Appendix D
Effects of Truckee Canal Capacity on Water Supply for the Newlands Project

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
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Appendix D1
Effects of Truckee Canal Capacity on Newlands Project Water Supply

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Draft Special Report

Prepared by

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Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
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Abbreviations and Acronyms

cfs	cubic feet per second
OCAP	Operating Criteria and Procedures for the Newlands Project
Project	Newlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Study	Newlands Project Planning Study
TAF	thousand acre-feet
TROA	Truckee River Operating Agreement

Appendix D1 – Effects of Truckee Canal Capacity on Newlands Project Water Supply

This analysis serves as the starting point for the development of alternatives in the Newlands Project Planning Study (Study). The Study alternatives must fulfill two objectives: (1) Newlands Project (Project) safety for Truckee Canal operations, and (2) reliability for Project water rights (Chapter 2). The development of alternatives was structured around a range of previously identified methods for attaining the Project safety objective, and the anticipated future capacity of the Truckee Canal. The methods identified for providing canal safety include flow stages of 600, 350, and 250 cubic feet per second (cfs). For the purposes of isolating the effects of capacity changes on Project water supplies, it was assumed that the Truckee Canal would continue to experience seepage losses. Decommissioning the Truckee Canal is another identified method (hereafter, 0 cfs), as is 150 cfs, which is the anticipated future capacity of the Truckee Canal without any further maintenance or repairs (Chapter 3).

The following document characterizes the ability of the Project to meet its anticipated future demands (Appendix C) with the identified range of safe flow-stage scenarios (600, 350, 250, 150, and 0 cfs). The "baseline" performance of these flow-stage conditions was needed to identify deficiencies in water supply that would need to be addressed to meet the Study's water supply objective.

A challenge existed in defining an appropriate reliability standard for measuring whether various conditions meet the Study's water supply objective. No quantitative standard exists in the Project water rights, beyond the right to available supplies within the bounds of governing laws. Available supplies vary from year to year and can be reduced by changes in the Project (e.g., smaller Truckee Canal capacity) in a manner that arguably no longer meets the intended standards of the Project. Thus, available supply alone did not meet the Project needs for the water supply objective.

Historically, the Truckee and Carson rivers have provided the Newlands water rights holders with what could be considered an exceptionally high level of service. However, real and severe shortfalls have occurred over time and, thus, developing a standard for full service for all water rights in all years would be above and beyond historical expectations.

Historical rates of diversion from the Truckee River were also considered an unreasonable standard for the Project's water supply objective. First, the operating conditions allowing for the range of historical diversions no longer exist: operating criteria have changed significantly over the past 50 years, and the Truckee Canal's capacity has deteriorated significantly since project

construction – even before the breach. Further, several water rights acquisition and retirement programs have been slowly eroding the total volume of Project rights, reducing the need for diversions in comparison to historical conditions.

This document develops the "Desired Reliability" model scenario to provide a reasonable definition for expected Project reliability. This scenario assesses the reliability (ability to meet all Project water rights) across the full 100-year historical hydrology, but for conditions that were governing operations at the time the Truckee Canal breached, including:

- Regulatory conditions set by the 1997 Operating Criteria and Procedures for the Newlands Project (OCAP)
- Truckee Canal capacity equal to its designed 900 cfs capacity
- Project demand set by the current water rights ownership (Appendix C)

Thus, the Desired Reliability scenario quantifies the water supply conditions that would have been experienced by the Project, if the operating conditions at the time of the 2008 Truckee Canal breach had prevailed over the 1901 through 2000 period, and if all of the current and potentially active water rights had called upon their full duty each year.

This document also develops five "reference scenarios," which serve as the starting point for development of Study alternatives. The five reference scenarios assess reliability for operating conditions that differ from the Desired Reliability in two manners. First, the reference scenarios limit the Truckee Canal capacity to one of the five flow stages identified for consideration by the Study (600, 350, 250, 150, and 0 cfs). Second, all of the reference scenarios operate to meet the full duty of future water rights. Differences between current and future rights account for the completion of current water rights transfer and retirement programs (as described in Appendix C), amounting to an anticipated 4 percent reduction in demand for the Project.

The Results and Conclusions section of this document compares the flow-stage reference scenarios and the Desired Reliability scenario. These comparisons serve as the basis for identifying the measures needed to meet the Study's water supply objective (Chapter 4).

Methods

The Pre-Truckee River Operating Agreement (TROA) Planning Model was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. This analysis looks at the sensitivity of Project water supplies (measured as percent of total demand met) to six flow-stage scenarios for the Truckee Canal and two levels of Project demands.

The Pre-TROA Planning Model is built in a RiverWare modeling environment, and slots are features of the RiverWare environment that accept inputs. Flow-stage restrictions are entered to the model through the slot TRUCKEECANALDIV.CANALCAPACITYDEFAULT. The flow-stage conditions evaluated include 600, 350, 250, 150, and 0 cfs.

Changes in demand are entered as acres of water rights for different levels of duty (e.g., bench duties are 4.5 feet). Acreages of demand are specified in the model through seven separate slots. The slots used for specifying changes to water rights acreages are indicated in Table D1-1.

Table D1-1. Model Slots Used to Specify Acreages of Water Rights

Division	User	RiverWare Slots Used to Specify Acreages of Water Rights
Carson Division	Project Irrigators	MHEDATA.CARSONDIVISIONWRANDIRRIG
	Paiute-Shoshone Irrigation	MHEDATA.FALLONINDIANRESERVATION
	City of Fallon	MHEDATA.CARSONDIVISIONWRANDIRRIG
	Environmental	MHEDATA.FALLONINDIANRESERVATIONWETLANDS MHEDATA.STILLWATERNATIONALWILDLIFEREGFUGE MHEDATA.CARSONLAKEANDPASTURE
Truckee Division	Project Irrigators	MHEDATA.TRUCKEEDIVISONWRANDIRRIG
	City of Fernley	DERBYDAMDATA.DERBYBYPASSCOMPONENTS (FERNLEY C3)
	Environmental	DERBYDAMDATA.DERBYBYPASSCOMPONENTS (PLPT_C3)

This analysis varied acreages in the Pre-TROA Planning Model between a current level and distribution of water rights, and an anticipated future level and distribution of water rights. These conditions are described in Appendix C.

The output slots of the RiverWare model that are considered in the reference scenario analyses are shown in Table D1-2. Data from these outputs are compiled for analyses in the Results and Conclusions section.

Table D1-2. Model Output Slots Used in Subsequent Analyses

Description	RiverWare Output Slot Name
Newlands Project annual deliveries (AF)	NPPS.DeliveryNewlands
Newlands Project annual deliveries (%)	NPPS.PercentTotalNewlandsDelivered
Annual deliveries to the Carson Division (AF)	NPPS.DeliveryCD
Annual total Carson Division demand that was delivered (%)	NPPS.PercentTotalCDDDelivered
Annual deliveries to the entire Truckee Division (AF)	NPPS.DeliveryTD
Average monthly power generated down the V Canal in the Carson Division (MW)	NPPS.26FtDropAvgMonthlyPower
Average monthly power generated at the Lahontan Reservoir (MW)	NPPS.LahontanAvgMonthlyPower
Annual Lahontan Reservoir spills to the Stillwater National Wildlife Refuge (TAF)	NPPS.SpillsToStillwater
Annual flow into Pyramid Lake (TAF)	NPPS.PyramidAnnualInflow

Key:
AF = acre-foot
MW = megawatt
TAF = thousand acre-feet

For brevity, the results of simulations in this document are labeled with flow stages for the future condition runs, and with “Desired Reliability” for the preexisting condition run. A summary of these simplified labels and corresponding conditions is provided in Tables D1-3. Appendix C has detailed explanations of various water users, their land holdings, and water usage within the Project region.

Table D1-3. Explanation of Labels for Results in This Appendix

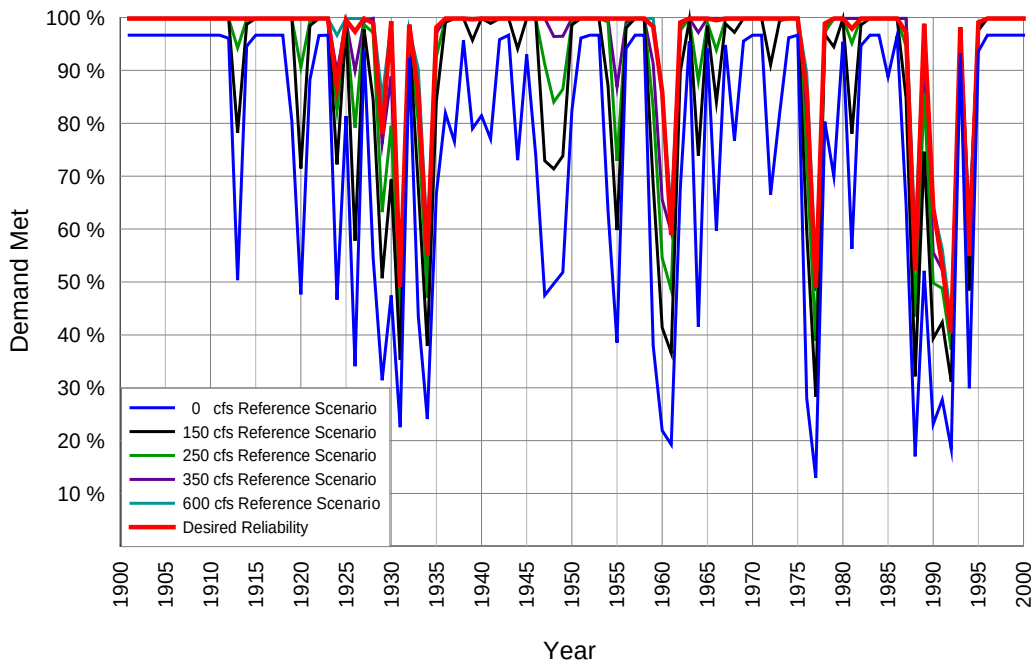
Labels for Results in Appendix D1	Simulated Conditions for:			
	Truckee Canal Capacity	Newlands Project Demand		
			Water-Righted Acreage (ac)	Maximum Annual Demand (TAF)
Desired Reliability	900 cfs	Current Ownership	63,596	225,461
600 cfs	600 cfs	Anticipated Future Ownership	62,996	216,332
350 cfs	350 cfs			
250 cfs	250 cfs			
150 cfs	150 cfs			
0 cfs	Canal removed from service			

Key:
ac = acre
cfs = cubic feet per second
TAF = thousand acre-feet

Results and Conclusions

This appendix does not present water supply reliability in terms of a singular number. Reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, reliability must be presented in a two-dimensional context that allows for the evaluation of both frequency and magnitude.

For this analysis, each scenario was simulated over the full 100-year hydrologic record. The water supply availability for each scenario is presented chronologically in Figure D1-1. Chronological plots are useful for depicting the variability in shortages over time and in demonstrating how periods of prolonged drought (such as in the 1930s and early 1990s) lead to progressively larger shortfalls. However, chronological plots make it difficult to understand relative magnitudes and frequencies of shortfalls.

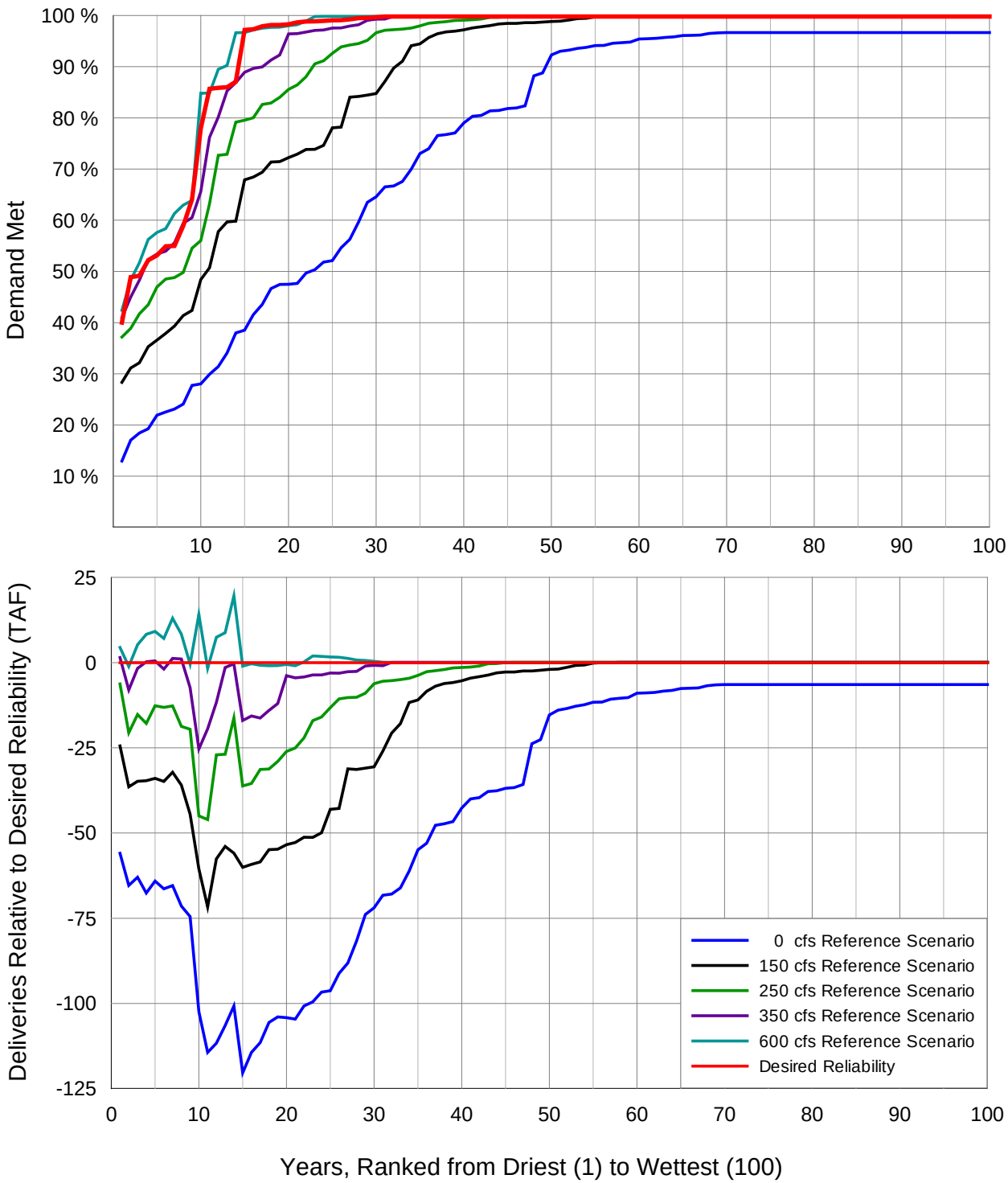


Key:
cfs = cubic feet per second

Figure D1-1. The Chronological Plot of Various Flow Stages for Newlands Project Allocations

Exceedence plots, similar to the plot shown in Figure D1-2, provide a more direct depiction of shortfall frequencies and magnitudes. In these plots, the annual proportion of demand met is ranked from lowest to highest and plotted on a chart in that order. Because the data set the Study used includes exactly 100 years, this plot can simultaneously represent the proportion of years a certain level of demand is met. For example, in the Desired Reliability scenario, at least 80 percent of demand is met 9 out of 10 years. Such a representation is

more readable than chronologically organized plots, allowing the reader to make quick assessments about the likelihood and magnitude of shortfalls under a range of hydrologic conditions.



Key:
cfs = cubic feet per second

Figure D1-2. Relative Reliability of Annual Newlands Project Deliveries Under Truckee Canal Flow-Stage Reference Scenarios

The bottom half of Figure D1-2 compares the Desired Reliability with each of the reference scenarios in terms of the difference of annual deliveries in thousands of acre-feet (TAF). A difference in delivery of zero TAF represents the Desired Reliability; a volume above zero is shown when the canal capacity flow-stage reference scenario's performance surpasses the Desired Reliability, and below zero when the performance falls short of the Desired Reliability.

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

Several observations can be made from comparing the performances of the various scenarios plotted in D1-2. The following subsections summarize each of the scenarios considered and compare the performance of each flow-stage reference scenario to the Desired Reliability scenario. The assessments help to clarify the extent to which alternatives built around each flow stage will need to include additional water supply measures to meet the Study's objectives.

Desired Reliability Scenario

Based on the Under the Desired Reliability scenario:

- The average demand met across the 100-year analysis is 95 percent.
- The lowest demand met is 40 percent, which would occur under conditions like those experienced in 1992 during the drought of record.
- In the driest 10 out of 100 years, an average of about 50 percent of demand is met.
- In the second driest 10 out of 100 years, about 90 percent of demand is met.
- In the wettest 80 out of 100 years, at least 98 percent of demand is met.

Despite a high level of water supply reliability among U.S. Department of the Interior, Bureau of Reclamation (Reclamation) projects, Project water users do experience severe shortfalls. The largest simulated shortfalls included in this Study's analysis occurred during three prominent West-wide droughts: 1930 – 1936 (during the Dust Bowl), 1977, and 1987 – 1994 (the drought of record) (see tables in the attachment to this appendix). The intent of this Study is to develop alternatives that perform to a level of reliability comparable to the

Desired Reliability curve (Figure D1-3), inherent in which are some amount of shortages associated with extremely dry years.

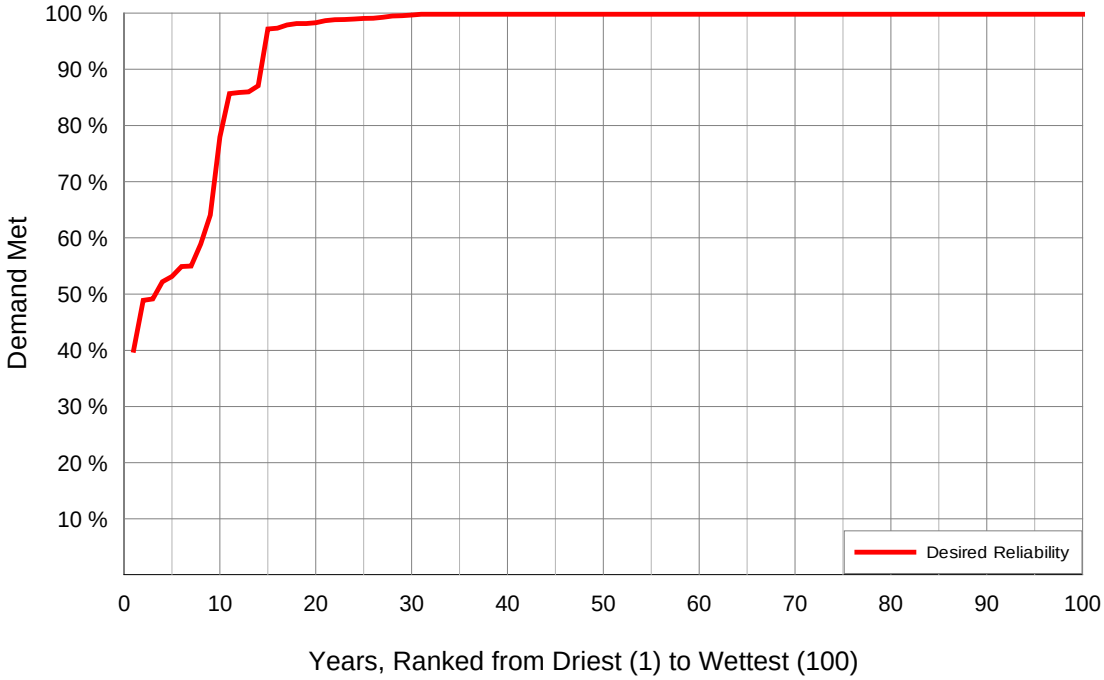


Figure D1-3. Newlands Project Annual Deliveries for Desired Reliability Scenario

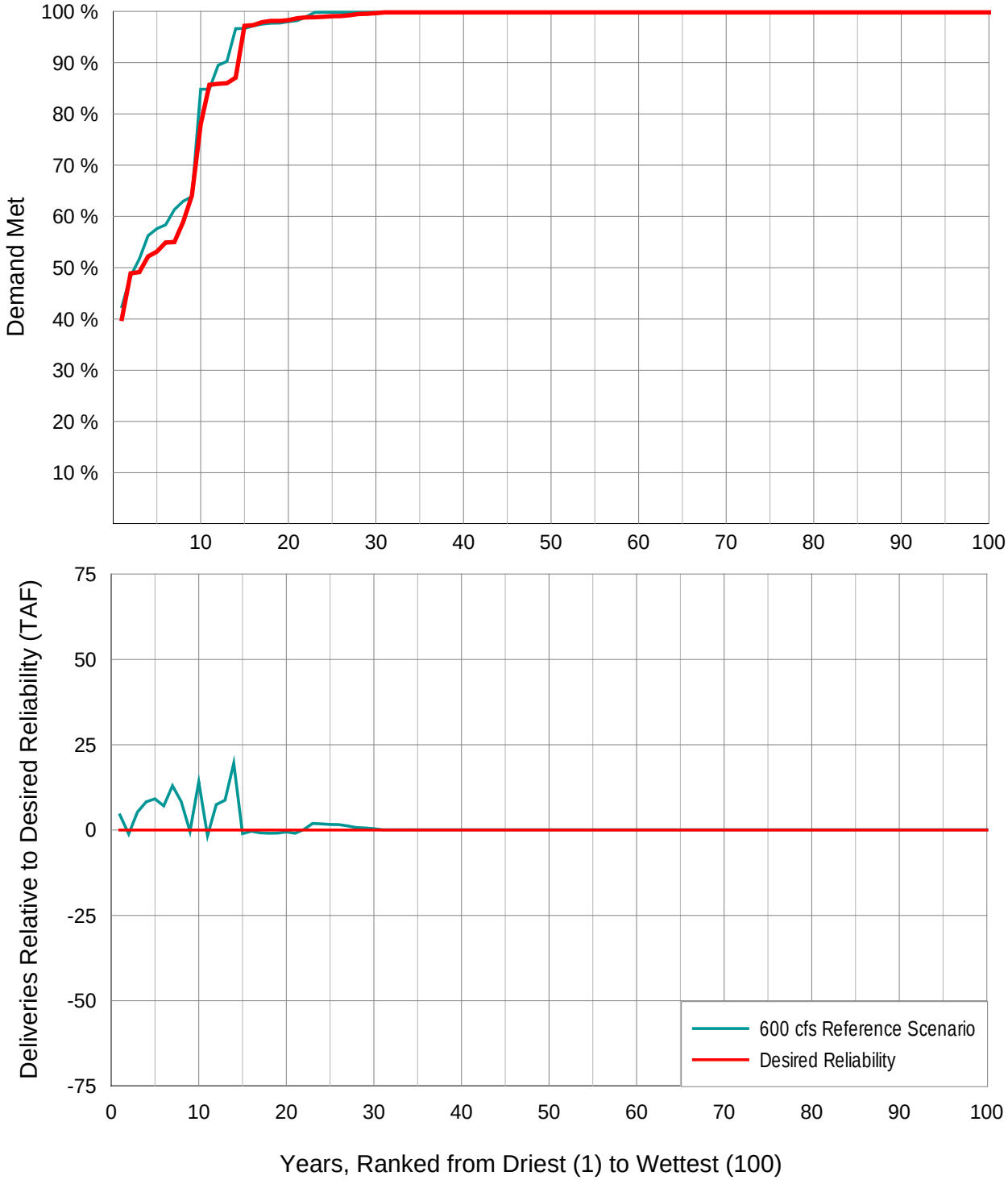
600 cfs Reference Scenario

The 600 cfs reference scenario meets or exceeds the Desired Reliability level. Figure D1-4 suggests the following with regard to Project reliability under the 600 cfs reference scenario:

- The average demand met across the 100-year period is 95 percent.
- The lowest level of demand met is 42 percent, which would occur under conditions like those experienced in 1992 during the drought record.
- In the driest 10 out of 100 years, an average of about 60 percent of demand is met.
- In the second driest 10 out of 100 years, about 90 percent of demand is met.
- In the wettest 80 out of 100 years, at least 98 percent of demand is met.
- Delivery volume is better than under the Desired Reliability by up to 20 TAF in some years.

Under the current OCAP, a 600 cfs canal is more reliable at meeting anticipated future Project demands than a 900 cfs Truckee Canal capacity would be at meeting current demands (see Figure D1-4). The increase in reliability with a decrease in Truckee Canal capacity results from the anticipated 4 percent reduction in Project demand under the future condition, resulting from water rights transfers and retirement programs.

No additional measures would be required to meet Desired Reliability levels if the future capacity of the Truckee Canal was at or above the 600 cfs flow stage.



Key:
cfs = cubic feet per second

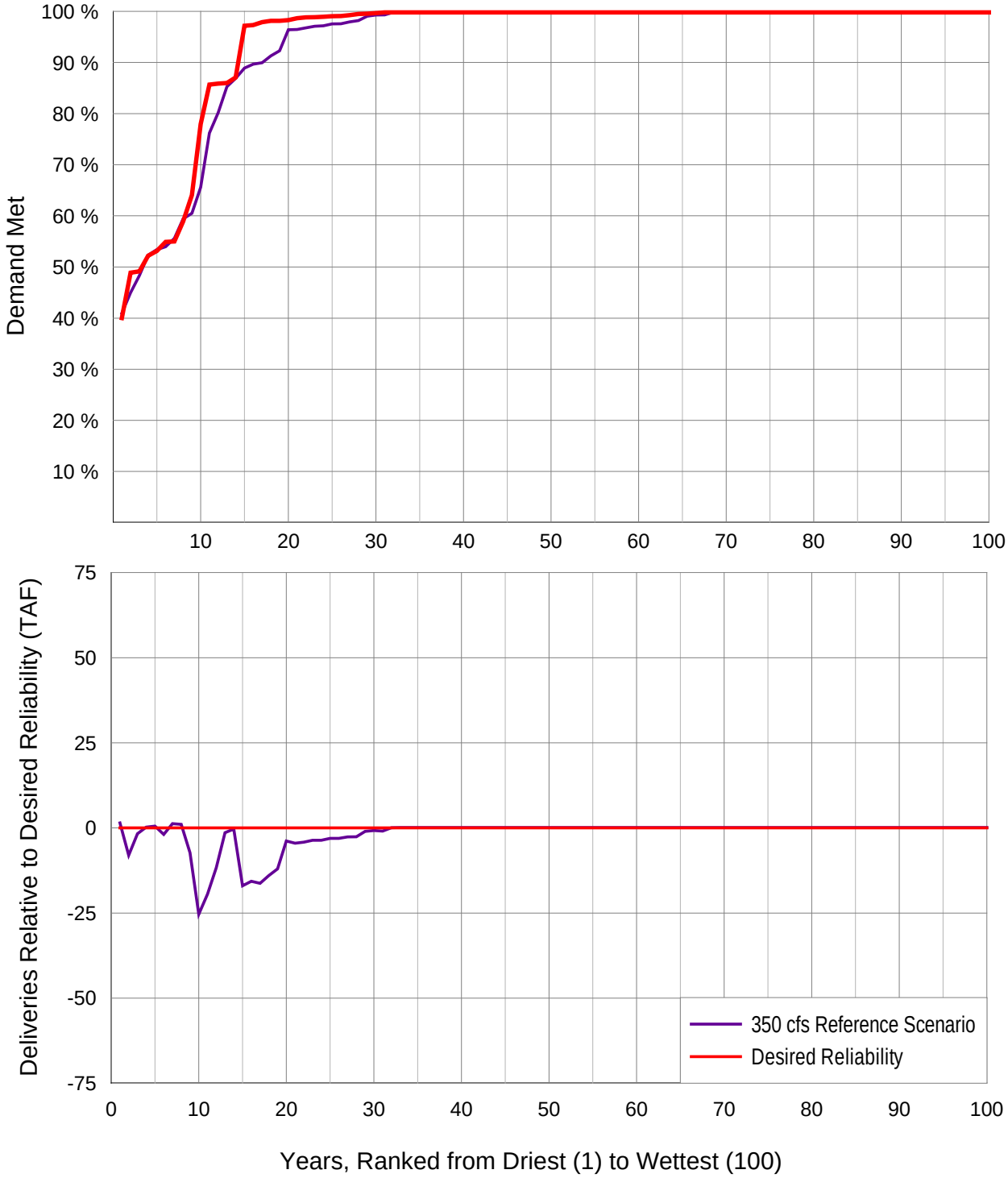
Figure D1-4. Relative Performance of Truckee Canal 600 cfs Flow-Stage Reference Scenario on Annual Newlands Project Deliveries

350 cfs Reference Scenario

The 350 cfs reference scenario is similar to the Desired Reliability and performs almost as well. Figure D1-5 suggests the following with regard to Project reliability under the 350 cfs reference scenario:

- The average demand met across the 100-year period is 94 percent.
- The lowest level of demand met is 41 percent, which would occur under conditions like those experienced in 1992 during the drought record.
- In the driest 10 out of 100 years, an average of about 55 percent of demand is met.
- In the second driest 10 out of 100 years, an average of about 80 percent of demand is met.
- In the wettest 80 out of 100 years, at least 96 percent of demand is met.
- Delivery volume is as much as 25 TAF lower than the Desired Reliability delivery volumes in some years.

The Desired Reliability and 350 cfs reference scenarios have a similar reliability, but the largest difference occurs within the driest 20 percent of years. Although shortfalls are more frequent, only a small improvement would be necessary for the 350 cfs flow stage to meet the Desired Reliability as part of an alternative (see Figure D1-5).



Key:
cfs = cubic feet per second

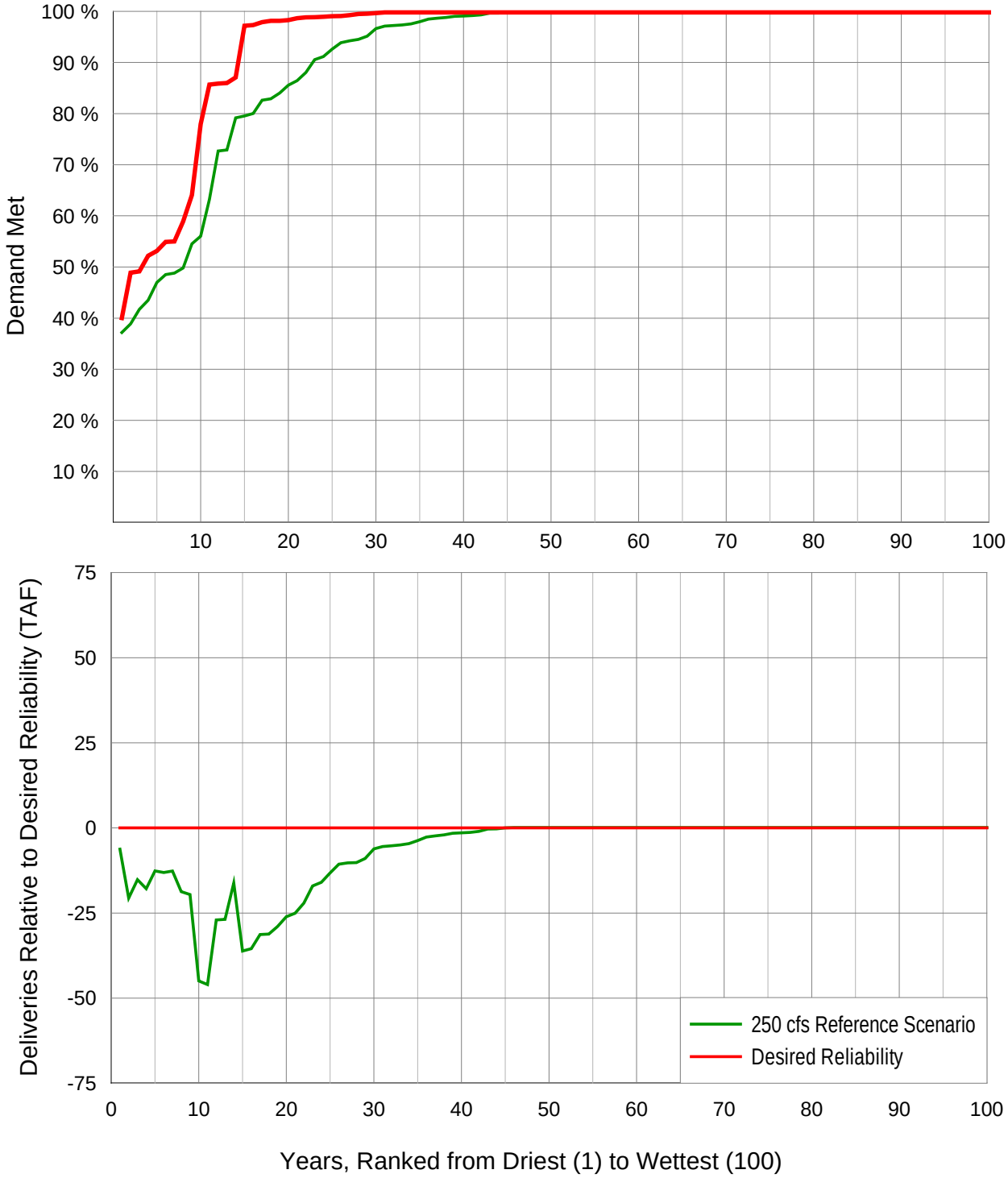
Figure D1-5. Relative Performance of Truckee Canal 350 cfs Flow-Stage Reference Scenario on Annual Newlands Project Deliveries

250 cfs Reference Scenario

Figure D1-6 suggests the following with regard to Project reliability under the 250 cfs reference scenario:

- The average allocation across the 100-year period is 91 percent.
- The lowest level of demand met is 37 percent, which would occur under conditions like those experienced in 1992 during the drought record.
- In the driest 10 out of 100 years, about 45 percent of demand is met.
- In the second driest 20 out of 100 years, an average of about 80 percent of demand is met.
- In the wettest 70 out of 100 years, at least 95 percent of demand is met.
- Delivery volume could be up to 46 TAF lower than the Desired Reliability delivery volumes in some years.

The 250 cfs reference scenario is less reliable than the Desired Reliability scenario. Shortfalls are more frequent and more severe. Additional measures would be needed for the 250 cfs reference scenario to equal or exceed the Desired Reliability scenario (see Figure D1-6).



Key:
cfs = cubic feet per second

Figure D1-6. Relative Performance of Truckee Canal 250 cfs Flow-Stage Reference Scenario on Annual Newlands Project Deliveries

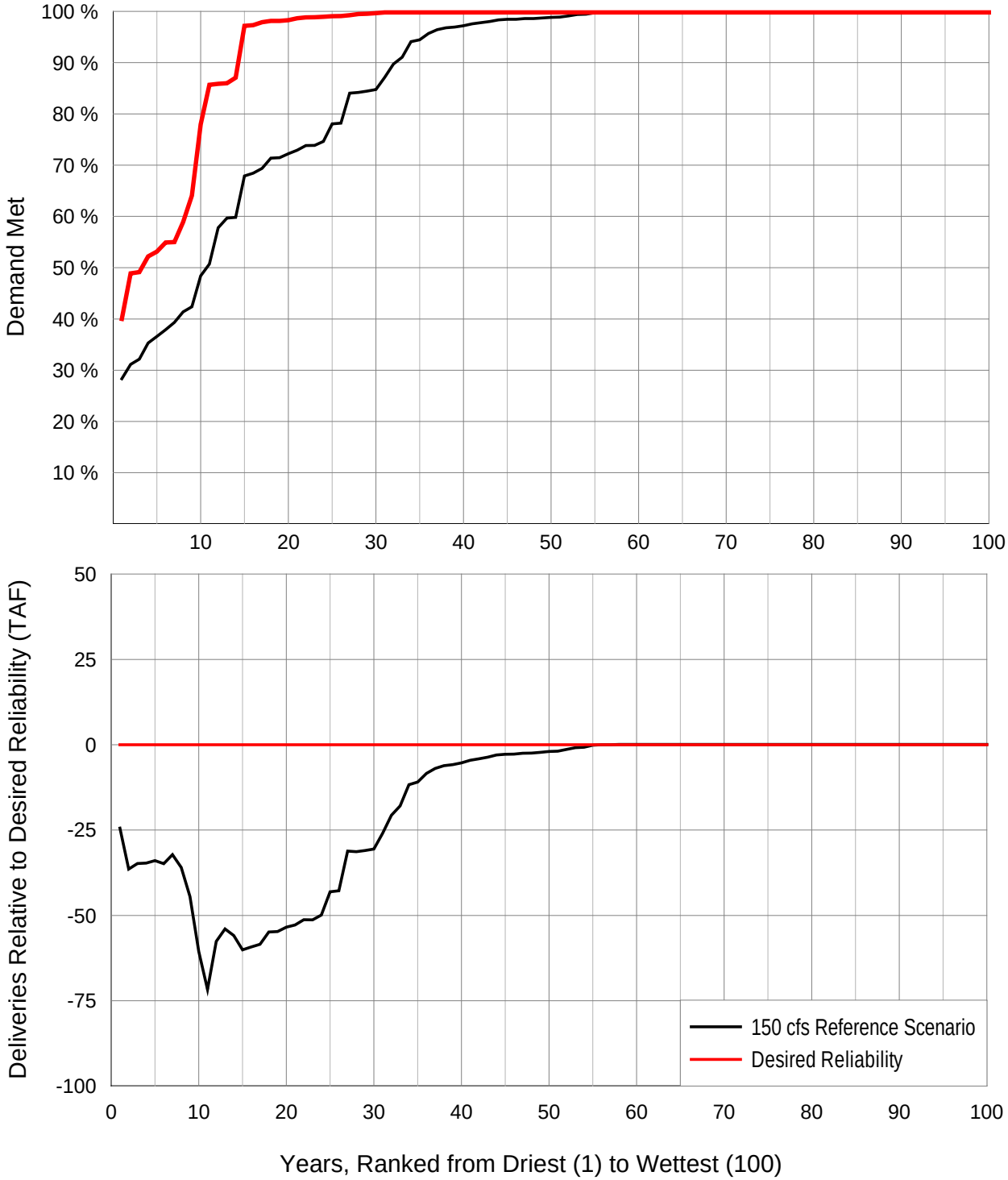
150 cfs Reference Scenario (Likely Future Without-Action Condition)

The 150 cfs reference scenario represents the Truckee Canal's performance under the likely future without-action condition considered by the Study, as described in Chapter 3 and Appendix A to the Special Report. Figure D1-7 suggests the following with regard to Project reliability under the 150 cfs reference scenario:

- The average allocation across the 100-year period is 87 percent.
- In the driest 10 out of 100 years, an average of about 40 percent of demand is met.
- In the second driest 30 out of 100 years, an average of about 80 percent of demand is met.
- In the wettest 60 out of 100 years, at least 96 percent of demand is met.
- The lowest level of demand met is 28 percent, which would occur under conditions like those experienced in 1977. This is 12 percentage points below the lowest allocation under Desired Reliability.
- Delivery volume could be up to 72 TAF lower than the Desired Reliability delivery volumes in some years.

The 150 cfs reference scenario is significantly less reliable than the Desired Reliability scenario. Shortfalls are more frequent and more severe in about half of all years.

Additional measures would be needed for the 150 cfs reference scenario to equal or exceed the Desired Reliability scenario (see Figure D1-7).



Key:
cfs = cubic feet per second

Figure D1-7. Relative Performance of Truckee Canal 150 cfs Flow-Stage Reference Scenario on Annual Newlands Project Deliveries

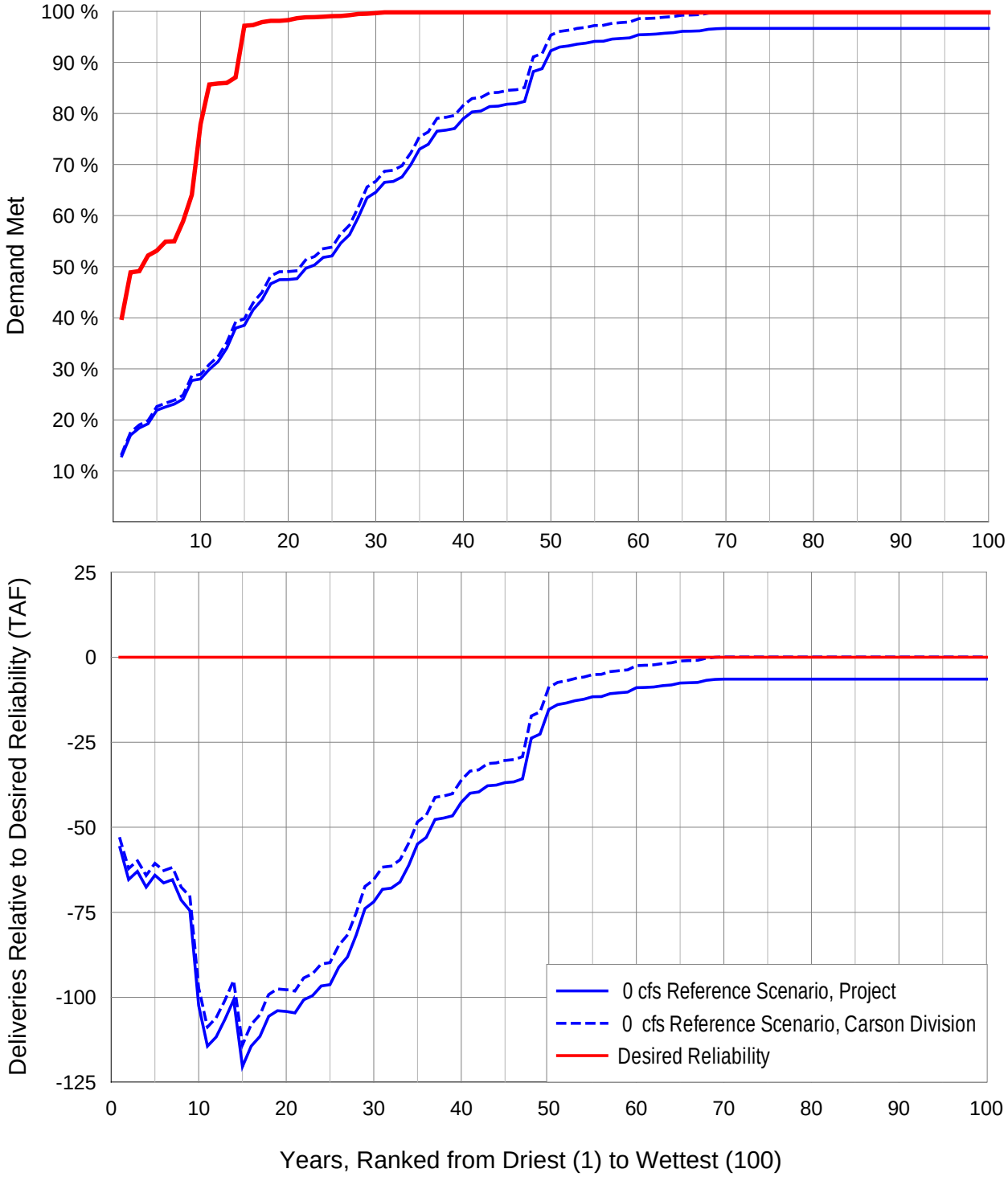
0 cfs Reference Scenario

The 0 cfs reference scenario graphs shown in Figure D1-8 only considers the Carson Division in examining water supply reliability. This is because the 0 cfs scenario assumes decommissioning of the Truckee Canal, in which case demand would never be met in the Truckee Division without an alternative water supply source or mechanism for delivery. An alternative delivery system will be included for the Truckee Division under any 0 cfs flow-stage alternative developed. The Desired Reliability curve for the entire Project and for the Carson Division are nearly identical; as such, and to void confusion, the Desired Reliability does not change for Figure D1-8 and is the same curve used throughout the Study.

Figure D1-8 suggests the following with regard to the Carson Division's reliability under the 0 cfs reference scenario:

- The average allocation across the 100-year period is 75 percent.
- The lowest allocation is 13 percent, which would occur under conditions like those experienced in 1977.
- In the driest 10 out of 100 years, an average of about 20 percent of demand is met.
- In the second driest 10 out of 100 years, an average of about 40 percent of demand is met.
- In the third driest 30 out of 100 years, an average of about 75 percent of demand is met.
- In the wettest 50 out of 100 years, at least 95 percent of demand is met.
- Delivery volume could be up to 112 TAF lower than the Desired Reliability delivery volumes in some years.

The 0 cfs reference scenario is less reliable than the Desired Reliability scenario. Multiple water supply measures will be needed, both to serve the Truckee Division rights holders with an adequate supply of water and for the 0 cfs reference scenario to equal or exceed the Desired Reliability (see Figure D1-8).



Key:
cfs = cubic feet per second

Figure D1-8. Relative Performance of Truckee Canal 0 cfs Flow-Stage Reference Scenario on Annual Newlands Project Deliveries

Summary of Results

The tables in this subsection summarize some of the primary findings from the analysis of reliability and annual Project deliveries under different Truckee Canal capacity flow stages.

Table D1-4 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability reference scenario and Truckee Canal flow-stage reference scenarios.

Table D1-4. Project Reliability for Desired Reliability and Flow-Stage Reference Scenarios

	Number of Years Where >95% of Demand is Met	Number of Years Where <50% of Demand Met	Percent of Demand Met in Driest Year
Desired Reliability	86	3	40%
600 cfs	87	2	42%
350 cfs	81	3	41%
250 cfs	72	8	37%
150 cfs	65	10	28%
0 cfs[1]	41	22	13%

Notes:
[1] Carson Division only; Truckee Division demand will be met through means other than the Truckee Canal in a 0 cfs alternative.

Key:
cfs = cubic foot per second

To support additional use by the Study or other parties, Table D1-5 notes the effects of Truckee Canal lining on average Truckee River flows to Pyramid Lake, annual hydropower generation at Lahontan Dam and the 26-Foot Drop (V Canal) Power Plant, and the annual average and maximum annual spills from Lahontan Reservoir.

Table D1-5. Additional Characteristics under Desired Reliability and Flow-Stage Reference Scenarios (Annual Basis)

	Lahontan Reservoir Hydropower Generation (MWH)	V Canal Hydropower Generation (MWH)	Pyramid Lake Inflows (TAF)	Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability	15.676	3,309	460	236	12
600 cfs	16,209	3,091	472	239	12
350 cfs	15.613	3,032	480	239	12
250 cfs	14,985	2,935	492	239	11
150 cfs	13,862	2,766	513	239	10
0 cfs	12,168	2,407	583	239	10

Key:
cfs = cubic feet per second
MW = megawatt
TAF = thousand acre-feet

Appendix D1
Effects of Truckee Canal Capacity on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The table in this attachment summarizes water supply over the 100-year period of screening analysis, and includes results from the same period for the flow-stage reference scenarios and the Desired Reliability scenario.

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Table: Annual Deliveries to Carson Division in TAF

	REFERENCE SCENARIOS					
Year	**0cfs**	**150cfs**	**250cfs**	**350cfs**	**600cfs**	**900cfs**
1901	198	198	198	198	198	205
1902	198	198	198	198	198	205
1903	198	198	198	198	198	205
1904	198	198	198	198	198	205
1905	198	198	198	198	198	205
1906	198	198	198	198	198	205
1907	198	198	198	198	198	205
1908	198	198	198	198	198	205
1909	198	198	198	198	198	205
1910	198	198	198	198	198	205
1911	198	198	198	198	198	205
1912	197	198	198	198	198	205
1913	103	155	187	198	198	205
1914	194	196	198	198	198	205
1915	198	198	198	198	198	205
1916	198	198	198	198	198	205
1917	198	198	198	198	198	205
1918	198	198	198	198	198	205
1919	165	198	198	198	198	205
1920	98	142	180	198	198	205
1921	181	195	197	198	198	205
1922	198	198	198	198	198	205
1923	198	198	198	198	198	205
1924	96	143	164	178	192	178
1925	167	195	196	197	198	204
1926	70	115	157	179	198	200
1927	192	194	196	197	198	205
1928	112	168	193	198	198	203
1929	64	101	126	152	169	160
1930	97	138	158	176	196	204
1931	46	72	85	91	98	104
1932	189	193	194	194	194	203
1933	89	136	160	171	181	178
1934	49	77	95	108	116	116
1935	137	168	185	194	194	203
1936	168	197	198	198	198	205
1937	157	198	198	198	198	205
1938	196	198	198	198	198	205
1939	162	190	198	198	198	204
1940	167	198	198	198	198	205
1941	158	196	198	198	198	205
1942	197	198	198	198	198	205
1943	198	198	198	198	198	205
1944	150	186	198	198	198	205
1945	191	198	198	198	198	205
1946	152	198	198	198	198	205
1947	97	145	181	198	198	205
1948	102	142	167	191	198	205
1949	106	147	172	191	198	205
1950	169	196	197	198	198	205
1951	197	198	198	198	198	205
1952	198	198	198	198	198	205
1953	198	198	198	198	198	205
1954	130	173	197	198	198	205
1955	79	119	145	173	198	205
1956	193	195	195	197	198	205
1957	198	198	198	198	198	205
1958	198	198	198	198	198	205
1959	78	136	165	181	198	201
1960	45	82	108	130	169	176
1961	39	73	97	119	126	122
1962	139	178	194	194	194	203
1963	196	197	198	198	198	205
1964	85	147	175	193	198	205
1965	193	195	197	198	198	205
1966	122	167	186	198	198	204
1967	194	196	198	198	198	205
1968	157	193	198	198	198	205
1969	196	198	198	198	198	205
1970	198	198	198	198	198	205
1971	198	198	198	198	198	205
1972	136	181	198	198	198	205
1973	168	197	198	198	198	205
1974	197	198	198	198	198	205
1975	198	198	198	198	198	205
1976	57	119	144	159	178	176
1977	27	57	78	97	104	102
1978	165	192	193	194	193	203
1979	144	187	198	198	198	205
1980	196	198	198	198	198	205
1981	115	155	189	198	198	200
1982	194	196	198	198	198	205
1983	198	198	198	198	198	205
1984	198	198	198	198	198	205
1985	182	198	198	198	198	205
1986	198	198	198	198	198	205
1987	132	168	187	198	198	199
1988	35	65	88	109	118	110
1989	107	148	170	183	194	203
1990	47	79	100	112	128	134
1991	57	85	98	105	113	111
1992	38	63	75	83	86	85
1993	191	192	193	193	193	202
1994	61	98	113	122	124	116
1995	192	194	194	195	195	203
1996	198	198	198	198	198	205
1997	198	198	198	198	198	205
1998	198	198	198	198	198	205
1999	198	198	198	198	198	205
2000	198	198	198	198	198	205
Average	**154**	**173**	**182**	**186**	**189**	**194**
Maximum	**198**	**198**	**198**	**198**	**198**	**205**
Minimum	**27**	**57**	**75**	**83**	**86**	**85**

Table: Annual Deliveries to Truckee Division in TAF

	REFERENCE SCENARIOS					
Year	0cfs	150cfs	250cfs	350cfs	600cfs	900cfs
1901	0	7	7	7	7	10
1902	0	7	7	7	7	10
1903	0	7	7	7	7	10
1904	0	7	7	7	7	10
1905	0	7	7	7	7	10
1906	0	7	7	7	7	10
1907	0	7	7	7	7	10
1908	0	7	7	7	7	10
1909	0	7	7	7	7	10
1910	0	7	7	7	7	10
1911	0	7	7	7	7	10
1912	0	7	7	7	7	10
1913	0	5	6	7	7	10
1914	0	7	7	7	7	10
1915	0	7	7	7	7	10
1916	0	7	7	7	7	10
1917	0	7	7	7	7	10
1918	0	7	7	7	7	10
1919	0	7	7	7	7	10
1920	0	5	6	7	7	10
1921	0	7	7	7	7	10
1922	0	7	7	7	7	10
1923	0	7	7	7	7	10
1924	0	5	5	6	7	9
1925	0	7	7	7	7	10
1926	0	4	5	6	7	10
1927	0	7	7	7	7	10
1928	0	6	7	7	7	10
1929	0	3	4	5	5	8
1930	0	5	5	6	6	10
1931	0	1	1	1	1	2
1932	0	6	6	6	6	10
1933	0	3	4	4	4	6
1934	0	1	1	2	2	3
1935	0	5	5	5	5	9
1936	0	7	7	7	7	10
1937	0	7	7	7	7	10
1938	0	7	7	7	7	10
1939	0	7	7	7	7	10
1940	0	7	7	7	7	10
1941	0	7	7	7	7	10
1942	0	7	7	7	7	10
1943	0	7	7	7	7	10
1944	0	6	7	7	7	10
1945	0	7	7	7	7	10
1946	0	7	7	7	7	10
1947	0	5	6	7	7	10
1948	0	5	6	6	7	10
1949	0	5	6	7	7	10
1950	0	7	7	7	7	10
1951	0	7	7	7	7	10
1952	0	7	7	7	7	10
1953	0	7	7	7	7	10
1954	0	6	7	7	7	10
1955	0	4	5	6	7	10
1956	0	7	7	7	7	10
1957	0	7	7	7	7	10
1958	0	7	7	7	7	10
1959	0	4	5	6	7	10
1960	0	3	3	4	5	9
1961	0	2	3	3	3	5
1962	0	6	7	7	7	10
1963	0	7	7	7	7	10
1964	0	5	6	7	7	10
1965	0	7	7	7	7	10
1966	0	5	6	7	7	10
1967	0	7	7	7	7	10
1968	0	7	7	7	7	10
1969	0	7	7	7	7	10
1970	0	7	7	7	7	10
1971	0	7	7	7	7	10
1972	0	6	7	7	7	10
1973	0	7	7	7	7	10
1974	0	7	7	7	7	10
1975	0	7	7	7	7	10
1976	0	4	5	5	6	9
1977	0	1	1	2	2	3
1978	0	7	7	7	7	10
1979	0	6	7	7	7	10
1980	0	7	7	7	7	10
1981	0	5	7	7	7	10
1982	0	7	7	7	7	10
1983	0	7	7	7	7	10
1984	0	7	7	7	7	10
1985	0	7	7	7	7	10
1986	0	7	7	7	7	10
1987	0	6	6	7	7	10
1988	0	1	1	2	2	3
1989	0	5	6	6	7	10
1990	0	2	2	2	3	4
1991	0	2	2	2	2	3
1992	0	1	1	1	1	2
1993	0	6	6	6	6	9
1994	0	1	2	2	2	2
1995	0	7	7	7	7	10
1996	0	7	7	7	7	10
1997	0	7	7	7	7	10
1998	0	7	7	7	7	10
1999	0	7	7	7	7	10
2000	0	7	7	7	7	10
Average	**0**	**6**	**6**	**6**	**6**	**10**
Maximum	**0**	**7**	**7**	**7**	**7**	**10**
Minimum	**0**	**1**	**1**	**1**	**1**	**2**

Table: Annual Deliveries to Newlands Project in TAF

	REFERENCE SCENARIOS					
Year	**0cfs**	**150cfs**	**250cfs**	**350cfs**	**600cfs**	**900cfs**
1901	198	205	205	205	205	215
1902	198	205	205	205	205	215
1903	198	205	205	205	205	215
1904	198	205	205	205	205	215
1905	198	205	205	205	205	215
1906	198	205	205	205	205	215
1907	198	205	205	205	205	215
1908	198	205	205	205	205	215
1909	198	205	205	205	205	215
1910	198	205	205	205	205	215
1911	198	205	205	205	205	215
1912	197	205	205	205	205	215
1913	103	160	193	205	205	215
1914	194	202	204	205	205	215
1915	198	205	205	205	205	215
1916	198	205	205	205	205	215
1917	198	205	205	205	205	215
1918	198	205	205	205	205	215
1919	165	205	205	205	205	215
1920	98	147	186	205	205	215
1921	181	202	204	205	205	215
1922	198	205	205	205	205	215
1923	198	205	205	205	205	215
1924	96	148	169	184	198	188
1925	167	202	203	204	205	214
1926	70	119	162	184	205	210
1927	192	201	202	204	205	215
1928	112	173	199	205	205	213
1929	64	104	130	156	174	168
1930	97	142	163	182	203	214
1931	46	72	86	92	99	106
1932	189	199	200	200	200	212
1933	89	139	164	175	185	184
1934	49	78	96	110	118	118
1935	137	173	190	199	199	211
1936	168	203	205	205	205	215
1937	157	205	205	205	205	215
1938	196	205	205	205	205	215
1939	162	196	205	205	205	215
1940	167	205	205	205	205	215
1941	158	203	205	205	205	215
1942	197	205	205	205	205	215
1943	198	205	205	205	205	215
1944	150	193	205	205	205	215
1945	191	205	205	205	205	215
1946	152	205	205	205	205	215
1947	97	150	187	205	205	215
1948	102	146	172	198	205	215
1949	106	151	177	198	205	215
1950	169	202	203	205	205	215
1951	197	205	205	205	205	215
1952	198	205	205	205	205	215
1953	198	205	205	205	205	215
1954	130	179	203	205	205	215
1955	79	123	149	178	205	215
1956	193	201	202	203	205	215
1957	198	205	205	205	205	215
1958	198	205	205	205	205	215
1959	78	140	170	187	205	212
1960	45	85	112	134	174	185
1961	39	75	99	122	129	127
1962	139	184	200	201	201	213
1963	196	204	205	205	205	215
1964	85	151	181	199	205	215
1965	193	202	203	205	205	215
1966	122	172	193	205	205	214
1967	194	203	204	205	205	215
1968	157	199	205	205	205	215
1969	196	205	205	205	205	215
1970	198	205	205	205	205	215
1971	198	205	205	205	205	215
1972	136	187	205	205	205	215
1973	168	204	205	205	205	215
1974	197	205	205	205	205	215
1975	198	205	205	205	205	215
1976	57	122	149	164	184	185
1977	27	58	80	99	106	105
1978	165	199	199	200	200	213
1979	144	194	205	205	205	215
1980	196	205	205	205	205	215
1981	115	160	195	205	205	211
1982	194	202	205	205	205	215
1983	198	205	205	205	205	215
1984	198	205	205	205	205	215
1985	182	205	205	205	205	215
1986	198	205	205	205	205	215
1987	132	174	194	205	205	209
1988	35	66	89	111	120	112
1989	107	153	175	189	200	213
1990	47	81	102	114	131	138
1991	57	87	100	107	115	114
1992	38	64	76	84	87	87
1993	191	198	198	198	198	211
1994	61	99	115	124	126	118
1995	192	200	201	201	201	213
1996	198	205	205	205	205	215
1997	198	205	205	205	205	215
1998	198	205	205	205	205	215
1999	198	205	205	205	205	215
2000	198	205	205	205	205	215
Average	**154**	**179**	**187**	**192**	**195**	**204**
Maximum	**198**	**205**	**205**	**205**	**205**	**215**
Minimum	**27**	**58**	**76**	**84**	**87**	**87**

Appendix D2
Effects of Truckee Canal Seepage on Newlands Project Water Supply

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Abbreviations and Acronyms

cfs	cubic feet per second
OCAP	Operating Criteria and Procedures for the Newlands Project
Project	Newlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Study	Newlands Project Planning Study
TAF	thousand acre-feet
TROA	Truckee River Operating Agreement

Appendix D2 – Effects of Truckee Canal Losses on Newlands Project Water Supply

Under average historic operations, the Truckee Canal has lost around 20,000 acre-feet of water per year to seepage losses. This appendix characterizes how various measures aimed at reducing seepage losses would contribute to the water supply objective of the Newlands Project Planning Study (Study). The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Newlands Project (Project) or actions to mitigate water supply conditions that are less than reliable.

This appendix presents one of several screening assessments conducted for the Study, all of which are presented in Appendices D1 through D7. These screening analyses were designed to provide inter-comparisons among several measures that could contribute to meeting the Study's water supply objective. Thus, the measures studied and outcomes published in this appendix are not being proposed as alternatives for the Study, but are instead presented to inform decisions on which measures best meet the Study's objectives.

The following analysis describes how reducing Truckee Canal seepage losses would change the water supply of the Project. A variety of methods were identified for reducing seepage losses from the Truckee Canal, some of which additionally contribute to the Study's safety objective. The measures include lining the Truckee Canal with a geomembrane and concrete liner; and compacting existing earthen embankments within the Truckee Canal using vibratory compaction methods. The lining option this Study considers is consistent with the recommendation in U.S. Department of the Interior, Bureau of Reclamation's (Reclamation) 2011 *Corrective Action Study Alternatives and Appraisal Level Cost Estimates*, which is to line 17 miles of the Truckee Canal, including the entire Fernley Reach; this is assumed to reduce seepage losses by 85 percent of their current levels based on delivery data from the last decade provided by Reclamation and the Truckee-Carson Irrigation District. Although evaporation losses would still occur, the proportion of losses attributed to evaporation is expected to be extremely small in comparison to seepage, and evaporation losses are treated as negligible.

Performance toward the water supply objective is measured against two conditions:

1. A Desired Reliability scenario, which represents the desired performance.

2. Flow-stage reference scenarios, which serve as starting points for applying additional measures (such as lining).

The Desired Reliability scenario describes the ability of the Project to meet current levels of demand, in compliance with the 1997 Operating Criteria and Procedures for the Newlands Project (OCAP) with a 900-cubic-feet-per-second (cfs) Truckee Canal capacity. As the name implies, the flow-stage reference scenarios are built around a range of Truckee Canal flow stages tested by Reclamation for meeting a certain safety standard for operation of the canal (600, 350, 250, 150, and 0 cfs). The flow-stage reference scenarios consider the ability of the Project to meet anticipated future levels of demand, under the 1997 OCAP, with the indicated flow-stage capacity for the Truckee Canal. Reductions in seepage are applied to the flow-stage reference scenarios, with the intent of meeting or exceeding the Desired Reliability conditions. The Desired Reliability and flow-stage reference scenarios are described in Appendix D1.

Methods

The following analysis looks at results of varying Truckee Canal capacity and application of a seepage-reduction measure, such as lining. The Pre-Truckee River Operating Agreement (TROA) Planning Model was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RiverWare modeling environment, and "slots" are features of the RiverWare environment that accept user inputs.

Truckee Canal capacity is entered to the Pre-TROA Planning Model through the TruckeeCanalDiv.CanalCapacityDefault slot. The flow-stage conditions evaluated include 350, 250, and 150 cfs.

To simulate the reduction of Truckee Canal seepage, a factor of 0.85 was applied to the slot TCanalAtHazen.LocalInflow for each time step within the model run. By doing this, the Truckee Canal seepage losses are held at 85% of historical seepage rates.

As described in Appendix B2, this – and all other screening analyses – were evaluated over a 100-year period, from 1901 through 2000.

Results and Conclusions

Rather than present water supply reliability in terms of a singular number, the Study's concept for reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, this Study presents reliability in a two-dimensional context that allows for the evaluation of both frequency and magnitude. This section presents modeling results through a number of plots that illustrate these two components of reliability for flow-stage reference scenarios with and without reduced Truckee Canal seepage and relative to the Desired Reliability scenario. The reference scenario for each flow

stage represents the starting point for each screening analysis of the measure for lining portions of the Truckee Canal.

General conclusions about the performance of the Truckee Canal seepage-reduction measure include the following:

- Reducing Truckee Canal seepage losses has an overall positive effect on Project reliability at all flow stages, and is generally substantial enough for consideration in developing preliminary alternatives.

- Reducing Truckee Canal seepage losses improves the performance of all flow-stage scenarios relative to the Desired Reliability scenario. For the 350 cfs scenario, preventing canal seepage is sufficient to reach Desired Reliability performance levels for the Project.

- Reducing seepage is more effective for scenarios with the largest capacities. In scenarios with flow stages above 250 cfs, the relative improvement from canal lining appears to be a compelling measure.

Figures in the subsections below are provided for visual comparisons of changes in reliability. On the plot in the top portion of the figures, the Desired Reliability and flow-stage scenarios are represented as lines, and include results from 100 years of simulated data (see Appendix D1). Additionally, the bottom half of each figure is a chart that illustrates the difference (flow-stage scenario or reference scenario minus Desired Reliability) in Project deliveries, expressed as a volume (thousands of acre-feet (TAF)).

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

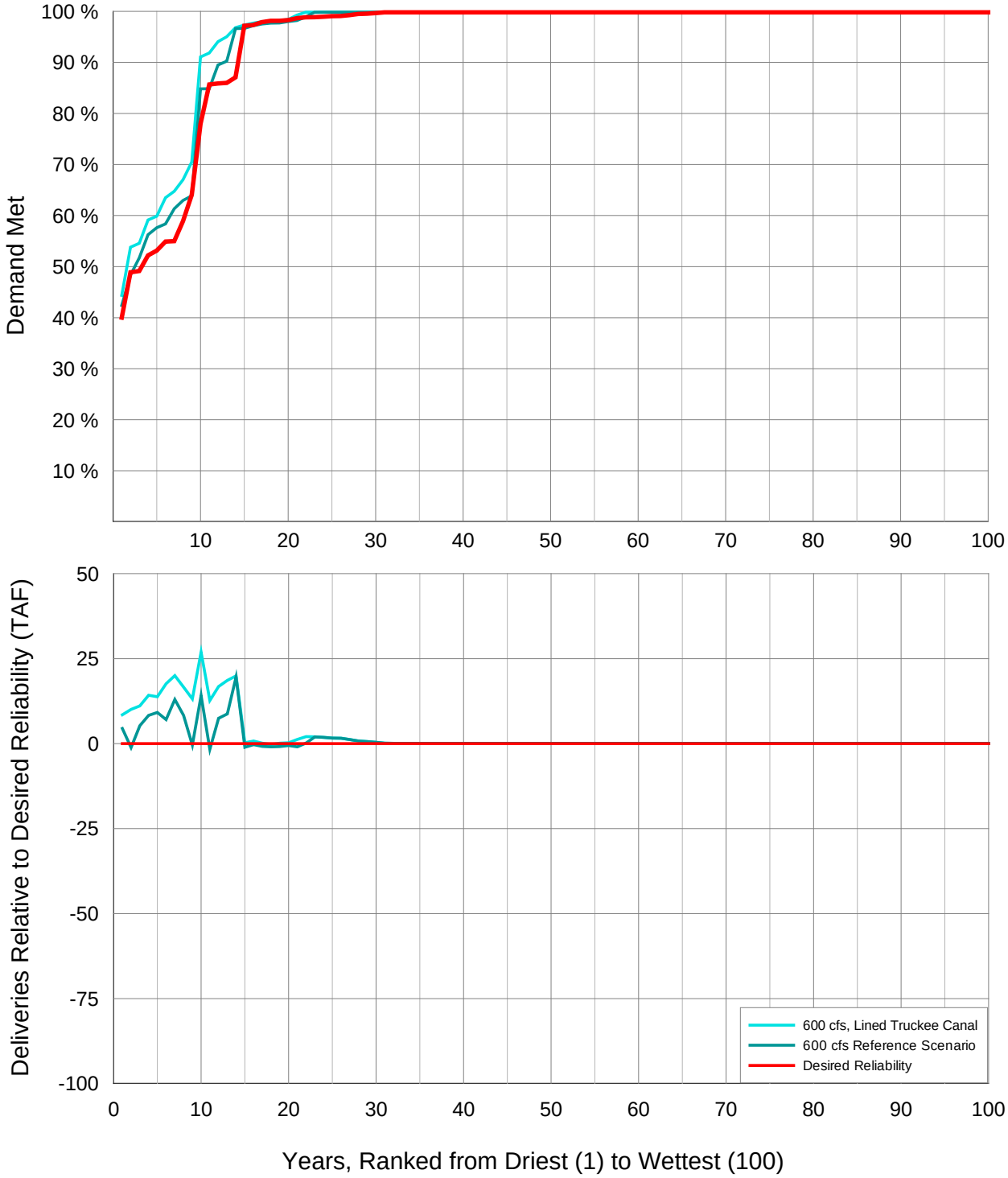
NOTE: the rank of a specific year will not necessarily match between the Desired Reliability and flow-stage reference scenarios, or even across the range of reference scenarios. It follows that implementing measures, such as reducing losses on the Truckee Canal, would similarly result in a change to the ranking of years. The resulting line (sequencing in a manner that does not consistently ascend from low to high rank) reflects the complex manner in which different actions affect the water supply of the Project. Despite this, the trends and results from reducing losses from the Truckee Canal can be clearly interpreted.

600 cfs Scenario with Reduced Truckee Canal Seepage

The 600 cfs reference scenario is equivalent to or better than the Desired Reliability scenario in nearly all years, without reducing Truckee Canal seepage.

Figure D2-1 presents the additional gains to water supply reliability that would result from reducing seepage at this flow stage. Net differences between the Desired Reliability and the range of 600 cfs flow stages are as follows:

- +112 TAF for the 600 cfs reference scenario
- +240 TAF with the reduction in Truckee Canal seepage losses



Key:
cfs = cubic feet per second

Figure D2-1. Relative Performance of Lining Portions of Truckee Canal on Annual Newlands Project Deliveries, 600 cfs Flow Stage

350 cfs Scenario with Reduced Truckee Canal Seepage

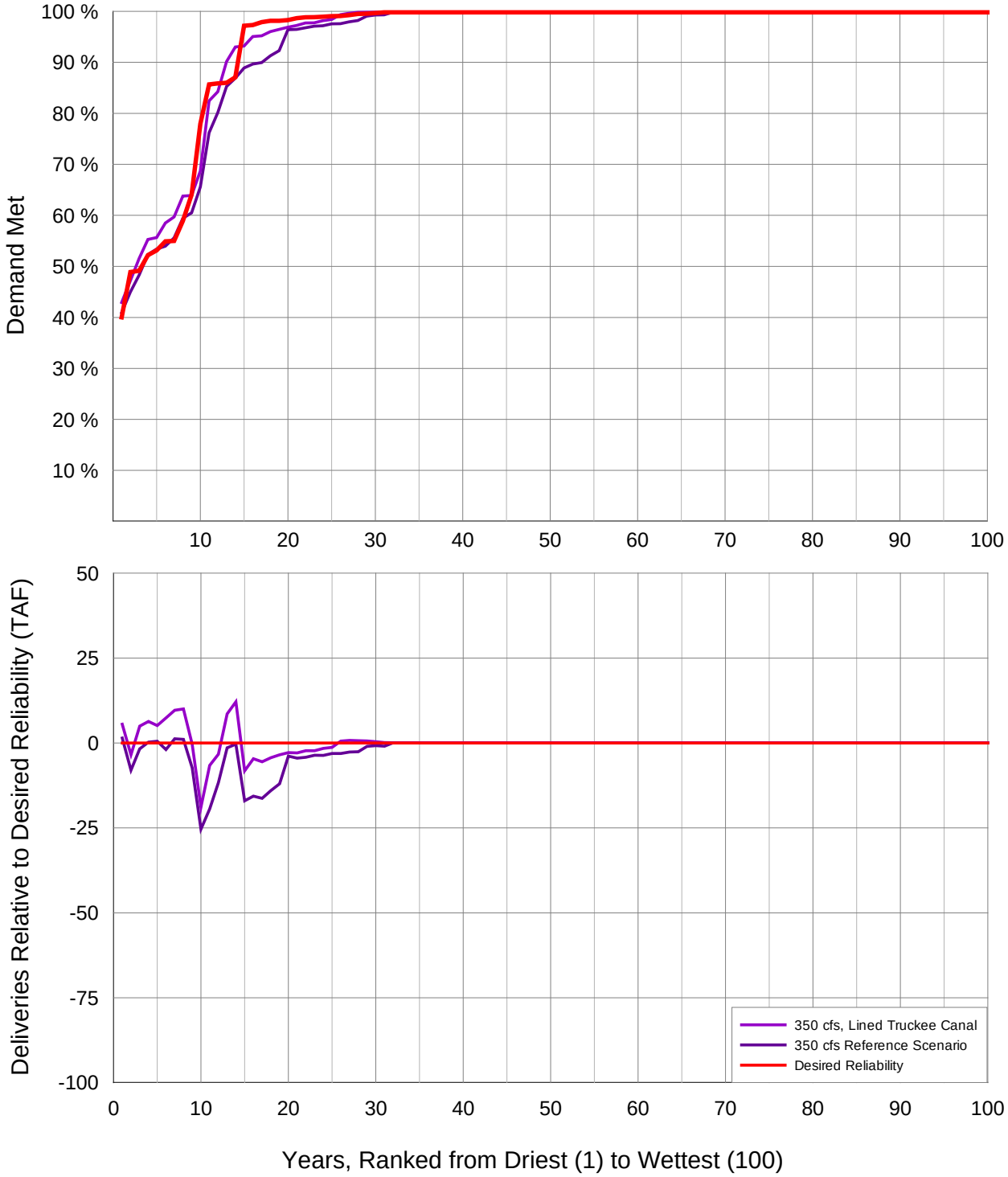
Figure D2-2 demonstrates that, for alternatives that consider a 350 cfs flow-stage for the Truckee Canal, a reduction in Truckee Canal seepage losses results in a water supply reliability that closely approximates the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 350 cfs flow stages are as follows:

- -176 TAF for the 350 cfs reference scenario
- +6 TAF with a reduction in Truckee Canal seepage losses

For the lowest-ranked years, the reduced seepage losses add about 5 percent to the water supply available for delivery. For years ranked between 10 and 30, the reduction in losses decreases the magnitude of shortages relative to the 350 cfs reference scenario by up to 5 percent, bringing deliveries very close to Desired Reliability levels.

For alternatives that consider a 350 cfs flow stage for the Truckee Canal, reduction of seepage losses would likely be the only measure needed to meet Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic feet per second

Figure D2-2. Relative Performance of Lining Portions of Truckee Canal on Annual Newlands Project Deliveries, 350 cfs Flow Stage

250 cfs Scenario with Reduced Truckee Canal Seepage

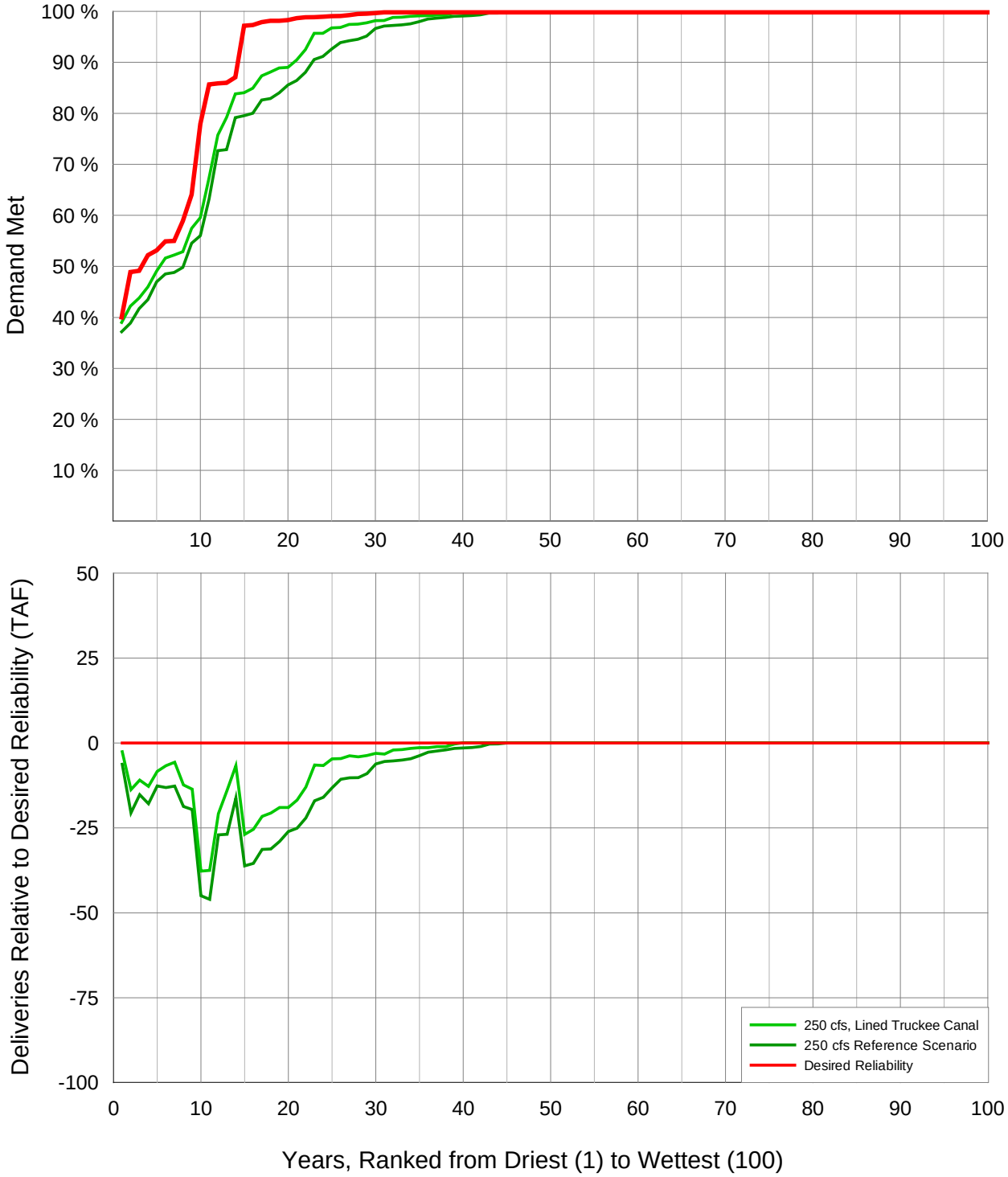
Figure D2-3 demonstrates that, for alternatives that consider a 250 cfs flow stage for the Truckee Canal, a reduction in Truckee Canal seepage losses results in improved water supply reliability, but does not create conditions equal to the Desired Reliability.

Net differences between the Desired Reliability and the range of 250 cfs flow stages are as follows:

- -660 TAF for the 250 cfs reference scenario
- -412 TAF with a reduction in Truckee Canal seepage losses

For the lowest-ranked years, the reduction of Truckee Canal seepage losses adds less than 5 percent to the water supply available for delivery. For years ranked between 10 and 30, the reduction of seepage losses brings reliability levels 5 percent closer to the Desired Reliability.

For alternatives that consider a 250 cfs flow stage for the Truckee Canal, reduction of seepage losses would need to be accompanied with other measures needed to meet the Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic feet per second

Figure D2-3. Relative Performance of Lining Portions of Truckee Canal on Annual Newlands Project Deliveries, 250 cfs Flow Stage

150 cfs Scenario with Reduced Truckee Canal Seepage

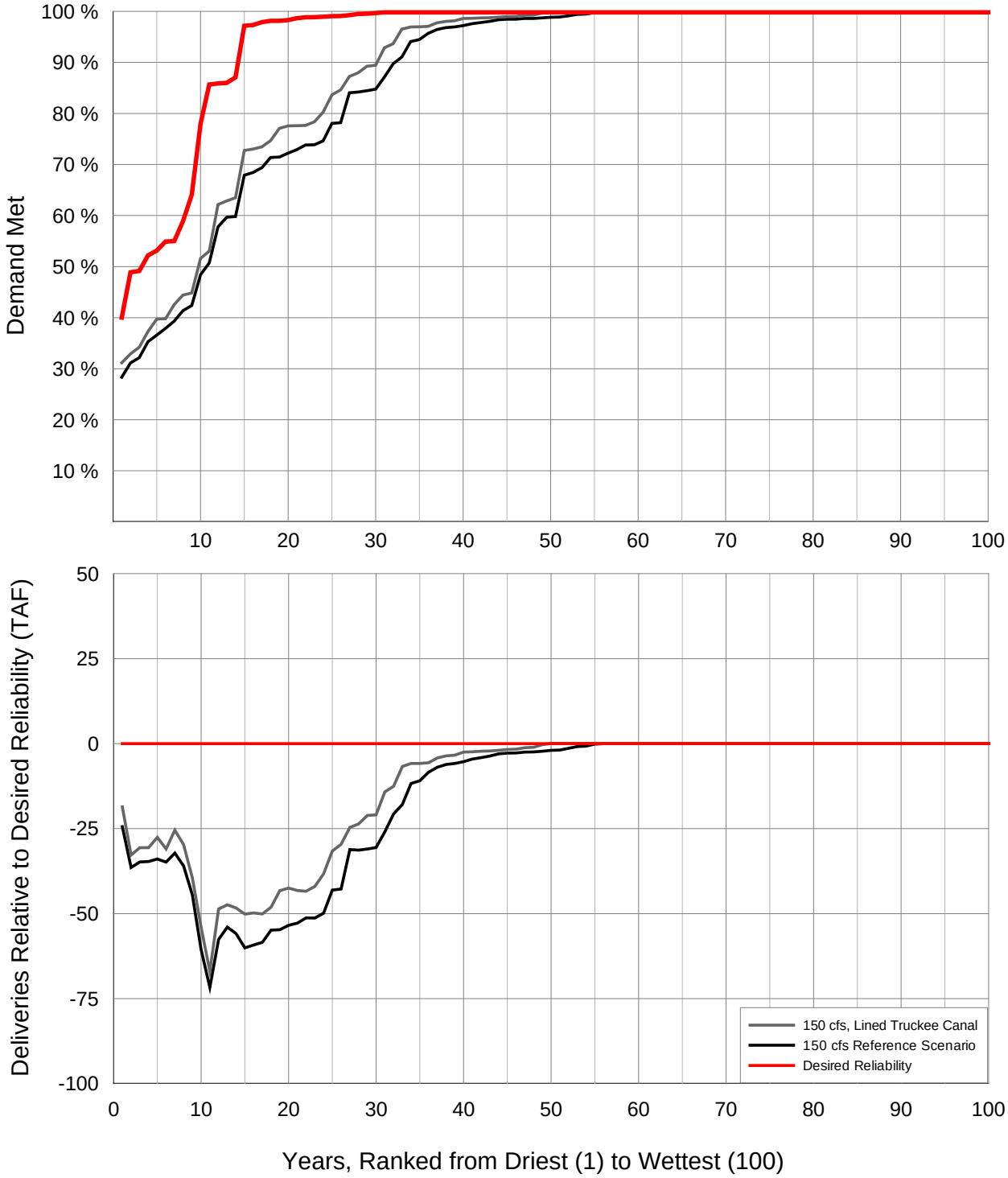
Figure D2-4 demonstrates that, for alternatives that consider a 150 cfs flow stage for the Truckee Canal, a reduction in Truckee Canal seepage losses results in improved water supply reliability, but does not create conditions equal to the Desired Reliability.

Net differences between the Desired Reliability and the range of 150 cfs flow stages are as follows:

- -1,519 TAF for the 150 cfs reference scenario
- -1,209 TAF with a reduction in Truckee Canal seepage losses

For the lowest-ranked years, it would add up to 5 percent to the water supply available for delivery. For years ranked between 10 and 30, where the reference scenario was below the Desired Reliability by up to 35 percent, seepage reduction brings reliability to levels that are within 10 to 30 percent of the Desired Reliability.

For alternatives that consider a 150 cfs flow stage for the Truckee Canal, reduction of seepage losses would need to be accompanied with other measures needed to meet the Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic feet per second

Figure D2-4. Relative Performance of Lining Portions of Truckee Canal on Annual Newlands Project Deliveries, 150 cfs Flow Stage

Summary of Results

The tables in this subsection summarize some of the primary findings from the analysis of Truckee Canal performance with reduced seepage.

Table D2-1 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability scenario, flow-stage reference scenarios, and flow-stage scenarios once the seepage-reduction measure is applied.

Table D2-1. Project Reliability for Desired Reliability Reference Scenario and with Reduced Truckee Canal Seepage Losses

	Number of Years Where >95 Percent of Demand is Met	Number of Years Where <50 Percent of Demand is Met	Percent of Demand Met in Driest Year
Desired Reliability	86	3	40%
600 cfs Reduced Seepage	88	1	44%
350 cfs Reduced Seepage	85	2	43%
250 cfs Reduced Seepage	78	5	39%
150 cfs Reduced Seepage	68	9	31%

Key:
cfs = cubic feet per second

To support additional use by the Study or other parties, Table D2-2 notes the effects of Truckee Canal lining on average Truckee River flows to Pyramid Lake, annual hydropower generation at Lahontan Dam and the 26-Foot Drop (V Canal) Power Plant, and the annual average and maximum annual spills from Lahontan Reservoir.

Table D2-2. Additional Characteristics of Reduced Truckee Canal Seepage (Annual Basis)

	Lahontan Reservoir Hydropower Generation (MWH)	V Canal Hydropower Generation (MWH)	Pyramid Lake Inflows (TAF)	Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability	15,676	3,309	460	236	12
600 cfs	16,562	3,148	478	243	13
350 cfs	16,008	3,099	485	243	13
250 cfs	15,382	3,017	496	243	12
150 cfs	14,381	2,860	515	243	11

Key:
cfs = cubic feet per second
MW = megawatts
TAF = thousand acre-feet

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Appendix D2
Effects of Truckee Canal Losses on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The table in this attachment summarizes water supply over the 100-year period of screening analysis, and includes results from the same period for the flow-stage reference scenarios and the Desired Reliability scenario from Appendix D1.

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Table: Annual Deliveries to Carson Division in TAF

Year	Desired Reliability	Reduced Truckee Canal Seepage		
		150 cfs	250 cfs	350 cfs
1901	205	198	198	198
1902	205	198	198	198
1903	205	198	198	198
1904	205	198	198	198
1905	205	198	198	198
1906	205	198	198	198
1907	205	198	198	198
1908	205	198	198	198
1909	205	198	198	198
1910	205	198	198	198
1911	205	198	198	198
1912	205	198	198	198
1913	205	168	197	198
1914	205	196	198	198
1915	205	198	198	198
1916	205	198	198	198
1917	205	198	198	198
1918	205	198	198	198
1919	205	198	198	198
1920	205	154	190	198
1921	205	196	198	198
1922	205	198	198	198
1923	205	198	198	198
1924	178	156	176	190
1925	204	196	197	198
1926	200	125	167	189
1927	205	195	196	198
1928	203	178	198	198
1929	160	106	134	164
1930	204	146	167	185
1931	104	76	89	96
1932	203	193	194	194
1933	178	146	170	181
1934	116	80	99	113
1935	203	174	191	194
1936	205	197	198	198
1937	205	198	198	198
1938	205	198	198	198
1939	204	197	198	198
1940	205	198	198	198
1941	205	198	198	198
1942	205	198	198	198
1943	205	198	198	198
1944	205	198	198	198
1945	205	198	198	198
1946	205	198	198	198
1947	205	159	192	198
1948	205	148	175	198
1949	205	154	180	198
1950	205	196	197	198
1951	205	198	198	198
1952	205	198	198	198
1953	205	198	198	198
1954	205	184	198	198
1955	205	124	157	185
1956	205	195	196	197
1957	205	198	198	198
1958	205	198	198	198
1959	201	145	174	189
1960	176	88	114	137
1961	122	79	104	127
1962	203	186	194	195
1963	205	198	198	198
1964	205	154	184	198
1965	205	196	197	198
1966	204	175	195	198
1967	205	197	198	198
1968	205	198	198	198
1969	205	198	198	198
1970	205	198	198	198
1971	205	198	198	198
1972	205	192	198	198
1973	205	198	198	198
1974	205	198	198	198
1975	205	198	198	198
1976	176	126	151	167
1977	102	63	85	104
1978	203	192	193	194
1979	205	198	198	198
1980	205	198	198	198
1981	200	166	198	198
1982	205	196	198	198
1983	205	198	198	198
1984	205	198	198	198
1985	205	198	198	198
1986	205	198	198	198
1987	199	177	197	198
1988	110	69	93	121
1989	203	153	177	191
1990	134	85	106	117
1991	111	90	104	111
1992	85	67	79	87
1993	202	192	193	193
1994	116	104	121	129
1995	203	194	195	195
1996	205	198	198	198
1997	205	198	198	198
1998	205	198	198	198
1999	205	198	198	198
2000	205	198	198	198
Average	**194**	**176**	**184**	**188**
Maximum	**205**	**198**	**198**	**198**
Minimum	**85**	**63**	**79**	**87**

Table: Annual Deliveries to Truckee Division in TAF

Year	Desired Reliability	Reduced Truckee Canal Seepage		
		150 cfs	250 cfs	350 cfs
1901	10	7	7	7
1902	10	7	7	7
1903	10	7	7	7
1904	10	7	7	7
1905	10	7	7	7
1906	10	7	7	7
1907	10	7	7	7
1908	10	7	7	7
1909	10	7	7	7
1910	10	7	7	7
1911	10	7	7	7
1912	10	7	7	7
1913	10	5	7	7
1914	10	7	7	7
1915	10	7	7	7
1916	10	7	7	7
1917	10	7	7	7
1918	10	7	7	7
1919	10	7	7	7
1920	10	5	6	7
1921	10	7	7	7
1922	10	7	7	7
1923	10	7	7	7
1924	9	5	6	6
1925	10	7	7	7
1926	10	4	5	6
1927	10	7	7	7
1928	10	6	7	7
1929	8	3	4	5
1930	10	5	5	6
1931	2	1	1	1
1932	10	6	6	6
1933	6	3	4	4
1934	3	1	1	2
1935	9	5	5	5
1936	10	7	7	7
1937	10	7	7	7
1938	10	7	7	7
1939	10	7	7	7
1940	10	7	7	7
1941	10	7	7	7
1942	10	7	7	7
1943	10	7	7	7
1944	10	7	7	7
1945	10	7	7	7
1946	10	7	7	7
1947	10	5	6	7
1948	10	5	6	7
1949	10	5	6	7
1950	10	7	7	7
1951	10	7	7	7
1952	10	7	7	7
1953	10	7	7	7
1954	10	6	7	7
1955	10	4	5	6
1956	10	7	7	7
1957	10	7	7	7
1958	10	7	7	7
1959	10	5	6	6
1960	9	3	4	4
1961	5	2	3	3
1962	10	6	7	7
1963	10	7	7	7
1964	10	5	6	7
1965	10	7	7	7
1966	10	6	7	7
1967	10	7	7	7
1968	10	7	7	7
1969	10	7	7	7
1970	10	7	7	7
1971	10	7	7	7
1972	10	7	7	7
1973	10	7	7	7
1974	10	7	7	7
1975	10	7	7	7
1976	9	4	5	5
1977	3	1	1	2
1978	10	7	7	7
1979	10	7	7	7
1980	10	7	7	7
1981	10	5	7	7
1982	10	7	7	7
1983	10	7	7	7
1984	10	7	7	7
1985	10	7	7	7
1986	10	7	7	7
1987	10	6	7	7
1988	3	1	1	2
1989	10	5	6	6
1990	4	2	2	3
1991	3	2	2	2
1992	2	1	1	1
1993	9	6	6	6
1994	2	1	2	2
1995	10	7	7	7
1996	10	7	7	7
1997	10	7	7	7
1998	10	7	7	7
1999	10	7	7	7
2000	10	7	7	7
Average	**10**	**6**	**6**	**6**
Maximum	**10**	**7**	**7**	**7**
Minimum	**2**	**1**	**1**	**1**

Table: Annual Deliveries to Newlands Project in TAF

Year	Desired Reliability	Reduced Truckee Canal Seepage		
		150 cfs	250 cfs	350 cfs
1901	215	205	205	205
1902	215	205	205	205
1903	215	205	205	205
1904	215	205	205	205
1905	215	205	205	205
1906	215	205	205	205
1907	215	205	205	205
1908	215	205	205	205
1909	215	205	205	205
1910	215	205	205	205
1911	215	205	205	205
1912	215	205	205	205
1913	215	174	203	205
1914	215	203	205	205
1915	215	205	205	205
1916	215	205	205	205
1917	215	205	205	205
1918	215	205	205	205
1919	215	205	205	205
1920	215	159	196	205
1921	215	202	204	205
1922	215	205	205	205
1923	215	205	205	205
1924	188	161	182	197
1925	214	202	203	205
1926	210	129	172	195
1927	215	201	203	204
1928	213	183	205	205
1929	168	109	138	169
1930	214	151	172	191
1931	106	76	90	97
1932	212	199	200	200
1933	184	149	174	185
1934	118	81	101	114
1935	211	179	196	199
1936	215	204	205	205
1937	215	205	205	205
1938	215	205	205	205
1939	215	203	205	205
1940	215	205	205	205
1941	215	205	205	205
1942	215	205	205	205
1943	215	205	205	205
1944	215	205	205	205
1945	215	205	205	205
1946	215	205	205	205
1947	215	165	199	205
1948	215	153	181	205
1949	215	159	186	205
1950	215	203	204	205
1951	215	205	205	205
1952	215	205	205	205
1953	215	205	205	205
1954	215	190	205	205
1955	215	127	162	191
1956	215	201	203	204
1957	215	205	205	205
1958	215	205	205	205
1959	212	150	179	195
1960	185	91	118	141
1961	127	82	107	131
1962	213	192	200	201
1963	215	204	205	205
1964	215	159	190	205
1965	215	202	204	205
1966	214	180	201	205
1967	215	203	205	205
1968	215	205	205	205
1969	215	205	205	205
1970	215	205	205	205
1971	215	205	205	205
1972	215	199	205	205
1973	215	205	205	205
1974	215	205	205	205
1975	215	205	205	205
1976	185	130	155	173
1977	105	64	87	106
1978	213	199	200	200
1979	215	205	205	205
1980	215	205	205	205
1981	211	172	205	205
1982	215	203	205	205
1983	215	205	205	205
1984	215	205	205	205
1985	215	205	205	205
1986	215	205	205	205
1987	209	183	203	205
1988	112	70	94	122
1989	213	158	183	198
1990	138	87	108	120
1991	114	92	106	113
1992	87	67	80	88
1993	211	198	198	199
1994	118	106	122	131
1995	213	200	201	202
1996	215	205	205	205
1997	215	205	205	205
1998	215	205	205	205
1999	215	205	205	205
2000	215	205	205	205
Average	**204**	**182**	**190**	**194**
Maximum	**215**	**205**	**205**	**205**
Minimum	**87**	**64**	**80**	**88**

Appendix D3
Effects of Storage Increases on Newlands Project Water Supply

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Abbreviations and Acronyms

cfs	cubic feet per second
OCAP	Operating Criteria and Procedures for the Newlands Project
Project	Newlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Study	Newlands Project Planning Study
TAF	thousand acre-feet
TROA	Truckee River Operating Agreement

Appendix D3 – Effects of Reducing Demand on Newlands Project Water Supply

This appendix characterizes how reducing agricultural demands within the Newlands Project (Project) would contribute to the water supply objective of the Newlands Project Planning Study (Study). The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Project or actions to mitigate water supply conditions that are less than reliable.

This appendix presents one of several screening assessments conducted for the Study, all of which are presented in Appendices D1 through D7. These screening analyses were designed to provide inter-comparisons among several measures that could potentially contribute to meeting the Study's water supply objective. Thus, the measures studied and outcomes published in this appendix are not being proposed as alternatives for the Study, but are instead presented to inform decisions on which measures best meet the Study's objectives.

The following analysis describes how reducing Project agricultural demands would change the water supply of the Project. Two fundamentally different types of measures were identified for reducing demand: (1) permanent land-use modification programs (such as acquiring and retiring water rights), and (2) temporary demand reduction programs, (such as dry-year insurance programs or forbearance agreements). Since permanent demand reductions would also permanently reduce the 1997 Operating Criteria and Procedures for the Newlands Project (OCAP) storage targets at Lahontan Reservoir, a supplemental analysis was conducted to demonstrate the potential effects of temporary reductions in demand, which would not change these OCAP targets.

The potential reduction in demand that would be possible under these measures is not known. For this analysis, a range of demand reductions was selected to bracket any foreseeable discussions. The range of analysis considered includes reductions of 10, 25, 50, and 75 percent of the total Project demand for irrigated agriculture. Other demands – such as those for the cities of Fernley and Fallon, the Fallon Paiute-Shoshone tribal irrigation lands, or for wetland restoration by the US Fish and Wildlife Service at Stillwater National Wildlife Refuge – were not reduced as part of these sensitivity studies and remain at the full demand reported for future conditions in Appendix C.

Performance toward the water supply objective is measured against two conditions:

1. A Desired Reliability scenario, which represents the desired performance.

2. Flow-stage reference scenarios, which serve as starting points for applying additional measures (such as land buy-out or fallowing).

The Desired Reliability scenario describes the ability of the Project to meet current levels of demand, in compliance with the 1997 OCAP and with the 900-cubic-feet-per-second (cfs) Truckee Canal capacity. As the name implies, the flow-stage reference scenarios are built around a range of Truckee Canal flow stages tested by the U.S. Department of the Interior, Bureau of Reclamation (Reclamation) for meeting a certain safety standard for operation of the canal (600, 350, 250, 150, and 0 cfs). The flow-stage reference scenarios consider the ability of the Project to meet anticipated future levels of demand, under the 1997 OCAP, with the indicated flow-stage capacity for the Truckee Canal. Reductions in demand are applied to the flow-stage reference scenarios, with the intent of meeting or exceeding the Desired Reliability conditions. The Desired Reliability and flow-stage reference scenarios are described in Appendix D1.

Methods

The analysis looks at results of varying Truckee Canal capacity and Project demand for irrigated agriculture. Numerical results are simulated outputs of the Pre-Truckee River Operating Agreement (TROA) Planning Model, which was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RIVERWARE modeling environment, and "slots" are features of the RIVERWARE environment that accept user inputs.

As described in Appendix B2, these – and all other screening analyses – were evaluated over a 100-year period, from 1901 through 2000.

The Truckee Canal capacity is entered to the Pre-TROA Planning Model through the slot TRUCKEECANALDIV.CANALCAPACITYDEFAULT. The flow-stage conditions evaluated include 350, 250, 150 and 0 cfs.

The measures described for reducing Project demands apply exclusively to irrigated agriculture. Demands are calculated within the Pre-TROA Planning Model from user inputs that specify the acreage of land being irrigated by classification (e.g., bench or bottom land). The Carson Division Water Righted and Irrigation water user category is represented in the RiverWare slot MHEDATA.CARSONDIVISIONWRANDIRRIG, containing both the Carson Division urban and agricultural demands. Only the agricultural portion of the user-input irrigated acreage has been reduced while the urban portion and all other water user categories remain unchanged. Table D3-1 contains the Carson Division Water Righted and Irrigation category's irrigated acreage inputs for the Carson Division, for the levels of demand considered in this analysis.

Table D3-1. Acres of Commercial and Noncommercial Agricultural Water Rights, by Duty Classification and Scenario

Scenario	Duty Classification				
	TD Bench	Bench	Bottom	Wetland	Pasture
Anticipated Future Water Righted Lands	1,451	9,830	19,104	22	2,382
10% Demand Reduction	1,306	8,847	17,194	20	2,144
25% Demand Reduction	1,088	7,373	14,328	17	1,787
50% Demand Reduction	7,26	4,915	9,552	11	1,191
75% Demand Reduction	363	2,458	4,776	6	596

Notes:
All acreages are for the Carson Division, except those marked TD, which are in the Truckee Division
Water Right duties vary by land classification as follows:
Pasture = 1.5 acre-feet/acre
Wetlands = 2.99 acre-feet/acre
Bottom Land = 3.5 acre-feet/acre
Bench Land = 4.5 acre-feet/acre

Key:
TD = Truckee Division

Results and Conclusions

Rather than present water supply reliability in terms of a singular number, the Study's concept for reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, reliability must be presented in a two-dimensional context that allows for the evaluation of both frequency and magnitude. This section presents modeling results through a number of plots that illustrate these two components of reliability for flow-stage reference scenarios with and without various levels of reduced Project demand and relative to the Desired Reliability scenario. The reference scenario for each flow stage represents the starting point for each screening analysis of land buy-outs, fallowing programs, and other similar measures.

Demand reduction could play an important role in improving project reliability for the 350 cfs, 250 cfs, 150 cfs, and 0 cfs canal capacity scenarios; particularly, because demand reduction is the only measure capable of meeting the water supply reliability objective in full for all flow scenarios, and because strategies for reducing demands are scalable. This Study recognizes that, while it is technically possible to meet the water supply reliability objective with only demand reduction, doing so may not be feasible from social, political, or economic perspectives; these perspectives will be considered in the formulation of Study alternatives.

The scalability of demand reduction allows for some fraction of demand to be reduced when other water supply measures have already been applied and the alternative still does not meet the Desired Reliability levels. In certain cases,

reducing demand may be the only method available for reducing the remaining shortfalls.

This appendix looks solely at the reduction in agricultural demand required to meet the water supply objective alone. In general, smaller Truckee Canal capacities require higher levels of demand reduction to match long-term average reliability under Desired Reliability conditions. In summary, the Desired Reliability can be met with an agricultural demand reduction of:

- About 10 percent at a 350 cfs flow stage
- About 25 percent at a 250 cfs flow stage
- About 45 percent at a 150 cfs flow stage
- About 75 percent at a 0 cfs flow stage

Figures in the subsections below are provided for visual comparisons of changes in reliability. On the plot in the top portion of the figures, the Desired Reliability and flow-stage scenarios are represented in terms of percent of annual demand met, and include the ranked results from 100 years of simulated data (see Appendix D1). The bottom half of each figure is a chart that illustrates the difference between each scenario and the Desired Reliability, expressed as a volume (thousands of acre-feet (TAF)).

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

NOTE: the rank of a specific year will not necessarily match between the Desired Reliability and flow-stage reference scenarios, or even across the range of reference scenarios. It follows that implementing measures, such as reducing demand in the Carson Division, would similarly result in a change to the ranking of years. The resulting line (sequencing in a manner that does not consistently ascend from low to high rank) reflects the complex manner in which different actions affect the water supply of the Project. Despite this, the trends and results from applying demand reduction measures can be clearly interpreted.

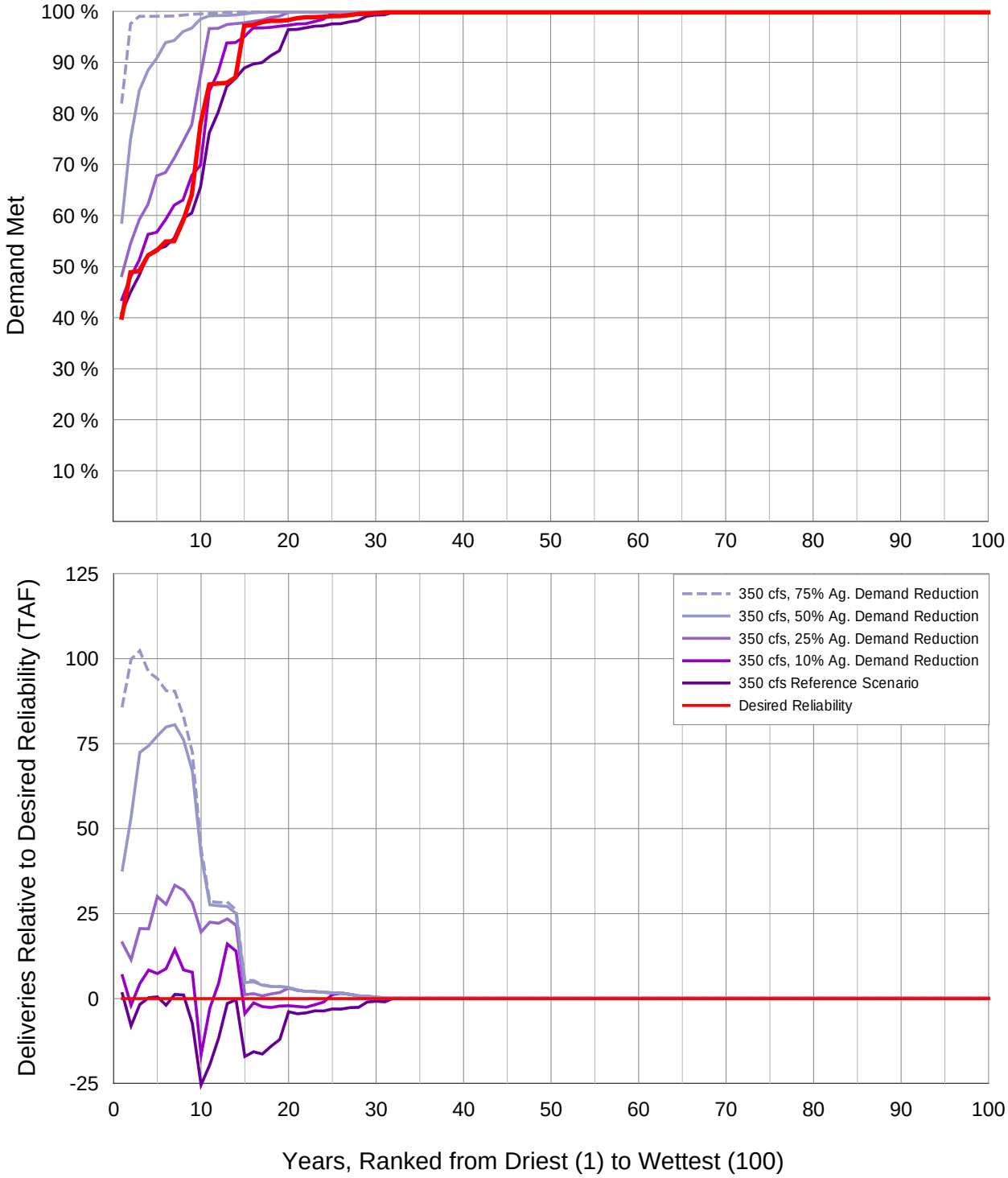
350 cfs Scenario with Reduced Demand

Figure D3-1 demonstrates that, for alternatives that consider a 350 cfs flow stage for the Truckee Canal, a 10 percent reduction in agricultural demand produces a water supply reliability that closely approximates the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 350 cfs flow stages are as follows:

- -176 TAF for the 350 cfs reference scenario
- +69 TAF with a 10 percent reduction in agricultural demand
- +361 TAF with a 25 percent reduction
- +816 TAF with a 50 percent reduction
- +1,024 TAF with a 75 percent reduction

With a 10 percent reduction for a 350 cfs flow stage, the net difference in deliveries relative to the Desired Reliability is positive (69 TAF), indicating that a 10 percent demand reduction exceeds the long-term average water supply deliveries for the Desired Reliability.



Key:
cfs = cubic feet per second

Figure D3-1. Relative Performance of Reducing Demand on Annual Newlands Project Deliveries, 350 cfs Flow Stage

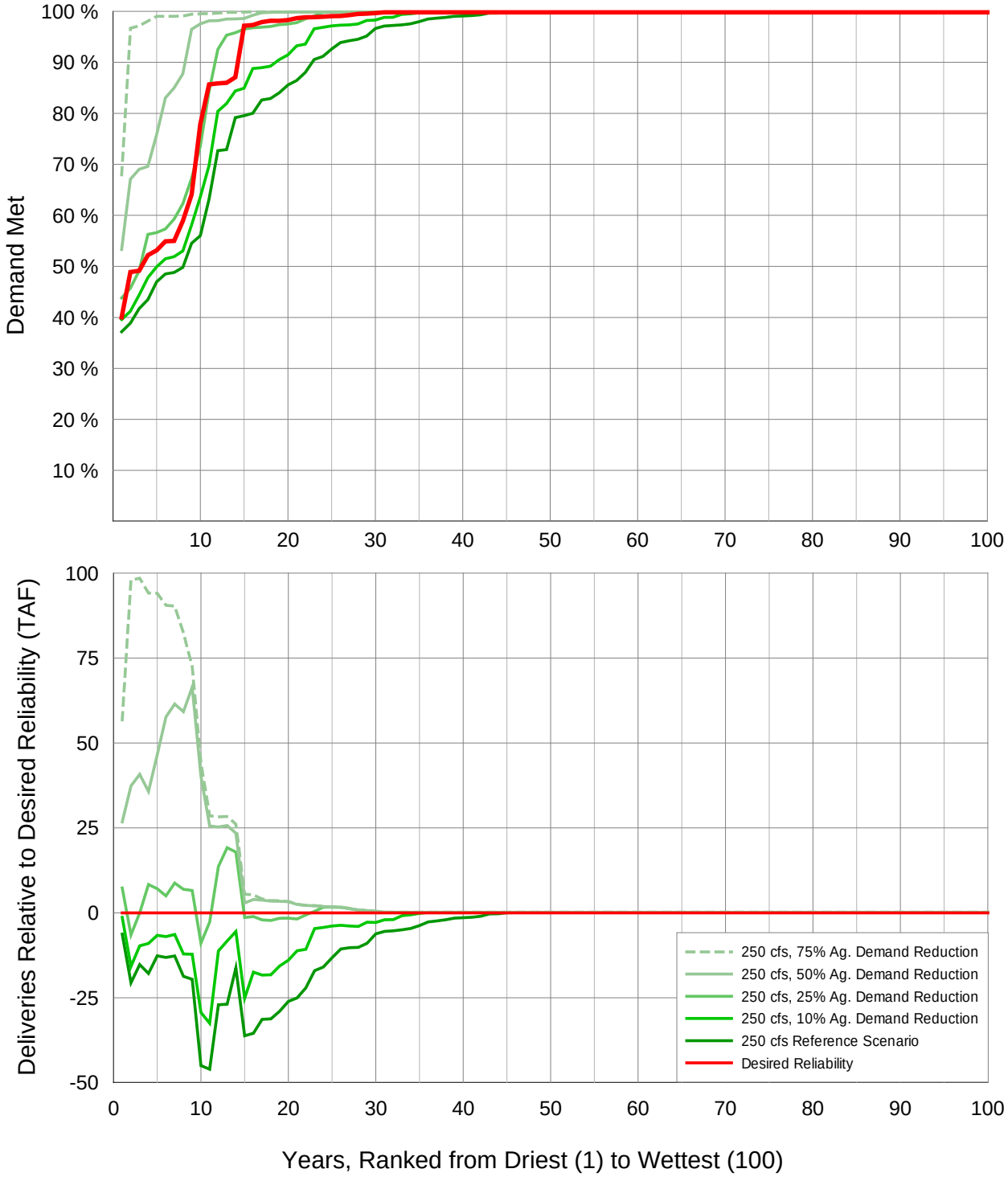
250 cfs Scenario with Reduced Demand

Figure D3-2 demonstrates that, for alternatives that consider a 250 cfs flow stage for the Truckee Canal, a 25 percent reduction in agricultural demand produces a water supply reliability that closely approximates the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 250 cfs flow stages are as follows:

- -660 TAF for the 250 cfs reference scenario
- -328 TAF with a 10 percent reduction in agricultural demand
- +86 TAF with a 25 percent reduction
- +617 TAF with a 50 percent reduction
- +987 TAF with a 75 percent reduction

With a 25 percent reduction for a 250 cfs flow stage, the net difference in deliveries relative to the Desired Reliability is positive (86 TAF), indicating that a 25 percent demand reduction exceeds the long-term average water supply deliveries for the Desired Reliability.



Key:
cfs = cubic feet per second

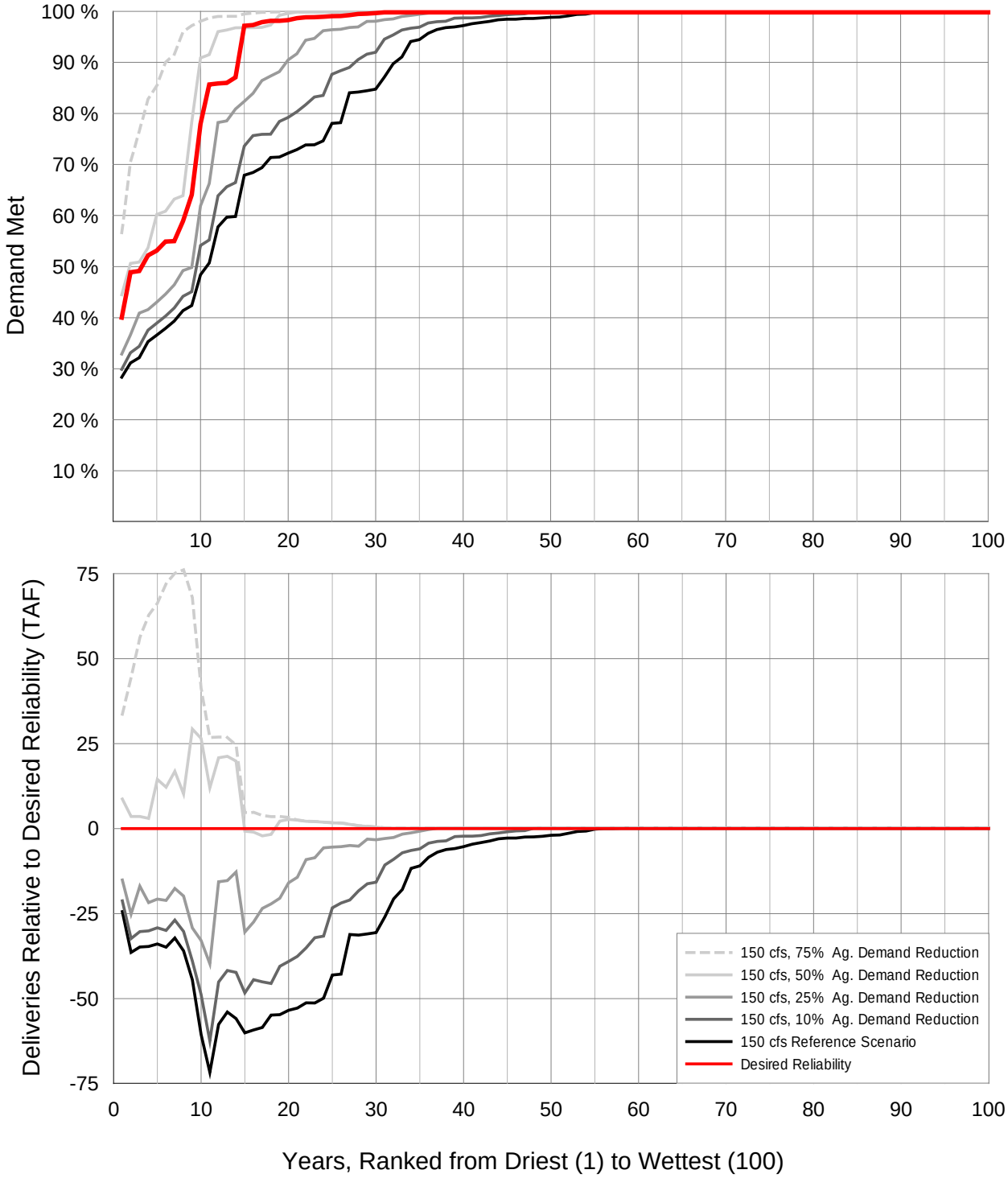
Figure D3-2. Relative Performance of Reducing Demand on Annual Newlands Project Deliveries, 250 cfs Flow Stage

150 cfs Scenario with Reduced Demand

Figure D3-3 demonstrates that, for alternatives that consider a 150 cfs flow-stage for the Truckee Canal, a 50 percent reduction in agricultural demand produces a water supply reliability that exceeds the Desired Reliability for nearly the full range of hydrologic conditions. Net differences between the Desired Reliability and the range of 150 cfs flow stages are as follows:

- -1,519 TAF for the 150 cfs reference scenario
- -1,086 TAF with a 10 percent reduction in agricultural demand
- -512 TAF with a 25 percent reduction
- +226 TAF with a 50 percent reduction
- +753 TAF with a 75 percent reduction

With a 50 percent reduction for a 150 cfs flow stage, the net difference in deliveries relative to the Desired Reliability is positive (226 TAF), indicating that a 50 percent demand reduction exceeds the long-term average water supply deliveries for the Desired Reliability.



Key:
cfs = cubic feet per second

Figure D3-3. Relative Performance of Reducing Demand on Annual Newlands Project Deliveries, 150 cfs Flow Stage

0 cfs Scenario with Reduced Demand, Carson Division Only

Unlike the scenarios considered above, the analysis for the 0 cfs flow-stage only considers the Carson Division. If the Truckee Canal were decommissioned, the Truckee Division would require a combination of both a water source and conveyances to meet the water supply objectives of the Study. This topic is given further consideration in Chapter 4 of the Study.

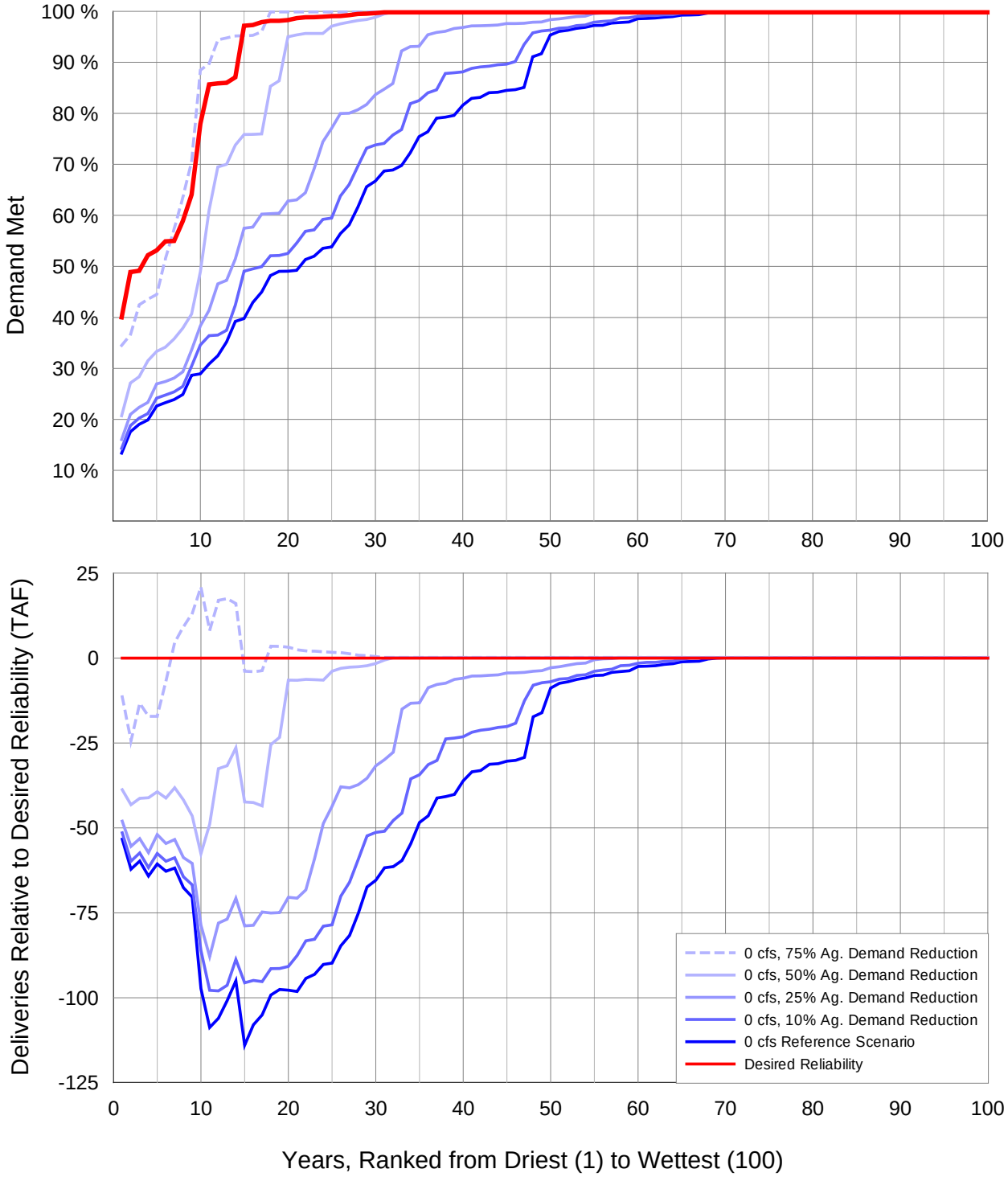
Unlike the Truckee Division, the Carson Division does not rely entirely upon diversions from the Truckee River. The Carson Division would be able to meet some portion of its demands in the Carson River, and carry over storages in the Lahontan Reservoir. The following analysis focuses upon the quantity of agricultural demand reduction needed in the Carson Division to meet the Study objectives for the Carson Division alone.

Figure D3-4 demonstrates that, for alternatives that consider a 0 cfs flow stage for the Truckee Canal, a 75 percent reduction in agricultural demand produces a water supply reliability that nearly approximates the Desired Reliability for nearly the full range of hydrologic conditions. Net differences between the Desired Reliability and the range of 0 cfs flow stages are as follows:

- -3,962 TAF for the Carson Division in the 0 cfs reference scenario
- -2,820 TAF with a 10 percent reduction in agricultural demand
- -1,993 TAF with a 25 percent reduction
- -786 TAF with a 50 percent reduction
- +42 TAF with a 75 percent reduction

With a 75 percent reduction for a 0 cfs flow stage, the net difference in deliveries relative to the Desired Reliability is positive (42 TAF), indicating that a 75 percent demand reduction exceeds the long term average water supply deliveries for the Desired Reliability.

Although the 75 percent reduction in agricultural demand results in positive net difference in reliability, conditions for the driest 10 years are approximately 10 percent below levels experienced in the Desired Reliability. This condition may create economic conditions that are not equivalent to the Desired Reliability. Thus, for alternatives that consider a 0 cfs flow stage, reductions of more than 75 percent of Carson Division agricultural demand may be necessary to meet the Desired Reliability conditions for the Carson Division.



Key:
cfs = cubic feet per second

Figure D3-4. Relative Performance of Reducing Demand on Carson Division Deliveries, 0 cfs Flow Stage

Summary of Results

The tables in this subsection summarize some of the primary findings from the analysis of Truckee Canal performance with reduced demands in the Carson Division.

Table D3-2 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability scenario, flow-stage reference scenarios, and flow-stage scenarios once the measures to purchased or fallow land are applied.

Table D3-2. Project Reliability for Reference Scenarios and with Reduced Carson Division Demand

		Number of Years Where >95 Percent of Demand is Met	Number of Years Where <50 Percent of Demand is Met	Percent of Demand Met in Driest Year
Desired Reliability		86	3	40%
350 cfs	75% Reduction	99	0	82%
	50% Reduction	93	0	59%
	25% Reduction	90	1	48%
	10% Reduction	86	2	44%
250 cfs	75% Reduction	99	0	68%
	50% Reduction	92	0	53%
	25% Reduction	88	3	44%
	10% Reduction	78	5	40%
150 cfs	75% Reduction	93	0	57%
	50% Reduction	89	1	44%
	25% Reduction	77	9	33%
	10% Reduction	69	9	30%
0 cfs[1]	75% Reduction	83	5	34%
	50% Reduction	75	10	20%
	25% Reduction	53	13	16%
	10% Reduction	45	17	14%

Note:
[1] Considers demands in Carson Division, only.
Key:
cfs = cubic foot per second

To support additional use by the Study or other parties, Table D3-3 notes the effects of reducing demand in the Carson Division on annual average Truckee River flows to Pyramid Lake, annual hydropower generation at Lahontan Dam and the 26-Foot Drop (V Canal) Power Plant, and annual average and maximum annual spills from Lahontan Reservoir.

Table D3-3. Additional Effects of Reduced Carson Division Demand (Annual Basis)

		Lahontan Reservoir Hydropower Generation (MWH)	V Canal Hydropower Generation (MWH)	Pyramid Lake Inflows (TAF)	Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability		15,676	3,309	460	236	12
350 cfs	75%	13,093	1,901	539	243	19
	50%	14,327	2,283	522	243	19
	25%	15,504	2,673	501	243	19
	10%	15,721	2,899	488	243	18
250 cfs	75%	12,916	1,893	541	242	16
	50%	14,071	2,255	526	242	16
	25%	15,001	2,623	508	242	16
	10%	15,095	2,826	498	242	15
150 cfs	75%	12,633	1,866	546	241	14
	50%	13,551	2,196	535	241	13
	25%	14,150	2,518	522	241	13
	10%	14,144	2,681	516	241	12
0 cfs	75%	11,927	1,779	583	240	12
	50%	12,370	2,041	583	240	12
	25%	12,476	2,262	583	240	11
	10%	12,379	2,356	583	240	11

Key:
MWH = megawatt-hours
TAF = thousand acre-feet

Appendix D3
Effects of Reducing Demand on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The table in this attachment summarizes water supply over the 100-year period of screening analysis, and includes results from the same period for the flow-stage reference scenarios and the Desired Reliability scenario from Appendix D1.

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Table: Annual Deliveries to Carson Division in TAF

Year	Desired	0 cfs, Reduction in Demand				150 cfs, Reduction in Demand				250 cfs, Reduction in Demand				350 cfs, Reduction in Demand			
	Reliabili	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%
1901	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1902	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1903	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1904	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1905	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1906	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1907	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1908	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1909	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1910	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1911	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1912	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1913	205	111	126	141	112	164	169	141	112	187	170	141	112	187	170	141	112
1914	205	183	167	141	112	185	170	141	112	187	170	141	112	187	170	141	112
1915	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1916	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1917	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1918	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1919	205	175	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1920	205	98	109	141	112	153	160	141	112	182	170	141	112	187	170	141	112
1921	205	179	166	141	112	185	169	141	112	187	170	141	112	187	170	141	112
1922	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1923	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1924	178	111	136	141	112	156	166	141	112	174	170	141	112	187	170	141	112
1925	204	167	165	141	112	185	170	141	112	187	170	141	112	187	170	141	112
1926	200	70	70	86	112	123	133	141	112	159	164	141	112	181	170	141	112
1927	205	181	164	137	112	183	167	141	112	185	170	141	112	187	170	141	112
1928	203	119	131	141	112	171	170	141	112	187	170	141	112	187	170	141	112
1929	160	65	65	69	101	102	105	128	112	131	144	141	112	158	164	141	112
1930	204	97	98	98	100	138	137	136	112	158	157	141	112	175	170	141	112
1931	104	46	47	47	48	72	72	73	97	85	85	99	112	91	94	121	112
1932	203	180	163	135	107	181	165	137	111	182	166	139	112	183	166	140	112
1933	178	93	103	120	112	143	151	141	112	168	170	141	112	177	170	141	112
1934	116	50	50	51	65	77	77	91	112	95	97	126	112	108	117	137	112
1935	203	137	137	135	108	167	164	137	112	182	165	140	112	182	166	141	112
1936	205	168	166	141	112	186	170	141	112	187	170	141	112	187	170	141	112
1937	205	157	157	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1938	205	185	169	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1939	204	166	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1940	205	167	166	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1941	205	158	158	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1942	205	186	169	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1943	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1944	205	164	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1945	205	186	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1946	205	154	165	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1947	205	98	98	140	112	156	161	141	112	184	170	141	112	187	170	141	112
1948	205	102	102	104	112	142	143	141	112	167	170	141	112	187	170	141	112
1949	205	106	107	107	112	147	147	141	112	171	170	141	112	187	170	141	112
1950	205	169	166	139	112	185	168	141	112	186	170	141	112	187	170	141	112
1951	205	186	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1952	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1953	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1954	205	142	158	141	112	178	170	141	112	187	170	141	112	187	170	141	112
1955	205	79	80	107	112	120	133	141	112	153	163	141	112	178	170	141	112
1956	205	182	165	139	112	183	167	141	112	185	169	141	112	186	170	141	112
1957	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1958	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1959	201	93	117	141	112	142	156	141	112	166	170	141	112	181	170	141	112
1960	176	45	46	53	79	83	84	111	112	109	114	141	112	131	149	141	112
1961	122	40	40	40	41	73	73	72	80	97	97	95	112	119	117	129	112
1962	203	139	139	135	107	177	165	137	109	182	166	138	112	183	166	140	112
1963	205	185	168	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1964	205	92	102	122	112	150	154	141	112	175	170	141	112	187	170	141	112
1965	205	182	166	140	112	184	168	141	112	186	170	141	112	187	170	141	112
1966	204	130	142	141	112	169	170	141	112	187	170	141	112	187	170	141	112
1967	205	184	168	141	112	186	170	141	112	187	170	141	112	187	170	141	112
1968	205	165	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1969	205	186	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1970	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1971	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1972	205	153	169	141	112	186	170	141	112	187	170	141	112	187	170	141	112
1973	205	167	165	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1974	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1975	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1976	176	68	87	138	112	124	140	141	112	151	162	141	112	165	170	141	112
1977	102	27	27	29	50	57	57	77	94	78	79	108	111	97	102	126	112
1978	203	165	162	134	107	181	164	137	110	182	165	139	112	182	166	140	112
1979	205	144	144	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1980	205	185	168	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1981	200	124	136	141	112	165	170	141	112	187	170	141	112	187	170	141	112
1982	205	183	167	141	112	186	170	141	112	187	170	141	112	187	170	141	112
1983	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1984	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1985	205	186	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1986	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1987	199	138	146	141	112	172	170	141	112	187	170	141	112	187	170	141	112
1988	110	35	36	44	71	66	71	90	102	91	107	119	112	118	128	134	112
1989	203	107	107	107	106	148	148	137	111	169	166	139	112	182	167	141	112
1990	134	48	48	48	49	79	80	87	104	100	102	121	112	112	122	134	112
1991	111	57	57	57	58	85	86	86	87	98	99	99	110	107	107	107	112
1992	85	38	38	38	39	63	63	64	64	76	76	76	77	83	83	84	93
1993	202	180	163	135	107	181	164	136	108	181	164	137	109	182	165	137	110
1994	116	68	79	99	112	105	114	131	112	121	127	141	112	129	134	141	112
1995	203	181	164	138	112	183	166	141	112	184	167	141	112	184	168	141	112
1996	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1997	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1998	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
1999	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
2000	205	187	170	141	112	187	170	141	112	187	170	141	112	187	170	141	112
Average	**194**	**150**	**144**	**128**	**107**	**167**	**157**	**135**	**111**	**174**	**162**	**138**	**112**	**178**	**164**	**139**	**112**
Maximum	**205**	**187**	**170**	**141**	**112**	**187**	**170**	**141**	**112**	**187**	**170**	**141**	**112**	**187**	**170**	**141**	**112**
Minimum	**85**	**27**	**27**	**29**	**39**	**57**	**57**	**64**	**64**	**76**	**76**	**76**	**77**	**83**	**83**	**84**	**93**

Table: Annual Deliveries to Truckee Division in TAF

Year	Desired	0 cfs, Reduction in Demand				150 cfs, Reduction in Demand				250 cfs, Reduction in Demand				350 cfs, Reduction in Demand			
	Reliabilit	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%
1901	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1902	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1903	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1904	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1905	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1906	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1907	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1908	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1909	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1910	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1911	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1912	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1913	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1914	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1915	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1916	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1917	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1918	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1919	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1920	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1921	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1922	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1923	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1924	9	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1925	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1926	10	0	0	0	0	4	4	3	2	5	5	3	2	6	5	3	2
1927	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1928	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1929	8	0	0	0	0	3	3	3	2	4	4	3	2	5	5	3	2
1930	10	0	0	0	0	4	4	3	2	5	5	3	2	6	5	3	2
1931	2	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1932	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1933	6	0	0	0	0	3	3	2	1	4	4	2	1	4	3	2	1
1934	3	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1935	9	0	0	0	0	5	4	3	1	5	4	3	1	5	4	3	1
1936	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1937	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1938	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1939	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1940	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1941	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1942	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1943	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1944	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1945	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1946	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1947	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1948	10	0	0	0	0	5	4	3	2	5	5	3	2	6	5	3	2
1949	10	0	0	0	0	5	4	3	2	6	5	3	2	6	5	3	2
1950	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1951	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1952	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1953	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1954	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1955	10	0	0	0	0	4	4	3	2	5	5	3	2	6	5	3	2
1956	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1957	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1958	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1959	10	0	0	0	0	4	5	3	2	5	5	3	2	6	5	3	2
1960	9	0	0	0	0	3	2	2	2	3	3	3	2	4	4	3	2
1961	5	0	0	0	0	2	2	1	1	3	2	2	1	3	3	2	1
1962	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1963	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1964	10	0	0	0	0	5	4	3	2	6	5	3	2	6	5	3	2
1965	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1966	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1967	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1968	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1969	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1970	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1971	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1972	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1973	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1974	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1975	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1976	9	0	0	0	0	4	4	3	2	5	5	3	2	5	5	3	2
1977	3	0	0	0	0	1	1	1	1	1	1	1	1	2	1	1	1
1978	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1979	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1980	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1981	10	0	0	0	0	5	5	3	2	6	5	3	2	6	5	3	2
1982	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1983	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1984	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1985	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1986	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1987	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1988	3	0	0	0	0	1	1	1	1	1	1	1	1	2	2	1	1
1989	10	0	0	0	0	5	4	3	2	5	5	3	2	6	5	3	2
1990	4	0	0	0	0	2	2	1	1	2	2	2	1	2	2	2	1
1991	3	0	0	0	0	2	1	1	1	2	2	1	1	2	2	1	1
1992	2	0	0	0	0	1	1	1	0	1	1	1	0	1	1	1	1
1993	9	0	0	0	0	5	4	3	1	5	4	3	1	5	4	3	1
1994	2	0	0	0	0	1	1	1	1	2	2	1	1	2	2	1	1
1995	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1996	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1997	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1998	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
1999	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
2000	10	0	0	0	0	6	5	3	2	6	5	3	2	6	5	3	2
Average	**10**	**0**	**0**	**0**	**0**	**5**	**4**	**3**	**2**	**5**	**5**	**3**	**2**	**5**	**5**	**3**	**2**
Maximum	**10**	**0**	**0**	**0**	**0**	**6**	**5**	**3**	**2**	**6**	**5**	**3**	**2**	**6**	**5**	**3**	**2**
Minimum	**2**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**1**	**1**

Table: Annual Deliveries to Newlands Project in TAF

Year	Desired	0 cfs, Reduction in Demand				150 cfs, Reduction in Demand				250 cfs, Reduction in Demand				350 cfs, Reduction in Demand			
	Reliabili	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%	10%	25%	50%	75%
1901	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1902	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1903	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1904	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1905	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1906	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1907	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1908	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1909	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1910	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1911	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1912	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1913	215	111	126	141	112	169	174	144	114	193	175	144	114	193	175	144	114
1914	215	183	167	141	112	191	175	144	114	193	175	144	114	193	175	144	114
1915	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1916	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1917	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1918	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1919	215	175	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1920	215	98	109	141	112	158	165	144	114	188	175	144	114	193	175	144	114
1921	215	179	166	141	112	191	174	144	114	193	175	144	114	193	175	144	114
1922	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1923	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1924	188	111	136	141	112	161	171	144	114	180	175	144	114	193	175	144	114
1925	214	167	165	141	112	191	175	144	114	192	175	144	114	193	175	144	114
1926	210	70	70	86	112	127	137	144	114	164	169	144	114	187	175	144	114
1927	215	181	164	137	112	189	172	144	114	191	175	144	114	193	175	144	114
1928	213	119	131	141	112	177	175	144	114	193	175	144	114	193	175	144	114
1929	168	65	65	69	101	104	108	131	114	135	147	144	114	163	169	144	114
1930	214	97	98	98	100	142	141	139	114	163	162	144	114	181	174	144	114
1931	106	46	47	47	48	72	73	73	98	86	86	100	113	92	95	122	113
1932	212	180	163	135	107	187	169	140	113	188	170	142	114	188	171	143	114
1933	184	93	103	120	112	147	154	143	114	172	173	143	114	181	173	143	114
1934	118	50	50	51	65	78	78	92	113	96	98	127	113	109	118	139	113
1935	211	137	137	135	108	172	168	140	114	187	169	142	114	187	170	144	114
1936	215	168	166	141	112	192	175	144	114	193	175	144	114	193	175	144	114
1937	215	157	157	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1938	215	185	169	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1939	215	166	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1940	215	167	166	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1941	215	158	158	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1942	215	186	169	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1943	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1944	215	164	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1945	215	186	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1946	215	154	165	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1947	215	98	98	140	112	161	166	144	114	190	175	144	114	193	175	144	114
1948	215	102	102	104	112	146	147	144	114	172	175	144	114	193	175	144	114
1949	215	106	107	107	112	151	151	144	114	177	175	144	114	193	175	144	114
1950	215	169	166	139	112	190	173	144	114	192	175	144	114	193	175	144	114
1951	215	186	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1952	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1953	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1954	215	142	158	141	112	184	175	144	114	193	175	144	114	193	175	144	114
1955	215	79	80	107	112	123	137	144	114	158	167	144	114	183	175	144	114
1956	215	182	165	139	112	189	172	144	114	191	174	144	114	192	175	144	114
1957	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1958	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1959	212	93	117	141	112	146	160	144	114	171	175	144	114	187	175	144	114
1960	185	45	46	53	79	85	86	113	114	112	118	144	114	135	153	144	114
1961	127	40	40	40	41	75	75	73	81	99	99	97	114	122	120	131	114
1962	213	139	139	135	107	182	169	140	111	188	170	141	114	189	171	143	114
1963	215	185	168	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1964	215	92	102	122	112	155	158	144	114	181	175	144	114	193	174	144	114
1965	215	182	166	140	112	190	173	144	114	192	175	144	114	193	175	144	114
1966	214	130	142	141	112	175	175	144	114	193	175	144	114	193	175	144	114
1967	215	184	168	141	112	192	175	144	114	193	175	144	114	193	175	144	114
1968	215	165	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1969	215	186	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1970	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1971	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1972	215	153	169	141	112	192	175	144	114	193	175	144	114	193	175	144	114
1973	215	167	165	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1974	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1975	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1976	185	68	87	138	112	128	144	144	114	155	167	144	114	170	175	144	114
1977	105	27	27	29	50	58	57	78	95	79	80	110	112	99	103	128	113
1978	213	165	162	134	107	187	169	140	112	187	170	142	114	188	171	143	114
1979	215	144	144	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1980	215	185	168	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1981	211	124	136	141	112	171	175	144	114	193	175	144	114	193	175	144	114
1982	215	183	167	141	112	191	175	144	114	193	175	144	114	193	175	144	114
1983	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1984	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1985	215	186	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1986	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1987	209	138	146	141	112	177	175	144	114	193	175	144	114	193	175	144	114
1988	112	35	36	44	71	66	71	91	103	92	109	120	113	120	130	136	113
1989	213	107	107	107	106	153	153	141	113	175	171	142	114	188	172	144	114
1990	138	48	48	48	49	81	81	88	105	102	104	123	114	114	125	136	114
1991	114	57	57	57	58	87	87	87	87	100	100	101	111	109	109	108	113
1992	87	38	38	38	39	64	64	64	65	76	77	77	78	84	84	85	94
1993	211	180	163	135	107	186	168	139	110	186	169	139	110	187	169	140	111
1994	118	68	79	99	112	107	116	132	113	123	129	142	113	131	136	142	113
1995	213	181	164	138	112	189	171	144	114	189	172	144	114	190	173	144	114
1996	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1997	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1998	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
1999	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
2000	215	187	170	141	112	193	175	144	114	193	175	144	114	193	175	144	114
Average	**204**	**150**	**144**	**128**	**107**	**172**	**161**	**138**	**112**	**180**	**166**	**141**	**114**	**183**	**168**	**142**	**114**
Maximum	**215**	**187**	**170**	**141**	**112**	**193**	**175**	**144**	**114**	**193**	**175**	**144**	**114**	**193**	**175**	**144**	**114**
Minimum	**87**	**27**	**27**	**29**	**39**	**58**	**57**	**64**	**65**	**76**	**77**	**77**	**78**	**84**	**84**	**85**	**94**

Appendix D4
Effects of Reducing Demand on Newlands Project Water Supply

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

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Abbreviations and Acronyms

cfs	cubic-feet per second
GIS	geographic information system
OCAP	Operations Criteria and Procedures for the Newlands Project
Project	Newlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Study	Newlands Project
TAF	thousand acre-feet
TCID	Truckee Carson Irrigation District
TROA	Truckee River Operating Agreement
USFWS	U.S. Fish and Wildlife Service

Appendix D4 – Effects of Increasing Efficiency of Deliveries on Newlands Project Water Supply

This appendix characterizes how improving the delivery efficiency of the Newlands Project (Project) – through reductions of conveyance losses experienced in the Carson Division – would contribute to the water supply objective of the Newlands Project Planning Study (Study). The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Project or actions to mitigate water supply conditions that are less than reliable.

This appendix presents one of several screening assessments conducted for the Study, all of which are presented in Appendices D1 through D7. These screening analyses were designed to provide inter-comparisons among several measures that could potentially contribute to meeting the Study's water supply objective. Thus, the measures studied and outcomes published in this appendix are not being proposed as alternatives for the Study, but are instead presented to inform decisions on which measures best meet the Study's objectives.

The following analysis describes how increasing the efficiency of Project deliveries would change the water supply of the Project. Several measures were identified that would result in efficiency improvements within the Carson Division, including improvements to the delivery system and improvements to on-farm water application technology.

During workshops conducted at the start of the Study, members of the public suggested that efficiency improvements within the Project may have unintended consequences of reducing Project reliability (Public comments, August 25, 2011). The reasoning for this suggestion was as follows:

1. Water duties within the Carson Division are set, in part, on depths to groundwater, where:

    a. Lands with a depth to groundwater greater than 5 feet and the inability to hold more than 8 inches of water in the root zone are classified as "bench lands," and receive a duty of 4.5 acre-feet per acre.

    b. Lands with a depth to groundwater less than 5 feet or the ability to hold 8 inches or less of water in the root zone are classified as "bottom lands," and receive a duty of 3.5 acre-feet per acre.

2. Current rates of seepage loss from the Carson Division canal network maintain the groundwater at elevations above where it otherwise would be, without the seepage.

3. Implementation of seepage-reduction measures could reduce groundwater elevations to an extent that promotes the reclassification of some bottom lands as bench lands.

4. Reclassification from bottom land to bench land would increase duties on the affected fields from 3.5 to 4.5 acre-feet per acre, increasing the total demands within the Carson Division despite gains in efficiency, which would perhaps reduce Project water supply reliability.

Unfortunately, several conditions make these concerns hard to assess in a direct, technical analysis. An incomplete understanding of how each Project field has been classified, coupled with an inability to predict how changes in efficiency would change groundwater depths beneath each field, makes it impossible to pinpoint whether – or to what extent – changes in land classification would result from increases in efficiency. However, sufficient information is available for bracketing how a reclassification of water right duties coupled with efficiency improvements would affect the reliability of Project water supplies. This analysis develops and considers an "outer-bound" condition, where attainable improvements for Project efficiency are assessed in conjunction with the largest conceivable shifts in bench land to bottom land, and the associated shifts in demand.

Performance toward the water supply objective is measured against two conditions:

1. A Desired Reliability scenario, which serves as the desired performance.

2. Flow-stage reference scenarios, which serve as starting points for applying additional measures–such as increasing the efficiency of the Project.

The Desired Reliability scenario describes the ability of the Project to meet current levels of demand, in compliance with 1997 Operations Criteria and Procedures for the Newlands Project (OCAP), with a 900-cubic-feet-per-second (cfs) Truckee Canal capacity. As the name implies, the flow-stage reference scenarios are built around a range of Truckee Canal flow stages developed for meeting U.S. Department of the Interior, Bureau of Reclamation (Reclamation) safety standards (600, 350, 250, 150 and 0 cfs). The flow-stage reference scenarios consider the ability of the Project to meet anticipated future levels of demand, under OCAP, with the indicated flow-stage capacity for the Truckee Canal. Reductions to demand are applied to the flow-stage reference conditions, with the intent of meeting or exceeding the Desired Reliability conditions. The

Desired Reliability and flow-stage reference scenarios are described in Appendix D1.

Estimated Project Water Delivery Efficiency

As part of the Newlands Project Efficiency Study (Reclamation 1994), Reclamation developed and evaluated several measures for reducing seepage losses from Project delivery canals. The purpose of the 1994 study was to identify plans for achieving Project delivery efficiencies at or above 75 percent. Appendix C reports on several canal lining options that were considered, resulting in Project efficiencies between 68 and 86 percent. Table D4-1 presents three of the canal-lining options that are being included as potential measures in this Study.

Table D4-1. Selected Canal-Lining Options Developed for the 1994 Newlands Project Efficiency Study

Name of Option	Estimated Annual Water Savings (thousand acre-feet)	Estimated Resulting OCAP Efficiency (percent)
Option 1	50 – 69	73 – 78
Option 1 Expanded	59 – 82	75 – 81
Option 1 Expanded T Canal	70 – 96	77 – 86

Source: Reclamation 1994, Newlands Project Efficiency Study, Appendix C – Details of Possible Lining Options and Methods for Newlands Project Canals

Notes:

Estimated costs are at 1994 levels, including 25% contingencies, 35% non-contract costs.

Key:

OCAP = Operations Criteria and Procedures for the Newlands Project

To be conservative, the middle-range efficiency outcome (75 percent) was selected for use in this analysis. Thus, it is possible that the result of implementing any of the canal-lining options could be different than reported in this analysis, and should undergo further investigation if selected for implementation.

Examination of Potential Extent of Land Reclassification

As mentioned before, an improvement in canal efficiency and subsequent reductions in canal losses to groundwater could result in land reclassification from bottom land to bench land. Several technical conditions would need to be understood to predict any potential for land reclassification within the Project. These conditions include:

- A full understanding of which parcels in the Carson Division are classified as bench land and bottom land, and whether that classification would be sensitive to changes in groundwater elevations.

- An understanding of the current groundwater elevations beneath each field and how changes in Project delivery efficiencies might change these elevations.

Per the first of these two conditions, an understanding of which lands are currently bench land and bottom land is not readily available. Land-use classification in the Study area has been managed through court proceedings for more than 3 decades, and relates little to topography in the region. Developing a comprehensive understanding of the geography of bench and bottom lands would be a considerable undertaking, requiring the review of hundreds of court decisions and appeals as well as a thorough review of Project records of water rights, water use, and assessor's parcel numbers. The Truckee Carson Irrigation District (TCID) has been working on a comprehensive geographic information system (GIS) database of this information for the past several years, but work to input existing data has not yet been completed and the time frame for a useful product is not known (Jo Moore, Reclamation, personal communication, October 2011).

The second of the two conditions has even less available information, but the reasons for this are partially due to complexities of the local aquifers. The complexity and lack of understanding of Project groundwater conditions was noted by the Newlands Project Efficiency Study in 1994:

> *The ground-water system under the Newlands Project area is highly variable hydrologically due to the complex depositional history of the valley-fill sediments. Surface water irrigation from the Newlands Project has altered the natural ground-water regime. The depth to ground water in most of the project area is less than 25 feet below ground surface, and near irrigated areas it is less than 10 feet below ground surface.*
>
> *These shallow ground-water conditions are directly related to unlined surface water delivery systems, including a plethora of unlined secondary canals, drains, and other minor waterways. These systems recharge and discharge shallow ground water in various ways. This makes quantitative analysis of the shallow ground-water system for the Newlands Project extremely difficult (Reclamation 1994).*

Although the 1994 Efficiency Study did recommend the implementation of a groundwater management plan, the monitoring and management of this area has not yet improved to a level that would be useful in projecting these changes, and analytical tools are not yet available for predicting how increases in Project

efficiency would affect depths to groundwater throughout the Project (Eric Morway, USGS, personal communication, February 2012).

In the process of developing an appropriate and reasonable method to examine the effects of potential water righted land conversions, the following ideas were considered.

Following the Historical Classification Scheme of the "Walker Line"

A historical classification scheme for Carson Division bench and bottom lands presented an opportunity to estimate the potential outer bound for land reclassification. The so-called "Walker Line," an elevation contour line at 3,980 feet above mean sea level, had been used to designate bench and bottom lands when other information was indeterminate. The Walker Line had been based on knowledge of the soil conditions in 1927 and represented the transition from bench to bottom lands at that time. However, delineation of bench land and bottom land never strictly adhered to the Walker Line, and local conditions had historically been applied in an inconsistent manner. Ultimately, the inconsistent use of the Walker Line led to its dismissal as an appropriate manner for classifying land. Figure D4-1 presents the extents of the TCID service area for the Carson Division, in relation to the Walker Line.

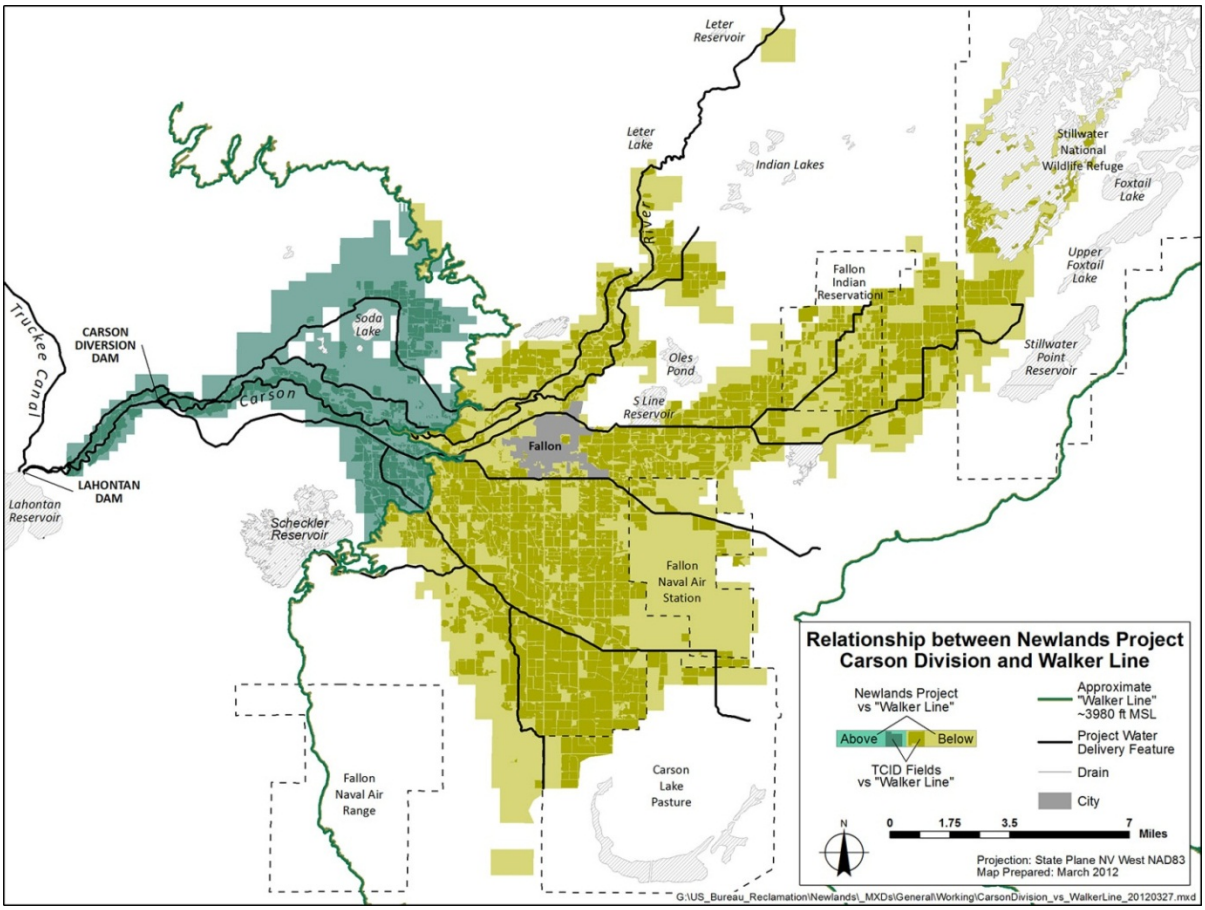

Figure D4-1. Portions of the Carson Division Above and Below the Walker Line

Approximately one-quarter of the Carson Division service area lies above the Walker Line. This would infer that perhaps up to a quarter of the Carson Division could be classified as bench land, if groundwater elevations receded to 1927 levels.

Although the Walker Line presents an interesting view of the proportion of bench and bottom lands in the Carson Division at a very early point in the Project's history, it was ultimately dismissed by the courts for not being adhered to in a consistent manner. These inconsistencies would similarly complicate any attempt to use the Walker line as the basis for this analysis.

Referring to Current and Historical Records

Records of water-righted lands were provided by TCID for use in this Study. This tabular data (described further in Appendix C) was provided for each water right with quantities of acreages within each right that pertained to a bench land, bottom land, pasture, and/or wetland duty. In many cases, acreages were noted for multiple duties, making the geographic distribution of these types of land classifications difficult to discern. Nevertheless, the tabulated data allowed for comparing the total acreage of each type of duty within the Carson Division. According to these records, 17 percent (10,223 acres) of the potentially active rights in the Carson Division (59,003 acres) are designated for use on bench lands.

In January 1992, Reclamation compiled surveys of acreages and duty classifications for the Project. Reclamation compiled this information into what are referred to as the "Initial Maps." The Initial Maps show approximately 5,000 acres of bench lands in the Carson Division. Comparing these acreages to current TCID records indicates that approximately 5,000 acres of bottom lands have been reclassified as bench lands over the previous 20 years. At this rate, an additional 10,000 acres could change from bottom land to bench land by the assumed future condition for this Study, the year 2050.

While the trend of conversion from bottom land to bench land is notable, it cannot be directly applied to the Project for several reasons. First, information and analysis does not exist to explain the cause or history of this trend. It is unknown whether the trend is continuing, slowing, or speeding up; and it is further unknown whether the trend is caused by on-farm efficiency upgrades, delivery system efficiency upgrades, or results from widespread land retirement. These unknowns remove the ability of this Study to state whether the trend will continue, accelerate, or end.

Additionally, the conversion process is costly and only applies to irrigated agricultural lands. Given the known and parallel trend for Carson Division lands to change ownership, it could be argued that most or all of the lands requiring this conversion would be among the approximately 12,500 acres acquired by the US Fish & Wildlife Service (USFWS) instead of converted. Furthermore, this Study predicts that by the end of USFWS acquisitions,

approximately 33,000 acres of land will remain in agricultural production. Thus, assuming that an additional 10,000 acres of agricultural land would convert would result in 66 percent of the remaining Carson Division agricultural lands (approximately 20,000 acres) having a bench land classification under the future condition, which seems unrealistic as an outer boundary for consideration.

The Selected Approach

The distribution of land classifications within the Carson Division is not clearly known and it seems evident that the use of the Walker Line as an empirical, geographic approximation for potential conversions would not yield a defensible outcome. Further, data exist to confirm a historic trend of conversion, but these data do not lend information that would help predict likely future without-action conditions when considering other factors, such as the extent, location, and effect of ongoing water rights acquisitions.

Lacking any quantitative guidance on the potential for future conversions from bottom to bench land classifications in the Carson Division, a precise assessment of potential future changes could not be made. Instead, this analysis relies upon the qualitative interpretation that, as an outer bound, the acreage of bench and bottom land within the Carson Division could be equal for the future condition.

The distribution of acreages for the assumed future condition can be compared to the assumed outer bound for land-use conversions in Table D4-2. Only the agricultural portion of the user-input irrigated acreage has been altered while the urban portion and all other water-user categories remain unchanged from the Study's assumed future conditions. These acreages were used as inputs for the Carson Division Water Rights and Irrigation water user category in the Pre-Truckee River Operating Agreement (TROA) Planning Model, MHEDATA.CARSONDIVISIONWRANDIRRIG.

With the outer bound land conversion, the future agricultural land classified as bench and bottom and would be 14,467 acres, each, and the overall fraction of land within the Carson Division classified as bench land would increase to 25 percent (15,108 of 59,003 acres). This seems similar to the analysis from the Walker Line; however, this acreage represents 42 percent of the land being irrigated for agriculture in the Carson Division (34,362 acres). These shifts in land classification result in a 2 percent increase (4,637 acre-feet) in total Carson Division demands.

NOTE: This interpreted outer bound is not an expectation. Instead, this outer bound serves as the practical limit for testing whether conversions from bench to bottom land classifications have a negative impact on Project water supply reliability, and whether any negative impacts have the ability to undo the positive impacts of measures such as increasing the delivery efficiency within the Carson Division. Shifts in land classification are not part of the assumed

future condition for this Study, and are not used in analysis of either preliminary or final Study alternatives.

Table D4-2. Potentially Active Carson Division Water Rights, with Associated Maximum Potential Demand[1]

Projected Future Carson Division Rights		Bench (acres)	Bottom (acres)	Wetland (acres)	Pasture (acres)	TOTAL Acres	Maximum Demand (acre-feet)
Ag	Commercial and Noncommercial Farms	9,830	19,104	22	2,382	31,338	114,739
	Fallon Paiute-Shoshone Irrigated Lands	-	3,025	-	-	3,025	10,588
M&I	City of Fallon & Churchill County	118	648	-	-	766	2,799
Env	USFWS Water Rights	-[2]	-[2]	20,362[2]	641	21,003	61,844
	Carson Lake and Pasture	-[2]	-[2]	2,403[2]	-	2,403	7,183
	Fallon Paiute-Shoshone Tribal Wetlands	-	-	468	-	468	1,400
	Carson Division Subtotal	9,948	22,778	23,255	3,023	59,003	198,553

Projected Future Carson Division Rights with an Outer Bound Conversion from Bottom to Bench		Bench (acres)	Bottom (acres)	Wetland (acres)	Pasture (acres)	TOTAL Acres	Maximum Demand (acre-feet)
Ag	Commercial and Noncommercial Farms	14,467	14,467	22	2,382	31,338	119,376
	Fallon Paiute-Shoshone Irrigated Lands	-	3,025	-	-	3,025	10,588
M&I	City of Fallon & Churchill County	118	648	-	-	766	2,799
Env	USFWS Water Rights	-[2]	-[2]	20,362[2]	641	21,003	61,844
	Carson Lake and Pasture	-[2]	-[2]	2,403[2]	-	2,403	7,183
	Fallon Paiute-Shoshone Tribal Wetlands	-	-	468	-	468	1,400
	Carson Division Subtotal	14,585	18,140	23,255	3,023	59,003	203,190

Notes:

[1] Figures have been rounded to their whole-number equivalents; as a result, some rounding errors may exist.

[2] TCID records indicate acreages of water rights attributed to USFWS and Carson Lake and Pasture with bench and bottom land duties. This Study assumes that these acreages will be transferred to a Wetland duty designation, and values of USFWS rights have been adjusted to reflect this assumption. Unadjusted projected acreages for USFWS are 290, 12,667, and 7,395 for bench, bottom, and wetland, respectively. Unadjusted acreages for Carson Lake and Pasture are 60, 28, and 2,314 for bench, bottom, and wetland, respectively.

Key:

Ag = Agricultural

Env = Environmental

M&I = municipal and industrial

USFWS = U.S. Fish and Wildlife Service

Methods

For this analysis, a "bracketing" approach was developed to test a combination of two conditions: (1) an attainable extent of delivery efficiency gains; and (2) a reclassification of all bottom lands to bench lands that would increase demand, and has been identified as a potential concern associated with increases in delivery efficiency. The information used to develop ranges for these two conditions are described in the following subsections.

The following analysis looks at results of varying Truckee Canal capacity and eliminating losses. The Pre-TROA Planning Model was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RIVERWARE modeling environment, and "slots" are features of the RIVERWARE environment that accepts user inputs.

Truckee Canal capacity is entered to the Pre-TROA Planning Model through the slot, TRUCKEECANALDIV.CANALCAPACITYDEFAULT. The flow-stage conditions evaluated for each test include 350, 250, 150, and 0 cfs.

Carson Division is entered to the Pre-TROA Planning Model through the slot LAHONTANDATA.USERINPUTCDEFFICIENCYFACTOR. For the analysis, the efficiency factor was changed, increasing from 0.65 to 0.75.

As described in Appendix B2, this – and all other screening analyses – were evaluated over a 100-year period, from 1901 through 2000.

Results and Conclusions

Rather than present water supply reliability in terms of a single number, the Study's concept for reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, reliability must be presented in a two-dimensional context that allows for the evaluation of both frequency and magnitude. This section presents modeling results through a number of plots that illustrate these two components of reliability for flow-stage reference scenarios with and without improvements to project delivery efficiency, both relative to the Desired Reliability scenario. The reference scenario for each flow stage represents the starting point for each screening analysis of the measure for improving delivery efficiencies. Each flow-stage plot includes an additional scenario that reports the effect of an increase in demand resulting from the outer bound reclassification of land in combination with improvements to delivery efficiencies. This provides perspective on the potential effects of future land classification changes.

In general, improving the delivery efficiencies:

- Significantly increases Project reliability at all flow stages for the full range of hydrologic conditions.
- Appears sufficient for meeting the water supply objective for scenarios with flow stages at 350 and 250 cfs.
- Largely overshadows the potential negative effects of increased demand that have been raised as a concern and potential consequence of additional delivery system efficiency improvements.

Each figure in the subsections below contains two plots that are different representations of the same reliability scenario comparisons. On the first plot, the Desired Reliability and flow-stage scenarios are represented according to percentage of demand met, and include results from 100 years of simulated data (see Appendix D1). Additionally, the bottom half of each figure is a chart that illustrates the difference (flow-stage scenario or reference scenario minus Desired Reliability) in Project deliveries, expressed as a volume (thousands of acre-feet (TAF)).

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

NOTE: the rank of a specific year will not necessarily match between the Desired Reliability and flow-stage reference scenarios, or even across the range of reference scenarios. It follows that implementing measures, such as reducing losses within the Carson Division, would similarly result in a change to the ranking of years. Despite this, the trends and results from reducing losses from the Carson Division canals can be clearly interpreted.

350 cfs Scenario with Reduced Carson Division Canal Seepage

Figure D4-2 demonstrates that, for alternatives that consider a 350 cfs flow stage for the Truckee Canal, improving Project delivery efficiencies to 75 percent results in a water supply reliability that closely approximates the Desired Reliability for the full range of hydrologic conditions. Thus, when Project delivery efficiencies are improved to 75 percent, 90 percent of demand is met almost 9 of 10 years and 100 percent of demand is met almost 8 out of 10 years. Additionally, the percentage of demands met improves by about 5 to 10 percent for the driest 20 percent of years.

Net differences between the Desired Reliability and the range of 350 cfs flow-stage scenarios are as follows:

- -176 TAF for the 350 cfs reference scenario
- +282 TAF with a 75 percent Project delivery efficiency
- +238 TAF with a 75 percent Project delivery efficiency and land reclassification

For alternatives that consider a 350 cfs flow stage for the Truckee Canal, a 75 percent delivery efficiency would be the only measure needed to meet Desired Reliability for the full range of hydrologic conditions. The result of land reclassification causes a marginal decrease in water supply reliability that does not overcome the benefits of increasing delivery efficiencies.

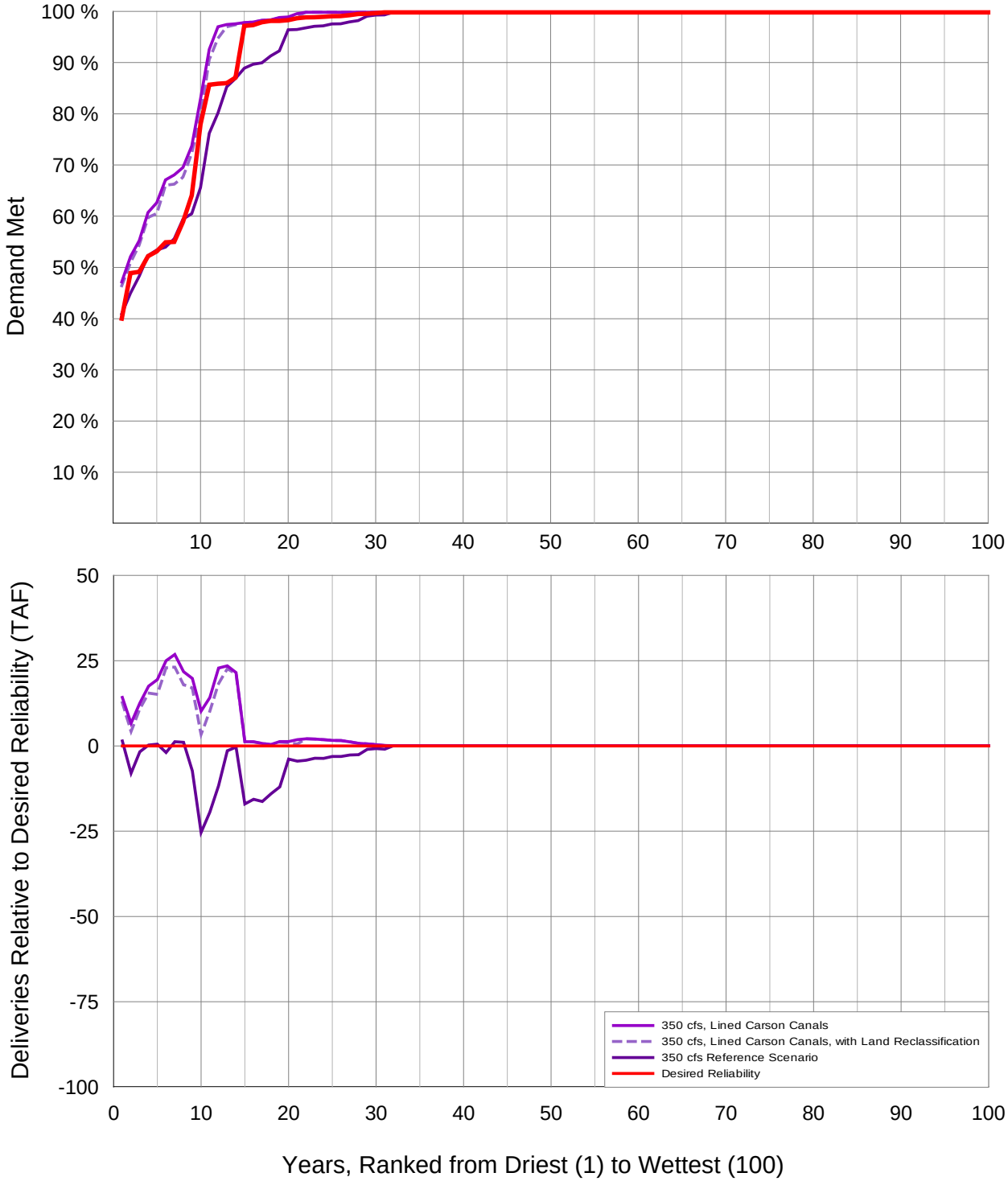

Figure D4-2. Relative Performance of Lining Portions of the Carson Division Canal on Annual Newlands Project Deliveries, 350 cfs Flow Stage

250 cfs Scenario with Reduced Carson Division Canal Seepage

Figure D4-3 demonstrates that, for alternatives that consider a 250 cfs flow stage for the Truckee Canal, improving Project delivery efficiencies to 75 percent results in a water supply reliability that closely approximates the Desired Reliability for the full range of hydrologic conditions. Thus, when Project delivery efficiencies are improved to 75 percent, 90 percent of demand is met almost 85 of 100 years, and 100 percent of demand is met almost 7 out of 10 years. Additionally, the percentage of demand met improves by about 5 to 15 percent for the driest 30 percent of years.

Net differences between the Desired Reliability and the range of 250 cfs flow-stage scenarios are as follows:

- -660 TAF for the 250 cfs reference scenario
- -13 TAF with a 75 percent Project delivery efficiency
- -72 TAF with a 75 percent Project delivery efficiency and land reclassification

For alternatives that consider a 250 cfs flow stage for the Truckee Canal, a 75 percent delivery efficiency would be the only measure needed to meet Desired Reliability for the full range of hydrologic conditions. The result of land reclassification causes a marginal decrease in water supply reliability that does not overcome the benefits of increasing delivery efficiencies.

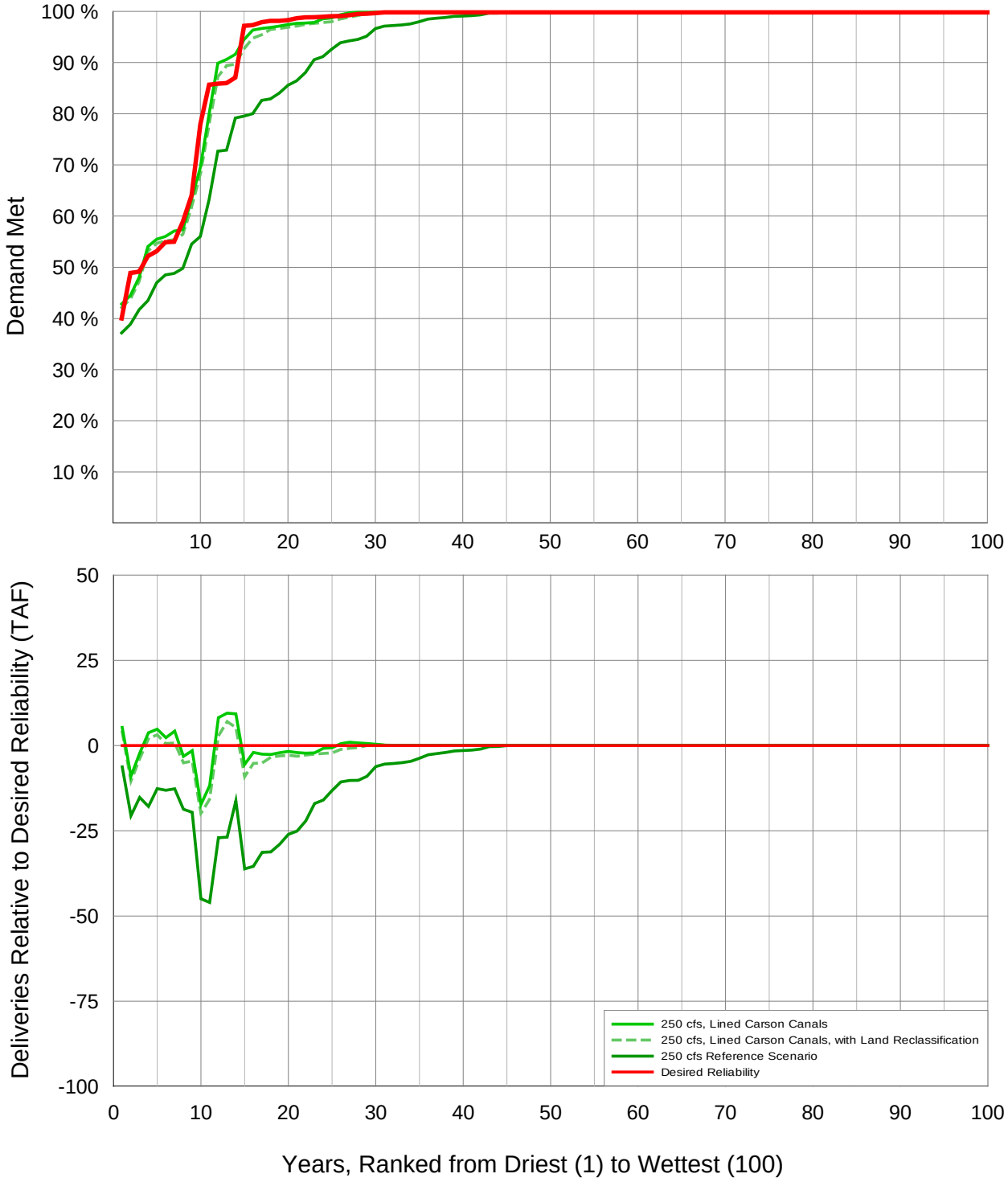

Figure D4-3. Relative Performance of Lining the Carson Division Canals on Annual Newlands Project Deliveries, 250 cfs Flow Stage

150 cfs Scenario with Reduced Carson Division Canal Seepage

Figure D4-4 demonstrates that, for alternatives that consider a 150 cfs flow stage for the Truckee Canal, improving Project delivery efficiencies to 75 percent improves water supply reliability. However, additional measures would be necessary to meet the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 150 cfs flow-stage scenarios are as follows:

- -1,519 TAF for the 150 cfs reference scenario
- -638 TAF with a 75 percent Project delivery efficiency
- -723 TAF with a 75 percent Project delivery efficiency and land reclassification

The result of land reclassification causes a marginal decrease in water supply reliability that does not overcome the benefits of increasing delivery efficiencies.

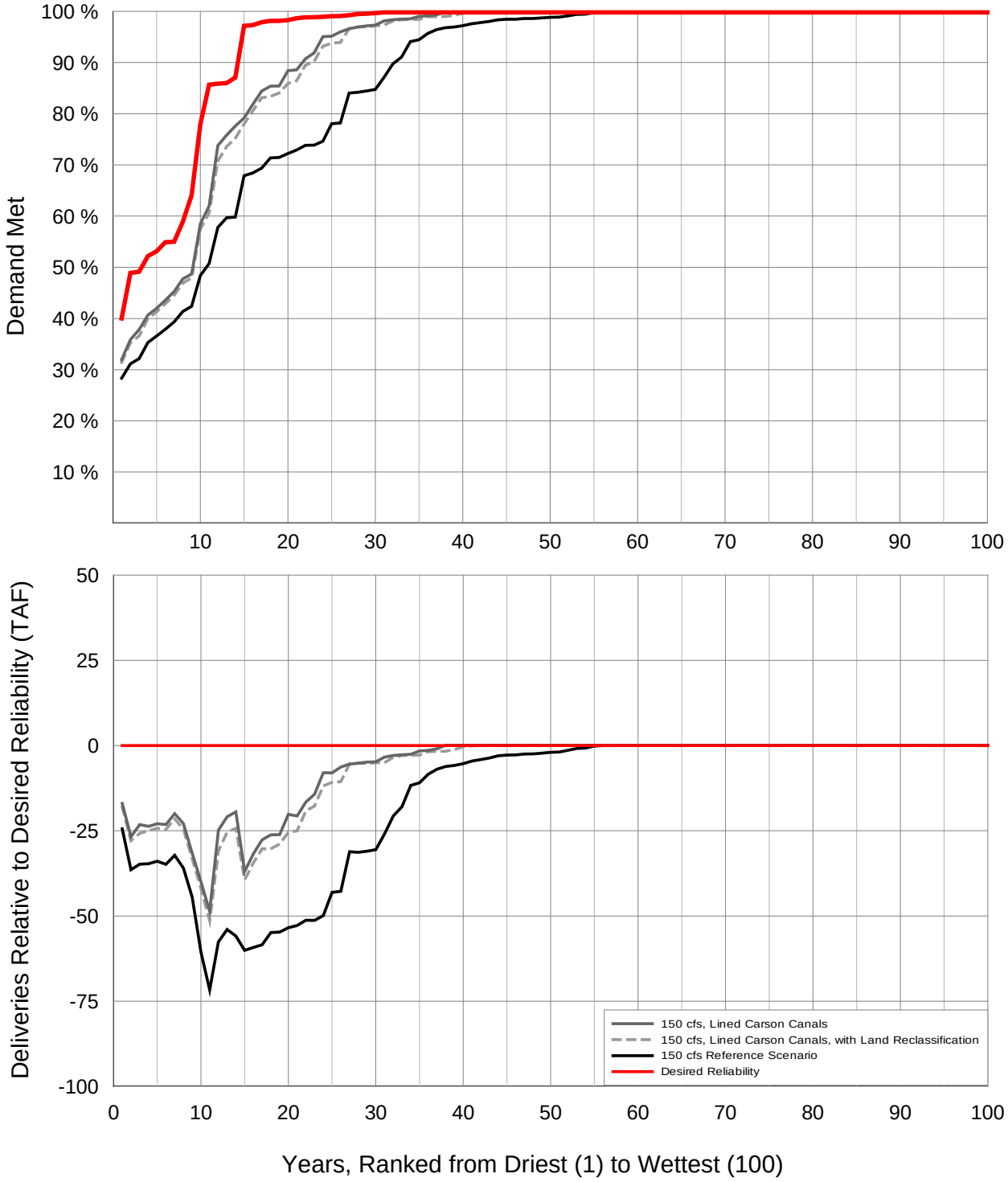

Figure D4-4. Relative Performance of Lining the Carson Division Canals on Annual Newlands Project Deliveries, 150 cfs Flow Stage

0 cfs Scenario with Reduced Carson Division Canal Seepage

Unlike the scenarios considered above, the analysis for the 0 cfs flow stage only considers the Carson Division. If the Truckee Canal were decommissioned, the Truckee Division would require a combination of both a water source and conveyances in order to meet the water supply objectives of the Study. This topic is given further consideration in Chapter 4 of the Study.

Figure D4-5 demonstrates that, for alternatives that consider a 0 cfs flow stage for the Truckee Canal, improving Project delivery efficiencies to 75 percent improves water supply reliability. However, additional measures would be necessary to meet the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 150 cfs flow-stage scenarios are as follows:

- -3,962 TAF for the 150 cfs reference scenario
- -2,739 TAF with a 75 percent Project delivery efficiency
- -2869 TAF with a 75 percent Project delivery efficiency and land reclassification

The result of land reclassification causes a marginal decrease in water supply reliability that does not overcome the benefits of increasing delivery efficiencies.

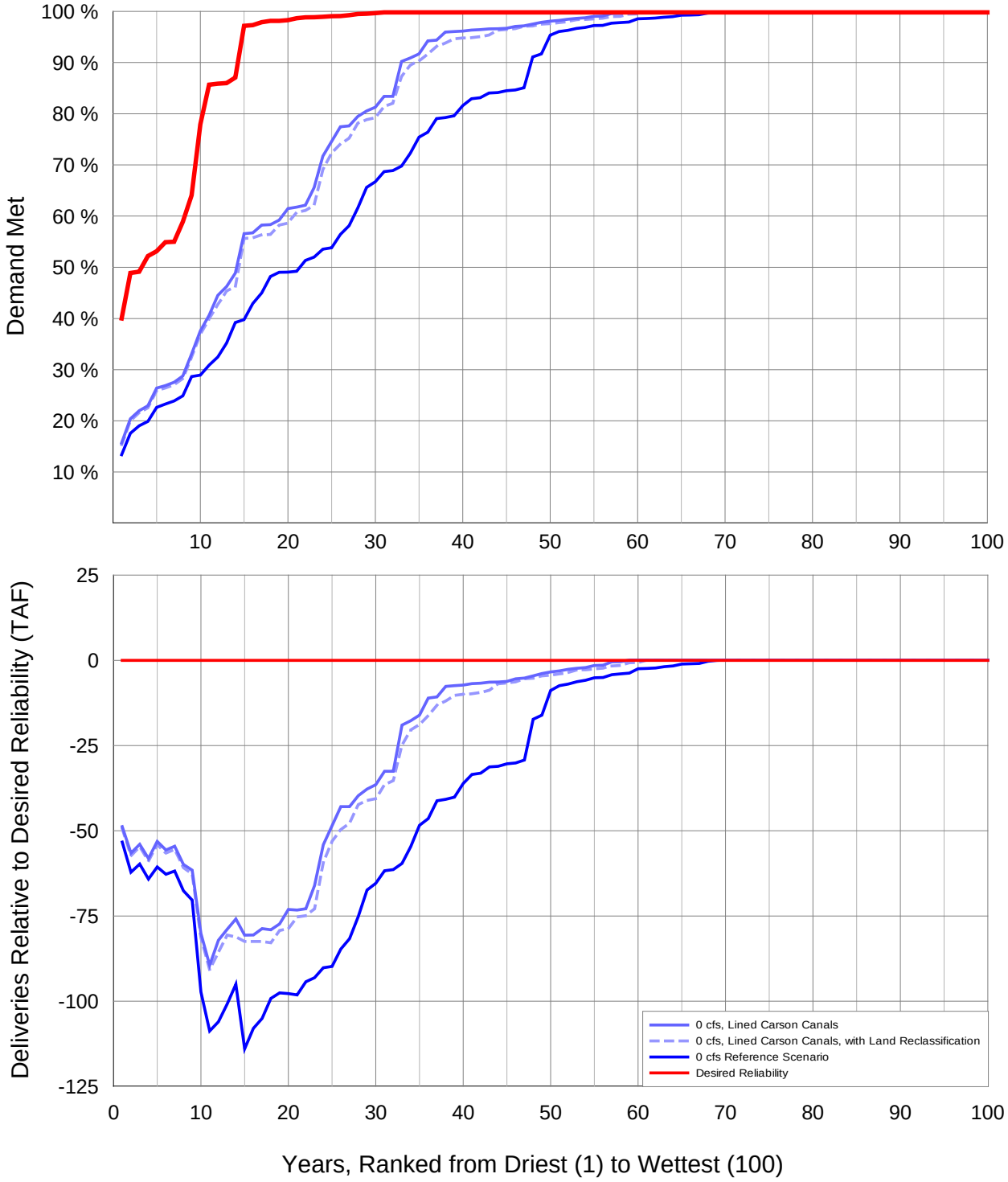

Figure D4-5. Relative Performance of Lining the Carson Division Canals on Annual Newlands Project Deliveries, 0 cfs Flow Stage

Summary of Results

The tables in this subsection summarize some of the primary findings from the analysis of Project performance with reduced seepage of the Carson Division canals.

Table D4-3 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability scenario, flow-stage reference scenarios, and flow-stage scenarios once the seepage reduction measure is applied. The minor effects of potential land reclassification are not shown.

Table D4-3. Project Reliability for Desired Reliability Reference Scenario and with Increased Efficiency of Carson Division Canals

	Number of Years Where >95% of Demand is Met	Number of Years Where <50% of Demand is Met	Percent of Demand Met in Driest Year
Desired Reliability	86	3	40%
600 cfs Increased Efficiency	91	1	49%
350 cfs Increased Efficiency	89	1	47%
250 cfs Increased Efficiency	85	3	43%
150 cfs Increased Efficiency	77	9	32%
0 cfs Increased Efficiency	50	14	15%

Key:
cfs = cubic feet per second

To support additional use by the Study or other parties, Table D4-4 notes the effects of Carson Division lining on average Truckee River flows to Pyramid Lake, annual hydropower generation at Lahontan Dam and the 26-Foot Drop (V Canal) Power Plant, and annual average and maximum spills from Lahontan Reservoir.

Table D4-4. Additional Characteristics of Increased Efficiency of Carson Division Canals (Annual Basis)

	Lahontan Reservoir Hydropower Generation (MWH)	V Canal Hydropower Generation (MWH)	Pyramid Lake Inflows (TAF)	Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability	15,676	3,309	460	236	12
600 cfs	15,795	2,747	493	241	14
350 cfs	15,414	2,713	498	241	14
250 cfs	14,883	2,659	506	241	13
150 cfs	14,100	2,549	520	241	13
0 cfs	12,492	2,288	583	241	12

Key:
cfs = cubic feet per second
MWH = megawatt-hours
TAF = thousand acre-feet

Appendix D4
Effects of Increasing Efficiency of Deliveries on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The table in this attachment summarizes water supply over the 100-year period of screening analysis, and includes results from the same period for the flow-stage reference scenarios and the Desired Reliability scenario from Appendix D1.

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Table: Annual Deliveries to Carson Division in TAF

Year	Desired Reliability	Increase in Efficiency of Carson Division Canals			
		0 cfs	150 cfs	250 cfs	350 cfs
1901	205	198	198	198	198
1902	205	198	198	198	198
1903	205	198	198	198	198
1904	205	198	198	198	198
1905	205	198	198	198	198
1906	205	198	198	198	198
1907	205	198	198	198	198
1908	205	198	198	198	198
1909	205	198	198	198	198
1910	205	198	198	198	198
1911	205	198	198	198	198
1912	205	198	198	198	198
1913	205	142	190	198	198
1914	205	196	198	198	198
1915	205	198	198	198	198
1916	205	198	198	198	198
1917	205	198	198	198	198
1918	205	198	198	198	198
1919	205	198	198	198	198
1920	205	122	180	198	198
1921	205	195	197	198	198
1922	205	198	198	198	198
1923	205	198	198	198	198
1924	178	154	188	198	198
1925	204	191	198	198	198
1926	200	81	151	187	198
1927	205	193	195	198	198
1928	203	148	195	198	198
1929	160	75	116	159	184
1930	204	112	157	180	198
1931	104	53	82	97	106
1932	203	192	193	194	195
1933	178	116	171	193	198
1934	116	57	88	109	127
1935	203	158	190	194	194
1936	205	191	198	198	198
1937	205	180	198	198	198
1938	205	198	198	198	198
1939	204	195	198	198	198
1940	205	191	198	198	198
1941	205	182	198	198	198
1942	205	198	198	198	198
1943	205	198	198	198	198
1944	205	198	198	198	198
1945	205	198	198	198	198
1946	205	187	198	198	198
1947	205	113	182	198	198
1948	205	118	162	196	198
1949	205	123	168	194	198
1950	205	192	197	198	198
1951	205	198	198	198	198
1952	205	198	198	198	198
1953	205	198	198	198	198
1954	205	179	198	198	198
1955	205	92	147	182	198
1956	205	194	196	197	198
1957	205	198	198	198	198
1958	205	198	198	198	198
1959	201	130	176	198	198
1960	176	52	95	126	165
1961	122	46	84	111	134
1962	203	160	193	194	195
1963	205	197	198	198	198
1964	205	116	176	198	198
1965	205	194	197	198	198
1966	204	161	198	198	198
1967	205	196	198	198	198
1968	205	198	198	198	198
1969	205	198	198	198	198
1970	205	198	198	198	198
1971	205	198	198	198	198
1972	205	192	198	198	198
1973	205	191	198	198	198
1974	205	198	198	198	198
1975	205	198	198	198	198
1976	176	97	154	178	194
1977	102	31	65	90	111
1978	203	187	192	193	194
1979	205	166	198	198	198
1980	205	197	198	198	198
1981	200	154	198	198	198
1982	205	196	198	198	198
1983	205	198	198	198	198
1984	205	198	198	198	198
1985	205	198	198	198	198
1986	205	198	198	198	198
1987	199	166	198	198	198
1988	110	41	77	115	140
1989	203	123	169	192	195
1990	134	55	91	115	136
1991	111	66	98	113	122
1992	85	44	73	87	96
1993	202	191	192	193	193
1994	116	88	125	141	149
1995	203	193	195	196	196
1996	205	198	198	198	198
1997	205	198	198	198	198
1998	205	198	198	198	198
1999	205	198	198	198	198
2000	205	198	198	198	198
Average	**194**	**167**	**182**	**188**	**191**
Maximum	**205**	**198**	**198**	**198**	**198**
Minimum	**85**	**31**	**65**	**87**	**96**

Table: Annual Deliveries to Truckee Division in TAF

Year	Desired Reliability	Increase in Efficiency of Carson Division Canals			
		0 cfs	150 cfs	250 cfs	350 cfs
1901	10	0	7	7	7
1902	10	0	7	7	7
1903	10	0	7	7	7
1904	10	0	7	7	7
1905	10	0	7	7	7
1906	10	0	7	7	7
1907	10	0	7	7	7
1908	10	0	7	7	7
1909	10	0	7	7	7
1910	10	0	7	7	7
1911	10	0	7	7	7
1912	10	0	7	7	7
1913	10	0	7	7	7
1914	10	0	7	7	7
1915	10	0	7	7	7
1916	10	0	7	7	7
1917	10	0	7	7	7
1918	10	0	7	7	7
1919	10	0	7	7	7
1920	10	0	6	7	7
1921	10	0	7	7	7
1922	10	0	7	7	7
1923	10	0	7	7	7
1924	9	0	7	7	7
1925	10	0	7	7	7
1926	10	0	5	6	7
1927	10	0	7	7	7
1928	10	0	7	7	7
1929	8	0	3	5	6
1930	10	0	5	6	6
1931	2	0	1	1	1
1932	10	0	6	6	6
1933	6	0	4	5	5
1934	3	0	1	2	2
1935	9	0	5	5	5
1936	10	0	7	7	7
1937	10	0	7	7	7
1938	10	0	7	7	7
1939	10	0	7	7	7
1940	10	0	7	7	7
1941	10	0	7	7	7
1942	10	0	7	7	7
1943	10	0	7	7	7
1944	10	0	7	7	7
1945	10	0	7	7	7
1946	10	0	7	7	7
1947	10	0	6	7	7
1948	10	0	5	7	7
1949	10	0	6	7	7
1950	10	0	7	7	7
1951	10	0	7	7	7
1952	10	0	7	7	7
1953	10	0	7	7	7
1954	10	0	7	7	7
1955	10	0	5	6	7
1956	10	0	7	7	7
1957	10	0	7	7	7
1958	10	0	7	7	7
1959	10	0	6	7	7
1960	9	0	3	4	5
1961	5	0	2	3	4
1962	10	0	7	7	7
1963	10	0	7	7	7
1964	10	0	6	7	7
1965	10	0	7	7	7
1966	10	0	7	7	7
1967	10	0	7	7	7
1968	10	0	7	7	7
1969	10	0	7	7	7
1970	10	0	7	7	7
1971	10	0	7	7	7
1972	10	0	7	7	7
1973	10	0	7	7	7
1974	10	0	7	7	7
1975	10	0	7	7	7
1976	9	0	5	6	7
1977	3	0	1	1	2
1978	10	0	7	7	7
1979	10	0	7	7	7
1980	10	0	7	7	7
1981	10	0	7	7	7
1982	10	0	7	7	7
1983	10	0	7	7	7
1984	10	0	7	7	7
1985	10	0	7	7	7
1986	10	0	7	7	7
1987	10	0	7	7	7
1988	3	0	1	2	2
1989	10	0	6	7	7
1990	4	0	2	3	3
1991	3	0	2	2	2
1992	2	0	1	1	1
1993	9	0	6	6	6
1994	2	0	2	2	2
1995	10	0	7	7	7
1996	10	0	7	7	7
1997	10	0	7	7	7
1998	10	0	7	7	7
1999	10	0	7	7	7
2000	10	0	7	7	7
Average	**10**	**0**	**6**	**6**	**6**
Maximum	**10**	**0**	**7**	**7**	**7**
Minimum	**2**	**0**	**1**	**1**	**1**

Table: Annual Deliveries to Newlands Project in TAF

Year	Desired Reliability	Increase in Efficiency of Carson Division Canals			
		0 cfs	150 cfs	250 cfs	350 cfs
1901	215	198	205	205	205
1902	215	198	205	205	205
1903	215	198	205	205	205
1904	215	198	205	205	205
1905	215	198	205	205	205
1906	215	198	205	205	205
1907	215	198	205	205	205
1908	215	198	205	205	205
1909	215	198	205	205	205
1910	215	198	205	205	205
1911	215	198	205	205	205
1912	215	198	205	205	205
1913	215	142	197	205	205
1914	215	196	205	205	205
1915	215	198	205	205	205
1916	215	198	205	205	205
1917	215	198	205	205	205
1918	215	198	205	205	205
1919	215	198	205	205	205
1920	215	122	186	205	205
1921	215	195	204	205	205
1922	215	198	205	205	205
1923	215	198	205	205	205
1924	188	154	195	205	205
1925	214	191	205	205	205
1926	210	81	155	194	205
1927	215	193	202	205	205
1928	213	148	202	205	205
1929	168	75	120	164	190
1930	214	112	162	186	204
1931	106	53	83	99	107
1932	212	192	199	200	201
1933	184	116	175	198	203
1934	118	57	89	111	128
1935	211	158	195	199	200
1936	215	191	205	205	205
1937	215	180	205	205	205
1938	215	198	205	205	205
1939	215	195	205	205	205
1940	215	191	205	205	205
1941	215	182	205	205	205
1942	215	198	205	205	205
1943	215	198	205	205	205
1944	215	198	205	205	205
1945	215	198	205	205	205
1946	215	187	205	205	205
1947	215	113	188	205	205
1948	215	118	168	202	205
1949	215	123	173	200	205
1950	215	192	203	205	205
1951	215	198	205	205	205
1952	215	198	205	205	205
1953	215	198	205	205	205
1954	215	179	205	205	205
1955	215	92	151	188	205
1956	215	194	202	204	205
1957	215	198	205	205	205
1958	215	198	205	205	205
1959	212	130	182	205	205
1960	185	52	98	130	170
1961	127	46	86	114	138
1962	213	160	200	201	202
1963	215	197	205	205	205
1964	215	116	181	205	205
1965	215	194	203	205	205
1966	214	161	205	205	205
1967	215	196	205	205	205
1968	215	198	205	205	205
1969	215	198	205	205	205
1970	215	198	205	205	205
1971	215	198	205	205	205
1972	215	192	205	205	205
1973	215	191	205	205	205
1974	215	198	205	205	205
1975	215	198	205	205	205
1976	185	97	159	184	200
1977	105	31	66	91	113
1978	213	187	199	200	201
1979	215	166	205	205	205
1980	215	197	205	205	205
1981	211	154	205	205	205
1982	215	196	205	205	205
1983	215	198	205	205	205
1984	215	198	205	205	205
1985	215	198	205	205	205
1986	215	198	205	205	205
1987	209	166	205	205	205
1988	112	41	78	117	143
1989	213	123	175	198	202
1990	138	55	93	118	140
1991	114	66	100	115	125
1992	87	44	74	88	97
1993	211	191	198	199	199
1994	118	88	127	143	151
1995	213	193	201	202	203
1996	215	198	205	205	205
1997	215	198	205	205	205
1998	215	198	205	205	205
1999	215	198	205	205	205
2000	215	198	205	205	205
Average	**204**	**167**	**188**	**194**	**197**
Maximum	**215**	**198**	**205**	**205**	**205**
Minimum	**87**	**31**	**66**	**88**	**97**

Appendix D5
Potential Opportunities to Store Newlands Project Water in Truckee River Reservoirs

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

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Abbreviations and Acronyms

cfs	cubic feet per second
OCAP	Operating Criteria and Procedures for the Newlands Project
Project	Newlands Project
Reclamation	U.S. Department of the Interior, Bureau of Reclamation
Study	Newlands Project Planning Study
TAF	thousand acre-feet
TROA	Truckee River Operating Agreement

Appendix D5 – Effects of Acquiring Additional Carson River Storage and Water Rights on Newlands Project Water Supply

This appendix characterizes how dedicating storage or water rights above the Lahontan Reservoir to the Newlands Project (Project) would contribute to the water supply objective of the Newlands Project Planning Study (Study). The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Project or actions to mitigate water supply conditions that are less than reliable.

This appendix presents one of several screening assessments conducted for the Study, all of which are presented in Appendices D1 through D7. These screening analyses were designed to provide inter-comparisons among several measures that could potentially contribute to meeting the Study's water supply objective. Thus, the measures studied and outcomes published in this appendix are not being proposed as alternatives for the Study, but are instead presented to inform decisions on which measures best meet the Study's objectives.

The following analysis describes the effects of two measures, identified as part of the Study:

1. How acquiring Carson River rights directly upstream of Lahontan Dam (Segment 7 of the Carson River) for the Project would change Project water supply reliability.

2. How acquiring storage rights in the existing small lakes and reservoirs in the upper reaches of the Carson River Basin, and delivering their storage during to Lahontan Reservoir during the off-season for the Project would change Project water supply reliability.

Performance toward the water supply objective is measured against two conditions:

1. A Desired Reliability scenario, which represents the desired performance.

2. Flow-stage reference scenarios, which serve as a starting point for applying additional measures – such as acquiring upstream water rights.

The Desired Reliability scenario describes the ability of the Project to meet current levels of demand, in compliance with Operations Criteria and

Procedures for the Newlands Project (OCAP), with a 900-cubic-feet-per-second (cfs) Truckee Canal capacity. As the name implies, the flow-stage reference scenarios are built around a range of Truckee Canal flow stages developed for meeting U.S. Department of the Interior, Bureau of Reclamation (Reclamation) safety standards (600, 350, 250, 150, and 0 cfs). The flow-stage reference scenarios consider the ability of the Project to meet anticipated future levels of demand, under OCAP, with the indicated flow-stage capacity for the Truckee Canal. The Desired Reliability and flow-stage reference scenarios are described in Appendix D1.

Acquiring Segment 7 Water Rights

The Alpine decree divides the Carson River into segments, and each segment is administered autonomously such that if water rights are acquired in the river in an upstream segment, the additional water left in the river then becomes available to the next downstream segment. Seniority is maintained within segments, but not among segments. As a result, the acquisition of upstream surface water rights or storage has no guarantee of increasing flows to Lahontan Reservoir, unless those supplies are delivered outside of the agricultural season when diversions from intermediary segments are not being made (Dave Wathen, Office of the Federal Watermaster, personal communication, December 2011).

The most direct method identified for acquiring surface rights from upper Carson River segments for the Project is to acquire them from the downstream segments before moving upstream. Segment 7 of the Carson River stretches from the Carson City Gage to Lahontan Reservoir, and is the most downstream segment on the river above Lahontan Reservoir. Segment 7 is subdivided into five subsegments. Currently, up to 80 percent of the water rights in this section could be available for acquisition (Dave Wathen, Office of Federal Watermaster, personal communication, March 2012). Table D5-1 shows current water rights in Segment 7.

Table D5-1. Carson River Segment 7 Water Rights, by Subsegment

Subsegment	Water Rights (acres)	Transferrable Portion of Water Rights (acre-feet)
7A	1,068.0	2,670.0
7B	227.8	569.5
7C	658.6	1,646.4
7D	671.9	1,679.8
7E	1,184.0	2,960.0
TOTAL	3,810.3	9,525.7

Source: Dave Wathen, Federal Watermaster, personal communications, February 2008

Note:
The Alpine Decree states that the net consumptive use of surface water for irrigation of the lands above Lahontan Reservoir is 2.5 acre-feet per acre

The first method to realize additional water into Lahontan is to purchase water rights with points of diversion within Segment 7 of the river. To model this scenario, the 100-year historic time series of flows at the Fort Churchill Gage was altered to reflect the flows that would occur as a result of this water rights acquisition in Segment 7. It was assumed that 80 percent of the water rights (7,500 acre-feet) were acquired for this measure. However, because Segment 7 is at the bottom of the Carson Valley, and because of the intermittent nature of the Carson River, especially in the late summer and fall, sufficient flow in the river to meet all of the demands of the Segment 7 water users is not guaranteed. When flows into Segment 7 are below a certain threshold amount, the river cannot serve all of the water rights in the section and shortages occur. Therefore, not all acquired water rights will result in additional flow into the Lahontan Reservoir. Thirty-five cfs is needed to serve all current users with water rights. When the flow is below this 35 cfs threshold, users in Segment 7 will not receive their full allotment of surface water (Garry Stone, Office of Federal Watermaster, personal communications, March 2012).

It was further assumed that if 80 percent of land with water rights in Segment 7 were acquired, then this minimum flow threshold would also drop 80 percent from its current value to about 7 cfs. To model this scenario, the volume of acquired water rights was first distributed evenly across the number of days in the irrigation season (March 25 – November 15). This resulted in a potential daily adjustment for the Fort Churchill historic inflow hydrograph. Then, for days when the flow was greater than 7 cfs in the historic record, the daily adjustment amount was added to the historic daily flow value; for days when the flow was less than 7 cfs, the daily adjustment was not made.

As a result, even though 7,500 acre-feet of water rights were acquired in this scenario, only an average of 5,466 acre-feet of water per year actually makes it to Lahontan Reservoir. This is because in drier times, little to no flow enters Segment 7 resulting in no additional flow into Lahontan Reservoir. Table D5-3

in attachments shows the annual additional volume that makes it to Lahontan as a result of purchasing these Segment 7 water rights.

Acquiring Rights to Upstream Carson River Storage

The second method to increase flows to Lahontan Reservoir, and thereby potentially improve the reliability of Newlands Project deliveries, considers the lease or acquisition of water rights that can be stored in lakes and reservoirs of the upper Carson River Basin. The *Alpine* Decree permits these reservoirs to fill when the water is available during the spring melt season, which is then released later in the year, outside of the irrigation season. By releasing this stored water outside of the irrigation season, it is possible to protect it from use by other water right holders and assure its complete delivery to Lahontan Reservoir.

For this analysis, it was assumed that all of the available upstream storage was acquired, which totals to 11,766 acre-feet. To represent this scenario, the Fort Churchill Gage inflow was altered from the baseline (historic) condition. It is assumed that this water would be released each year either on days outside of the irrigation season, or on days when the flow in the Carson River was greater than 1,000 cfs. Under both of these conditions, it can be safely assumed that the released water would make it to Lahontan Reservoir without being used by other Carson River water right holders in the intervening segments, which would be permitted under the *Alpine* Decree. This alteration was calculated by taking the entire volume of water rights acquired, assumed to be 11,766 acre-feet, and dividing it evenly over the total number of days that are either outside of the irrigation season or high-flow days, with at least 1,000 cfs at the Fort Churchill Gage. It was assumed that these reservoirs fill every year and that the water is always able to be released and realized in total at Lahontan Reservoir. The additional volume at Lahontan Reservoir under this scenario is 11,766 acre-feet each year.

Methods

The following analysis looks at effects of varying Truckee Canal capacity and increasing inflows to the Lahontan Reservoir. The Pre-Truckee River Operating Agreement (TROA) Planning Model was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RiverWare modeling environment, and “slots” are features of the RiverWare environment that accept user inputs.

Truckee Canal capacity is entered to the Pre-TROA Planning Model through the slot TruckeeCanalDiv.CanalCapacityDefault. The flow-stage conditions evaluated include 350, 250, 150, and 0 cfs.

Inflow to Lahontan Reservoir is entered to the Pre-TROA Planning Model through the slot CARSONATFTCHURCHILL.GAGE OUTFLOW. Although the rights and storage on the upper Carson River are both administered under the *Alpine* Decree, differences in how they could be made available to the Project necessitates separate evaluation. The adjustments described above for representing changes in upstream water use and storage were made to the Fort Churchill inflow to Lahontan Reservoir in the Pre-TROA Planning Model using the slot CARSONATFTCHURCHILL.GAGE OUTFLOW.

This analysis was evaluated over a 100-year period, from 1901 through 2000, and is described in Appendix B2.

Results and Conclusions

Rather than present water supply reliability in terms of a singular number, the Study's concept for reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, reliability must be presented in a two-dimensional context that allows for the evaluation of both frequency and magnitude. This section presents modeling results through a number of plots that illustrate these two components of reliability for flow-stage reference scenarios with and without additional Carson River storage and water rights, relative to the Desired Reliability scenario. The reference scenario for each flow stage represents the starting point for each screening analysis of acquiring rights to storage or surface water supplies on the Carson River.

Figures in the subsections below are provided for visual comparisons of changes in reliability. Each flow-stage subsection refers to two figures of two plots each, the first illustrating the effects of acquiring Segment 7 water rights, and the latter illustrating the effects of acquiring upstream storage rights. On the plot in the top portion of each figure, the Desired Reliability and flow-stage scenarios are represented in terms of percent of annual demand met, and include the ranked results from 100 years of simulated data (see Appendix D1). The bottom half of each figure is a chart that illustrates the difference between each scenario and the Desired Reliability, expressed as a volume (thousands of acre-feet (TAF)).

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

NOTE: the rank of a specific year will not necessarily match between the Desired Reliability and flow-stage reference scenarios, or even across the range

of reference scenarios. It follows that implementing measures, such as acquiring Carson River storage and water rights, would similarly result in a change to the ranking of years. The resulting line (sequencing in a manner that does not consistently ascend from low to high rank) reflects the complex manner in which different actions affect the water supply of the Project. Despite this, the trends and results from applying demand reduction measures can be clearly interpreted.

350 cfs Scenario with Upstream Carson River Water Rights and Storage

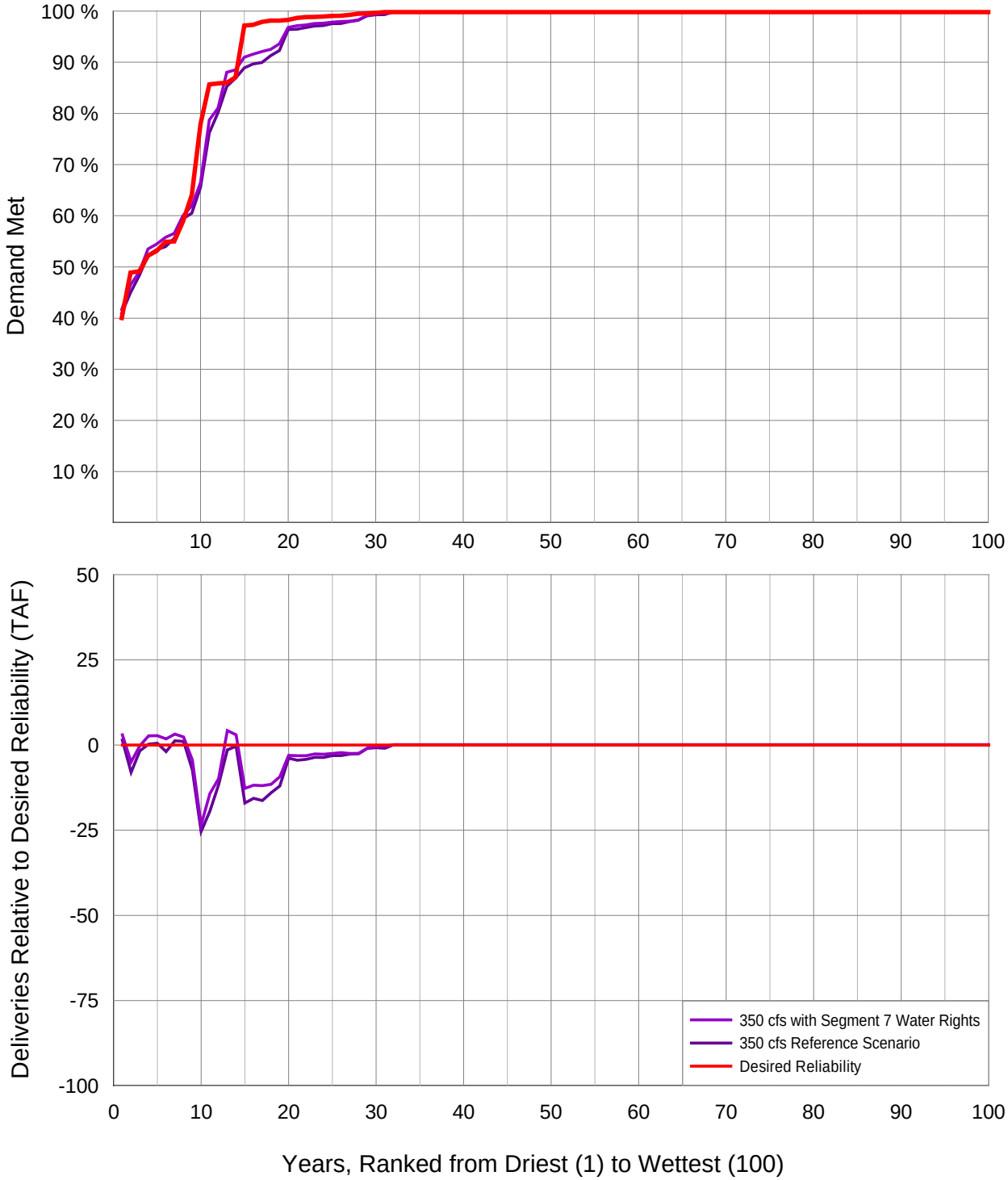
Figures D5-1 and D5-2 demonstrate the effects of acquiring upstream water and storage rights, respectively, for alternatives that consider a 350 cfs flow stage for the Truckee Canal. Acquiring upstream Carson River water rights does not significantly improve water supply reliability relative to that of the Desired Reliability. However, acquiring upstream storage rights does significantly improve reliability relative to that of the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 350 cfs flow stages are as follows:

- -176 TAF for the 350 cfs reference scenario
- -112 TAF with Segment 7 water rights
- -45 TAF with upstream Carson River storage rights

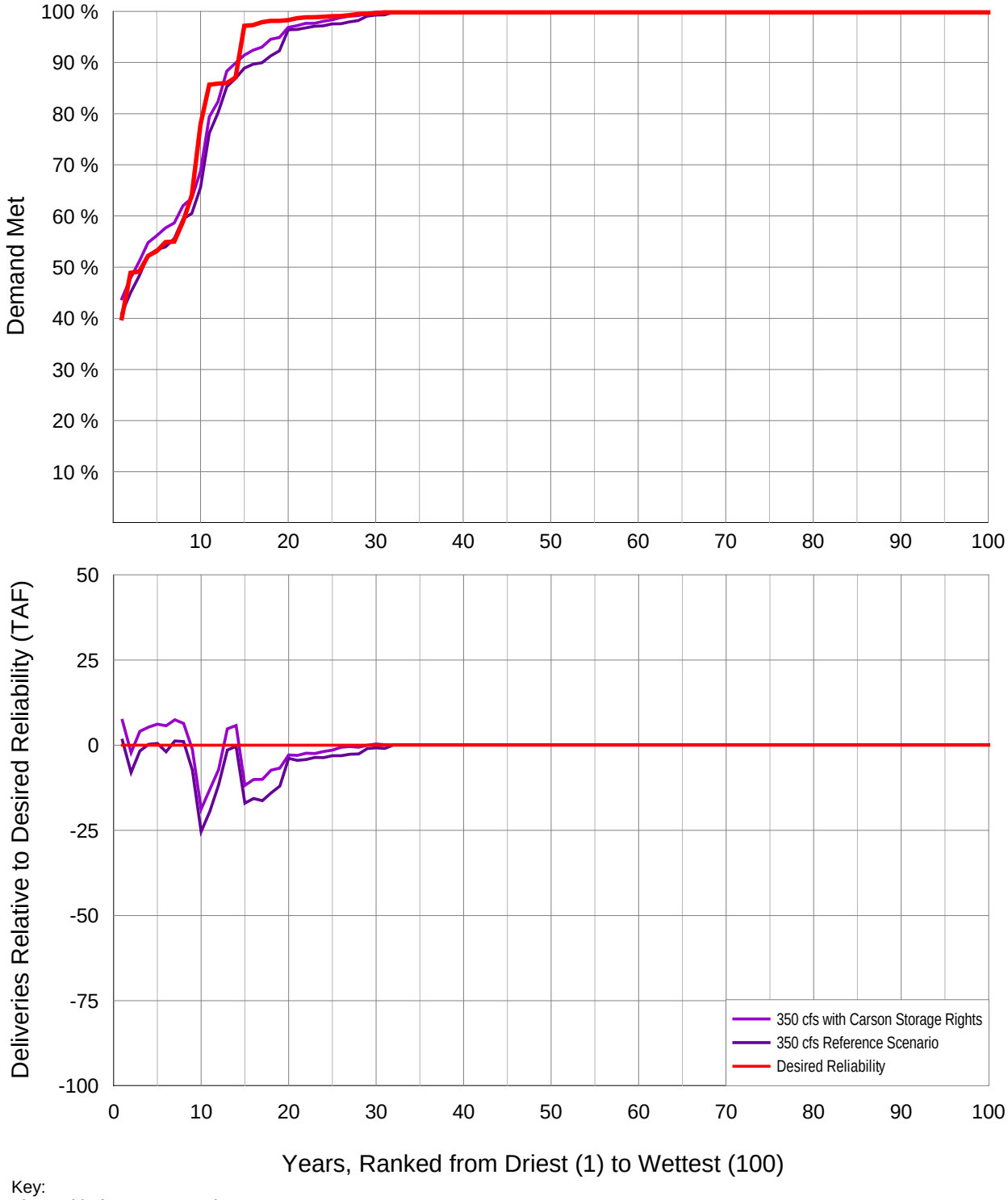
Acquiring Segment 7 water rights for a 350 cfs flow stage improves the water supply reliability by 2 percent to 3 percent, at most, for the few years ranked around 15. The net difference in deliveries relative to the Desired Reliability remain negative (-112 TAF). This minor improvement is not significant enough to further consider this measure.

Acquiring storage rights for a 350 cfs flow stage improves the water supply reliability by 2 percent to 3 percent consistently for most years. The net difference in deliveries relative to the Desired Reliability, while still negative, improves significantly, by +129 TAF for the entire 100-year duration. However, this measure would need to be accompanied with other measures to meet Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-1. Relative Performance of Acquiring Segment 7 Water Rights on Annual Newlands Project Deliveries, 350 cfs Flow Stage



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-2. Relative Performance of Acquiring Carson River Storage Rights on Annual Newlands Project Deliveries, 350 cfs Flow Stage

250 cfs Scenario with Upstream Carson River Water Rights and Storage

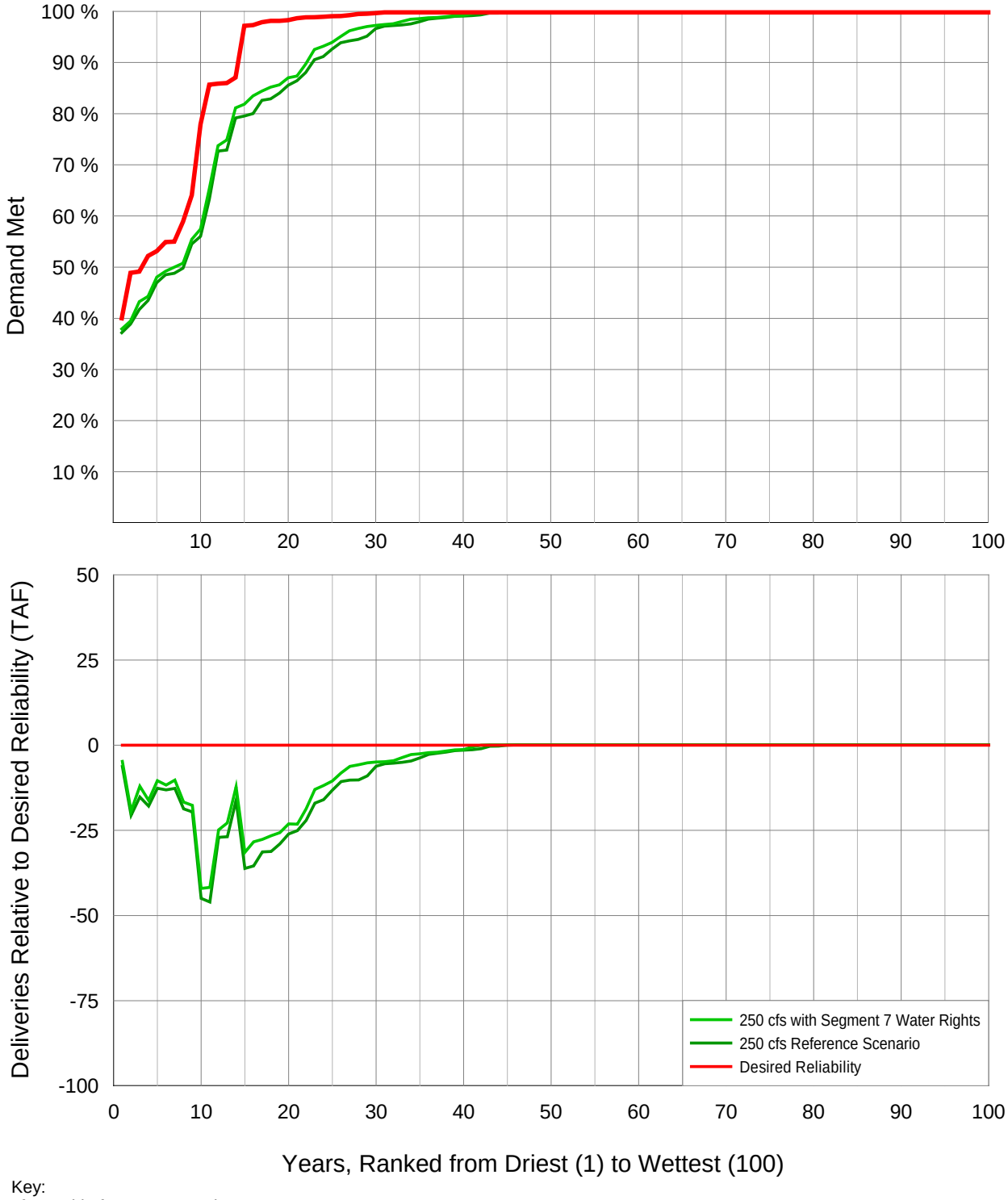
Figures D5-3 and D5-4 demonstrate the effects of acquiring upstream water and storage rights, respectively, for alternatives that consider a 250 cfs flow stage for the Truckee Canal. Acquiring upstream Carson River water rights does not significantly improve water supply reliability relative to that of the Desired Reliability. However, acquiring upstream storage rights does significantly improve reliability relative to that of the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 250 cfs flow stages are as follows:

- -660 TAF for the 250 cfs reference scenario
- -556 TAF with Segment 7 water rights
- -470 TAF with upstream Carson River storage rights

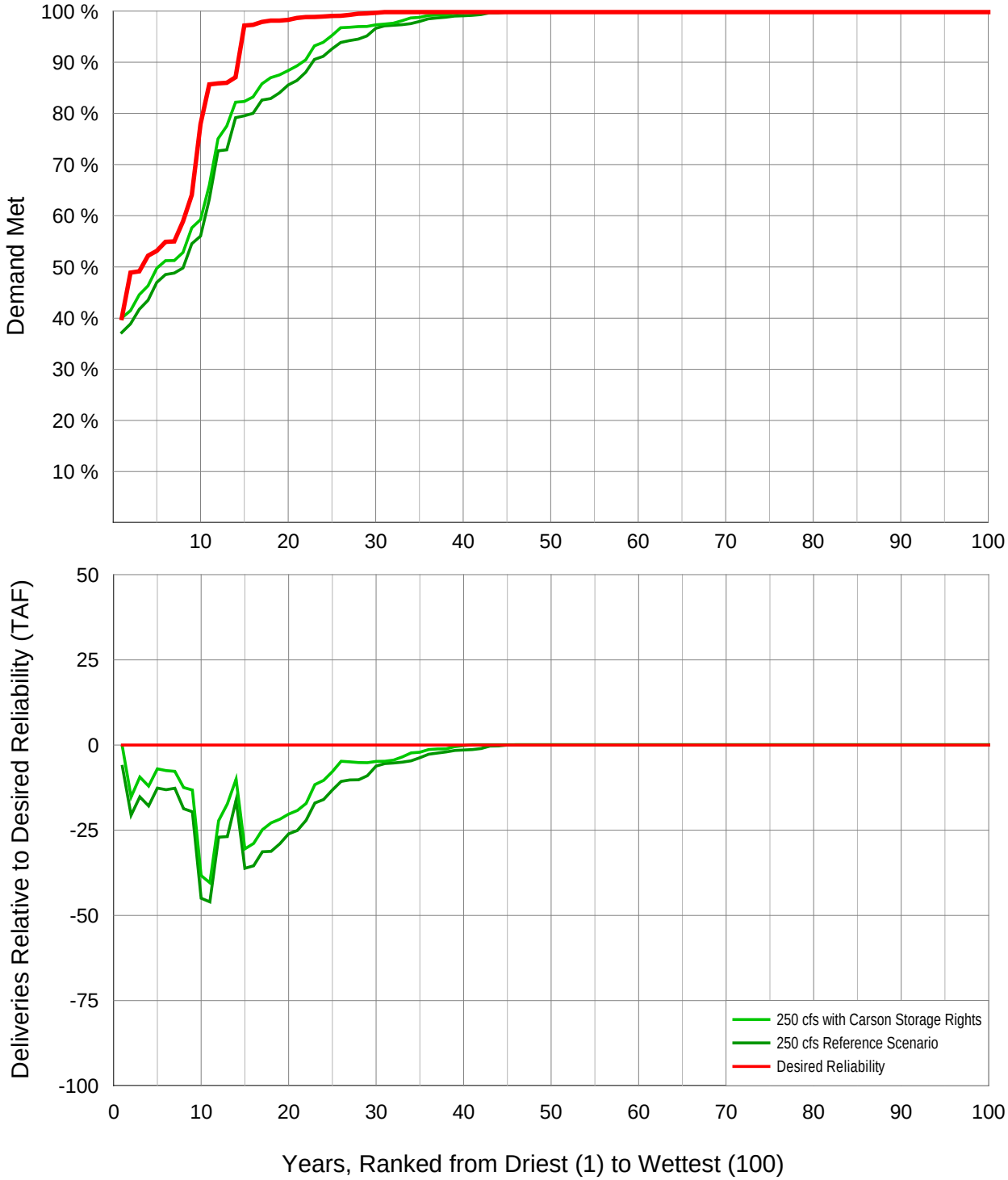
Acquiring Segment 7 water rights for a 250 cfs flow stage improves the water supply reliability by 2 percent to 3 percent, at most, for years ranked 15 – 30. The net difference in deliveries relative to the Desired Reliability remain negative (-556 TAF). This minor improvement is not significant enough to further consider this measure.

Acquiring storage rights for a 250 cfs flow stage improves the water supply reliability by 2 percent to 3 percent consistently for most years. The net difference in deliveries relative to the Desired Reliability, while still negative, improves significantly, by +190 TAF for the entire 100-year duration. However, this measure would need to be accompanied with other measures to meet Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-3. Relative Performance of Acquiring Segment 7 Water Rights on Annual Newlands Project Deliveries, 250 cfs Flow Stage



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-4. Relative Performance of Acquiring Carson River Storage Rights on Annual Newlands Project Deliveries, 250 cfs Flow Stage

150 cfs Scenario with Upstream Carson River Water Rights and Storage

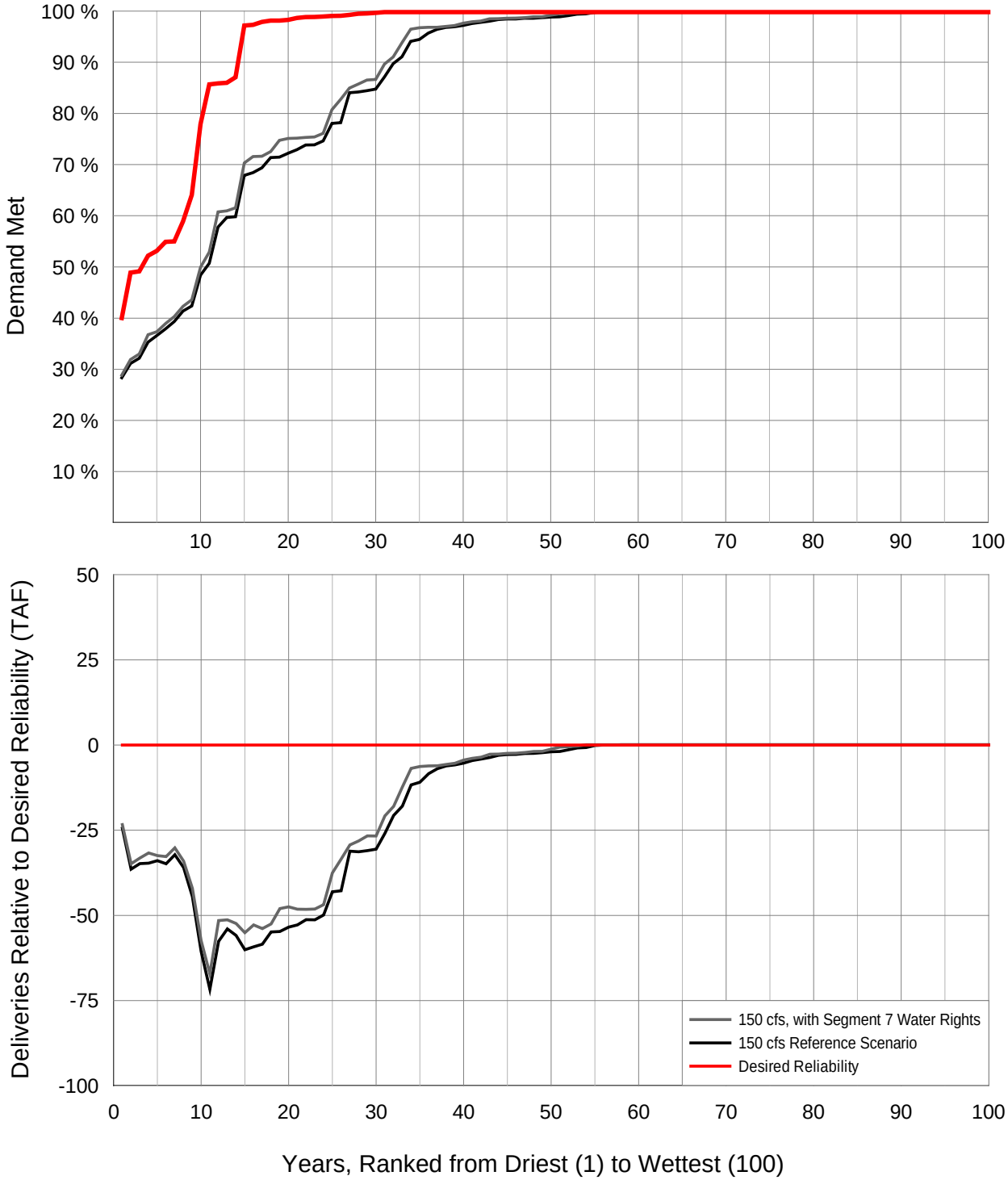
Figures D5-5 and D5-6 demonstrate the effects of acquiring upstream water and storage rights, respectively, for alternatives that consider a 150 cfs flow stage for the Truckee Canal. Acquiring upstream Carson River water rights does not significantly improve water supply reliability relative to that of the Desired Reliability. However, acquiring upstream storage rights does significantly improve reliability relative to that of the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 150 cfs flow stages are as follows:

- -1519 TAF for the 150 cfs reference scenario
- -1372 TAF with Segment 7 water rights
- -1254 TAF with upstream Carson River storage rights

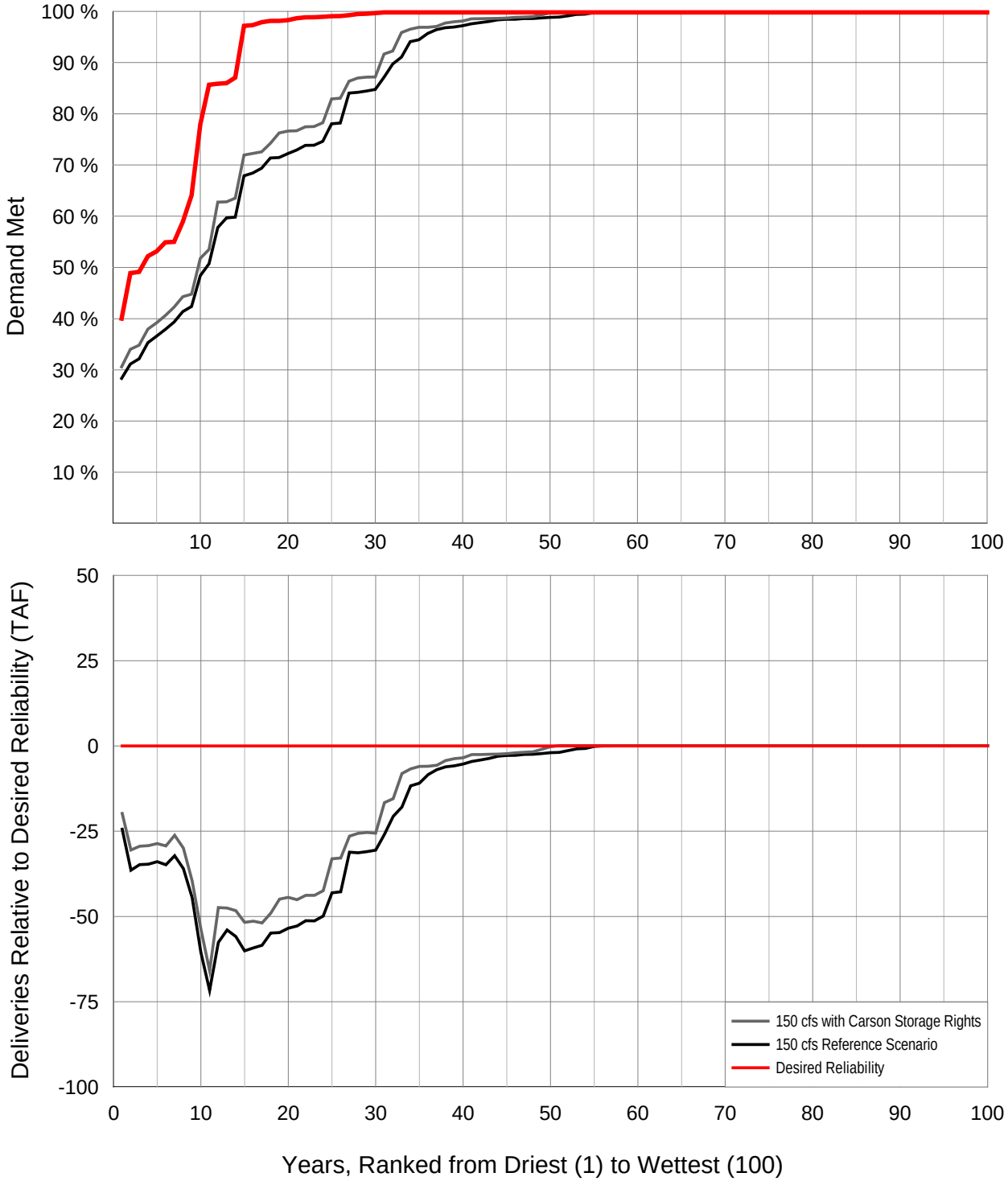
Acquiring Segment 7 water rights for a 150 cfs flow-stage improves the water supply reliability by 2 percent to 3 percent, at most, for years ranked 15 – 35. The net difference in deliveries relative to the Desired Reliability remain negative (-1372 TAF). This minor improvement is not significant enough to further consider this measure.

Acquiring storage rights for a 150 cfs flow stage improves the water supply reliability by 2 percent to 3 percent consistently for most years. The net difference in deliveries relative to the Desired Reliability, while still negative, improves significantly, by +265 TAF for the entire 100-year duration. However, this measure would need to be accompanied with other measures to meet Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-5. Relative Performance of Acquiring Segment 7 Water Rights on Annual Newlands Project Deliveries, 150 cfs Flow Stage



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-6. Relative Performance of Acquiring Carson River Storage Rights on Annual Newlands Project Deliveries, 150 cfs Flow Stage

0 cfs Scenario with Upstream Carson River Water Rights and Storage

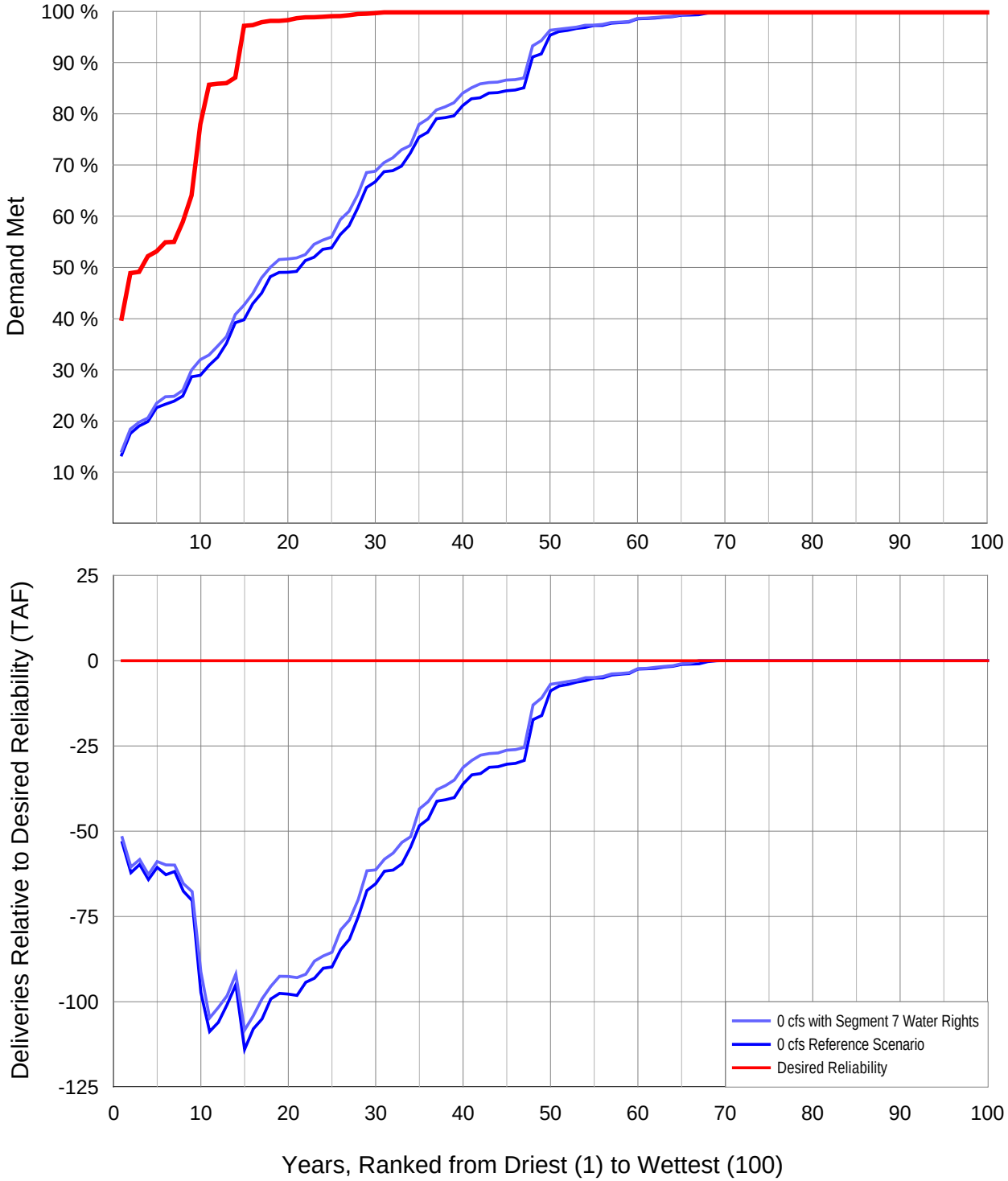
Figures D5-7 and D5-8 demonstrate the effects of acquiring upstream water and storage rights, respectively, for alternatives that consider a 0 cfs flow stage for the Truckee Canal. Acquiring upstream Carson River water rights does not significantly improve water supply reliability relative to that of the Desired Reliability. However, acquiring upstream storage rights does significantly improve reliability relative to that of the Desired Reliability for the full range of hydrologic conditions.

Net differences between the Desired Reliability and the range of 0 cfs flow stages are as follows:

- -3344 TAF for the 0 cfs reference scenario
- -3137 TAF with Segment 7 water rights
- -2993 TAF with upstream Carson River storage rights

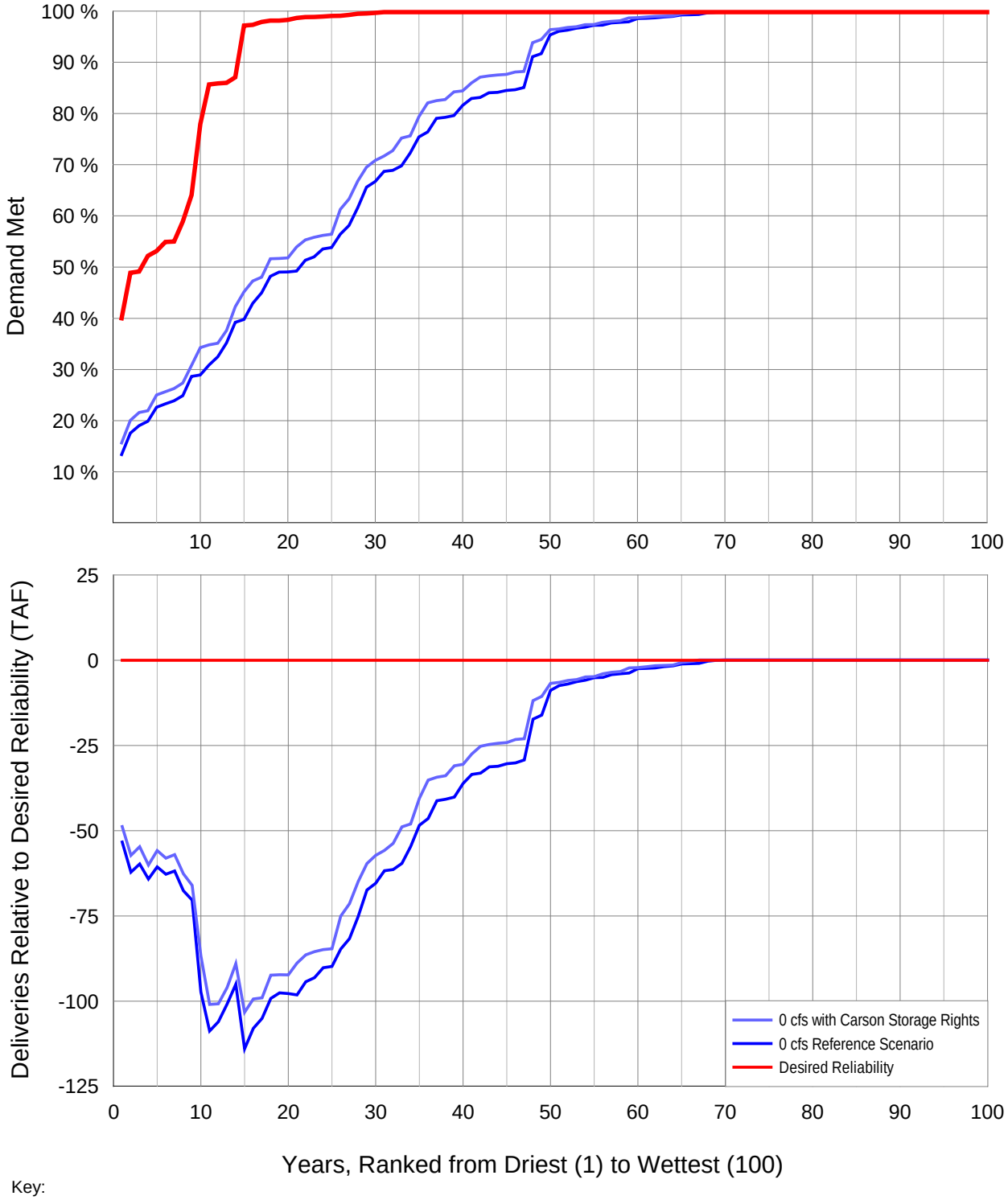
Acquiring Segment 7 water rights for a 0 cfs flow stage improves the water supply reliability by 0 percent to 3 percent for all ranked years. The net difference in deliveries relative to the Desired Reliability remain negative (-3137 TAF). This minor improvement is not significant enough to further consider this measure.

Acquiring storage rights for a 0 cfs flow stage improves the water supply reliability by 2 percent to 5 percent consistently for most years. The net difference in deliveries relative to the Desired Reliability, while still negative, improves significantly, by +351 TAF for the entire 100-year duration. However, this measure would need to be accompanied with other measures to meet Desired Reliability for the full range of hydrologic conditions.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-7. Relative Performance of Acquiring Segment 7 Water Rights on Annual Newlands Project Deliveries, 0 cfs Flow Stage



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D5-8. Relative Performance of Acquiring Carson River Storage Rights on Annual Newlands Project Deliveries, 0 cfs Flow Stage

Summary of Results

The tables in this subsection summarize some of the primary findings from the analysis of Project performance with Carson River water rights and water storage rights acquisition.

For all flow stages, acquiring Segment 7 water rights resulted in marginal changes in the water supply of the Project. Acquiring upstream storage rights had a more significant impact on water deliveries, but this measure may not be feasible from a non-physical perspective. Potential explanations for these results and backgrounds for these conclusions are as follows.

1. The volumes considered are small, relative to the existing supplies from the Carson and Truckee rivers. The water made available from Segment 7 of the Carson River (7,500 acre-feet) represents 2.1 percent of the total demand for the Carson Division; the volume of storage assessed (11,766 acre-feet) represents 3.3 percent.

2. These water rights are not entirely reliable. The intermittent availability of Segment 7 rights results in an average annual inflow to Lahontan Reservoir of 5,466 acre-feet (28 percent less than the full water-righted volume). Additionally, because droughts on Segment 7 occur in the same years as droughts for the Project, the supplies that are available do not align with the times of greatest need for the Project. An increase in storage would help in times of drought, and this made some improvement in the results.

3. An increase in upstream water rights and storage does not result in additional storage in Lahontan Reservoir when the reservoir is at or above its OCAP-mandated storage targets. Better efficiency in using Carson River water will instead reduce diversions through the Truckee Canal and increase flows into Pyramid Lake through the lower Truckee River. OCAP forces the storage in Lahontan Reservoir to be no more than is needed to meet current year demands in the Carson Division of the Project while the Truckee Canal is diverting Truckee River water. Thus, water cannot be stored cumulatively across multiple years. This renders additional flows into Lahontan Reservoir from the Carson River effective for increasing Project reliability only in the year in which they originate and only when the storage in Lahontan Reservoir would otherwise fall below its OCAP targets.

4. The measure assumed all Segment 7 water rights and storage rights were acquired for the Project, which is not a realistic assumption. The result, therefore, is an upper bound and represents the most benefit that can be potentially realized from rights acquisition. In reality, the increase in water supply reliability by acquiring a proportion of these rights would be less than shown.

For these water rights acquisition measures to be effective, either a volume of water rights in excess of the Newlands Project Claim 3 would need to be acquired from the upper Carson River Basin and dedicated to the Project, or the OCAP storage targets would need to be adjusted for the Project to take more advantage of the newly acquired rights. Because neither of these conditions seems likely, these measures were removed from consideration by the Study.

Table D5-2 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability scenario and flow-stage scenarios assuming corresponding water rights acquisition.

Table D5-2. Project Reliability for Desired Reliability Reference Scenario and with Segment 7 Water Rights

	Number of Years Where >95 Percent of Demand is Met	Number of Years Where <50 Percent of Demand is Met	Percent of Demand Met in Driest Year	Net Difference with Desired Reliability (TAF)
Desired Reliability	86	3	40%	NA
350 cfs Segment 7 Water Rights	81	3	42%	-112
250 cfs Segment 7 Water Rights	75	6	38%	-556
150 cfs Segment 7 Water Rights	67	10	29%	-1,372
0 cfs[1] Segment 7 Water Rights	41	19	14%	-3,137
350 cfs Water Storage Rights	81	2	44%	-45
250 cfs Water Storage Rights	76	5	40%	-470
150 cfs Water Storage Rights	68	9	31%	-1,254
0 cfs[1] Water Storage Rights	43	18	15%	-2,993

Note:
[1] Carson Division only; Truckee Division demand will be met through means other than the Truckee Canal in a 0 cfs alternative.

Key:
cfs = cubic foot per second
TAF = thousand acre-feet

To support additional use by the Study or other parties, Table D5-3 notes the annual average and maximum annual spills from Lahontan Reservoir.

Table D5-3. Additional Characteristics of Acquiring Carson River Water Rights (Annual Basis)

	Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability	236	12
350 cfs Seg 7	242	12
250 cfs Seg 7	242	12
150 cfs Seg 7	242	11
0 cfs Storage	242	10
350 cfs Storage	244	13
250 cfs Storage	236	12
150 cfs Storage	244	12
0 cfs Storage	244	11

Key:
cfs = cubic foot per second
TAF = thousand acre-feet

Appendix D5
Effects of Acquiring Additional Carson River Water Rights and Storage on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The following data table summarizes results for the 100-year period of screening analysis, and includes results from the same period for the flow-stage reference scenarios and Desired Reliability scenario from Appendix D1.

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Table: Annual Deliveries to Carson Division in TAF

Year	Desired Reliability	Upstream Carson Storage Rights				Segment 7 Rights			
		0 cfs	150 cfs	250 cfs	350 cfs	0 cfs	150 cfs	250 cfs	350 cfs
1901	205	198	198	198	198	198	198	198	198
1902	205	198	198	198	198	198	198	198	198
1903	205	198	198	198	198	198	198	198	198
1904	205	198	198	198	198	198	198	198	198
1905	205	198	198	198	198	198	198	198	198
1906	205	198	198	198	198	198	198	198	198
1907	205	198	198	198	198	198	198	198	198
1908	205	198	198	198	198	198	198	198	198
1909	205	198	198	198	198	198	198	198	198
1910	205	198	198	198	198	198	198	198	198
1911	205	198	198	198	198	198	198	198	198
1912	205	198	198	198	198	198	198	198	198
1913	205	111	165	192	198	111	164	192	198
1914	205	194	196	198	198	194	196	198	198
1915	205	198	198	198	198	198	198	198	198
1916	205	198	198	198	198	198	198	198	198
1917	205	198	198	198	198	198	198	198	198
1918	205	198	198	198	198	198	198	198	198
1919	205	175	198	198	198	173	198	198	198
1920	205	103	151	185	198	103	149	185	198
1921	205	186	196	198	198	185	196	198	198
1922	205	198	198	198	198	198	198	198	198
1923	205	198	198	198	198	198	198	198	198
1924	178	110	154	174	187	103	150	170	183
1925	204	173	196	197	198	172	195	196	198
1926	200	75	125	163	183	72	121	161	182
1927	205	193	194	196	198	192	194	196	197
1928	203	122	173	198	198	118	172	196	198
1929	160	69	107	131	158	69	105	130	157
1930	204	102	143	163	181	102	142	162	180
1931	104	51	77	90	97	49	74	88	94
1932	203	192	193	194	194	192	193	194	194
1933	178	95	145	167	177	95	143	167	177
1934	116	54	82	101	114	52	79	97	110
1935	203	142	173	190	194	140	171	187	194
1936	205	174	197	198	198	171	197	198	198
1937	205	163	198	198	198	160	198	198	198
1938	205	197	198	198	198	196	198	198	198
1939	204	167	192	198	198	167	193	198	198
1940	205	173	198	198	198	170	198	198	198
1941	205	164	198	198	198	162	198	198	198
1942	205	197	198	198	198	197	198	198	198
1943	205	198	198	198	198	198	198	198	198
1944	205	164	198	198	198	157	192	198	198
1945	205	196	198	198	198	194	198	198	198
1946	205	158	198	198	198	155	198	198	198
1947	205	103	155	186	198	99	150	184	198
1948	205	107	147	173	198	104	144	169	194
1949	205	112	152	177	197	108	148	173	193
1950	205	175	196	197	198	172	196	197	198
1951	205	197	198	198	198	197	198	198	198
1952	205	198	198	198	198	198	198	198	198
1953	205	198	198	198	198	198	198	198	198
1954	205	141	182	198	198	136	178	198	198
1955	205	84	125	154	179	81	121	149	175
1956	205	193	195	196	197	193	195	196	197
1957	205	198	198	198	198	198	198	198	198
1958	205	198	198	198	198	198	198	198	198
1959	201	90	144	170	185	85	140	168	183
1960	176	50	88	115	137	47	84	110	132
1961	122	44	78	102	124	41	75	98	120
1962	203	144	183	194	195	142	180	194	194
1963	205	196	198	198	198	196	198	198	198
1964	205	94	152	180	196	89	149	178	195
1965	205	193	196	197	198	193	196	197	198
1966	204	133	171	192	198	127	169	189	198
1967	205	195	196	198	198	195	196	198	198
1968	205	168	198	198	198	163	198	198	198
1969	205	197	198	198	198	196	198	198	198
1970	205	198	198	198	198	198	198	198	198
1971	205	198	198	198	198	198	198	198	198
1972	205	150	190	198	198	145	186	198	198
1973	205	174	198	198	198	171	198	198	198
1974	205	198	198	198	198	198	198	198	198
1975	205	198	198	198	198	198	198	198	198
1976	176	68	126	149	164	63	122	147	161
1977	102	31	62	84	103	28	58	80	99
1978	203	171	192	193	194	169	192	193	194
1979	205	149	196	198	198	147	192	198	198
1980	205	196	198	198	198	196	198	198	198
1981	200	126	165	198	198	121	160	195	198
1982	205	195	196	198	198	194	196	198	198
1983	205	198	198	198	198	198	198	198	198
1984	205	198	198	198	198	198	198	198	198
1985	205	188	198	198	198	187	198	198	198
1986	205	198	198	198	198	198	198	198	198
1987	199	138	173	192	198	137	172	191	198
1988	110	40	70	94	116	37	67	90	113
1989	203	112	154	175	188	110	151	173	186
1990	134	52	85	106	118	49	81	102	113
1991	111	61	90	103	110	59	88	101	108
1992	85	43	69	81	89	39	65	77	85
1993	202	191	192	193	193	191	192	193	193
1994	116	70	105	120	128	65	101	116	125
1995	203	192	194	195	195	192	194	195	195
1996	205	198	198	198	198	198	198	198	198
1997	205	198	198	198	198	198	198	198	198
1998	205	198	198	198	198	198	198	198	198
1999	205	198	198	198	198	198	198	198	198
2000	205	198	198	198	198	198	198	198	198
Average	**194**	**158**	**176**	**184**	**188**	**157**	**175**	**183**	**187**
Maximum	**205**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**
Minimum	**85**	**31**	**62**	**81**	**89**	**28**	**58**	**77**	**85**

Table: Annual Deliveries to Truckee Division in TAF

Year	Desired	Upstream Carson Storage Rights				Segment 7 Rights			
	Reliability	0 cfs	150 cfs	250 cfs	350 cfs	0 cfs	150 cfs	250 cfs	350 cfs
1901	10	0	7	7	7	0	7	7	7
1902	10	0	7	7	7	0	7	7	7
1903	10	0	7	7	7	0	7	7	7
1904	10	0	7	7	7	0	7	7	7
1905	10	0	7	7	7	0	7	7	7
1906	10	0	7	7	7	0	7	7	7
1907	10	0	7	7	7	0	7	7	7
1908	10	0	7	7	7	0	7	7	7
1909	10	0	7	7	7	0	7	7	7
1910	10	0	7	7	7	0	7	7	7
1911	10	0	7	7	7	0	7	7	7
1912	10	0	7	7	7	0	7	7	7
1913	10	0	5	7	7	0	5	7	7
1914	10	0	7	7	7	0	7	7	7
1915	10	0	7	7	7	0	7	7	7
1916	10	0	7	7	7	0	7	7	7
1917	10	0	7	7	7	0	7	7	7
1918	10	0	7	7	7	0	7	7	7
1919	10	0	7	7	7	0	7	7	7
1920	10	0	5	6	7	0	5	6	7
1921	10	0	7	7	7	0	7	7	7
1922	10	0	7	7	7	0	7	7	7
1923	10	0	7	7	7	0	7	7	7
1924	9	0	5	6	7	0	5	6	6
1925	10	0	7	7	7	0	7	7	7
1926	10	0	4	5	6	0	4	5	6
1927	10	0	7	7	7	0	7	7	7
1928	10	0	6	7	7	0	6	7	7
1929	8	0	3	4	5	0	3	4	5
1930	10	0	5	5	6	0	5	5	6
1931	2	0	1	1	1	0	1	1	1
1932	10	0	6	6	6	0	6	6	6
1933	6	0	3	4	4	0	3	4	4
1934	3	0	1	1	2	0	1	1	2
1935	9	0	5	5	5	0	5	5	5
1936	10	0	7	7	7	0	7	7	7
1937	10	0	7	7	7	0	7	7	7
1938	10	0	7	7	7	0	7	7	7
1939	10	0	7	7	7	0	7	7	7
1940	10	0	7	7	7	0	7	7	7
1941	10	0	7	7	7	0	7	7	7
1942	10	0	7	7	7	0	7	7	7
1943	10	0	7	7	7	0	7	7	7
1944	10	0	7	7	7	0	7	7	7
1945	10	0	7	7	7	0	7	7	7
1946	10	0	7	7	7	0	7	7	7
1947	10	0	5	6	7	0	5	6	7
1948	10	0	5	6	7	0	5	6	7
1949	10	0	5	6	7	0	5	6	7
1950	10	0	7	7	7	0	7	7	7
1951	10	0	7	7	7	0	7	7	7
1952	10	0	7	7	7	0	7	7	7
1953	10	0	7	7	7	0	7	7	7
1954	10	0	6	7	7	0	6	7	7
1955	10	0	4	5	6	0	4	5	6
1956	10	0	7	7	7	0	7	7	7
1957	10	0	7	7	7	0	7	7	7
1958	10	0	7	7	7	0	7	7	7
1959	10	0	5	6	6	0	4	5	6
1960	9	0	3	4	4	0	3	4	4
1961	5	0	2	3	3	0	2	3	3
1962	10	0	6	7	7	0	6	7	7
1963	10	0	7	7	7	0	7	7	7
1964	10	0	5	6	7	0	5	6	7
1965	10	0	7	7	7	0	7	7	7
1966	10	0	6	7	7	0	6	6	7
1967	10	0	7	7	7	0	7	7	7
1968	10	0	7	7	7	0	7	7	7
1969	10	0	7	7	7	0	7	7	7
1970	10	0	7	7	7	0	7	7	7
1971	10	0	7	7	7	0	7	7	7
1972	10	0	7	7	7	0	6	7	7
1973	10	0	7	7	7	0	7	7	7
1974	10	0	7	7	7	0	7	7	7
1975	10	0	7	7	7	0	7	7	7
1976	9	0	4	5	5	0	4	5	5
1977	3	0	1	1	2	0	1	1	2
1978	10	0	7	7	7	0	7	7	7
1979	10	0	7	7	7	0	7	7	7
1980	10	0	7	7	7	0	7	7	7
1981	10	0	5	7	7	0	5	7	7
1982	10	0	7	7	7	0	7	7	7
1983	10	0	7	7	7	0	7	7	7
1984	10	0	7	7	7	0	7	7	7
1985	10	0	7	7	7	0	7	7	7
1986	10	0	7	7	7	0	7	7	7
1987	10	0	6	7	7	0	6	7	7
1988	3	0	1	1	2	0	1	1	2
1989	10	0	5	6	7	0	5	6	6
1990	4	0	2	2	3	0	2	2	3
1991	3	0	2	2	2	0	2	2	2
1992	2	0	1	1	1	0	1	1	1
1993	9	0	6	6	6	0	6	6	6
1994	2	0	1	2	2	0	1	2	2
1995	10	0	7	7	7	0	7	7	7
1996	10	0	7	7	7	0	7	7	7
1997	10	0	7	7	7	0	7	7	7
1998	10	0	7	7	7	0	7	7	7
1999	10	0	7	7	7	0	7	7	7
2000	10	0	7	7	7	0	7	7	7
Average	**10**	**0**	**6**	**6**	**6**	**0**	**6**	**6**	**6**
Maximum	**10**	**0**	**7**	**7**	**7**	**0**	**7**	**7**	**7**
Minimum	**2**	**0**	**1**	**1**	**1**	**0**	**1**	**1**	**1**

Table: Annual Deliveries to Newlands Project in TAF

Year	Desired Reliability	Upstream Carson Storage Rights				Segment 7 Rights			
		0 cfs	150 cfs	250 cfs	350 cfs	0 cfs	150 cfs	250 cfs	350 cfs
1901	215	198	205	205	205	198	205	205	205
1902	215	198	205	205	205	198	205	205	205
1903	215	198	205	205	205	198	205	205	205
1904	215	198	205	205	205	198	205	205	205
1905	215	198	205	205	205	198	205	205	205
1906	215	198	205	205	205	198	205	205	205
1907	215	198	205	205	205	198	205	205	205
1908	215	198	205	205	205	198	205	205	205
1909	215	198	205	205	205	198	205	205	205
1910	215	198	205	205	205	198	205	205	205
1911	215	198	205	205	205	198	205	205	205
1912	215	198	205	205	205	198	205	205	205
1913	215	111	170	199	205	111	170	199	205
1914	215	194	203	205	205	194	203	205	205
1915	215	198	205	205	205	198	205	205	205
1916	215	198	205	205	205	198	205	205	205
1917	215	198	205	205	205	198	205	205	205
1918	215	198	205	205	205	198	205	205	205
1919	215	175	205	205	205	173	205	205	205
1920	215	103	156	191	205	103	154	191	205
1921	215	186	202	204	205	185	202	204	205
1922	215	198	205	205	205	198	205	205	205
1923	215	198	205	205	205	198	205	205	205
1924	188	110	159	180	194	103	155	176	190
1925	214	173	202	203	205	172	202	203	204
1926	210	75	129	169	190	72	125	166	188
1927	215	193	201	203	204	192	201	203	204
1928	213	122	179	205	205	118	178	203	205
1929	168	69	110	135	163	69	109	134	161
1930	214	102	148	169	188	102	147	168	187
1931	106	51	78	91	98	49	75	89	95
1932	212	192	199	200	200	192	199	200	200
1933	184	95	148	171	181	95	147	171	182
1934	118	54	83	102	115	52	80	99	112
1935	211	142	178	195	199	140	176	193	199
1936	215	174	204	205	205	171	203	205	205
1937	215	163	205	205	205	160	205	205	205
1938	215	197	205	205	205	196	205	205	205
1939	215	167	199	205	205	167	199	205	205
1940	215	173	205	205	205	170	205	205	205
1941	215	164	205	205	205	162	205	205	205
1942	215	197	205	205	205	197	205	205	205
1943	215	198	205	205	205	198	205	205	205
1944	215	164	205	205	205	157	198	205	205
1945	215	196	205	205	205	194	205	205	205
1946	215	158	205	205	205	155	205	205	205
1947	215	103	161	193	205	99	154	190	205
1948	215	107	152	178	205	104	149	175	201
1949	215	112	157	183	203	108	153	179	200
1950	215	175	202	204	205	172	202	203	205
1951	215	197	205	205	205	197	205	205	205
1952	215	198	205	205	205	198	205	205	205
1953	215	198	205	205	205	198	205	205	205
1954	215	141	188	205	205	136	184	205	205
1955	215	84	129	159	184	81	125	154	181
1956	215	193	201	202	203	193	201	202	203
1957	215	198	205	205	205	198	205	205	205
1958	215	198	205	205	205	198	205	205	205
1959	212	90	149	176	191	85	144	173	189
1960	185	50	91	118	141	47	87	114	136
1961	127	44	80	105	127	41	77	101	123
1962	213	144	189	200	201	142	187	200	201
1963	215	196	204	205	205	196	204	205	205
1964	215	94	157	186	203	89	154	184	201
1965	215	193	202	204	205	193	202	203	205
1966	214	133	177	199	205	127	174	195	205
1967	215	195	203	205	205	195	203	205	205
1968	215	168	205	205	205	163	204	205	205
1969	215	197	205	205	205	196	205	205	205
1970	215	198	205	205	205	198	205	205	205
1971	215	198	205	205	205	198	205	205	205
1972	215	150	197	205	205	145	192	205	205
1973	215	174	205	205	205	171	204	205	205
1974	215	198	205	205	205	198	205	205	205
1975	215	198	205	205	205	198	205	205	205
1976	185	68	130	154	169	63	126	151	166
1977	105	31	63	85	105	28	59	81	101
1978	213	171	199	200	200	169	199	199	200
1979	215	149	202	205	205	147	199	205	205
1980	215	196	205	205	205	196	205	205	205
1981	211	126	170	205	205	121	166	202	205
1982	215	195	203	205	205	194	202	205	205
1983	215	198	205	205	205	198	205	205	205
1984	215	198	205	205	205	198	205	205	205
1985	215	188	205	205	205	187	205	205	205
1986	215	198	205	205	205	198	205	205	205
1987	209	138	179	199	205	137	177	197	205
1988	112	40	71	95	118	37	68	91	114
1989	213	112	159	181	195	110	156	178	192
1990	138	52	87	108	120	49	83	104	116
1991	114	61	92	105	112	59	89	103	110
1992	87	43	70	82	90	39	65	78	86
1993	211	191	198	198	199	191	198	198	199
1994	118	70	106	122	130	65	102	118	127
1995	213	192	200	201	202	192	200	201	202
1996	215	198	205	205	205	198	205	205	205
1997	215	198	205	205	205	198	205	205	205
1998	215	198	205	205	205	198	205	205	205
1999	215	198	205	205	205	198	205	205	205
2000	215	198	205	205	205	198	205	205	205
Average	**204**	**158**	**182**	**189**	**194**	**157**	**180**	**189**	**193**
Maximum	**215**	**198**	**205**	**205**	**205**	**198**	**205**	**205**	**205**
Minimum	**87**	**31**	**63**	**82**	**90**	**28**	**59**	**78**	**86**

Appendix D6
Effects of Increasing Efficiency of Deliveries on Newlands Project Water Supply

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

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Abbreviations and Acronyms

cfs	cubic feet per second
Derby Dam	Derby Diversion Dam
Project	Newlands Project
Study	Newlands Project Planning Study
TROA	Truckee River Operating Agreement

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Appendix D6 – Potential Opportunities to Store Newlands Project Water in Truckee River Reservoirs

The following document describes the technical potential for multi-year carry-over storage of Newlands Project (Project) water supplies from the Truckee River (Claim 3 of the *Orr Ditch* Decree) in reservoirs within the Truckee River Basin (e.g., Prosser Reservoir). This measure was identified by the Truckee-Carson Irrigation District for consideration, in conjunction with smaller Truckee Canal flow capacities, by the Newlands Project Planning Study (Study). In response to this suggestion, a measure for using Truckee River Basin storage was included in the list of initial Study measures for discussions with basin stakeholders and members of the public. The feasibility of implementing this measure was questioned several times, by a range of stakeholders.

Several institutional barriers exist that prevent this measure from being evaluated with modeling tools. An appropriate technical evaluation would require the development of computer logic describing the constraints on increased storage within the Truckee Basin. The development of an appropriate framework of constraints would require the participation of several stakeholders, and the time and scope to achieve this does not exist within the scope of this Study. Implementing this measure to take advantage of upstream Truckee River Basin reservoirs also requires legal and political agreements among the numerous agencies that exist throughout the basin. Because such foundations do not exist, technical evaluation of this measure was not possible.

However, Federal planning processes (WRC 1983) require the consideration of measures that may be technically possible, even if they would be institutionally difficult. For completeness, this document provides information for assessing how Truckee River Basin storage might contribute to the Study's water supply objective, without formal evaluation. The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Project or actions to mitigate water supply conditions that are less than reliable.

The analysis in this appendix is limited to a summary of three time series from the Pre-Truckee River Operating Agreement (TROA) Planning Model:

1. Available storage in three Truckee River Basin reservoirs downstream from Lake Tahoe.

2. Undiverted Claim 3 water supplies, which is water that could be legally diverted to the Truckee Canal but is currently not due to canal capacity limitations.

3. Newlands project water delivery shortages.

These outputs should be helpful for any future discussions on Project storage in Truckee River reservoirs, but this appendix does not speculate on the potential benefits of such a program for meeting the Study's water supply objective.

Methods

The time series reported in this appendix are simulated outputs of the Pre-TROA Planning Model, which was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RIVERWARE modeling environment, and "slots" are features of the RIVERWARE environment that accept user inputs. The time series presented in this appendix were produced by the 100-year simulation of the 900 cubic feet per second (cfs) Desired Reliability scenario, as described in Appendix D1. This scenario assumes that there are no capacity restrictions in the Truckee Canal (i.e., capacity equals 900 cfs).

Truckee River Storage Capacity

Available storage is defined by the difference between storage used by other supplies and "rule curves" that limit storage to capacities below the total physical capacity of each reservoir (e.g., flood control storage reductions). This study includes the assessment of available storage of three reservoirs: Boca Reservoir, Prosser Creek Reservoir, and Stampede Reservoir. Lake Tahoe's ability to store water is complicated by required flow rates at the Floriston Gage, shoreline flooding issues, and higher rates of evaporation. For these reasons, available storage in Tahoe was not included when examining Truckee River storage capacities; however, it should be considered if upstream Truckee River storage is ever investigated in greater detail.

The time series outputs and slots that define storage constraints are noted in Table D6-1.

Table D6-1. Time Series Used To Describe Available Storage

Reservoir	Storage Slot	Rule Curve Slot(s)
Boca	BOCA.STORAGE	BOCADATA.FLOODCONTROLCAPACITY
Prosser Creek	PROSSER .STORAGE	PROSSERDATA.FLOODCONTROLCAPACITY
Stampede	STAMPEDE STORAGE	STAMPEDEDATA.FLOODCONTROLCAPACITY

Undiverted Claim 3 Water

Undiverted Claim 3 water is water that could be legally diverted into the Truckee Canal according to the *Orr Ditch* Decree, but currently is not diverted due to Truckee Canal capacity limitations. Instead, this water flows to Pyramid Lake. In the model, the quantity of this unclaimed water is calculated by

determining the volume that went over the Derby Diversion Dam (Derby Dam) minus the flows that were required further downstream from the dam, which includes environmental flows, Claims 1 and 2 of the *Orr Ditch* Decree water rights, portions of Claim 3 water rights purchased or leased to flow to Pyramid Lake, and a small number of other waters. This was done in the model on a monthly basis in the slot NPPS.UNCLAIMEDC3WATERATDERBY.

Newlands Project Shortages

Project water supply shortfalls are calculated from the differences between total Truckee and Carson division deliveries, and total demands within each division. This total demand number excludes Truckee Division water rights that do not need to be diverted (e.g., rights acquired for Pyramid Lake by the Water Quality Settlement Act). Deliveries are recorded within the slots TRUCKEEDIVISION.DIVERSION and CARSONDIVISION.DIVERSION as daily flows, and in NPPS.PERCENTTOTALTDDDELIVERED and NPPS.PERCENTTOTALCDDDELIVERED as annual percentage of full allotment. Total anticipated future demand for the Project is described in Appendix C, and equals 205,082 acre-feet.

Results and Conclusions

The institutional mechanisms for allowing multi-year carry-over storage of Claim 3 water in upstream reservoirs on the Truckee River have not been developed. As a result, significant speculation would be necessary to use a computer simulation to test the ability of this measure to meet the water supply objective of the Study. Thus, this appendix relies on a comparison of three factors to demonstrate the physical potential for this measure to provide water supply benefits for the Project. These factors are:

1. Volume and timing of storage available in Truckee River Basin reservoirs, upstream from Derby Dam.

2. Volume and timing of Claim 3 water supplies that could not be diverted through the Truckee Canal because of insufficient capacity in the Truckee Canal.

3. Volume and timing of Project shortages.

Figure D6-1 presents the volume of storage (blue) held in upstream Truckee River Basin reservoirs (Boca, Prosser Creek, and Stampede) for the full 100 years of simulation. This storage is held beneath an annually fluctuating red line, which represents the total available storage in all reservoirs, combined. This red line is not a constant volume because U.S. Army Corps of Engineers-mandated operating rules at each reservoir (e.g., for flood control) require annual reductions in storage in each reservoir for predetermined periods of time. The storage shown in Figure D6-1 does not include storage at Lake Tahoe.

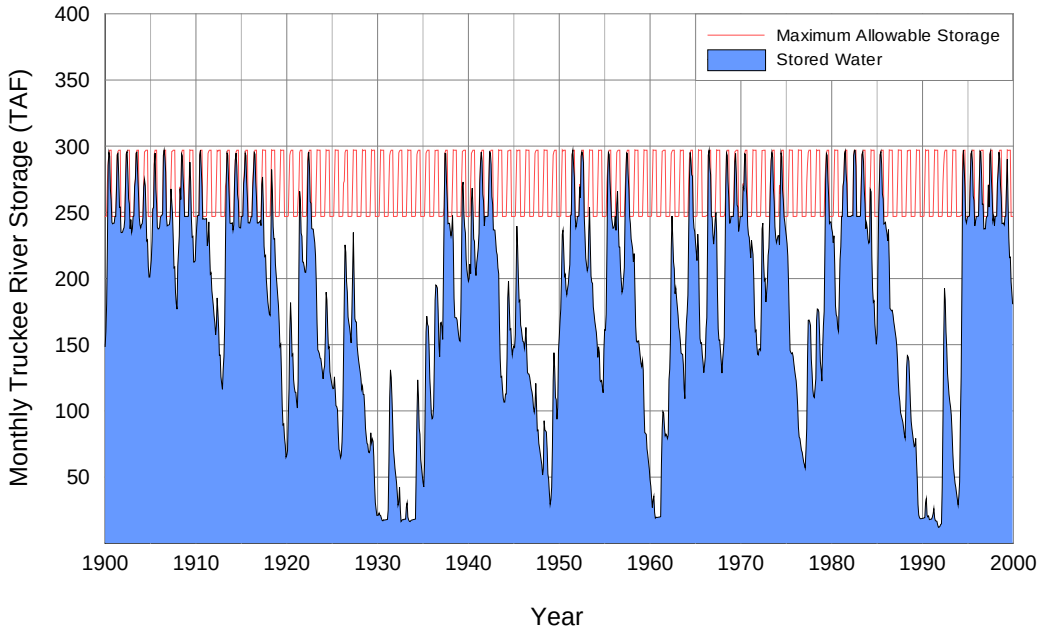

Figure D6-1. Monthly Upstream Truckee River Storage Compared to the Maximum Allowable Storage

While the upstream storage is occasionally used in full, there are significant periods with considerable volumes of available, unused storage space. The plot at the top of Figure D6-2 presents the monthly time series of unused or available reservoir capacities, which is simply the difference between the Maximum Allowable Storage and Stored Water from Figure D6-1.

The second, middle time series in Figure D6-2 presents the annual time series of undiverted Claim 3 water. As noted above, this water could have been available for diversion at Derby Dam for the Project, but the conveyance capacity of the Truckee Canal is not sufficient. By visual inspection, storage in upstream Truckee River Basin reservoirs seems to be available during periods with undiverted Claim 3 water. The volumes of available storage appear larger than the volumes of undiverted Claim 3 water.

The third, bottom time series in Figure D6-2 presents the time series of Project shortages. These shortages are the difference between the annual demand and the annual water supply delivered. By visual inspection, undiverted Claim 3 water seems to occur in close proximity to periods with Project shortages. The volumes of undiverted Claim 3 water appear larger than the Project shortages.

In general, historically wet periods have limited opportunities for storing undiverted Claim 3 water. However, the historically wet periods for the Truckee and Carson river basins tend to align, and shortfalls during these periods are low as a result. More significantly, during dry periods – when availability of storage space in the Truckee River Basin is highest – the volumes

of shortage and undiverted Claim 3 water are also at their highest. This suggests that changing Truckee River reservoir operations and capturing this undiverted Claim 3 water may be the lowest cost and most effective manner of meeting the Study's water supply objectives.

Several of the Study alternatives deviate from the Desired Reliability conditions evaluated in this appendix, and the conditions of each of these alternatives change the timing, frequency, and magnitude of the volumes shown in D6-2. In general, smaller Truckee Canal capacities result in smaller diversions at Derby Dam and larger shortfalls for the Project. These varying conditions are not explored in this appendix, and such analyses would be needed to determine how a diminished Truckee Canal would affect Claim 3 water rights.

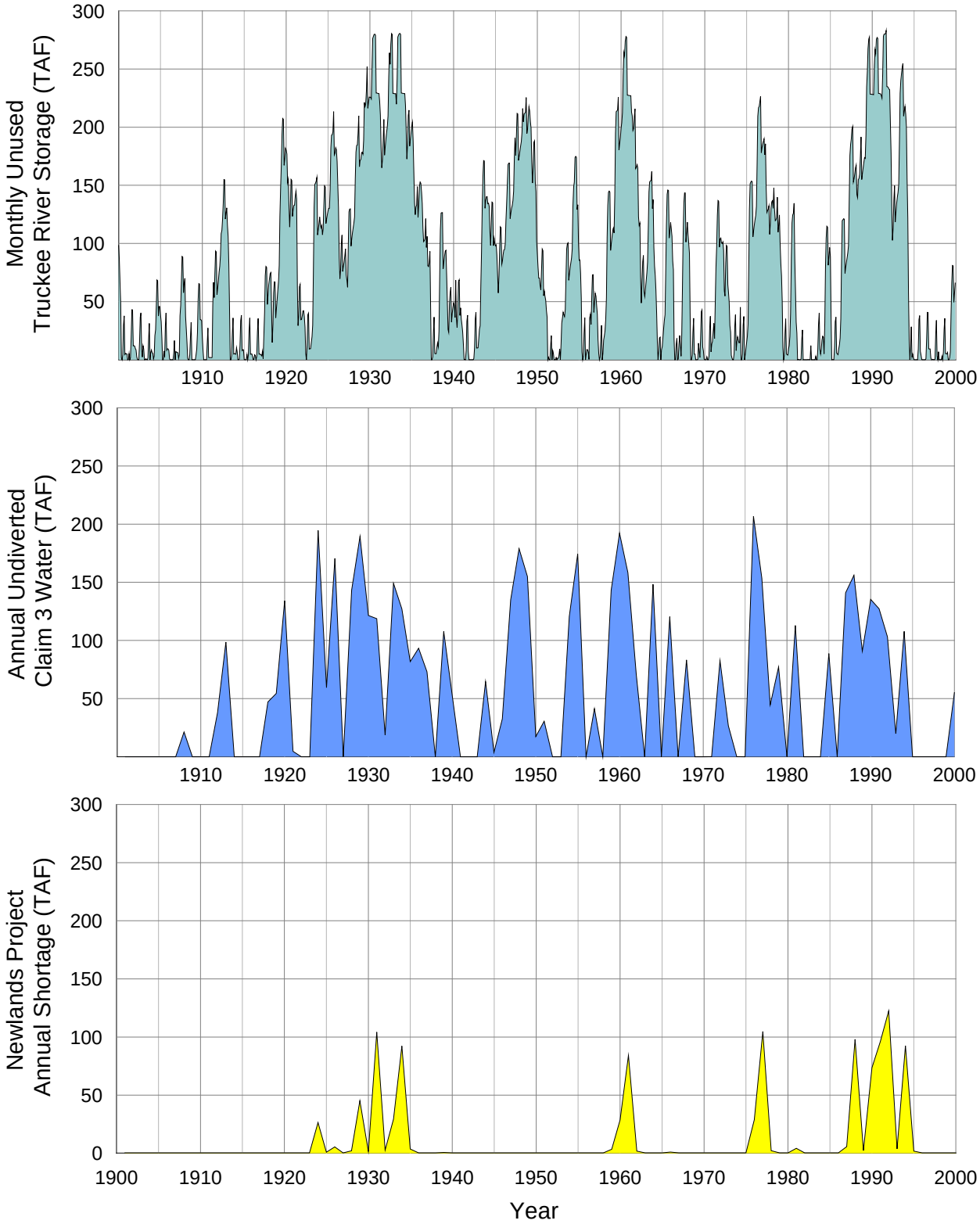

Figure D6-2. Comparison of Unused Truckee River Storage, Undiverted Claim 3 Water, and Newlands Project Annual Shortages

Appendix D7
Effects of Acquiring Additional Carson River Storage and Water Rights on Newlands Project Water Supply

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
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U.S. Department of the Interior
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Abbreviations and Acronyms

cfs	cubic feet per second
OCAP	Operations Criteria and Plan for the Newlands Project
Project	Newlands Project
Study	Newlands Project Planning Study
TAF	thousand acre-feet
TROA	Truckee River Operating Agreement

Appendix D7 – Effects of Lahontan Storage Increases on Newlands Project Water Supply

This appendix characterizes how increasing Lahontan Reservoir storage capacity contributes to the water supply objective of the Newlands Project Planning Study (Study). The Study's water supply objective requires the reliable delivery of water supplies to water rights holders in the Newlands Project (Project) or actions to mitigate water supply conditions that are less than reliable.

This appendix presents one of several screening assessments conducted for the Study, all of which are presented in Appendices D1 through D7. These screening analyses were designed to provide inter-comparisons among several measures that could potentially contribute to meeting the Study's water supply objective. Thus, the measures studied and outcomes published in this appendix are not being proposed as alternatives for the Study, but are instead presented to inform decisions on which measures best meet the Study's objectives.

The following analysis describes how increasing the storage capacity of Lahontan Reservoir would change the water supply of the Project. A variety of methods were identified for increasing storage at Lahontan Reservoir, including lining the Carp Lobe of Lahontan Reservoir and reopening it, reinforcing flashboards at Lahontan Reservoir and allowing for surcharging during wet conditions, and raising Lahontan Dam. The additional storage provided by these measures would fall between 10 thousand acre-feet (TAF) and 166 TAF. For this analysis, a range of storage increases was selected to bracket discussions of projects that may increase storage. The range of analysis considered includes additions of 10, 20, 150, and 200 TAF of storage to Lahontan Reservoir.

Performance toward the water supply objective is measured against two conditions:

1. A Desired Reliability scenario, which represents the desired performance.

2. Flow-stage reference scenarios, which serve as a starting point for applying additional measures – such as increasing available storage.

The Desired Reliability scenario describes the ability of the Project to meet current levels of demand, in compliance with Operations Criteria and Procedures for the Newlands Project (OCAP), with a 900-cubic-feet-per-second (cfs) Truckee Canal capacity. As the name implies, the flow-stage reference scenarios are built around a range of Truckee Canal flow stages developed for meeting U.S. Department of the Interior, Bureau of Reclamation, safety

standards (600, 350, 250, 150, and 0 cfs). The flow-stage reference scenarios consider the ability of the Project to meet anticipated future levels of demand, under OCAP, with the indicated flow-stage capacity for the Truckee Canal. Increases in storage are applied to the flow-stage reference conditions, with the intent of meeting or exceeding the Desired Reliability conditions. The Desired Reliability and flow-stage reference scenarios are described in Appendix D1.

Methods

The following analysis looks at effects of varying Truckee Canal capacity and Lahontan Reservoir storages. Numerical results are simulated outputs of the Pre-Truckee River Operating Agreement (TROA) Planning Model, which was selected and modified for use in the Study, as described in Appendices B1, B2, B3, and C. The Pre-TROA Planning Model is built in a RIVERWARE modeling environment, and both "slots" are features of the RIVERWARE environment that accept user inputs.

Truckee Canal capacity is entered to the Pre-TROA Planning Model through the slot, TRUCKEECANALDIV.CANALCAPACITYDEFAULT. The flow-stage conditions evaluated include 600, 350, 250, 150, and 0 cfs.

The alternative storage capacities were modeled by updating the Lahontan Reservoir Elevation Volume Table and Elevation Area Table. In addition, the LAHONTANDATA.STORAGES slot was updated to include the new maximum storage capacities at the crest of the dam. This slot is used to assign releases from Lahontan Reservoir.

The existing Lahontan Reservoir storage capacity is assumed to be 289,721 acre-feet. The following analysis was structured to evaluate the effects of adding an additional 10, 20, 150, and 200 TAF. The additional storage volume is modeled by altering the storage-elevation curve for Lahontan Reservoir, beginning at 4,152 feet – 10 feet below the crest of the dam. The surface area of the new reservoir was adjusted to provide the four storage increase alternatives. Table D7-1 shows the adjustments to the storage-capacity curves for each increment of additional storage being assessed.

Table D7-1. Lahontan Reservoir Storage Elevation Relationships Used for Screening Analyses

Pool Elevation (feet)	Initial Condition Storage (acre-feet)	+10 TAF Storage (acre-feet)	+20 TAF Storage (acre-feet)	+150 TAF Storage (acre-feet)	+200 TAF Storage (acre-feet)
4,152	191,624	191,624	191,624	191,624	191,624
4,162	289,721	299,721	309,721	439,721	489,721

Key:
TAF = thousand acre-feet

For the purposes of this analysis, the use of flashboards to provide additional storage after the peak inflow has occurred has been turned off. All other aspects of Lahontan Reservoir operations within the Study version of the Pre-TROA Planning Model remain unchanged, including OCAP storage target logic, maximum release capacities, spill capacities, and loss logic. Losses on Lahontan Reservoir are calculated using a regression equation that was developed based on historic data and therefore does not fully represent the new hypothetical reservoir capacities. In these simulations Lahontan Reservoir losses are underrepresented.

The methodology selected underestimates potential losses from Lahontan Reservoir from evapotranspiration, so improvements to reliability are likely overstated. This was deemed acceptable for screening measures.

As described in Appendix B2, this – and all other screening analyses – were evaluated over a 100-year period, from 1901 through 2000.

Results and Conclusions

Rather than present water supply reliability in terms of a singular number, the Study's concept for reliability includes two features: (1) the frequency of shortfall, and (2) the magnitude of shortfall. As such, reliability must be presented in a two-dimensional context that allows for the evaluation of both frequency and magnitude. This section presents modeling results through a number of plots that illustrate these two components of reliability for flow-stage reference scenarios with and without additional Lahontan Reservoir storage, relative to the Desired Reliability scenario. The reference scenario for each flow stage represents the starting point for each screening analysis of increasing Lahontan storage capacity.

Figures in the subsections below are provided for visual comparisons of changes in reliability. On the plot in the top portion of the figures, the Desired Reliability and flow-stage scenarios are represented in terms of percent of annual demand met, and include the ranked results from 100 years of simulated data (see Appendix D1). The bottom half of each figure is a chart that illustrates

the difference between each scenario and the Desired Reliability, expressed as a volume (TAF).

For each flow stage, observations are made about the **net difference** in deliveries relative to the Desired Reliability, which is calculated from the sum of positive and negative volumes depicted in the lower plots shown for each flow stage. Negative net differences indicate that a deficit exists between the Desired Reliability the long-term average water supply for the given scenario. Positive, or net zero conditions, indicate that the long-term average delivery appears equal to or better than the Desired Reliability condition.

NOTE: the rank of a specific year will not necessarily match between the Desired Reliability and flow-stage reference scenarios, or even across the range of reference scenarios. It follows that implementing measures, such as increasing Lahontan Reservoir storage capacity, would similarly result in a change to the ranking of years. The resulting line (sequencing in a manner that does not consistently ascend from low to high rank) reflects the complex manner in which different actions affect the water supply of the Project. Despite this, the trends and results from applying demand reduction measures can be clearly interpreted.

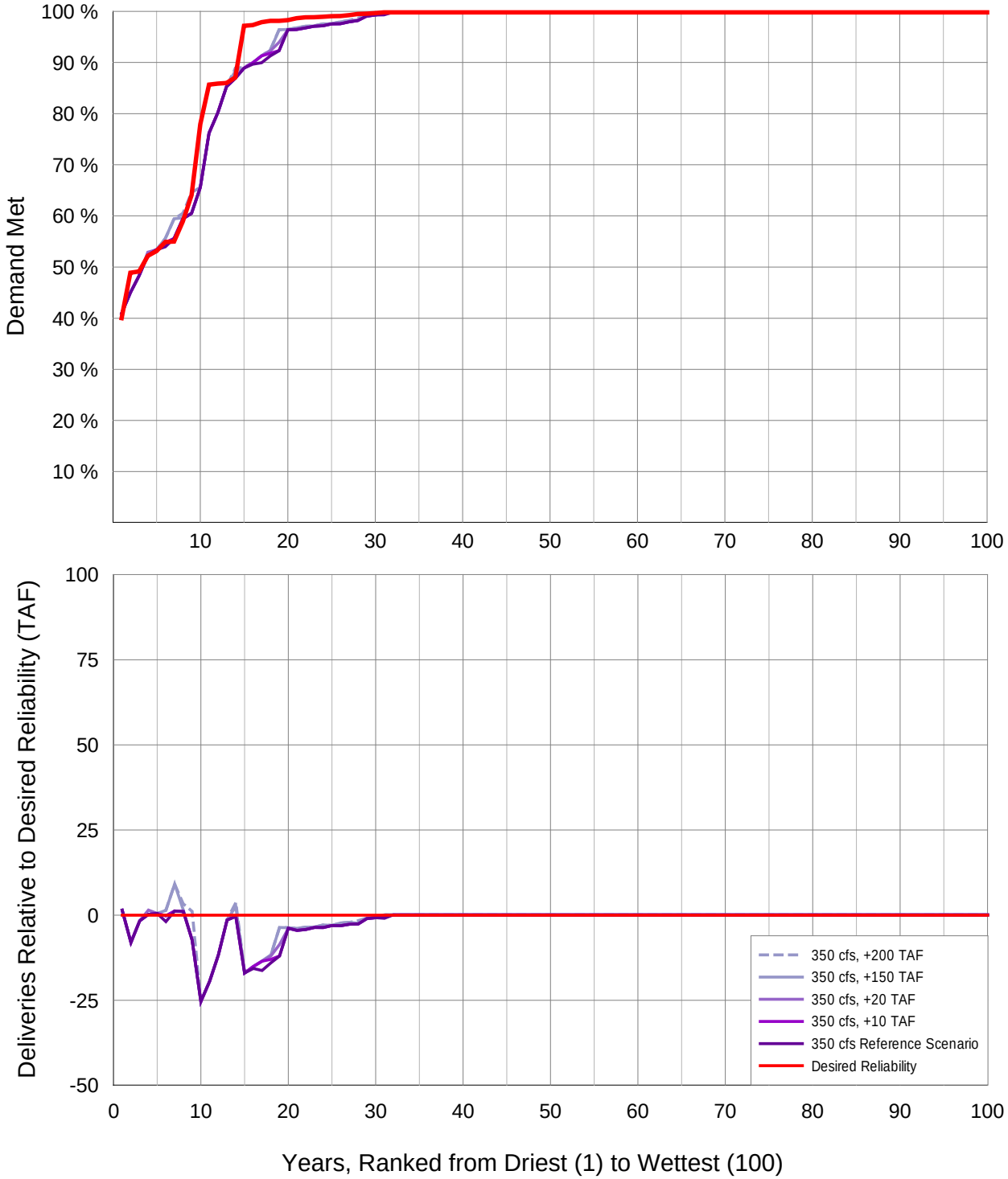
350 cfs Scenario with Increased Lahontan Storage Capacity

Figure D7-1 demonstrates the effects of increasing Lahontan storage capacity for alternatives that consider a 350 cfs flow stage for the Truckee Canal. Increasing Lahontan storage capacity does not significantly improve water supply reliability relative to that of the Desired Reliability, regardless of the size of the capacity increase.

Net differences between the Desired Reliability and the range of 350 cfs flow stages are as follows:

- -176 TAF for the 350 cfs reference scenario
- -170 TAF with an additional 10 TAF storage capacity
- -164 TAF with an additional 20 TAF storage capacity
- -143 TAF with an additional 150 TAF storage capacity
- -129 TAF with an additional 200 TAF storage capacity

Increasing Lahontan storage capacity for a 350 cfs flow stage does not significantly improve the water supply reliability. The net differences in deliveries relative to the Desired Reliability remain negative with only minor improvements, and these results are not significant enough to further consider this measure.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D7-1. Performance of the 350 cfs Scenario, with Additional Storage

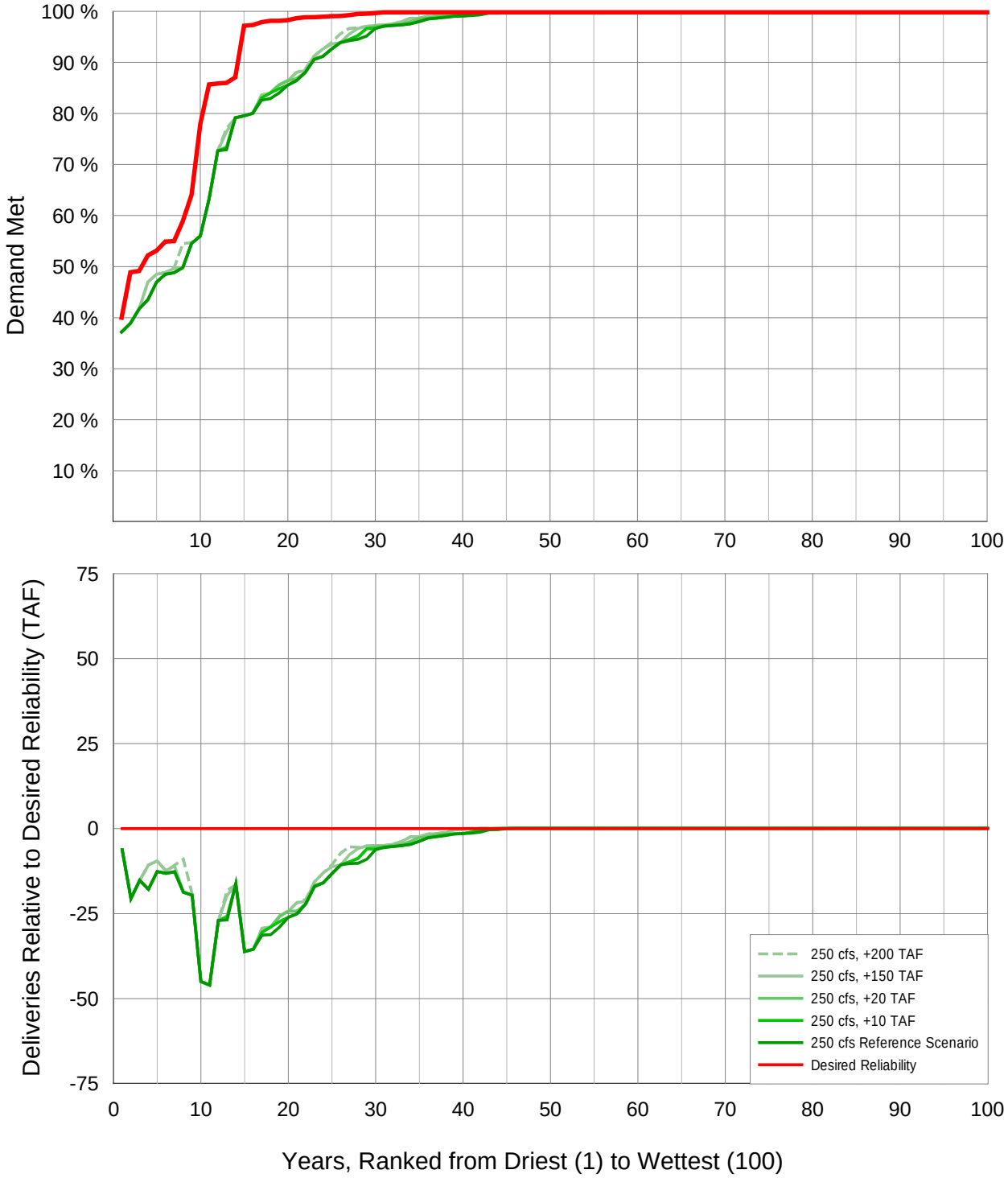
250 cfs Scenario with Increased Lahontan Storage Capacity

Figure D7-2 demonstrates the effects of increasing Lahontan storage capacity for alternatives that consider a 250 cfs flow stage for the Truckee Canal. Increasing Lahontan storage capacity does not significantly improve water supply reliability relative to that of the Desired Reliability, regardless of the size of the capacity increase.

Net differences between the Desired Reliability and the range of 250 cfs flow stages are as follows:

- -660 TAF for the 250 cfs reference scenario
- -647 TAF with an additional 10 TAF storage capacity
- -638 TAF with an additional 20 TAF storage capacity
- -594 TAF with an additional 150 TAF storage capacity
- -574 TAF with an additional 200 TAF storage capacity

Increasing Lahontan storage capacity for a 250 cfs flow stage does not significantly improve the water supply reliability. The net differences in deliveries relative to the Desired Reliability remain negative with only minor improvements, and these results are not significant enough to further consider this measure.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D7-2. Performance of the 250 cfs Scenario, with Additional Storage

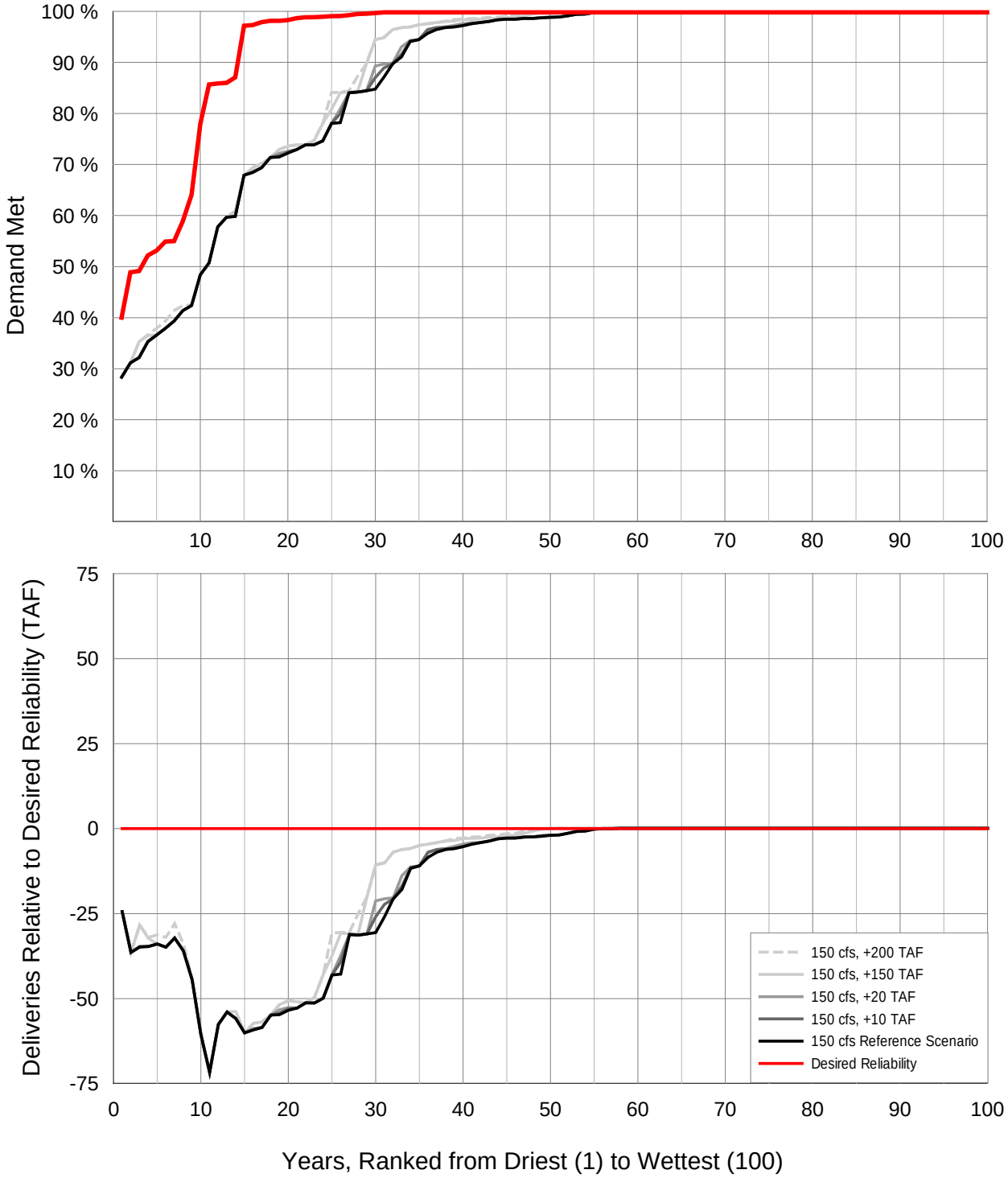
150 cfs Scenario with Increased Lahontan Storage Capacity

Figure D7-3 demonstrates the effects of increasing Lahontan storage capacity for alternatives that consider a 150 cfs flow stage for the Truckee Canal. Increasing Lahontan storage capacity does not significantly improve water supply reliability relative to that of the Desired Reliability, regardless of the size of the capacity increase.

Net differences between the Desired Reliability and the range of 150 cfs flow stages are as follows:

- -1519 TAF for the 150 cfs reference scenario
- -1502 TAF with an additional 10 TAF storage capacity
- -1486 TAF with an additional 20 TAF storage capacity
- -1353 TAF with an additional 150 TAF storage capacity
- -1322 TAF with an additional 200 TAF storage capacity

Increasing Lahontan storage capacity for a 150 cfs flow stage does not significantly improve the water supply reliability. The net differences in deliveries relative to the Desired Reliability remain negative with only minor improvements, except for the additional 150 and 200 TAF scenarios for years ranked 30 – 35. Overall, these results are not significant enough to further consider this measure.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D7-3. Performance of the 150 cfs Scenario, with Additional Storage

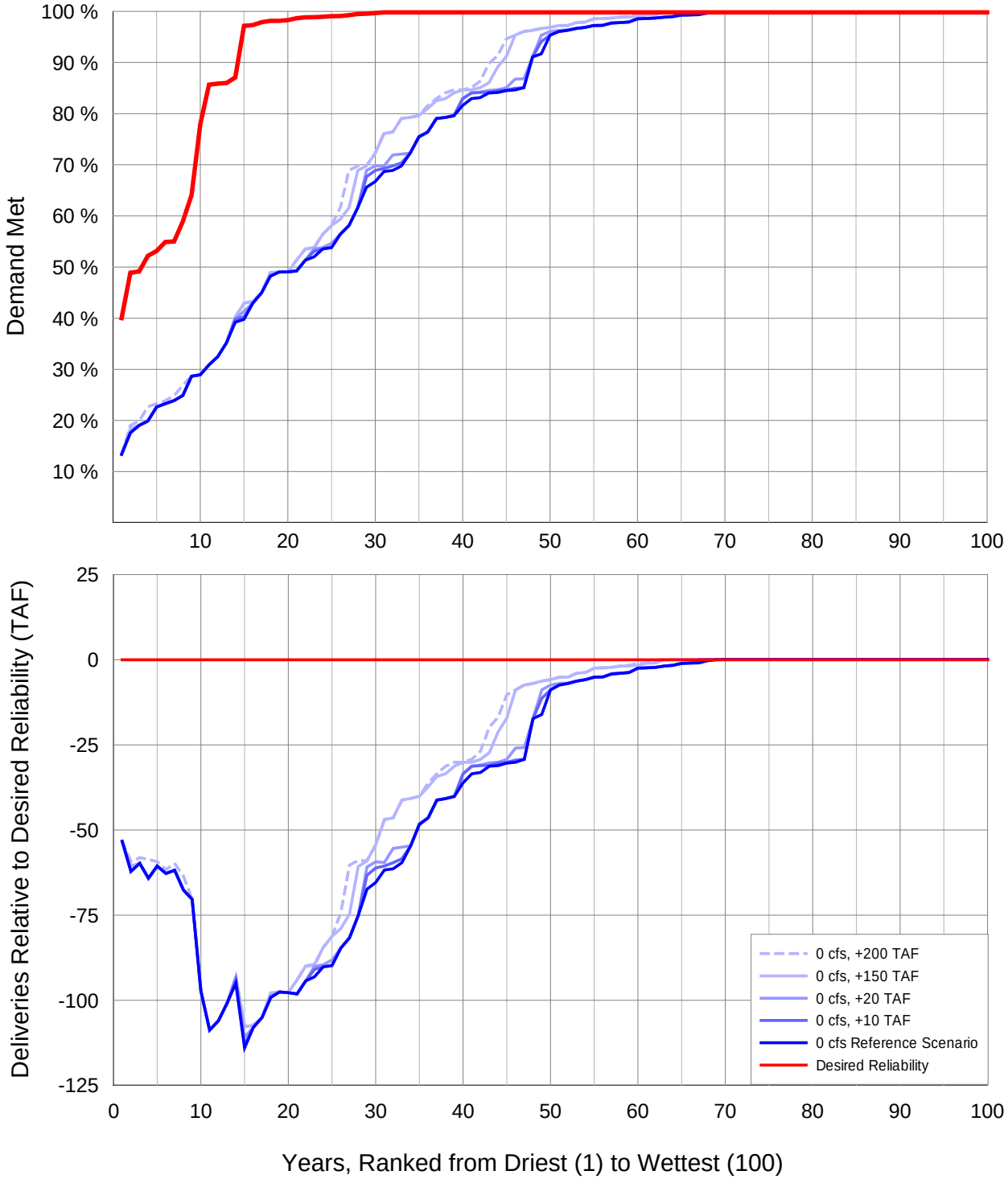
0 cfs Scenario with Increased Lahontan Storage Capacity

Figure D7-4 demonstrates the effects of increasing Lahontan storage capacity for alternatives that consider a 0 cfs flow stage for the Truckee Canal. Increasing Lahontan storage capacity does not significantly improve water supply reliability relative to that of the Desired Reliability, regardless of the size of the capacity increase.

Net differences between the Desired Reliability and the range of 0 cfs flow stages are as follows:

- -3344 TAF for the 0 cfs reference scenario
- -3312 TAF with an additional 10 TAF storage capacity
- -3279 TAF with an additional 20 TAF storage capacity
- -3019 TAF with an additional 150 TAF storage capacity
- -2953 TAF with an additional 200 TAF storage capacity

Increasing Lahontan storage capacity for a 0 cfs flow stage does not significantly improve the water supply reliability. The net differences in deliveries relative to the Desired Reliability remain negative with only minor improvements, except for the additional 150 and 200 TAF scenarios for years ranked 25 – 50. Overall, these results are not significant enough to further consider this measure.



Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

Figure D7-4. Performance of the 0 cfs Scenario, with Additional Storage

Summary of Results

Additional storage capacity in Lahontan Reservoir produces a number of changes to water supply deliveries in the Truckee and Carson river basins, but does not increase water supply reliability for the Project. Increased storage capacity would allow Lahontan Reservoir to capture a greater portion of Carson River inflows, resulting in a reduction in spills (Table D7-2). Spills do not count toward water rights deliveries. However, the U.S. Fish and Wildlife Service currently benefits from incidental spills, which can be delivered to wetlands for ecosystem maintenance purposes. This ecosystem demand will not be met if the storage capacity increased and spills were to be eliminated. The lack of water delivery improvement with additional Lahontan storage capacity may be due to this ecosystem demand.

Table D7-2. Cumulative Spill from Lahontan Reservoir for the Period of 1901 Through 2000, by Flow-Stage Scenario and by Lahontan Storage Increase

		Truckee Canal Flow-Stage Scenario				
		0 cfs	**150 cfs**	**250 cfs**	**350 cfs**	**600 cfs**
Lahontan Reservoir Increase	**Reference Scenarios**	**349**	**364**	**371**	**380**	**397**
	10 TAF	909	969	1040	1088	1142
	20 TAF	862	921	980	1022	1080
	150 TAF	641	664	677	696	696
	200 TAF	567	580	584	598	603

Key:
cfs = cubic feet per second
TAF = thousand acre-feet

Capturing greater volumes of Carson River supplies during wet years does not translate into a greater available supply during dry years. OCAP establishes end-of month storage targets in Lahontan Reservoir, and only allows enough water to be delivered from the Truckee River to meet these storage targets. Scenarios with additional storage capacities store more water from the Carson River, closer to the OCAP storage targets in the years following wet conditions on the Carson River. As a result, these years receive less water from the Truckee River and end up with a water supply condition that is similar to conditions without the additional storage (Table D7-3). As noted in the Methods section, this analysis understates reservoir losses so the gain in reliability from an enlarged Lahontan Reservoir would be less than the simulated results.

Table D7-3. Average Annual Delivery to the Newlands Project, by Flow-Stage Scenario and by Lahontan Storage Increase

		Truckee Canal Flow-Stage Scenario				
		0 cfs	**150 cfs**	**250 cfs**	**350 cfs**	**600 cfs**
Lahontan Reservoir Increase	**Reference Scenarios**	**75%**	**87%**	**91%**	**94%**	**95%**
	10 TAF	75%	87%	91%	94%	95%
	20 TAF	76%	87%	92%	94%	95%
	150 TAF	77%	88%	92%	94%	95%
	200 TAF	77%	88%	92%	94%	95%

Key:
cfs = cubic feet per second
TAF = thousand acre-feet

Because of the way OCAP limits Truckee River diversions, increases in Lahontan Reservoir storage results in improvements to the average water supply for Pyramid Lake (Table D7-4).

Table D7-4. Average Annual Inflow (TAF) to Pyramid Lake, by Flow-Stage Scenario and by Lahontan Storage Increase

		Truckee Canal Flow-Stage Scenario				
		0 cfs	**150 cfs**	**250 cfs**	**350 cfs**	**600 cfs**
Lahontan Reservoir Increase	**Reference Scenarios**	**583**	**523**	**502**	**491**	**482**
	10 TAF	583	524	503	492	484
	20 TAF	583	524	504	493	485
	150 TAF	583	528	510	500	494
	200 TAF	583	528	511	502	495

Key:
cfs = cubic feet per second
TAF = thousand acre-feet

Three general conclusions can be drawn from this analysis:

1. Project demands exceed the existing supplies from the Carson River.

2. OCAP prevents additional Lahontan Reservoir storage from increasing the water supply reliability of the Project.

3. Enlarging the storage of Lahontan Reservoir could improve reliability for the Project if combined with actions that increase Project supplies, including:

    i. If the Project obtained a volume of water rights from the upper Carson River that replaces or exceeds the Project supplies from the Truckee River (see Appendix D5); or

ii. If OCAP were restructured to allow for diversion of supplies from the Truckee River to exceed needs for a single year of operation; or

iii. If storage were provided to better regulate the timing of deliveries from Truckee River supplies (see Appendix D6).

Table D7-5 below reports on and compares the frequency and magnitude of shortages in the Project under the Desired Reliability scenario, flow-stage reference scenarios, and flow-stage scenarios once the increase in Lahontan Reservoir storage measure is applied.

Table D7-5. Project Reliability for Desired Reliability Reference Scenario and with Increased Lahontan Reservoir Storage Capacity

		Number of Years Where >95% of Demand is Met	Number of Years Where <50% of Demand is Met	Percent of Demand Met in Driest Year	Net Difference with Desired Reliability (TAF)
Desired Reliability		**86**	**3**	**40%**	**NA**
350 cfs	200 TAF	82	3	41%	-129
	150 TAF	82	3	41%	-143
	20 TAF	81	3	41%	-164
	10 TAF	81	3	41%	-170
250 cfs	200 TAF	75	7	37%	-574
	150 TAF	74	8	37%	-594
	20 TAF	73	8	37%	-638
	10 TAF	73	8	37%	-647
150 cfs	200 TAF	69	10	28%	-1,322
	150 TAF	69	10	28%	-1,353
	20 TAF	65	10	28%	-1,486
	10 TAF	65	10	28%	-1,502
0 cfs[1]	200 TAF	46	21	13%	-2,953
	150 TAF	46	21	13%	-3,019
	20 TAF	41	22	13%	-3,279
	10 TAF	41	22	13%	-3,312

Note:
[1] Carson Division only; Truckee Division demand will be met through means other than the Truckee Canal in a 0 cfs alternative.
Key:
cfs = cubic-foot per second
TAF = thousand acre-feet

To support additional use by the Study or other parties, Table D7-6 notes the annual average and maximum annual spills from Lahontan Reservoir.

Table D7-6. Additional Characteristics of Increased Lahontan Reservoir Capacity (Annual Basis)

		Lahontan Reservoir Maximum Spill (TAF)	Lahontan Reservoir Average Spill (TAF)
Desired Reliability		**236**	**12**
600 cfs	200 TAF	226	6
	150 TAF	228	7
	20 TAF	237	11
	10 TAF	238	11
350 cfs	200 TAF	226	6
	150 TAF	228	7
	20 TAF	237	10
	10 TAF	238	11
250 cfs	200 TAF	226	6
	150 TAF	228	7
	20 TAF	237	10
	10 TAF	238	10
150 cfs	200 TAF	226	6
	150 TAF	228	7
	20 TAF	237	9
	10 TAF	238	10
0 cfs	200 TAF	226	6
	150 TAF	228	6
	20 TAF	237	9
	10 TAF	238	9

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Appendix D7
Effects of Storage Increases on Newlands Project Water Supply

Attachment: Data Table

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

January 2013

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Attachment: Data Table

The following tables summarize results for the 100-year period of analysis, relative to both the Desired Reliability and flow-stage reference scenarios from Appendix D1. Tables show annual summaries of water deliveries to the Project.

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Table: Annual Deliveries to Carson Division in TAF

Year	Desired Reliability	0 cfs, Increase in Lahontan Storage				150 cfs, Increase in Lahontan Storage				250 cfs, Increase in Lahontan Storage				350 cfs, Increase in Lahontan Storage			
		10 TAF	20 TAF	150 TAF	200 TAF	10 TAF	20 TAF	150 TAF	200 TAF	10 TAF	20 TAF	150 TAF	200 TAF	10 TAF	20 TAF	150 TAF	200 TAF
1901	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1902	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1903	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1904	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1905	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1906	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1907	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1908	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1909	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1910	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1911	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1912	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1913	205	105	108	164	188	159	161	195	198	187	187	198	198	198	198	198	198
1914	205	194	194	196	198	196	196	198	198	198	198	198	198	198	198	198	198
1915	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1916	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1917	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1918	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1919	205	169	172	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1920	205	98	98	118	139	142	143	160	173	180	180	186	192	198	198	198	198
1921	205	181	181	181	181	195	195	196	197	197	197	198	198	198	198	198	198
1922	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1923	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1924	178	96	96	97	97	144	144	146	146	168	172	175	176	182	186	195	196
1925	204	167	167	167	167	195	195	195	195	196	197	197	197	198	198	198	198
1926	200	70	70	70	70	115	115	115	115	157	157	157	157	179	178	178	178
1927	205	192	192	192	192	194	194	194	194	196	196	196	196	197	197	197	197
1928	203	112	112	112	112	168	168	168	168	193	193	193	193	198	198	198	198
1929	160	64	64	64	64	101	101	101	101	126	126	126	126	152	152	152	152
1930	204	97	97	97	97	138	138	138	138	158	158	158	158	176	176	176	176
1931	104	46	46	46	46	72	72	72	72	85	85	85	85	91	91	91	91
1932	203	189	189	189	189	193	193	193	193	194	194	194	194	194	194	194	194
1933	178	89	89	89	89	136	136	136	136	160	160	160	160	171	171	171	171
1934	116	49	49	49	49	77	77	77	77	95	95	95	95	108	108	108	108
1935	203	137	137	137	137	168	168	168	168	185	185	185	185	194	194	194	194
1936	205	168	168	168	168	197	197	197	197	198	198	198	198	198	198	198	198
1937	205	157	157	157	157	198	198	198	198	198	198	198	198	198	198	198	198
1938	205	196	196	196	196	198	198	198	198	198	198	198	198	198	198	198	198
1939	204	167	172	198	198	192	194	198	198	198	198	198	198	198	198	198	198
1940	205	167	167	171	171	198	198	198	198	198	198	198	198	198	198	198	198
1941	205	158	158	158	158	196	196	198	198	198	198	198	198	198	198	198	198
1942	205	197	197	197	197	198	198	198	198	198	198	198	198	198	198	198	198
1943	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1944	205	150	150	151	151	187	187	188	188	198	198	198	198	198	198	198	198
1945	205	191	191	191	191	198	198	198	198	198	198	198	198	198	198	198	198
1946	205	152	152	152	152	198	198	198	198	198	198	198	198	198	198	198	198
1947	205	97	97	97	97	145	145	145	145	181	181	181	181	198	198	198	198
1948	205	102	102	102	102	142	142	142	142	167	167	167	167	191	191	191	191
1949	205	106	106	106	106	147	147	147	147	172	172	172	172	191	191	191	191
1950	205	169	169	169	169	196	196	196	196	197	197	197	197	198	198	198	198
1951	205	197	197	197	197	198	198	198	198	198	198	198	198	198	198	198	198
1952	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1953	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1954	205	134	139	177	178	176	178	198	198	198	198	198	198	198	198	198	198
1955	205	79	79	80	80	119	119	121	121	146	146	152	153	173	173	175	177
1956	205	193	193	193	193	194	194	195	195	195	196	196	196	197	197	197	197
1957	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1958	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1959	201	80	82	86	86	136	136	139	140	165	165	166	166	181	181	181	181
1960	176	45	45	45	45	82	82	82	82	108	108	108	108	130	130	130	130
1961	122	39	39	39	39	73	73	73	73	97	97	97	97	119	119	119	119
1962	203	139	139	139	139	178	178	178	178	194	194	194	194	194	194	194	194
1963	205	196	196	196	196	197	197	197	197	198	198	198	198	198	198	198	198
1964	205	85	85	85	85	147	147	147	147	175	175	175	175	193	193	193	193
1965	205	193	193	193	193	195	195	195	195	197	197	197	197	198	198	198	198
1966	204	122	122	122	122	167	167	167	167	186	186	186	186	198	198	198	198
1967	205	194	194	194	194	196	196	196	196	198	198	198	198	198	198	198	198
1968	205	157	157	157	157	193	193	193	193	198	198	198	198	198	198	198	198
1969	205	196	196	196	196	198	198	198	198	198	198	198	198	198	198	198	198
1970	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1971	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1972	205	140	143	161	162	182	185	195	196	198	198	198	198	198	198	198	198
1973	205	168	168	168	168	197	198	198	198	198	198	198	198	198	198	198	198
1974	205	197	197	197	197	198	198	198	198	198	198	198	198	198	198	198	198
1975	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1976	176	57	57	57	57	119	119	119	119	144	144	144	144	159	159	159	159
1977	102	27	27	27	27	57	57	57	57	78	78	78	78	97	97	97	97
1978	203	165	165	165	165	192	192	192	192	193	193	193	193	194	194	194	194
1979	205	144	144	144	144	187	187	187	187	198	198	198	198	198	198	198	198
1980	205	196	196	196	196	198	198	198	198	198	198	198	198	198	198	198	198
1981	200	115	115	115	115	155	155	155	155	189	189	189	189	198	198	198	198
1982	205	194	194	194	194	196	196	196	196	198	198	198	198	198	198	198	198
1983	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1984	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1985	205	187	191	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1986	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1987	199	138	143	198	198	173	177	198	198	192	196	198	198	198	198	198	198
1988	110	35	35	37	53	65	65	74	86	88	88	100	110	111	111	120	130
1989	203	107	107	107	106	148	148	148	148	170	170	170	170	183	183	183	183
1990	134	47	47	47	47	79	79	79	79	100	100	100	100	112	111	111	112
1991	111	57	57	57	57	85	85	85	85	98	98	98	98	105	106	105	106
1992	85	38	38	38	38	63	63	63	63	75	75	75	75	83	83	83	83
1993	202	191	191	191	191	192	192	192	192	193	193	193	193	193	193	193	193
1994	116	61	61	61	61	98	98	98	98	113	113	113	113	122	122	122	122
1995	203	192	192	192	192	194	194	194	194	194	194	194	194	195	195	195	195
1996	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1997	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1998	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
1999	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
2000	205	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198	198
Average	**194**	**155**	**155**	**158**	**158**	**173**	**174**	**175**	**175**	**182**	**182**	**182**	**182**	**186**	**186**	**187**	**187**
Maximum	**205**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**	**198**
Minimum	**85**	**27**	**27**	**27**	**27**	**57**	**57**	**57**	**57**	**75**	**75**	**75**	**75**	**83**	**83**	**83**	**83**

Table: Annual Deliveries to Truckee Division in TAF

Year	Desired Reliability	0 cfs, Increase in Lahontan Storage				150 cfs, Increase in Lahontan Storage				250 cfs, Increase in Lahontan Storage				350 cfs, Increase in Lahontan Storage			
		10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF
1901	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1902	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1903	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1904	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1905	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1906	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1907	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1908	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1909	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1910	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1911	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1912	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1913	10	0	0	0	0	5	5	7	7	6	6	7	7	7	7	7	7
1914	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1915	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1916	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1917	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1918	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1919	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1920	10	0	0	0	0	5	5	5	6	6	6	6	7	7	7	7	7
1921	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1922	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1923	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1924	9	0	0	0	0	5	5	5	5	6	6	6	6	6	6	7	7
1925	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1926	10	0	0	0	0	4	4	4	4	5	5	5	5	6	6	6	6
1927	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1928	10	0	0	0	0	6	6	6	6	7	7	7	7	7	7	7	7
1929	8	0	0	0	0	3	3	3	3	4	4	4	4	5	5	5	5
1930	10	0	0	0	0	5	5	5	5	5	5	5	5	6	6	6	6
1931	2	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1932	10	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6
1933	6	0	0	0	0	3	3	3	3	4	4	4	4	4	4	4	4
1934	3	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2
1935	9	0	0	0	0	5	5	5	5	5	5	5	5	5	5	5	5
1936	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1937	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1938	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1939	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1940	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1941	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1942	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1943	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1944	10	0	0	0	0	6	7	7	7	7	7	7	7	7	7	7	7
1945	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1946	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1947	10	0	0	0	0	5	5	5	5	6	6	6	6	7	7	7	7
1948	10	0	0	0	0	5	5	5	5	6	6	6	6	6	6	6	6
1949	10	0	0	0	0	5	5	5	5	6	6	6	6	7	7	7	7
1950	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1951	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1952	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1953	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1954	10	0	0	0	0	6	6	7	7	7	7	7	7	7	7	7	7
1955	10	0	0	0	0	4	4	4	4	5	5	5	5	6	6	6	6
1956	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1957	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1958	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1959	10	0	0	0	0	4	4	4	4	5	5	5	5	6	6	6	6
1960	9	0	0	0	0	3	3	3	3	3	3	3	3	4	4	4	4
1961	5	0	0	0	0	2	2	2	2	3	3	3	3	3	3	3	3
1962	10	0	0	0	0	6	6	6	6	7	7	7	7	7	7	7	7
1963	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1964	10	0	0	0	0	5	5	5	5	6	6	6	6	7	7	7	7
1965	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1966	10	0	0	0	0	5	5	5	5	6	6	6	6	7	7	7	7
1967	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1968	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1969	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1970	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1971	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1972	10	0	0	0	0	6	6	7	7	7	7	7	7	7	7	7	7
1973	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1974	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1975	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1976	9	0	0	0	0	4	4	4	4	5	5	5	5	5	5	5	5
1977	3	0	0	0	0	1	1	1	1	1	1	1	1	2	2	2	2
1978	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1979	10	0	0	0	0	6	6	6	6	7	7	7	7	7	7	7	7
1980	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1981	10	0	0	0	0	5	5	5	5	7	7	7	7	7	7	7	7
1982	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1983	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1984	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1985	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1986	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1987	10	0	0	0	0	6	6	7	7	7	7	7	7	7	7	7	7
1988	3	0	0	0	0	1	1	1	1	1	1	1	2	2	2	2	2
1989	10	0	0	0	0	5	5	5	5	6	6	6	6	6	6	6	6
1990	4	0	0	0	0	2	2	2	2	2	2	2	2	2	3	2	2
1991	3	0	0	0	0	2	2	2	2	2	2	2	2	2	2	2	2
1992	2	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	1
1993	9	0	0	0	0	6	6	6	6	6	6	6	6	6	6	6	6
1994	2	0	0	0	0	1	1	1	1	2	2	2	2	2	2	2	2
1995	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
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1997	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1998	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
1999	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
2000	10	0	0	0	0	7	7	7	7	7	7	7	7	7	7	7	7
Average	**10**	**0**	**0**	**0**	**0**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**	**6**
Maximum	**10**	**0**	**0**	**0**	**0**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**
Minimum	**2**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Table: Annual Deliveries to Newlands Project in TAF

Year	Desired Reliability	0 cfs, Increase in Lahontan Storage				150 cfs, Increase in Lahontan Storage				250 cfs, Increase in Lahontan Storage				350 cfs, Increase in Lahontan Storage			
		10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF	10 TAF	20 TAF	100 TAF	250 TAF
1901	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1902	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1903	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1904	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1905	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1906	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1907	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1908	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1909	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1910	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1911	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1912	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1913	215	105	108	164	188	164	166	201	205	194	194	205	205	205	205	205	205
1914	215	194	194	196	198	203	203	205	205	204	204	205	205	205	205	205	205
1915	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1916	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1917	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
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1919	215	169	172	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1920	215	98	98	118	139	147	148	166	179	186	186	192	198	205	205	205	205
1921	215	181	181	181	181	202	202	203	203	204	204	204	205	205	205	205	205
1922	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1923	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1924	188	96	96	97	97	149	149	151	151	174	178	181	182	188	193	202	202
1925	214	167	167	167	167	202	202	202	202	203	203	204	204	204	205	205	205
1926	210	70	70	70	70	119	118	118	118	162	162	162	162	184	184	184	184
1927	215	192	192	192	192	201	201	201	201	202	202	202	202	204	204	204	204
1928	213	112	112	112	112	173	173	173	173	199	199	199	199	205	205	205	205
1929	168	64	64	64	64	104	104	104	104	130	130	130	130	156	156	156	156
1930	214	97	97	97	97	142	142	142	142	163	163	163	163	182	182	182	182
1931	106	46	46	46	46	72	72	72	72	86	86	86	86	92	92	92	92
1932	212	189	189	189	189	199	199	199	199	200	200	200	200	200	200	200	200
1933	184	89	89	89	89	139	139	139	139	164	164	164	164	175	175	175	175
1934	118	49	49	49	49	78	78	78	78	96	96	96	96	110	110	110	110
1935	211	137	137	137	137	173	173	173	173	190	190	190	190	199	199	199	199
1936	215	168	168	168	168	203	203	203	203	205	205	205	205	205	205	205	205
1937	215	157	157	157	157	205	205	205	205	205	205	205	205	205	205	205	205
1938	215	196	196	196	196	205	205	205	205	205	205	205	205	205	205	205	205
1939	215	167	172	198	198	199	201	205	205	205	205	205	205	205	205	205	205
1940	215	167	167	171	171	205	205	205	205	205	205	205	205	205	205	205	205
1941	215	158	158	158	158	203	203	205	205	205	205	205	205	205	205	205	205
1942	215	197	197	197	197	205	205	205	205	205	205	205	205	205	205	205	205
1943	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1944	215	150	150	151	151	193	193	194	195	205	205	205	205	205	205	205	205
1945	215	191	191	191	191	205	205	205	205	205	205	205	205	205	205	205	205
1946	215	152	152	152	152	205	205	205	205	205	205	205	205	205	205	205	205
1947	215	97	97	97	97	150	150	150	150	187	187	187	187	205	205	205	205
1948	215	102	102	102	102	146	146	146	146	172	172	172	172	198	198	198	198
1949	215	106	106	106	106	151	151	151	151	177	177	177	177	198	198	198	198
1950	215	169	169	169	169	202	202	202	202	203	203	203	203	205	205	205	205
1951	215	197	197	197	197	205	205	205	205	205	205	205	205	205	205	205	205
1952	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1953	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1954	215	134	139	177	178	182	184	205	205	205	205	205	205	205	205	205	205
1955	215	79	79	80	80	123	123	125	125	150	151	157	158	178	178	181	183
1956	215	193	193	193	193	201	201	201	201	202	202	202	202	203	203	203	203
1957	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1958	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1959	212	80	82	86	86	140	141	144	144	170	170	171	171	187	187	187	187
1960	185	45	45	45	45	85	85	85	85	112	112	112	112	134	134	134	134
1961	127	39	39	39	39	75	75	75	75	99	99	99	99	122	122	122	122
1962	213	139	139	139	139	184	184	184	184	200	200	200	200	201	201	201	201
1963	215	196	196	196	196	204	204	204	204	205	205	205	205	205	205	205	205
1964	215	85	85	85	85	151	151	151	151	181	181	181	181	199	199	199	199
1965	215	193	193	193	193	202	202	202	202	203	203	203	203	205	205	205	205
1966	214	122	122	122	122	172	172	172	172	193	193	193	193	205	205	205	205
1967	215	194	194	194	194	203	203	203	203	204	204	204	204	205	205	205	205
1968	215	157	157	157	157	199	199	200	200	205	205	205	205	205	205	205	205
1969	215	196	196	196	196	205	205	205	205	205	205	205	205	205	205	205	205
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1971	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1972	215	140	143	161	162	188	191	202	203	205	205	205	205	205	205	205	205
1973	215	168	168	168	168	204	204	205	205	205	205	205	205	205	205	205	205
1974	215	197	197	197	197	205	205	205	205	205	205	205	205	205	205	205	205
1975	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1976	185	57	57	57	57	122	122	122	122	149	149	149	149	164	164	164	164
1977	105	27	27	27	27	58	58	58	58	80	80	80	80	99	99	99	99
1978	213	165	165	165	165	199	199	199	199	199	199	199	199	200	200	200	200
1979	215	144	144	144	144	194	194	194	194	205	205	205	205	205	205	205	205
1980	215	196	196	196	196	205	205	205	205	205	205	205	205	205	205	205	205
1981	211	115	115	115	115	160	160	160	160	195	195	196	196	205	205	205	205
1982	215	194	194	194	194	202	202	202	202	205	205	205	205	205	205	205	205
1983	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1984	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1985	215	187	191	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1986	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1987	209	138	143	198	198	178	183	205	205	198	203	205	205	205	205	205	205
1988	112	35	35	37	53	66	66	75	87	89	89	102	112	112	112	122	133
1989	213	107	107	107	106	153	153	153	153	175	175	176	176	189	189	189	190
1990	138	47	47	47	47	81	81	81	81	102	102	102	102	114	114	114	114
1991	114	57	57	57	57	87	87	87	87	100	100	100	100	107	109	107	108
1992	87	38	38	38	38	64	64	64	64	76	76	76	76	84	84	84	84
1993	211	191	191	191	191	198	198	198	198	198	198	198	198	198	198	198	198
1994	118	61	61	61	61	99	99	99	99	115	115	115	115	124	124	124	124
1995	213	192	192	192	192	200	200	200	200	201	201	201	201	201	201	201	201
1996	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1997	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1998	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
1999	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
2000	215	198	198	198	198	205	205	205	205	205	205	205	205	205	205	205	205
Average	**204**	**155**	**155**	**158**	**158**	**179**	**179**	**181**	**181**	**188**	**188**	**188**	**188**	**192**	**192**	**193**	**193**
Maximum	**215**	**198**	**198**	**198**	**198**	**205**	**205**	**205**	**205**	**205**	**205**	**205**	**205**	**205**	**205**	**205**	**205**
Minimum	**87**	**27**	**27**	**27**	**27**	**58**	**58**	**58**	**58**	**76**	**76**	**76**	**76**	**84**	**84**	**84**	**84**

Appendix D8
Market Value of Non-diverted Water Under a 0 cfs Truckee Canal

Newlands Project Planning Study
Draft Special Report

Prepared by

Bureau of Reclamation
Mid-Pacific Region
Lahontan Basin Area Office

U.S. Department of the Interior
Bureau of Reclamation

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Abbreviations and Acronyms

cfs	cubic feet per second
WQSA	Water Quality Settlement Agreement

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Appendix D8 – Market Value of Non-diverted Water Under a 0 cfs Truckee Canal

Population growth and rapid real estate development during the early to mid-2000s resulted in increased water right trading and prices in the Reno-Sparks (Truckee Meadows region) and Fernley (Truckee Division region) areas. Water right prices in the Truckee Meadows region reached $50,000 per acre-foot during 2005 and 2006 at the height of development activity. Downstream, water right prices also increased within the Truckee Division (Fernley region) primarily as a result of real estate development activity and environmental water right purchases. As the recession worsened in 2008, a flood of short sales and foreclosures hit the state leaving one out of seven homes abandoned by their owners. Commensurate with the real estate market decline, demand for water rights in the Truckee Meadows declined significantly as few new homes were being constructed and water providers held ample water right inventories. The Truckee Division experienced a similar decline although water right prices never reached the heights observed in the Truckee Meadows market.

The following sections provide an overview of the water right market within the Truckee-Carson region. The primary purpose of the analysis is to present an estimate of the value of additional water supply to Pyramid Lake. The Pyramid Lake Tribe, Reno-Sparks, and Washoe County have been purchasing water rights to benefit environmental flows in the lower Truckee River and the level of Pyramid Lake under the 1996 Water Quality Settlement Agreement. Much of the water supply acquired under the Truckee River Water Quality Settlement Agreement (WQSA) is associated with Truckee Division water rights and other water rights that are generally not transferrable to uses within the historically higher-priced Truckee Meadows market. As a result, this analysis also presents water right prices observed within the Truckee Division. These prices are considered to be the most relevant for identifying the value of additional water supply to Pyramid Lake.

Truckee-Carson Water Right Market Overview

Water right transaction activity in the Truckee and Carson Basins has primarily consisted of surface water of in the Truckee and Carson Rivers. Relatively few transactions have involved sales of groundwater, but when they do occur in some subbasins. The average unit price in the region varied from a trough of $3,500 per acre-foot in 2002 to a peak at $17,000 per acre-foot in 2006 which then turned to a 10-year low of $ 2,000 per acre-foot in 2011. The prices have recovered to an average of $3,700 as of third quarter of 2012. The highest prices per acre-foot of water were observed in Truckee Meadows sub-basin and the lowest were associated with Carson Basin water transactions.

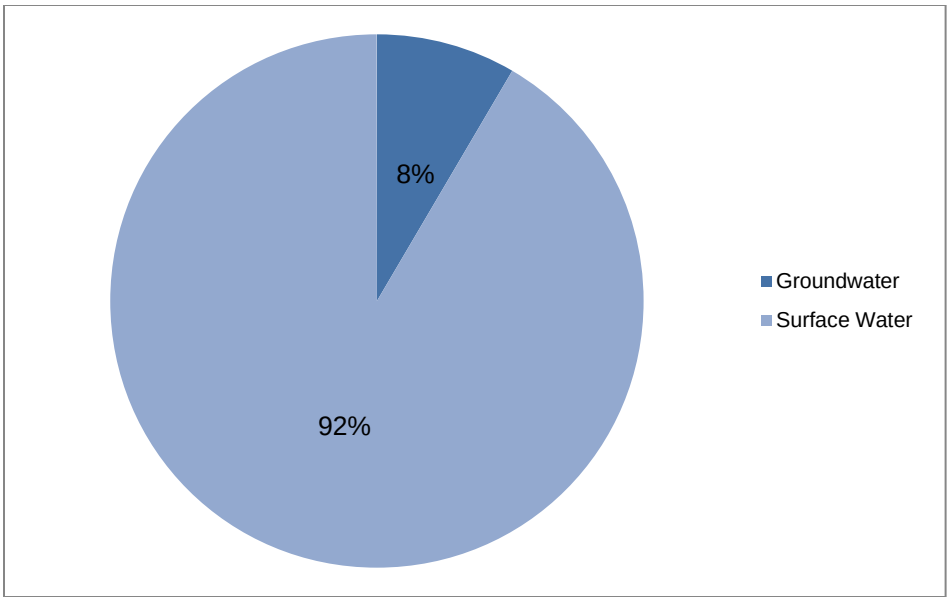

Figure D8-1. Transactions by Water Right Type

Groundwater rights transactions accounted for 8 percent of all transactions from 2002-2012 with the slightly higher average unit price than surface water rights. As shown by the following chart, the average prices for ground and surface water rights have tracked relatively closely since 2002.

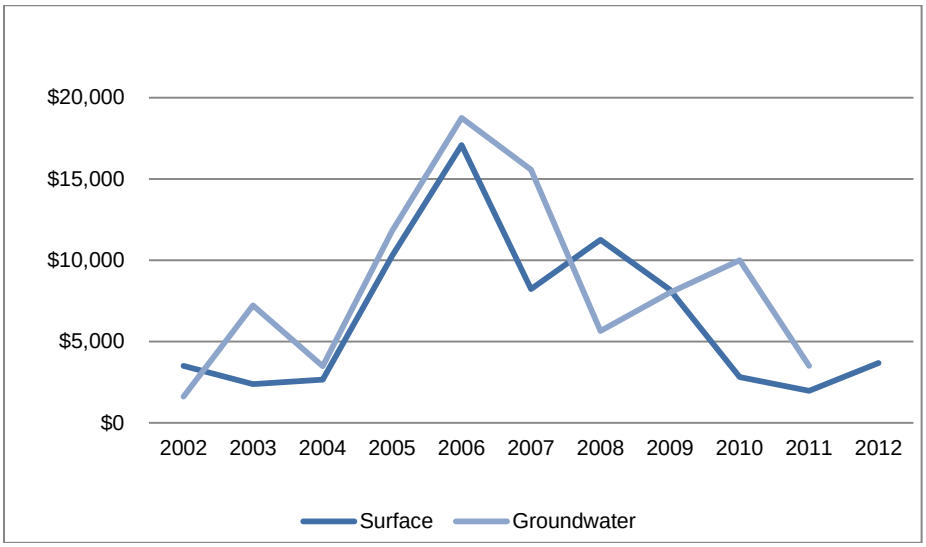

Figure D8-2. Unit Price by Water Right Type ($/AF)

The following charts provide the average annual price and volume traded from 2002 to 2012. As shown, the average price and volume peaked in 2006 as a result of water right purchases in support of real estate development activity in the Reno-Sparks and Fernley areas. Since then, average prices have declined to

2002-2004 levels as developers largely exited the market. Current trading activity is mostly taking place in the Carson Division (water right purchases by U.S. Fish and Wildlife Service) and in the Truckee Division (water right purchases by Pyramid Lake Tribe and Tahoe Reno Industrial Center).

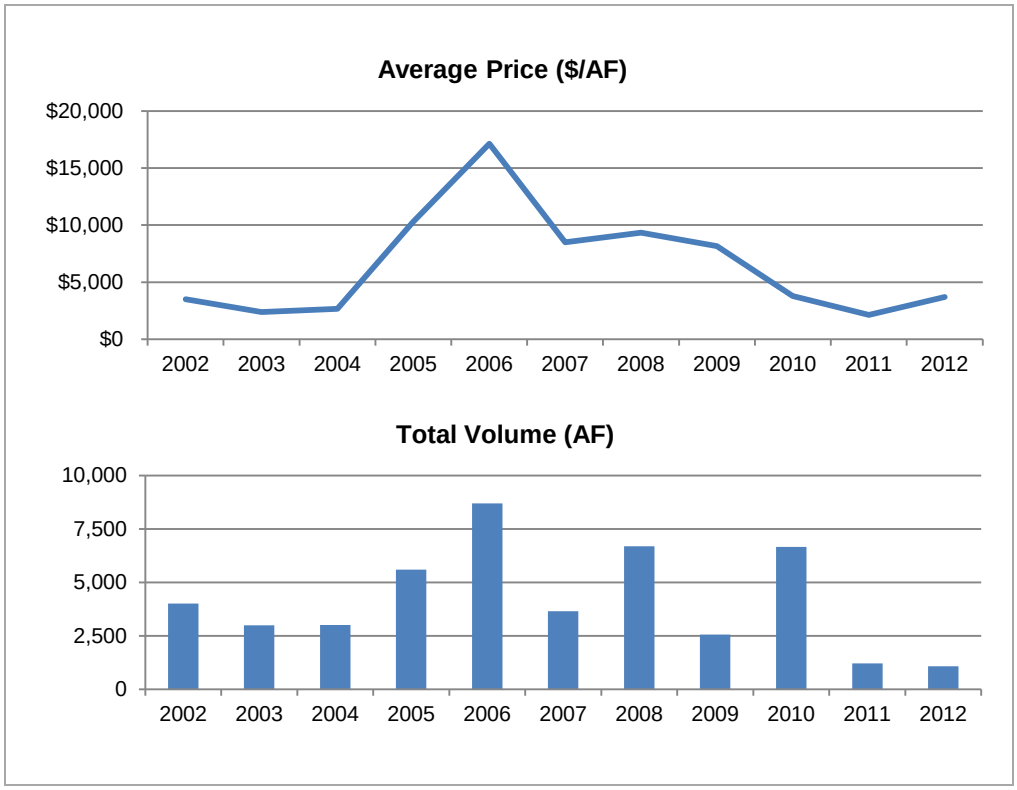

Figure D8-3. Truckee-Carson Market Overview, 2002-2012

Truckee Division Market Summary

Within the Truckee Division during the mid-2000s, water rights were being purchased by real estate developers and dedicated to the City of Fernley as part of the property development process. This led to an increase in water right prices and trading volume. On average, water rights within the Truckee Division have sold for approximately $10,000 per acre-foot from 2003 to 2012 (see Table D8-1).

Table D8-1. Summary of Truckee Division Water Right Sales, 2003 – 2012

	Price ($/AF)	Volume(AF)
Average	$10,034	58
Median	$8,551	21
Maximum	$35,000	942
Minimum	$1,500	0.6
Count	57	57

Key:
AF = acre-foot

However, this average masks the large variability in water right prices over the same timeframe. Similar to the Truckee Meadows market, the Truckee Division has experienced significant decline in water right prices and trading volume as home building stopped. Water right prices peaked in 2006 at an average of $16,000 per acre-foot (see Figure D8-4).

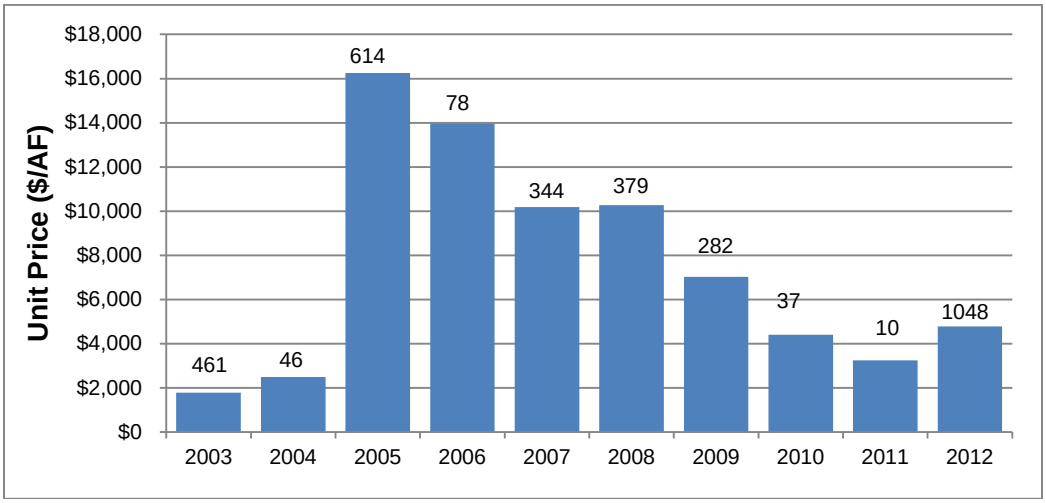

Figure D8-4. Water Right Sale Prices by Year and Volume Traded in Truckee Division

Since 2006, there has been a steady price decline and fewer transactions. The most recent transactions involved purchases by the Pyramid Lake Paiute Tribe at prices between $4,000 and $6,000 per acre-foot. This price range is considered to be the relevant value of additional water supply to Pyramid Lake.

Calculating the Value of Water not Diverted into the Truckee Canal

The price range for the most recent Truckee Division water right purchases by the Pyramid Lake Paiute Tribe provide the basis for calculating the market value of the additional water that would flow to Pyramid Lake if the Truckee Canal were decommissioned.

Under the 0 cubic feet per second (cfs) reference scenario for the Truckee Canal, annual flow to Pyramid Lake averages 583,000 acre-feet per year; under the likely future condition without action, 150 cfs, annual flow to Pyramid Lake averages 513,000 acre-feet (see Appendix D1). The difference between the two, 70,000 acre-feet per year, represents the flow that would not be diverted to the Newlands Project if the Truckee Canal were decommissioned. Thus, the value of the non-diverted water that flows to Pyramid Lake is estimated at between $280 million and $420 million. The annual benefit is estimated at between $13.03 million and $19.55 million.

Table D8-2. Value of Non-diverted Truckee River Water

Market Value $/AF	$4,000 – $6,000
Non-diverted Flow at 0 cfs	70,000 AF/year
Value of Non-diverted Flow	$280 million – $420 million
Annual Benefit of Non-diverted Flow[1]	$13.03 million – $19.55 million

Notes:
[1] Estimated over 50 years at the current Federal discount rate of 4 percent.
Key:
AF = acre-foot
cfs = cubic feet per second

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