Appendix B

TROA Planning Model Verification – October 2022

TROA PLANNING MODEL VERIFICATION – OCTOBER 2022

Abstract

This report documents a verification of the TROA Planning Model for Water Year 2016 to Water Year 2021 to identify how well the model simulates the historical operations in the Truckee River Basin. The report details the verification process, its key results and findings, and it provides suggestions for TROA Planning Model development.

To: Lahontan Basin Area Office, Bureau of Reclamation

By: Patrick Noe, M.S. & Tony Powell, P.E.

DATE: October 1, 2022

RE: DRAFT - For Discussion Purposes Only

Precision Water Resources Engineering
720.261.7007 www.precisionwre.com
3401 County Road 16 ● Loveland, CO ● 80537

1 CONTENTS

2 Introduction 5
2.1 Background 6
2.2 RiverWare© Simulation Models of the Truckee/Carson Basins 6
3 Verification Methods 7
3.1 Examples of Comparison Output 9
3.1.1 Nash-Sutcliffe Efficiency Factor Comparison 9
3.1.2 Trace Plots 10
3.1.3 EOY Storage Comparisons 11
3.1.4 Party Water Balance Comparisons 13
3.2 Limitations of Party Summary Reports in WY 2016 to WY 2018 15
3.3 Limitations of Comparing A Planning Model to an Accounting Model 15
3.3.1 Underlying Data Differences 16
3.3.2 Scheduling Differences 17
4 Summary of Results 18
4.1 Floriston Rate and Annual Volumes 18
4.1.1 Summary 18
4.1.2 WY 2021 Floriston Rate Deliveries 19
4.2 EOY Storage Volumes in the Truckee Basin Reservoirs, Lahontan Reservoir, and Pyramid Lake 21
4.2.1 WY 2016 Summary 21
4.2.2 WY 2017 Summary 25
4.2.3 WY 2018 Summary 26
4.2.4 WY 2019 Summary 28
4.2.5 WY 2020 Summary 30
4.2.6 WY 2021 Summary 34
4.3 Canal Annual Diversion Volumes 35

4.3.1 Summary 35
4.3.2 WY 2016 and WY 2021 Canal Diversions 37
4.3.3 WY 2019 Canal Diversions 38
4.4 Flow and Annual Delivery Volumes for the Truckee River at Nixon Gage 39
4.4.1 Summary 39
4.4.2 WY 2016 Truckee River at Nixon Gage Flows 40
4.4.3 WY 2021 Truckee River at Nixon Gage Flows 42
4.5 Summary of Stakeholder (Party) Volumes for each WY 43
4.5.1 WY 2019 44
4.5.2 WY 2020 49
4.5.3 WY 2021 56
5 Key Iterations of Model Development 61
5.1 Iteration 1 61
5.1.1 Donner Drawdown Modelling 61
5.1.2 Precipitation and Losses Modelling 63
5.2 Iteration 2 65
5.2.1 TMWA Augmentation of Fall/Winter Flows 65
5.2.2 PLPT Improvements 67
5.2.3 Prosser Drawdown Modelling 69
5.2.4 CA Preferred Flows Schedule 71
6 Conclusion 73
6.1 Future Development 73
6.1.1 PLPT 73
6.1.2 CA 74
6.1.3 TMWA 74
6.1.4 WQSA 75
6.1.5 Other 75
6.2 Closing Remarks 76

7 Appendix A: Summary of WY 2016 Comparison 76
7.1 Floriston Rate, WY 2016 77
7.2 Reservoir Plots, WY 2016 77
7.3 Canal Diversions, WY 2016 81
7.4 Truckee River at Nixon Gage, WY 2016 82
8 Appendix B: Summary of WY 2017 Comparison 82
8.1 Floriston Rate, WY 2017 82
8.2 Reservoir Plots, WY 2017 83
8.3 Canal Diversions, WY 2017 86
8.4 Truckee River at Nixon Gage, WY 2017 87
9 Appendix C: Summary of WY 2018 Comparison 87
9.1 Floriston Rate, WY 2018 88
9.2 Reservoir Plots, WY 2018 88
9.3 Canal Diversions, WY 2018 92
9.4 Truckee River at Nixon Gage, WY 2018 92
10 Appendix D: Summary of WY 2019 Comparison 93
10.1 Floriston Rate, WY 2019 93
10.2 Reservoir Plots, WY 2019 94
10.3 Canal Diversions, WY 2019 98
10.4 Truckee River at Nixon Gage, WY 2019 98
11 Appendix E: Summary of WY 2020 Comparison 98
11.1 Floriston Rate, WY 2020 99
11.2 Reservoir Plots, WY 2020 99
11.3 Canal Diversions, WY 2020 103
11.4 Truckee River at Nixon Gage, WY 2020 103
12 Appendix F: Summary of WY 2021 Comparison 104
12.1 Floriston Rate, WY 2021 104
12.2 Reservoir Plots, WY 2021 104

12.3 Canal Diversions, WY 2021 108
12.4 Truckee River at Nixon Gage, WY 2021 109
13 Appendix G: Summary of Model Edits By Iteration and Change 109
13.1 Donner Drawdown Modelling (Iteration 1) 109
13.2 Precipitation and Losses Modelling (Iteration 1) 109
13.3 TMWA Augmentation of Fall/Winter Flows (Iteration 2) 110
13.4 PLPT Improvements (Iteration 2) 110
13.5 Prosser Drawdown Modelling (Iteration 2) 111
13.6 CA Preferred Flows Schedule (Iteration 2) 111
13.7 Party Summary Reports 111
13.8 Other Changes From Model Debugging 112
14 Bibliography 112

2 INTRODUCTION

The Lahontan Basin Area Office of the Bureau of Reclamation (LBAO) has requested a verification analysis for the Truckee River Operating Agreement (TROA) Planning Model. The purpose of this verification is to determine:

- How effectively the TROA Planning Model simulates the basin operations under TROA (implemented in Water Year (WY) 2016).
- How well the TROA Planning Model represents the large-scale water balance within the Truckee-Carson basins.

The verification period includes WY 2016 through WY 2021, and the TROA Planning Model's performance is determined throughout this period by comparing model results to the actual historical conditions in the Truckee River basin. These historical results are represented by output from the TROA Operations and Accounting Model for the WY 2016 to WY 2021.

One TROA Planning Model simulation was made for each WY between 2016 and 2021. Each set of simulation output was compared to what occurred historically during the respective WY, and iterative edits were made to the TROA Planning Model to enhance the model's performance. Through the iterative process, the performance of the TROA Planning Model was evaluated through comparison to the observed operations in the Truckee River Basin.

To facilitate this verification process, two efforts were made. The first was to develop a set of verification tools to achieve the desired level of comparison and make the verification process more efficient. This effort was concluded in November 2021 and these tools facilitated much of the comparison provided in this document. The second effort included developing the necessary input hydrology data for WY 2016 through WY 2021. This effort concluded in the Summer of 2022.

This document details the verification process, its key results and findings, and suggestions for possible future TROA Planning Model development. The **Background** section details the Truckee River Basin and the RiverWare© simulation models used in this verification. The **Verification Methods** section discusses how the verification is evaluated and provides examples of comparisons used. Results from the final iteration of development in the TROA Planning Model are presented in the **Summary of Results** section, followed by a section describing the iterative steps of TROA Planning Model development that were made in the verification effort. A summary of these edits made to the TROA Planning Model are described, followed by Appendices of model comparison for each WY between 2016 and 2021.

2.1 Background

The Truckee River flows from the Lake Tahoe dam outlet in California. It is approximately 120 miles long (Rieker, 2010) and flows from the high Sierra Mountains in California to its dry terminus at Pyramid Lake. Pyramid Lake sits within the boundary of the Pyramid Lake Paiute Tribe nation. Between the outlet of Lake Tahoe and the Nevada border, the river gains flow via both natural inflow (referred to as *sidewater* in this paper) that flows to the river naturally and from operated reservoir releases. The reservoirs, in order of contribution, include Donner Lake, Prosser Creek Reservoir, Martis Creek Reservoir, and the Little Truckee Reservoirs of Independence Lake, Stampede Reservoir, and Boca Reservoir.

The Truckee River flows from these reservoirs in California into Nevada, crossing the border near the town of Floriston, California. From the border, the river flows through the Truckee Meadows where water is removed from the river through a variety of municipal and agricultural diversions, and water is gained in the river through accretions from inflows that include natural inflow and return flow from the diversions.

Below the Truckee Meadows, the river flows to Derby Dam where the Truckee Canal (Canal) diverts water that is delivered to the Carson River Basin through Lahontan Reservoir. From Derby Dam, the river flows through the town of Nixon, Nevada and into its terminus in Pyramid Lake.

2.2 RiverWare© Simulation Models of the Truckee/Carson Basins

There have been efforts over the past decades to produce simulation tools for the Truckee and Carson River basins. The two models used in this verification effort are the TROA Operations and Accounting RiverWare© Model (Accounting Model) and the TROA Planning RiverWare© Model (Planning Model).

The Accounting Model is used by the Federal Water Master (Water Master) who is responsible for accounting of the reservoir releases and diversions in the Truckee and Carson Basins. The model has both backward and forward-looking simulation periods. The backward-looking period allows the Water Master to allocate water, so the observed releases and diversions are reconciled in a way that meets TROA party requests and schedules. This is a reconciliation of the observed flow and diversions for the parties of the TROA. The forward looking period allows for short-term planning/scheduling by the Water Master and the TROA parties. At the end of each WY, the Accounting Model is archived with the reconciled accounting of each TROA Party and a record of the observed flows. These archived models are considered the "baseline" to compare to in verifying the Planning Model for each WY.

The Planning Model is an exclusively forward-looking model. The Planning Model allows TROA parties to ask "what if" questions about the system by varying hydrology, demand, a TROA party's schedule, or TROA policy that is coded into the model. The model operates the system via logic coded into the RiverWare© platform. Unlike the Accounting model in which operations are generally scheduled by the user, the Planning model operates the system according to logic which captures the general operating criteria of the parties and the Water Master. The baseline policy coded into the model is the main Planning Model component that is being evaluated in this process.

3 VERIFICATION METHODS

Figure 1 shows the iterative method used in the verification of the Planning Model. Currently, six year-long Accounting Models have been archived by the Water Master for each of WY between 2016 and 2021 inclusive. The data within these Accounting Models represents simulated, reconciled results produced from the actual operation of the Truckee Basin reservoirs for meeting targets and achieving the goals of the stakeholders in the system. Relevant data to facilitate comparisons with the Planning Model is exported from the Accounting Model into a comparison workbook.

For each WY between 2016 and 2021, a Planning Model run was performed in a forward-looking forecast mode with the same run period of the corresponding Accounting Model. Each Planning Model was input with historical initialization conditions, developed WY hydrology, and actual demands from the respective WY (Precision Water Resources Engineering, 2022).[1] The results from each of these Planning Model simulations is exported to the comparison workbook.

[1] Note, demands were retrieved from what was recorded in the Accounting Model and input to the Planning Model.

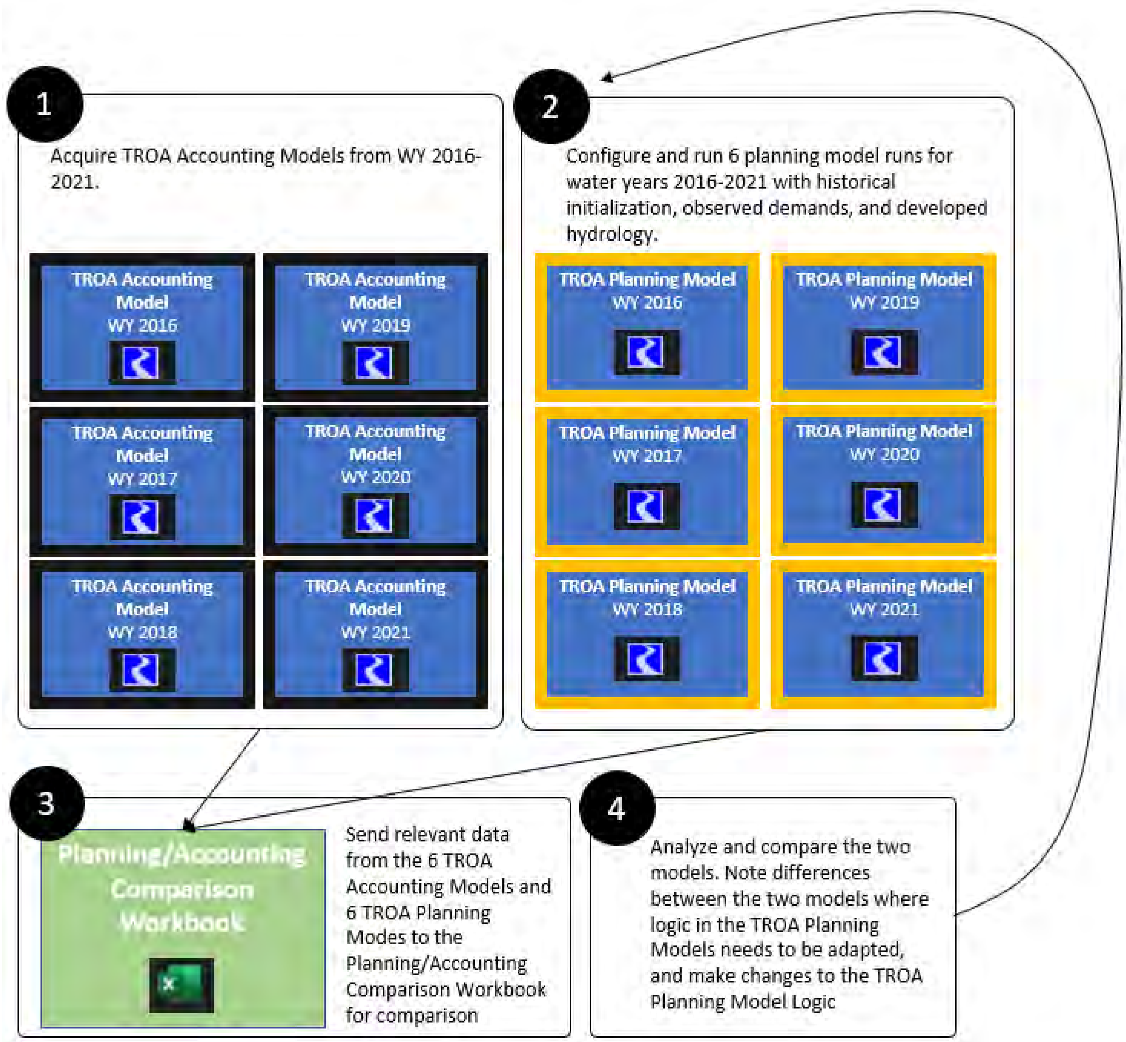


Figure 1. Iterative process for used for the TROA Planning Model Verification.

Once output data from each of the Planning Models and Accounting Models is sent to the comparison workbook, quantitative and qualitative comparison of several key metrics in the Truckee River Basin can be made for each WY. These metrics include:

1. Floriston Rate and Annual Volumes at the Farad Gage
2. End of Year (EOY) storage volumes in Lake Tahoe, Donner Lake, Prosser Creek Reservoir, Independence Lake, Stampede Reservoir, Boca Reservoir, Lahontan Reservoir, and Pyramid Lake
3. Canal Annual Diversion Volumes
4. Annual Flow Volumes for the Truckee River at Nixon Gage
5. Summary of Stakeholder (Party) Volumes for each WY

Review of these key metrics reveals differences between the way the Planning Models simulate operations in the basin and what is recorded in the Accounting Models (or how the basin was operated in history). Evaluation of Accounting and Planning model operations is conducted prior to making necessary edits to the Planning Model. Then, the Planning Models are then re-simulated, and new results are compared to determine if further changes are needed. This iterative process is replicated several times with multiple edits to the Planning Model which are detailed in the **Key Iterations** section of this report.

The comparisons include several evaluation methods to evaluate a model's performance. For flow values, the Nash Sutcliffe Efficiency (NSE), correlation coefficients (R^2), and comparisons of time series data over the WY are used. For storage values, the starting storage, min, max, and end of WY storage are compared. This is done for each WY and all these metrics are shown in Appendices A to F.

3.1 Examples of Comparison Output

3.1.1 Nash-Sutcliffe Efficiency Factor Comparison

The NSE is recommended by the American Society of Civil Engineers (ASCE) and has been found to be a reliable objective function for reflecting the overall fit of a hydrograph (McCuen et al, 2006). The NSE evaluates how well the observed versus simulated data points match the 1:1 line. Equation 1 displays the NSE formula with the variable Y representing the dataset being evaluated. The NSE ranges from -∞ to 1. Typically, an NSE between 0 and 1 are viewed as acceptable levels of performance (Moriasi et al, 2007). However, a stricter criterion proposed by (Moriasi et al, 2007) sets grading criteria for the NSE in Table 1.

Equation 1. Formula for Nash Sutcliffe Efficiency.

$$NSE = 1 - \left[\frac{\sum_{I=1}^{n}\left(Y_i^{obs} - y_i^{sim}\right)^2}{\sum_{I=1}^{n}\left(Y_i^{obs} - y_i^{mean}\right)^2}\right]$$

Table 1. Nash Sutcliffe Efficiency grading criteria (Moriasi et al, 2007).

NSE Score Range	Performance Description
0.75 - 1.00	Very Good
0.65 - 0.75	Good
0.50 - 0.65	Satisfactory
< 0.50	Unsatisfactory

An example of evaluations of the NSE for Stampede outflow are provided in Table 2. Using these values, years that performed unsatisfactorily can be identified and investigated in more depth as a part of the verification effort. Table 2 is color coded in the following manner:

- Green color coding (i.e., an NSE score greater than 0.5) represents performances considered satisfactory or better Moriasi.
- Yellow color coding (i.e., an NSE score between 0 and 0.5) represents performances considered unsatisfactory by Moriasi but acceptable in less stringent interpretations of the NSE score.
- Red color coding (i.e., an NSE score less than 0) represents performance considered unacceptable and in need of improvement.

Table 2. Nash Sutcliffe Efficiency values for Stampede outflow by WY.

	2016	2017	2018	2019	2020	2021
Stampede Outflow	-0.10	0.43	-0.16	0.4	0.63	-8.80

3.1.2 Trace Plots

Another type of comparison output utilized in this verification study is trace comparison plots. Figure 2 shows the trace comparison plot of Stampede outflow as simulated from the Accounting Model and the Planning Model for WY 2019. Referring to Table 2, the NSE computed for this year is 0.74 for Stampede outflow, a value determined to be "good" when comparing hydrographs. Figure 3 shows a year during which the outflow comparison is not similar, WY 2021 (NSE of -8.80). Differences such as those shown in Figure 3 will be discussed in detail later in this report.

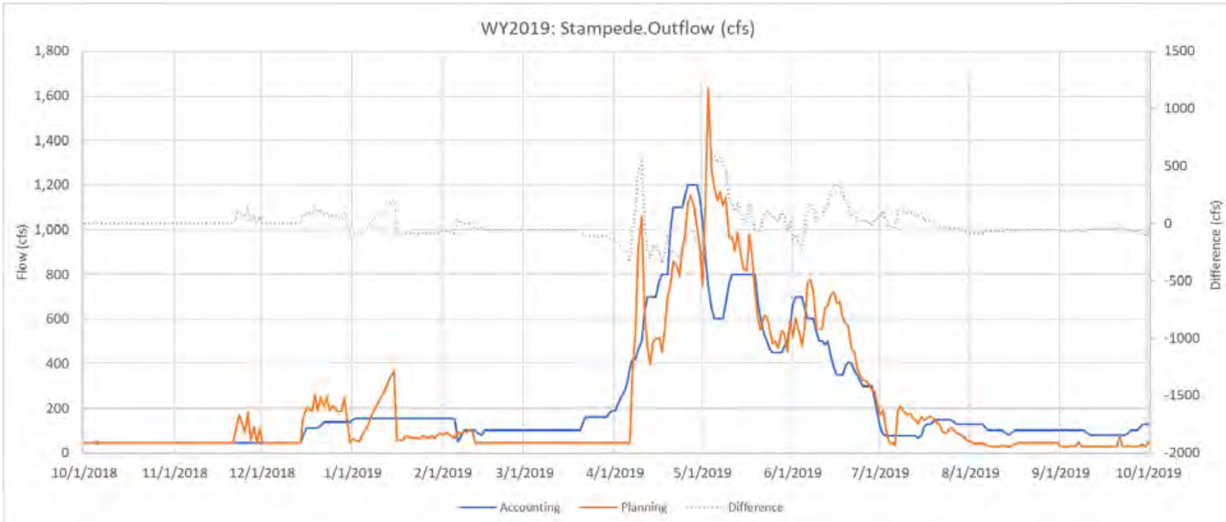


Figure 2. Accounting (blue) and Planning (orange) Model Stampede Outflow comparison for WY 2019.

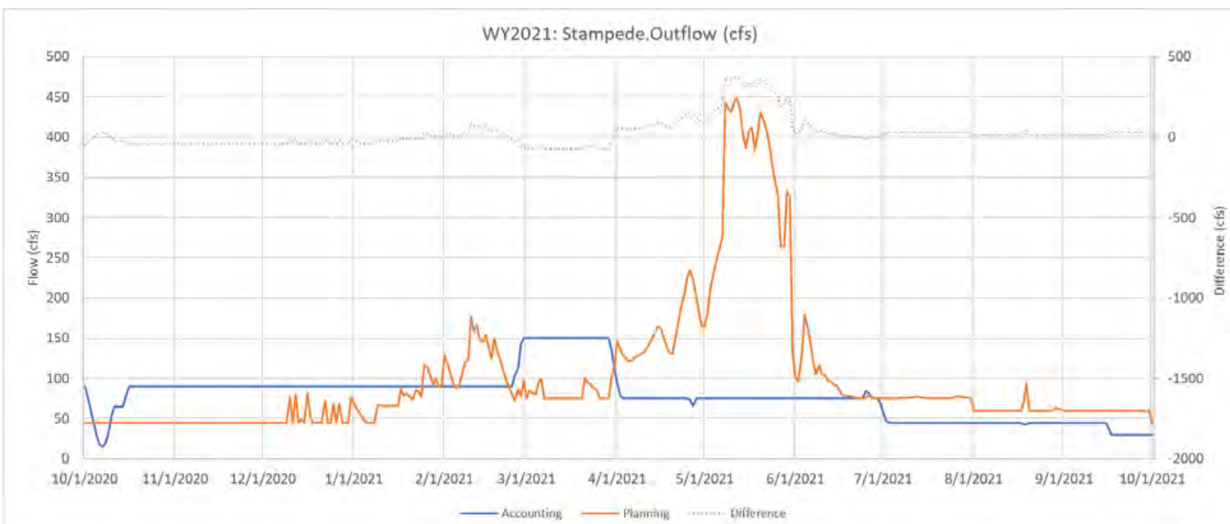


Figure 3. Accounting (blue) and Planning (orange) Model Stampede Outflow comparison for WY 2021.

3.1.3 EOY Storage Comparisons

When considering a reservoir, the storage component needs to be used for comparison. The change in storage from the beginning of the WY and end of WY can be evaluated. Each WY simulation in both the Accounting and Planning Models start with the same storage in each reservoir. Table 3 shows the EOY storage for WY 2016 to WY 2021 for Stampede Reservoir. In 2019 and 2021, the EOY storage is only slightly different between the two models (5% and -5% respectively). For 2019, this difference occurs because the operation of outflow timing was in sync between the two models. In 2021, a very different outflow pattern between the Accounting Model and the Planning Model results in a similar EOY storage value. This is not an example of a problem in the Planning Model. Instead, it indicates that the actual operation of Stampede in 2021 is different than typical Stampede operations which happens in some years (Figure 4). The similar EOY storage means the Planning Model had similar WY operations, but the timing was different. This is a result that is not surprising given the frequency of unique operations that occur in many years. In fact, it is preferrable that a Planning Model does not attempt to mimic one-off operations. The planning model is designed to represent consistent operations according to the general "law of the river" and best practices. As such, results of this type shown in 2021 are considered acceptable when comparing the Planning Model to an Accounting Model.

Table 3. Stampede Reservoir comparison of EOY Storage for WY 2016 to WY 2021.

Year	Model	Type	Stampede.Storage (acre-feet)
2016	Accounting	EOY Value	85,879
2016	Planning	EOY Value	86,001
2016		Difference	122
2016		Percentage Difference	0%
2017	Accounting	EOY Value	213,149
2017	Planning	EOY Value	225,127
2017		Difference	11,978
2017		Percentage Difference	6%
2018	Accounting	EOY Value	203,462
2018	Planning	EOY Value	201,992
2018		Difference	-1,470
2018		Percentage Difference	-1%
2019	Accounting	EOY Value	212,318
2019	Planning	EOY Value	223,354
2019		Difference	11,036
2019		Percentage Difference	5%
2020	Accounting	EOY Value	116,825
2020	Planning	EOY Value	136,897
2020		Difference	20,072
2020		Percentage Difference	17%
2021	Accounting	EOY Value	80,115
2021	Planning	EOY Value	75,955
2020		Difference	-4,160
2021		Percentage Difference	-5%

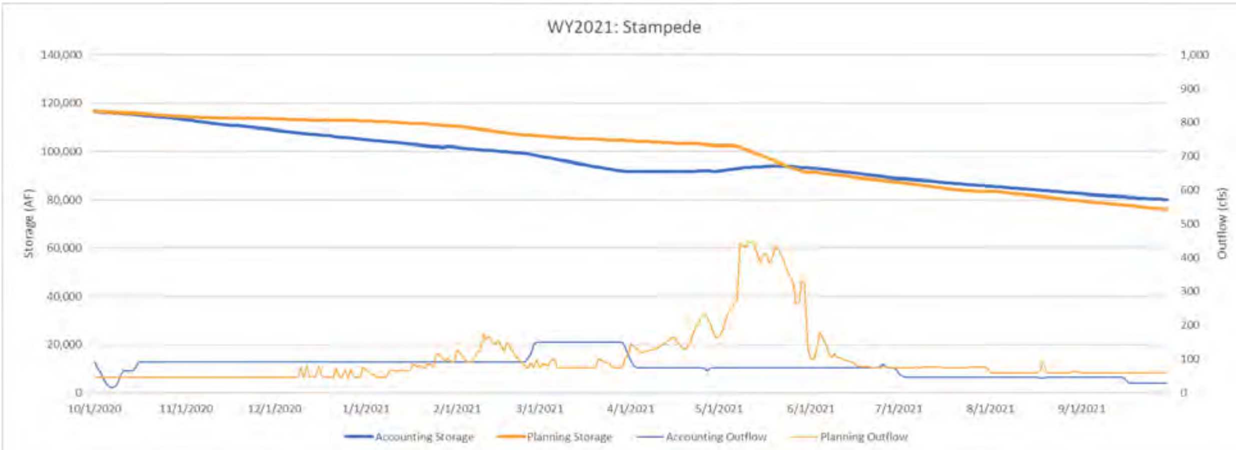


Figure 4. Accounting (blue) and Planning (orange) Model Stampede Reservoir Storage comparison for WY 2021.

3.1.4 Party Water Balance Comparisons

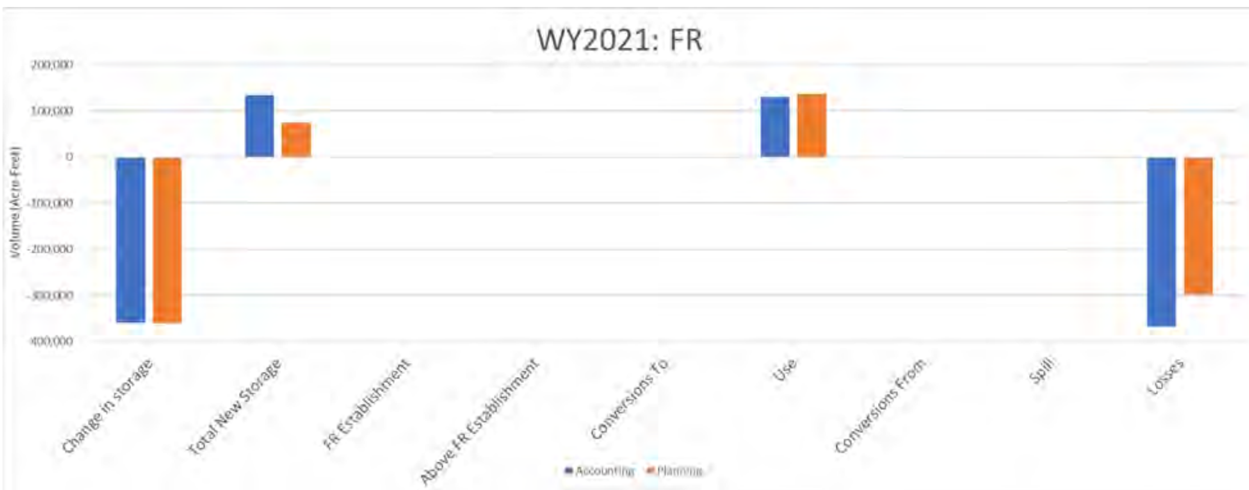
In the examples above, comparisons were made between models for metrics that are physical in the river basin (flows and storage). To fully understand the system and make comprehensive comparisons between the Planning and Accounting Models, evaluation of the underlying accounting that drives the modeled operations is needed. To facilitate this, this report also contains a collection of output called "Party Water Balance Comparison plots" that summarize the "ins and outs" for each TROA Scheduling Party: Floriston Rate (FR), Pyramid Lake Paiute Tribe (PLPT), Truckee Meadows Water Authority (TMWA), California Department of Water Resources (CA), Fernley, Newlands, and Water Quality (WQ). These plots depict how well the Planning Model simulated party operations that occurred in history. The components of the water balance summarized for each party include:

1. *Change in Storage* – The total change in TROA Party storage in the model run.
2. *Total New Storage* – The total volume of new Project Water a TROA Party accumulated in a model run.
3. *FR Establishment* – The total volume of FR Establishment a party exercised in a model run.
4. *Above FR Establishment* – The total volume of Above FR Establishment a party exercised in a model run.
5. *Conversions To* – The total volume of conversions of water to a TROA Party that occurred in a model run.
6. *Use* – The total volume of water a TROA Party released in a model run.

7. *Conversions From* – The total volume of conversions of water from a TROA Party that occurred in a model run.
8. *Spill* – The total volume of a TROA Party's water that spilled in a model run.
9. *Losses* – The total volume of losses (i.e., evaporation) incurred by a TROA Party's storage in a model run.

Figure 5 provides an example of the Party Water Balance comparisons utilized in this report displayed as a comparison of the FR water balance between the Accounting Model and Planning Model for WY 2021. The change in storage between the two simulations is 1%. The Total New Storage is approximately two times higher in the Accounting Model. This discrepancy is due to inherent differences between Planning and Accounting Models, and it is explained in detail in the section of this report titled ***Limitations of Comparing A Planning Model to an Accounting Model***.

Figure 5. Accounting (blue) and Planning (orange) Model FR Storage comparison for WY 2021.



	383,906	24,153	-359,754	134,034	N/A	N/A	0	130,439	-116	0	-366,202
	384,788	23,975	-360,813	73,416	N/A	N/A	0	138,245	0	0	-298,072
	882	-177	-1,059	-60,618	N/A	N/A	0	7,806	116	0	68,131
	0.23%	-0.73%	0.29%	-45.23%	N/A	N/A	0.00%	5.98%	-100.00%	0.00%	-18.60%

Evaluation of these types allowed for a useful comparison of the Planning Models to the Accounting Models to evaluate the policy in the Planning Model. The proceeding two sub-sections will discuss some limitations in the party water balance comparisons and in making comparisons between Accounting and Planning Models.

3.2 Limitations of Party Summary Reports in WY 2016 to WY 2018

TROA Party water balance component calculations were implemented fully in the Accounting Model during WY 2020, and previous years of the Accounting Model did not contain these calculations. The reason why this development was not completed until WY 2020 was that major modifications to the accounting structure of the Accounting Model were made in WY 2019 and WY 2020 that allowed for the components of the party water balance listed above to be calculated easily. Prior to WY 2019, the accounting structure of the Accounting Model was prohibitively complex, making the party water balance calculations unattainable. For this reason, WY 2016 to WY 2018 do not have a complete version of the Party Summary Reports in the Accounting Model, and comparisons of party results between the Planning and Accounting Models for these years is not included in this report.

3.3 Limitations of Comparing a Planning Model to an Accounting Model

The comparison process utilized in this verification is limited in some ways based on inherent differences between the Accounting and Planning Models. The main differences between these models fall into two categories: the first is in the underlying data behind the model, and the second is in how TROA Party schedules are set.

The Accounting Model is based on reconciled party operations from observed flow and reservoir releases. At the time this reconciliation is performed by the Water Master on a given day, the model must utilize Water Master time adjusted data that is derived from provisional USGS Gage flows to facilitate the accounting process. This means that the underlying hydrologic inflow data computed in the Accounting Models is preliminary data. This is necessary because accounting must be performed in real time. Furthermore, each day, the Water Master performs accounting and sets reservoir releases based off what TROA Parties have scheduled. TROA Party schedules are typically based on forecasts that are uncertain.

In contrast, the Planning Models utilize hydrologic inflow data that was developed as a part of the Data Development project (Precision Water Resources Engineering, 2022). The data development process utilizes Water Master time adjusted flow to produce a dataset for the hydrologic inflows utilized by the Planning Model.

Furthermore, the Planning Model performs TROA Party operations in a more generic manner. The Planning Model sets a TROA Party’s schedule based on logic coded into the Planning Model that represents the TROA Parties’ general objectives and criteria in managing their water. This logic attempts to answer the question, "What would a TROA Party generally schedule given the current and forecasted hydrologic conditions within the Planning Model?" The logic considers current simulated reservoir levels, basin conditions (drought, TROA specified regimes, etc.), account storage conditions, and hydrology within the Planning Model. The actual schedule of a TROA Party, which is what drives operations in the Accounting Model, may be influenced by real world conditions that are unique to that year, or take into consideration one-off conditions like facility maintenance, or other unique conditions.

These differences between the Planning and Accounting Models and their impacts to this study are detailed in the following two sections.

3.3.1 Underlying Data Differences

The differences in the underlying hydrologic inflows, though subtle, can cause differences in the results. An example of how this nuance can manifest in the verification results is visible in the WY 2020 final verification results for FR Party Water Balance (see Figure 6). The FR Change in Storage and Use was roughly equivalent between the Accounting Model and Planning Model for WY 2020; however, the FR Total New Storage and the FR Losses are roughly 75 KAF greater in magnitude in the Accounting Model than in the Planning Model.

This discrepancy is explained by the underlying differences in the data between the models. Much of the FR Storage in the basin occurs in Lake Tahoe, and real-time pool elevation readings on Lake Tahoe tend to be highly variable day to day. Because Lake Tahoe has such a large surface area, small variability in pool elevations translates into large storage differences. The Accounting Model interprets small variability in pool elevation on a day as a large hydrologic inflow and credits the FR Account in Lake Tahoe with new storage. Once the variability decreases, the model interprets this as a large negative hydrologic inflow, or a loss to the FR Account.

In contrast, the underlying data in the Planning Model was developed using a smoothing algorithm on reservoir pool elevation measurements on Lake Tahoe, resulting in smoother hydrologic inflow to the lake. While the smoothed hydrologic inflows used by the Planning Model may represent a more realistic inflow to what occurred on Lake Tahoe, this is not what was utilized to perform accounting in the Accounting Model. As a result, the Planning Models show less overall FR New Project

Storage and Losses, yet the net effect is minimal on the total change in storage shown by the two models.

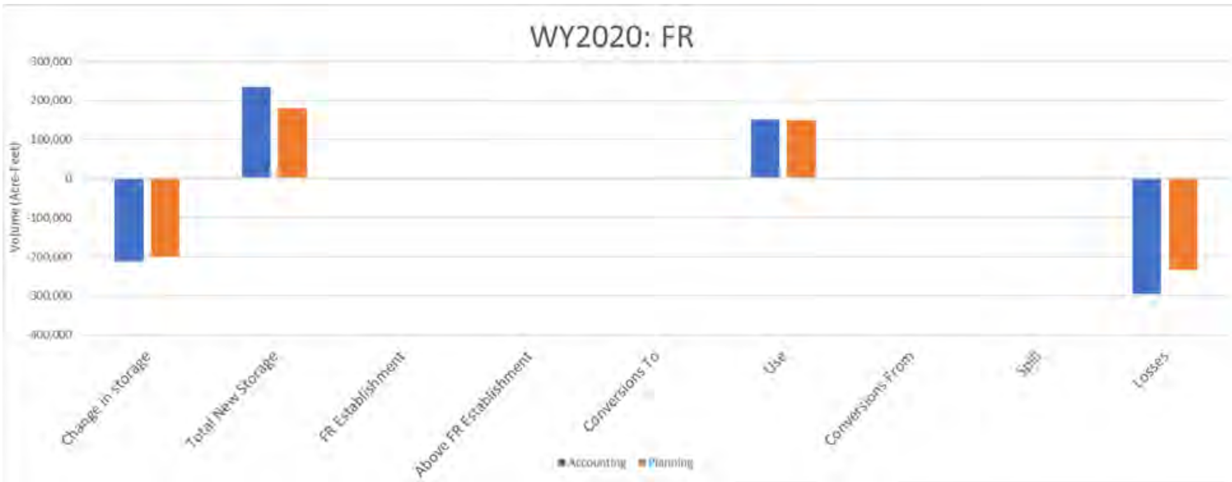


Figure 6. Accounting (blue) and Planning (orange) Model Party Water Balance Comparison for FR in WY 2020.

3.3.2 Scheduling Differences

The TROA Party scheduling between the two model approaches is fundamentally different. The Accounting Model has scheduling that is based on variable hydrology forecasts and is reactionary throughout the year to what inflows are observed to the system. TROA Parties edit their schedule, which is input to the Accounting Model, throughout a year in reaction to observed and changing forecasted conditions in the Truckee Basin. The Planning Model has generic Party scheduling coded into the model logic. This code is based on simulated reservoir levels, basin conditions (i.e., drought designation, regime selection, etc.) and the hydrology within the model. TROA Party operations in the Planning Model are not reactionary because they are, in part, determined by Planning Model utilizing a "perfect forecast" (i.e., utilizing the input hydrology in the Planning Model as a proxy for the forecast).

Some of the improvements made by this study were done to address areas in which the Planning Model was not appropriately scheduling parties based off what the parties did in history. The changes were limited and a full review of TROA Party scheduling will require input from TROA Parties for any substantial change in the Planning Model's logic. Furthermore, there have been periods in the past when TROA Parties perform operations that are "unusual" or not what would be considered within standard scheduling for the Party. These types of differences, or outliers, were intentionally not coded into the Planning Model logic and explain some of the differences that are seen between the two models.

The differences in results that occur due to the different scheduling methods will be detailed in the section of this report titled ***Summary of Stakeholder (Party) Volumes for each WY***.

4 SUMMARY OF RESULTS

The following section summarizes the results of the final iteration of the Planning Model verification study. Each subsection will focus on the key metrics identified in the ***Verification Methods*** section of this report. Results in this section focus on high level comparisons and will provide more in-depth dialogue for verification metrics that do not perform well. Additional verification results are reported in the respective appendix for each WY.

4.1 FLORISTON RATE AND ANNUAL VOLUMES

4.1.1 Summary

The maintenance of FR is the fundamental operational criteria in the basin under TROA. Therefore, this is a particularly important quantity to validate in the Planning Model versus the actual basin accounting that is tracked in the Accounting Model. For the purposes of this verification study, the annual FR volume is the volume of water classified as FR water by the model's accounting logic that passes by the Farad Gage during the WY plus any FR Holdbacks that occurred. This volume is limited each day by the FR Target value which is prescribed by the FR logic in the model. Note, FR holdbacks are included in the calculation because when an FR Holdback occurs, a TROA Party is "exercising" their water right at a reservoir, and this water does not physically flow past the Farad Gage. This may suggest that the FR Target was not met on a day when actuality it was.

Table 4 provides a summary of FR volumes by WY. FR volumes were very consistent between the two models. The largest volumetric difference occurs in WY 2021 where FR volumes differed between the two models by roughly 7 KAF. Table 5 provides a summary of the NSE Scores for daily FR volumes. By the NSE Metric, each WY performed well. WY 2021 has the worst performance with an NSE score of 0.87, which is a very strong score (Table 1).

The reason for the similar results is that FR targets are well prescribed by TROA and are less subject to scheduling. These results show that the Planning Model is performing satisfactorily in modelling the FR in the basin. The following section provides a more in-depth analysis of WY 2021, which showed a slightly worse performance than other years. Figures of daily FR volumes for all other years can be found in the respective years' Appendix.

Table 4. Accounting and Planning Model Annual FR Volumes in KAF by WY.

WY	Model	Calculation	FR (KAF)
2016	Accounting	WY Volume	231
	Planning	WY Volume	233
		Difference	3
		% Change	1%
2017	Accounting	WY Volume	293
	Planning	WY Volume	294
		Difference	1
		% Change	0%
2018	Accounting	WY Volume	332
	Planning	WY Volume	333
		Difference	1
		% Change	0%
2019	Accounting	WY Volume	332
	Planning	WY Volume	333
		Difference	
		% Change	0%
2020	Accounting	WY Volume	332
	Planning	WY Volume	333
		Difference	1
		% Change	0%
2021	Accounting	WY Volume	266
	Planning	WY Volume	272
		Difference	1 7
		% Change	3%

Table 5. NSE Scores of daily Planning Model FR flow compared to daily Accounting Model FR flow by WY.

	2016	2017	2018	2019	2020	2021
Floriston Rate	0.96	0.96	0.99	1.00	1.00	0.87

4.1.2 WY 2021 Floriston Rate Deliveries

Figure 7 shows the daily FR volume recorded in the Accounting and Planning Models for WY 2021. FR volumes were very similar in the two models between October of 2020 and August of 2021. The differences between the models throughout this period are minor and are explained by the Planning Model's ability to operate to a "perfect forecast" and hit the FR Target more precisely than the Accounting Model.

The most notable difference between the two models, and the reason why the NSE Score is slightly worse in WY 2021 than other year, is the first date that the FR Target is not met. The Accounting Model records that the first date the FR is missed was on August 19th, 2021, while the Planning Model results show the first day of missing the FR is on August 28th, 2021. This discrepancy is mainly due to differences in hydrologic inflow data. Figure 8 shows the daily hydrologic inflow for Lake Tahoe used in the Planning and Accounting Models and the cumulative difference in hydrologic inflow between the two models in acre-feet (AF). In mid-February, the Planning Model Tahoe Hydrologic Inflow shows more inflow than the Accounting Model over a short period surrounding a storm which results in a volumetric difference in inflow between the two models of approximately 4,000 AF. This difference directly results in additional FR storage in Lake Tahoe and Lake Tahoe's Pool Elevation being slightly higher in the Planning Model. As a result, more FR water can be moved out of Lake Tahoe into other basin reservoirs. This additional storage FR in the system was used to meet the FR in the Planning Model and is the explanation for why the first date the FR Target is missed in the Planning Model is later than that of the Accounting Model.

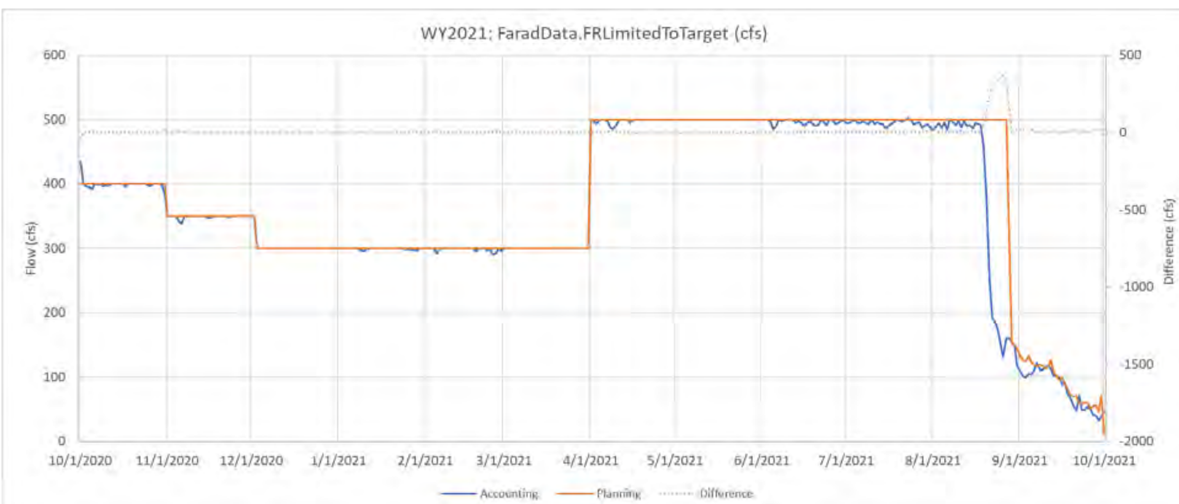


Figure 7. WY 2021 Accounting (blue) and Planning (orange) Model Daily FR flow inclusive of holdbacks and limited to the FR Target.

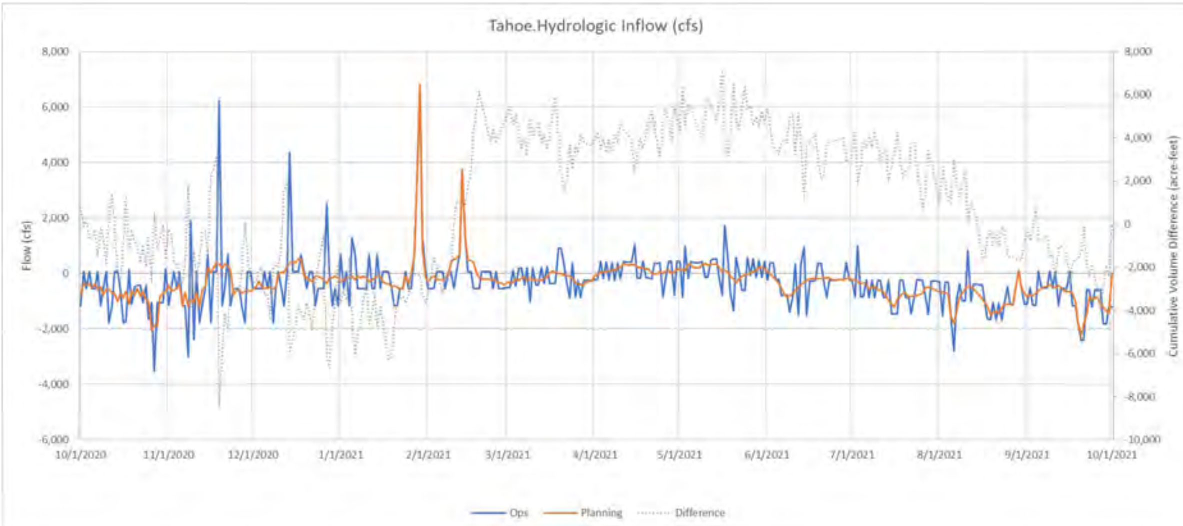


Figure 8. WY 2021 Accounting (blue) and Planning (orange) Model Daily Hydrologic Inflow to Lake Tahoe (left-axis) and cumulative difference between the two models (right-axis).

4.2 EOY Storage Volumes in the Truckee Basin Reservoirs, Lahontan Reservoir, and Pyramid Lake

EOY Storage Volumes in the Truckee Basin Reservoirs, Lahontan Reservoir, and Pyramid Lake by WY allow for in-depth analysis of discrepancies between the Accounting and Planning Models. The following section provides a discussion of EOY Storage Volume differences within each WY. All other results are presented in the "Reservoir Plots" section of a respective WY Appendix.

4.2.1 WY 2016 Summary

Table 6 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2016. The most notable differences for EOY storages between the Accounting and Planning Models exist on Boca Reservoir, Prosser Creek Reservoir, and Lahontan Reservoir, and the differences on these three reservoirs will be discussed in more detail in the proceeding sections.[2]

[2] Note, while Donner Lake does show a larger percent change of -16%, the lake storages are low because it has been drawn down. In actuality, the two models only show a 604 AF difference in EOY Storages, which is an acceptable deviation in this verification effort.

Table 6. WY 2016 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2016		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	10,424	85,879	16,038	14,209	3,757
Planning	EOY Value	19,109	86,001	14,944	9,559	3,153
	Difference	8,685	122	-1,094	-4,650	-604
	% Change	83%	0%	-7%	-33%	-16%

WY 2016		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	822	6,222.73	4,305	21,031,023
Planning	EOY Value	800	6,222.70	66,619	20,666,120
	Difference	-22	0.0	62,314	-364,903
	% Change	-3%	-	1447%	-2%

4.2.1.1 Boca Reservoir, WY 2016

Figure 9 provides a comparison of daily Storage and Outflow values for Boca Reservoir from the Accounting and Planning Models for WY 2016. Boca Reservoir ended the WY in the Planning Model with 19,109 AF of storage, or 8,685 AF more than the Accounting Model.

Ultimately, this discrepancy is caused by differences in the flow regime, or environmental targets at the Truckee River at Nixon Gage, that is used by each model (see **WY 2016 Truckee River at Nixon Gage Flows**). More storage is required to meet these environmental targets in the Accounting Model in comparison to the Planning Model.

This additional storage in the Planning Model results from Fish Water in Prosser Creek Reservoir that is exchanged to Boca Reservoir where it becomes Fish Credit Water. This exchange occurs during Prosser Creek Reservoir's is drawn down, and it occurs because the draw down outflows of Fish Water from Prosser Creek Reservoir are not demanded downstream. In contrast, the Fish Water storage in Prosser Creek Reservoir in the Accounting Model is needed to meet flow targets at the Truckee River at Nixon Gage, and this storage is therefore not exchanged to Boca Reservoir. Rather, it is released and used downstream.

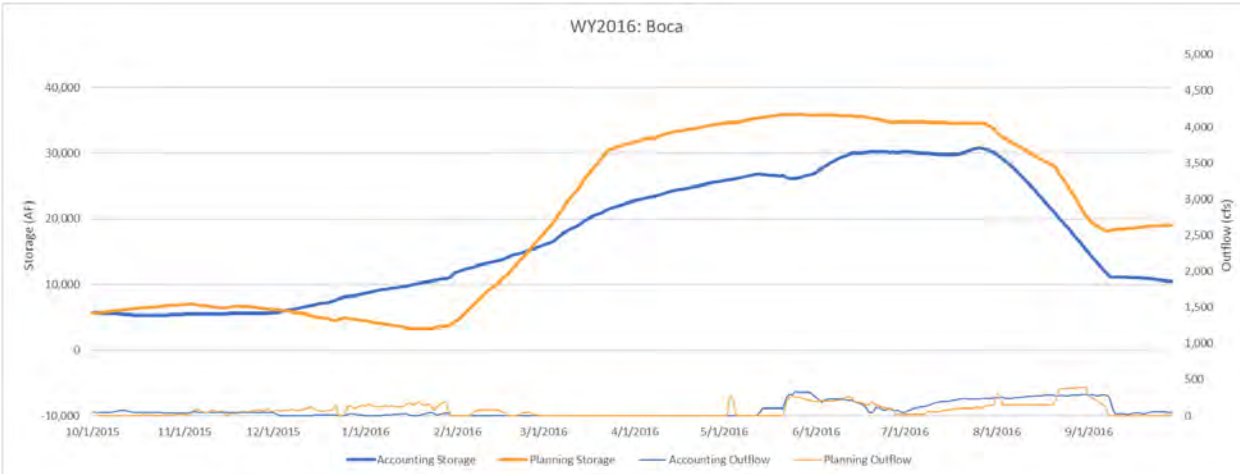


Figure 9. WY 2016 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.1.2 Prosser Creek Reservoir, WY 2016

Figure 10 provides a comparison of daily Storage and Outflow values for Prosser Creek Reservoir from the Accounting and Planning Models for WY 2016. Prosser Creek Reservoir ended the WY in the Planning Model with 9,559 AF of storage, or 4,650 AF less storage than the Accounting Model. Unlike the Accounting Model, the Planning Model stores Tahoe Prosser Exchange water in Prosser Creek Reservoir, explaining why Prosser Creek Reservoir storage is higher through the summer months of 2016. The mechanism by which Tahoe Prosser Exchange water accumulates in the Planning Model is the Tahoe Prosser Exchange (TPX Exchange, TROA 5.B.6(b)(3)). The purpose of the TPX Exchange is to enable Lake Tahoe to meet a minimum flow of 70 cubic feet per second (cfs) by exchanging FR water into Prosser Creek Reservoir from Lake Tahoe. The result of the exchange is that Prosser Creek Reservoir's FR release is reduced by the same amount that Lake Tahoe's FR release is increased to meet its minimum flows. As a result, FR water is moved to Prosser Creek Reservoir from Lake Tahoe where it is stored as Tahoe Prosser Exchange water. The Accounting Model meets Lake Tahoe's minimum flow requirements via a different mechanism: Article 8S Minimum Flow Exchanges (TROA 9.C.2(a)). These exchanges meet Lake Tahoe's minimum flow by moving Tahoe FR water from Lake Tahoe to Stampede by foregoing a Fish Water release out of Stampede. For Article 8S Minimum Flow Exchanges to occur, there must be a release of Fish Water out of Stampede. Furthermore, because Tahoe's minimum flows were met through the Article 8S Exchange in the Accounting Model, there was no need to utilize the TPX Exchange and thus create TPX water in Prosser. Article 8S Minimum Flow Exchange was not utilized in the Planning Model to meet Lake Tahoe's minimum release because there was no demand of Fish Water from Stampede at the time. The Tahoe Prosser Exchange water stays in Prosser Creek Reservoir and, combined with less Prosser Creek Reservoir water needed to meet flow targets at the Truckee River at Nixon Gage, allows more of the water to be exchanged to Boca as Fish Credit water. This draws Prosser Creek Reservoir down lower in the Planning Model than in the Accounting Model.

Ultimately, the discrepancy between the models on Prosser Creek Reservoir is due to differences in Fish Demand in WY 2016. This is discussed in more detail in the section of the report titled **WY 2016 Truckee River at Nixon Gage Flows**.

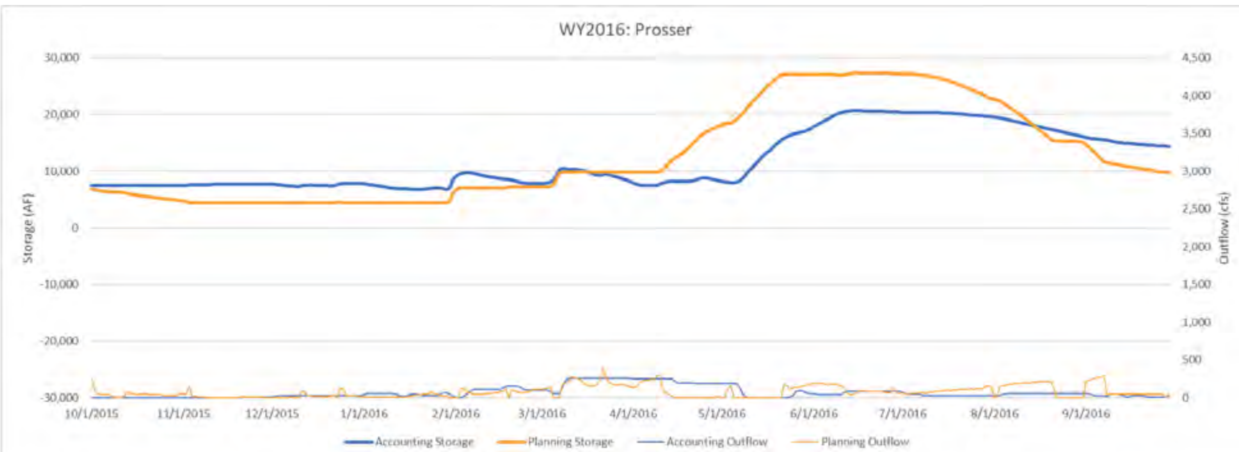


Figure 10. WY 2016 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.1.3 Lahontan Reservoir, WY 2016

Figure 11 is a comparison of daily Storage and Outflow values for Lahontan Reservoir from the Accounting and Planning Models for WY 2016. The Lahontan Outflow values are similar, but the resulting end of WY storage values differ on the order of 62 KAF (Table 6). The difference is due to the 67 KAF of additional diversion through the Canal in the Planning Model compared to the Accounting Model (see **WY 2016 and WY 2021 Canal Diversions**). The additional storage in Lahontan allows deliveries from Lahontan to be met in the Planning Model through the end of the WY. The Accounting Model reached the minimum Lahontan Storage of 4 KAF before the end of WY 2016.

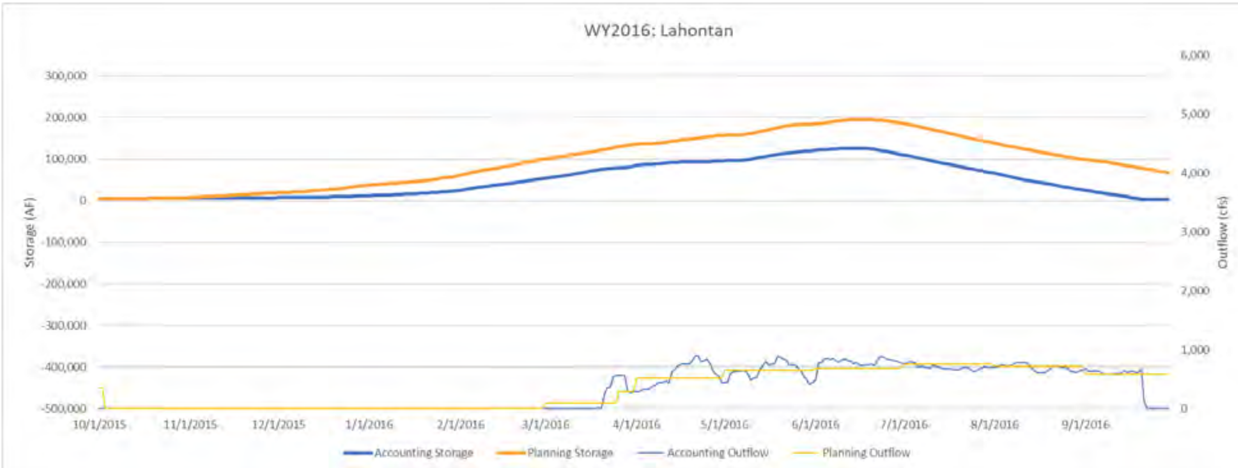


Figure 11. WY 2016 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.2 WY 2017 Summary

Table 7 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2017. Differences in the reservoirs are noted and are due mainly to the reservoirs filling differently or drawing down differently in the fall months. This is the case for Boca Reservoir, Lahontan Reservoir, and Donner Lake. These reservoirs have the largest EOY storage differences. WY 2017 was a historically high inflow year and the differences in the model results were due to the drawdown of stored water after reservoirs filled. In general, the reservoirs were drawn down to similar levels in the models, the timing was different, and the EOY values taken on September 30, 2017, were different between the Planning Model simulation and the Accounting Model operations.

Table 7. WY 2017 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2017		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	33,991	213,149	15,040	14,749	4,118
Planning	EOY Value	40,476	225,127	15,425	14,113	5,505
	Difference	6,485	11,978	386	-636	1,387
	% Change	19%	6%	3%	-4%	34%

WY 2017		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	872	6,228	200,060	21,965,047
Planning	EOY Value	800	6,228	225,681	21,758,343
	Difference	-72	0	25,621	-206,704
	% Change	-8%	0%	13%	-1%

4.2.3 WY 2018 Summary

Table 8 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2018. The most notable differences for EOY storages between the Accounting and Planning Models exist on Boca Reservoir, Prosser Creek Reservoir, and Lahontan Reservoir.

Table 8. WY 2018 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2018		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	20,646	203,462	15,067	13,762	3,096
Planning	EOY Value	28,061	201,992	14,892	8,548	3,090
	Difference	7,415	-1,470	-175	-5,214	-6
	% Change	36%	-1%	-1%	-38%	0%

WY 2018		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	877	6,227	113,156	22,112,328
Planning	EOY Value	800	6,227	138,007	21,916,799
	Difference	-77	0	24,851	-195,530
	% Change	-9%	2%	22%	-1%

4.2.3.1 Boca Reservoir, WY 2018

Figure 12 is a comparison of daily Storage and Outflow values for Boca Reservoir from the Accounting and Planning Models for WY 2018. The difference in EOY storage for WY 2018 in Boca Reservoir is due to the accounting operations drawing Boca down differently at the end of 2018 than the Planning Model. Construction on the Boca Reservoir Dam in 2019 (see **Boca Reservoir, WY 2019**) was anticipated at the end of WY 2018, and the Planning Model logic exchanges more Fish Credit water into Boca Reservoir that did not happen in the Accounting Model.

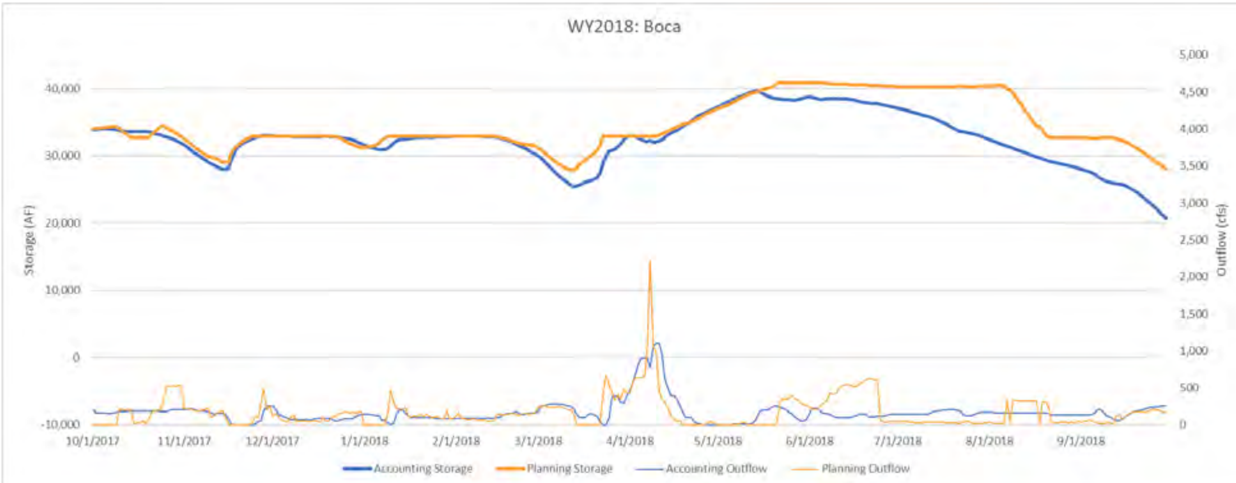


Figure 12. WY 2018 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.3.2 Prosser Creek Reservoir, WY 2018

Figure 13 is a comparison of daily Storage and Outflow values for Prosser Creek Reservoir from the Accounting and Planning Models for WY 2018. The difference in storage values between the Accounting and Planning Model simulations is due to a large release in the Accounting Model in May of 2018 to meet flow targets in the Truckee River at Nixon Gage. These targets were operationally set to a higher value than the targets in the Planning Model and require a higher release. Later in the WY, more water is exchanged to Boca Reservoir in the Planning Model than in the Accounting Model drawing Prosser Creek Reservoir to a lower level.

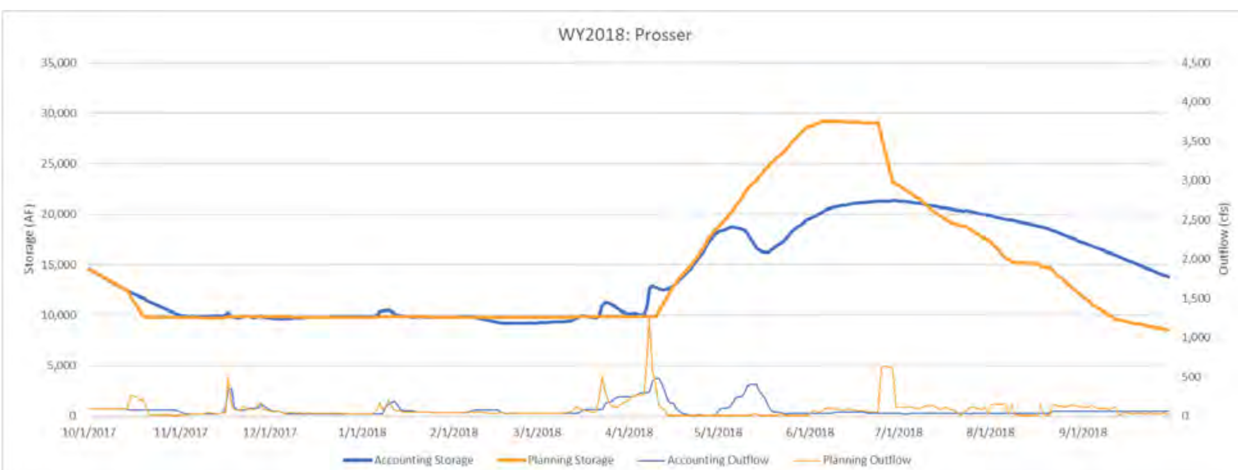


Figure 13. WY 2018 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.3.3 Lahontan Reservoir, WY 2018

Figure 14 is a comparison of daily Storage and Outflow values for Lahontan Reservoir from the Accounting and Planning Models for WY 2018. Differences in storage throughout WY 2018 are due to the difference between a perfect forecast in the Planning Model and a variable hydrology forecast that occurs in the real world (Accounting Model). This is shown in the April precautionary releases that occurred to draw Lahontan Reservoir down that do not occur in the Planning Model. Higher releases throughout the rest of the WY in the Accounting Model result in a lower EOY storage than the Planning Model. These differences can be attributed to the difference in how the models handle forecasts (see **Limitations of Comparing A Planning Model to an Accounting Model**).

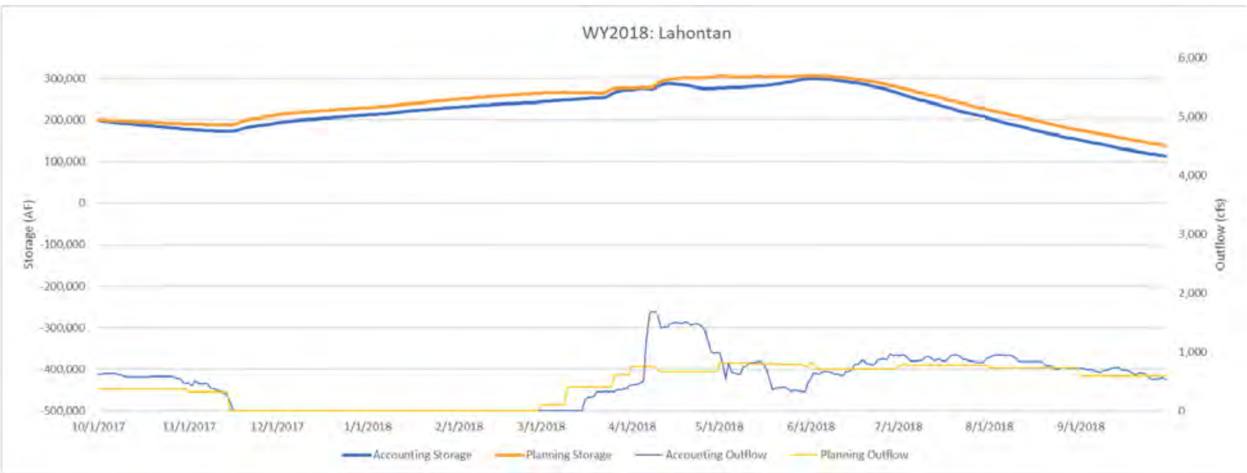


Figure 14. WY 2018 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.4 WY 2019 Summary

Table 9 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2019. The main difference in results between the Accounting and Planning Model results were due to construction on the Boca Reservoir dam that was not considered in the Planning Model. The maximum observed storage of Boca Reservoir in WY 2019 was just above 18 KAF to allow for construction. This can be viewed in the major difference in EOY storage for Boca Reservoir in WY 2019. Results for differences will be detailed for Boca Reservoir and for Lahontan Reservoir.

Table 9. WY 2019 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2019		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	15,067	212,318	14,729	14,644	5,275
Planning	EOY Value	36,303	223,354	15,173	14,948	5,979
	Difference	21,236	11,036	444	304	704
	% Change	141%	5%	3%	2%	13%

WY 2019		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	874	6,228	173,306	22,639,340
Planning	EOY Value	800	6,228	197,813	22,311,420
	Difference	-74	0	24,507	-327,920
	% Change	-8%	-1%	14%	-1%

4.2.4.1 Boca Reservoir, WY 2019

Figure 15 is a comparison of daily Storage and Outflow values for Boca Reservoir from the Accounting and Planning Models for WY 2019. The outflow for Boca Reservoir is similar, but the storage differences are due to construction that occurred on Boca Reservoir in WY 2019. The Accounting Model shows how Boca was required to stay below a storage of 20 KAF for the WY.

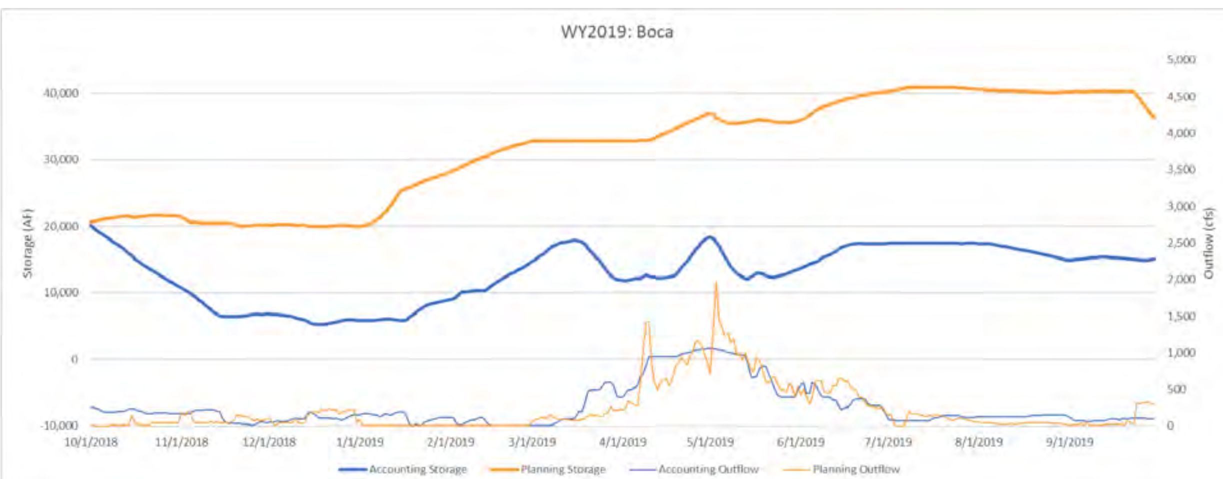


Figure 15. WY 2019 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.4.2 Lahontan Reservoir, WY 2019

Figure 16 is a comparison of daily Storage and Outflow values for Lahontan Reservoir from the Accounting and Planning Models for WY 2019. The difference in storage is a result of the difference in releases from Lahontan Reservoir where the Accounting

Model is a result of a variable forecast and releases are made with the variable hydrology driving operations. The Planning Model releases are based:

1. A prescribed stair step pattern based on monthly historical averages and Carson Division Demand.
2. A perfect forecast.

Because Planning Model releases are made based on a perfect forecast, they are both smoother and more efficient that those of the Accounting Model. This results in a different EOY storage between the Accounting and Planning Models for WY 2019.

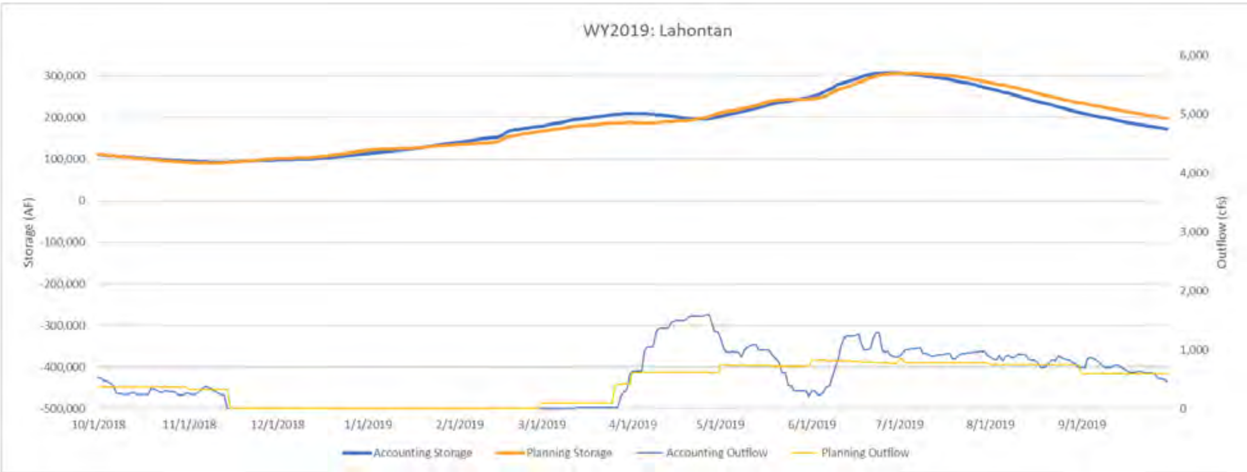


Figure 16. WY 2019 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.5 WY 2020 Summary

Table 10 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2020. WY 2020 showed differences on several reservoirs when considering the EOY storage values. Details of the differences on Boca Reservoir, Stampede Reservoir, Prosser Creek Reservoir, Donner Lake, and Lahontan Reservoir are detailed below.

Table 10. WY 2020 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2020		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	14,146	116,825	12,241	13,132	7,390
Planning	EOY Value	20,230	136,897	13,138	8,300	3,139
	Difference	6,084	20,072	897	-4,832	-4,251
	% Change	43%	17%	7%	-37%	-58%

WY 2020		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	867	6,226	59,387	22,483,517
Planning	EOY Value	800	6,226	73,673	22,233,344
	Difference	-67	0	14,286	-250,173
	% Change	-8%	-3%	24%	-1%

4.2.5.1 Boca Reservoir, WY 2020

Figure 17 is a comparison of daily Storage and Outflow values for Boca Reservoir from the Accounting and Planning Models for WY 2020. Differences in storage on Boca Reservoir between the Accounting and Planning Models in WY 2020 are due to construction on the Boca Reservoir Dam that occurred in WY 2020. The releases from Boca Reservoir are similar except when releases were recorded in the Accounting Model to keep Boca Reservoir below levels necessary for construction to be completed.

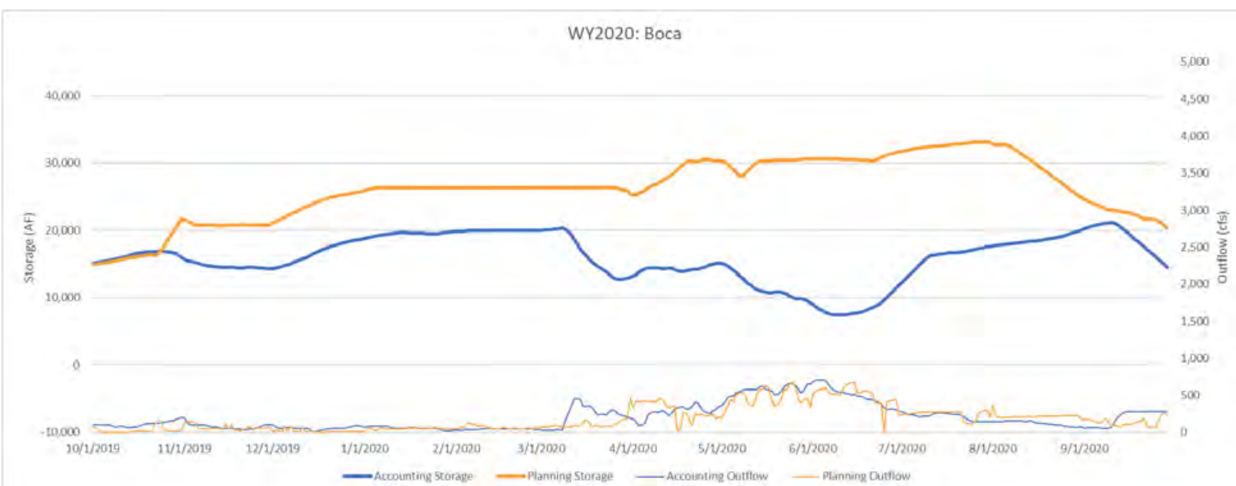


Figure 17. WY 2020 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.5.2 Stampede Reservoir, WY 2020

Figure 18 is a comparison of daily Storage and Outflow values for Stampede Reservoir from the Accounting and Planning Models for WY 2020. The difference in Stampede Reservoir storage at the end of WY 2020 between the Accounting and Planning Models is due to the outflow operations. The Accounting Model released steady flows in April through mid-July to meet flow targets downstream of the Truckee River at Nixon Gage where the Planning Model released the exact amount of water needed to meet the flow target. As a result, the flows at the Truckee River at Nixon Gage are higher in the Accounting Model (see **WY 2021 Truckee River at Nixon Gage Flows**). Steady flows after the beginning of August are due to preferred release targets of 90 cfs in the Accounting Model and 45 cfs in the Planning Model. These discrepancies result in the difference in Storage at the end of the year for WY 2020.

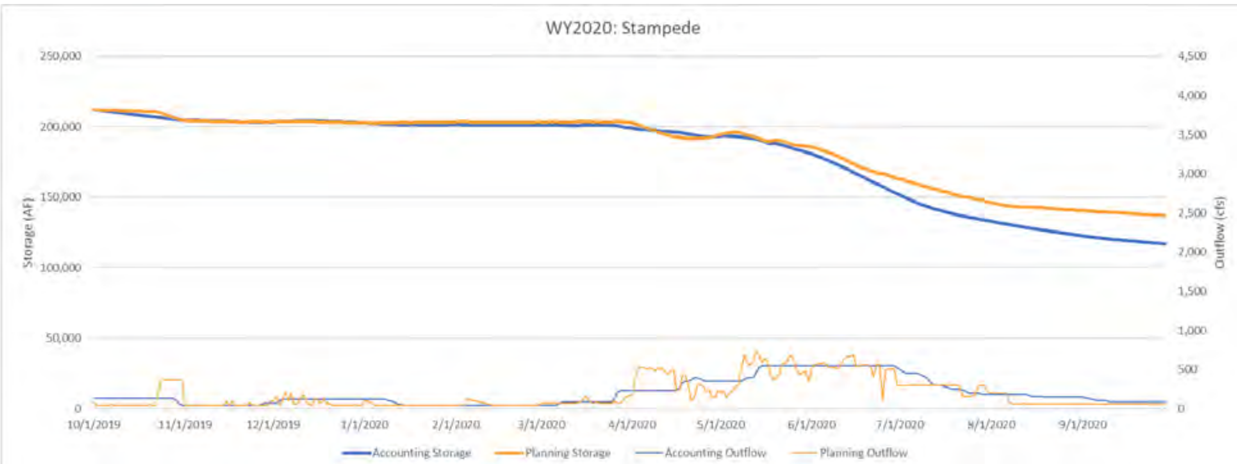


Figure 18. WY 2020 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.5.3 Prosser Creek Reservoir, WY 2020

Figure 19 is a comparison of daily Storage and Outflow values for Prosser Creek Reservoir from the Accounting and Planning Models for WY 2020. The difference in storage between the Accounting and Planning Models for Prosser Creek Reservoir in WY 2020 is a result of different outflow from the reservoir. The California Preferred Flows requests maintained Prosser Creek Reservoir Outflow for the entire WY 2020 in the Accounting Model. The Planning Model allowed for releases from Prosser Creek Reservoir that met flow targets at the Truckee River at Nixon Gage.

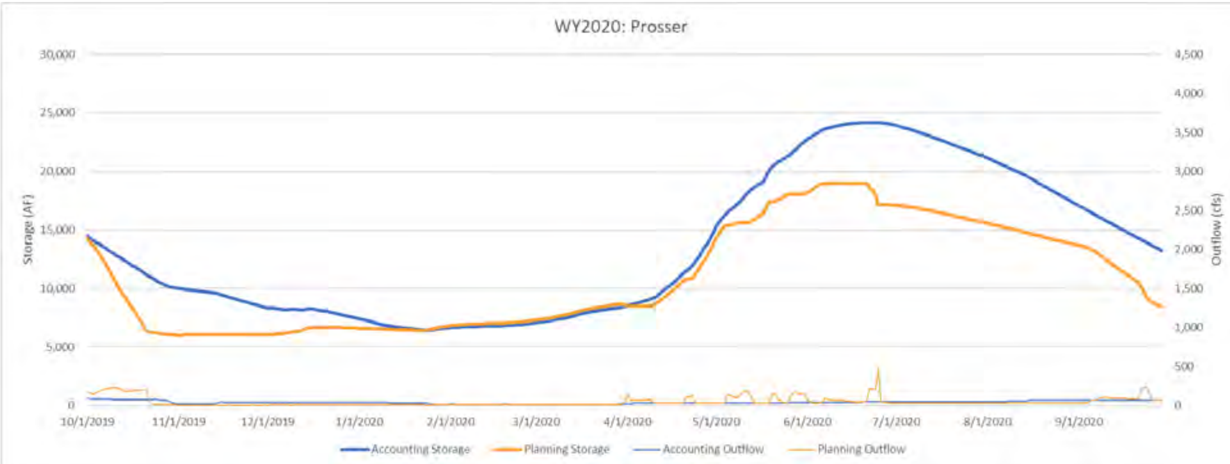


Figure 19. WY 2020 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.5.4 Donner Lake, WY 2020

Figure 20 is a comparison of daily Storage and Outflow values for Donner Lake from the Accounting and Planning Models for WY 2020. Differences in storage for Donner Lake between the Accounting and Planning Models in WY 2020 are due to the different filling and drawdown operations that occurred in the two models. The Planning Model fills Donner Lake later and draws the lake down sooner in the fall than was operated in WY 2020.

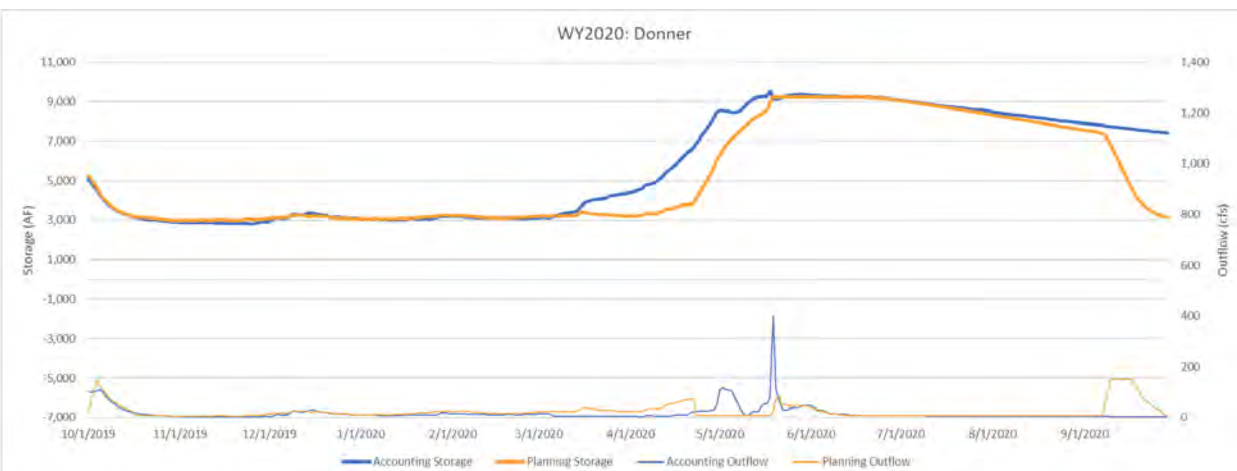


Figure 20. WY 2020 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.5.5 Lahontan Reservoir, WY 2020

Figure 21 is a comparison of daily Storage and Outflow values for Lahontan Reservoir from the Accounting and Planning Models for WY 2020. Differences in storage in

Lahontan Reservoir in WY 2020 between the models are due to the Accounting Model outflow being set with hydrology variability driving operations. The result is outflows that are not as smooth as the Planning Model, which uses a perfect forecast to set outflows. This results in a different EOY storage for WY 2020 between the Accounting and Planning Models.

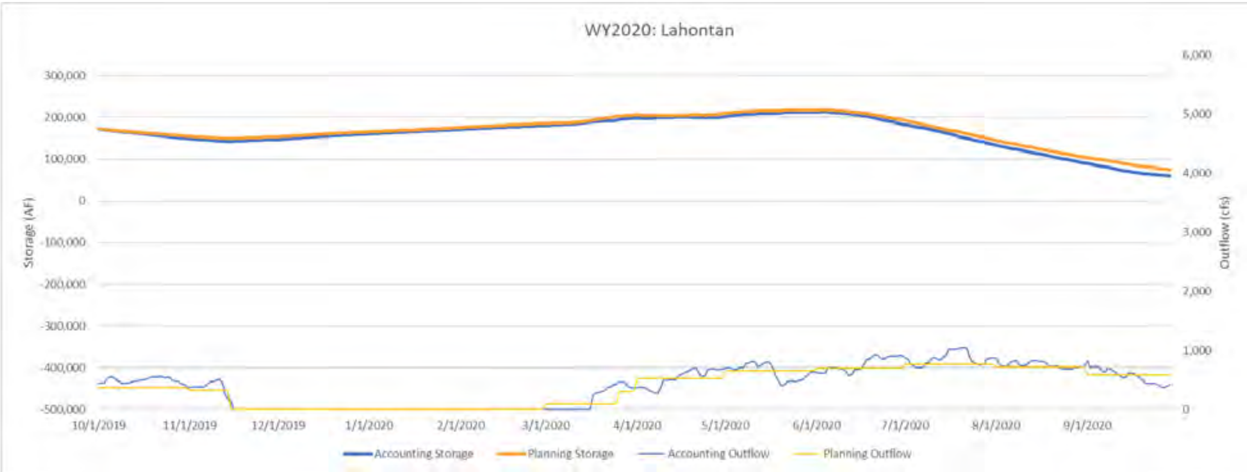


Figure 21. WY 2020 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

4.2.6 WY 2021 Summary

Table 11 provides a summary of EOY storage/pool elevation values for reservoirs in the system for WY 2021. The operations in WY 2021 resulted in lower storage values for all the reservoirs in the Truckee and Carson basins. Donner Lake, Lake Tahoe, and Lahontan Reservoir all show values for percent change that are large; however, because the system is dry and reservoirs storages are low in comparison to their max capacity, the magnitude of the difference between the models is small. The differences between EOY storages for WY 2021 are minor and not considered significant enough for detailed review. Figures for each can be viewed in **Appendix F: Summary of WY 2021 Comparison**.

Table 11. WY 2021 EOY Values of Storages/Pool Elevations for Truckee River Reservoirs/Lakes and Lahontan Reservoir in the Accounting and Planning Models.

WY 2021		Boca Storage (AF)	Stampede Storage (AF)	Independence Storage (AF)	Prosser Storage (AF)	Donner Storage (AF)
Accounting	EOY Value	21,321	80,115	12,706	10,318	3,382
Planning	EOY Value	22,082	75,955	11,909	10,546	4,122
	Difference	761	-4,160	-797	228	740
	% Change	4%	-5%	-6%	2%	22%

WY 2021		Martis Storage (AF)	Tahoe Pool Elevation (ft)	Lahontan Storage (AF)	Pyramid Storage (AF)
Accounting	EOY Value	854	6,223	5,987	22,133,580
Planning	EOY Value	800	6,223	3,990	21,895,139
	Difference	-54	0	-1,997	-238,441
	% Change	-6%	-19%	-33%	-1%

4.3 Canal Annual Diversion Volumes

4.3.1 Summary

Several constraints were placed on Canal operations in the Planning Model for this verification effort. Throughout the verification period (WY 2016-2021), the Canal was never operated to divert at its full capacity. Furthermore, there were several durations of time when the Canal was turned off when it could have been diverting due maintenance or other reasons. One issue with limiting the physical capacity of the Canal within the Planning Model is that it has effects on other parts of the system. For example, Canal operations have a direct impact to how much water flows in the Truckee River to Pyramid Lake. This, in turn, has an impact on how much water is released from upstream reservoirs to meet flow targets at the Truckee River at Nixon Gage. Those differences in release change what other releases occur. However, overly limiting the Canal in the Planning Model may have unintended effects on the modelling results, like allowing for Fish Credit water establishment at times when this did not occur historically.

To strike a balance between the impacts of Canal limitations to the system and modelling how the Canal behaved in history, two constraints were implemented. The first was that the Canal's physical capacity was limited to maximum of 400 cfs across the Planning Model runs. The second was that the Canal's physical capacity was set to 0 cfs any time during history that the Canal was turned off.

Table 12 contains values for Accounting and Planning Model Canal Diversion Volumes by WY. The Annual Diversion Volumes metric for WY 2017, WY 2018, WY 2019 and

WY 2020 validated well against what happened historically. In contrast, WY 2016 and WY 2021 showed 61 KAF and 38 KAF volumes of difference between the Planning and Ops Models, respectively. Furthermore, the Planning Model diverted more through the Canal in all years except WY 2019. An explanation for this is that the Planning Model can operate and hit targets more efficiently than what is operationally feasible in real-time. A second explanation for this is that there were several limitations on Canal operations that occurred throughout the verification period that were unable to be applied to the Planning Models.

Table 13 shows NSE scores for comparison of daily Canal Diversions between Planning and Accounting Models. Interestingly, while the Planning Model annual diversion volume in 2019 validated well, the NSE score suggests that the timing of these diversions was different between the two models. Furthermore, WY 2016 and WY 2021, which showed diversion volumes differences that were much more significant than WY 2019, performed much better than WY 2019 in terms of NSE Scores.

The following subsections discuss the three years that showed unsatisfactory performances in terms of the Annual Diversion Volume and NSE metrics.

Table 12. Accounting and Planning Model Canal Annual Diversion Volumes in KAF by WY.

WY	Model	Calculation	Truckee Canal Annual Delivery (KAF)
2016	Accounting	WY Volume	116
	Planning	WY Volume	178
		Difference	61
		% Change	52%
2017	Accounting	WY Volume	63
	Planning	WY Volume	73
		Difference	10
		% Change	15%
2018	Accounting	WY Volume	22
	Planning	WY Volume	25
		Difference	3
		% Change	15%
2019	Accounting	WY Volume	58
	Planning	WY Volume	55
		Difference	-2
		% Change	-4%
2020	Accounting	WY Volume	92
	Planning	WY Volume	107
		Difference	15
		% Change	16%
2021	Accounting	WY Volume	147
	Planning	WY Volume	185
		Difference	38
		% Change	26%

Table 13. NSE Scores of daily Planning Model Canal Diversions compared to daily Accounting Model Canal Diversions by WY.

	2016	2017	2018	2019	2020	2021
Truckee Canal Diversion	0.25	0.63	0.74	-0.30	0.90	0.13

4.3.2 WY 2016 and WY 2021 Canal Diversions

The relatively poor performance in the Planning Model for WY 2016 and 2021 were similar in nature. Figure 22 and Figure 24 show the daily diversions of the Canal as recorded by the Accounting Model and the Planning Model results for WY 2016 and WY 2021, respectively. As shown in the figures, the main difference between the results is that the Planning Model was allowed to divert at rates much higher than was done historically in these years. This explains both the poor performance in comparison of the Annual Diversion Volumes between the two models and the unsatisfactory NSE score.

As explained above, over limiting the Canal diversions in the Planning Model to match more closely what happened historically has ripple effects on other major components of the model. *Development could be introduced into the Planning Model that would incorporate Canal maintenance, limited diversion rates, and imperfect Canal diversions.*

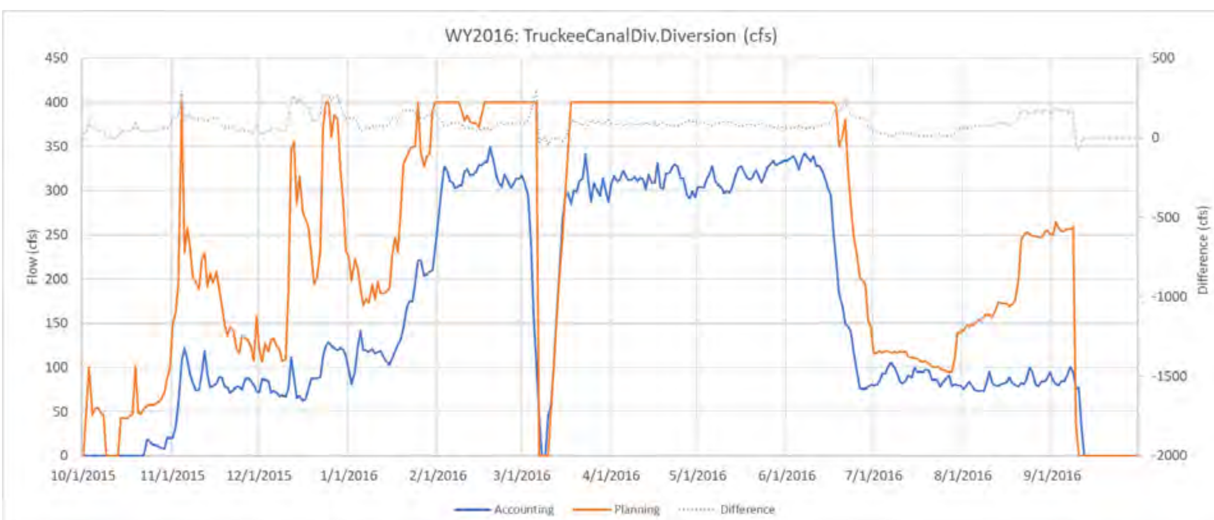


Figure 22. WY 2016 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

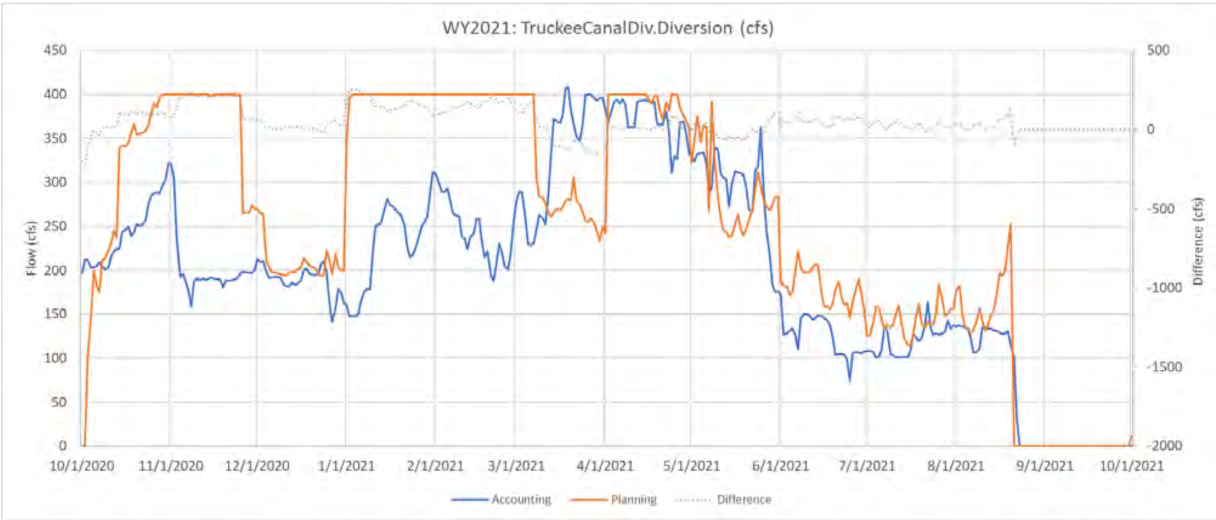


Figure 23. WY 2021 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

4.3.3 WY 2019 Canal Diversions

The Accounting and Planning Models recorded an Annual Canal Diversion Volume of 58 and 53 KAF, respectively, and the Planning Model showed roughly 5 KAF less diversions than the Accounting Model. The NSE Score for this WY was 0.22, which is an unsatisfactory result for this metric.

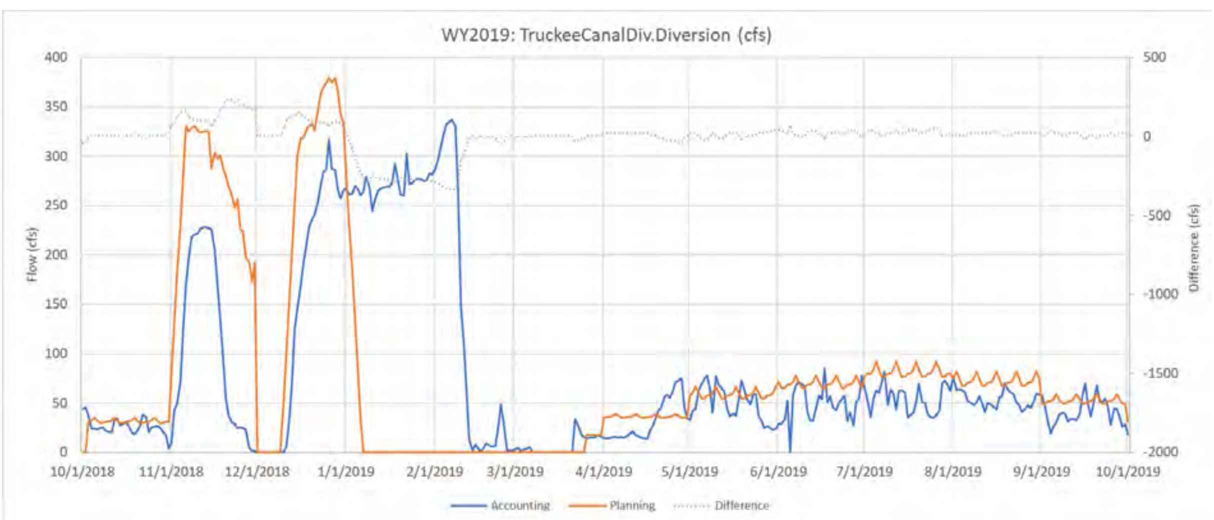


Figure 24. WY 2019 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

Figure 24 shows the daily diversions of the Canal as recorded by the Accounting Model and the Planning Model results for WY 2019. As shown in the figure, the Planning

Model diverted at a much faster rate than the Accounting Model when the Canal was entitled to take diversions between November and early January. In early January, the Planning Model determined that the Canal no longer needed to make diversions, while the Accounting Model continued to make diversions. The Accounting Model continued diverting at a high rate until mid-February while the Planning Model diverted nothing during this period. After February, the daily diversions were relatively consistent between the two models. The difference in diversion is directly related to the variability of forecasts used to operate the Canal in the Accounting Model and the perfect forecast used in the Planning Model. Because of this, the Planning Model determined lower storage targets in Lahontan reservoir in January than what was determined for the Accounting Model. This results in less water diverted through the Canal in the Planning Model. *Development could be introduced into the Planning Model to represent an imperfect forecast. This would allow certain questions that are answered with the Planning Model to be addressed more accurately.*

4.4 Flow and Annual Delivery Volumes for the Truckee River at Nixon Gage

4.4.1 Summary

Table 14 contains values for Accounting and Planning Model Annual Delivery Volumes at the Truckee River at Nixon Gage by WY. Planning Model results of Annual Delivery Volumes for WY 2017, WY 2018, WY 2019, and WY 2020 are within 3% of the Accounting Model results, which is considered a minor difference. The two years that perform the worst for this metric are WY 2016 and WY 2021. Table 15 provides NSE scores for comparison of daily Truckee River at Nixon Gage flows between Planning and Accounting Models. This metric shows that WY 2016 through WY 2020 performed satisfactorily, with strong scores for WY 2017 and WY 2019. WY 2021 had an NSE score of 0.33 and was the only year that had an unsatisfactory score. The following subsection discusses performance issues of WY 2016 and 2021 in more depth. Figures for the remaining year for Truckee River at Nixon Gage flow can be found in the respective years appendix.

Table 14. Accounting and Planning Model Farad at Nixon Annual Delivery Volumes in KAF by WY.

WY	Model	Calculation	Truckee at Nixon Annual Delivery (KAF)
2016	Accounting	WY Volume	190
	Planning	WY Volume	148
		Difference	-43
		% Change	-22%
2017	Accounting	WY Volume	1,446
	Planning	WY Volume	1,461
		Difference	16
		% Change	1%
2018	Accounting	WY Volume	611
	Planning	WY Volume	599
		Difference	-12
		% Change	-2%
2019	Accounting	WY Volume	893
	Planning	WY Volume	863
		Difference	-30
		% Change	-3%
2020	Accounting	WY Volume	292
	Planning	WY Volume	282
		Difference	-10
		% Change	-3%
2021	Accounting	WY Volume	117
	Planning	WY Volume	105
		Difference	-12
		% Change	-10%

Table 15. NSE Scores of daily Planning Model Truckee River at Nixon Gage flows compared to daily Accounting Model Truckee River at Nixon Gage flows by WY.

	2016	2017	2018	2019	2020	2021
Truckee at Nixon	0.72	0.91	0.71	0.86	0.57	0.33

4.4.2 WY 2016 Truckee River at Nixon Gage Flows

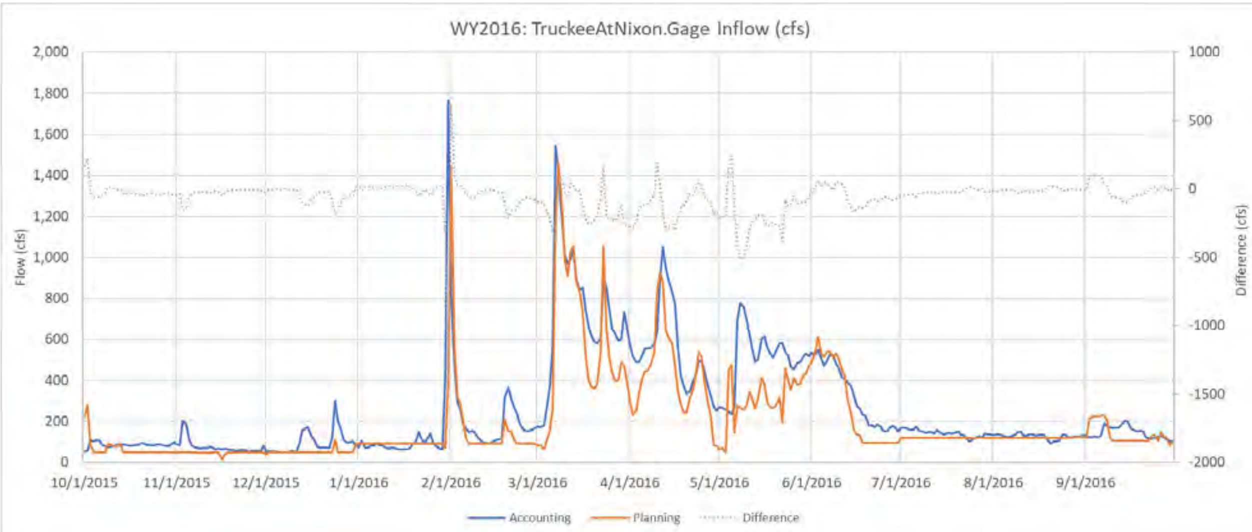


Figure 25. WY 2016 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

The NSE Score comparing daily flows at the Nixon Gage from Planning Model to the Accounting Model was 0.72, which is a very strong score. However, the volume of flow that reached the Nixon Gage in the two models over the course of the WY was significantly different. The Accounting Model shows that a total of 190 KAF flowed past the Nixon Gage in WY 2016, and the Planning Model shows that only 148 KAF flowed past the Nixon Gage. This discrepancy between annual volume and NSE score suggests that while the timing of flows at the Nixon Gage is relatively accurate between the two models, there is a discrepancy between the magnitude of flows reaching the gage. This is substantiated by Figure 25.

Figure 25 shows that flows at the Nixon Gage were relatively similar between the start of the WY and mid-February. The main difference in this period is that the Planning Model is able hit flow regime targets more precisely because the model is operating to a perfect forecast. During the runoff period when fish runs occur, the daily flows at the Nixon Gage between the two models show discrepancies.

The reason for the discrepancies in the flows during the runoff period between the two models is related to the Nixon Targets. In the Planning Model, a fish regime is selected based off Storage in Stampede and the forecast March through July volume of runoff. WY 2016 had a median runoff, and the basin was coming out of a drought, so Stampede storages were very low. Because of this, logic in the Planning Model that selects flow regime selected a sub-six flow regime 7, which is the flow regime with the lowest targets at the Nixon Gage.[3]

What happened in history was that, despite low storages in Stampede, PLPT decided to adjust the targets more adaptively at the Nixon Gage in response to the fish run that occurred. The result is that PLPT made releases from Tahoe, Prosser and Stampede between February and June for an approximate total volume of 53 KAF. In contrast, the Planning Model during this timeframe only released roughly 3 KAF. These differences in Fish releases explain the differences in annual volumes at the Nixon Gage.

To address this issue in the Planning Model was beyond the scope of this verification study: *a more in-depth analysis of Fish Regime Selection logic and Fish Release logic in coordination with PLPT would be needed to enhance the Planning Model's capabilities of capturing historical operations.*

4.4.3 WY 2021 Truckee River at Nixon Gage Flows

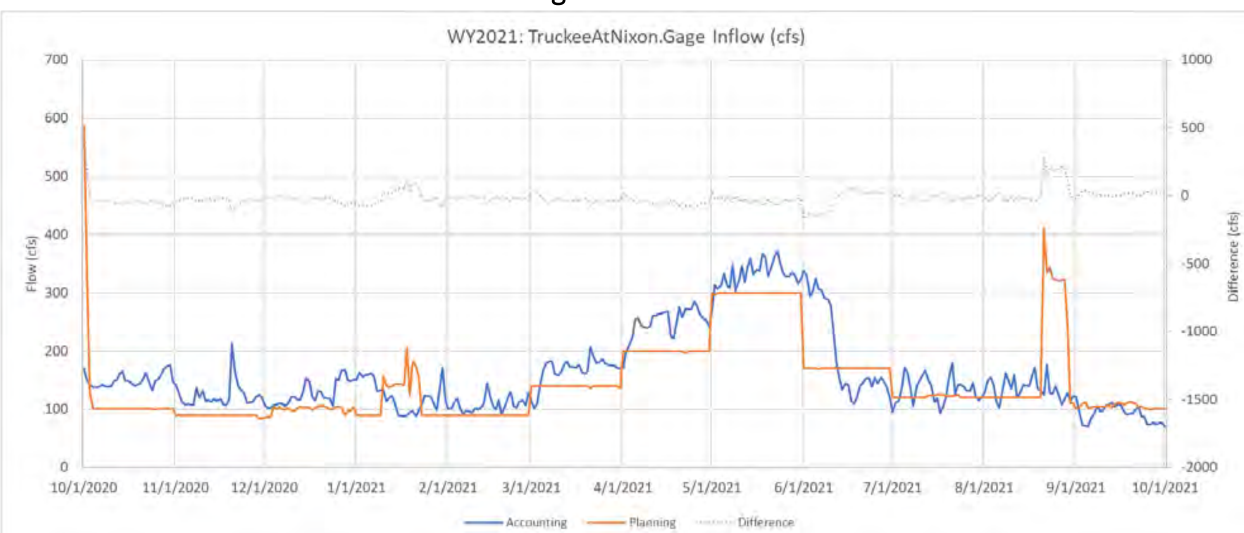


Figure 26. WY 2021 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

WY 2021 was the other year that performed poorly when comparing Truckee at Nixon Gage flows between the Accounting and Planning Models. The NSE Score for WY 2021

[3] A sub-six flow regime, while not an official flow regime, was developed in conjunction with Curtis Lawler of Stetson Engineers based on operations in 2015. In the Planning Model, the sub-six flow regime prevents PLPT storage from depleting to 0 AF during extremely dry periods when flow regime 6 would have been used.

was 0.33, and the Planning Model showed 12 KAF less flow at Nixon over the course of the WY than the Accounting Model.

Figure 26 provides a comparison of daily flows at the Truckee at Nixon Gage in the Accounting Model and Planning Models. For most of the WY, the Accounting Model shows more water passing the Nixon Gage than the Planning Model even though the Fish Regime between the two models is the same. A large contributor to the difference between the two models is that the Planning Model hits the targets precisely. The Accounting Model shows how actual operations occur and how releases to meet a target are set with hydrologic and operational variability in the system; to ensure that a target at the Truckee River at Nixon Gage is always met, a set release is made from a reservoir. In WY 2021, this release is from Stampede Reservoir (see **Reservoir Plots, WY 2021**). This results in a higher flow at the Truckee River at Nixon Gage.

Another major difference between the two models can be seen in late August. The Planning Model shows flows rising significantly from 110 cfs to above 300 cfs. This difference is due to the timing of when the Canal was set to not divert water in the Planning Model and the additional days of meeting the FR target in WY 2021. The Planning Model was scheduled for the Canal to have no capacity starting on August 18, 2021, the date that the FR target is missed in the Accounting Model. Subsequently, the Canal diversions are limited over the next days, getting to 0 cfs by August 23, 2021. The FR target is met in the Planning Model until August 27, 2021 (roughly 9 days later than in the Accounting Model), and that water flows past the Canal and to the Truckee River at Nixon Gage.

4.5 Summary of Stakeholder (Party) Volumes for each WY

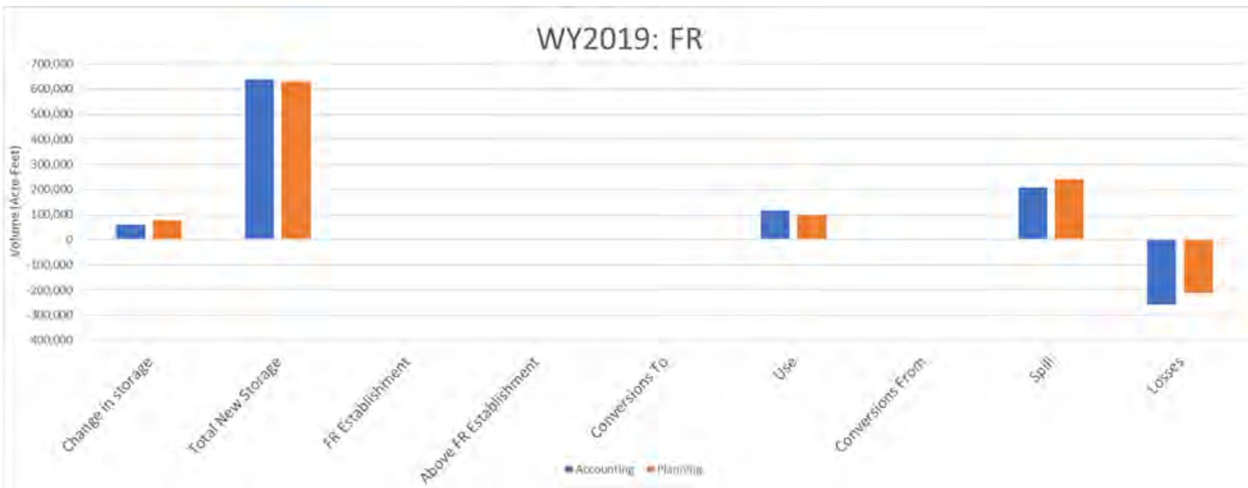
This section of the report summarizes the Stakeholder Volumes for each WY. It utilizes Party Water Balance Comparisons to analyze Planning Model performance in comparison to the Accounting Model. Refer to **Party Water Balance Comparisons** for a detailed description of the Party Water Balance Comparison plots. Furthermore, this comparison metric is limited to WY 2019-2021 (see **Limitations of Party Summary Reports in WY 2016 to WY 2018**). Note that Fernley Volumes are not included in this report as their water use has been minimal and experimental throughout the duration of the verification period.

4.5.1 WY 2019

4.5.1.1 Floriston Rate, WY 2019

Figure 27 provides a comparison of the FR water balance in the Planning and Accounting Model for WY 2019. FR water was impacted in WY 2019 by the limited Boca Reservoir storage in the Accounting Model due to construction. Also, the differences in model input hydrology result in differences in the Total New Storage of FR volume for WY 2019 (see **Underlying Data Differences**).

Figure 27. Comparison of Accounting and Planning Model Floriston Rate Water Balance for WY 2019.



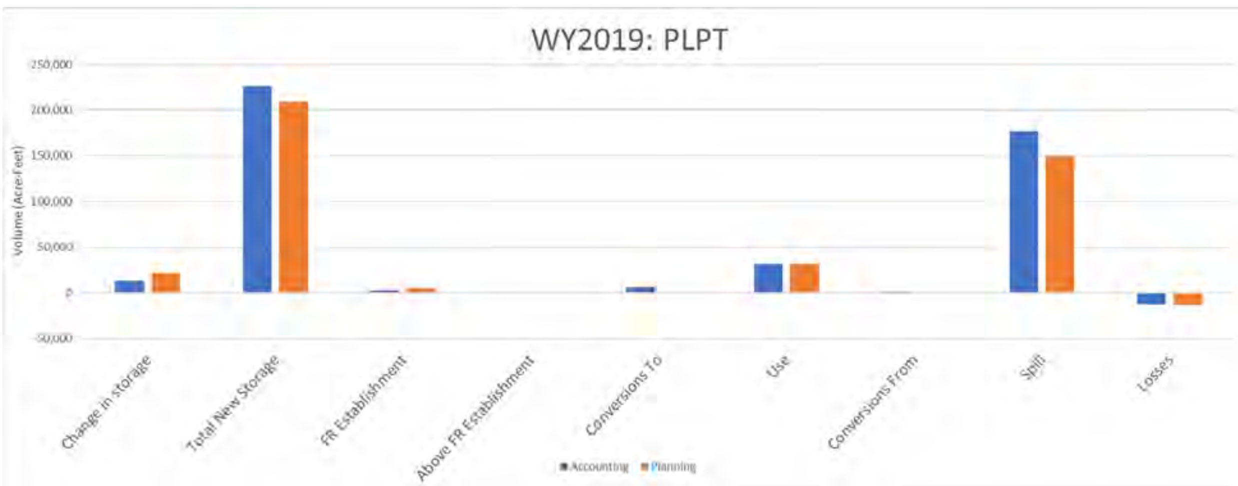
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	539,237	600,644	61,407	638,419	N/A	N/A	0	114,126	93	208,780	-258,319
Planning	541,412	620,049	78,638	630,403	N/A	N/A	0	97,942	139	241,618	-214,194
Difference	2,175	19,405	17,230	-8,016	N/A	N/A	0	-16,184	46	32,837	-44,125
% Difference	0.40%	3.23%	28.06%	-1.26%	N/A	N/A	Inf	-14.18%	50.03%	15.73%	-17.08%

4.5.1.2 PLPT, WY 2019

Figure 28 shows the PLPT water balance for WY 2019 in the Accounting and Planning Models. In the Accounting Model, roughly 17,000 AF more Fish Project Storage occurred than in the Planning Model, and this difference between the two models is offset by the amount of spill that occurs. Overall, the Accounting Model shows the total change in storage over the course of the WY is roughly 8,000 AF less than in the Planning Model. The difference in the amount of new project water stored is due to the construction that occurred in Boca Reservoir in 2019. The accounting and storage is different because the Planning Model stores more water in Boca Reservoir instead of passing water through the reservoirs to ensure space for the construction in Boca

Reservoir. This results in different storage amounts of both FR water (Figure 27) and Fish Project Storage between the Accounting and Planning models. The difference in storage at the end of the WY (~8,000 AF) is due to different operations that occur in the release of Fish Project Storage. The Accounting Model shows releases that have significantly higher flows at the Truckee River at Nixon Gage. This could have been an operational strategy to increase flows at the Truckee River at Nixon Gage or an effort to draw down water in the Truckee Basin reservoirs. As a result, the simulation of the Planning Model results in 8,000 AF more storage at the end of the WY than the Accounting Model.

Figure 28. Comparison of Accounting and Planning Model PLPT Water Balance for WY 2019.

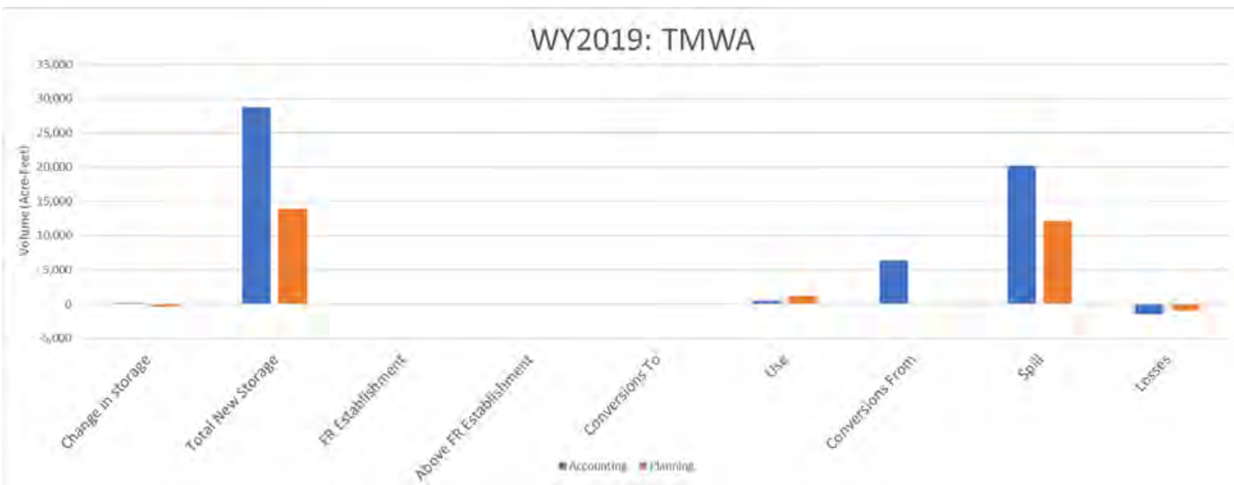


	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	203,337	217,138	13,801	226,602	3,325	N/A	5,826	31,474	1,421	176,566	-12,549
Planning	203,207	224,863	21,656	209,350	5,193	N/A	139	31,100	139	148,781	-13,194
Difference	-130	7,725	7,855	-17,252	1,867	N/A	-5,687	-373	-1,282	-27,786	645
% Difference	-0.06%	3.56%	56.92%	-7.61%	56.16%	N/A	-97.62%	-1.19%	-90.23%	-15.74%	5.14%

4.5.1.3 TMWA, WY 2019

Figure 29 provides a comparison of the TMWA water balance in the Planning and Accounting Model for WY 2019. The most notable differences in the water balance comparison are the Total New Storage, Spills, and Conversions From. The differences in Total New Storage and Spills between the two models mostly offset one another, and they occur because of underlying accounting differences between the models. In the Accounting Model, additional project storage was credited to TMWA while the reservoirs were full, and this additional project water spilled almost immediately. In the Planning Model, this additional project storage was not credited initially to TMWA, and thus the new project storage nor the additional spill showed up in the water balance.

Figure 29. Comparison of Accounting and Planning Model TMWA Water Balance for WY 2019.



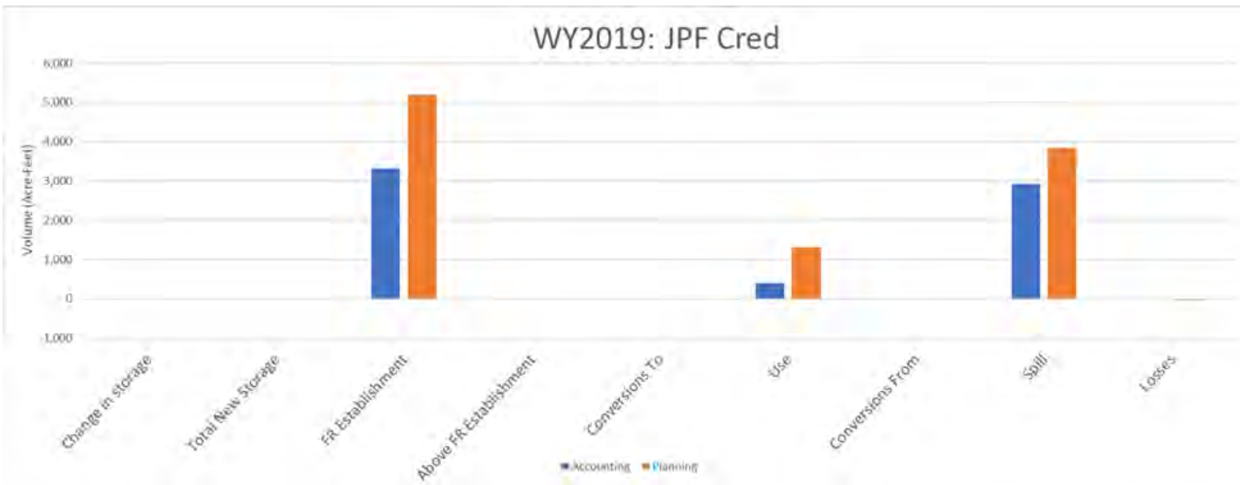
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	36,155	36,306	151	28,647	0	0	N/A	509	6,281	20,206	-1,518
Planning	36,172	35,785	-387	13,950	0	0	N/A	1,138	0	12,192	-1,011
Difference	17	-521	-538	-14,697	0	0	N/A	629	-6,281	-8,014	-508
% Difference	0.05%	-1.43%	-356.13%	-51.30%	0.00%	0.00%	N/A	123.53%	-100.00%	-39.66%	-33.45%

A more notable difference is the Conversions From category of the water balance. The Accounting Model recorded more than 6,000 AF of Conversions From TMWA, and the Planning Model recorded 0 AF. The conversion occurring in the Accounting Model was the "Independence Natural Flow Conversion". When Independence is passing all or part of its inflow because the reservoir is full, the accounting within the model should treat the additional inflow as it were natural inflow to Stampede Reservoir, and this inflow should ultimately be accounted for as FR or Fish Water depending on accrual on the Boca storage license. This conversion was in effect and tracked in the Accounting

Model but not the Planning Model. *This issue in the Planning Model will need to be researched further and addressed in future development*.

4.5.1.4 JPF Cred, WY 2019

Figure 30. Comparison of Accounting and Planning Model JPF Cred Water Balance for WY 2019.

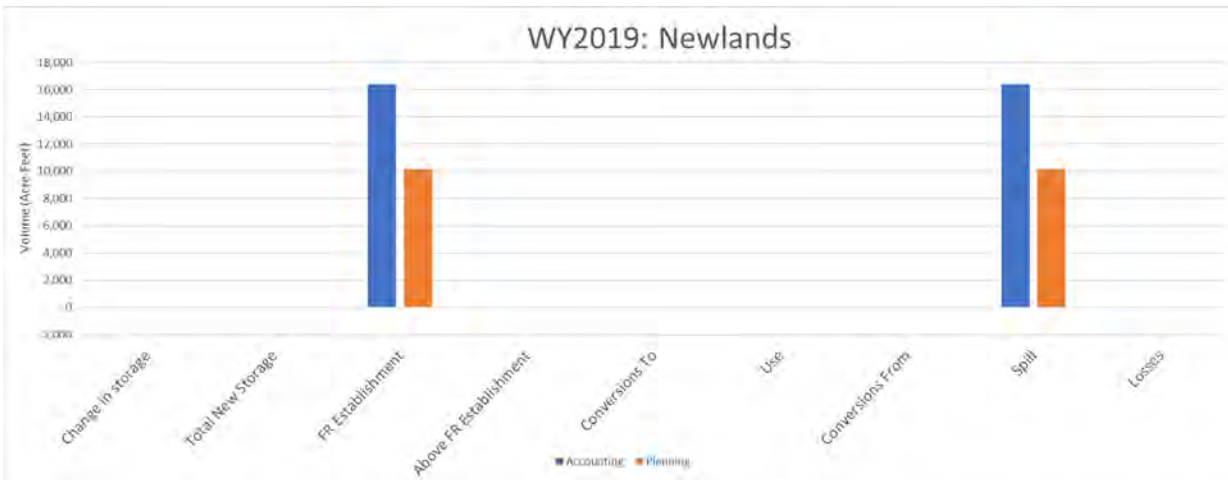


	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	0	0	N/A	3,325	N/A	N/A	403	N/A	2,914	-9
Planning	0	0	0	N/A	5,193	N/A	N/A	1,306	N/A	3,842	-45
Difference	0	0	0	N/A	1,867	N/A	N/A	903	N/A	928	36
% Difference	0.00%	0.00%	0.00%	N/A	56.16%	N/A	N/A	224.36%	N/A	31.85%	414.26%

Figure 30 shows the Planning and Accounting Model water balance comparison for JPF Cred in WY 2019. Overall, the major difference between the two models is the amount of JPF Cred Establishment that occurred: the Planning Model shows roughly 2,000 AF more JPF Cred establishment than the Accounting Model. Per TROA 7.C.7 (b), JPF Cred establishment is dependent on the amount of Fish Credit Water established. TROA 7.C.6 (b) specifies that a portion, specified by CA and up to 50%, of any Fish Credit Water established is designated as JPF Cred. Furthermore, TROA also specifies that Fish Credit Water is the lowest priority of FR Establishment to occur; all other parties can establish credit water prior to PLPT. WY 2019 results show that Newlands Project Credit Water (NPCW) established roughly 6,000 AF less of credit water in the Planning Model than in the Accounting Model (see **Newlands, WY 2019**), and, in turn, much more establishment was available to be exercised by PLPT in the Planning Model (and thus increasing the amount of JPF Cred establishment). The reason why less NPCW was established in the Planning Model is discussed in more detail in the proceeding section of this report. Overall, the reservoirs in 2019 were full, and all JPF Cred in the system spilled or was released downstream and the EOY storages for JPF Cred between the two models were identical.

4.5.1.5 Newlands, WY 2019

Figure 31. Comparison of Accounting and Planning Model Newlands Water Balance for WY 2019.



	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	0	0	N/A	16,442	0	N/A	0	0	16,442	0
Planning	0	0	0	N/A	10,116	0	N/A	0	0	10,116	0
Difference	0	0	0	N/A	-6,326	0	N/A	0	0	-6,327	0
% Difference	0.00%	0.00%	0.00%	N/A	-38.48%	0.00%	N/A	0.00%	0.00%	-38.48%	Inf

The WY 2019 summary is shown in Figure 31. The Accounting Model established more Newlands Project Credit Water than the Planning Model, and this is due to “High Establishment Limits” in the Planning Model. These limits exist to prevent parties from establishing in reservoirs when reservoir storages are above a threshold to avoid credit water spill. “High Establishment Limits” are not proscribed by TROA and can be waived at a Parties discretion. NPCW is established in Stampede Reservoir and Boca Reservoir in the Accounting Model despite High Establishment Limits, and this does not occur in the Planning Model. All water established in both models is spilled and the EOY storage for the Accounting and Planning Models in WY 2019 is 0 AF.

4.5.1.6 Water Quality, WY 2019

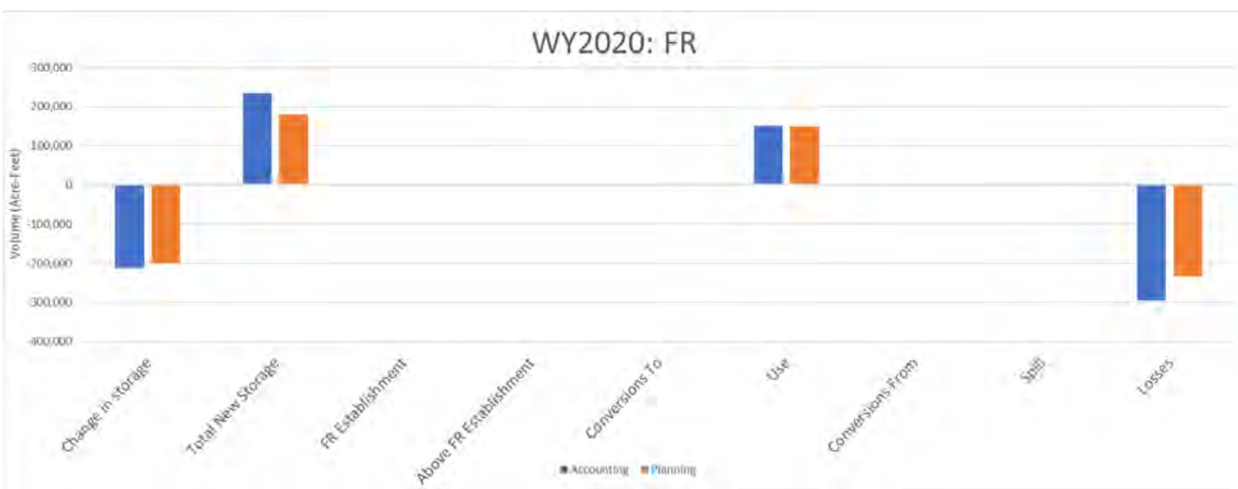
As there was no Water Quality Credit Water (WQCW) establishment throughout WY 2019 in the Accounting Models, the results are not included in this report.

4.5.2 WY 2020

4.5.2.1 Floriston Rate, WY 2020

Figure 32 provides a summary of the Planning and Accounting Model FR water balances for WY 2020. The differences seen in Total New Storage and Losses were explained previously in this report in the section titled **Underlying Data Differences**, and these differences offset one another in the water balance. Overall, the total change in the FR Storage over the course of the WY was 5% less in the Planning Model than in the Accounting Model.

Figure 32. Comparison of Accounting and Planning Model Floriston Rate Water Balance for WY 2020.



	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	599,086	386,877	-212,210	233,407	N/A	N/A	0	151,346	325	0	-295,503
Planning	598,134	397,675	-200,459	181,029	N/A	N/A	0	149,191	0	812	-233,893
Difference	-952	10,798	11,751	-52,378	N/A	N/A	0	-2,155	-325	812	-61,610
% Difference	-0.16%	2.79%	-5.54%	-22.44%	N/A	N/A	0.00%	-1.42%	-100.00%	Inf	-20.85%

4.5.2.2 PLPT, WY 2020

Figure 33 shows the PLPT water balance for WY 2020 in the Accounting and Planning Models. The two major differences in the modelling results are the amount of Fish Credit Water Establishment that occurred and the Use of storage to meet downstream demands. The Accounting Model shows that nearly 13,000 AF more Fish Credit Water was established than was modeled by the Planning Model. This occurred for three reasons:

(1) Roughly half of the establishment that occurred in the Accounting Model occurred in Lake Tahoe. Lake Tahoe was "high" in WY 2020, and, because of this, PLPT was more limited in their ability to establish Fish Credit Water in Lake Tahoe in the Planning Model due to "High Establishment Limits" (see **Newlands, WY 2019** for more detail on High Establishment Limits). In WY 2020, PLPT scheduled to store credit water in Lake Tahoe despite the reservoir's risk of spill.

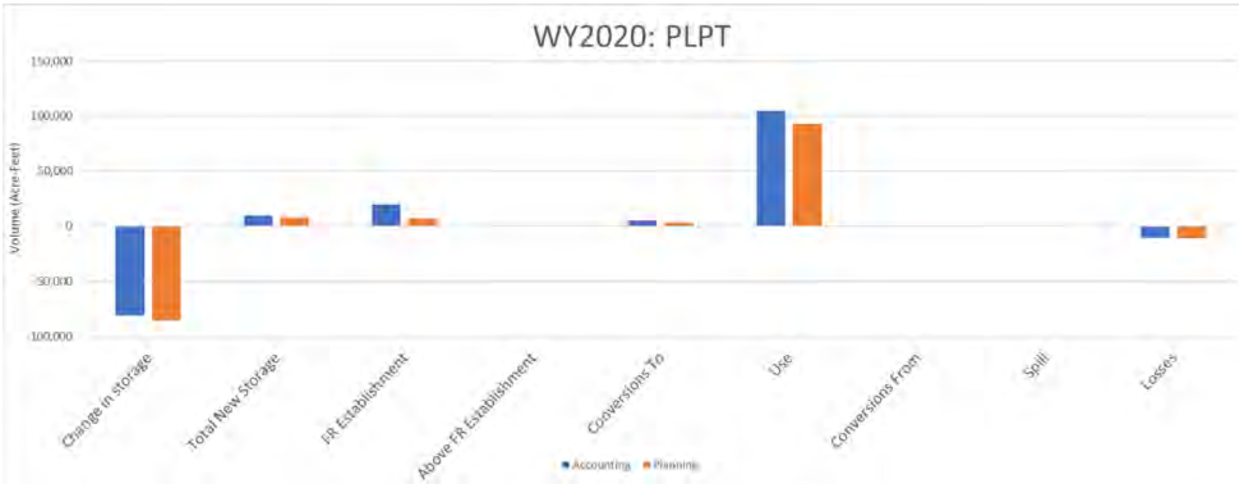
(2) In the Planning Model, Fish holdbacks are limited to occur at a maximum rate of 100 cfs per day. In the Accounting Model, PLPT Scheduled variable establishment rates between 100 and 250 cfs over the WY, and PLPT was able to establish at these higher rates at times. It is rare that PLPT would schedule to establish at these rates because establishment lowers the flows in the Truckee River. Furthermore, it is rare that PLPT could establish at such a high rate due to the limitations that (1) all other parties have a higher priority to establish, and (2) hydrology typically limits these establishment rates from being achievable by PLPT. In WY 2020, however, PLPT was able to achieve establishment rates up to 250 cfs due to other party's establishment schedules and the hydrology that occurred in the year.

(3) Both more WQCW and NPCW establishment occurred in the Planning Model in WY 2020 than in the Accounting Model, leaving less opportunity for Fish Credit Water to be established in the Planning Model.

The greater volume of PLPT Use shown in the Accounting Model in comparison the Planning Model results from the additional storage available to PLPT in the Accounting Model due to Fish Credit Water Establishment. There was an additional 12,800 AF of Fish Credit Water Storage available in the Accounting Model to PLPT that was then released during runoff and in the fall to supplement instream flows. This storage was not available in the Planning Model, and this explains the roughly 12,000 AF discrepancy in Use between the two models. Overall, the total change in PLPT storage only differed by roughly 4,5 00 AF, or 5.3%.

In conclusion, it is unknown if the scheduling pattern exhibited by PLPT in WY 2020 is standard practice, and more collaboration with PLPT would be needed to determine the *conditions when, if ever, the Planning Model should allow Fish Credit Water to be stored at high rates.*

Figure 33. Comparison of Accounting and Planning Model PLPT Party Water Balance for WY 2020.



	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	216,900	135,713	-81,187	9,616	19,837	N/A	5,192	105,118	383	0	-10,569
Planning	216,912	131,361	-85,551	8,059	7,037	N/A	3,312	92,903	0	0	-11,283
Difference	12	-4,352	-4,364	-1,556	-12,800	N/A	-1,880	-12,216	-383	0	714
% Difference	0.01%	-3.21%	5.37%	-16.18%	-64.53%	N/A	-36.21%	-11.62%	-100.00%	0.00%	6.76%

4.5.2.3 TMWA, WY 2020

Figure 34 provides a comparison of the TMWA water balance in the Planning and Accounting Model for WY 2020. TMWA's Use represents the largest discrepancy between the two models: the Accounting Model recorded nearly 4,500 AF of storage use while the Planning Model showed only 478 AF. In the Accounting Model, TMWA scheduled winter releases between the end of November until mid-January to maintain a Farad Target of 300 cfs. During this period, PLPT established at a rate that would reduce the Farad Gage flow to 250 cfs. Thus, for TMWA to meet a 300 cfs Farad Target required a storage release of 50 cfs per day throughout this period. In the Planning Model, PLPT established much less water primarily because the Planning Model did not allow Fish Credit Water establishment to occur in Lake Tahoe (see **PLPT, WY 2020**), and the flows at Farad remained above 300 cfs. Furthermore, the Planning Model currently assumes that TMWA would only augment winter flows in the Truckee River up to 250 cfs. *TMWA's standard practice in making winter releases is unknown, and further consultation would be needed with TMWA to model their winter release targets more accurately.*

The Conversions From category of the water balance represents the other major discrepancy between the two models. The Accounting Model recorded that 5,192 AF of Conversions From TMWA occurred in WY 2020, while the Planning Model only recorded 3,312 AF. The reason for this difference is twofold. The first is that there was roughly 1,300 AF of Privately Owned Stored Water (POSW) stored in Boca in the Planning Model at the end of the calendar year 2019. Per TROA 8.N.3, POSW stored in Boca should convert to Non-Firm M&I Credit Water at the end of the calendar year. *This conversion did not occur in the Planning Model because the model is not appropriately modelling TROA 8.N.3: this issue will need to be addressed in future development.* As a result, there was 1,300 AF less Non-Firm M&I Credit Water in the system that did not convert to Fish Credit Water on April 15th per TROA 7.B.4 (e). Conversions of POSW in the Accounting Model did adhere to TROA which largely explains the discrepancies in Conversions From.

The second reason for the discrepancy in the Conversions From category of the TMWA Water Balance in WY 2020 is a byproduct of the differences in Total New Storage. The Planning Model results show that roughly 650 AF less Total New Storage accumulated for TMWA than in the Accounting Model. This resulted from TMWA's 3,000 AF senior priority storage license on Independence not fully being utilized in the Planning Model. *The 8,000 AF of inflow to Independence during the storage season on TMWA's license is more than enough water to fill this license, and this discrepancy will need to be addressed in future development of the Planning Model.*

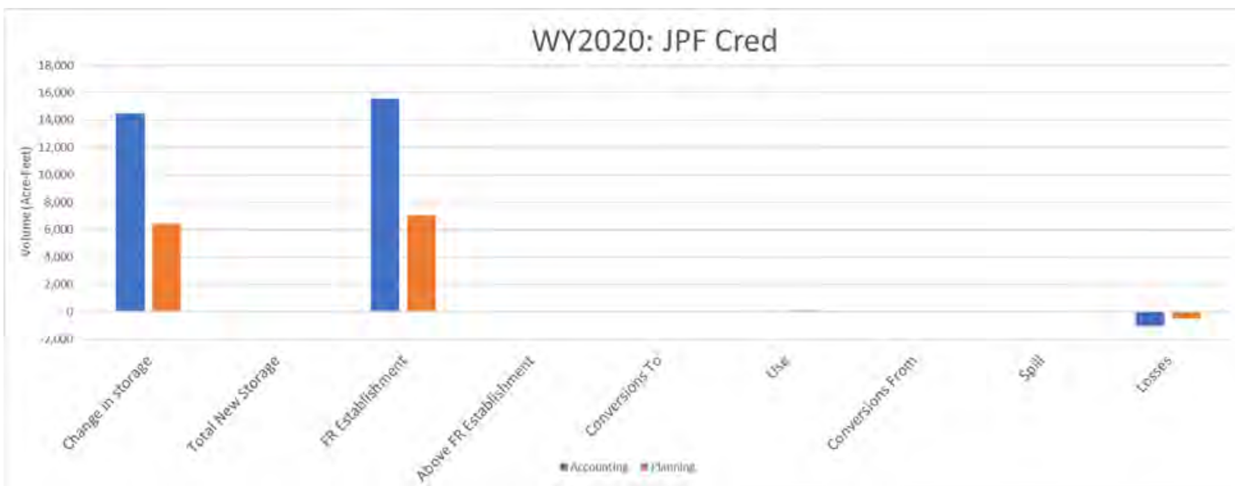
Figure 34. Comparison of Accounting and Planning Model TMWA Party Water Balance for WY 2020.

	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	36,305	35,099	-1,206	10,524	0	0	N/A	4,486	5,192	0	-2,053
Planning	36,305	40,436	4,131	9,865	0	0	N/A	478	3,312	65	-1,879
Difference	0	5,337	5,337	-659	0	0	N/A	-4,008	-1,880	65	-174
% Difference	0.00%	15.21%	-442.47%	-6.26%	0.00%	0.00%	N/A	-89.34%	-36.21%	Inf	-8.47%

4.5.2.4 JPF Cred, WY 2020

Figure 35 shows a comparison of the water balance for JPF Cred for WY 2020 in the Accounting and Planning Models. Nearly 8,500 AF more establishment occurred in the Accounting Model in comparison to the Planning Model. As described in **JPF Cred, WY 2019**, the JPF Cred establishment volumes are primarily dependent on Fish Credit Water establishment volumes. Thus, the discrepancies in JPF Cred Establishment between the two models are like those described in detail in the **PLPT, WY 2020** section of this report.

Figure 35. Comparison of Accounting and Planning Model JPF Cred Party Water Balance for WY 2020.



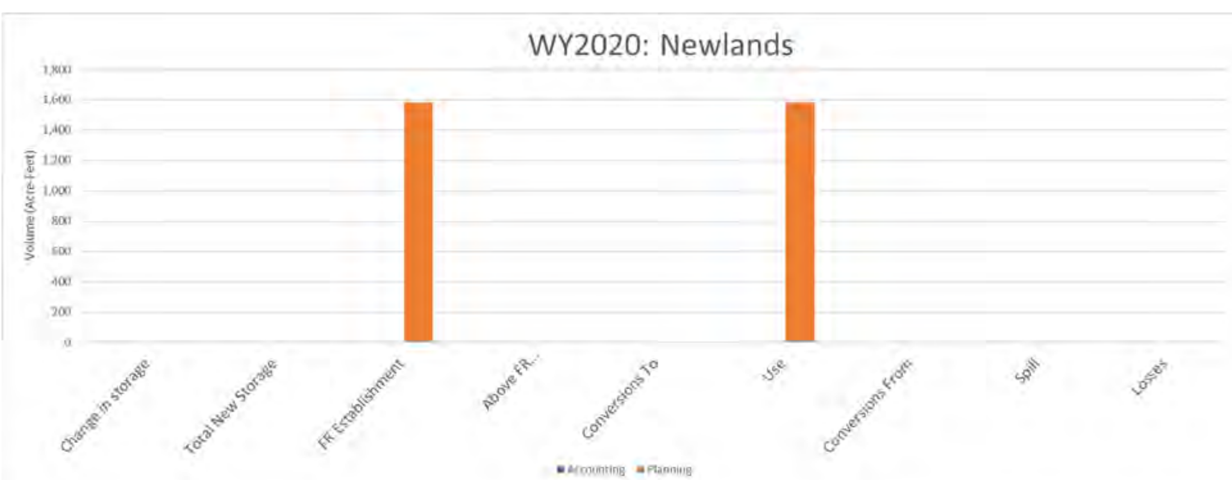
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	14,486	14,486	N/A	15,558	N/A	N/A	21	N/A	0	-1,052
Planning	0	6,453	6,453	N/A	7,037	N/A	N/A	95	N/A	0	-488
Difference	0	-8,033	-8,033	N/A	-8,522	N/A	N/A	75	N/A	0	-563
% Difference	0.00%	-55.45%	-55.45%	N/A	-54.77%	N/A	N/A	363.29%	N/A	0.00%	-53.57%

In the WY 2020 Accounting Model, PLPT established roughly 19,000 AF of credit water (see Figure 33) while only 15,500 AF of JPF Cred was established in WY 2020. The Planning Model shows that 7,037 AF of both Fish Credit Water and JPF Cred was established in WY 2020. TROA 7.C.6 (b) prescribes that CA is responsible for scheduling the amount, up to 50%, of Fish Credit Water that is designated as JPF Cred upon establishment. Typically, CA schedules this value at 50% to maximize the amount of JPF Cred in storage. In WY 2020, however, there was a brief period that CA scheduled this value at 25% to better meet CA preferred flow objectives, and this explains why the volumes of Fish Credit Water and JPF Cred establishment in the Accounting Models were not equivalent. This type of schedule by CA DWR is rare, and it is not captured by the Planning Model. *Additional Planning Model development would be possible to better capture how CA schedules this conversion percentage, and this would require further coordination with CA.*

4.5.2.5 Newlands, WY 2020

Figure 36 shows the comparison of Newlands Project Credit Water operations between the Accounting and Planning Models. Approximately 1,600 AF of credit water was established in Boca Reservoir in the Planning Model in April. That water was then released in June and delivered to Lahontan Reservoir. The Accounting Model limited establishment of Newlands Project Credit Water for two reasons. The first is that Boca Reservoir was limited due to construction in 2020 (see **Boca Reservoir, WY 2020**), and the second is that the scheduling of the credit water in the Accounting Model never shows an opportunity where the credit water would be beneficial if it were stored in Truckee Basin reservoirs. By the end of the year, the storage of Newlands Project Credit Water is 0 AF in both models.

Figure 36. Comparison of Accounting and Planning Model Newlands Party Water Balance for WY 2020.



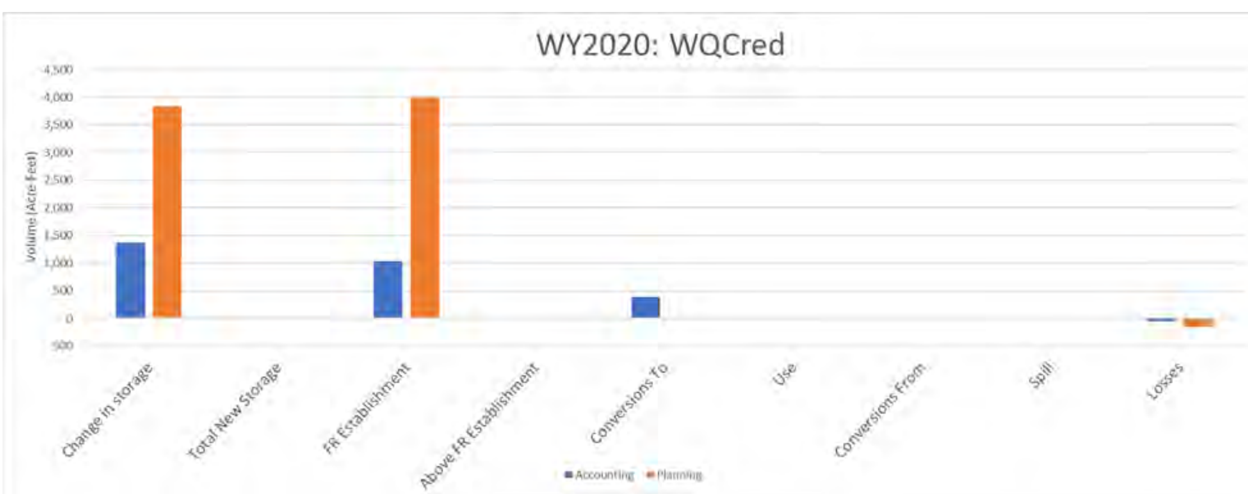
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	0	0	N/A	0	0	N/A	0	0	0	0
Planning	0	0	0	N/A	1,580	0	N/A	1,580	0	0	0
Difference	0	0	0	N/A	1,580	0	N/A	1,580	0	0	0
% Difference	0.00%	0.00%	0.00%	N/A	Inf	0.00%	N/A	Inf	0.00%	0.00%	0.00%

4.5.2.6 Water Quality, WY 2020

Figure 37 provides water balance comparisons between the Accounting and Planning Models for Water Quality Credit Water (WQCW) in WY 2020. The amount of WQCW Establishment that occurred represents the largest discrepancy between the two models, and this is caused by scheduling differences. In the Accounting Model, the Water Quality Settlement Agreement (WQSA) parties (PLPT, Reno, Sparks, and Washoe County) scheduled to utilize a portion of their water rights as instream and the remainder as "credit storable". Water rights utilized as instream are not reflected in the water balance. The Planning Model is currently input to utilize all WQSA water rights as "credit storable", which is in line with their WQSA's general strategy in managing their water rights. These scheduling differences amount to a total EOY storage difference of 2,500 AF between the two models. *The Planning Model operates to a more standard schedule for WQSA*, and *it could be developed to better adapt to how WQSA would schedule based on basin conditions. This would require consultation with the WQSA parties.*

Figure 37 also records a 383 AF conversion to Water Quality Credit water that occurred in the Accounting Model but not in the Planning Model. This conversion is outlined in TROA 7.B.4 (f), which specifies a conversion attributed to Toilet Replacement of Non-Firm M&I Credit Water to WQCW. *This conversion is not currently modeled in the Planning Model.*

Figure 37. Comparison of Accounting and Planning Model Water Quality Party Water Balance for WY 2020.



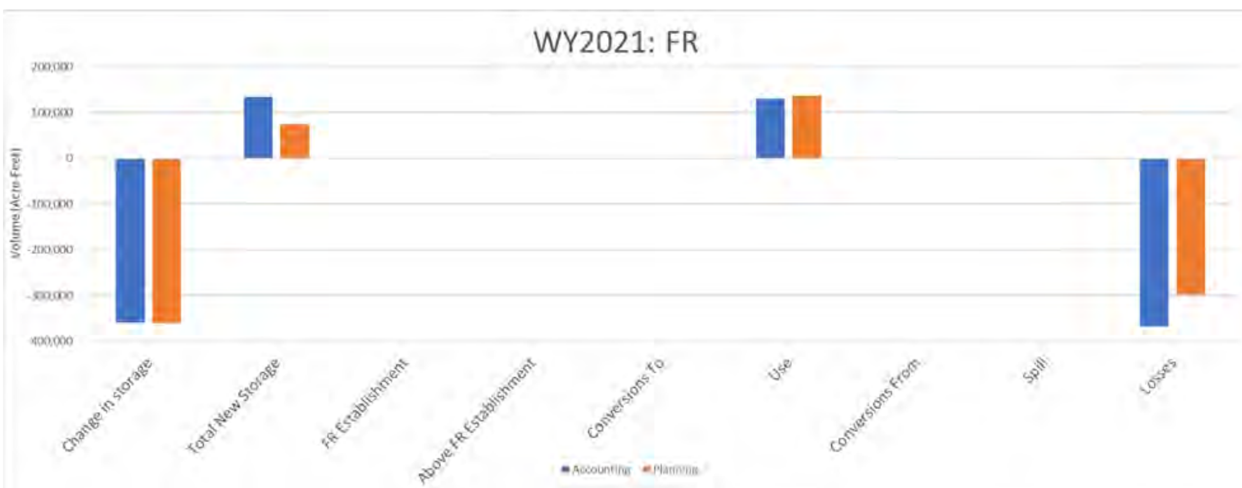
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	1,377	1,377	N/A	1,037	#N/A	383	0	N/A	0	-43
Planning	0	3,828	3,828	N/A	3,993	0	0	0	N/A	0	-165
Difference	0	2,451	2,451	N/A	2,957	N/A	-383	0	N/A	0	122
% Difference	0.00%	177.98%	177.98%	N/A	285.20%	#N/A	-100.00%	0.00%	N/A	0.00%	287.21%

4.5.3 WY 2021

4.5.3.1 Floriston Rate, WY 2021

Figure 38 provides a FR water balance comparison between Planning and Accounting Models in WY 2021. The differences seen in Total New Storage and Losses were explained in the previous section of this report titled **Underlying Data Differences**. The differences in these two water balance categories largely offset one another, and the total change in the FR Storage over the course of the WY was only .3% greater in the Planning Model than in the Accounting Model.

Figure 38. Comparison of Accounting and Planning Model Floriston Party Water Balance for WY 2021.



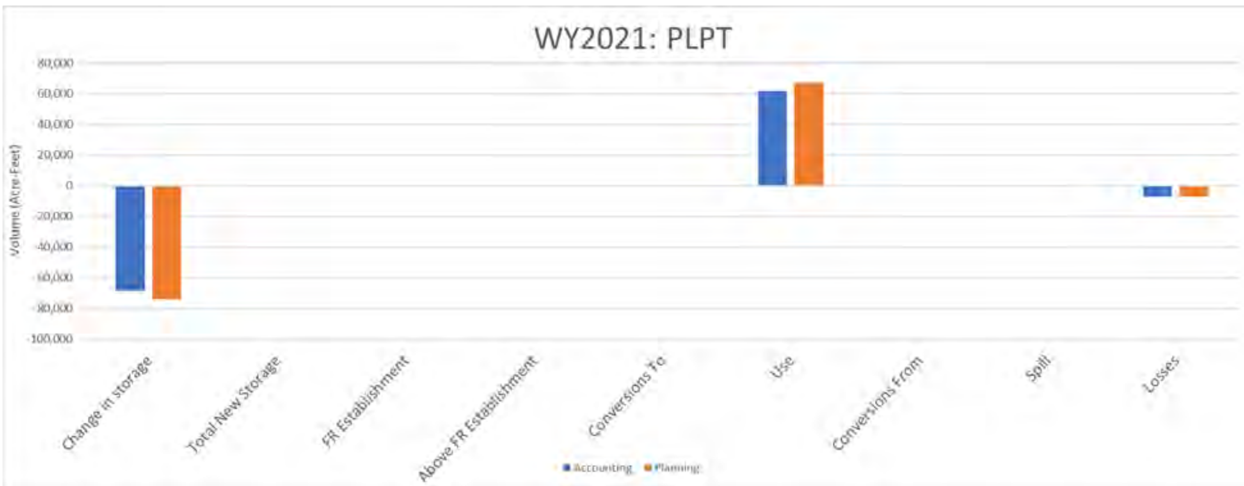
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	383,906	24,153	-359,754	134,034	N/A	N/A	0	130,439	-116	0	-366,202
Planning	384,788	23,975	-360,813	73,416	N/A	N/A	0	138,245	0	0	-298,072
Difference	882	-177	-1,059	-60,618	N/A	N/A	0	7,806	116	0	-68,131
% Difference	0.23%	-0.73%	0.29%	-45.23%	N/A	N/A	0.00%	5.98%	-100.00%	0.00%	-18.60%

4.5.3.2 PLPT, WY 2021

Figure 39 provides a comparison between Planning and Accounting Models of the PLPT Water Balance for WY 2021. Overall, the PLPT water balance for WY 2021 verified well. The main difference is in the 5,400 AF of additional Use in the Planning Model. In mid-June, the operations in the Accounting Model reduced any use to 0 cfs, allowing all flow at the Truckee River at Nixon Gage to be met with senior PLPT instream water rights. The Planning Model meets flow targets at the Truckee River at Nixon Gage through the end of June before allowing the senior rights to meet the flow targets in

July. This difference is considered minor but could warrant further input from PLPT on how and when their instream water rights are scheduled.

Figure 39. Comparison of Accounting and Planning Model PLPT Party Water Balance for WY 2021.



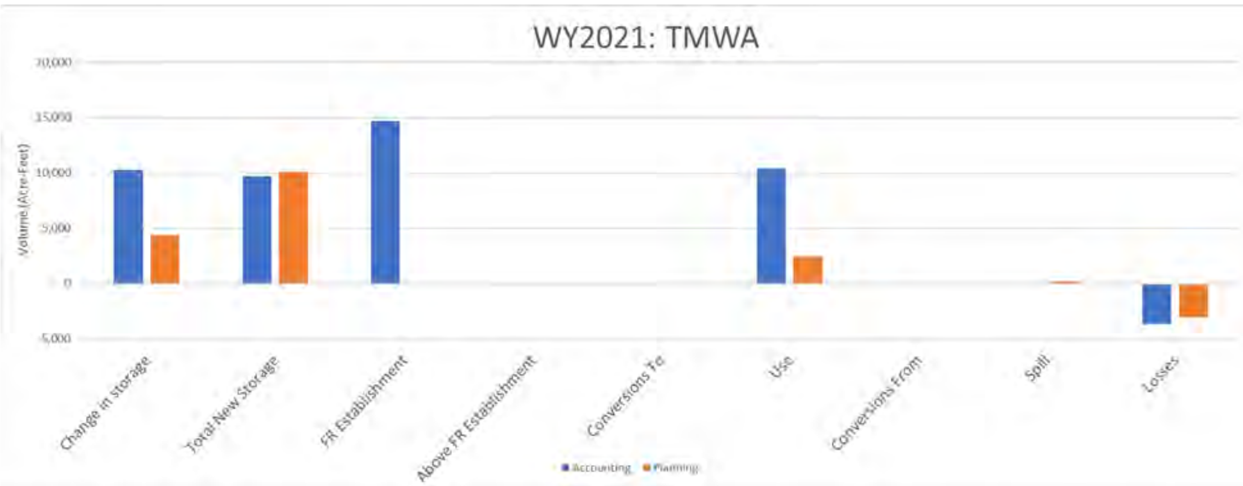
	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	135,542	66,894	-68,648	0	0	N/A	0	61,542	0	0	-7,277
Planning	135,690	61,942	-73,749	0	551	N/A	0	66,907	0	254	-7,160
Difference	149	-4,952	-5,101	0	551	N/A	0	5,365	0	254	-116
% Difference	0.11%	-7.40%	7.43%	0.00%	Inf	N/A	0.00%	8.72%	0.00%	Inf	-1.60%

4.5.3.3 TMWA, WY 2021

Figure 40 provides a comparison of the TMWA water balance in the Planning and Accounting Model for WY 2021. The Accounting Model recorded 15,000 AF of TMWA Credit Water Establishment that did not occur in the Planning Model. The logic within the Planning Model for TMWA establishment was derived from a study funded by TMWA which was published in 2020 (TMWA, 2020) that identified decision criteria for TMWA establishment. The study resulted in development in the Planning Model to limit TMWA to times when additional storage was needed to meet TMWA's demands during a drought. While TMWA scheduled to establish in WY 2021, the Planning Model logic determined that TMWA establishment was not necessary. *The volumetric difference in establishment between the two models is not trivial, and further coordination with TMWA would be needed to assess the accuracy of scheduling logic within the Planning Model based on history and TMWA's standard establishment practices.*

Furthermore, The Accounting Model recorded over 8,000 AF of additional Use in comparison with the Planning Model. Discrepancies in groundwater modelling between the two models largely explain this difference. In WY 2021, the Planning Model utilized nearly 9,000 AF of groundwater to meet demands while the Accounting Model did not draw any groundwater to meet demands. As a result, TMWA did not draw as much from surface water sources in the Planning Model to meet demands. *This discrepancy suggests that the Planning Model may require improvements to TMWA's groundwater modelling to better match their historical practices.*

Figure 40. Comparison of Accounting and Planning Model TMWA Party Water Balance for WY 2021.



	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	35,086	45,378	10,292	9,678	14,700	0	N/A	10,448	0	0	-3,649
Planning	35,098	39,459	4,361	10,082	0	0	N/A	2,458	0	188	-3,076
Difference	11	-5,920	-5,931	405	-14,700	0	N/A	-7,990	0	188	-573
% Difference	0.03%	-13.05%	-57.63%	4.18%	-100.00%	0.00%	N/A	-76.47%	0.00%	Inf	-15.71%

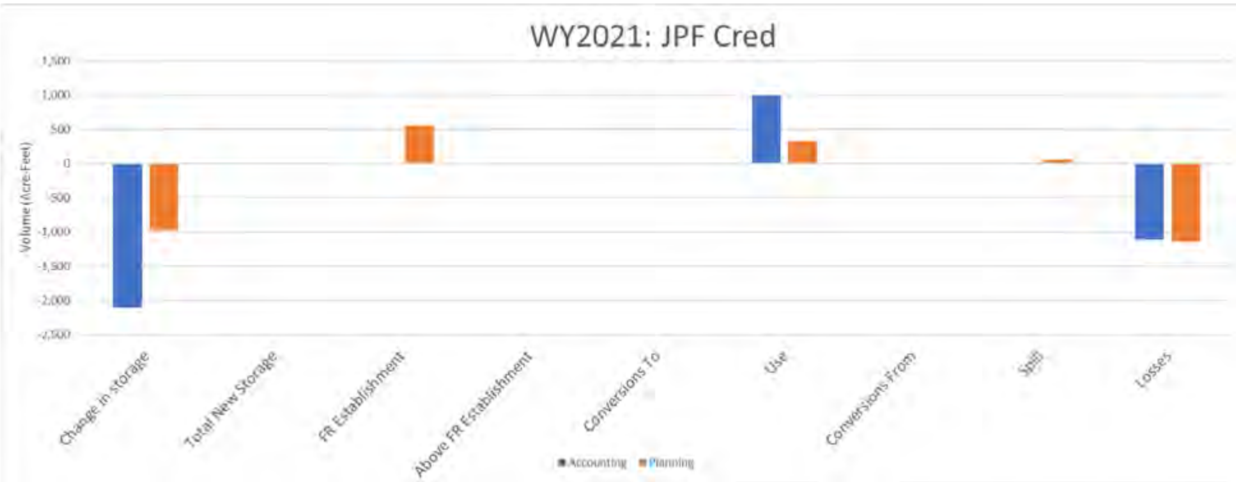
4.5.3.4 JPF Cred, WY 2021

Figure 41 provides a comparison of the JPF Cred water balance in the Planning and Accounting Model for WY 2021. The Accounting Model recorded nearly 1,000 AF of Use in WY 2021 while the Planning Model modeled only 323 AF. Operations on Prosser Creek Reservoir caused this difference. While both models had similar CA schedules to maintain 20 cfs below Prosser, the Accounting Model achieved this flow target throughout September by direct releasing JPF Cred from Prosser. The Planning Model did not meet this target throughout September because it did not direct release JPF Cred to meet the target. *This discrepancy will need to be addressed in future development.*

The differences in establishment between the two models are attributable to PLPT scheduling (see **PLPT, WY 2021**).

In conclusion, the differences in the volume of Use and Establishment between the two models were additive and account for the 1,135 AF difference in the change in storage over the WY observed between the two models.

Figure 41. Comparison of Accounting and Planning Model JPF Cred Party Water Balance for WY 2021.

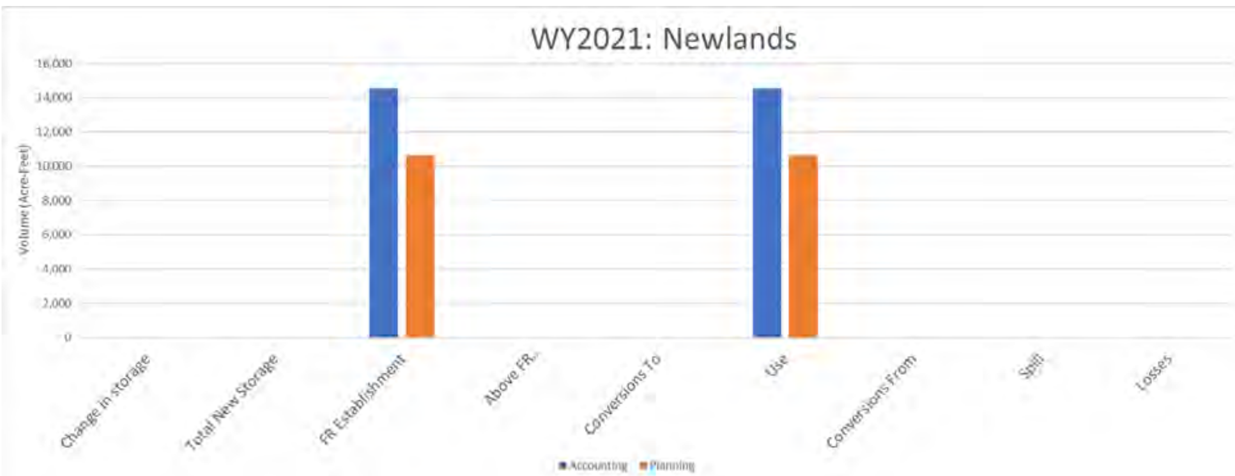


	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	14,479	12,374	-2,104	N/A	0	N/A	N/A	998	N/A	0	-1,114
Planning	14,489	13,519	-970	N/A	551	N/A	N/A	323	N/A	58	-1,136
Difference	10	1,145	1,135	N/A	551	N/A	N/A	-675	N/A	58	23
% Difference	0.07%	9.25%	-53.91%	N/A	Inf	N/A	N/A	-67.64%	N/A	Inf	2.03%

4.5.3.5 Newlands, WY 2021

Figure 42 shows the comparison of Newlands Project Credit Water operations for WY 2021 between the Accounting and Planning Models. An additional 4,000 AF of establishment occurred in the Accounting Model than in the Planning Model, and all the additional establishment was delivered to Lahontan reservoir later in the year. In the Planning Model, NPCW establishment is scheduled utilizing model logic and a perfect forecast. Because of this, the model can operate NPCW efficiently. In contrast, scheduling of NPCW establishment in the Accounting Model occurs in real-time with evolving and uncertain forecasts, which causes operational inefficiency.

Figure 42. Comparison of Accounting and Planning Model Newlands Party Water Balance for WY 2021.

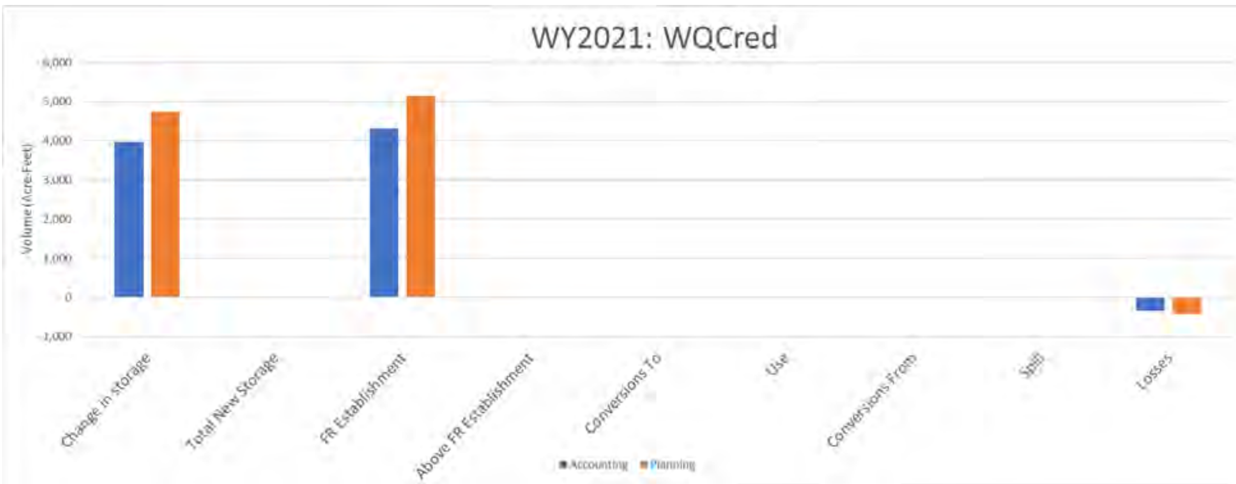


	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	0	0	0	N/A	14,539	0	N/A	14,539	0	0	0
Planning	0	0	0	N/A	10,612	0	N/A	10,612	0	0	0
Difference	0	0	0	N/A	-3,927	0	N/A	-3,927	0	0	0
% Difference	0.00%	0.00%	0.00%	N/A	-27.01%	0.00%	N/A	-27.01%	0.00%	0.00%	0.00%

4.5.3.6 Water Quality, WY 2021

Figure 43 provides the water balance summary for Water Quality Credit Water (WQCW) in WY 2021. Like WY 2020, WQCW Establishment represents the main difference between the Planning and Accounting Models. This is attributable to scheduling in the Accounting Model that differs from the standard schedule of the WQSA parties in the Planning Model (see **Water Quality, WY 2020**).

Figure 43. Comparison of Accounting and Planning Model



	Storage			Accumulations				Reductions			
	Initial Storage	EOWY Storage	Change in storage	Total New Storage	FR Establishment	Above FR Establishment	Conversions To	Use	Conversions From	Spill	Losses
Accounting	1,377	5,330	3,953	N/A	4,307	0	0	0	N/A	0	[illegible]
Planning	1,377	6,116	4,739	N/A	5,151	0	0	0	N/A	0	-412
Difference	0	786	786	N/A	844	0	0	0	N/A	0	58
% Difference	0.01%	14.75%	19.88%	N/A	19.60%	0.00%	0.00%	0.00%	N/A	0.00%	[illegible]

5 Key Iterations of Model Development

The verification effort resulted in two main iterations of development to the Planning Model to address some of the issues discovered in the verification process. Each subsection below explains what elements of the model were addressed within the iteration and provides figures to contextualize the improvements made to the Planning Model. See **Appendix G: Summary of Model Edits By Iteration and Change** for a list of the specific changes made to the Planning Model workspace, rules, and functions.

5.1 Iteration 1

5.1.1 Donner Drawdown Modelling

TMWA is required to draw Donner Lake down each Fall. During years when POSW Storage is not needed to meet downstream demands, TMWA exchanges POSW out of Donner Lake into Lake Tahoe or the Little Truckee reservoirs where it is converted to Non-Firm M&I Credit Water. These "Drawdown Exchanges" in the model allow TMWA to avoid making un-demanded releases of POSW when drawing down Donner.

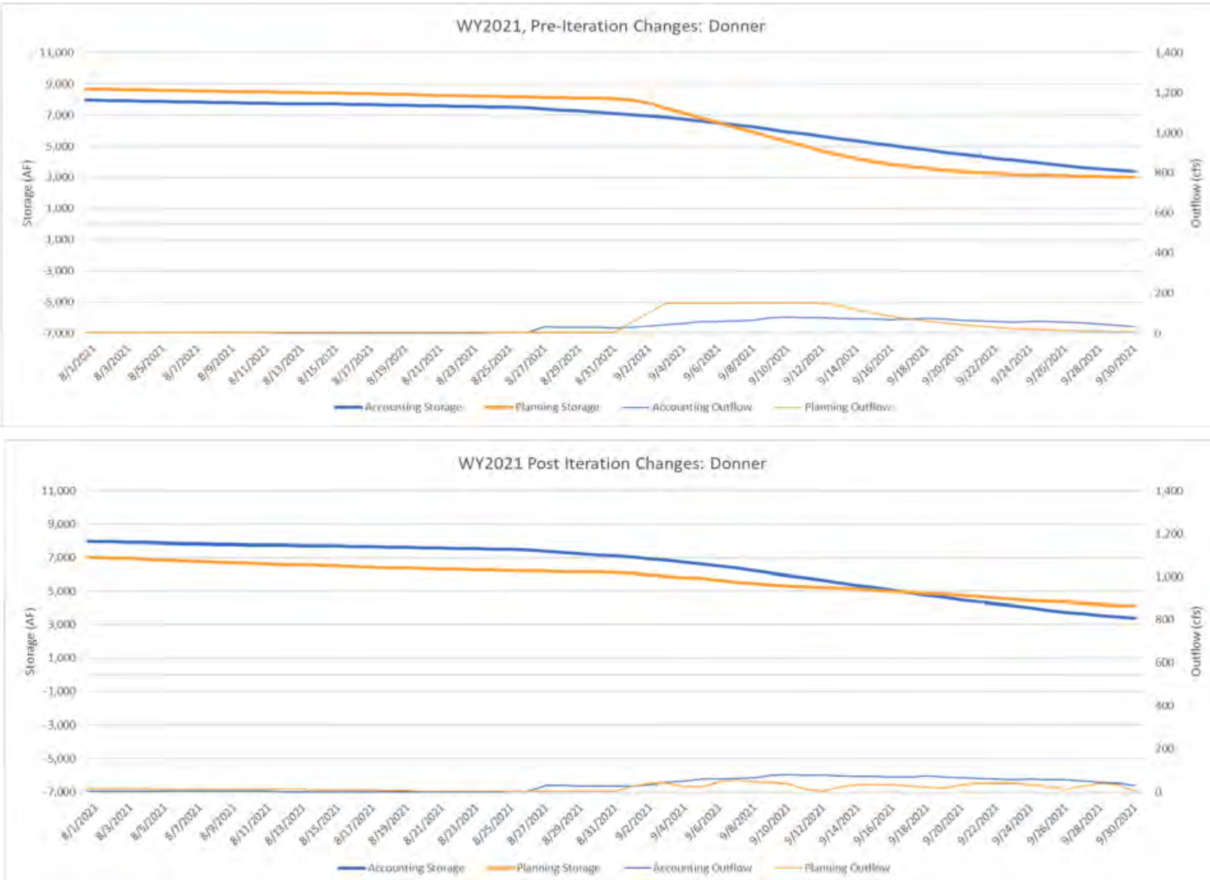


Figure 44. WY 2021 Donner Lake Storage and Outflow results in the Accounting Model (blue) and Planning Model (orange) prior to the Iteration 1 changes to the Planning Model (top) and after Iteration 1 changes to the Planning Model

Figure 44 illustrates the improvements made to Donner drawdown in WY 2021. The top plot shows the Accounting and Planning Model results of Donner Storage and Outflow prior to the changes made during Iteration 1, and the bottom plot shows Donner Storage and Outflow after the changes made during Iteration 1. Prior to Iteration 1 changes, the Planning Model draws Donner down starting in early September by ramping up releases to a steady rate of 150 cfs until Donner is under rim control and the releases taper off. This operation is problematic in the Planning Model because it does not limit Donner's drawdown release to what can be exchanged out of the reservoir; rather, the model releases POSW in Donner downstream even though is not demanded. In practice, TMWA will draw Donner down by limiting its releases to what can be exchanged out of Donner into other reservoirs. The Accounting Model results for WY 2021 illustrate this operation. Starting in late August, the Accounting Model recorded that Donner started making releases at a rate limited to what could be exchanged into other reservoirs in the system at a much lower release than that of the Planning Model. Iteration 1 of the verification effort addressed this issue, and the results after this model development show a much more limited drawdown release on Donner that more accurately depicts what occurred in the Accounting Model. Figure 45 provides a similar plot for WY 2020 and depict similar improvements to WY 2021.

Figure 45. WY 2020 Donner Lake Storage and Outflow results in the Accounting Model (blue) and Planning Model (orange) prior to the Iteration 1 changes to the Planning Model (top) and after Iteration 1 changes to the Planning Model (bottom).

5.1.2 Precipitation and Losses Modelling

Differences in the Losses calculation of the Party Water Balances represents a second issue identified during Iteration 1 of the verification process. Figure 46 shows results for PLPT losses in the Accounting and Planning Models prior to and after Iteration 1 changes. Prior to Iteration 1 changes, PLPT losses differed by over 3,000 AF between the two models. In the model, the calculated losses are debited to parties in accordance with

TROA. The losses calculation requires an estimate of the "net-evaporation," or difference between precipitation and evaporation volume, that occurred on a reservoir. In the Accounting Model, precipitation is input to what was measured. Prior to Iteration 1, the Planning Model calculated precipitation that occurred on a reservoir by distributing the historical monthly average precipitation on a given reservoir equally across the days of the month. This affects the losses calculation because, each day, the evaporation is offset by daily precipitation, causing the Planning Model to record much less loss in comparison with the Accounting Model. Iteration 1 changes introduced a method into the Planning Model utilized by the TROA Operations and Accounting Model to disaggregate monthly precipitation totals into a limited number of days across the month. The number of days to disaggregate precipitation in to is determined by the historical average number of days of precipitation that occurs each month. As a result, daily precipitation does not offset the evaporation that occurs as often, resulting in more losses on the reservoirs. The right plot of Figure 46 illustrates the results of this change: the difference in PLPT Losses between the Accounting and Planning Models for WY 2018 was reduced to 94 AF.

Table 16 provides a summary of PLPT Losses from WY 2018 to WY 2021 in the Accounting and Planning Models before and after Iteration 1 changes were implemented. In every year other than WY 2021, the results were improved significantly.

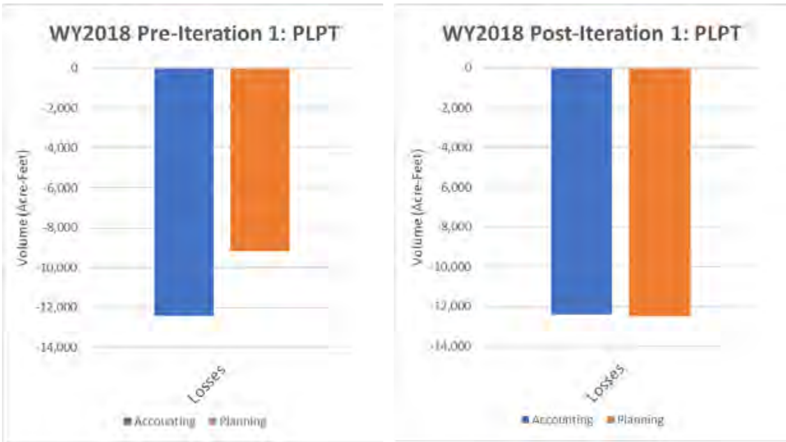


Figure 46. WY 2018 Accounting and Planning Model results for PLPT Losses prior to Iteration 1 changes (left) and after Iteration 1 changes (right).

Table 16. Summary of WY 2018 to WY 2021 PLPT Losses in the Accounting and Planning Models before and after changes implemented in Iteration 1.

		Pre Iteration PLPT Losses (AF)	Post Iteration PLPT Losses (AF)
WY 2018	Accounting	-12,416	-12,416
	Planning	-9,171	-12,510
	Difference	3,245	-94
WY 2019	Accounting	-12,549	-12,549
	Planning	-9,527	-12,876
	Difference	3,022	-328
WY 2020	Accounting	-10,569	-10,569
	Planning	-7,889	-11,121
	Difference	2,680	-552
WY 2021	Accounting	-7,277	-7,277
	Planning	-7,929	-7,996
	Difference	-653	-719

5.2 Iteration 2

The second iteration of model changes in the Planning Model included developing TMWA winter releases logic, making improvements to PLPT operations, updating the California Preferred Flows schedule, and making improvements to Prosser drawdown.

5.2.1 TMWA Augmentation of Fall/Winter Flows

Over the 6 years of TROA, TMWA has exhibited an operational pattern of making releases of POSW from storage in the late fall and winter to hit flow targets at the Farad Gage. Prior to this verification study, the Planning Model did not have the capability of modelling this. Basic functionality was added to the Planning Model during Iteration 2 to model TMWA's fall and winter Truckee River flows augmentation.

Figure 47 and Figure 48 show Accounting and Planning Model results for TMWA releases to maintain fall and winter flow targets at Farad. The Accounting Model records a total release of 1,255 AF of POSW to maintain a 250 cfs Target between November and January. The Post-Iteration 2 Planning Model results show a 650 AF release of POSW to maintain the 250 cfs target during the same period. Note, the Farad Gage flows both prior to and after Iteration 2 changes are included in Figure 48 to illustrate that TMWA's releases augmenting the Farad Gage flows to meet the target.

Note, differences in Farad Gage flows exist in the months of November and January between the two iterations of model results. These differences are caused by a separate change related to nuances in limiting Canal operations in the model that was made between these two iterations. Refer to **Canal Annual Diversion Volumes** for more description on this topic.

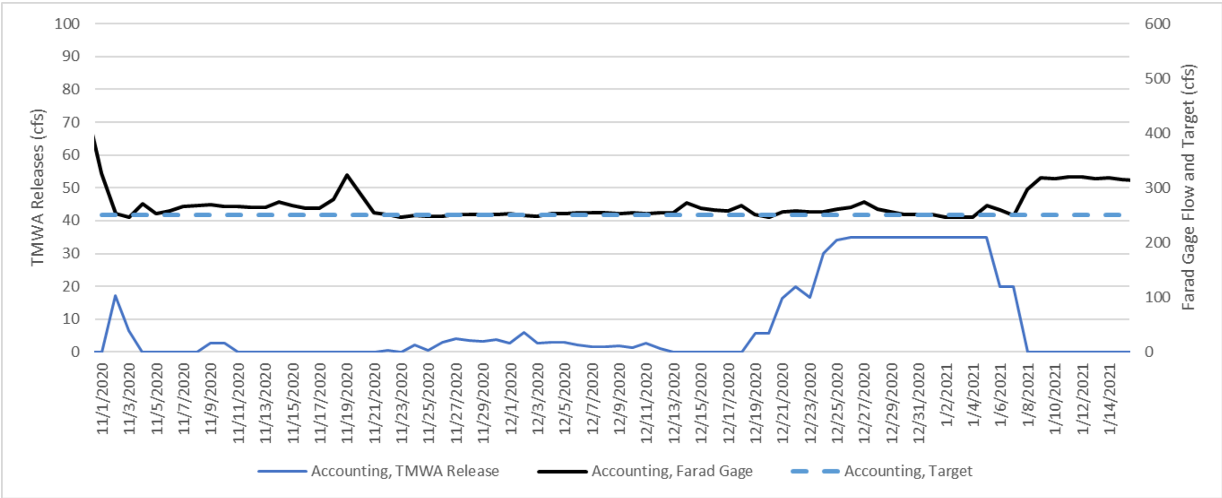


Figure 47. WY 2021 Accounting Model results for TMWA Fall/Winter Releases to maintain Farad Target.

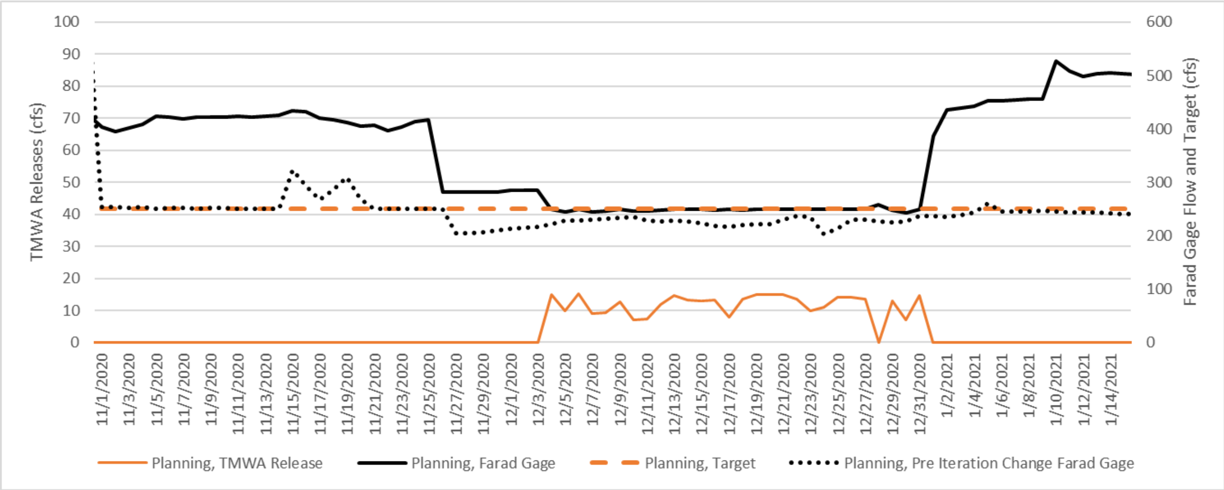


Figure 48. WY 2021 Planning Model results for TMWA Fall/Winter Releases to maintain Farad Target. The solid black line represents modeled Farad Gage Flows after Iteration 2 changes, and the dotted black line represents Farad Gage flows prior to Iteration 2 changes.

Currently, the logic in the Planning Model reflects TMWA's fall and winter flow augmentation as they were scheduled in WY 2021. That is, TMWA will make releases between November and January to maintain a 250 cfs target at the Farad Gage. *TMWA has maintained higher targets in the past, but the decision-making criterion for these targets is* *unknown. The Planning Model currently operates to the lowest target that has been scheduled in TROA history. Further consultation with TMWA would be required to ensure that the Planning Model logic accurately reflects what TMWA would do operationally given a variety hydrologic and storage conditions.*

5.2.2 PLPT Improvements

5.2.2.1 Conversions to PLPT

TROA 7.B.4 (e) prescribes the volume of conversion and conditions in the basin that must exist when converting Non-Firm M&I Credit Water to Fish Credit Water in April of each year. TROA specifies that a drought designation in the basin must not be in effect for this conversion to occur. In April of 2021, a drought was designated in the basin, and no conversions of Non-Firm M&I Credit Water to Fish Credit Water were recorded in the Accounting Model. It was identified during Iteration 2 of this verification effort that the Planning Model violated TROA by allowing this conversion to occur in April of 2021. The Planning Model was adapted to limit the conversion to occur only during times the basin is not in a drought designation. Figure 49 illustrates these results.

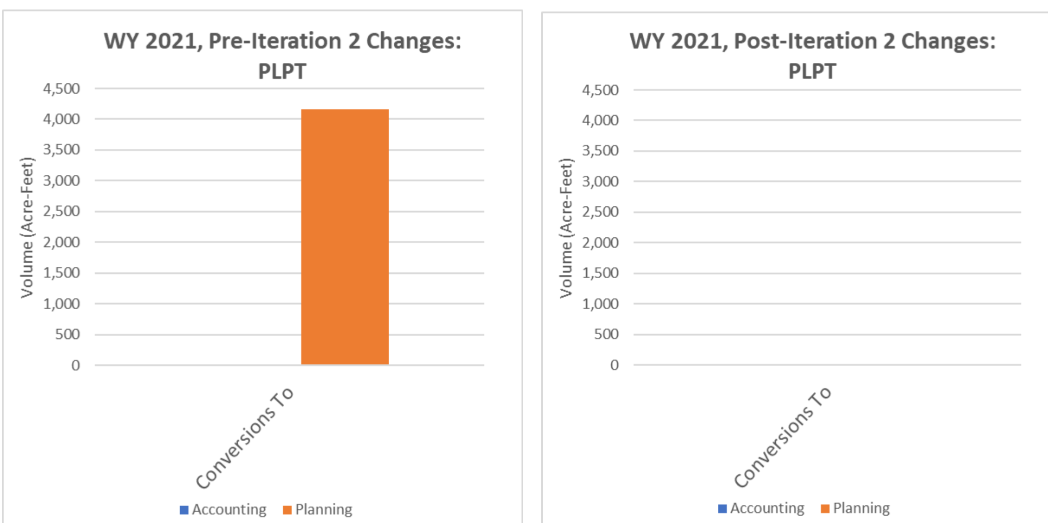


Figure 49. WY 2021 Accounting and Planning Model results for Conversions To PLPT prior to Iteration 2 changes (left) and after Iteration 2 changes (right).

5.2.2.2 PLPT Exchanges out of Tahoe and Prosser

In dry years when Lake Tahoe is projected to go below its natural rim of 6,223 ft, TROA Parties strategize to move all credit water accumulations in Lake Tahoe to other reservoirs to avoid having their credit water inaccessible in Lake Tahoe. WY 2021 was a dry year, and Lake Tahoe was projected to go below its rim. In response, TROA Parties scheduled to have their credit water exchanged out of Tahoe starting in March of 2021. Figure 50 shows the modeled WY 2021 Fish Credit Water Storage results in Lake Tahoe in the Accounting Model, the Pre-Iteration 2 Planning Model, and the Post-Iteration 2 Planning Model. The Accounting Model shows that PLPT moved Fish Credit Water out of Lake Tahoe starting in late March. The Pre-Iteration 2 Planning Model began moving water out in November of 2020; however, not all the Fish Credit Water was moved out of Lake Tahoe. There was enough demand out of other reservoirs to facilitate exchanges to move all Fish Credit Water out of Tahoe, but these exchanges were not configured in the Planning Model. During Iteration 2 of development, the appropriate exchanges were coded into the Planning Model. As a result, the Post-Iteration 2 Planning Model results show all Fish Credit Water moving out of Lake Tahoe by roughly the same date shown in the Accounting Model.

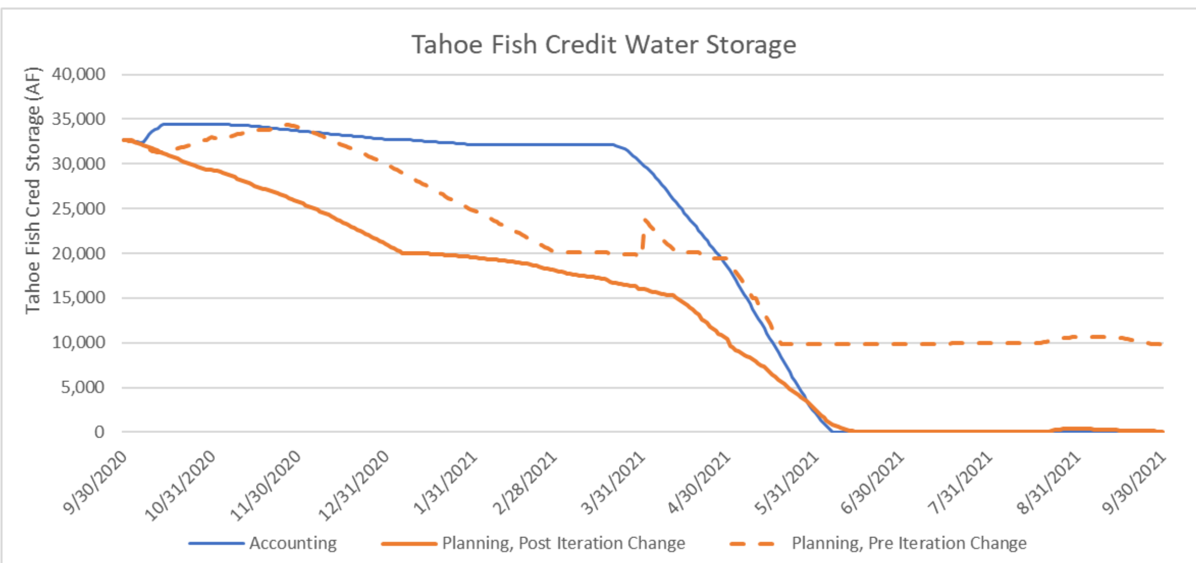


Figure 50. WY 2021 Accounting results (blue), Pre-Iteration 2 Changes Planning Model Results (dashed orange), and Post Iteration 2 Changes Planning Model results (solid orange) for Fish Credit Water Storage in Lake Tahoe.

Similar issues were noted in the Planning Model on Prosser Creek Reservoir. Figure 51 shows the Accounting Model, Pre-Iteration 2 Planning Model, and Post-Iteration 2 Planning Model results for Prosser Creek Reservoir. The Pre-Iteration 2 Planning Model shows over 9,000 AF of Fish Credit Water storage in Prosser. Prosser must be physically drawn down to 9,840 AF by the end of October. Leaving too much Fish Credit Water in Prosser at the end of WY 2021 is a risky operation because there may not be enough time in October to exchange this water out to avoid spill due to flood control capacity limitations. In the Post-Iteration 2 Planning Model, new exchanges were added to the model to facilitate moving Fish Credit Water out of Prosser, and the results show Fish Credit Water moving out of Prosser starting at the end of June when the reservoir began to drawdown physically. These exchanges reduced Fish Credit Water storage in Prosser down to 4,000 AF at the end of the WY and reduce the risk of Prosser spilling greatly.

The Accounting Model recorded only 1,000 AF of Fish Credit Water in Prosser starting in May through the end of the WY, and this differs significantly from Fish Credit Water storage in Prosser in the Post-Iteration 2 Planning Model. *This difference is explained by scheduling, and it is unknown if the PLPT operations on Prosser in the Accounting Model are standard. Consultation with PLPT would be necessary to determine how to most accurately model Fish Credit Water storage in Prosser in the Planning Model.*

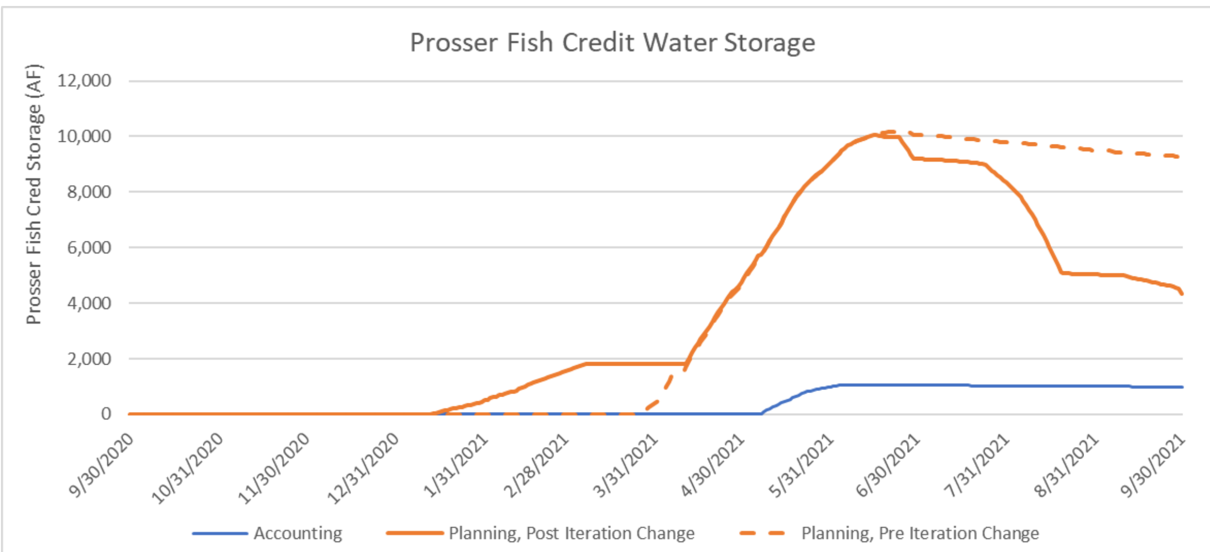


Figure 51. WY 2021 Accounting results (blue), Pre-Iteration 2 Changes Planning Model Results (dashed orange), and Post Iteration 2 Changes Planning Model results (solid orange) for Fish Credit Water Storage in Prosser Creek Reservoir.

5.2.3 Prosser Drawdown Modelling

Planning Model results for drawdown of Prosser Creek Reservoir exhibited similar issues in drawdown operations of Donner Lake (see **Donner Drawdown Modelling**). During the drawdown season of late Summer and early Fall, parties strategize to exchange the un-demanded portion Prosser's drawdown release to other reservoirs. Figure 52 shows the WY 2021 Accounting Model results for the drawdown of Prosser Creek Reservoir that occurred in October and early November of 2020. The results show that Prosser was drawn down to under flood control capacity at a roughly steady rate over the course of October. Figure 53 shows the WY 2021 Pre-Iteration 2 and Post-Iteration 2 Planning Model results for Prosser drawdown that occurred in October and Early November of 2020. The Pre-Iteration 2 results show Prosser being drawn down slowly at a steady rate until the end of October when releases were ramped up to over 300 cfs to draw the reservoir down to below flood control capacity on November 1st. This large outflow was categorized as JPF Cred spill, and CA would avoid this operation. In Iteration 2, Prosser drawdown logic in the Planning Model was updated to set Prosser releases to avoid spill by allowing CA to exchange JPF Cred out of Prosser, which is a preferred operation on the reservoir. *However, CA prefers to see steady releases out of Prosser in October, and additional development to the Planning Model and coordination with CA would be needed to more accurately model Prosser drawdown operations.*

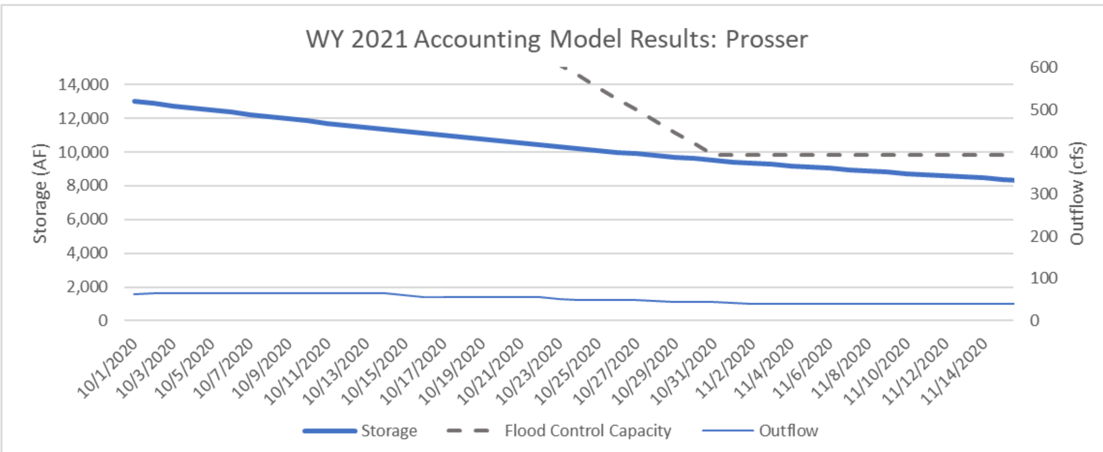


Figure 52. WY 2021 Accounting Model Results for Prosser drawdown.

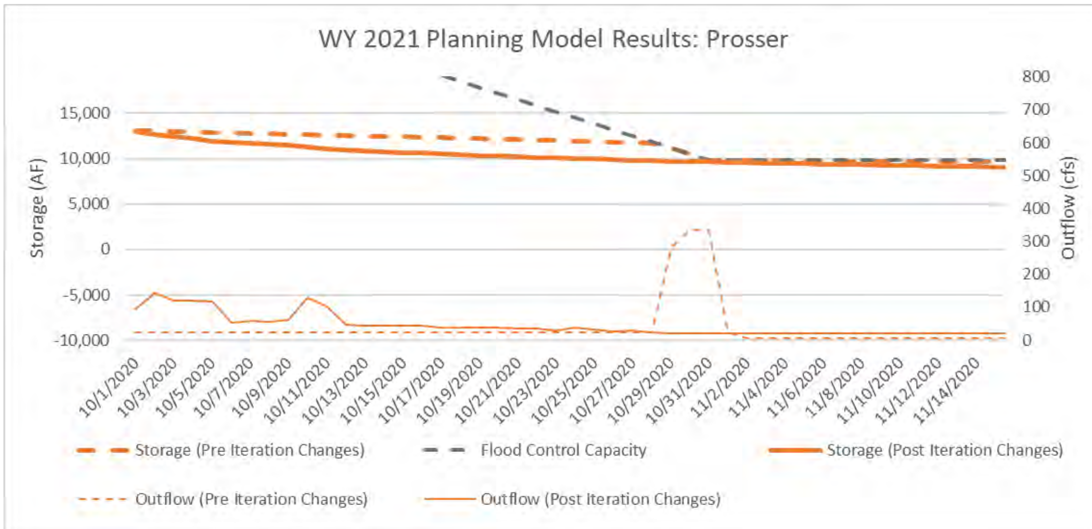


Figure 53. WY 2021 Pre-Iteration 2 Planning Model and Post-Iteration 2 Planning Model results for Prosser drawdown.

5.2.4 CA Preferred Flows Schedule

The CA Preferred Objectives schedule was updated in the Planning Model during Iteration 2 of development to capture, generally, the historical schedule of CA throughout TROA. One adjustment made was to Lake Tahoe's CA Preferred Flow Schedule. In the Summer, CA schedules to maintain Lake Tahoe flows between 200 cfs to 375 cfs to facilitate rafting flows below the Lake. The Accounting Model shows that CA scheduled Preferred Flows on Lake Tahoe between 220 cfs and 375 cfs were maintained from July 1 to mid-August (see Figure 54). No maximum flow was scheduled in the Pre-Iteration 2 Planning Model, and the results show that Lake Tahoe Outflow above the preferred rafting range of 375 cfs from July 1 through Mid-August (see Figure 55). CA would operate to maintain these rafting flows, and a Maximum Flow target was introduced in Iteration 2 of the Planning Model development. As a result, the Post-Iteration 2 Planning Model results show Tahoe's outflow hitting CA Preferred Targets from early July through mid-August (see Figure 56).

In general, *CA's Preferred Objective schedule is reactive to conditions in the basin. To most accurately CA Operations in the Planning Model would require more consultation with CA.*

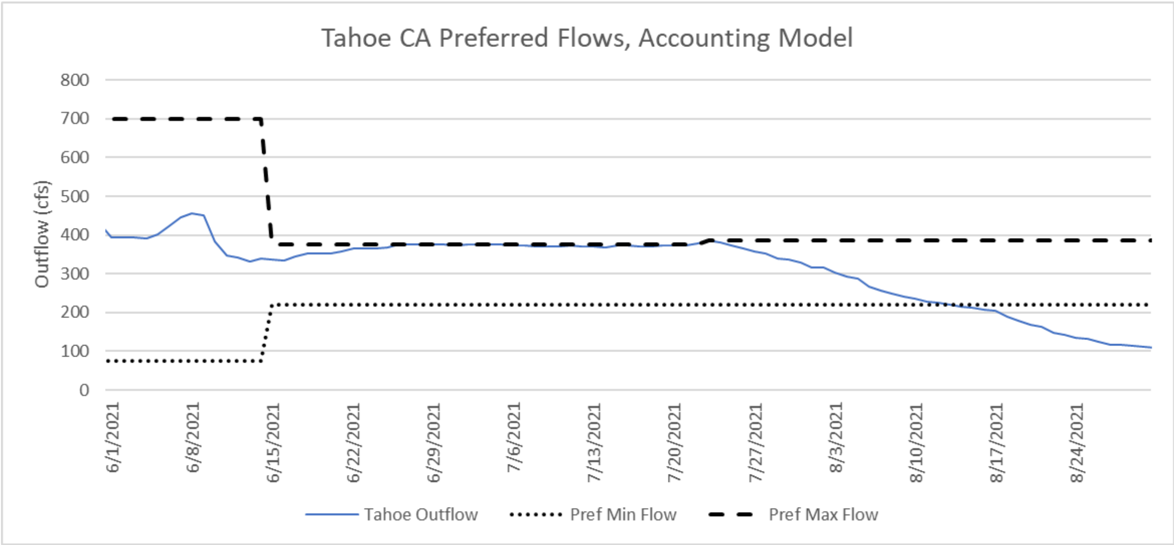


Figure 54. Accounting Model results for summer of WY 2021 Lake Tahoe Outflows and CA Preferred Flows.

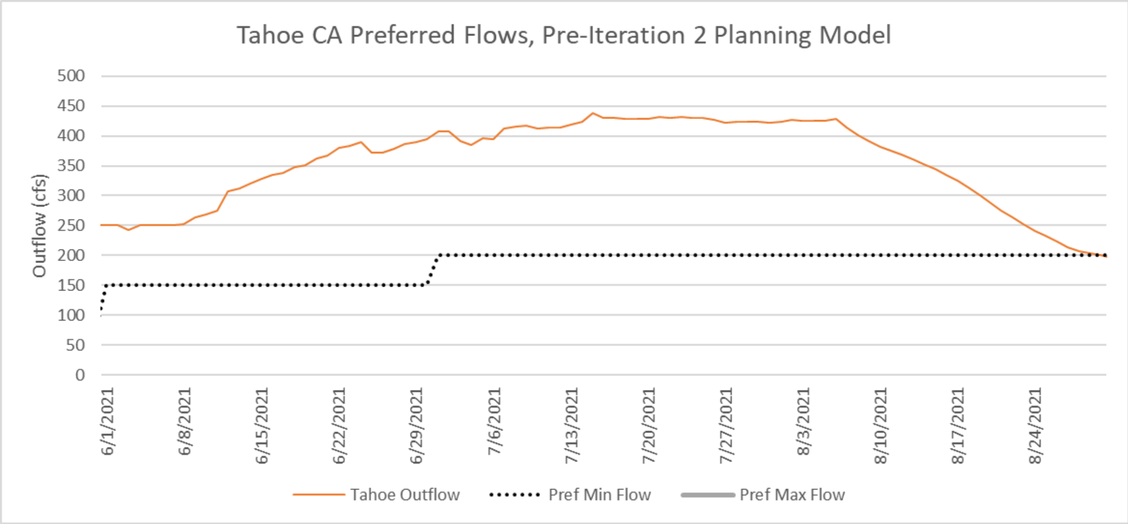


Figure 55. Pre-Iteration 2 Planning Model results for summer of WY 2021 Lake Tahoe Outflows and CA Preferred Flows. Note, there was no Pref Max Flow scheduled in the Pre-Iteration 2 Planning Model.

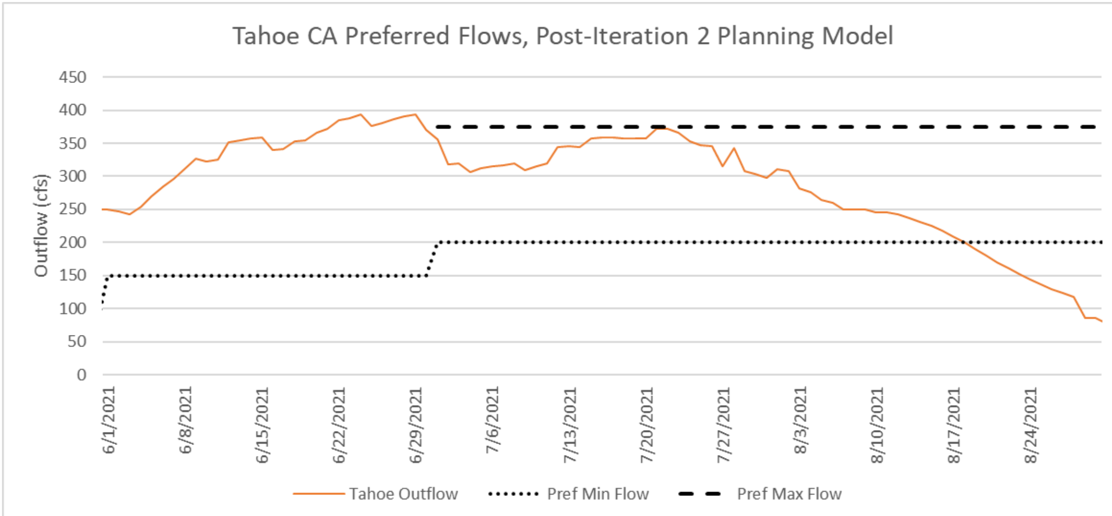


Figure 56. Post-Iteration 2 Planning Model results for summer of WY 2021 Lake Tahoe Outflows and CA Preferred Flows.

6 Conclusion

6.1 Future Development

The verification effort identified several areas of the Planning Model in need of future development. Many of these items surround TROA Party operations in the Planning Model and would require input from the parties to determine how to better model their operations in different basin conditions. The following subsections describe areas of recommended development for several TROA Parties in more detail. Also included are other general improvements that could be made to the model.

6.1.1 PLPT

This report detailed several areas of recommended development to improve the modelling of PLPT operations. The following list summarizes these recommendations:

- Determine rate limits on Fish Credit Water establishment (see **PLPT, WY 2020**). This development would require answers to the following questions:
    - Is there a maximum daily flow rate PLPT would establish Fish Credit Water?
    - Does this rate depend on the time of year and flows in the lower Truckee River?

- A second recommended area of development is update maximum storage thresholds and reservoir priorities of Fish Credit Water in Truckee River Reservoirs (see **PLPT Exchanges out of Tahoe and Prosser**).
- A third area of recommended development is to update PLPT's reservoir release priorities to have different configurations for Drought and Non-Drought years. In drought years, PLPT would likely use Fish Credit Water out of Tahoe to meet demands to avoid stranding credit water in the Lake. In non-drought years, PLPT would like to keep Fish Credit Water in Lake Tahoe to facilitate minimum release out of the reservoir, while demands downstream would be met by storage in other reservoirs.

6.1.2 CA

While the verification study did make updates to CA Preferred Objectives scheduling in the Planning Model, a comprehensive update of CA scheduling requires more input from CA. This report provided the following examples of areas of future improvement for CA operations:

- Logic to identify when, if ever, the Planning Model should utilize a conversion percentage of Fish Credit Water to JPF Cred that is less than 50% (see **JPF Cred, WY 2020**).
- Logic and conditions that identify when, if ever, the Planning Model should be allowed to meet CA Preferred Flows from different reservoirs utilizing direct release of JPF Cred (see **JPF Cred, WY 2021**).
- Develop Planning Model to ensure direct release of JPF Cred meet CA DWR objectives when scheduled (see **JPF Cred, WY 2021**).
- Updates to CA exchange logic to better meet ramping considerations on reservoirs (see **Prosser Drawdown Modelling**).
- Development to include CA schedules in the Planning Model based on hydrologic conditions (dry, normal, and wet scenarios) and total JPF Cred in storage.

6.1.3 TMWA

This report detailed several areas of recommended development to improve the modelling of TMWA operations. The following list summarizes these recommendations:

- Further development of TMWA's fall/winter releases to maintain Farad Targets (see **TMWA, WY 2020** and **TMWA Augmentation of Fall/Winter Flows**).
- Develop Planning Model to ensure conversions of POSW stored in Boca to Non-Firm M&I Credit at end of calendar year (see **TMWA, WY 2020**).
- Develop Planning Model to ensure Independence Lake's inflow is properly accounted for on TMWA's Independence storage license (see **TMWA, WY 2020**).
- Coordinate with TMWA to determine if Planning Model logic for TMWA establishment accurately reflects how they would schedule (see **TMWA, WY 2021**).
- Coordinate with TMWA to determine if groundwater operations in the Planning Model accurately represent how groundwater is used to meet their demands (see **TMWA, WY 2021**)

6.1.4 WQSA

This report detailed one area of recommended development to improve the modelling of WQSA operations. Currently the Planning Model assumes that WQSA will store all their water rights as credit water (see **Water Quality, WY 2020**). While this is their current strategy, in some years in TROA they have utilized portions of their water rights as instream. In coordination with WQSA, the Planning Model could be adapted to have a more intelligent method for selecting the portion of WQSA water rights utilized as instream and credit storable in any given year of the model run based on current storage conditions and forecasted hydrology.

6.1.5 Other

The following list provides several general items for future development in the Planning Model identified in this verification effort.

- Introduce Imperfect Forecasts into the Planning Model. Currently, the Planning Model will often look ahead at hydrology in the model to determine operations. In other words, these operations are determined from a "perfect" forecast of hydrology by taking the hydrology used to run the Planning Model as a proxy for a forecast. This could be updated in strategic places to introduce uncertainty into the modelling (see **WY 2019 Canal Diversions**, **Lahontan Reservoir, WY 2018** , **WY 2016 Truckee River at Nixon Gage Flows**, and **Newlands, WY 2021**)

- Update the Water Rights Solver and Accounting Structure in the Planning Model to up to date values for water rights in the Truckee River Basin.
- Introduce functionality into the Planning Model to incorporate Canal maintenance, limited diversion rates and imperfect Canal diversions (see **WY 2016 and WY 2021 Canal Diversions**).

6.2 Closing Remarks

In conclusion, this verification effort provided a technical framework to facilitate comparisons between Planning and Accounting Models. It identified areas of the model, like FR operations, that perform well, and other areas of the model that need improvement. The challenge with making improvements to the Planning Model is that operations within in it are interdependent, and this process requires a wholistic approach to making incremental advancements in the Planning Model's ability to model the basin effectively. It is important to identify the root cause of the verification issues and not spend time "fixing" issues that are symptoms and not causes. Specifically, operations of the Canal significantly impact the rest of the system. When the Canal does not verify well, several other metrics within the basin will not verify well. In this example it would be important to address the Canal simulation issues which would end up improving the model's overall ability to simulate the complex and interdependent operations of the Truckee system under TROA.

Overall, the Planning Model in its current form performs adequately at simulating TROA Operations, and the areas of development specified by this report, when implemented, would enhance its effectiveness as the water resources management planning tool in the Truckee River Basin.

7 Appendix A: Summary of WY 2016 Comparison

This appendix provides plots comparing the WY 2016 Accounting Model and final Iteration of the WY 2016 Planning Model for metrics used within this verification effort.

7.1 Floriston Rate, WY 2016

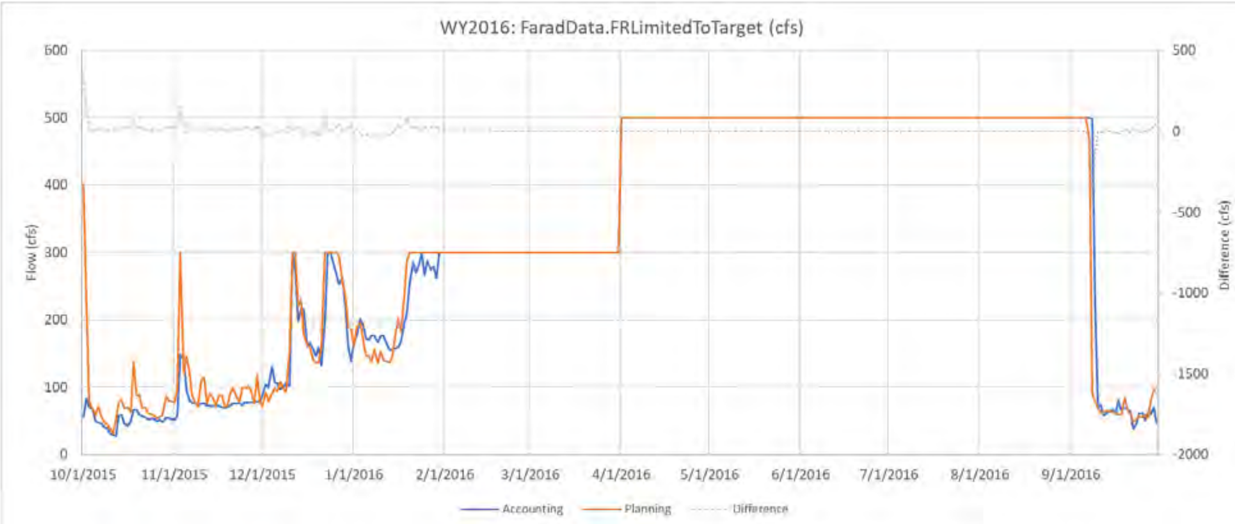


Figure 57. WY 2016 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

7.2 Reservoir Plots, WY 2016

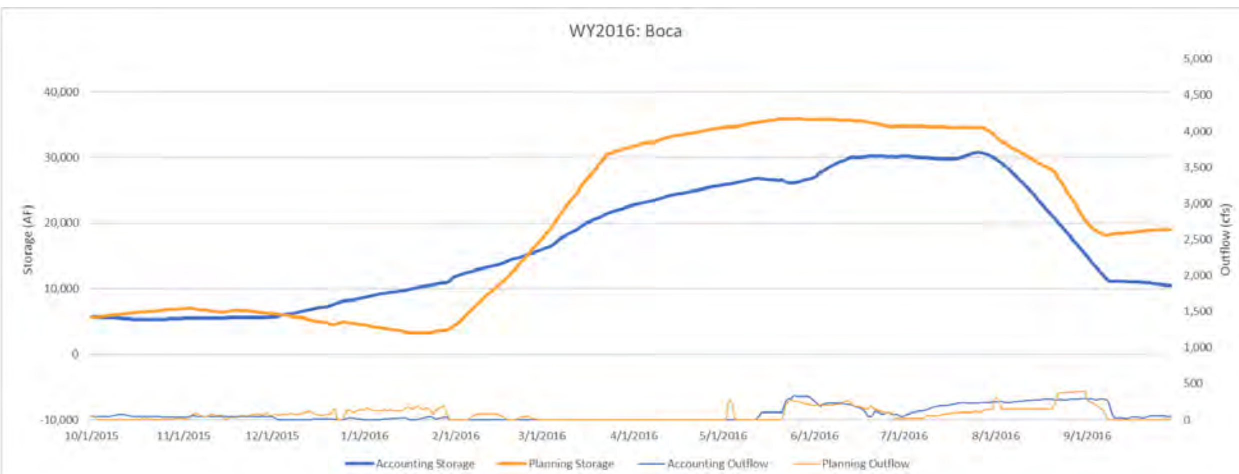


Figure 58. WY 2016 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

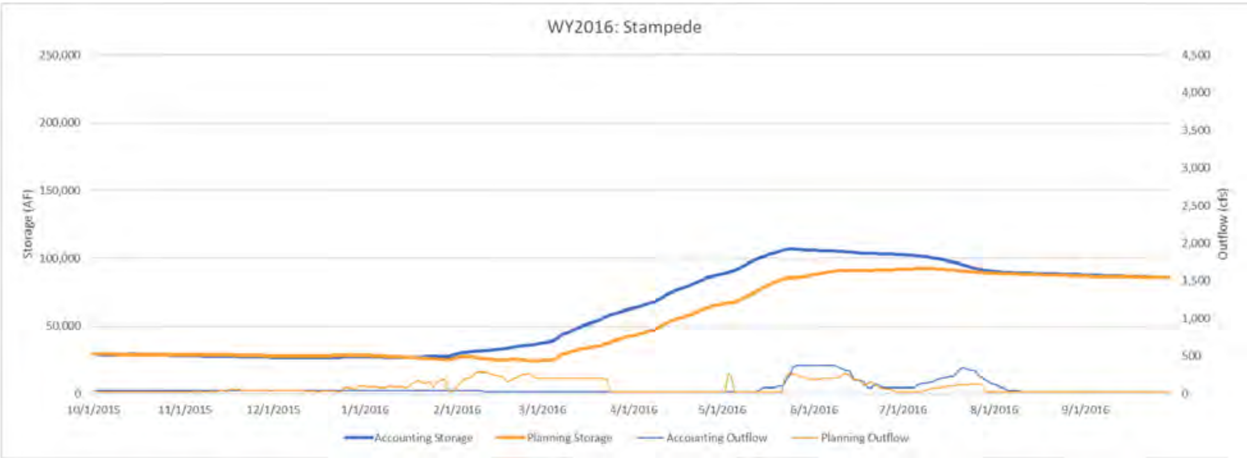


Figure 59. WY 2016 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

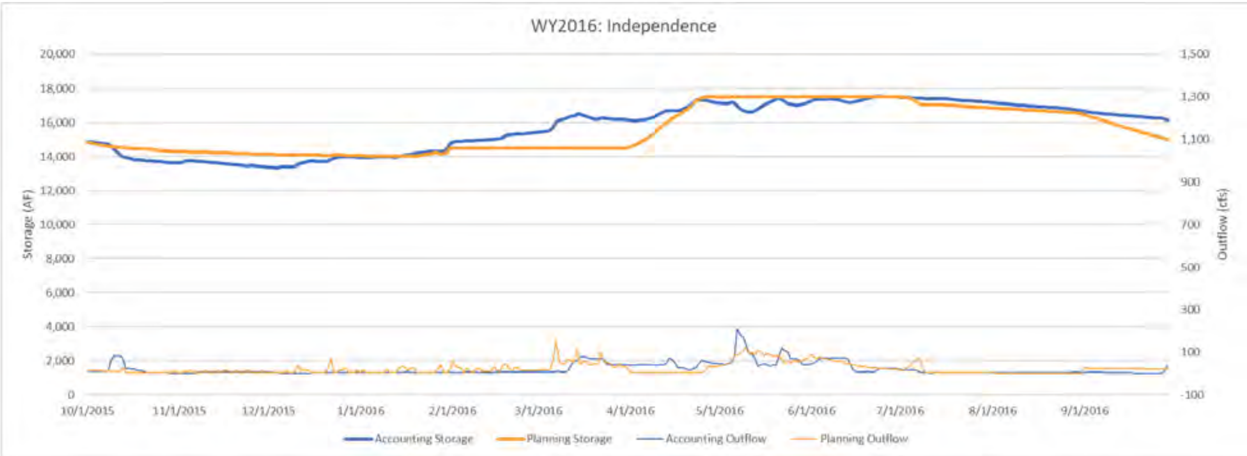


Figure 60. WY 2016 Independence Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

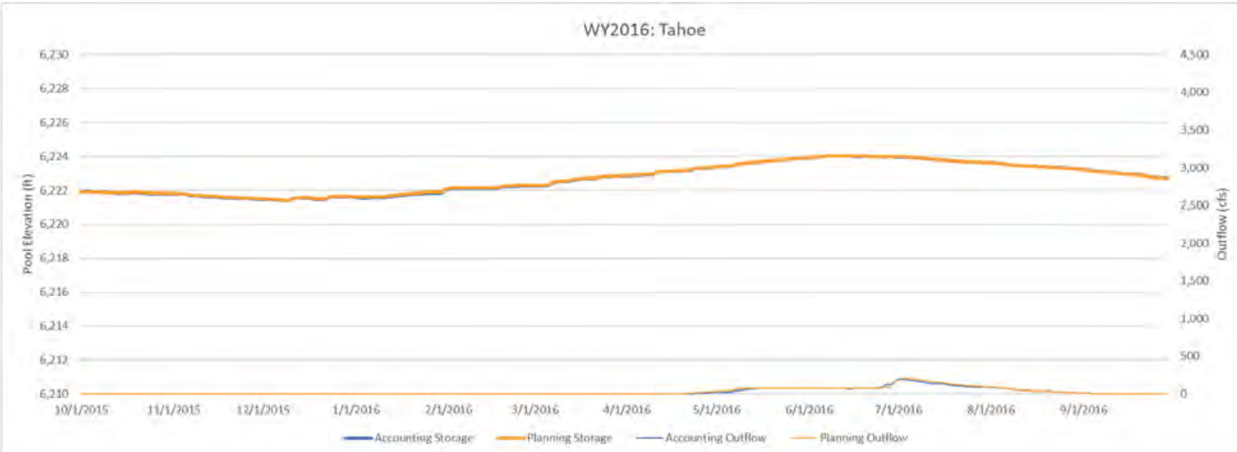


Figure 61. WY 2016 Lake Tahoe Outflow (right axis) and Pool Elevation (left axis) results from the Accounting (blue) and Planning Models (orange).

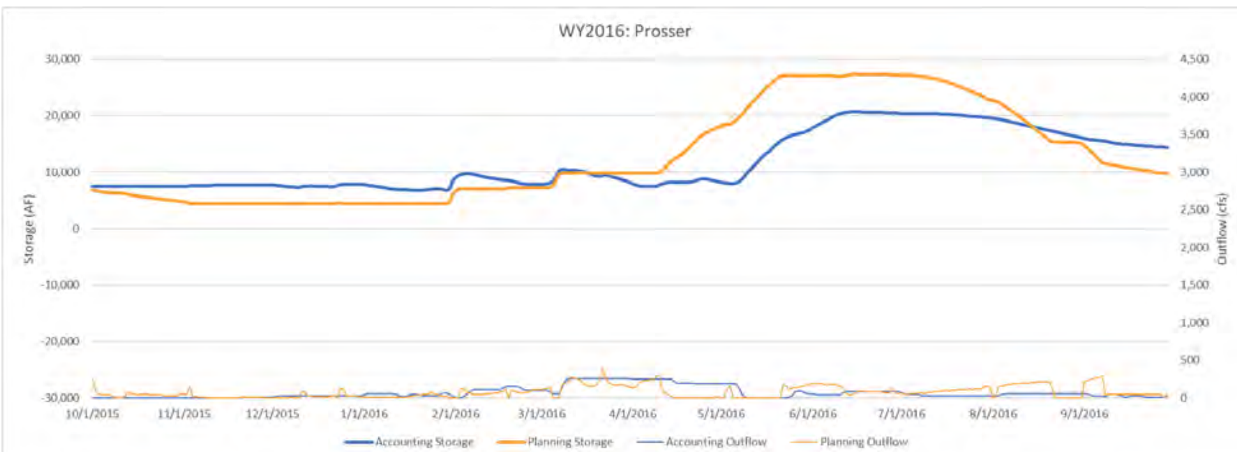


Figure 62. WY 2016 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

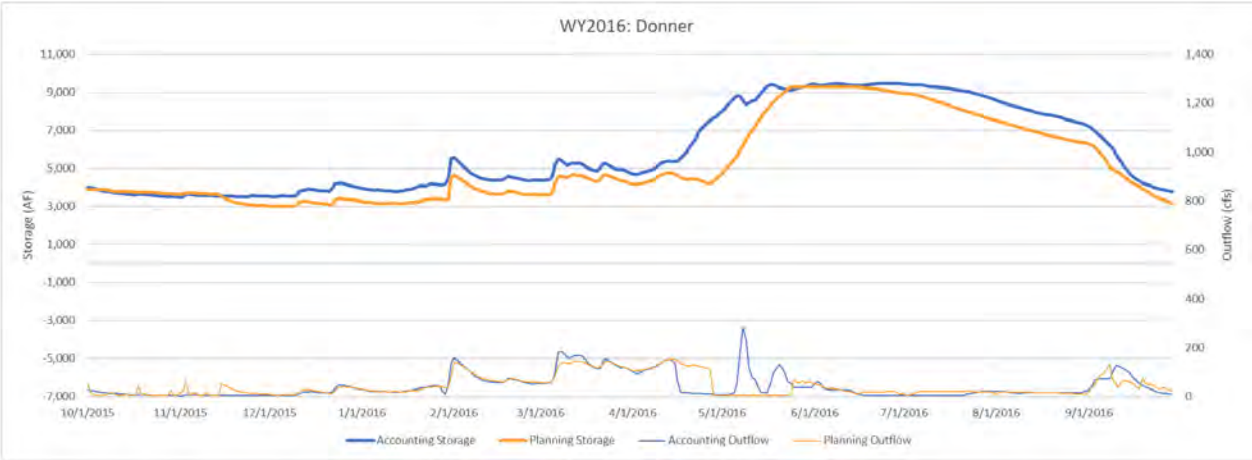


Figure 63. WY 2016 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

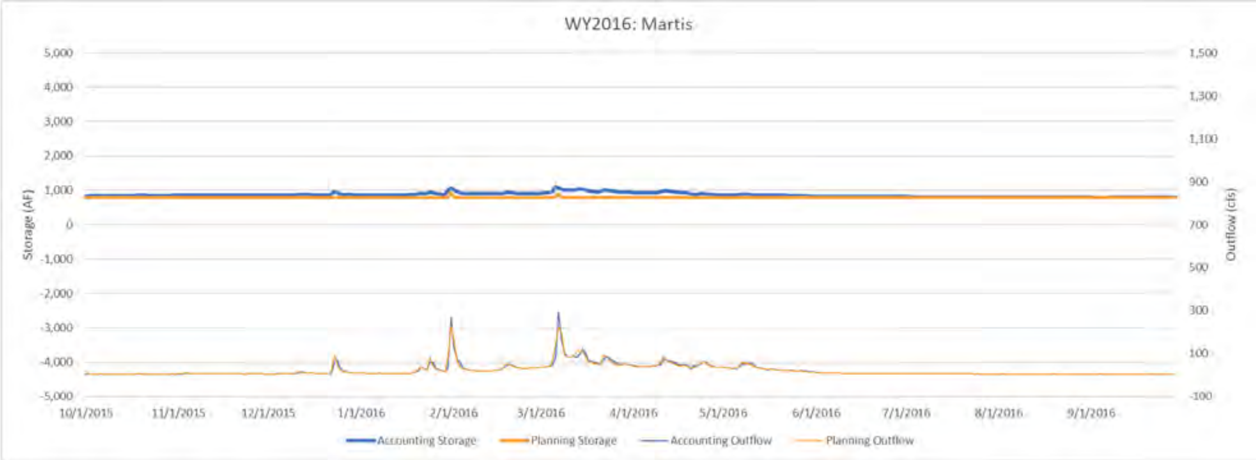


Figure 64. WY 2016 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

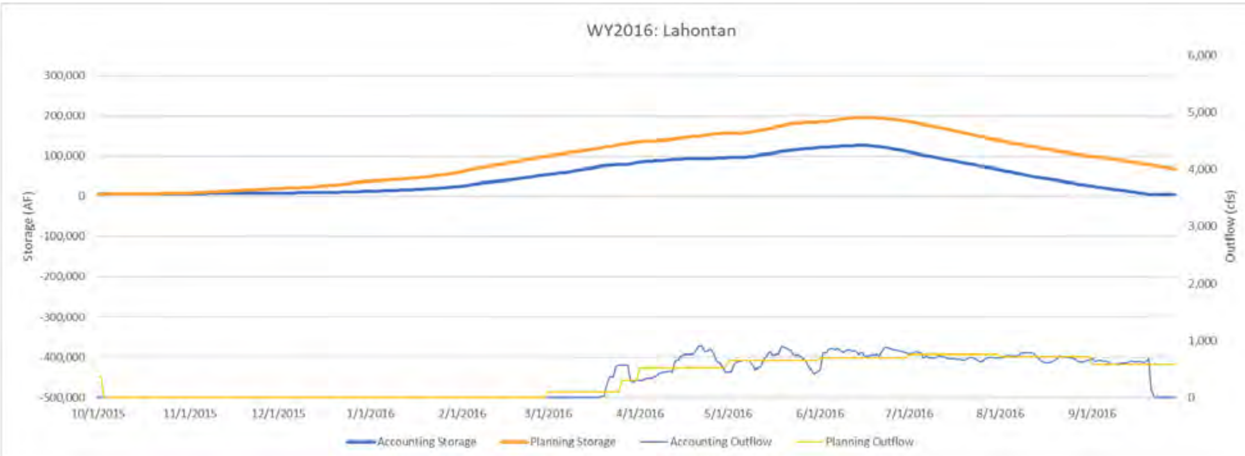


Figure 65. WY 2016 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

7.3 Canal Diversions, WY 2016

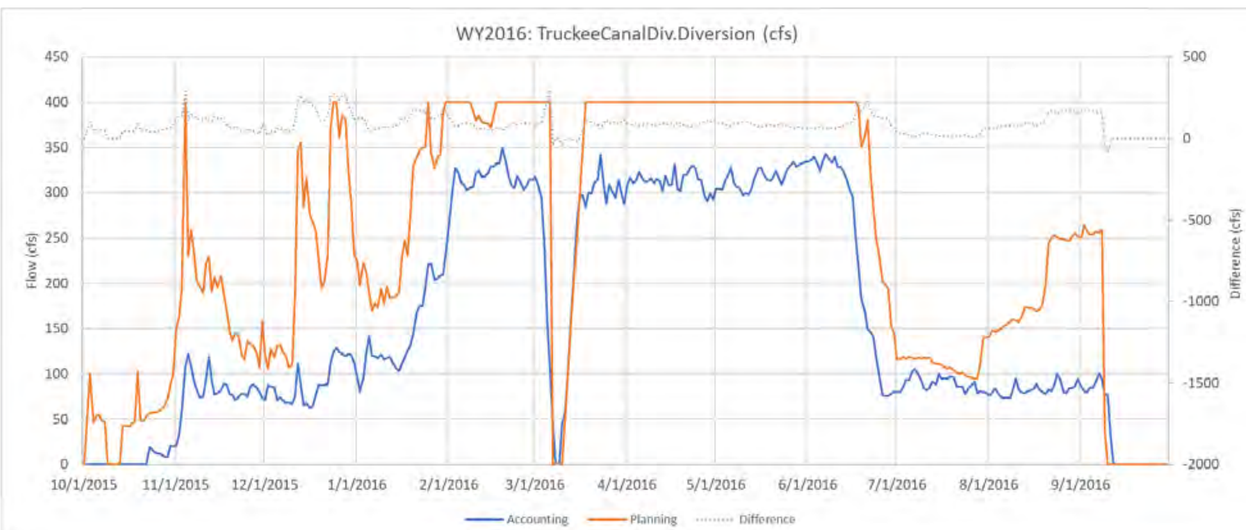


Figure 66. WY 2016 Accounting (blue) and Planning Model (orange) Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

7.4 Truckee River at Nixon Gage, WY 2016

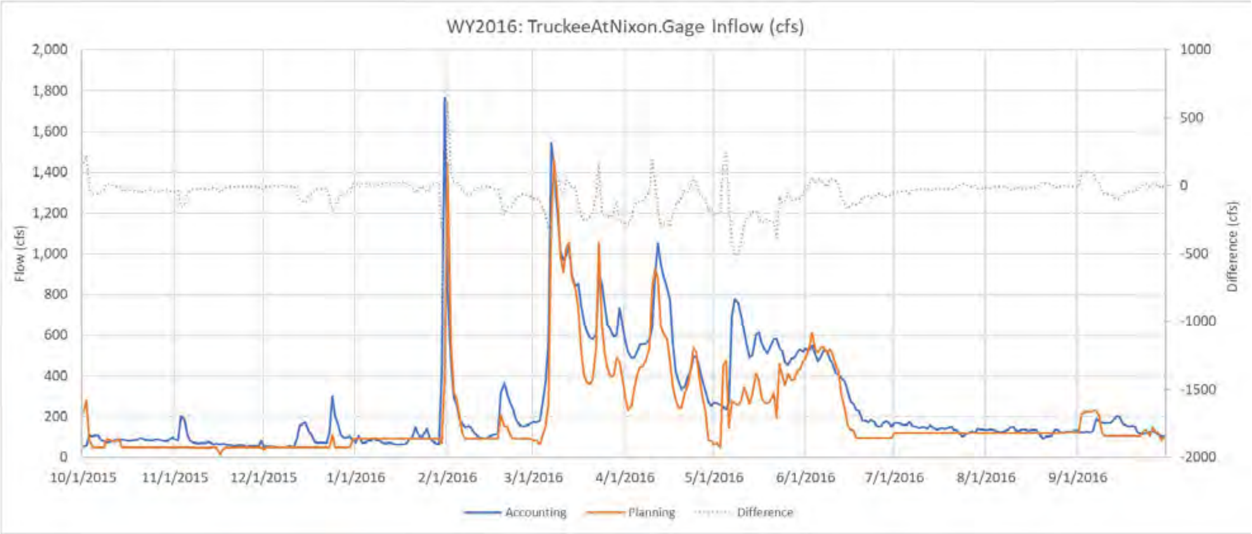


Figure 67. WY 2016 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

8 Appendix B: Summary of WY 2017 Comparison

This appendix provides plots comparing the WY 2017 Accounting Model and final Iteration of the WY 2017 Planning Model for metrics used within this verification effort.

8.1 Floriston Rate, WY 2017

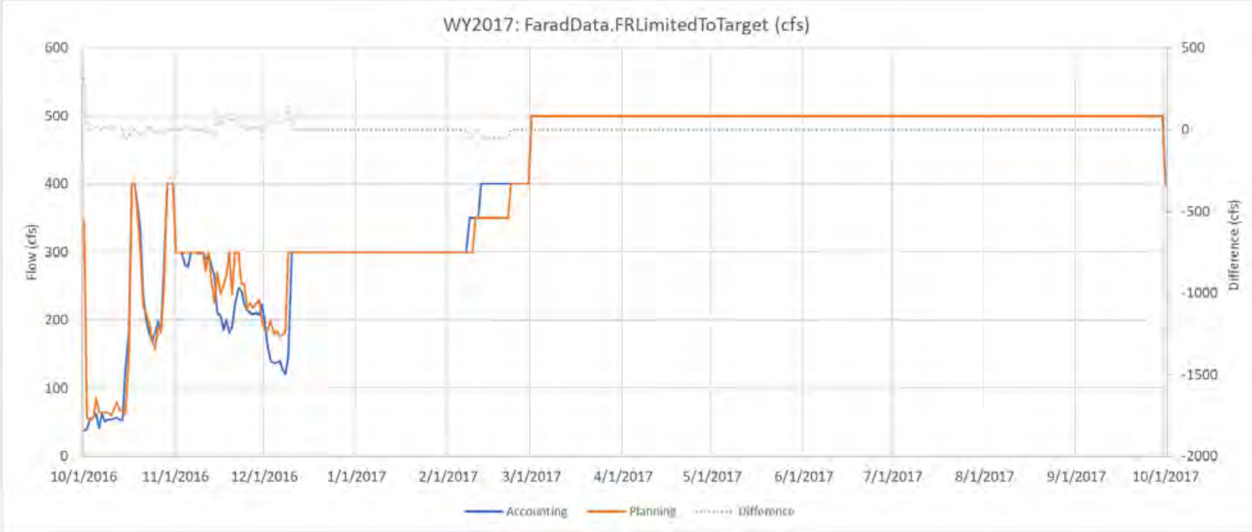


Figure 68. WY 2017 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

8.2 Reservoir Plots, WY 2017

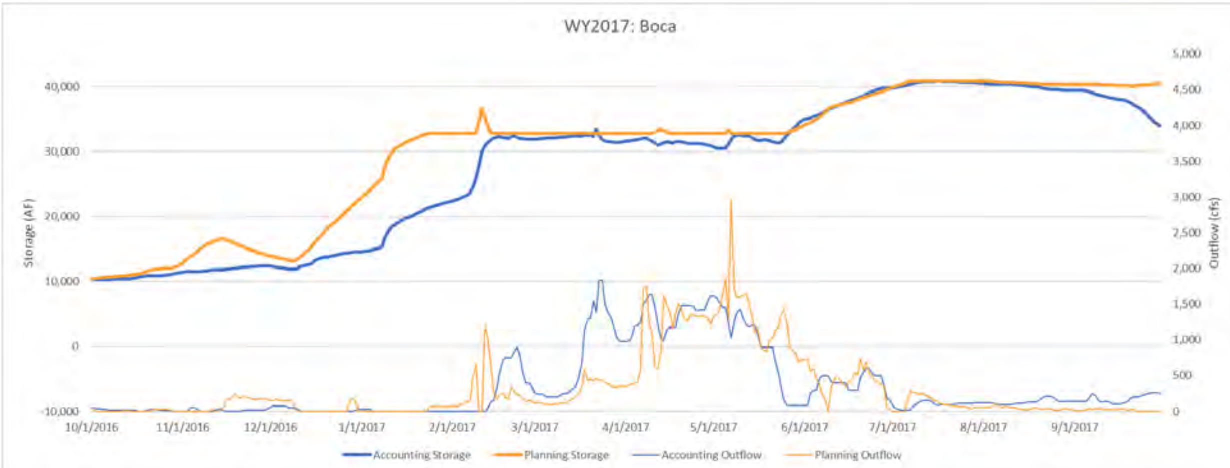


Figure 69. WY 2017 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

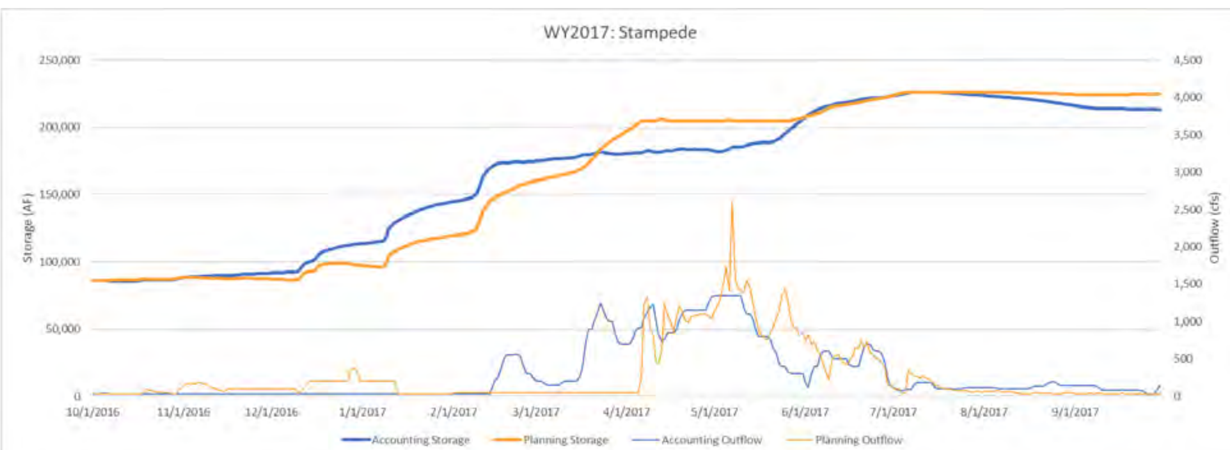


Figure 70. WY 2017 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

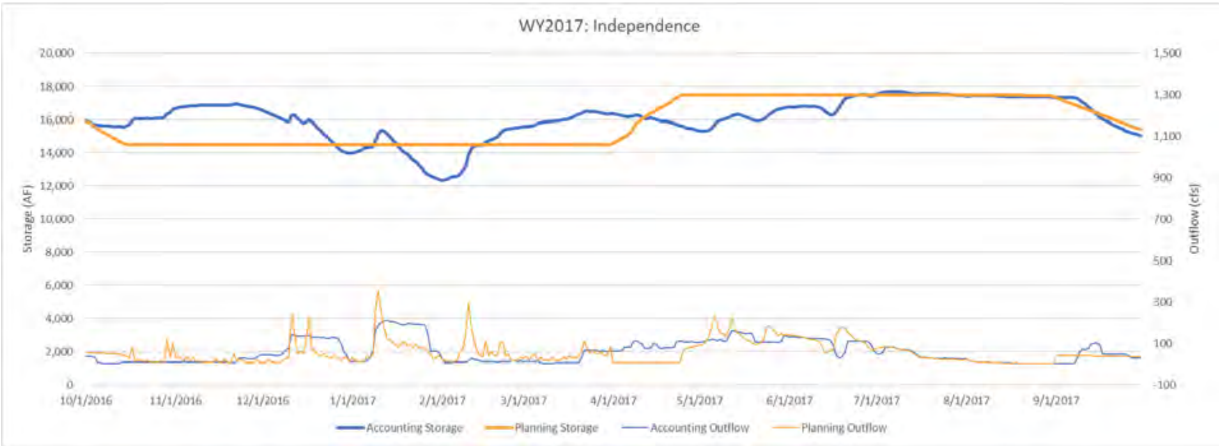


Figure 71. WY 2017 Independence Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

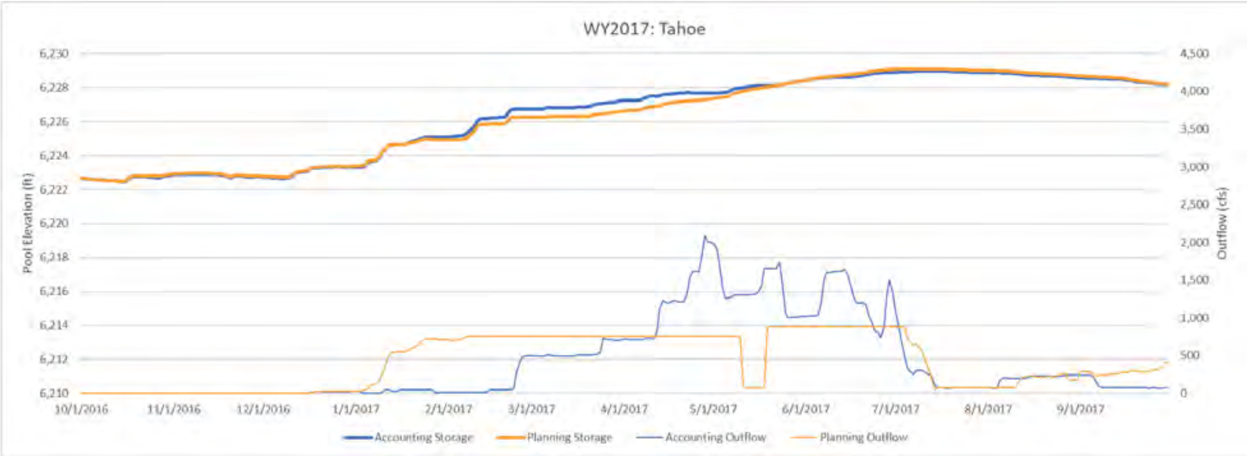


Figure 72. WY 2017 Lake Tahoe Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

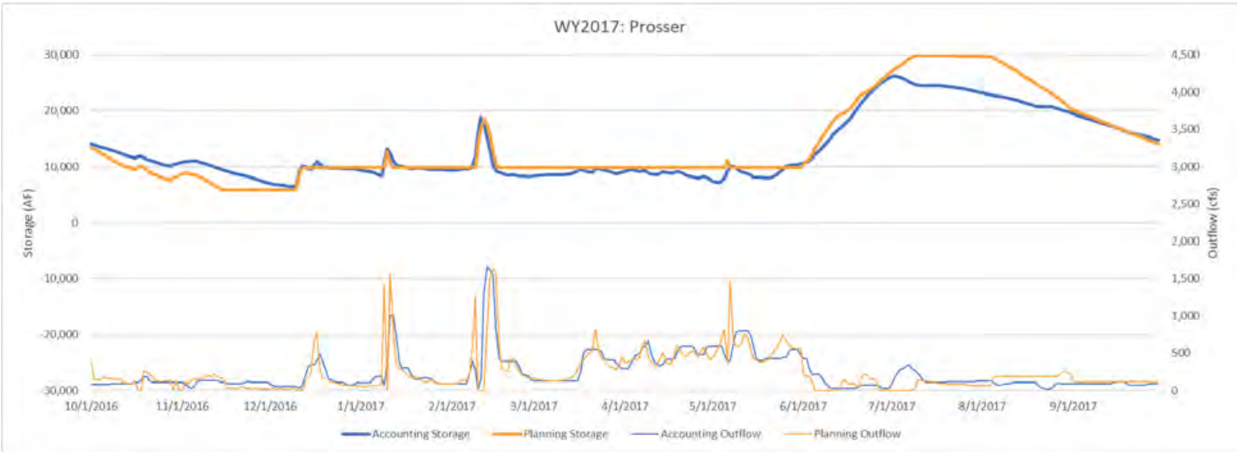


Figure 73. WY 2017 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

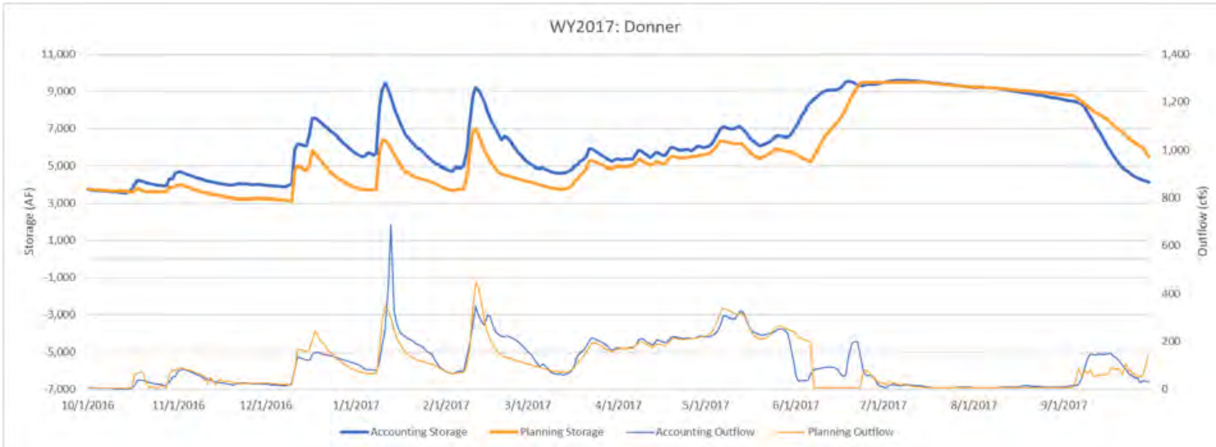


Figure 74. WY 2017 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

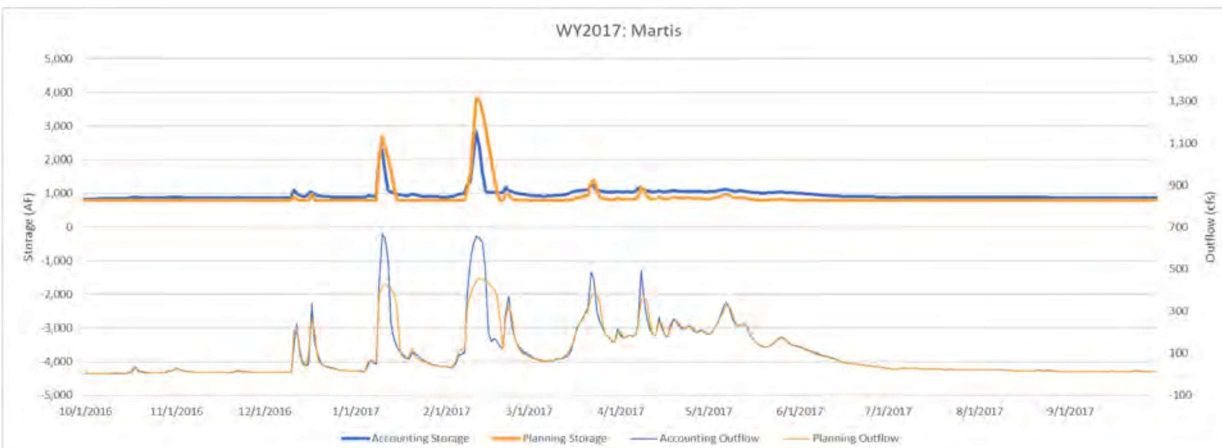


Figure 75. WY 2017 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

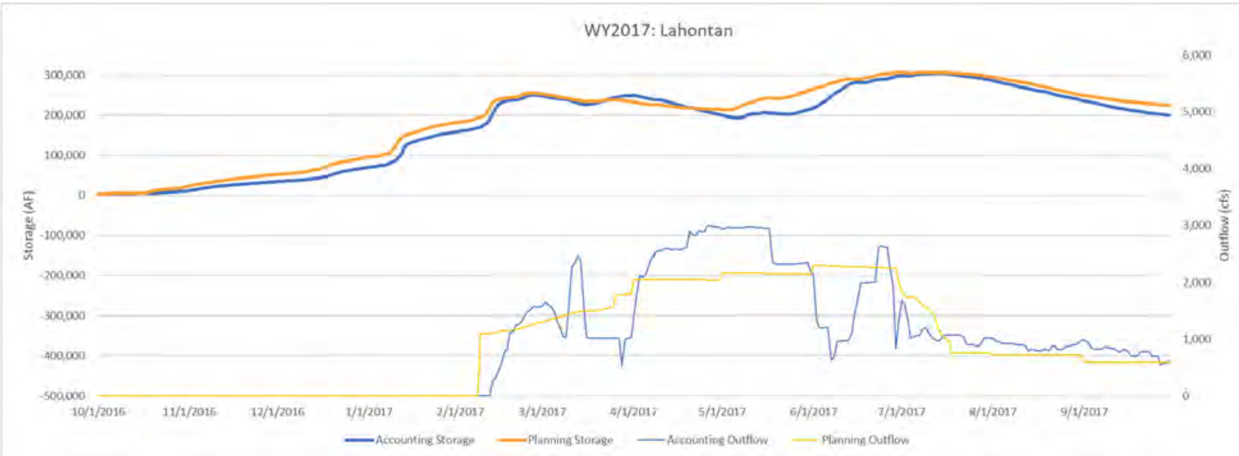


Figure 76. WY 2017 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

8.3 Canal Diversions, WY 2017

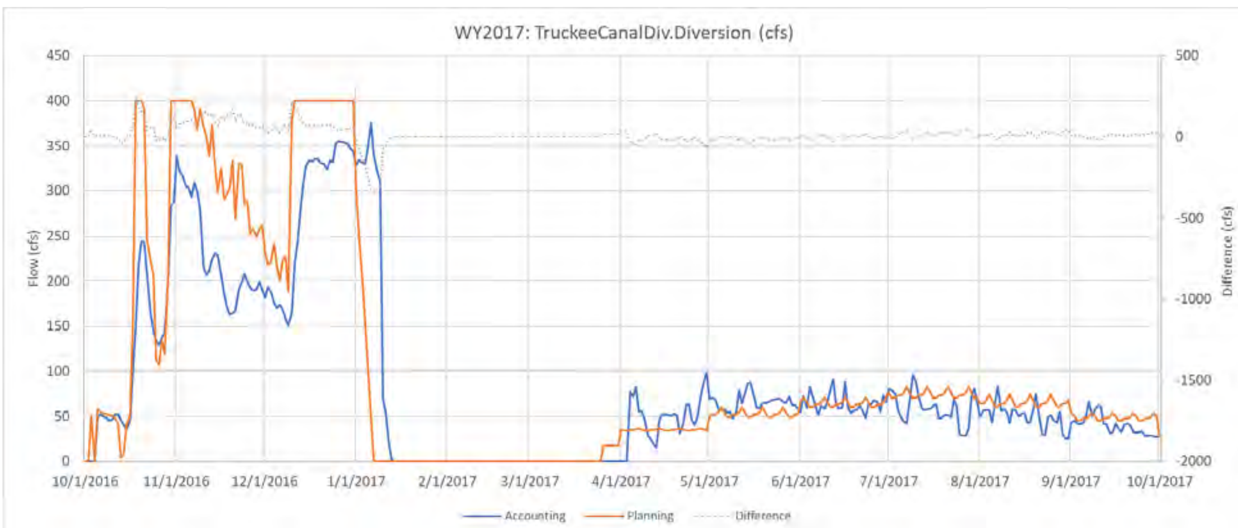


Figure 77. WY 2017 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

8.4 Truckee River at Nixon Gage, WY 2017

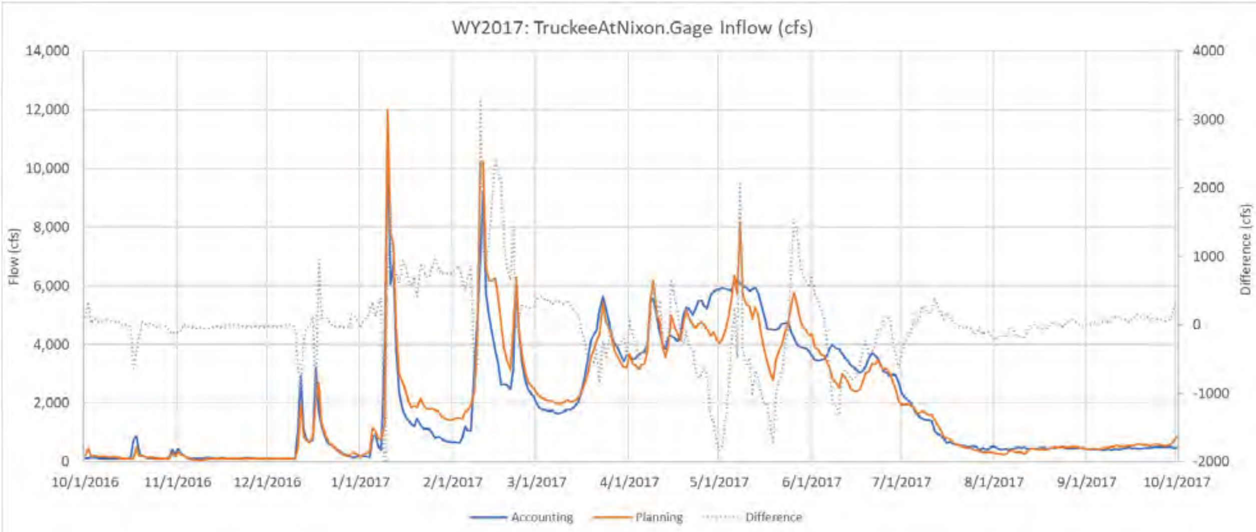


Figure 78. WY 2017 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

9 Appendix C: Summary of WY 2018 Comparison

This appendix provides plots comparing the WY 2018 Accounting Model and final Iteration of the WY 2018 Planning Model for metrics used within this verification effort.

9.1 Floriston Rate, WY 2018

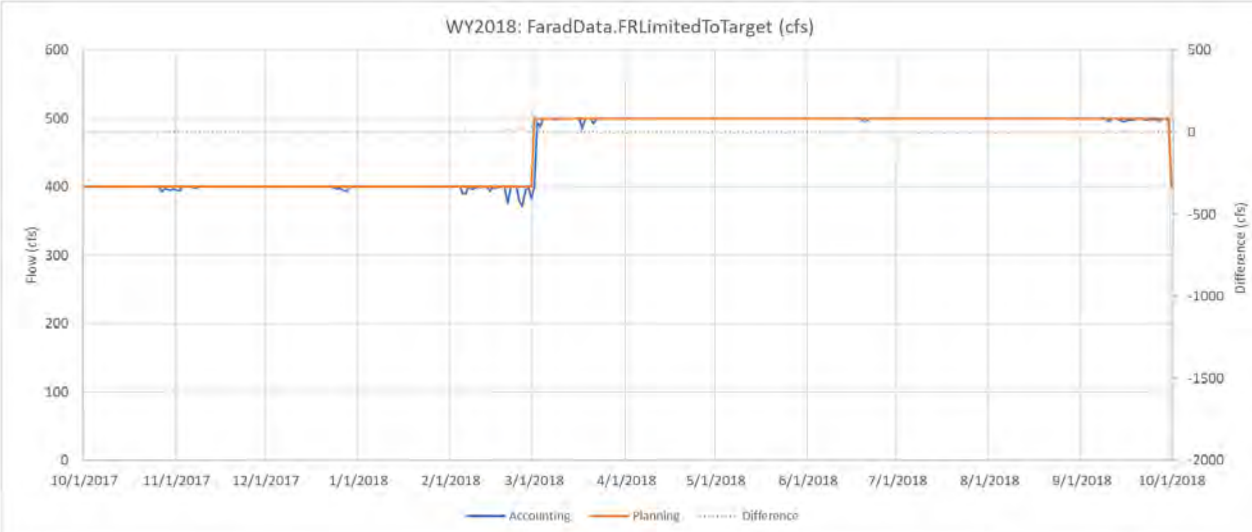


Figure 79. WY 2018 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

9.2 Reservoir Plots, WY 2018

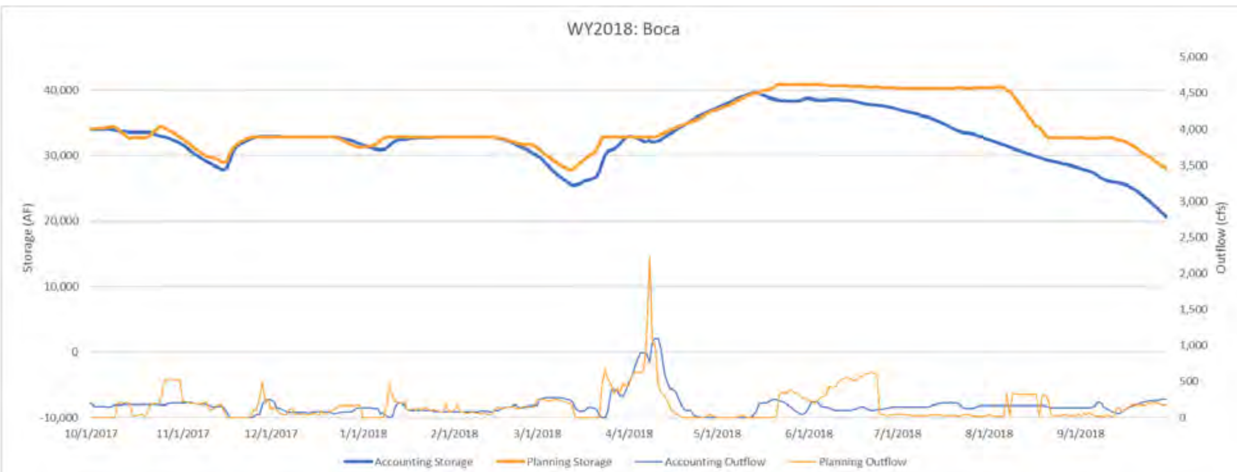


Figure 80. WY 2018 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

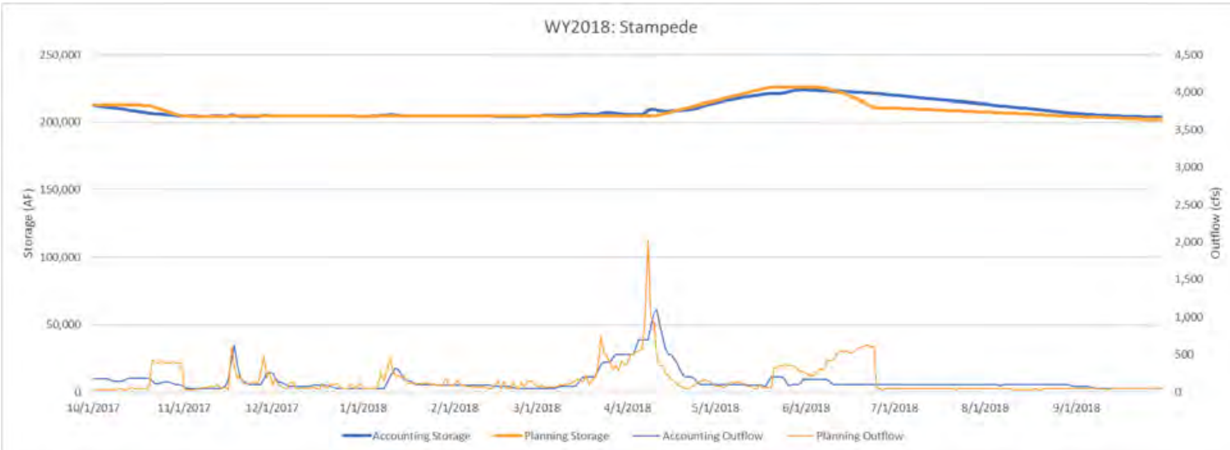


Figure 81. WY 2018 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

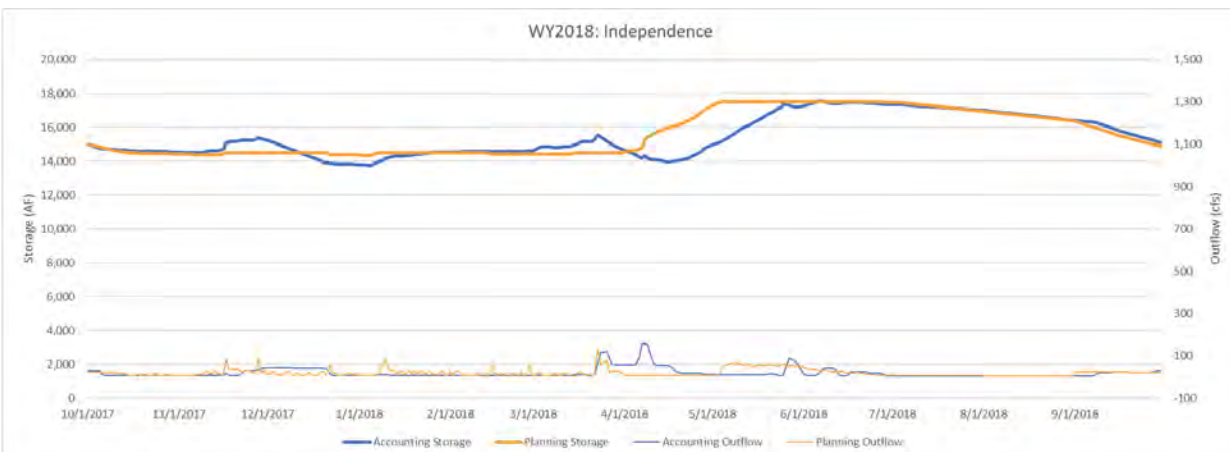


Figure 82. WY 2018 Independence Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

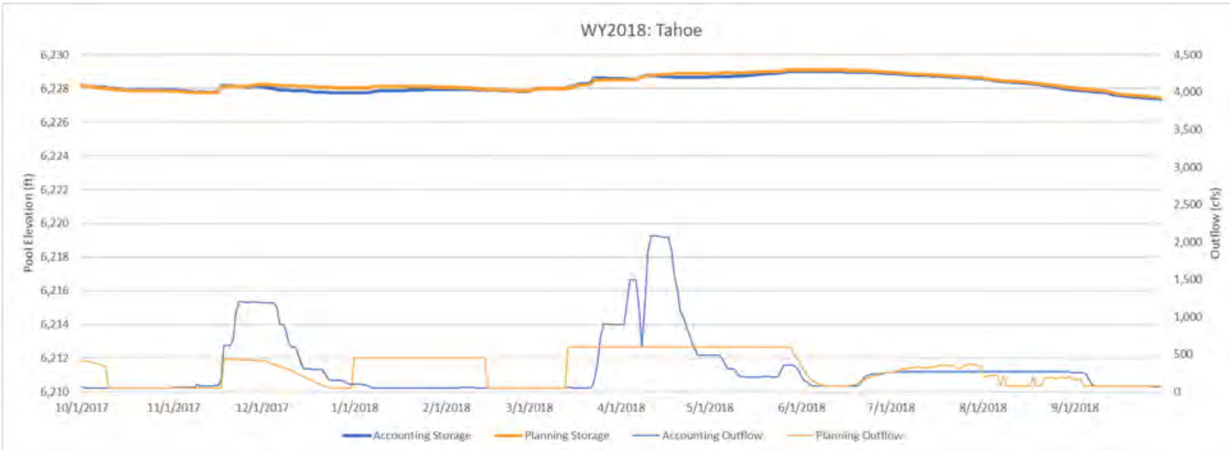


Figure 83. WY 2018 Lake Tahoe Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

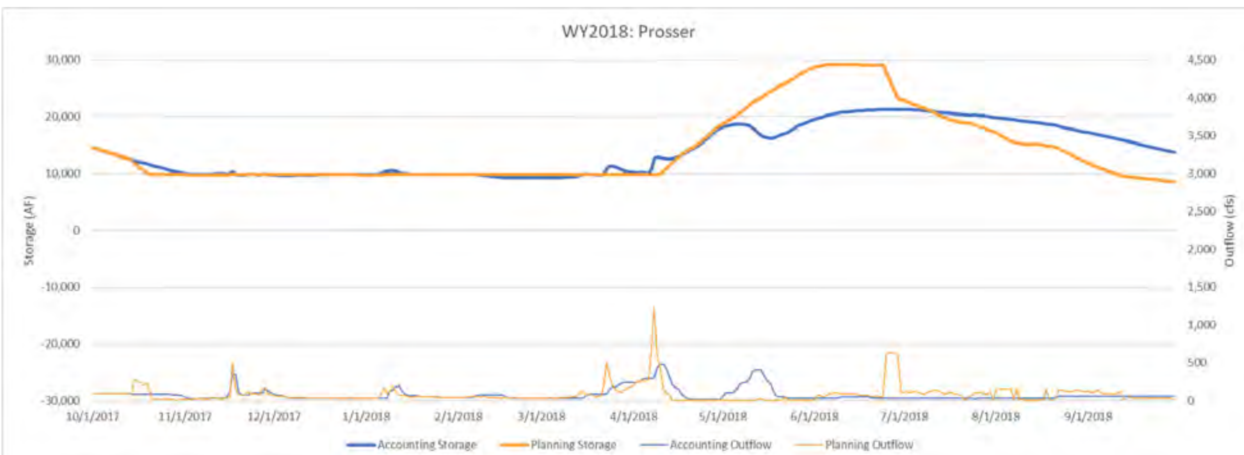


Figure 84. WY 2018 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

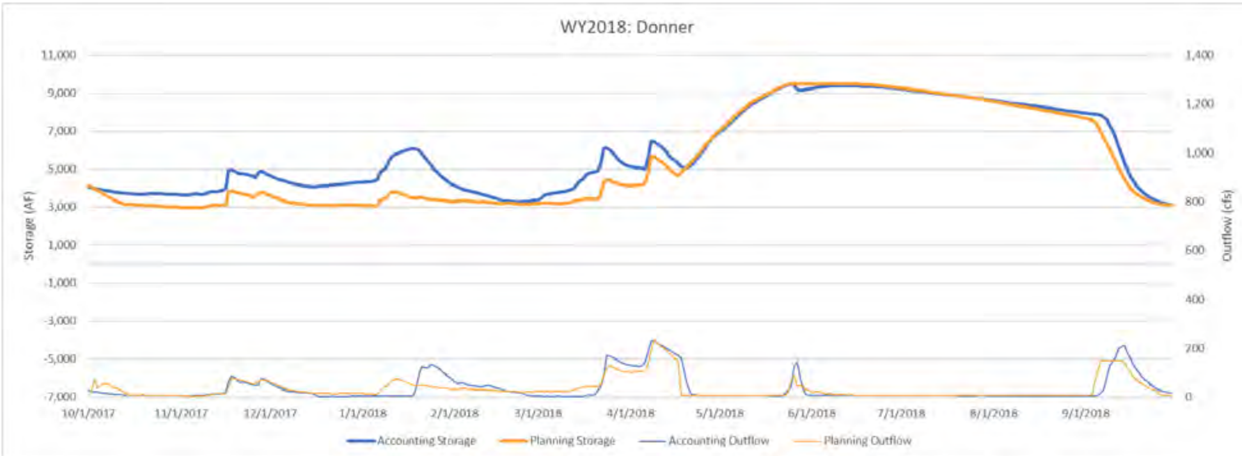


Figure 85. WY 2018 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

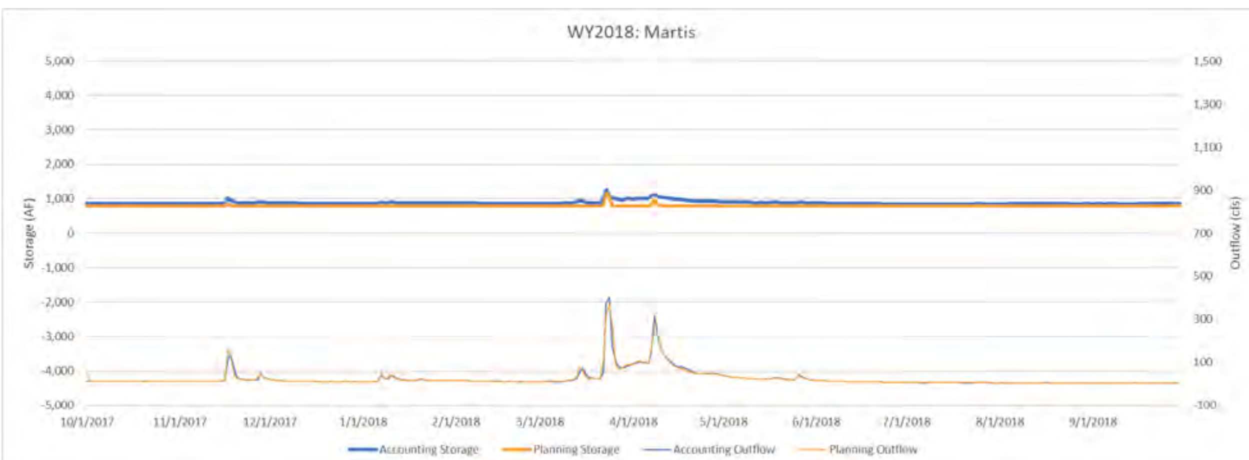


Figure 86. WY 2018 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

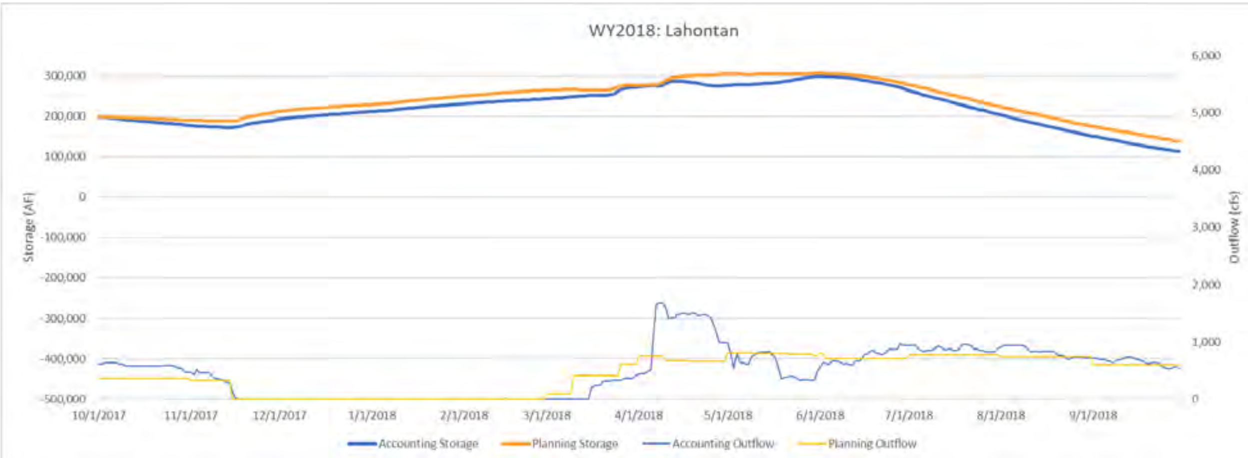


Figure 87. WY 2018 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

9.3 Canal Diversions, WY 2018

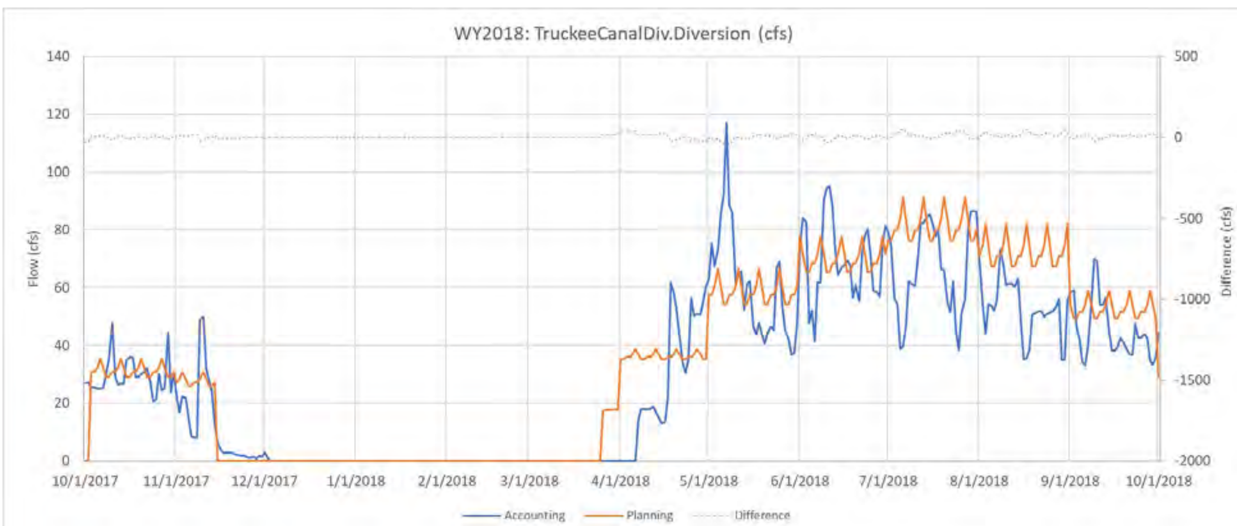


Figure 88. WY 2018 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

9.4 Truckee River at Nixon Gage, WY 2018

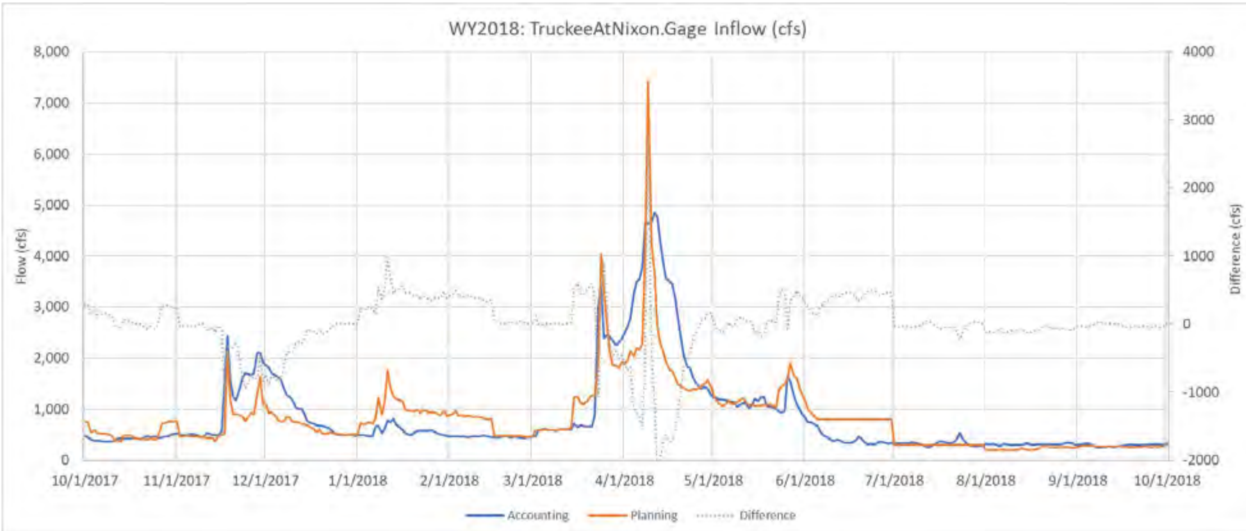


Figure 89. WY 2018 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

10 Appendix D: Summary of WY 2019 Comparison

This appendix provides plots comparing the WY 2019 Accounting Model and final Iteration of the WY 2019 Planning Model for metrics used within this verification effort.

10.1 Floriston Rate, WY 2019

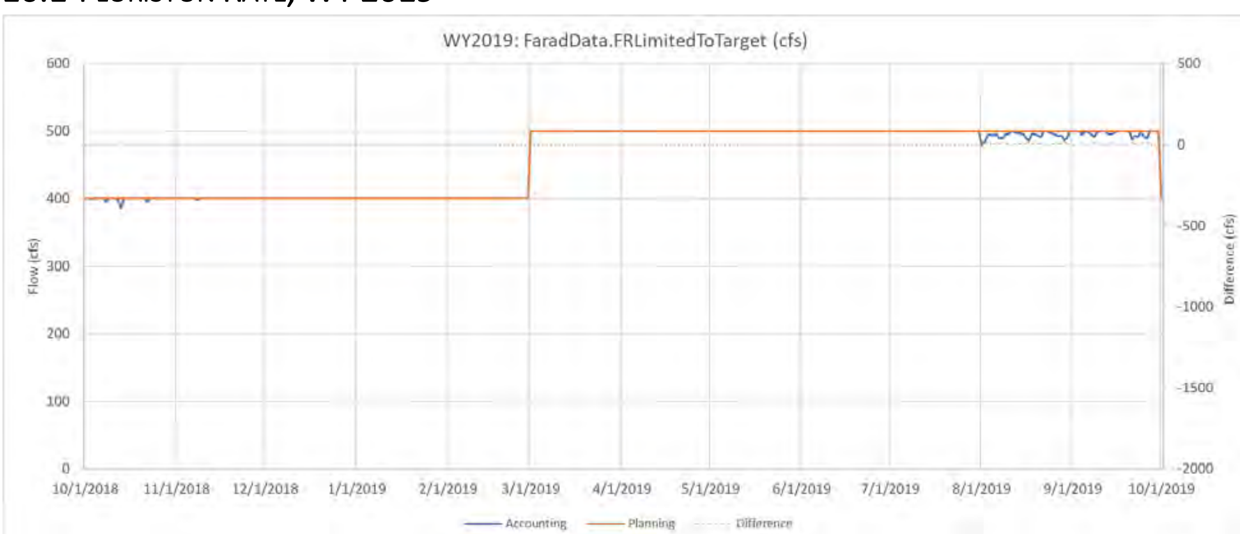


Figure 90. WY 2019 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

10.2 Reservoir Plots, WY 2019

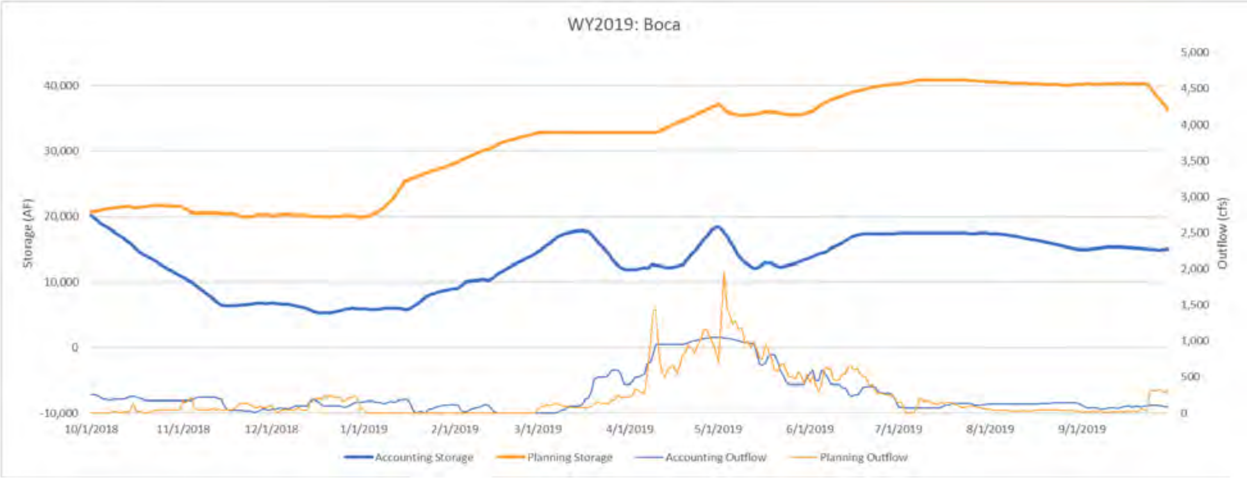


Figure 91. WY 2019 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

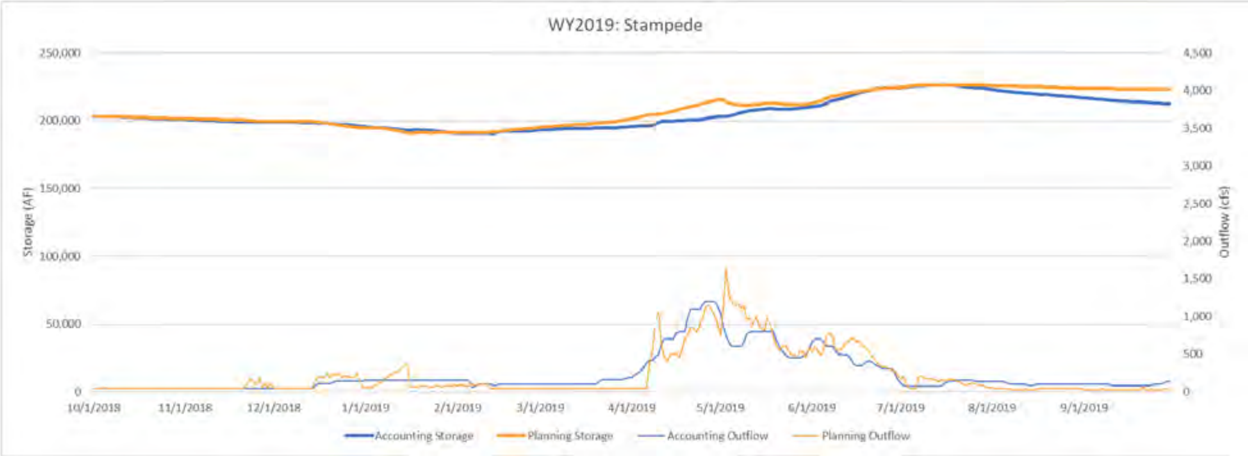


Figure 92. WY 2019 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

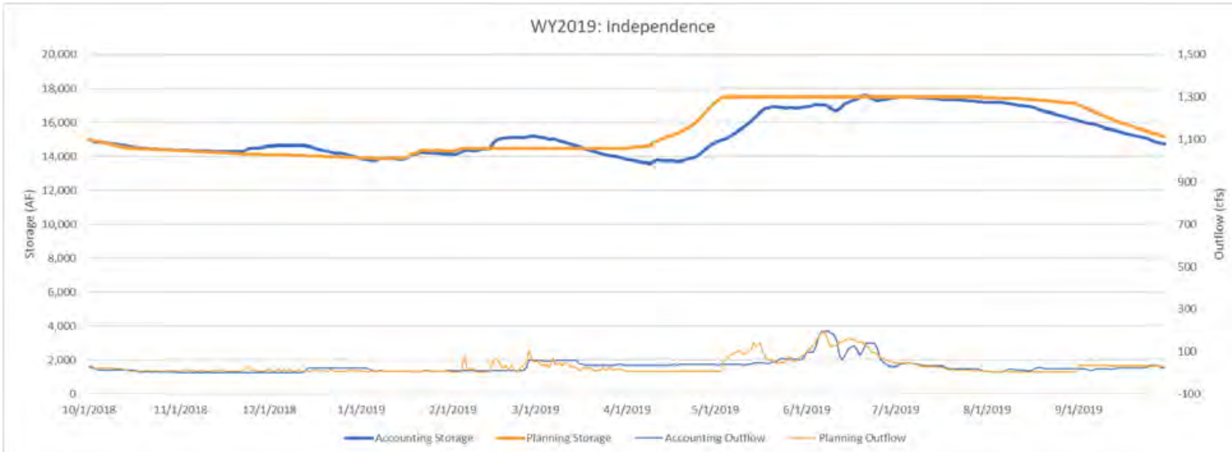


Figure 93. WY 2019 Independence Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

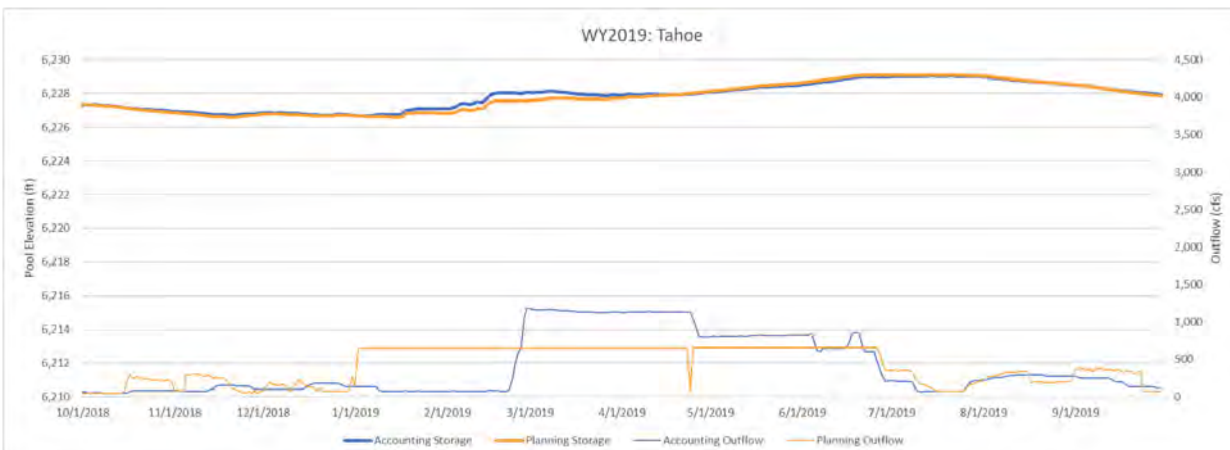


Figure 94. WY 2019 Lake Tahoe Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

Figure 95. WY 2019 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

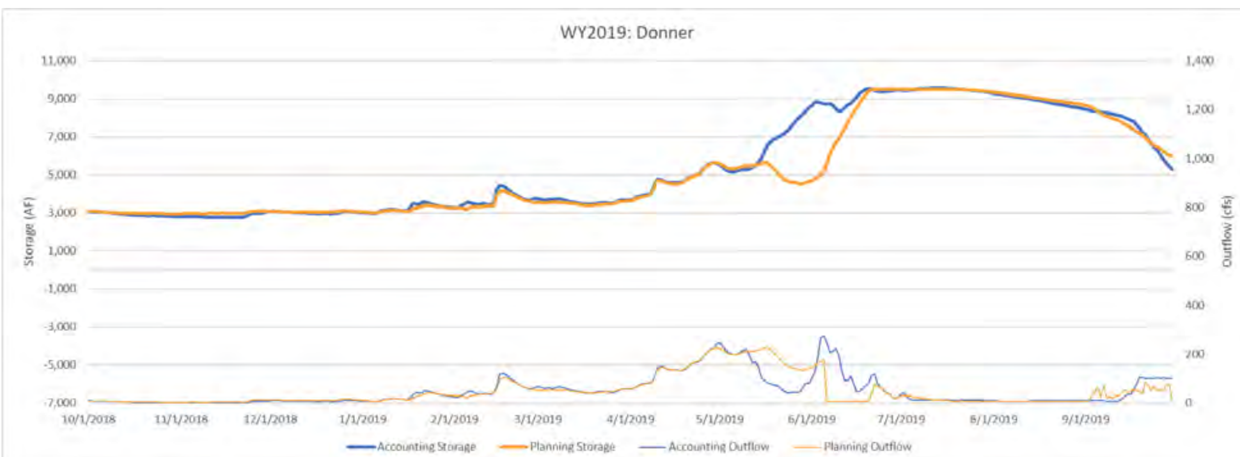


Figure 96. WY 2019 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

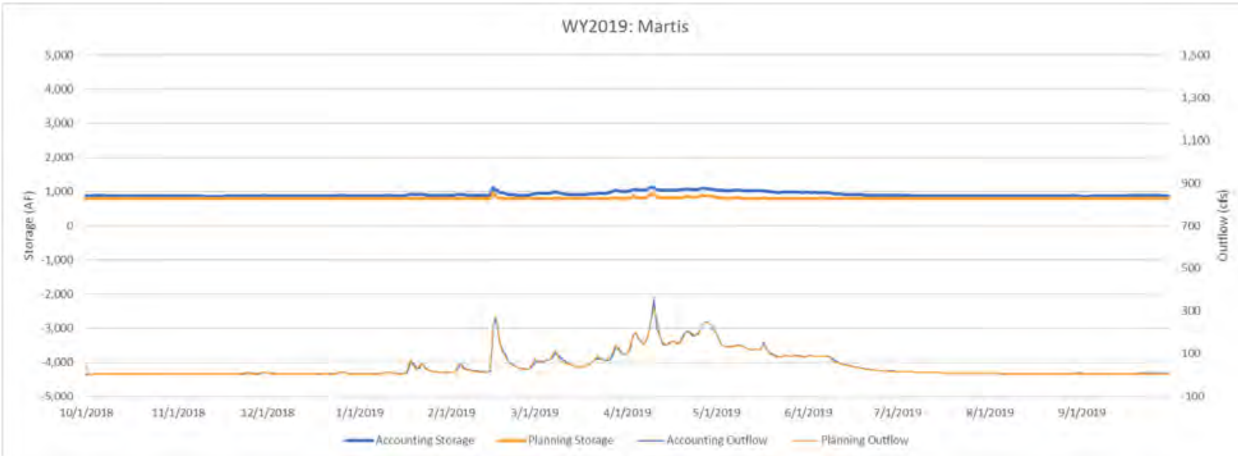


Figure 97. WY 2019 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

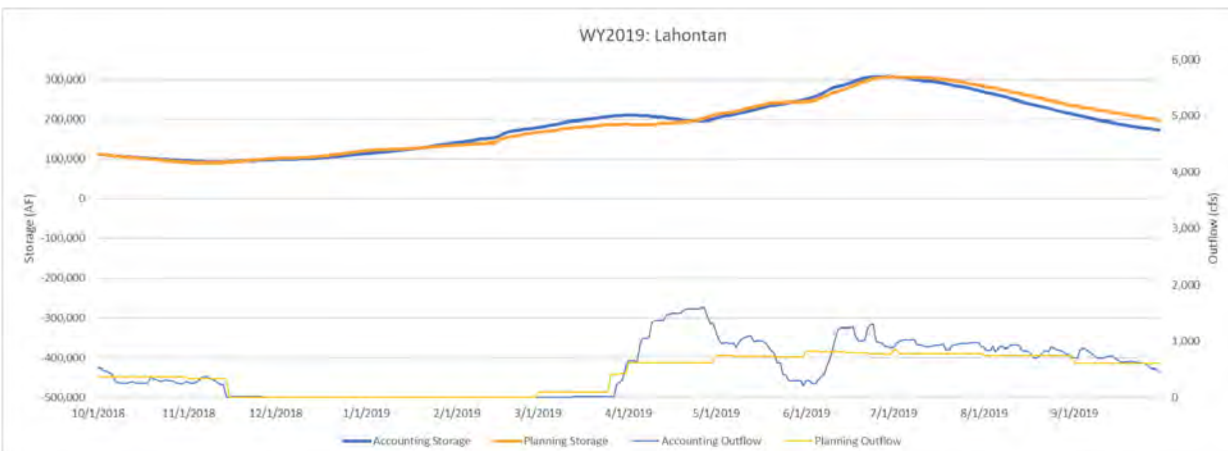


Figure 98. WY 2019 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

10.3 Canal Diversions, WY 2019

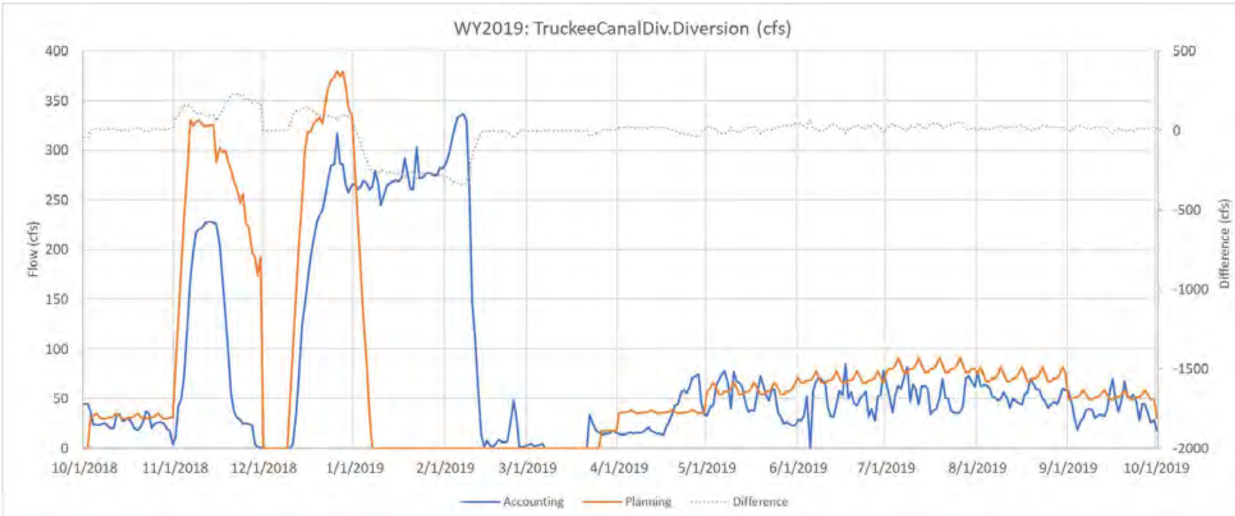


Figure 99. WY 2019 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

10.4 Truckee River at Nixon Gage, WY 2019

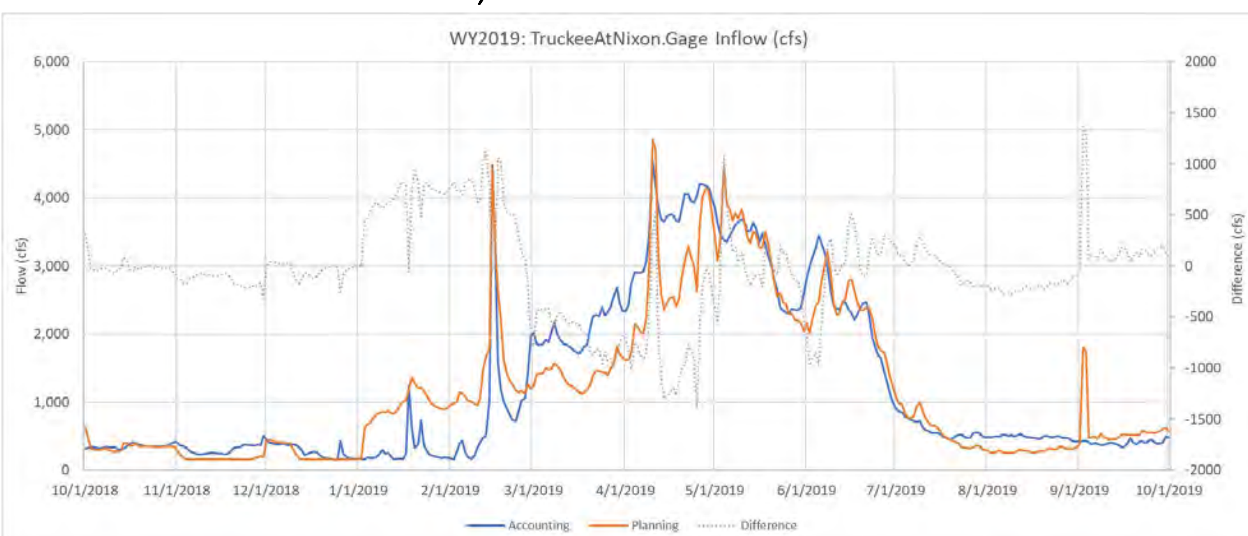


Figure 100. WY 2019 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

11 Appendix E: Summary of WY 2020 Comparison

This appendix provides plots comparing the WY 2020 Accounting Model and final Iteration of the WY 2020 Planning Model for metrics used within this verification effort.

11.1 Floriston Rate, WY 2020

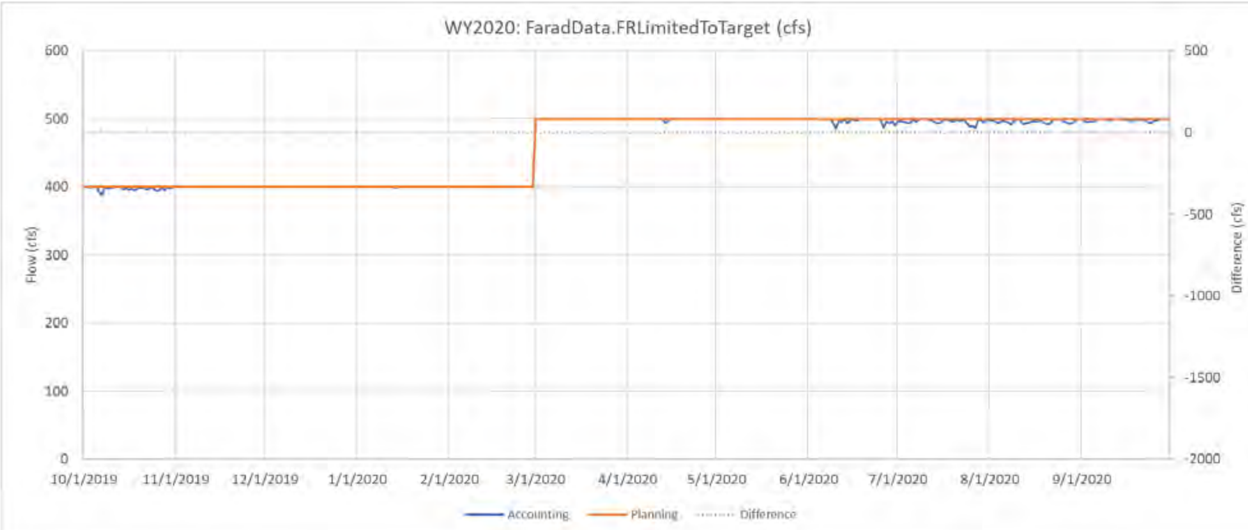


Figure 101. WY 2020 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

11.2 Reservoir Plots, WY 2020

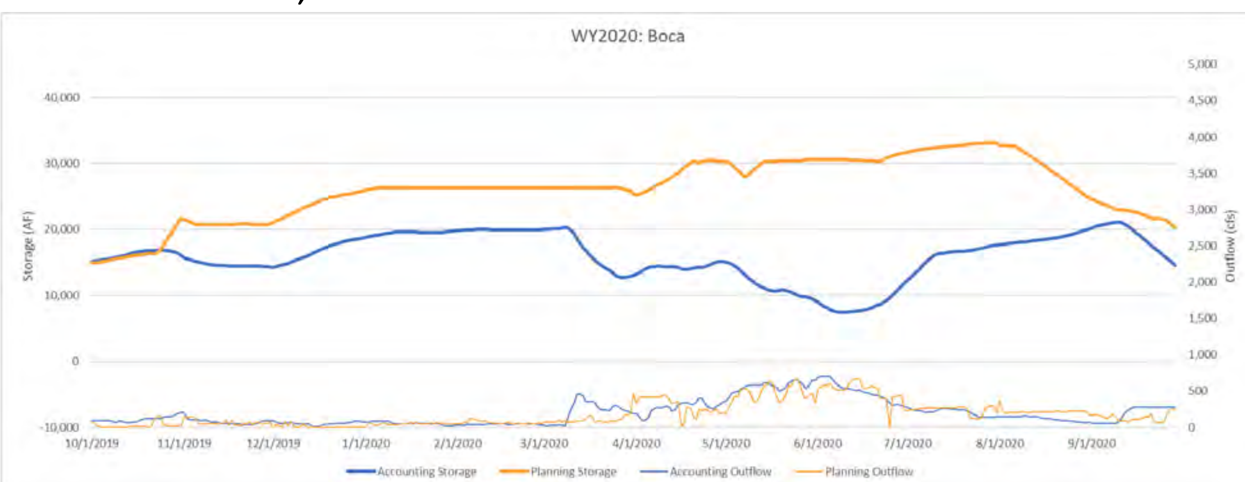


Figure 102. WY 2020 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

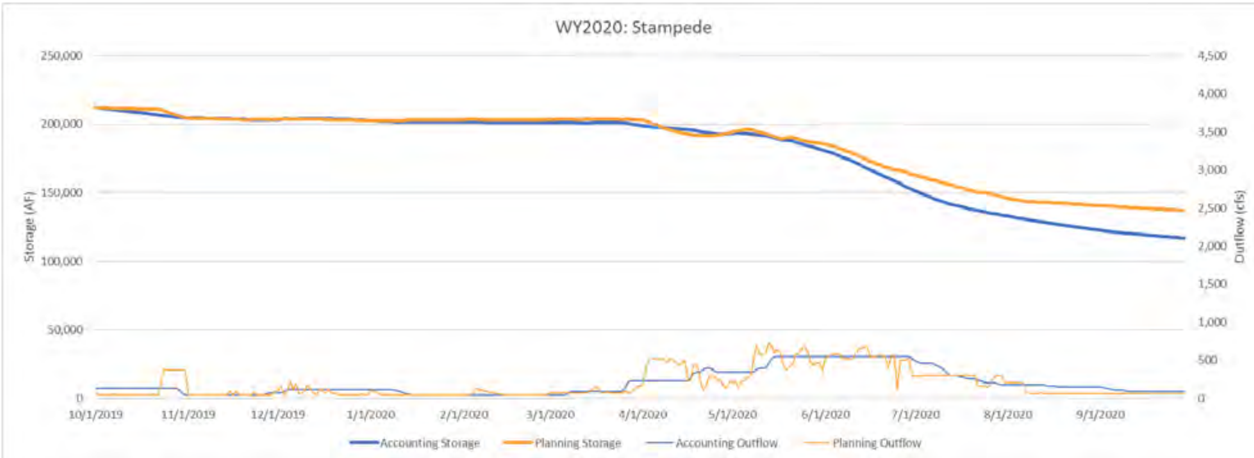


Figure 103. WY 2020 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

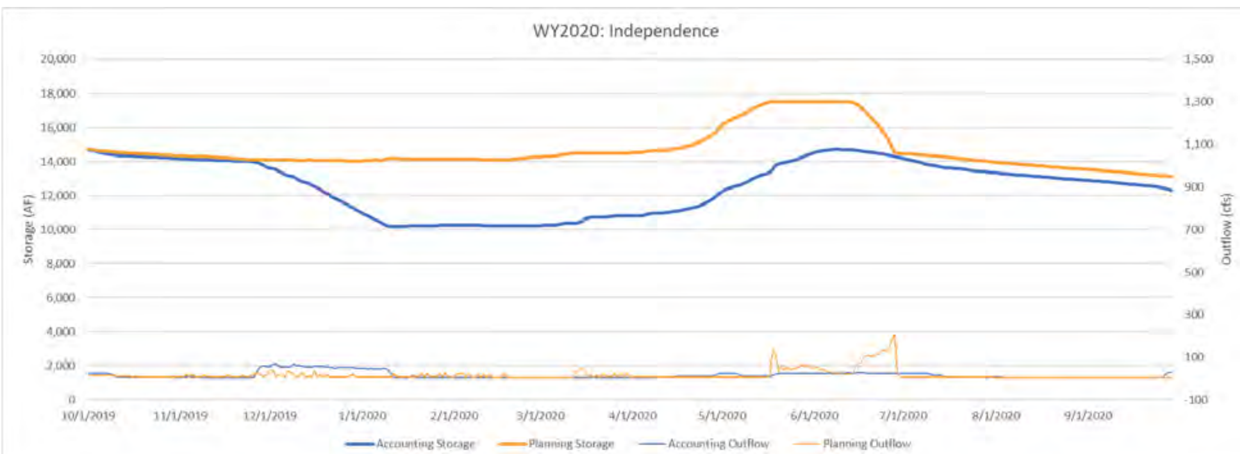


Figure 104. WY 2020 Independence Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

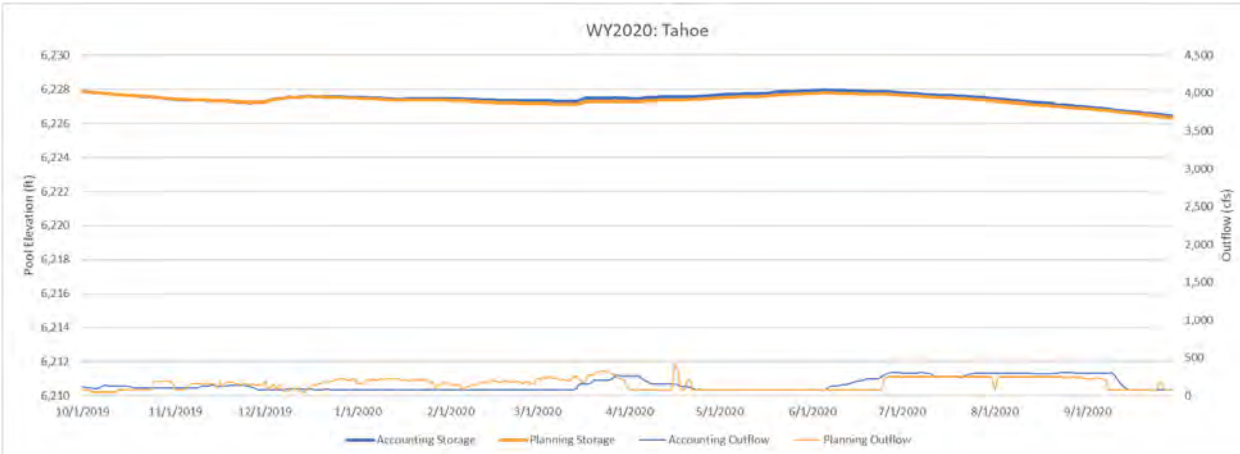


Figure 105. WY 2020 Lake Tahoe Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

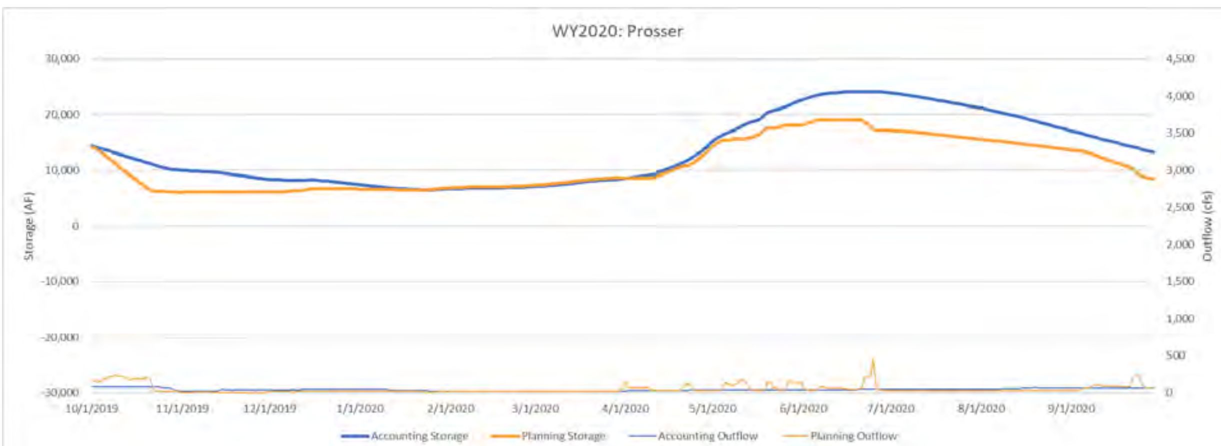


Figure 106. WY 2020 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

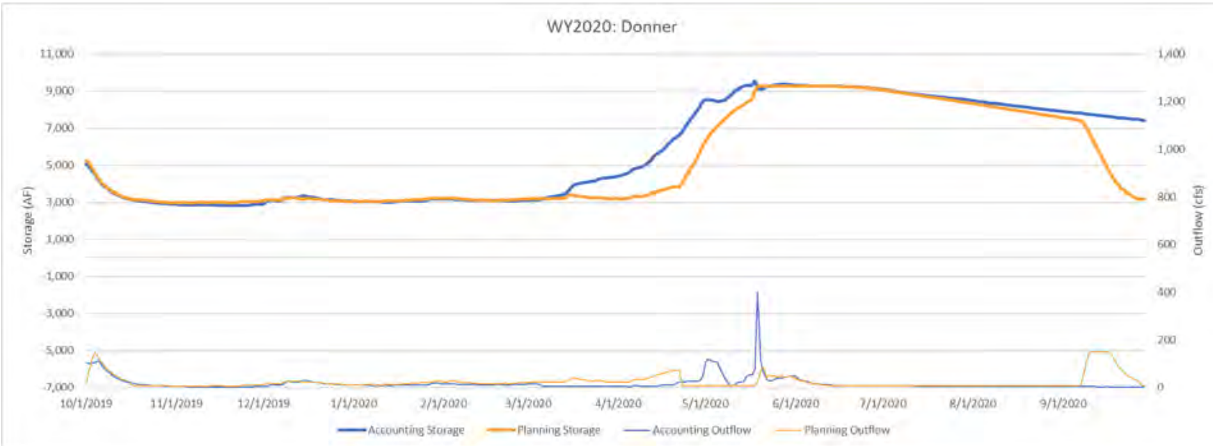


Figure 107. WY 2020 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

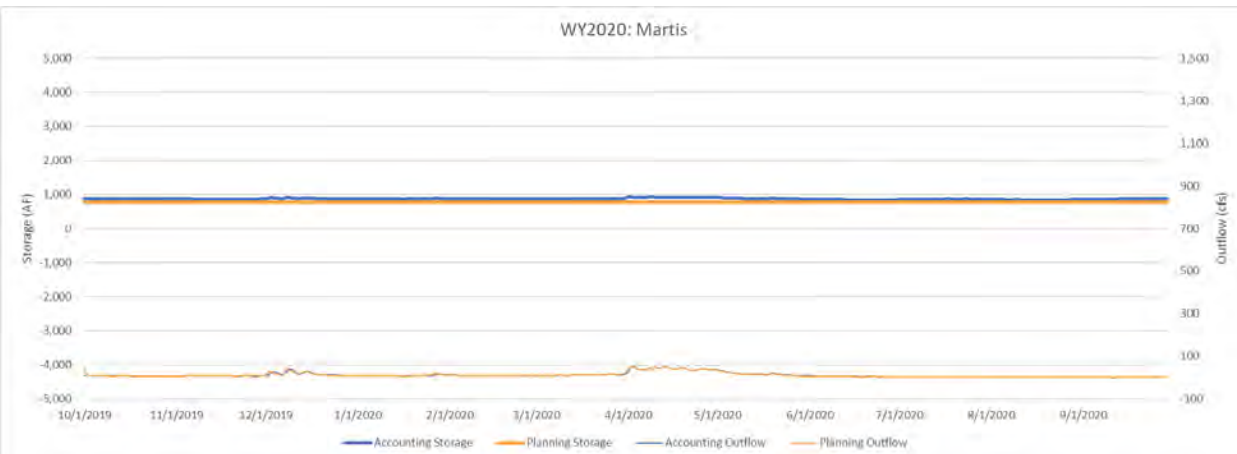


Figure 108. WY 2020 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

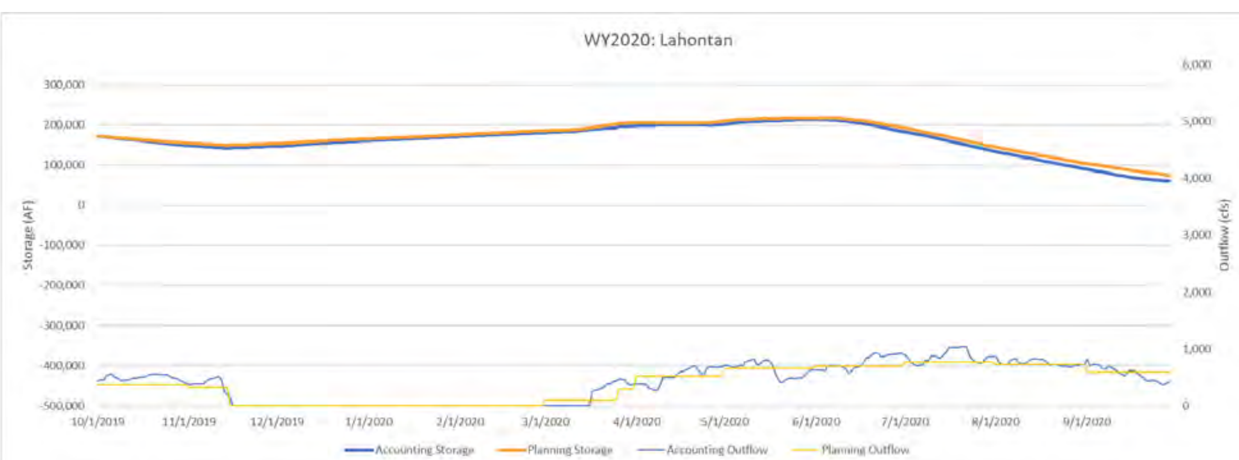


Figure 109. WY 2020 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

11.3 Canal Diversions, WY 2020

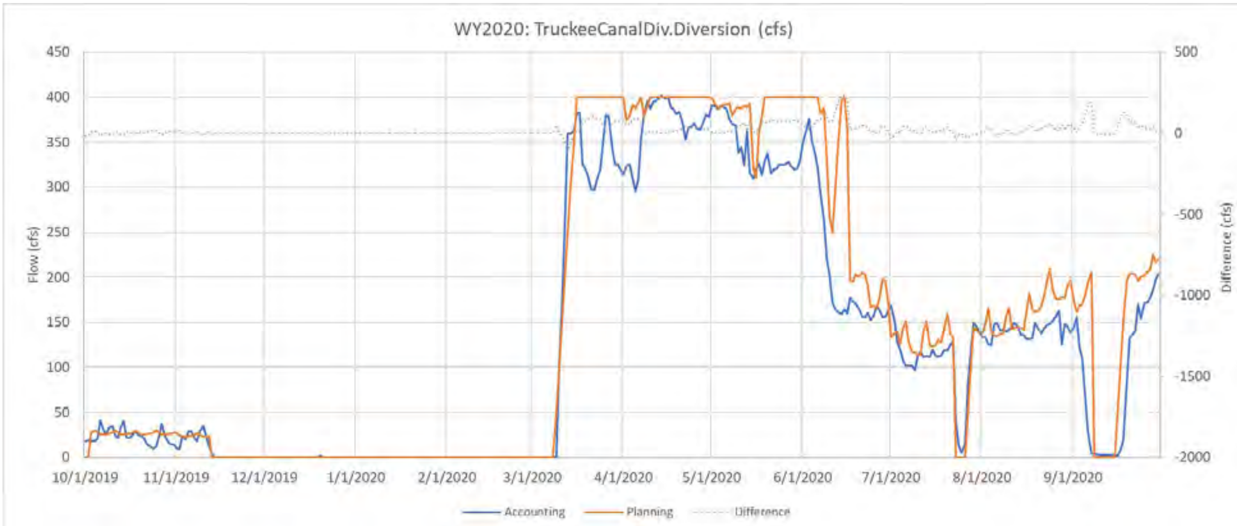


Figure 110. WY 2020 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

11.4 Truckee River at Nixon Gage, WY 2020

Figure 111. WY 2020 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

12 Appendix F: Summary of WY 2021 Comparison

This appendix provides plots comparing the WY 2021 Accounting Model and final Iteration of the WY 2021 Planning Model for metrics used within this verification effort.

12.1 Floriston Rate, WY 2021

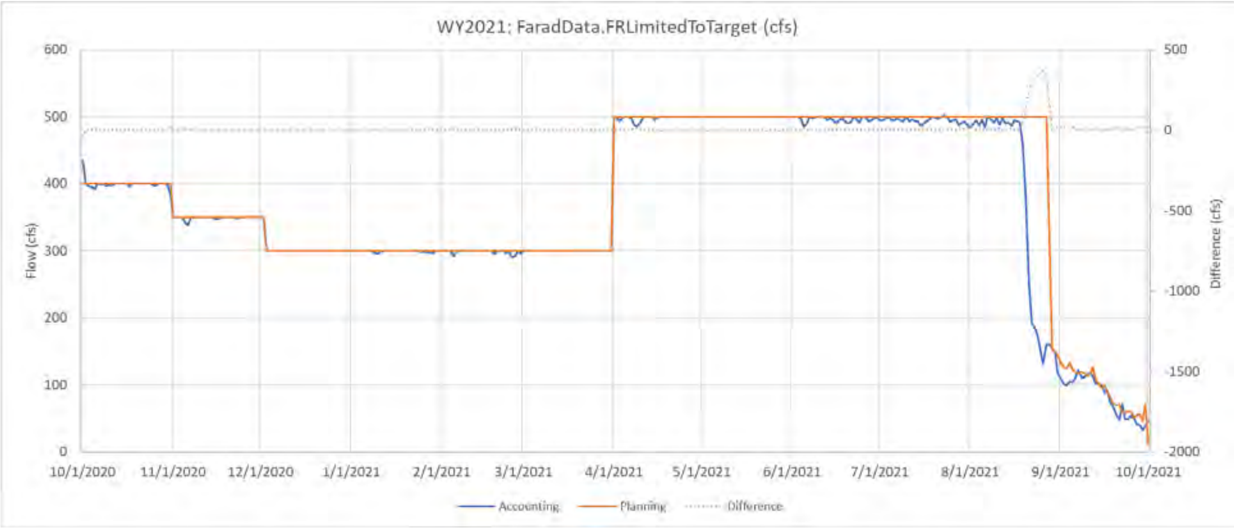


Figure 112. WY 2021 Accounting (blue) and Planning (orange) Model Daily FR inclusive of holdbacks and limited to the FR Target.

12.2 Reservoir Plots, WY 2021

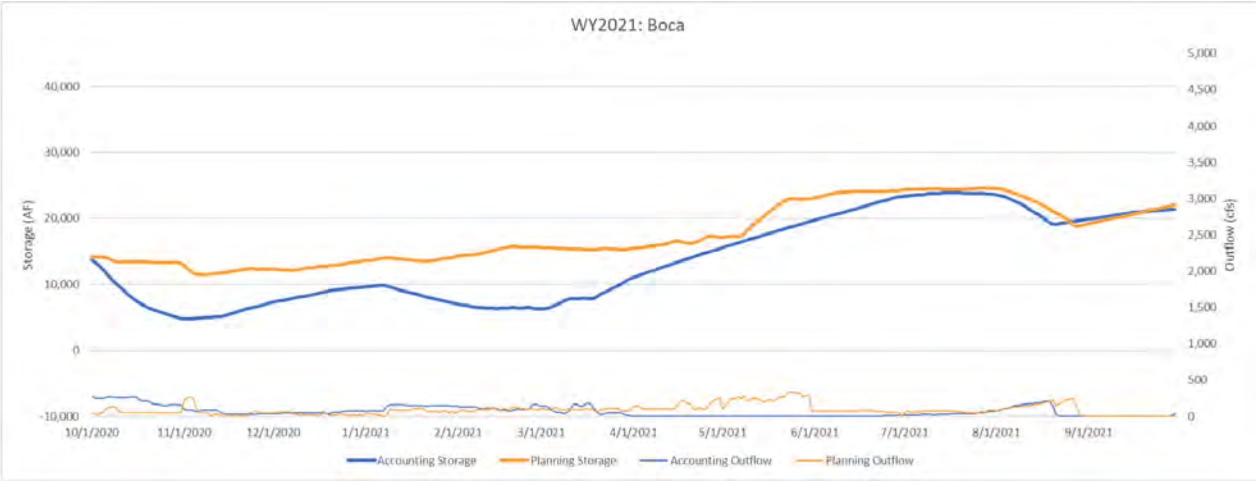


Figure 113. WY 2021 Boca Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

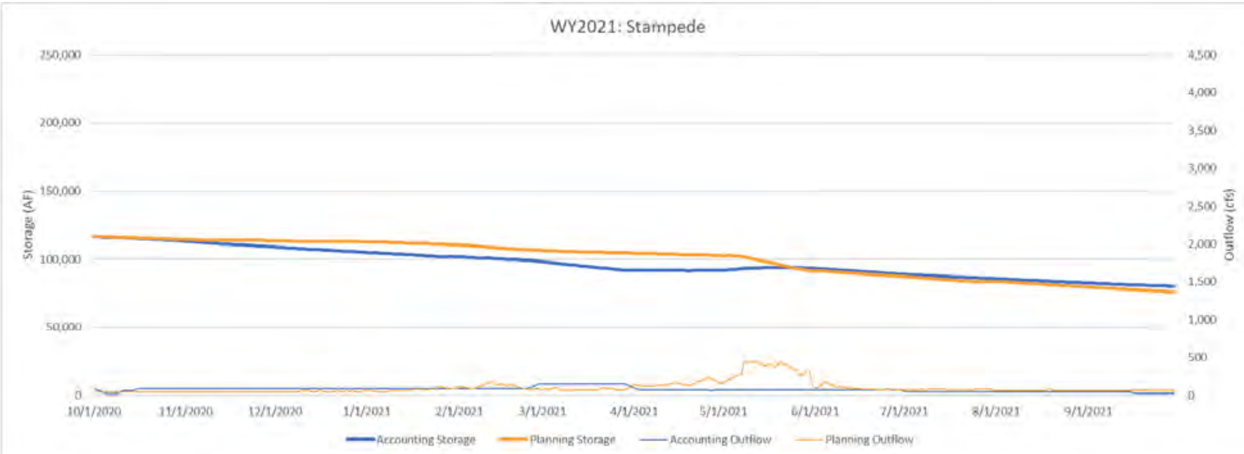


Figure 114. WY 2021 Stampede Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

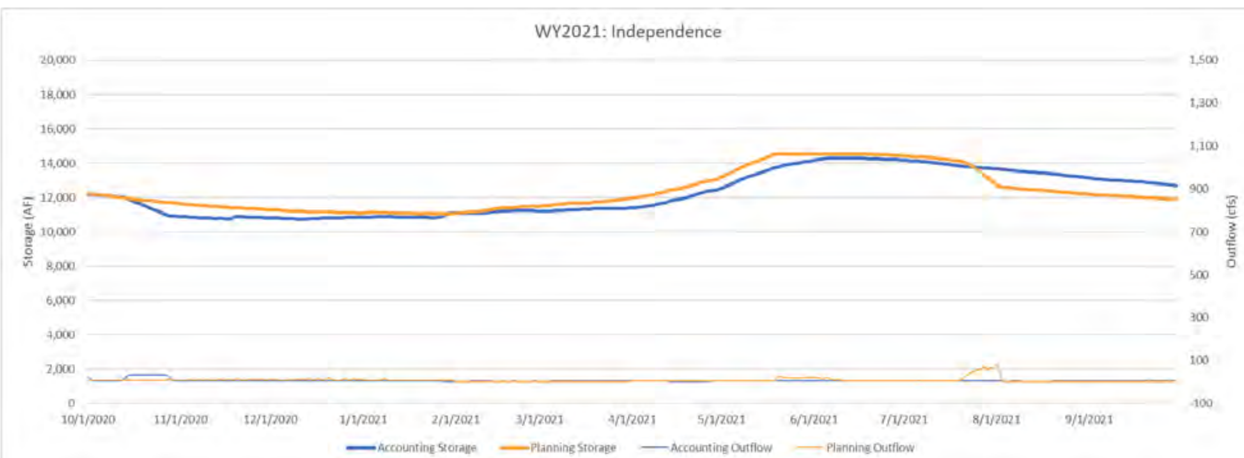


Figure 115. WY 2021 Independence Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

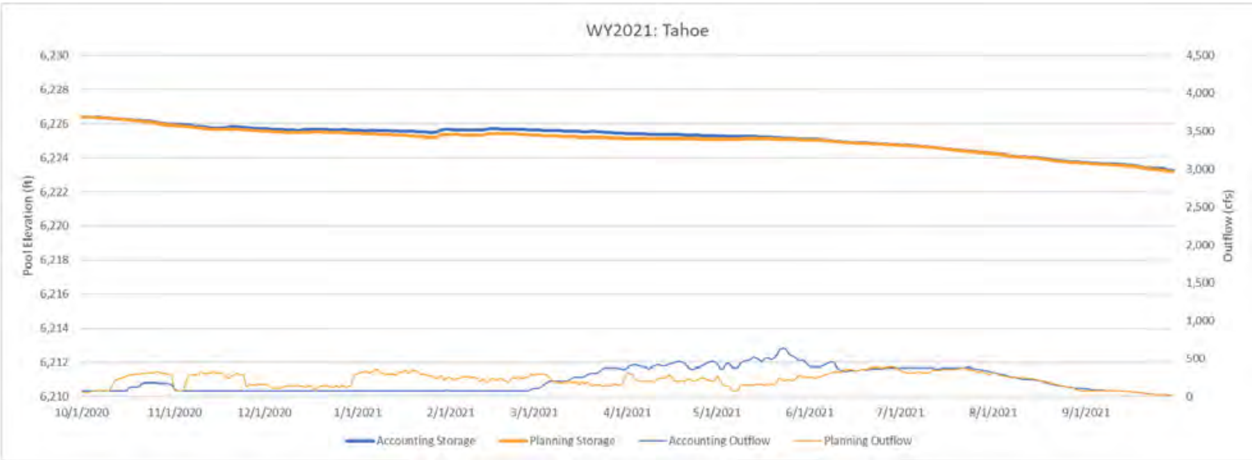


Figure 116. WY 2021 Lake Tahoe Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

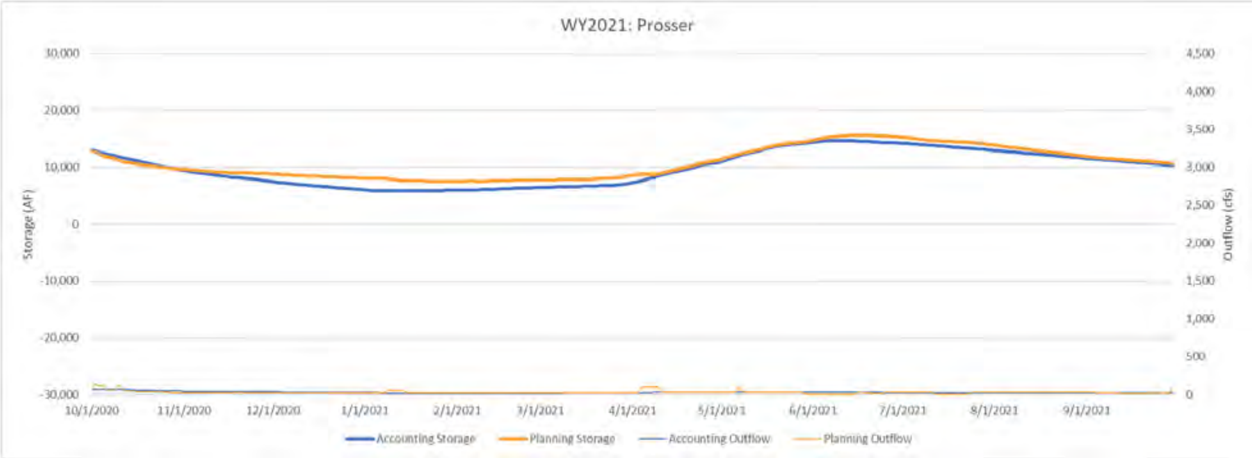


Figure 117. WY 2021 Prosser Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

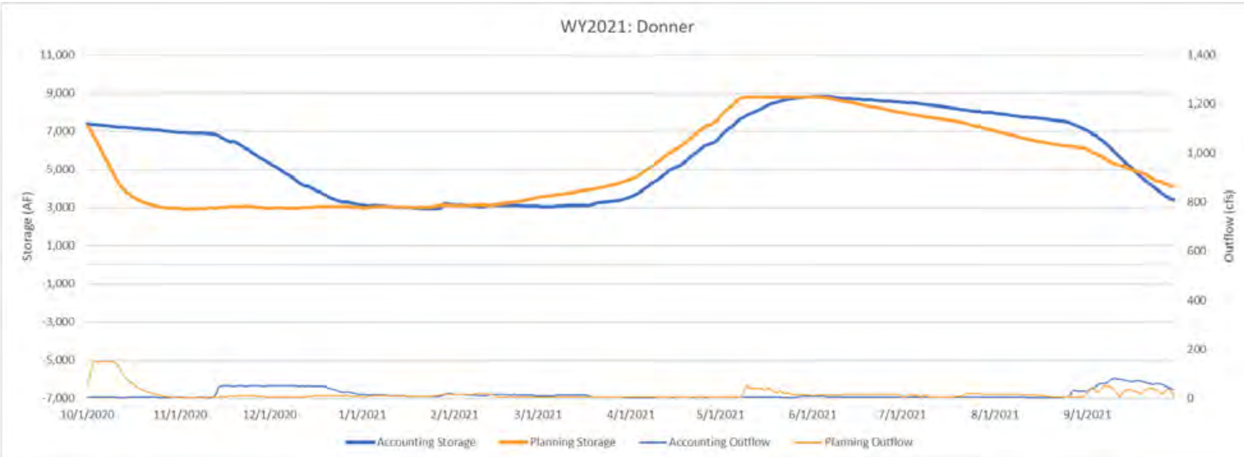


Figure 118. WY 2021 Donner Lake Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

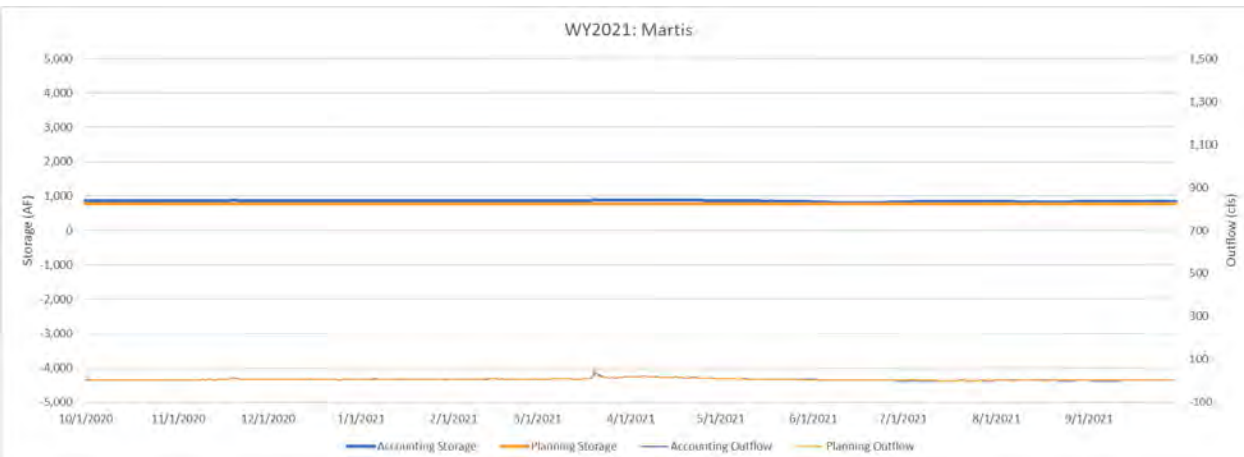


Figure 119. WY 2021 Martis Creek Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

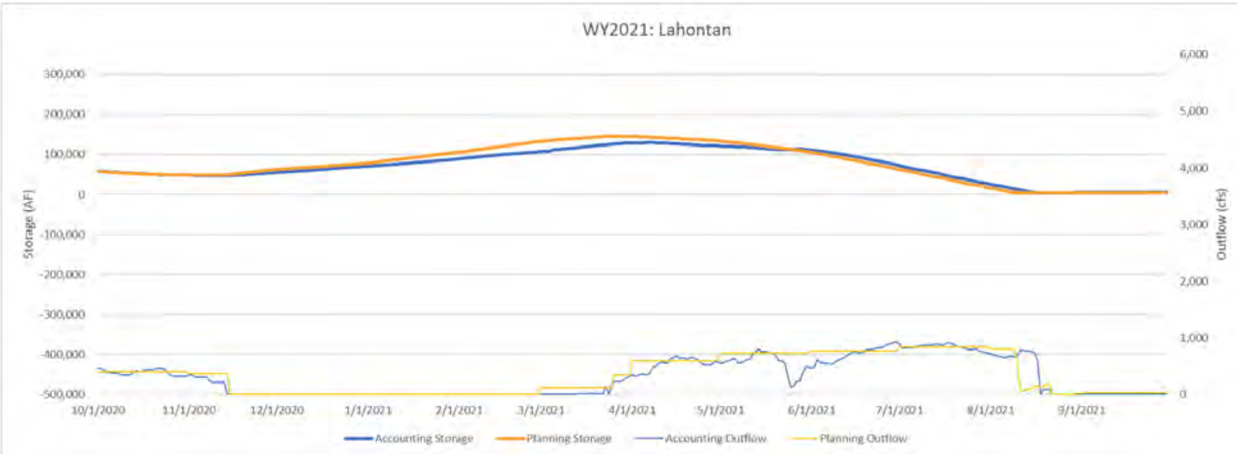


Figure 120. WY 2021 Lahontan Reservoir Outflow (right axis) and Storage (left axis) results from the Accounting (blue) and Planning Models (orange).

12.3 Canal Diversions, WY 2021

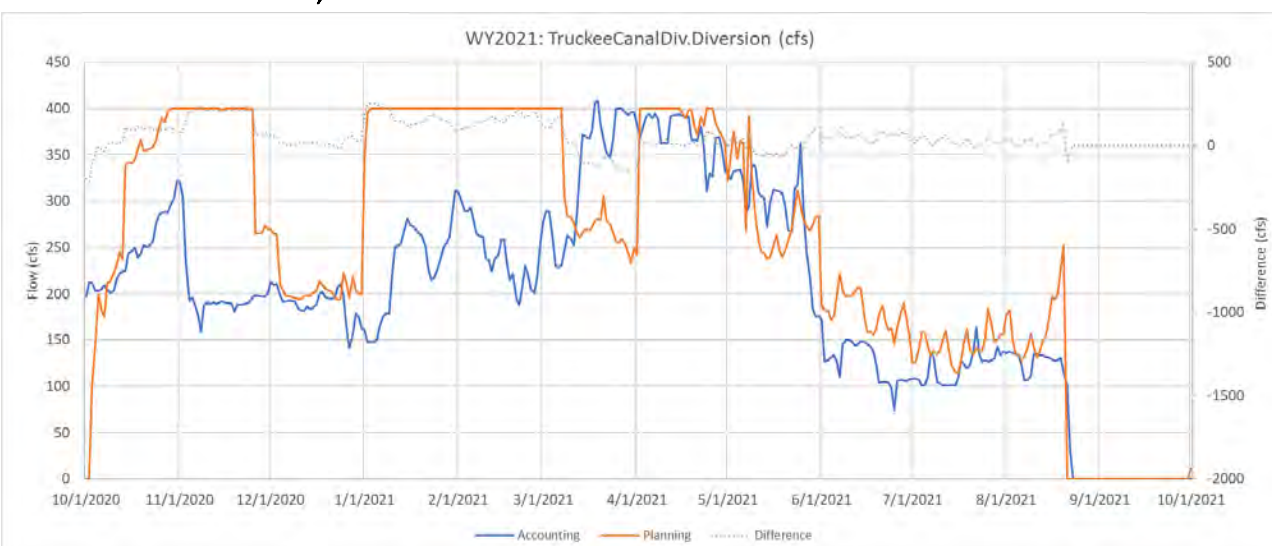


Figure 121. WY 2021 Accounting (blue) and Planning (orange) Model Daily Canal Diversions (left axis) and the two models' daily difference (right axis).

12.4 Truckee River at Nixon Gage, WY 2021

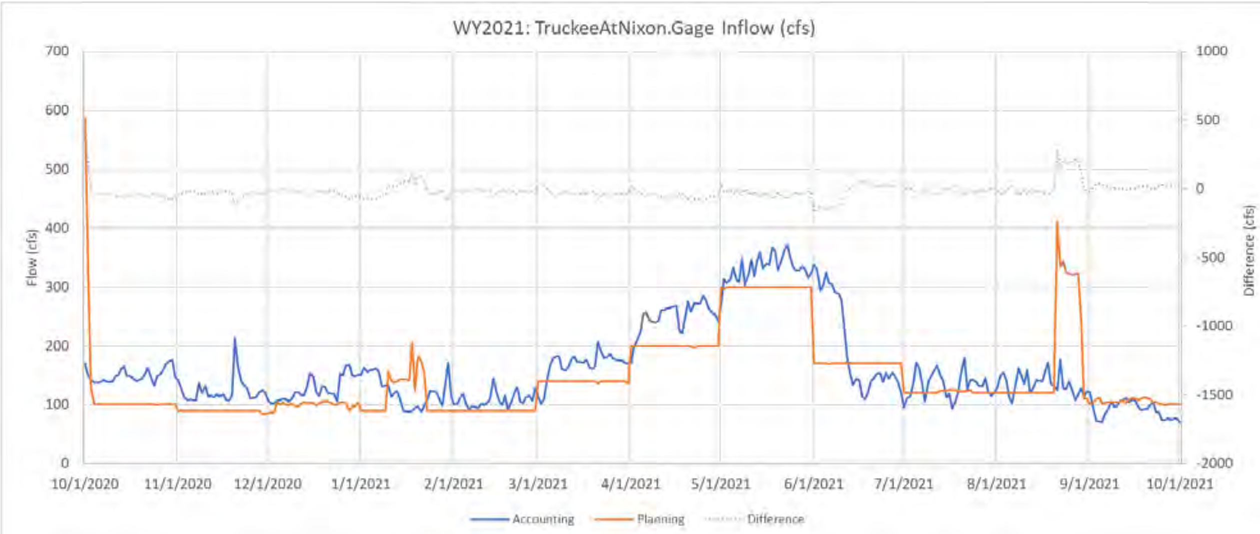


Figure 122. WY 2021 Accounting (blue) and Planning (orange) Model Daily Truckee River at Nixon Gage flows (left axis) and the two models' daily difference (right axis).

13 Appendix G: Summary of Model Edits By Iteration and Change

This appendix provides lists the workspace, rules, and function changes that were made to the Planning Model in this verification effort. Each subsection below corresponds to the improvements made in the **Key Iterations** section of this report

13.1 Donner Drawdown Modelling (Iteration 1)

- **Rule changes:**
  - Set Donner Direct Demand Switch and Drawdown Outflow
- **Function changes**:
  - IsDrawdownExchange
- **Workspace Changes:**
  - TradesAndExchanges.ExchangeTables_tmwa (Slot)

13.2 Precipitation and Losses Modelling (Iteration 1)

- **Rule changes:**
  - Disaggregate Monthly Precipitation to Daily Rates
- **Workspace Changes:**
  - TahoeData.AveragePrecipitationDays (slot)
  - MartisData.AveragePrecipitationDays (slot)

- DonnerData.AveragePrecipitationDays (slot)
- ProsserData.AveragePrecipitationDays (slot)
- BocaData.AveragePrecipitationDays (slot)
- IndependenceData.AveragePrecipitationDays (slot)
- StampedeData.AveragePrecipitationDays (slot)
- Stampede.Evaporation Rate Periodic (slot)
- Donner.Evaporation Rate Periodic (slot)
- Martis.Evaporation Rate Periodic (slot)
- Prosser.Evaporation Rate Periodic (slot)
- Boca.Evaporation Rate Periodic (slot)
- Independence.Evaporation Rate Periodic (slot)

13.3 TMWA Augmentation of Fall/Winter Flows (Iteration 2)

- **Rule changes:**
  - Set Prioritized TMWA Hydropower Outflows
  - TMWA Hydropower Accounts
  - Compute TMWA Hydropower Demand
  - Independence Accrual to Date
- **Function changes**:
  - PrioritizedWaHydroPowerOutflows
  - IsDirectDemand
  - WaterAvailableForHydroPowerRelease
  - IsReleaseTypeTransferSupplies
- **Workspace Changes:**
  - Passthru accounts from Independence and Donner downstream to ToWQInstreamWRAbvSparks object
  - Transfer supplies from TMWA Accounts in Boca, Stampede, Independence, and Donner to new instream supply chain (Release type of waPOSWHydroPower).
  - TradesAndExchanges.ExchangeTables_tmwa (Slot)

13.4 PLPT Improvements (Iteration 2)

- **Function changes**:
  - NonFirmMItoFishCredConversionAmount
  - IsDateForNonFirmMICredConversion
  - FireTROA8F2

- AdditionalExchangeLimits
- ReservoirLimiitedExchange
- **Workspace Changes:**
  - ProsserData.MinPRWStorage (Slot)
  - TradesAndExchanges.ResExchangeLimitsByParty (Slot)
  - TradesAndExchanges.FishW (Slot)
  - ProsserFishBocaFRExchangeSourcePriorityTables (Object)
  - ProsserFishTahoeFRExchangeSourcePriorityTables (Object)
  - ProsserFishBocaFRExchange (Exchange)
  - ProsserFishTahoeFRExchange (Exchange)

13.5 Prosser Drawdown Modelling (Iteration 2)

- **Function changes**:
  - ProsserDrawdownReleaseCalc
- **Workspace Changes:**
  - ProsserData.Storages (Slot)

13.6 CA Preferred Flows Schedule (Iteration 2)

- **Workspace Changes:**
  - CalPreferred_Flows.BocaPreferredFlowandStorage (Slot)
  - CalPreferred_Flows.DonnerPreferredFlowandStorage (Slot)
  - CalPreferred_Flows.ProsserPreferredFlowandStorage (Slot)
  - CalPreferred_Flows.StampedePreferredFlowandStorage (Slot)
  - CalPreferred_Flows.TahoePreferredFlowandStorage (Slot)

13.7 Party Summary Reports

- **Workspace Changes:**
  - Party Summary Reports.Total WQ Above FR Credit Water Establishment (Slot)
  - Party Summary Reports.WQ Water Balance Check (Slot)
  - Party Summary Reports.Total Fish Losses (Slot)
  - FR Credit Water Establishment.System Total FR Holdbacks (Slot)

- Party Summary Reports.Total TMWA Daily New Project Storage (Slot)
- Party Summary Reports.Total TMWA Surface Water Use (Slot)

13.8 Other Changes From Model Debugging

- **Rule changes:**
  - Set Donner Direct Demand Switch and Drawdown Outflow
- **Function changes**:
  - TahoeFRWVolume
  - TahoeFRRelease
  - SimulatedDailyTahoeRelease
  - TheoreticalCurrentPreTroaUnalbeledReservoirRelease
  - WaterAvailableFor
  - maxReleaseFromFish
  - ComputeInstreamWRDiversionRequest
  - Scheduling Party Demand Limits
- **Workspace Changes:**
  - OCAPData.LahontanPhysicalTargetScalar (Slot)

14 Bibliography

McCuen et al. (2006). *Evaluation of the Nash-Sutcliffe Efficiency Index.* Journal of Hydrologic Engineering.

Moriasi et al. (2007). *Model Evaluation Guidelines For Systematic Quantification of Accuracy in Watershed Simulations.* Transactions of the ASABE.

Precision Water Resources Engineering. (2022). *Truckee River Basin Historical Data Development Methodologies, Water Years 2001-2021.* Loveland, CO.

Rieker, J. D. (2010, June 29). Testimony of Jeffrey D. Rieker Before State Water Resources Control Board At Hearing Regarding Water Right Applications 31487 and 31488 by US Bureau of Reclamation.

TMWA. (2020, 09 02). *2020-2040 Water Resource Plan*. Retrieved from https://tmwa.com/wp-content/uploads/2020/11/TMWA-WRP-2020-Final.pdf