8 Integrated Model

The watershed model, groundwater model and surface water model are linked to form the integrated model which is designed to be a dynamic representation of the total water budget for the COHYST area Platte River system. Each model is run individually, but the inputs of one model are passed to the next and the models must be run in a linear manner to achieve integration. The primary purpose of integration is to replace the observed reach gain-loss values used in the historical surface water model with the runoff and baseflow values that are the output from the watershed and groundwater models respectively. Thus, streamflow estimates are the integrated results of all three models.

8.1 Integration of Models

The integrated model concept and the physical processes it represents are described in detail in Section 3. The integration of the watershed, groundwater and surface water models occurs through the processing and transfer of data between the models. A simplified illustration of this data exchange is shown in **Figure 8.1-1**.

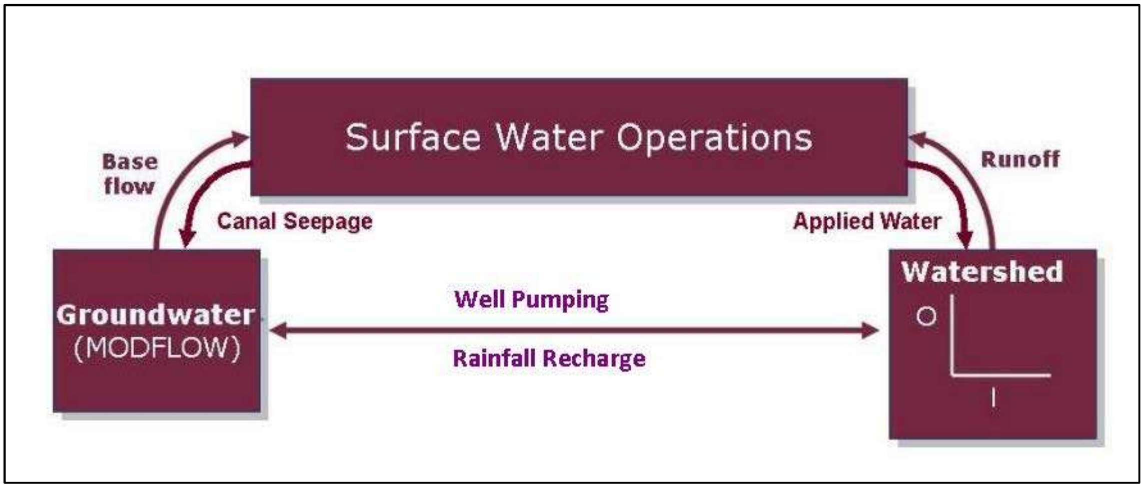


Figure 8.1-1. Linkage of Individual Models within the Integrated Model.

The sequence of individual model simulations and the data transfers to achieve an integrated simulation is described in **Table 8.1-1**.

Table 8.1-1. Integrated Modeling Sequence.

Step	Model	Operation	Assumptions	Output
1.	Watershed	• Develop irrigation water demands based on irrigated acreage estimates • Partition precipitation and applied water between ET, deep percolation, and field runoff (in turn partitioned to runoff to stream, recharge via transmission losses, and non-beneficial ET)	• There is no shortage of surface water and all surface water demands are met. • Canal seepage from calibrated run used	• Irrigation demands for SW (to STELLA) • Watershed runoff (to STELLA)
2.	STELLA	• Import SW demands and runoff from Watershed • Use irrigation demands from Watershed, system operating rules and targets, and initial reach gains for initial simulation • Compute reach gains from baseflow estimates from calibrated GW model plus SW runoff returns from step 1	• Rely on baseflow values from calibrated groundwater model for initial simulation. • Rely on reservoir seepage values from calibrated groundwater model for initial simulation.	• Streamflow, diversions, returns • Initial total flow estimates at mainstem nodes (to MODFLOW) • Irrigation delivery to SW irrigated acreages (to Watershed) • Canal seepage amounts based on water diverted at each headgate to meet demands from Step 1.
3	Watershed	• Repeat of Step (1) using irrigation deliveries from STELLA to determine amount of supplemental pumping required for comingled acres	• Any shortage in surface water supplies is met by groundwater pumping for comingled lands.	• GW pumping and recharge (to MODFLOW) • Total stream flows including runoff (to MODFLOW & STELLA)
4.	MODFLOW	• Import pumping and recharge file from Watershed model • Import total streamflow (with estimated baseflows) from Watershed	• 1980 to 1985 period is sufficient to establish starting heads for 1985.	• Groundwater levels • Baseflow by reach (to STELLA) • Reservoir Seepage (to STELLA)
5.	STELLA	• Import baseflow from MODFLOW • Import reservoir seepage from MODFLOW • Repeat of Step (2) using MODFLOW baseflow to replace estimated baseflow in computing reach gains	• None- At this point all values have been calculated. See step 6a and 6b to determine if re-calculation is necessary.	• Streamflow, diversions, returns • Total flow at mainstem nodes (to MODFLOW) • Canal Seepage Losses by segments or nodes (to Watershed and MODFLOW) • Irrigation delivery to SW irrigated acreages (to Watershed)

Step	Model	Operation	Assumptions	Output
6a.	Watershed	• Determine if updated estimates of diversions would cause a significant shift in SW or GW uses (i.e. more or less supplemental GW pumping).		• If so, go to Step (3) and provide output to STELLA for another iteration • If not, modeling sequence is complete.
6b.	MODFLOW	• Determine if updated total flow values would cause a significant shift in computed baseflows		• If so, go to Step (3) and provide output to STELLA for another iteration • If not, modeling sequence is complete.

The model runs described in this report are coded as 28b_14_28, meaning watershed model run 28 (the b designation corresponds to Step (3) meaning deficits in SW deliveries computed by STELLA have been accounted for), Stella surface water model run 14, and MODFLOW groundwater model run 28.

8.1.1 Baseflow and Runoff Exchange

Baseflow output from the groundwater model and runoff output from the watershed model is imported into the surface water model. This allows the surface water model to re-evaluate how demands are met given the changes in baseflow and runoff.

The baseflow output is provided as a daily volume (acre-feet) for the 1st and 15th of each month aggregated at each main stem Platte River gage node in the surface water model. The values between are interpolated creating a different value for each day. The data are interpolated using Microsoft Excel and the daily values are imported into the surface water model. For reaches where intermediate main stem nodes are present in the surface water model (for example at locations of diversions), the reach baseflow gain is partitioned using the lengths of sub-reaches between the intermediate nodes (see figure 6.3-1 for location of Platte River Stella nodes).

The watershed runoff is provided in monthly volume (acre-feet) for each sub-basin shown in the **Figure 8.1-2**. [This map is the same as COHYST runoff zones, Figure 5.2-9.] Using Microsoft Excel, the sub-basin runoff is aggregated at each main stem Platte River gage node in the surface water model. The reach runoff is discretized into daily values by taking the monthly volume and dividing by the number of days in the month. The same value for each day of the month is used and imported into the surface water model. For reaches where intermediate main stem nodes are present in the surface water model (for example at locations of diversions), the reach runoff is partitioned using the lengths of sub-reaches between the intermediate nodes.

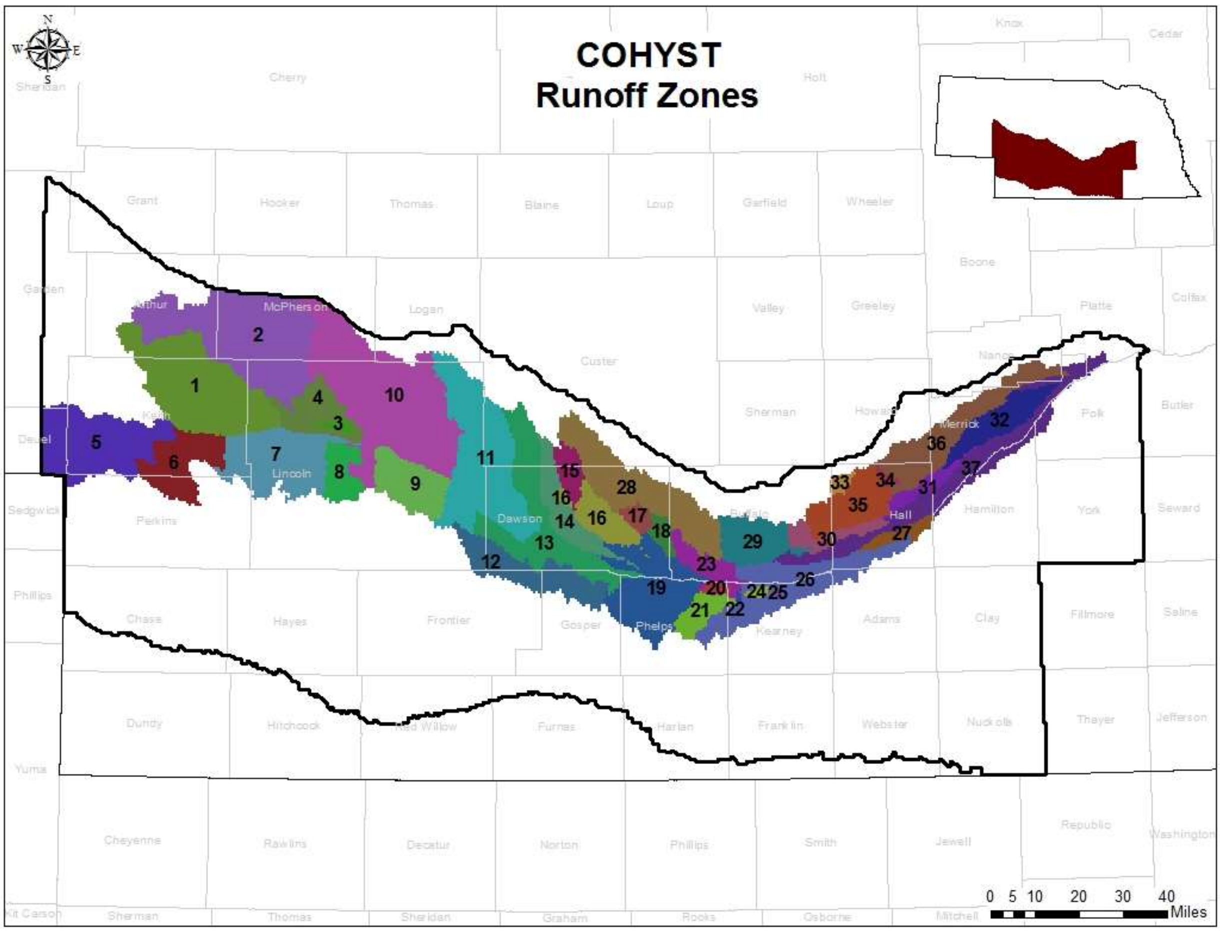


Figure 8.1-2. Drainage Basins Used in Watershed Model.

8.1.2 Recharge from Canal and Reservoirs

Canal and reservoir recharge is converted and passed from the surface water model to the watershed model using a Microsoft Excel based macro. The macro program uses the calculated seepage values from the surface water model, which are provided in daily volumes (acre-feet), for each canal reach and reservoir. Using the grid coverage of the groundwater and watershed models, computed daily seepage from each canal reach and reservoir is partitioned on an equal basis amongst the grid cells associated with each canal reach/reservoir. **Figure 8.1-3** illustrates the intersection of the canals/reservoirs with the watershed model grid for Sutherland Canal and Lake Maloney.

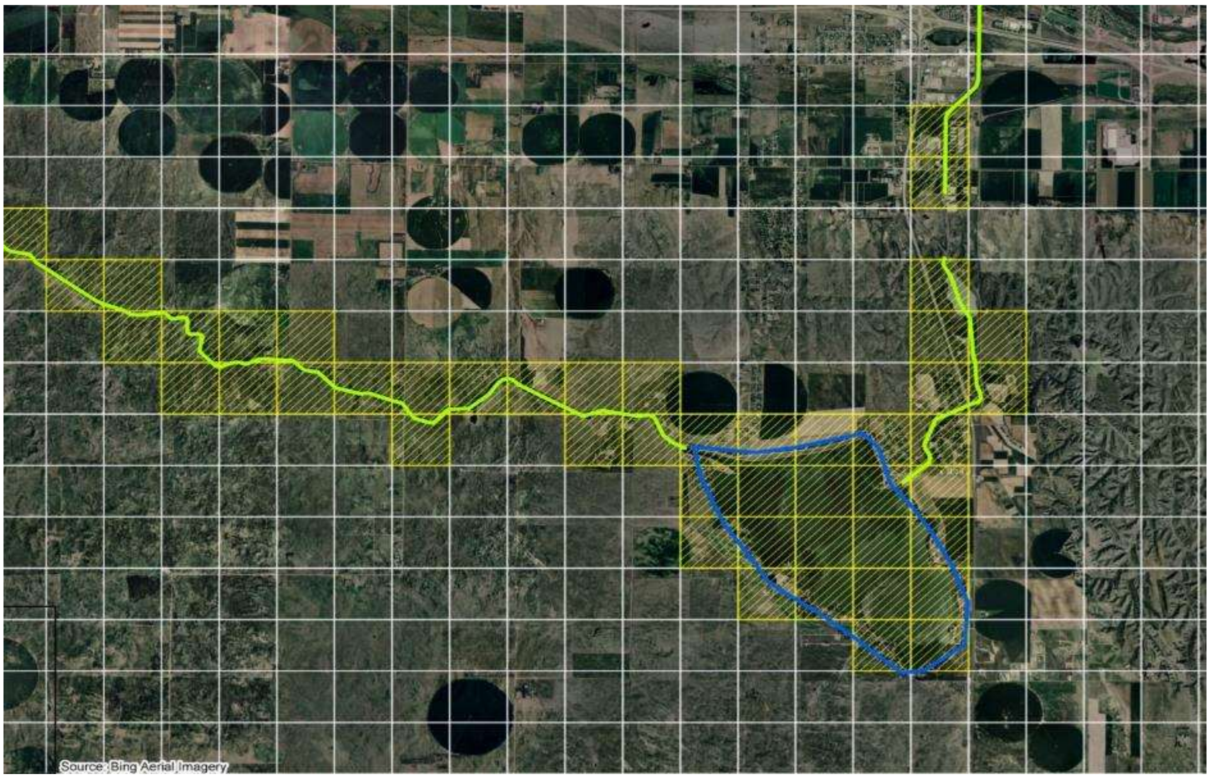


Figure 8.1-3. Intersection of Surface Water Features with Groundwater Grid Cells.

8.1.3 Calculated Irrigation Delivery

Irrigation demands calculated by the watershed model are used to develop surface water diversion demands as discussed in Section 6.6.1. In the integrated modeling sequence, irrigation deliveries to meet those demands are calculated to identify deficits in crop deliveries due to limitations in available water for delivery. If there is a deficit between the crop irrigation demand and the available water for delivery, then the deficit is passed back to the watershed model (Step 3 in the modeling sequence) and ground water pumping is increased to compensate for the deficit.

8.1.4 Calibration

Total flow at the main stem stream gages and the overall system water budget serve as the primary calibration targets for the integrated model, with reservoir elevations and canal diversions serving as secondary calibration targets for the integrated model run. After comparison of the calibration targets, adjustments were made to each individual model independent of the other models. The groundwater, surface water and watershed models are each checked at the individual level before making another integrated simulation.

Observed reach gain/loss was not used as a calibration target. However, during the evaluation of the integrated model results for total flows at the main stem gages, comparisons of observed and computed reach gain/loss provided insight into potential causes of discrepancies between simulated main stem flows and historic observations.

8.2 Integrated Model Results

The results for the integrated model simulations are illustrated through a series of tables and plots summarizing reach statistics and water budgets. Select plots are included in the subsequent sections with the remainder included in appendices.

8.2.1 Platte River Gages

Table 8.2-1 summarizes the cumulative differences between model predictions and historic observations at the main stem gage locations for the 1990-2005 calibration period. **Figure 8.2-1** illustrates the daily historic versus simulated flow at Duncan and the cumulative difference between the two over the 1990-2005 calibration period. These charts use a color scheme to illustrate wet, normal and dry hydrologic conditions for the Platte River Basin to allow evaluation of model performance during varying hydrologic conditions as defined by the Platte River Recovery Implementation Program (see their Website for how conditions are computed using Mean Streamflow, Snowpack, Reservoir levels, and Palmer Drought Severity Index). The example given shows that the model provides a good match during dry periods. This match was achieved at the expense of poorer accuracy at other times; however, the technical team deemed matching the dry periods was a priority for the model, and thus accepted the poorer match in other areas.

Table 8.2-1. Stream gage Cumulative Volume Calculated by Integrated Model Results, for Platte River Gages, 1990-2005.

		South Platte River		North Platte River		
		Roscoe	N. Platte	Mac Rls	Keystone	N. Platte
Total Historic Volume (AF)		6,723,080	4,918,050	13,409,800	3,865,950	6,149,390
Avg. Historic Daily Flow (cfs)		580	430	1,160	330	530
Cumulative Difference from Historic at End of Simulation	Acre-Feet	-638,830	-533,550	-114,510	-636,170	-640,730
	CFS (avg/day)	-60	-50	-10	-50	-60
	% of Total Volume	-10%	-11%	-1%	-16%	-10%

		Platte River						
		N. Platte	Brady	Cozad	Overton	Odessa	Grand Island	Duncan
Total Historic Volume (AF)		20,929,690	6,886,060	5,440,250	15,885,210	16,077,930	17,486,920	21,151,880
Avg. Historic Daily Flow (cfs)		1,810	600	470	1,370	1,390	1,510	1,830
Cumulative Difference from Historic at End of Simulation	Acre-Feet	-931,170	-1,979,760	-674,210	-1,886,240	-1,626,670	-2,584,260	-5,557,920
	CFS (avg/day)	-80	-170	-60	-160	-140	-220	-480
	% of Total Volume	-4%	-29%	-12%	-12%	-10%	-15%	-26%

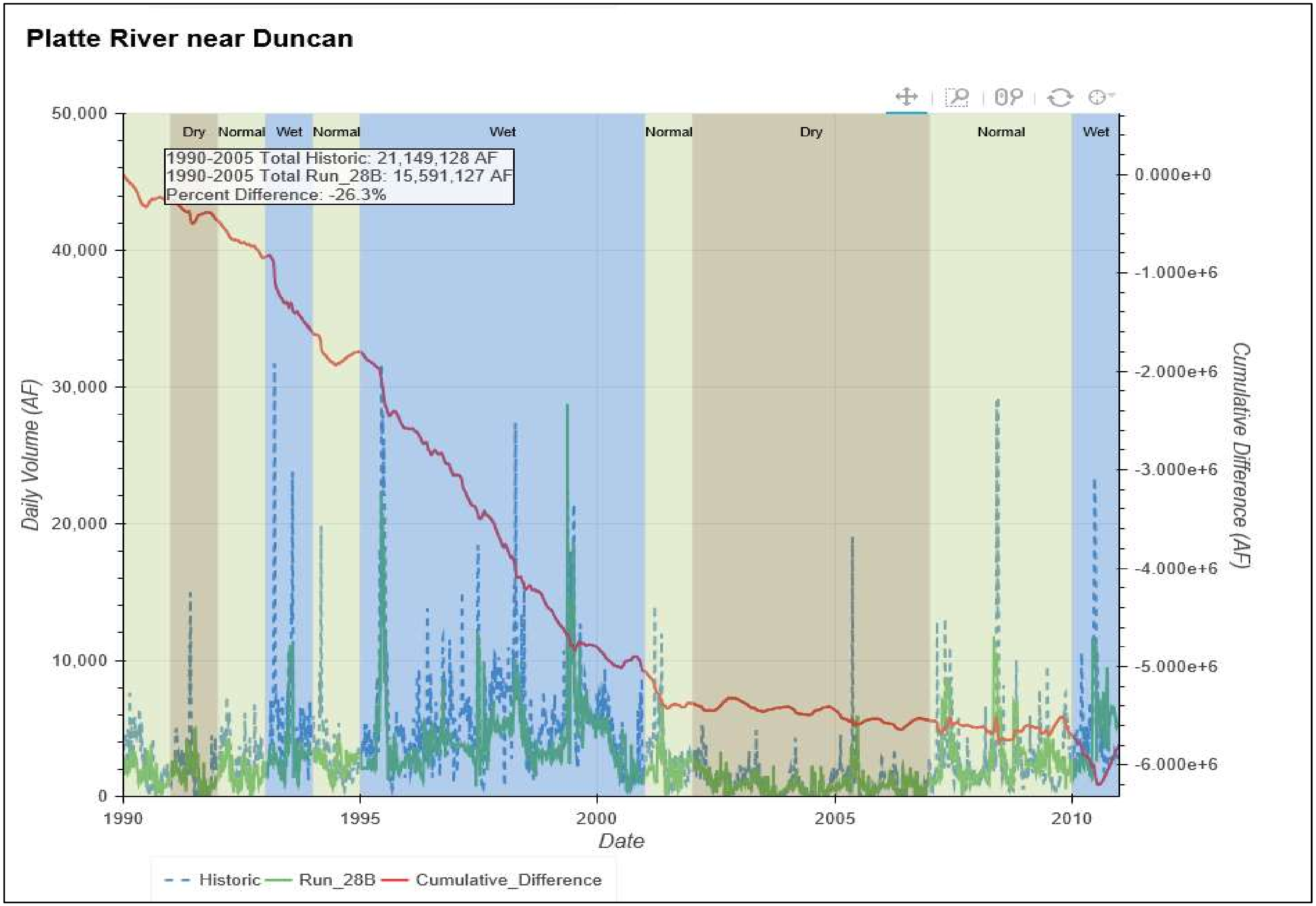
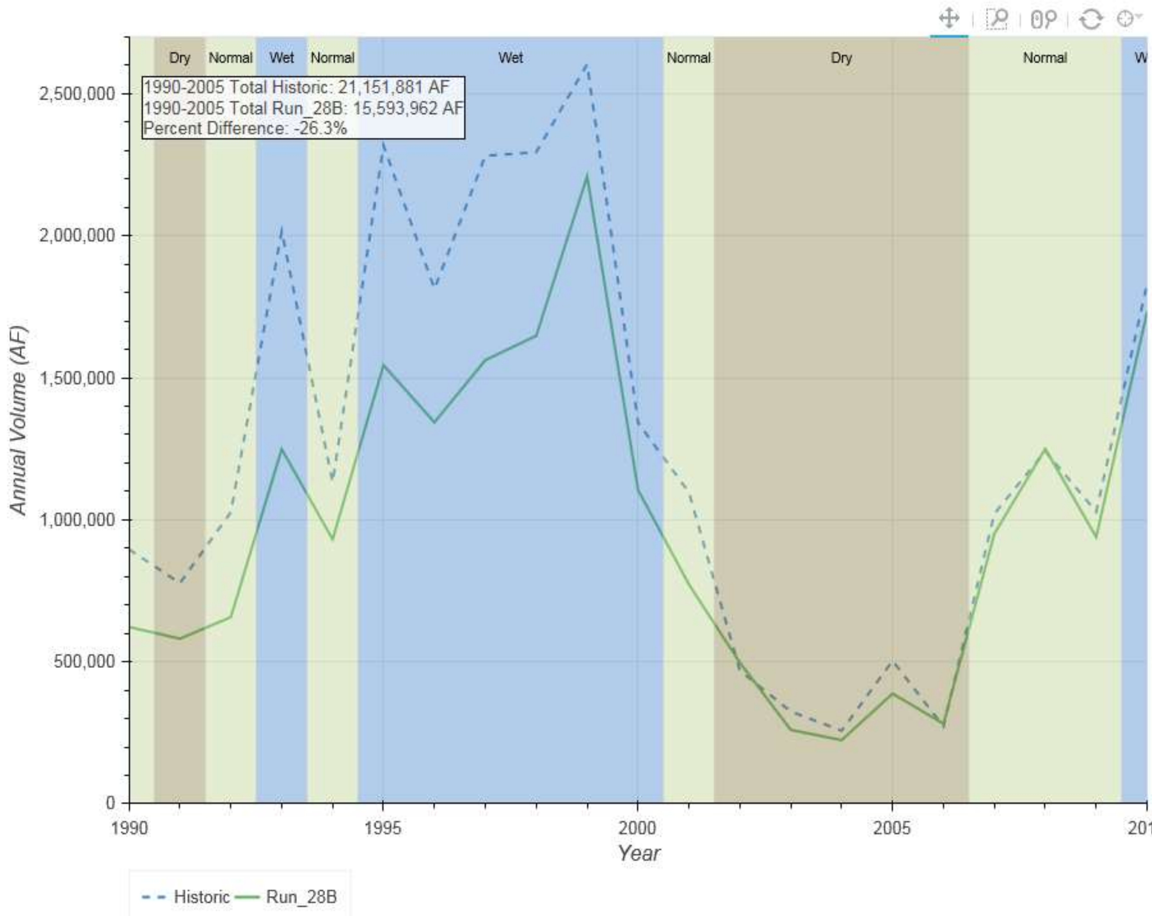


Figure 8.2-1. Comparison Calculated and Historic Streamflow and Cumulative Differences, Platte River near Duncan.

Figure 8.2-2 illustrates annual total flow for the Platte River near Duncan. It compares the historic gage record to the model results for both the historical reach gain/loss simulation and the integrated model simulation. Similar plots of annual and daily simulated results and historic observations for all river gages are included in **Appendix 8-A**. Simulation results presented in Figures 8.2-1 and 8.2-2 for the integrated simulation are generally representative of results and show a shortage of water compared to the model results from the historical reach gain/loss simulation. The following are observations regarding the integrated model simulation of main stem flows.

- The model does a good job of replicating observations for seasonal/annual trends during wet/dry/normal hydrologic conditions
- The surface water operating rules are robust and function appropriately to address water shortages in the integrated model
- The integrated model does function appropriately in translating water shortages to the individual models (i.e. supplemental pumping, etc. when required) and therefore accounts for water budget impacts to the system.
- The integrated model performs reasonably well during drought conditions (2002-2005) - better than during wet conditions – but does not simulate the dry river reach conditions between Grand Island and Duncan observed during that period.
- The integrated model results were accomplished without compromising calibration/parameters of the individual models.

Platte River near Duncan



Year	Historic	Run_28B
1990	896,040	622,702
1991	776,920	581,133
1992	1,026,614	657,193
1993	2,015,676	1,248,701
1994	1,132,088	931,105
1995	2,318,108	1,544,242
1996	1,813,170	1,343,328
1997	2,281,898	1,562,101
1998	2,294,396	1,648,015
1999	2,603,722	2,209,490
2000	1,342,044	1,104,961
2001	1,096,421	772,044
2002	469,058	496,900
2003	324,941	260,166
2004	257,187	224,062
2005	503,598	387,819
2006	272,373	282,060
2007	1,021,701	951,203
2008	1,241,399	1,249,972
2009	1,028,435	939,176
2010	1,830,319	1,732,419
Total	26,546,108	20,748,792

Figure 8.2-2. Annual Total Flow for Calculated, Historical Reach Gain/Loss and Integrated Model Simulation for the Platte River near Duncan.

8.2.2 Secondary Integrated Calibration Targets

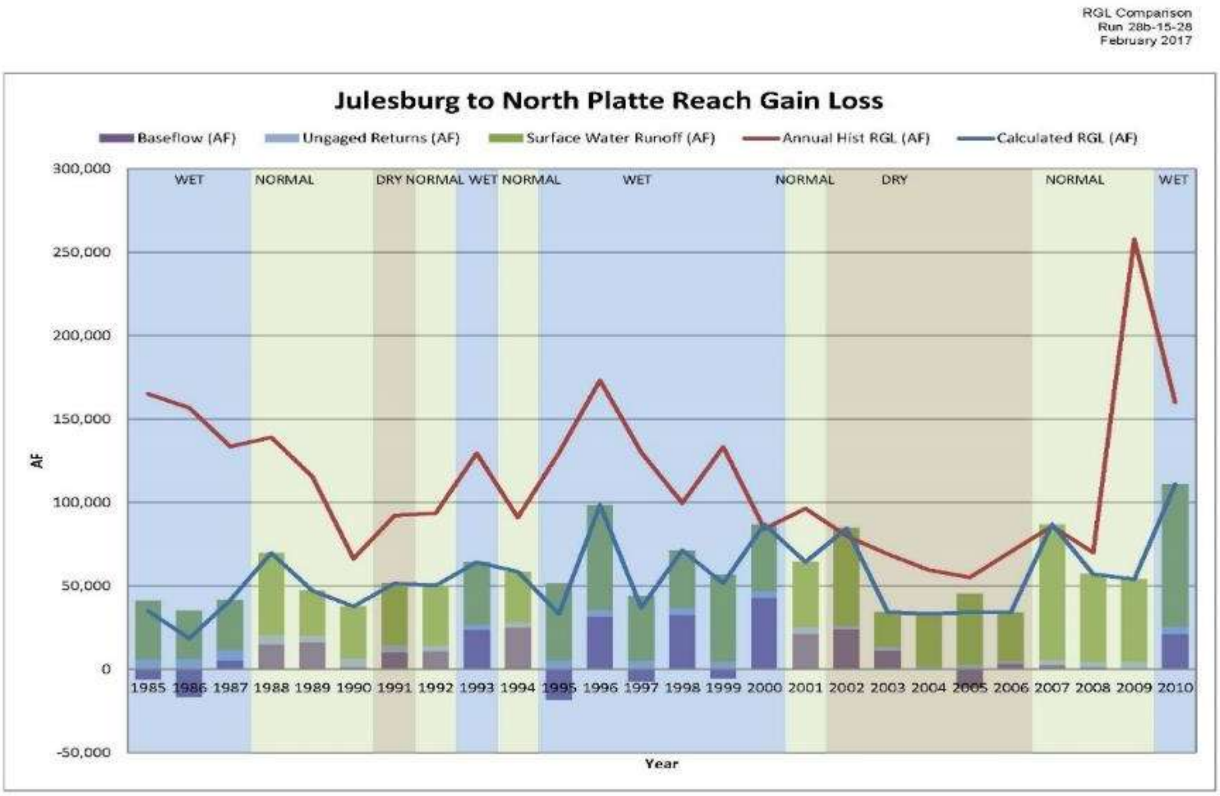
While the mainstem gages served as the primary calibration targets, the same calibration targets and evaluations referenced in the surface water model calibration (Section 6.7) were also evaluated as secondary targets for the integrated model runs. These results for the integrated models runs include:

- **Appendix 8-B** - Integrated Model Calibration Results – Canal Diversions and Returns
- **Appendix 8-C** - Appendix 8-C – Integrated Model Calibration Results – Reservoirs
- **Appendix 8-D** - Integrated Model Calibration Results – Reach Scale Water Budgets

The simulation results for these secondary calibration targets are consistent with the surface water model results and trends in model performance discussed in Section 6.7, with the primary difference being generally less water available for diversion. This water shortage is appropriately reflected in the simulation results and compare reasonably well with historic observations.

8.2.3 Reach Gain/Loss

In looking at the integrated model results at the main stem gages, the simulated flows were typically less than historical flows. To characterize the shortages, an analysis was performed of the historic reach gain/loss versus the simulated reach gain/loss (baseflow, runoff, and ungagged returns predicted by the COHYST 2010 model components) on an annual and average daily basis. Annual and average daily reach gain/loss comparisons across the spatial extents of the model are illustrated by the Julesburg to North Platte reach (**Figure 8.2-3**), North Platte to Brady reach (**Figure 8.2-4**), Odessa to Grand Island reach (**Figure 8.2-5**), and the Grand Island to Duncan reach (**Figure 8.2-6).** Comparisons for other reaches are included in **Appendix 8-E**.



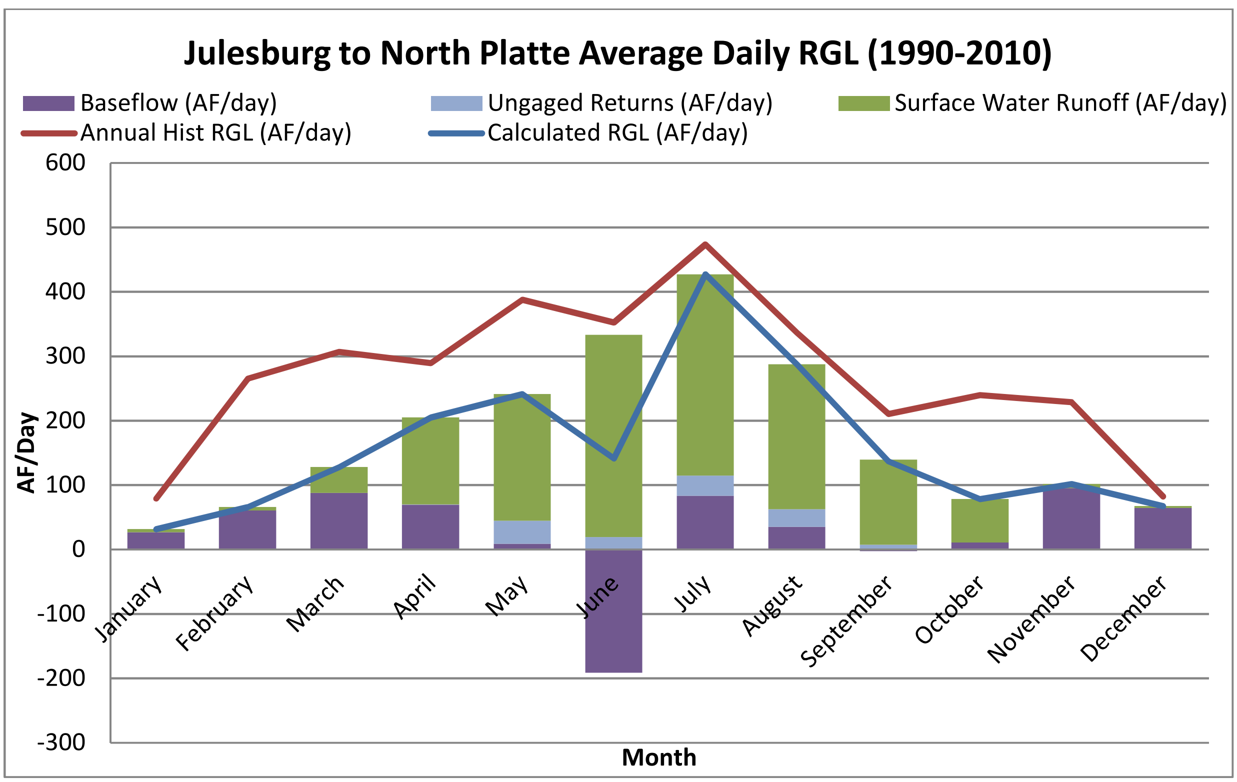
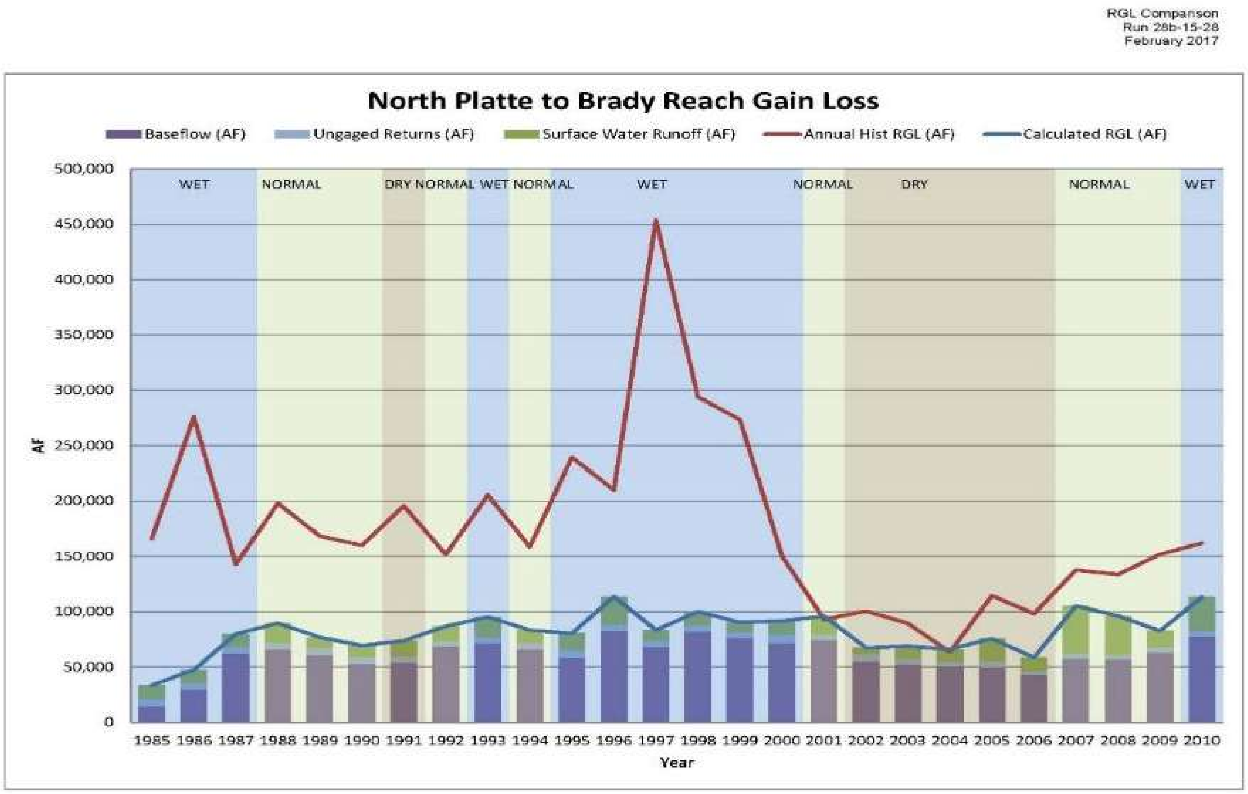


Figure 8.2-3. Comparison of Annual and Average Daily Reach Gains/Loss for South Platte River Reach between Julesburg and North Platte.



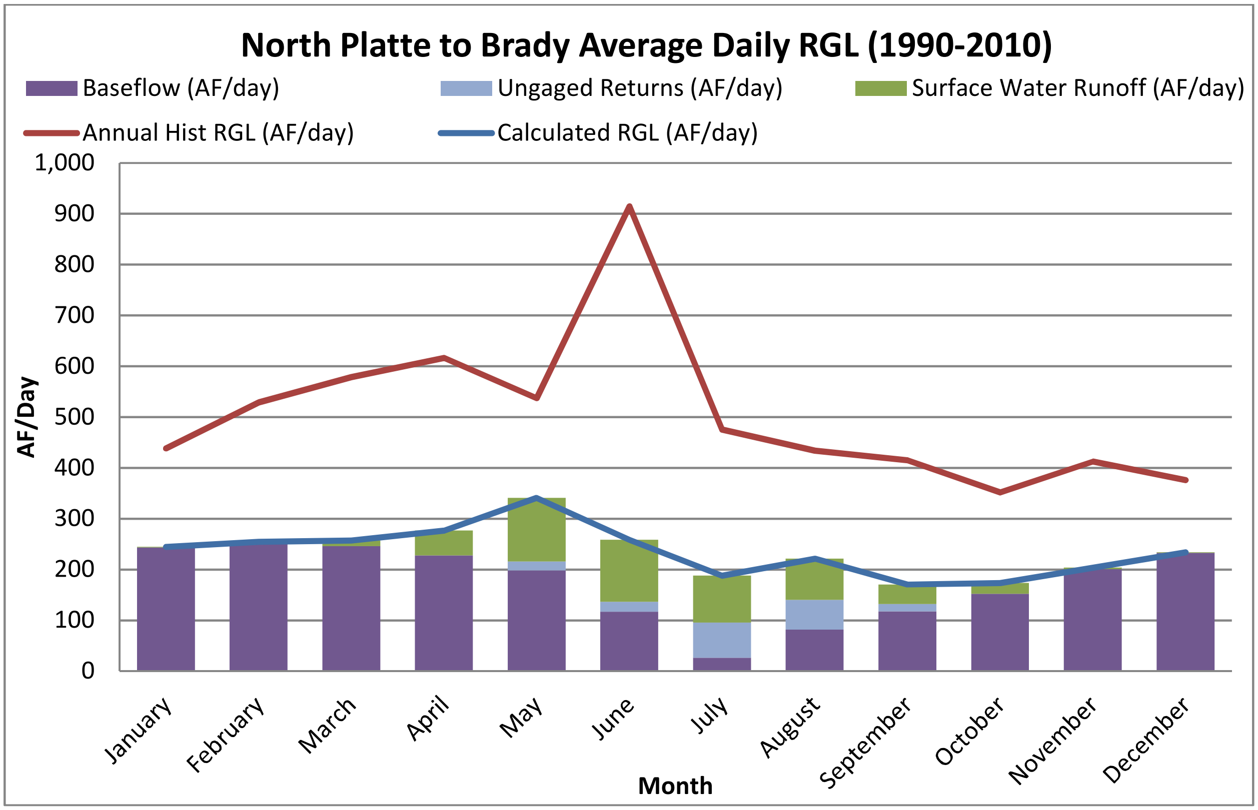


Figure 8.2-4. Comparison of Annual and Average Daily Reach Gains/Loss for Platte River Reach between North Platte and Brady.

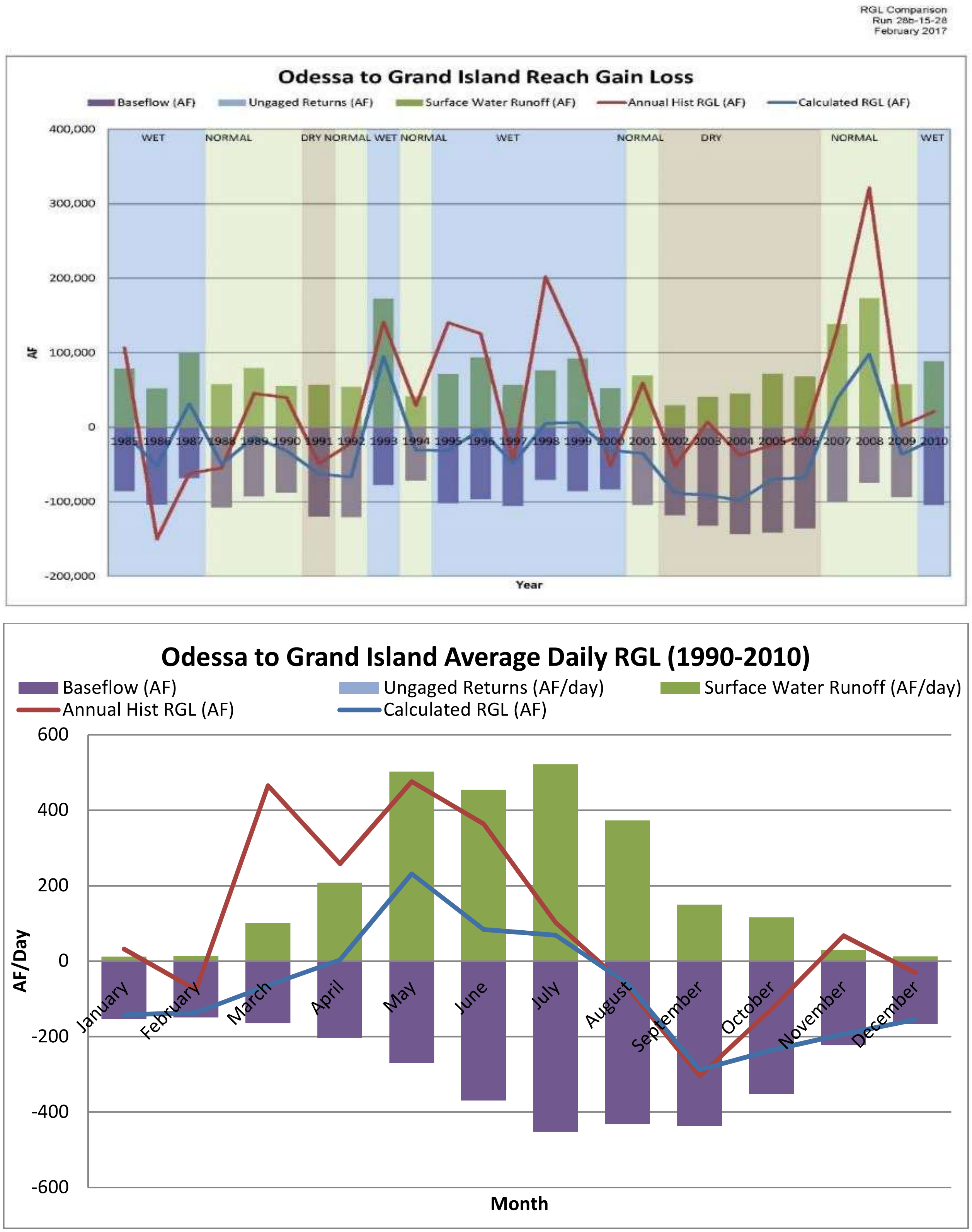
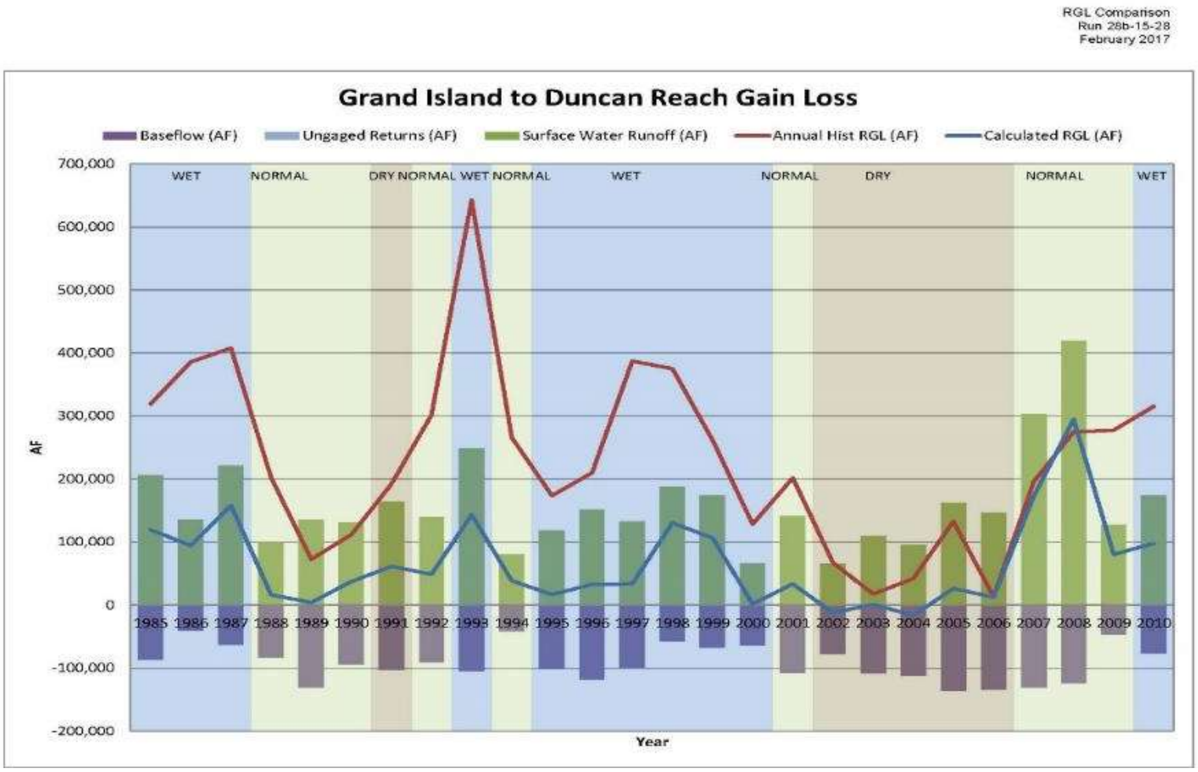


Figure 8.2-5. Comparison of Annual and Average Daily Reach Gains/Loss for Platte River Reach between Odessa and Grand Island.



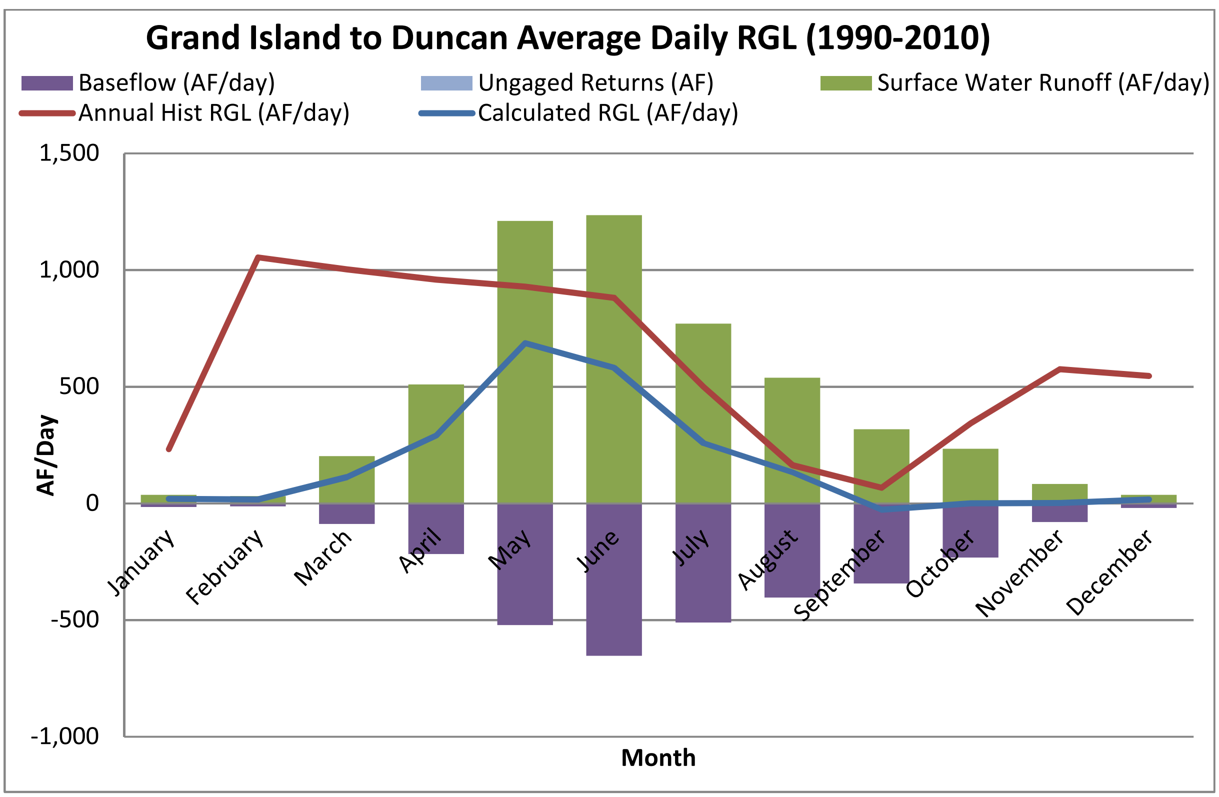


Figure 8.2-6. Comparison of Annual and Average Daily Reach Gains/Loss for Platte River Reach between Grand Island and Duncan.

The following observations relate to the reach gain/loss evaluation.

- The trends in observed reach gain/loss corresponding to wet/dry/normal hydrologic conditions are generally reflected well by the integrated model.
- The integrated model under predicts reach gains along the South Platte River, the North Platte to Brady reach, the Odessa to Grand Island reach, and the Grand Island to Duncan reach. The North Platte River and the Brady to Cozad reach are over predicted.
- The considerable variability in the observed reach gain/loss – both annually and seasonally as reflected in the average daily figures (for example between 1992 and 1993 for the Grand Island to Duncan reach) - is not captured by the integrated model. This illustrates a limitation of the current approach used in the watershed model as it is unable to capture significant runoff events since it models precipitation events based on a monthly time step and not a daily or hourly time step.
- The integrated model consistently predicts annual gains for 7 of the 8 reaches across the spatial extents of the model. The Odessa to Grand Island reach historically has varied, sometimes on an annual basis, between a gaining and losing reach. The model in its current state captures that variability of gaining and losing reaches. However, it currently overestimates losses in many years showing it as a losing reach instead of a gaining reach.

8.2.4 Flow Duration Curves

In looking at the integrated model flow results for Lake McConaughy releases and the main stem gages, in general the simulated flows were typically less for high duration flows and more for low duration flows. **Appendix 8-F** shows the flow duration curves for 1990 through 2005. Curves were also developed for dry years (1991, 2002-2005), for average / normal years (1990, 1992, 1994, 2001), and for wet years (1993, 1995 -2000). **Figures 8.2-7 through 10** display the flow duration curves at Overton for all years, dry years, normal years, and wet years. The all year graph and the dry year graph shows the model overestimates the lower frequency flows and slightly underestimates the higher duration flows. The graphs for normal and wet years show the lower frequency flows and the higher frequency flows are underestimated. Overall model performance is judged to be acceptable.

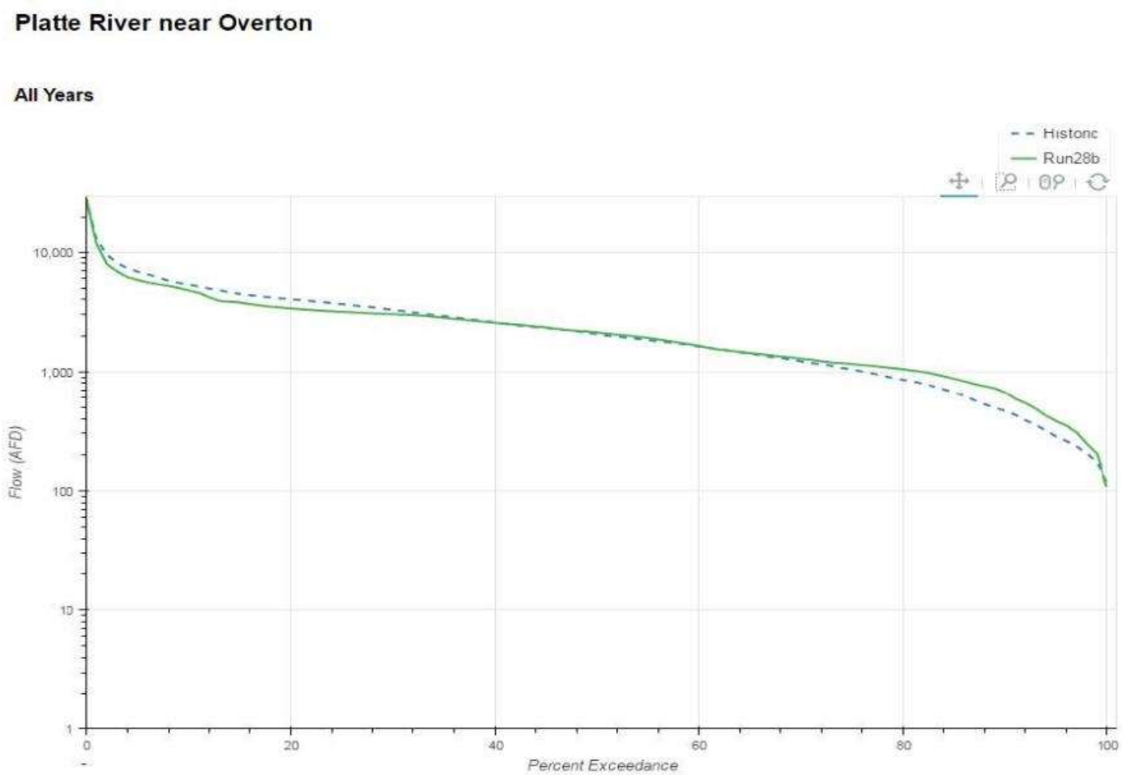


Figure 8.2-7. Comparison of Historic and Calculated flow duration for 1990 through 2005

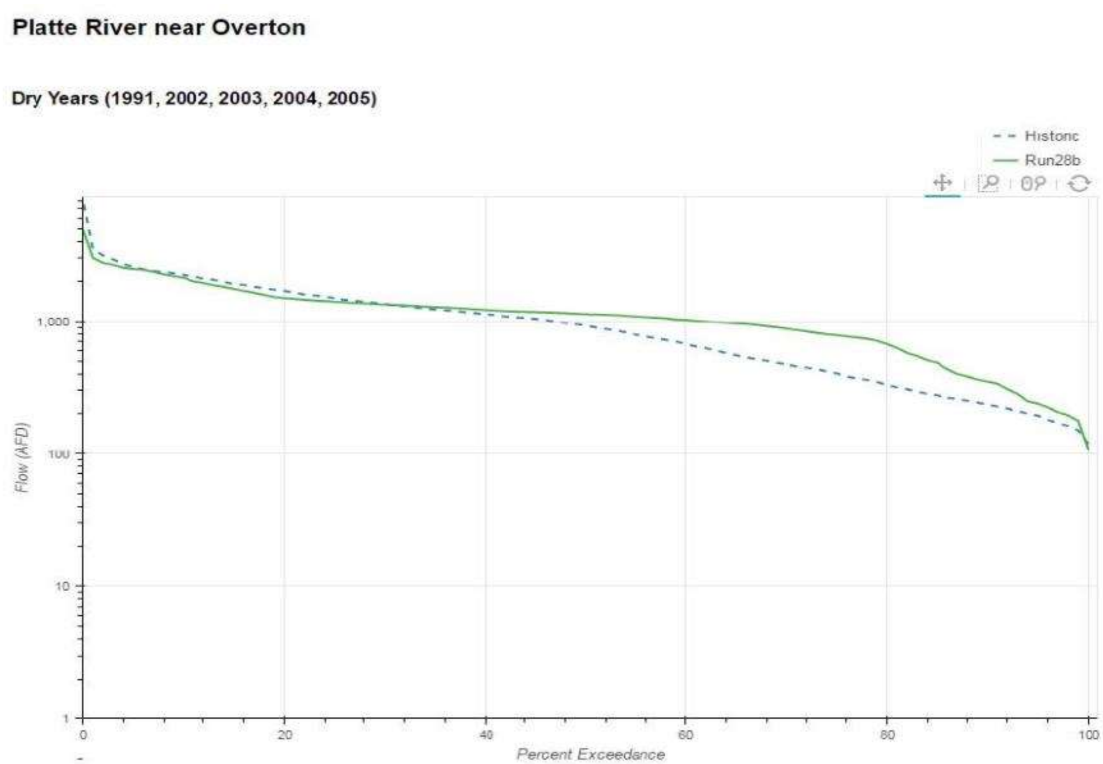


Figure 8.2-8. Comparison of Historic and Calculated flow duration for dry years

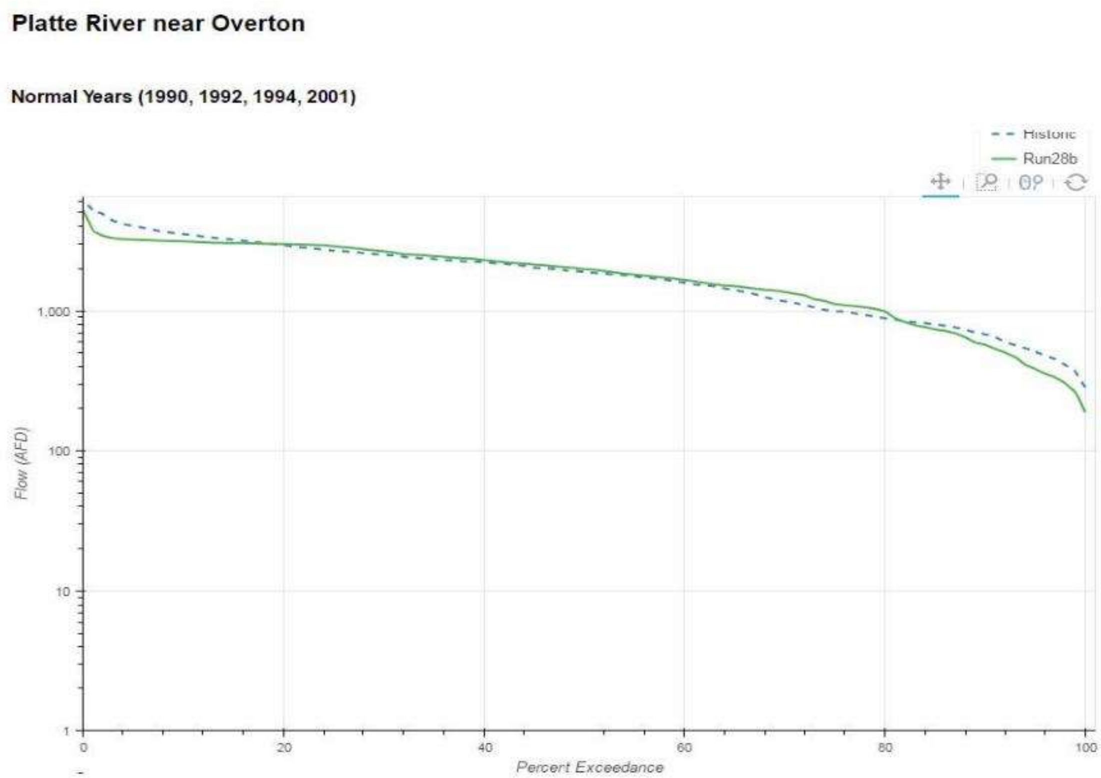


Figure 8.2-9. Comparison of Historic and Calculated flow duration for normal years

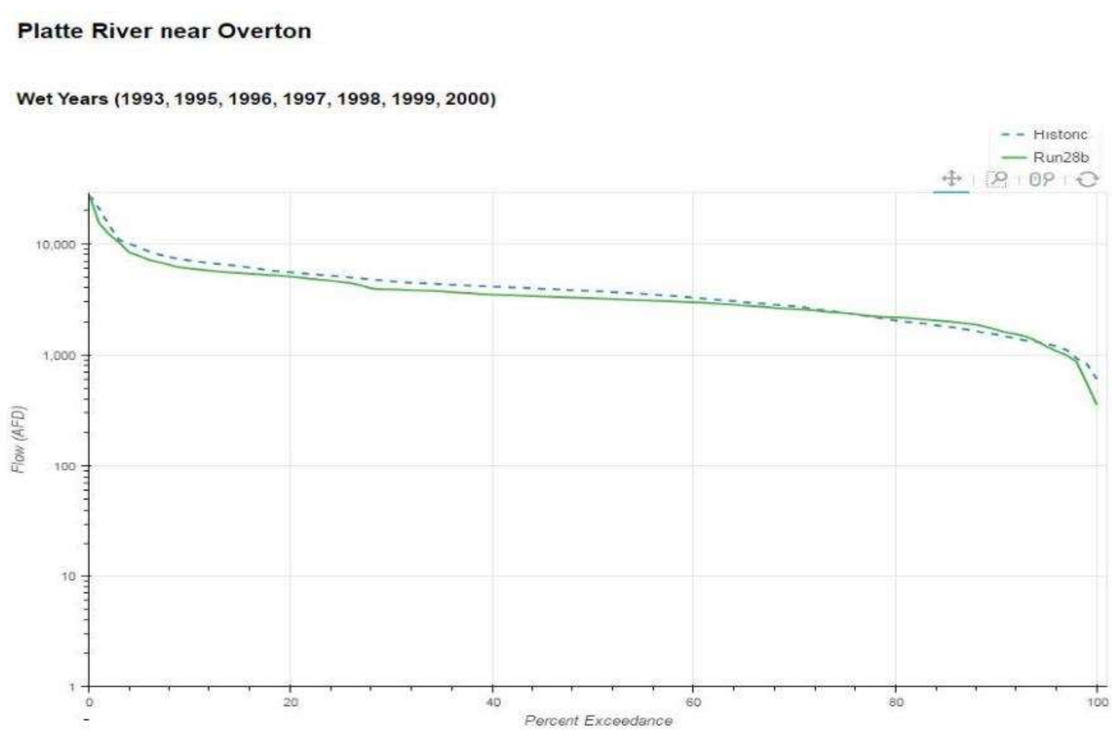


Figure 8.2-10. Comparison of Historic and Calculated flow duration for wet years

8.3 Comparison of Integrated Results to Phase I Water Budget

The water budget comparison results are discussed in this section of the report. The water budget comparison was developed as part of the integrated model calibration process. The comparisons discussed in this section of the report include the Phase I observed water budget presented in **Section 3.3** and the final integrated model results from watershed model (run 28), Stella surface water model (run 14) and MODFLOW groundwater model (run 28).

8.3.1 Mean Annual Water Budget Summary

The mean annual model water budget is shown in **Table 8.3-1**. The major water budget input is precipitation at 94.6 % of the total inflow. This represents approximately 22.4 inches on the 12.4 million acres in the study area. Under the output side of the water balance evapotranspiration accounts for 92.8% of the total inflow and represents around 22.0 inches of use on the 12.4 million acres in the study area. The surface water inflow and outflow in the water balance accounts for only 5.3% and 6.3% respectively of the total inflow. The groundwater inflow and outflow in the water balance is less than 0.1%.

In Section 3 of the report the observed water budget or COHYST 2010 Phase I water budget was presented. Table 3.3-1 shows very similar water budget numbers. Several items to note include the evapotranspiration water balance value in the observed budget is 93.2% of the inflow which represents 22 inches of use on the 12.4 million acres in the study area. This represents a good average annual fit for the regional models that where developed and calibrated. One additional difference is groundwater inflow and outflow. The Phase I water balance estimated these inflows and outflows are 3 to 5 times higher than what is modeled. This difference however represents a small part 0.3% of the water budget inflows. When comparing the mean net change in storage between 1985 and 2005 the observed and modeled water balances are similar for surface water but groundwater storage was depleted more by the GW model than historic. The surface water storage showed very similar numbers with 49,900 acre-feet being drawn out of storage in the observed and 41,030 acre-feet in the modeled. Groundwater storage change for the 1985 through 2005 period shows the observed decrease of 132,000

Table 8.3-1. Mean Annual Modeled Water Budget and Balance for Entire Hydrologic Cycle in the COHYST 2010 Study Area for the Entire Period 1985-2005.

INPUTS		Units AF	Percentage
1A	Precipitation onto the land surface	23,206,294.8	94.6%
1B	Precipitation onto the water surface (1A and 1B together cover 100% of acres)	0.0	0.0%
1C.	Surface water inflows from upstream, whether native flow, storage, imports	1,305,058.4	5.3%
1D	Subflow from upgradient (all boundaries)	25,250.1	0.1%
	Total IN	24,536,603.2	100.0%
OUTPUTS			% Inflow
2A	Evapotranspiration from the land surface	22,770,117.3	92.8%
2B	Evapotranspiration from water surface (2A and 2B together cover 100% of acres)	0.0	0.0%
2C.	Surface water discharges to downstream (Platte, Republican, Blue, and Loup)	1,553,630.2	6.3%
2D	Subflow to downgradient (all boundaries)	14,902.2	0.1%
	Total OUT	24,338,649.7	99.2%
CHANGES IN STORAGE			
3A	Net change in soil moisture (ignore for a 1985-2005 calculation)	32,564.0	
3B	Net change in bank storage (ignore for a 1985-2005 calculation)		
3C	Net change in reservoir storage within area	-41,029.9	
3D	Net change in aquifer storage	-698,442.5	
	Net Storage	-706,908.1	

acre-feet while the modeled change was a decrease of 698,442 acre-feet. This difference in observed storage and model storage represents a small change in terms of groundwater levels 0.05 feet across the 12.4 million acre model area.

8.3.2 Annual Water Budget Summary

This annual water budget sub-section discusses and illustrates observed and modeled water balance comparisons. The annual balance of water inflow (IN) and outflow (OUT) of the models is shown in **Figure 8.3-1**. This chart shows the annual variation of inflow and outflow for the 1985 through 2005 period and it closely matches the observed Phase I water budget balance chart shown in Figure 3.3-1. The largest error, in 1993, reflects a very wet year with more runoff than the current model simulates.

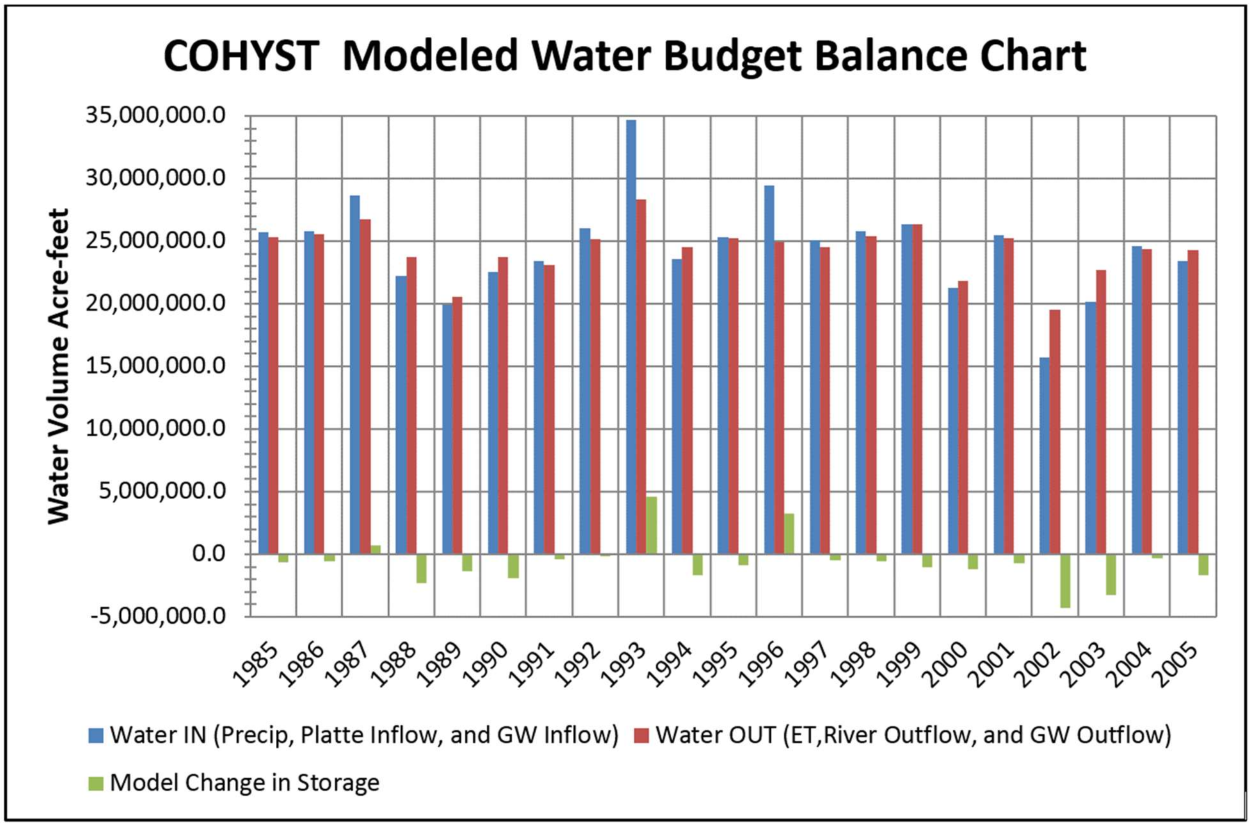


Figure 8.3-1. Annual Modeled Water Balance for Inflow, Outflow, and Change in Storage.

Other annual observed and modeled water budget comparisons were made for the various components of the budget. They include Precipitation, Evapotranspiration, Surface water inflows (Lewellen and Julesburg), Platte River surface water outflow at Duncan, Surface water reservoir change in storage, Groundwater inflow and outflow, and Groundwater change in aquifer storage. **Figures 8.3-2** through **8.3-8** displays these annual comparisons.

The graphs in the figures below were created in a water budget spreadsheet that incorporates summary outputs from the three models that make-up the integrated model. The outputs from the Watershed model, Stella Model and MODFLOW groundwater model are moved into worksheets within this spreadsheet. The Modeled Water Budget worksheet is then created to summarize the water balance. In the same spreadsheet, the Phase I observed water budget is added as a worksheet so comparisons and chart can be created. The final integrated model spreadsheet is named “Water_Budget_run028b_14_28_11092016”, available on the COHYST Website.

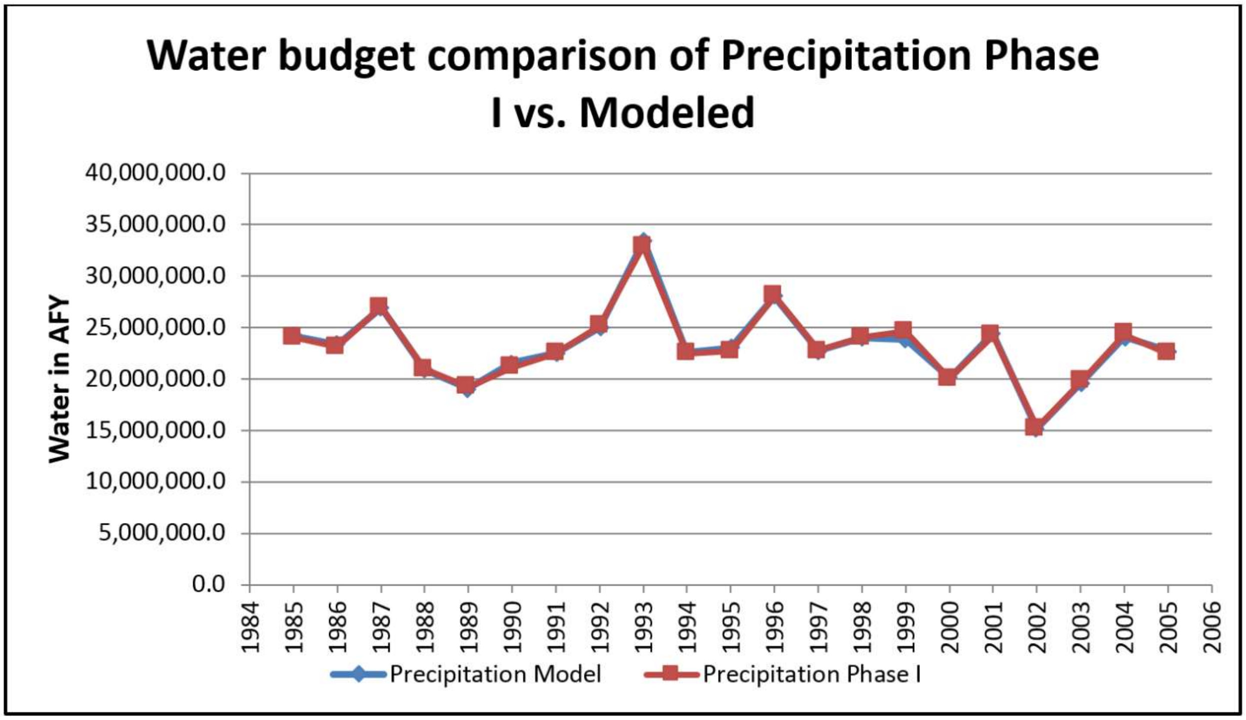


Figure 8.3-2. Annual Observed and Modeled Precipitation.

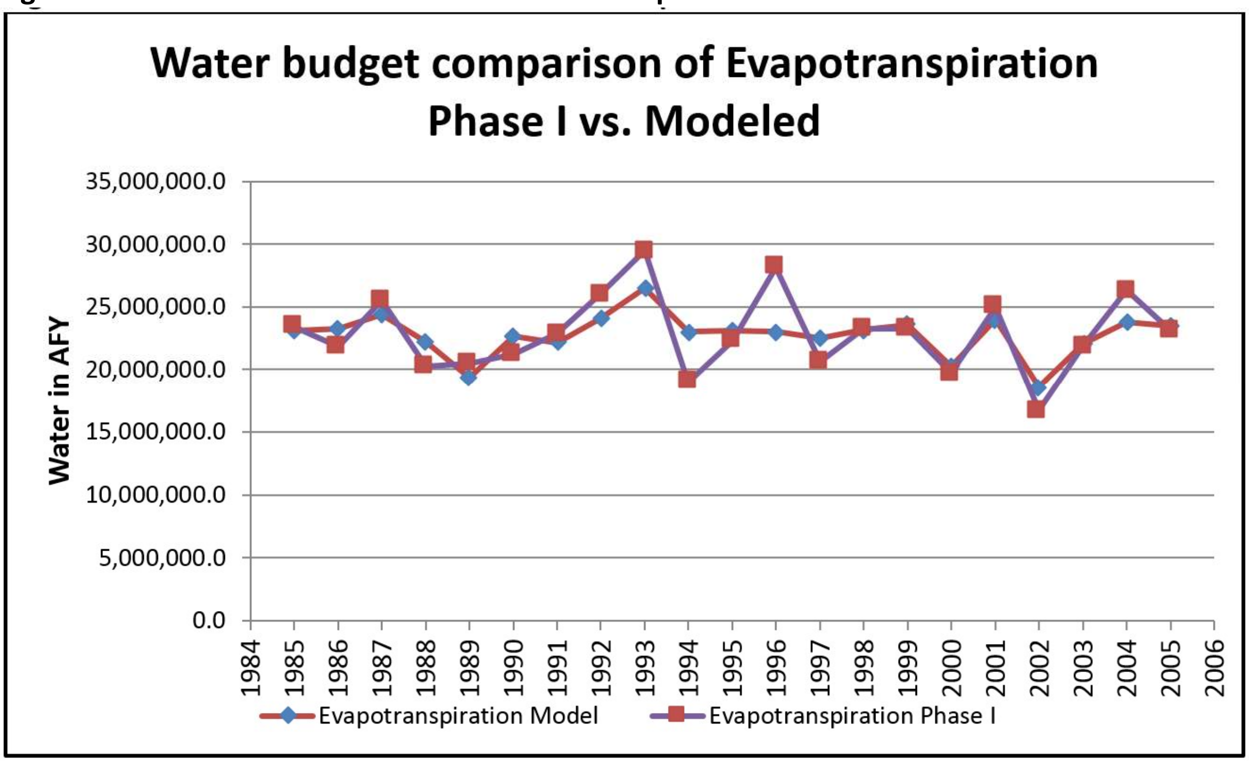


Figure 8.3-3. Annual Observed and Modeled Evapotranspiration.

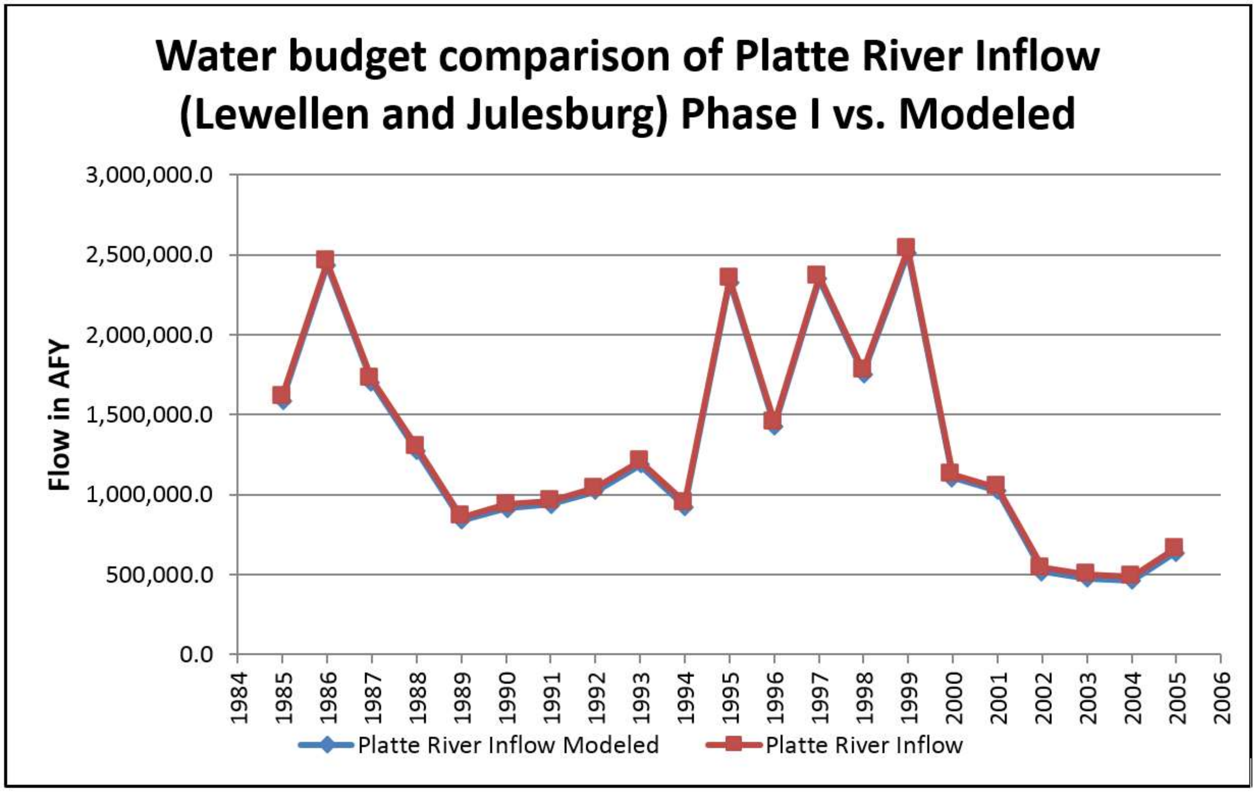


Figure 8.3-4. Annual Observed and Modeled Platte River Inflow.

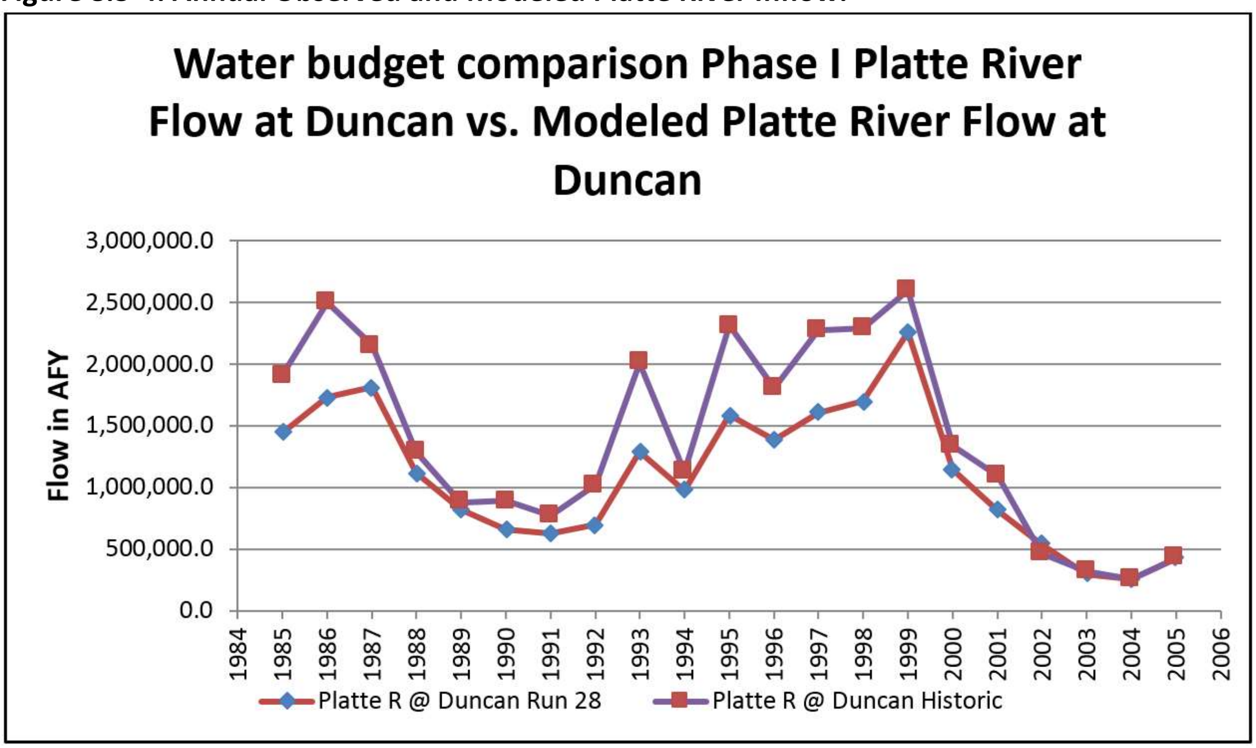


Figure 8.3-5. Annual Observed and Modeled Platte River Flow at Duncan.

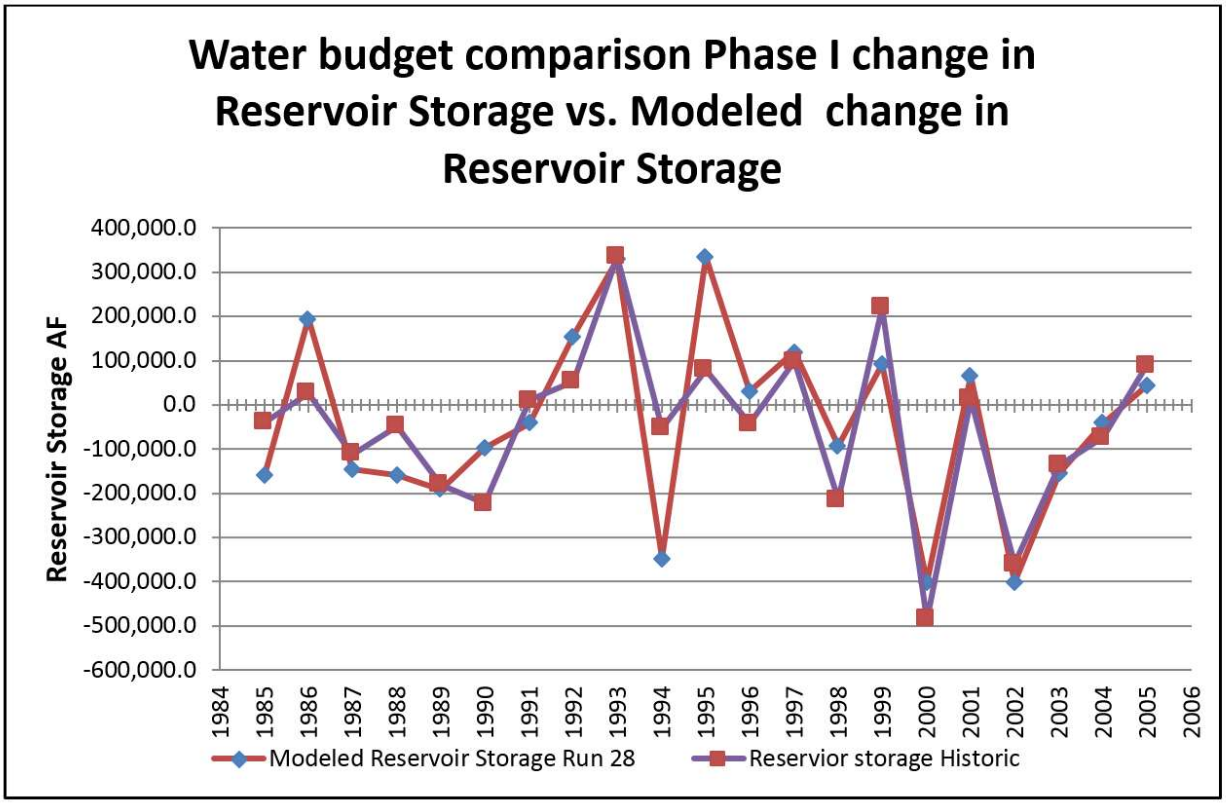


Figure 8.3-6. Annual Observed and Modeled Reservoir Storage Change.

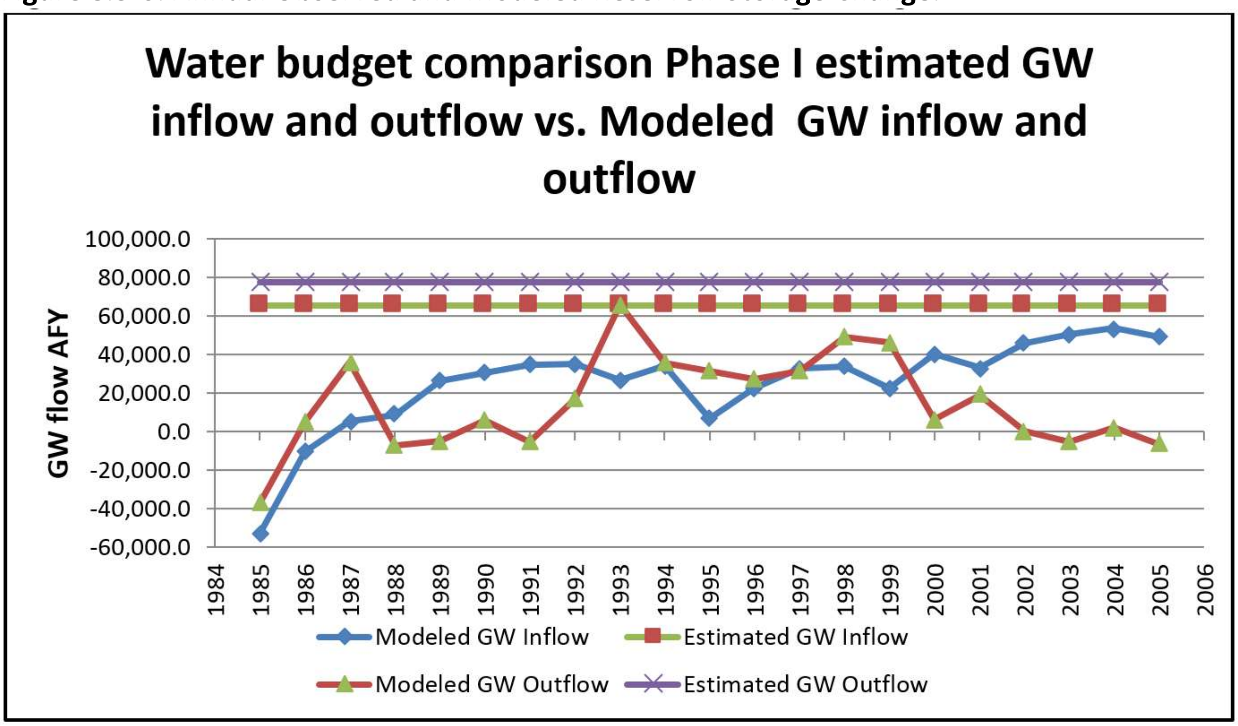


Figure 8.3-7. Annual Observed and Modeled Groundwater Inflow and Outflow.

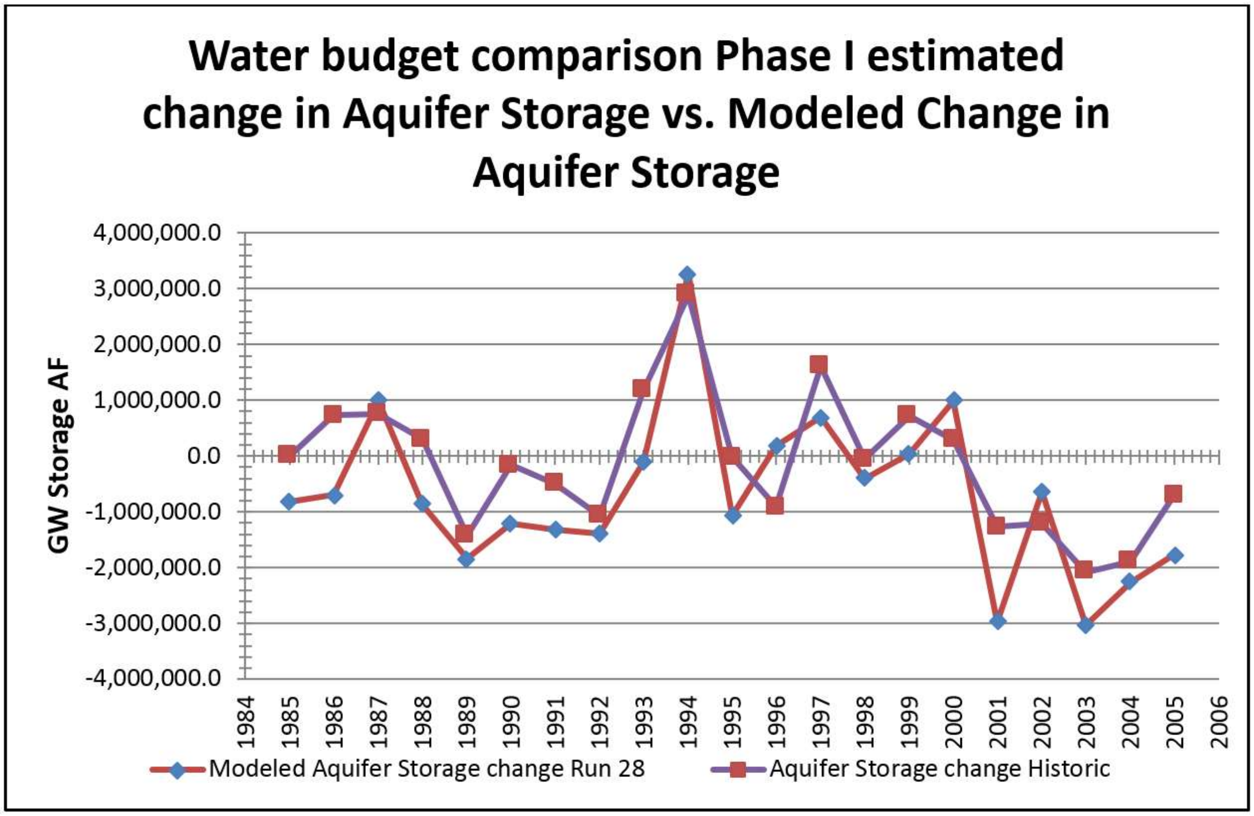


Figure 8.3-8. Annual Observed and Modeled Groundwater Aquifer Storage.

There are several assessments from the annual water budget charts.

1. The observed and modeled inputs (Precipitation and Platte River Inflows) shown in Figures 8.3-2 and 8.3-4 match well and provide a quality assurance check on the model inputs.
2. The observed and modeled Platte River flow at Duncan Figure 8.3-5 shows modeled flow is less than observed in normal and wet years (1990 through 2001) and very similar in dry years (2002 through 2005). The modeled flow at Duncan in the normal to wet years averages about 400,442 Acre-feet per year lower than observed; the fact that larger runoff events are not captured in the model is the expected result of the methodology used. In the dry years, the modeled flow averages 12,000 Acre-feet per year higher than observed.

3. Annual reservoir storage change in Figure 8.3-6 shows in the last 9 years of the study period is a better match to historic storage change than in earlier years. The surface water model development emphasized current operating rules and was not programmed to match historic operating rules that may have modified over time.
4. Groundwater inflow and outflow shown in Figure 8.3-7 are smaller for the modeled analysis. This probably reflects the changes in aquifer properties made during the groundwater model calibration.
5. Annual change in Aquifer Storage shown in Figure 8.3-8 for the model and observed values match reasonably well. These changes are shown for the April to March period each year. The modeled years of largest storage increase occurred over 2 years 1993 and 1994 while the largest decrease in storage occurred in 1995 and again in 2001.

8.3.3 Cumulative Water Budget Comparisons

Cumulative water budget comparisons created based upon cumulative annual water budget datasets for the observed (Phase I) and modeled data (see spreadsheet). A graph was created that displays how cumulative Platte River flow at Duncan versus precipitation compared for the observed and modeled water balance (see **Figure 8.3.9**). This graph shows that the cumulative flow difference between the integrated model and the observed flow at the end of sixteen years is around 4,755,000 AF or 297,200 Acre-feet per year. This shortage of streamflow indicates the need for additional runoff, return flow, or baseflow. To get better understanding of when over the 16-year period additional flow is needed a cumulative Platte River net gain graph was created **Figure 8.3-10**. Net gain in Platte River flow is defined as the Platte River outflow at Duncan minus the Platte River inflows at Julesburg and Lewellen. The wet and normal years like 1993 through 2000 show net gains to the River are short on rainfall runoff and baseflow gains. **Figure 8.3-11** a graph of cumulative groundwater aquifer storage change which shows some of the larger changes in storage occurred in wet years. Thus, increased runoff in wet years and reduced recharge in wet years could provide a better match to observed data.

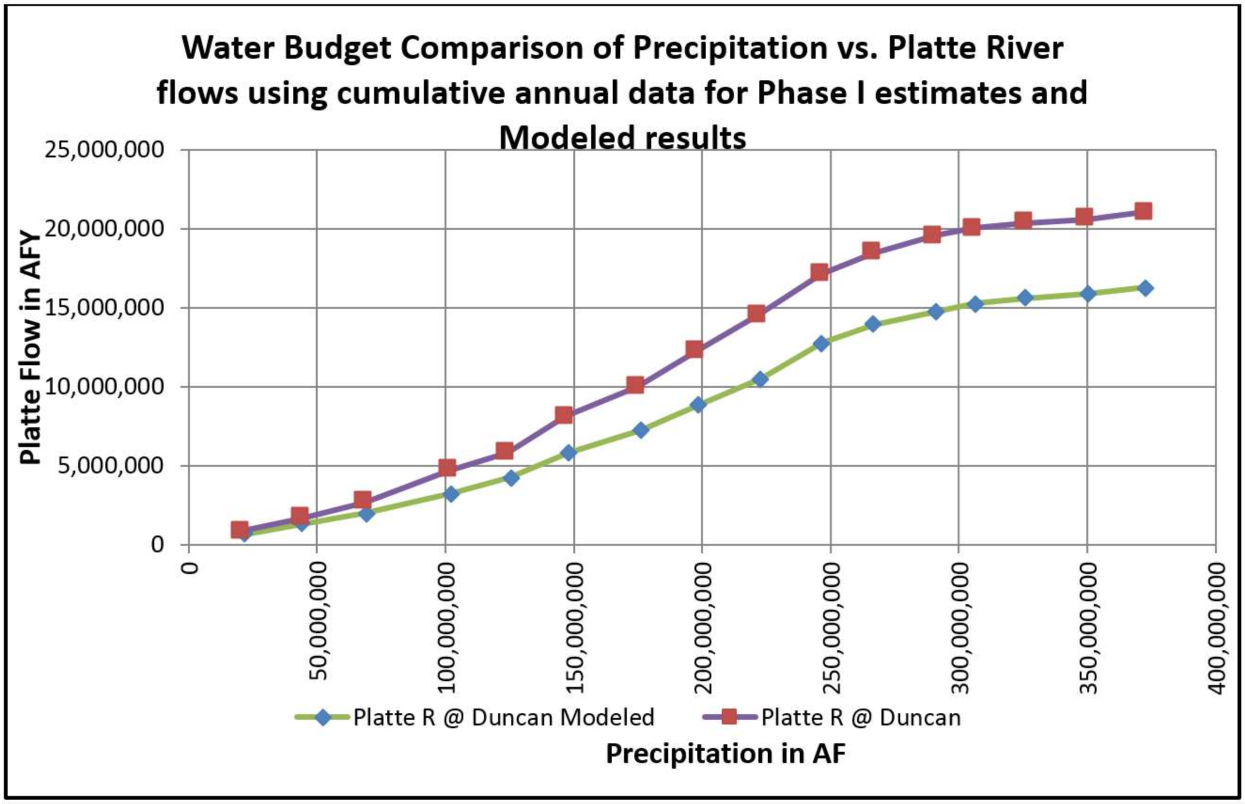


Figure 8.3-9. Annual Cumulative Platte River Flow at Duncan for the Observed and Modeled Data.

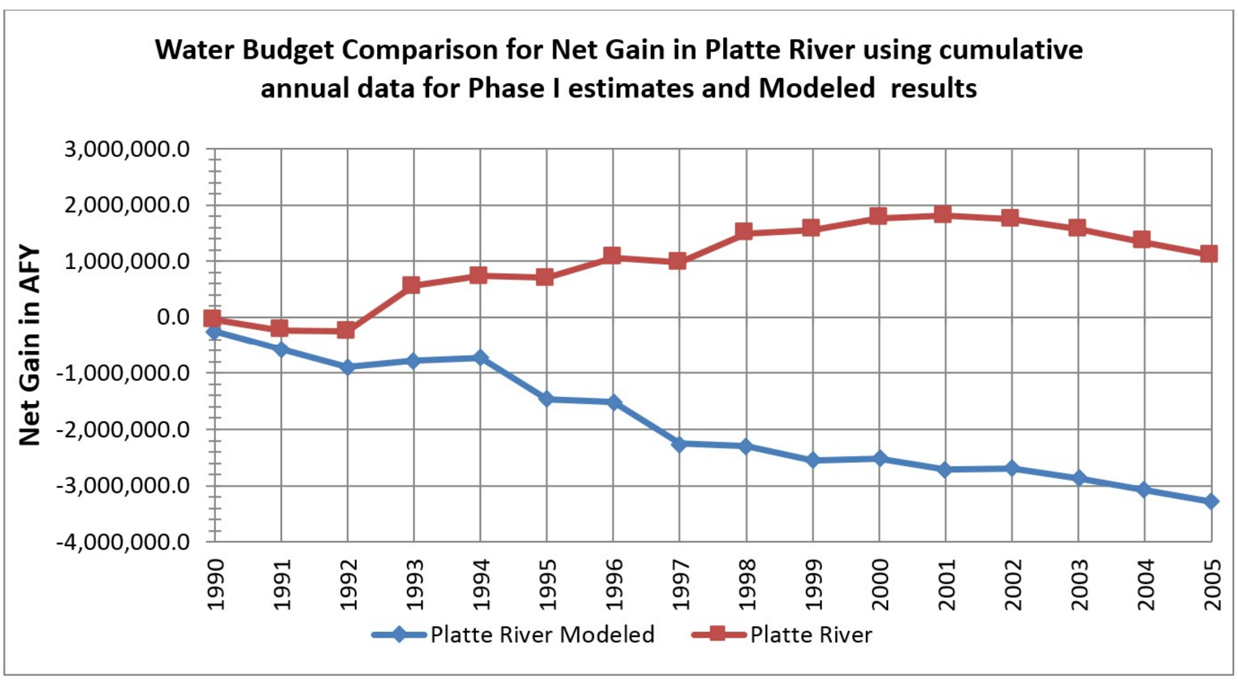


Figure 8.3-10. Annual Cumulative Net Gain for the Observed and Modeled Data.

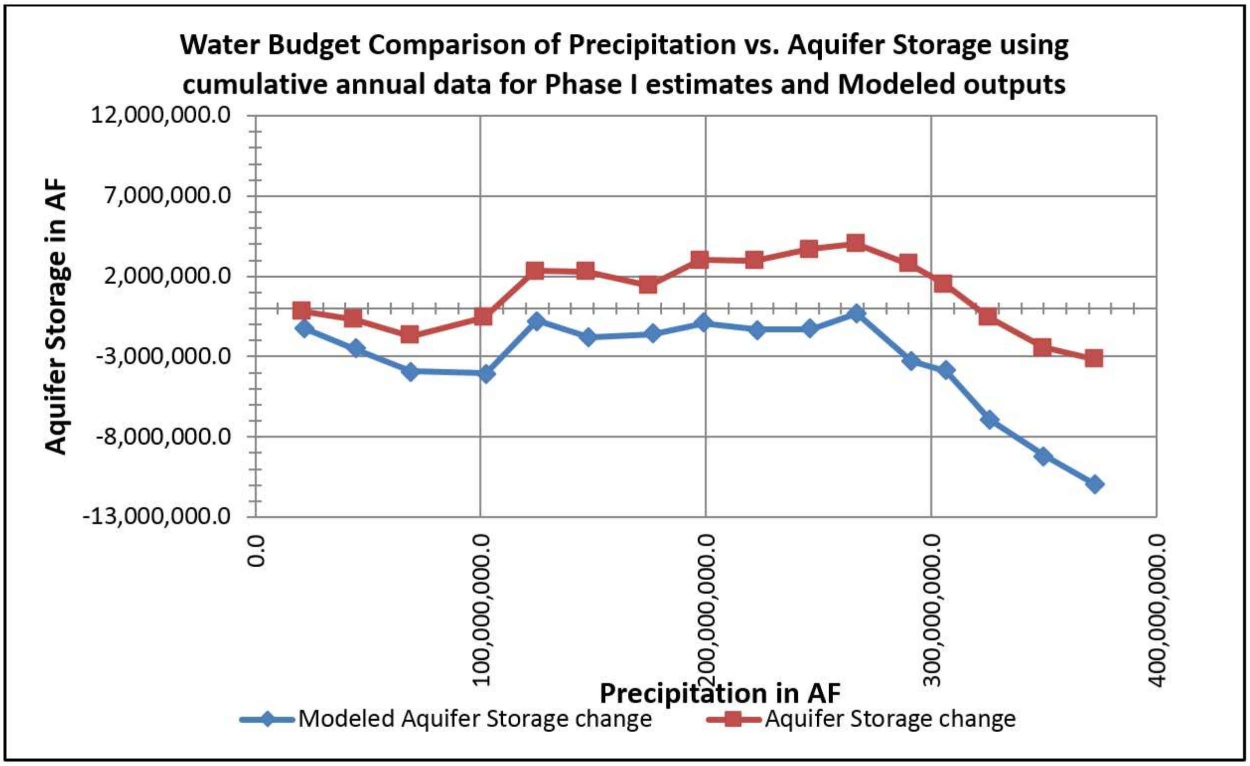


Figure 8.3-11. Annual Cumulative Changes in Groundwater Storage for the Observed and Modeled Data.

8.4 Integrated Model Graphical User Interface (GUI)

While there are only three primary components in the Integrated Model, some of these components involve multiple steps, and many data conversions are required to complete an Integrated Model analysis. Originally a manual run of the model was completed by three groups of experts (watershed model by the Flatwater Group, surface water model by HDR, and the groundwater model by Lee Wilson and Associates). Completing a model run requires a number of steps that generally include receiving input data, running a model, data processing (including Excel macros or short scripts), and providing outputs to another modeler. The total process required weeks to complete given the involvement of so many people.

To simplify this process and make the model more useable, a Graphical User Interface (GUI) was created that automates the process of conducting an integrated model run. The user must provide input files for each of the models that follow specific requirements. The input files are used as templates to setup the actual simulation files. The GUI copies the input template files which are modified as needed for the specific run, converts and passes data between models, and runs the component executables. A complete simulation including multiple iterations can be performed without user intervention. Using the GUI allows a user to run the model in 4 to 8 hours depending on computing power, and because it no longer requires user inputs while running, it can be run before leaving for the day. It also has been configured to allow the user to start the integrated run at any one of the 18 different modeling tasks, letting the user skip time consuming steps when those steps have no effect on the end results or to only rerun the portions necessary when making model changes due to input errors or other changes. While the GUI makes it easier to conduct Integrated Model runs, subject matter experts are required to properly set up the input files and review the model results. The GUI has specific setup and use requirements that are described further in the user's manual (**Appendix 8-G).** The current version of the GUI runs COHYST 2010 Integrated model runs for the 1984 through 2010 period.

During February 23rd and 24th, 2016 a GUI training was held at the HDR office in Omaha and the agenda included:

- Background on the integrated modeling process and the individual models
- Background on the GUI
- Preparing model files and folders to run the GUI
- Running integrated models using the GUI
- Debugging/troubleshooting when things go wrong
- Analyzing and visualizing model results
- Discussion on possible future directions and feature requests

8.4.3 GUI Verification

To verify that simulation results using the GUI for the integrated model give the same answers as running the individual models manually, the integrated calibration simulation performed manually was rerun using the GUI. At each step of the process, the model outputs and GUI-generated inputs were compared to the files used to perform the manual simulation. In almost all cases the values generated by the GUI were Identical to those from the manual simulation.

This comparison did determine that with respect to the method for converting MODFLOW outputs to STELLA base flow inputs, the GUI adopted an approach developed by the DNR which uses a lookup table to identify the conversion between MODFLOW cells to STELLA base flow input locations. The manual simulation uses a FORTRAN code to perform this conversion. The two approaches produce similar but not identical base flow inputs to STELLA. The modeling team determined that the excellent agreement between the final results suggests that the GUI is performing as expected and verified the ability to effectively replicate the manual integrated simulation results using the GUI.