URGWOM Rules Review

version 4.1.1

Technical Team DRAFT

prepared by

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Executive Summary

A review of the current single Upper Rio Grande Water Operations Model (URGWOM) ruleset used with both the planning and water operations modules was completed with consideration for the coded policy versus actual policy. Such a review is complicated by numerous factors including questions about how operations would be conducted under situations that day-to-day operators have not seen historically. Assumptions about policy during many situations can only be considered in a hypothetical sense. Also, actual operations include consideration of numerous details about a situation that simply cannot be fully captured in coded policy, and many details very well may not need to be represented for the use of URGWOM for long term planning studies or for preparing an Annual Operating Plans (AOP).

Model results from a rulebased simulation with URGWOM could be compared to historical operations to evaluate the coded policy, but due to the variations in actual operations from year to year and smaller details of operations that are not captured by the model, such a comparison would be of limited value. Due to the difficulty with using model results and historical data to check coded policy, the rules review documented in this report represents a qualitative evaluation of the coded policy with thorough documentation of all the model assumptions such that all agency representatives and stakeholders can assist with continued model enhancements. A significant component of the documentation is flowcharts developed for different aspects of policy to allow for agency representatives and stakeholders to review coded policy without having to look at the accounts in URGWOM or RiverWare rule policy language (RPL).

Information from the review is presented with initial focus on the key demands that drive other aspects of operations. Details on policy for the storage and release of water at Heron, El Vado, and Abiquiu Reservoirs is presented next followed by aspects of operations for Cochiti, Jemez, Elephant Butte, and Caballo dams. The discussion for different aspects of policy includes a review of all the current model assumptions.

A clear finding from the review is that the URGWOM ruleset has been under development for many years and has been tested through applications for planning studies and for preparing AOPs. Results from Water Operations Model runs have been specifically scrutinized each year and several changes have been made to the rules to address past identified issues; however, there are a few changes that could be implemented to make the current ruleset and entire model more transparent. These include adjusting coded policy for setting releases of Rio Grande water from Heron Reservoir and editing or deleting coded policy for Albuquerque loans to other contractors and MRGCD loans to Albuquerque or Reclamation. A few other updates could be incorporated to add some needed flexibility and assure the model reflects most current operations. These potential changes include adjusting calculations for filling downstream allocated storage space and incorporating more flexibility for contractor allocated storage space for San Juan-Chama Project water at El Vado and Abiquiu Reservoirs.

I. Introduction

A review of the current single Upper Rio Grande Water Operations Model (URGWOM) ruleset used with both the planning and water operations modules was completed with consideration for the coded policy versus actual policy. Such a review is complicated by numerous factors including questions about how operations would be conducted under situations that day-to-day operators have not seen historically. Assumptions about policy during many situations can only be considered in a hypothetical sense. Many aspects of future operations are very difficult to know including details on how contractors for San Juan-Chama Project water may use their allocations, how available storage space at El Vado, Abiquiu, and Elephant Butte Reservoir may be used, or what kind of potential water agreements may be implemented between water users. Policy is somewhat contingent on the hydrology and the available water supply over the next few decades. Also, actual operations include consideration of numerous details about a situation that simply cannot be fully captured in coded policy, and many details very well may not need to be represented for the use of URGWOM for long term planning studies or for preparing an Annual Operating Plans (AOP).

Model results from a rulebased simulation with URGWOM could be compared to historical operations to evaluate the coded policy, but due to the variations in actual operations from year to year and smaller details of operations that are not captured by the model, such a comparison would be of limited value. Slight discrepancies between the rules and actual policy could cause significant differences in results over time. As an example, a slight difference in the timing for when the stipulations of Article VII of the Compact are in effect could affect storage of native Rio Grande water at El Vado Reservoir and subsequently the water supply available to MRGCD. Such a difference may not be related to any problem with coded policy but just be due to a unique situation that affected actual operations that should not necessarily be included in coded policy. Due to this difficulty with using model results and historical data to check coded policy, the rules review documented in this report represents a qualitative evaluation of the coded policy with thorough documentation of all the model assumptions such that all agency representatives and stakeholders can assist with continued model enhancements. A significant aspect of the documentation is flowcharts developed for different aspects of policy to allow for agency representatives and stakeholders to review coded policy without having to look at the accounts in URGWOM or RiverWare rule policy language (RPL).

Information from the review is presented with initial focus on the key demands that drive other aspects of operations. Details on policy for the storage and release of water at Heron, El Vado, and Abiquiu Reservoirs is presented next followed by aspects of operations for Cochiti, Jemez, Elephant Butte, and Caballo dams. The discussion for different aspects of policy includes a review of all the current model assumptions with flowcharts that depict the logic or approach used in the URGWOM ruleset followed by comments from the review. A review of potential proposed actions or water agreements as studied previously with URGWOM was also completed as part of the full review of the URGWOM ruleset.

II. Demands

Four primary water uses are represented in URGWOM: diversions for MRGCD (and the six Middle Valley pueblos) and the associated demand at Cochiti, Albuquerque Bernalillo County Water Utility Authority (Albuquerque) surface water diversions, water needs for target flows as defined per the Biological Opinion (Service, 2003), and letter water deliveries for contractors for San Juan-Chama Project water to payback the river for depletions. Coded policy and assumptions related to each are presented below followed by *review comments* on the model approach versus actual operations.

2.1. MRGCD Diversions and Demand at Cochiti

Historical MRGCD diversion data are used when modeling historical conditions as needed for model calibration, but future simulations entail using synthetic diversion schedules that represent typical seasonal diversion patterns for each of the four main MRGCD diversions: Cochiti, Angostura, Isleta, and San Acacia. Two separate schedules are used for the Sili Canal and East Side Main canal at the Cochiti diversion, and two schedules are used for the Albuquerque Main Canal and Atrisco Feeder at the Angostura diversion. Five separate schedules are used for the Chical Lateral, Chical Acequia, Peralta Main Canal, Cacique Acequia, and Belen High Line Canal. Separate diversion schedules are included for the Low Flow Conveyance Channel and main canal at the San Acacia diversion; however, actual diversions from the river at the San Acacia diversion to the main canal are computed daily in the model and reduced based on the contribution from the Unit 7 drain. Diversions to the Low Flow Conveyance Channel would likely be set to zero for a planning study, but gains from groundwater seepage result in flows in the Low Flow Conveyance Channel.

Rio Grande water or San Juan-Chama Project water may be released from storage to provide flows for the MRGCD diversions if needed. These releases are made to meet an identified total demand at Cochiti. This total demand includes water for Prior and Paramount (P&P) needs. Releases of native Rio Grande water in storage or MRGCD San Juan-Chama Project water in storage are curtailed based on any releases of P&P water to meet the separate P&P demand schedule, discussed further in section 2.1.1. Since some return flows to the river are available for diversion downstream, the total demand is less than the sum of the diversions.

Seasonal variations in the assumed MRGCD demand at Cochiti Dam were determined with reference to historical MRGCD demands. Refer to Figure 2.1 for a plot of the demand curve used in URGWOM and some historical data for the MRGCD demand. As evident based on the historical data, the MRGCD demand fluctuates significantly based on varying climatic factors, changes in consumption, irrigation rotations, etc.

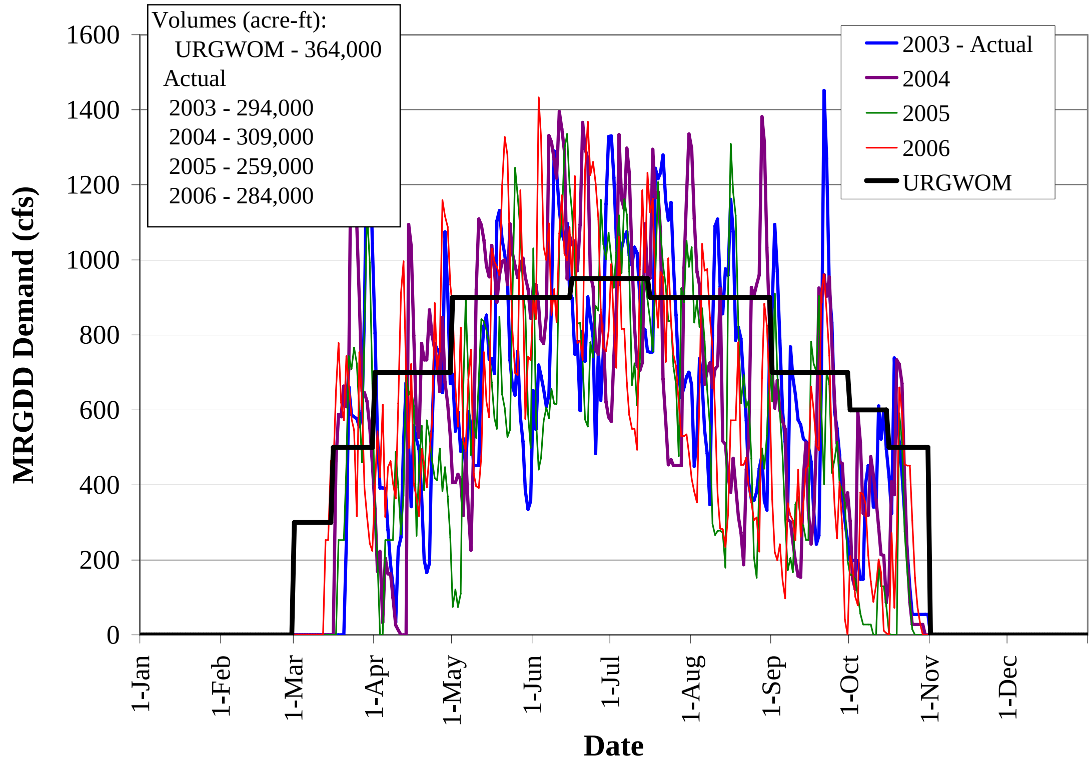


Figure 2.1. MRGCD Demand at Cochiti

Review Comments

A potential change to the URGWOM rules that has been discussed by the URGWOM Technical Team would entail using daily variations in MRGCD consumption (based on simulated crop evapotranspiration, canal seepage, etc.) to identify more precise estimates for the daily needs at the diversions, and estimated river conveyance losses (due to simulated river seepage, open water evaporation, etc.) could then be referenced to identify a corresponding daily demand at Cochiti Dam that would be tied to the actual MRGCD depletions. While this approach would provide an MRGCD demand at a finer resolution, the calculations would involve estimating consumption for a day or two into the future. The model is capable of estimating future conditions very accurately, but this approach may not accurately reflect actual operations where conditions a day or two into the future would not be known with such precision. Also, the resulting demand at Cochiti would still need to be met with releases made from El Vado Reservoir a day earlier, which would require conditions to be forecasted an additional day into the future.

Such a potential approach would essentially match the current approach used to estimate flows needed for targets where the model is used to simulate into the future to estimate the needed amount of supplemental water at the current timestep. The limited ability in actual operations to predict water needs a few days in advance, as can be accomplished with the model, results in actual releases being higher than modeled releases because operations cannot actually be conducted with the precision represented in URGWOM.

As discussed further in section 2.4.2, a safety factor is applied to targets to reflect this limited capability in actual operations to meet demands two or three days in the future with the same precision that can be accomplished with the model.

As depicted in Figure 2.1, the volume of the annual MRGCD demand curve in URGWOM is higher by approximately 28 percent than the average of the historical demand from 2003 through 2006 and reflects a limited ability in actual operations to exactly meet an identified demand due to the uncertainty about flows from the mainstem, conveyance losses, etc. combined with the travel time from El Vado Reservoir to Cochiti Reservoir and to the diversion locations along with other physical operational constraints. If a consumption driven approach was set up in URGWOM for setting MRGCD diversions and the demand at Cochiti, a safety factor would likely need to be applied to the results such that water needs from El Vado Reservoir match historical volumes.

The current approach for representing the daily MRGCD demand from Cochiti Dam and assumed diversions at each diversion is likely adequate and most appropriate for long term planning studies and also for forecasting operations for preparing AOPs; however, a more detailed consumption driven approach may be appropriate for a real-time water operations model (The URGWOM Tech Team is currently reviewing needs for setting up a real-time water operations module of URGWOM that would simulate system conditions for a few days or couple weeks to use for real-time decision support and to reference for improving the efficiency of day-to-day operations). Moreover, a real-time water operations module of URGWOM would be an excellent means for testing potential alternate approaches for utilizing a more consumption driven approach for setting the MRGCD demand at Cochiti Dam. Findings from an application of a real-time water operations module could then be used to potentially develop an approach for incorporating into the ruleset used with the planning or water operation modules of URGWOM; however, as this topic continues to be reviewed, one aspect will likely continue to be an issue. While the demand varies, it is very difficult to adjust releases at El Vado Reservoir to meet daily changes in the demand in the Middle Valley with the travel time for releases from El Vado Dam to some diversion locations being a couple days or longer.

2.1.1. Diversions for the Six Middle Valley Pueblos

Irrigated acreage for the six Middle Valley pueblos (Cochiti, Santo Domingo, San Felipe, Santa Ana, Sandia, and Isleta) is not distinguished from MRGCD land in URGWOM and diversions to the pueblos are included with MRGCD diversions; however, the storage and release of P&P water to assure the P&P demand is met is tracked separately in URGWOM. An initial storage requirement is set on March 1st (or April 1st if not set on March 1st) with the SetElVadoIndianStorageReqAprilAndMarch rule. The storage requirement includes additional storage needed for any dead storage (or unavailable storage below the outlet works) at El Vado Reservoir. (Dead storage at El Vado Reservoir is 480 acre-ft based on the rating curve for the outlet works and the elevation-capacity table in the current model.) The Indian storage requirement is then updated for each subsequent month for the storage required to meet the demand for the remainder of the irrigation season using the SetElVadoIndianStorageReqAfterApril rule.

The storage requirement is computed as an estimated storage required to meet the monthly demand for the remainder of the year minus the estimated flow that will be available for the remainder of the year as computed with reference to an Otowi forecast volume. Refer to Figure 2.2 for a flowchart depicting the timing for computing the storage requirement and Figure 2.3 for a diagram summarizing how the calculation of the storage requirement for an individual month is completed in the URGWOM ruleset. Separate functions are used for steps in the calculation as shown in Figure 2.3.

A release is made from P&P storage at El Vado if the flow from the mainstem, based on the modeled flow at Embudo, would not meet the demand for the pueblos. This release is made independently of the available supply for MRGCD. The needed release is computed with the IndianStorageRequirementRelease rule. The demand curve is presented in Figure 2.4. Refer to Figure 2.5 for a flow chart that depicts the logic for computing the release.

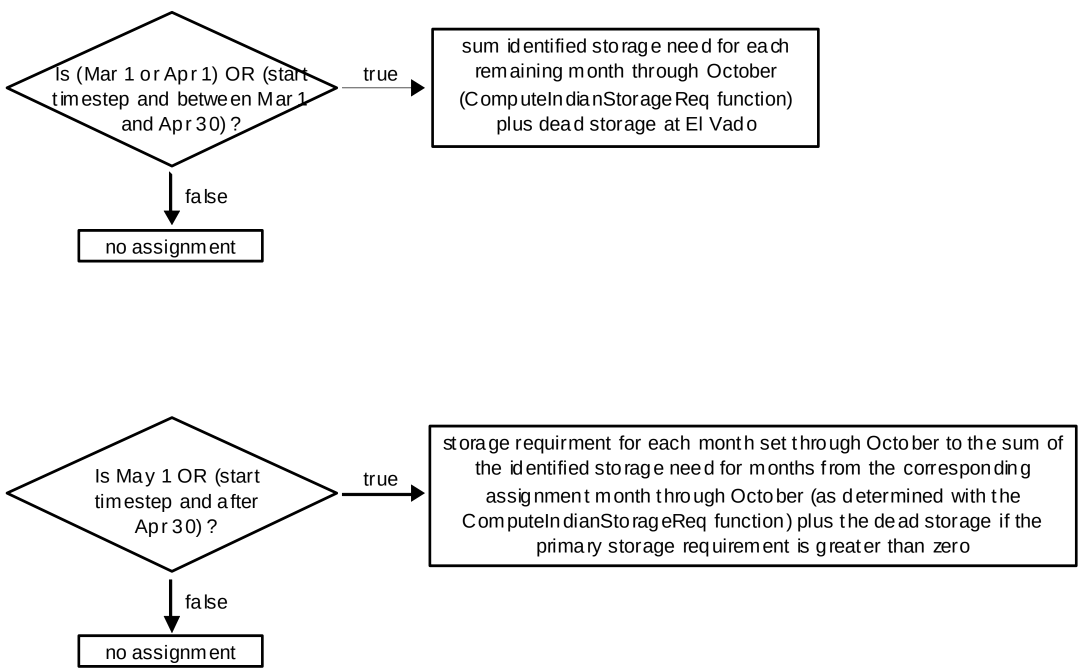


Figure 2.2. Flow Chart Depicting the Timing for Computing Indian Storage Requirement

(ComputeMonthlyIndianStorageReq function)

(Indian Demand - ElVado Usable Flow) / IndianStorageAdjFactor (input as 0.8) * (1.0 + FuturePossibilitiesIndianStorageRequirementAdjustment (input as 0.0))

(ElVadoUsableFlow function)

(ComputeSupplyAtOtowi * Usable Flow Factor (lookup))

(ComputeSupplyAtOtowi function)

(LowRecordLateSummer lookup + ElVadoRunoffLeft * Monthly Percentage lookup - Anticipated Storage)

(ElVadoRunoffLeft function)

If March,

OtowiForecast * ForecastFactor lookup

If between April and July

Otowi Forecast - RealizedOtowiForecast * Forecast Factor Lookup

Else

0 acre-ft

(RealizedOtowiForecast function)

If start timestep and after March 1,

Input initial realized forecast for April + Input initial realized forecast for May

else

Sum Otowi flow from Mar 1 (or start timestep if later)
+
Change in Rio Grande storage from end of February (or initial timestep if later) through the end of the previous month
+
Input initial realized forecast for April + Input initial realized forecast for May
-
sum SanJuan-Chama outflows from Abiquiu

Figure 2.3. Steps for Computing the Indian Storage Requirement

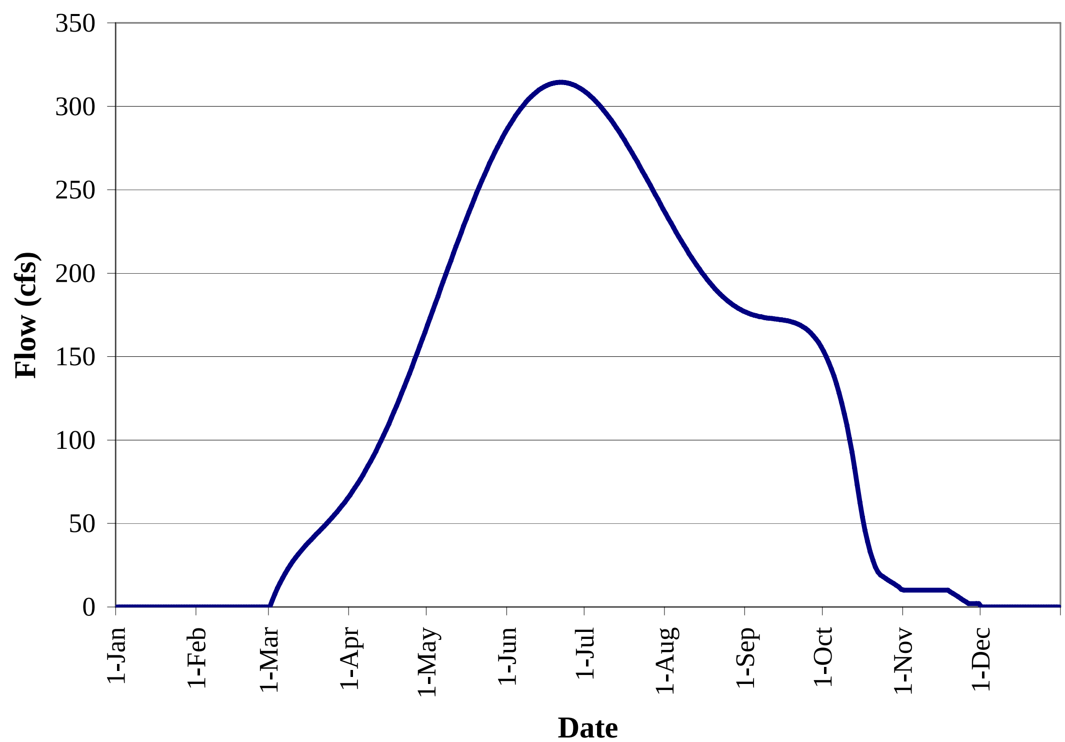


Figure 2.4. Indian Demand Curve

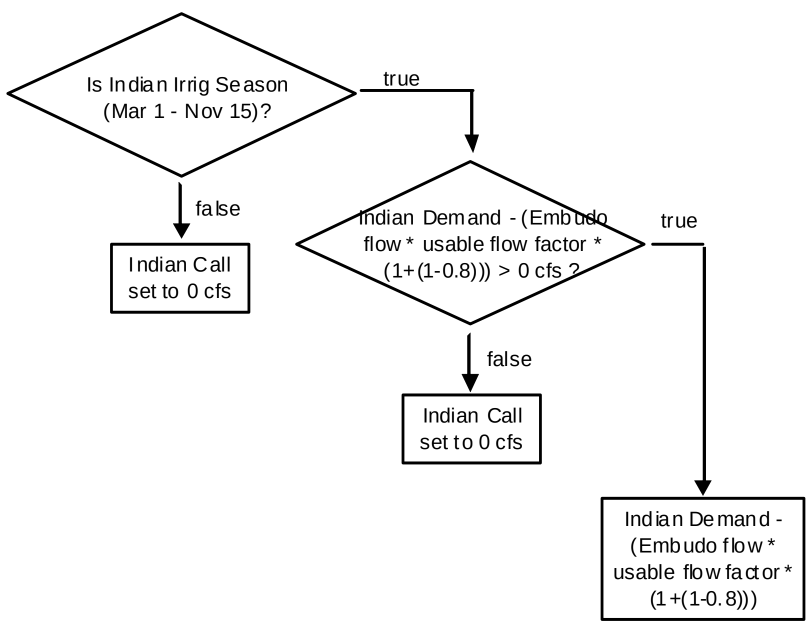


Figure 2.5. Flow Chart Depicting the Calculation of Releases from P&P Storage

Review Comments

The methodology in URGWOM for computing a P&P storage requirement each year and the subsequent releases from P&P storage match a previously implemented approach. A few needed changes were identified by Westfall (2009) and all these changes were implemented prior to this review except for an adjustment to the monthly demand values that are used to compute the storage requirement (these updated monthly values are still being reviewed by the Bureau of Indian Affairs, Reclamation, and the pueblos). Note that a detailed review of an actual approach for computing a P&P storage requirement and a method for subsequent releases extends beyond the scope of this URGWOM rules review.

Based on five separate 10-year simulations completed with URGWOM using five synthetic hydrologic sequences (Roach, 2009), flows at Cochiti always exceed the demand curve with the current approach. Storage allocated to meet the P&P demand is used during the simulations and occasionally drops to zero within the irrigation season, but the P&P demand is still met with flows from the mainstem and native Rio Grande water bypassed at El Vado Reservoir as needed. It should be emphasized that the MRGCD Demand curve actually represents the full demand at Cochiti for both MRGCD and the pueblos, and releases of native Rio Grande water or MRGCD San Juan-Chama Project water at El Vado Reservoir designated to meet the full MRGCD demand curve are reduced to account for any release of P&P water.

2.1.2. Increased Angostura Diversions

When MRGCD is in a shortage situation which is indicated when the MRGCD Demand at Cochiti cannot be met with available water in storage for MRGCD, diversions at Angostura are then increased from the regular diversion requested values to the total canal capacity of 400 cfs. This adjustment is completed with the ResetAngosturaDiversionForShortageOps rule. These increased diversions assure water is delivered to the pueblos and reflect adjustments in MRGCD operations during shortage situations such that the limited supply is used most efficiently.

Review Comments

This aspect of policy for P&P operations was incorporated into the ruleset based on the findings from an interagency review of model results completed by the Population and Habitat Viability Assessment Hydrology ad hoc work group (PHVA work group) of the Middle Rio Grande Endangered Species Collaborative Program. This aspect of policy results in modeled river drying in reaches below the Angostura diversion whenever MRGCD is in a shortage situation and also results in a need for supplemental water for target flows at Central if such targets are included for a model run.

2.2. Albuquerque Surface Water Diversions

Albuquerque began surface water diversions in 2009, and URGWOM is set up to model full diversions with a check against an input year for the startup of the diversions and against established preemptive cutoff criteria where a preemptive cutoff is implemented before actual permit restrictions would result in curtailed diversions or also during high flows. The preemptive cutoff represents the assumption that Albuquerque would switch to groundwater during low flows before curtailment per the permit would occur or during high flows when it may be unsafe or impractical to operate the diversion dam or when flood control operations at Abiquiu or Cochiti might prevent Albuquerque from receiving a delivery of their allocated San Juan-Chama Project water. The high flow thresholds for a preemptive diversion cutoff are set to 1800 cfs out of Abiquiu or 4500 cfs out of Cochiti. The threshold low flow for a preemptive cutoff is 200 cfs and diversions will not restart until at least two weeks after any preemptive cutoff criterion is not satisfied and the flow at Central is greater than 250 cfs. Refer to Figure 2.6 and 2.7 for flow charts that depict the logic referenced when setting the diversion as completed with the SetAlbuquerqueDiversion rule along with the criteria for a preemptive cutoff.

Full Albuquerque diversions are set to 130 cfs where 65 cfs is provided by delivered San Juan Chama Project water and the other 65 cfs is native Rio Grande water that will be returned. Releases of Albuquerque's San Juan-Chama Project water are set to provide the 65 cfs with loss rates applied. The loss rate is based on the San Juan-Chama loss rate of 1.23 percent from Abiquiu to Cochiti and monthly loss rates from Cochiti to the diversion.

While the current preemptive cutoff criteria would prevent diversions from being curtailed or cutoff per permit restrictions, the permit restrictions are still being checked with the rules. Refer to Figure 2.8 for a flowchart that depicts the logic for curtailment or cutoff per the permit.

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

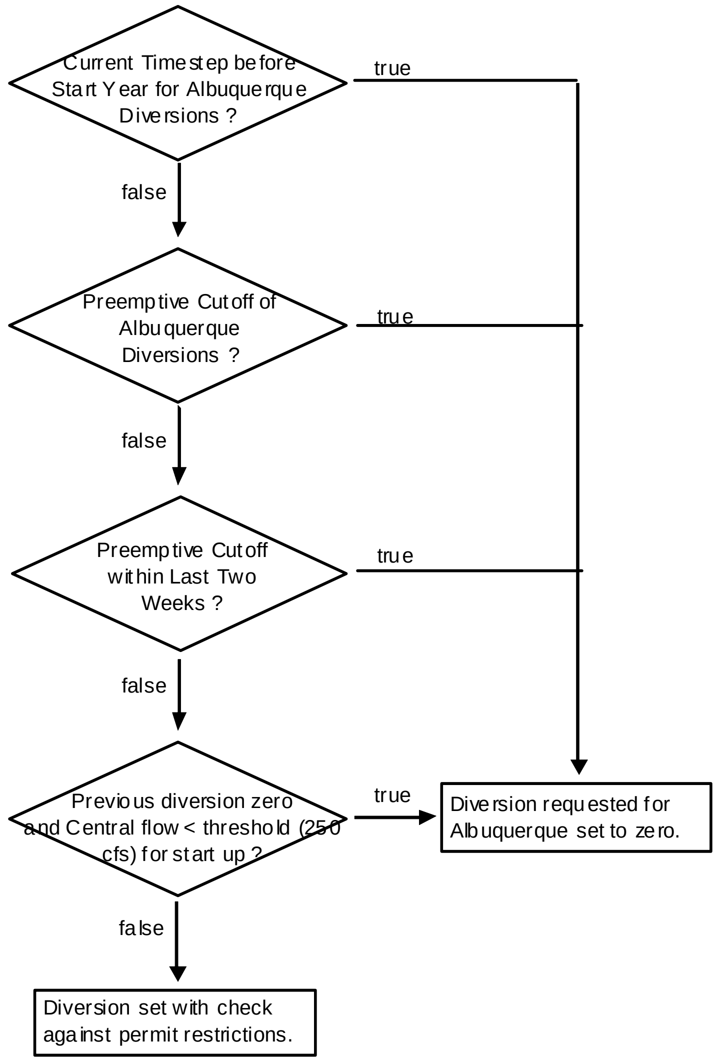


Figure 2.6. Criteria Checked Daily when Setting the Albuquerque Diversion Requested

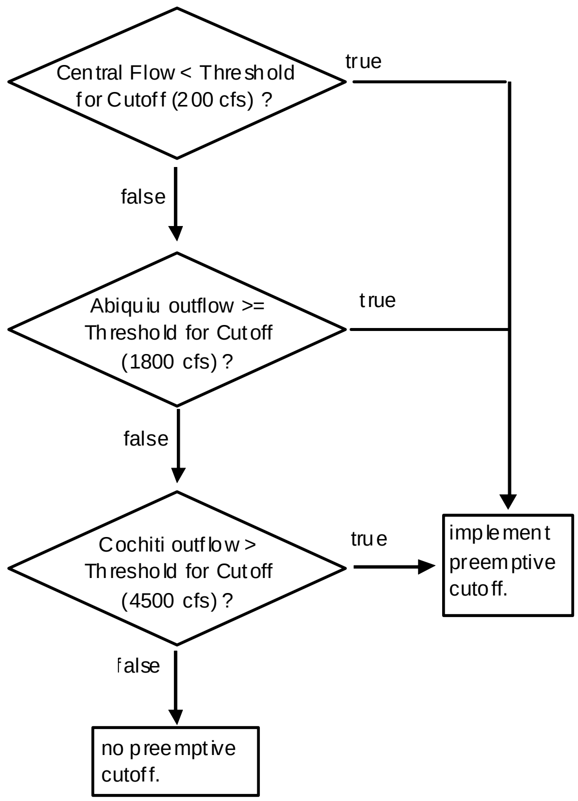


Figure 2.7. Criteria Checked for a Preemptive Cutoff of Albuquerque Diversions

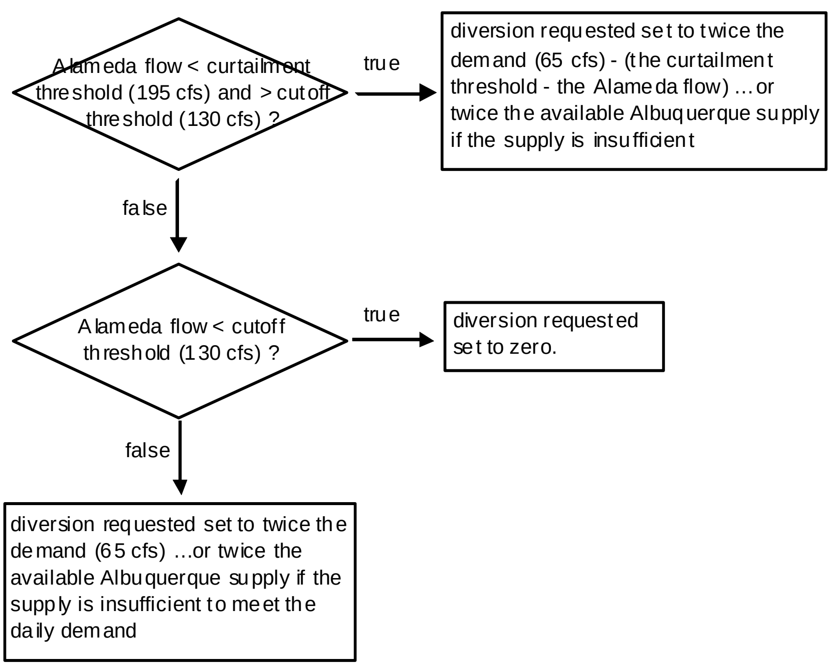


Figure 2.8. Permit Restrictions Checked when Setting Albuquerque Diversions

Review Comments

Actual policy for providing water for the Albuquerque diversion is continuing to become clearer as operations are conducted following the recent startup of the surface water diversions. Actual policy for cutting off diversions and switching to groundwater may evolve over the first couple years of actual diversions due to numerous factors related to the operation of Albuquerque's system.

A potential needed change to the coded policy in URGWOM may be to include an exchange that allows for Albuquerque to continue surface water diversions when Abiquiu Dam is operating for channel capacity and only native Rio Grande water is being released. Such an exchange would entail allowing Albuquerque diversions to continue when Abiquiu Dam is operated under channel capacity restrictions, and Albuquerque could accrue a debt that would be paid back with their San Juan-Chama Project water after flood control operations have ceased. Details on the timing for such a payback would need to be identified.

2.3. Letter Water Deliveries

Contractors for San Juan-Chama Project water may cause depletions in the basin and then use allocated San Juan-Chama Project water to payback the river. Schedules for these paybacks are input in URGWOM based on assumed delivery schedules (or based on historical data for a calibration run). Actual paybacks are determined by the Office of the State Engineer using the regional groundwater model (Depletions are generally caused by groundwater pumping), and the deliveries are requested through letters from the Office of the State Engineer to Reclamation, hence the name "letter water deliveries." Within URGWOM, the Exchanges Manager in RiverWare is used to establish debts for contractors to deliver water to the location of the Otowi stream gage object in the model based on input delivery schedules. Separate accounts are set up for the delivery of water from allocated storage space for individual contractors to Otowi, and these debts are established using the SetNoAlbuquerqueLoanEXs rule and the SetAlbuquerqueJemezEXs rule. (Refer to section 4.1.5 for more information on the potential option in URGWOM where Albuquerque may loan water to contractors to make letter water deliveries.)

The current baseline schedules include a portion of the delivery made during the irrigation season to contribute to the MRGCD demand and effectively payback MRGCD for depletions to the river and the remaining portion is delivered during the non-irrigation season to contribute to Compact deliveries to Elephant Butte Reservoir and effectively payback the Compact for depletions. Releases to meet the MRGCD demand at Cochiti as discussed in section 2.1 are curtailed for the contribution from letter water deliveries.

If a contractor does not have water in storage at the time of a delivery request, the debt is maintained until the contractor has the water to make the payback, so actual releases from storage may not exactly match the input schedules. Numerous contractors are combined into one account in the Planning Model, so only two delivery schedules are input for the Albuquerque account and Combined account in the Planning Model. In the Water Operations Model, separate accounts are included for individual contractors, and letter water deliveries actually represent the single water use for most contractors. Numerous accounts are included in the Water Operations Model for contractors to payback the river from different source locations: water in storage at Heron, El Vado, and/or Abiquiu Reservoirs.

The current rules are hard coded such that the source location for letter water deliveries for some contractors is dependent on the actual accounts set up in the model. If multiple accounts are established for a single contractor, the deliveries are made from Abiquiu Reservoir unless an account is also set up for that contractor to make the delivery from Heron Reservoir, and deliveries are made from El Vado Reservoir if an account exists unless a contractor also has an account set up to make the payback from Abiquiu Reservoir. In the Planning Model, the result of this approach and the accounts in the model is that deliveries for the Combined are made from Abiquiu Reservoir.

Review Comments

One primary needed change to the setup for letter water deliveries has been identified as part of the interagency coordination on modeling work for the PHVA work group of the Collaborative Program. This change entails setting up the portion of the payback to be made to MRGCD as a direct transfer to MRGCD's account for storage of San Juan-Chama Project water as opposed to being sent down the river and included as a contribution toward meeting the MRGCD demand at Cochiti.

Rather than using a continuous series of daily requests for letter water deliveries, a more appropriate approach may be to include annual payback volumes for each contractor and then for each contractor, establish a typical delivery schedule for the transfers to MRGCD's account and a typical schedule for deliveries to be made during the winter to payback the Compact. Also, a consideration when adjusting the approach is that water may not always be available in the source account based on an initial identified delivery schedule. In these cases, the debt is established and will be paid back as soon as the water is available. The set up in regards to the source location for deliveries would also be changed with these pending edits to the approach.

2.3.1. Alternate Timing for Letter Water Deliveries

A proposed action that has been analyzed with URGWOM entails modeling alternate schedules for letter water deliveries if specific conditions are satisfied for the portion of deliveries made to payback the Compact. The alternate delivery schedules have been studied to evaluate benefits of the alternate delivery timing on augmenting flows needed for target flows and to prevent river drying, for recruitment, or to help manage recession after the runoff.

The current approach is coded for specific defined criteria for implementing the alternate schedule for letter water deliveries. Letter water deliveries from Albuquerque to payback the Compact would be used to provide a 7-day spiked release at the timing of the peak (Figure 2.9) if Cochiti deviations are not implemented and the Compact credit is greater than 70,000 acre-ft. As a second but lower priority alternate schedule, Albuquerque letter water deliveries to payback the Compact would occur during September and October as opposed to November and December if the Compact credit is greater than 70,000 acre-ft and the flow at San Acacia is greater than 150 cfs for the last seven days of August (Figure 2.10). Flows for the first alternate delivery to provide a spiked release is computed in the model. Each year, conditions are evaluated to determine if an alternate delivery schedule should be simulated.

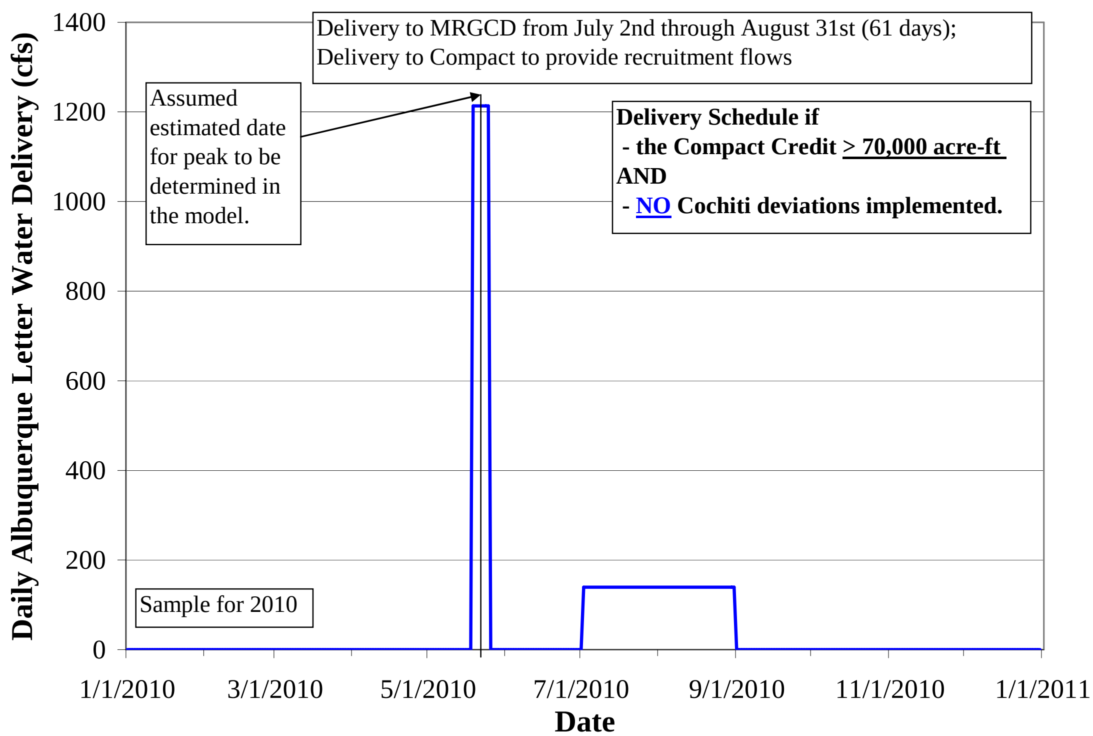


Figure 2.9. Sample *Alternate* Schedule for Albuquerque Letter Water Deliveries to Provide Spiked Release

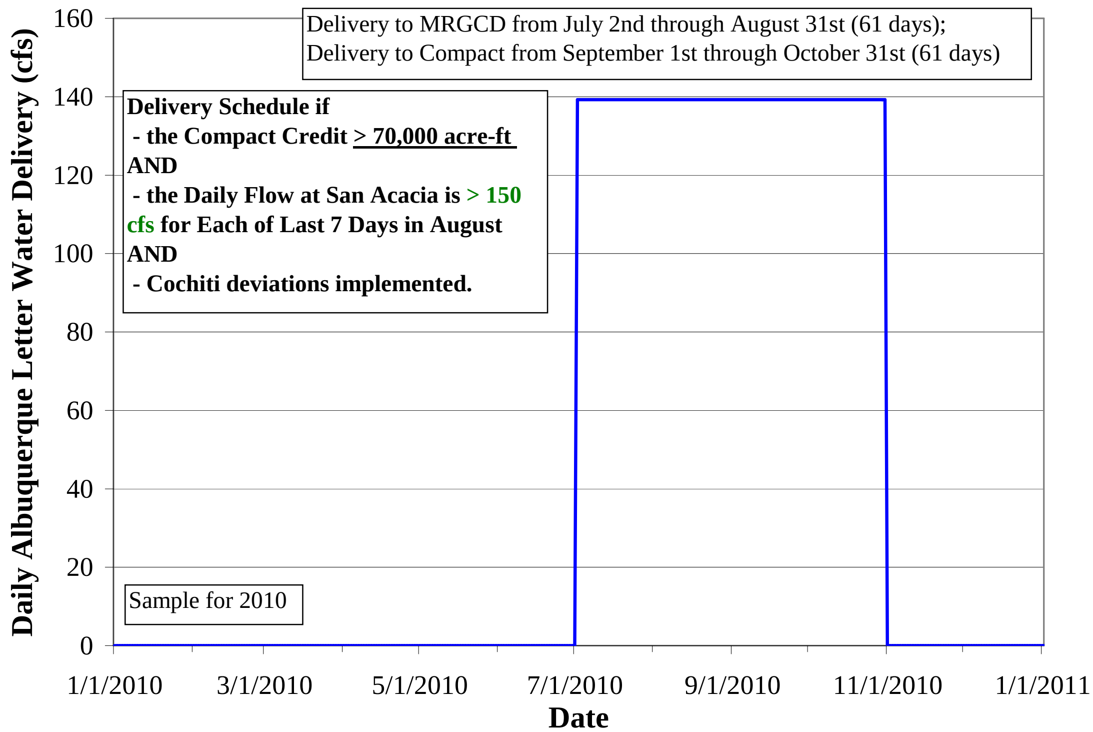


Figure 2.10. Sample *Alternate* Schedule for Albuquerque Letter Water Deliveries

Letter water deliveries for Santa Fe and half of the amount for other contractors not including PVID will be delivered at an alternate time if the Compact credit is greater than 70,000 acre-ft. That portion will be delivered in a 7-day spike around the peak (Figure 2.11) if Cochiti deviations are not implemented or as a constant release from June 15th through June 30th to help manage recession if the Compact credit is greater than 70,000 acre-ft but Cochiti deviations were implemented. The second alternative is presented in Figure 2.12.

If values are directly input to the original Albuquerque or Combined series slots in the DeliveryRequests data object in the model, those delivery schedules will always be utilized and the alternate deliveries will not be made and the alternate delivery schedules are inconsequential.

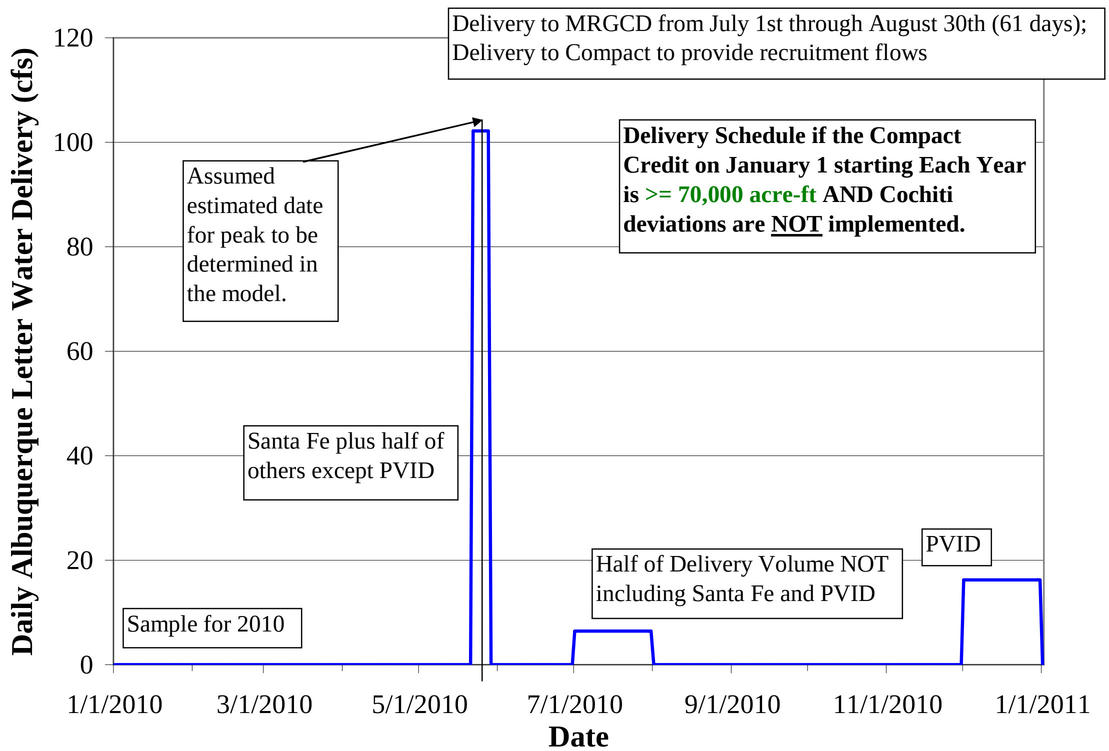


Figure 2.11. Sample *Alternate* Schedule for Combined Account Letter Water Deliveries to Provide Spiked Release

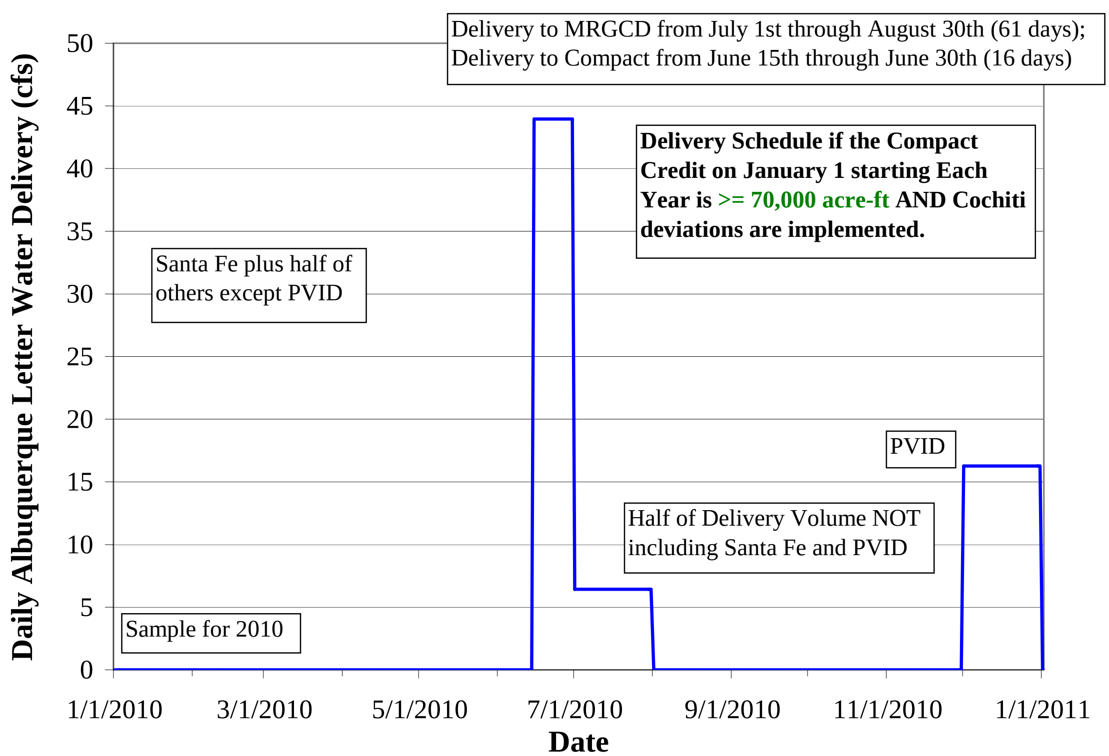


Figure 2.12. Sample *Alternate* Schedule for Combined Account Letter Water Deliveries

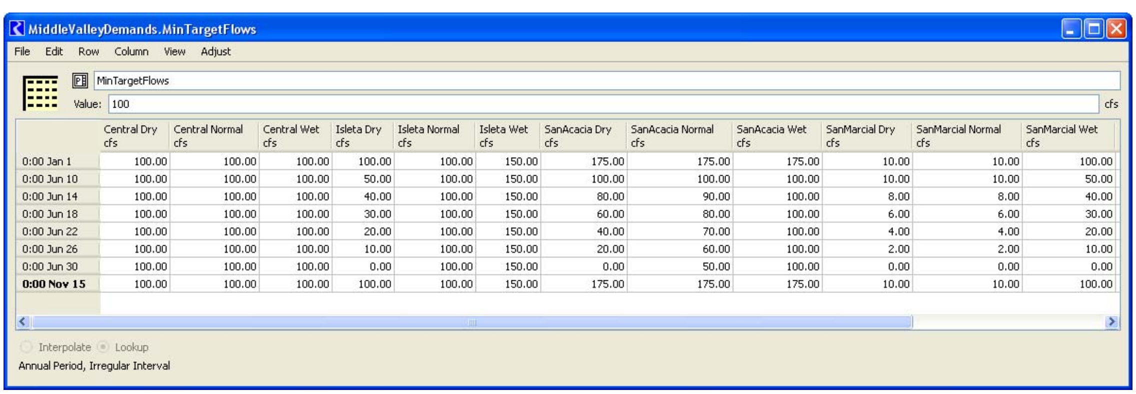
Review Comments

This proposed approach for alternate timing for letter water deliveries is specific for one particular study. It serves as an example of the type of proposed action that could be analyzed with URGWOM. If such a policy were actually implemented, the approach would likely need to be edited based on the final details of the implemented policy. Also, as the rules for making transfers per letter water deliveries are updated as discussed in section 2.3, this approach for alternate timing for letter water deliveries would also need to be updated. If no such action is implemented, these rules could eventually be deleted.

2.4. Target Flows

Releases of supplemental water for targets as documented in the Biological Opinion (Service, 2003) are made in the model with consideration of the physical losses as represented by all the different methods in the model. The physical model was calibrated with reference to results from a simulation for historical operations versus historical gage data. Supplemental water consists of leased San Juan-Chama Project water or Emergency Drought water stored at El Vado Reservoir that is specifically designated for targets. More details on these two sources of supplemental water are presented in sections 4.1.2 and 5.2.

Targets for the Biological Opinion are input to a table (Figure 2.13) where targets identified for a date in the table are maintained until the next date in the table. Separate targets are established for hydrology year types: dry, average, or wet. The targets in the table are adjusted based on an input safety factor. A step down in targets after the continuous flow requirement is included in the current target table, and additional step downs at Isleta, San Acacia, and San Marcial may be implemented for discretionary operations as discussed further in section 2.4.3. Targets are identified at each timestep using the MinCentralTarget and MinIsletaSanAcaciaSanMarcialFlowTargets rules. The Central targets may be modified to provide recruitment or overbank flows as part of Cochiti deviations as discussed further in section 7.2. .



	Central Dry cfs	Central Normal cfs	Central Wet cfs	Isleta Dry cfs	Isleta Normal cfs	Isleta Wet cfs	SanAcacia Dry cfs	SanAcacia Normal cfs	SanAcacia Wet cfs	SanMarcial Dry cfs	SanMarcial Normal cfs	SanMarcial Wet cfs
0:00 Jan 1	100.00	100.00	100.00	100.00	100.00	150.00	175.00	175.00	175.00	10.00	10.00	100.00
0:00 Jun 10	100.00	100.00	100.00	50.00	100.00	150.00	100.00	100.00	100.00	10.00	10.00	50.00
0:00 Jun 14	100.00	100.00	100.00	40.00	100.00	150.00	80.00	90.00	100.00	8.00	8.00	40.00
0:00 Jun 18	100.00	100.00	100.00	30.00	100.00	150.00	60.00	80.00	100.00	6.00	6.00	30.00
0:00 Jun 22	100.00	100.00	100.00	20.00	100.00	150.00	40.00	70.00	100.00	4.00	4.00	20.00
0:00 Jun 26	100.00	100.00	100.00	10.00	100.00	150.00	20.00	60.00	100.00	2.00	2.00	10.00
0:00 Jun 30	100.00	100.00	100.00	0.00	100.00	150.00	0.00	50.00	100.00	0.00	0.00	0.00
0:00 Nov 15	100.00	100.00	100.00	100.00	100.00	150.00	175.00	175.00	175.00	10.00	10.00	100.00

Figure 2.13. Target Table from URGWOM

2.4.1. Hydrology Year Type

The year classification for setting targets in the model is set using the Hydrology Year Type rule based on a March through July forecasted flow volume at Otowi calculated with reference to input inflows. This approach essentially matches the actual approach of referencing the runoff forecast. The year will be classified as dry or wet if the forecasted flow volume is less than 80% of the average Otowi flow volume or greater than 120% of average, respectively. The determined year classification on May 1st is maintained for the remainder of a calendar year. A year is classified as dry regardless of the forecast if the stipulations of Article VII of the Compact are in effect, but since the year classification is set for the remainder of the year on May 1st, the year classification will not change if the Article VII status changes after May 1st. (Article VII of the Compact is discussed further in section 5.1.)

Review Comments

One primary finding from the review of the established year classification in the model pertains to the trends in regards to the timing for when Article VII is in effect during a calendar year. Usable storage tends to increase during the runoff as inflows to Elephant Butte Reservoir exceed the demand from the lake, and usable storage may *temporarily* increase above 400,000 acre-ft only to decrease below 400,000 acre-ft shortly thereafter as the runoff ends and releases to the lower valley continue. If the year classification is established during this brief period that the stipulations of Article VII are not in effect, the year could be classified as Average or Wet, depending on the forecast, even though Article VII will inevitably be in effect after the runoff ends. Through coordination with the PHVA work group of Collaborative Program, interagency representatives have confirmed that the current model approach is appropriate.

The current approach for setting year classifications for defining targets may not yield one wet year out of every six years as prescribed in the current Biological Opinion. Alternate criteria to force a wet year every six years would need to be identified. Simply setting every sixth year as a wet year if the past six years had not been wet could be implemented, but actual operations to ensure a wet year is established at least once every six years would not be so simple. Such a basic approach would not be realistic. Actual policy for assuring one out of every six years is established as wet needs to be defined before the policy can be incorporated into the URGWOM ruleset.

2.4.2. Safety Factor

A safety factor is included in URGWOM to increase targets by a percentage (i.e. a target of 100 cfs will increase to 125 cfs with a 25% safety factor). A 25% safety factor is currently applied to targets because the model can set releases from Abiquiu to hit targets in the Middle Valley with much better precision than can be done in actual operations. Uncertainty about conveyance losses, MRGCD returns, local inflows, etc. combined with the travel time from Abiquiu to target locations and other physical operational constraints prevent actual releases from being adjusted with such precision, so a safety factor is applied to targets in the model such that modeled supplemental water releases more accurately reflect actual release volumes.

Review Comments

An appropriate safety factor was identified based on a recent review of historical supplemental water use from 2003 through 2006 and model results for supplemental water needed from a run using historical 2003 through 2006 hydrology. This analysis is complicated by the fact that historical operations are conducted differently with agreements between Reclamation and MRGCD established for bypasses at Isleta Diversion Dam (and San Acacia Diversion Dam) as needed for targets in return for set releases of supplemental water from Abiquiu Reservoir. URGWOM is set up to model releases of supplemental water from Abiquiu Reservoir entirely based on the estimated need with reference to the physical conveyance losses to target locations. Actual volumes for released supplemental water through Reclamation-MRGCD agreements are likely appropriate based on the physical losses but will not reflect much of the daily variability in the water needed caused by the fluctuating loss rates. These agreements are clearly implemented to address the numerous operational complications with trying to meet target flows in the Middle Valley with releases from Abiquiu Dam and to simplify operations for all parties; however, URGWOM is set up differently.

Planning Model runs completed to evaluate supplemental water needed for different potential targets are completed with focus on the physical losses as modeled. If agreements between Reclamation and MRGCD would continue in the future, it is expected that such agreements would result in approximately the same need for supplemental water that would be determined with specific detailed focus on physical losses. One consideration for updating the Water Operations Model as used to prepare AOPs would be to incorporate any short-term agreements between Reclamation and MRGCD pertaining to the release of supplemental water and bypasses at diversions, but details about such agreements may not be known at the time that AOPs are prepared.

2.4.3. Discretionary Operations

URGWOM is set up to simulate discretionary operations as part of the Biological Opinion which entail using supplemental water to manage recession after the runoff and control the rate of drying after river rewetting for minnow salvage. Coded policy for representing discretionary operations entails implementing a 30-day step down in targets at the end of the runoff and 7-day step downs in targets thereafter following each river rewetting event.

River drying is defined when the flow at Isleta, San Acacia, or San Marcial drops below the drying trigger flow of 70, 175, and 30 cfs, respectively. The 30-day step down to manage recession is implemented at the first occurrence of river drying. Trigger flows used to determine if river rewetting has occurred are referenced where river rewetting is defined by threshold flows of 100, 225, and 50 cfs being exceeded at all three locations: Isleta, San Acacia, and San Marcial.

Magnitudes for the initial flow for the step downs in targets are set to 50, 100, and 50 cfs for initial targets at Isleta, San Acacia, and San Marcial with targets decreasing to zero in five steps for the initial 30-day step down and 7 steps for the subsequent 7-day step downs. The logic used in the ResetIsletaSanAcaciaSanMarcialTargetsForStepDown rule for potentially resetting the targets originally set with reference to the table in Figure 2.13 to a step down in targets is depicted by the flow chart in Figure 2.14.

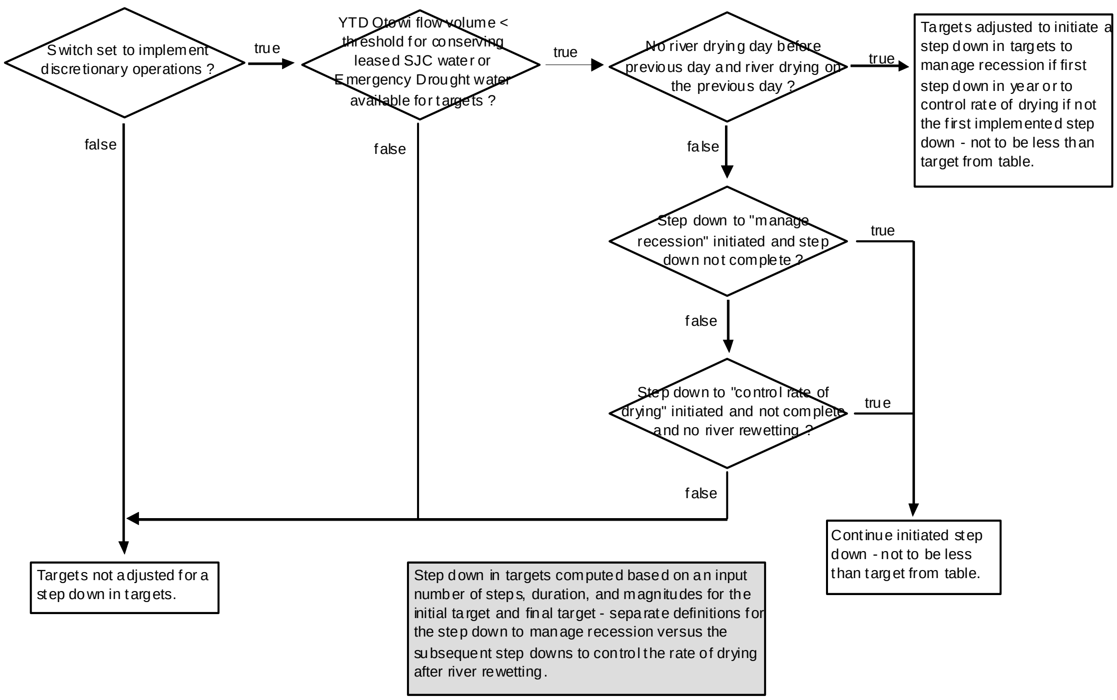


Figure 2.14. Flow Chart Depicting Logic for Establishing Step Downs in Targets

Review Comments

The step downs in targets for discretionary operations were identified as a needed component in the URGWOM ruleset as part of the interagency modeling work for the PHVA work group of the Collaborative Program. The current approach was needed to represent this important use of supplemental water such that model results for supplemental water needed accurately reflected actual supplemental water use under the current Biological Opinion. Actual discretionary operations are contingent on several factors and are not dependent on hard coded criteria, hence the name discretionary operations, but the current rules were thoroughly reviewed and were determined to be appropriate for capturing the additional supplemental water use from operations conducted under the 2003 Biological Opinion. If a new Biological Opinion is issued or adjustments to the past policy are implemented, the rules would then need to be updated accordingly. Discretionary operations can easily be turned off in the model with an established switch. Also, note that if a model run includes the option that supplemental water is to be conserved when the year-to-date Otowi flow volume reaches a set threshold as discussed further in Section 2.4.4.1, targets established for discretionary operations would not be met.

2.4.4. Supplemental Water Needed For Targets

Daily needed releases from Abiquiu Dam to meet targets at Central, Isleta, San Acacia, and San Marcial are computed in the model using hypothetical simulations, or separate side simulations in RiverWare used to iterate and solve for the upstream flow needed to meet a target at a downstream location. Needed releases are determined for the downstream targets set with reference to the table in Figure 2.13 with a safety factor applied and as reset for discretionary operations (Targets at Central may be reset for Cochiti deviations as discussed further in section 7.2, and reregulation storage at Cochiti would be used to meet targets during those periods). The separate side simulations include consideration for all MRGCD diversions and estimated returns and any diversions by Albuquerque. Four instances of hypothetical simulation are completed for each target location with the rules that include ComputeReleaseToMeetMinimum… in the rule name and the highest needed flow at Cochiti is determined with the SetCochitiMinimumFlow rule. The determined minimum flow is a *total flow* needed for targets that includes water needed for MRGCD and Albuquerque diversions. Another instance of hypothetical simulation is completed for the segment of the model from Abiquiu Dam to Cochiti Reservoir to determine the total flow needed from Abiquiu Reservoir as determined in the AbiquiuTotalFlowToMeetTarget rule.

The amount of supplemental water needed from Abiquiu is computed by subtracting the release of native Rio Grande water, letter water deliveries, any release of MRGCD San Juan-Chama Project water, and the release of Albuquerque's San Juan-Chama Project water for the surface water diversion from the determined total flow needed at Abiquiu for targets. This calculation is completed in the ComputeAbiquiuMinFlowsDemand rule. The resulting amount of supplemental water needed varies daily based on the estimated physical losses, but the needed release of supplemental water, as set with the SetAbiquiuMinFlowsDemand rule, is not adjusted until the supplemental water needed based on the physical losses has changed by more than 50 cfs and will not be adjusted twice within three days. The computational approach for adjusting the releases is configured such that the volume for the release of supplemental water approximately matches the volume of supplemental water needed based on the hypothetical simulations. Refer to Figure 2.15 for a flow chart that depicts the series of steps for setting a release of supplemental water from Abiquiu Reservoir starting with the targets at the four target locations.

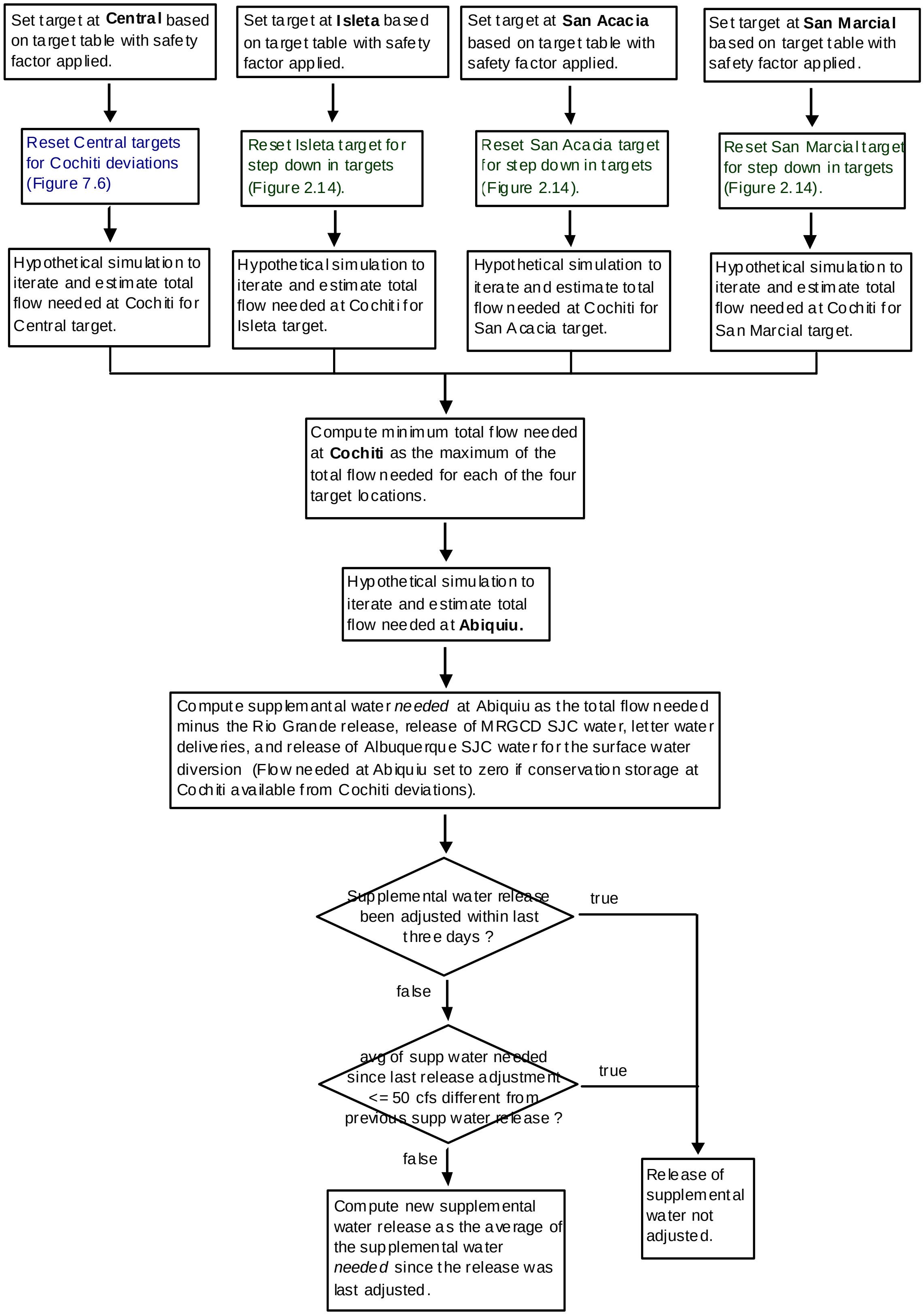


Figure 2.15. Flow Chart for Logic to Set Release of Supplemental Water from Abiquiu

Review Comments

The rule for maintaining constant releases for at least three days and until the supplemental water needed has changed by more than 50 cfs was implemented recently based on the interagency modeling work for the PHVA work group of the Collaborative Program. The work group had identified that operations would never entail daily changes in the releases of supplemental water from Abiquiu Reservoir, so this approach was implemented such that the model more closely reflects actual operations.

As discussed in reference to the Safety Factor, the model approach for setting releases of supplemental water is based on a calculation of the supplemental water needed with reference to the physical losses as represented by all the methods in URGWOM. Meeting target flows in the Middle Valley with releases from Abiquiu Dam are actually complicated by many factors, so historical operations have been conducted with temporary agreements between Reclamation and MRGCD for bypasses at MRGCD diversions in return for releases of supplemental water from Abiquiu Reservoir. Volumes for releases of supplemental water should still be similar, but the model approach is different.

2.4.4.1. Threshold YTD Otowi Flow Volume for Conserving Lease Water

A sample policy for conserving leased San Juan-Chama Project water during wet periods is currently established in URGWOM where lease water will not be used for targets after a threshold year-to-date Otowi flow volume has been reached. Available Emergency Drought water for meeting targets as discussed in section 5.2 would still be used to meet targets regardless of the year-to-date Otowi flow volume. This policy is accomplished by setting targets to zero for the remainder of a calendar year after the threshold volume has been reached. A threshold volume of 1,000,000 acre-ft has been analyzed previously. To turn off this policy, the value could be set to a threshold that would never be met such as 999,999,999 acre-ft. This policy only applies to leased water.

Review Comments

This policy is included in URGWOM as a potential approach for conserving leased San Juan-Chama Project water but should only be used if such a policy is actually implemented or simulating the policy is desired for an analyses being completed with URGWOM. Similar alternative policies for conserving leased water could also be implemented but any new defined proposed policy would need to be implemented into the model.

2.4.5. Shorted Diversions

If MRGCD is in a shortage situation and does not have the supply to meet their full demand, it is possible that full MRGCD requested diversions would not be met.

"Requested diversions" may then be shorted in the model in such a shortage situation to prevent the diversion of released supplemental water that is specifically designated for meeting target flows. This adjustment is implemented in a simulation with the Shorted Middle Valley Diversions rule by completing additional side simulations to iterate and solve for what the diversions would be without supplemental water, and requested diversions at the main MRGCD diversions are *reset* from the full requested diversions to the determined shorted diversion. **This assumption is currently only applied if there are downstream targets.** If there are no downstream targets, it is assumed that any supplemental water still in the river is available for diversion. For example, if supplemental water is released to meet a target flow at Central, diversions may be shorted at Cochiti or Angostura if MRGCD would not have received their full requested diversion at those locations without supplemental water, but if there were no targets below Central, remaining supplemental water in the river at Isleta may be diverted at the Isleta diversion during a shortage situation.

Review Comments

A primary finding from the applied rule for shorted diversions is that diversions are not shorted if there are no downstream targets as noted above. This is specifically relevant when Angostura diversions are increased for P&P operations (Refer to Section 2.1.2). This would result in a significant need for supplemental water to meet a target flow of 100 cfs at Central, but a portion of this supplemental water would reach the Isleta diversion which could then be entirely diverted by MRGCD if there are no downstream targets, so MRGCD's supply would be partially augmented by such an operation. This setup was reviewed as part of modeling tasks by the PHVA work group of the Collaborative Program, and the interagency work group concurred that this configuration matches actual operations.

Another finding is that estimated shorted diversions under a shortage situation could be set under the assumption that the release from Cochiti Dam will match the MRGCD Demand; however, if the assumed demand is slightly insufficient to meet the diversions based on the modeled physical losses, the diversion requested values would be reset accordingly as opposed to being maintained at the full requested values. This is not a significant problem based on the current demand curve and assumed full requested diversion schedule, but model users should be aware of this sensitivity in the computational approach.

2.4.6. Pumping from the Low Flow Conveyance Channel

URGWOM is set up to model pumping of flows from the Low Flow Conveyance Channel (LFCC) to the river to prevent river drying. Refer to Figure 2.16 for a picture of pumps used to pump from the LFCC. Diversions at the Neil Cupp site, North Boundary of the Bosque del Apache National Wildlife Refuge, and South Boundary are simulated (Pumping at the Fort Craig site was determined to be inconsequential to URGWOM simulation results and is not included). Water that seeps into the Low Flow Conveyance

Channel is pumped to the river where pumping begins based on specific river flow triggers. Different triggers could be established as a function of the year classification for setting targets; although, the threshold low San Acacia flow triggers for initiating pumping at each site are the same in the current model regardless of the year type. The rate of pumping does vary based on year type (Figure 2.17, 2.18, and 2.19). Different values can be set up for the winter of wet years.

After pumping has initiated at a site, pumping will continue for a minimum of one week and until the flow at San Acacia has exceeded 150 cfs. Pumping will cease for the year at each site after input dates for each site. It is assumed in the current model that pumps at the Neil Cupp site and North Boundary would not be used after June 30th. This aspect of operations can be turned off fairly easily by setting the date to shut off pumping at each site to January 1st.

Figure 2.16. Low Flow Conveyance Channel Pumps

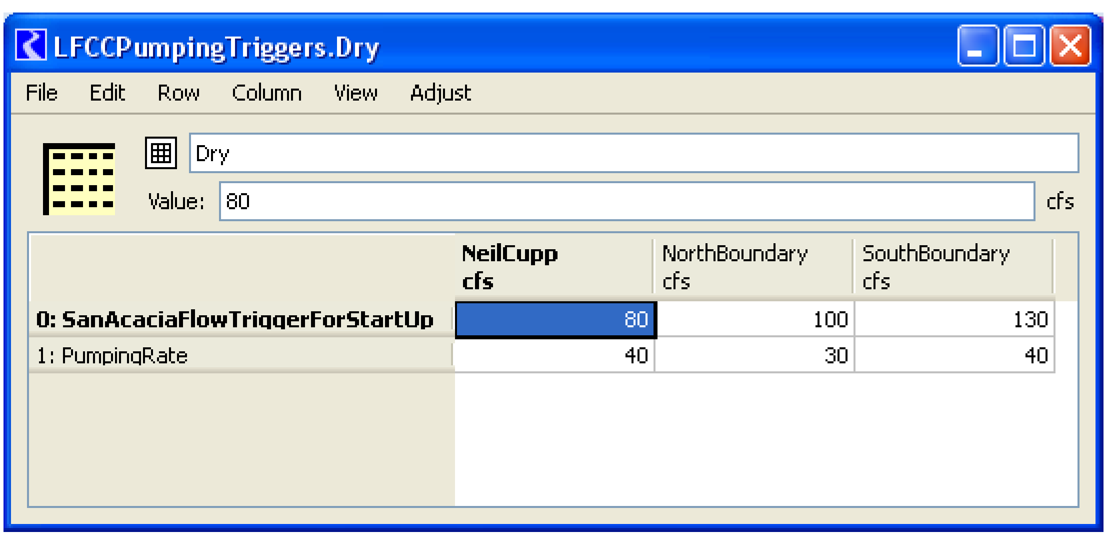
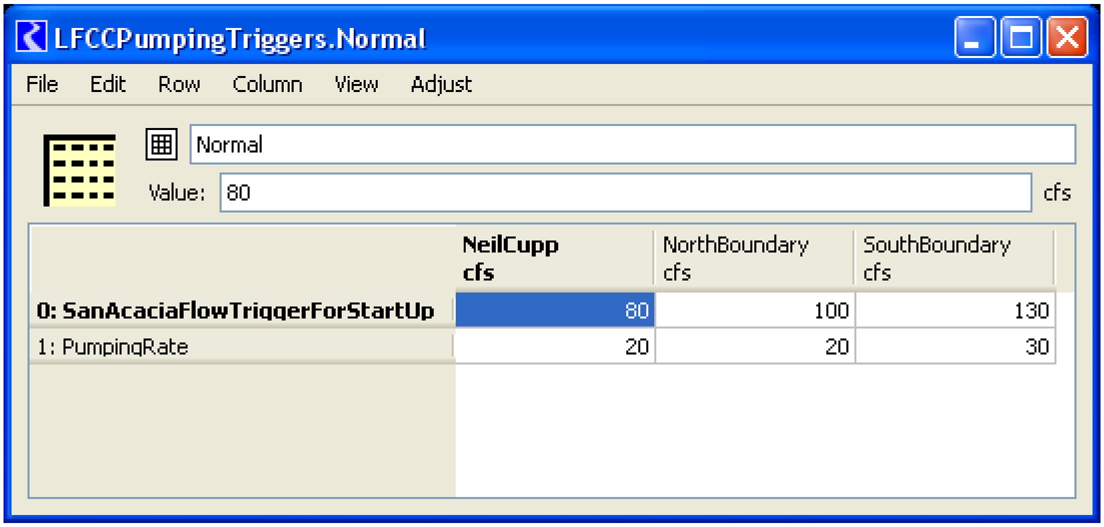


Figure 2.17. LFCCPumpingTriggers.Dry Table Slot



LFCCPumpingTriggers.Normal

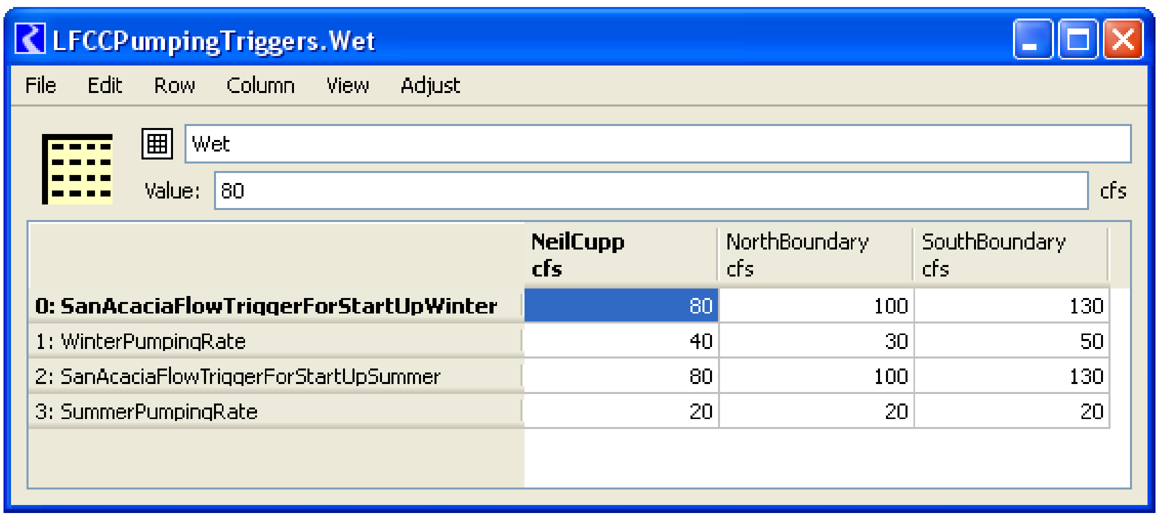
File Edit Row Column View Adjust

Normal

Value: 80 cfs

	NeilCupp cfs	NorthBoundary cfs	SouthBoundary cfs
0: SanAcaciaFlowTriggerForStartUp	80	100	130
1: PumpingRate	20	20	30

Figure 2.18. LFCCPumpingTriggers.Normal Table Slot



LFCCPumpingTriggers.Wet

File Edit Row Column View Adjust

Wet

Value: 80 cfs

	NeilCupp cfs	NorthBoundary cfs	SouthBoundary cfs
0: SanAcaciaFlowTriggerForStartUpWinter	80	100	130
1: WinterPumpingRate	40	30	50
2: SanAcaciaFlowTriggerForStartUpSummer	80	100	130
3: SummerPumpingRate	20	20	20

Figure 2.19. LFCCPumpingTriggers.Wet Table Slot

Review Comments

Operations of the pumps on the LFCC are included as part of Reclamation's discretionary operations and are contingent on numerous factors. Data for actual pumping may reflect factors such as operational constraints for turning on the pumps including the available head in the LFCC. Operations may also be impacted schedules for conducting minnow salvage operations and by field operations being conducted in the Isleta reach. Actual operations are sensitive to the exact rate of drying in the reach as opposed to flows at San Acacia. Policy may vary from year-to-year based on several factors; however, the current approach does represent this basic component of the operation and the impact of the pumps for preventing drying in the San Acacia reach and the subsequent reduced need for supplemental water from Abiquiu to keep the reach wet. Actual operations should continue to be reviewed, but the current rules represent a reasonable representation of the pumping operation.

III. San Juan Diversions

Trans-basin diversions from the San Juan basin are determined within URGWOM with consideration for legal restrictions and all the physical constraints of the San Juan-Chama Project infrastructure. The San Juan-Chama Project allows for New Mexico to use its portion of the San Juan water under the Upper Colorado River Compact. Trans-basin diversions to Heron Reservoir are computed with reference to flows in the Rio Blanco, Little Navajo River, and Navajo River above the diversions. Refer to Figure 3.1 for a map of the three diversion locations in the San Juan basin and a schematic of the tunnel to Willow Creek. Capacities at the Blanco, Oso, and Little Oso diversions are 520, 650, and 150 cfs, respectively. Diversions are set to assure minimum bypasses are provided in each of the tributaries to the San Juan River and may be limited due to an annual diversion limit (270,000 acre-ft), ten-year diversion limit (1,350,000 acre-ft), and available space at Heron Reservoir (maximum pool elevation of 6970.01 ft).

Policy for setting the diversions includes detail on how diversions would be set at each of the three diversions if diversions are limited. Refer to Figure 3.2 for a flowchart that depicts the logic used when setting the San Juan diversions. Note that a switch can be set in the model that allows for diversions to be set to a constant input value as opposed to being set by the rules.

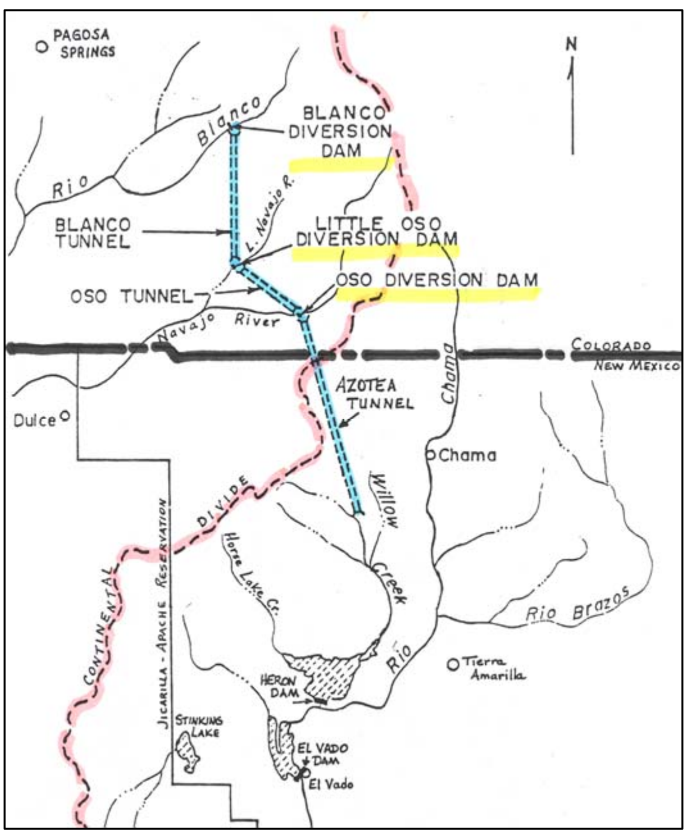


Figure 3.1. Map of Locations of Diversions and Tunnels for San Juan Diversions

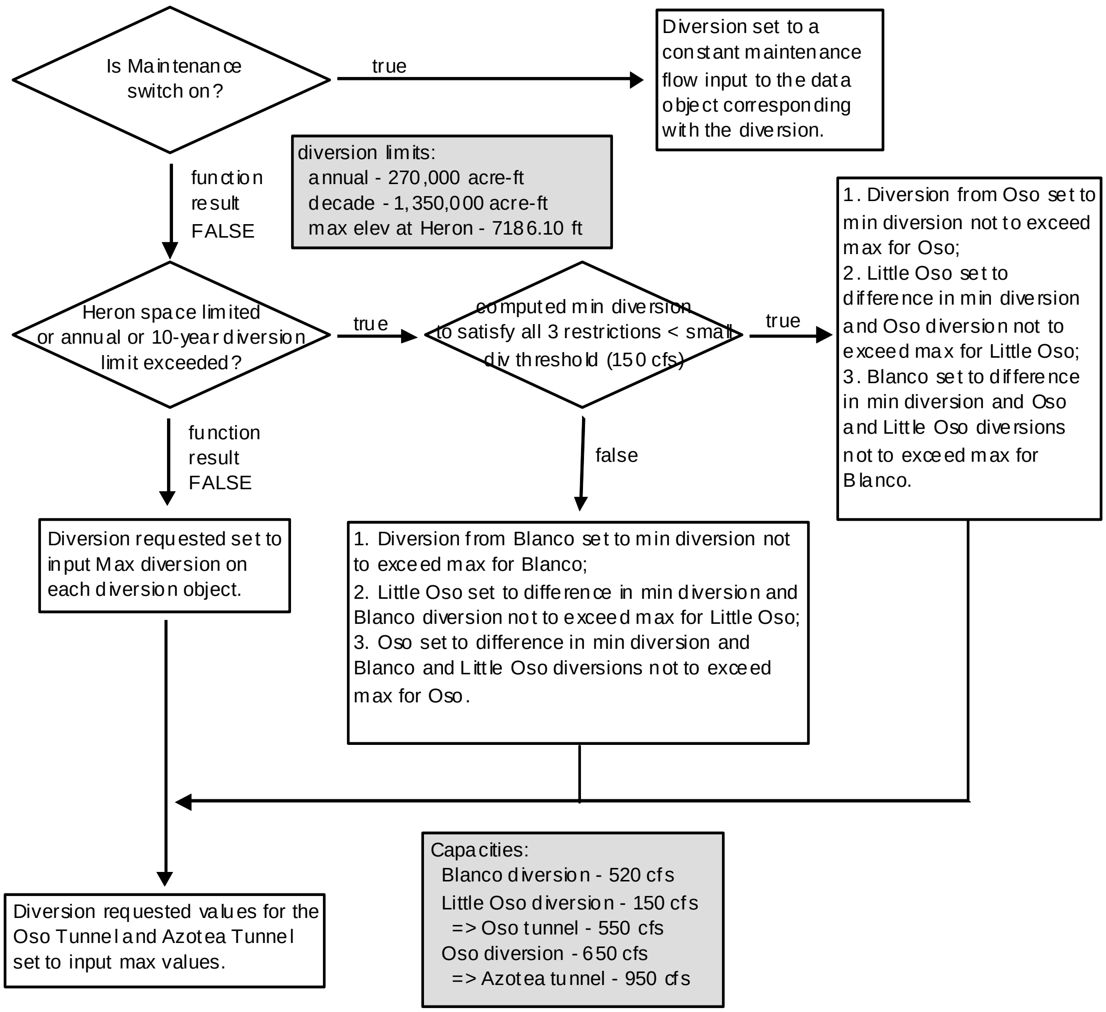


Figure 3.2. Flow Chart Depicting Logic for Setting San Juan Diversions

Review Comments

URGWOM includes a detailed representation of the policy for setting diversions from the San Juan basin. Including such detail results in the rules accurately setting diversions with consideration for the capacity at each tunnel which may actually result in the full diversion capacity at the Azotea tunnel from being reached. It is good to have the detail in regards to the diversion capacities such that the yield from the diversions is determined accurately in the model.

Based on simulations completed with the Planning Model using the five synthetic hydrologic sequences (Roach, 2009), diversions are never curtailed based on the annual diversion limit of 270,000 acre-ft and the decade diversion limit of 1,350,000 acre-ft; however, Heron Reservoir may fill to the maximum pool elevation of 7186.1 ft (or a storage of 401,335 acre-ft) which could result in curtailed diversions from the San Juan basin. When completing simulations with URGWOM, such curtailments should be monitored closely. If the timing for when Heron is at the maximum pool elevation is different between two model runs, this could impact the yield from the Azotea tunnel and result in a different contribution of San Juan-Chama Project water to the overall water supply. This difference could be significant relative to other indicators in the model that are being reviewed.

This situation of Heron Reservoir being full and resulting in curtailed San Juan diversions serves is an excellent example of the type of situation that could cause a change in policy. The system may be operated in a different manner under conditions that simply are not actually known since managers that deal with day-to-day operations have not had to consider such a situation. Operations could be adjusted if possible to move some water in Heron Reservoir to downstream storage space and create space at Heron Reservoir for San Juan-Chama Project water, but there may be interest in leaving space available in El Vado Reservoir to capture the runoff of native Rio Grande flows and Abiquiu Reservoir may already be nearly full to the maximum pool elevation of 6220 ft.

3.1. Allocations of San Juan-Chama Project Water

San Juan-Chama Project water at Heron is first tracked in the model with the FederalSanJuan storage account on the Heron storage reservoir object. Water is allocated to contractors for San Juan-Chama Project water on January 1st of each calendar year based on the annual allocations for each contractor (Table 3.1) using the SetSanJuanContractorAllocations rule (Additional allocations are made on July 1st in the model using the SetSanJuanContractorAllocationsJuly1 rule with available water in the FederalSanJuan account if full allocations cannot be made on January 1st). Refer to Figure 3.3 for a flowchart that portrays the logic for setting allocations each year.

Table 3.1. Contractor Annual SJC Allocations

Contractor	Allocation (acre-ft)
Albuquerque	48,200
MRGCD	20,900
Jicarilla	6500
Santa Fe	5605
Cochiti Rec Pool	5000
Department of Energy	1200
PVID	1030
Espanola	1000
Belen	500
Bernalillo	400
Taos	400
Los Lunas	400
Red River	60
Twining	15
Uncontracted	2990
San Juan Pueblo	2000
TOTAL:	96,200

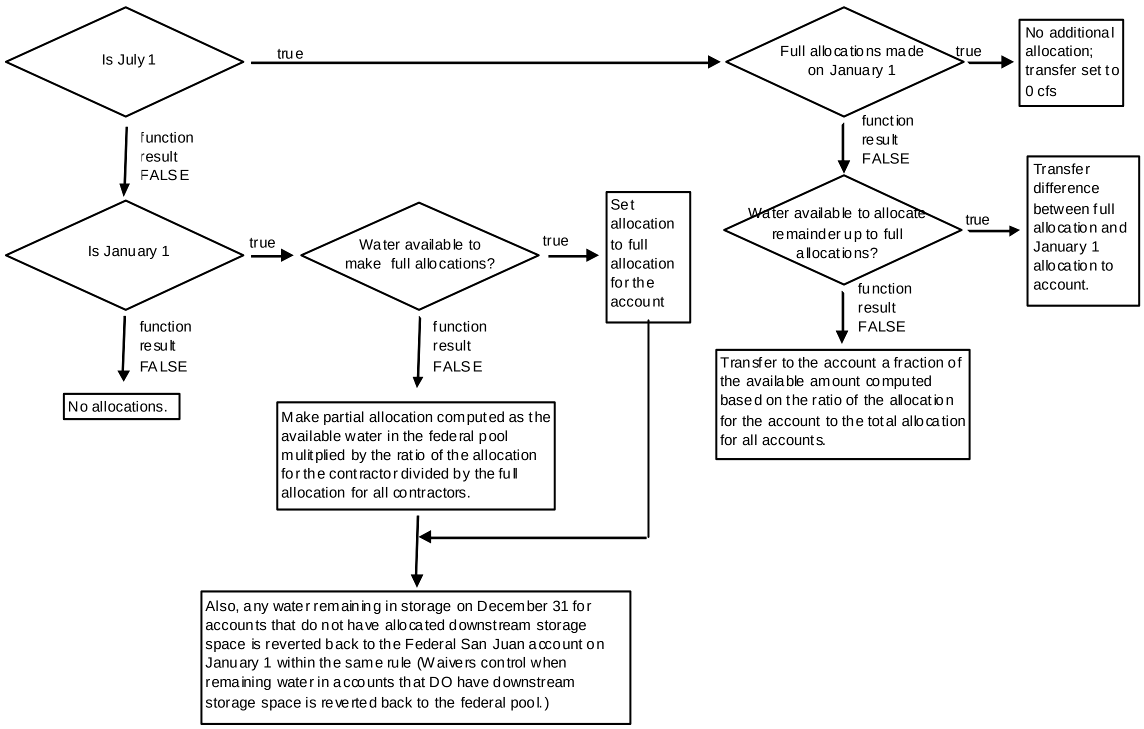


Figure 3.3. Flow Chart Depicting Logic for Setting Allocations of SJC Water

IV. Heron Operations

Operations at Heron Reservoir primarily entail storage of San Juan-Chama Project water that is allocated to contractors each year and moved downstream to meet the specific needs for the contractors. Native Rio Grande water is effectively bypassed at Heron Dam. Releases are set in URGWOM by first computing an initial total outflow of San Juan-Chama Project water to meet all identified demands and an initial outflow of native Rio Grande water. Refer to Figure 4.1 for a schematic of the calculation of the initial total outflow of San Juan-Chama Project water as completed with the EstimateHeronSJRelease rule. The different components of the calculation are discussed further in the following sections. The computed outflow of San Juan-Chama Project water would be reset to zero if Heron has full ice coverage or is spilling, as depicted by the flowchart in Figure 4.2, in which case all outflow would be native Rio Grande water. The outflow of native Rio Grande water is discussed further in section 4.2.

A total initial outflow is set to the sum of the initial Rio Grande outflow and initial outflow of San Juan-Chama Project water with the HeronOutflow rule and is checked against the physical constraints of the outlet works and a restriction that the pool elevation at Heron Reservoir cannot change by more than a foot in a day (HeronCheckDeltaStorage rule). After a final outflow has been set, final reconciled values are computed for the actual outflow of Rio Grande water and outflow of San Juan-Chama Project water. Accounting supplies are then set for the Rio Grande outflow and numerous different deliveries of San Juan-Chama Project water. The reconciled values for the total outflow of Rio Grande and San Juan-Chama Project water generally match the initial computed values unless some physical constraint prevented the desired releases from being made; however, final individual deliveries may not match the initial computations for separate deliveries due to priorities for meeting all the different downstream demands.

All separate accounts for deliveries of San Juan-Chama Project water are set using the similar computations that are referenced when estimating the initial outflow of San Juan-Chama Project water, but individual accounts are set based on input priorities for the type of delivery (e.g. to fill downstream allocated storage space, letter water deliveries, etc.) and priorities in regards to the contractors or accounts. The available water supply for contractors is updated as deliveries are set and initial set deliveries may impact the water supply available for subsequent deliveries for the same contractor. Refer to Figure 4.3 for a flow chart that depicts the steps for setting an initial total outflow, checking that total release against the change in pool elevation limit, and setting the accounting supplies. This same general approach for setting the releases and accounting supplies is also used for El Vado and Abiquiu Dams.

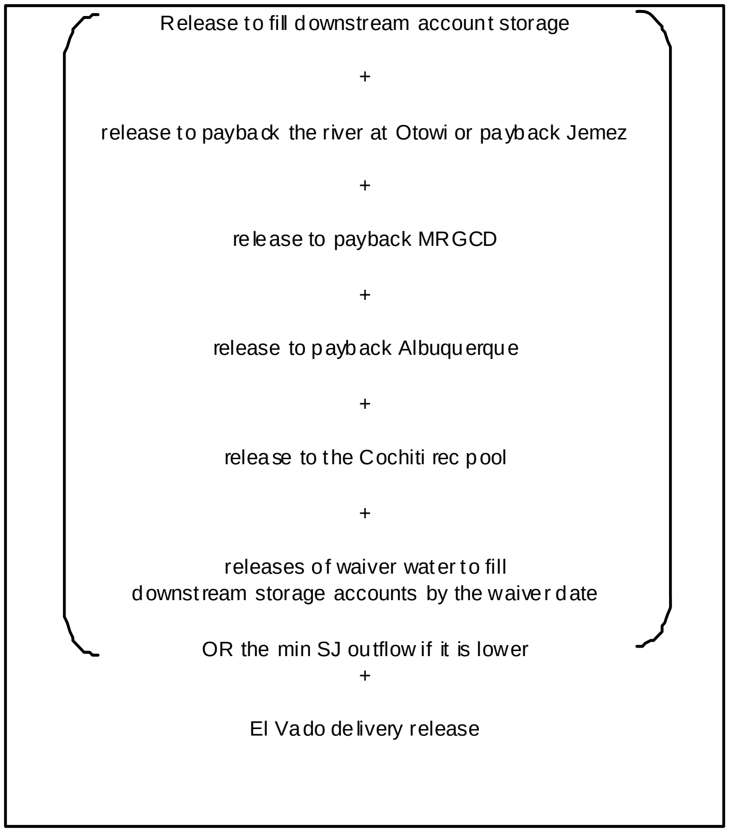


Figure 4.1. Components of Initial Total Release of SJC Water from Heron Reservoir

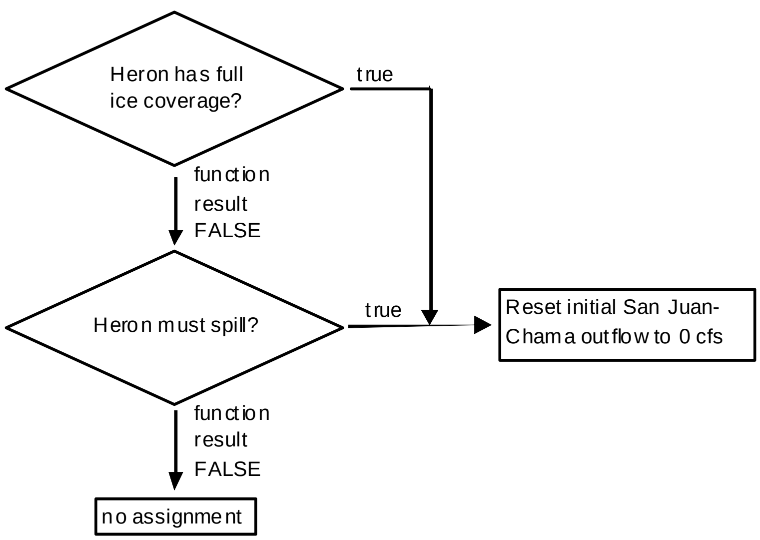


Figure 4.2. Flow Chart with Logic for Potentially Resetting Initial SJC Outflow to Zero

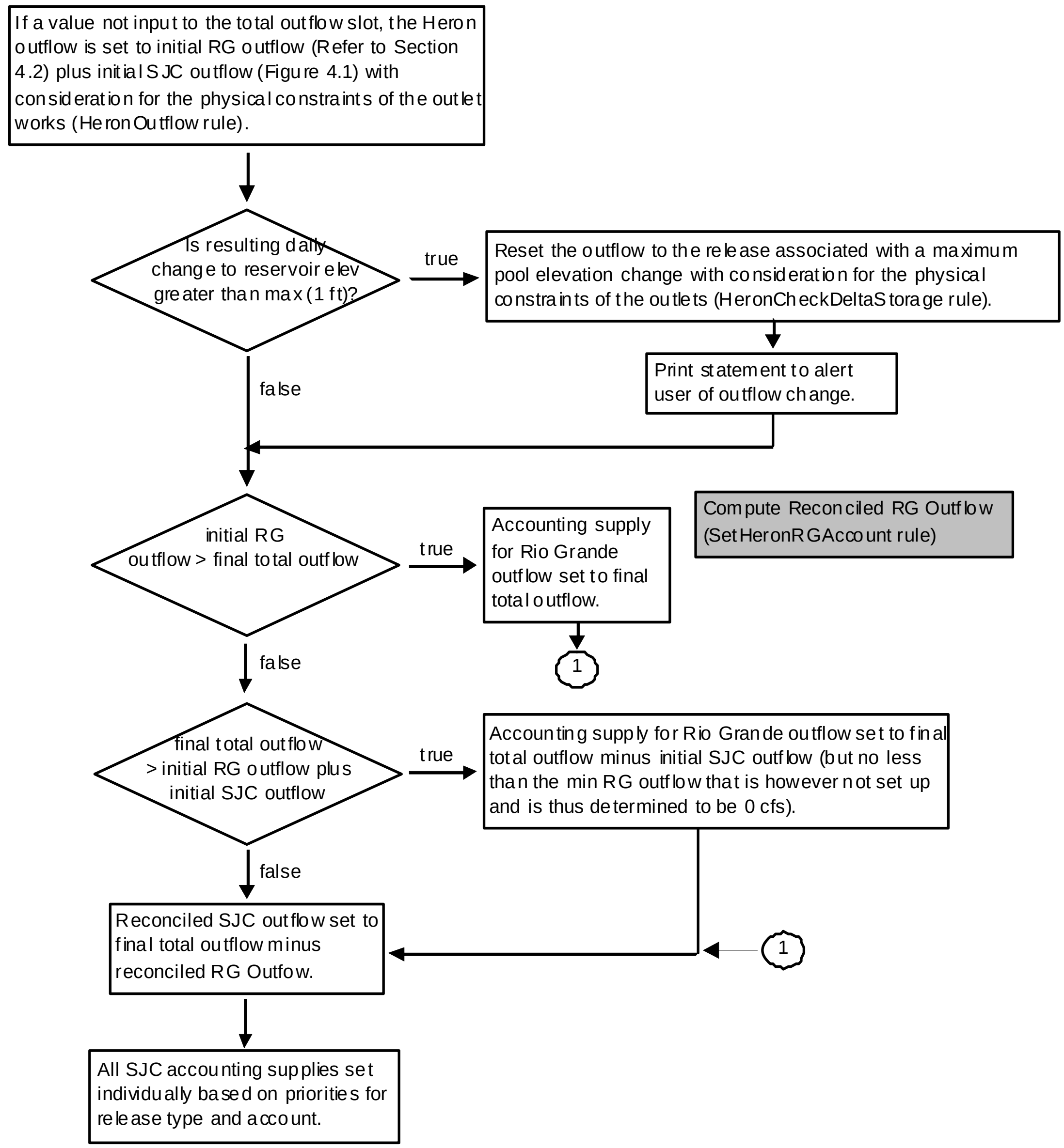


Figure 4.3. Flow Chart Depicting Computation of Initial Heron Outflow, Check against Delta Storage Limit, Calculated Reconciled RG and SJC Outflow, and Final Step to Set Accounting Supplies

4.1. San Juan-Chama Project Water

San Juan-Chama Project water from the Azotea tunnel is stored in a common pool (i.e. the FederalSanJuan storage account) at Heron Reservoir and that water is allocated to contractors for San Juan-Chama Project water. Contractors have individual storage accounts and release water to fill downstream allocated storage space or to meet other identified demands. Contractors must release their allocated water by December 31st unless waivers are issued which allow contractors to continue to store allocated water at

Heron Reservoir into the year following the year of allocation. Reservoir operations include the storage and release of San Juan-Chama Project water allocated to maintain the Cochiti Recreation Pool along with the storage and release of water leased to Reclamation to use for meeting targets in the Middle Valley.

4.1.1. Downstream Allocated Storage Space

Contractors have allocated storage space for San Juan-Chama Project water at El Vado and Abiquiu Reservoir. Allocated San Juan-Chama Project water in storage at Heron Reservoir is delivered to fill the downstream allocated storage space as space becomes available and with reference to target delivery volumes for set periods within a year.

MRGCD generally has all available storage space at El Vado Reservoir, but MRGCD may allow other contractors to temporarily store water at El Vado Reservoir. The total allocated storage space at El Vado Reservoir for San Juan-Chama Project water should not exceed 183,000 acre-ft (i.e. the approximate storage at the maximum El Vado pool elevation of 6901 ft). Albuquerque has historically used the largest portion of available storage space at Abiquiu Reservoir, but with Albuquerque using more of their allocated San Juan-Chama Project water for surface water diversions to the new drinking water plant, more storage space will be available at Abiquiu Reservoir for other contractors. Storage is allowed at Abiquiu Reservoir up to a pool elevation of 6220 ft (Easement approvals from land owners are needed for storage above 6220 ft). A small pool at Abiquiu Reservoir is generally allocated to MRGCD, primarily to provide operational flexibility for MRGCD to move water from El Vado Reservoir through Abiquiu Reservoir.

Allocated storage space as set up in URGWOM is unchanged for an entire simulation. Refer to Figures 4.4 and 4.5 for sample tables for contractor allocated storage space at El Vado and Abiquiu Reservoirs, respectively, from the current Planning Model where the storage accounts for numerous contractors are combined into one Combined account.

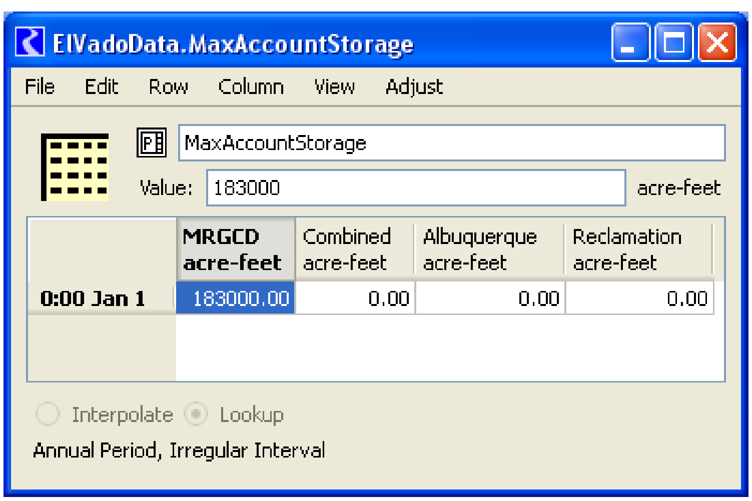


Figure 4.4. ElVadoData.MaxAccountStorage Periodic Slot

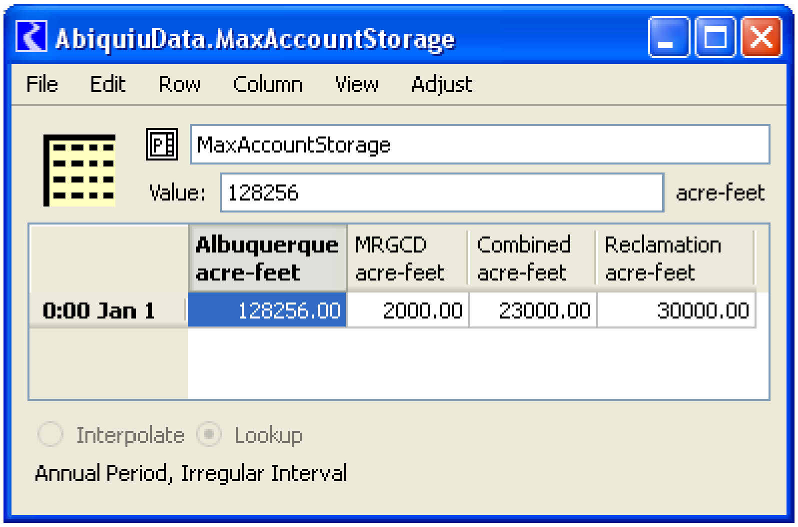


Figure 4.5. AbiquiuData.MaxAccountStorage Periodic Slot

Review Comments

Having rigid established amounts of allocated storage space for an entire simulation may not be a problem for a Water Operations Model run that simulates operations through the end of one calendar year, but more flexibility is needed for longer term simulations. Planning Model simulations have historically been completed for 10-year periods or longer, and storage space for contractors would not realistically be so set so rigidly for such a long period. Also, the current situation with Albuquerque not needing as much storage space in the near future specifically increases the need for more flexibility to vary allocated storage space within a Planning Model run. Albuquerque will need less and less storage space at Abiquiu Reservoir with the startup of their surface water diversions and increased letter water deliveries to payback for past pumping. More space will then be available for other contractors.

4.1.2. Reclamation Leases

Supplemental water is defined as water designated to be released to meet target flows in the Middle Valley and may come from two sources: water leased by Reclamation from contractors for San Juan-Chama Project water or native Rio Grande water stored as Emergency Drought water at El Vado specifically to be used for targets (Refer to section 5.2 for more details on Emergency Drought water). Leases of San Juan-Chama Project water by Reclamation from contractors are represented in URGWOM as transfers from the account storage for the other contractors to Reclamation's account. These transfers may be completed at Heron, El Vado, or Abiquiu Reservoirs and occur based on an input daily schedules for a simulation period. In the Water Operations Model, leases are represented with more detail as leases from individual contractors are included; whereas, in the Planning Model, leases may come from the Combined account set up as a lumped account for several contractors.

Review Comments

Leases are not set up as exchanges where a debt is established and the contractor transfers water to Reclamation's account when the contractor has water available. Leases are set up as scheduled transfers, and if a contractor does not have water in storage for an input lease amount, no transfer occurs. This is not a problem, but model users need to consider whether a contractor will have water available at the time that a transfer is scheduled based on the input lease amounts. Transfers should be checked in the model. Also, based on the current code, leases come from a source contractor's current year allocation and do not affect the contractor's waiver balance (discussed further in the next section).

4.1.3. Waivers

Reclamation may allow contractors for San Juan-Chama Project water to retain current year allocated water, as discussed in section 3.1, still in storage at Heron Reservoir at the end of a calendar year, into the following year until a waiver date. Currently, the authorized waiver date is September 30th. Coded policy entails tracking a waiver balance starting on January 1st of each year based on a contractor's storage on December 31st. Current year allocated water and waiver water is included in the single storage account for a contractor, but storage is then reduced on September 30th by the amount of any remaining waiver balance on that waiver date. That water is reverted back to the common pool and the storage in the FederalSanJuan storage account at Heron increases accordingly. Waiver water is released as possible during the following year such that available downstream allocated storage space for the contractor is filled by the waiver date or all waiver water at Heron Reservoir is released by the waiver date. The waiver option may be turned on or off for individual years within a simulation with a switch set up in URGWOM.

Review Comments

Waivers represent a good example of an aspect of policy that has evolved and coded policy may need to continue to be maintained based on changes to actual policy. A primary reason that waivers are allowed by Reclamation is because of the potential benefit from subsequent Reclamation leases of that waiver water from contractors and the use of that leased water to meet target flows in the Middle Valley. Reclamation is not currently set up to store leased water at Heron into the year following when the water was originally allocated to the contractors that leased the water to Reclamation. Currently, it is assumed that leased water through transfers at Heron Reservoir come from the current year allocated water for a contractor. Coded policy for tracking a waiver balance should probably be adjusted such that the waiver balance, if there is a waiver balance, is adjusted under the assumption that leased water is actually waiver water, and Reclamation must move that water out of Heron Reservoir by the waiver date based on the policy for moving waiver water. In general, Reclamation's leased water at Heron Reservoir is immediately delivered to allocated storage space for Reclamation at Abiquiu Reservoir in the current model.

Policy for allowing waivers could also be adjusted such that waivers are not permitted unless a potential lease to Reclamation may occur or another potential benefit is desired such as allowing a contractor to delay delivery to downstream allocated storage space to provide desired rafting flows below El Vado Dam or to temporarily allow Reclamation to use downstream allocated storage space. The timing for transfers at El Vado Reservoir or Abiquiu Reservoir for Reclamation leases should be input appropriately based on the timing for waivers and how these leases will then affect the space available for contractor water and the amount of time available for contractors to fill that space before the waiver date.

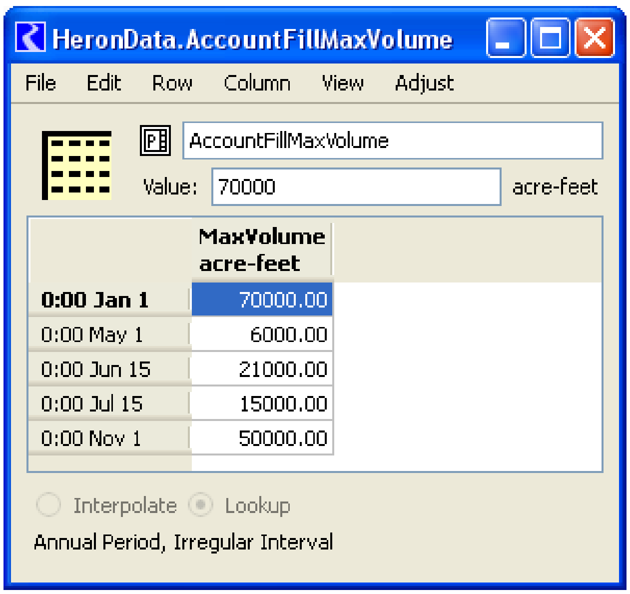
When waiver water is delivered downstream to fill allocated storage space, some current year allocated water may also be delivered at the same time to fill downstream allocated storage space (as discussed further in section 4.1.4). Releases of waiver water to fill downstream allocated storage space are computed without reference to computed deliveries of current year allocated water. The equation for setting the release of waiver water and the release of current year allocated water should be set up such that movement of current year allocated water is dependent on whether waiver water is available. Even though waiver water is established as a higher priority release in the release type priority tables discussed in the next section, releases are still made with both waiver water and current year allocated water (i.e. release type of AccountFill) at the same time. Currently, a release rate for waiver water is computed daily to fill allocated storage space by the waiver date, or release all waiver water by the waiver date, but current year allocated water is also being released, so the calculated release rate is actually adjusted each day as available space is filled by water from different sources as opposed to being set at a consistent rate until the waiver date. A potential easy fix to the current approach would likely be to use one calculation and simply assume that waiver water is used first and current year allocated water all remains in storage until the waiver balance is zero.

Note that as Albuquerque water use increases with the startup of surface water diversions and increased letter water deliveries, Albuquerque would be using their annual allocation of San Juan-Chama Project water every year and never benefit from waivers at Heron Reservoir. Also, MRGCD moves allocated San Juan-Chama Project water to El Vado Reservoir every year and would not benefit from waivers unless MRGCD came out of a very wet year with no space available at El Vado Reservoir.

4.1.4. Deliveries to Allocated Storage Space

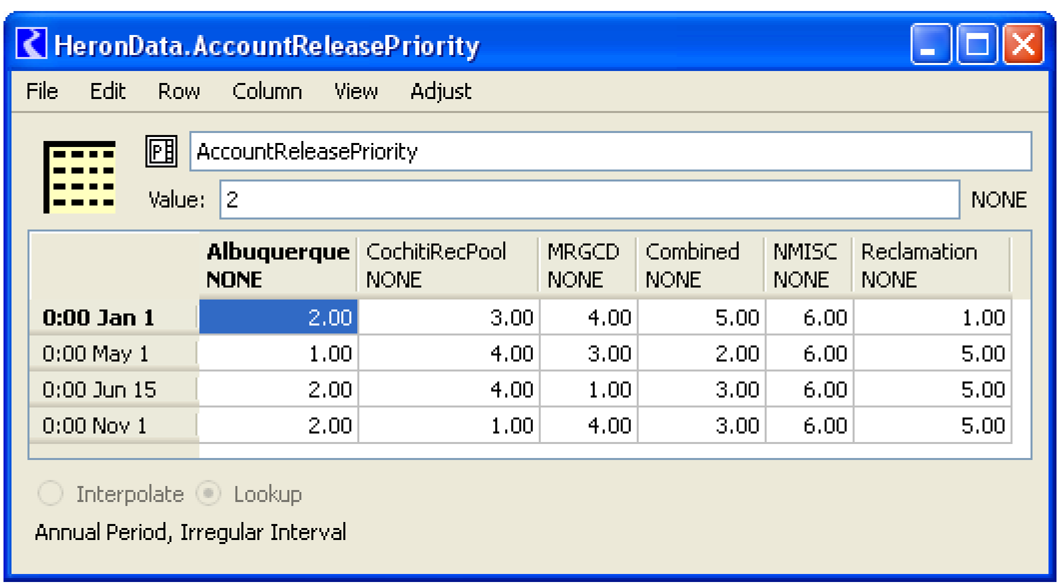
San Juan-Chama Project water at Heron Reservoir allocated to contractors is periodically delivered to allocated downstream storage space at El Vado and Abiquiu Reservoirs. Total delivery amounts from Heron over set periods to fill allocated storage space are input into URGWOM (Refer to Figure 4.6 for a sample table of periodic account fill volumes). Releases are made at an average rate to make the total release by the end of the period. The release volumes represent a total delivery amount with deliveries set for specific contractors based on input account priorities (Refer to Figure 4.7 for a sample table of account priorities). Deliveries are made sequentially based on the input priorities with consideration for available storage at Heron for a contractor and available downstream storage space for a contractor. Note that waiver water, which is delivered gradually up to the waiver date, may be delivered at the same time which will impact the timing for when allocated storage space is filled.

Separate accounts are set up for MRGCD water to be moved to El Vado to specifically maintain a minimum storage of 15,000 acre-ft if other aspects of policy do not indirectly assure this storage is maintained. These accounts have a release type of ElVadoDelivery.



	MaxVolume acre-feet
0:00 Jan 1	70000.00
0:00 May 1	6000.00
0:00 Jun 15	21000.00
0:00 Jul 15	15000.00
0:00 Nov 1	50000.00

Figure 4.6. HeronData.AccountFillMaxVolume Periodic Slot



	Albuquerque NONE	CochitiRecPool NONE	MRGCD NONE	Combined NONE	NMISC NONE	Reclamation NONE
0:00 Jan 1	2.00	3.00	4.00	5.00	6.00	1.00
0:00 May 1	1.00	4.00	3.00	2.00	6.00	5.00
0:00 Jun 15	2.00	4.00	1.00	3.00	6.00	5.00
0:00 Nov 1	2.00	1.00	4.00	3.00	6.00	5.00

Figure 4.7. HeronData.AccountReleasePriority Periodic Slot

Review Comments

The current approach for filling downstream allocated storage space is adequate at timing the movement of San Juan-Chama Project water from Heron downstream such that downstream demands (e.g. MRGCD diversions, letter water deliveries, Albuquerque surface water diversions, etc.) can be met, but some enhancements could be incorporated such that the movement more accurately reflects actual operations. Such changes would not have any impact on model results in the Middle Valley.

The current approach for moving contractor San Juan-Chama Project water from Heron Reservoir to El Vado and Abiquiu Reservoirs is robust in that new accounts could be established in URGWOM and the current rules could be used with the new accounts. The current approach allows for numerous accounts representing different deliveries for different contractors to all be set with a general approach. Some flexibility is included in that model users can adjust the periodic total release volumes for filling downstream allocated storage space and the priorities for which contractor's water is moved first; although, a desired delivery schedule for some contractors may still be difficult to obtain using the current approach.

The URGWOM Technical Team has identified this aspect of coded policy as an area where the model could potentially be enhanced and is also discussing the current approach with the RiverWare software developers at CADSWES. An alternate approach may be less robust but allow for requested delivery schedules to be computed differently for the individual contractors. A different approach may be more appropriate for capturing some detailed aspects of policy such as movement of Albuquerque and Reclamation's leased water at a time to provide rafting flows below El Vado Dam. The schedule for movement of MRGCD's San Juan-Chama Project water could be set up to be specifically a function of their water needs. MRGCD would generally prefer that their San Juan-Chama Project water is moved as late as possible, but during drier periods when storage of native Rio Grande water is low, San Juan-Chama Project water may be needed sooner. A key problem with the current approach is that water cannot be moved for two contractors for the same time (A different release type is currently set up to accomplish this as discussed further in section 4.1.4.2).

4.1.4.1. Cochiti Rec Pool

Releases of San Juan-Chama Project water for the Cochiti Recreation Pool are set in a similar manner to the releases to fill allocated storage space at El Vado and Abiquiu Reservoirs but Cochiti Rec Pool releases are tracked separately. Releases are made from Heron Reservoir to release set volumes over set periods and at an average rate to release the input volume by the next date in the table. Releases are essentially made to offset evaporation losses from the recreation pool. The allocated volume is 5000 acre-ft/year at Heron Reservoir.

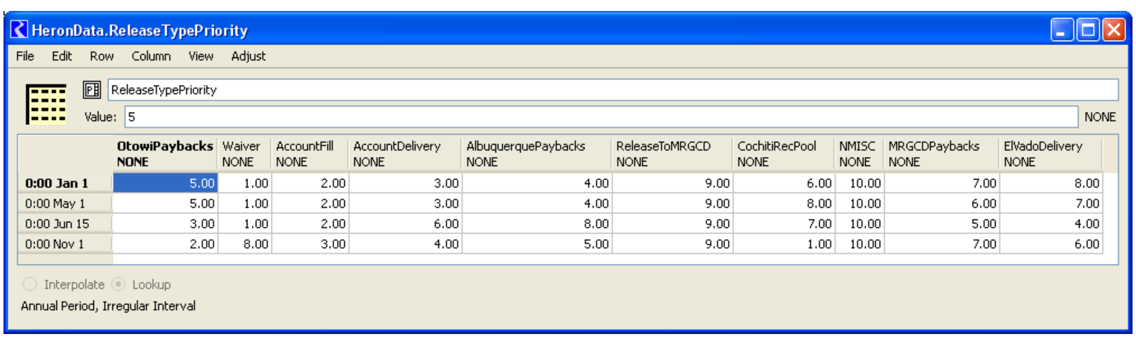
The allocated rec pool space at Cochiti is input as a storage value of 49,370 acre-ft that provides a Cochiti rec pool surface area of 1200 acres based on the input elevation-area-capacity tables. With simulated sediment accumulation at Cochiti Reservoir, the reservoir storage for maintaining the rec pool gradually increases during a model run. The timing for deliveries may be affected by the input priority for releasing water from Heron Reservoir to the Cochiti rec pool as set in the account release priority table.

Review Comments

The current approach for maintaining a surface area of 1200 acres for a recreation pool at Cochiti Reservoir entails that the storage required to provide an area of 1200 acres increases with any sediment accumulation. An alternate assumption could be that sediment accumulation does not impact the pool elevation required to maintain a surface area of 1200 acres, and the storage required to maintain the recreation pool would actually decrease with sediment accumulation. The impact of using one assumption versus the other would likely have a negligible impact on model results.

4.1.4.2. Priority Tables for Releases

Deliveries from Heron Reservoir to fill allocated storage space are made with accounts that have a release type of AccountFill and are made based on the priority for this release type in a priority table (Figure 4.8). Accounts for other deliveries have different release types such as OtowiPaybacks for letter water deliveries as discussed in section 2.3. As depicted in Figure 4.3, initial demands for moving water are computed as part of a determined initial total outflow (Figure 4.1) and then deliveries are made based on the input priorities for release type. Assuming the initial computed release to meet different demands could be made and was not restricted due to operational constraints and the accounts have water in storage to make all designated deliveries, all initial computed demands should be met.



	OtowiPaybacks NONE	Waiver NONE	AccountFill NONE	AccountDelivery NONE	AlbuquerquePaybacks NONE	ReleaseToMRGCD NONE	CochitiRecPool NONE	NMISC NONE	MRGCDPaybacks NONE	ElVadoDelivery NONE
0:00 Jan 1	5.00	1.00	2.00	3.00	4.00	9.00	6.00	10.00	7.00	8.00
0:00 May 1	5.00	1.00	2.00	3.00	4.00	9.00	8.00	10.00	6.00	7.00
0:00 Jun 15	3.00	1.00	2.00	6.00	8.00	9.00	7.00	10.00	5.00	4.00
0:00 Nov 1	2.00	8.00	3.00	4.00	5.00	9.00	1.00	10.00	7.00	6.00

Figure 4.8. HeronData.ReleaseTypePriority Periodic Slot

Review Comments

The release type priorities table is a robust approach for setting numerous accounts fairly easily, but the approach is rather cryptic in that assumptions used to compute initial demands may drive the releases regardless of the input priorities; moreover, the priority tables may override the initial assumptions for demands. Water originally designated for one demand may be used for a different demand based on the release type priorities.

The release type priorities table provides some flexibility in allowing users to identify which release types should be set first, but the table does not exactly work in this manner. The initial computed total release of San Juan-Chama Project water is set to meet demands associated with all release types (e.g. letter water deliveries, releases to fill allocated storage space, releases of waiver water, etc.) A reconciled outflow of San Juan-Chama Project water will likely match this initial outflow, and accounts are then set for each delivery. All accounts should be set to match the initial computed demand, so the priority table should be inconsequential unless there is an inconsistency between the approach for setting the accounting supplies versus the computation of the initial total outflow. The release type priority table should only affect results if some operational constraint prevents the full total release from being made or the available supply for a contractor prevents two different downstream demands from being met.

After a release type is identified, different accounts with that release type are set based on the account priority table (Figure 4.7). One problem with the coded approach is that there is often a need to have deliveries made at the same time for two different accounts that have the same release type, but the setup only allows deliveries with the same release type to be set sequentially. For example, during a dry period, there may be a need to deliver allocated San Juan-Chama Project water to fill downstream allocated storage space for both Albuquerque and MRGCD at the same time. (This is accomplished in the current model but is done with separate accounts not included as part of the initial total release. Specific accounts designated with a release type of AccountDelivery are set to assure MRGCD's allocated storage space is filled, but downstream demands included as part of the initial total outflow are then not met as a result.).

The release type priority approach is effective but introduces an inconsistency between the calculation of the initial outflow and the approach for setting accounting supplies. The approach is cryptic and could be changed to make the model more transparent. The URGWOM Technical Team has been discussing the approach with the software developers at CADSWES and is scheduled to edit the approach.

4.1.5. Loans between Contractors

URGWOM is currently set up to allow Albuquerque to loan unused San Juan-Chama Project water to other contractors. These loans would be made contingent on a contractor's need to meet their demand and the available supply for Albuquerque. URGWOM is also set up to model loans from MRGCD to either Reclamation or Albuquerque where schedules for these loans are input. Loans would be made if MRGCD has the water in storage to loan based on these input schedules and then paid back to MRGCD when Reclamation or Albuquerque has water available for the payback.

Review Comments

With the startup of surface water diversions, the policy to have Albuquerque loan unused water to other contractors that need water to meet their demands is likely no longer relevant. If any loans were to be modeled, circumstances may be different to where the existing setup would need to be modified anyway. A significant step toward making the model and ruleset more transparent would be to eliminate all the accounts, exchanges, and rules for simulating loans from Albuquerque to other contractors. The process for making the transfers, establishing the debts, and having contractors eventually payback the debts is somewhat involved. Accounts and exchanges are set up to specifically model this past aspect of operations, and even though the loans are not currently modeled, the rules are complicated by all the considerations for the potential transfers or paybacks along with the overall calculation of the total demands for San Juan-Chama Project water at each reservoir and the approach for setting other unrelated accounting supplies.

Loans from MRGCD to Reclamation or Albuquerque may be a more likely scenario in the future, but if any future loans between these contractors were to be modeled, the details of the policy would likely need to be reviewed against the current coded policy.

4.2. Native Rio Grande Water

Native Rio Grande water is effectively bypassed at Heron Reservoir as computed with the ComputeHeronRGRelease rule. Rio Grande water is evacuated if the accumulated storage exceeds 100 acre-ft (an additional check is included against a maximum Rio Grande storage of 5000 acre-ft), but no release is made if Heron has full ice coverage. Separate equations are used to compute the release of Rio Grande water for the first half of a month versus the second half of a month.

For the first half of the month, the release is set on Mondays to bypass an assumed average monthly baseflow and also evacuate the current storage over the next 7 days. For each day of the week after Monday, the previous release is maintained minus any computed seepage that would reduce the storage that needs to be evacuated. On the next Monday, the outflow is recomputed and any storage resulting from an error in the assumed baseflow would be included in the new storage to be evacuated. For the second half of the month, the release is set differently. The outflow is set on Mondays and Thursdays (as opposed to just Mondays) to just evacuate the storage over the next 4 or 3 days, respectively. For each following day of the week, the previous release is maintained. The equation for the second half of the month does not include a calculation to bypass of any assumed baseflow, so storage could increase if inflows are higher. Also, when releases are continued, seepage is not subtracted.

Refer to Figures 4.9 and 4.10 for flow charts that depict the initial checks for setting the release and Figures 4.11 and 4.12 for schematics that show the calculation of the release during the first half of a month and during the second half of a month. The computations for the first half of the month include a check of the release needed to lower the pool elevation back down to the maximum pool elevation if relevant.

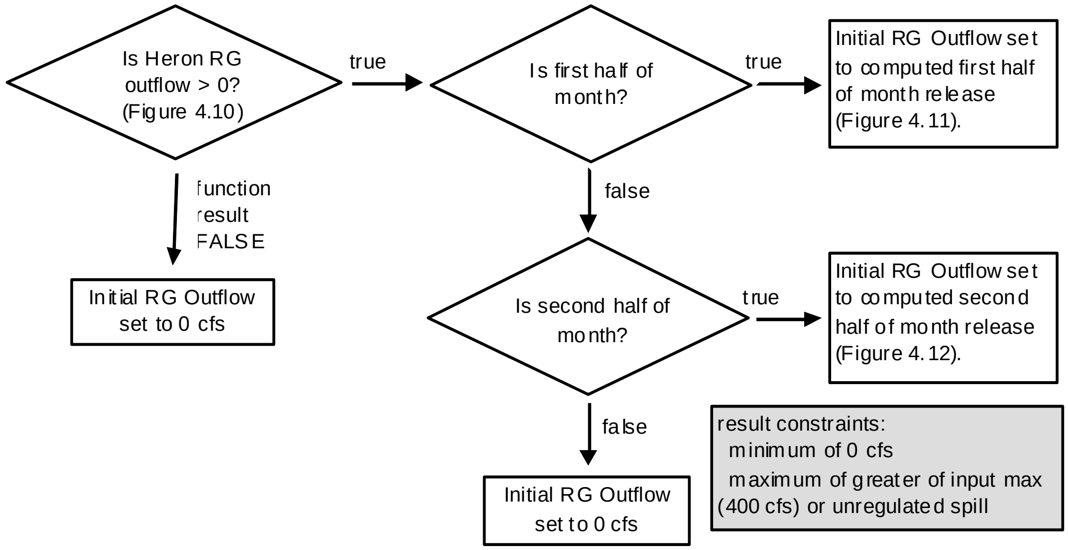


Figure 4.9. Flow Chart for Initial Checks to Set Rio Grande Release from Heron

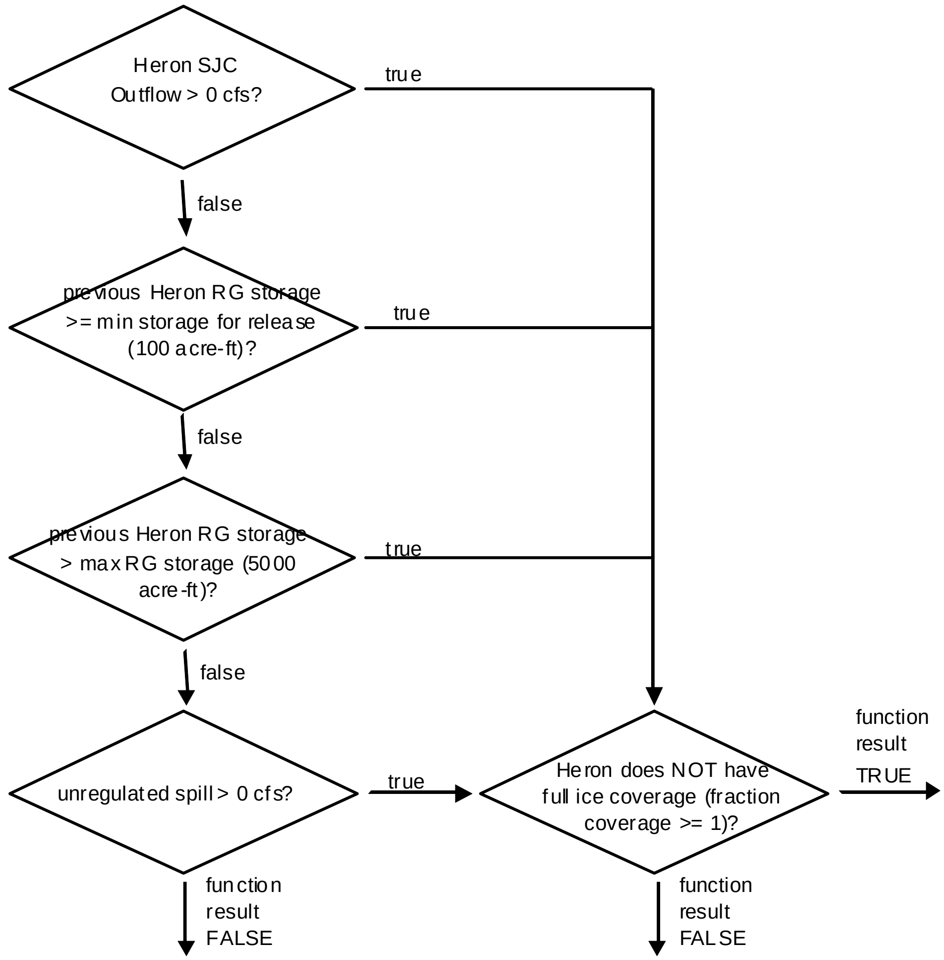


Figure 4.10. Flow Chart Depicting Details of Check of Heron Rio Grande Outflow > 0

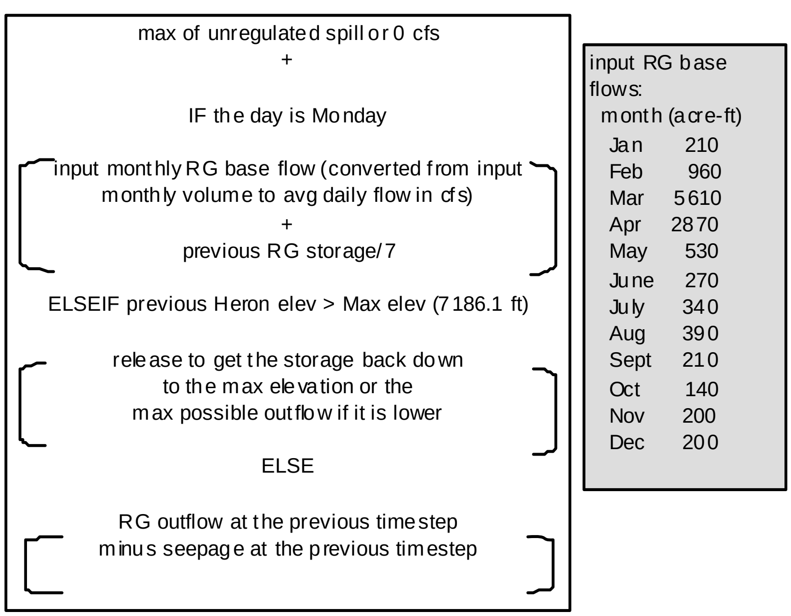


Figure 4.11. Calculation for Rio Grande Release – First Half of Month

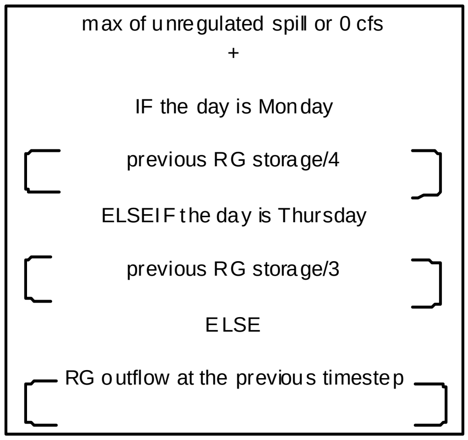


Figure 4.12.Calculation for Rio Grande Release – Second Half of Month

Review Comments

The current approach for setting the release of Rio Grande water from Heron Reservoir is effective at bypassing the native Rio Grande inflow. The Rio Grande inflows are conveyed to El Vado Reservoir and the algorithm for setting the release has little impact on model results below Heron Reservoir. The code is, however, an area in the ruleset that could be significantly simplified.

Actual operations do not involve such a detailed calculation for the release of native Rio Grande water, and the current calculation results in small fluctuations in storage due to incorrect estimates for the inflow. For the first half of a month, the release includes an *assumed* base flow, but if the assumed base flow is too high, the computed release may push the Rio Grande storage negative. For the second half of a month, the release is set for a few days to evacuate the storage assuming no inflows, but if actual inflows are higher, Rio Grande storage may increase.

For actual operations, Rio Grande water at Heron Reservoir is bypassed during the runoff, generally at a constant rate that is adjusted every few days (Releases of native Rio Grande water may vary to maintain a constant total release if San Juan-Chama Project water is being released at the same time). The release of native Rio Grande water is generally set to zero after the runoff, and if storage of Rio Grande water begins to accumulate, a temporary constant release will be made to evacuate the water. Releases of Rio Grande water are not actually set each week with such an involved computation as currently included in the URGWOM ruleset. Also, actual releases could ideally be set such that 350 acre-ft has accumulated by December 31st where the December 31 annual accounting adjustment to transfer of 350 acre-ft to the FederalSanJuan account would subsequently yield zero storage of native Rio Grande water to start the next calendar year (Refer to the HeronRioGrandeAdjustment rule).

V. El Vado Operations

Operations at El Vado Reservoir entail storage of San Juan-Chama Project water for MRGCD and storage of native Rio Grande water as not needed for downstream demands *if* the stipulations of Article VII of the Compact are not in effect. Storage of native Rio Grande water for Prior and Paramount needs is included and storage may occur when Article VII is in effect as Emergency Drought water if Compact credits are relinquished. Releases are set in URGWOM in a similar manner used for Heron where an initial total outflow of San Juan-Chama Project water to meet all identified demands is computed along with an initial outflow of native Rio Grande water.

Demands in the Middle Valley are met with specific sources of water. The MRGCD Demand at Cochiti is first met with natural flows including any letter water deliveries that may originate from Heron, El Vado, or Abiquiu Reservoir. The MRGCD demand is also met with any releases of P&P water. Available native Rio Grande water in storage at El Vado (as tracked separately from P&P water) is released from storage to augment flows if needed to the meet the full MRGCD demand at Cochiti. If no native Rio Grande water is available, MRGCD San Juan-Chama Project water is released to meet the demand. Any Emergency Drought water allocated to MRGCD as discussed further in section 5.2 would be used before MRGCD's San Juan-Chama Project water. (If no San Juan-Chama Project water allocated to MRGCD is available, MRGCD is in a shortage situation and requested diversions likely will not be made). The outflow of native Rio Grande water is discussed further in section 5.3.

Releases of San Juan-Chama Project water may include releases to meet the MRGCD Demand if native Rio Grande water is insufficient to meet the demand. Other contractors for San Juan-Chama Project water that may have allocated storage space at El Vado Reservoir may release water for letter water deliveries to payback the river at Otowi. Water may be released by contractors as a payback to MRGCD or Albuquerque as a result of loans as discussed in section 4.1.5. If Reclamation leased San Juan-Chama Project water is in storage at El Vado Reservoir, that water is moved to allocated storage space at Abiquiu as space becomes available. Releases also include San Juan-Chama Project water that was released from Heron Reservoir and is passing through El Vado Reservoir. Refer to Figure 5.1 for a schematic of the calculation of the initial total outflow of San Juan-Chama Project water.

release to meet MRGCD demand

\+

release to payback the river

\+

release to payback MRGCD

\+

release to payback Albuquerque

\+

release to move Reclamation water to Abiquiu

\+

flow through water

Figure 5.1. Components of Initial Total Release of SJC Water from El Vado Reservoir

A total initial outflow from El Vado Dam is computed as the sum of the initial Rio Grande outflow and initial outflow of San Juan-Chama Project water and is checked against the physical constraints of the outlet works. The outflow is also checked against the release that would be required to reduce the pool elevation down to the maximum El Vado pool elevation of 6901 ft, if relevant, and the channel capacity of 5000 cfs below El Vado Dam. After a final outflow has been set, final reconciled releases are computed for the actual outflow of Rio Grande water and outflow of San Juan-Chama Project water. Accounting supplies are set that identify the Rio Grande outflow and for the numerous different deliveries of San Juan-Chama Project water.

All separate accounts for deliveries of San Juan-Chama Project water are set using the same computations referenced when estimating the initial outflow of San Juan-Chama Project water, but individual accounts are set based on input priorities for the type of delivery (e.g. release to MRGCD, letter water deliveries, passthrough, etc.) and priorities in regards to the contractors or accounts. The available supply for contractors is updated based as deliveries and initial set deliveries may impact the supply available for subsequent deliveries for the same contractor. Refer to Figure 5.2 for a flow chart that depicts the steps for setting an initial total outflow, checking operational constraints, and setting the accounting supplies.

Review Comments

The El Vado elevation-area-capacity table in URGWOM should be checked and updated with the table from the latest survey. The reference datum for the table should be identified and the maximum pool elevation of 6901 ft should be checked against the datum used for the input elevation-area-capacity table. The elevation-area-capacity table may need to be adjusted to match the established datum referenced for flood control operations.

Note that the channel capacity restriction is included as higher priority over the maximum pool elevation. Simulated storage at El Vado Reservoir could exceed the maximum pool elevation if needed to keep the release below the downstream channel capacity based solely on the established priorities for these two rules, but for recent simulations completed with the Planning Model using the five synthetic sequences, this circumstance does not occur. Chances of this situation occurring depend primarily on the policy for storing native Rio Grande water during the runoff (when Article VII is not in effect). This issue is discussed further as part of the review comments in section 5.3.

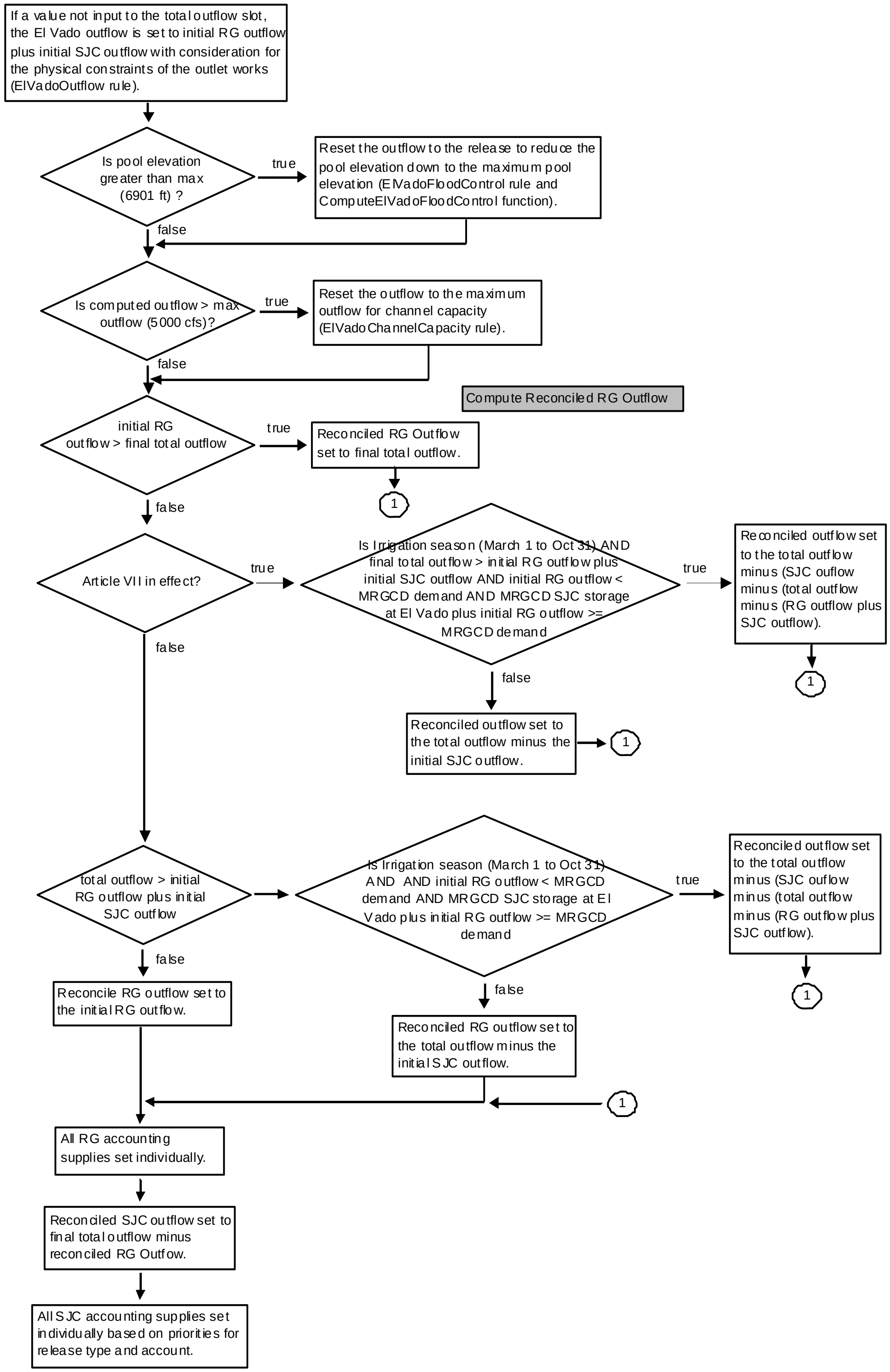


Figure 5.2. Flow Chart Depicting Computation of Initial El Vado Outflow, Check against Flood Control Operations, Calculated Reconciled RG and SJC Outflow, and Final Step to Set Accounting Supplies

5.1. Article VII of the Compact

Inflows of native Rio Grande water at El Vado Reservoir will be stored if not needed to meet downstream demands and if the stipulations of Article VII of the Compact are not in effect. Article VII of the Compact (States of New Mexico, Colorado, and Texas, 1938) stipulates that water may not be stored in post-Compact Reservoirs if there is less than 400,000 acre-ft of usable storage where usable storage is calculated as the sum of storage at Elephant Butte Reservoir, not including New Mexico credit water, plus storage at Caballo Reservoir. Usable storage is computed with the CompactVIIUsableStorage rule and the Article VII status is tracked with a switch set with the SetCompactVIISwitch rule. Refer to Figure 5.3 for a flow chart depicting how the Article VII status is checked. As stipulations of Article VII go into effect, any native Rio Grande water already in storage is retained until needed meet downstream demands (or a call is made per Article VIII of the Compact as discussed in section 5.3.1).

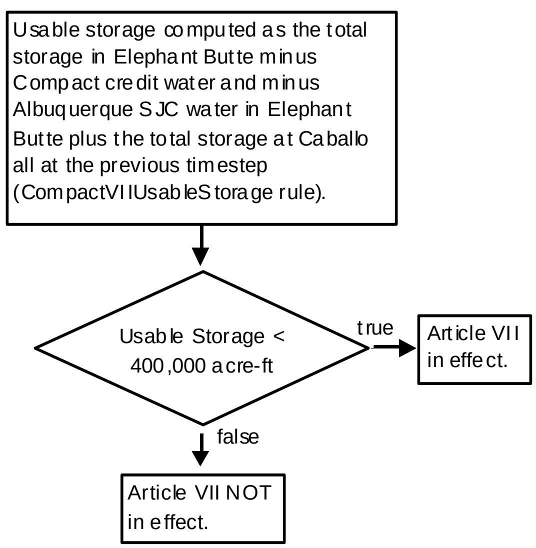


Figure 5.3. Flow Chart Depicting Check of Article VII Status

Review Comments

If model changes are made to allow contractor storage of San Juan-Chama Project water at Elephant Butte Reservoir to be exchanged later with native Rio Grande water in upstream reservoirs, the accounting set up should be set up with appropriate consideration for this water in the calculation of usable storage.

5.2. Relinquished Credits and Emergency Drought Water

Agreements have been made in the past where Compact credits are relinquished and allocations are made for storage of native Rio Grande water at El Vado Reservoir as Emergency Drought water when stipulations of Article VII of the Compact are in effect.

Policy is coded in the URGWOM ruleset to simulate relinquished Compact credits and the subsequent storage of Emergency Drought water. The current model assumption is that Compact credits will be relinquished annually on January 1st of each year during a model run if the Compact credit exceeds 100,000 acre-ft to reduce the credit to 70,000 acre-ft (SetRelinquishedNMCredits rule). Allocations for subsequent storage of Emergency Drought water at El Vado Reservoir are set in the UpdateEmergencyDroughtStorageAllocations rule to 1/3 of the relinquished credit for each of three purposes: MRGCD, ESA, and municipalities. Initial allocations for Emergency Drought storage, from past relinquished credits, can also be input. Allocations are tracked for the three separate purposes where any water in storage for the corresponding account contributes to the allocation. When water is released from a storage account established for one of the three purposes, the allocation has been used and is reduced.

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

Water for MRGCD is tracked in an MRGCDDrought account at El Vado reservoir and is used to meet the MRGCD demand when native Rio Grande water is no longer available to meet the MRGCD demand at Cochiti but before any of MRGCD's San Juan-Chama Project water would be used. Emergency Drought water for meeting targets is tracked in the SupplementalESA account at El Vado Reservoir and is used to meet targets before leased San Juan-Chama Project water in the Reclamation account at Abiquiu is used. A specific season for using SupplementalESA water can be defined; however, the entire calendar year is designated in the current model.

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

To not simulate relinquished credits, all values for the relinquished credit slot can simply be input as zero. If relinquished credits are not modeled, any Emergency Drought water in storage as an initial condition would still be used.

Review Comments

For actual Emergency Drought water tracked in the Accounting Model, allocations for storage of Emergency Drought are not filled on a daily basis based on inflows while in Article VII. Allocations are filled with many other considerations. The current model approach seems to be most appropriate for an actual modeling study, but as policy for Relinquished Credits and storage of Emergency Drought water continues to be reviewed with potential further agreements, more detailed policy for filling Emergency Drought storage for an allocation could potentially be coded that more closely reflects the actual accounting.

Modeling alternate assumptions about the timing and magnitude for relinquished Compact credits could be accomplished with some very simple changes to the rules, but the current rules are coded for a specific calculation as the difference in the Compact credit and 70,000 acre-ft.

5.3. Storage and Release of Native Rio Grande Water

If the stipulations of Article VII of the Compact *are in effect*, inflows of native Rio Grande water will be bypassed after water has been stored to meet the computed P&P storage requirement as discussed in section 2.1.1 and water has been stored to fill any allocated space for Emergency Drought water as a result of relinquished Compact credits. Releases from storage may include the release of any available native Rio Grande water needed to meet the MRGCD demand and the computed release of P&P water as needed. Emergency Drought water may be released from storage to meet the MRGCD demand or for target flows in the Middle Valley. Also, any water in storage for P&P needs that is determined to not be needed based on the updated monthly P&P storage requirement will be evacuated.

If Article VII *is not in effect*, native Rio Grande water will be stored at El Vado Reservoir as not needed to meet the MRGCD demand to ultimately fill the reservoir to a target elevation by a target date. During a calendar year, all available native Rio Grande inflows are stored *during the runoff*, prior to the May 25th input target date, until the storage reaches <u>65% of the storage</u> corresponding with that target elevation. This input value of 65% of the target storage yields an elevation of 6878.35 which approximately matches the elevation at the crest of the spillway gates. A computed percentage of native Rio Grande inflows are bypassed thereafter, as set with the SetPercentRGRelease rule, such that the reservoir will reach the target fill date on May 25th based on forecasted inflows. The magnitude of the release while Article VII is in effect is also set with consideration for any needed release of Emergency Drought water for targets and any release from P&P storage.

After the reservoir has filled, water will be gradually evacuated to target the input elevation of 6879 on December 1st <u>if Article VII is not in effect</u>. This operation entails evacuating water as needed before the winter to prevent icing on the spillway gates but is not implemented if Article VII is in effect with the assumption that all water in storage should be retained as possible if Article VII is in effect. Also, storage of San Juan-Chama project water is not evacuated even if the pool elevation exceeds this target winter pool elevation. Refer to Figure 5.4 for the input target dates and pool elevations referenced for setting El Vado releases when Article VII is not in effect. A flowchart that depicts the logic for setting the release of native Rio Grande water from El Vado Dam is shown in Figure 5.5.

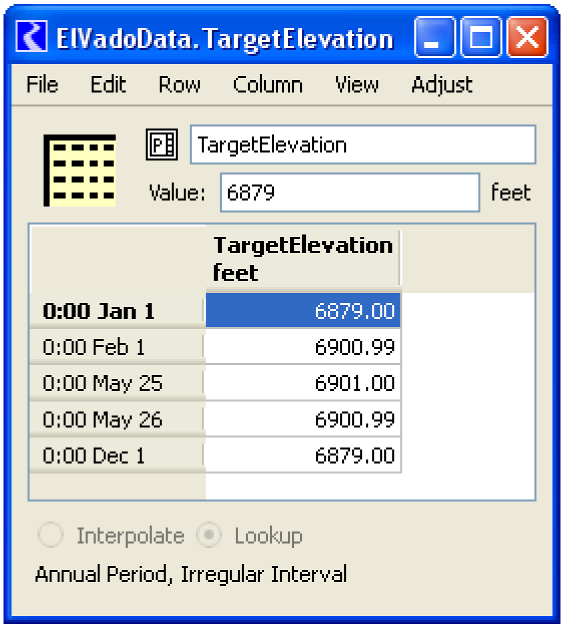


Figure 5.4. ElVadoData.TargetElevation Periodic Slot – when Article VII NOT in Effect

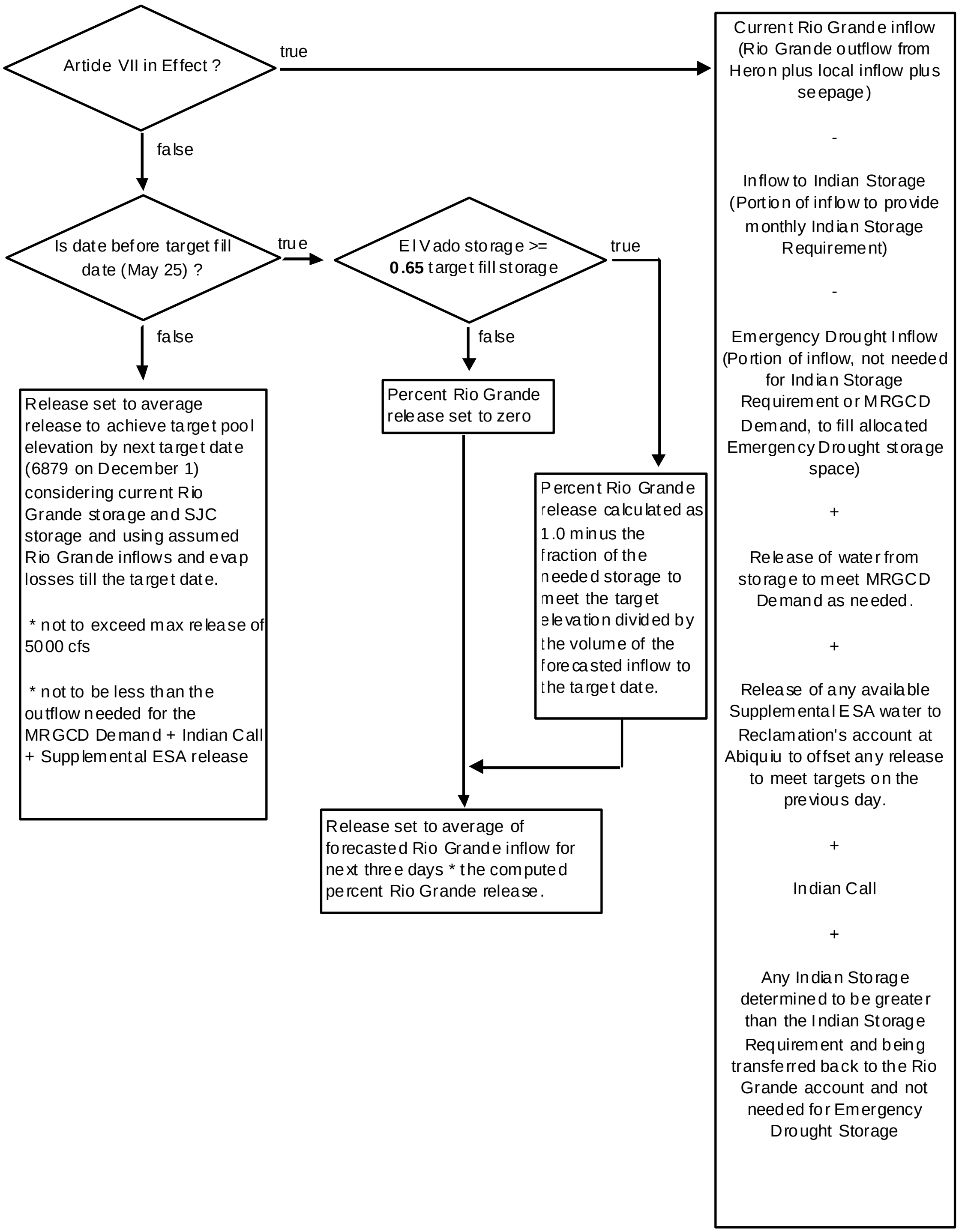


Figure 5.5. Flow Chart with Logic to Set Release of Rio Grande Water from El Vado

Review Comments

When Article VII is not in effect and water is stored during the runoff, a clear goal is to be able to fill El Vado Reservoir but also prevent El Vado from filling too early such that operations to keep the pool elevation below the maximum pool elevation do not conflict with operations to maintain flows below El Vado Dam below the channel capacity. The current approach has clearly been refined from past applications and appears to work well. The approach is also flexible in that model users can adjust the input target fill date if needed. The elevation to begin bypassing a percent of the inflows (i.e. the input percentage used to identify the storage as a percent of full when a portion of inflows are bypassed) could also be adjusted easily. This flexibility is particularly valuable for Water Operations Model runs where more precision is desired for representing operations. This approach could be more transparent if the percentage of full storage to begin bypassing a portion of inflows was just input as a specific elevation instead.

While the current approach may be adequate, some alternate approaches for filling El Vado Reservoir could be used that would assure El Vado Reservoir fills while also minimizing the amount of time that El Vado is full while also keeping flows below El Vado under the channel capacity. Alternative policy could include an estimate for the timing of the peak inflow; although, the timing for a peak can be estimated with much better accuracy in the model than can be accomplished in actual operations, so the approach should reflect the actual uncertainty and difficulty with timing the filling of the reservoir. As an example, a potential alternate approach may be to allow El Vado to almost fill but not completely fill until after the peak has passed. Then, the reservoir could be filled on the falling limb of the runoff hydrograph before the flows drop so low that all flows are needed to meet downstream demands. Reclamation has been reviewing El Vado operating procedures as this URGWOM ruleset review was being completed, so Reclamation may have some specific suggestions at a later date for editing coded policy for El Vado operations (Sharp, 2010).

Policy for evacuating water from El Vado Reservoir before the winter could potentially be deleted since heaters are now installed to prevent icing on the gates, but the operation is still included in the model to reflect standard operating procedures that are still in place.

5.3.1. Article VIII of the Compact

URGWOM is set up to model El Vado Dam releases that would be made based on a call by Texas per Article VIII of the Compact which essentially states that Texas may call for a release, starting in January, of water in storage from post-Compact reservoirs to the amount of an accrued Compact debt to bring the usable storage up to 600,000 acre-ft. A switch is included that allows for this aspect of policy to be turned on or off for a simulation. A threshold debt for when a call would actually be made is include which is currently set to -20,000 acre-ft based on the assumption that Texas would not actually make a call until the debt accrued to exceed 20,000 acre-ft. Releases are set to a computed average rate to release the volume equal to the Compact debt over an input period defined as the Article VIII release season in the model, but no release will be made if there is no RioGrande water in storage.

Review Comments

This aspect of operations was identified as a needed component in the URGWOM ruleset as part of the interagency modeling work for the PHVA work group of the Collaborative Program. Based on simulations completed with the Planning Model using the five synthetic hydrologic sequences, releases per Article VIII are only triggered a couple times in the fifty years of simulation from those runs. For the wetter sequences, a Compact debt accrues, but usable storage is generally already over 600,000 acre-ft, so releases are not triggered. In the drier sequences, usable storage is generally less than 600,000 acre-ft but no water is available at El Vado to release when a Compact debt has accrued.

There is a narrow window between a usable storage of 400,000 acre-ft when Article VII is not in effect and native Rio Grande water would be stored at El Vado and a usable storage of 600,000 acre-ft when a release per Article VIII of the Compact would then not be triggered. When there is a Compact debt, usually, either usable storage is already over 600,000 acre-ft or there is no native Rio Grande water in storage at El Vado Reservoir to release because usable storage has been below 400,000 acre-ft. This operation has not occurred much historically and no detailed records have been located on exactly how operations are conducted, but the PHVA work group agreed that the results match the expected frequency that the operations would occur and the rules correctly represent this aspect of operations and assure the impact is included for analyses completed with URGWOM.

VI. Abiquiu Operations

Operations at Abiquiu Reservoir are driven primarily by passthrough water being delivered from upstream and releases of San Juan-Chama Project water from storage at Abiquiu as needed for Albuquerque's demand for surface water diversions, Albuquerque letter water deliveries, and letter water deliveries for other contractors. Reclamation's leased San Juan-Chama Project water may also be released from storage for target flows in the Middle Valley. Refer to Figure 6.1 for a schematic of the initial calculation for the release of San Juan-Chama Project water as computed with the ComputeAbiquiuSJRelease rule.

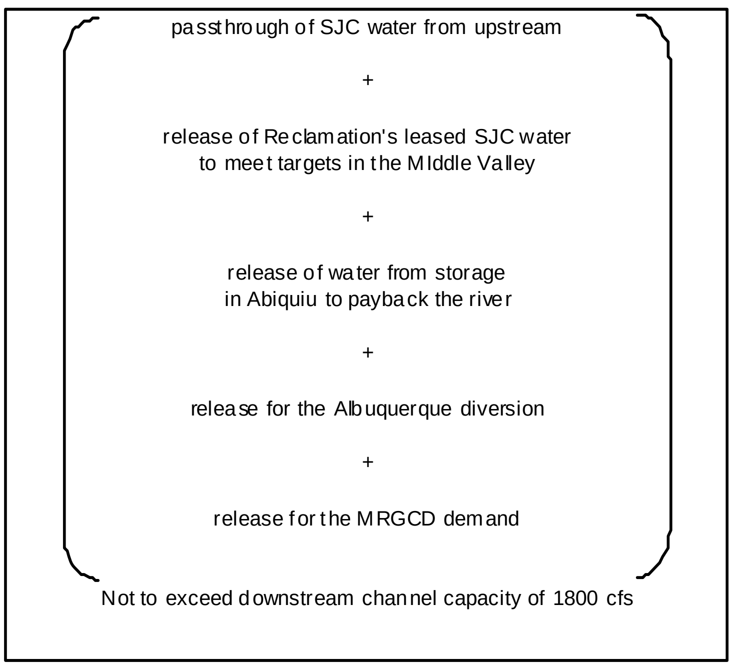


Figure 6.1. Components of Initial Total Release of SJC Water from Abiquiu Reservoir

Operations at Abiquiu Dam are controlled by a channel capacity of 1800 cfs below Abiquiu Dam. Native Rio Grande water may be stored if needed for flood control operations. Policy for potentially locking in this water as carryover storage is included in the URGWOM ruleset along with policy for representing stepped releases. Refer to Figure 6.2 for a flow chart that shows the steps for setting an initial total outflow, checking that total release against different operational constraints, and setting the accounting supplies.

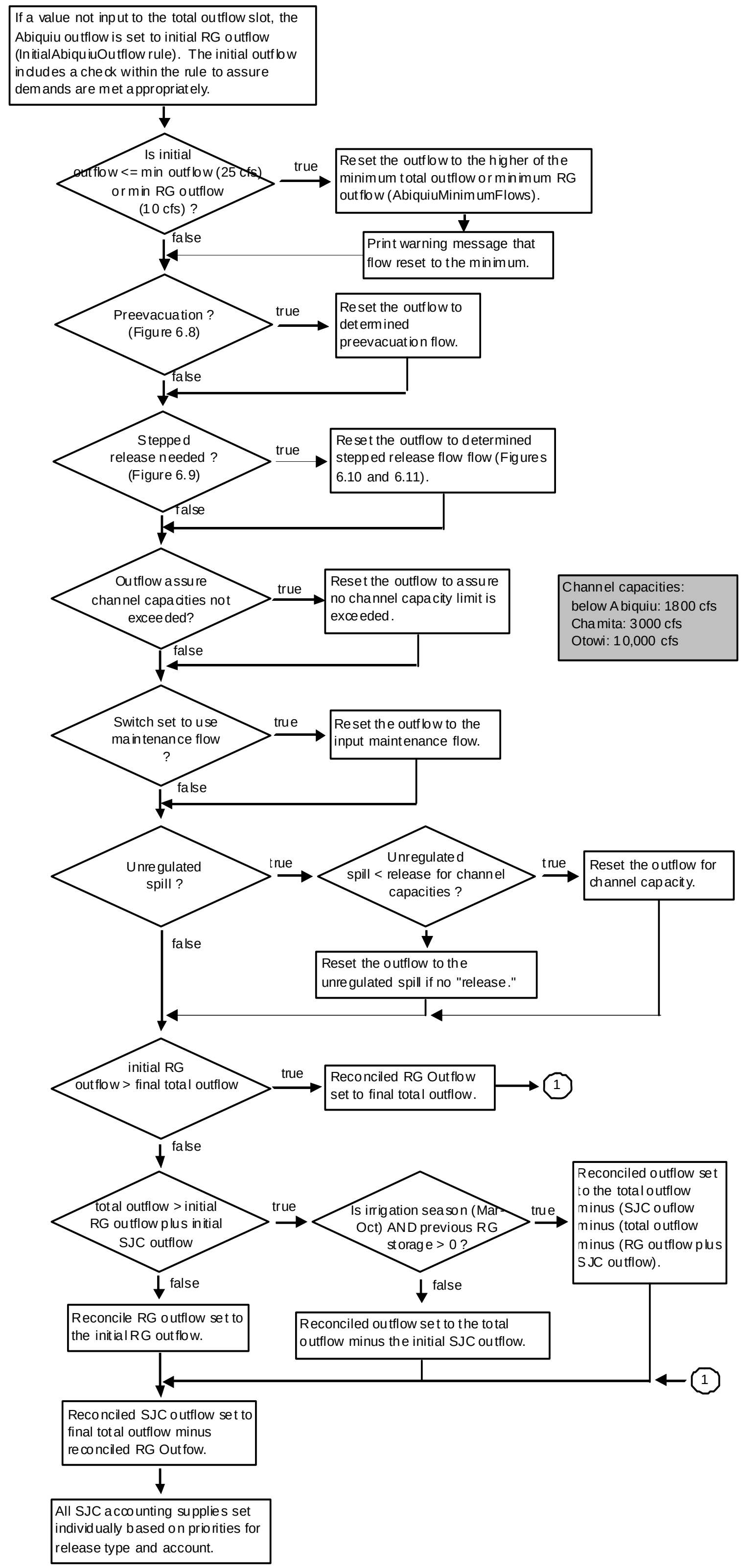


Figure 6.2. Flow Chart Depicting Computation of Initial Abiquiu Outflow, Check Operational Constraints, Calculated Reconciled RG and SJC Outflow, and Final Step to Set Accounting Supplies

Review Comments

Releases are made from Abiquiu Reservoir to assure the MRGCD demand is met. If inflows to Abiquiu Reservoir are not sufficient to provide the MRGCD demand, small amounts of MRGCD San Juan-Chama Project water will be released from Abiquiu Reservoir to assure the specific estimated demand at Abiquiu is met. The impact of this operation is very small but does result in a small amount of MRGCD San Juan-Chama Project water at Abiquiu being used to meet the demand when native Rio Grande water at El Vado Reservoir is the primary source for meeting the demand.

Releases of San Juan-Chama Project water are not made when Abiquiu Reservoir is under flood control operations and releases are controlled by downstream channel capacities. An exchange could be set up to allow Albuquerque to divert native Rio Grande water during these periods and payback the river with their San Juan-Chama Project water at a later date; however, such an operation is not currently set up in URGWOM.

6.1. Storage and Release of Native Rio Grande Water

Native Rio Grande water is bypassed at Abiquiu Reservoir. Any incidental content that results from storage for flood control operations will be evacuated as possible if that water is not locked in as carryover storage. Refer to Figure 6.4 for a flow chart that depicts the storage adjustment for any incidental content when setting the release of Rio Grande water. Rio Grande water in Abiquiu Reservoir as carryover storage is released at an average rate from November through March and this release is subtracted for the computation of the incidental content to be evacuated per the Rio Grande storage adjustment computation. Refer to Figure 6.3 for a flow chart that depicts how the outflow of Rio Grande water is computed with consideration for any reregulation (or conservation) storage, if reregulation storage is being modeled (Reference the ComputeAbiquiuRGRelease rule).

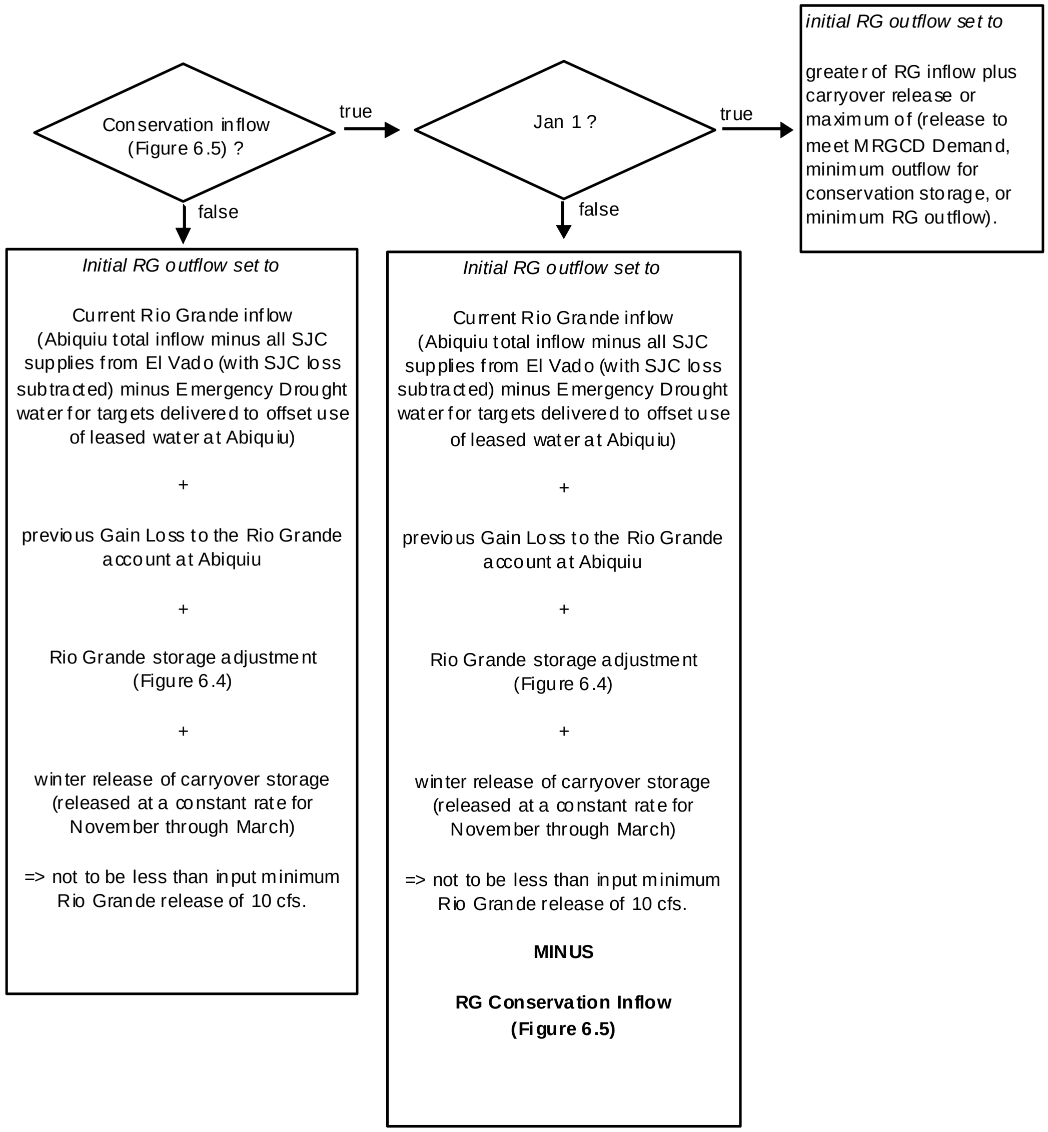


Figure 6.3. Flow Chart with Logic to Set Release of Rio Grande Water from Abiquiu

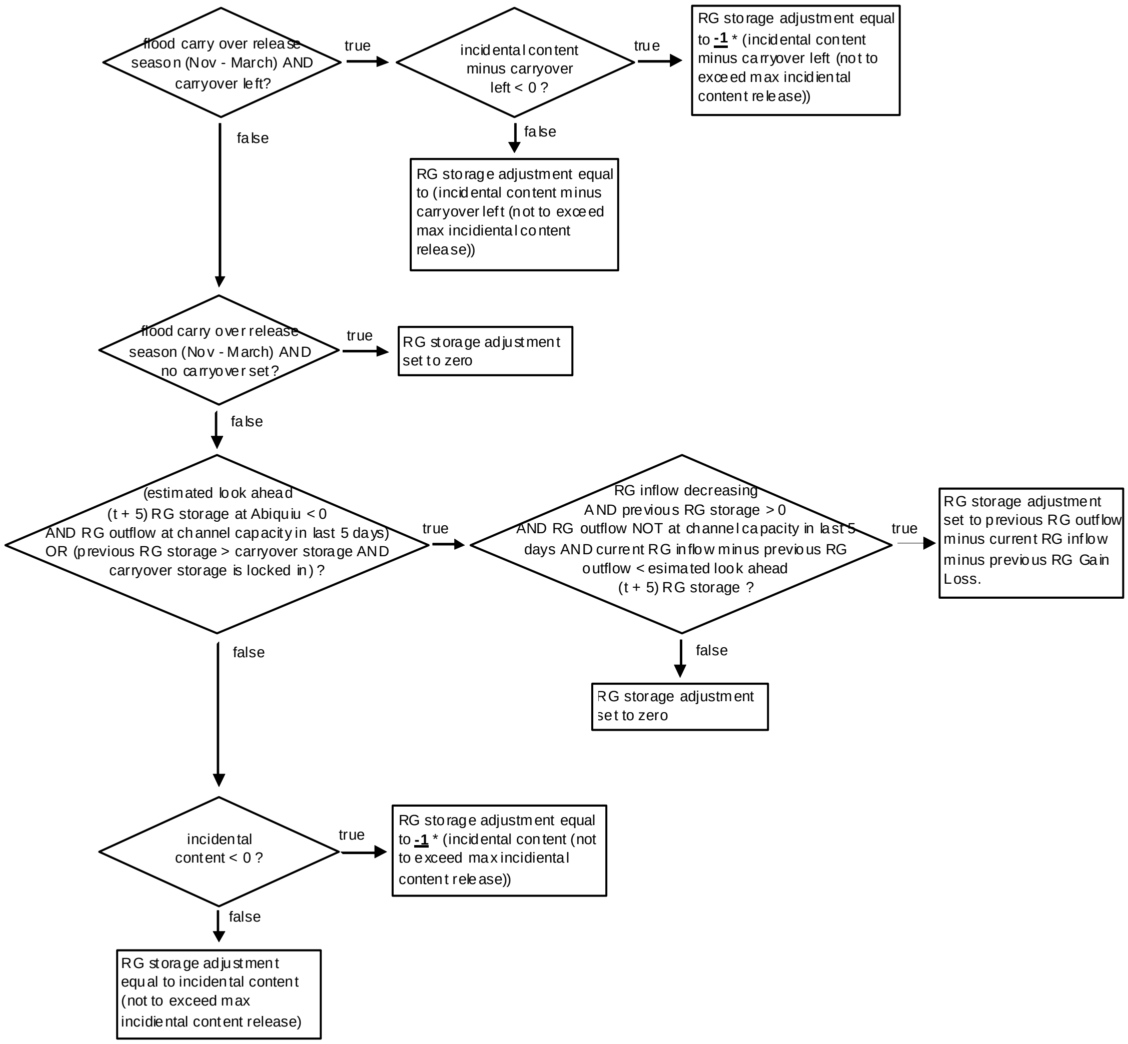


Figure 6.4. Flow Chart of Logic for Adjustment to Rio Grande Storage at Abiquiu

6.1.1. Reregulation Storage

Reregulation storage (referred to as Conservation storage within the model) at Abiquiu is not currently authorized but has been modeled with URGWOM for planning studies. Reregulation storage entails allowing storage at Abiquiu Reservoir above the current maximum easement pool elevation of 6220 ft. If the total storage with reregulation storage was to be increased for a study, this maximum easement pool elevation would be increased in the model.

Reregulation storage essentially allows storage of native Rio Grande inflows not needed to meet the MRGCD demand as tracked with a separate Rio Grande Conservation storage account on the Abiquiu object in URGWOM. Refer to Figure 6.5 for a flowchart that shows how the inflow to reregulation storage is set in the model with the SetAbiquiuRGConservationAccount rule. Reregulation storage is then released as needed for target flows in the Middle Valley and used before Reclamation's leased San Juan-Chama Project water (based on current input account priorities for Abiquiu). Reregulation storage still in Abiquiu Reservoir at the end of the year is completely evacuated at a computed constant rate (Past studies have also entailed using alternate coded policy to only evacuate reregulation storage as needed to keep the Compact credit whole).

Review Comments

Reregulation storage at Abiquiu Reservoir is hypothetical and is not currently authorized by the Corps. Assumptions for reregulation storage should be reviewed for any future study, but all the accounts and rules are in place now to model scenarios that include reregulation storage. Reregulation storage at Cochiti Reservoir is currently simulated as part of Cochiti deviations as discussed in section 7.2, and the URGWOM Tech Team is working on setting up URGWOM to simulate potential reregulation storage at Jemez Reservoir.

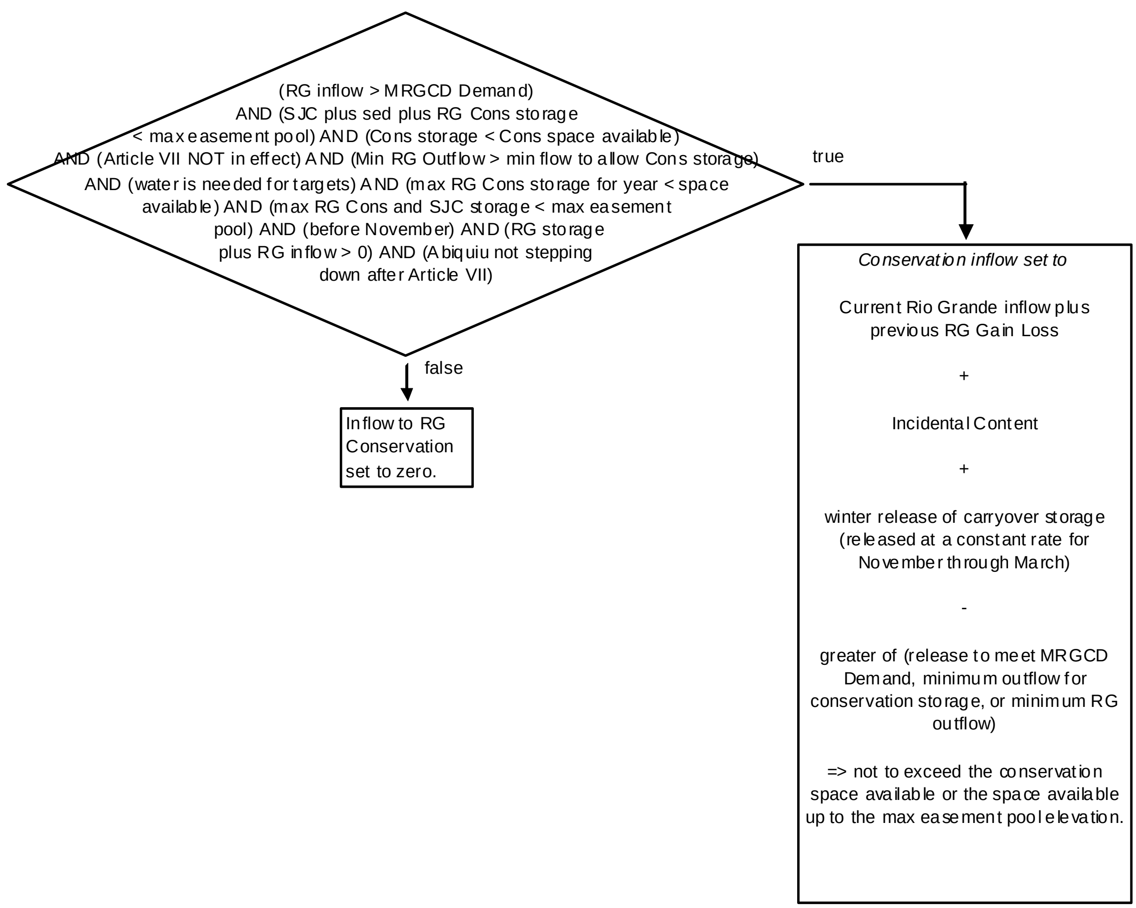


Figure 6.5. Flow Chart for Calculation of Inflow to Reregulation Storage at Abiquiu

6.1.2. Carryover Storage

Water will be stored at Abiquiu as needed to assure the downstream channel capacities are not exceeded as input to the AbiquiuData.ChannelCapacities table slot. The capacity immediately below Abiquiu Dam is input as 1800 cfs, and the capacities at Chamita and Otowi are 3000 and 10,000 cfs, respectively. The incidental content stored at Abiquiu Reservoir during flood control operations will be subsequently released as possible. This adjustment is made with the logic included in the Rio Grande storage adjustment calculation depicted by the flow chart in Figure 6.4. Any water still in storage after July 1st and after the flow at Otowi drops below 1500 cfs is tagged as carryover storage and will be retained through the irrigation season.

Logic for locking in storage includes a five-day look ahead at conditions with the goal of locking in storage at Abiquiu Reservoir as opposed to Cochiti Reservoir if carryover storage is imminent. Refer to Figure 6.6 for the logic used for the look ahead check and Figure 6.7 for the logic used for the lock in assignment for the current timestep (AbiquiuLockedIn rule). Carryover storage is subsequently released starting in November at an average rate to evacuate the carryover storage by the end of March, unless a carryover release rate is input.

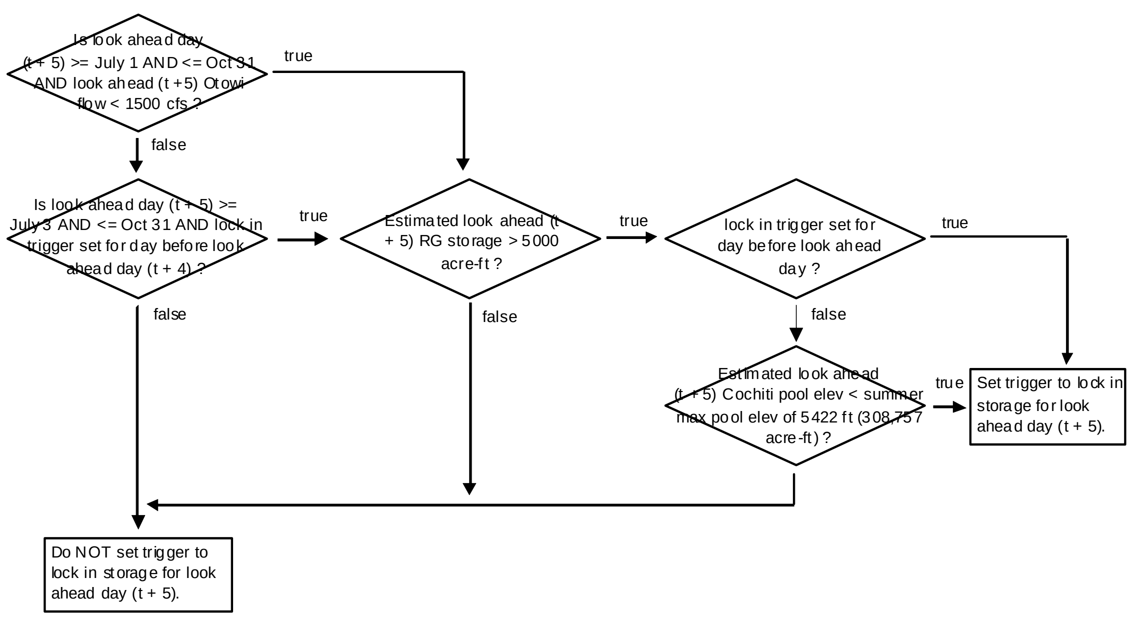


Figure 6.6. Flow Chart Depicting Look Ahead Check to Lock In Carryover Storage

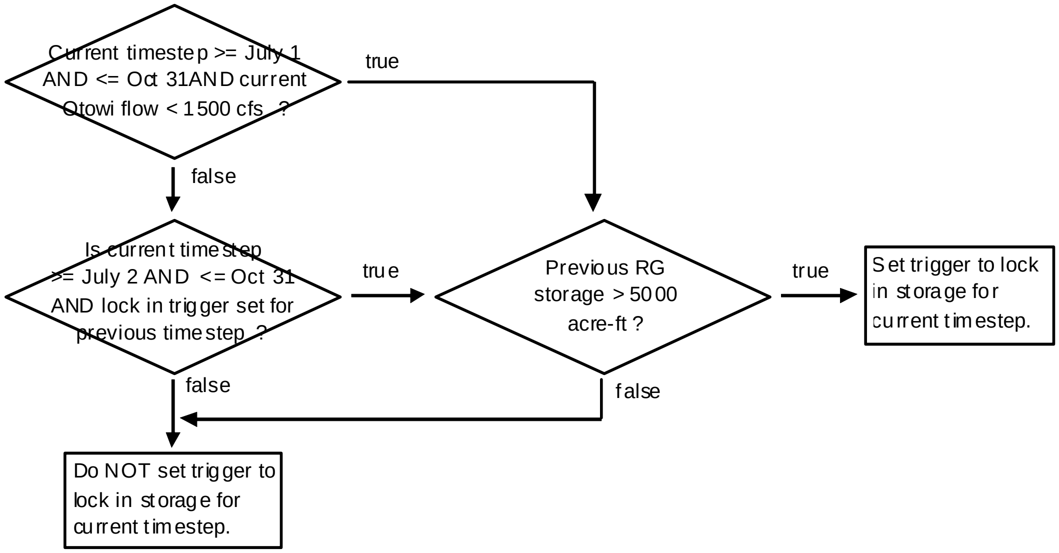


Figure 6.7. Flow Chart Depicting Current Timestep Check to Lock In Carryover Storage

Review Comments

Carryover storage is usually not an issue for operations. For simulations completed with the five 10-year synthetic hydrologic sequences, storage is only locked in as carryover storage three times for the fifty years of simulation, and the current rules appear to be effective at locking in carryover storage at Abiquiu Reservoir as opposed to Cochiti Reservoir.

6.1.3. Preevacuation Releases

Rules are coded for preevacuation of water in storage at Abiquiu Reservoir if the forecasted inflow would result in the storage level at Abiquiu Reservoir exceeding 6280 ft with consideration for additional storage in available space at El Vado Reservoir below the maximum El Vado pool elevation. Refer to Figure 6.8 for a flow chart that shows the current logic for potentially setting a preevacuation release (AbiquiuPreEvacuation rule).

Review Comments

For simulations completed with the five 10-year synthetic hydrologic sequences, conditions never result in a preevacuation release based on the coded policy. The Corps is currently working with the Tech Team to edit the rule slightly, but it is anticipated that this aspect of policy would rarely affect operations.

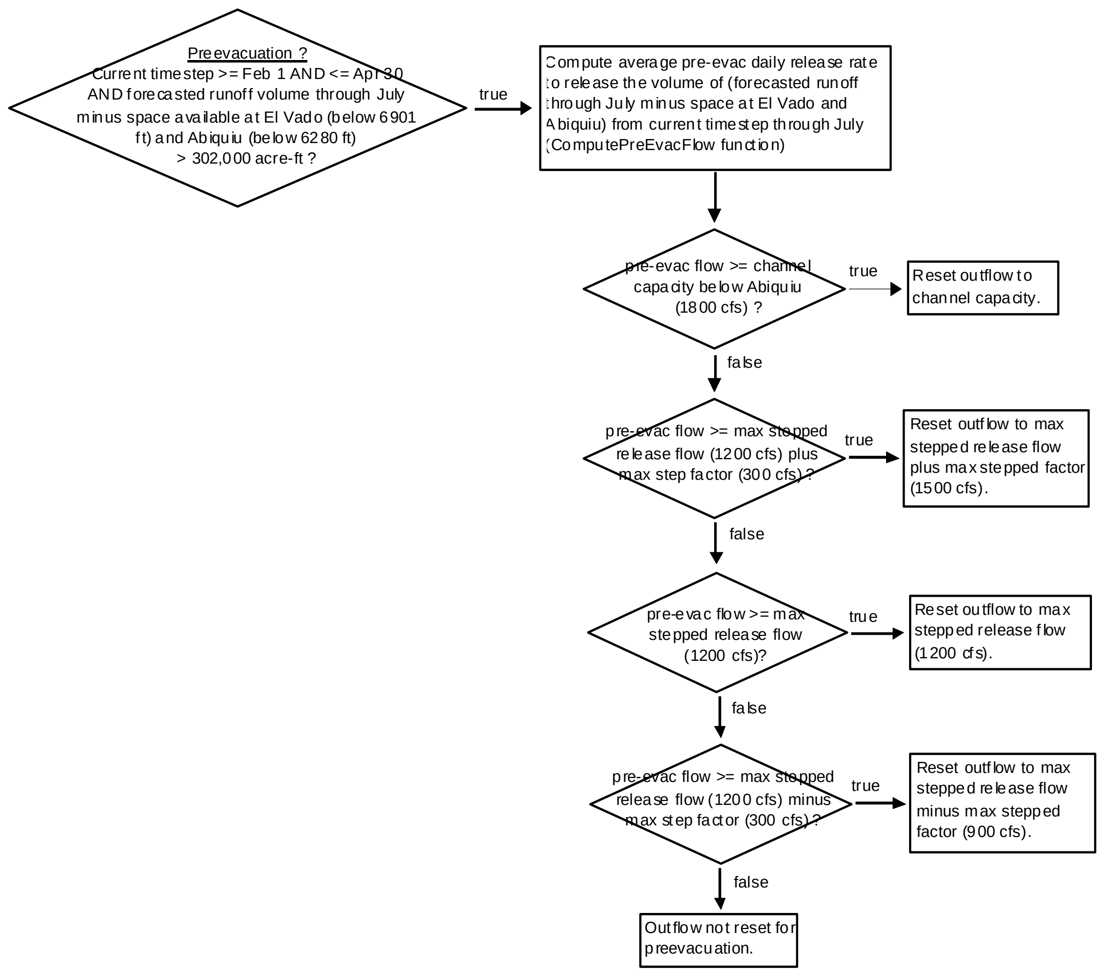


Figure 6.8. Flow Chart with Logic for Setting Abiquiu Preevacuation Releases

6.1.4. Stepped Releases

Operations for Abiquiu Reservoir include stepped releases to control the rate of change in downstream flows (AbiquiuSteppedRelease rule). Policy is coded for stepped releases as shown in Figures 6.9, 6.10, and 6.11. Note that the exact same policy, but potentially different inputs and stepped release factors, are also applied at Jemez and Cochiti.

Review Comments

Stepped releases may control the Abiquiu outflow for a day or two for some instances where the runoff is increasing or decreasing at a significant rate or there is a sudden change in the modeled downstream demand. The Corps is currently working with the URGWOM Tech Team on some potential edits to the rule such that the implemented adjustments are accurate, but the effect of stepped releases at Abiquiu on model results is fairly small.

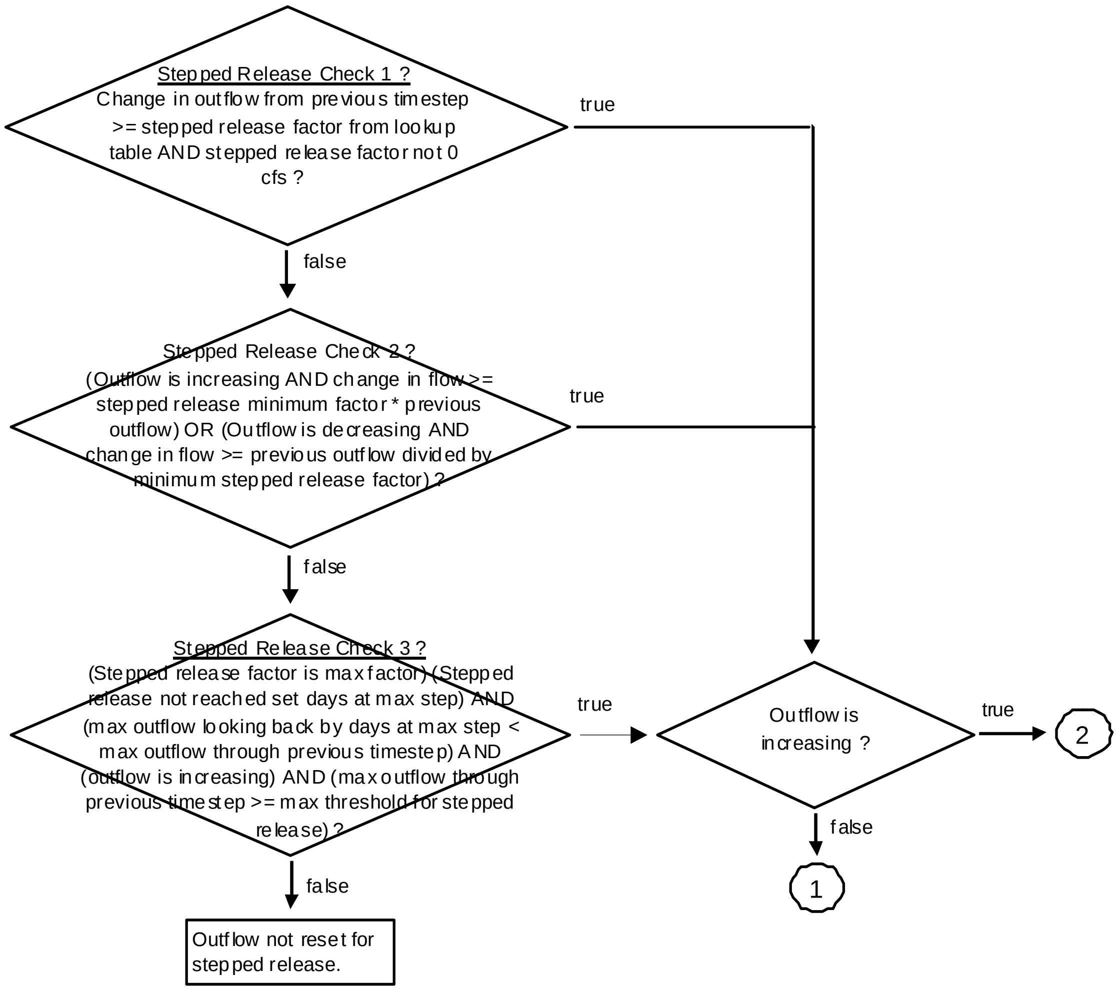


Figure 6.9. Flow Chart Depicting Checks for whether Stepped Release Needed

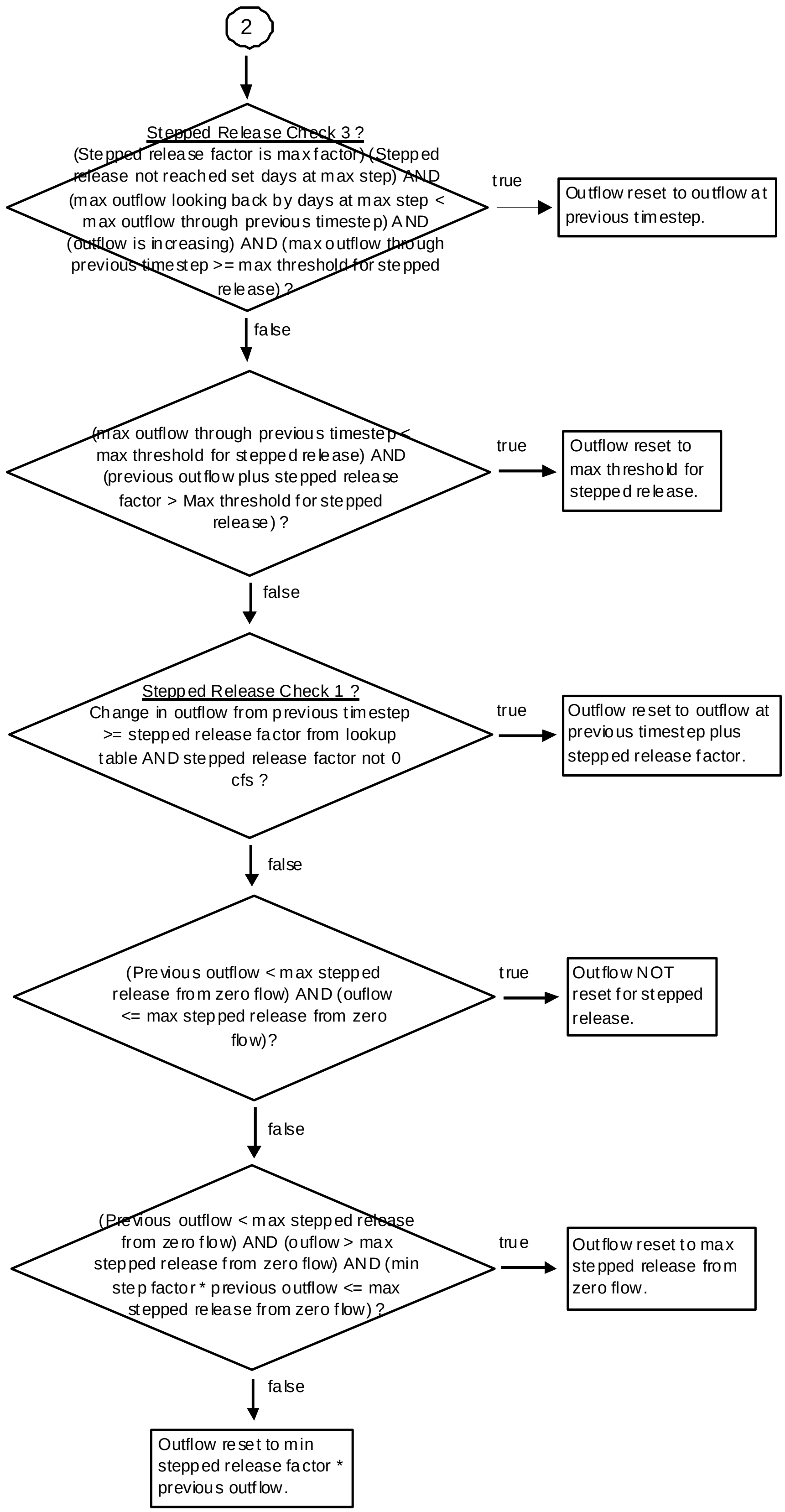


Figure 6.10. Flow Chart for Calculation of Stepped Release when Outflow is Increasing

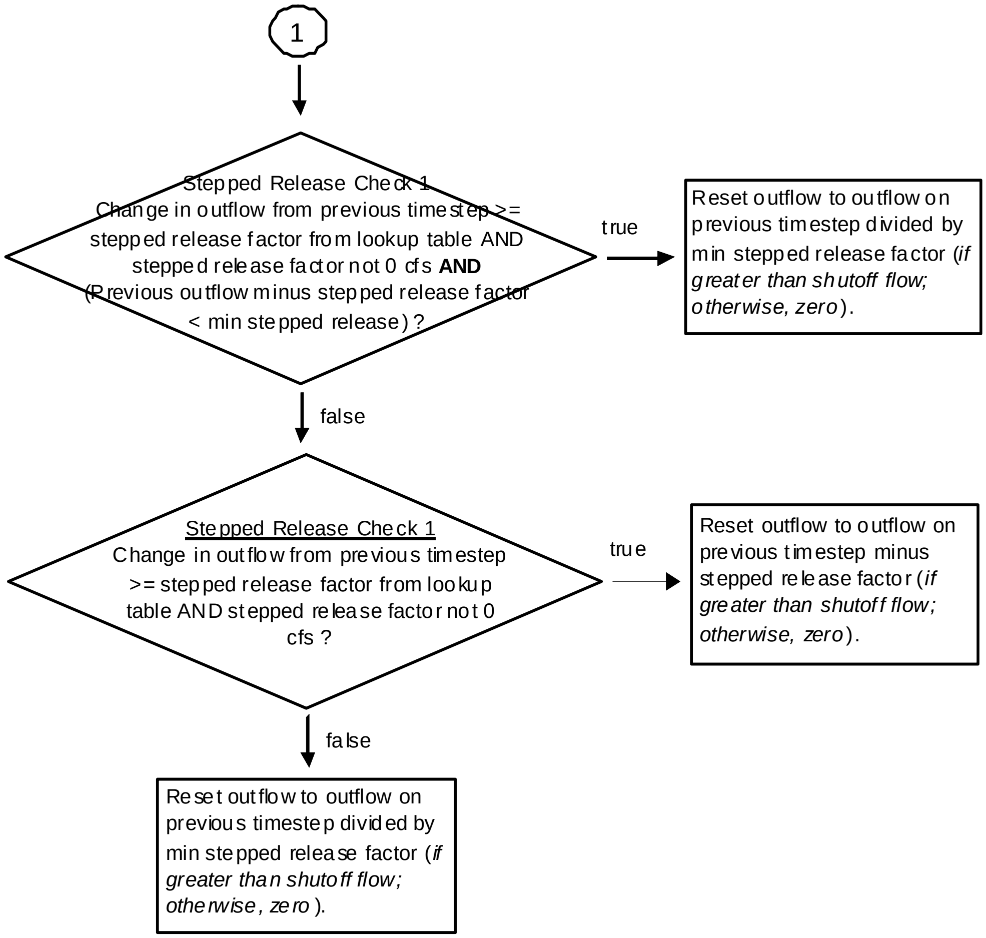


Figure 6.11. Flow Chart for Calculation of Stepped Release when Outflow is Decreasing

VII. Cochiti and Jemez Operations

Inflows are bypassed at Cochiti Dam unless channel capacities or other operational constraints result in storage, or reregulation storage occurs as part of Cochiti deviations. San Juan-Chama Project water released from upstream is bypassed at Cochiti Dam with passthrough accounting supplies set accordingly. An initial release from Cochiti is actually computed as the outflow to maintain the current Cochiti Rec Pool storage and any reregulation storage plus any inflows to these accounts. That initial determined outflow is adjusted for incidental content (Figure 7.2) and any needed release from reregulation storage for Cochiti deviations targets (Figure 7.6). Inflows are bypassed at Jemez Dam unless storage is needed for channel capacity restrictions through coordinated operations with Cochiti Dam.

Channel capacities below Cochiti Dam include a channel capacity of 7000 cfs at Central and a channel capacity of 5000 cfs at San Marcial. Stepped releases may be implemented using the same logic applied at Abiquiu Dam (Figures 6.9, 6.10, and 6.11). Operations at Cochiti and Jemez may be adjusted to assure balanced operations for the channel capacity at Central as discussed further in section 7.1. Reregulation storage of native Rio Grande water may occur if Cochiti deviations are implemented to provide recruitment flows or overbank flows as discussed in section 7.2. Refer to Figure 7.1 for a flowchart that depicts the logic for setting an initial outflow for Jemez and Cochiti Dams, checking the releases against operational constraints, computing reconciled Rio Grande outflows, and setting accounting supplies.

Review Comments

The following comment primarily pertains to the coding approach. For the Cochiti rules, the carryover release is reflected in the storage adjustment for incidental content where the incidental content is reset each day based on a carryover left volume set based on a computed carryover release rate; whereas, for Abiquiu, a carryover release is included in the calculated outflow and the storage adjustment is only for other incidental content. It would probably be more accurate to just add the carryover release into the Initial Cochiti outflow function and let the storage adjustment function represent the storage adjustment for any other incidental content; although, the release is being computed correctly with the current approach.

The computation for an initial outflow of San Juan-Chama Project water should include an adjustment for any storage of San Juan-Chama Project water that occurs due to operational constraints. The impact of storage on these passthrough accounts is negligible, but it should be included in the initial computation. This adjustment is included when setting the accounting supplies.

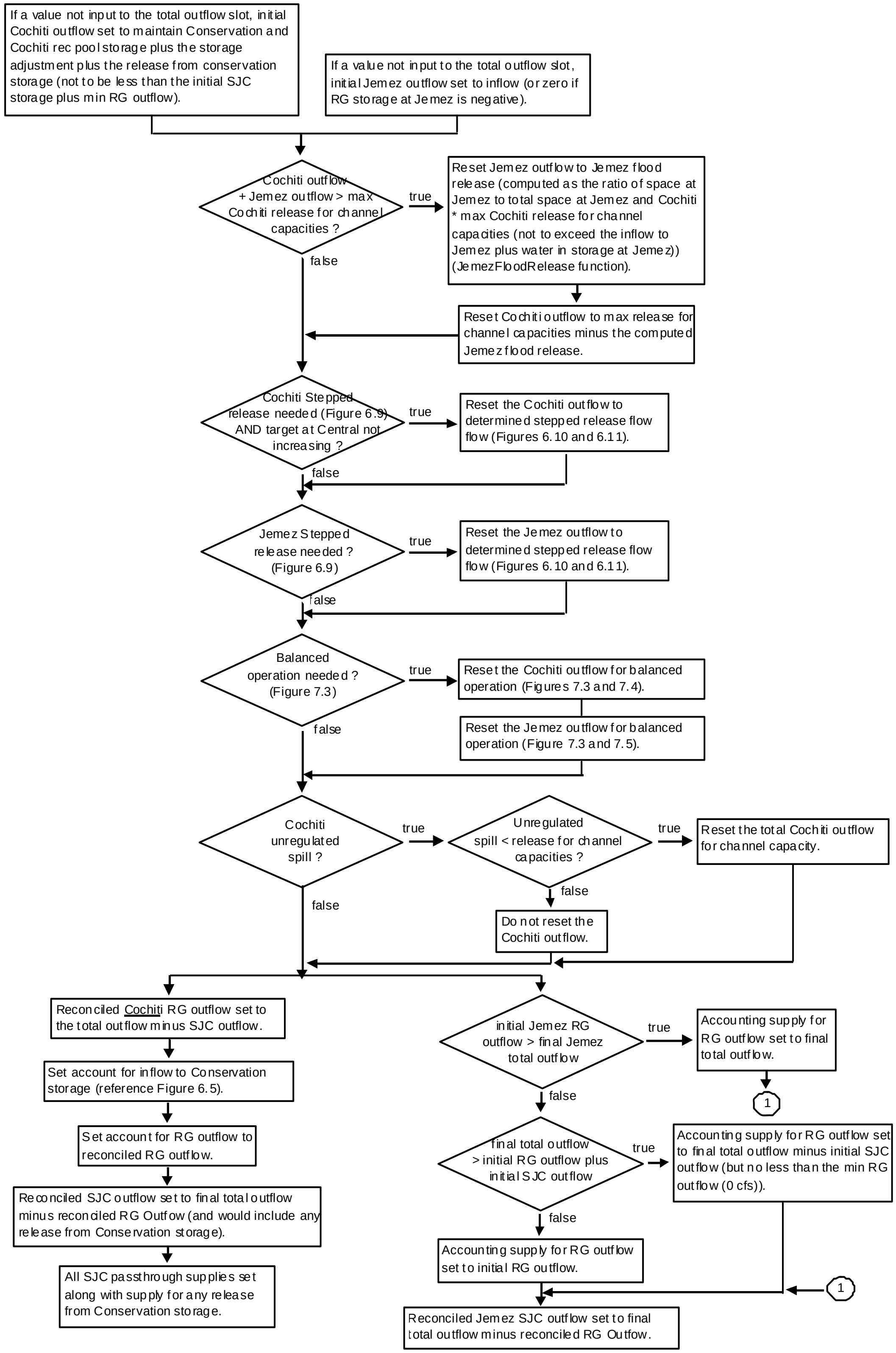


Figure 7.1. Flow Chart Depicting Computation of Initial Cochiti Outflow, Check against Operational Constraints, Calculated Reconciled RG and SJC Outflow, and Final Step to Set Accounting Supplies

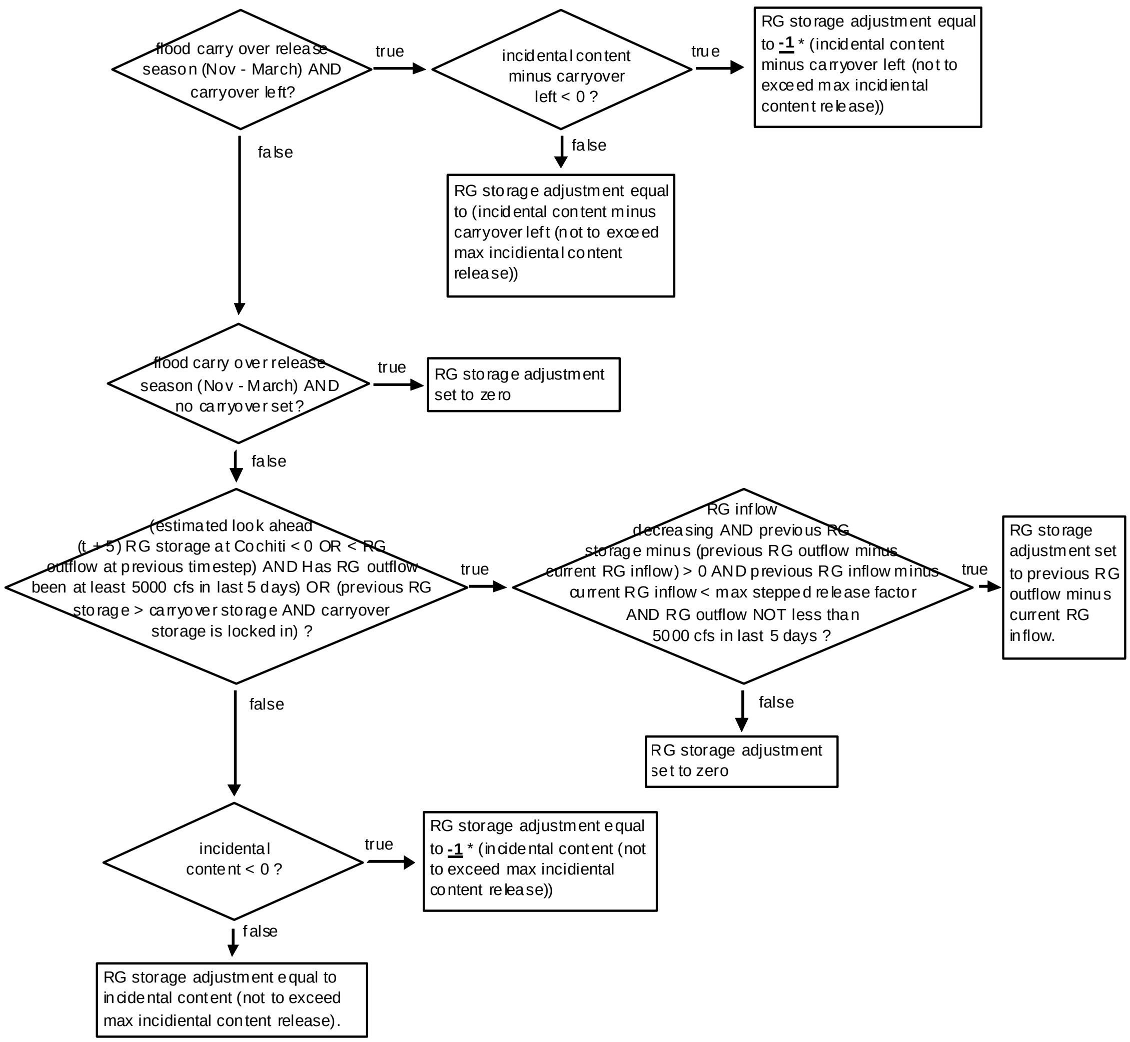


Figure 7.2. Flow Chart of Logic for Adjustment to Rio Grande Storage at Cochiti

7.1. Cochiti and Jemez Balanced Operations

Releases from Cochiti Dam and Jemez Dam may be adjusted as needed for the channel capacity at Central as part of “balanced operations” if the available flood storage space is more than 50 percent used at both Cochiti and Jemez. The available flood storage space at Cochiti is based on the space between the hold pool and an elevation of 5455.63 ft, which is the reservoir level when 7000 cfs would flow over the spillway. The available flood storage space at Jemez is based on the space between the sediment pool elevation of 5196.7 ft and the top of the flood pool at 5232.0 ft. Subsequently, the outflow may be reset depending on which reservoir has more space available. Refer to Figures 7.3, 7.4, and 7.5 for a full illustration of the logic used to potentially reset the outflow from each reservoir for balance operations (CochitiWCMBalancedRelease).

Review Comments

Balanced operations very rarely would affect releases at Cochiti and Jemez Dams, and the effect on model results is fairly small, but the developed flowcharts should help with the review of this operation in the event that such a wet condition would occur. This aspect of policy never controls the dam releases in Planning Model runs completed with the five 10-year synthetic hydrologic sequences.

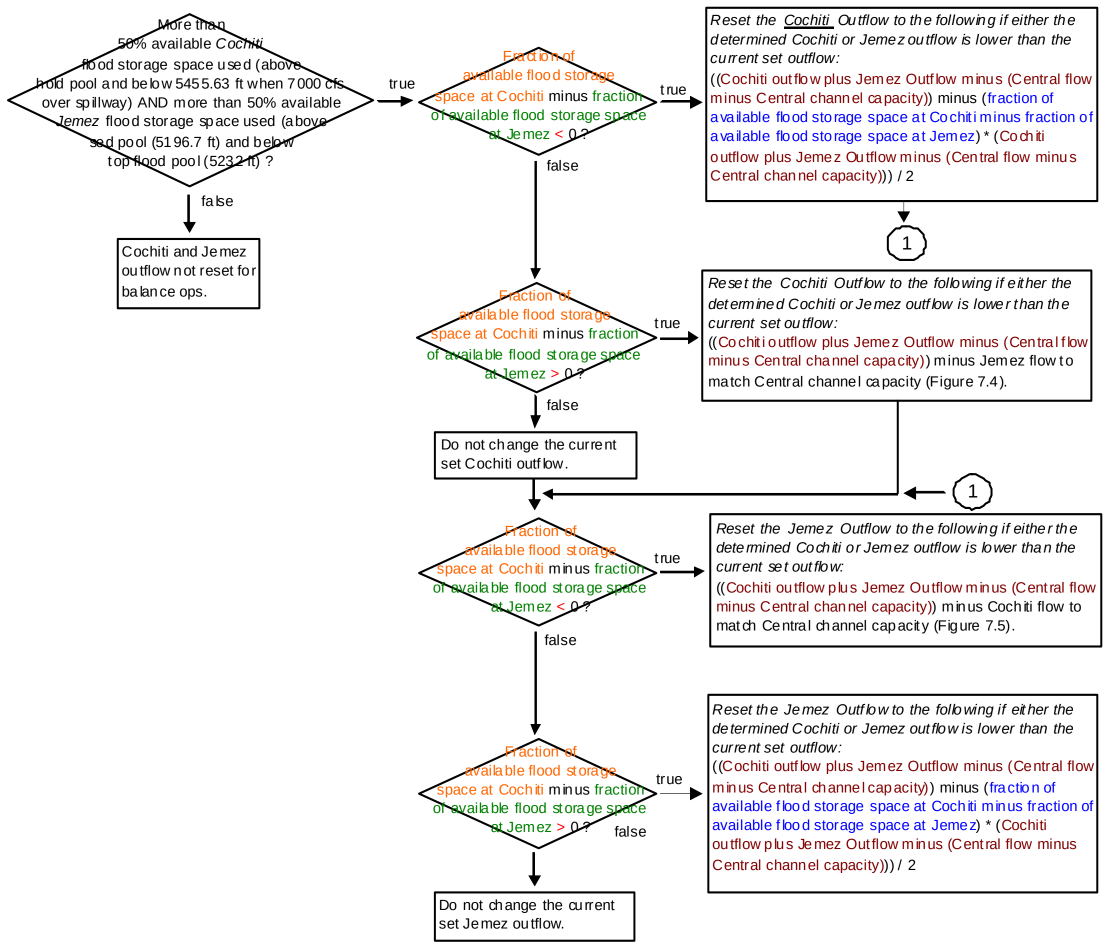


Figure 7.3. Flow Chart with Logic for Setting Cochiti and Jemez Balanced Operations

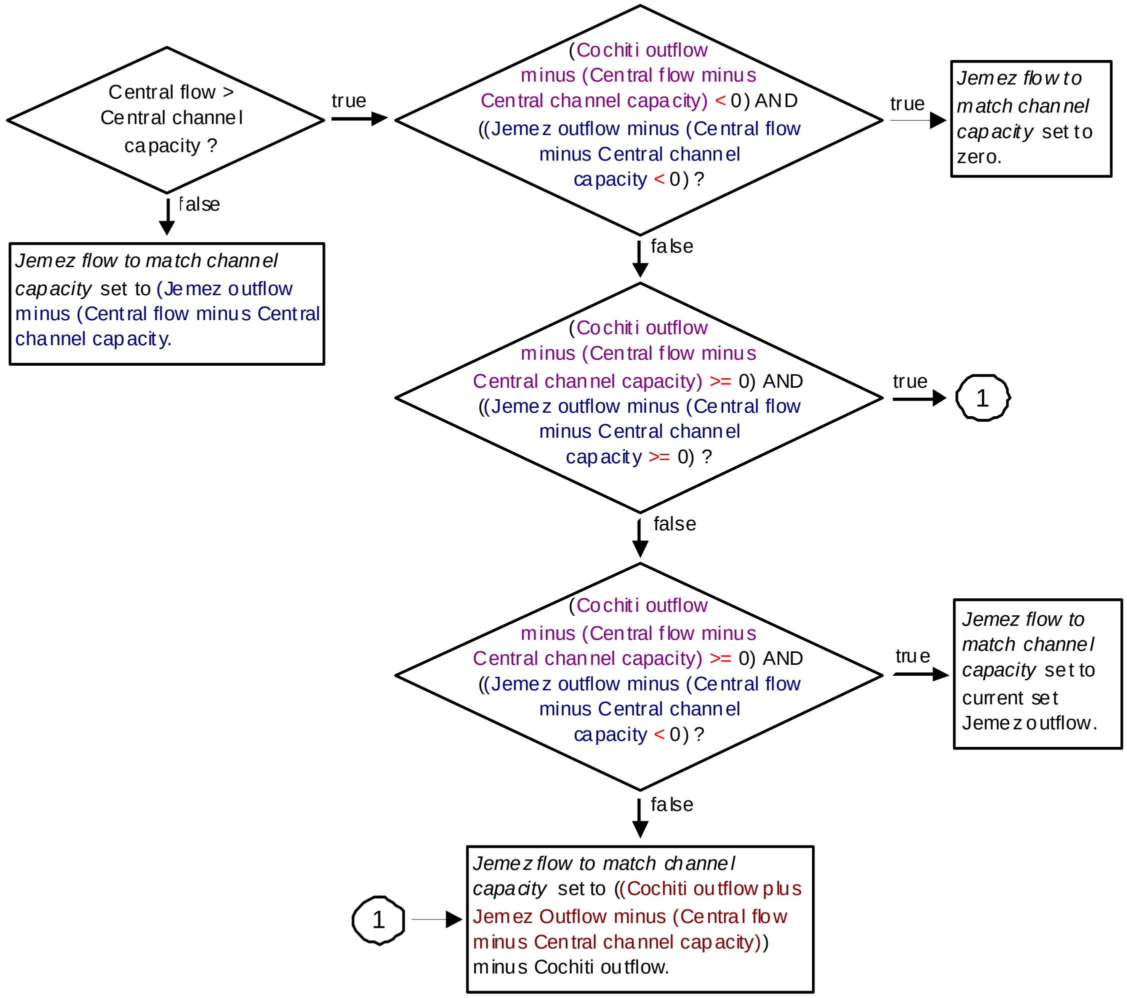


Figure 7.4. Flow Chart for Setting Jemez Flow for Channel Capacity – Balanced Ops

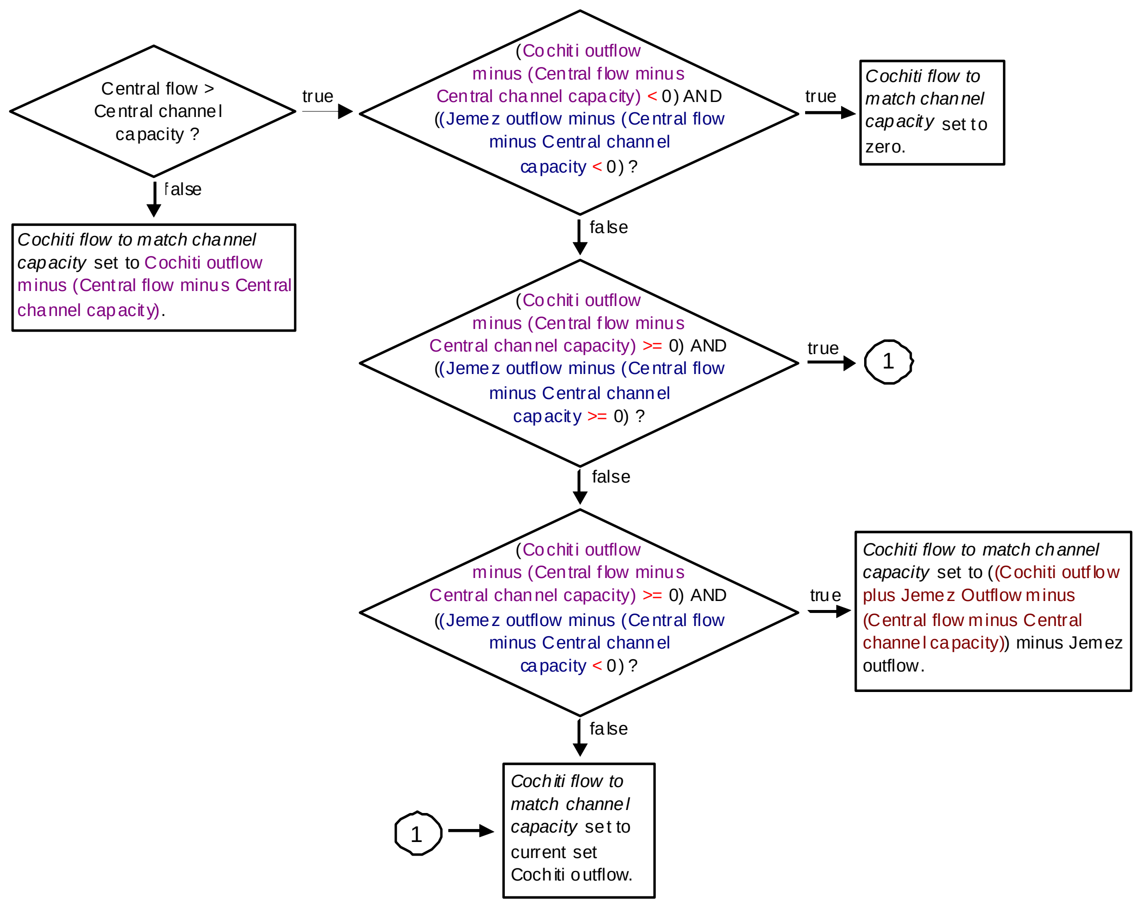


Figure 7.5. Flow Chart for Setting Cochiti Flow for Channel Capacity – Balanced Ops

7.2. Cochiti Deviations

Cochiti deviations are authorized through 2013 where the Corps may temporarily store native Rio Grande water to be released at the time of the peak and augment flows to provide recruitment flows in the Middle Valley (Corps, 2009). Specific criteria are coded for identifying whether the runoff is sufficient to enact Cochiti deviations to provide recruitment flows (or overbank flows) for the benefit of species listed under the Endangered Species Act but the runoff is insufficient for providing the needed hydrograph by just bypassing inflows at Cochiti Reservoir. Operations entail providing overbank flows if conditions support providing the higher flows. This aspect of policy can be set to expire based on an input year as the last year that Cochiti deviations are authorized – currently set to 2013.

Deviations will be implemented to provide *recruitment* flows if the March through July Otowi flow forecast is between 50% and 80% of average and the projected peak inflow to Cochiti Reservoir during the recruitment or overbank season is between 1800 and 5000 cfs or the March through July forecast is greater than 80% of average but the projected peak inflow is less than 3500 cfs. The projected peak inflow to Cochiti is estimated during an URGWOM simulation based on input inflows. Deviations will be implemented to provide *overbank* flows if the Otowi forecast is between 80% and 120% of average and the projected peak inflow to Cochiti is between 3500 and 10,000 cfs or the Otowi forecast is between 50% and 80% of average but the projected peak inflow is greater than 5000 cfs.

If deviations are implemented, an amount of allowable reregulation storage is set with the ComputeCochitiRGConservationSpaceAvailableHydrographKnowledge rule based on a lookup table as a function of the Otowi forecast and whether deviations are implemented for recruitment or overbank flows. Inflows to reregulation storage are set using the same logic applied at Abiquiu (Reference the flowchart in Figure 6.5).

The date to start storage at Cochiti Reservoir for deviations can be input to URGWOM, but if no preset date is input in the current model, the date to begin storage is set to 24 days before the projected date of the peak inflow to Cochiti Reservoir. Target flows to provide recruitment or overbank flows are input as 30-day target hydrographs. If deviations are implemented, targets at Central are reset such that day five in the appropriate target hydrograph matches the date of the projected peak inflow to Cochiti Reservoir (Refer to the WriteNewMinTargetsForRecruitmentHydrographKnowledge and WriteNewMinTargetsForOverbankHydrographKnowledge rules). Refer to Figure 7.6 for a flowchart that depicts the logic for implementing Cochiti deviations.

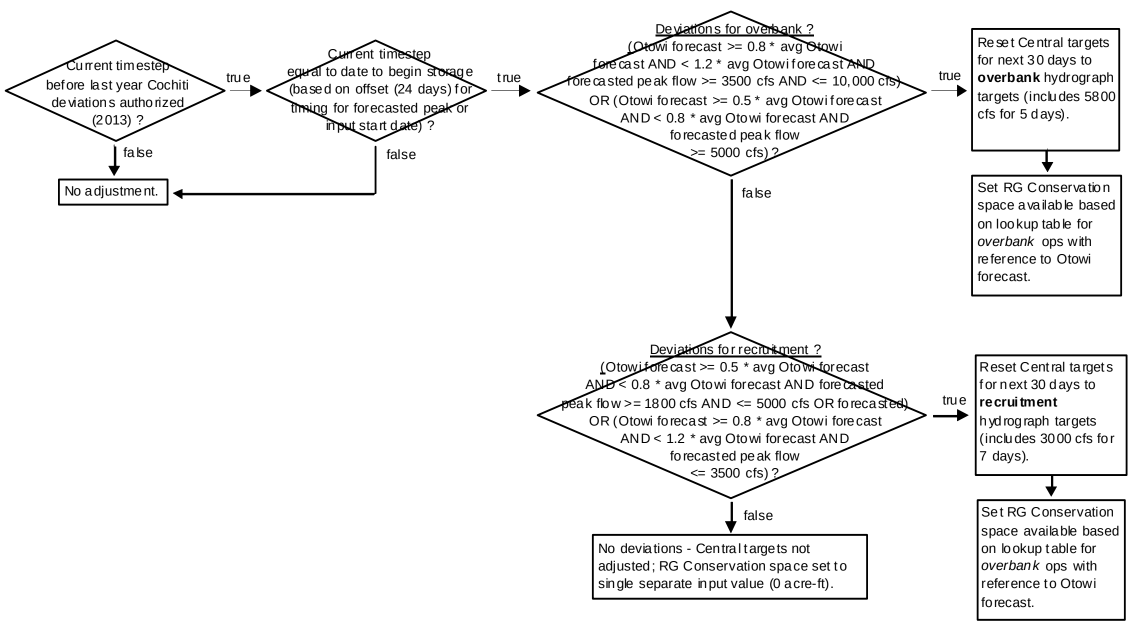


Figure 7.6. Flowchart for Implementing Cochiti Deviations

Water in reregulation storage for Cochiti deviations is released as needed for targets where the needed release reflects the adjusted targets at Central to provide either recruitment or overbank flows. Remaining water in reregulation storage will then be evacuated by the end of a deviations period which lasts for 45 days as currently input

(ComputeCochitiRGConservationRelease rule). Water will begin to be evacuated 15 days before the end of the Cochiti deviations period at a constant rate if that constant rate is greater than the flow needed to meet targets. Refer to Figure 7.7 for a flowchart that shows the calculation for the release from reregulation storage. When the reregulation storage drops below 3000 acre-ft, targets are adjusted back to the original Central targets with the EndTargetsForOverbankOrRecruitment rule. This adjustment is needed to prevent other sources for supplemental water (i.e. leased San Juan-Chama Project water or Emergency Drought water) from being used to meet the recruitment or overbank targets.

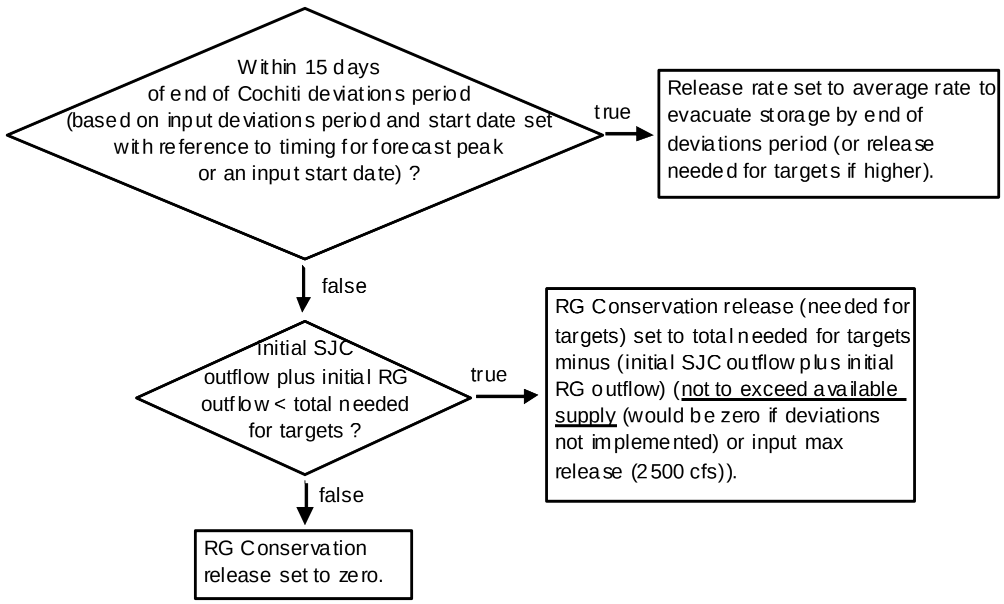


Figure 7.7. Flowchart of Calculation of Release from Reregulation Storage per Cochiti Deviations

Review Comments

Coded policy for Cochiti deviations has been reviewed by the Corps as a result of including this policy in Water Operations Model runs for recent AOPs and other analyses. This aspect of policy was also modeled as a potential flow tool by the PHVA work group of the Collaborative Program and the coded policy was determined to be appropriate by the interagency work group.

One aspect of the rules for Cochiti deviations that may need to be adjusted is the approach for evacuating water at the end of deviations period as more details on the approach implemented for actual operations becomes available. As more model runs are completed, the timing for initiating storage before the peak may also need to be tweaked to assure water is stored for an appropriate amount of time before releases need to be made for the recruitment or overbank flow targets.

One result that may need to be addressed is that rules for stepped releases may prevent outflows from decreasing quickly enough following the peak deviations targets. The additional outflow as a result of releases not being stepped down quickly enough may cause the storage in the Rio Grande account to go negative. The negative storage is quickly offset as part of the Rio Grande storage adjustment (Figure 7.2), but a modification may need to be applied to prevent stepped releases from controlling in the model as operations for Cochiti deviations are ceased. Actual operations would be conducted in a manner to prevent stepped releases from controlling operations. Related to this effect, the storage adjustment function may result in significant storage at Cochiti Reservoir to offset for the negative Rio Grande storage and this adjustment may cause downstream demands to not be met. Model results would only be impacted by this adjustment for a day or two but the storage adjustment should probably be modified such that downstream demands are met before negative Rio Grande storage is corrected.

Depending on the importance of the target flows at Central, a tolerance (e.g. 100 cfs) could be added to peak targets in the target hydrographs to assure the downstream targets are definitely met. Note that the safety factor applied to targets as discussed in section 2.4.2 is not applied to Cochiti deviations targets.

VIII. Elephant Butte and Caballo Operations

Releases from Elephant Butte Dam are set to provide an input full demand if the supply is available based on the storage at Elephant Butte and Caballo Reservoirs plus a forecasted Elephant Butte Reservoir inflow volume from the runoff. The full demand for a year is input as an annual series that reflects the typical variation in the downstream demand. If the full demand cannot be provided, a percentage of the demand that can be met is computed monthly, through May, based on the ratio of the available supply to the remaining demand for the year (Reference the Determine Percentage rule). The demand from Caballo Reservoir is set with reference to the same computed percentage but a separate input demand schedule for Caballo Reservoir. Releases from Elephant Butte and Caballo Dams are set to the outflow to provide the corresponding computed demand with consideration for flood control operations.

Releases from Elephant Butte Reservoir may be adjusted to assure “prudent” available flood storage space is provided at Elephant Butte. Prudent space is defined as 25,000 acre-ft in the winter (November through February) and 50,000 acre-ft during the irrigation season (March through October). The Elephant Butte outflow may be set higher than the demand to provide the prudent space. Releases at Elephant Butte may also be adjusted if needed for Caballo flood control operations, and the channel capacity below Elephant Butte Dam is defined as 5000 cfs. Caballo releases may also be adjusted for the channel capacity of 11,000 cfs at El Paso and also if the storage rises into the flood storage space at 4172.45 ft. Refer to Figure 8.1 for a flowchart that shows how releases are set at Elephant Butte and Caballo Dams. The approach for setting releases from Elephant Butte Dam with consideration for Caballo operations for flood control is depicted by the flowchart in Figure 8.2, and the approach for setting Caballo releases when the pool elevation exceeds the low flood pool elevation is shown in Figure 8.3.

Review Comments

Elephant Butte and Caballo Dam operations are primarily set up to model flood control operations at the reservoirs with standard releases set with reference to the input annual demand schedule. The URGWOM Technical Team is working on setting up a more detailed representation of the physical system below Caballo Dam, and more detailed rules will likely be established as part of this model development to reflect standard operations as a function of the downstream consumption.

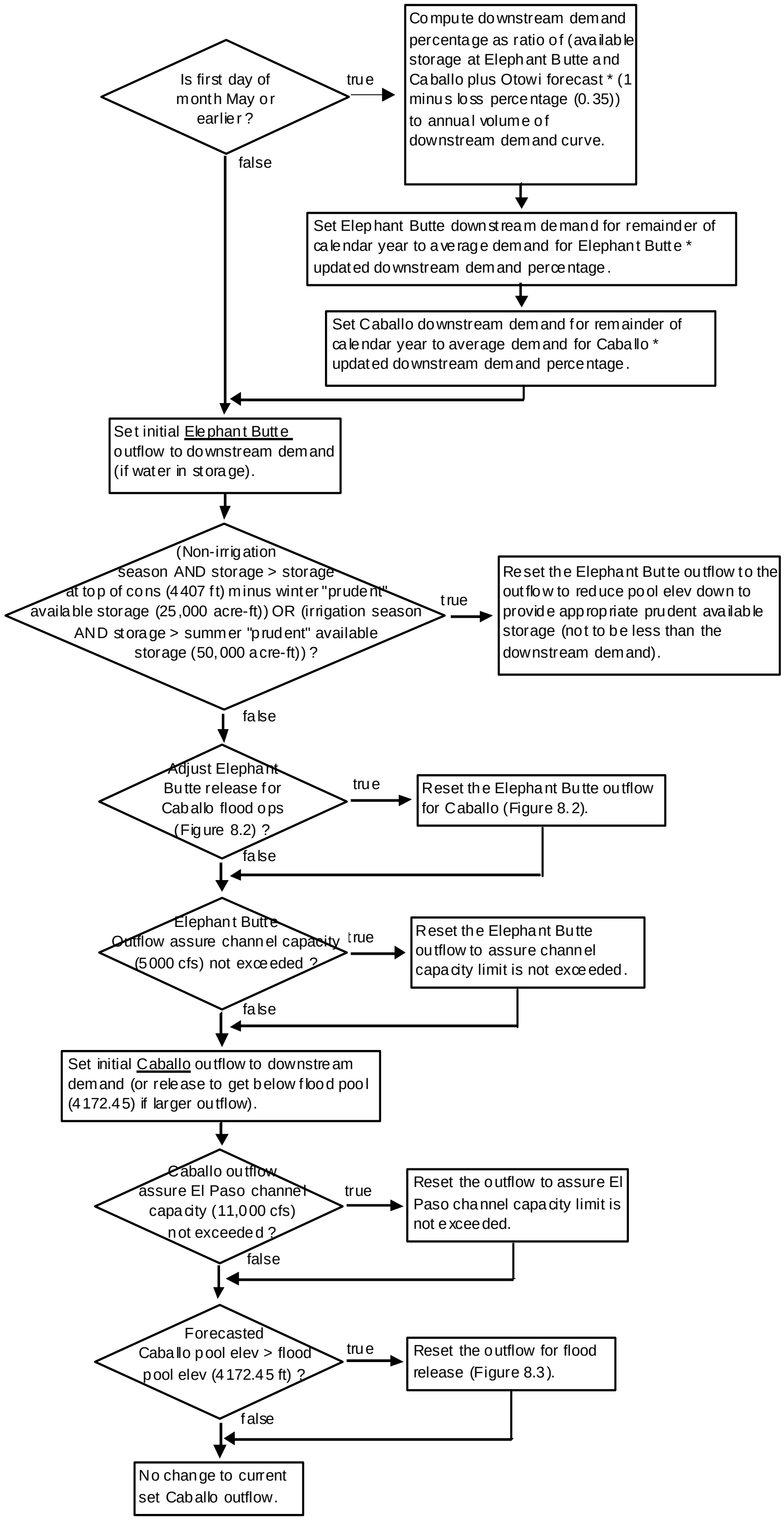


Figure 8.1. Flowchart for Setting Elephant Butte and Caballo Outflows

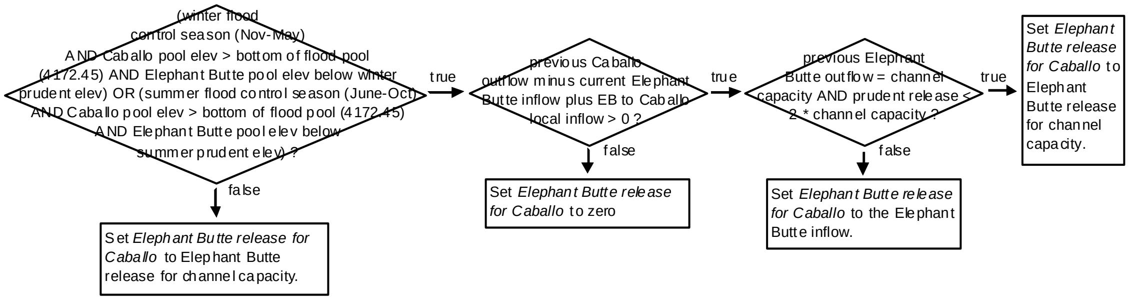


Figure 8.2. Flowchart for Setting Elephant Butte Outflow with Consideration for Caballo Flood Control Operations

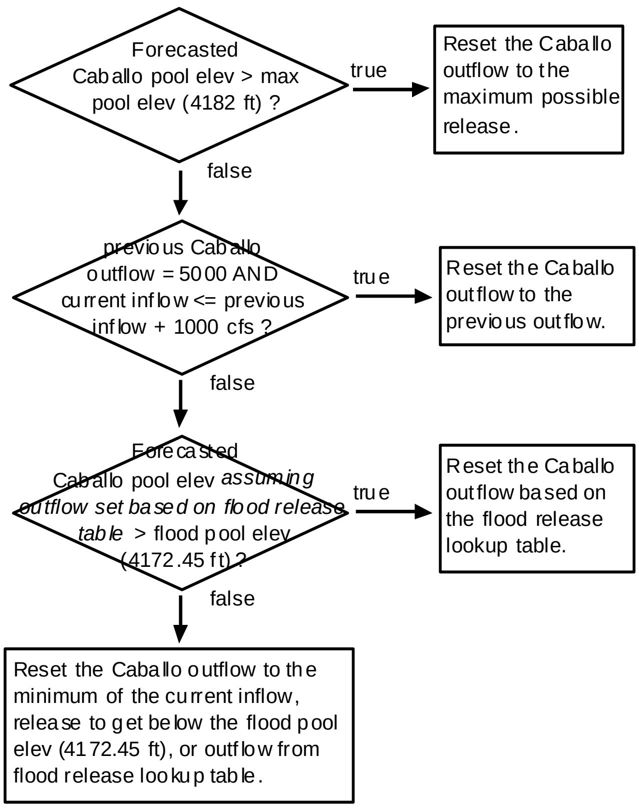


Figure 8.3. Flowchart for Setting Caballo Outflow when above Low Flood Pool Elevation

IX. Conclusions and Recommendations

The URGWOM ruleset has been under development for many years and has been tested through applications for planning studies and for preparing AOPs. Results from Water Operations Model runs have been specifically scrutinized each year and several changes have been made to the rules to address past identified issues. This ongoing evaluation of coded policy has involved many agencies including the Corps, Reclamation, ISC, and USGS. The URGWOM ruleset now serves as a detailed representation of policy for operating dams in the basin in New Mexico and is set up with the needed flexibility for completing planning studies and AOP runs.

Findings from this review of the URGWOM ruleset primarily pertain to small needed updates to reflect most current operations and some changes that could be implemented to make the ruleset and entire model more transparent. Some of the considerations are a function of apparent modeling needs. All the details for all the different factors considered when operating facilities in the basin do not need to be included in the model for most investigations completed with URGWOM. In addition, the representation of policy needed for long-term planning studies is different from what is needed for preparing shorter-term AOPs. Some details in the current ruleset could even be removed for purposes of completing a planning study, but it would be most efficient to just maintain a single ruleset for both applications. Details of policy and assumptions for a potential real-time water operations module of URGWOM are then a different consideration that are still being reviewed by the URGWOM Technical Team.

One finding from the review is that there are a few specific areas in the coded policy that could be adjusted that would significantly help with simplifying the ruleset. While the current approach is effective at meeting modeling needs, simplifying the model and ruleset would make model use much easier for new agency representatives and also help various stakeholders with their interpretation of the model. This consideration may become even more important as other planned model enhancements are incorporated that will further complicate the set up (e.g. incorporating more detail for the Lower Valley, adding the Colorado portion, modeling consumption by Rio Chama diverters, etc.) The following areas were identified as two key areas where the current URGWOM ruleset and model could potentially be simplified.

- Adjust coded policy for setting releases of Rio Grande water from Heron Reservoir.

  Actual policy for effectively bypassing native Rio Grande inflows to Heron Reservoir is fairly basic and the current coded approach could be simplified to just represent the actual approach for periodically evacuating Rio Grande water from Heron Reservoir as storage starts to accumulate.

- Edit or delete coded policy for Albuquerque loans to other contractors and MRGCD loans to Albuquerque or Reclamation.

  The current ruleset includes some rather involved policy that allows for Albuquerque to loan unused San Juan-Chama Project water to other contractors that do not have the water to meet their demands. This aspect of policy is effectively turned off in the current model, but all the code includes consideration for these potential transfers and the resulting potential paybacks. Transfers are made after checking the conditions for making a loan, debts are established for contractors to make the payback, and the paybacks are made when the contractors have the water supply to make the payback. The resulting configuration with the potential loans and subsequent paybacks complicates the calculation for releases of San Juan-Chama Project water.

  Since future operations likely will not include such loans from Albuquerque to other contractors with the startup of Albuquerque's surface water diversions, and assuming there really will not be any modeling needs for modeling such loans, the ruleset and accounting setup could be simplified significantly by removing this setup from the model and ruleset.

Other potential updates to the ruleset were identified to not only make the model more transparent but address some new identified modeling needs and update the model accordingly. The following recommendations pertain to updating the rules to reflect the most recent details of actual policy and capture details of policy that have evolved as water use and water needs have changed.

- Adjust calculations for filling downstream allocated storage space.

  Releases for contractors to fill downstream allocated storage space could be set with simpler calculations. Currently, waiver water may be released at the same time as current year allocated water, and the computed outflows for the different release types is set independently of the other. Available storage space is considered when setting the individual deliveries, but other deliveries that may be occurring at the same time are not considered. (Deliveries made to make paybacks for loans as releases to available account storage at a payback location are also made independently of other release types.) The URGWOM Technical Team is planning to implement some changes to this approach that would also better capture actual delivery timing to reflect rafting releases and other factors.

- Adjust approach from using priority tables to set accounts at Heron, El Vado, and Abiquiu.

  The current approach for setting accounting supplies after reconciled outflows are determined is robust and allows for numerous accounts to be set with a few rules, but the approach is the arguably the most cryptic aspect of the URGWOM ruleset. The tables are somewhat misleading in suggesting that some needs will have priority over others, but actual releases to meet different needs are actually computed as part of an initial outflow and referenced again when setting the accounting supplies. In some cases, the tables prevent multiple needs from being met at the same time. Also, while the current approach is effective at moving water to meet downstream demands, the resulting movement of water from Heron to El Vado and to Abiquiu is not completely matching actual operations. An alternate approach could be developed that may require the same amount of calculations and may be less robust but would be much easier to follow and represent actual operations better.

- Adjust approach for letter water deliveries.

The URGWOM Tech Team has identified the approach for representing letter water deliveries as an area in the model that could be set up differently to be more accurate from an accounting perspective. Changes are planned to include the payback to MRGCD as a transfer to MRGCD's storage account and also set deliveries based on input annual payback volumes while referencing typical daily delivery schedules.

- Incorporate more flexibility for contractor allocated storage space for San Juan-Chama Project water at El Vado and Abiquiu Reservoirs.

The current rigid settings for allocated storage space for contractors' San Juan-Chama Project water is effective for shorter simulations such as AOP runs, but this assumption is not as reasonable for longer-term Planning Model runs, especially with the recent increased water use by Albuquerque and their pending reduced need for allocated storage space at Abiquiu Reservoir. The setup in URGWOM should be adjusted to provide some more flexibility to the allocated storage space for contractors.

Another area in the ruleset where an alternative approach could be implemented pertains to the rules for setting the MRGCD demand. A different computation could be set up based on daily variations in consumption, but this aspect of policy could first be reviewed further as part of a real-time water operations module of URGWOM. Findings from that application could then be used to potentially enhance the coded policy in the ruleset used with the Water Operations Model and Planning Model.

The URGWOM ruleset provides a detailed representation of policy for operating facilities in the Rio Grande basin in New Mexico. Model results have been reviewed by agencies over several years, and policy has subsequently been reviewed and enhanced as part of past investigations. While there are some clear areas where the ruleset could be simplified and also adjusted to reflect the most up-to-date use of the available water supply and the current approaches for moving water from Heron Reservoir to El Vado and Abiquiu Reservoirs, the current ruleset provides an excellent framework for how water is stored and released at reservoirs in the system. The discussion in this report and flowcharts for different aspects of policy should now serve as tools for agency representatives and stakeholders to assist with continued review of the very involved policy for operating the dams in the basin.

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