CITY OF FERNLEY MUNICPAL SURFACE WATER DEMAND

Firm Yield Study

Abstract

PWRE was contracted to perform a yield study analysis for the City of Fernley's 10,000 afa of surface water rights. The goal was to determine the amount of surface water demand which could be reliably met each year through the delivery of surface water rights and credit storage.

To:	Taggart and Taggart, Ltd.	DATE:	December 12, 2016
By:	Heather Gacek, PE	RE:	Firm Yield Study

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P W R E PRECISION WATER RESOURCES ENGINEERING

1 PURPOSE AND OVERVIEW OF STUDY

Taggart & Taggart, Ltd. has contracted with Precision Water Resources Engineering (PWRE) on behalf of the City of Fernley, Nevada (Fernley) to perform an engineering analysis to determine the amount of additional municipal and industrial (M&I) demand that could be reliably served by Fernley by exercising its 10,000 afa of Claim 3 Orr Ditch Decree water rights in conjunction with its upstream storage capacity under the Truckee River Operating Agreement (TROA). The analysis was performed using the current version of the RiverWare Planning Model (Model) provided by the Lahontan Basin Area Office (LBAO) of the Bureau of Reclamation. The purpose of the study is to determine the firm yield of the 10,000 afa of Fernley's Claim 3 surface water rights. These water rights were divided into two portions:

1. Surface Water Demand – this portion of the water rights are exercised normally by diversion of flows in the Truckee Canal
2. Credit Storage Goal - this portion of the water rights are exercised by credit water establishment in upstream reservoirs. This process is known in TROA as changed diversion rights.

The Model was configured to, in normal years, have Fernley divert directly the Surface Water Demand portion of its 10,000 afa of water rights, and to attempt to credit store in upstream reservoirs the Credit Storage Goal. In dry years when the flow in the system is insufficient to meet Fernley's Surface Water Demand, the Model then initiates releases of Fernley Credit Water to meet the deficit. In order to determine the firm yield of Fernley's water rights, the Model was run multiple times, each run varying the Surface Water Demand. The firm yield was determined to be the Surface Water Demand in the model run in which Fernley is able to just meet its surface water demands throughout the run with no excess credit water in storage at the end of the most severe drought in the run period.

2 MODEL SETTINGS

2.1 GENERAL MODEL SETTINGS

The RiverWare Planning Model simulates operations in the Truckee and Carson basins according to current policy including TROA on a daily timestep. The Model was initialized to water year 2016 starting conditions with a run period of October 1, 2016 through December 31, 2066. The model was driven with basin-wide historical inflows from the years 1966 through 2015. The 1966 through 2000 inflows came from the "TCDATFIL" dataset (1900-2000) which is a well-accepted historical hydrology dataset used in many other studies involving the RiverWare Planning Model. This dataset was also use in the TROA EIS modeling performed by LBAO in the 2000's. PWRE developed a 2001 through 2015 historical hydrology dataset from USGS gaged datasets. The water user demands were set using the "Existing Trends" dataset developed and used for LBAO's "Truckee Basin Study." Additional information about and references for this data are available upon request.

2.2 CITY OF FERNLEY OPERATIONS

The City of Fernley intends to divert water from the Truckee Canal for M&I use, though as of the date of this report, there is no physical structure in place for doing so. In the Model the water user object representing Fernley is located along the Truckee Canal, just upstream of the Truckee Division Agricultural water user object for the Newlands Project. The water available for Fernley to divert is modeled in conjunction with the Truckee Division Agricultural object because together they represent the total Truckee Division diversions allowed under the Operating Procedures and Criteria (OCAP) for the Newlands Project. The irrigation season established by the Nevada State Engineer for the Truckee Canal water users is March 15th through November 15th.

2.2.1 Demands

In the Model Fernley's total M&I system demand is met by two different sources, a groundwater and a surface water source. The demand for surface water is separated from the demand for groundwater. This was done so that this study could focus on the surface water component exclusively, while leaving constant the groundwater source and demand. These two components summed together determine Fernley's Total System Demand.

Because the Model runs on a daily timestep, Fernley's Total System Demand was first disaggregated to a monthly demand by applying a pattern that came from Figure 2.4 of the Stanka report (Stanka Consulting, 2013). Then the resulting monthly system demands were evenly distributed across the days of each month to create a daily demand pattern in the Model. The Model then operates Fernley's two sources to meet this daily demand using both groundwater and surface water.

The Groundwater Demand was set to a constant 3,500 afa in all runs, which is roughly Fernley's current groundwater demand. The 3,500 afa of available groundwater was modeled as being used in full every calendar year. The model reserved exactly enough groundwater to meet the daily demands outside of the irrigation season when the surface water is not available for diversion. Any remaining available groundwater was then distributed evenly throughout the irrigation season. During the irrigation season the remaining demand, unmet by groundwater, was met by surface water diversions. Available Truckee Canal water was utilized first by normal exercise of Claim 3 Orr Ditch Decree water rights. In dry years when there was not enough surface water available to meet the daily demand, releases were made from Fernley's upstream credit water storage to make up the shortage, when possible. Credit water operations are discussed in more detail in the following sections.

2.2.2 Credit Water Establishment and Management

Fernley is modeled to have 10,000 afa (calendar year) of total Claim 3 water rights. The model will attempt to establish credit water storage using the difference of the 10,000 afa of total water rights and the specified Surface Water Demand each year. For example, the model with a Surface Water Demand of 6,000 afa will have a Credit Storage Goal of 4,000 afa.

TROA 7.F.1 states that Fernley may establish credit water at any time but will make their "best effort" to establish credit storage outside of the irrigation season. However, the State Engineer's Ruling #6102 permits Fernley to divert and establish credit water only during the "decreed" irrigation season, March 15 through November 15. Because of this inconsistency two scenarios were modeled as part of this study, one which permits Fernley to establish credit water throughout the entire calendar year and one which only allows Fernley to establish credit water during the irrigation season. The first scenario

assumes that the State Engineer's ruling would be amended to allow Fernley to establish at times when the system demands are lower, i.e. outside of the typical agricultural irrigation season; while the second adheres the State Engineer's Ruling #6102.

TROA 7.F.3, requires Fernley to convert any credit water storage in excess of 10,000 ac-ft to Fish Credit Water on April 1 in non-drought years. The Model logic prevents the establishment of any Fernley Credit Water that would take the total storage in the system above 10,000 ac-ft prior to April 1 in non-drought years. After April 1 Fernley attempts to establish the full Credit Storage Goal. During drought years TROA does not require the conversion of Fernley Credit Water to Fish Credit Water. Therefore, the Model does not limit establishment of credit water prior to April 1 in years designated as drought years. The exercise of water rights (by direct delivery or by credit storage) is also limited to 25% of the annual volume in any one month. This limitation is applied as a "120 day rate" in the Model, which is roughly equivalent to 25% per month. Therefore, in any one timestep (day) Fernley may not exercise more than the annual water rights allocation divided by 120 days.

Credit water establishment is further limited by available reservoir storage space, and the potential reduction in outflow, meaning that reservoir minimum release criteria cannot be violated by holding back outflow to establish credit water. Credit water may also be lost through reservoir spills. Fernley credit water has a relatively low spill priority (fifth in any reservoir) under TROA 5.C and will therefore spill before several other categories of stored water when a reservoir's storage exceeds the flood space criteria. In order to reduce the loss of credit water from spills, the model logic attempts to exchange water out of Prosser Reservoir where it is very susceptible to spills, and store it in the Little Truckee Reservoirs instead. While TROA permits many other potential exchanges and mechanisms to manage Fernley's Credit Water more efficiently, no other transfers are currently implemented within the model.

2.2.3 Surface Water Delivery

2.2.3.1 Floriston Rate Water

Floriston Rate water diverted through the Truckee Canal is available for diversion to Fernley throughout the irrigation season. Fernley's water rights are at the same priority level, Claim 3, as the other Truckee Canal water rights. Therefore, when the available flow in the Canal is less than the sum of the Fernley and Truckee Division demands, the model splits the available water proportionally between the two water users based on their daily demands.

2.2.3.2 City of Fernley Credit Water

Delivery of Fernley Credit Water from storage is initiated when surface water supplies are insufficient to meet Fernley's Surface Water Demand. But these releases can only happen during the irrigation season per Nevada State Engineer Ruling #6102. In the Model as in real-world TROA operations, credit water may become temporarily trapped within a reservoir, usually Lake Tahoe, if the storage level falls below the outlet works, the natural rim, or if the reservoir's release capacity is inadequate to pass the additional credit water release. Currently the Model does not attempt to exchange or transfer Fernley Credit Water from reservoirs whose storages approach these levels, except for Prosser Reservoir. Additional water management strategies will need to be developed by the City of Fernley to facilitate such movement of credit water in the Model. Consequently, the results from this study are conservative because in real operations, Fernley's Credit Water would very likely be managed more efficiently to minimize or even eliminate situations where Fernley Credit Water becomes inaccessible.

2.2.3.3 Conveyance Loss

TROA 5.E states that credit water should bear the additional losses that occur when it is delivered on top of project (FR) water within the Truckee River. However there is no statement about if/how losses within the Truckee Canal should be allocated to credit water. For this study it was assumed that Fernley Credit Water would be subject to Truckee Canal losses in the same manner as other Truckee Division diversions. This assumption is reasonable because Fernley's Credit Water delivery is required when there is not enough Floriston Rate water to meet demands along the Truckee Canal. As a result, Fernley Credit Water is often the only water in the Canal and therefore must take the loss. It is important to note that credit water operations for the Newlands Project are not currently modeled in the RiverWare Planning Model. So, during these model runs there will be times when Fernley Credit Water is the only flow in the Truckee Canal while future operations may also include Newlands Project Credit Water at times when Fernley Credit Water is needed for delivery. This may reduce the losses experienced by Fernley Credit Water as the loss would be shared with the Newlands Projects Credit Water as well.

Losses in the Truckee Canal are modeled using a regression equation based on the flow in the Canal. Diversions occurring along the Canal, as opposed to deliveries to Lahontan at the end of the Canal, are charged 50% of the regression calculated loss for their deliveries. The required releases from Fernley's credit storage are increased to cover the Canal loss and Truckee River conveyance loss associated with their delivery. Therefore, releases from Fernley's Credit Water storage in the reservoirs are greater than the actual delivery to the water user.

3 STUDY RESULTS

3.1 FIRM YIELD ANALYSIS SUMMARY

For this study three separate demand scenarios were evaluated. Scenario 1 represents Fernley Credit Water establishment being permitted throughout the entire calendar year. Scenario 2 represents Fernley Credit Water establishment being permitted only within the decreed irrigation season. Scenario 3 represents the utilization of the full 10,000 afa of surface water rights with no Fernley Credit Water storage permitted. These three scenarios are detailed in the following subsections with select results from the critical model runs.

3.1.1 Scenario 1: Credit Water Establishment Allowed throughout the Year

Model runs were made with Fernley's Surface Water Demand ranging from 2,000 afa to 10,000 afa. Table 1 displays the full run menu of Model runs made for scenario 1. Each run added an additional 500 afa to the Surface Water Demand. The results of each run were analyzed to determine if there was ever a shortage in the delivery of surface water to Fernley, and what the ending Fernley Credit Water storage level was for the period. The run with the highest Surface Water Demand that showed no significant shortage to Fernley is the critical run in which its Surface Water Demand is also the firm yield of the 10,000 afa of surface water rights. An additional run was made with a Surface Water Demand set halfway between the two critical runs, the run where there was no significant shortage experienced and the first run with a significant shortage experienced. This was done to further define the firm yield amount and determine if the initial result was conservative or not.

Table 1. Scenario 1 Run Menu

Surface Water Demand (afa)	2,000	2,500	3,000	3,500	4,000	4,500	5,000	5,500
Surface Water Rights (afa)	10,000	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Credit Storage Goal (afa)	8,000	7,500	7,000	6,500	6,000	5,500	5,000	4,500
Groundwater Demand (afa)	3,500	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Total System Demand (afa)	5,500	6,000	6,500	7,000	7,500	8,000	8,500	9,000
Maximum Annual Shortage (ac-ft)	-	-	-	-	-	-	4	4

Surface Water Demand (afa)	6,000	6,250	6,500	7,000	7,500	8,000	8,500
Surface Water Rights (afa)	10,000	10,000	10,000	10,000	10,000	10,000	10,000
Credit Storage Goal (afa)	4,000	3,750	3,500	3,000	2,500	2,000	1,500
Groundwater Demand (afa)	3,500	3,500	3,500	3,500	3,500	3,500	3,500
Total System Demand (afa)	9,500	9,750	10,000	10,500	11,000	11,500	12,000
Maximum Annual Shortage (ac-ft)	4	4	573	2,553	3,204	3,835	4,551

For the first scenario, in which Fernley is permitted to establish credit water throughout the entire calendar year, the study determined a firm yield of 6,250 afa. A surface water demand of 6,500 afa resulted in an annual shortage of approximately 560 ac-ft with 725 ac-ft of credit water trapped below the rim in Lake Tahoe. More sophisticated water management practices may enable the City of Fernley to exchange this storage out of Lake Tahoe before it becomes trapped below the rim. A Surface Water Demand of 7,000 afa resulted in an annual diversion shortage during one year of the model run which exceeded the available credit water storage. Surface water demands greater than 7,000 afa resulted in additional annual diversion shortages. A pair of figures is presented below (Figures 1-6) for each of the model runs representing the surface water demand values of: 6,250 afa, 6,500 afa, and 7,000 afa. The figure on the left displays the monthly surface water delivery shortage while the figure on the right focuses on the driest period of time during our hydrology. The period from August through October in 2045 is when the Model runs with higher surface water demands experienced delivery shortages. Tables 2-4 contain a summary of the annual Model output data for these three runs.

Small shortages of approximately 3.5 ac-ft were experienced in the model runs with a Surface Water Demand of 5,000 afa or greater during August of 2042. This is due a diversion shortage which occurred on a single day during the month. This single day shortage of less than 2 cfs was deemed insignificant and the annual Surface Water Demands were considered to be successfully met.

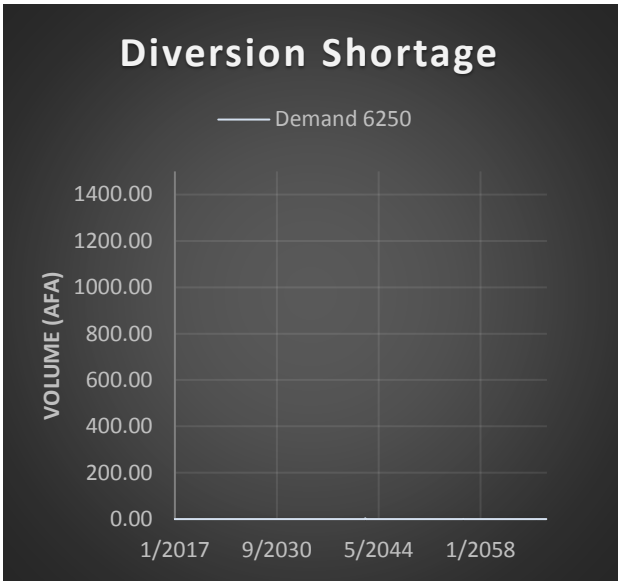

Figure 1. Monthly Diversion Shortages for Surface Water Demand of 6,250 afa

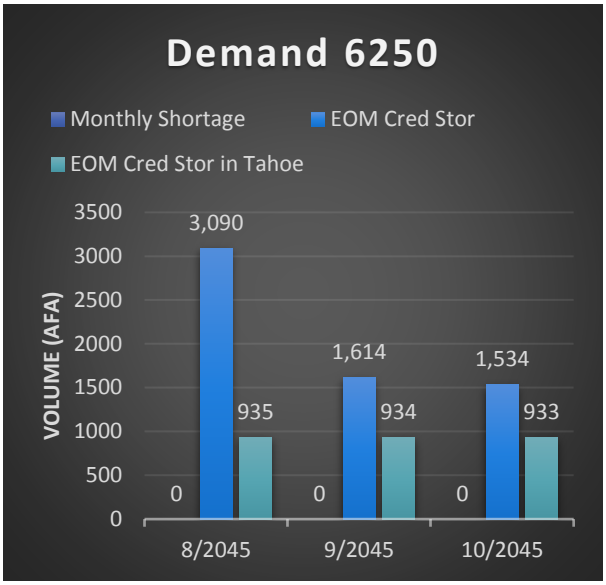

Figure 3. Limiting Period for Surface Water Demand of 6,250 afa

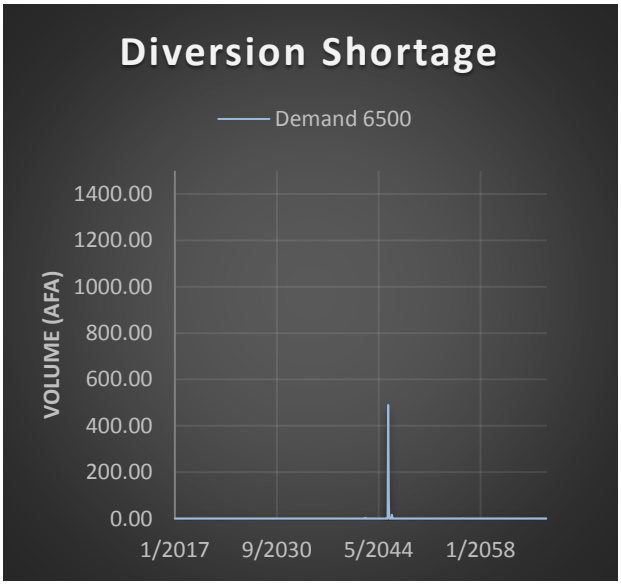

Figure 2. Monthly Diversion Shortages for Surface Water Demand of 6,500 afa

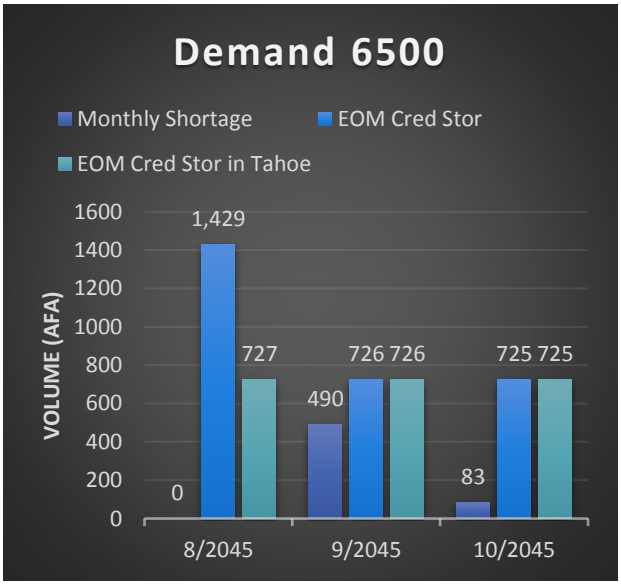

Figure 4. Limiting Period for Surface Water Demand of 6,500 afa

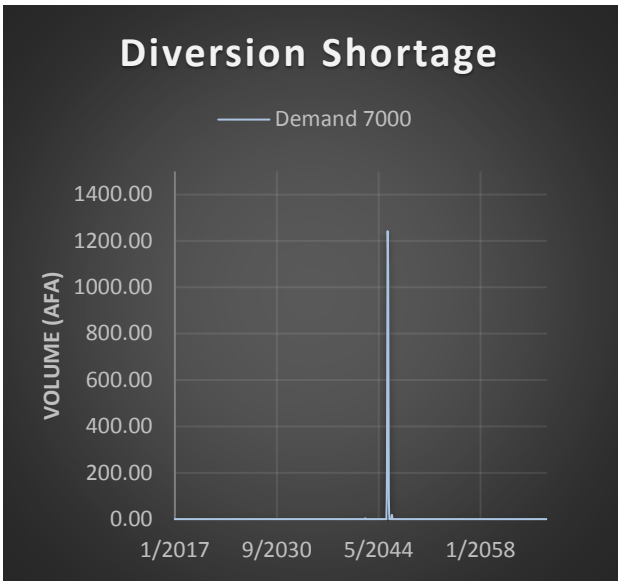

Figure 5. Monthly Diversion Shortages for Surface Water Demand of 7,000 afa

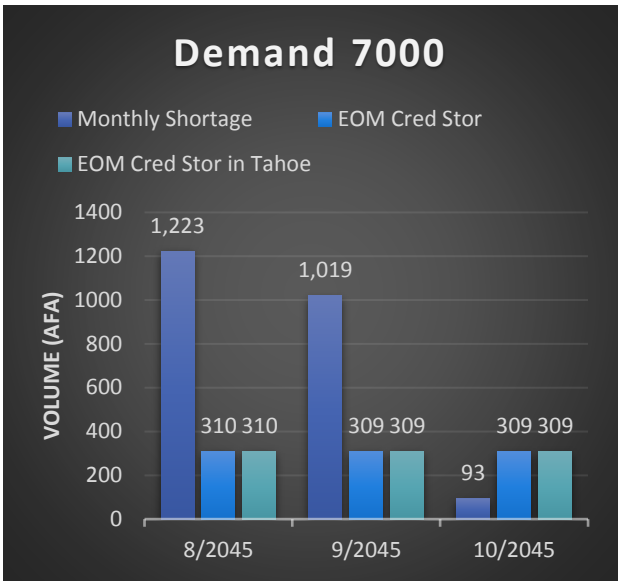

Figure 4. Limiting Period for Surface Water Demand of 7,000 afa

Table 2. Summary Result for Surface Water Demand of 6,250 afa

Surface Water Demand 6,250 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	9750	0	0%	7477	688
1/2018	9750	0	0%	7833	0
1/2019	9750	0	0%	5556	0
1/2020	9750	0	0%	5119	0
1/2021	9750	0	0%	2226	0
1/2022	9750	0	0%	3214	0
1/2023	9750	0	0%	6725	0
1/2024	9750	0	0%	7188	0
1/2025	9750	0	0%	3840	0
1/2026	9750	0	0%	5261	0
1/2027	9750	0	0%	5811	0
1/2028	9750	0	0%	9414	2158
1/2029	9750	0	0%	10109	0
1/2030	9750	0	0%	13435	0
1/2031	9750	0	0%	13399	0
1/2032	9750	0	0%	12577	0
1/2033	9750	0	0%	11384	0
1/2034	9750	0	0%	3482	0
1/2035	9750	0	0%	1634	0
1/2036	9750	0	0%	5098	0
1/2037	9750	0	0%	3449	0
1/2038	9750	0	0%	6949	0
1/2039	9750	0	0%	10538	3546
1/2040	9750	0	0%	10078	0
1/2041	9750	0	0%	13049	2352
1/2042	9750	4	0%	13503	3784
1/2043	9750	0	0%	12812	6784
1/2044	9750	0	0%	6745	743
1/2045	9750	0	0%	8339	6640
1/2046	9750	0	0%	4626	17
1/2047	9750	0	0%	4623	0
1/2048	9750	0	0%	3281	0
1/2049	9750	0	0%	3339	0
1/2050	9750	0	0%	3389	0
1/2051	9750	0	0%	3720	0
1/2052	9750	0	0%	7291	0
1/2053	9750	0	0%	10625	0
1/2054	9750	0	0%	13569	0
1/2055	9750	1	0%	15403	413
1/2056	9750	0	0%	15422	0
1/2057	9750	0	0%	12803	0
1/2058	9750	0	0%	7194	0
1/2059	9750	0	0%	10565	0
1/2060	9750	0	0%	13186	0
1/2061	9750	0	0%	14181	0
1/2062	9750	0	0%	12225	0
1/2063	9750	0	0%	9386	0
1/2064	9750	0	0%	12921	0
1/2065	9750	0	0%	16141	1571
1/2066	9750	0	0%	15505	6927

Table 3. Summary Result for Surface Water Demand of 6,500 afa

Surface Water Demand 6,500 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	10000	0	0%	6978	706
1/2018	10000	0	0%	7341	0
1/2019	10000	0	0%	5087	0
1/2020	10000	0	0%	4650	0
1/2021	10000	0	0%	1997	0
1/2022	10000	0	0%	2971	0
1/2023	10000	0	0%	6247	0
1/2024	10000	0	0%	6918	0
1/2025	10000	0	0%	3571	0
1/2026	10000	0	0%	4994	0
1/2027	10000	0	0%	5467	0
1/2028	10000	0	0%	8770	2222
1/2029	10000	0	0%	9122	0
1/2030	10000	0	0%	12290	0
1/2031	10000	0	0%	12252	0
1/2032	10000	0	0%	11341	0
1/2033	10000	0	0%	10134	0
1/2034	10000	0	0%	3236	0
1/2035	10000	0	0%	1407	0
1/2036	10000	0	0%	4727	0
1/2037	10000	0	0%	3204	0
1/2038	10000	0	0%	6469	0
1/2039	10000	0	0%	9904	3643
1/2040	10000	0	0%	9141	0
1/2041	10000	0	0%	12094	2416
1/2042	10000	4	0%	12479	3882
1/2043	10000	0	0%	11491	6942
1/2044	10000	0	0%	5328	769
1/2045	10000	573	6%	6757	5927
1/2046	10000	16	0%	4174	2
1/2047	10000	0	0%	4170	0
1/2048	10000	0	0%	3042	0
1/2049	10000	0	0%	3098	0
1/2050	10000	0	0%	3145	0
1/2051	10000	0	0%	3470	0
1/2052	10000	0	0%	6867	0
1/2053	10000	0	0%	9904	0
1/2054	10000	0	0%	12643	0
1/2055	10000	1	0%	14470	424
1/2056	10000	0	0%	14483	0
1/2057	10000	0	0%	12549	0
1/2058	10000	0	0%	6713	0
1/2059	10000	0	0%	9854	0
1/2060	10000	0	0%	12409	0
1/2061	10000	0	0%	13404	0
1/2062	10000	0	0%	11969	0
1/2063	10000	0	0%	8703	0
1/2064	10000	0	0%	12026	0
1/2065	10000	0	0%	15061	1622
1/2066	10000	0	0%	14340	7097

Table 4. Summary Result for Surface Water Demand of 7,000 afa

Surface Water Demand 7,000 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	10500	0	0%	5979	742
1/2018	10500	0	0%	6344	0
1/2019	10500	0	0%	4150	0
1/2020	10500	0	0%	3712	0
1/2021	10500	0	0%	1540	0
1/2022	10500	0	0%	2484	0
1/2023	10500	0	0%	5291	0
1/2024	10500	0	0%	6245	0
1/2025	10500	0	0%	2988	0
1/2026	10500	0	0%	4459	0
1/2027	10500	0	0%	4508	0
1/2028	10500	0	0%	7351	2351
1/2029	10500	0	0%	7170	0
1/2030	10500	0	0%	9888	0
1/2031	10500	0	0%	9850	0
1/2032	10500	0	0%	9177	0
1/2033	10500	0	0%	7902	0
1/2034	10500	0	0%	2742	0
1/2035	10500	0	0%	952	0
1/2036	10500	0	0%	3795	0
1/2037	10500	0	0%	2715	0
1/2038	10500	0	0%	5600	0
1/2039	10500	0	0%	8451	3839
1/2040	10500	0	0%	7093	0
1/2041	10500	0	0%	10008	2544
1/2042	10500	4	0%	10061	4078
1/2043	10500	0	0%	8489	7258
1/2044	10500	0	0%	2148	830
1/2045	10500	2553	24%	3459	3117
1/2046	10500	19	0%	3268	2
1/2047	10500	0	0%	3263	0
1/2048	10500	0	0%	2567	0
1/2049	10500	0	0%	2613	0
1/2050	10500	0	0%	2660	0
1/2051	10500	0	0%	2971	0
1/2052	10500	0	0%	5960	0
1/2053	10500	0	0%	8483	0
1/2054	10500	0	0%	10807	0
1/2055	10500	1	0%	12642	447
1/2056	10500	0	0%	12648	0
1/2057	10500	0	0%	12047	0
1/2058	10500	0	0%	5752	0
1/2059	10500	0	0%	8431	0
1/2060	10500	0	0%	10949	0
1/2061	10500	0	0%	11944	0
1/2062	10500	0	0%	11461	0
1/2063	10500	0	0%	7000	0
1/2064	10500	0	0%	9929	0
1/2065	10500	0	0%	12446	1724
1/2066	10500	0	0%	11705	7439

3.1.2 Scenario 2: Credit Water Establishment Allowed During Irrigation Season, Only

For scenario 2 which allows Fernley to only establish credit storage during the irrigation season, runs were made with Surface Water Demands ranging from 5,000 to 6,500 afa. The run menu, Table 5, was smaller as the expected range for the firm yield could be narrowed after performing the scenario 1 runs. The initial Model run was made using the firm yield from Scenario 1 (6,250 afa) for the Surface Water Demand. This run resulted in a shortage so one additional run was made with a greater Surface Water Demand than this value to follow the standard of using 500 afa Surface Water Demand increments. To determine the firm yield runs were made with decreasing Surface Water Demands.

Table 5. Scenario 2 Run Menu

Surface Water Demand (afa)	**5,000**	**5,500**	**5,750**	**6,000**	**6,250**	**6,500**
Surface Water Rights (afa)	10,000	10,000	10,000	10,000	10,000	10,000
Credit Storage Goal (afa)	5,000	4,500	4,250	4,000	3,750	3,500
Groundwater Demand (afa)	3,500	3,500	3,500	3,500	3,500	3,500
Total System Demand (afa)	8,500	9,000	9,250	9,500	9,750	10,000
Maximum Annual Shortage (ac-ft)	4	4	4	455	1,137	1,930

The study determined that the firm yield in this case to be 5,750 afa. This represents a 500 ac-ft decrease from scenario 1. This means that the limited credit water establishment season reduces the firm yield of the 10,000 afa water rights by approximately 500 ac-ft. A Surface Water Demand of 6,000 afa resulted in a maximum monthly shortage of approximately 380 ac-ft during September, 2045. At the same time, over 1,300 ac-ft of Fernley Credit Water remained in Lake Tahoe, trapped below the natural rim. Again, exchanges or trades may be possible under TROA to prevent this water from becoming trapped. A Surface Water Demand of 6,500 afa resulted in significant shortages, well in excess of the remaining credit water storage trapped in Lake Tahoe. A pair of figures is presented below, Figures 7-13, for each of the Model runs representing the Surface Water Demand values of: 5,750 afa, 6,000 afa, and 6,500 afa. The figure on the left displays the monthly surface water delivery shortage while the figure on the right focuses on the driest period of time during our hydrology. The period from August through October in 2045 is when the model runs with higher Surface Water Demands experienced the greatest delivery shortages. Tables 6-8 contain a summary of the annual Model output data for these three runs.

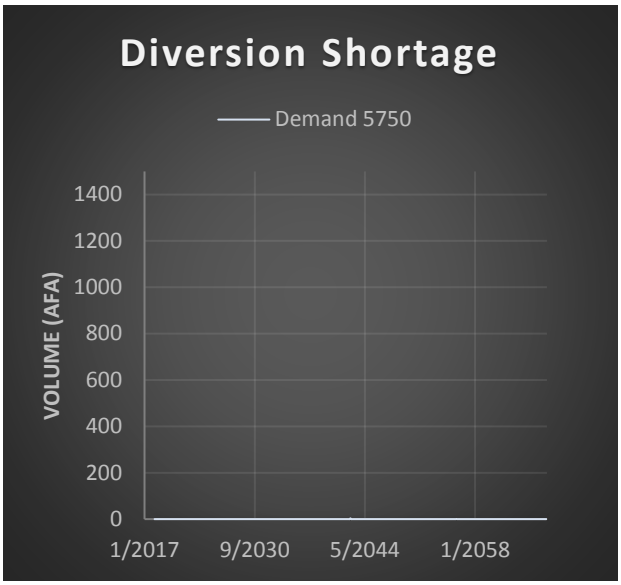

Figure 5. Monthly Diversion Shortages for Surface Water Demand of 5,750 afa

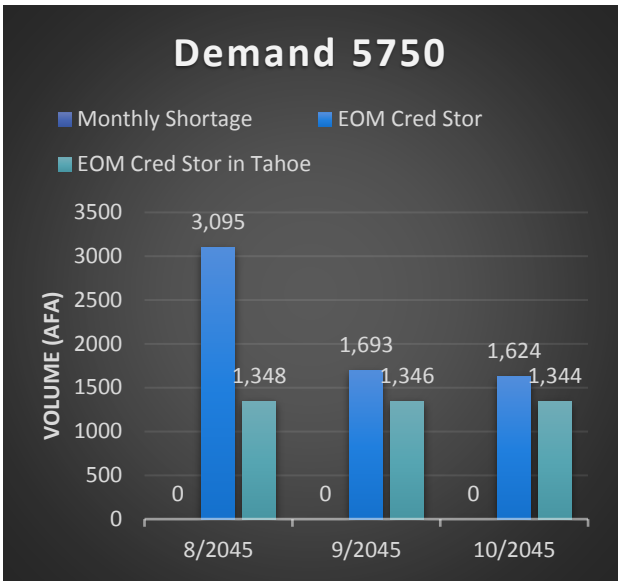

Figure 7. Limiting Period for Surface Water Demand of 5,750 afa

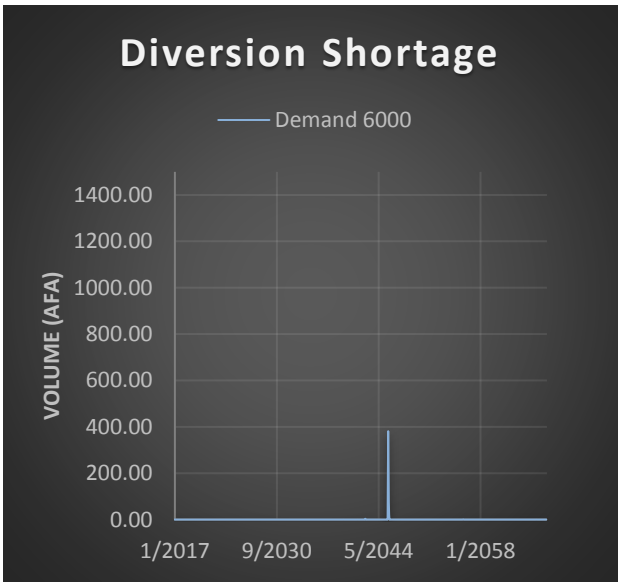

Figure 6. Monthly Diversion Shortages for Surface Water Demand of 6,000 afa

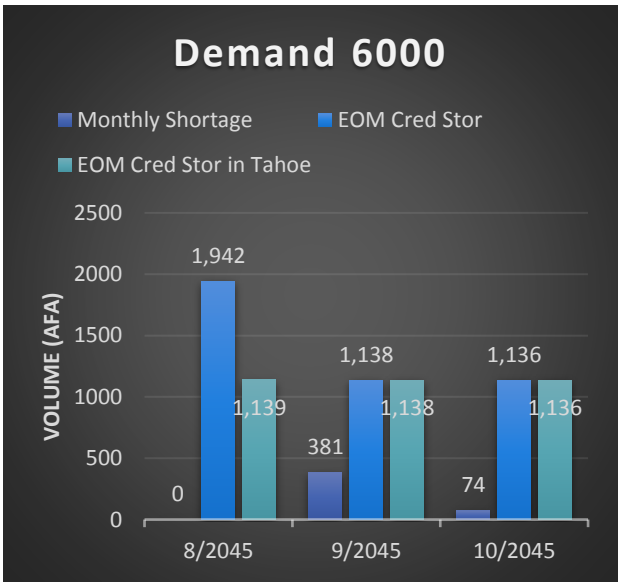

Figure 108. Limiting Period for Surface Water Demand of 6,000 afa

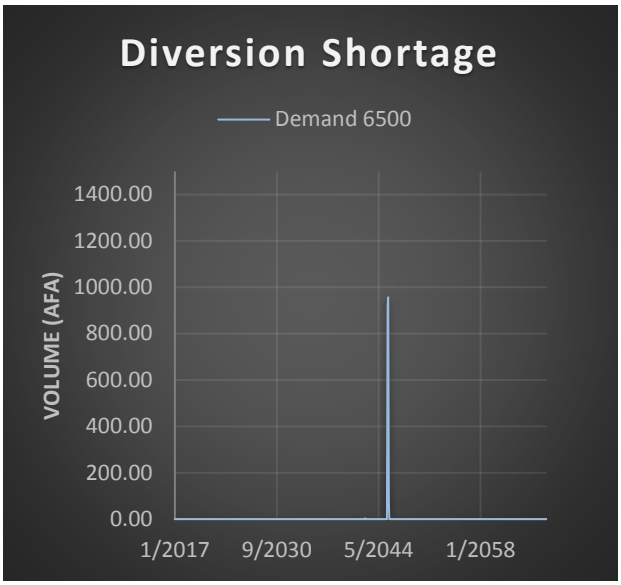

Figure 11. Monthly Diversion Shortages for Surface Water Demand of 6,500 afa

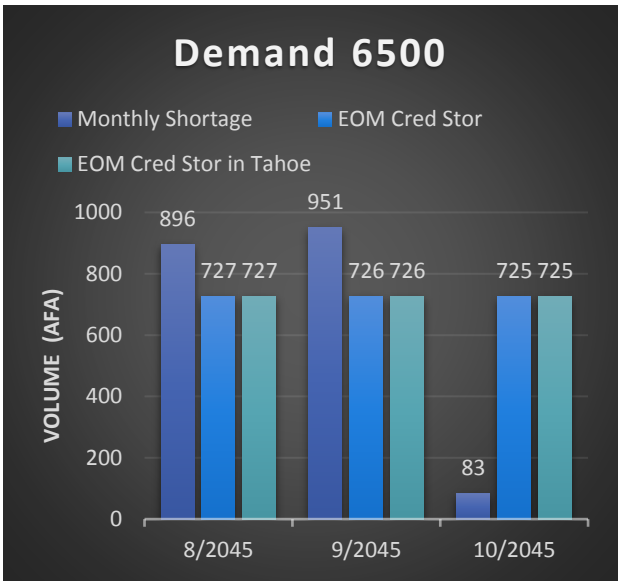

Figure 9. Limiting Period for Surface Water Demand of 6,500 afa

Table 6. Summary Result for Surface Water Demand of 5,750 afa

Surface Water Demand 5750 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	9250	0	0%	4800	652
1/2018	9250	0	0%	5352	0
1/2019	9250	0	0%	6746	0
1/2020	9250	0	0%	6310	0
1/2021	9250	0	0%	2686	0
1/2022	9250	0	0%	3562	0
1/2023	9250	0	0%	7549	0
1/2024	9250	0	0%	7614	0
1/2025	9250	0	0%	4324	0
1/2026	9250	0	0%	5158	0
1/2027	9250	0	0%	6730	0
1/2028	9250	0	0%	10463	2034
1/2029	9250	0	0%	12078	0
1/2030	9250	0	0%	13978	0
1/2031	9250	0	0%	13949	0
1/2032	9250	0	0%	13938	0
1/2033	9250	0	0%	12724	0
1/2034	9250	0	0%	3823	0
1/2035	9250	0	0%	1794	0
1/2036	9250	0	0%	5662	0
1/2037	9250	0	0%	3939	0
1/2038	9250	0	0%	7907	0
1/2039	9250	0	0%	11607	3353
1/2040	9250	0	0%	11608	0
1/2041	9250	0	0%	13451	2226
1/2042	9250	4	0%	13935	3590
1/2043	9250	0	0%	13574	6468
1/2044	9250	0	0%	6617	693
1/2045	9250	0	0%	8090	6323
1/2046	9250	0	0%	4561	14
1/2047	9250	0	0%	4555	0
1/2048	9250	0	0%	3761	0
1/2049	9250	0	0%	3818	0
1/2050	9250	0	0%	3876	0
1/2051	9250	0	0%	3858	0
1/2052	9250	0	0%	7725	0
1/2053	9250	0	0%	11272	0
1/2054	9250	0	0%	15062	0
1/2055	9250	1	0%	16581	390
1/2056	9250	0	0%	16063	0
1/2057	9250	0	0%	11374	0
1/2058	9250	0	0%	8155	0
1/2059	9250	0	0%	11989	0
1/2060	9250	0	0%	14363	0
1/2061	9250	0	0%	14614	0
1/2062	9250	0	0%	13486	0
1/2063	9250	0	0%	9800	0
1/2064	9250	0	0%	13817	0
1/2065	9250	0	0%	17214	1456
1/2066	9250	0	0%	16594	6587

Table 7. Summary Result for Surface Water Demand of 6,000 afa

Surface Water Demand 6000 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	9500	0	0%	4789	670
1/2018	9500	0	0%	5315	0
1/2019	9500	0	0%	6328	0
1/2020	9500	0	0%	5892	0
1/2021	9500	0	0%	2456	0
1/2022	9500	0	0%	3458	0
1/2023	9500	0	0%	7205	0
1/2024	9500	0	0%	7460	0
1/2025	9500	0	0%	4156	0
1/2026	9500	0	0%	5107	0
1/2027	9500	0	0%	6261	0
1/2028	9500	0	0%	9939	2097
1/2029	9500	0	0%	11271	0
1/2030	9500	0	0%	13722	0
1/2031	9500	0	0%	13689	0
1/2032	9500	0	0%	13675	0
1/2033	9500	0	0%	12466	0
1/2034	9500	0	0%	3708	0
1/2035	9500	0	0%	1786	0
1/2036	9500	0	0%	5410	0
1/2037	9500	0	0%	3694	0
1/2038	9500	0	0%	7428	0
1/2039	9500	0	0%	11073	3449
1/2040	9500	0	0%	10926	0
1/2041	9500	0	0%	12750	2289
1/2042	9500	4	0%	13104	3688
1/2043	9500	0	0%	12629	6626
1/2044	9500	0	0%	5558	718
1/2045	9500	455	5%	7029	5788
1/2046	9500	0	0%	4317	16
1/2047	9500	0	0%	4312	0
1/2048	9500	0	0%	3520	0
1/2049	9500	0	0%	3578	0
1/2050	9500	0	0%	3632	0
1/2051	9500	0	0%	3614	0
1/2052	9500	0	0%	5736	0
1/2053	9500	0	0%	9323	0
1/2054	9500	0	0%	12931	0
1/2055	9500	1	0%	14487	401
1/2056	9500	0	0%	13972	0
1/2057	9500	0	0%	12503	0
1/2058	9500	0	0%	7675	0
1/2059	9500	0	0%	11274	0
1/2060	9500	0	0%	13616	0
1/2061	9500	0	0%	13866	0
1/2062	9500	0	0%	13231	0
1/2063	9500	0	0%	9318	0
1/2064	9500	0	0%	13110	0
1/2065	9500	0	0%	16399	1518
1/2066	9500	0	0%	15590	6756

Table 8. Summary Result for Surface Water Demand of 6,500 afa

Surface Water Demand 6500 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	10000	0	0%	4532	706
1/2018	10000	0	0%	5019	0
1/2019	10000	0	0%	5392	0
1/2020	10000	0	0%	4953	0
1/2021	10000	0	0%	1997	0
1/2022	10000	0	0%	2971	0
1/2023	10000	0	0%	6247	0
1/2024	10000	0	0%	6918	0
1/2025	10000	0	0%	3571	0
1/2026	10000	0	0%	4994	0
1/2027	10000	0	0%	5467	0
1/2028	10000	0	0%	8770	2222
1/2029	10000	0	0%	9554	0
1/2030	10000	0	0%	12746	0
1/2031	10000	0	0%	12707	0
1/2032	10000	0	0%	11801	0
1/2033	10000	0	0%	10590	0
1/2034	10000	0	0%	3236	0
1/2035	10000	0	0%	1407	0
1/2036	10000	0	0%	4727	0
1/2037	10000	0	0%	3204	0
1/2038	10000	0	0%	6469	0
1/2039	10000	0	0%	9904	3643
1/2040	10000	0	0%	9145	0
1/2041	10000	0	0%	10931	2416
1/2042	10000	4	0%	11146	3883
1/2043	10000	0	0%	10205	6942
1/2044	10000	0	0%	2922	770
1/2045	10000	1930	19%	4505	3737
1/2046	10000	0	0%	3759	18
1/2047	10000	0	0%	3754	0
1/2048	10000	0	0%	3042	0
1/2049	10000	0	0%	3098	0
1/2050	10000	0	0%	3145	0
1/2051	10000	0	0%	3125	0
1/2052	10000	0	0%	5261	0
1/2053	10000	0	0%	8382	0
1/2054	10000	0	0%	11534	0
1/2055	10000	1	0%	13087	424
1/2056	10000	0	0%	12558	0
1/2057	10000	0	0%	12445	0
1/2058	10000	0	0%	6712	0
1/2059	10000	0	0%	9853	0
1/2060	10000	0	0%	12107	0
1/2061	10000	0	0%	12727	0
1/2062	10000	0	0%	12720	0
1/2063	10000	0	0%	8324	0
1/2064	10000	0	0%	11656	0
1/2065	10000	0	0%	14709	1619
1/2066	10000	0	0%	13581	7097

3.2 No Credit Water Storage Analysis

A Model run was performed with the Surface Water Demand set to the full 10,000 afa of Fernley's water rights. The run menu with the model input settings for Fernley operations is displayed in Table 9. Since the entire volume of water rights is requested for delivery to Fernley, the Model does not attempt to establish any credit storage. The purpose of this run was to determine the firm yield of the full 10,000 afa of surface water rights without the utilization of credit storage in the above Farad gage reservoirs. The firm yield is considered to be the minimum annual delivery of surface water during the Model run, or the Surface Water Demand less the maximum annual shortage amount.

Table 9. Run Menu for 10,000 afa Surface Water Demand

Surface Water Demand (afa)	**10,000**
Surface Water Rights (afa)	10,000
Credit Storage Goal (afa)	-
Groundwater Demand (afa)	3,500
Total System Demand (afa)	13,500
Maximum Annual Shortage (af)	6,877

The results of this Model run show the greatest shortage experienced occurred in the last year of the run, 2066, with an annual volume of shortage of approximately 6,900 afa. Therefore, without credit storage a firm yield of approximately 3,100 afa can be met reliably. It is interesting to note that the greatest shortage experienced during this run was in the year 2066 while the largest shortages within the Model runs with credit storage occurred during the year 2045. The magnitude of the drought in 2066 is greater than that of 2045, but the drought conditions in 2045 were preceded by several years of dry hydrology, leaving less credit water storage available at this time for scenario 1 and scenario 2. The following plot, Figure 13, shows the annual shortages experienced during the run with 10,000 afa of Surface Water Demand and no credit water storage. Additional Model output information is presented in Table 10.

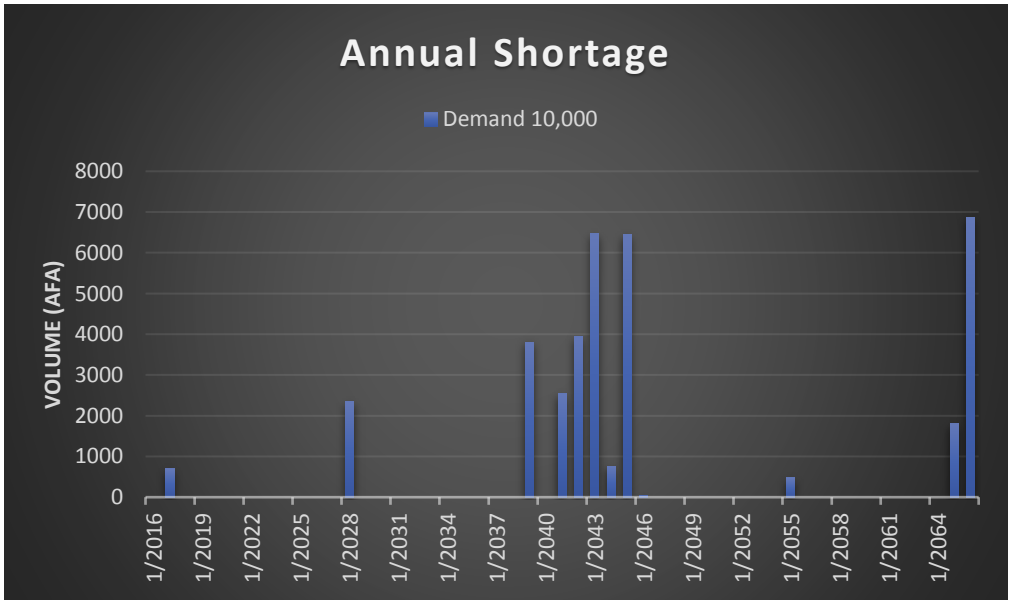

Figure 10. Annual Shortage for 10,000 afa Surface Water Demand

Table 10. Summary Result for Surface Water Demand of 10,000 afa

Surface Water Demand 10,000 Credit Water Summary					
Year	**Total Demand (AFA)**	**Delivery Shortage (AFA)**	**Percent Shortage of Total Demand**	**Max CW Storage (AFA)**	**CW Use (AFA)**
1/2017	13500	696	5%	0	0
1/2018	13500	0	0%	0	0
1/2019	13500	0	0%	0	0
1/2020	13500	0	0%	0	0
1/2021	13500	0	0%	0	0
1/2022	13500	0	0%	0	0
1/2023	13500	0	0%	0	0
1/2024	13500	0	0%	0	0
1/2025	13500	0	0%	0	0
1/2026	13500	0	0%	0	0
1/2027	13500	0	0%	0	0
1/2028	13500	2346	17%	0	0
1/2029	13500	0	0%	0	0
1/2030	13500	0	0%	0	0
1/2031	13500	0	0%	0	0
1/2032	13500	0	0%	0	0
1/2033	13500	0	0%	0	0
1/2034	13500	0	0%	0	0
1/2035	13500	0	0%	0	0
1/2036	13500	0	0%	0	0
1/2037	13500	0	0%	0	0
1/2038	13500	0	0%	0	0
1/2039	13500	3800	28%	0	0
1/2040	13500	0	0%	0	0
1/2041	13500	2537	19%	0	0
1/2042	13500	3937	29%	0	0
1/2043	13500	6468	48%	0	0
1/2044	13500	757	6%	0	0
1/2045	13500	6449	48%	0	0
1/2046	13500	36	0%	0	0
1/2047	13500	0	0%	0	0
1/2048	13500	0	0%	0	0
1/2049	13500	0	0%	0	0
1/2050	13500	0	0%	0	0
1/2051	13500	0	0%	0	0
1/2052	13500	0	0%	0	0
1/2053	13500	0	0%	0	0
1/2054	13500	0	0%	0	0
1/2055	13500	472	3%	0	0
1/2056	13500	0	0%	0	0
1/2057	13500	0	0%	0	0
1/2058	13500	0	0%	0	0
1/2059	13500	0	0%	0	0
1/2060	13500	0	0%	0	0
1/2061	13500	0	0%	0	0
1/2062	13500	0	0%	0	0
1/2063	13500	0	0%	0	0
1/2064	13500	0	0%	0	0
1/2065	13500	1804	13%	0	0
1/2066	13500	6877	51%	0	0

3.3 RESULTS SUMMARY

In summary, the firm yields from the three scenarios were determined to be:

Scenario 1. Credit Storage throughout the year, firm yield of 6,250 afa
Scenario 2. Credit Storage only during irrigation season, firm yield of 5,750 afa
Scenario 3. No Credit Storage, firm yield of 3,100 afa

As expected, the largest firm yield can be obtained by allowing credit storage establishment year round as allowed by TROA. However, this operation is contrary to the Nevada State Engineer's Ruling #6102. According to this study, a firm yield of 5,750 afa can be achieved with the currently permitted operations. The results of this study are considered to be conservative as the management operations for Fernley's Credit Water Storage are limited within the model. A fully developed management strategy may allow for a greater firm yield to be achieved under both scenario 1 and scenario 2. Reservoir release capacity is a common limiting factor for meeting Fernley's Surface Water Demands with Credit Water Storage. A possible solution is to exchange water out of reservoirs where it is likely to become trapped during a given year through the exchange mechanisms permitted under TROA.

4 REFERENCES

Stanka Consulting, L. (2013). *City of Fernley Water Supply Supplemental Storage Analysis.* Carson City.

TROA. (2008, September 6). *Truckee River Operating Agreement*. Retrieved from http://www.troa.net/documents/TROA_Sep2008/troa_final_09-08_full.pdf