence the name "letter water deliveries. Other contractors for San Juan-Chama Project water may also cause depletions in the basin and then use allocated San Juan-Chama Project water to payback the river.

Native Rio Grande water is bypassed at Heron Dam, and Rio Grande water is stored at El Vado Reservoir if Article VII of the Rio Grande Compact is not in effect as defined by usable storage at Elephant Butte and Caballo reservoirs that exceeds 400,000 acre-ft (States of New Mexico, Colorado, and Texas, 1938). Computed usable storage does not include any Compact credit water, based on the status as of the end of the previous year, or San Juan-Chama Project water in storage at Elephant Butte Reservoir. If Article VII is not in effect, El Vado Reservoir is filled with native Rio Grande inflows not needed to meet the daily irrigation demand in the Middle Rio Grande and in a manner to assure downstream channel capacities are not exceeded. If Article VII is in effect, native Rio Grande water is bypassed at El Vado Reservoir as not needed for storage to meet the Prior and Paramount (P&P) needs of the six Middle Rio Grande pueblos. Native Rio Grande water is bypassed at Abiquiu Reservoir and Cochiti Lake unless storage is needed to maintain flows below downstream channel capacities. Any potential storage at Abiquiu or Cochiti Lake is evacuated as possible but may be retained as carryover storage until after the irrigation season if inflows decrease and conditions are satisfied to lock in storage until the non-irrigation season.

Water is delivered from El Vado Reservoir to meet the MRGCD demand at Cochiti Dam using available native Rio Grande water in storage, if needed, and with MRGCD's San Juan-Chama Project water used when native supplies are exhausted. Deliveries to meet the full demand at Cochiti include P&P water released for the six Middle Rio Grande pueblos if needed to meet their demand. Diversions occur at Cochiti and the Angostura, Isleta, and San Acacia diversions.

Water is released from Elephant Butte and Caballo Dams to meet a standard demand schedule for the lower valley below Caballo Dam with curtailments to the full demand schedule implemented if needed based on the available usable storage at Elephant Butte and Caballo Reservoirs.

2.3.2. Edits to Rules for Standard Operations

Several changes were implemented into the model and ruleset as needed to better represent the latest policy for different aspect of operations and make key needed adjustments for the analyses completed by the PHVA work group and for BA preparation. These changes include several smaller changes such as setting up the model to only allow storage at El Vado Reservoir for MRGCD, to assure the Cochiti Rec Pool is maintained a priority even when there are shortages to contractor allocations, and to not include San Juan-Chama Project water at Elephant Butte Reservoir and also reference the Compact credit water in storage as of the end-of the previous year for the computation of usable storage. Other more significant changes were reviewed which pertained to model policy for diversions of Santa Fe City and County water at the Buckman Direct Diversion, ABCWUA diversions, shorting MRGCD diversions to assure supplemental water for meeting flow targets is not diverted, increased Angostura diversions when MRGCD is in a shortage situation, reregulation at El Vado Reservoir for P&P needs, and releases from El Vado Dam per Article VIII of the Compact.

2.3.2.1. Buckman Direct Diversion

URGWOM was updated to represent diversions at the Buckman Direct Diversion for Santa Fe City and County San Juan-Chama Project water and native Rio Grande water per acquired water rights. The physical layout of the model was edited to include the diversions from the river below the USGS gage Rio Grande at Otowi Bridge, NM (ID# 08313000) (herein after referred to as Otowi). Accounts were established in URGWOM for the delivery of Santa Fe City and County water as included in the Combined account in the planning module of URGWOM. Policy was coded in the URGWOM ruleset for setting daily diversion amounts based on assumed average diversion daily rates for native Rio Grande water (1.50 cfs), along with native water used for mixing operations at the diversion that is immediately discharged back to the river (1.00 cfs), and for Santa Fe City and County use of their annual allocations of San Juan-Chama Project water (7.75 cfs). Policy is also included to represent the curtailment and cutoff of diversions of native Rio Grande water based on threshold flows at Otowi of 325 and 200 cfs, respectively. Deliveries of Santa Fe City and County San Juan-Chama Project water are made to meet diversion needs which may be cutoff if Abiquiu Dam is in flood control operations to maintain downstream flows below channel capacities. With this change to the model, Santa Fe City and County's use of their annual allocation of San Juan-Chama Project water is represented and thus reflected in all the final model run results.

2.3.2.2. ABCWUA Diversions

Policy for representing deliveries of ABCWUA water to their surface water diversion was refined for the modeling for the PHVA work group and for BA preparation. URGWOM is set up to model full diversions with a check against an input year for the startup of the diversions and against established preemptive cutoff criteria where a preemptive cutoff is implemented before actual permit restrictions would result in curtailed diversions or when diversions would be cut off due to high river flows. The preemptive cutoff represents the assumption that Albuquerque would switch to groundwater supplies 1) during low flows before curtailments would occur per the permit, 2) during high flows when it may be unsafe or impractical to operate the diversion dam, or 3) when flood control operations at Abiquiu or Cochiti might prevent Albuquerque from receiving a delivery of their allocated San Juan-Chama Project water. The high flow thresholds

for a preemptive diversion cutoff are 1800 cfs out of Abiquiu Dam or 4500 cfs out of Cochiti Dam. The threshold low flow for a preemptive cutoff is 200 cfs and diversions will not restart until at least two weeks after any preemptive cutoff criterion is not satisfied and the flow at Central is greater than 250 cfs.

Full Albuquerque diversions are set to 130 cfs where 65 cfs is provided by delivered San Juan Chama Project water and the other 65 cfs is native Rio Grande water that will be returned. Releases of Albuquerque's San Juan-Chama Project water are set to provide the 65 cfs with loss rates applied. The loss rate is based on the San Juan-Chama loss rate of 1.23 percent from Abiquiu Dam to Cochiti Lake and monthly loss rates from Cochiti Dam to the diversion. While the current preemptive cutoff criteria would prevent diversions from being curtailed or cutoff per permit restrictions, the permit restrictions are still checked with the rules.

Wastewater returns from Albuquerque are set as an input based on historical data and are not affected by a cutoff to the surface water diversions as actual wastewater returns are not dependent on whether surface water or groundwater is being used to provide drinking water. Assumed returns range from approximately 77.5 cfs to 83.4 cfs (slightly more than half the diversion).

2.3.2.3. Shorted Diversions

If MRGCD is in a shortage situation and the supply is inadequate to meet the demand for all Middle Rio Grande Project diversions, it is possible that full requested diversions would not be met. Under these circumstances (i.e. there is no water in storage for meeting irrigation demands and the river flow is less than the full demand at Cochiti Dam), "requested diversions" at the Middle Rio Grande Project diversions are set to the lower amounts that would be received. Shorting the diversions is a modeling approach needed to prevent supplemental water from being diverted that is specifically designated for meeting target flows for ESA. Key changes for the modeling for the PHVA work group included adjustments to the model policy where diversions are only shorted if there are no downstream targets. That is, during shortage situations, supplemental water could then be diverted if needed to meet the full requested diversion and there are no downstream targets. Edits also included adjustments needed with the Middle Valley Rework implemented to appropriately consider contributions from the Unit 7 Drain to the Socorro Main Canal when setting the potential shorted diversion at the San Acacia diversion.

2.3.2.4. Increased Angostura Diversions

Policy for setting diversions at the Angostura diversion were adjusted such that diversions are increased when MRGCD is in a shortage situation as indicated by no water in storage and river flow at Cochiti that is less than the full demand for the Middle Rio Grande Project diversions. Diversions are set higher at the Angostura Diversion to assure the six Middle Rio Grande Pueblos receive their water and allow for MRGCD to utilize the limited supply as efficiently as possible. At these times, diversions at Angostura are increased from the regular input diversion requested values to the total capacity of the canals of 400 cfs. The rule for setting shorted diversions was adjusted to appropriately consider times when diversions at Angostura might be increased. Also, model policy for setting the flow returned to the river at the Central wasteway versus the flow delivered down the Albuquerque drain was adjusted for when Angostura diversions are increased to assure all the flow is delivered down the Albuquerque drain at these

times (i.e. no flow is returned to the river via the Central wasteway during such shortage operations).

2.3.2.5. Reregulation for P&P at El Vado Reservoir

Policy for reregulation at El Vado Reservoir for P&P was reviewed. Edits were incorporated such that model policy matched actual implemented policy. Details of the needed model changes were documented by a consultant for the Bureau of Indian Affairs, Brian Westfall (2009), and all those documented changes were incorporated for the modeling for the PHVA work group and for BA preparation, except monthly demand values from 2003 were maintained in URGWOM per a PHVA work group decision at the work group meeting held on October 26, 2010 (PHVA work group, 2010).

Note that changes included additional adjustments made after Reclamation's DRAFT BA was distributed in 2011. Changes for the final model runs included adjustments to the approach for computing calls for releases from P&P storage to reference loss coefficients in URGWOM and usable flow factors equal to 1.0 (Different usable flow factors are used to compute the P&P storage requirement). In addition, storage at El Vado Reservoir to meet P&P storage requirements, regardless of the status of the stipulations of Article VII of the Compact, begins on January 5th up to a computed minimum P&P storage requirement. Storage for the P&P storage requirement continues as needed after the storage requirements are then computed beginning on March 1st with reference to a forecasted runoff volume. These last changes for the final model runs were implemented based on communication with the BIA and representatives from the six Middle Rio Grande Pueblos after the DRAFT BA was distributed. The monthly demand values from 2003 were still maintained for the final model runs for computing the storage requirement.

2.3.2.6. Article VIII of the Compact

For the modeling for the PHVA work group, URGWOM was set up to model El Vado Dam releases that would be made based on a call by Texas per Article VIII of the Compact which essentially states that Texas may call for a release, starting in January, of water in storage from post-Compact reservoirs to the amount of an accrued Compact debt to bring the usable storage up to 600,000 acre-ft (States of New Mexico, Colorado, and Texas, 1938). A threshold debt for when a call would actually be made is included in the model which was set to -20,000 acre-ft based on the assumption that Texas would not actually make a call until the debt accrued to exceed 20,000 acre-ft. El Vado Dam releases are set to a computed average rate to release the volume equal to the Compact debt over an input period defined as the Article VIII release season in the model (January 2nd through February 20th), but no release will be made if there is no Rio Grande water in storage.

2.4. Flow Tools

In preparation for modeling for the PHVA work group, flow tools to be analyzed as potential solutions to meeting flow needs for ESA purposes were defined and set up in URGWOM. Flow tools include actions that have been implemented as temporary actions in the past such as Cochiti deviations, relinquished Compact credits/storage of Emergency Drought water, Reclamation leases of San Juan-Chama Project water, and pumping from the LFCC to the river. Details of potential future operations were defined for modeling these actions. Other modeled flow tools include alternate delivery schedules for letter water deliveries to payback the Compact based on a timing that would benefit ESA needs and defined policy for conserving leased San Juan-Chama Project water during years with a wet runoff. Details of the flow tools as set up in the model and ruleset for the modeling for the PHVA work group are presented below.

2.4.1. Cochiti Deviations

Cochiti deviations are currently authorized through 2013 where the Corps may temporarily store native Rio Grande water to be released at the time of the runoff peak flow to further augment flows sufficiently to provide recruitment flows (or overbank flows) in the Middle Rio Grande (Corps, 2009). Specific criteria are coded in the URGWOM rules for identifying whether the runoff is sufficient to enact Cochiti deviations to provide recruitment flows (or overbank flows) but insufficient to provide the needed hydrograph by just bypassing inflows at Cochiti Reservoir. Operations entail providing overbank flows if conditions support providing the higher flows.

Within URGWOM, deviations are implemented to provide *recruitment* flows if the March through July flow forecast at Otowi is between 50% and 80% of average and the projected peak inflow to Cochiti Reservoir during the recruitment or overbank season is between 1,800 and 5,000 cfs or the March through July forecast is greater than 80% of average but the projected peak inflow is less than 3,500 cfs. The projected peak inflow to Cochiti is estimated during an URGWOM simulation based on input inflows. Deviations are implemented to provide *overbank* flows if the Otowi forecast is between 80% and 120% of average and the projected peak inflow to Cochiti is between 3,500 and 10,000 cfs or the Otowi forecast is between 50% and 80% of average but the projected peak inflow is greater than 5,000 cfs.

If deviations are implemented, model target flows at Central are reset to provide recruitment (or overbank) flows based on input 30-day target hydrographs that include 3,000 cfs for 7 days for recruitment (or 5,800 cfs for 5 days for overbank flows). An appropriate amount of allowable re-regulation at Cochiti Reservoir is then established in the model. Inflows for re-regulation are set daily to the inflow of native Rio Grande water not needed to meet downstream demands and re-regulation begins a set period before the time of the projected peak inflow such that water can stored and subsequently released to augment the peak inflow. Refer to Figure 2.4 for a flowchart that depicts the model policy for implementing Cochiti deviations. Water from re-regulation is released as needed for targets where the needed release at Cochiti Dam reflects the adjusted targets at Central to provide the recruitment (or overbank) flows. No supplemental water is released from Abiquiu Reservoir when Cochiti deviations are implemented.

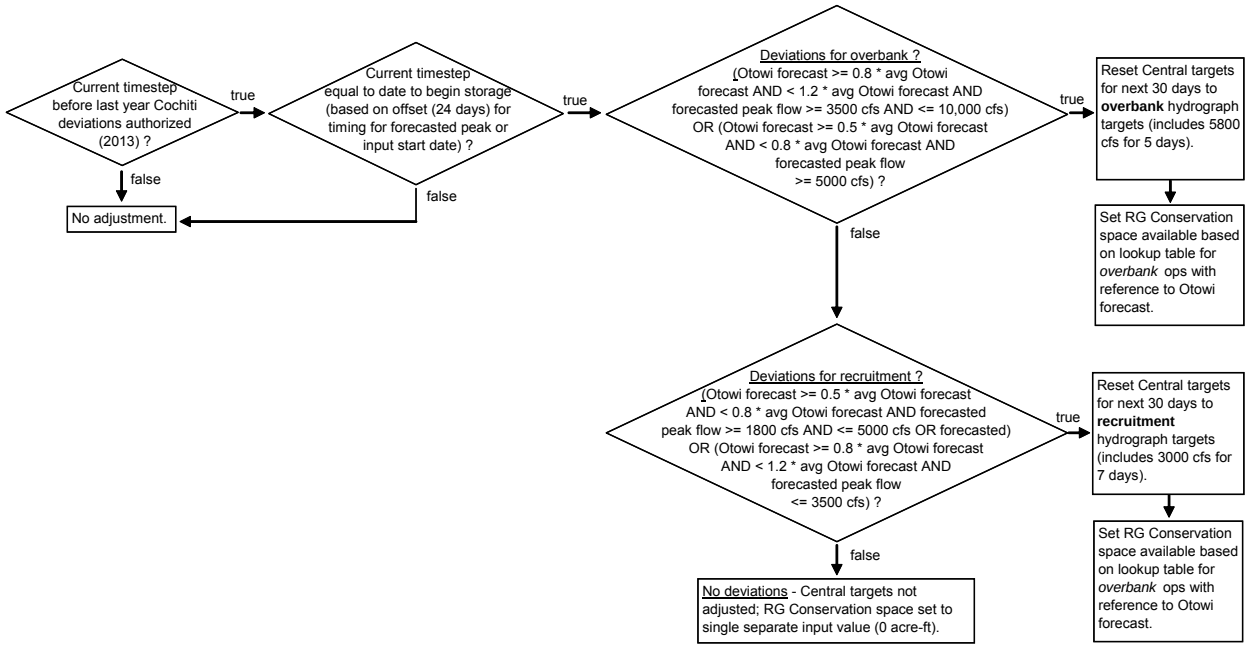

Figure 2.4. Flowchart for Implementing Cochiti Deviations

2.4.2. Relinquished Compact Credits/Storage of Emergency Drought Water

Agreements have been made in the past where Compact credits are relinquished and allocations are made for storage of native Rio Grande water at El Vado Reservoir as Emergency Drought water when stipulations of Article VII of the Compact are in effect. Policy is coded in the URGWOM ruleset to simulate potential future relinquished Compact credits and the subsequent storage of Emergency Drought water. The current model assumption is that Compact credits will be relinquished annually each year if the Compact credit at the beginning of the year exceeds 100,000 acre-ft to reduce the credit to 70,000 acre-ft. Allocations for subsequent storage of Emergency Drought water at El Vado Reservoir are set to 1/3 of the relinquished credit for each of three purposes: MRGCD, ESA, and municipalities. Initial allocations for storage of Emergency Drought water, from past relinquished credits, can also be input. Allocations are tracked for the three separate purposes where any water in storage for the corresponding account contributes to the allocation. When water is released from a storage account established for one of the three purposes, the allocation has been used and is reduced.

Inflows of native Rio Grande water to El Vado Reservoir when Article VII is in effect are stored to separate accounts for Emergency Drought water after any storage requirement for P&P needs is met first. Storage accumulates in the Emergency Drought accounts with the actual inflow of native Rio Grande water. Available inflows of native Rio Grande water for Emergency Drought storage are split between the MRGCDDrought and SupplementalESA accounts based on the ratio of available allocation for the accounts. An allocation for storage of Emergency Drought water for municipalities is tracked but is not used since exact policy for how such water would be used by municipalities has not been defined.

Water for MRGCD is tracked in an MRGCDDrought account at El Vado reservoir and is used to meet the MRGCD demand when native Rio Grande water is no longer available to meet the

MRGCD demand at Cochiti but before any of MRGCD's San Juan-Chama Project water would be used. Emergency Drought water for meeting targets is tracked in the SupplementalESA account at El Vado Reservoir and is used to meet targets before leased San Juan-Chama Project water in the Reclamation account at Abiquiu is used. A specific season for using SupplementalESA water can be defined; however, the entire calendar year was designated for all model runs completed for the PHVA work group.

Within URGWOM, releases from the SupplementalESA account are effectively bypassed through Reclamation's account at Abiquiu (Water is first released from the Reclamation account to meet targets and water in the SupplementalESA account is released to replenish the storage in the Reclamation account if SupplementalESA water is available); thus, Emergency Drought water is effectively used first before available leased San Juan-Chama Project water. Note that Compact calculations are appropriately configured in URGWOM to not count Emergency Drought water that passes through Abiquiu Reservoir as San Juan-Chama Project water.

2.4.3. Reclamation Leases

Supplemental water is defined as water designated to be released to meet target flows in the Middle Rio Grande and may come from two sources: water leased by Reclamation from contractors for San Juan-Chama Project water or native Rio Grande water stored as Emergency Drought water at El Vado specifically to be used for targets (Refer to section 2.4.2 for more details on Emergency Drought water). Leases of San Juan-Chama Project water by Reclamation from contractors are represented in URGWOM as transfers at Heron Reservoir from the account storage for the source contractor to Reclamation's account.

For the final model runs completed for the PHVA work group, leases are represented as 12,000 acre-ft/year for the first five years and 8,000 acre-ft/year for the following five years of simulation from the Combined account which represents all contractors for San Juan-Chama Project water other than MRGCD, ABCWUA, and the Cochiti Rec Pool. These lease volumes reflect estimated future leases where it is anticipated that less water will be available after five years as contractors continue to develop water uses. Leased water transferred at Heron Reservoir is moved to 30,000 acre-ft of allocated space at Abiquiu Reservoir for supplemental water as space becomes available.

2.4.3.1. Conservation of Lease Water at Threshold Year-to-Date Otowi Flow Volume

A related side flow tool defined by the PHVA work group entails conserving leased San Juan-Chama Project water after the year-to-date Otowi flow volume reaches 1,000,000 acre-ft. This approach represents a policy of conserving lease water after a wet runoff to increase the chances of having supplemental water during more potential dire situations in future years. The policy also represents one approach for prioritizing the use of available supplemental water where the represented priority is effectively to use supplemental water earlier in the year and also bank supplemental water during wetter years to have for the early part of subsequent years by not using supplemental water during the summer following wetter runoffs. Note that the policy does not affect the use of Emergency Drought water allocated for ESA purposes. Any available Emergency Drought water for ESA is always used as needed to meet targets.

2.4.4. Low Flow Conveyance Channel Pumping

URGWOM was set up to model pumping of flows from the LFCC to the river to manage recession and ameliorate and/or prevent river drying. Refer to Figure 2.5 for a picture of pumps used to pump from the LFCC. Diversions at the Neil Cupp site, North Boundary of the Bosque del Apache National Wildlife Refuge, and South Boundary are simulated (Pumping at the Fort Craig site was determined by the PHVA work group to be inconsequential to URGWOM simulation results and is not included). Water that seeps into the LFCC is pumped to the river where pumping begins based on different trigger low flows at San Acacia for each site (130, 100, and 80 cfs, respectively), and the rate of pumping varies based on the year classification under the 2003 Biological Opinion (2003 BO). After pumping has initiated at a site, pumping will continue for a minimum of one week and until the flow at San Acacia has exceeded 150 cfs. Pumping will cease for the year at each site after input dates for each site. For the final model runs completed for the PHVA work group, pumping at each site was set to end for the year on July 15th to effectively represent using the pumps to manage the recession after the continuous flow requirement and/or after the runoff but no later. Minimum bypasses in the LFCC are established at each pump site to reflect the actual constraint of only being able to pump the available water above a minimum LFCC flow: 10 cfs at the Neil Cupp and North Boundary sites and 5 cfs at the South Boundary site.

Figure 2.5. Low Flow Conveyance Channel Pumps

2.4.5. Alternate Letter Water Delivery Schedules

A flow tool defined by the PHVA work group entails using alternate schedules for letter water deliveries, if specific conditions are satisfied, for the portion of deliveries to payback the Compact. The alternate delivery schedules represent using the paybacks to augment flows needed for targets, augment flows for recruitment, to prevent river drying, or to help manage the recession after the continuous flow requirement or after the runoff.

The approach coded into URGWOM for the PHVA work group entails using letter water deliveries from ABCWUA to payback the Compact by providing a 7-day spiked release at the timing of the peak (Figure 2.6) if Cochiti deviations are not implemented and the Compact credit is greater than 70,000 acre-ft. As a second but lower priority alternate schedule, ABCWUA letter water deliveries to payback the Compact would occur during September and October as

opposed to November and December if the Compact credit is greater than 70,000 acre-ft and the flow at San Acacia is greater than 150 cfs for the last seven days of August (Figure 2.7). Flows for the first alternate delivery to provide a spiked release is computed in the model. Each year, conditions are evaluated to determine if an alternate delivery schedule should be simulated. The typical delivery schedule for ABCWUA is presented in Figure 2.8

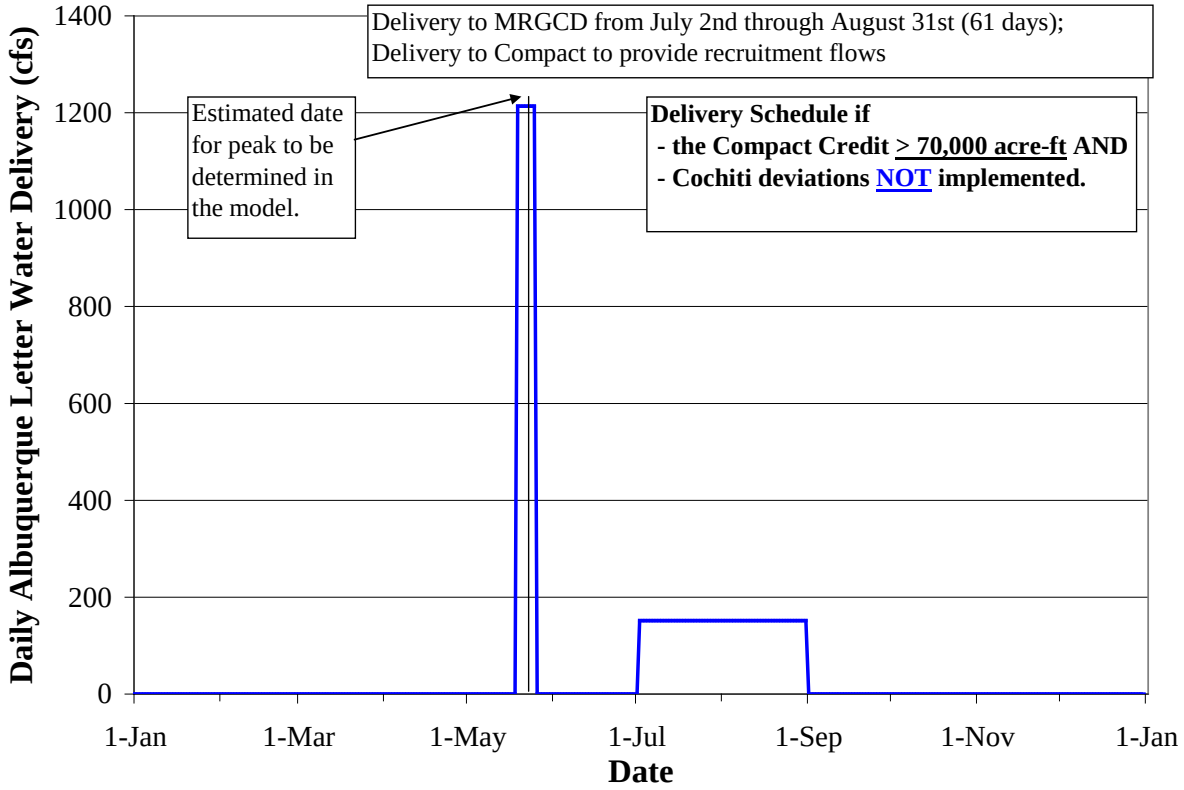

Figure 2.6. Sample *Alternate* Schedule for ABCWUA Letter Water Deliveries to Provide Spiked Release

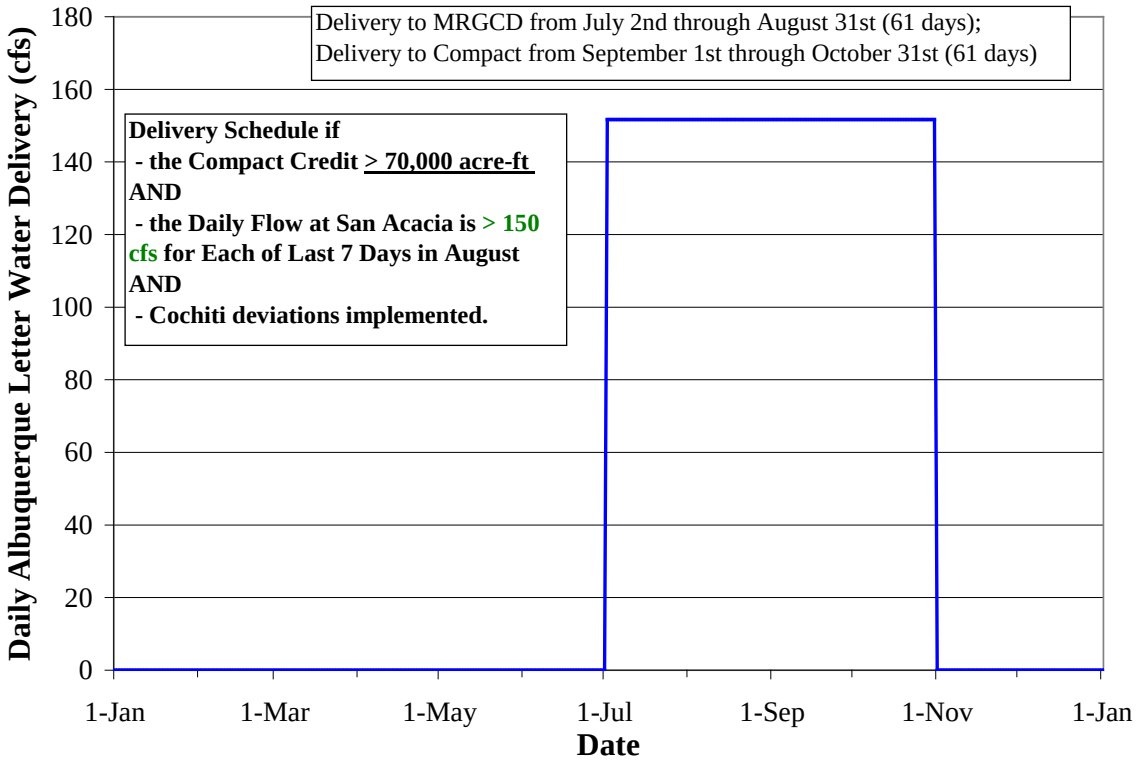

Figure 2.7. Sample *Alternate* Schedule for ABCWUA Letter Water Deliveries

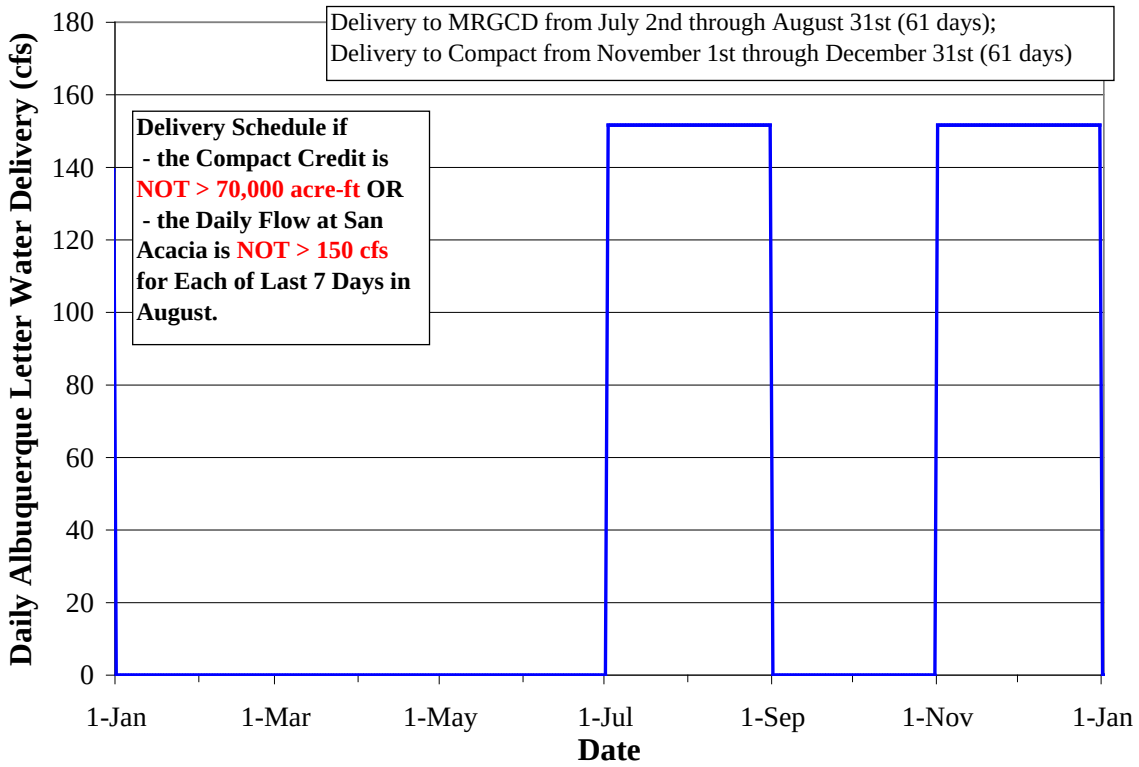

Figure 2.8. Sample Typical Schedule for ABCWUA Letter Water Deliveries

Alternate letter water delivery schedules for the Combined account entail the following. Deliveries for Santa Fe and half of the amount for other contractors not including PVID will be delivered at an alternate time if the Compact credit is greater than 70,000 acre-ft. That portion will be delivered in a 7-day spike around the peak (Figure 2.9) if Cochiti deviations are not implemented or as a constant release from June 15th through June 30th to help manage recession if the Compact credit is greater than 70,000 acre-ft but Cochiti deviations are implemented. The second alternative is presented in Figure 2.10. The typical delivery schedule for the Combined account is presented in Figure 2.11.

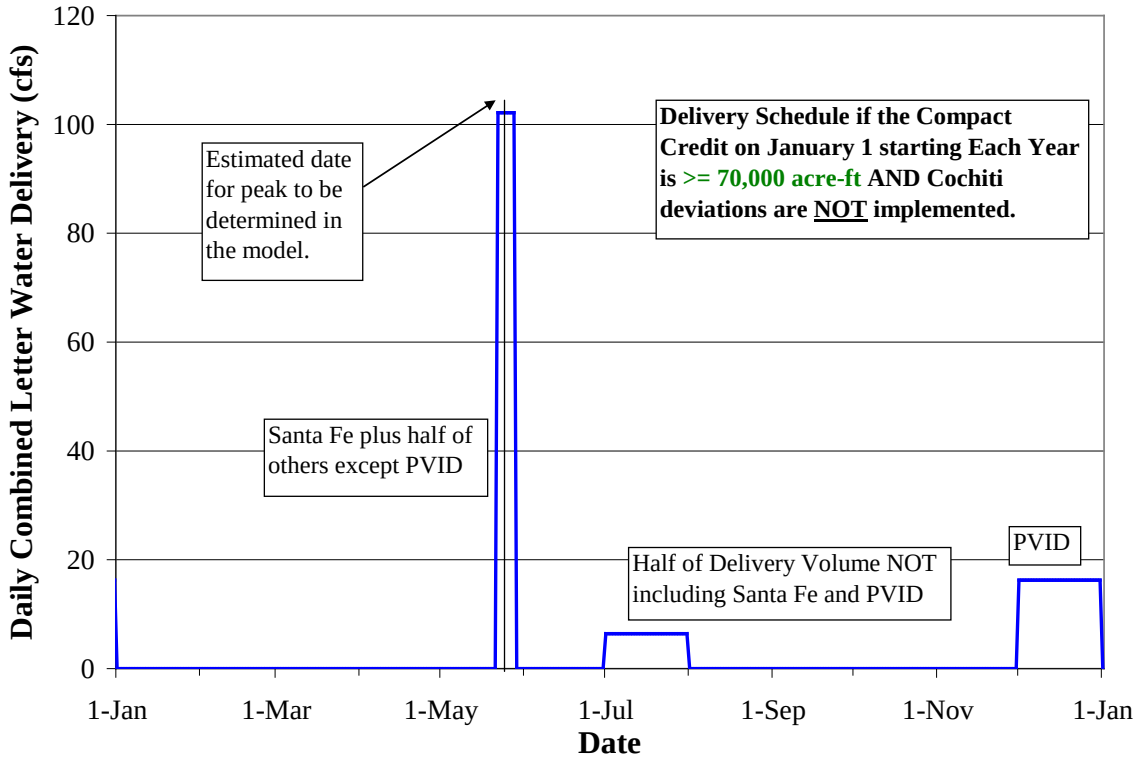

Figure 2.9. Sample *Alternate* Schedule for Combined Account Letter Water Deliveries to Provide Spiked Release

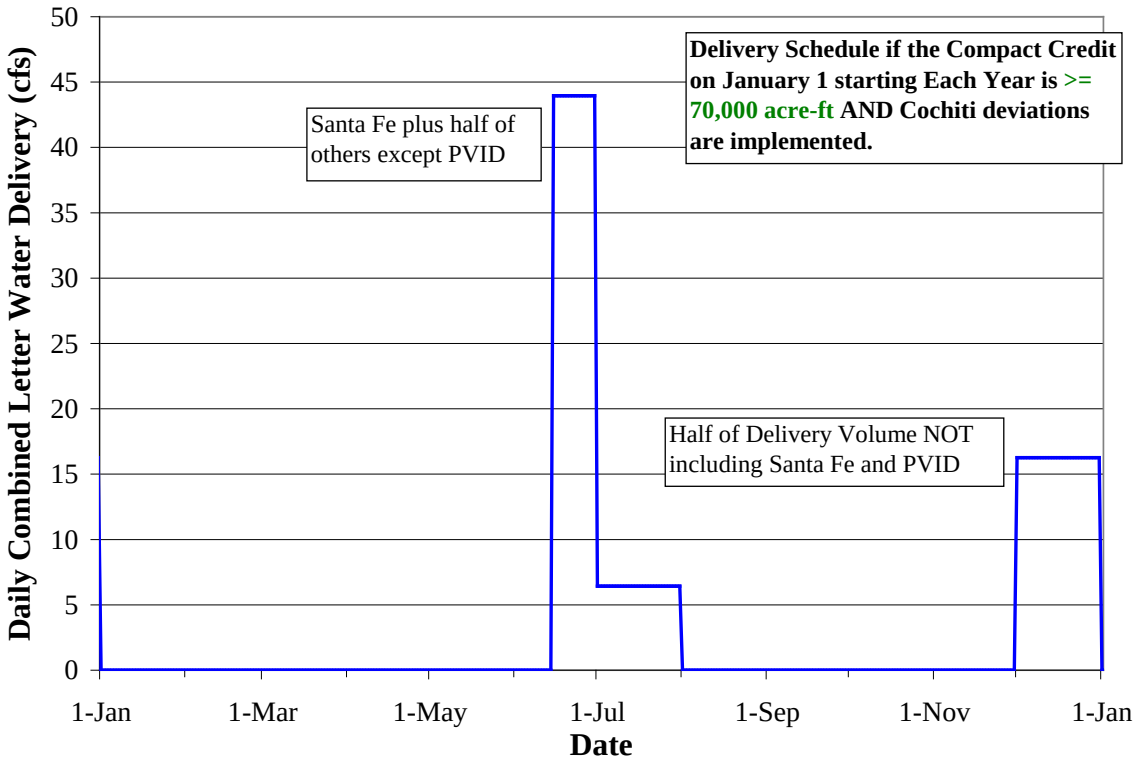

Figure 2.10. Sample *Alternate* Schedule for Combined Account Letter Water Deliveries

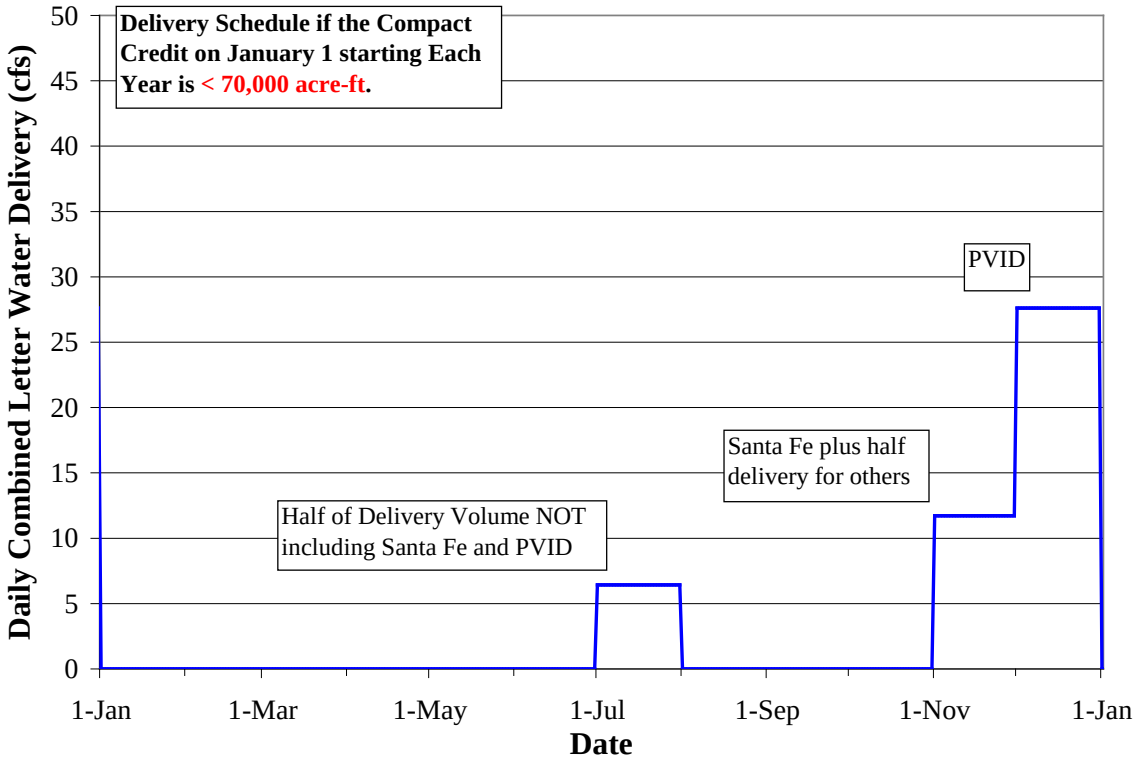

Figure 2.11. Sample Typical Schedule for Combined Account Letter Water Deliveries

2.5. Policy for Use of Supplemental Water

The model approach for representing the release of supplemental water from Abiquiu Dam was reviewed in detail prior to completing the final simulations. Supplemental water consists of Reclamation leases of San Juan-Chama Project water and any Emergency Drought water allocated for ESA purposes. The model is set up to simulate the use of supplemental water to meet flow requirement per the 2003 BO (Service, 2003) which consists of different flow requirements based on the year classification (i.e. wet, average, or dry). Within URGWOM, years are classified as Wet, Average, or Dry based on the forecasted March through July flow volume at Otowi relative to an average flow volume for the same period. A year will automatically be classified as Dry if storage restrictions per Article VII of the Rio Grande Compact are in effect (States of New Mexico, Colorado, and Texas, 1938). The year classification as of May 1st is maintained for the remainder of the year in URGWOM. Needs for supplemental water are represented in the model using target flows at four locations: Central, below the Isleta Diversion Dam (herein after referred to as Isleta), at the location of the USGS gage Rio Grande Floodway at San Acacia, NM (ID# 08354900) (hereinafter referred to as San Acacia), and San Marcial. Refer to Table 2.1 for the 2003 BO targets as represented in URGWOM. A target in the table is maintained until the next date in the table and note that targets are used to represent the continuous flow requirement (the darker shaded cells) and step downs in targets (the lighter shaded cells) are used to represent the use of supplemental water to manage the recession after the continuous flow requirement.

Table 2.1. 2003 BO Targets at Middle Rio Grande Locations for Different Year Classifications

	Central			Isleta			San Acacia			San Marcial		
Date	**Dry**	**Avg**	**Wet**	**Dry**	**Avg**	**Wet**	**Dry**	**Avg**	**Wet**	**Dry**	**Avg**	**Wet**
Jan 1	100	100	100	100	100	150	175	175	175	10	10	100
June 10	100	100	100	50	100	150	100	100	100	10	10	50
June 14	100	100	100	40	100	150	80	90	100	8	8	40
June 18	100	100	100	30	100	150	60	80	100	6	6	30
June 22	100	100	100	20	100	150	40	70	100	4	4	20
June 26	100	100	100	10	100	150	20	60	100	2	2	10
June 30	100	100	100	0	100	150	0	50	100	0	0	0
Nov 15	100	100	100	100	100	150	175	175	175	10	10	100

Values with darker shading represent targets for the continuous flow requirement.
Values with lighter shading represent targets to manage the recession after the continuous flow requirement.

Target flows are used in the model to represent discretionary operations where supplemental water is used to manage the recession after the runoff and to also control the rate of drying after any river rewetting (river drying is restricted to no more than eight additional miles per day per the 2003 BO). A 30-day step down in targets at Isleta, San Acacia, and San Marcial may be implemented at the end of the runoff to manage the recession, and seven-day step downs in target flows may be instituted for the same three locations with the onset of river drying following any river rewetting to represent the use of supplemental water to control the rate of drying. Trigger river flows are used to indicate when step downs need to be established and model inputs are also set up for establishing the step down in target flows and the number of steps.

Refer to Figure 2.12 for a sample plot of flows at San Acacia (zoomed in to a low flow range) and step downs in the San Acacia targets – after the continuous flow requirement – followed by a 30-day step down to manage the recession after the runoff followed by 7-day step downs in targets to drive the use of supplemental water to control the rate of drying after any river rewetting. Target flows may not be met if there is not supplemental water available during the simulation to meet the targets. Within URGWOM, triggers are set up to allow for both the 30-day step downs to manage the recession or the 7-day step downs in targets for controlling the rate of river drying to be turned on or off independently. Note that both policies were modeled for Reclamation's DRAFT BA distributed in 2011, but only the 30-day step down to manage the recession was included as part of the Proposed Action model runs for the final simulations.

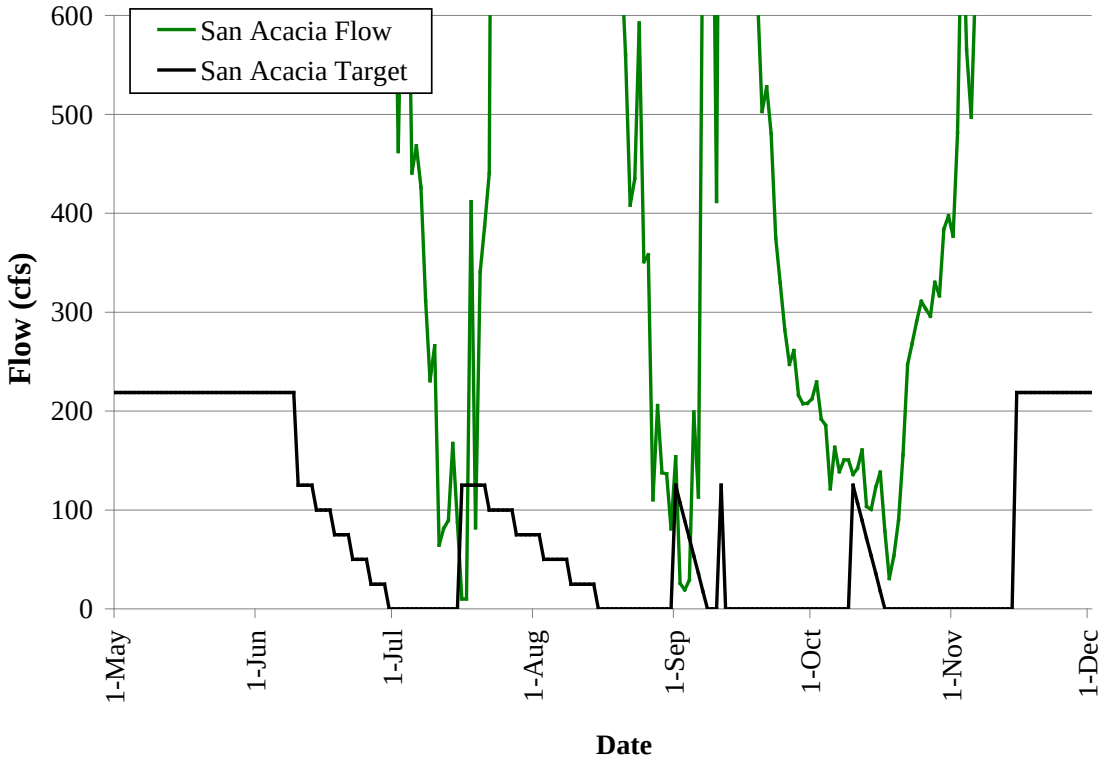

Figure 2.12. Sample Plot of Step Downs in Target Flows at San Acacia

The review of the modeled use of supplemental water included a review of supplemental water used in a rulebased simulation with the 2003 BO targets and the 2003 through 2006 hydrology versus actual supplemental water used during the same historical years. This analysis indicated that the model represents the use of supplemental water at a much higher precision than can be attained in actual operations due to the travel time from Abiquiu Dam to target locations (which may exceed four days to San Marcial), physical operational constraints at the dams, and several uncertainties about conditions in actual operations that can significantly affect river flows such as varying MRGCD wasteway returns, monsoon season tributary inflows, and varying loss rates to evaporation and riparian ET. The review of modeled supplemental water use versus historical supplemental water use for 2003 through 2006 indicated that applying an adjustment factor of 25% yields a more accurate representation of the annual volumes of supplemental water that would be needed under actual operations (i.e. for a defined target of 100 cfs, a target of 125 cfs is

used in the model to reflect the additional supplemental water really needed due to the various actual constraints and uncertainties in actual operations).

The model is used to determine the amount of supplemental water needed to meet targets based on all the conveyance losses and physical processes in the system. Actual historical operations have entailed agreements between Reclamation and MRGCD for providing certain flows below a major diversion in return for releases of supplemental water from Abiquiu Reservoir. While such agreements may be developed with accurate consideration of the physical conveyance losses from Abiquiu Dam to the diversion location, such agreements are not directly modeled in URGWOM.

3.0. Description of Water Management Scenarios

Modeling for the PHVA work group was completed in separate phases as exact needs for modeling evolved. Work to identify an appropriate Proposed Action for BA preparation started with a full list of potential operational scenarios to provide different flow conditions in habitat for listed species. A qualitative review of the scenarios was completed and the list was pared down to 11 scenarios for screening to develop a reasonable list for analysis given the resources required to complete model runs and analyze results. Some initial options were identified as impractical such as operating for target flows at San Acacia without targets at Isleta, and other scenarios were deemed too similar to other scenarios to warrant separate analysis.

After modeling the 11 scenarios, a best scenario was identified but dismissed by the Service during a meeting of the Executive Committee of the Collaborative Program. Focus then shifted to evaluating conditions with no actions taken for listed species to represent a Pre-ESA Management scenario that would be used for a non-front loaded BA but further review led to a final Proposed Action in Reclamation's BA that includes Reclamation's Supplemental Water Program that includes leases of San Juan-Chama Project water and pumping from the LFCC. Details of the different water management scenarios modeled through the PHVA work group activities leading to the final simulations are discussed in more detail below.

3.1. Initial Water Management Scenarios

Initial work by the PHVA work group entailed developing numerous scenarios for analysis that were defined primarily by different target flows at different locations in the Middle Rio Grande where the timing along with the location of targets reflect an area of focus for the scenario in regards to managing for the Albuquerque (Angostura to Isleta), Isleta (Isleta to San Acacia), and/or San Acacia (San Acacia to San Marcial) reaches. The original list of scenarios was pared down to 11 options for screening based on an initial qualitative evaluation completed by Collaborative Program representatives at a PHVA work group meeting. Names for the 11 scenarios and defined targets are noted below:

1. BO Targets,
2. Dry Year Targets,
3. BO Targets with no continuous flow requirement,
4. New Targets A – 2003 BO targets with an adjustment to 100 cfs year round target at Isleta and San Acacia in average and wet years,

5. New Targets B – 2003 BO targets with an adjustment to 100 cfs year round target at Isleta and 50 cfs year round target at San Acacia in average and wet years,
6. New Targets C – 2003 BO targets with an adjustment to 50 cfs year round target at Isleta and San Acacia in average and wet years,
7. Flow Target Management A – 100 cfs year round target at Central, Isleta, and San Acacia – no San Marcial target,
8. Flow Target Management B – 100 cfs year round target at Central and Isleta and 50 cfs year round target at San Acacia – no San Marcial target,
9. Flow Target Management C – 100 cfs year round target at Central and 50 cfs year round target at Isleta and San Acacia – no San Marcial target,
10. Albuquerque-Isleta Management A – 100 cfs year round target at Central and Isleta – no San Acacia or San Marcial targets, and
11. Albuquerque-Isleta Management B – 100 cfs year round target at Central and 50 cfs year round target at Isleta – no San Acacia or San Marcial target.

Modeling was then completed for the 11 potential operational scenarios and results for various key indicators were evaluated. The list was then reduced to five scenarios for further screening based on results for the timing and extent of expected river drying under a scenario and the supplemental water needed to meet the targets given the projected available supply of supplemental water. The ability to bank supplemental water under a scenario to be available for dire situations was also considered. The next round of screening of the five remaining scenarios was completed using an approach where "elements", or issues of concern, were evaluated for each scenario based on the results from the URGWOM runs. Considerations included May-June flow volumes, miles and duration of river drying, supplemental water needed, and deficits at meeting targets with projected available supplemental water. Weightings were given to the importance of different elements, and overall ratings were developed and the scenarios were ranked. The process led to selection of the Albuquerque-Isleta Management B scenario as the best operational scenario which is defined based on using available supplemental water to specifically manage the Albuquerque and Isleta reaches, but this scenario was dismissed by the Service at a meeting of the Executive Committee of the Collaborative Program.

3.2. Pre-ESA Management Scenario

After results from the screening process were dismissed, focus of the PHVA work group's efforts shifted to analyzing a Pre-ESA Management scenario for preparing a non-front loaded BA. The Pre-ESA Management scenario reflects river conditions if operations matched current operations but with no considerations for ESA implemented in regards to flow requirements. URGWOM runs were completed using all the infrastructure and physical aspects of the system modeled as is and with no targets in the Middle Valley. No PHVA flow tools were included, except for Cochiti deviations simulated for the first three years of the simulation per the authorized of the operation through 2013. The PHVA work group worked on a model run for the Pre-ESA Management scenario, but the focus later shifted to the final Proposed Action for Reclamation's BA that includes the 2003 BO Targets met as possible with just Reclamation's flow tools (or Reclamation's Supplemental Water Program).

3.3. Final Water Management Scenario for Proposed Action

Final model runs were completed to represent the Proposed Action in Reclamation's BA that entails meeting the 2003 BO targets as possible with supplemental water available from

Reclamation's Supplemental Water Program that includes the projected leases of San Juan-Chama Project water and LFCC pumping. With recent developments to infrastructure, including the ABCWUA drinking-water diversion project and Santa Fe's Buckman diversion, the availability of San Juan-Chama Project water for lease to Reclamation's Supplemental Water Program is expected to decline. Total lease volumes are anticipated to drop to approximately 12,000 acre-ft/year for the next five years and 8,000 acre-ft/year for the following five years.

The Proposed Action entails using the available supply of supplemental water to meet the 2003 BO targets as possible. Resulting conditions in the river will be based on using the available supply *immediately* as needed to meet the 2003 BO with requirements. There is no established priority in regards to which flow requirements have priority under the conditions of a limited supply of supplemental water. When supplemental water is gone, target flows may not be met. Targets are included with the Proposed Action to represent the use of supplemental water under discretionary operations to manage the recession after the continuous flow requirement (or after the runoff) and also to control the rate of drying after any river rewetting as discussed in section 2.5. These actions support Rio Grande silvery minnow salvage operations.

The Proposed Action includes pumping from the LFCC to the river in the San Acacia reach. Pumps have been installed at sites along the LFCC to pump to the river the water that has accumulated in the LFCC from groundwater seepage. This operation includes pumping at the Neil Cupp, North Boundary, and South Boundary sites at which Reclamation performs pumping to help manage the recession and control the rate of the drying after the continuous flow requirement or after the runoff. Pumping is conducted at all sites to manage the recession after the continuous flow requirement or after the runoff, but no pumping is included later in the summer under the Proposed Action.

3.4. Model Scenarios for Evaluating Impacts of Reclamation Actions and Non-Fed Actions

As needed for BA preparation, URGWOM simulations were completed to evaluate impacts of Reclamation's water operations actions (Heron Dam operations for the San Juan-Chama Project along with the Supplemental Water Program and Middle Rio Grande Project operations) and non-Federal actions (including operations of the Middle Rio Grande Project diversion structures to provide flows to MRGCD and the six Middle Rio Grande Pueblos). Impacts were analyzed by utilizing model runs set up for the Proposed Action and sequentially turning off each action. Each action is described below.

3.4.1. Heron Dam Ops for the San Juan-Chama Project and the Supplemental Water Program

The San Juan-Chama Project involves the trans-mountain diversion to the Rio Grande basin of a portion of New Mexico's allocation under the Upper Colorado River Basin Compact. Water is diverted from tributaries of the San Juan River, and delivered beneath the continental divide by way of the Azotea Tunnel to Willow Creek, then to the Rio Grande via Heron Reservoir and the Rio Chama. Reclamation maintains this water in a Project pool at Heron Reservoir and allocates it to contractors each year.

Water at Heron Reservoir that is allocated to contractors and subsequent deliveries out of Heron Reservoir are tracked with a daily accounting model. All inflows to Heron Reservoir that are native to the basin are bypassed and are not included with San Juan-Chama accounting. Water allocated to MRGCD is released from Heron Dam to El Vado Reservoir each year as space is

available in El Vado Reservoir and is then used as needed to meet MRGCD's daily demand. Water allocated to ABCWUA is released from Heron Dam to Abiquiu Reservoir, depending on available space in Abiquiu, and is delivered to ABCWUA's surface-water diversion structure in Albuquerque or is released as letter water deliveries to offset depletions to surface water supplies caused by groundwater pumping, as assessed by the Office of the State Engineer. Water allocated to other contractors may also be released from Heron Dam to offset depletions or may be released for storage in available storage space at El Vado and/or Abiquiu Reservoir. In the near future, water allocated to Santa Fe will be released from Heron Dam to provide water to Santa Fe's Buckman Direct Diversion. San Juan-Chama Project water used to offset evaporation losses from the recreation pool maintained at Cochiti Lake may be partially released from Heron Dam during the first part of July but is generally released from Heron Dam in the late fall and winter.

Allocated San Juan-Chama Project water to contractors may be maintained in storage at Heron Reservoir until the end of the calendar year. Under normal operations, any contractor water remaining in Heron Reservoir on December 31st is reverted back to the Project pool; although, Reclamation may issue waivers to allow contractors to continue storing allocated water until September 30th of the year following the year that the water was allocated if there is a benefit to Reclamation. Historically, contractors have utilized waivers and leased their allocated water to Reclamation's Supplemental Water Program; however, the supplies available for lease are projected to decline as planned water uses by contractors, including ABCWUA and Santa Fe drinking-water diversions, come on-line.

URGWOM runs were completed to evaluate the impacts of Reclamation's operations to provide water to San Juan-Chama contractors from Heron Dam, which constitute Reclamation's discretionary actions under the San Juan-Chama Project. These model runs specify no trans-basin diversions from the San Juan basin, no new allocations of San Juan-Chama Project water to contractors, and no releases of San Juan-Chama Project Water from Heron Dam. Without these operations, MRGCD would not have additional supplies from annual allocations of San Juan-Chama Project water, and ABCWUA would not have supplies for its drinking-water diversion project. No deliveries would be made to offset losses from a Cochiti Recreation Pool, and there would be no letter water deliveries to offset impacts of groundwater pumping.

For the analysis of the impacts of Heron Dam operations, any San Juan-Chama Project water for MRGCD, ABCWUA, and other contractors already in storage at El Vado and Abiquiu Reservoirs as an initial condition is used to meet standard demands, but no new San Juan-Chama Project water is available once these supplies are depleted. All San Juan-Chama Project water initially in Heron Reservoir is retained and gradually evaporates. Supplemental Water available under initial conditions is used to meet targets for the 2003 BO as long as the supply lasts, but no additional San Juan-Chama Project water is made available for lease to the Supplemental Water Program; therefore, under these model runs, Middle Rio Grande flow targets are not always met after the initial supply is used. A list of aspects of project operations turned off to evaluate the impact of Heron Dam operations for the San Juan-Chama Project is presented in the column labeled "El Vado Ops and MRGCD Divs (no SJC Project Ops or Supplemental Water Program) No SJC Ops" in Table 3.1.

Reclamation maintains a Supplemental Water Program composed of contractor San Juan-Chama Project water leased annually from contractors and LFCC pumping for meeting the 2003 BO flow requirements. Impacts of Reclamation's Supplemental Water Program were evaluated

separately by comparing resulting river flows at Middle Rio Grande locations from simulations completed for the Proposed Action with the Supplemental Water Program to model runs completed for the Proposed Action without the Supplemental Water Program included but all other aspects of operations the same. This approach allowed for the specific impacts of the Supplemental Water Program to be isolated.

3.4.2. El Vado Dam Operations

El Vado Reservoir is used to store water native to the Rio Grande basin for later use to meet Middle Rio Grande Project irrigation demands. Storage in El Vado Reservoir may occur if native flows are available on the Rio Chama and restrictions to storage are not in place per Article VII of the Rio Grande Compact. Under normal reservoir operations, water is typically stored during the descending limb of the spring snowmelt runoff hydrograph to assure that releases can be restricted and do not exceed the downstream channel capacity. A limited amount of water will be stored each year regardless of Article VII restrictions to assure that water can be provided to meet the demand for the six Middle Rio Grande Pueblos, which is tracked separately with a daily accounting model and released as needed to specifically meet the demand for the Pueblos. Other native water in storage is released as needed to meet the MRGCD demand when available flows in the Middle Rio Grande from the mainstem of the river and tributary inflows are insufficient. The extent of Reclamation's discretion in the operation of the Middle Rio Grande Project is the storage and release of water from El Vado Reservoir. Diversion of the released water, as well as San Juan-Chama water or native water from the mainstem of the Rio Grande, is under the control of the MRGCD.

Impacts of El Vado Dam operations were evaluated using URGWOM runs for which the following actions are shut off:

- Heron Dam operations for the San Juan-Chama Project (as discussed in the section 3.4.2), and
- Storage of native Rio Grande water in El Vado Reservoir.

All inflows of native Rio Grande water are bypassed, and there is no storage of San-Juan Chama Project water for use by MRGCD water-right's holders when native Rio Grande flows drop below demand. MRGCD would only have any native and San Juan-Chama Project water present in El Vado Reservoir under initial conditions. Note that Reclamation could not operate El Vado Dam to assure that channel capacities in the reach of the Rio Chama below El Vado Dam are not exceeded; however, operations at Abiquiu Reservoir to prevent exceedence of channel capacities below Abiquiu Dam would still be included in these runs.

Since the Supplemental Water Program is not included and Heron Dam operations under the San Juan-Chama Project are also not included, there are no new Reclamation leases. Also, ABCWUA has no new San Juan-Chama Project water available to use for letter water deliveries or drinking-water project diversions. Impacts of El Vado Dam operations are indicated by a comparison between these model runs and model runs in which the Supplemental Water Program and Heron Dam operations for the San Juan-Chama Project are shut off. A list of aspects of project operations turned off to evaluate the impact of Middle Rio Grande Project operations is presented in the next to the last column in Table 3.1.

3.4.3. Middle Rio Grande Project Diversions

Water is diverted at Cochiti Dam and diversion structures at Angostura, Isleta, and San Acacia for irrigation of lands for MRGCD and the six Middle Rio Grande Pueblos, generally from March 1st through October 31st. Irrigation demand is highest during the months of June and September and may be high in July and August if there are not significant rainfall contributions from monsoon season storm events.

Impacts of Middle Rio Grande Project diversions were evaluated by completing URGWOM runs with no diversions. No native Rio Grande water is stored at El Vado Reservoir and released to meet the irrigation demand. Also, no Heron Dam operations are included for the San Juan-Chama Project; thus, no new MRGCD San Juan-Chama Project water is available in storage at El Vado Reservoir. Refer to the last column in Table 3.1 for a list of aspects of operations that are included for these model runs. Impacts of the diversions are indicated by differences in these model runs versus the model runs with diversions but no El Vado Dam operations, no Heron Dam operations for the San Juan-Chama Project, and no Supplemental Water Program.

Table 3.1. List of Operations Included for "Action by Action" Effects Analysis for Reclamation's BA

#	Operation	Current Ops (*not modeled - actual data referenced*)	Proposed Action (*with actual and unlimited supply of supplemental water*)	Proposed Action (SJC Ops, El Vado Ops, and MRGCD Divs) with No Supplemental Water Program	El Vado Ops and MRGCD Divs (no SJC Project Ops or Supplemental Water Program)	MRGCD Divs only	No Actions
1	Reclamation Leases	X	X				
2	LFCC Pumping	X	X				
3	SJC Project Diversions	X	X	X			
4	Heron Waivers	X	X	X			
5	MRGCD SJC Storage at El Vado	X	X	X			
6	ABCWUA SJC Storage at Abiquiu	X	X	X			
7	ABCWUA Diversions	X	X	X			
8	ABCWUA Letter Water Delivery	X	X	X			
9	SJC Combined Account Storage at Abiquiu	X	X	X			
10	Combined Letter Water Delivery	X	X	X			
11	Refilling of Cochiti Recreation Pool	X	X	X			
12	Maintain Target Flows	X	X	X			
13	P&P Storage at El Vado	X	X	X	X		
14	Releases of P&P Water from El Vado	X	X	X	X		
15	Storage for Initial Unused Allocation of Emergency Drought Water	X	X	X	X		
16	Rio Grande Storage at El Vado	X	X	X	X		
17	RG Releases from El Vado for MRGCD	X	X	X	X		
18	El Vado Storage for Channel Capacity	X	X	X	X		
19	MRGCD Diversions for Non-Indians	X	X	X	X	X	
20	Diversions for Pueblos	X	X	X	X	X	
21	Cochiti Deviations (years 1 and 2)	X	X	X	X	X	X
22	New Relinquished Credits						
23	Alternate Letter Water Deliveries						
24	Conserve Supplemental Water after YTD Otowi Volume exceeds 1,000,000 acre-ft						

Compare with previous scenario to evaluate impact of Reclamation's Supplemental Water Program at offsetting impacts of Reclamation's actions.

Compare with proposed action to evaluate impact of Reclamation's SJC Project operations, including Heron Dam Operation and the Supplemental Water Program.

Compare with previous scenario to evaluate impact of Reclamation's El Vado Dam operations.

Compare with previous scenario to evaluate impact of MRGCD Diversions.

3.5. Model Runs with All PHVA Flow Tools

In addition to the primary model runs for the Proposed Action as discussed in section 3.3, model runs were also completed during the process with *all* PHVA flow tools incorporated, as described in section 2.4, to evaluate impacts of all the identified potential solutions for meeting flow needs. Draft results from those model runs are not discussed in detail in this report but allowed for the impact of flow tools not included with the Proposed Action to be reviewed. The finding was that new allocations for storage of Emergency Drought Water from any new Relinquished Compact credits would significantly augment the supplemental water supply for meeting target flows in the Middle Rio Grande but would also reduced the accrued Compact credit. The additional flow tool to use alternate delivery schedules for letter water to payback the Compact yielded smaller benefits for meeting ESA needs.

3.6. Initial Conditions

Initial conditions are needed for all URGWOM model runs and inputting needed initial values is a step for setting up the model runs. In preparation for all modeling, the PHVA work group developed a template spreadsheet for inputting all needed initial conditions. Values are exported to ASCII files from the Excel spreadsheet with a macro and a RiverWare control file/executable DMI was set up in URGWOM for importing the initial conditions. The same initial conditions were used for all final model runs that represent the best estimate of December 31, 2011 conditions at the time final model files were set up.

All details and assumptions for developing initial conditions were documented by Boroughs (2011). Total storage levels at each reservoir along with the status for each storage account used as initial conditions are presented in Table 3.2. Initial conditions also include unused allocations for storage of Emergency Drought water from previous Relinquished Compact credits. The estimated unused allocations as initial conditions are 50,500 acre-ft for MRGCD and 19,500 acre-ft for ESA. Emergency Drought water is stored during simulation for these initial unused allocations. Initial river flows are also needed for several locations in the model but are inconsequential to the results. Initial shallow aquifer levels were also input as identified by the URGWOM Technical Team based on equilibrium conditions from completed calibration runs.

Table 3.2. Estimated December 31, 2011 Total and Account Storage Levels and Incidental, Carryover, and Sediment Contents used as Initial Conditions for Final Model Runs

Account	Heron	El Vado	Abiquiu	Cochiti	Jemez	Elephant Butte
TOTAL	219,833	98,522	177,294	53,926	0	280,000
San Juan-Chama Project Water:						
Federal Pool	151,032	---	---	---	---	---
Albuquerque	48,200	0	154,196	---	---	29,487
MRGCD	0	79,326	1100	---	---	---
Combined	20601	0	1942	---	---	19,103
Cochiti Rec Pool	0	---	---	48,037	---	---
Reclamation	0	0	16308	---	---	---
NMISC	---	---	0	---	---	---
Jemez Sediment Pool	---	---	---	---	0	---
Native Rio Grande Water:						
Rio Grande	0	0	0	0	-1114	164,410
Indian Storage	---	0	---	---	---	---
MRGCD Drought	---	0	---	---	---	---
Supplemental ESA	---	19,196	---	---	---	---
Rio Grande Conservation	---	---	0	0	0	---
NM Credit	---	---	---	---	---	65,000
CO Credit	---	---	---	---	---	2000
Incidental Content	---	---	0	0	-1114	---
Carryover Content	---	---	0	0	0	---
Sed Deposition	---	---	3748	5889	1114	---
Total storage at Caballo Reservoir is 11,093 acre-ft.						

3.7. Sequences

All simulations were completed using five 10-year synthetic hydrologic sequences developed by the PHVA work group with reference to paleo-data for representing a wide range of potential hydrologic conditions that could occur over the next 10 years. The sequences are comprised of historical years when data are available as needed for URGWOM simulations but years are re-sequenced to represent wet spells and drought spells not evident in the historical data. Refer to the documentation on sequence selection by Roach (2009) for details on the process for developing the sequences. The selected five sequences represent hydrologic conditions, defined by 10-year Otowi flow volumes, that would be exceeded 10, 30, 50, 70, and 90 percent of the time based on the paleo-data. Refer to Figures 3.1 through 3.5 for charts showing the historical years included with each synthetic 10-year hydrologic sequence. In addition to the annual Otowi flow volumes, or Otowi Index Supply (OIS), the charts also include a depiction of a representative monsoon volume (RMV) that is independent of the sequence selection approach, so the RMV would have its own different exceedence probability under each sequence.

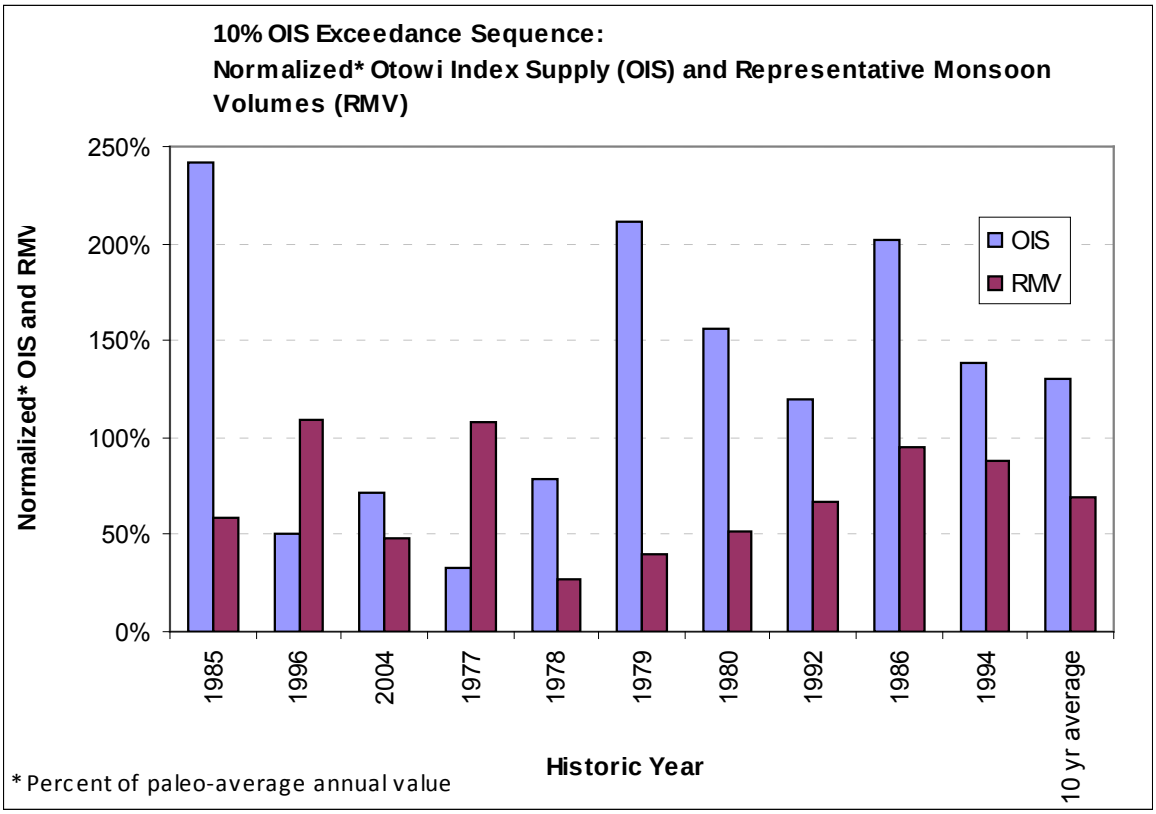

Figure 3.1. Synthetic Hydrologic Sequence with 10 percent Exceedence

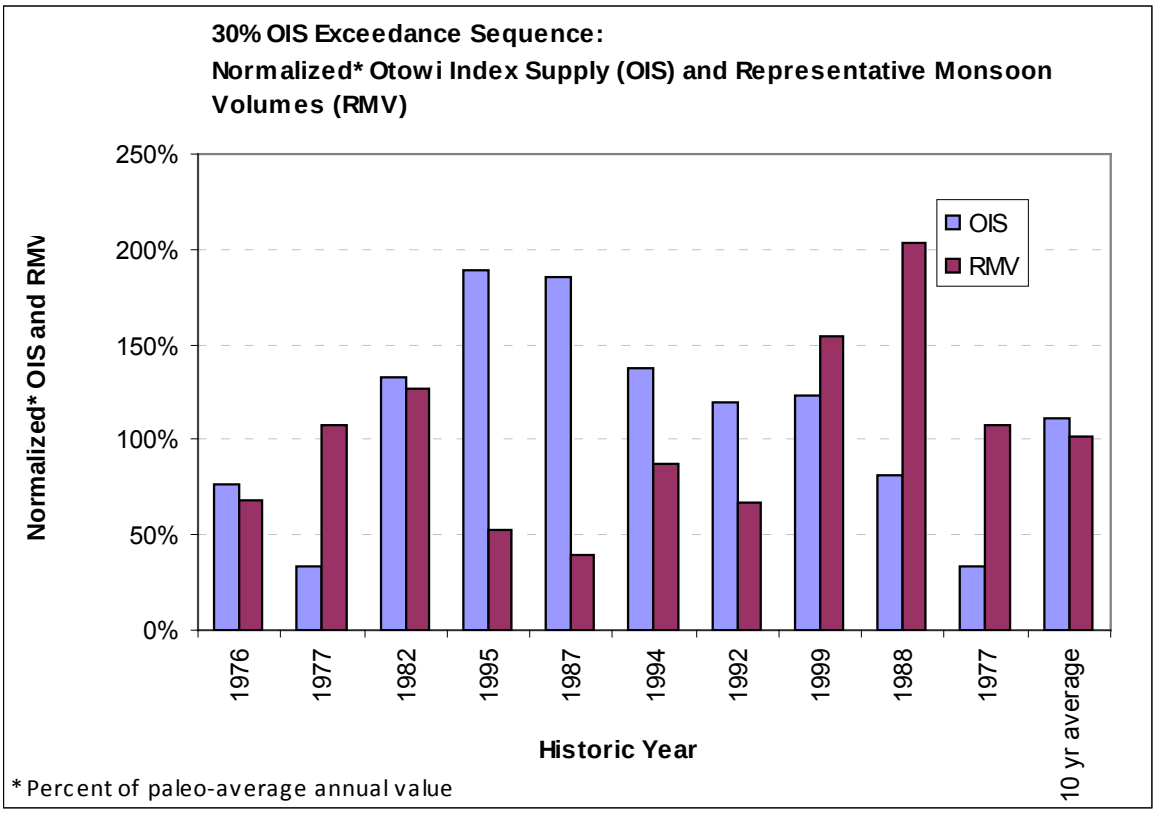

Figure 3.2. Synthetic Hydrologic Sequence with 30 percent Exceedence

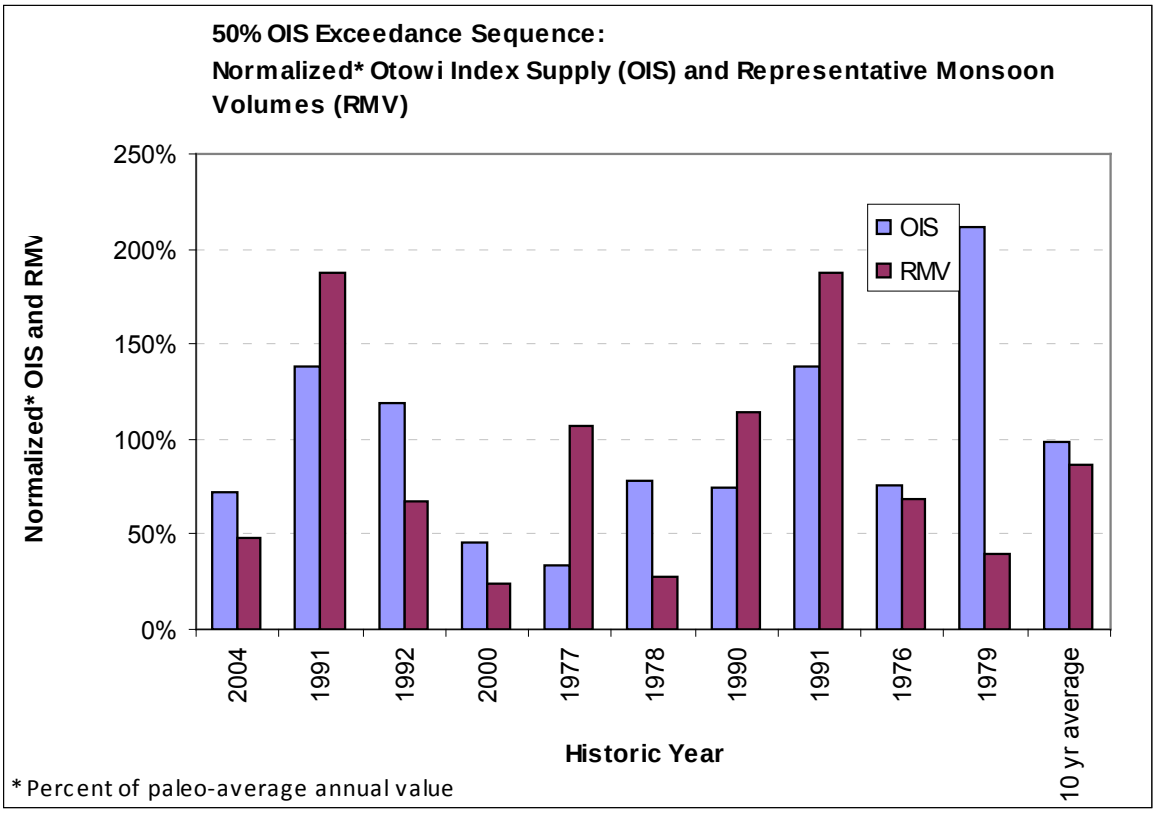

Figure 3.3. Synthetic Hydrologic Sequence with 50 percent Exceedence

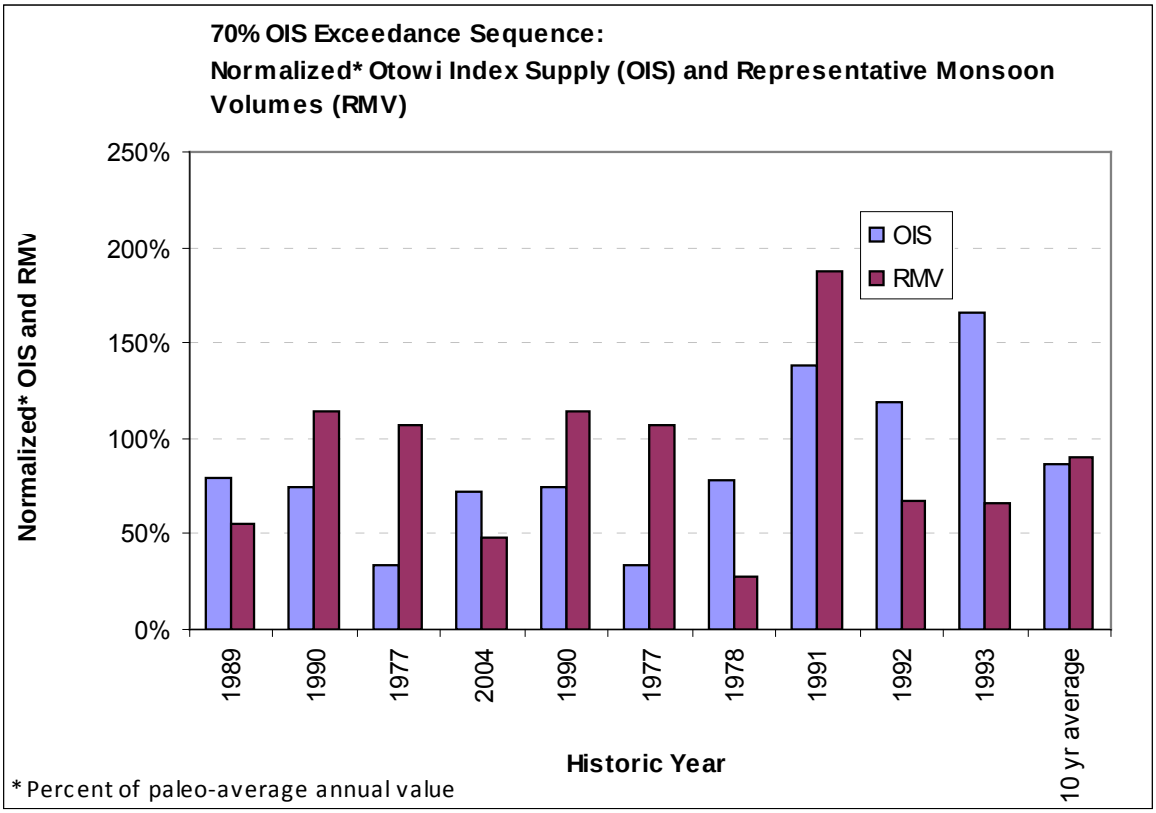

Figure 3.4. Synthetic Hydrologic Sequence with 70 percent Exceedence

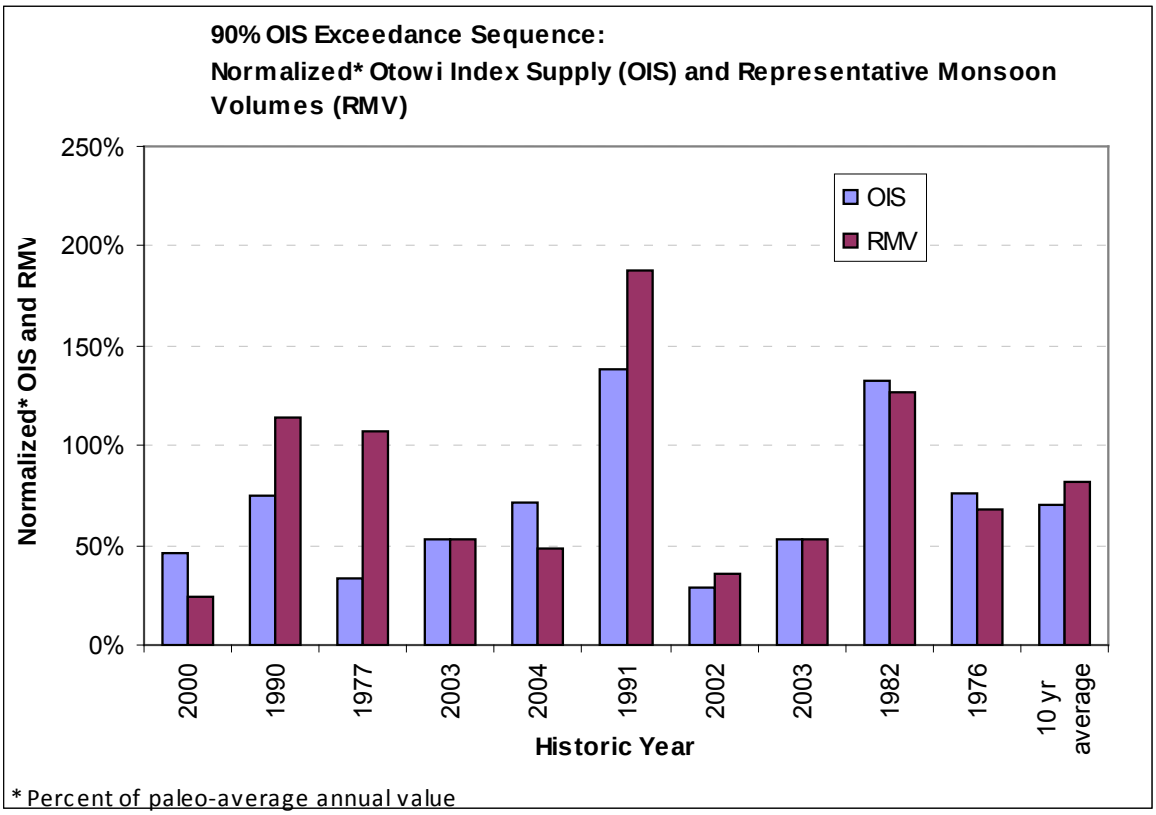

Figure 3.5. Synthetic Hydrologic Sequence with 90 percent Exceedence

4.0. Model Run Results

Five final model runs were completed for the Proposed Action as described in section 3.3 with the five synthetic hydrologic sequences presented in section 3.7 and the initial conditions discussed in section 3.6. Results were analyzed to determine impacts of operations as defined for the Proposed Action on numerous identified indicators. Five additional companion model runs were completed with a hypothetical unlimited supply of supplemental water that were used solely to evaluate the total amount of supplemental water needed to meet the 2003 BO targets and resulting river flows if the targets could always be met. Additional model runs were completed to evaluate the impacts of Reclamation's actions and non-Federal actions as described in section 3.4. The analysis of these model runs was completed with focus on resulting river flows with actions removed.

4.1. Proposed Action

Results for the Proposed Action run were evaluated for resulting river flows, the timing and extent of river drying, the resulting supply for MRGCD, ABCWUA supply, the cumulative Compact credit, and Article VII status. In addition, results from the companion model runs with an unlimited supply included were reviewed to evaluate the total amount of supplemental water needed to meet the 2003 BO targets and the additional supplemental water needed above that available under the Proposed Action.

4.1.1. River Flows

Exceedence curves were developed that represent the amount of time over the entire 50-years of analysis from the five 10-year model runs that flows are exceeded. The curves indicate the amount of time that the flow at a site would be exceeded under the given hydrology and modeled operations. Separate curves were developed for each key target location with reference to the model runs for the Proposed Action versus the model runs with the hypothetical unlimited supply included. Refer to Figure 4.1 for the exceedence curves developed with modeled flows at Central where the focus is zoomed in on lower flows. Lower flows are exceeded more often with the unlimited supply of supplemental water available to always meet the 2003 BO flow requirements during the simulation. Curves are presented in Figures 4.2 and 4.3 for the same location that were developed with focus on model results for the irrigation seasons (March through October) and the non-irrigation seasons (November through February), respectively. These curves clearly indicate that the benefit from having an unlimited supply of supplemental water is evident primarily during the irrigation season. Targets can mostly be met during the non-irrigation season, even with the limited supply of supplemental water represented by the Proposed Action.

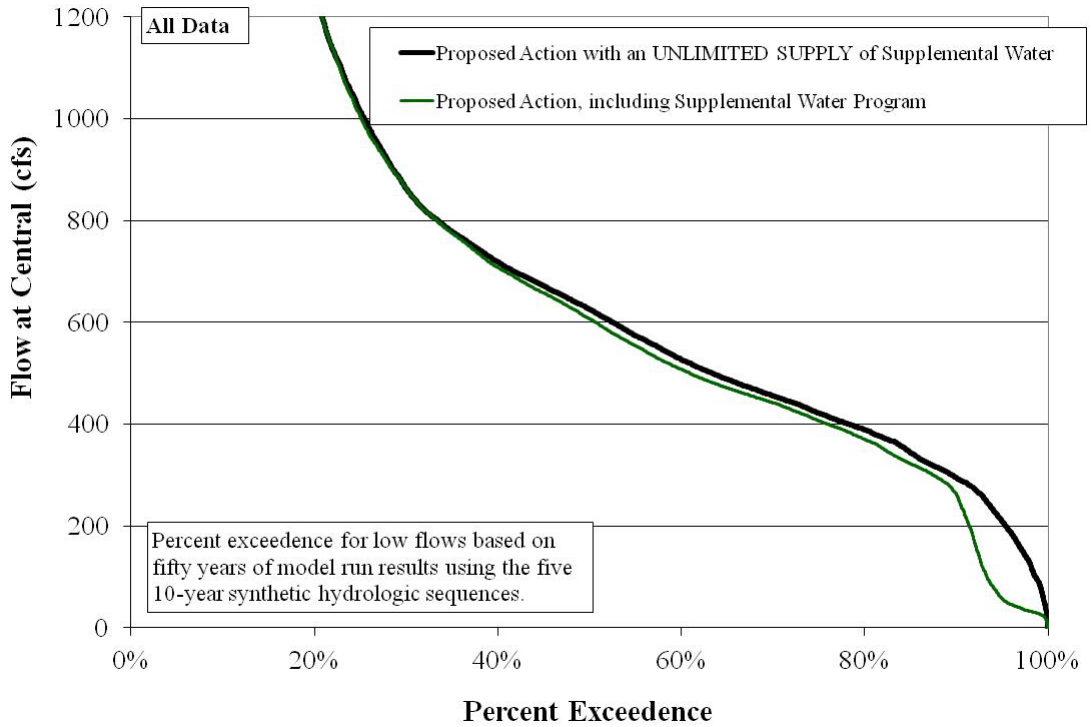

Figure 4.1. Exceedence Curves for Modeled Flows at Central – All Data

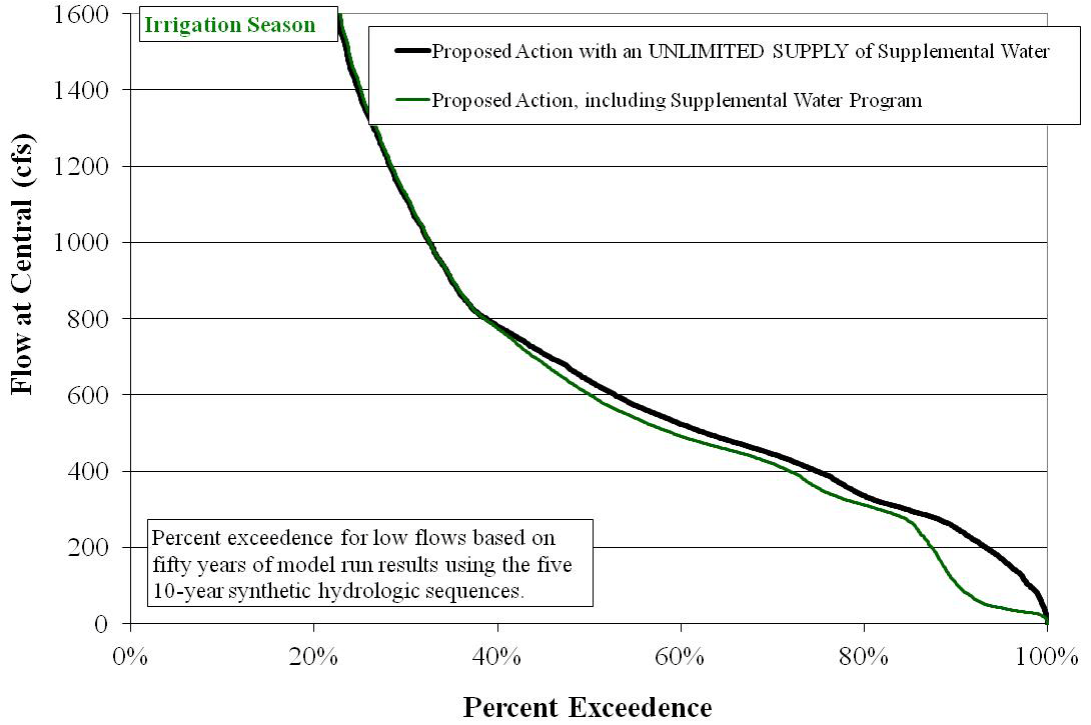

Figure 4.2. Exceedence Curves for Modeled Flows at Central – Irrigation Season

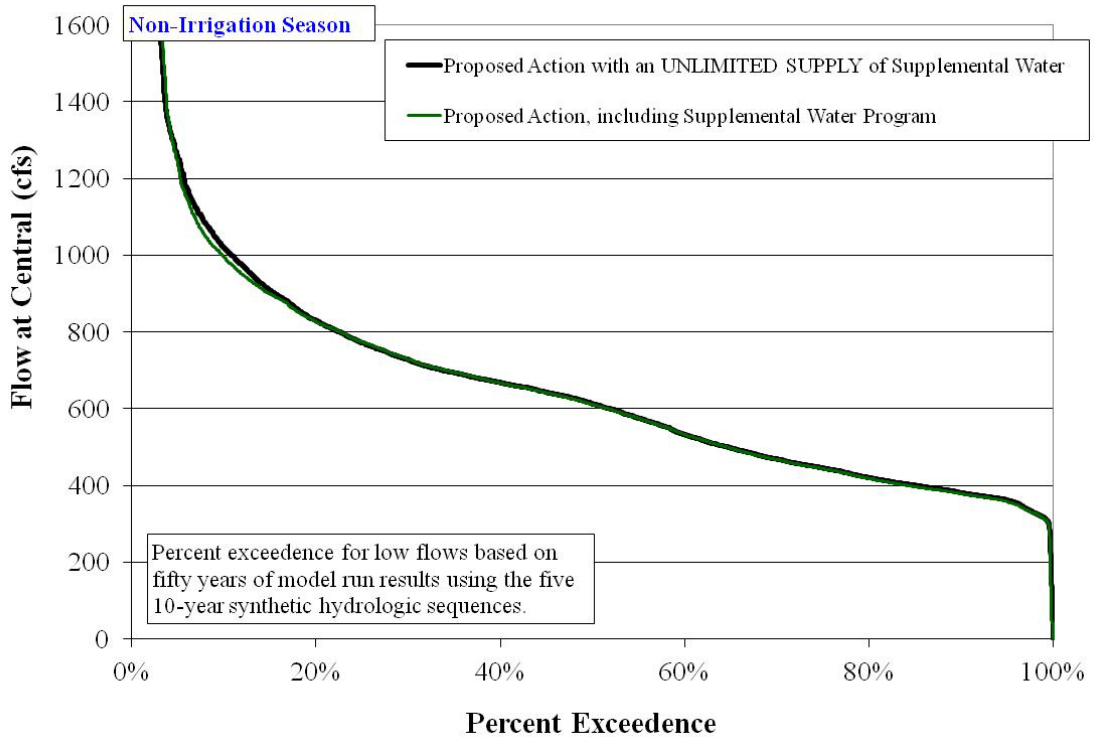

Figure 4.3. Exceedence Curves for Modeled Flows at Central – Non-Irrigation Season

Flow exceedence curves are presented in Figure 4.4 and 4.5 for the resulting flows at Isleta during the irrigation season and non-irrigation season, respectively. Each chart includes curves for the resulting flows under the Proposed Action and with an unlimited supply of supplemental water included. The x-axes on these charts are labeled based on the number of days that a flow is not exceeded during the irrigation season (or non-irrigation season) on average. This alternate x-axis format allows for the average number of days of drying at the location to be identified. Based on the curves in Figure 4.4, an additional 15 days per year of river drying could be expected under the Proposed Action versus if the 2003 BO targets were always met as occurs in the model runs with an unlimited supply of supplemental water. Note that river drying is allowed under the 2003 BO, so river drying is still indicated when an unlimited supply of supplemental water is used. Curves are presented for the irrigation season results at San Acacia and San Marcial in Figures 4.6 and 4.7.

Based on work with all the PHVA flow tools during the study, results would be similar if all PHVA flow tools were modeled with low flows exceeded slightly more often and flow targets achieved a bit more often, primarily due to additional Emergency Drought water with new modeled relinquished Compact credits, but flows would still not match the results with an unlimited supply of supplemental water as there would still be a shortage in the amount of supplemental water needed to always meet the 2003 BO flow requirements with all PHVA flow tools included.

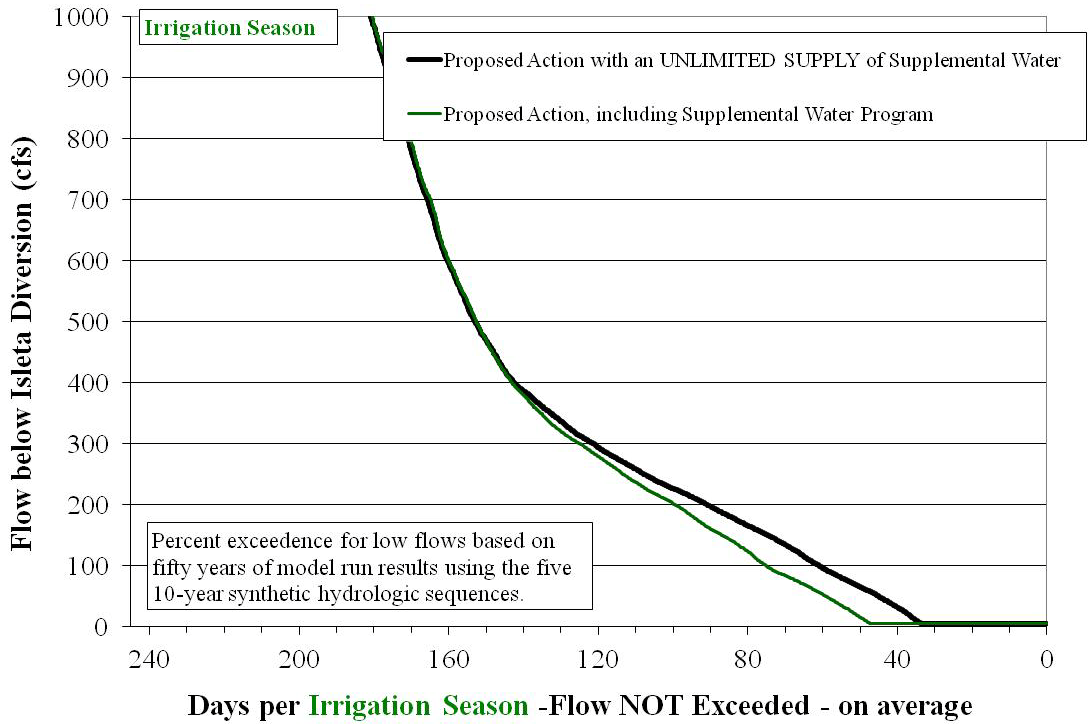

Figure 4.4. Exceedence Curves for Modeled Flows at Isleta – Irrigation Season

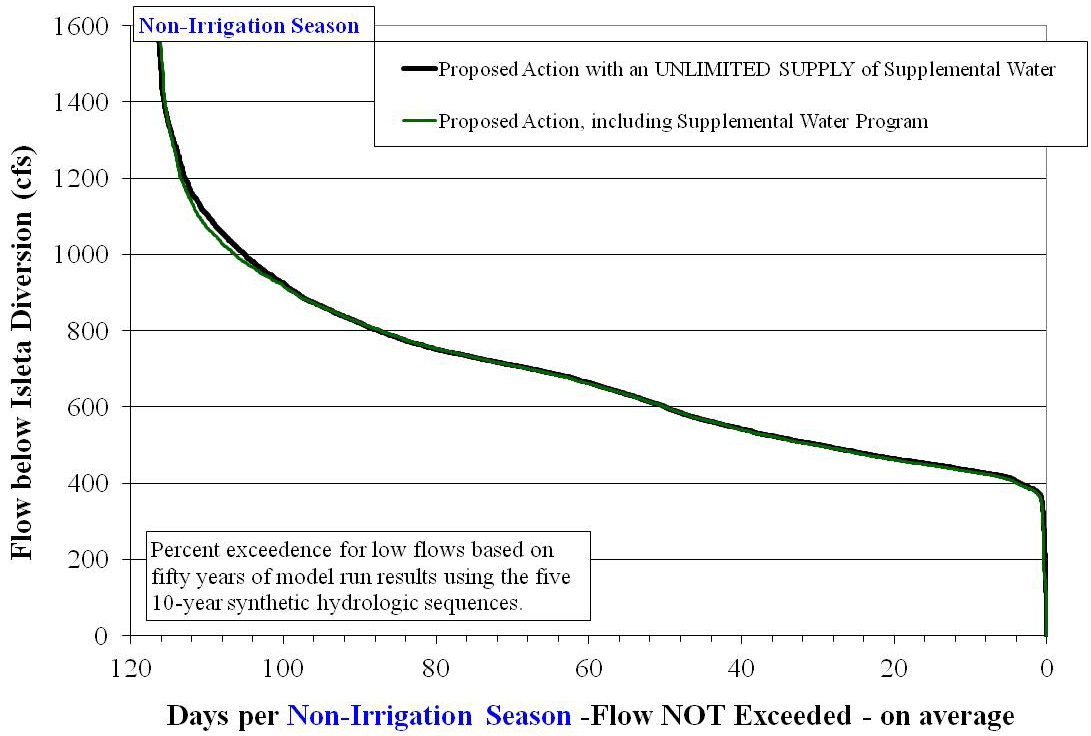

Figure 4.5. Exceedence Curves for Modeled Flows at Isleta – Non-Irrigation Season

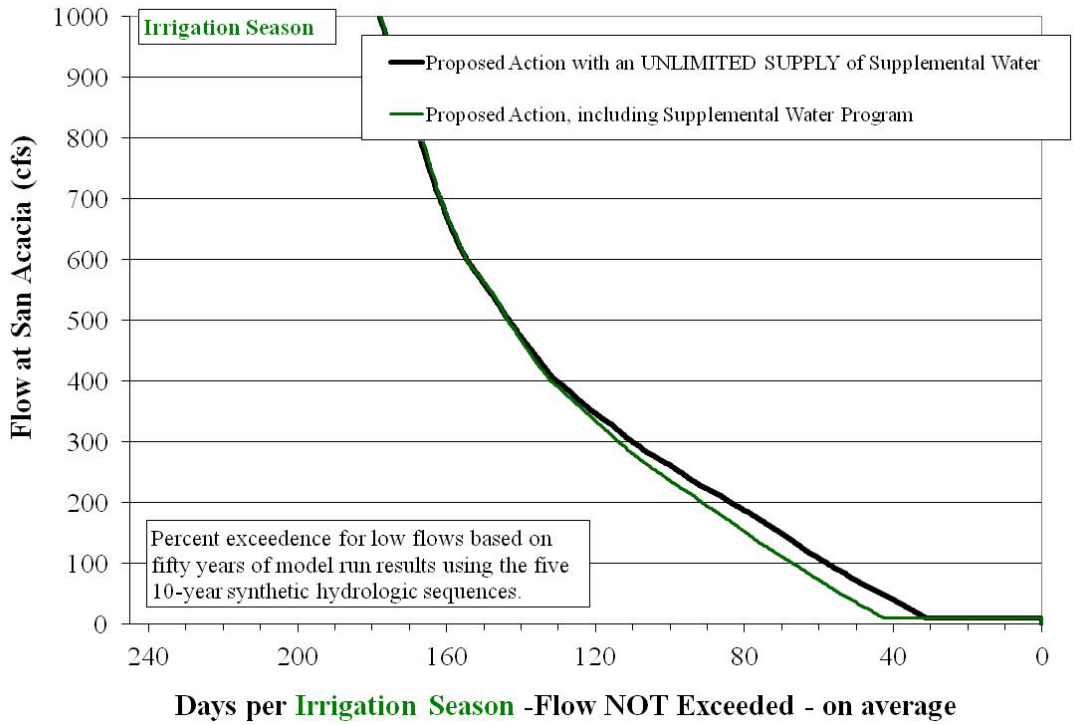

Figure 4.6. Exceedence Curves for Modeled Flows at San Acacia – Irrigation Season

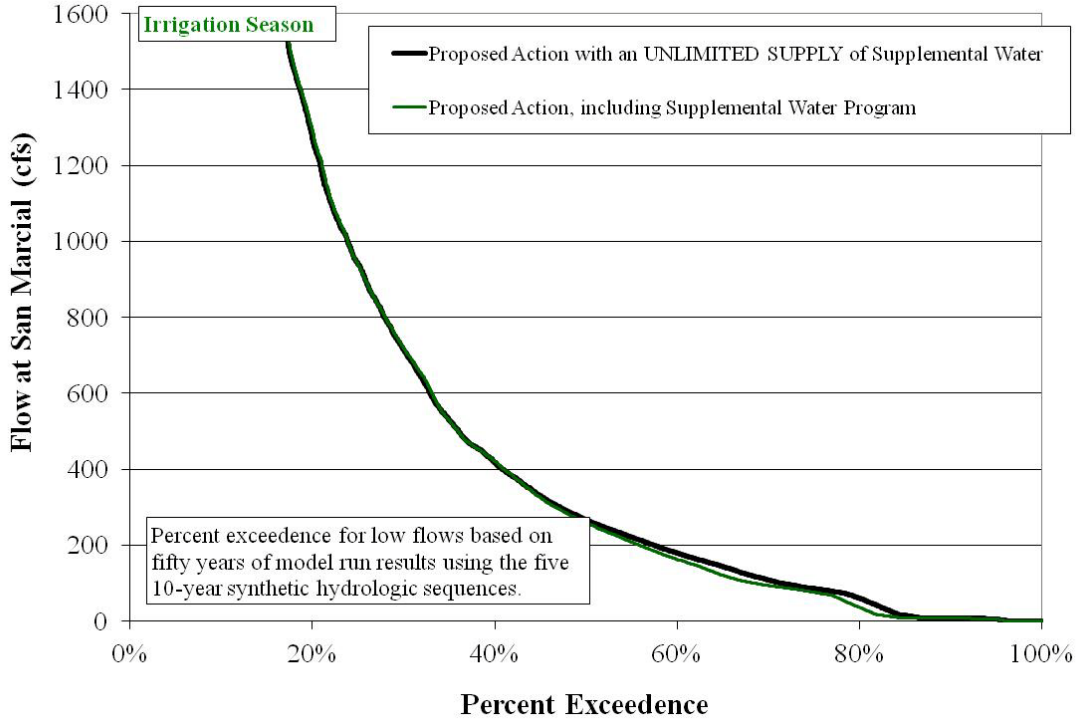

Figure 4.7 Exceedence Curves for Modeled Flows at San Marcial – Irrigation Season

4.1.2. River Drying and Recruitment or Overbank Flows

The exceedence curves presented in the figures in section 4.1.1 provide an indication as to when river drying would be expected based on the flow at the target locations, but more resolution on the timing and extent of river drying can be determined based on the modeled flows at individual subreaches in URGWOM. Separate charts were developed to depict when river drying would be expected for a particular subreach or anywhere within the main reaches (e.g. Angostura to Isleta, Isleta to San Acacia, or San Acacia to San Marcial). These charts were then created for each model run with each sequence with additional separate charts for the model runs with an unlimited supply of supplemental water included.

Two sample charts are presented in Figures 4.8 and 4.9. The timing for expected river drying is depicted by the date within the calendar year, as designated for the x-axis, for each year of a run, as designated on the y-axis (Years 2010 through 2019 are used on the presented charts but any years could be noted for a 10-year analysis period). The orange bars represent the timing for when river drying is indicated under the Proposed Action. In addition, recruitment flows are depicted to allow for impacts between the timing for recruitment flows and the timing of river drying to be evaluated. The red bars in the chart represent times when recruitment flows (at least 3000 cfs for 7 days at Central) are provided under the Proposed Action. The timing for when Cochiti Deviations are implemented is depicted by blue bars.

General conclusions from the review of all the produced river drying charts from the analysis include the following: More river drying is evident under the proposed action versus with an unlimited supply of supplemental water because the amount of supplemental water under the Proposed Action is insufficient for always meeting the flow requirements under the 2003 BO. Note that with an unlimited supply of supplemental water included, some river drying still occurs as allowed under the 2003 BO. For the final model runs, the 7-day step downs in target flows to represent the use of supplemental water for controlling the rate of river drying after any river rewetting are turned off (as discussed in section 2.5); thus, more river drying is apparent without this operation and additional use of supplemental water. Also note that based on the review of all the PHVA flow tools throughout the modeling process, less river drying would be expected with any new relinquished Compact credits and the resulting additional Emergency Drought water.

The occurrence of recruitment (and overbank) flows is a function of the hydrology and not impacted by the flow requirements under the 2003 BO, but it could be emphasized that Cochiti deviations do help with providing additional recruitment (or overbank) flows in years when defined recruitment or overbank flows would not otherwise be achieved. Deviations prevent extended periods without recruitment or overbank flows during drought periods. Cochiti deviations were only modeled for years 1 and 2 based on the current authorization for the operation, but the benefit can still be seen from this limited range of application.

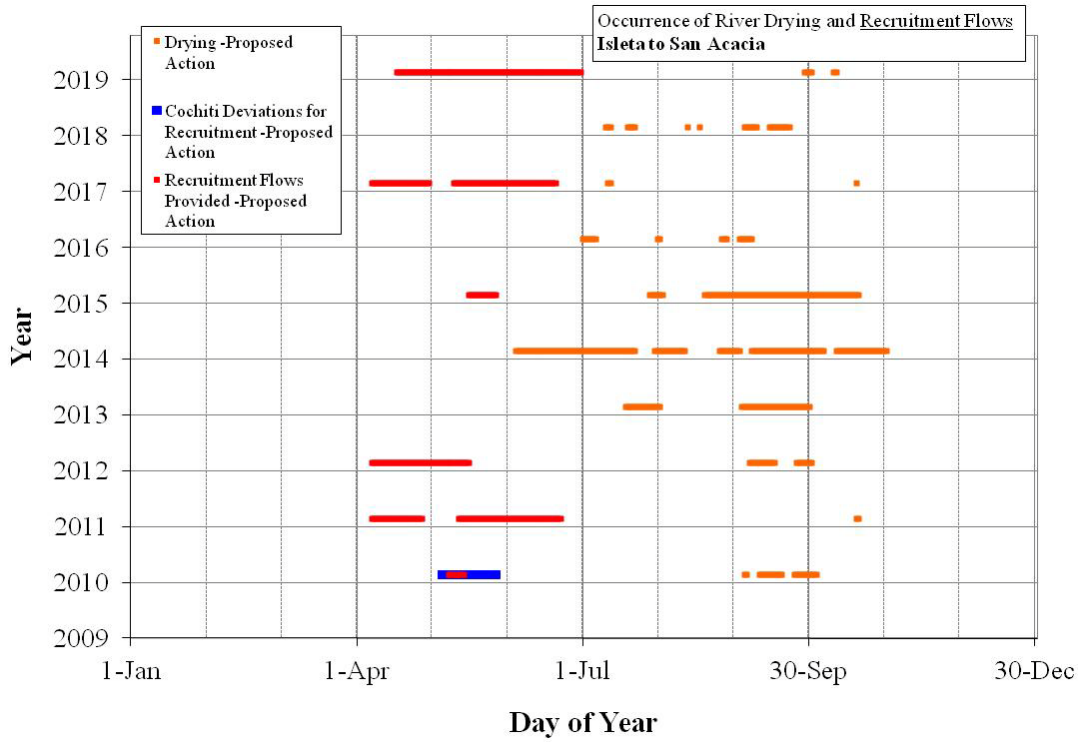

Figure 4.8. Depiction of Timing of River Drying and Recruitment Flows (and Cochiti Deviations for Recruitment) for Proposed Action – 50 percent Exceedence Sequence

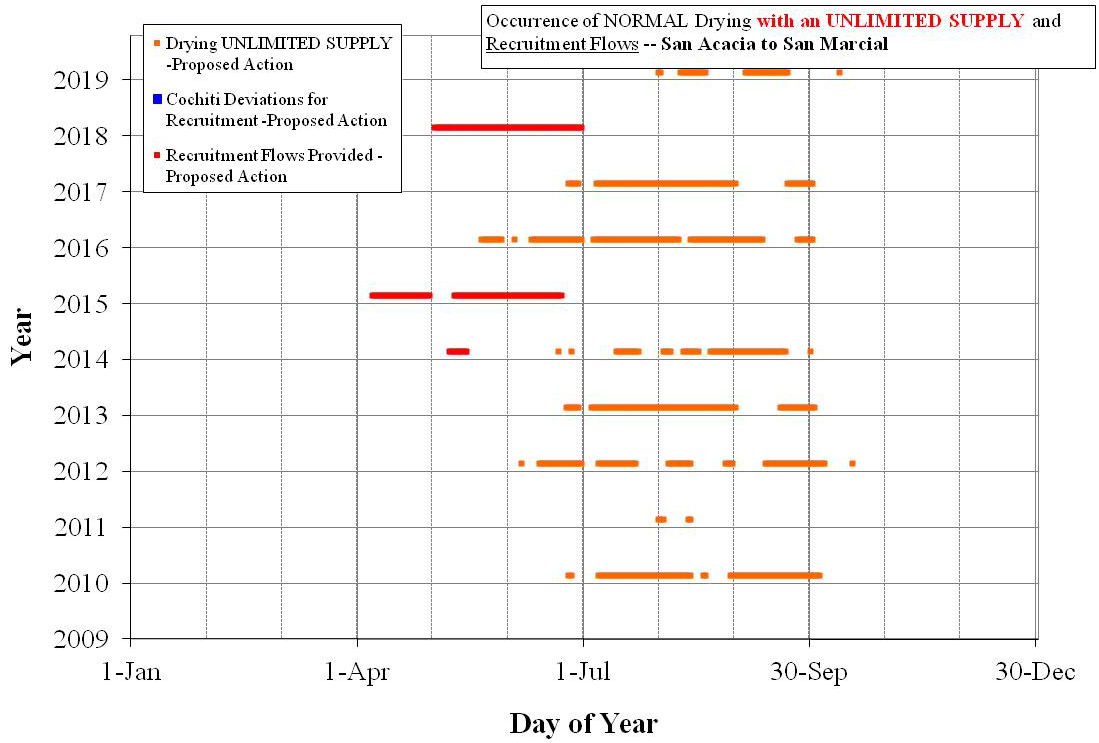

Figure 4.9. Depiction of Timing of River Drying and Recruitment Flows (and Cochiti Deviations for Recruitment) for Proposed Action *with an Unlimited Supply* – 90 percent Exceedence Sequence

4.1.3. Supplemental Water Needed for the 2003 BO Flow Requirements

Model results from the simulations with a hypothetical unlimited supply of supplemental water included were reviewed to evaluate the total amount of supplemental water needed at Abiquiu Reservoir to meet the 2003 BO flow requirements under each hydrologic sequence. Refer to Figure 4.10 for a plot of the 10-year total volumes needed. The fifty values for the annual total supplemental water needed to meet the 2003 BO flow requirements from the five 10-year runs were also used to develop an exceedence chart (Figure 4.11). The chart can be used to identify the chance that an annual volume of supplemental water would be needed based on the model runs with the five sequences. The exceedence chart could also be used to identify how often an identified available amount of water would be sufficient. Note that the volumes of supplemental water used in actual operations for the historical period from 2001 through 2011 are noted on the chart to provide some perspective of where these recent historical years fall relative to what could occur based on the model runs with the hydrologic sequences.

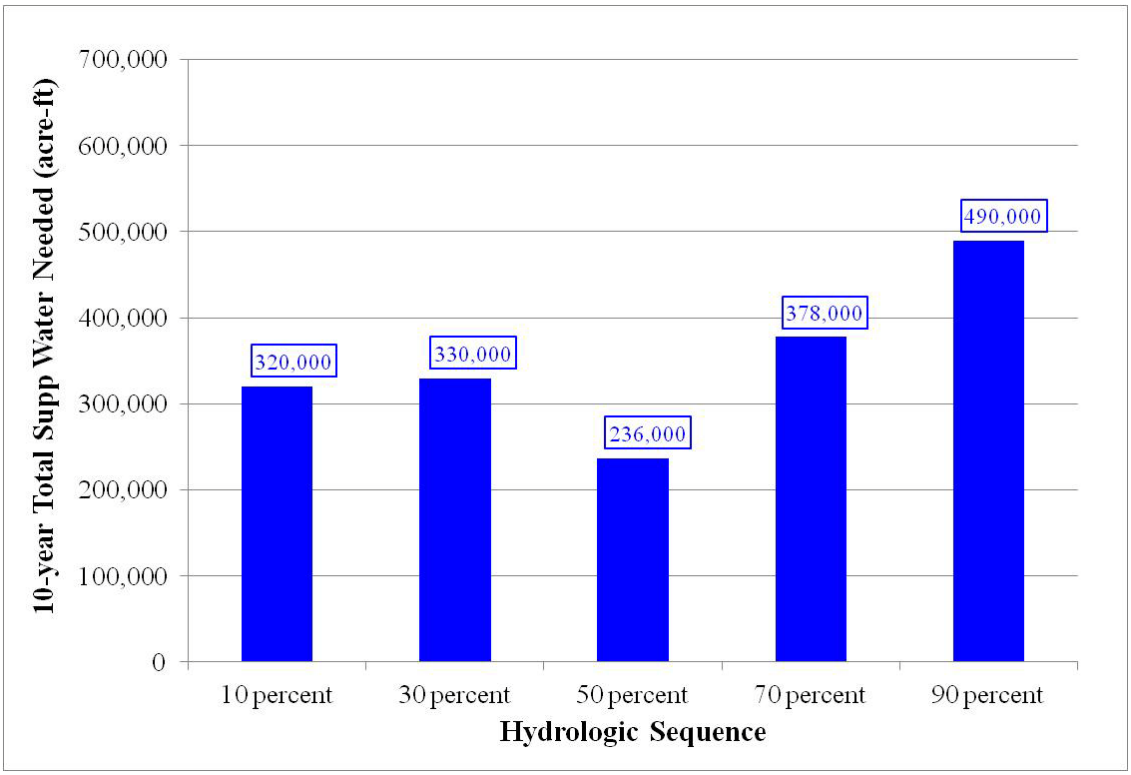

Figure 4.10. 10-year Total Supplemental Water Needed to Meet 2003 BO Flow Requirements

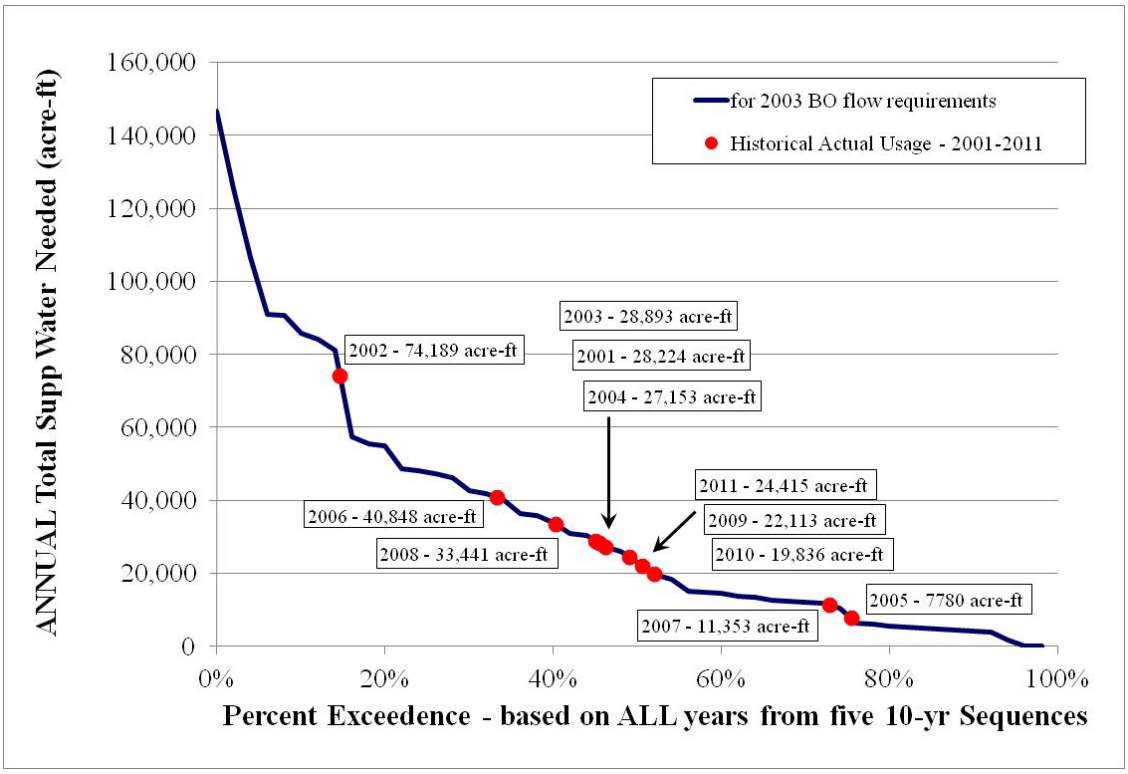

Figure 4.11. Exceedence Chart for Annual Total Supplemental Water Needed to Meet 2003 BO Flow Requirements

Model results for the Proposed Action were compared to the companion model results with an unlimited supply of supplemental water included to identify the additional supplemental water that would be needed above that provided under the Proposed Action to meet the 2003 BO flow requirements. Refer to Figure 4.12 for a plot of the supplemental water needed split between the amount provided under the Proposed Action and the additional supplemental water needed to always meet the 2003 BO flow requirements. Values are evaluated as a volume needed at Abiquiu Reservoir. The amount of supplemental water provided at the source is depicted by the additional line in the chart which is higher due to losses to Abiquiu Reservoir from the source for the supplemental water (e.g. Reclamation leases of San Juan-Chama Project water at Heron Reservoir). Simply divide the values by 10 to obtain corresponding annual values.

Based on the review of all PHVA flow tools during the modeling process, the additional amount of supplemental water needed would be less if supplemental water was provided due to new Relinquished Compact credits; although, the new allocations for storage of Emergency Drought water with any new Relinquished Compact credits would not completely cover the additional supplemental water needed beyond that provided under the Proposed Action.

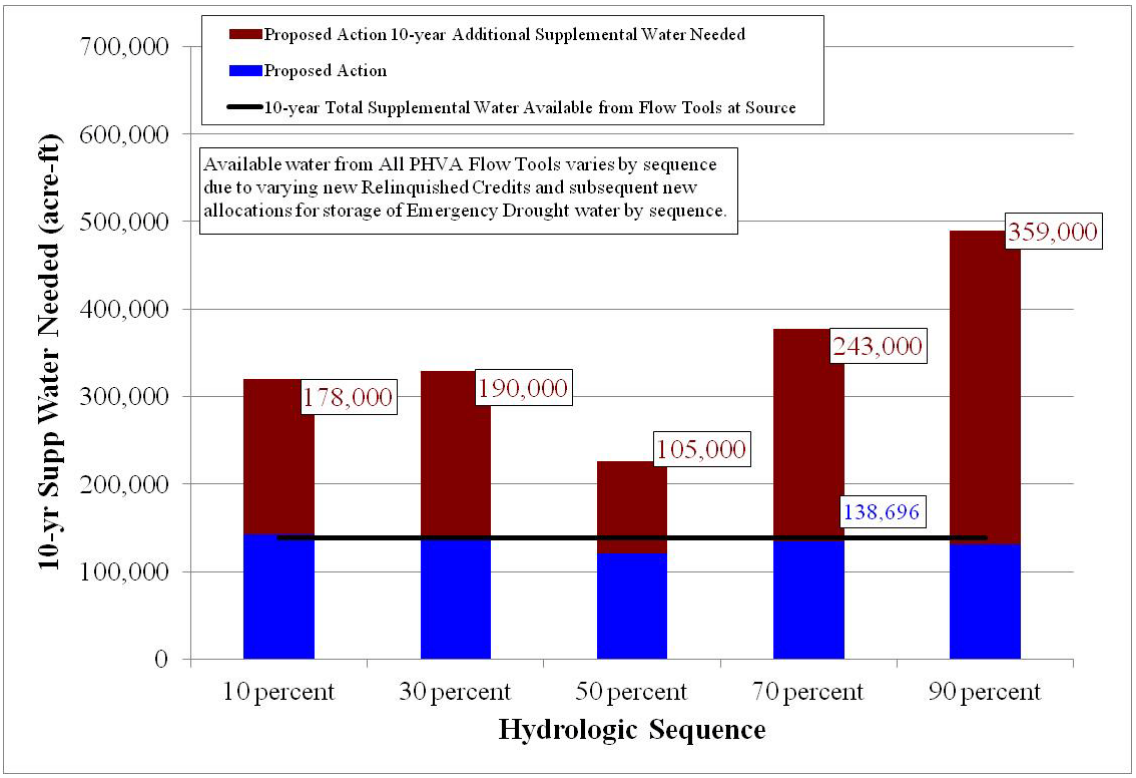

Figure 4.12. 10-year Additional Supplemental Water Needed under the Proposed Action

4.1.3.1. Water Needs by Individual Flow Requirement

Results for the total supplemental water needed to meet the 2003 BO flow requirements as modeled with a hypothetical unlimited supply of supplemental water were reviewed to break down the contribution of supplemental water needed 1) for the continuous flow requirement through June 15th, 2) to manage the recession after the continuous flow requirement (or after the runoff), and 3) to control the rate of drying after any river rewetting. The total average need based on all five model runs with each sequence is just over 35,000 acre-ft/year where the water needs for the three particular aforementioned individual flow requirements average approximately 11,000 acre-ft/year, 9,600 acre-ft/year, and 0 acre-ft/year, respectively; although, it should be emphasized that supplemental water was not used to control the rate of river drying after any river rewetting in the final model runs. These are average values, so the actual amount needed in a given year for a particular flow requirement could be much higher or as low as zero. It should also be emphasized that the hydrologic sequences are comprised of historical years since 1975, but the runoff ends earlier for some previous years (e.g. 1950 and 1951) where the needs for supplemental water to meet the continuous flow requirement would begin very early and be very high in volume to maintain continuous flow through June 15th (Llewellyn, 2011). Water needs to meet the continuous flow requirement for these particular earlier years would not be indicated in the model results based on the simulations completed with hydrologic year from 1975 and later included in the hydrologic sequences.

A separate analysis was completed to identify that over 13,000 acre-ft/year, on average, would be needed solely for the 100 cfs year round target at Central. Results are presented in Figure 4.13 as average annual water needs based on the results using all hydrologic sequences. Other individual flow requirements also contribute to the total amount of supplemental water needed

for the 2003 BO flow requirements such as targets at Isleta and different target flows used during average and wet years.

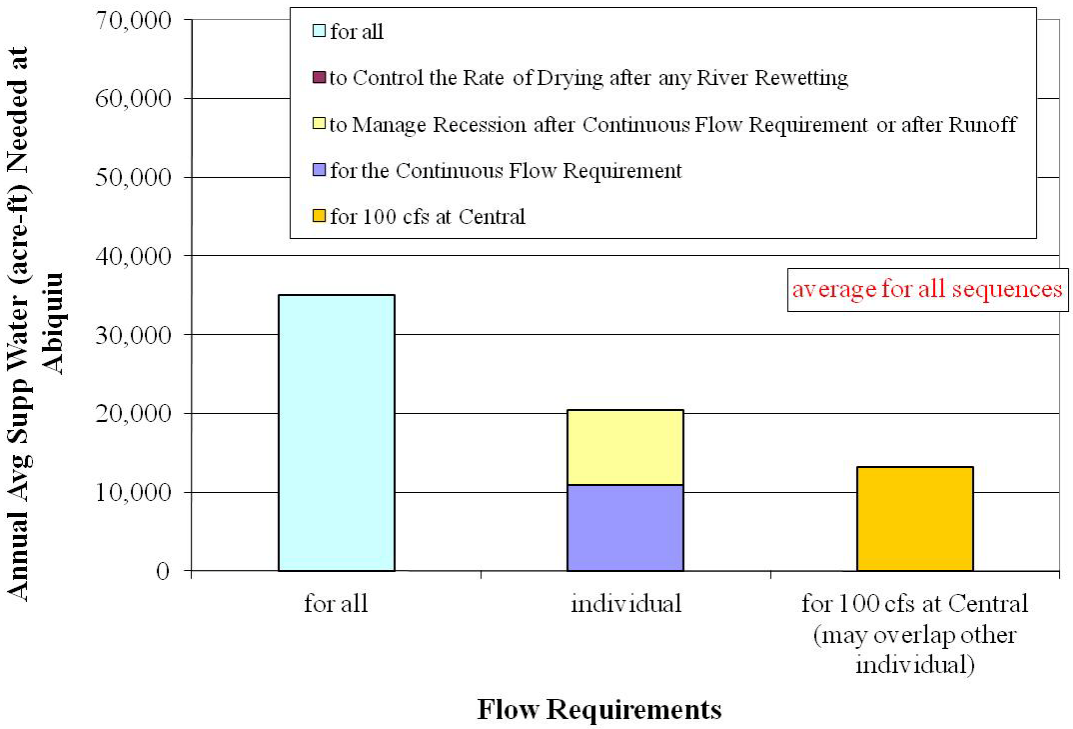

Figure 4.13. 10-year Additional Supplemental Water Needed with All PHVA Flow Tools

4.1.4. Compact Credit and Article VII Status

The simulated cumulative Compact credit under the Proposed Action for each sequence is plotted in Figure 4.14. The charts reflect the annual adjustment to the Compact credit at the end of each year based on the delivery for the year and Compact calculations. A gradual reduction in the Compact credit is evident, when it is positive, due to evaporation losses to the additional water in storage at Elephant Butte Reservoir. The model results indicate a Compact credit that would never go negative under the Proposed Action except with the wettest 10 percent exceedence sequence, and there would be a slight gain to the cumulative Credit over the 10-year analysis period under all the hydrologic sequences. Note that Compact delivery obligations are more difficult to attain during wet periods when all flows as measured at Otowi above a constant allowable depletion amount (used for higher flow years) must be delivered to Elephant Butte Reservoir. The implemented approach for the Compact calculations allows for an annual credit to be more likely achieved during drier years.

Based on all the work during the modeling process with all the PHVA flow tools, it should be conveyed that the cumulative Compact credit would indeed be lower with any new relinquished Compact credits and the Compact credit would be more susceptible to going negative or even decrease below a critical threshold of 200,000 acre-ft of debt; nonetheless, the projected credit under the Proposed Action without any new relinquishments indicates that there is still an opportunity for new relinquishments and subsequent new allocations for storage of Emergency Drought water without yielding cumulative credits below critical debt levels.

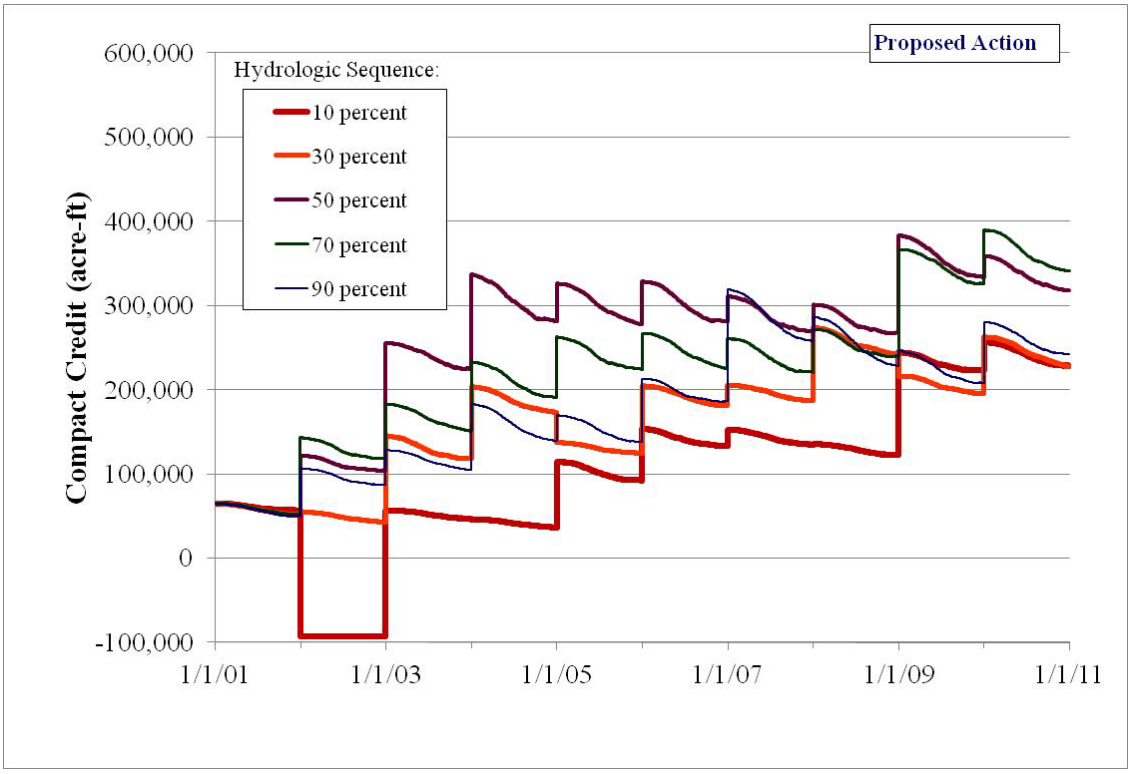

Figure 4.14. Cumulative Compact Credit under the Proposed Action for Each Hydrologic Sequence

4.1.4.1. El Vado Releases per Article VIII of the Compact

As discussed in section 2.3.2.6, the model was set up to simulate El Vado Dam releases that would be made based on a call by Texas per Article VIII of the Compact. Final model runs were reviewed to evaluate the impact of this policy, and results indicate that such releases are not ever triggered based on Article VIII policy. If there is a Compact debt, conditions do not occur when native Rio Grande water is in storage at El Vado Reservoir to release to bring the usable storage up to 600,000 acre-ft. Native Rio Grande water cannot be stored at El Vado Reservoir when the usable storage is less than 400,000 acre-ft, so this separate provision of the Compact effectively prevents water from being available at El Vado Reservoir during periods with low usable storage. When there is native Rio Grande water in storage, there is no Compact debt or the usable storage already exceeds the 600,000 acre-ft threshold to trigger a release per Article VIII of the Compact. The finding is that Article VIII of the Compact pertains to a very narrow window of system conditions that is not seen in the model results where native Rio Grande water would be in storage at El Vado Reservoir but usable storage is below 600,000 acre-ft while there is a Compact debt.

4.1.5. MRGCD Supply

Results for the simulations for the Proposed Action were reviewed to assess the status of MRGCD's water supply in storage under each of the hydrologic sequences. The supply is a function of the hydrology with releases set as needed to meet the MRGCD demand at Cochiti.

The supply primarily consists of native Rio Grande water, MRGCD's San Juan-Chama Project water, and Emergency Drought water at El Vado Reservoir. These three sources for the MRGCD supply are tracked with separate accounts in URGWOM and are plotted in Figures 4.15 through 4.19 from the model runs with each hydrologic sequence. Native Rio Grande water is stored as not needed to meet the daily demand if storage restrictions per Article VII of the Compact are not in effect. Emergency Drought water for MRGCD is from storage during the simulation, while restrictions per Article VII of the Compact are in effect, for the initial unused allocation of 50,500 acre-ft. MRGCD's San Juan-Chama Project is essentially banked and used when native supplies are exhausted. Periods with no San Juan-Chama Project water, no native Rio Grande water, and no Emergency Drought water in storage represent times when MRGCD would be in a shortage situation unless the native flows in the river provided the full demand and assuming no additional water is available at Heron or Abiquiu Reservoirs. As presented in Figure 4.19, extended shortage periods are evident from the model run with the driest 90 percent exceedence sequence.

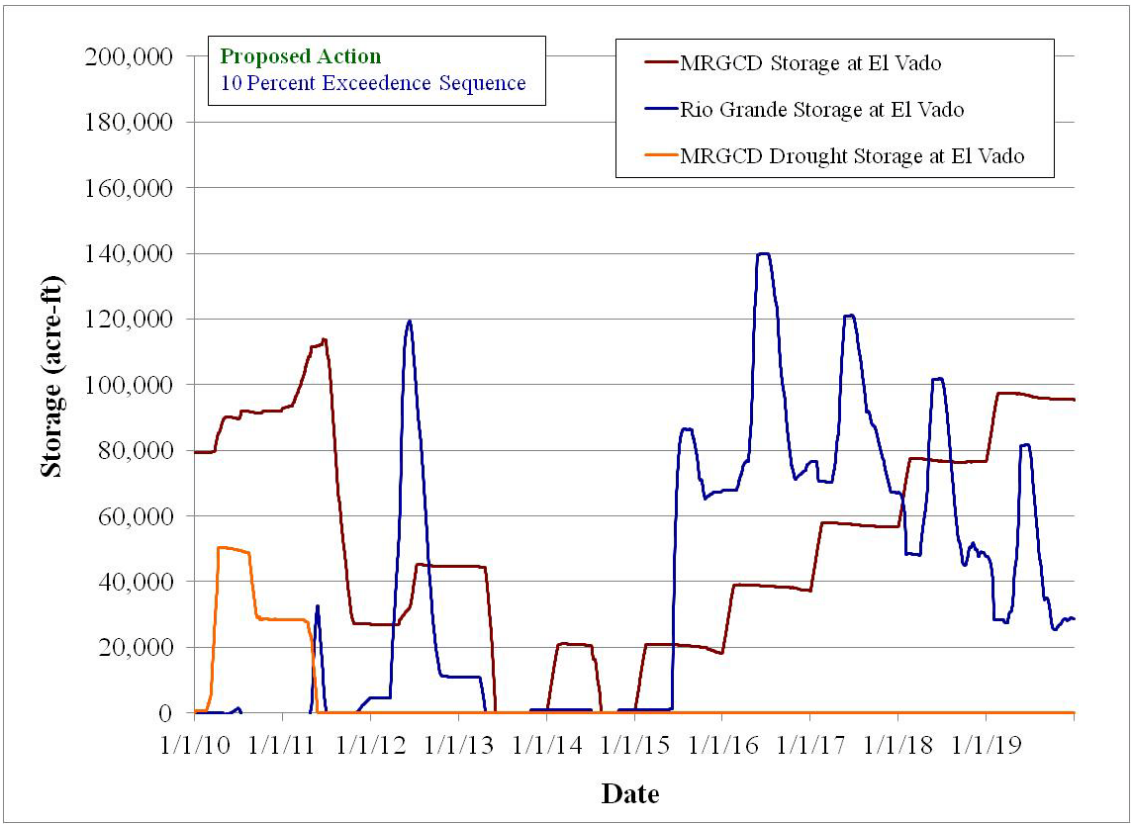

Figure 4.15. MRGCD's Supply of San Juan-Chama Water, Native Rio Grande Water, and Emergency Drought Water at El Vado Reservoir – 10 percent Exceedence Sequence

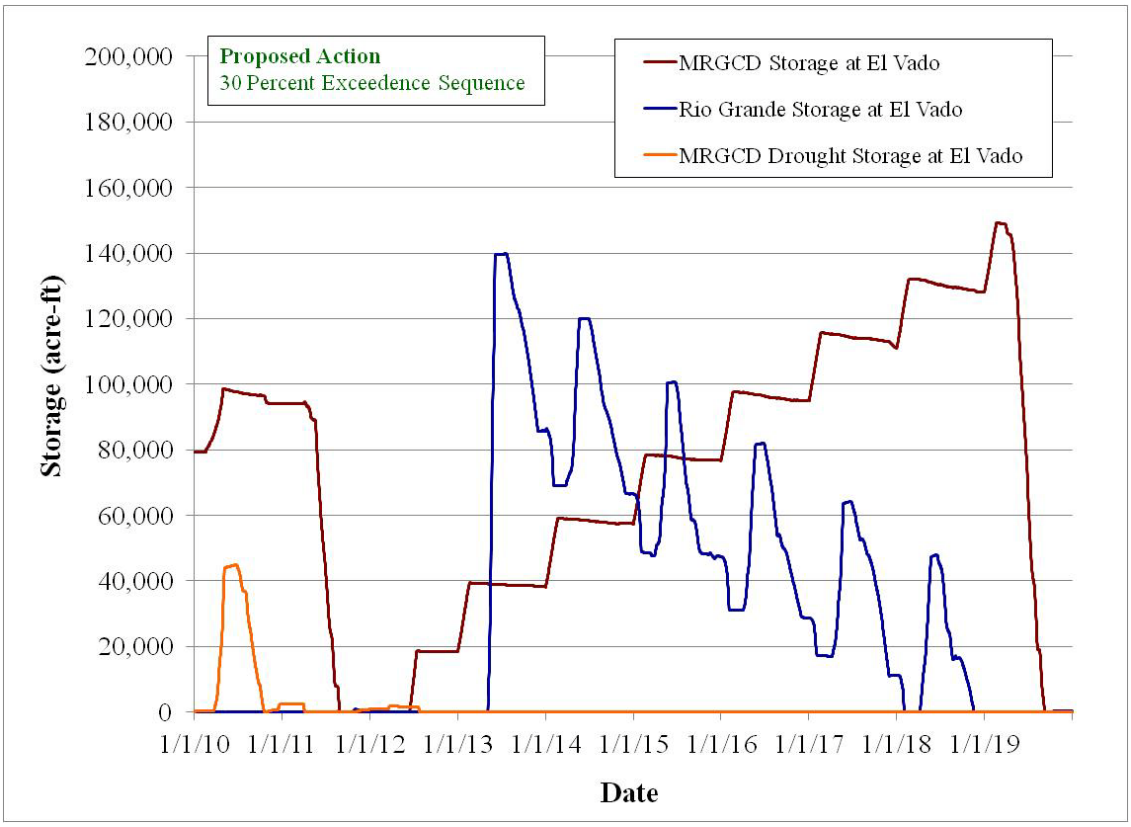

Figure 4.16. MRGCD's Supply of San Juan-Chama Water, Native Rio Grande Water, and Emergency Drought Water at El Vado Reservoir – 30 percent Exceedence Sequence

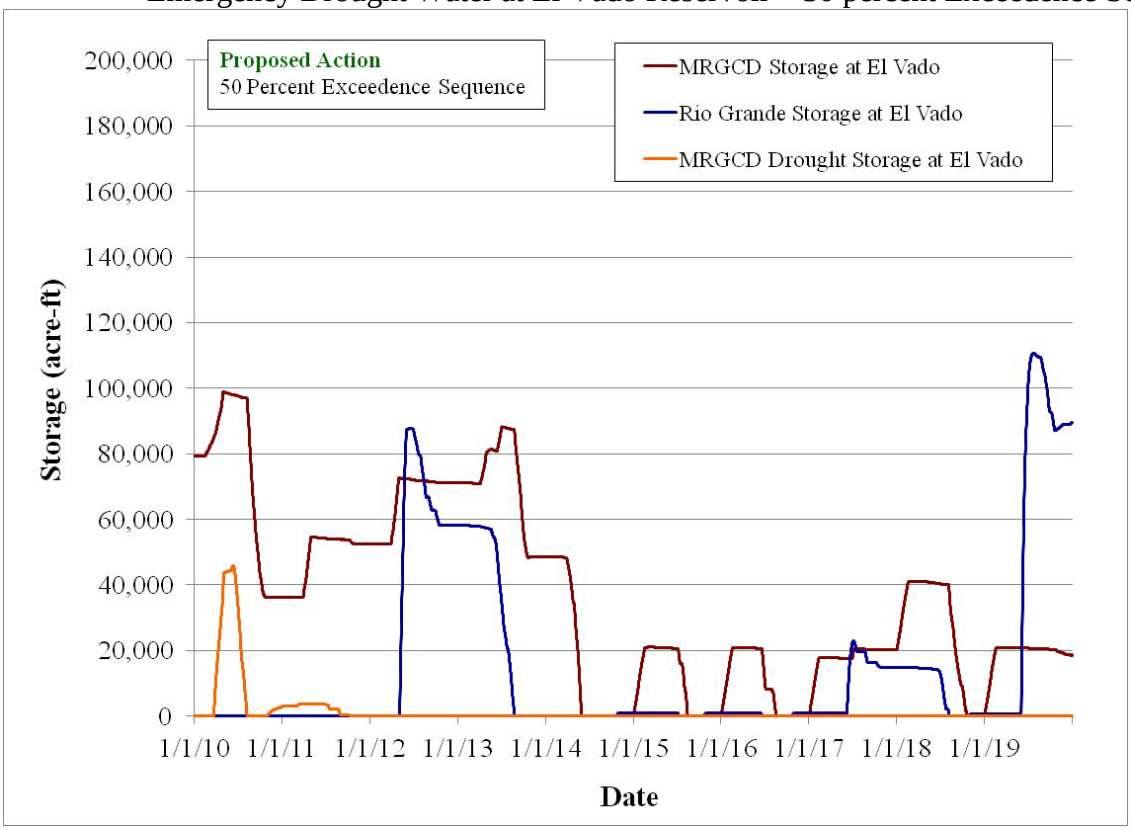

Figure 4.17. MRGCD's Supply of San Juan-Chama Water, Native Rio Grande Water, and Emergency Drought Water at El Vado Reservoir – 50 percent Exceedence Sequence

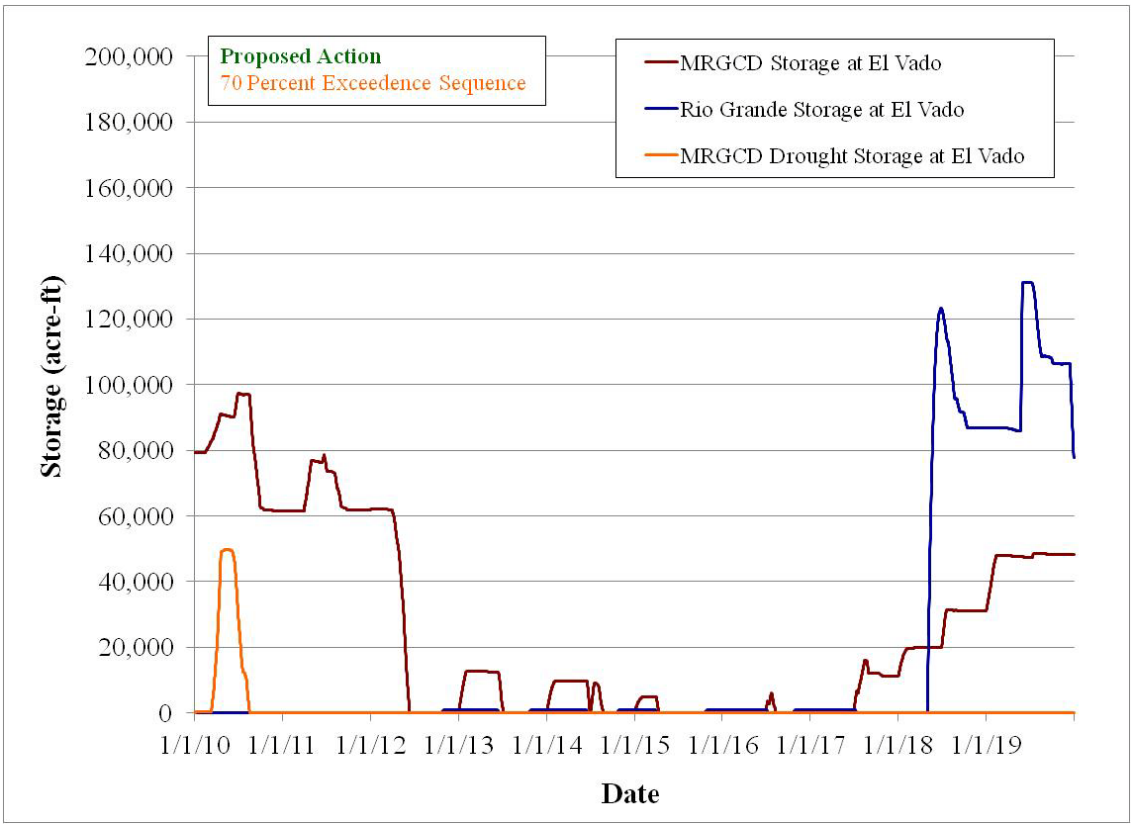

Figure 4.18. MRGCD's Supply of San Juan-Chama Water, Native Rio Grande Water, and Emergency Drought Water at El Vado Reservoir – 70 percent Exceedence Sequence

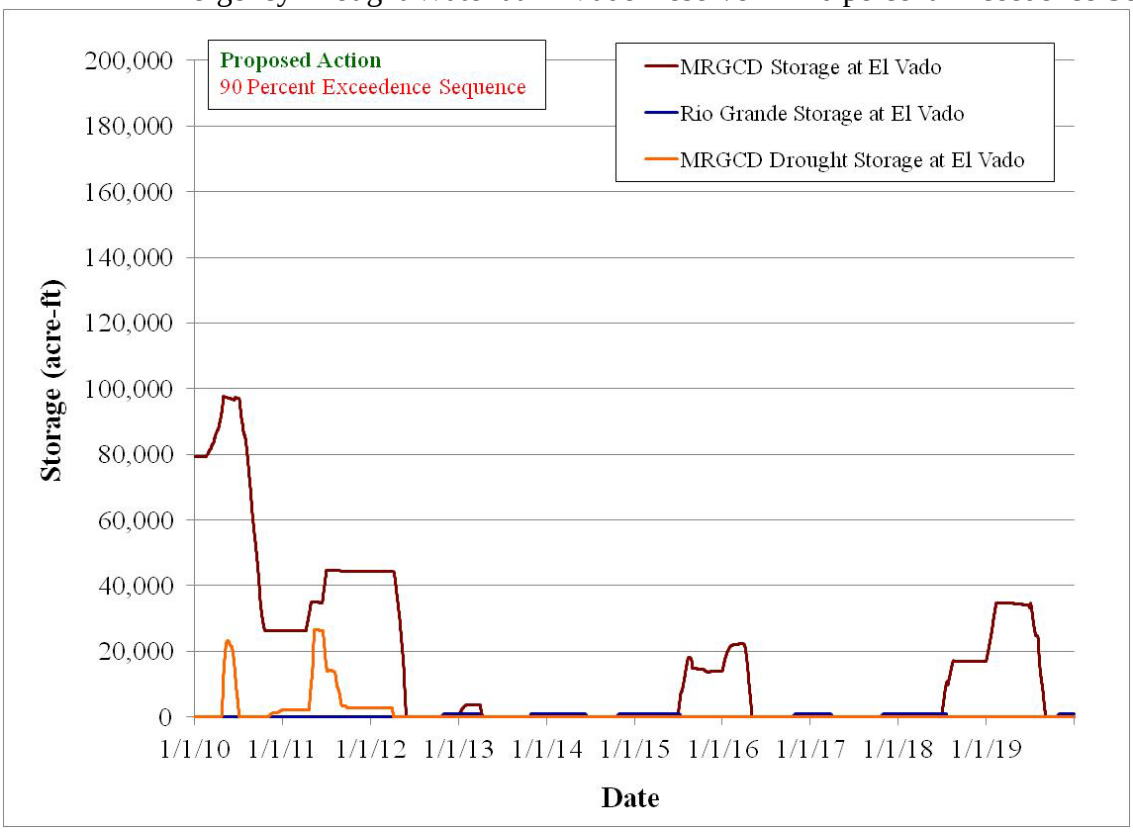

Figure 4.19. MRGCD's Supply of San Juan-Chama Water, Native Rio Grande Water, and Emergency Drought Water at El Vado Reservoir – 90 percent Exceedence Sequence

4.1.6. ABCWUA Supply

Results for the simulations for the Proposed Action were reviewed to evaluate the status of ABCWUA's water supply in storage under each of the hydrologic sequences. The supply is a function of the annual allocation of San Juan-Chama Project water and releases to meet the demands for the surface water diversion and letter water deliveries. With similar demand schedules regardless of the hydrologic sequence and a full allocation received in essentially every year, the supply is similar between the model runs for each sequence and mostly independent of the hydrology unless a full allocation of San Juan-Chama Project water is not received due to a shortage in the supply at Heron Reservoir. Refer to Figures 4.20 through 4.24 for plots of the ABCWUA supply at Heron and Abiquiu Reservoirs for the model runs completed with each of the five hydrologic sequences. The plots show an initial high storage of ABCWUA San Juan-Chama Project water with water at Heron eventually moved to Abiquiu Reservoir as space becomes available while utilizing a waiver at Heron Reservoir. With the higher demands as a result of the startup of the surface water diversion and higher ABCWUA letter water deliveries to payback for the impacts of past groundwater pumping, the supply is gradually drawn down to where ABCWUA is simply utilizing the full allocation each year.

Full allocations are made on January 1st for every year with the 10 percent exceedence sequence. Note that when full allocations cannot be made at Heron on January 1st, additional allocations are made on July 1st within URGWOM. With the additional allocations on July 1st, full allocations are made in every year with the 30 and 50 percent exceedence sequences. A full allocation still cannot be made for the sixth year under the 70 percent exceedence hydrologic sequence with only a 43% allocation made for that year. Also, full allocations cannot be made for the fourth, fifth, seventh, and eighth years under the 90 percent exceedence hydrologic sequence with 84%, 81%, 48%, and 57% of the full allocation made in those years, respectively. Allocations for all other contractors would be curtailed with same percentages. Results for ABCWUA's supply in the model runs with all PHVA flow tools included are similar as ABCWUA's supply is not impacted by the additional flow tools.

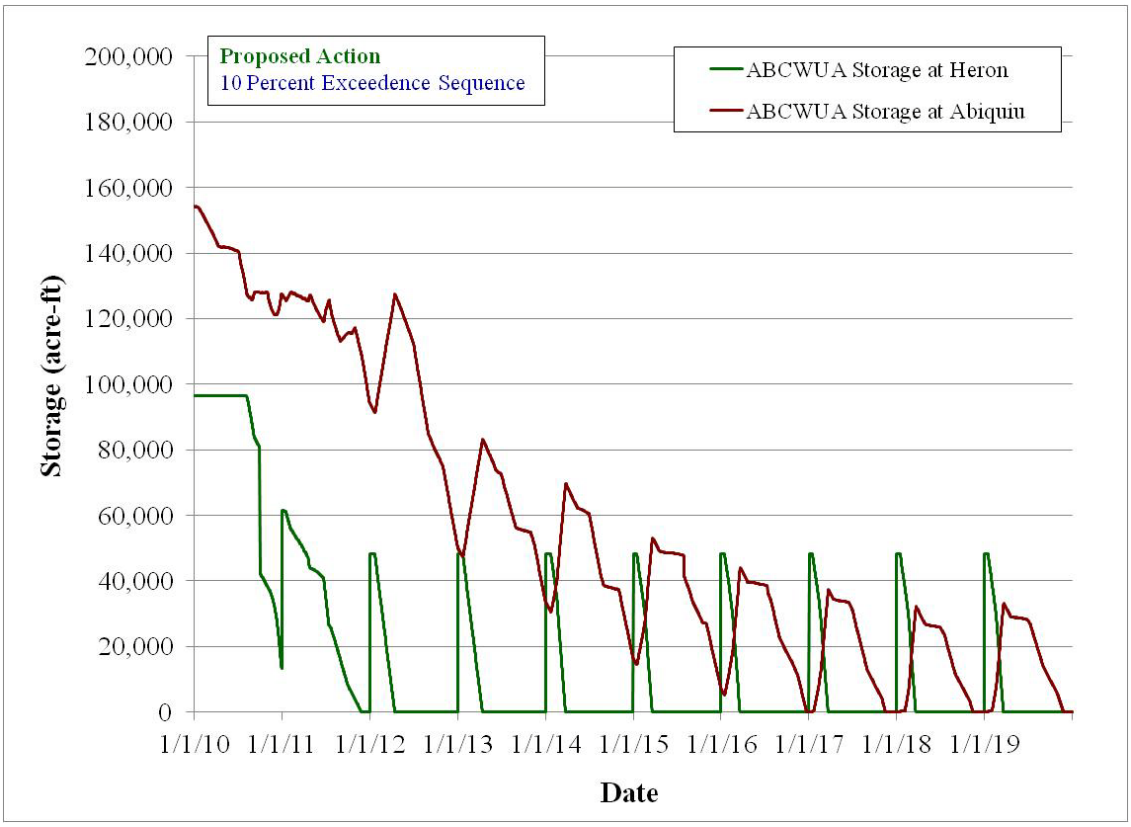

Figure 4.20. ABCWUA's Supply of San Juan-Chama Water at Heron and El Vado Reservoirs – 10 percent Exceedence Sequence

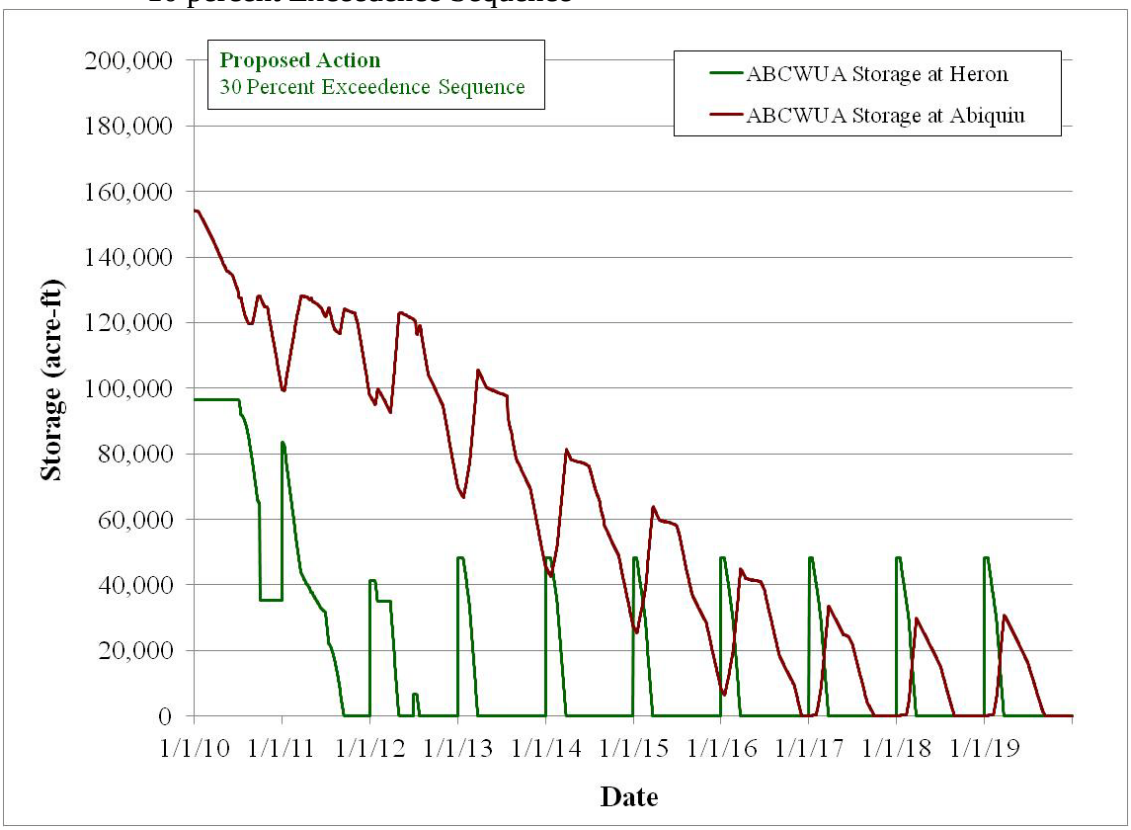

Figure 4.21. ABCWUA's Supply of San Juan-Chama Water at Heron and El Vado Reservoirs – 30 percent Exceedence Sequence

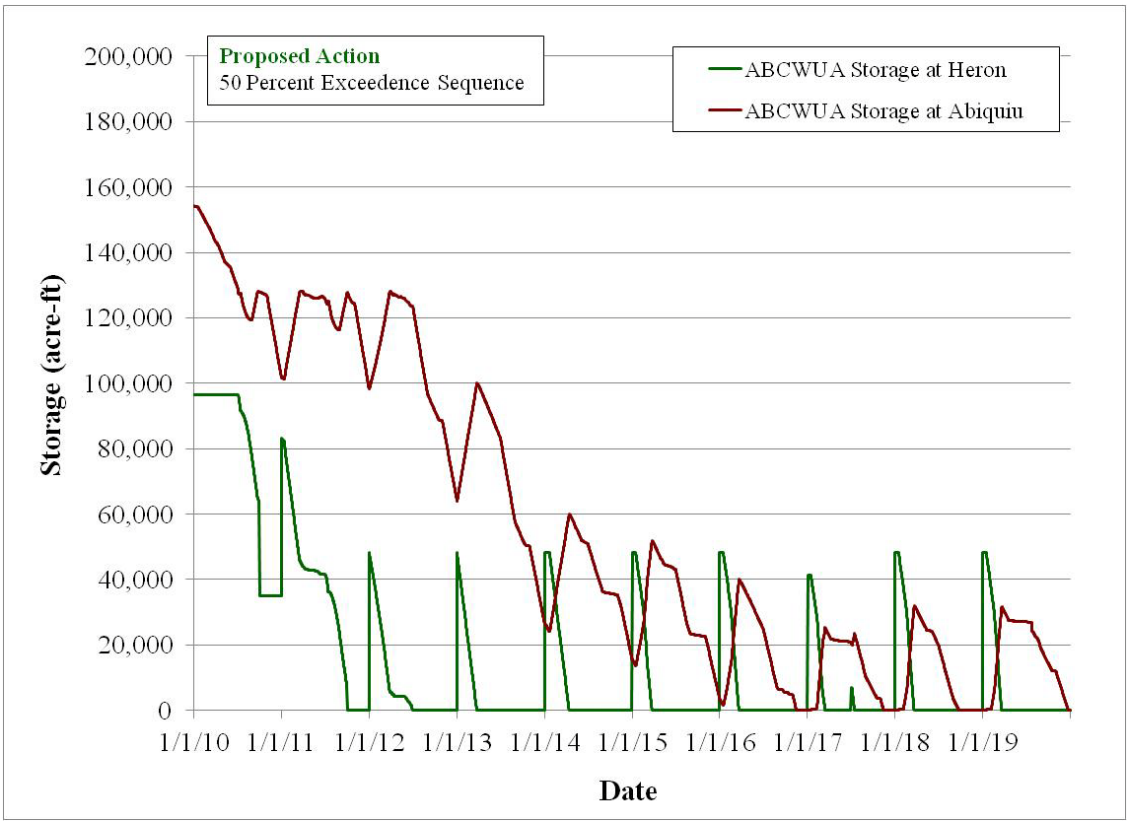

Figure 4.22. ABCWUA's Supply of San Juan-Chama Water at Heron and El Vado Reservoirs – 50 percent Exceedence Sequence

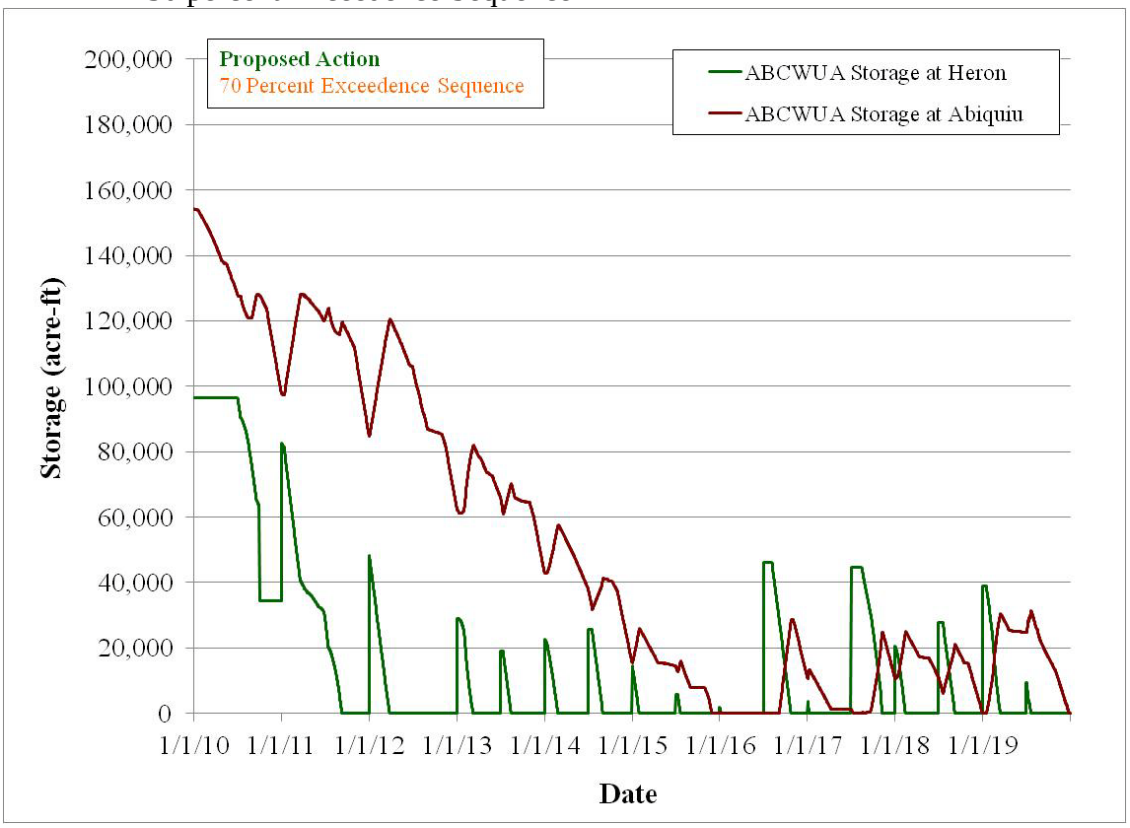

Figure 4.23. ABCWUA's Supply of San Juan-Chama Water at Heron and El Vado Reservoirs – 70 percent Exceedence Sequence

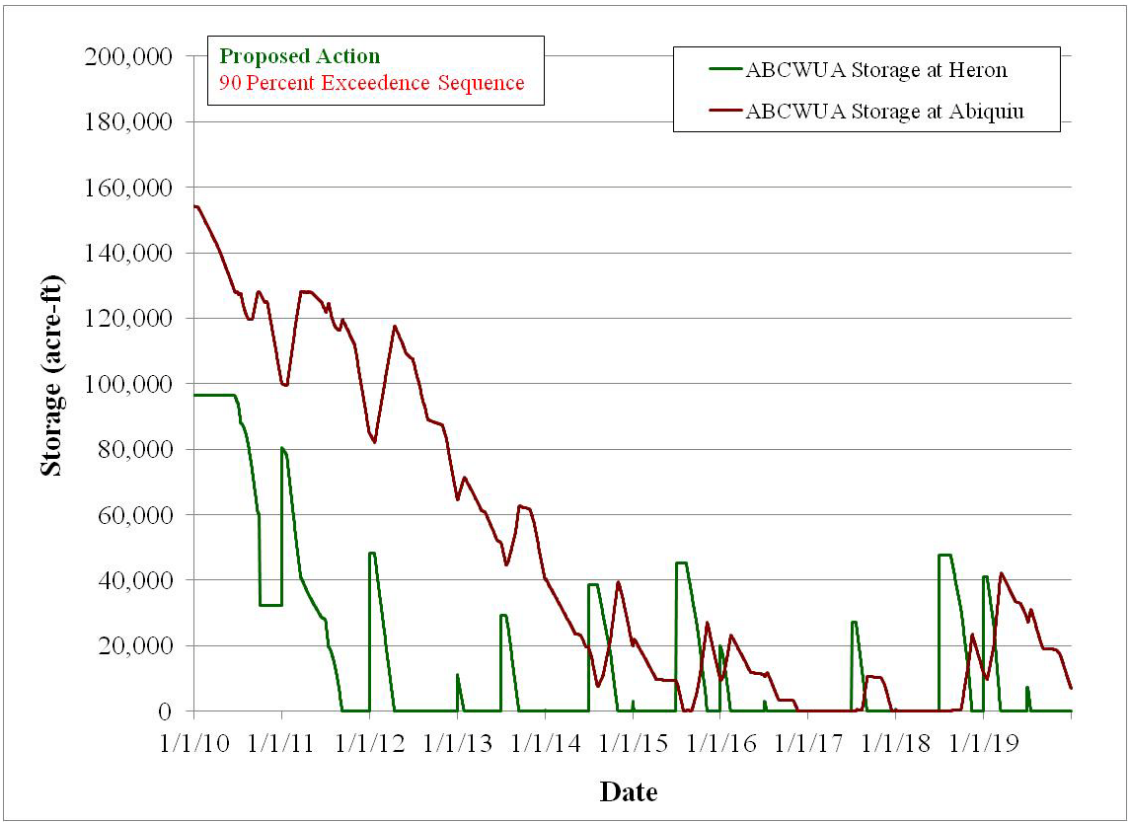

Figure 4.24. ABCWUA's Supply of San Juan-Chama Water at Heron and El Vado Reservoirs – 90 percent Exceedence Sequence

4.2. Reclamation Actions and Non-Fed Actions

Results were reviewed from model runs set up to evaluate the impact of Reclamation's water operations actions (Heron Dam operations for the San Juan-Chama Project and Middle Rio Grande Project operations along with the Supplemental Water Program) and non-Federal actions (including operations of the Middle Rio Grande diversion structures to provide flows to MRGCD and the six Middle Rio Grande pueblos) as described in section 3.4. Impacts were analyzed by utilizing the model runs set up by sequentially turning off each action, and flow exceedence curves are presented to illustrate the impacts of each action on the occurrence of low flows in the Middle Rio Grande from the fifty years of simulation results using the five 10-year hydrologic sequences.

4.2.1. Heron Dam Ops, El Vado Dam Ops, and the Supplemental Water Program

Reclamation's operations of Heron Dam for the San Juan-Chama Project result in augmented flows below Cochiti Dam as a result of ABCWUA deliveries to their surface water diversion and MRGCD deliveries during periods when native supplies may be exhausted and MRGCD would otherwise be in a shortage situation. Reclamation's leases of San Juan-Chama Project water also contribute to flows in the Middle Rio Grande with leased water released to meet flow requirements under the 2003 BO. Other uses of San Juan-Chama Project water are upstream and do not affect flows in the Middle Rio Grande. Many contractors use their San Juan-Chama Project water to provide an even offset for depletions caused further upstream, as administered

by the Office of the State Engineer. Cochiti Recreation Pool water is used to offset evaporation losses from the recreation pool upstream of the Middle Rio Grande.

El Vado Dam operations to store native Rio Grande flows for MRGCD and deliver this water later as needed to meet the need for MRGCD diversions results in augmented flows in habitat for the Rio Grande silvery minnow during low flow periods. Model run results indicate that recruitment or overbank flows would occur for a few extra days during some years with no El Vado Dam operations, but thresholds for defined recruitment or overbank flows would occur anyway during these years. Also, during drier years, storage at El Vado Reservoir often does not occur anyway due to storage restrictions in place per Article VII of the Compact or the inflows to the reservoir are too low for any appreciable storage to occur while still meeting the daily Middle Rio Grande Project irrigation demand. Also, storage at Abiquiu Reservoir for the 1800 cfs channel capacity below Abiquiu Dam results in curtailed flows from the Rio Chama during the runoff, and these curtailments would still occur if inflows were always bypassed at El Vado Dam. Reclamation's operations at El Vado Dam have a slight impact on the occurrence of recruitment or overbank flows.

Refer to Figure 4.25 for a comparison of exceedence curves developed for the Proposed Action with the Supplemental Water Program, the Proposed Action without the Supplemental Program, and MRGCD Diversions Only (or no Heron Dam operations or El Vado Dam operations). The difference in the curve for conditions with the MRGCD Diversions Only and the curve for the Proposed Action without the Supplemental Water Program depicts the benefits of Reclamation's actions of Heron Dam Operations for the San Juan-Chama Project and El Vado Dam operations. These operations result in augmented flows in the Middle Rio Grande with just a slight impact on higher flows. A comparison then to the curve for the Proposed Action with the Supplemental Water Program depicts the additional benefits from Reclamation's leases of San Juan-Chama Project water.

While increased flows are evident below Cochiti Dam and at Central from Heron Dam operations, much of the additional flows are diverted at the ABCWUA diversion or at MRGCD diversions at Cochiti, Angostura, or Isleta. Additional flows below Isleta from San Juan-Chama Project water are essentially entirely from leased water to Reclamation's Supplemental Water Program minus conveyance losses. Note that benefits of supplemental water used to meet targets will not be realized in lower reaches with no targets since supplemental water will be diverted by MRGCD if there are no downstream targets, and Heron Dam operations for the San Juan-Chama Project have essentially no impact on the occurrence of recruitment or overbank flows in the Middle Rio Grande. Also, available supplies of lease water are now limited but Heron Dam operations and the deliveries of San Juan-Chama Project water to ABCWUA and MRGCD and the remaining supplemental water will help to reduce the future occurrences of river drying. The positive impact of San Juan-Chama water will be most apparent during drier conditions when MRGCD would otherwise be out of native supplies and ABCWUA would be using groundwater to meet drinking water needs. Under these conditions, San Juan-Chama water will be the primary source for flows in the river and habitat for the silvery minnow.

The model results indicate that river drying would be more frequent with no El Vado Dam operations and more prolonged periods of river drying can be expected that coincide with an increased amount of time that MRGCD would be in a shortage situation as a result of not having the additional supply from storage at El Vado Reservoir during the runoff. With no storage at El Vado Reservoir, diversions at Angostura will be increased after the runoff every year to allow for

the available water to be used as efficiently as possible and allow for water to be delivered to the six Middle Rio Grande pueblos. At these times, river drying could be expected in the Albuquerque reach in addition to drying in typical problem areas along the Isleta and San Acacia reaches. Drying would be expected an additional eight percent of the time (28 more days/year on average) below the Isleta Diversion as indicated by the flow exceedence curves in Figure 4.25. It should also be noted that not including pumping operations from the Low Flow Conveyance Channel would also significantly increase the amount of river drying along the San Acacia reach. With no pumping operations, increased river drying can be expected below each pump site.

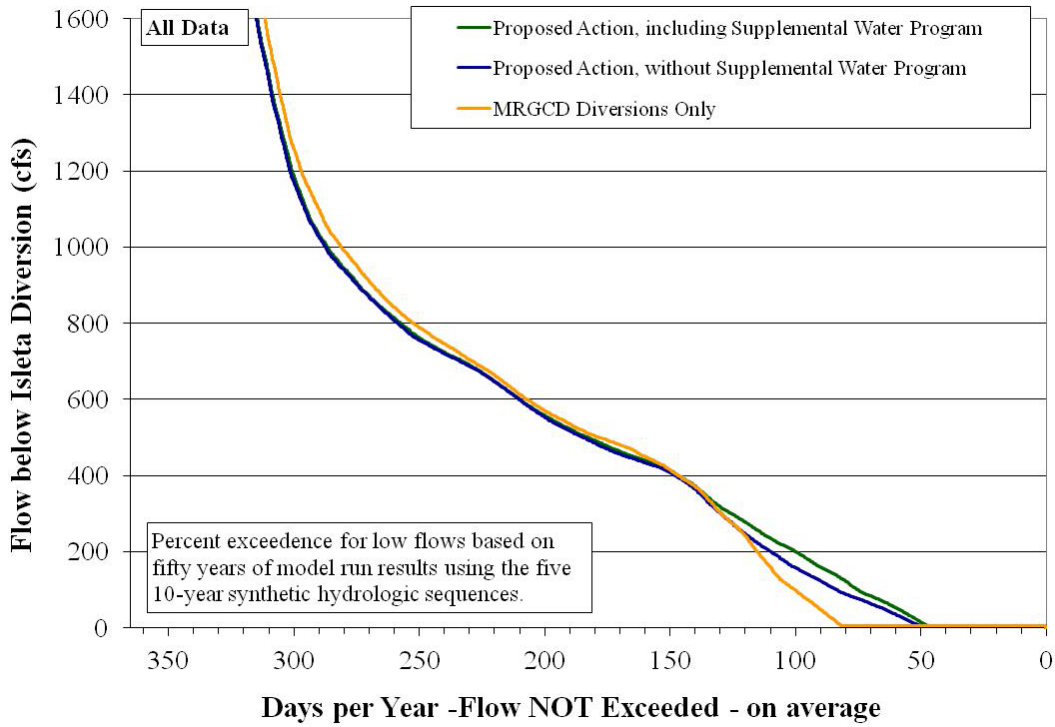

Figure 4.25. Flow Exceedence Curves Depicting the Impact of Reclamation's Actions (Heron Dam Operations for San Juan-Chama Project and El Vado Dam Operations) and the Supplemental Water Program on Flows at below the Isleta Diversion Dam

4.2.2. Middle Rio Grande Project Diversions

Middle Rio Grande Project diversions at Cochiti, Angostura, Isleta, and San Acacia are operated by MRGCD to divert and deliver water to MRGCD customers and also provide water to the six Middle Rio Grande pueblos. Demand for MRGCD begins with the irrigation season on March 1st each year and generally increases toward the middle of the irrigation season and subsequently decreases with water needs ending at the end of the irrigation season on October 31st. Diversions impact river flows up to the capacity of MRGCD diversions as river flows are available, and river flows would then subsequently be augmented downstream by return flows from drains and MRGCD wasteways.

Flows in the Middle Rio Grande would be significantly augmented as a result of no Middle Rio Grande Project diversions. Refer to Figure 4.26 for flow exceedence curves depicting the impact

on flows at Central where the additional flows with no diversion would essentially entirely occur during the irrigation season as indicated by Figures 4.27 and 4.28. It should be noted that calibrating URGWOM to simulate the occurrence of river drying under these conditions was particularly difficult due to the dearth of historical data under the situation of no Middle Rio Grande Project diversions, but it is emphasized that some river drying would still be expected during very dry periods directly below the Angostura diversion and along reaches of the Isleta and San Acacia reach that are most prone to drying.

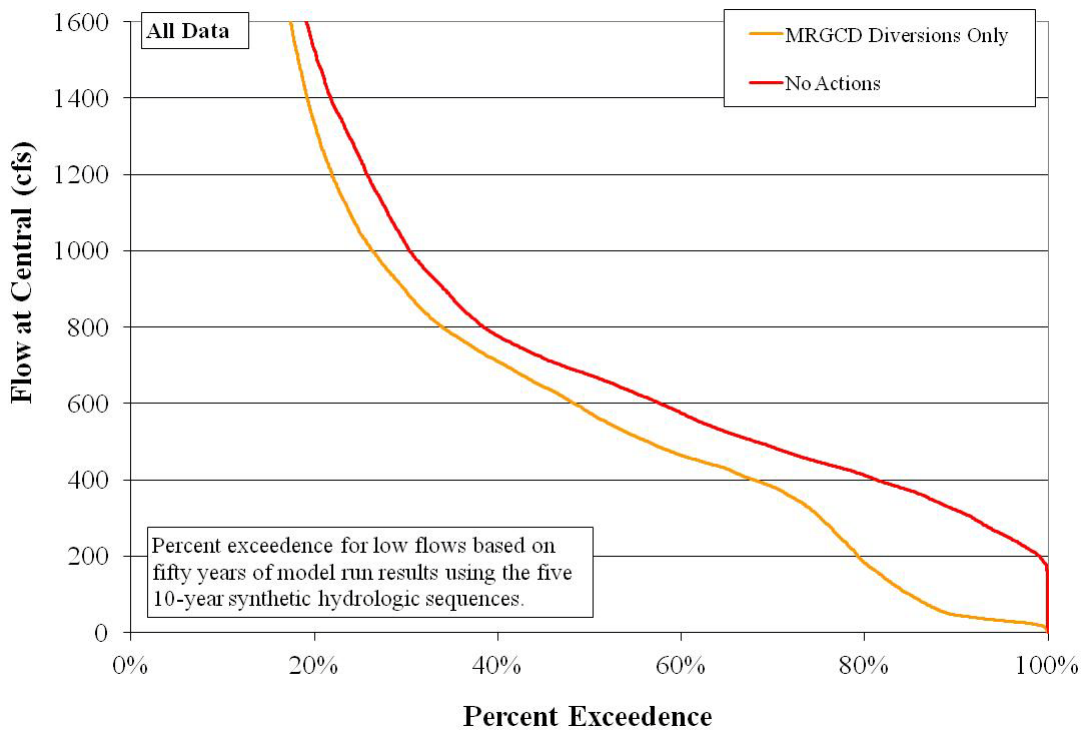

Figure 4.26. Flow Exceedence Curves Depicting Impacts of MRGCD Diversions on Flows at Central

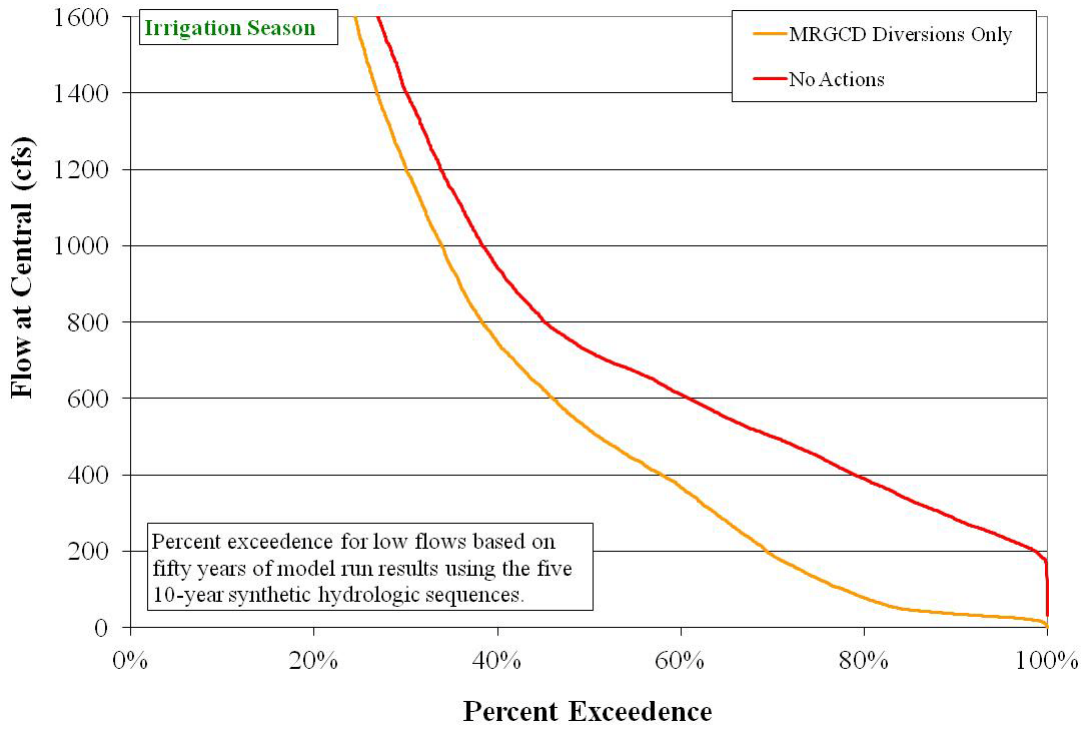

Figure 4.27. Flow Exceedence Curves Depicting Impacts of MRGCD Diversions on Flows at Central – Irrigation Season

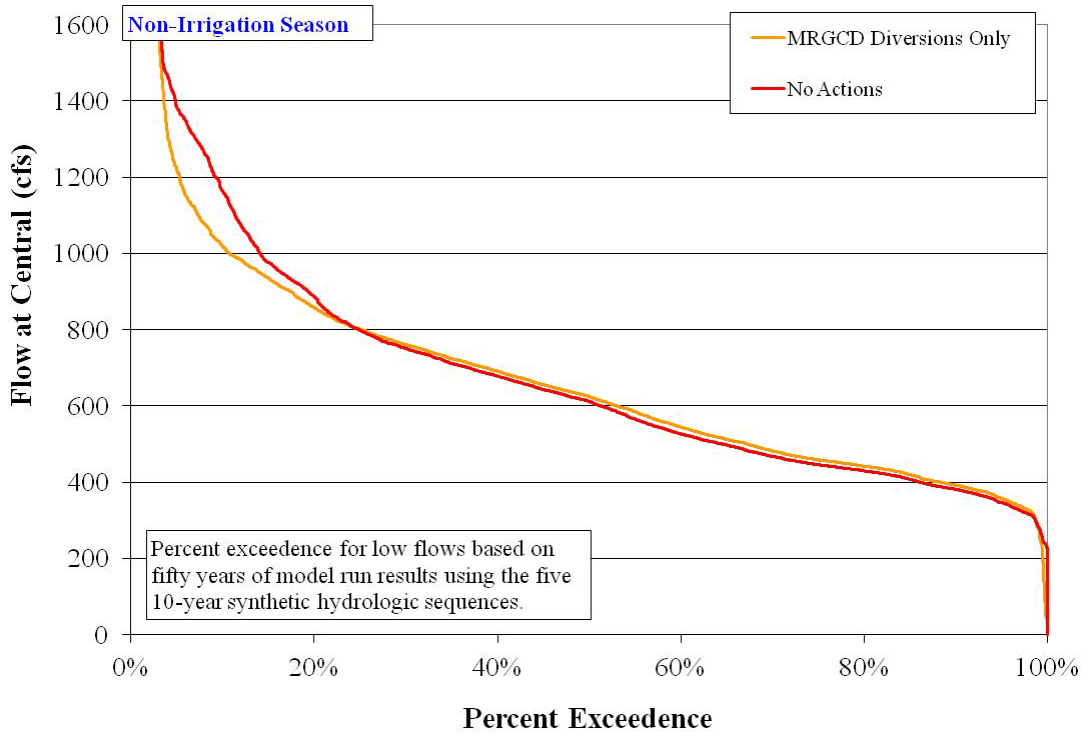

Figure 4.28. Flow Exceedence Curves Depicting Impacts of MRGCD Diversions on Flows at Central – Non-Irrigation Season

4.2.3. Contributions to Meeting Middle Rio Grande Project Diversion Demand

Results from the simulation of the Proposed Action were reviewed to evaluate the source for contributions to meeting the total demand at Cochiti for the Middle Rio Grande Project diversions between 1) natural flow, 2) releases of native Rio Grande water from storage at El Vado Reservoir, and 3) releases of MRGCD's San Juan-Chama Project water. Contributions are delineated in Figures 4.29 through 4.33 for the five model runs completed for the Proposed Action with each hydrologic sequence. Periods when MRGCD would be in shortage operations and their full demand could not be met are indicated by gaps between the contributions and the total demand. The plots clearly indicate years when MRGCD would be in an extended shortage situation if contributions from the release of native Rio Grande water from storage at El Vado Reservoir and/or MRGCD's San Juan-Chama Project water were not available. The breakdown in contributions for each model run as a percentage of the total demand is presented in Table 4.1 along with average percentages included based on all five model runs.

Table 4.1. Contributions to Meeting the MRG Project Diversion Demand at Cochiti Dam

Contribution	10 percent sequence	30 percent sequence	50 percent sequence	70 percent sequence	90 percent sequence	Avg
Natural Flow	78.8	80.8	82.0	79.3	74.5	79.2
Releases from Storage	12.0	8.4	6.3	4.9	4.0	5.9
SJC Project Water	4.8	7.2	6.8	5.9	6.8	6.7
Shortage	4.4	3.5	4.9	9.9	14.7	8.2

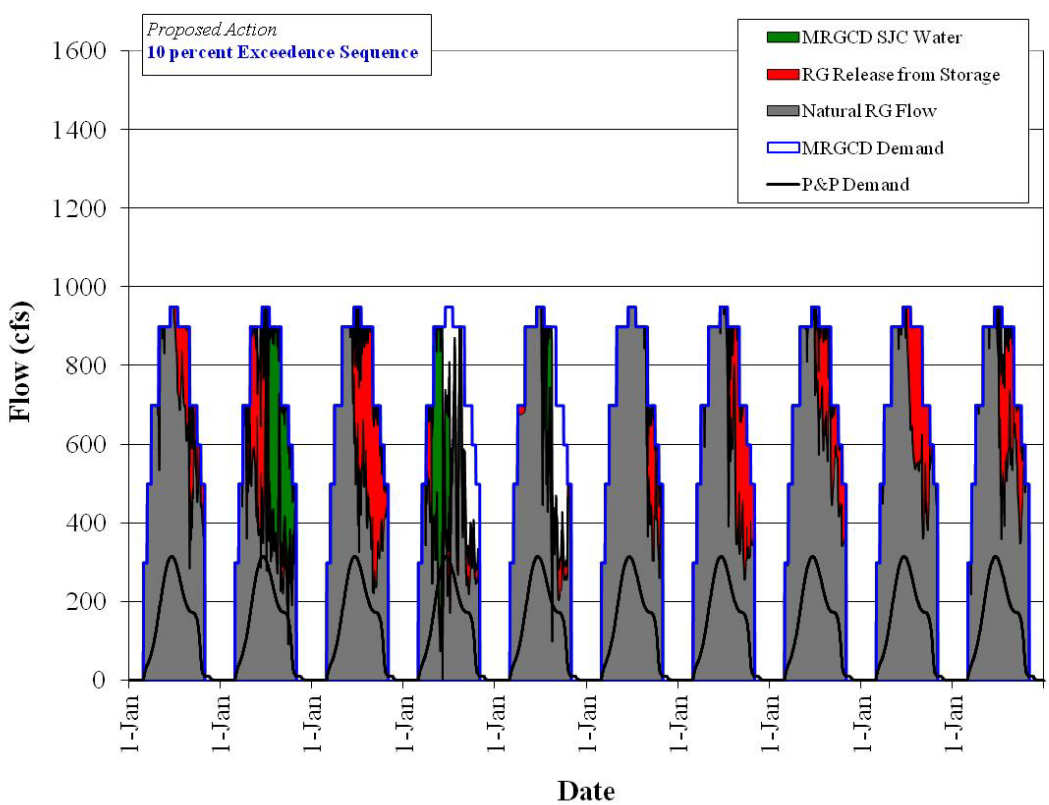

Figure 4.29. Breakdown in Contributions to Meeting the Full Middle Rio Grande Project Diversion Demand at Cochiti Dam – 10 percent Exceedence Hydrologic Sequence

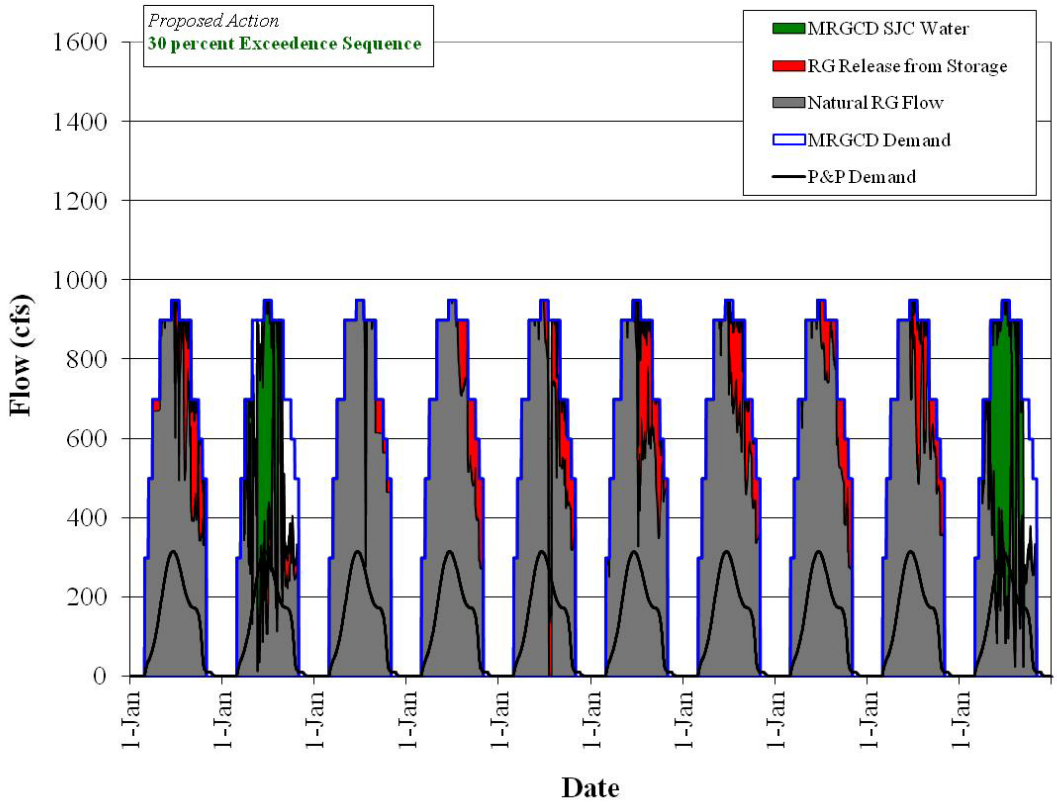

Figure 4.30. Breakdown in Contributions to Meeting the Full Middle Rio Grande Project Diversion Demand at Cochiti Dam – 30 percent Exceedence Hydrologic Sequence

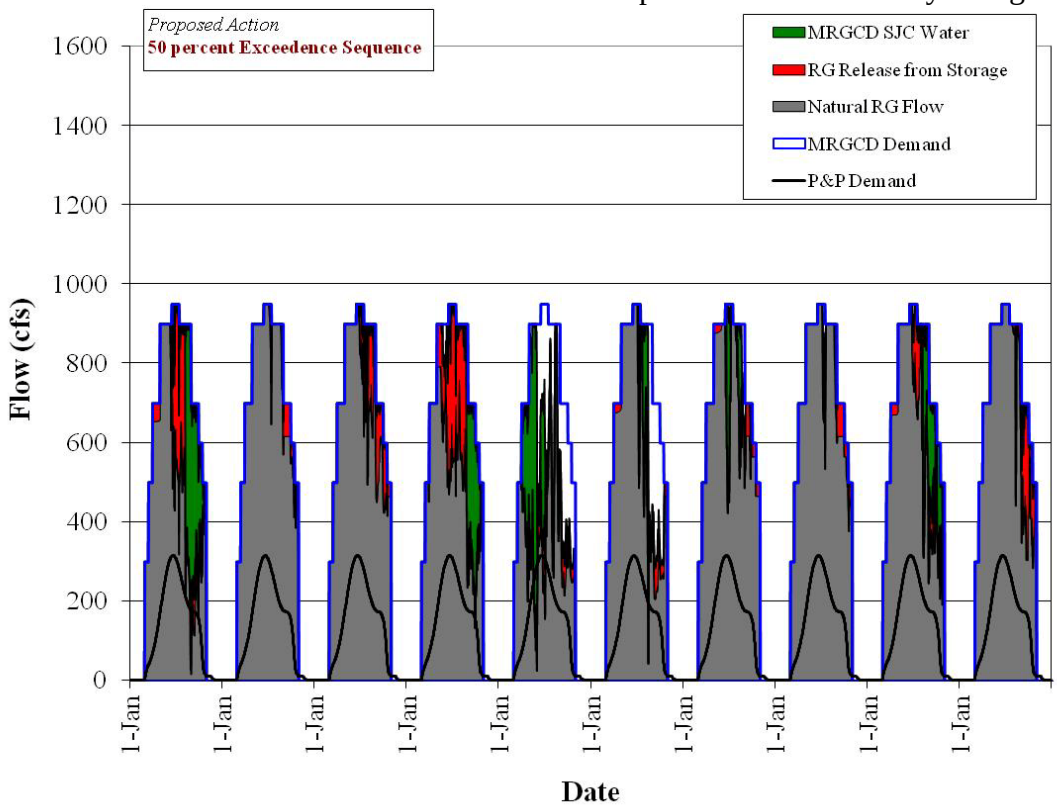

Figure 4.31. Breakdown in Contributions to Meeting the Full Middle Rio Grande Project Diversion Demand at Cochiti Dam – 50 percent Exceedence Hydrologic Sequence

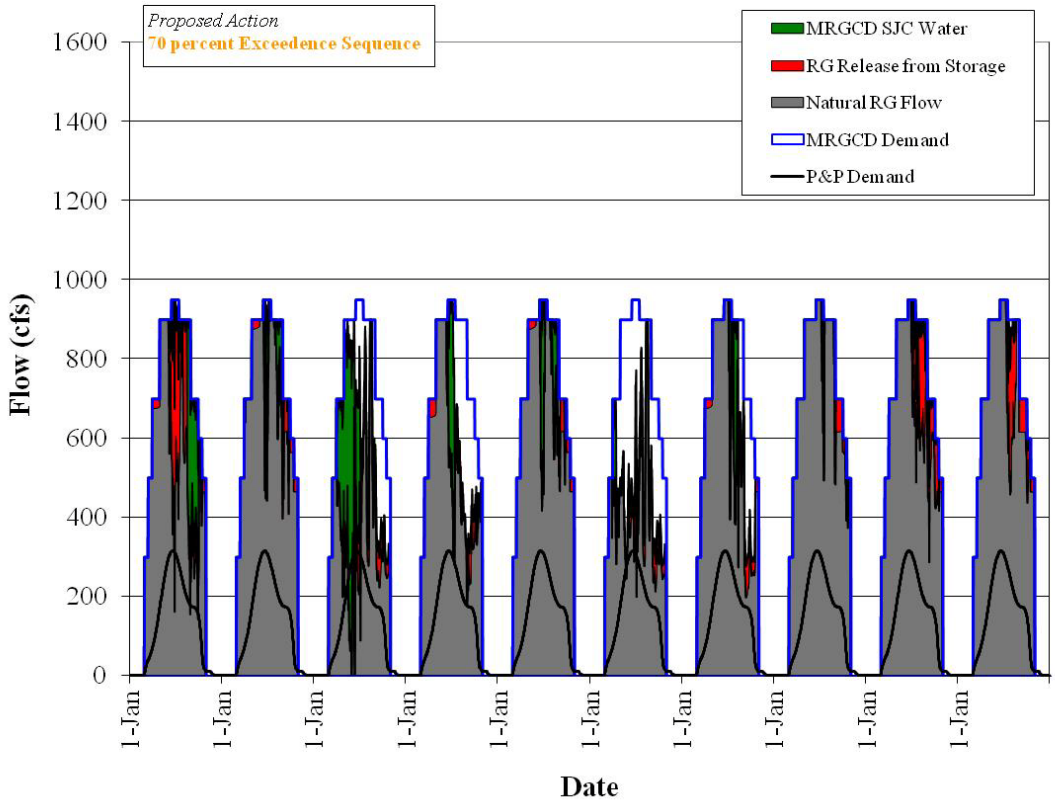

Figure 4.32. Breakdown in Contributions to Meeting the Full Middle Rio Grande Project Diversion Demand at Cochiti Dam – 70 percent Exceedence Hydrologic Sequence

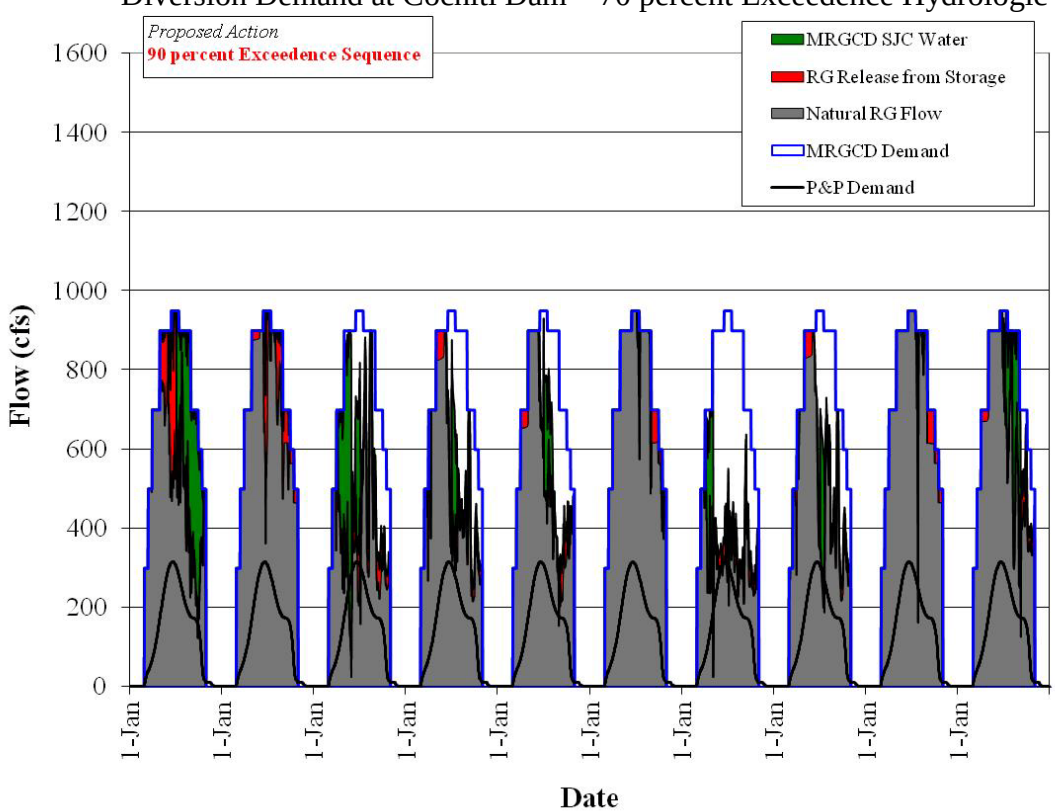

Figure 4.33. Breakdown in Contributions to Meeting the Full Middle Rio Grande Project Diversion Demand at Cochiti Dam – 90 percent Exceedence Hydrologic Sequence

5.0. Coordination with PVA Work Group

The PHVA work group was created to provide hydrologic information needed by Reclamation and the Corps to write their Rio Grande water operations BAs for use in consultation with the Service (PHVA Work Group, 2010a). This effort was to include steps to provide information to the Population Viability Analysis (PVA) work group of the Collaborative Program for their work to assess impacts of scenarios on the southwestern willow flycatcher and Rio Grande silvery minnow. Working PVA models were not developed for preparing the Bas; however, the PHVA work group provided model output and documentation and participated in joint PHVA-PVA work group sessions and ongoing communicated with the PVA work group to provide information needed to test the PVA models. This communication included a PHVA refresher held on December 2, 2009 where all PHVA work group activities were reviewed in a formal presentation for the entire Collaborative Program, and a submittal was provided to the PVA work group in 2011 in response to a formal list of needs received from the PVA work group in July, 2011. The submittal included streamflow data, URGWOM rules documentation, and information on the synthetic hydrologic sequences.

5.1. Template Output Spreadsheet

Modeled May-June flow volumes at key locations in the Middle Rio Grande was identified early in the PHVA-PVA coordination process as a potential key input to the PVA models, and sample May-June flow volumes were provided for testing the PVA models. In addition, a template spreadsheet was developed that is configured to present other output information from URGWOM simulations completed by the PHVA work group. The spreadsheet includes various types of information that can be provided from the URGWOM runs including the expected timing and extent of river drying in the Middle Rio Grande, timing of recruitment and overbank flows, the timing that Cochiti deviations are implemented, and information on the use of supplemental water to meet flow requirements. Flow exceedence curves were provided that depict the percent of time that low flows are exceeded at different locations in the Middle Rio Grande for an analysis period. In addition to series output for different slots in URGWOM, the spreadsheets include summary tables and plots of river flows and reservoir storage. A sample spatial depiction of river drying was also developed that could be used to depict the timing and extent of river drying. Any output needed from URGWOM for the PVA models is likely included in the template spreadsheets, but a table with 192 URGWOM output slots was also provided to the PVA work group with a description of what each model slot represents and background information on the output that could be provided.

5.2. Key Points Document

A document was provided to the PVA work group during the summer of 2010 and updated with small edits in 2011 (PHVA work group, 2011). The document provides key points on the modeling and analyses completed by the PHVA work group and how information is determined for providing needed inputs for the PVA models. The report includes background information on the physical layout of the system in URGWOM, model calibration, initial conditions used for simulations, the synthetic hydrologic sequences, and flow tools analyzed by the PHVA work group for potentially meeting ESA needs. A summary is also presented in the document on how target flows are used to represent the use of supplemental water to meet flow requirements and

the approach for representing discretionary operations conducted under the 2003 BO. An approach for analyzing model output to estimate when river drying would be expected is also presented that includes boundary information on subreaches included in URGWOM.

5.3. Work to Set Up URGWOM for Potential 50-year Simulations

The PVA work group has emphasized the need for lots of output from multiple longer 50-year simulations to develop distributions for inputs to the PVA models, which are stochastic models. URGWOM is a daily timestep model that includes complex accounting and a detailed representation of physical processes in the basin, and as a result, continuous model runs for periods much longer than 10 years cannot be completed due to memory limitations. An analysis period of 10 years had been defined for preparing the BAs, but the URGWOM Technical Team has been working on different tasks to be able to eventually complete 50-year simulations.

Initially, an updated set of scripts were developed for use in an Excel wrapper to complete 50-year model runs as five 10-year simulations completed in series with any combination of the five existing 10-year synthetic hydrologic sequences. While the process works, it is very cumbersome and results in significant resources being required to complete model runs and review output. With this approach, all the output from the full 50-year simulations is then not contained in a single RiverWare model file but only the exported output is available in database files. Model checking and debugging becomes very difficult, and the full simulations take several hours to complete. Output from a 50-year model run completed with the Excel wrapper was provided to the PVA work group by the Interstate Stream Commission (ISC) to use to test the PVA models for a simulation for the Pre-ESA Management scenario. A description of the Pre-ESA Management scenario was provided in February 2010.

Reclamation and the Corps also contributed funding to the RiverWare developers at CADSWES to develop a version of RiverWare for 64-bit machines. The new version of RiverWare is now available. Representatives on the URGWOM Technical Team have begun working with the IT departments at their agencies to get set up with 64-bit machines and Windows 7 to run the new version of RiverWare for 64-bit machines. A 31-year test URGWOM run was completed by the URGWOM Technical Team using the available historical record. The Tech Team has also begun work on two key next steps to 1) develop new 50-year synthetic hydrologic sequences and 2) develop an approach for efficiently populating model runs with inputs for sequences. Historical data needed to run URGWOM are only available for years 1975 and later, so this is an issue that will need to be considered as part of developing new meaningful hydrologic sequences.

The URGWOM Technical Team has also completed a detailed review of the model to identify areas where the model could be adjusted to improve the efficiency for simulations and allow for longer model runs to be set up. Such changes include eliminating accounting supplies and exchanges that are no longer used in simulations and simplify the approach for representing movement of water allocated for different contractors for San Juan-Chama Project water. The Tech Team is also looking into a simpler approach for representing crop consumption from irrigated lands in the Middle Valley. The RiverWare developers have also provided some suggestions for changes to the approach for coding rules that should improve the model performance. The Tech Team has also initiated a long-term effort to develop a monthly timestep RiverWare model (Boroughs, 2011); although, it is not expected that needed inputs for the PVA models could be provided accurately with simulations completed at a monthly timestep.

6.0. Conclusions

URGWOM was used as a tool for providing needed information for the Corps and Reclamation to prepare their Rio Grande water operations BAs. After an extensive review of the existing model and ruleset and model enhancements were implemented to meet the needs for the analyses completed by the PHVA work group of the Collaborative Program, the model was used to analyze impacts of a final determined Proposed Action for Reclamation's BA. The Proposed Action entails meeting the 2003 BO requirements as possible utilizing an initial supply of supplemental water and future Reclamation leases of San Juan-Chama Project water (12,000 acre-ft/year for the first five years and 8000 acre-ft/year for the following five years). Pumping from the Low Flow Conveyance Channel is also included to manage the recession after the continuous flow requirement (or after the runoff).

Flow requirements under the 2003 BO cannot be fully met under the Proposed Action. More river drying will occur. Results from the modeling indicate the total annual amount of supplemental water needed to meet the 2003 BO flow requirements over the next ten years may average from 32,000 acre-ft/year to 49,000 acre-ft/year depending on the hydrology. The additional amount of supplemental water needed beyond the amount provided under the Proposed Action may average from 17,800 acre-ft/year to 35,900 acre-ft/year.

A review of the impact of Reclamation's actions including Heron Dam operations for the San Juan-Chama Project and El Vado Dam operations along with the Supplemental Water Program was completed. It was determined that Heron Dam operations help to augment flows in the Middle Rio Grande as a result of providing San Juan-Chama Project water to MRGCD and ABCWUA along with leases of San Juan-Chama Project water used for meeting flow requirements under the 2003 BO. El Vado Dam operations also help to augment flows in the Middle Rio Grande. Water stored during the runoff as not needed to meet the daily Middle Rio Grande Project irrigation demand, and when storage restrictions per Article VII of the Compact are not in effect, is released later in the summer and helps to provide additional flows in the Middle Rio Grande. It was determined that Middle Rio Grande Project diversions adversely impact flows; flows in the Middle Rio Grande would be augmented without diversions.

A review of other PHVA flow tools, throughout the modeling process, as not included with the Proposed Action indicates that additional Relinquished Credits would significantly contribute to the needed supply of supplemental water to meet flow requirements under the 2003 BO and reduce the amount of river drying, but a significant additional amount of supplemental would still be needed to always meet the 2003 BO flow requirements. Also, Cochiti deviations would continue to help with reducing prolonged periods with no recruitment or overbank flows.

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APPENDIX 8

DRAFT MRGRIP PROGRAM DOCUMENTS, ACTION PLAN, AND COOPERATIVE AGREEMENTS

Draft
Middle Rio Grande Collaborative Recovery Implementation Program (RIP) Document

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July 12, 2012 Draft

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I. Statement of Purpose and Goals

This Program Document provides the framework for the Middle Rio Grande Collaborative Recovery Implementation Program (RIP). It describes, among other things, the RIP's purpose and goals, its scope, the organizational structure and governance protocols (Appendix __) for RIP implementation, the substantive RIP Action Plan (Appendix __) elements, criteria for measuring progress, and principles for compliance under the Endangered Species Act (ESA) of 1973 as amended.

A. Purpose

The general purpose of the RIP is:

To protect and improve the status of species listed pursuant to the ESA within the Middle Rio Grande (MRG) by implementing certain recovery activities to benefit those species and their associated habitats, with special emphasis on the Rio Grande silvery minnow (*Hybognathus amarus*; silvery minnow) and the Southwestern Willow Flycatcher *(Empidonax traillii extimus*; flycatcher);

and, simultaneously,

To protect existing and future water uses while complying with applicable state and federal laws, rules and regulations, and to serve as the ESA coverage vehicle for water uses and management actions in the MRG Program area (see area map on page 7).

B. Goals

The goals of the RIP are to:

1. Alleviate jeopardy to the listed species and adverse modification of their designated critical habitats in the MRG Program area

    - Avoid actions that preclude survival or recovery of the listed species

    - Continually identify the critical scientific questions and uncertainties that will be addressed through adaptive management (AM) in support of a hydrologically and biologically sustainable MRG water operations Biological Opinion[1] (BO)

2. Conserve and contribute to the recovery of the listed species within the constraints of the RIP
    - Stabilize existing populations through ongoing and future management activities

[1] The U.S. Army Corps of Engineers submitted a Biological Assessment and has requested a separate BO.

- Support the development of self-sustaining populations

3. Protect existing and future water uses

    - Provide a mechanism for ESA compliance for identified federal and non-federal actions that do not create additional net depletions to the MRG

    - Provide a process for streamlined Section 7 consultation for future water uses needing compliance with the ESA

C. Principles

The RIP may not impair state water rights of individuals and entities or federal reserved water rights of individuals and entities; federal or other water rights of Indian nations and Indian individuals, or Indian trust assets; San Juan-Chama Project contractual rights; or the State of New Mexico's ability to comply with Rio Grande Compact delivery obligations. Water to be acquired or otherwise made available for endangered species benefits must be from a willing donor, seller or lessor and be used in compliance with applicable federal law and the laws of the State of New Mexico including, but not limited to, permitting requirements.

The RIP will use adaptive management processes pursuant to Section VII.

The RIP will be implemented in a manner that is transparent to stakeholders, the public, and other interested parties.

II. History of Program

A. Species Listings, Critical Habitat Designations, and Resulting Actions

The silvery minnow was listed as endangered by the U.S. Fish and Wildlife Service (Service) in 1994 and the flycatcher was listed in 1995. Critical habitat was designated for the silvery minnow in 2003 and revised for the flycatcher in 2005; both areas include the MRG (excluding Pueblo lands).

Drought conditions in 1996and the realization that the needs of the endangered species could conflict with the needs of MRG water users served as impetus for increased cooperation among affected entities to develop proactive solutions. Supplemental water management to support ESA compliance and MRG water operations began in 1996.

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In 1997, federal agencies joined to outline alternatives to satisfy the water needs of the silvery minnow and accommodate the needs of the MRG water users. The alternatives were presented in a white paper and included water acquisition, water management, and water-use efficiencies. The white paper also recommended the development of a plan of action. In 1998, certain environmental community members formed the Alliance for the Rio Grande Heritage and worked to develop a green paper because they felt the white paper lacked specific recommendations. The green paper stated that the long-term solution: 1) needed to include all the key players and interested participants; 2) must assure adequate river flows; and 3) had shared responsibility among all who benefit from the river. The green paper proposed acquisition and storage of water for conservation purposes. In 1998, the two groups began meeting and exchanging information to evaluate and prioritize potential solutions and define future collaborative actions. Participating organizations included American Rivers, Defenders of Wildlife, Forest Guardians, Land and Water Fund, National Audubon Society-New Mexico, New Mexico Sportsmen, Rio Grande Restoration, Sierra Club, City of Albuquerque, City of Santa Fe, Middle Rio Grande Conservancy District (MRGCD), New Mexico Interstate Stream Commission (NMISC), New Mexico Office of the State Engineer (OSE), the Service, U.S. Army Corps of Engineers (Corps), and Bureau of Reclamation (Reclamation).

Despite their efforts, in 1999 a complaint was filed, on behalf of the silvery minnow, against Reclamation and the Corps for alleged ESA and National Environmental Policy Act violations. However, all parties remained active in the collaborative process.

Court-ordered mediation in 2000 led to an Agreed Order[2] that provided additional supplemental water for both ESA and irrigation purposes. Subsequent efforts involved pumping from the Low Flow Conveyance Channel, the development of the City of Albuquerque's silvery minnow naturalized refugium, and support for improved metering and water transport efficiency of the MRGCD.

B. History of the Collaborative Program, MRG Water Management ESA Section 7 Consultations, and Related Legislation

In 2001, the Collaborative Program first received congressional appropriations for implementing projects beneficial to federally listed species, and Reclamation and the Corps (the action agencies) began consultations with the Service over their MRG water operations and maintenance. The Service issued a three-year BO that provided ESA compliance for continued water deliveries and for implementation of Collaborative Program activities.

In April 2002, a Memorandum of Understanding was signed to recommit the parties and formalize the Collaborative Program's governance.

[2][Cite to the Agreed Order.]

In 2003, Reclamation and the Corps again consulted with the Service and the Service issued a 10-year BO in March. This 2003 BO had a significant number of required flow and non-flow activities and offered broad ESA coverage utilizing a broad water depletions-based analysis.

As directed by Congress (P.L. 108-199), the Secretary of the Interior established an Executive Committee (EC) in 2004 to increase the efficiency of the Collaborative Program and implement a 75/25 federal/non-federal cost sharing provision. The EC consists of designated representatives of signatory members of the Collaborative Program and has operated to assist in making priority decisions and meeting specific goals. The Collaborative Program approved Program By-laws in October 2006 and approved a Long Term Plan (LTP) in November 2006.

In 2008, the EC adopted a Memorandum of Agreement (MOA) establishing the Collaborative Program in accordance with the 2006 By-laws. The Consolidated Appropriations Act, 2008 (Appendix ___) determined that the acquisition of water necessary to comply with the 2003 BO or in furtherance of objectives set forth in the Collaborative Program LTP shall be at full federal expense, and established that the non-federal share of activities shall be 25 percent.

The Omnibus Appropriations Act, 2009 (Appendix ___) authorized the Secretary of the Army to carry out and fund planning studies, watershed surveys and assessments, or technical studies at 100 percent federal expense to accomplish purposes of the 2003 BO, any related subsequent BO, and the Collaborative Program LTP. It also authorized the Secretary of Interior (acting through the Commissioner of Reclamation), in collaboration with the EC, to enter into any grants, contracts, cooperative agreements, interagency agreements, or other agreements that the Secretary determines to be necessary to comply with the 2003 BO or any related subsequent BO or in furtherance of the objectives set forth in the Collaborative Program LTP. This recognized a 25% non-federal cost share in cash or in-kind contributions; specified that the acquisition of water and any administrative costs shall be at full federal expense; and provided that not more than 15% of amounts appropriated shall be made available for administrative expenses.

In 2009, the EC directed efforts to pursue the transition of the Collaborative Program to a RIP to enhance the focus on recovery activities and serve as an ESA compliance vehicle using a new LTP (Appendix __) as a mechanism for advancing the Program based on the framework of the silvery minnow and flycatcher recovery plans.

C. RIP Documents

Formal documents establishing the RIP are defined as this Program Document, an Action Plan, [the LTP], and a Cooperative Agreement (Appendix __). The EC decided to develop these documents in 2011 for inclusion in the ESA Section 7 consultation for proposed federal and non-federal MRG water use and management actions. Also in 2011, the EC agreed to follow an AM approach throughout the recovery implementation process and an AM guidance document (Adaptive Management Plan Version 1 (AMP-1)) (Appendix __) was produced.

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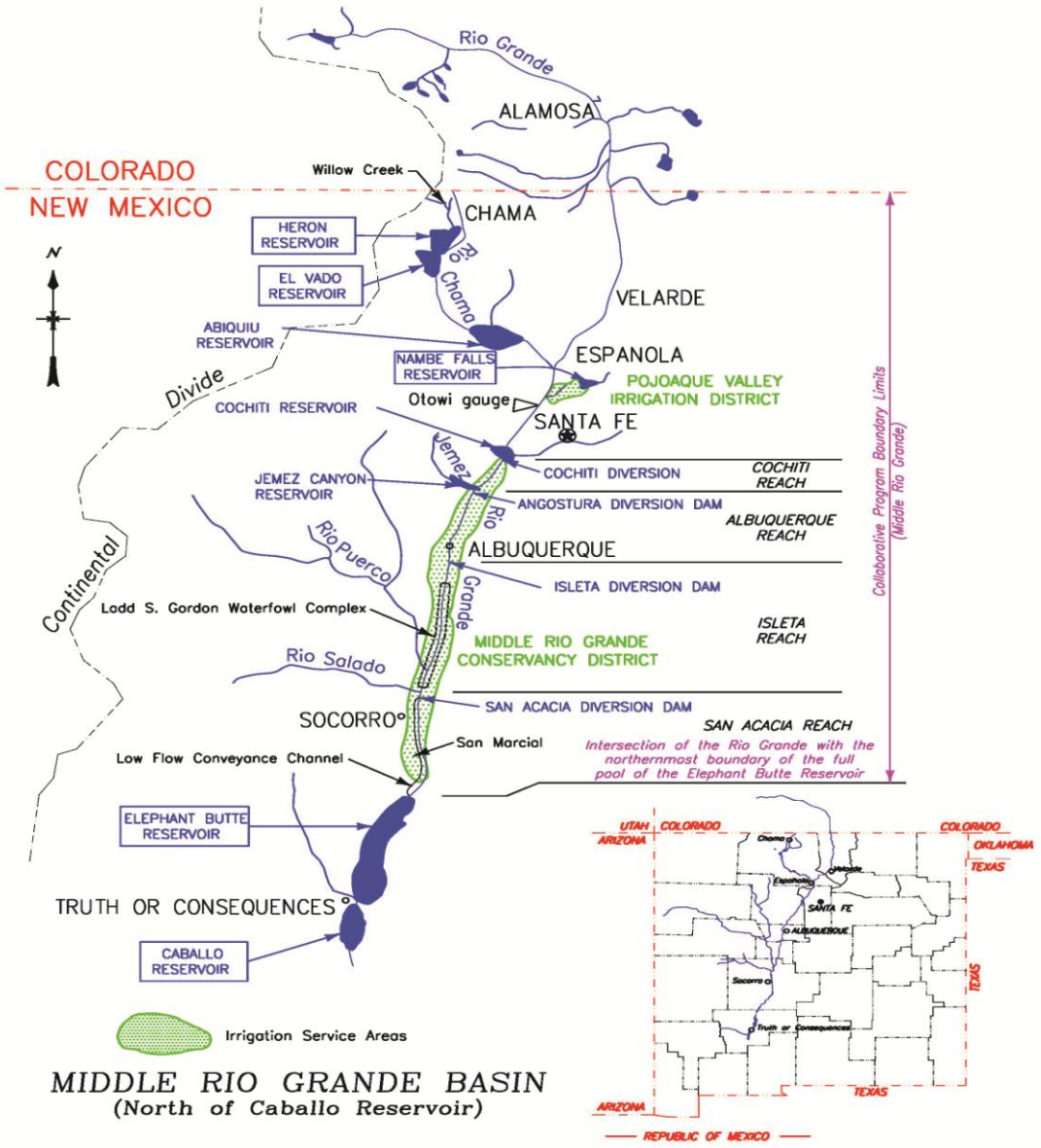
III. Program Scope

A. Middle Rio Grande Program Area

The RIP geographic area consists of the headwaters of the Rio Chama watershed and the Rio Grande, including tributaries, from the New Mexico-Colorado state line downstream to the intersection of the Rio Grande with the northernmost boundary of the full pool of the Elephant Butte Reservoir as illustrated in the MRG Basin map. Indian Pueblo and Tribal lands and resources within the RIP area will not be included in the RIP without the express written consent of the affected Indian Pueblo or Tribe. This definition does not preclude the Program from funding activities outside of this geographic area pursuant to the RIP Governance Procedures.[3]



[3] It is anticipated that certain contributions by ISC under this RIP will also contribute toward ESA compliance for the Elephant Butte temporary channel which will be addressed in a separate consultation.

B. Listed Species and Critical Habitat

The RIP is currently scoped to address two species listed under the ESA: the silvery minnow and the flycatcher. The EC may decide to include other listed species or candidate species at any time in the future.

Silvery Minnow

On July 20, 1994, the Service published a final rule to list the silvery minnow as an endangered species with proposed critical habitat (59 Fed. Reg. 36988-36995)[4]. The Service initiated a five-year review of the status of the species in 2010 (75 Fed. Reg. 15454-15456). A five-year review considers all new information available at the time of the review. There is no regulatory timeframe for completing the review; however, the Service currently has a target date of December 2012.

Critical habitat was designated for silvery minnow in 1999 (64 Fed. Reg. 36274-36290), with revisions published on February 19, 2003 (68 Fed. Reg. 8088-8135). Designated critical habitat in the Rio Grande extends through Sandoval, Bernalillo, Valencia, and Socorro Counties, New Mexico generally beginning at Cochiti Reservoir downstream to the utility line crossing the Rio Grande at the upstream end of the Elephant Butte Reservoir pool. The utility line marks the northern boundary of Reclamation's Rio Grande Project. The lateral extent of critical habitat includes those areas bounded by existing levees. In areas without levees, the lateral extent of critical habitat is defined as 300 feet (91.4 meters) of riparian zone adjacent to each side of the river.

The designation also includes a five mile segment of the Jemez River from Jemez Canyon Dam to the upstream boundary of Santa Ana Pueblo, Sandoval County. Pueblo lands in Santo Domingo, Santa Ana, Sandia, and Isleta Pueblos are excluded from critical habitat. The Service considered the Rio Grande around Big Bend National Park in Texas and the Pecos River between Ft. Sumner Dam and Brantley Reservoir in New Mexico as essential to conservation but did not designate as critical habitat.

Flycatcher

A final rule was published in the February 27, 1995 Federal Register to list the southwestern U.S. population of the flycatcher as an endangered species under the ESA with proposed critical habitat. However, the final rule designating critical habitat for the species range-wide (published on July 22, 1997) did not include the Rio Grande (62 Fed. Reg. 39129) at that time. A proposal to re-designate critical habitat was published October 12, 2004 (69 Fed. Reg. 60706), with a final designation published October 19, 2005 (70 Fed. Reg. 60886). The 2005 final designation of critical habitat defines two units located along the Rio Grande: the Upper Rio Grande Management Unit which includes 664 hectares (ha) (1,640 acres), encompassing 66 kilometers

[4] The silvery minnow is currently listed as endangered on the New Mexico state list of endangered species, having first been listed on May 25, 1979 as an endangered endemic population of the Mississippi silvery minnow (*Hybognathus nuchalis*).

(km) (41 miles), and the MRG Management Unit which includes 13,410 ha (33,137 acres) along 135 km (84 miles). The Service released a new proposal for critical habitat on August 15, 2011 (76 Fed. Reg. 50542).

C. Water Uses and Management Operations (Covered Actions)

Water uses and management operations as proposed by federal and non-federal agencies include the following:

1. Reclamation proposes the following water management operations:

    a. Operation of Heron Dam and Reservoir as part of the SJC Project to store and deliver water to downstream users;

    b. Operation of El Vado Dam and Reservoir as part of the MRG Project; and

    c. River maintenance.

2. The Corps proposes the following action:

    a. Operation and maintenance of Abiquiu Dam and Reservoir, Cochiti Dam and Lake, Galisteo Dam, and Jemez Canyon Dam and Reservoir for flood control, water storage, and sediment control.

3. Non-federal entities propose the following actions:

    a. The MRGCD proposes the following actions:

        i. Operation of the MRG Project Diversion Dams for the purpose of delivering water to district lands to meet agricultural demand of lands with appurtenant water rights, including the lands of the Six MRG Pueblos; and

        ii. Operation of irrigation drains and wasteways to return water to the river.

    b. The State of New Mexico proposes to take actions through its representative agencies to fulfill their respective missions; and

    c. [Other categories of non-federal actions to be updated and included with final BA information]

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D. RIP Activities

The RIP activities are intended to minimize the effects of the actions in Section III.C above for purposes of ESA coverage and will contribute to the recovery of the species.

The RIP activities will address elements such as species reproduction and survival, minnow captive propagation and augmentation, and research and monitoring, as described in Section V of this document and detailed in the RIP Action Plan.

IV. RIP Organizational Structure and Governance Procedures

A. Organizational Structure and Membership

The following describes the roles and responsibilities of committees/groups and staff associated with the RIP, and the membership composition of each group.

1. Executive Committee

The EC, as the governing committee of the RIP, is responsible for all decision-making related to the RIP and for ensuring that the goals of the RIP are achieved in a timely manner. The EC sets policy and directs the work of the RIP including the activities of the Executive Director, Program staff, and advisory committees, and makes assignments to the Independent Science Panel. Primary responsibilities for the EC are detailed in the By-laws (to be revised) (Appendix _). The EC, through the Executive Director, serves as the primary point of contact for all requests to the RIP. The EC may coordinate with local or regional conservation initiatives and other interests, consistent with the goals of the RIP. The EC will have a reasonable opportunity to address any conflict resolution within the RIP as needed.

The initial EC for the RIP shall be comprised of all members serving on the EC for the Collaborative Program who execute the RIP Cooperative Agreement with the Service. If an EC member chooses to withdraw from the RIP, a letter shall be submitted to the EC which describes its reason(s) and the EC will attempt to resolve any problem(s). If an EC member's participation in the RIP is essential to implementing a Reasonable and Prudent Alternative (RPA), a Reasonable and Prudent Measure (RPM), or maintaining the existing BO coverage, the withdrawal of such an entity may result in reinitiation of consultation under the ESA related to the concern(s) at issue.

An entity may apply to become a member of the EC provided there are membership openings available on the EC and such entity submits a letter of interest and signs the Cooperative

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Agreement[5]. The EC may consider the following criteria in determining whether to accept an application from another entity to become a member of the EC. An applicant need not meet all criteria, and meeting the criteria does not guarantee an applicant's acceptance as a member of the EC. These criteria shall apply to any entity that reapplies to the EC following a cessation of membership on the RIP. These criteria include, but are not limited to:

a. Representation of a sizable constituency, for example through public outreach or membership;

b. Contribution to the non-federal cost share, reported annually including in-kind services;

c. Ownership of an interest affected by the Program, such as land, water, or other property rights;

d. Jurisdictional or regulatory responsibility, including sovereignty; and

e. Commitment to participation.

Decisions whether to accept an application for EC membership shall be made by the EC pursuant to the voting procedures described in the By-laws. Within one week following EC action on an application, the co-chairs will notify the applicant in writing of the EC's decision.

EC members shall designate one primary and one alternate member to the EC; this shall be provided in writing to the Executive Director upon an entity's approved membership on the EC. Primary and alternate members of the EC and applicable staff are allowed attendance during closed sessions. All meetings shall allow for public comments and be open to the public with the exception of closed sessions.

On [*insert date*], the following entities executed a Cooperative Agreement with the Service committing their participation as members of the RIP's EC:

[Insert entities]

2. RIP Participants

The execution of the Cooperative Agreement commits an entity to participate in the RIP as described in the Program Document. Participation in the RIP is voluntary, and in no way alters the Secretary of Interior's ultimate responsibility for administering the ESA, nor shall it affect the authorities and responsibilities of the State, districts and Tribes to manage and administer

[5] The EC shall maintain a wait list of such applicants in the event no membership openings are available, and shall consider applications in the order in which they appear in the list.

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their water and fish and wildlife resources. RIP participants must make independent judgments to determine their ability to perform RIP activities, and each is responsible for assessing how the goals of the RIP are being accomplished.

If a RIP participant chooses to withdraw from the RIP, a letter shall be submitted to the EC which describes its reason(s) and the EC will attempt to resolve any problem(s). If a RIP participant's activities in the RIP are essential to implementing a RPA or RPM, or maintaining the existing BO coverage, the withdrawal of such entity may result in reinitiation of consultation under the ESA related to the concern(s) at issue.

3. Executive Director & Staff [EC needs to decide]

The EC will hire an Executive Director to carry out the directions of and to serve at the pleasure of the EC. The Executive Director will hire and supervise Program staff consisting of at least a Science Coordinator and an Administrative Assistant. Additional staff positions could include scientist(s), engineer(s), contract specialist(s), public affairs specialist, etc. In addition to the reporting requirements described in Section V below, the Executive Director will prepare quarterly expenditure reports and progress reports, decision papers, and white papers, as needed. Fundamental to the Executive Director position is to coordinate and provide staff for activities of EC advisory committees; communicate with local governments, Pueblos, the public, media, and federal and state agencies; and establish and maintain an independent science panel. The Executive Director and staff will also prepare solicitation packages for EC approval, execute contracts and agreements with successful bidders, and review and approve invoices for payment.

The Science Coordinator and other Program staff will provide technical support to the RIP at the direction of the Executive Director. Primary responsibility of the Science Coordinator is to provide guidance on scientific issues, as well as assign tasks to and oversee the work of the RIP. Other responsibilities include being the scientific lead for adaptive management planning and implementation, conducting technical reviews of Program projects including research objectives, monitoring implementation and oversight, data syntheses, and other technical duties as assigned. The Science Coordinator will assist the Executive Director in preparing and updating the Long Term Plan, RIP Action Plan, and Annual Work Plan described below. All products produced by or under the direction of the Science Coordinator are subject to approval by the Executive Director or EC, as determined by the EC.

4. EC Advisory Committees

The EC may establish technical, stakeholder, or policy advisory committees or sub-committees as needed to provide recommendations on issues or interests consistent with the goals of the RIP. The EC will provide clear direction on the goals, objectives, and activities of any advisory committees including expectations, responsibilities, processes and reporting requirements. Advisory committees will establish charters for approval by the EC. Technical advisory

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committees will be described in RIP Action Plan and may change over time. Committee membership may consist of EC members, Program staff, staff from EC members/RIP participants, or individual(s) obtained though contracts or financial assistance agreements.

5. Independent Science Panel [EC needs to decide.]

The Independent Science Panel (ISP) will, at the direction of the EC and independent of the Science Coordinator and advisory committees, provide the EC with feedback on technical/scientific issues, input to adaptive management and peer reviews, priority recommendations for recovery activities, and perform other review-based duties as assigned by the EC. As directed by the EC, the ISP will perform annual reviews on selected aspects of the RIP, such as habitat construction and monitoring, species management, adaptive management assessments, and flow augmentation and comprehensive programmatic reviews as needed.

B. U. S. Fish and Wildlife Service Roles and Responsibilities

The Service will:

- Serve regulatory role and partnership role in the RIP
  - Conduct Section 7 consultations as needed on new RIP activities or new actions coming in for coverage under the RIP
  - Conduct ESA permitting as needed for new RIP activities
  - Provide advice and recommendations during implementation of the RIP to facilitate meeting the goals of the RIP
- Assess annual sufficient progress
- Assist in developing annual work plan [and approve the plan – see question below]
- Assist in developing annual water operations plan [to be updated for consistency with RIP Action Plan]

C. Governance Procedures

The EC makes decisions regarding Program policy and management, including budgets, annual work plans, procedures, organizational structure, and membership. Decisions may be made only when a quorum of EC members is present, meaning that __% or greater of EC members are present. EC meeting agendas will specify decision items, and EC members and their alternates will be provided with appropriate background material related to each voting decision identified on the agenda. Meeting procedures applicable to the EC are set forth in the By-laws.
All designated members of the EC are allowed a single vote during decision-making procedures. The EC shall seek consensus in reaching decisions. In lieu of consensus, a decision may be deferred to the next scheduled EC meeting. At such meeting the decision may be approved by a super majority of the EC (75%) pursuant to the By-laws. If a non-consensus decision is made, the minority may submit a report to the EC for its administrative record. Certain decisions require unanimous consent, as noted in Section IX of the Program Document.

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The federal action agencies reserve the right to ensure appropriate use of federal funds consistent with applicable laws and regulations. The other EC members reserve the right to ensure appropriate use of their respective funding contributions consistent with applicable laws, regulations, and authorities.
[Should certain decision items require the affirmative vote of the regulatory and funding agencies?]

V. Implementation of the RIP

A. Long Term Plan

[The nature and role of the LTP is to be described for purposes of this consultation; draft LTP to be revised pursuant to an initial task under the Action Plan].

The Long-Term Plan (LTP) is a background guidance document that provides an inventory describing beneficial activities that may be implemented by the RIP to meet its purposes and goals.

The RIP's LTP will be based on the framework of the silvery minnow and flycatcher recovery plans approved by the Service in 2010 and 2002, respectively. Addition of future activities into the LTP will incorporate new information on the hydrology of the MRG and on the life history of the species and will consider any revised recovery plan actions. The LTP will also incorporate principles of adaptive management pursuant to Section VII.

The RIP's LTP will consist of categories of RIP activities including: physical habitat restoration and management; water management; predator/non-native control; population augmentation/propagation (silvery minnow only); water quality management (silvery minnow only); research, monitoring, and adaptive management; policies and laws; public information and outreach; and Program management. Goals, actions, and tasks will be identified under each of the categories. The goals will specify desired outcomes for particular activities, and the tasks will describe specific activities that may be undertaken. The RIP's LTP will present a long-term schedule that will provide general guidance as a roadmap for the sequence and approximate timing of activities over an extended period of time. While the RIP participants do not currently agree upon the criteria in the Service's current species recovery plans, nor upon all activities and tasks in the draft LTP, the participants will seek to come to agreement on these activities and tasks so that the LTP can be viewed as a guidance document for the RIP Action Plan with confidence, recognizing that both the LTP and RIP Action Plan will undergo routine reviews and updates to ensure that implemented activities advance the accomplishment of the RIP's goals.

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B. RIP Action Plan

The RIP's LTP will be used as a foundational document from which necessary beneficial activities will be drawn for the ongoing 5-year RIP Action Plan. The RIP Action Plan will identify the specific activities and tasks that will be implemented by the RIP on an ongoing basis.

The RIP Action Plan will be updated on an annual basis in a manner consistent with the RIP's purposes and goals. The annual update shall be completed each year so as to assist in annual work plan development, budget decisions, and activity implementation. The annual update of the RIP Action Plan shall consider new information from the adaptive management process, input from the Service regarding adjustments to the RIP Action Plan activities or metrics, and input from other RIP evaluations concerning improvements to or modification of the management activities. All updates or revisions to the RIP Action Plan shall be approved by the EC.

C. Annual Work Plan

The RIP Executive Director will develop an annual work plan for EC approval that tiers from the RIP Action Plan and reflects the specific activities and tasks to be implemented by the RIP during the year.

Thus, the RIP will implement activities identified in an Annual Work Plan that tiers from the RIP Action Plan. Those documents will draw from the LTP, which is based on the framework of the species recovery plans. The EC will update RIP documents in a manner consistent with the RIP's purposes and goals and in consideration of new information from the adaptive management process, input from the Service, and other RIP evaluations. These linkages are designed to assure that the RIP provides meaningful benefits to the species and continues to serve as the ESA compliance vehicle under the 2013 BO.

D. Annual Water Management Planning

[Under development: RIP water management plan; entity-specific Water Management Agreements?]

VI. Principles for ESA Compliance

A. Regulatory Certainty under the RIP

The signatories to the Cooperative Agreement intend that the inclusion of the RIP as the conservation measure in the new BO provides regulatory certainty under the ESA for the actions

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referenced in Section III.C of this Program Document (covered actions). ESA compliance[6] will be afforded through the [contemplated] programmatic BO which relies on implementation of the RIP. The RIP Action Plan includes activities from the LTP inventory for which there is commitment from the responsible entities and which are based on recovery actions from the silvery minnow and flycatcher recovery plans. Through implementation of the RIP Action Plan there are linkages to recovery actions that are expected to achieve progress toward recovery of the species.

Nothing herein shall limit the Service in fulfilling its independent statutory obligations under the ESA. Nor shall anything herein change the legal standards under Section 7 of the ESA applicable to the covered actions.

B. Sufficient Progress Determination

The Service will make an annual determination [in January?] of each year of whether the RIP is making sufficient progress towards recovery of listed species. This determination of sufficient progress [provided the RIP serves to minimize effects of the proposed water use and management actions] ensures continued ESA compliance for covered actions. The Service's annual assessment will consider sufficient progress factors[7] that address the reduction of threats to the species and the status of the species and their habitats. These factors are broad categories that will be identified in the [contemplated] BO, and are intended to remain consistent as long as the [contemplated] BO remains in effect.

The RIP will adopt criteria (metrics) by which these factors are assessed. The metrics will address (1) implementation of tasks under the RIP designed to reduce threats to the species and improve their status, and (2) measurements of the status of the species. These metrics will be used by the Service as its criteria for sufficient progress determination. These metrics may change from year to year, though they remain supportive of the broad sufficient progress factors per the [contemplated] BO.

RIP activities tier from species recovery plans. Because the RIP will implement recovery activities identified in an annual work plan [approved by the Service] and reduction of threats to

[6] "ESA compliance" will include: (1) the RIP serving as the conservation measure minimizing effects of actions evaluated in the [contemplated] programmatic BO to the listed species and critical habitat; (2) a finding that such actions are not likely to jeopardize listed species or destroy or adversely modify their critical habitat under Section 7 of the ESA [note: if the Service concludes that the Proposed Action including the conservation measure will cause jeopardy or adverse modification, then a reasonable and prudent alternative would be developed or the Proposed Action modified such that jeopardy and adverse modification are avoided]; and (3) the Incidental Take Statement supporting the [contemplated] programmatic BO providing the reasonable and prudent measures exempting those actions from ESA Section 9 take prohibitions. The composition of the measures will be identified during the [contemplated] formal Section 7 consultation.

[7] These factors relate to the implementation of recovery activities and species status, population responses, captive population, threat reduction, flow, and habitat.

species recovery will be addressed, the RIP expects to achieve sufficient progress towards recovery.

If there are circumstances that undermine the RIP's ability to implement priority recovery activities on schedule, it may not be possible to fully meet all sufficient progress factors and metrics considered. A deficiency that is temporary or is limited to a single or few metrics may not result in a lack of overall progress toward recovery. If the metrics are not being met and the Service makes an initial determination that the RIP is not making sufficient progress, the Service will notify the EC and request its assistance in resolving the situation. If such attempts at resolution are unsuccessful, the Service may document the situation regarding the lack of sufficient progress and make a written request of the EC to take corrective action. It is fully intended that it will be feasible for the EC to take whatever corrective actions are needed to achieve sufficient progress and that resolution will occur. If the potential deficiency towards achieving progress to recovery is not resolved by the EC, it is recognized that the Service may conclude that sufficient progress toward recovery has not been maintained. Lack of sufficient progress may or may not trigger re-initiation of consultation. Failure of the RIP to continue to minimize the effects of the covered actions may trigger reinitiation of consultation related to the concerns at issue. The Service and federal action agencies agree to work expeditiously on any such re-initiation. The Service further agrees to consider the benefits from the potential continuation of contributions by RIP entities during any reinitiated consultations, including in the development of new reasonable and prudent alternatives or other measures in new or revised BO(s).

1. Reduction of Threats

The Service has identified threats to the species in its species listing rules and in the recovery plan for each species. Each recovery plan includes recovery actions that are intended to reduce or eliminate the threats. The RIP Action Plan draws from the LTP inventory which is based on the framework of the Service's silvery minnow and flycatcher recovery plans. The RIP Action Plan activities are designed, in part, to reduce the threats to the species identified in those documents. The Action Plan activities and associated metrics[8] will be approved by the EC, and will be updated on an annual basis pursuant to the procedures in Section VI.D below. It is anticipated that reduction of threats will be accomplished based upon timely implementation of the recovery activities in the RIP Action Plan that link to addressing threats specified in Section IV. F of the flycatcher recovery plan and Chapter 5.0 of the silvery minnow recovery plan as validated by monitoring and modified through adaptive management.

2. Status of Species

    a. Silvery Minnow

[8] The metrics may be defined quantitatively or qualitatively. They will be defined in quantitative terms to the extent possible.

A priority activity under the RIP Action Plan is to develop a RIP monitoring program by the end of the second year of the RIP that builds upon existing population and genetics monitoring efforts. This priority activity recognizes that the current monitoring protocols are not sufficiently precise and sensitive to be endorsed by the RIP for purposes of measuring species response to specific management activities and progress toward recovery, given year-to-year population variability. Based upon the RIP monitoring program, the RIP will work to develop demographic metric(s) to assess population trends and progress toward recovery under the RIP. During the first two years of RIP implementation, the RIP will consider the results of ongoing monitoring in its implementation of activities and annual update of the RIP Action Plan, but will not use such data in a sufficient progress metric. Rather, the EC will work together during this period to determine an appropriate and scientifically supportable metric to assess the status of the species. Sufficient progress will be assessed during this interim period by reference to implementation of RIP activities including procedures to develop the metrics to assess species' status. It is recognized that annual sufficient progress toward recovery may be maintained notwithstanding a failure to meet one of more of the demographic metrics.

b. Flycatcher

[To be completed]

C. Annual RIP Report

The Executive Director will prepare a RIP Annual Progress Report by [December 1?] of each year summarizing the status of the metrics and implementation efforts under the RIP Action Plan, for approval by the EC. The Service will consider that report in its annual evaluation of sufficient progress towards recovery and will, as a member of the EC, identify changes, if any, it believes necessary as part of the annual updating process.

D. RIP Action Plan Updates

The RIP Action Plan will be updated on an annual basis in a manner consistent with the RIP's purposes and goals. The annual update shall be completed by [March 1?] of each year so as to assist in the annual work plan and budget decision and execution process for the RIP. The annual update of the RIP Action Plan shall consider new information from the adaptive management process, input from the Service regarding adjustments to the RIP Action Plan activities or metrics, and input from other RIP evaluations. All updates or revisions to the RIP Action Plan shall be approved by the EC. Subsequent annual work plans will tier off those Action Plans (see Section V.C).

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E. Linkage to Programmatic Biological Opinion

The signatories intend that this RIP be implemented, following its evaluation during the programmatic ESA Section 7 consultation(s) on water operations, river maintenance, flood control, and related non-federal activities in the MRG, to avoid jeopardy to the listed species, to avoid adverse modification of their designated critical habitats, and to contribute to their conservation and ultimate recovery. It is anticipated that implementation of this RIP will be identified in the [contemplated] 2013 programmatic BO(s) and any subsequent opinions as a means to minimize the effects of the actions described in Section III.C for purposes of ESA compliance.

F. Reliance on the RIP for ESA Compliance

Section 7(a)(2) of the ESA requires federal agencies to ensure their actions are not likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat (see 50 C.F.R. 402.01). Jeopardy occurs when an action is reasonably expected, directly or indirectly, to diminish a species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced. This ESA requirement also includes any non-federal actions that have a federal nexus, where a federal agency funds, authorizes, or carries out the action in whole or in part. Section 9 of the ESA prohibits federal and non-federal parties subject to the jurisdiction of the United States from "taking" endangered species. In the MRG Basin, a variety of federal and non-federal activities related to water operations, water management and use, river maintenance, and flood control are subject to the ESA. The term "ESA Coverage" as used in this Program Document includes obtaining both an exemption from prohibitions for incidental take as well as assurance that actions proposed in the biological assessments are not likely to jeopardize listed species or destroy or adversely modify critical habitat under the [contemplated] BO.

Compliance with the [contemplated] BO will convey ESA coverage for included actions identified in the Proposed Actions put forth in separate biological assessments by the Corps and Reclamation. For any federal or non-federal party to receive ESA coverage through the BO(s), that party's actions must be assessed in the effects analysis of the biological assessments. For non-federal actions, there must also be a link to the appropriate responsible federal agency for providing that coverage (through a federal nexus such as participation in the RIP or as an activity interrelated or interdependent to the Proposed Action). [Note: Still need to reach agreement on the scope of activities/actions/operations that may affect the listed species/habitats and are to be included in the Proposed Action and evaluated in the consultation.]

Signatories may withdraw from the RIP upon a 90 day written notice to the other signatories and seek ESA compliance through other avenues. Signatories undertaking or proposing to undertake any activity that may affect MRG endangered species are not required to rely on the RIP for purposes of ESA compliance. Non-federal signatories' reliance on the RIP shall be voluntary. In

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the event an entity chooses not to so rely, or chooses to discontinue reliance on the RIP in the future, the Service will not consider the RIP as the means for ESA compliance for such entity. An entity withdrawing from the RIP may trigger reinitiation of ESA Section 7(a)(2) consultation.

G. ESA Compliance Protocols for Individual Actions

1. Section 7 Consultation documentation procedures for covered actions

Actions described in the Reclamation and Corps biological assessments and addressed in the programmatic BO effects analysis and described in Section III.C of this Program Document will have been consulted on as part of that Section 7 consultation and may rely on the RIP as the means for ESA compliance, provided that the RIP as addressed in the BO adequately minimizes the effects of the actions, the proponent of the action signs the Cooperative Agreement with the Service if not already a signatory to the Cooperative Agreement, and the RIP is maintaining sufficient progress toward recovery as determined by the Service pursuant to the procedures in Section VI.A above

Federal action agencies may choose to request confirmation from the Service of coverage for such individual actions upon submission of documentation establishing that the action is within the scope of actions covered by the programmatic BO and that the proponent is a signatory to the Cooperative Agreement.

2. MRG Section 7 Consultation procedures for other actions

Actions not covered by the analysis in the programmatic BO may benefit from the action-specific consultation procedures described in Appendix__ [to be developed in concert with the Service's draft MRG Section 7 Guidelines for Consultation]. These guidelines have been adopted by the EC and have been found by the Service to be consistent with the ESA and its implementing regulations at 50 C.F.R. Part 402 [pending]. It is recognized that the determination of whether RIP activities provide RPAs and RPMs for such actions is solely the responsibility of the Service.

VII. Adaptive Management

A. Role of Adaptive Management

1. The RIP intends to use adaptive management as a structured and systematic approach for designing, implementing, monitoring and evaluating management actions to maximize learning about critical scientific questions and uncertainties that affect management decisions regarding the use of Program resources to achieve the RIP goals of (1) alleviating jeopardy to listed species and adverse modification of their critical habitats in

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the MRG Program area, (2) conserving and contributing to the recovery of the listed species, and (3) protecting existing and future water uses.

2. Learning resulting from adaptive management activities and monitoring will be used as a tool to improve management decisions in order to more quickly and cost-effectively attain RIP objectives.

B. Science and Management Coordination Meeting

[frequency and purpose to be determined]

C. AMP-1 and Next Steps in Refining Adaptive Management

1. AMP-1 (Appendix __) provides a potential framework for the development of a scientifically defensible adaptive management design specific to the RIP. It also includes a set of principles for designing adaptive management actions and examples of management actions and appropriate monitoring plans. As an important priority, the RIP will use guidance in AMP-1 and the adaptive management experience of this and other programs to develop a formal Adaptive Management Plan, ideally within the first year of the RIP's existence. The RIP will identify specific management activities, monitoring, and research that will be used to evaluate and improve management decisions and will identify the decision-making framework for flexible water management and non-flow related activities that provide for meeting the RIP goals.

2. Adaptive management is not intended as a broad-based research program. In keeping with the purpose of adaptive management, only learning relevant to management decision-making will be sought through the adaptive management process.

3. Adaptive management will be implemented within the existing financial and hydrological resources available to the RIP.

VIII. Data and Peer Review

A. Transparency for Data and Science Used by the RIP

1. In order for the RIP to achieve its goals, it is imperative that best available scientific information be considered in management decision-making.

2. All RIP participants, including but not limited to Cooperative Agreement signatories and their representatives and contractors and their representatives, will abide by the Scientific Code of Conduct for the Middle Rio Grande Endangered Species Collaborative Program, which has been approved by the EC (Appendix __).

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3. All contracts, grants, or other vehicles pursuant to which scientific activities may be conducted on behalf of the RIP shall require that all data collected in carrying out the scientific activities be made available to the RIP in a form accessible and usable by the RIP concurrent with the submission of the deliverables.

4. All data used in management or sufficient progress decisions shall be made available to the RIP upon request in a form accessible and usable by the RIP.

5. The RIP will develop policies and procedures by which data is collected, stored, and made available for the RIP.

B. Peer Review Process

1. The RIP recognizes the importance of peer review to a scientifically-based resource management program. The EC may submit any RIP activity or management decision option for peer review.

2. The EC will adopt formal written Internal Review Procedures (Appendix __) [place holder].

3. The EC will also adopt a formal External Peer Review Process for the RIP (Appendix __) [placeholder]. In the interim, the RIP will follow the Interim External Peer Review Process set forth in Appendix__.

IX. Program Modification

A. Amendment of the RIP Program Document

1. The RIP Program Document has been approved and adopted by all of the signatories to the Cooperative Agreement [pending]. Modifications to the RIP Program Document may be made by following the RIP governance and decision-making protocol, as referenced in section IV.C, without requiring modification of the Cooperative Agreement.

2. Notwithstanding subsection (1) above, the following changes to the RIP Program Document will require unanimous consent of the EC members:

    a. A change to provisions which recognize that the RIP may not impair state water rights of individuals or entities or federal reserved water rights of individuals and entities; federal or other water rights of Indian nations and Indian individuals, or Indian trust assets; San Juan-Chama Project contractual rights; or the State of New Mexico's ability to comply with Rio Grande Compact delivery obligations.

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Also a change to the provision of the RIP recognizing that water to be acquired or otherwise made available must be from a willing donor, seller or lessor.

b. A change to Section VI of the Program Document regarding the principles governing ESA compliance and regulatory predictability under the RIP.

XI. RIP Budget Guiding Principles

It is anticipated that funding to the RIP will be provided by entities to address ESA covered actions. Funding provided can be in the form of cash or in-kind contributions. Reclamation's authorizing language requires non-federal entities to provide a 25 percent cost share, which can be in the form of in-kind contributions on all Collaborative Program activities, except Reclamation's water acquisitions and administrative expenses. Historical funding levels from the federal and non-federal entities are found in Table 1. In support of proposed budget categories and levels of funding in Table 3, a breakdown of Reclamation's historical funding by category is found in Table 2.

Table 1 – Historical MRG Program Funding Levels

	AMOUNT		
Year	**Reclamation**	**USACE**	**Non-Fed**
2001	$ 5,688,000	NA	$ 588,965.02
2002	$ 16,000,000	NA	$ 676,315.23
2003	$ 13,467,000	NA	$ 2,119,560.27
2004	$ 10,070,671	NA	$ 1,112,419.25
2005	$ 10,185,020	NA	$ 1,361,120.11
2006	$ 12,619,000	NA	$ 1,662,484.28
2007	$ 14,189,580	NA	$ 2,133,267.22
2008	$ 16,010,000	NA	$ 2,353,754.38
2009	$ 12,769,000	$ 196,000.00	$ 1,451,655.77
2010	$ 10,687,000	$ 2,981,686.28	$ 1,292,156.34
2011	$ 11,252,000	$ 2,469,979.04	$ 111,605.00
Total	**$ 132,937,271**	**$ 5,647,665**	**$ 14,863,303**
Average	**$ 12,085,206**	**$ 1,882,555**	**$ 1,351,209**

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Table 2 – Reclamation's Collaborative Program Funding Categories and Levels

	Percent of Total Budget				
Historical Budget Categories	**2008**	**2009**	**2010**	**2011**	**Average**
Program Management, Assessment and Outreach	16%	13%	13%	11%	13%
Activities Supporting Development of a new BA/BiOp	0%	11%	7%	8%	9%
Captive Propagation	8%	15%	16%	10%	12%
Habitat Improvement (Construction, Planning and Fish Passage)	22%	12%	14%	13%	15%
Other Monitoring and Research and Rescue/Salvage	16%	12%	6%	11%	11%
Program Technical Support	0%	0%	2%	2%	1%
Water Operations and Management	37%	35%	41%	45%	40%
Water Quality	1%	2%	1%	0%	1%

The following budget categories and spending percentages are intended to assist the Executive Director in preparing the annual work plan and budget. The approximate breakdown of funding by historical Collaborative Program activity is provided as a starting point for budget development based on the foreseeable needs of the RIP and not as hard targets for spending. It is anticipated that additional RIP participants may or may not affect these budget categories and levels of funding.

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Table 3 – RIP Budget Categories and Funding

Budget Category	Percent of Total Budget	Range of Historical Funding
Program Administration and Outreach [a*]		
Adaptive Management Assessments		
Species Management, surveys, monitoring, augmentation, captive propagation & genetic integrity		
Flow protection, management, augmentation, and monitoring		
Habitat Construction and Monitoring		
Independent Science Panel & Peer Review		

[a*] Program Administration includes: Executive Director, Science Coordinator, other administrative staff, technical staff, website, public outreach, contracting support, facilitation, note taking, annual report preparation, etc.

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Potential Appendices (in no particular order)

- RIP Action Plan (under development)
- MRG Section 7 Guidelines for Consultation (under development)
- Procedure for other actions to be included in the RIP (to be developed if necessary)
- Scientific Code of Conduct for the Middle Rio Grande Endangered Species Collaborative Program
- RIP External Peer Review Process [place holder]
- RIP Internal Review Procedures [place holder]
- Adaptive Management Plan Version 1 (AMP-1)
- Cooperative Agreement (under development)
- Governance Protocols (RIP By-laws [place holder]; RIP Advisory Committee Charters [place holder])
- New MOA [place holder, if needed for funding]
- Federal Authorizations

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Draft 06/12/12

ESA Section 7 Guidelines for Consultation on Water Management Actions Affecting Federally Listed Species in the Middle Rio Grande, New Mexico

Introduction

The Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*) includes responsibilities in section 7 for interagency consultation on actions that may affect ESA-listed species and their designated critical habitat. The roles and responsibilities of Federal agencies and other parties during section 7 consultation are also contained in the implementing regulations at 50 CFR 402. This document – *ESA Section 7 Guidelines for Consultation on Water Management Actions Affecting Federally Listed Species in the Middle Rio Grande, New Mexico* (Guidelines) – is provided to articulate the approach to ESA section 7 consultation in the Middle Rio Grande basin (MRG) using a recovery implementation program (RIP). These Guidelines do not alter any of the requirements, responsibilities, and procedures found in the existing statute and regulations; rather, this document is intended to explain how ESA section 7 will be implemented consistent with those existing requirements, responsibilities, and procedures. The biological opinion issued for covered water use and management operations and river maintenance actions (water management biological opinion) will define the conditions of ESA compliance. These guidelines are intended to lay out processes and information to establish a common understanding of how ESA compliance and RIP participation are related but it is important to note that these guidelines are not legally enforceable.

Applicability

The U.S. Bureau of Reclamation and the U.S. Army Corps of Engineers (together, the Federal action agencies) are reinitiating formal ESA consultation on Federal water operations, river maintenance, flood control, and related non-Federal activities in the MRG basin[1]. In conjunction with this formal consultation, the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) is intending to establish and implement a RIP that would identify and implement recovery actions or activities (RIP activities) that assist in the recovery of ESA-listed species and facilitate compliance with the ESA for existing and new water management[2] actions subject to section 7 consultation in the Collaborative Program area. These Guidelines are provided to articulate the approach to ESA section 7 consultation in the MRG using a RIP (see *RIP Approach to ESA Compliance in the MRG* below). Accordingly, once agreed upon, these Guidelines apply to those parties involved with the programmatic[3] ESA section 7 consultation on

1 This refers to reinitiation of the 2003 *Biological and Conference Opinions on the Effects of the Bureau's Water and River Maintenance Operations, Army Corps of Engineers' Flood Control Operation, and Related Non-Federal Actions on the Middle Rio Grande* (2003 BO).

2 The phrase "water management" in these Guidelines is intended to encompass those activities described in the Biological Assessments provided by the Federal action agencies in connection with reinitiation of the 2003 BO. This includes water operations, diversion, storage, and use; and management projects; flood control; river maintenance; and other activities affecting flow quantity or timing.

3 The biological opinion may be referred to as a programmatic biological opinion because the river maintenance

water management in the MRG and the RIP effort, including the Federal action agencies, signatories of the RIP Cooperative Agreement, any Applicants[4] involved, and the U.S. Fish and Wildlife Service (Service). These Guidelines articulate (1) the RIP approach to ESA compliance in the MRG that applies to the new water management biological opinion, (2) procedures for any reinitiation of that new biological opinion (50 CFR 402.16), and (3) procedures for future biological opinions and coverage of any additional future actions through the RIP approach once the programmatic water management biological opinion is in place.

Recovery Implementation Program (RIP) Approach to ESA Compliance in the MRG for actions covered by the Water Management Biological Opinion

ESA compliance in the MRG through section 7 consultation with the application of these Guidelines provides for a unified approach to species recovery contributions and facilitates compliance with the ESA for water management actions in the basin. This is achieved through a RIP that implements activities to support progress toward recovery of the species. The water management biological opinion provides ESA compliance for actions described in the biological assessments including RIP actions. The RIP may be relied upon to provide ESA coverage for those water management actions provided the RIP adequately minimize the effects of such water management actions. The RIP includes development of the following components by the Federal action agencies and the Executive Committee:

1) A Cooperative Agreement to establish and implement a RIP,
2) a RIP Document that describes implementation of the RIP,
3) a Long Term Plan (LTP), which is based on the framework of the Service's species recovery plans and contains activities to benefit ESA-listed species and their habitat,
4) a RIP Action Plan that further focuses and prioritizes near term RIP activities,
5) Annual Work Plans identifying specific activities from the LTP to be implemented each year,
6) annual water operations plans,
7) an Adaptive Management Plan to guide scientific hypothesis-testing and provide a framework for appropriate adjustments to future management.

Comment [DF1]: References to LTP, Action Plan, etc. may need to be adjusted depending on what documents and terminology are ultimately used.

The ability of the Executive Committee to facilitate ESA compliance through a RIP approach is contingent on: 1) including activities in the Long Term Plan (LTP), RIP Action Plan, Annual Work Plans, and annual water operations plans that assist in the recovery of the species, 2) funding the implementation of these activities, 3) implementing activities in accordance with the schedule in the LTP and RIP Action Plan, as periodically amended, 4) monitoring implementation and performance of all RIP activities pursuant to criteria specified in the RIP documents and water management biological opinion, and 5) reporting results to the Service on an annual basis.

The Service will consider the adequacy of RIP activities in avoiding jeopardy to listed species, avoiding destruction or adverse modification of designated critical habitat, and contributing to

program and the recovery implementation program are currently expected to be within the scope of actions proposed by one or more of the action agencies.

4 The term 'Applicant' may refer to any non-Federal party with an action covered through this process.

species recovery. The determination of whether the RIP activities minimize effects of water management actions covered in the water management biological opinion is solely the responsibility of the Service.

Additional Options for ESA Section 7 Consultation in the MRG
It is recognized that Federal agencies and Applicant(s) may wish enter into section 7 consultation for various actions independent of the water management biological opinion and not rely on RIP activities to facilitate their ESA coverage. In addition, Federal agencies and Applicant(s) may be able to modify their actions to eliminate or minimize adverse effects, avoid jeopardy, avoid destruction or adverse modification of critical habitat, and avoid incidental take and by so doing, remove the need for the RIP activities to facilitate ESA coverage. Other water management and river maintenance activities that were proposed in the past and may be ongoing already have ESA compliance through previously-issued biological opinions for those activities independent of the current reinitiation and are part of the environmental baseline. It is also recognized that additional, future actions may occur in the MRG that are not covered by the current reinitiation of consultation on MRG water management. These future actions may involve subsequent section 7 consultation for ESA compliance and could be eligible or appropriate for coverage through the approach described in these Guidelines (see *ESA Coverage of Additional Future Actions through the Program* below).

Section 7 Consultation Process
As part of the water management consultation, the Service considers the effects of the actions, including conservation measures, described in the Federal action agencies' Biological Assessments on ESA-listed species and their designated critical habitats. The Service works with the Federal action agency(-ies) and Applicant(s) during consultation to attempt to identify mutually agreeable opportunities to minimize impacts. It is recognized that (1) it is the responsibility of the Federal action agency(-ies) to define the action(s) subject to consultation and to determine their effects on listed species and critical habitat; and (2) it is the Service's responsibility to evaluate these effects of the action(s) and make the determination as to whether the action(s) are likely to jeopardize listed species, destroy or adversely modify critical habitat, and whether incidental take will occur.

If the Service concludes these actions, including any conservation measures, will not likely jeopardize listed species, or destroy or adversely modify critical habitat, then development of an RPA is not necessary. If the Service concludes these actions are likely to jeopardize listed species, or destroy or adversely modify critical habitat, then development of an RPA is necessary to be able to provide coverage for those actions under the water management biological opinion[5]. RPMs are also developed to minimize any incidental take that results from the actions included in the consultation, and Conservation Recommendations are provided to facilitate compliance by Federal agencies with ESA section 7(a)(1). Conservation measures, the RPA, RPMs, and Conservation Recommendations are defined below and described in terms of their connection to the RIP approach.

[5] Please note that the Service recommends that the RIP and any other conservation measures be included in the Proposed Action to minimize effects of water management actions.

Conservation Measures

Conservation measures are actions to benefit or promote the recovery of listed species that are included by the Federal agency as an integral part of the proposed action. These actions will be taken by the Federal agency or applicant, and serve to minimize or compensate for project effects on the species under review. It is anticipated that the RIP will serve as a conservation measure.

RPAs

As defined in 50 CFR 402.02, RPAs are alternative actions that:

1) the Service believes will avoid the likelihood of jeopardy or adverse modification;
2) can be implemented in a manner consistent with the intended purpose of the action;
3) can be implemented in a manner consistent with the scope of the action agency's legal authority and jurisdiction; and
4) are economically and technologically feasible.

If an RPA is necessary to avoid jeopardy to listed species and destruction or adverse modification of designated critical habitat, the Federal action agencies and Applicant(s) will develop options for an RPA with technical assistance from the Service. In reviewing the RPA, the Service will consider the proposed RIP activities. If the RPA is adopted by the Federal action agencies, and if any incidental take due to an RPA is addressed in the water management biological opinion, then there is no further section 7 consultation required prior to implementation of the RPA. If there will be incidental take due to elements of an RPA and that take is not addressed in the water management biological opinion, those actions would undergo subsequent section 7 consultation to exempt that take.

Incidental Take and RPMs

Section 9 of the ESA and Federal regulation pursuant to section 4(d) of the ESA prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or to attempt to engage in any such conduct. Harm is further defined by the Service to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering. Harass is defined by the Service as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns which include, but are not limited to, breeding, feeding, or sheltering. Incidental take is defined as take that is incidental to, and not the purpose of, the carrying out of an otherwise lawful activity. Under the terms of section 7(b)(4) and section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered to be prohibited taking under the ESA provided that such taking is in compliance with the terms and conditions of this Incidental Take Statement.

RPMs will be included in the water management biological opinion as measures the Service believes are necessary or appropriate to minimize the impacts of incidental take resulting from the actions included in the consultation (50 CFR 402.02).

The Service will make the final determinations in the water management biological opinion on (1) adequacy of an RPA to alleviate jeopardy to listed species and destruction or adverse modification to critical habitat, as well as on (2) adequacy of the RPMs that minimize incidental take. This determination is based on the following factors:

- Environmental baseline
- Status of species, their populations, and critical habitat in the Middle Rio Grande Program area
- Adequacy of flows
- Magnitude of the impact of the action(s) under consultation
- Implementation of Program activities that will result in a measurable positive population response over time, a measurable improvement in habitat quantity and quality for the listed species, and provision of and legal protection of flows needed to meet life history requirements or provide for recovery

During the programmatic consultation, the Service will determine if implementation of the RIP (including activities in the LTP, RIP action plan, annual work plan framework, annual water operations framework, Adaptive Management plan, and any other associated documentation) will be adequate to minimize impacts of the water management actions covered in the programmatic consultation and/or to serve as the RPA and RPMs. In this determination, RIP activities that are underway or planned may be included. The Service has the ultimate responsibility for determining whether the RIP activities minimize and continue to minimize impacts of the covered actions and/or whether the RIP activities provide the necessary content of the RPA and RPMs. If the Service finds they do not, the Service will identify activity(-ies) that it believes must also be included and implemented to maintain ESA compliance and/or to provide the RPA and RPMs. This occurs during the programmatic consultation as well as during subsequent years as part of the Service's annual review and assessment of the RIP (see *Annual Service Review and Assessment of Program* below).

Conservation Recommendations

Section 7(a)(1) of the ESA directs Federal agencies to use their authorities to further the purposes of the ESA by carrying out conservation programs for the benefit of listed species. Conservation Recommendations are provided by the Service in the biological opinion as discretionary agency activities that would help Federal agencies meet their 7(a)(1) requirements, and can include activities that would further minimize or avoid adverse effects of an action on listed species or their designated critical habitat, help implement recovery plans, or obtain scientific or operational information. In identifying Conservation Recommendations, the Service will consider other ongoing or future activities that benefit the listed species in the action area.

Annual Service Review and Assessment of Program

Comment [UF&WS2]: This section still needs updating and will be revisited following further EC discussions.

As part of the RIP approach to ESA coverage for MRG water management actions, the Service will conduct a yearly assessment and determine whether RIP implementation is making sufficient progress toward recovery of the species. This provides for the use of adaptive management, where hypothesis-testing and learning over time can allow for adjustment of RIP and water management activities as appropriate and without automatically requiring reinitiation of consultation.

The evaluation will consider, in the aggregate, many different factors and dozens of different measures. However, if there are circumstances that undermine the RIPs ability to implement priority activities on schedule, it may not be possible to fully meet all factors and measures considered. In fact, success surrounding the various measures is expected to vary from year to year but the trend over time will be upward. In any given year as soon as the Service has any concern about the RIP or indication of a deficiency in any area, the Service will notify the EC and request its assistance in resolving the situation. If such attempts at resolution are unsuccessful, the Service may document the situation and make a written request of the EC. If the situation remains unresolved, it is recognized that progress towards recovery may fall short and the Service may ultimately conclude that sufficient progress has not been achieved.

In its annual assessment, the Service will identify any concerns and areas in need of adjustment for implementing the RIP to maintain ESA compliance. The Service will provide an annual written "Sufficient Progress Report" to the Federal action agencies and the Executive Committee that provides the annual assessment and recommended adjustments.

The annual Service assessment will consider the status of the listed species and critical habitat, changes in the environmental baseline, and RIP accomplishments and shortcomings with respect to activities identified and scheduled for implementation in the RIP Action Plan and annual work plan, and the effectiveness of those activities. The assessment will include review of the prior year's implementation of the annual work plan (tiered from the LTP and RIP Action Plan); review of the prior year's annual water operations; and review of the end-of-year results including implementation, monitoring, and scientific research. Factors that the Service will consider during the annual assessment include the following:

Comment [DF3]: This section and the bulleted factors need further discussion to identify specific agreed upon metrics by which the Service will evaluate sufficient progress. This is needed for the RIP to afford a reasonable degree of predictability of ESA compliance for covered actions.

Factors Related to Species Status

- Species status – including genetic status – in the geographic area considered within the scope of the Collaborative Program. [Includes consideration of declining, stable, increasing trends, progress toward meeting recovery plan targets, and for RGSM, achievements towards self-sustaining populations]
- Measurable positive population responses over time that meet some threshold.
    - Positive population responses – taking into account (1) the annual ability of the RGSM population to fluctuate but still maintain a positive upward trend, (2) the effects of the augmentation program on RGSM population response, and (3) the distribution of the flycatcher population.
    - Meeting some threshold – taking into account (1) the thresholds identified in the species recovery plans, (2) the need for some interim thresholds, and (3) the recognition that the Collaborative Program takes actions that will prevent extinction and contribute to recovery but the composite of those actions will not culminate in down-listing or de-listing of either species (note that this could change if the Collaborative Program includes actions to achieve a self-sustaining population of RGSM in Big Bend and/or an additional reach).
- Appropriate number of RGSM in captive facilities.
- Threats to species reduced or eliminated. [The threats are identified in the listing rule (50 CFR Part 17), recovery plans, and new threats are identified in the Service database.]

Factors Related to Habitat and River Flows

- Measurable improvement in habitat quantity and quality for both species, taking into account:
    - the net additional habitat that recognizes the phases of planning, design, construction, and maintenance.
    - the dynamic nature of flycatcher habitat.
- Adequacy of flows provided for both species and/or legal protection of those flows needed to meet life history requirements and provide for recovery of the species.

Additional detail on the factors or specific measures by which the Service will evaluate progress of the RIP will be developed with input by RIP signatories prior to establishment of the RIP. It is expected that the Executive Committee will work with the Service to identify the specific factors and measures by which the Service's progress determination is made. Final decisions regarding sufficient progress factors will be made by the Service. For any concerns during the annual assessment that may affect continued ESA coverage, the Service will describe adjustments needed to address these concerns, including any needed changes to the LTP or RIP Action Plan, the next year's annual work plan, and the next year's water operations plan. In the event the Service concludes some new, beneficial activity not listed in the existing LTP or associated documents is necessary to have the RIP maintain ESA coverage for the covered actions, the Service will notify the Federal action agency(-ies) and Applicant(s), and with their consent, will inform the Executive Committee in writing to identify the additional activity(-ies) needed. The Executive Committee will have an opportunity to review the additional activity(-ies) needed and incorporate them into the LTP and associated documents (see *Annual Update of the LTP* below). Conversely, in the event the Service annual assessment determines that an existing activity listed in the LTP or associated documents is no longer necessary or is not contributing to the RIP and ESA compliance, this will be identified in writing to the Federal action agency(-ies), Applicant(s), and the Executive Committee for consideration. For example, in certain situations, recovery activities that were included in the LTP or RIP Action Plan may no longer be effective or appropriate. These situations would be evaluated by the Service during the annual assessment and may include, but are not limited to: (a) critical deadlines for specified RIP activities are missed, (b) specified RIP activities are determined to be infeasible; (c) significant new information about the needs or population status of the species becomes available; or (d) no positive response by the species to Program activities is observed.

In addition to the annual assessment, the Service would notify the Federal action agencies, Applicant(s), and the Executive Committee if at any time the Service concludes the following: (a) that the RIP is not implementing Program activities needed for recovery progress, (b) that the RIP is not implementing those activities on schedule, or (c) that a significant change has occurred in the status of the species that may impact the ability of the RIP to provide ESA coverage. In this notification, the Service would identify the corrective action needed to minimize adverse effects of covered actions.

Annual Update of the LTP and RIP Action Plan

Revisions to the LTP, the RIP Action Plan and preparation of the annual work plans (tiered off the LTP) may include the insertion of new RIP activities and modification of existing or planned

activities needed to assist recovery, as well as updates to the scheduled implementation of those activities. These revisions will be conducted by the RIP and occur following the Service's annual review (see *Annual Service Review and Assessment of Program* above). RIP signatories will make recommendations on updates to the LTP, RIP Action Plan and annual work plan. The Executive Committee will approve these updates annually. The updates will consider activities and other modifications identified by the Service. The Federal action agencies in conjunction with the Executive Committee will modify timing, funding, and priorities in the LTP and RIP Action Plan to remain in compliance with the water management biological opinion.

Reinitiation of Consultation

The preceding section addressed the programmatic section 7 consultation using a RIP approach for ESA coverage of water management actions in the MRG. The process of adaptive management with annual assessment by the Service allows for modification of RIP activities and water operations over time and confirmation by the Service that the RIP is maintaining ESA compliance, without automatically requiring reinitiation of consultation. However, once this consultation on MRG water management is concluded and the water management biological opinion is issued, reinitiation may become necessary in the future if certain triggers are met. All biological opinions issued by the Service contain reinitiation triggers that define when the applicable Federal agency(-ies) will reinitiate consultation. This section describes the process of reinitiation of consultation on water management actions for which the RIP is serving to minimize impacts to listed species.

As provided in 50 CFR 402.16, reinitiation of consultation is required where discretionary Federal agency involvement or control over the action has been retained (or is authorized by law) and one or more of the following occur:

1) The amount or extent of taking specified in the incidental take statement is exceeded.
2) New information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered.
3) The identified action is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion.
4) A new species is listed or critical habitat designated that may be affected by the identified action.

Additional reinitiation triggers may apply as appropriate, and would be developed by the Service in consultation with the Federal action agencies and any applicants and described in the water management biological opinion. The biological opinion will also describe adaptive management procedures for which reinitiation will not be required, upon concurrence by the Service that ESA compliance is maintained. These include revisions to the RIP Document, the LTP, the RIP Action Plan, the Annual Work Plan, and other components of the RIP.

If it is determined that reinitiation of consultation over the water management biological opinion may be necessary, the Service or the Federal action agency(-ies) would provide such information to the Executive Committee. The Executive Committee will attempt to identify RIP activities that can be implemented to avoid the need for reinitiation.

If reinitiation becomes necessary because of any of the triggers listed below, the following courses of action would be taken while reinitiation of consultation is occurring, as long as they do not slow or delay reinitiation of consultation:

1) <u>If the amount or extent of taking specified in the incidental take statement is exceeded:</u>
   The assessment and determination of whether incidental take has been exceeded is the responsibility of the Service in discussion with the Federal action agency(-ies). If additional actions are needed, the Service will identify those actions and provide the Executive Committee with the opportunity to incorporate them into the LTP, RIP Action Plan, and/or Annual Work Plan and implement those actions.

2) <u>If new information reveals effects of the action that may affect listed species or critical habitat in a manner or to an extent not previously considered</u>:
   The Service will notify the Federal action agency(-ies) and the RIP's Executive Committee when such a situation is foreseeable or actually occurs. If the Federal action agency(-ies) or the Executive Committee becomes aware of such a situation before the Service, the Federal action agency(-ies) or Executive Committee will notify the Service. Outside interests may also notify the Service of this new information. The Federal action agency(-ies) will assess potential impacts to the species and critical habitat; however, the final conclusion regarding the extent of any impacts to endangered species lies with the Service. The action agency(-ies) and Executive Committee will work with the Service to evaluate the situation and develop the most appropriate response to revise or restore the RIP activities such as adjusting long-term and short-term implementation plans, developing a supplemental recovery action for incorporation into the LTP, shortening the timeframe on other RIP activities, etc, so that the action remains in compliance.

   If RIP activities can no longer serve to minimize effects of the action, during reinitiation the Federal action agencies and Applicant(s), with technical assistance from the Service, will develop options outside the RIP for ESA compliance needs.

3) <u>If the identified action that has been consulted on is subsequently modified in a manner that causes an effect to the listed species or critical habitat that was not considered in the biological opinion:</u>
   If an action is modified in such a manner so as to require reinitiation of consultation, the Service, with assistance from the Federal action agencies and Applicant(s), will identify additional or different items from the LTP to serve as the minimization measure for the action where possible.

4) <u>If a new species is listed or critical habitat designated that may be affected by the identified action</u>:
   The Service will make recommendations to the Federal action agencies and the Executive Committee for amendments to the LTP to avoid the likelihood of jeopardy and destruction or adverse modification of critical habitat, as well as recommendations to minimize take for any new species listed as threatened or endangered. The Executive Committee will then decide

whether to make the amendments to the LTP. If the amendments are made, the Service will consider the adequacy of the amended LTP to serve as the minimization measure during reintiation. If the RIP is not amended by the Executive Committee to address the new species or critical habitat, then during reinitiation of consultation the Federal action agency(-ies) and Applicant(s) would work to develop content for alternate minimization measures regarding impacts to the new species or new critical habitat.

[Guidance may include potential paragraph addressing coverage for individual actions addressed by category (if any) in water management biological opinion.]

ESA Coverage of Additional Future Actions through the Program

These Guidelines can also apply to any future, additional water management actions within the action area that are not covered by the water management biological opinion but seek to use the RIP in ESA consultation as content for conservation measures, RPAs or RPMs. Recovery activities may facilitate ESA compliance for additional individual actions or programmatic related actions that undergo separate ESA section 7 consultation. These Guidelines may be modified as needed for accommodating future consultations into this process (see *Modification of Guidelines* below).

Recovery actions may serve as conservation measures to minimize impacts of new actions and may provide the RPA and RPMs for impacts of more than one action. For new actions, any RPA and RPMs must be implemented before the impact from the action occurs. If the Service finds during a separate section 7 consultation that RIP activities are sufficient to facilitate ESA compliance for that new water management action, the biological opinion for that new action will identify those conservation measures, if any, and identify the RIP activities that provide the content for an RPA and RPMs. If the Service finds that RIP activities are not able to offset impacts of the new action and/or are not able to provide content for the RPA and RPMs related to the new water management action, the biological opinion for this new action will be written to identify which activity(-ies) need to be incorporated into the LTP, the RIP Action Plan, and/or the Annual Work Plan and implemented to provide coverage for the new action. If this occurs, the Service (with the consent of the Federal action agency(-ies) and Applicant(s)) will notify the RIP's Executive Committee in writing, identify the additional beneficial activity needed, and provide the Executive Committee an opportunity to review the needed activity and incorporate the activity into the LTP, the RIP Action Plan and/or the Annual Work Plan. If the Executive Committee does not incorporate the new activity, the Service will work with the Federal agency(-ies) and Applicant(s) for that new water management action to ensure compliance with ESA section 7 through means other than the RIP. Coordination with the Executive Committee will not alter the timeframe for consultation.

Because water in the MRG is fully appropriated, when considering new water-related management actions, only water projects or actions that result in no new net depletions may be considered within the context of the RIP and receive ESA compliance following these Guidelines. The Service will also consider whether the anticipated success of the RIP in contributing toward ESA species recovery is compromised as a result of a new water management action under consultation.

Modification of Guidelines

Once adopted by the Service, the Federal action agencies, and the Executive Committee, these Guidelines describe how ESA compliance will be facilitated in the MRG through a RIP approach. Experience may dictate a need to modify these Guidelines in the future.

A review of these Guidelines may be initiated by the Federal action agencies, the RIP's Executive Committee, or the Service if the need becomes apparent. Suggested modifications to these Guidelines will be provided to the Service and the Federal action agencies for review and approval.

Middle Rio Grande Collaborative Recovery Implementation Program (RIP)

Action Plan

Activities, Schedule, and Budget Projections for Middle Rio Grande Endangered Species Recovery Implementation Program

DRAFT

June 21, 2012

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Preface

The Middle Rio Grande ~~Collaborative~~ Recovery Implementation Program (~~MRGRIP or Program~~RIP) is established through the following formal documents: the RIP Document, this RIP Action Plan, and a Cooperative Agreement. utilizes three main plans to plan and implement activities to benefit the listed endangered species: the Long Term Plan (LTP); the Action Plan; and the Annual Work Plan.

The LTP provides a list of activities, a proposed schedule of time, and estimated costs to implement and complete those activities, and designation of responsible parties for activities through the year 2030. ~~The LTP The Long Term Plan (LTP) provides comprehensive description of Program activities, schedules, and responsibilities to the year 2030. It is a roadmap for the actions and activities anticipated for the MRGRIP to meet its purposes and goals. lists the criteria and metrics (including interim and short term) that will be used to measure sufficient progress, which will ensure ongoing compliance with the ESA for covered actions.~~

The Action Plan tiers off the ~~2013 Long Term Plan~~LTP and includes the activities that are projected to be implemented during the first 5 years after the RIP is established~~necessary to establish a recovery implementation program and transition the Collaborative Program into the MRGRIP. The Action Plan provides for system management so that adaptive management principles can be applied within the Middle Rio Grande.~~ and to ~~necessary to establish a recovery implementation program and~~ transition the Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) into the MRGRIP. Implementation of t~~T~~he Action Plan will proceed when appropriate according to ~~provides for system management so that~~ adaptive management principles ~~can be applied within the M~~middle Rio Grande ~~(MRG)~~. The Action Plan has a 5-year window of planning activities and is expected to be the document that is updated on an annual or biannual basis.

<*Note: Gray shading indicates BOR edit that is inconsistent with F&W edit previously made*>

The Annual Work Plan is the list of activities, schedule, and budget that will be funded during the upcoming federal fiscal year by the MRGRIP. It will take all the contributions, federal and nonfederal, into consideration.

In addition to the three MRGRIP plans, federal and non-federal water management entity Program members ~~have~~will establish~~ed~~ a Water Management Plan (WMP) that includes the suite of water management tools available to assist the Program in meeting its species goals. The WMP is referenced in the LTP and the Action Plan.

Comment [PR31]: We had discussed deleting this sentence as an artifact that in fact was describing the Action Plan (which at one time would have been renamed the "Long Term Plan")

Comment [PR32]: Suggested revision to eliminate superfluous language.

Comment [PR33]: Suggested revision to "soften" adaptive management language as discussed at June 15th meeting

Comment [JM4]: Need to add references in the LTP

Acronyms

AM – Adaptive Management

AMP – Adaptive Management Plan

Collaborative Program – Middle Rio Grande Endangered Species Collaborative Program

ESA – The Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*)

LTP – Long-Term Plan

MRGRIP – Middle Rio Grande Collaborative Recovery Implementation Program

Service – U.S. Fish and Wildlife Service

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Definitions<Move to an appendix>

Adaptive Management (AM) – A structured, iterative and analytical process for designing and implementing management actions to maximize learning about critical uncertainties that affect decisions, while simultaneously striving to meet multiple management objectives. It involves synthesizing existing knowledge and identifying critical uncertainties, developing hypotheses related to those critical uncertainties, exploring alternative management actions to test those hypotheses, making explicit predictions of their outcomes including level of risk involved with implementation, selecting one or more actions to implement, conducting monitoring and research to see if the actual outcomes match those predicted, and then using these results to learn and adjust future management and policy.

Flycatcher – The shortened name given in this document to the southwestern willow flycatcher (*Empidonax traillii extimus*).

Larvae – The newly-hatched form of a fish in which the individual lacks a functional mouth and fully developed fins, and it continues to feed off a yolk-sac. Larval fish are often very small (5-15 mm) and bear little resemblance to adults. Approximately 4 to 7 days depending on temperature.

Minnow – The shortened name given in this document to the Rio Grande silvery minnow (*Hybognathus amarus*).

Population Viability Analysis (PVA) – ~~One of the most important uses of population viability models comes from modern conservation biology, which uses these models to determine whether a population is in danger of~~A risk-assessment methodology applied to calculate species -extinction or recovery probability. PVA uses population-specific time-series and life history data to construct a probabilistic population model which includes provisions for uncertainty about environmental drivers, uncertainty about chance demographic processes, and uncertainty about parameters of the model. ~~PVA's . This is called population viability analysis (PVA) and consists of demographic and possibly genetic models that are appropriate means for predicting the effects of a proposed action on species of concern in ESA consultations and are used to make decisions on how to manage populations of threatened or endangered species. The National Research Council has called population viability analysis "the cornerstone, the obligatory tool by which recovery objectives and criteria [for endangered species] are identified."~~

Sufficient Progress Metric – ~~Across concept used in different disciplines, a measure of to gauge the satisfactory ongoing performance of a program in accordance with a plan or established set of standards. The concept~~~~Determinations~~ ~~of sufficient progress have~~~~s recently been increasingly adopted utilized by the U.S. Department of the Interior as an a~~

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Comment [PR35]: The original "adopted" implies a formal rulemaking process or issuance of policy guidance that have not occurred.

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~~method for~~ ~~assessmenting~~ ~~the~~~~of accomplishments and shortcomings of a conservation program that is being used as a "reasonable and prudent alternative," a reasonable and prudent measure," or as a "conservation measure" as~~~~in order to achieve and maintain compliance with the Endangered Species Act (ESA).~~ In a recovery implementation program, s~~S~~ufficient progress metrics ~~in this context~~ are~~is~~ generally a series of factors or criteria used by the program and the U.S. Fish and Wildlife Service to evaluate whether the program is performing satisfactorily to promote progress toward recovery and can continue to ~~receive~~ allow coverage for related proposed actions under Section 7 (jeopardy) or Sections 9 (take) of the ESA.

Viability (genetic) – To be genetically viable, a ~~group of individuals~~population must start out with, and maintain, sufficient genetic diversity to adapt to the anticipated range of environmental conditions that it will encounter. Factors which can work against the maintenance of genetic diversity include: episodes of extremely small numbers of breeding individuals, high frequency of inbreeding, and selection in artificial environments.

~~have a realistic chance of avoiding the problems of inbreeding that results from a small number of individuals increasing the chances of sibling crosses. A population of plants or animals requires a certain amount of genetic diversity and consequently a certain minimum number of members. Where a population has become extremely small in a population bottleneck, it may have lost its genetic viability, and if numbers recover it will be through inbreeding, possibly leaving a genetically unhealthy population.~~

Viability (population) – A species ~~The ability of a~~ population's ability to persist and to avoid extinction~~, or the calculated likelihood of a population avoiding extinction~~. The viability of a population ~~will increase or decrease in response to~~typically varies with changes in the rates of birth, death, and growth of individuals. In natural populations, these rates ~~are not stable, but undergo~~ themselves fluctuate~~ions~~ ~~due~~ in response to external forces (floods, droughts, introduced species), and internal forces (competition and genetic composition). Such factors can drive populations to extinction if they are severe or if several detrimental events occur before the population can recover.

Young-of-Year – A fish that is less than one year of age from the approximate date in which it was hatched. ~~Young-of-year may include the "larval" stage which may span for only about the first month of life (see Larvae).~~

Comment [PR36]: Suggested revision, necessary for context.

Comment [UF&WS7]: PVA is the calculated probability of extinction or persistence. Viability is a more general term not limited to PVA.

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1 Introduction

1.1 Background

The Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) will transition to the Middle Rio Grande Collaborative Recovery Implementation Program (MRGRIP). This Action Plan identifies substantive MRGRIP elements, actions and tasks that are necessary to meet the purpose and goals of the MRGRIP.

The following purposes and goals of the MRGRIP were adopted from the Collaborative Program. The purposes are to:

Comment [PR38]: Have these been "synched" with the Program Document as discussed?

- Promote the conservation and contribute to the recovery of the endangered species in the Program area;
- Assist in attainment of Endangered Species Act (ESA) compliance for all parties with the concurrence of the U.S. Fish and Wildlife Service; and
- Encourage water development and management activities consistent with State and Federal laws and mandates.

The following goals were established by the Collaborative Program as a means to fulfill the above purposes. All signatories believe that the ~~Collaborative~~ Recovery Implementation Program <update from Program document> is the best mechanism to carry out the following goals in accordance with State and Federal laws and Rio Grande Compact obligations.

1. Alleviate jeopardy to the listed species in the Program area.
   a. Identify and articulate the critical scientific questions that will help evaluate flexibility in the system that wasn't known to be there in 2003.
   b. Understand the system well enough to develop adaptive management tools to support a sustainable Biological Opinion.
2. Conserve and contribute to the recovery of the listed species.
   a. Stabilize existing populations.
   b. Develop self-sustaining populations.
3. Protect existing and future water uses.
4. Report to the community at large about the work of the Program.

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1.2 Need for Action Plan

This Action Plan is needed to identify ~~This Action Plan identifies~~ specific actions and tasks that the MRGRIP plans to implement, according to Annual Workplans, ~~need to be implemented annually by the MRGRIP~~during the first five years of its existence to ~~comply with~~advance the purposes and goals ~~as~~ stated above. Future 5-year~~This~~ Action Plans ~~covers a 5-year ongoing period, and it shall~~will be updated annually with revised actions and ~~from~~ tasks generally drawn from and tiered from the broader inventories of possible species recovery actions identified and described in the~~a~~ Program's Long-Term Plan (LTP) and species Recovery Plans. All updates or revisions to the RIP Action Plan shall be approved by the EC. ~~This Action Plan organizes tasks according to species life history and not by program element as in the LTP so that activities are integrated and can be performed following the principles of adaptive management.~~ In selecting future Action Plan actions and tasks, the EC's decision-making will be guided by species needs for survival and recovery as determined by the best available scientific information and shall consider new information from the adaptive management process, ~~input from the Service regarding adjustments to the RIP Action Plan activities or metrics, and~~ recommendations in the ~~RIP Evaluation Team's~~ River Advisory Team's Report concerning improvements to or modification of the management activities, input from the Service regarding adjustments to the RIP Action Plan activities or metrics, and other appropriate sources of information~~?~~.

<Latest version of LTP modifies this language (sync with that <see note in Preface>)> The Long-Term Plan (LTP) is a background guidance document that provides an inventory describing the full range of potential activities that may be implemented by the RIP to meet its purposes and goals. The previous 2006 Long Term Plan will be updated and replaced by a revised LTP pursuant to one of the tasks under the first Action Plan for the RIP. ~~The LTP extends to the year 2030 and it provides a prioritized list of activities, a proposed schedule of time, and estimated costs to implement and complete those activities, as well as a designation of responsible parties for each activity.~~ The LTP lists the criteria and metrics (including interim and short term) that will may be used to measure sufficient progress, --subject to revised indicators of species viability revealed by the best available scientific information—and satisfaction of which these metrics is expected to will ensure ongoing substantive compliance with the Endangered Species Act for covered actions.

Comment [ET9]: Somewhere in this section include "The Action Plan is needed to identify specific activities that are planned to be implemented during the first 5 years of the RIP. It is tiered from the LTP and the species recovery plans which include broader sets of possible recovery actions."

Comment [PR310]: This is included below.

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Comment [PR311]: This looks like what we agreed on

Comment [ET12]: This sentence is pre-decisional and cannot be used like this. "The LTP lists the criteria and metrics (including interim and short term) that will be used to measure sufficient progress, which will ensure ongoing compliance with the ESA for covered actions." There is no guarantee now that any future BO will be complied with indefinitely.

Comment [PR313]: The wording has been change from guarantee to expectation.

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1.3 Formulation of Elements and Activities

Comment [ET14]: Somewhere in this section include "The recovery actions identified in this Action Plan include those considered to be most important to alleviate threats to species and promote recovery within a 5 year timeframe."

Comment [PR315]: This has been done; see below.

<BOR has technical changes to add>The Elements and Activities described in this Action Plan and in the LTP are principally founded on the work and accomplishments of the Collaborative Program from 2000 to 2012 (see: http://www.middleriogrande.com/Default.aspx?tabid=174), the 2009 draft long-term plan (Water Consult 2010), the recovery plans for the southwestern willow flycatcher and the Rio Grande silvery minnow (U.S. Fish and Wildlife Service 2009, 2002), biological assessments (U.S. Bureau of Reclamation 2003, 2012), the 2003 Biological Opinion (U.S. Fish and Wildlife Service 2003), and the initial framework for an adaptive management plan (Murray et al. 2011).

This Action Plan includes activities for the endangered Rio Grande silvery minnow (Minnow; *Hybognathus amarus*) and the southwestern willow flycatcher (Flycatcher; *Empidonax traillii extimus*). The threatened Pecos sunflower (*Helianthus paradoxus*), the endangered Interior least tern (*Sternula antillarum athalassos*), and the candidate New Mexico meadow jumping mouse (*Zapus hudsonius luteus*) are not addressed in this Action Plan. The only population of the Pecos sunflower within the MRG water management action area is at the La Jolla Waterfowl Management Area in Socorro County near the confluence of the Rio Puerco. The least tern has been observed as a 'vagrant' or 'highly unusual' species in the area, and the jumping mouse nests in dry soils, but uses moist, streamside, dense riparian/wetland vegetation up to an elevation of about 8,000 feet. It is believed that activities designed to benefit the Minnow and the Flycatcher will not harm and possibly also benefit these other species.

This Action Plan is organized ~~such that it~~to focus~~es~~ RIP activities on the species of concern in a manner that promotes and emphasizes the integration of the essential components of species habitat (water, channel morphology, floodplain, food, water quality, etc.) within an adaptive management framework. This framework is an important premise underlying Action Plan implementation~~concept~~, as it directs that ~~means~~ the MRGRIP activities pertaining to and affecting species ~~must~~ should be designed and~~well~~ coordinated to incorporate, where ~~appropriate<~~warranted~~?>~~, appropriate hypotheses, research and monitoring of species needs and responses. ~~, so that and the implementation of these actions will reduce critical management uncertainties and the MRGRIP's and information learned from research and monitoring must be regularly exchanged within the Program and particularly to water management entities' future actions can be further refined in accordance with the information learned and species management uncertainties remaining to be investigated.~~ This information

will allow water managers and regulators to address species needs in a more effective and resource-efficient manner.

This Action Plan builds on and formalizes the existing coordination of water management agencies in the Middle Rio Grande (MRG), regulatory authorities, and program participants during the water year~~ A more formalized approach will be taken within this Action Plan~~ to ensure that MRG activities, including those contained in the WMP~~water management and operations~~, are coordinated ~~work together together~~ throughout the year and ~~those activities are~~ are well informed by ~~the~~ science. ~~This Action Plan provides the framework to conduct scientific research and monitoring to address relevant unknowns about the species and address natural and human caused uncertainties through an adaptive management process. For example, coupling scientific inquiry with the predicted runoff conditions occurring in a particular year will enable the MRGRIP to understand species behaviors to the natural varying conditions endemic to the MRG. This information will, in turn, allow water managers and regulators to address species needs in a more effective manner so that all available resources are better utilized in a comprehensive and collaborative manner.~~

The recovery actions and tasks identified in this Action Plan include those considered to be most important, within a 5 year timeframe, to alleviate threats to species and promote recovery. The Action Plan also describes ~~the~~ some elements, ~~and~~ acti~~vities~~ons and tasks that have been prescribed (under the 2003 Biological Opinion) and relied on to date in an attempt to ~~are adequately understood and have proven effective for~~ securely manage~~ing~~ the species while the current recovery implementation program formation effort~~s~~ has been~~are~~ in process <i.e., ongoing activities will continue>. In particular, the operation of Minnow propagation facilities that was prescribed to ensure survival and promote recovery will continue under a MRGRIP while these resources are needed.

While it is still unknown if two or more additional and distinct, self-sustaining populations can be established for the Minnow, the Program believes it is important to assist with efforts on range expansion outside the MRG. The Big Bend 10(j) efforts which have been underway since 2007 may provide one additional area if stocked fish become self-sustaining. The Program proposes relatively short-termed and phased-in assistance for additional range expansion efforts outside the MRG. In addition, within the Program Area certain efforts will be taken to expand the Minnow's range.

The MRGRIP will support recovery efforts for the Flycatcher within the Program Area. The formulation of elements and activities for the Flycatcher is presented in a similar manner to that of the Minnow. Many of the activities for the Minnow should be

Comment [PR316]: The observations in these sentences have been dispersed to more appropriate passages in this Introduction (adaptive management, etc.), to avoid repetition.

Comment [JM17]: how does scientific inquire and runoff predictions enable better understanding - wouldn't it be actual runoff?

Comment [PR318]: The observations in these sentences have been dispersed to, or rephrased in, more appropriate passages in this Introduction (adaptive management, etc.), to avoid repetition.

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Comment [PR319]: This assertion seems conclusory and not necessarily warranted scientifically (although it may turn out to be essentially true).

Comment [JM20]: define

beneficial for the Flycatcher as well. The efforts for Flycatcher that are funded by the MRGRIP are restricted to the Program Area with the exception of supporting monitoring at Elephant Butte, which is just south of the Program boundary.

1.4 Relationship to Adaptive Management

There is within the elements described in this is LTP Action Plan the acknowledgesment that there are still a number of unknowns critical uncertainties and hypotheses about the listed species and its their habitat that are relevant integral to water management and species recovery activities and are important to better understand to enable recovery. Many of these uncertainties and hypotheses were compiled from submissions by Program participants within Appendix C of the Adaptive Management Plan, Version 1.1 (AM Plan; Murray et al. 2011), completed by the Collaborative Program in 2011. For example, this Appendix C captures the uncertainty regarding the Minnow population benefits of managing flows to achieve positive October population monitoring responses, which can be critical because the current Recovery Plan focuses attention on these responses as extinction prevention and downlisting criteria and they thus to some extent drive official Minnow recovery efforts. The AM Plan suggests statistical analysis, including population viability analysis (PVA) modeling, as a means for testing alternative hypotheses with implications for revising the Program's flow and drying management strategies.

As early as 2009, PVA has produced analysis showing a resilient Minnow population with no response to normally diminishing summer flows, and suggested that PVA be deployed to support a targeted adaptive management revision with a monitoring model to detect early signs of possible failure of resilience, as well as models of a carefully designed intervention and species response to this intervention. As the Plan notes, rigorous adaptive management requires such a commitment of effort and resources to resolve significant uncertainty by deliberately designing and implementing management actions to test hypotheses, maximize learning and produce better decisions than would adherence to the status quo.

In addition to species uncertainties, the high variability in the climate, environmental changes, and the changing human landscape within the MRG creates manyconsiderable system uncertaintyies--as to environmental conditions and resource availability-—on an annual, and often, daily basis. Water operation and management is fairly complex and speciesthe effects, responses to management actions are on the species often cannot readily measurablediscerned with current monitoring be measured directly or even indirectly. Water rResources that can be used to supplement natural flows are not only

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very limited, but highly variable and often dependeant, physically, operationally and legally, often on what occurred during the previous year or two. ~~Therefore~~Due to this high level of uncertainty in the system and due also to the consequent managerial complexity, ~~to address ESA coverage and species recovery in the MRG,~~ integrating adaptive management into the culture of water management is believed to be the best approach to addressing ESA coverage and species recovery in the MRG, as it promises to enable decisive ~~change, to~~ adaptation ~~quickly and decisively as needed, and~~ to ~~utilize~~ new determinations of optimal management strategies ~~information~~ from focused managerial hypothesis testing, research and monitoring.

~~The Collaborative Program completed the Adaptive Management Plan Version 1 (AM Plan) in October of 2011 (AM Plan; Murray et al. 2011).~~ Th~~e~~is AM ~~p~~Plan provides a framework for completing activities to maximize species recovery progress and reduce management and technical uncertainties. The AM Plan provides specific design principles for ~~AM~~ adaptive management activities including: 1) meeting program goals; 2) includinge measureable triggers, safeguards and emergency activities to avoid jeopardy; 3) achievinge numerous attributes including that integration with flow and habitat restoration activities, be feasible to monitor and implement, be reversible or adjustable, and other attributes detailed within the AM Plan; and, 4) ~~communicate~~ communicating progress and results throughout the process.

~~Within~~ Implementation and periodic revision of elements, actions and tasks of thise Action Plan~~LTP~~ will proceed according to adaptive management principles: ~~will be identified in the design and implementation of~~the selection and design of specific acti~~vities~~ons and tasks will follow the identification of critical ~~that have~~ uncertainties regarding ~~their a~~effects on the species responses determined ~~by~~ PVA ~~to~~ to be important for survival and recovery-, will incorporate testable hypotheses related to these uncertainties, will explore alternative management actions to test those hypotheses, will make explicit predictions of the outcomes including the level of risk involved with implementation, and will select an action to implement based on all of the following criteria:

- Cost-benefit: it is believed, on sound evidence, that there is a good probability that it will work as intended, and will be worth adopting (i.e., feasible and economical) if it is; and
- Acceptable risk: the range of plausible outcomes if it does not work as intended, are either: (a) tolerable, or (b) controllable, and the early warning detection monitoring is in place and the damage control capability is ready to deploy; and

Comment [JM21]: Action Plan?

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Comment [PR322]: These criteria are synthesized from the "Principles for Designing AM Actions" and "Program Background" sections of ESSA's Adaptive Management Plan, Version 1 (at pages 43-44 and page 3, respectively).

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- Learning potential: there is a commitment to monitoring to determine if it does or does not work, and the statistical design of the monitoring has sufficient power for that task; and
- Management commitment: There is a commitment to revise management, as well as a clear and achievable allocation of responsibilities to do so, based on the outcome of the monitoring, and ~~there is an advance~~ decision rules are endorsed in advance to determine ~~for~~ whether the experimental action will be adopted as routine (and no longer experimental) or modified and tested further or abandoned.

~~and that can be improved through dynamic decision making. Reduction of unknowns and addressing uncertainties will be accomplished by conducting and utilizing focused research and monitoring with feedback to water managers as part of the process.~~

~~The Program's PVA models are a critical formal component of adaptive management, and t~~The RIP intends to~~is committed to ongoing use of PVA results, as consistent with~~ use the results of the best available science ~~standards,~~ to guide adaptive management implementation~~as these results become available~~. For example, the Program's PVA models can serve as a formal component of AM, by identifying critical uncertainties, evaluating the potential of a proposed experiments to reduce the uncertainties, providing a risk assessment for the experiment itself, and re-evaluating population status and management strategy after the results of the experiment are analyzed. In addition, ~~T~~the Program will use ~~A~~annual reviews and other information assimilation tools ~~will be used by the Program~~ ~~MRGRIP~~ to ensure that the ~~AM~~ adaptive management process is serving to reduce uncertainties and inform water management decisions

1.5 ~~Water Management~~ Tools and Strategies

<BOR to revisit?>ISC also to revist - The WMP describes the suite of water management tools and strategies available for providing flows or depletion offsets that support species elements and Program goals, and it identifies the specific tools provided by each federal and non-federal water management decision maker (the Water Managers). The MRGRIP will make recommendations to the Water Managers based on species needs, and the Water Managers will utilize the tools described in the WMP to meet the needs.

In response to the reduced opportunities for acquisition of traditional San Juan-Chama Project water supplies for Reclamation's Supplemental Water Program, the WMP identifies potential replacement supplies and alternative water management strategies. The WMP builds upon the Reclamation's 2006 Long Term Water Acquisition & Management Plan and New Mexico's 2008 Strategic Water Reserve Implementation

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Analysis Report, and identifies the supporting and institutional constraints/processes associated with implementation of the MRGRIP.

Although there has been sufficient water over the last ten years to meet the 2003 Biological Opinion flow targets under the dry, average and wet conditions, until the WMP no plan or strategy existed for getting through a critically dry scenario where there is limited to no water supply reserves. Included in the WMP is a shortage sharing strategy for managing water for species and habitat during drought conditions where water supplies are critically low. Additionally, stakeholders meet on a regular basis to coordinate river management actions that slow drying in the San Acacia and Isleta reaches.

1.6 Formulation of Sufficient Progress Metrics

This topic will be discussed in the June EC meeting. After the meeting, this section will be refined and inserted. To be refined such that most of content will be in Program Document with activities and tasks in Action plan identified as sufficient progress? Under discussion among Action Plan Team.

Proposed process for developing sufficient progress metric; distribute separately from AP: The Service will make an annual determination whether the RIP is making sufficient progress toward recovery of listed species. This determination of sufficient progress ensures continued ESA compliance for covered actions. It is conditioned on the Fish and Wildlife Service's assessment in its Biological Opinion that the RIP activities, combined with any other conservation measures, fully serve to minimize detrimental listed species effects of the proposed water use and management actions; and that covered actions in combination with RIP activities are not reasonably expected, directly or indirectly, to diminish listed species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced. The sufficient progress determination will also assess whether RIP activities are advancing species recovery by working toward the reduction of threats to listed species and the improvement of the status of listed species and their habitats.

RIP Sufficient Progress Metrics will consist of (1) measures of implementation of RIP activities listed in the current Five-Year Action Plan and (2) measures of species response to RIP activities, including demographic indicators of species survival, reproduction and recruitment and population viability analysis assessment of probability of species survival over a given period (e.g. 100 years). During the first two to three years of RIP operations, implementation measures will play the primary role in assessing RIP progress, as the RIP builds its capacity to implement a rigorous Adaptive Management program, as well as

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developing and refining its monitoring protocols to measure species response to specific management activities.[1] These Metrics, especially those measuring species response, will be quantitative to the extent possible, but qualitative Metrics may be used when no quantitative measure exists or is possible for the factor in question.

This framework for developing metrics may be visualized as filling in the following matrix. As represented here, this framework would allow the RIP to assess with some precision its level of success in implementing activities and promoting species responses that maintain and advance listed species' likelihood of survival and recovery—at both the population and the species level—as well as allowing the RIP to select and develop future activities, Adaptive Management approaches and metrics that are informed by such assessments:

	"Operational"	
"Interpretational"	Implementation	Species Response
Avoids appreciable reduction in likelihood of survival and recovery so as to trigger need for reinitiation.	e.g. *x* fish released from hatchery *x* miles of river bank lowered *x* af of water pumped into river	e.g. demographic indicators, CPUE index from monitoring sites PVA assessment of probability of survival at 100 years

[1] As discussed in RIP Program Document Section VI.B, a priority activity under the RIP Action Plan is to develop a RIP monitoring program by the end of the third year of the RIP that builds upon existing population and genetics monitoring efforts. This proposal recognizes that the current monitoring protocols are not sufficiently precise and sensitive to be endorsed by the RIP for purposes of measuring species response to specific management activities and progress toward recovery, given year-to-year population variability. Based upon that RIP monitoring program, the RIP will work to develop demographic metric(s) to assess population trends and progress toward recovery under the RIP. Before that information is available, the RIP will consider the results of ongoing monitoring in its implementation of activities and annual update of the RIP Action Plan. The status of the species will be assessed during this interim period with reference to implementation of the RIP activities, including procedures to develop the metrics to assess the status of the species. It is recognized that annual sufficient progress toward recovery may be maintained notwithstanding a failure to meet one of more of these demographic metrics.

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Achieves sufficient progress toward recovery	e.g. *x* + *y* fish released from hatchery *x* + *y* miles of river bank lowered *x* + *y* af of water pumped into river	e.g. demographic indicators, such as ??? PVA assessment of probability of recovery

At the May 29, 2012 Collaborative Program Executive Committee meeting, the Fish and Wildlife Service presented a table of potential Sufficient Progress Metrics that could fill this matrix, with most of the values to be assigned to each factor yet to be determined. It was agreed at the same meeting that some of these values would be determined as a result of the incorporation of upcoming scientific analysis from the sources listed below (e.g. 2012 Workshop(s), Program science) after assessment and decision by the EC. It is further anticipated that the initial development of RIP Metrics will benefit from the compilation and analysis of available science performed by the Service, as part of its preparation of the BiOp, as to effects of the covered actions and RIP activities on listed species. The Program's PVA modeling can perform the ongoing function of assessing the validity of each factor as a significant contributor to the likelihood of species' survival and recovery. PVA model outputs can thus validate indicators of progress and, further, can be used to propose other indicators and thereby assume an important role in ongoing development and refinement of the RIP's Sufficient Progress Metrics.2

Initially, the RIP Sufficient Progress Metrics will be approved by the EC, following issuance of the contemplated Middle Rio Grande water management and river maintenance Biological Opinion. Thereafter, the responsibility for updating RIP Sufficient Progress Metrics as the Five-Year Action Plan is annually updated and amended is expected to devolve upon the Science Coordinator, in coordination with and with the approval of the EC (including the Service). Because Sufficient Progress Metrics must continually remain relevant to species status and prospects for survival and

[2] As PVA model results consist of a probabilistic calculation of species extinction or recovery, the PVA Workgroup is currently discussing the appropriateness of utilizing its modeling results as a determinative, rather than a relative, indicator of the effects and effectiveness of management and conservation actions; e.g testing for preventing extinction (a 50% likelihood of survival over 100 years), warranting downlisting (75% likelihood), or warranting delisting (90% likelihood, per Recovery Criterion 3-A-1).

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recovery, utilizing the best available scientific information as this information is developed, key considerations to be utilized by the Science Coordinator and the EC in updating Sufficient Progress Metrics include:

- Relevance to species population viability (i.e. to maintaining the risk of extirpation below an acceptable level and the probability of recovery above an acceptable level);
- Relevance to RIP recovery actions identified in the Action Plan and Annual Workplan (since the metrics serve to evaluate these);
- Measurability of demographic and other factors important as indicators of viability (e.g. survival, reproduction, recruitment, distribution, genetic diversity), appropriate correlate measures, and the degree of confidence in such correlations;
- Feasibility and achievability of measured activities and/or population viability factors within resource (funding, water) and RIP organizational and institutional constraints.

During the initial and subsequent formulation of Sufficient Progress Metrics, the Science Coordinator and EC will consider the following sources of information to ensure that proposed Metrics maintain relevance to species population viability, utilizing the RIP protocols and procedures for internal science review and external peer review as needed:

- Long-Term Plan: activities deemed by RIP to be relevant to recovery goals;
- Recovery Plan: Criteria for recovery and preventing extinction; prescribed activities;
- Program science: Science Workgroup and Population Viability Analysis Workgroup, PVA response to questions posed by Service and others, Adaptive Management, internal peer review;
- Independent science: Fish and Wildlife Service's Five-Year Review, Science to be presented to Service before and during analysis for Biological Opinion, external peer review;
- Science Workshop(s) during summer 2012.

RIP activities in many instances tier from species recovery plans. Because the RIP will implement recovery activities identified in an Annual Workplan approved by the Service, the Service expects the RIP to achieve sufficient progress towards recovery.

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However, if there are circumstances that undermine the RIPs ability to implement priority activities on schedule, it may not be possible to fully meet all factors and metrics considered. A weakness or deficiency that is temporary or is limited to a single or few metrics would not necessarily result in a lack of overall progress toward recovery. If the Metrics are not being met and the Service makes an initial determination that the RIP is not making sufficient progress, the Service will notify the EC and request its assistance in resolving the situation. If such attempts at resolution are unsuccessful, the Service may document the situation and make a written request of the EC. If the situation is not resolved, it is recognized that Service may conclude that sufficient progress toward recovery has not been maintained, thereby triggering re-initiation of consultation related to the concerns at issue. Failure of the RIP to continue to offset the effects of the covered actions will trigger reinitiation of consultation related to the concerns at issue. The Service and federal action agencies agree to work expeditiously on any such re-initiation. The Service further agrees to consider the benefits from the potential continuation of contributions by entities during any reinitiated consultations, including in the development of new reasonable and prudent alternatives or other measures in new or revised biological opinion(s).

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2 Elements for Rio Grande Silvery Minnow

2.1 Element 1 - Spawning and Survival of Larvae

Action 1.1: Create <overbank/floodplain> habitat for spawning and larval rearing.

Task 1.1a: Develop and implement a habitat restoration strategy, resulting in a prioritized list of habitat projects.

Task 1.1b: Over 5 years, target a total of 300 acres of overbank/floodplain habitat in the Cochiti, Albuquerque, Isleta, and San Acacia reaches based on past experience and implementability.

Action 1.2: Provide spring-time hydrologic (flow) conditions <springtime environmental conditions> sufficient to produce Minnow spawning and larval fish survival.

Task 1.2a: In advance of spring runoff, the Action Team will evaluate the annual species management objectives, available resources, climatic projections, and other information to develop recommendations for that specific year.

Task 1.2b: Manage resources in accordance with Action Team's annual recommendations as needed to provide environmental conditions sufficient to produce Minnow spawning and larval fish survival.

Task 1.2c: Manage rates of recession to minimize stranding and mortality of Minnows.

Placeholder task: Provide wet river for at least 45 days post peak spawn <this will be covered in the Action Team's annual recommendations>

2.2 Element 2 - Post-Spawning <non-runoff survival?> Rephrase

Action 2.1: Provide viable wetted habitats during summer and fall that can be shown to improve survival and recruitment of Minnow during main channel drying events.

Task 2.1a: Develop a "Refuge Habitat Plan for Rio Grande Silvery Minnow During River Drying Events" to identify desirable areas for refuge sites, strategies for enhancing their benefits, available water sources, and evaluation methods.

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Task 2.1b: Construct and maintain "refuge habitats" in the Albuquerque, Isleta, and San Acacia reaches for Minnow during river drying events as prescribed by the Refuge Habitat Plan (Task 2.1a).

Action 2.2: Provide hydrologic (flow) <environmental> conditions in summer, fall, and winter to support survival in all years. <delete? reword? replace?> <Conduct operations in such a manner to avoid need for refuge habitats.>

Task 2.2a: In advance of spring runoff, the Action Team will evaluate the annual species management objectives, available resources, climatic projections, and other information to develop recommendations for that specific year.

Task 2.2b: Manage resources in accordance with Action Team's annual recommendations as needed to provide environmental conditions sufficient to produce Minnow post-spawning survival.

Task 2.2c: Manage rates of recession to minimize stranding and mortality of Minnows.

Placeholder tasks:

Review and update the "2006 Long Term Water Acquisition & Management Plan" and "2008 Strategic Water Reserve Implementation Analysis Report."

Engage the River Advisory Team to advise Water Managers regarding the need to slow the rate and extent of river drying during low-flow periods in summer, fall and winter. This will include advising on the need to implement the shortage sharing strategy in the WMP during critically dry years, and the need to coordinate river management actions, particularly in San Acacia Reach and Isleta reaches, to allow for Minnow to move to wetted areas; e.g., LFCC pumping, SADD minnow gate, and other activities or tools.

Provide hydrologic (flow) conditions in summer, fall, and winter to support survival in all years; e.g., implement a "Drought and Emergency Water Management Plan," provide depletion offsets for flood and irrigation management deviations and habitat restoration depletions; review and update strategic water management documents (e.g., "2006 Long Term Water Acquisition & Management Plan" and "2008 Strategic Water Reserve Implementation Analysis Report.")

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Action 2.3: Increase reach boundary connectivity.

Resolve later? Rick and Grace look at San Acacia study again and select tasks that are feasible for the next 5 years.

2.3 Element 3 - Conservation Hatchery Programs <Extinction prevention / Safety net / Source for propagation/augmentation?> Rephrase

<Was this element discussed or was it deferred?>

Action 3.1: Plan and evaluate Minnow propagation and augmentation program.

Just in case, tasks from table pasted into each of the Element 3 Action--delete if no consensus on them (consensus was reached in a previous meeting on the Actions themselves).

Task 3.1a: *Revise and refine "RGSM Genetics Management and Propagation Plan" including captive rearing and propagation to augment the population in the middle Rio Grande and identification of reintroduction sites to start new populations.*

Task 3.1b: *Perform genetic evaluation of captive and wild fish and determine effect of augmentation on genetic viability of wild populations.*

Task 3.1c: *Determine best propagation strategy for genetic viability of Minnow as part of Task 3.1.1a: Revise and refine "RGSM Genetics Management and Propagation Plan."*

Task 3.1d: *Determine genetic effective population size of the Minnow.*

Action 3.2: Develop, support, and maintain propagation and rearing facilities for Minnow.

Task 3.2a: *Continue to fund, maintain, and operate the Albuquerque BioPark Facility.*

Task 3.2b: *Continue to fund, maintain, and operate the Los Lunas Silvery Minnow Refugium.*

Task 3.2c: *Continue to fund and support technical assistance from the Dexter National Fish Hatchery and Technology Center (DNFH), including maintaining fish on site.*

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Continue efforts at Rio Grande silvery minnow Sanctuary

Action 3.3: Rear and maintain Minnow in captivity.

Task 3.3a: *Annually gather Minnow eggs in drift from wild populations and rear the young in captivity, with a goal of collection of approximately 500,000 eggs to meet annual stocking commitments.*

Task 3.3b: *Maintain at least 100,000 Minnow of wild genetic origin in captivity on an annual basis for restoration in case of a catastrophe.*

Task 3.3c: *Quantify and evaluate genetic diversity of wild and captive fish to ensure genetic diversity as part of Task 3.1.4a: Perform genetic evaluation.*

Task 3.3d: *Maintain sufficient numbers of Minnow to augment existing populations, as necessary.*

Continue augmentation program

Action 3.4: Augment wild populations as necessary.

Task 3.4a: *Develop a "Plan to Investigate and Identify Additional Introduction Sites for Minnow."*

Task 3.4b: *Conduct hydrology, habitat, and fish community analyses to identify suitable introduction sites most likely to support self-sustaining populations.*

2.4 Element 4 - Research, Monitoring, and Adaptive Management

<Rework and refine tasks in this element.>

Action 4.1: Develop and implement monitoring programs with sufficient reliability, precision, and accuracy for RIP needs.

Task 4.1a: Synthesize data.

Task 4.1b: Convene a workshop of species and monitoring experts, and Program managers, to evaluate and refine the existing monitoring program and to define standards of precision and change detection that will be met by the monitoring program.

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Task 4.1c: Write and scientifically review a refined "Fish Population Monitoring Plan" with the appropriate design and data analysis to meet the needs of Program managers.

Task 4.1d: Implement, evaluate, and refine the monitoring program, as necessary, to meet the criteria of precision and detection level needed by Program managers.

Task 4.1e: Develop metrics to recommend to Executive Committee.

Action 4.2: Identify and prioritize specific science <and adaptive management?> activities that address overall Program goals.

Task 4.2a: <Upon establishment of the Science Panel> Perform a "state of the science" review.

Task 4.2b: Hold an Executive Committee 1 to 2-day workshop to brief the Program and the Executive Committee on the "state of the science".

Task 4.2c: Develop a prioritized list of activities and related research that needs to be conducted in the foreseeable future.

Task 4.2d: Schedule periodic updates with the Executive Committee strictly focused on status of science activities, knowledge, and Program priorities.

Task 4.2e: Complete a draft Peer Review Process for EC review and approval. Implement process for multiple pending peer reviews including (list of reviews with target dates).

Task 4.2f: The RIP will establish a team to develop agreed-upon demographic metric(s) to assess population trends and progress toward recovery under the RIP.

Task 4.2g: Evaluate existing habitat projects as to whether it provides species benefits.

~~Task 4.2h: Evaluate existing habitat projects as to whether it provides species benefits.~~

Action 4.3: Conduct minnow research critical to RIP.

Task 4.3a: Determine factors that affect age structure, age-specific survival rates, and recruitment.

Task 4.3b: Determine factors that affect growth rates of Minnow.

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Task 4.3c: Determine fecundity (average number of eggs per female) and maternity (proportion of young produced per female that reach maturity).

Task 4.3d: Determine effective female:male gender ratio for spawning.

Task 4.3e: Determine food habits of the Minnow.

Task 4.3f: Conduct a series of flow/habitat experiments to determine optimum species life stage water needs.

Task 4.3g: Conduct a series of flow/habitat experiments to determine optimum species life stage water needs.

Action 4.4: Determine the viability of Minnow populations. *<Rick and Dave to tackle?>*

Placeholder? Task 4.4a: Conduct a Population Viability Analysis (PVA).

Task 4.4b: Develop, document, and implement "Quantitative Population Models in a PVA Framework."

Task 4.4c: Evaluate extinction risk for Minnow populations for various environmental conditions and management actions.

Task 4.4d: Evaluate effects/benefits of habitat restoration (including floodplains, refuges during drying events) on populations of Minnow.

Task 4.4e: Evaluate effectiveness of augmentation on wild population viability.

Task 4.4f: Evaluate potential impacts of climate change on viability of Minnow populations.

Action 4.5: Establish and maintain a Database Management System for RIP needs. *<Move to Program Management?>*

Task 4.5a: Procure original datasets from investigators in a flat-file, fixed format.

Task 4.5b: Reconcile all data errors, inconsistencies, and discrepancies with data collectors to ensure a clean and concise database.

Task 4.5c: Establish a "Data Assembly, Storage, and Quality Control Protocol" that provides data formats, dates for data submission, and conditions for data releases and accessibility to the data by the general public.

Task 4.5d: Assemble available data in a clear and concise manner.

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Task 4.5e: Coordinate future data assembly and quality control through an established "Data Assembly, Storage, and Quality Control Protocol."

2.5 Element 5 - Additional Wild Self-Sustaining Populations

Action 5.1: Support the development of additional wild self-sustaining populations of Minnow. *<Discussed briefly? Not completed?>*

Task 5.1a: Develop <of if one exists, Evaluate> an <EC-approved> "Plan to Investigate and Identify Additional Introduction Sites for Rio Grande Silvery Minnow."

Task 5.1b: Conduct hydrology, habitat, and fish community analyses to identify suitable introduction sites most likely to support self-sustaining populations.

Task 5.1c: Investigate and obtain authorization to introduce Minnow into potential sites through necessary means, including a 10(j) rule-making (experimental population).

Action 5.2: Rear and maintain minnow in captivity in order to augment wild populations as necessary (Actions 3.3 and 3.4).

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3 Elements for Southwestern Willow Flycatcher

3.1 Element 1 - Territory Establishment and Nesting Success

Action 1.1: Create habitat conducive to territory establishment and nesting success.

Action 1.2: Create hydrologic conditions conducive to territory establishment and nesting success.

3.2 Element 2 - Flycatcher Research, Monitoring, and Adaptive Management

Action 2.1: Assess, identify and prioritize specific science <and adaptive management?> activities that address overall Program goals.

Action 2.2: Conduct Flycatcher research critical to RIP.

Action 2.3: Determine the viability of Flycatcher populations.

Action 2.4: Develop and implement monitoring programs with sufficient reliability, precision, and accuracy for RIP needs.

Action 2.5: Incorporate Flycatcher data into RIP Database Management System.

<*Action 2.6:* Facilitate the exchange of information with other groups.>

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3.3 Element 3 - Populations Outside the Program boundaries (within New Mexico)

Action 3.1: Support the development of other populations of Flycatcher.

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4 Ongoing Action Plan Elements

4.1 Element 1 – RIP Management

<Actions need clarification>

Action 1.1: Facilitate Program planning and management <and implementation?>.

Action 1.2: Provide ongoing Program Management.

Action 1.3: Implement priority Program projects.

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5 Priorities, Responsible Parties, Dates of Performance

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6 Time Schedule

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7 Estimated Costs

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Formulation of Sufficient Progress Metrics

The Service will make an annual determination whether the RIP is making sufficient progress toward recovery of listed species. This determination of sufficient progress ensures continued ESA compliance for covered actions. It is conditioned on the Fish and Wildlife Service's assessment in its Biological Opinion that the RIP activities, combined with any other conservation measures, fully serve to minimize detrimental listed species effects of the proposed water use and management actions; and that covered actions in combination with RIP activities are not reasonably expected, directly or indirectly, to diminish listed species' numbers, reproduction, or distribution so that the likelihood of survival and recovery in the wild is appreciably reduced, or result in the destruction or adverse modification of critical habitat. The sufficient progress determination will also assess whether RIP activities are advancing species recovery by working toward the reduction of threats to listed species and the improvement of the status of listed species and their habitats.

The RIP will adopt specific criteria (Sufficient Progress Metrics) by which the above sufficient progress determination is assessed. The RIP Sufficient Progress Metrics ("Metrics") will consist of (1) measures of implementation of RIP activities listed in the current Five-Year Action Plan and (2) measures of species response to RIP activities, including demographic indicators of species survival, reproduction and recruitment and population viability analysis assessment of probability of species survival over a given period (e.g. 100 years). It is recognized that the current monitoring protocols are not sufficiently precise and sensitive to be endorsed by the RIP for purposes of measuring species response to specific management activities and progress toward recovery. During the first two years of RIP operations, the RIP will continue to collect and consider the results of ongoing demographic monitoring data in its implementation of activities under the RIP, but will not use such data in a Sufficient Progress Metric. During this interim period, implementation measures will play the primary role in assessing RIP progress, as the RIP builds its capacity to implement a rigorous Adaptive Management program, as well as developing and refining its monitoring protocols to measure species response to specific management activities.[1] Also during this period, the EC will work to determine appropriate and scientifically supportable Metric(s) to determine if the species is making progress towards recovery, and progress made by the RIP in reaching agreement upon use of CPUE and/or other methods and demographic metrics will be considered by the Service. It is recognized that annual sufficient progress toward recovery may be maintained notwithstanding a failure to meet one of more of the Metrics. These Metrics, especially those measuring species response, will be quantitative to the extent possible, but qualitative Metrics may be used when no quantitative measure exists or is possible for the factor in question.

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[2] I.e., where the available data lend themselves to PVA analysis and where a PVA model is constructed to perform this type of assessment.

Possible Final (as)

As described above, the Metrics are expected to incorporate and reflect both measures of implementation of RIP activities and of species response, as well as standards of avoiding jeopardy (and adverse critical habitat modification) and of advancing species recovery. This framework for developing metrics may be visualized as filling in the following matrix, which is presented purely as an example of the types of metrics that the RIP could utilize and not as a proposal to adopt these particular metrics. As represented here, this framework would allow the RIP to assess with some precision its level of success in implementing activities and promoting species responses that maintain and advance listed species' likelihood of survival and recovery—at both the population and the species level—as well as allowing the RIP to select and develop future activities, Adaptive Management approaches and metrics that are informed by such assessments:

Example of types of metrics to be utilized after interim period		
		"Operational"
"Interpretational"	Measures of Implementation of RIP Action Plan	Measures of Species Response
Avoids appreciable reduction in likelihood of survival and recovery (and adverse critical habitat modification) so as not to trigger reinitiation.	e.g. *x* fish released from hatchery *x* miles of river bank lowered *x* af of water pumped into river	e.g. demographic indicators, CPUE index from monitoring sites PVA assessment of probability of survival at 100 years
Achieves sufficient progress toward recovery	e.g. *x* + *y* fish released from hatchery *x* + *y* miles of river bank lowered *x* + *y* af of water pumped into river	e.g. demographic indicators, such as ??? PVA assessment of probability of recovery

Particular values for these types of metrics would be determined as a result of the incorporation of upcoming scientific analysis from the sources listed below (e.g. 2012 Workshop(s), Program science, science compiled for Biological Assessments, Biological Opinion, etc.) after assessment and decision by the EC. The Program's PVA modeling may be able to assess the contribution of each factor underlying such types of metrics (e.g. flow or habitat) to the likelihood of species'

survival and recovery.[2] PVA model outputs can thus validate indicators of progress and, further, can be used to propose other indicators and thereby assume an important role in ongoing development and refinement of the RIP's Sufficient Progress Metrics.

Initially, the RIP Sufficient Progress Metrics will be approved by the EC. Thereafter, updating RIP Sufficient Progress Metrics, as the Five-Year Action Plan is annually updated and amended, is expected to be the responsibility of the Science Coordinator (or related position or entity to be defined), in coordination with and with the approval of the EC (including the Service). Because Sufficient Progress Metrics must continually remain relevant to species status and prospects for survival and recovery, utilizing the best available scientific information as this information is developed, key considerations to be utilized by the Science Coordinator and the EC in updating Sufficient Progress Metrics include:

- Relevance to species population viability (i.e. to maintaining the risk of extirpation below an acceptable level and the probability of recovery above an acceptable level);
- Relevance to RIP recovery actions identified in the Action Plan and Annual Workplan (since the metrics serve to evaluate these);
- Measurability of demographic and other factors important as indicators of viability (e.g. survival, reproduction, recruitment, distribution, genetic diversity), appropriate correlate measures, and the degree of confidence in such correlations;
- Feasibility and achievability of measured activities and/or population viability factors within resource (funding, water) and RIP organizational and institutional constraints.

During the initial and subsequent formulation of Sufficient Progress Metrics, the Science Coordinator and EC will consider the following sources of information to ensure that proposed Metrics maintain relevance to species population viability, utilizing the RIP protocols and procedures for internal science review and external peer review as needed:

- Long-Term Plan: activities deemed by RIP to be relevant to recovery goals;
- Recovery Plan: Criteria for recovery and preventing extinction; prescribed activities;
- Program science: Science Workgroup and Population Viability Analysis Workgroup, PVA response to questions posed by Service and others, Adaptive Management, internal peer review;

[2] I.e., where the available data lend themselves to PVA analysis and where a PVA model is constructed to perform this type of assessment.

Possible Final (as)

- Scientific information considered by the Fish and Wildlife Service in its Five-Year Review and Biological Opinion, Scientific information presented to Service before and during analysis for Biological Opinion;
- External peer review;
- Science Workshop(s) during summer 2012.

The Water Management Plan for the MRG RIP

Principles and General Outline

The purpose of the Water Management Plan (WMP) for the Middle Rio Grande Recovery Implementation Program (MRG RIP) is to provide a framework for the MRG RIP to make informed water management decisions for simultaneously meeting the two purposes of the RIP:

- To provide sufficient resources for protecting and enhancing the existence of the MRG endangered species with the goal of achieving recovery; and
- To meet current and future water demands in the MRG.

The WMP will be based upon underlying principles of the RIP Program Document and prescribed river management goals and actions defined within the MRG RIP Action Plan and the Annual Work Plan. An interdisciplinary team utilizing acquired knowledge that is refined through the adaptive management process will formulate recommendations for water managers to use in developing and implementing annual water operations plans based on forecasted hydrologic conditions and specific MRG RIP goals. The guiding principles that will be utilized in developing the WMP are as follows:

<u>Guiding Principles:</u>

1) The participating water management agencies must and will continue to act in accordance with their statutory authorities, policies and responsibilities to their respective constituents. Each agency will operate within and will not cede their respective water management authorities or responsibilities.

2) There will not be any "takings" of private property rights (water rights and land). Any acquisitions of private/public property will only occur through negotiations between willing parties.

3) Existing agreements, authorities, policies and operating criteria will form the basis for development of the WMP.

4) The WMP will focus on a suite of actions that will seek to improve in-river conditions for species based on sound science implemented through an adaptive management process while utilizing available water supplies more effectively during high water years in order to meet desired conditions during anticipated drought years.

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Outline of the WPM:

While the Minnow Rider states that acquisition of water shall be at federal expense it does not preclude stakeholder agencies from providing benefits necessary for ESA compliance. Indeed, budgetary constraints and reduced opportunities for acquisition of San Juan-Chama Project water supplies, which has been the mainstay for Reclamation's Supplemental Water Program, require the development of alternative water management strategies, as will be contained in the MRG WMP. The WMP will build upon the Middle Rio Grande Endangered Species Collaborative Program's Water Acquisition and Management work group (WAM) and Species Water Management work group (SWM) efforts, as well as Reclamation's 2006 Long Term Water Acquisition & Management Plan and New Mexico's 2008 Strategic Water Reserve Implementation Analysis Report.

The WMP will be a companion plan to the MRG RIP Action Plan and Long Term Plan, and will contain the suite of water management tools available to meet the needs of listed species and water users. The WMP will include specific tools that each of the MRG water managers (the Bureau of Reclamation, the Army Corps of Engineers, Executive Agencies of the State of New Mexico, the Middle Rio Grande Conservancy District, and the Albuquerque Bernalillo County Water Utility Authority [collectively, the Water Managers]) will utilize to improve river conditions while meeting its principle water needs. The Fish and Wildlife Service (Service) will also be included in the WMP to reflect their involvement at Bosque Del Apache National Wildlife Refuge (BDANWR), as well as their regulatory and advisory role. Additionally, the six MRG Pueblos will be included in consideration of their status as the senior water right users, and their interest in MRG water management.

Each of the Water Managers will operate within and will not cede their respective water management authorities or responsibilities. The RIP action team (A Team) will make recommendations to the Water Managers based on forecasted hydrologic and water supply conditions, specified species needs, and identified scientific purposes, and the Water Managers will utilize the tools described in the WMP to meet those needs.

In the WMP, the tools will be sorted into one of three categories: 1) tools for minnow spawning and survival of larvae; 2) tools for providing suitable habitat for survival and recruitment of Minnow during low-flow periods in summer, fall, and winter; and 3) tools for enhancing coordination of water operations. Additionally, the WMP will describe a time horizon for each tool: short term, mid term and long term. Each tool will include a description, the principle water manager(s), the cooperating water manager(s), and a list of necessary actions that can be taken to fully implement the tool. Entering into specific water management agreement(s) with key parties may be a necessary action to implement some tools such as the Emergency Drought Water agreements.

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Included in the WMP will be development of a drought management pool in upstream reservoirs to supplement river flows during drought conditions where water supplies are critically low. Additionally, the WMP will include specific focus on the San Acacia reach, and within that team BDANWR will be a critical member.

Timeline:

Reclamation proposes to take in a lead role while fully working with the Water Managers and the Service concurrently with completing the BA, the Supplement of State and other non-Federal, non-Pueblo actions, and developing the draft Biological Opinion (BO). The WMP will be a critical component of the RIP and will be negotiated and finalized as part of the RIP Action Plan between now and mid-September. The Service would then use the totality of the Action Plan that includes the WMP to fully analyze the proposed measures. The goal is to have these documents and associated commitments serve as the essential conservation measure going forward under the MRG RIP.

The WMP will be a component of the MRG RIP Action Plan and will be referenced in the Cooperative Agreements that each of the Water Management agencies will sign as part of their commitment to the MRG RIP process. It is anticipated that the MRG RIP documents and Cooperative Agreements will be complete and ready for incorporation into the BO at year's end. Together the individual Cooperative Agreements and the MRG RIP Action Plan that includes the WMP will memorialize each agency's commitment to support the actions described in the Action Plan and to utilize the necessary resources to develop and use each tool.

We will have a new BO with the MRG RIP as the essential Conservation Measure by February 2013!!

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COOPERATIVE AGREEMENT

FOR THE MIDDLE RIO GRANDE COLLABORATIVE RECOVERY IMPLEMENTATION PROGRAM

This Cooperative Agreement is entered into by the[1] United States Bureau of Reclamation (Reclamation), the United States Army Corps of Engineers (Corps), the United States Fish and Wildlife Service (Service), the Pueblo of Sandia, the Pueblo of Santa Ana, the Pueblo of Isleta, the Santo Domingo Tribe, the New Mexico Interstate Stream Commission, the New Mexico Attorney General's Office the New Mexico Department of Game and Fish, the New Mexico Department of Agriculture, the City of Albuquerque, the Albuquerque-Bernalillo County Water Utility Authority, the Middle Rio Grande Conservancy District, the Assessment Payers Association of the Middle Rio Grande Conservancy District, and the University of New Mexico.

I. Background

The Middle Rio Grande Endangered Species Collaborative Program (Collaborative Program) was established by Memorandum of Understanding (MOU) in 2002 as a collaborative effort consisting of federal, state, and local governmental entities, Indian Tribes and Pueblos, and non-governmental organizations to: A) act to prevent extinction, preserve reproductive integrity, improve habitat, support scientific analysis, and promote recovery of the listed species, in a manner that benefits the ecological integrity, where feasible, of the Middle Rio Grande (MRG) riverine and riparian ecosystem; and B) exercise creative and flexible options under the Endangered Species Act (ESA) so that water use and development can proceed in compliance with applicable laws.

A Memorandum of Agreement (MOA) signed by Program participants in 2008 superseded the previous MOU, as amended. In the MOA, Program participants committed to participate and support the Collaborative Program through May 2021.

In 2009, the Executive Committee (EC) of the Collaborative Program agreed to investigate and consider the transition to a recovery implementation program (MRGRIP or RIP) to better address the conservation needs of the species and to serve as an ESA compliance vehicle for water related actions in the MRG. The goals of the RIP are to:

1. Alleviate jeopardy to the listed species in the MRG Program area
   - Avoid actions that preclude survival or recovery of the listed species
   - Continually identify the critical scientific questions and uncertainties that will be addressed through adaptive management in support of a hydrologically and biologically sustainable MRG water operations Biological Opinion (BO)

[1] This list of signatories will reflect those parties that actually join the RIP through signing this Cooperative Agreement. In this example, we listed all 16 members of the Collaborative Program.

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2. Conserve and contribute to the recovery of the listed species as described in the RIP
    - Stabilize existing population through ongoing and future management activities
    - Support the development of self-sustaining populations
3. Protect existing and future water uses
    - Provide a mechanism for ESA compliance for identified federal actions and ongoing non-federal water related actions
    - Provide a process for streamlined Section 7 consultation for future water uses needing compliance with the ESA
4. Be transparent to stakeholders, the public, and other interested parties

The RIP may not impair state water rights of individuals and entities or federal reserved water rights of individuals and entities; federal or other water rights of Indian nations and Indian individuals, or Indian trust assets; San Juan-Chama Project contractual rights; the State of New Mexico's ability to comply with Rio Grande Compact delivery obligations; or the Middle Rio Grande Conservancy District's statutory obligations to its constituents. Water to be acquired or otherwise made available must be from a willing seller or lessor and be used in compliance with the laws of the State of New Mexico including, but not limited to, permitting requirements.

To establish the foundation for a long term recovery implementation program, the RIP incorporates an Action Plan that draws from a Long Term Plan inventory based on the elements described in the species recovery plans. The RIP also incorporates an Adaptive Management Program framework for working towards recovery, and ESA compliance principles for water-related actions in the MRG.

II. Statement of Purpose and Agreement

The purpose of this Cooperative Agreement is to establish the Middle Rio Grande Collaborative Recovery Implementation Program. Through execution of this Cooperative Agreement, signatories are committing to participate in the MRG Collaborative RIP to the extent possible with full consideration given to the attached RIP Document that details RIP implementation.

[The following language is provisional as the Section 7 compliance process has not been completed.]
The [anticipated] 2013 BO identifies implementation of activities under the RIP's Action Plan (identified more specifically in annual work plans to be approved by the EC) as a conservation measure offsetting the effects of water related actions addressed in the 2013 BO. The Service agrees that implementation of that conservation measure will alleviate the likelihood of jeopardy and adverse modification under Section 7 of the ESA for the effects of water related actions addressed in the 2013 BO. The Service agrees that, except as provided in the 2013 BO, no other measure or actions shall be required or

imposed on the signatories to comply with the ESA with regard to the actions covered by the 2013 BO. The signatories are entitled to rely on this agreement in making the commitment described below.

The signatories to this Cooperative Agreement agree to participate in good faith to implement certain activities designed to offset the effects of water related actions in the MRG relating to species listed as threatened or endangered pursuant to the ESA and their associated habitats, and to use best efforts to work toward the recovery of such species, within the limits of each participant's authority. The recovery activities and the processes by which they are implemented are further identified in the attached RIP Document. The signatories to this Cooperative Agreement agree to participate in good faith and support the RIP including the committees established by the RIP. To the extent that implementing the RIP requires active cooperation by signatories, those signatories agree to take reasonable actions needed to implement the RIP. No signatory is required to take any action that would violate law or regulation, or an individual signatory's decrees or its statutory obligations or authorizations, or any applicable limits on its legal authority. No signatory is precluded from undertaking good faith negotiations over specifics applicable to implementation of the RIP.

III. Authorities and Responsibilities

A. Federal Cooperation with States. Section 2(c)(2) of the ESA, 16 U.S.C. 1531(c)(2), states that "the policy of Congress is that federal agencies shall cooperate with state and local agencies to resolve water resource issues in concert with conservation of endangered species." Under Section 6 of the ESA (16 U.S.C. 1535), the Secretary of the Interior is directed to cooperate to the maximum extent practicable with the states in carrying out the program authorized by the ESA and to consult with the affected states before acquiring any land and water, or interest therein, for the purpose of conserving listed species. Under 31 U.S.C. 6305, an executive agency should enter a cooperative agreement when anything of value will be transferred to a state or local government to carry out a public purpose authorized by federal statute.

B. Recovery Plans and Teams. Under Section 4(f) of the ESA, 16 U.S.C. 1533(f), the Secretary of the Interior is directed to develop and implement plans for the conservation of endangered species. The Secretary of the Interior may procure the services of public and private agencies, individuals and institutions in developing and implementing the recovery plans. Advice from these agencies, individuals, and institutions is not subject to the Federal Advisory Committee Act, 5 U.S.C. app.2.

C. Consultation and Regulatory Certainty. Under Section 7 of the ESA, 16 U.S.C. 1536, federal agencies shall use their programs and authorities in furtherance of the purposes of the ESA and ensure that their actions are not likely to jeopardize listed species or adversely modify designated critical habitat of such species. Under the Fish and Wildlife Coordination Act, 16 U.S.C. 661 *et seq*., federal agencies must consult with the Service and with state wildlife agencies on the impacts to fish and

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wildlife resources of federal or federally licensed or permitted water projects. The authority for federal agencies to enter into this Cooperative Agreement is provided under Section 1 of the Fish and Wildlife Coordination Act.

D. Operation of Federal Water Projects. The Reclamation and the Corps are charged with the operation of certain federal projects in the Middle Rio Grande Basin in New Mexico under applicable federal laws.

E. Operation of Water Projects by Local Authorities. Certain RIP signatories, such as the Albuquerque-Bernalillo County Water Utility Authority and Middle Rio Grande Conservancy District, have certain legal authorities and responsibilities to deliver water to meet the legitimate and legal demands of their ratepayers and constituents. Nothing in this Cooperative Agreement shall derogate from these signatories' authorities and responsibilities. These signatories will encourage habitat restoration and protection to the extent that goal is consistent with maximizing water resources dedicated to uses for present and future ratepayers and constituents.

F. Applicable State Law. Subject to applicable compacts and decrees, the State of New Mexico administers water rights, including water rights for fish and wildlife purposes. New Mexico also has certain statutory authorities and responsibilities to protect and manage its fish and wildlife resources. All water rights necessary to carry out the RIP will be applied for by a state agency or other project sponsor, and granted as appropriate under the state's water law and in keeping with state authorities and responsibilities for fish and wildlife. Nothing in this Cooperative Agreement shall be construed as creating federal water rights or requiring the granting of water rights to federal entities.

G. Applicable Tribal Law.
Text to be developed specific to signatories

H. Trust Responsibility.

a. The United States has a unique legal relationship with Indian tribal governments as set forth in the Constitution of the United States, treaties, statutes, Executive Orders, and court decisions. Since the formation of the Union, the United States has recognized Indian tribes as domestic dependent nations under its protection. The Federal Government has enacted numerous statutes and promulgated numerous regulations that establish and define a trust relationship with Indian Tribes.
b. Our Nation, under the law of the United States, in accordance with treaties, statutes, Executive Orders, and judicial decisions, has recognized the right of Indian tribes to self-government. As domestic dependent nations, Indian tribes exercise inherent sovereign powers over their members and territory. The United States continues to work with Indian tribes on a government-to-government basis to address issues concerning Indian tribal self-government, tribal trust resources, and Indian tribal treaty and other rights.

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c. The United States recognizes the right of Indian tribes to self-government and supports tribal sovereignty and self-determination.

I. State Responsibilities. Nothing herein shall affect the authority of New Mexico to manage, control and administer its water resources nor its authorities and responsibilities regarding its fish and wildlife resources. New Mexico shall efficiently manage costs in implementing RIP activities and encourage habitat protection by local authorities.

J. Statement of Authorities. The signatories hereby state that they have legal authority to enter into the Cooperative Agreement, and have legal authority to participate in the Middle Rio Grande Collaborative Recovery Implementation Program.

IV. Terms and Conditions

A. Effective Date and Duration. This Cooperative Agreement shall be effective upon execution and shall remain in effect until the federally listed species in the MRG addressed in the RIP are recovered or until amended pursuant to IV.D. below.

B. Approval. Government funding commitments made in this Program are subject to approval and appropriations by the appropriate Local, State, Tribal and Federal legislative bodies, and are subject to the approval of the signatories' governing bodies.

C. Anti-Deficiency Act. Nothing in this Agreement shall be interpreted to require any obligation or payment of funds in violation of the Anti-Deficiency Act (31 U.S.C. §1341).

D. Amendment. This Cooperative Agreement may be extended, amended, or terminated by agreement of the signatories. Any signatory may withdraw from the Cooperative Agreement upon written notice to the other signatories. Upon withdrawal, such signatory shall not be deemed to have waived or relinquished any right to challenge the legal, scientific, or technical validity of any aspect of the 2013 BO or agency action based thereon by virtue of its reliance on the RIP or by virtue of its support for the RIP in other administrative or judicial proceedings.

E. No Delegation or Abrogation. Although this Cooperative Agreement sets forth a cooperative process, all signatories to this Cooperative Agreement recognize that they each have legal and statutory responsibilities that cannot be delegated, and that this Cooperative Agreement does not, and is not intended to, abrogate any legal or statutory responsibility of the signatories. All signatories agree that they have respective rights, responsibilities and obligations, and each signatory will continue to act in an independent capacity, and no signatory is to be considered the officer, agent or employee of any other signatory.

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F. No Admissions by Signatories. The signatories are entering into this Cooperative Agreement on a voluntary and cooperative basis in an effort to resolve ESA species conflicts through a negotiated and mutually agreed upon basin-wide program. Nothing herein shall constitute an admission that any ongoing water related activities or new water related activities have caused or will cause adverse effects to the target species or their habitats. Nor shall anything herein change the legal standards under Section 7 of the ESA applicable to water related actions in the MRG.

G. Recovery Implementation Program Modifications. Modifications to the RIP may be made following Program governance and decision-making protocol without requiring modification to this Cooperative Agreement.

H. Consistency with Applicable Law. This Cooperative Agreement is subject to and is intended to be consistent with all applicable Federal, Tribal, and State laws and interstate compacts. The provisions of any statutes and/or regulations cited in this Agreement contain legally binding requirements. The Agreement itself does not alter, expand, or substitute for those provisions or regulations. This Agreement does not impose legally-binding requirements on the Parties, nor does it create a legal right of action for the Parties or any third party.

I. Agency and Partnership**.** Unless expressly provided by law, personnel or volunteers of one party shall not be considered to be agents, partners or employees of the other party for any purpose, and no joint venture or principal-agent relationship shall be deemed to exist. The personnel and volunteers of one party are not entitled to any of the benefits that any other party provides for its employees or volunteers.

J. Sovereign Immunity. The signatories to this Cooperative Agreement do not waive sovereign immunity by entering into this Agreement and specifically retain immunity and all defenses available to them as sovereigns pursuant to State and Federal law.

K. Legal Rights and Remedies**.** Nothing in this Agreement shall be construed to alter the legal rights and remedies that each party would otherwise have. No party waives any legal rights or defenses by entering into this Agreement or participating in the process contemplated hereby. This Agreement is not a Federal contract, rule, or regulation. This Agreement shall not be construed as or interpreted to be final Federal agency action.

L. Liability**.** To the extent authorized by law, on behalf of itself, its officers, directors, members, employees, agents, and representatives, each party agrees that it will be responsible for its own acts and omissions and the results thereof and that it shall not be responsible for the acts or omissions of other parties, nor the results thereof. To the extent authorized by law, each party therefore agrees that it will assume the risk and liability to itself, its agents, employees, and volunteers for any injury to or death of persons or loss or destruction of property resulting in any manner from the conduct of the party's own operations and/or the operations of its agents,

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employees, and/or volunteers under this Agreement. To the extent authorized by law, each party further releases and waives all claims against the other party for compensation for any loss, cost, damage, expense, personal injury, death, claim, or other liability arising out of the performance of this Agreement.

M. Notices section for points of contact?

N. Release of Information**.** Except as required by court order or ruling, no joint lead or cooperating agency will release any pre-decisional material or working information or documents to the public other than through an approved Freedom of Information Act request or comparable state law-based process, or unless the agency or agencies have already disseminated the specific materials or documents to the public. The agencies agree to inform each other if it is determined that there is a legal requirement to release any such information, and that information will include expected release date of the information.

O. Severability**.** Should any portion of this Agreement be judicially determined to be illegal or unenforceable, the remainder of the Agreement shall continue in full force and effect, and any party may renegotiate the terms affected by the severance.

P. Third Party Beneficiary Rights**.** The Parties do not intend to create in any other individual or entity the status of third party beneficiary, and this Agreement shall not be construed so as to create such status. The rights, duties and obligations contained in this Agreement shall operate only among the Parties to this Agreement, and shall inure solely to the benefit of the Parties to this Agreement. The provisions of this Agreement are intended only to assist the Parties in determining and performing their obligations under this Agreement.

Q. Endorsement**.** Nothing in this Agreement may be interpreted to imply that any party endorses any product, service or policy of the other Parties. No party will take any action or make any statement that suggests or implies such an endorsement.

R. Nondiscrimination**.** This Agreement is subject to all applicable statutes relating to nondiscrimination. Federal statutes relating to nondiscrimination include, but are not limited to: (a) Title VI of the Civil Rights Act of 1964 (P.L. 88-352); and (b) Title IX of the Education Amendments of 1972 (20 U.S.C. 1681-1683 and 1685-1686).

IN WITNESS WHEREOF each party has caused this Cooperative Agreement to be executed by an authorized official on the day and year set forth below by signature.

By _____ Date_____

U.S. Bureau of Reclamation

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By _____ Date_____
U.S. Army Corps of Engineers

By _____ Date_____
U.S. Fish and Wildlife Service

By _____ Date_____
Governor, Santo Domingo Tribe

By _____ Date_____
Governor, Pueblo of Sandia

By _____ Date_____
Governor, Pueblo of Santa Ana

By _____ Date_____
Governor, Pueblo of Isleta

By _____ Date_____
New Mexico Interstate Stream Commission

By _____ Date_____
New Mexico Attorney General's Office

By _____ Date_____
New Mexico Department of Game and Fish

By _____ Date_____
New Mexico Department of Agriculture

By _____ Date_____
City of Albuquerque

By _____ Date_____
Albuquerque-Bernalillo County Water Utility Authority

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By _____ Date_____
Middle Rio Grande Conservancy District

By _____ Date_____
Assessment Payers Association of the Middle Rio Grande Conservancy District

By _____ Date_____
University of New Mexico

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APPENDIX 9

MRGCD PROPOSED CONSERVATION MEASURES – 7/24/2012 DRAFT

Middle Rio Grande Conservancy District

Memorandum

To: MIKE HAMMAN, AREA MANAGER – US BUREAU OF RECLAMATION

From: SUBHAS K. SHAH, CE/CEO

Date: JULY 24, 2012

Re: **PROPOSED BA CONSERVATIONS MEASURES**

Attached are the proposed Conservation Measures to the Biological Assessment that were approved by the Middle Rio Grande Conservancy District Board of Directors at their regular meeting on July 23, 2012.

Please contact me if you have additional questions.

SKS/eb

Attachment

Proposed MRGCD Conservation Measures

Preamble

1. Pursuant to its statutory general grant of powers (NMSA 1978, § 73-14-48), MRGCD has authority to enter into an endangered species Recovery Implementation Program (RIP) and to undertake certain species survival and recovery actions to be incorporated within the MRGRIP Action Plan. However, MRGCD has no authority to violate its statutory obligations and MRGCD is specifically prohibited from relinquishing control of the waters or lands of the District or from administering or managing District waters in such a way as to impair the private water rights of individual irrigators or its own statutory water rights (NMSA 1978, § 73-14-47).[1]

2. MRGCD has the authority to develop an Operating Plan to carry out some of the programs within the RIP that will benefit listed species (NMSA 1978, §§ 73-14-48 *et seq.*), but MRGCD has no authority to relinquish its authority to implement the terms of such an Operating Plan to any third party, particularly when such implementation may involve control of the use of the District waters or lands (NMSA 1978, § 73-14-47).

3. MRGCD has the authority to lease or otherwise provide reservoir storage space for a "supplemental water pool" and to assist in developing programs for use of that storage to provide protection for the RGSM consistent with the RIP, and as a contribution to cost-share, but it cannot do so in a way that reduces storage for persons entitled to receive water from the MRGCD (NMSA 1978, § 73-14-47).

Consistent with the above limitations, the MRGCD proposes the following actions for conservation of the species:

A. The MRGCD recognizes the need for ESA compliance and the need to continue to cooperate with Reclamation in future compliance efforts, which include the conjunctive management of water for species needs, municipal withdrawals, RGC obligations, and irrigation needs. The MRGCD will develop annually an Operating Plan. This Plan will coordinate the delivery of irrigation water to water rights holders and water users within the MRGCD. The Plan will also assist in meeting the needs of the listed species for population survival and recovery, including spawning, recruitment and survival habitat needs as determined by using the best available scientific information. The development and implementation of this MRGCD

[1] *See Gutierrez v. MRGCD*, 34 N.M. 346, 282 P. 1 (1929) (citing the full protection of private water rights afforded by Section 316 of the Conservancy Act).

Operating Plan will be incorporated into the Middle Rio Grande Recovery Implementation Program (MRGRIP) Action Plan as part of the conservation actions and/or tasks which are expected to permit the MRGRIP to attain and maintain compliance with the ESA.

B. The MRGCD will cooperate with state and federal agencies in creation and operation of a "supplemental water pool" consisting of up to 30,000 AF to be stored in available space in Abiquiu reservoir. Water stored for ESA purposes may, subject to ISC approval, be stored under the authority of the Strategic Water Reserve. Water stored separately by MRGCD for irrigation purposes will be managed by the MRGCD under its authority contained in the Conservancy Act. The conjunctive management of MRGCD water will provide some environmental and biological benefits to RGSM. The creation of the SWR was authorized by the NM Legislature in 2005, for the purposes of providing a water reserve to help New Mexicans manage through drought periods. In addition to meeting the needs of water users and NM's delivery obligations under the RGC, a goal of the pool will be to assist in providing flows needed for ESA purposes, and in so doing, to protect the rights of existing water users. Storage space at Abiquiu Reservoir for the pool was set aside by the ABCWUA as a result of a settlement between ABCWUA and Environmental groups when the ABCWUA was seeking to permit and construct its SJC Diversion works.

Water supply for the pool may come from a variety of sources including uncontracted SJC water and purchases of SJC water by the Federal Government from willing sellers. The use of surplus SJC water would be a primary choice for development of water supply, along with RG water stored as a result of NM having relinquished credit water in Elephant Butte reservoir to Texas under the Rio Grande Compact. Use of this water would be subject to the limitations of New Mexico water law. MRGCD is largest and most likely recipient of credit water stored as a result of relinquishment and in the absence of ESA requirements would logically be the recipient of most of this water. Relinquishment credit water (more correctly stated as the right to store water against relinquished NM RGC credits) is made available by the New Mexico Rio Grande Compact Commissioner. MRGCD will urge that a percentage of water resulting from credit relinquishments to the pool be allocated for ESA purposes. MRGCD will cooperate with appropriate entities to maximize NM credit status under the RGC, and increase the opportunities for future credit relinquishment to benefit both the ESA needs and MRGCD water supply. Concurrently, MRGCD will expand its opportunity for storage to manage through drought by completion of agreements with ABCWUA to store up to 50,000 AF of water at Abiquiu Reservoir. Space at Abiquiu reservoir for this purpose was pledged by ABCWUA as a result of MRGCD withdrawing its objections to permitting and construction of the ABCWUA SJC diversion works. While MRGCD has authority over water it holds in storage, MRGCD will

cooperate and coordinate with NMISC, ABCWUA, BOR and other appropriate entities to conjunctively manage releases from storage and releases from the pool to maximize flexibility in Rio Chama water operations for the benefit of environmental/recreational concerns, and to minimize evaporative or conveyance losses.

C. Depending on the available water supply and consistent with its primary statutory mission of conveying and delivering water for its use in agriculture, when MRGCD has water surplus to the needs of its irrigators within its canal system, the MRGCD will manage its diversions and outfalls to return excess flows to the Rio Grande for habitat areas and other designated sites, as determined by, and consistent with tasks identified within the MRGRIP Action Plan. The MRGCD will participate with other MRGRIP entities, in particular with the U.S. Fish and Wildlife Service, the MRGRIP Science Coordinator and scientific workgroups, and the MRGRIP management and Executive Committee, to identify and study key habitat areas to which water can be returned, especially during critically dry periods, to serve species population needs for survival and recovery, as determined by the best available scientific information, by maintaining wetted habitat for silvery minnow when drying is occurring elsewhere in the river. This commitment will not compel the District to deliver water to habitat or other sites when it is needed to serve irrigators' requirements.

When the MRGCD determines that water surplus to irrigation needs is not available within the MRGCD system, and flow to designated habitat or other areas for species needs is desired, MRGCD will convey water to these areas from available species water resources. MRGCD's contribution will be to bear the conveyance loss from point of release at a reservoir to point of delivery at habitat area, if MRGCD is delivering water along these same pathways for irrigation purposes. An exception may occur if delivery of water to a designated habitat area requires the use of a canal or other water pathway which is not normally or currently in use, in which case species water would be required to incur actual conveyance losses.

D. The MRGCD will cooperate and assist with the creation and enhancement of specific habitat areas, the so-called "String of Pearls" to provide a series of refuge areas where RGSM populations may be maintained during normal periods of low and intermittent flow in the MRG. These areas tend to be located near MRGCD outfalls which typically discharge excess water, or which can be readily used to convey species water with minimal losses. These areas are located in the Albuquerque, Isleta, and San Acacia reaches of the Rio Grande. The MRGCD will maintain its outfalls and, consistent with existing agreements, the federal agencies will provide

maintenance and enhancement of river areas through channel shaping, bank modification, vegetation management, food management, and biological management (non-native or predator removal) to provide conditions suitable to preserving maximum numbers of RGSM in good health for extended periods of time. The "String of Pearls" will provide RGSM refugial habitat between Cochiti reservoir and Bosque del Apache. The locations of the pearls are illustrated in the following map:

E. To allow more precise control and management of water supply to San Acacia dam, MRGCD will pursue construction of a siphon near Bernardo, NM to deliver excess irrigation returns from the San Juan Riverside Drain system directly to the Unit 7/Socorro Main Canal system. This is envisioned to allow for more reliable water supply to the MRGCD Socorro division while simultaneously reducing the total annual volume of water required for diversion at San Acacia dam. This would be anticipated in turn to benefit peak flows through San Acacia dam, and sediment movement and river morphology upstream and downstream of San Acacia dam with associated benefits for RGSM. During times of low or no flow, the Bernardo siphon could be envisioned to assist with management of the "String of Pearls" by creating a refugial area downstream of the siphon itself, and creating a more dependable water supply at San Acacia dam for the maintenance of a refugial area downstream of the dam. It is anticipated that costs of this project operations will be borne in part by the MRGCD, and in part by the federal government. Once the anticipated water supply benefits of the Bernardo Siphon Project have been realized, distribution of water supplies resulting from the Project could be directed by the District to meet the needs of water users in the MRGCD Socorro division in conjunction with those of the listed species.

F. To provide a water supply for the last pearl on the string, MRGCD will construct a return flow collection system at its southern boundary. Excess water from the San Antonio Acequia, the Socorro Main South Canal, the Socorro Riverside Drain, and the Elemendorf Drain will be routed to a central collection/distribution point. At the distribution point, water will be directed into the Low Flow Conveyance Channel and will be lifted back to the Rio Grande through a permanent electrically powered pumping station to be constructed by the MRGCD and operated and maintained by the BOR. It is anticipated that costs of these operations will be supported as cost-share by the MRGCD, and also by the federal agencies and the MRGRIP. Distribution of water at this point will be to meet the needs of the listed species, the water rights of the Bosque del Apache National Wildlife Refuge, and RGC delivery obligations.

G. Recession Management

During inevitable low and intermittent flow periods on the RG, RGSM mortality may be greatly reduced by controlled rates of recession, allowing individuals to move to suitable habitat locations (the String of Pearls). Controlling this rate of recession can be challenging, and has in the past resulted in usage of large amounts of species water. This may be at the conclusion of the spring snowmelt period, or after periods of heavy precipitation. To the extent permitted by the Rio Grande Compact, a controlled rate of recession may be produced by USACE reducing releases from Cochiti reservoir in a series of small steps. As a part of the conservation measures to the MRGRIP, the MRGCD will establish a policy where during times of floodwater storage and managed recession for RGSM, MRGCD available natural flow will be determined by the theoretical release from Cochiti reservoir in the absence of any such managed recession. In this way, USACE may have greater flexibility in controlling the rate of recession for RGSM without affecting NM's RGC deliveries to Elephant Butte. This mechanism would require an update to the Water Control Manual for Cochiti reservoir.

H. The MRGCD will actively participate in the creation of habitat to benefit the lifecycle of the RGSM. Habitat creation will be the responsibility of an interagency team consisting of MRGCD, the NMISC, BOR, USFWS, and USACE. The MRGCD will provide assistance in obtaining funding (cost share, etc.) and/or land for habitat restoration. Habitat restoration may be focused on enhancing the interconnection between active river channel and floodplain, as well as other types of restoration. Habitat restoration will be engineered to provide progressively greater levels of inundation at increasing flows, resulting in a range of habitat types. An initial goal over a XX year period will be 75 acres of RGSM habitat across the range of discharges.

I. To the degree permitted by New Mexico water law, the MRGCD will cooperate with efforts to establish a program whereby groundwater users within the MRGCD may offer water for lease to BOR or other groups for the express purpose of providing flows from wells for endangered species. Water provided to this program will be from willing lessees with pre-1907 or pre-basin groundwater pumping rights for agricultural use. Transfers of use of irrigation wells to instream uses will need to go through the OSE application and permitting process. Administration of this program must necessarily involve close coordination with the NMOSE and MRGCD to establish appropriate volumes of water and rates of flow, and to insure and verify that land from which pre-1907 water rights have been transferred for species use do not continue to be irrigated (absent an MRGCD water bank withdrawal).

J. While the development of new modeling and analysis continues to assist in addressing species management uncertainties, the MRGCD will continue to fund the current PVA and statistical data analysis efforts through a research agreement as a contribution to the scientific understanding of the RGSM.

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Joint Biological Assessment,
Part I – Water Management
Appendices

APPENDIX 10

MRGCD ALTERNATIVE HYDROLOGY ANALYSIS

Comparison of No Action (Baseline) Water Management Conditions in the Middle Rio Grande with the Proposed Action Condition Using ET Toolbox as Inputs for MRG Consumptive Uses.

1.0 Introduction:

The URGWOM model does a remarkably good job of simulating realistic water management scenarios through the Rio Grande/Rio Chama system to Cochiti Reservoir based on past gauge data, expected runoff volumes, and reservoir operating rules. However, the outputs from the URGWOM model become appreciably less certain once water passes below Cochiti Dam. This is due to a highly complex interaction of consumptive uses and groundwater exchange into and out of the river. In recent years, significant effort has gone into calibrating the URGWOM model to better reflect MRG conditions, and it is improved. Still, calibration has only been possible against observed conditions, and considerable unknowns remain. The model has been adjusted in the MRG to produce outputs that mesh with observed conditions, but some of the underlying mechanisms that produce those conditions are not understood well enough to actually be modeled. The use of URGWOM to model MRG flows entering the MRG is appropriate, but URGWOM inadequate when estimating the effects of those flows at points of interest within the MRG for Reclamation's BA.

Language in the ESA and BA guidance documents requires the analysis of the effects of a proposed action, compared to the baseline condition, which indicate conditions without the proposed action. The authors of this language must have logically assumed any proposed action would be a new occurrence, changing conditions from what they had previously been. In this case, the No-Action condition would likely be obvious, and the more difficult part of the equation would be what effects the Proposed Action might have. However, in the case of the RGSM and the MRG the Proposed Action is to continue current actions, and the unknown quantity is the No-Action condition. This seeming contradiction is becoming more common as the use of the ESA expands over the years. This BA is particularly unusual in that the "proposed action" is the continuance of activities that have been occurring to varying degrees for centuries. Thus, there is no way to calibrate the URGWOM model for the No-Action condition, since it has never been observed in historic times. A different approach is called for.

The No-action scenario to be modeled must be capable of showing the effects of the operation of existing reservoirs, and any actions that are not part of the Proposed Action condition. The No-Action condition must also demonstrate the range of flows expected through the MRG in the absence of the proposed actions, which below Cochiti reservoir is primarily the operation of MRGCD diversions for water delivery to agricultural consumers. Initial attempts using the URGWOM model were made by removing the MRGCD Demand or MRGCD Diversion from the consumptive use below Cochiti. However, these factors include consumptive uses which would continue under the No-Action scenario. The "MRGCD Demand" includes riparian consumptive use, evaporation from the river itself, and seepage to aquifer recharge, all of which would logically be expected to continue in the absence of irrigation water diversion. Similarly, "MRGCD Diversion includes a component that is not consumptively used by agriculture, but instead returns to the river or drain system, where it may be consumptively used by riparian vegetation, evaporate, become groundwater recharge, or appear again as surface flow in the RG.

A refinement to the modeled scenarios can be derived utilizing the ET Toolbox model (ETT). The ETT produces daily consumptive use values for agricultural, riparian, and open water consumptive use based on weather conditions and acreage extents. This allows for the effects of agricultural consumptive use related to the operation of MRGCD diversion dams to be removed for the No Action condition, and restored for the Proposed Action condition. Or, perhaps stated properly, the use of ETT allows the effects of open-water evaporation and riparian consumption to remain as consumptive demands upon the river under all conditions. As with any model, there are limitations to ET Toolbox. ETT does not contain a component for groundwater recharge, and this must be compensated for in another way. Prior to 2011, ET Toolbox riparian and agricultural values were based on a version of the Penman-Montieth equation (PM) that had been modified by agricultural researchers at New Mexico State University (NMSU). The NMSU PM method tended to overestimate MRG ET by about 30% ("Comparisons of ET Toolbox Reference ET with Other Methods Using Weather Data for the Period January 1 through December 30, 20110, BOR, Al Brower letter of March 20, 2012). For 2011, ETT adopted the more conservative FAO-56 PM method (Crop Evapotranspiration –Guidelines for Computing Crop Water Requirements, United Nations Food and Agriculture Organization, FAO-Irrigation and Drainage Paper 56, Richard Allen, 1998).

2.0 The Flow Model

To simulate MRG flows, a spreadsheet model was constructed (using MS EXCEL). The construction of this Flow Model (FM) is possible due to the geographic and hydrologic characteristics of the MRG. It has been said that the MRG is where the Rio Grande spreads itself out to dry. Most flow inputs to the Rio Grande occur upstream of the MRG. Most flow in the RG originates from winter snows, resulting in a pronounced and often dramatic increase in flow during the spring runoff period, and much lower flow the remainder of the year as baseflow from groundwater (also snow origin) drains from the high mountains. Within the MRG, hydrology is heavily dominated by depletion. As the RG enters the MRG area, its valley widens and its slope lessens. Tributary contributions within the MRG are limited to the Rio Jemez, and a number of arroyos that normally flow only during and immediately after precipitation events. Climatic conditions become more harsh and open-water evaporation increases. The broad valley supports an extensive riparian forest, which consumes a sizable percentage of the total flow. Riverside drains collect water from the river and from surrounding agricultural lands, and that water is either returned to the river at drain outfalls or used for agricultural irrigation. Groundwater pumping causes de-watering of both shallow and deep aquifers, which in turn draws additional water from the river corridor. And of course water is diverted from the RG, and delivered onto agricultural lands where it is consumed by agricultural use.

Within the MRG, the river system is neatly oriented north-south. It can be broken into "reaches" by creating east-west boundary lines. For URGWOM and ETT purposes, the MRG is separated into 8 distinct reaches. Not coincidentally, these reaches correspond with points of interest for water managers and for describing flow characteristics for the BA. Reaches are related to these flow points of interest as:

Reach 1-3: Cochiti reservoir outflow to Central Avenue gauge (Albuquerque)

Reach 4: Central Avenue Gauge to Isleta Diversion dam

Reach 5-6: Isleta Diversion dam to San Acacia Diversion dam

Reach 7: San Acacia Diversion dam to San Marcial Gauge

Reach 8: San Marcial Gauge to Elephant Butte Reservoir

All of these reaches experience consumptive use of water for agricultural and riparian evapotranspiration and open water evaporation, with the exception of reach 8. Reach 8 includes effectively no agricultural use, but does have extensive riparian consumption. Reach 8 also includes a large amount of open water evaporation, highly variable due to the changing pool elevation of EB reservoir. For these reasons, and since the downstream end of Reach 8 is not a flow point of interest for this BA, the FM does not include reach 8.

The underlying and simple premise of the FM is that a certain flow enters each reach, and the amount leaving that reach is determined by subtracting the known depletions in that reach from the inflow. The outflow from that reach then becomes the inflow for the next reach. There are complicating factors, primarily the interaction of water into and out of the drainage system. As noted above, some reaches are aggregated for consideration, which eases the difficulty in accounting for these complicating factors.

2.1 Model Inputs

The FM depends on an input of the flow expected to enter the MRG from the outlet works of Cochiti reservoir. This input value is derived from the previous URGWOM modeling for various conditions. The FM then uses ETT-derived depletion estimates for agricultural, riparian, and open water depletions; and an estimation of the impact of municipal groundwater pumping in the Albuquerque area (reaches 3 and 4) to estimate flows arriving at four key points in the MRG; Central Avenue gauge in Albuquerque, below Isleta Dam, San Acacia Gauge, and San Marcial Gauge. The FM is prepared to accept 10-year sequences of flows (runs). Flows at these points are evaluated in terms of number of years of successful spawn/recruitment condition during each run (Central Avenue only), days of major drying over the course of the run, days of intermittency over the course of the run, number of years during the run in which major drying occurs, and number of years during the run in which some intermittency occurs.

The FM is constructed so that the user can readily specify (or modify) values to test for spawn/recruitment conditions, major drying, or intermittency. For the runs described by this document, the following conditions were specified:

	Spawn Flow/Duration	Major Drying	Intermittency
Central Avenue	3000 cfs/7 days	10 cfs	100 cfs
Below Isleta Dam		30 cfs	100 cfs
San Acacia Gauge		10 cfs	200 cfs
San Marcial Gauge		10 cfs	50 cfs

The FM also includes a user-adjustable factor that allows the extent of agricultural consumption to be specified. This allows for full agricultural consumptive use to occur in the FM under the Proposed Action, where it should be set to 1. However, for No-Action runs, agricultural consumption may still occur in some areas even when no diversion for that purpose is occurring, due to groundwater accretion in MRGCD drains. Reaches 1-3 contain no lands which can practically be served from these drains. A considerable portion of agricultural lands in Reach 4 can be served from drains. While a lesser percentage can be served in Reach 5-6, the very large agricultural acreage in Reach 5-6 makes this an important component. In Reach 7, about a third of agricultural lands are expected to be served from drains, primarily MRGCD lands south of Socorro and on the BDA National Wildlife Refuge. The following factors are used for the No-Action conditions described here.

Reach 1-3: 0

Reach 4: 0.5

Reach 5-6: 0.25

Reach 7: 0.33

Should one wish to evaluate conditions if no agricultural consumption were to occur, and groundwater accretion to drains were routed back to the RG, these values should all be set to zero.

2.1.1. ET DATA for Depletion Input

Ag/Riparian Evapotranspiration and Open Water Evaporation should be reasonably constant year to year, though will vary substantially over the course of a year. It is practical and reasonable to establish evapotranspiration/open-water consumption curves (for our purposes, a series of steps, roughly describing a curve); similar to what was previously used in the URGWOM model for MRGCD Demand and MRGCD Diversion. This is considerably less subjective than previous efforts, since reliable estimations of evapotranspiration and open-water evaporation may be produced from mathematical evaluation of known plant/water functional relationships with climate.

ETT values used as inputs in the FM are determined through a separate set of spreadsheets:

AG_ET_Corrected_2Week.xls

RIP_ET_Corrected_2Week.xls

OW_EVAP_Corrected_2Week.xls

Each of these worksheets contains 5 years (2007-2011) of daily values from ETT. An Average value for each day is produced from the five years. Then, the average values are used to determine the average for every 2-week period beginning Jan 1. Two small exceptions occur; the last period of the year includes 15 days, and where leap years occurs (2012, 2016) Feb 29 is given the same value as Feb 28. The use of the 2-week average was found to be necessary to produce a logical and evenly distributed "curve" for ET throughout the year, damping out the effects of daily weather disturbances from

seasonal climate. The five years chosen represent a fairly limited sample, and a longer record would clearly be desirable. However, ETT underwent significant changes from its inception in 2000 through 2005, and 2006 was an exceptional year due to record rains in the critical July-September period. For these reasons only the last 5 full years of ETT data were used to construct the agricultural, riparian, and open water consumptive use inputs. ETT daily values for years 2007-2010 are multiplied by 0.70 in the worksheet to adjust them to the FAO-56 method used in 2011.

Along similar lines, MRGCD diversions were also processed through an excel spreadsheet:

2.1.2. Diversions_Corrected.xls

In this worksheet, daily recorded values for the past 4 or 5 full years were culled from MRGCD records. For Isleta Diversion, years 2007-2010 were used. Similar logic was applied as with ETT data, with 2002 and earlier data representing a different MRGCD operational policy, 2003 and 2004 being years of short supply, and 2006 being the exceptional year of high rainfall. 2011 data is not yet reviewed and available, so only the four years of 2007-2010 were used to get an average value for diversion at Isleta Dam on any day. For San Acacia diversion, 2011 data are available, so a full five-year set, 2007-2011, was used for this diversion point. At present, diversions for Cochiti and Angostura are not being considered in the FM, so data from these diversions are not yet included in the spreadsheet.

2.1.3. Leakage to Groundwater

A value for seepage to groundwater use is also necessary, particularly for estimating flows through the Albuquerque reach of the river. While there are lesser groundwater withdrawals throughout the MRG, an initial estimate of this is done only for the ABCWUA withdrawal/return. Evaluation by NMISC of the present rate of loss from the river to ABCWUA groundwater recharge is approximately 60,000 AF/year. While the rate will vary slightly throughout the year, this averages out to a steady loss from the river of about 80 cfs. This loss is spread throughout the Albuquerque area, and is complicated by the fact that ABCWUA makes a substantial contribution to river flow through its surface water treatment plant. At present, this rate of return is averages about 70 cfs (NMISC). For modeling purposes, ABCWUA replaces nearly as much water as leaks from the river due to groundwater pumping. However, the return occurs midway through reach 4, while loss happens throughout reaches 3 and 4. Flow at the lower end of Reach 3 is of concern for the BA, so this must be appropriately accounted for. Accordingly, a seepage loss of 40 cfs each is assigned to Reaches 3 and 4, with and an inflow of 70 cfs to Reach 4, in an effort to accurately reflect flow at the end of each reach.

Other groundwater consumptive use is occurring in the MRG. Most notable would be Rio Rancho/Bernalillo area, the Albuquerque South valley area with its myriad of private domestic wells, and the Los Ulnas/Belen area. These consumptive uses are clearly substantial, but are impossible to incorporate into the FM at this time. In the past, these consumptive uses have tended to be masked by agricultural operations, as agricultural deliveries supply a considerable portion of the recharge to offset consumption. More precise regulation and monitoring of agricultural supply in the future will probably lead to quantification of this water use, and eventually of its incorporation into models of this type. At present however, it should be noted by the users of the FM, that the model may tend to overestimate

flow at critical measuring points due to this shortcoming. As with a number of other factors which cannot be fully defined in the FM, the overestimation should be consistent across all conditions, so values between conditions should remain comparable.

2.1.4. FM Relationships

As previously mentioned, the FM begins with an input value representing flow entering the MRG. This is supplied by the user from URGWOM model outputs for a particular condition to be modeled. The FM then depletes this flow by the aggregated depletions occurring in Reaches 1-3 for Riparian evapotranspiration (column C), open–water evaporation (column D), Agricultural consumption (column E) and ABCWUA groundwater pumping (column F). These inputs are derived from the INPUT sheet in the workbook. Ag depletion is subject to the user-entered depletion factor in column AA on the INPUT sheet, allowing agricultural depletions to be switched on/off, or adjusted for partial service from drain accretions. The end result is a rate of flow arriving at the outflow from reach 3, equivalent to the Central Avenue gauge. It is important to note that outflow from Reach 3 is not (in this version) partitioned between floodway and drain, and that particularly at lower flows, an appreciable percentage of total flow may be in the drain, rather than the floodway, with the model thus tending to underestimate river drying at Central avenue.

In Reach 4, the flow at Central Avenue is depleted by Riparian evapotranspiration (column H), open–water evaporation (column I), Agricultural consumption (column J) and ABCWUA groundwater pumping (column K). Then the MRG's largest tributary, the ABCWUA return flow, is added as an input to Reach 4 in column. L. This produces the flow arriving at Isleta dam (column M). Drain flow at this point is not substantial, as most drain flow is returned just above the dam, and only minor flows bypass the structure on the west side of the Rio Grande. To arrive at the flow in the Rio Grande just below Isleta dam, The MRGCD diversion at Isleta Dam (column. N) Is subtracted from available flow (column. M). A logical test is applied in column O, preventing diversion from exceeding available supply, and the resulting flow past Isleta dam is then displayed in Col. O.

Moving downstream, aggregated depletions in Reaches 5 and 6 are deducted from the available water at Isleta Dam (Col M) for Riparian (col P), Open water (col Q), Agricultural (Col R), to produce the total available water arriving at San Acacia Dam (col S). Note that the depletions are applied to total available flow at Isleta, and not the flow in the floodway below Isleta Dam. At San Acacia Dam, the split of the flow arriving via the Unit 7 is determined through logic in column. T, and then the flow below San Acacia Dam is determined by subtracting both the MRGCD diversion at San Acacia (column U) and the flow in the Unit 7 Drain. This has the practical effect of drawing the dividing line between Reach 6 and 7 just upstream of San Acacia Dam, but downstream of the point where Unit 7 drain can re-enter the floodway. The logic in column V results in the contents of the Unit 7 drain returning to the floodway if MRGCD diversions are zero, or remaining out of the floodway and in the drain if MRGCD is diverting. Accretion to Unit 7 Drain in reaches 5/6 is based on a percentage (7%) of flow in the floodway below Isleta dam, and 50% of the MRGCD Isleta diversion less agricultural depletions. The end result is realistic values for flows below San Acacia Dam (column V).

Reach 7 calculations in the FM involve subtracting depletions for Riparian evapotranspiration (column W), open–water evaporation (column X), and agricultural consumption (column Y) from the total available water at San Acacia (column S) to produce the total available water arriving at San Marcial (column AA). As at San Acacia, the flow at San Marcial is then partitioned into the component in the LFCC (column AB) by assuming 30% of flow at San Acacia (column S) winds up as groundwater accretion to the LFCC, or MRGCD return flow. The flow in the floodway at the San Marcial Gauge (column AC) is then determined by subtracting the component of flow in the LFCC (column AB) from the total arriving at San Marcial (column AA).

2.1.5. Output Analysis

The FM spreadsheet includes a sheet titled ANALYSIS. In this sheet, the values from the FLOW MODEL sheet are compared to user test conditions. The user adjustable conditions are set in the boxes across the top of the sheet, and this then produces number of days or years that particular condition is met in the model. For Central Avenue, user-adjustable test conditions are in column C, For Isleta, they are in column K, for San Acacia, they are in column S, and for San Marcial, they are in column AA. With a little consideration, the purpose and use of these test conditions should be readily apparent to the user.

2.1.6. Using the Flow Model

Any particular set of flow conditions should begin by opening the Flow_Model_10Year_Template file. This should then immediately be saved as a new file name identifying the flow scenario to be entered, preserving the unaltered template. The newly created file should then receive appropriate inputs. All inputs should be made in the INPUTS sheet. The primary input will be column B, into which the flow entering the MRG below Cochiti Dam should be cut/pasted from URGWOM output. Columns in the INPUT sheet for depletions (columns C through S) can be changed if necessary, but presumably will remain the same for the present. For Flow scenarios where MRGCD diversions are expected to operate, no additional changes are necessary. However, columns T through U contain average MRGCD diversions at the Isleta and San Acacia diversions, so if a flow scenario includes no diversion for MRGCD, the values in these two columns should be replaced with 0's (check carefully, as the top of the columns always show zeros anyway). Finally, there are four values at the top of the sheet in column D that represent the percent of agricultural depletions that are to be met. The template contains values believed appropriate for the No-Action (MRGCD not diverting) scenario. These are user adjustable, and for scenarios where MRGCD is expected to be in normal operation, these for values should all be set to "1" (100% ag depletions met).

Column Z in the INPUT sheet was included to simulate the effects of an additional water source in Reach 7. This was specifically included so that the effects of supplemental pumping could be considered. In the absence of pumping by Reclamation from the LFCC, this column should include all zeros, or appropriate values if pumping is to be included. At present, it is simply added to the available flow arriving at San Marcial. No provisions for additional sources of water are included in the FM, though this could readily be done in the future if desired.

After providing the correct Input values, the user should switch to the ANALYSIS sheet. There, one can view the number of days, and the number of years in which the defined conditions are met. The conditions can be changed if desired. In the template, values of 10 cfs are used as condition 1 to represent major or complete drying. Since, for a variety of reasons, the FM still probably overestimates flow, 10 cfs was selected as the "dry" threshold value, though a larger number may well be appropriate. Condition 2 is used to represent some drying, or scattered intermittency, and is considerably more subjective that Condition. 1. Probably every user will have some slightly different idea of what this number should be. The template contains the values above which this author believed continuous flow was likely.

To evaluate the presence or absence of conditions believed likely to produce successful spawning, a logical test is provided for flow and duration between April 15 and June 15 of each year. The values used can be set in the same box as the flow conditions for Central Avenue. Initial values used were 3000 cfs, for a minimum of 7 days, based on conversations with Gary Dean at BOR and Mickey Porter at the Corps. However the user is free to substitute any conditions he deems appropriate for a successful spawn. The logic in column N starts a counter whenever the minimum flow is reached, which continues to increment every day the flow occurs. It resets to zero if the flow is not reached on a day, and a fresh count starts. Logic in column O evaluates whether the count has reached the value specified for minimum duration, and if so writes a "1". Logic in column P tests to see if the value in column O is greater than zero in any year, indicating that successful spawn conditions were met that year.

2.1.6 Considerations to be aware of

At present, flow at Central Avenue is not being partitioned between drain flow and floodway. This may be producing less than the actual number of days/years drying at this point, particularly in the No-Action condition where all drain accretion would likely be routed to supply agricultural need in the South Valley area, rather than being returned to the floodway. A future iteration of the FM will attempt to correct this.

Until Cochiti and Angostura Diversions are incorporated in the model, the FM will tend to overestimate drying, since it is subtracting the full agricultural depletion for each reach, even though the diversion may not be present to meet that supply. This is apparent in the proposed action runs in some years in which the MRGCD has no supplemental storage. If URGWOM can supply information on whether MRGCD is fully supplied or not, some logic can likely be placed in the FM to proportion agricultural depletion to available supply.

The FM is does not incorporate potential rainfall inputs in the MRG. Theses tend to be unpredictable, and no reasonable methodology appeared to allow their inclusion. However, MRG rainfall inputs generally occur in the form of thunderstorms in the July-August period. These flows can and do contribute appreciable volume of water to the river system, however the duration is usually very brief. So while rainfall events might tend to reduce the number of drying days in a given year, it would probably not be a large impact. Also, while the number of days might be reduced, the drying condition

for a year likely would not change. In other words in a particular year, the drying might change from 100 days to 90 days, or 40 days to 30 days, but the drying condition would still have been met in the year.

The influence of summer precipitation events is not completely absent from the FM. The URGWOM model incorporates summer precipitation inputs. As a result the flow entering the MRG used as the primary input for the FM reflects precipitation events upstream of Cochiti Reservoir. Also, precipitation events within the MRG and incorporated in the URGWOM model help to determine NM compact deliveries, and by extension storage of water in and release of water from upstream reservoirs.

Along the same lines as the earlier mentioned unquantifiable groundwater depletions, rainfall events should affect all No Action and Proposed Actions the same way, so the relative difference between conditions should be comparable.

The FM does not account for time-lag between physical points. A flow at Cochiti translates instantly into a flow at San Marcial. Of course this is not reality, but for the purposes of the FM, and especially since other factors (agricultural consumption, riparian evapotranspiration, open-water evaporation, and MRGCD diversions) are entered into the model as averages over time, this is expected to give reasonable results. The FM could be easily time-lagged if desired, but it would introduce another layer of complexity to the spreadsheets, trying to keep up with which rows corresponded, and probably would not produce significantly better results.

Numbers in the model have not been rounded. Although the formatting is set to display only integer values, most numbers are floating point with many digits to the right of the decimal.

3.0 Outputs from Flow Condition Runs.

3.1 No-Action Condition

Several different conditions have been evaluated using the FM. The first, the No-Action (or "baseline") condition consists of 5 runs (separate spreadsheets) , representing 10-year URGWOM flow sequences selected to reflect a 10%, 30%, 50%, 70%, and 90% probability of exceedance. For the No-Action condition, reservoirs are operated under existing rules for flood operations and compliance with the Rio Grande Compact, but do not store or release water for agricultural use by the MRGCD. The ABCWUA and Buckman Direct Diversion continue to divert surface water for municipal use, and release from storage. Consumptive uses upstream of the MRG and not included in this BA, including diversions in Colorado, at Velarde, PVID, on the Rio Chama, and by innumerable small Acequia systems in Rio Grande tributaries will continue. MRGCD diversion from the Rio Grande at the diversion dams does not occur. BOR would not operate reservoirs or the SJC project to supply water to agricultural users in the MRG. Some agricultural use in the MRG will continue through uncontrolled accretions to drains, and subsequent delivery through irrigation canals. Leakage to aquifer recharge, replacing decades of past pumping, as well as ongoing modern depletions will continue. Riparian consumptive use and open-water evaporation will continue. Processing the appropriate URGWOM outputs through the FM results in in the following No-Action (or "baseline) conditions:

Central Ave.	Less than 100 cfs	Less than 100 cfs	Spawn (years out of the 10-year sequence)
	Days	Years	3000cfs/7dys
90%	47	3	3
70%	34	4	6
50%	16	3	6
30%	23	4	6
10%	31	4	8
All (50 yrs)	151	18	27

Below Isleta Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	64	3	261	8
70%	40	4	141	4
50%	16	3	71	3
30%	25	4	68	4
10%	39	5	127	6
All (50 yrs)	184	19	668	25

Below San Acacia Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	447	6	831	10
70%	277	4	640	10
50%	186	5	597	9
30%	175	6	460	8
10%	276	7	668	9
All (50 yrs)	1361	28	3096	46

Below San Marcial	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	824	10	900	10
70%	723	10	787	10
50%	670	10	730	10
30%	547	8	618	9
10%	683	10	765	10
All (50 yrs)	3447	48	3800	49

From the above table, it is apparent that flows less than 100cfs, indicative of possible intermittency downstream from that point, occasionally occur in the No-Action condition. While this represents a relatively small number of total days, it occurs in all 5 flow sequences, and in a little more than a third of all possible years (18 out of 50). Of particular interest is that conditions thought to represent successful

spawning conditions occur just over half the time, 27 out of a possible 50 years in the No Action condition.

Below Isleta Dam there are 19 years in which significant to complete drying could be expected. In half the total years, at least some degree of intermittency between Isleta and San Acacia dams would occur. In the other 25 years, there would presumably be enough flow entering the MRG to prevent drying in the Isleta Reach. Both drying and Intermittency occur in all of the 10 year sequences.

Below San Acacia dam complete or nearly complete drying occurs in over half of all years; and in about half the years in each 10-year sequence. Intermittency is even more dramatic, occurring in 46 out of 50 total years. Intermittency occurs an average of 62 days per year in the San Acacia reach over the 50-year time span. The two driest sequences have drying in all 10 years.

Below the San Marcial gauge, some amount of drying would be expected in virtually every year. In only one or two years in the 2nd wettest 10 year sequence is there enough water arriving at San Marcial to make it likely that the RG would stay connected all the way through to Elephant Butte reservoir.

3.2 Proposed Action Conditions

Under the proposed action, MRGCD diversions of water would occur as normal to meet agricultural demand. Reservoirs would be operated to store water during the spring runoff, for release later in the season to meet that agricultural demand. Other operations and consumptive uses would occur upstream of the MRG as described in the No-Action condition. BOR would operate reservoirs and the SJC Project to supply water for agricultural users in the MRG. No specific conservation measures, such as Supplemental Water, are included in this condition. Processing the appropriate URGWOM outputs through the FM results in in the following Proposed Action conditions:

Central Ave.	Less than 100 cfs	Less than 100 cfs	Spawn (YRS)
	Days	Years	3000cfs/7dys
90%	411	5	3
70%	258	4	6
50%	139	3	5
30%	95	3	6
10%	122	2	8
All (50 yrs)	1025	17	27

Below Isleta Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1187	10	1373	10

70%	1008	10	1208	10
50%	907	10	1127	10
30%	673	9	880	10
10%	779	9	985	9
All (50 yrs)	4554	49	5573	49

Blw San Acacia Dam	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1097	10	1486	10
70%	944	10	1391	10
50%	818	10	1266	10
30%	656	9	1046	10
10%	705	9	1092	10
All (50 yrs)	4220	48	6281	50

Blw San Marcial	Drying	Drying	Intermittency	Intermittency
	Days	Years	Days	Years
90%	1224	10	1296	10
70%	1155	10	1228	10
50%	1030	10	1122	10
30%	853	10	914	9
10%	907	10	980	10
All (50 yrs)	5169	50	5540	49

Comparing the above tables, with those for the No-Action condition provides an indication of the effects of the proposed action. The Proposed-Action appears to have very little influence on number of years where successful spawning conditions are met. In both cases, the threshold condition (3000 cfs, 7 days) occurs in 27 of the total 50 years. The distribution changes slightly when considering the 10 year sequences separately, with some sequences gaining a year, and others losing a year. The effect on flows is significant, but slightly contradictory. The total number of days of potential intermittency (less than 100 cfs) increases under the proposed action, but at the same time the total number of years in which intermittency can occur decreases (17).

There is a dramatic increase in drying and intermittency at the Below Isleta Dam location. Since MRGCD diverts the largest portion of irrigation water at Isleta Dam, and a primary difference between the two conditions is the absence/presence of diversion dam operation, this is an expected result. Total number of days in which drying occurs (less than 30 cfs) rises from 178 days to 4554. Dividing the number of days by the number of years produces a value of 8days/year for the No-Action condition, compared with 93 days/year for the Proposed Action condition. However it may prove to be more critical to know the

number of years in which drying can be expected, rather than the length of the drying events. The number of years drying could be expected increases in the Proposed Action condition from 21 years to 48 years out of 50. Again, this is an expected result, and consistent with past experience below Isleta dam, where drying has historically occurred virtually every year.

Similarly, there are increases in both number of days and years in which drying occurs at the at the San Acacia Gauge location. Since San Acacia would be expected to experience a much greater incidence of drying under the No-Action condition, the effect of the Proposed Action is not as dramatic as at Isleta. Total number of days increases to 4220, over 48 years. This resolves to 93 days/year, compared to 48 days/year under the No-Action condition. The number of years in which drying occurs increases to 48 under the Proposed Action, compared with 28 years under the No-Action condition.

The difference is even less noticeable at San Marcial Gauge. San Marcial gauge could be expected to experience drying in 48 years under the No-Action condition, increasing slightly to 50 years for the proposed Action. Total drying days increases to 5169, compared to 3447. On a number of days per year basis, this results in a change from 71 days/year to 103 days/year.