Appendix 6-G

Priority Accounting Summary

Appendix 6-G contains a summary of how priority accounting rules were created and implemented into the surface water model. The priority logic enables the model to “color” the water throughout the system and quantify the amount of natural flow and storage water at nodes along the river.

Memo

Date: Thursday, June 08, 2017

Project: COHYST

To: COHYST Group

From: HDR

Subject: Platte River Priorities

Background

The "Doctrine of Prior Appropriation" was officially adopted by Nebraska in 1895 and is the basis for Nebraska surface water law. Under this doctrine, the earliest dated, or senior water right user, is entitled to water before other junior water right holders, or "first in time is first in right." Table 1 lists the natural flow appropriations, priority dates and rankings for the canals within the COHYST Stella model extents. The Kearney Canal has the most senior right, with a priority date of 1882.

Table 1 – Canal Natural Flow Appropriations and Priority Dates (Listed from upstream to downstream)

Canal	Natural Flow Appropriation (cfs)	Date	Ranking
Keith Lincoln	81	2-2-1894	5
North Platte	201	5-13-1884	2
Paxton-Hershey	103	2-12-1894	6
Suburban	78	10-21-1893	3
Cody-Dillon	58.08	12-29-1893	4
Tri-County	630	1-13-1934	13
Gothenburg	253	9-22-1894	8
Thirty-Mile	275	9-7-1926	12
Six-Mile	24	10-22-1894	9
Cozad	235	12-28-1894	10
Orchard Alfalfa	84	1-23-1895	11
Dawson	377	6-26-1894	7
Kearney[1]	382	9-10-1882 (22 cfs, 140 cfs) 2-12-1920 (219 cfs)	1

[1]For simplicity, the total Kearney natural flow appropriation was assigned a priority date of 1882.

Logic and Assumptions

Because the the surface water system is administered based on priority in times of shortage, the COHYST sponsor group requested that priority rules be created and implemented into the Stella model logic. The priority logic enables the model to "color" the water throughout the system and quantify the amount of natural flow and storage water at nodes along the river. The natural flow diversion is limited to the minimum of the natural flow appropriation or canal demand within the STELLA model, assuming a canal will not take more than their appropriation. This logic was applied to the surface water irrigation districts during the irrigation season within the STELLA model.

Underlying assumptions of the priority logic in the STELLA model are listed below:

- Reach gain/loss is assigned to the natural flow, unless there is no natural flow in the river
- Rules incorporate priority dates and appropriated natural flow right
- Coloring of water is dependent on simulated available natural/storage upstream of diversion
- Anecdotal reach gain/loss used in rules (used when there is a senior appropriation downstream)
- Coloring of water in Stella is done on a daily time-step unlike PWAP, which is 'hindcasted'.

It is noted that the intention of the priority logic within the STELLA model is to evaluate the impacts on natural/storage flows in the river of alternative scenarios, not to serve as an accounting tool for administration. Appendix 1 of this memo explains the natural flow and storage water logic and assumptions at each point along the river where the natural and storage water are calculated. Appendix 2 shows a daily schematic of the colored water (including the total, natural flow and storage water values) at each point along the river and provides example calculations for the daily schematic.

Analysis

When the priorities were first entered in to the Stella model, the calculation was done in parallel to river routing and canal diversions, i.e. was used to simply account and track storage and natural flow diversions without limiting diversions based on priority. Currently, the Stella model is not set up to have the priority rules affect diversion volumes or 'shut-off' canals, generally consistent with the operations during the calibration period.

Gothenburg Canal is shown as an example. The canal labeled "Limited" represents where the diversion was limited based off of priority rules. As shown in Figure 1, the limited natural flow in the Gothenburg Canal typically decreases with the priority rules in place. This is due to senior rights that need to be met downstream limiting the diversion at Gothenburg Canal.

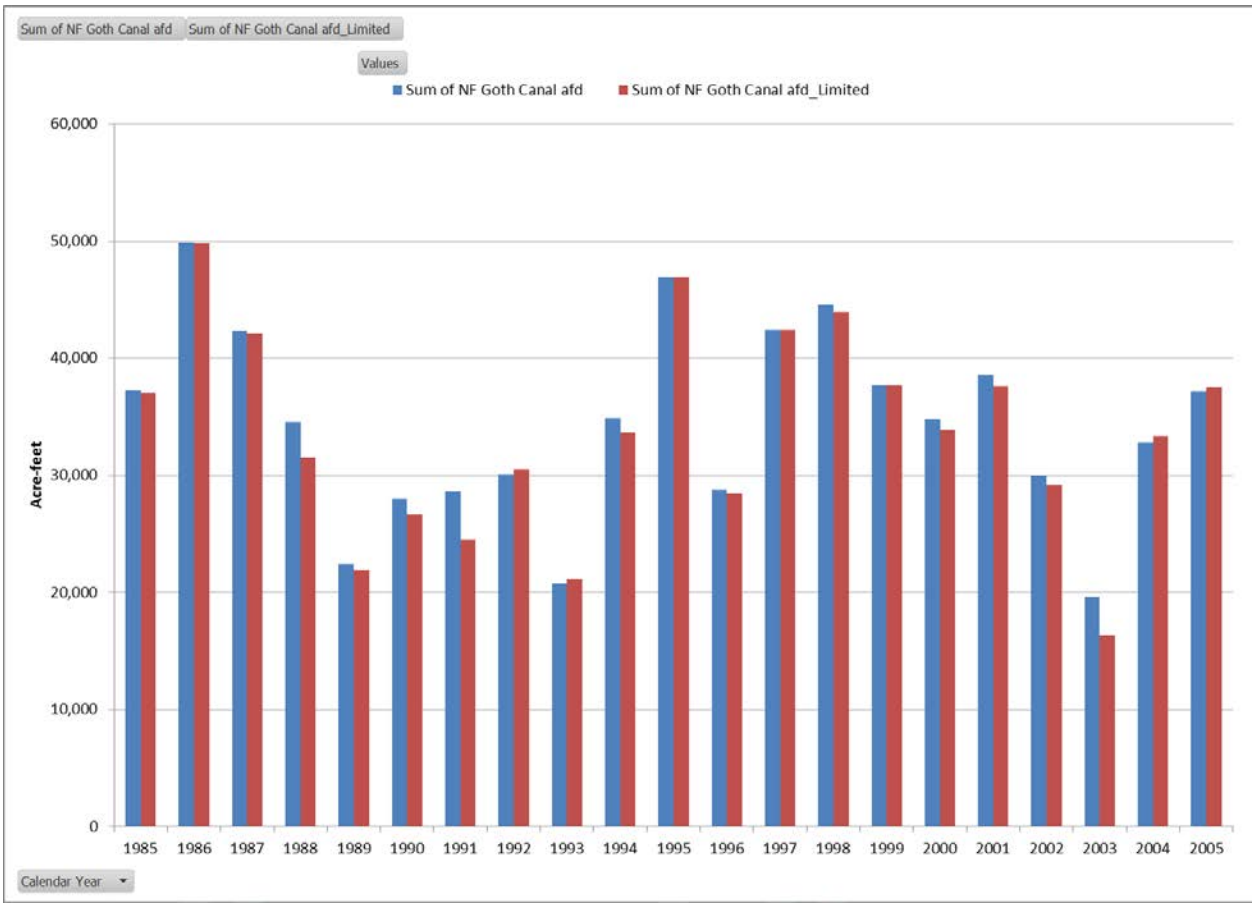


Figure 1. Gothenburg Natural Flow Comparing Parallel Calculations to Limited Calculations

Figure 2 shows that the limited storage water typically increases. The storage water change with the limited calculations is directly related to the change that is seen with the limitations on natural flow diversion.

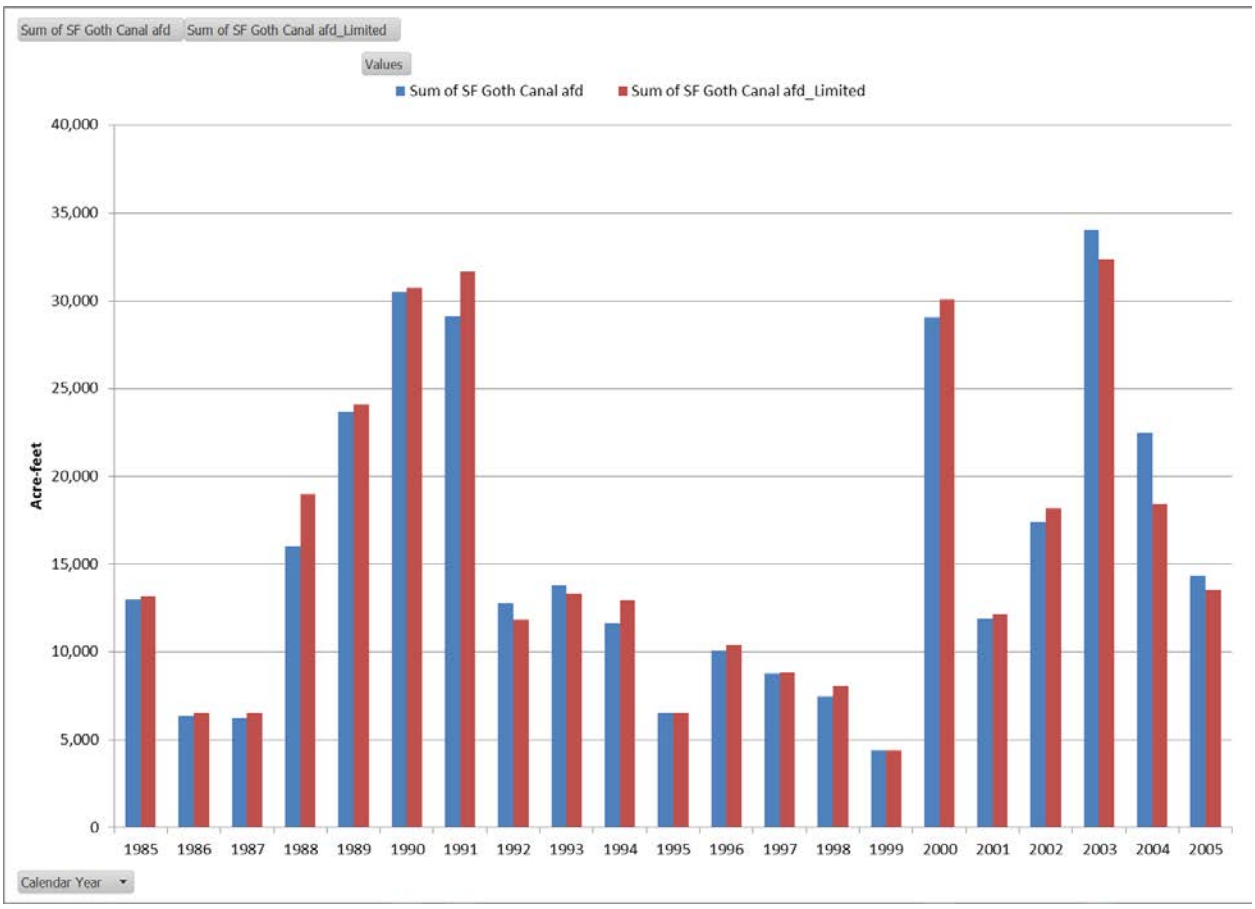


Figure 2. Gothenburg Storage Water Comparing Parallel Calculations to Limited Calculations

The total diversions at Gothenburg with parallel calculations are compared to the total diversion with limited calculations in the diversion rule in Figure 3. As seen in the figure, the total diversions are either the same or decrease when the rules are in place at the diversion.

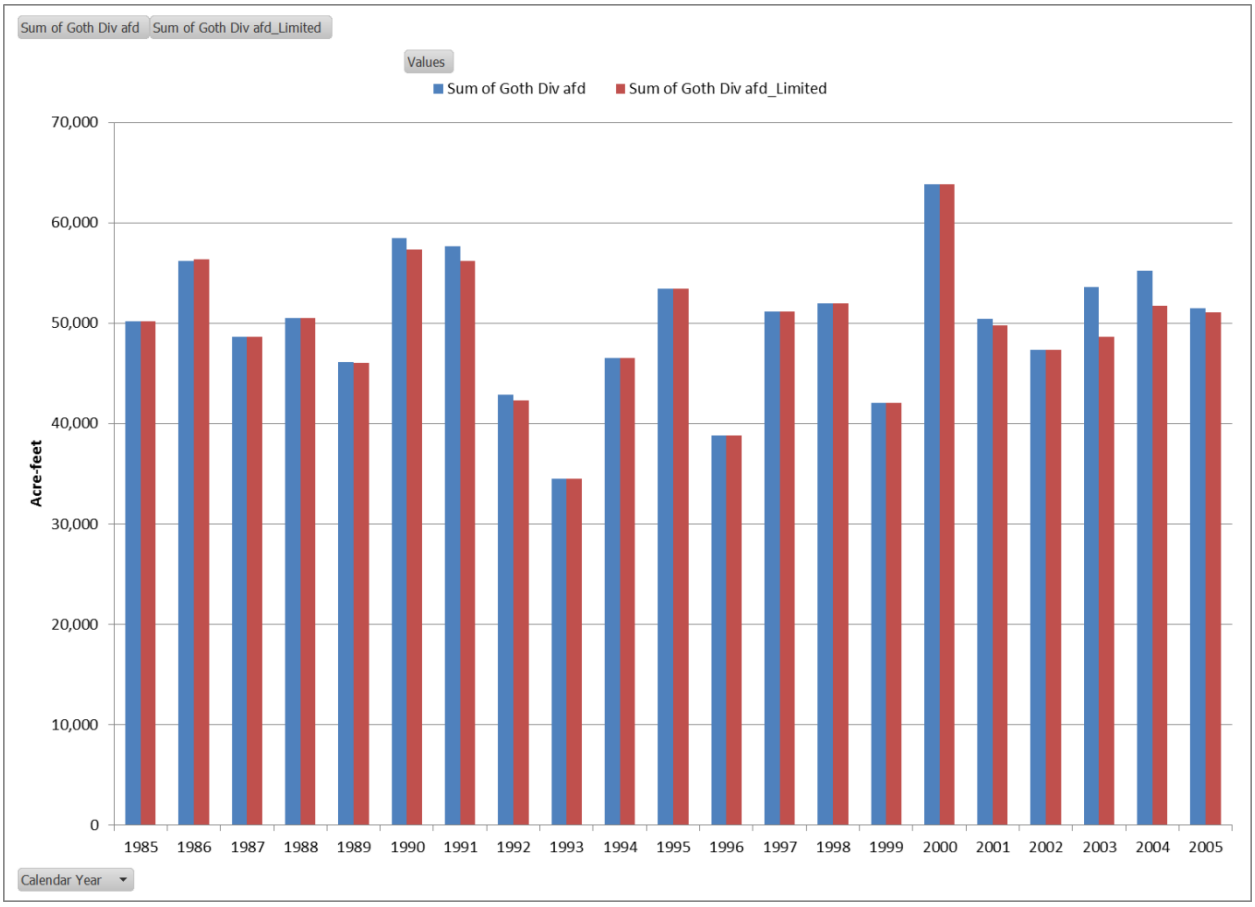


Figure 3. Gothenburg Total Diversions Comparing Parallel Calculations to Limited Calculations

Results

The results of the model calculated diversion (total, natural flow, and storage water) with the priority rules in place was compared to the limited historic data that was available. The blue bars on the plots represent the historic natural flow and the red bars represent the historic storage water. The solid red line represents the model calculated storage water and the solid blue line represents the calculated natural flow. The dashed black line represents the total historic diversion and the solid black line represents the total calculated diversion.

Figures 4 – 13 show the results for the irrigation district canals. General observations are listed below :

- The total calculated diversions are typically less than the total historic diversions, but generally follow the same pattern.
- The trends of calculated storage and natural flow generally follow historic trends well, with some variations in magnitude due in part to the differences in calculated and historic total diversions.
- Paxton Hershey Canal (Figure 6) illustrates how the total diversion is reflected. The total calculated diversion is typically less than the historic natural flow resulting in an under prediction of the storage flow.
- The wet-dry cycle is reflected in the accounting logic. The model is able to predict more storage water during a drought and more natural flow during wet cycles.
- 30-mile Canal (Figure 9) illustrates the model's ability to accurately predict junior priority status. Because 30-mile Canal has junior priority status, the diversion switches to using storage water during times of drought.
- Dawson Canal (Figure 13) illustrates the model's ability to accurately predict senior priority status. Dawson Canal has senior priority status and most of the diversion is natural flow.

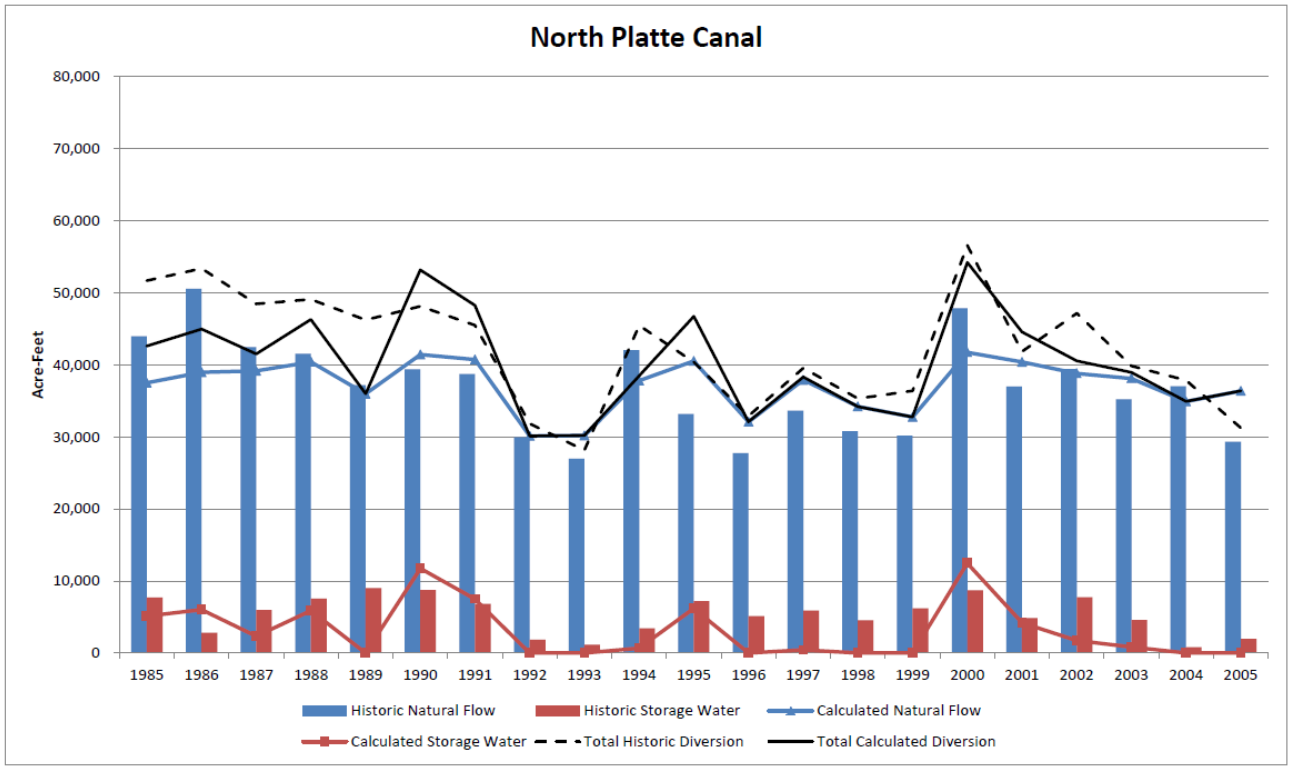


Figure 4. North Platte Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

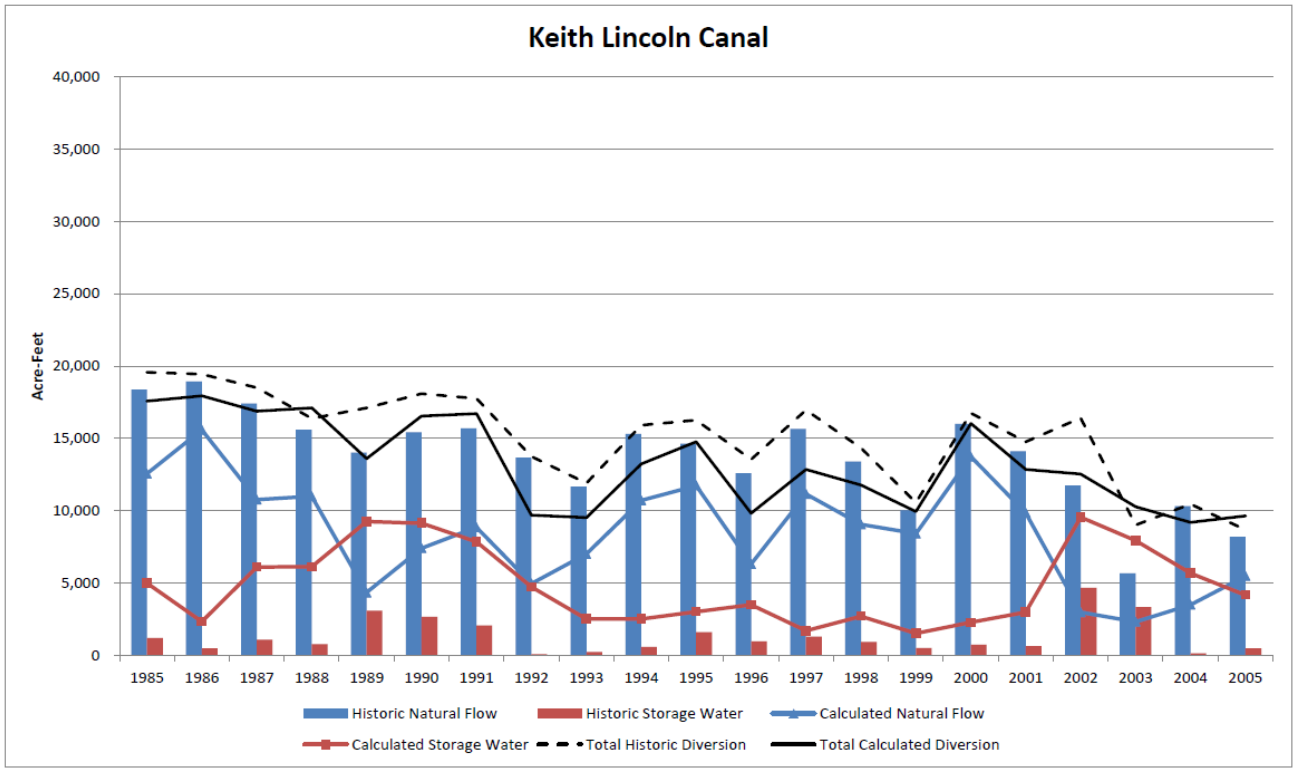


Figure 5. Keith Lincoln Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

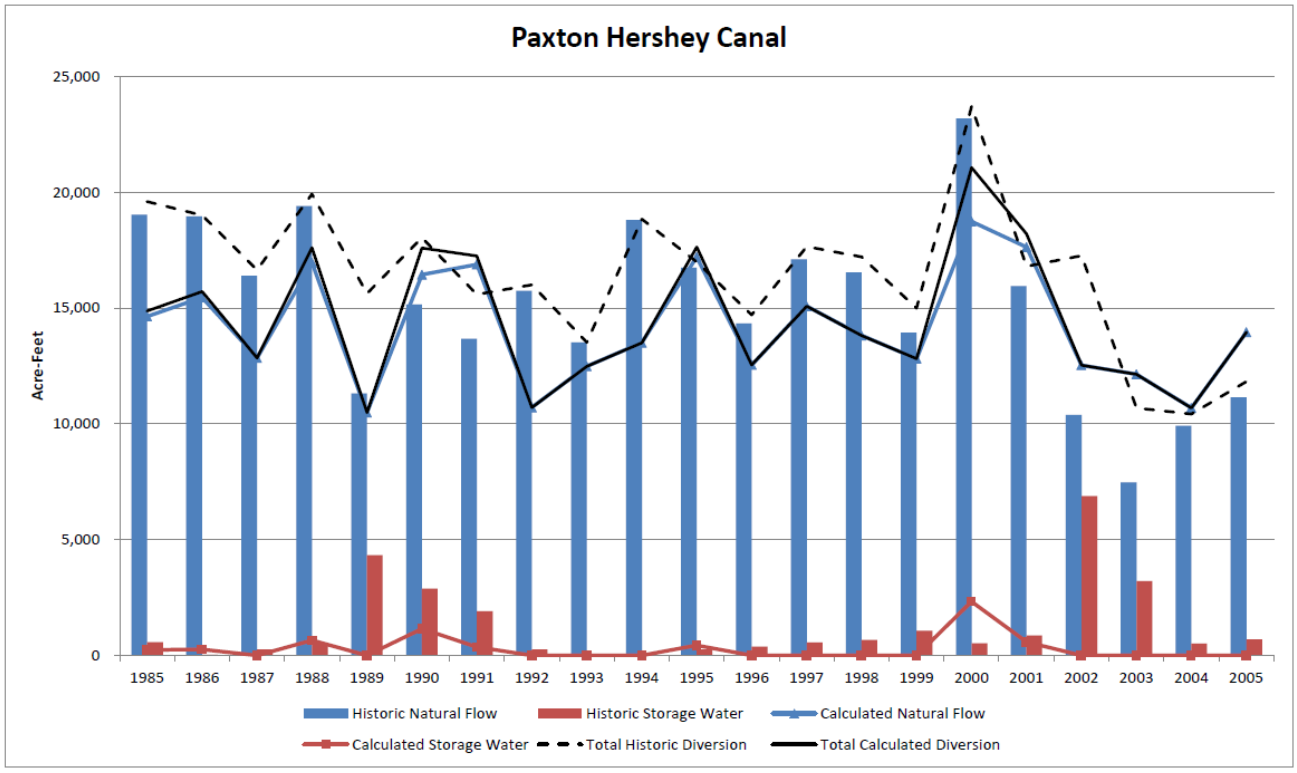


Figure 6. Paxton Hershey Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

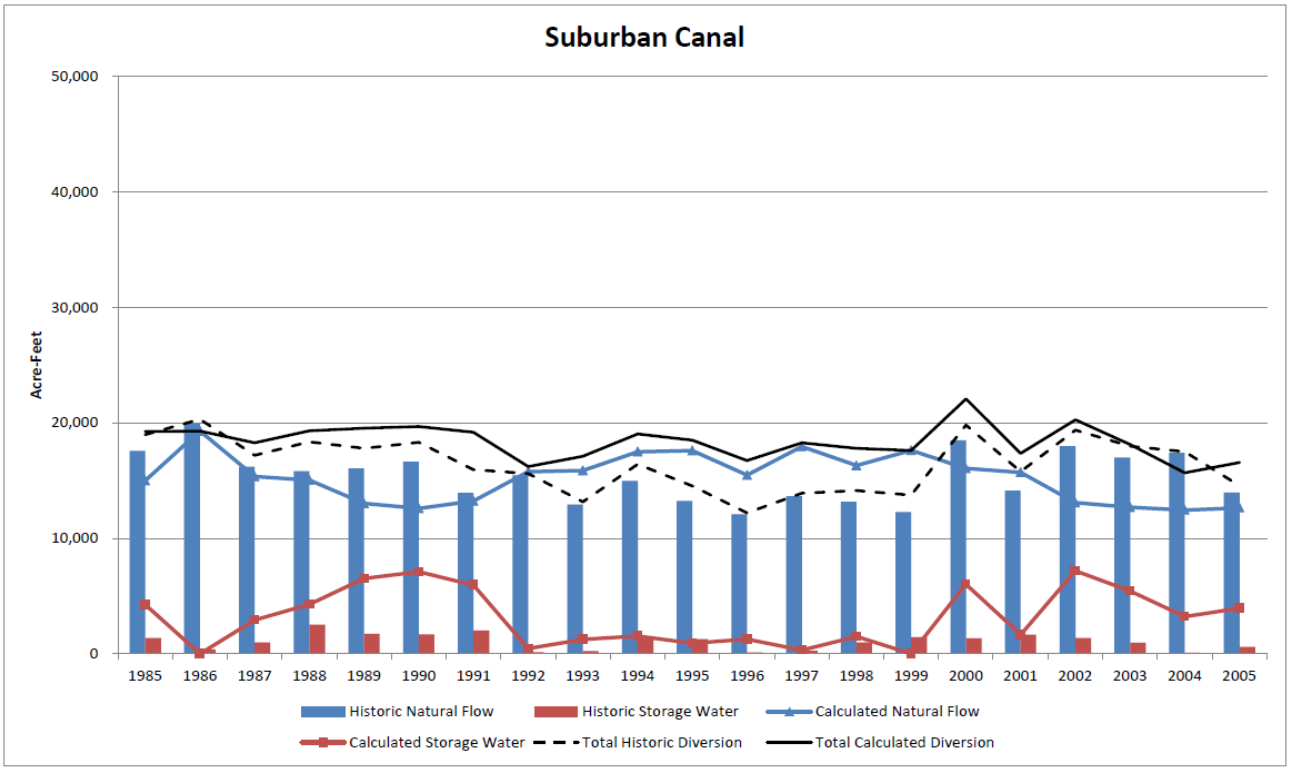


Figure 7. Suburban Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

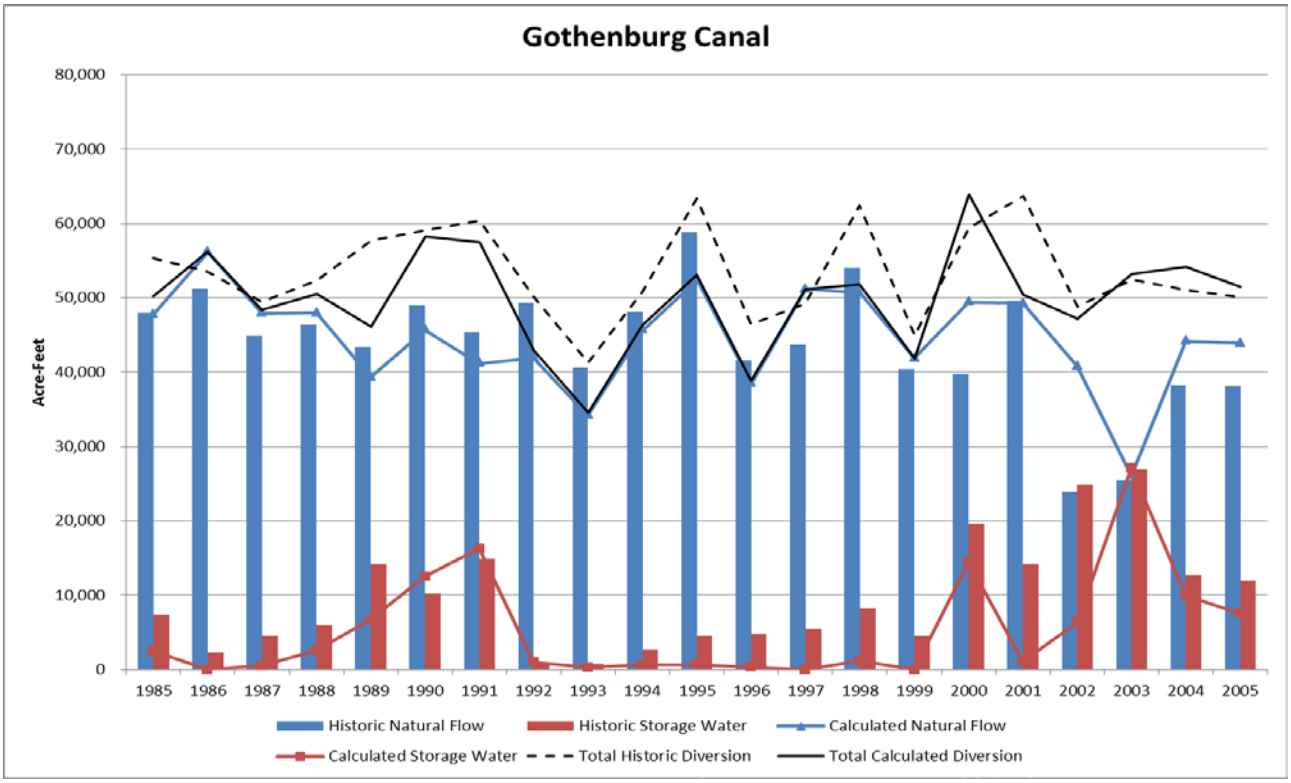


Figure 8. Gothenburg Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

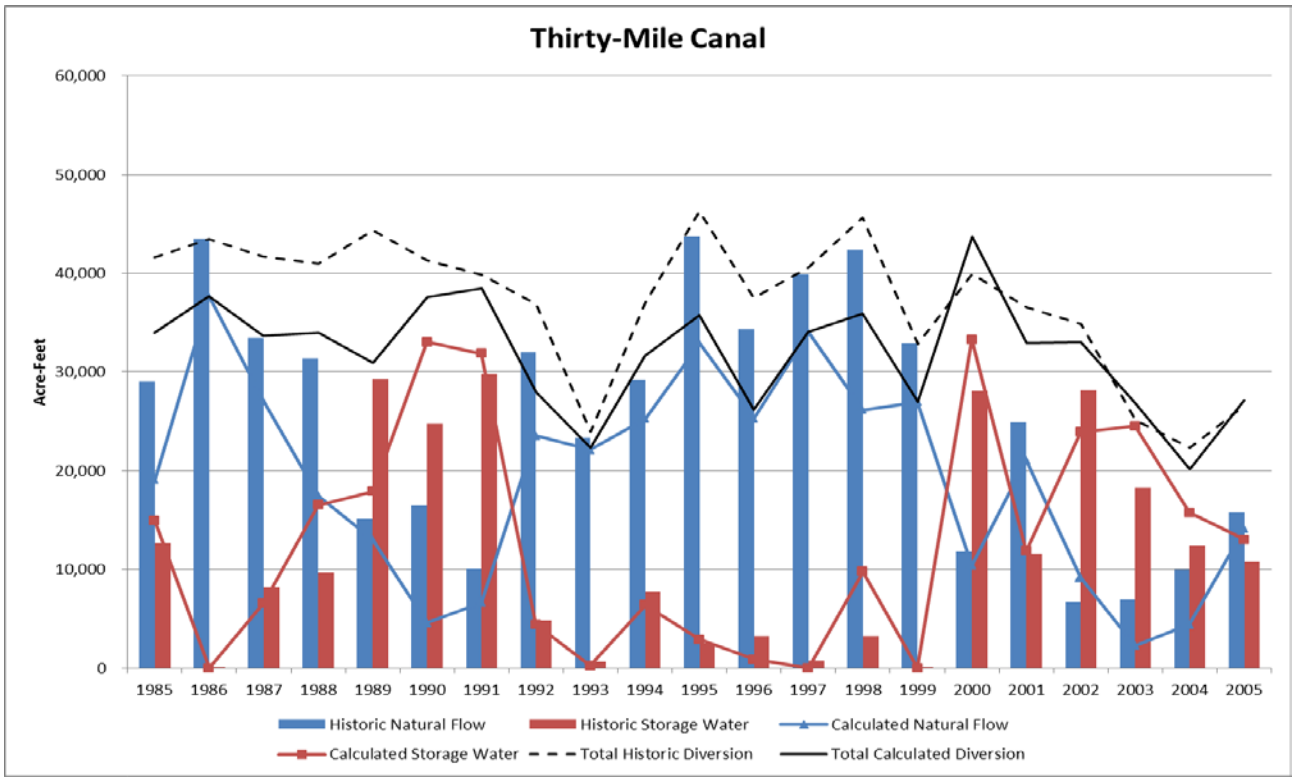


Figure 9. Thirty-Mile Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

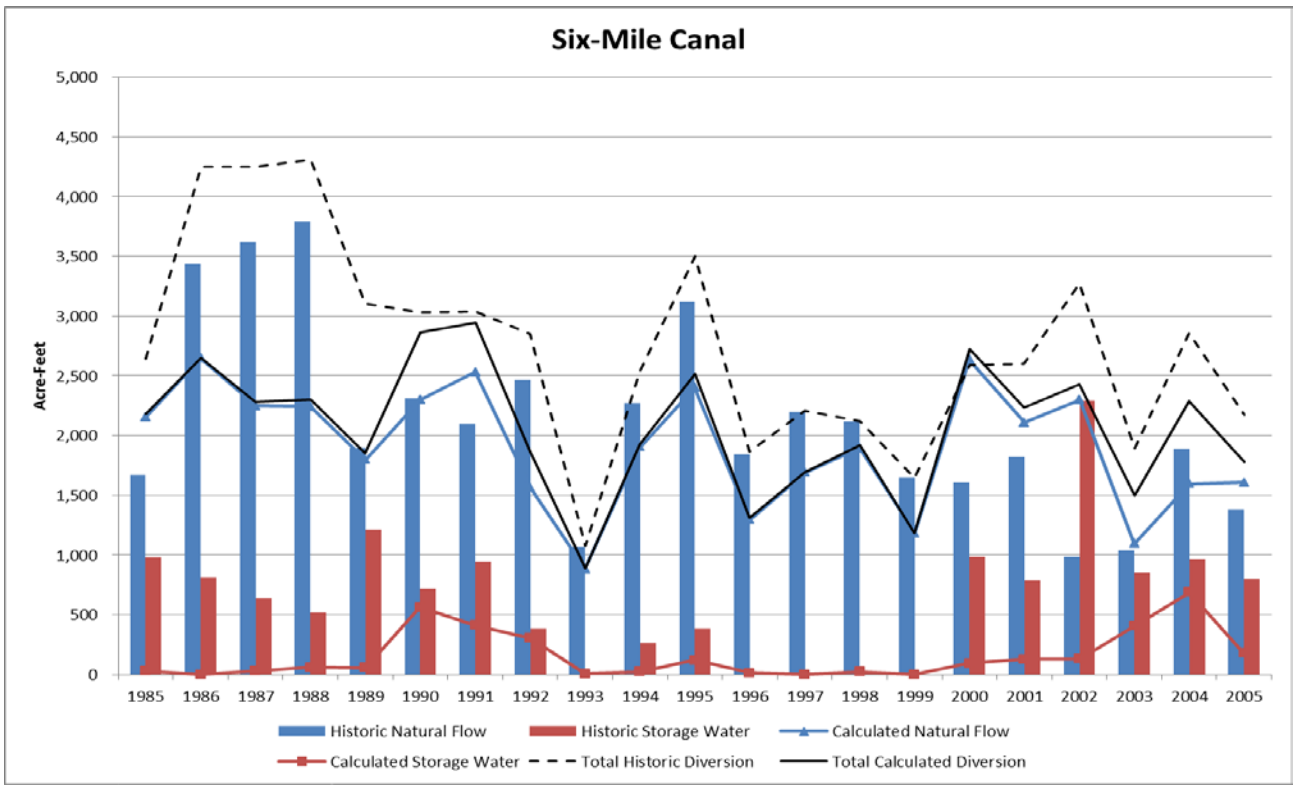


Figure 10. Six-Mile Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

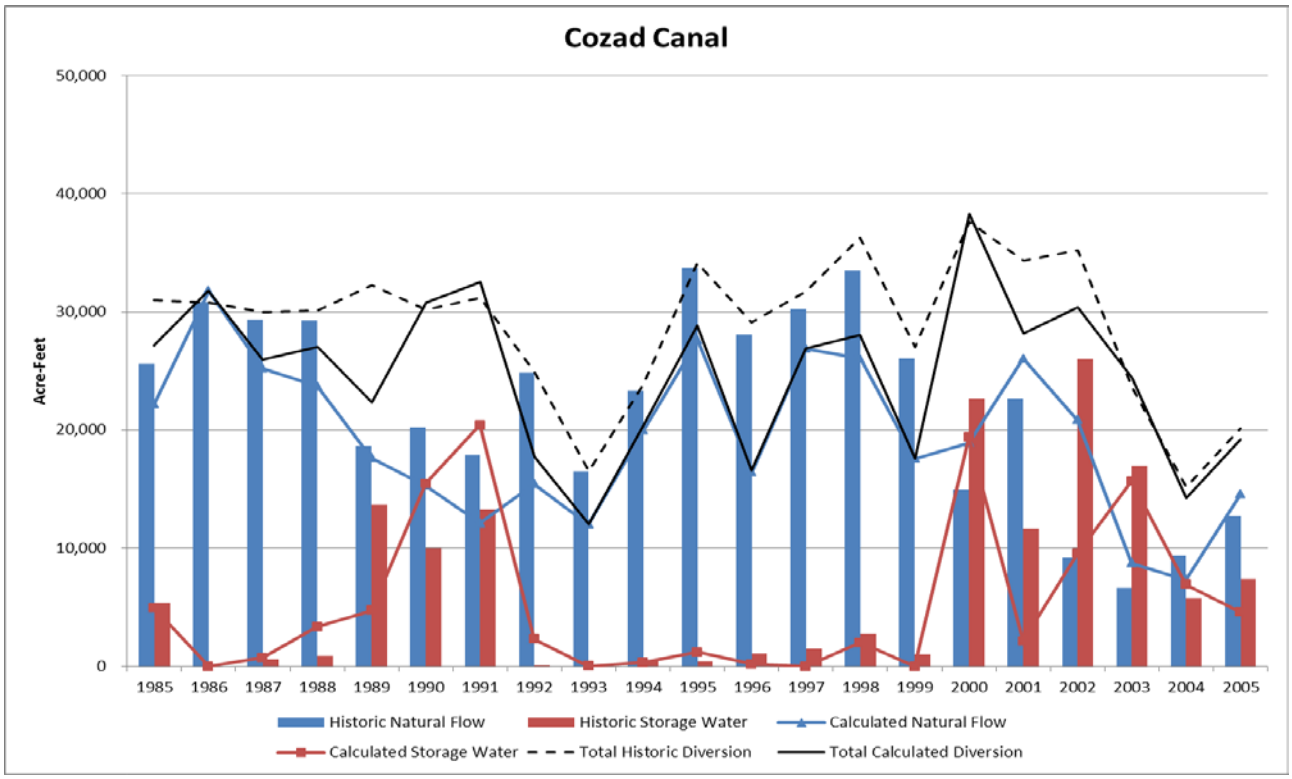


Figure 11. Cozad Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

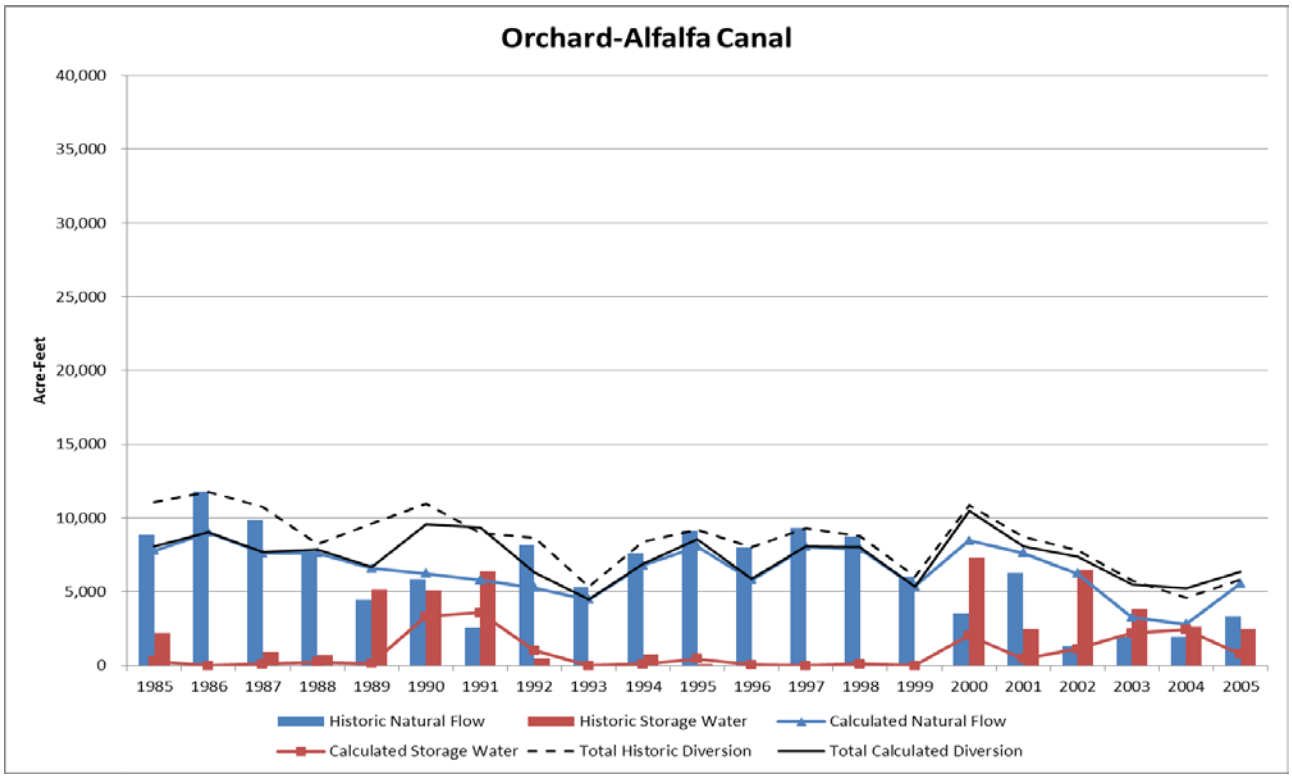


Figure 12. Orchard-Alfalfa Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

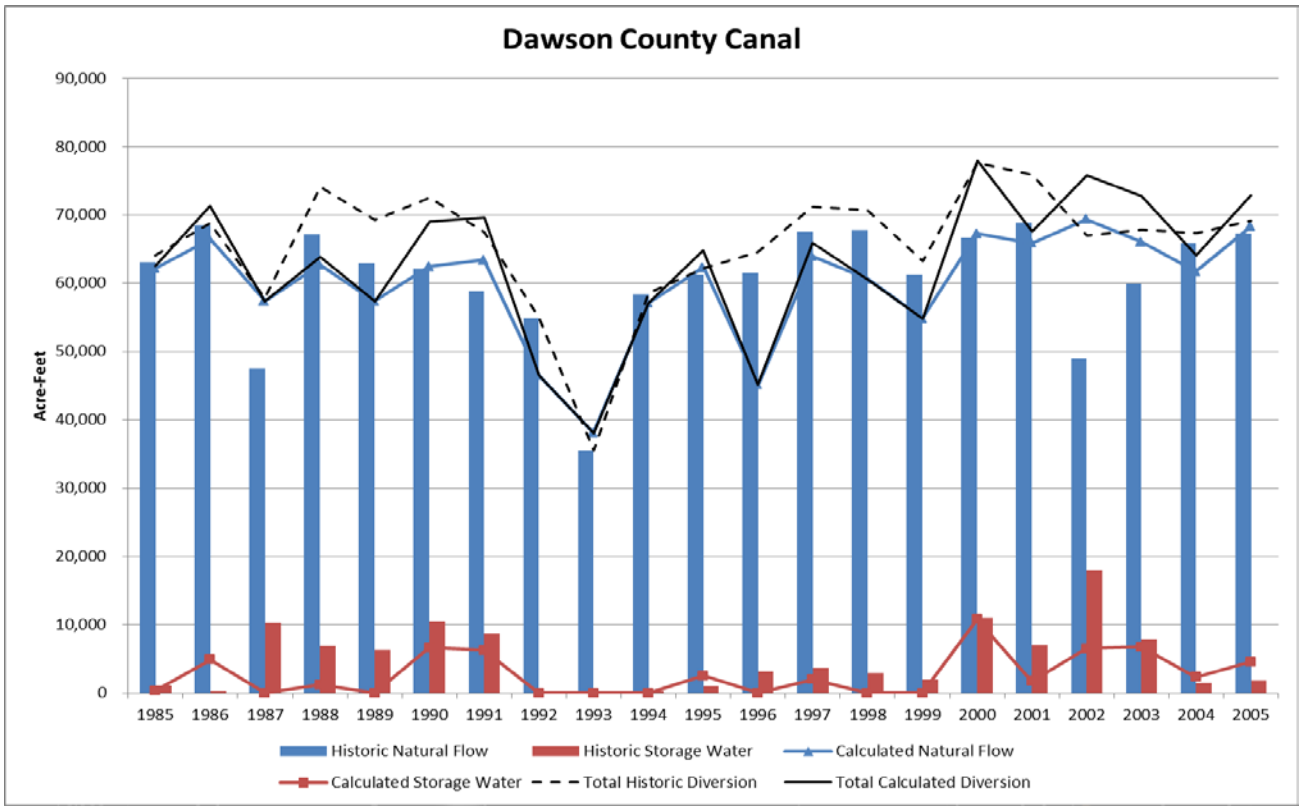


Figure 13. Dawson Canal – Historic and Calculated Natural Flow, Storage Water and Total Diversions

Summary

Because the surface water system is administered based on priority in times of shortage, the COHYST sponsor group requested that priority rules be created and implemented into the Stella model logic. The priority logic enables the model to "color" the water throughout the system and quantify the amount of natural flow and storage water at nodes along the river. The intention was not to create an accounting tool, but to provide a tool capable of assessing impacts to natural and storage diversions of potential alternatives (projects, management, etc.).

The calculated natural and storage flow diversions for the irrigation canals within the STELLA model compare favorably to historic values with respect to trends, quantities, and general response to wet and dry hydrologic conditions. Furthermore, the tool correctly reflects junior/senior status of appropriators when determining the natural/storage flow portions of each diversion.

Appendix 1 - Natural Flow & Storage Water Logic

Appendix 1 lists the nodes in the Stella model associated with the natural flow and storage water calculations. Each section includes the logic equation found within the Stella model and a description of logic and assumptions.

Define Lake McConaughy Change in Storage:

Lake_Mac_Storage_Change_afd = Lake_Mac_Net_Inf_afd-NGLs_Lake_Mac_afd-Mac\Ogal_Rel_to_NPR_afd

Logic & Assumptions:

- Lake Mac Net Inf is the gage at Lewellen + tributary flows
- NGL Lake Mac is seepage and net evap from Lake Mac
- Mac/Ogal Release is the demand placed on Lake Mac
- Lake Mac Storage Change: (+) Increase in Storage; (-) Decrease in Storage

Release from Lake McConaughy:

Lake_Mac_NF_Release_afd = MAX(MIN(Lake_Mac_Storage_Change_afd+ Mac\Ogal_Rel_to_NPR_afd, Mac\Ogal_Rel_to_NPR_afd) ,0)

Lake_Mac_SF_Release_afd = Mac\Ogal_Rel_to_NPR_afd-Lake_Mac_NF_Release_afd

Logic & Assumptions:

- If the natural flow is not sufficient to satisfy the demand then storage water is needed to meet the demand (with Mac/Ogal Release) and the natural flow released is the difference between the demand and the Lake Mac Storage Change.
- If the Lake Mac Storage Change is > 0, then no storage water is needed to meet the demand and the natural flow released = the demand.
- If the Lake Mac Storage Change + demand < 0 then the reservoir losses exceeded the demand and therefore the Lake Mac NF Release = 0.
- Lake Mac SF Release is the difference between the demand and Lake Mac NF Release

Keystone Canal:

SF_Key_Div_afd = MIN(Key_Div_afd,Lake_Mac_SF_Release_afd)

NF_Key_Div_afd = Key_Div_afd-SF_Key_Div_afd

Logic & Assumptions:

- Storage water diverted at Keystone Canal is the minimum of the storage water release at Lake Mac and the total flow diverted at Keystone Canal.
- Assumes that storage water will only be sent down the river if it exceeds the Keystone Diversion capacity.
- Natural flow at Keystone Canal is the difference between the total diversion at Keystone Canal and the storage water diverted at Keystone Canal.

N. Platte River at Keystone:

SF_NPR_nr_Key_afd = Lake_Mac_SF_Release_afd-SF_Key_Div_afd

NF_NPR_nr_Key_afd = Lake_Mac_NF_Release_afd-NF_Key_Div_afd

Logic & Assumptions:

- Storage water in the river downstream of Keystone Canal is the difference between the storage water released from Lake Mac and the storage water diverted at Keystone Canal.
- Natural flow in the river downstream of Keystone Canal is the difference between the natural flow released from Lake Mac and the natural flow diverted at Keystone Canal.

Keith Lincoln Canal:

SF_KL_Canal_afd = IF
(NF_NPR_nr_Key_afd+(Reach_Length_%_N_Platte_R_blw_Keystone_Gage*Anec_BF_Keystone_to_Sutherland_cfs*1.98)) < NP_NF_App_Demand_Check afd THEN KL_Canal_afd
ELSE MAX(KL_Canal_afd -
(NF_NPR_nr_Key_afd+(Reach_Length_%_N_Platte_R_blw_Keystone_Gage*Anec_BF_Keystone_to_Sutherland_cfs*1.98)-NP_NF_App_Demand_Check_afd),0)

NF_KL_Canal_afd = KL_Canal_afd-SF_KL_Canal_afd

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- If the natural flow in the river is not sufficient to satisfy the North Platte natural flow appropriation, then no natural flow is diverted and the total diversion at Keith Lincoln is all storage water.
- If the natural flow in the river is sufficient to satisfy the North Platte natural flow appropriation, then the storage water at Keith Lincoln is calculated by subtracting the amount of natural flow in the river near Keystone and the North Platte natural flow appropriation from the total diversion at Keith Lincoln.
- Natural flow at Keith Lincoln Canal is the difference between the total diversion at Keith Lincoln Canal and the storage water diverted at Keith Lincoln Canal.

North Platte Canal:

SF_NP_Canal_afd = NP_Canal_Div_afd-NF_NP_Canal_afd
NF_NP_Canal_afd = MIN(NP_NF_App_Demand_Check_afd,NP_Canal_Div_afd)

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- Storage water at North Platte Canal is the difference between the total diversion at North Platte Canal and the natural flow diverted at North Platte Canal.
- Natural flow at North Platte Canal is capped at the North Platte natural flow appropriation.

Paxton Hershey Canal:

SF_PH_Canal_afd = PH_Canal_afd-NF_PH_Canal_afd
NF_PH_Canal_afd = MIN(PH_NF_App_Demand_Check_afd,PH_Canal_afd)

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- Storage water at Paxton Hershey Canal is the difference between the total diversion at Paxton Hershey Canal and the natural flow diverted at Paxton Hershey Canal.
- Natural flow at Paxton Hershey Canal is capped at the Paxton Hershey Natural Flow Appropriation.

North Platte River nr Sutherland:

SF_NPR_nr_Suth_afd = MIN(MAX(SF_NPR_nr_Key_afd-SF_KL_Canal_afd
SF_NP_Canal_afd-SF_PH_Canal_afd, 0), Gage_NPR_nr_Suth_afd)
NF_ NPR_nr_Suth _afd = Gage_NPR_nr_Suth_afd-SF_NPR_nr_Suth_afd

Logic & Assumptions:

- Storage water in the river at Sutherland is storage at Keystone minus the storage water diverted at Keith-Lincoln, North Platte and Paxton-Hershey Canals.
- Natural flow in the river at Sutherland is the difference between the calculated storage water at Sutherland and the calculated gage (total) flow at Sutherland.

Suburban Canal:

SF_Sub_Canal_afd = IF
(NF_NPR_nr_Suth_afd+((Reach_Length_%_N_Platte_R_blw_Suth_Gage+Reach_Length_%_N_Plat

te_R_blw_Birdwood_Crk+Reach_Length_%_N_Platte_R_blw_Suburban_div)*Anec_BF_Sutherland_to_N_Platte_cfs*1.98)) < CD_NF_App_Demand_Check_afd THEN Sub_Canal_afd
ELSE MAX(Sub_Canal_afd -
(NF_NPR_nr_Suth_afd+((Reach_Length_%_N_Platte_R_blw_Suth_Gage+Reach_Length_%_N_Platte_R_blw_Birdwood_Crk+Reach_Length_%_N_Platte_R_blw_Suburban_div)*Anec_BF_Sutherland_to_N_Platte_cfs*1.98)-CD_NF_App_Demand_Check_afd),0)

NF_Sub_Canal_afd = Sub_Canal_afd-SF_Sub_Canal_afd

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- If the natural flow in the river is not sufficient to satisfy the Cody Dillon natural flow appropriation, then no natural flow is diverted and the total diversion at Suburban Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the Cody Dillon natural flow appropriation, then the storage water at Suburban Canal is calculated by subtracting the amount of natural flow in the river near Sutherland and the Cody Dillon natural flow appropriation from the total diversion at Suburban Canal.
- Natural flow at Suburban Canal is the difference between the total diversion at Suburban Canal and the storage water diverted at Suburban Canal.

Cody Dillon Canal:

SF_CD_Canal_afd = CD_Canal_Div_afd-NF_CD_Canal_afd
NF_CD_Canal_afd = MIN(CD_NF_App_Demand_Check_afd,CD_Canal_Div_afd)

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- Storage water at Cody Dillon Canal is the difference between the total diversion at Cody Dillon Canal and the natural flow diverted at Cody Dillon Canal.
- Natural flow at Cody Dillon Canal is capped at the Cody Dillon natural flow appropriation.

N. Platte River at N. Platte:

SF_NPR_at_NP_afd = MIN(SF_NPR_nr_Key_afd,Gage_NPR_at_NP_afd)
NF_NPR_at_NP_afd = MAX(Gage_NPR_at_NP_afd-SF_NPR_at_NP_afd,0)

Logic & Assumptions:

- Assumes that reach gain/loss is allocated to only the natural flow.
- Storage water in the N. Platte River at N. Platte is the minimum of the storage water at Keystone or the gaged flow in the river.
- Natural flow is the gaged flow minus storage water.

Sutherland Return:

SF_Suth_Rtn_afd = IF Key_Div_afd = 0 THEN 0 ELSE
MAX(MIN(SF_Key_Div_afd - MAX((Suth_System_Losses_afd*(SF_Key_Div_afd/Key_Div_afd)),0)-Suth_Res_Chng_Storage_af,Suth_rtn_afd-Korty_Div_afd),0)
NF_Suth_Rtn_afd = Suth_rtn_afd-SF_Suth_Rtn_afd

Logic & Assumptions:

- If there is no diversion at Keystone Canal, then storage water is zero.
- Sutherland system NGL (canal and reservoir seepage/evap) is prorated for the natural flow and storage water. If the sum of the system NGLs result in a gain, then the gain is zeroed for the storage water calculation (accounted for in the natural flow calculation).
- Storage water is calculated as the minimum of the following:
  - Storage water diverted at Keystone Canal minus the system NGLs minus the Sutherland Reservoir change in storage; or
  - The calculated Sutherland Return minus the Korty Diversion. Adding the “Sutherland Return minus the Korty Diversion” logic to the storage water calculation ensures that the Korty Diversion water is not stored in Sutherland Reservoir.

- The final check is to make sure the calculated storage water is not less than zero.
- Natural flow in Sutherland Return is the calculated return minus storage water.

S. Platte River at N. Platte:

SF_SPR_blw_Suth_Rtn_afd = SF_Suth_Rtn_afd
NF_SPR_blw_Suth_Rtn_afd = MAX(SPR_blw_Suth_rtn_afd-SF_SPR_blw_Suth_rtn_afd,0)

Logic & Assumptions:

- Storage water in the S. Platte River below Sutherland Return is equivalent to the storage water at Sutherland Return.
- Natural flow in the S. Platte River below Sutherland Return is the calculated gaged flow in the river below the return minus the storage water in the river.
- The final check is to make sure the calculated natural flow is not less than zero.

Platte River below the confluence:

SF_PR_blw_NPR\SPR_Conf_afd = SF_NPR_at_NP_afd+SF_SPR_blw_Suth_rtn_afd
NF_PR_blw_NPR\SPR_Conf_afd = NF_NPR_at_NP_afd+ NGL_NPR_blw_NP_Gage_afd+ NF_SPR_blw_Suth_rtn_afd+ NGL_SPR_blw_Suth_rtn_afd

Logic & Assumptions:

- Storage water at the confluence is the sum of the N. Platte River and S. Platte River storage water.
- Natural flow at the confluence is the sum of the N. Platte River and S. Platte River natural flow plus/minus reach gain/loss (river).

CNPPID Tri-County Diversion:

NF_TriCo_Div_afd = MAX(TriCo_Div_afd-SF_PR_blw_NPR\SPR_Conf_afd,0)
SF_TriCo_Div_afd = TriCo_Div_afd-NF_TriCo_Div_afd

Logic & Assumptions:

- Natural flow diverted at Tri-County is the calculated diversion minus the storage water in the river upstream of the diversion.
- Storage water diverted at Tri-County is the calculated diversion minus the natural flow diverted.

Platte River below Tri-County Diversion:

SF_PR_blw_TriCo_Div_afd = MAX(SF_PR_blw_NPR\SPR_Conf_afd-TriCo_Div_afd,0)
NF_PR_blw_TriCo_Div_afd = MAX(NF_PR_blw_NPR\SPR_Conf_afd-NF_TriCo_Div_afd,0)

Logic & Assumptions:

- Storage water and natural flow is calculated as the storage water and natural flow remaining in the river that is not diverted at Tri-County Diversion.

Platte River below Brady (above Jeffrey Return)

SF_PR_blw_Brady_Div_afd = MIN(SF_PR_blw_TriCo_Div_afd, PR_blw_Brady_afd)
NF_PR_blw_Brady_Div_afd = MAX(PR_blw_Brady_afd-SF_PR_blw_Brady_afd,0)

Logic & Assumptions:

- Storage water is the storage in the river below Tri-County Diversion
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Jeffrey Return:

NF_Jeff_Rtn_afd = MIN(Jeff_rtn_afd,NF_TriCo_Div_afd)
SF_Jeff_Rtn_afd = Jeff_rtn_afd-NF_Jeff_Rtn_afd

Logic & Assumptions:

- Natural flow returned at Jeffrey is the minimum of the calculated Jeffrey Return flow or the natural flow diverted at Tri-County.
- If Jeffrey Return is less than the natural flow diverted at Tri-County, then it is assumed the remainder is being used to serve CNPPID irrigation needs.
- Storage water returned at Jeffrey is the difference between the calculated Jeffrey Return and the natural flow returned.
- System losses (canal and reservoir) are incorporated into the calculated Jeffrey Return, therefore they are not explicitly represented in the NF/SF Jeffrey Return calculations.

Tri-County Supply Canal below Jeffrey Return:

NF_TriCo_blw_Jeff_Rtn_afd = MIN(NF_TriCo_Div_afd-NF_Jeff_Rtn_afd,TriCo_blw_Jeff_rtn_afd)

SF_TriCo_blw_Jeff_Rtn_afd = TriCo_blw_Jeff_rtn_afd-NF_TriCo_blw_Jeff_Rtn_afd

Logic & Assumptions:

- Natural flow in the supply canal below Jeffrey Return is the minimum of:
  - Natural flow diverted at Tri-County minus the natural flow returned at Jeffrey, or
  - Calculated water in the supply canal below Jeffrey Return
- The minimum function allows for any losses to be assigned only to the natural flow.
- Storage water in the supply canal below Jeffrey Return is the difference between the calculated natural flow and the calculated total flow below Jeffrey Return.

Platte River below Jeffrey Return (or below 30 mile diversion):

SF_PR_blw_30_Mi_Div_afd = SF_Jeff_Rtn_afd+SF_PR_blw_TriCo_Div_afd

NF_PR_blw_30_Mi_Div_afd = PR_blw_30_Mi_Div_afd-SF_PR_blw_30_Mi_Div_afd

Logic & Assumptions:

- Storage water is the storage returned at Jeffrey plus the storage in the river below Tri-County Diversion
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Gothenburg Diversion:

SF_Goth_Canal_afd = IF (NF_PR_blw_Jeff_Rtn_afd + (Reach_Length_%_Platte_R_blw_Brady_Gage_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) < Dawson_NF_App_Demand_Check_afd) THEN Goth_Div_afd ELSE MAX(Goth_Div_afd - (NF_PR_blw_Jeff_Rtn_afd + (Reach_Length_%_Platte_R_blw_Brady_Gage_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) - Dawson_NF_App_Demand_Check_afd),0)

NF_Goth_Canal_afd = Goth_Div_afd-SF_Goth_Canal_afd

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- If the natural flow in the river is not sufficient to satisfy the Dawson natural flow appropriation, then no natural flow is diverted and the total diversion at Gothenburg Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the Dawson natural flow appropriation, then the storage water at Gothenburg Canal is calculated by subtracting the amount of natural flow in the river below Jeff Rtn and the Dawson natural flow appropriation from the total diversion at Gothenburg Canal.
- Natural flow at Gothenburg Canal is the difference between the total diversion at Gothenburg Canal and the storage water diverted at Gothenburg Canal.

30-Mile Diversion:

SF_30_mi_Canal_afd = IF ((NF_PR_blw_Jeff_Rtn_afd-NF_Goth_Canal_afd) + (Reach_Length_%_Platte_R_blw_Brady_Gage_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) < NF_App_DownStream_30_mi_Canal_afd) THEN Thirty_Mi_Div_afd ELSE MAX(Thirty_Mi_Div_afd - ((NF_PR_blw_Jeff_Rtn_afd-NF_Goth_Canal_afd) + (Reach_Length_%_Platte_R_blw_Brady_Gage_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98)-NF_App_DownStream_30_mi_Canal_afd),0)

NF_30_mi_Canal_afd = Thirty_Mi_Div_afd-SF_30_mi_Canal_afd

Logic & Assumptions:

- If the natural flow in the river is not sufficient to satisfy the "Downstream natural flow appropriation" (including Cozad, Six Mile, Orchard-Alfalfa and Dawson), then no natural flow is diverted and the total diversion at 30-mile Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the "Downstream natural flow appropriation" (including Cozad, Six Mile, Orchard-Alfalfa and Dawson), then the storage water at 30-mile Canal is calculated by subtracting the amount of natural flow in the river below Jeffrey Return and the Downstream natural flow appropriation from the total diversion at 30-mile Canal.
- Natural flow at 30-mile Canal is the difference between the total diversion at 30-mile Canal and the storage water diverted at 30-mile Canal.

Platte River below 30-mile Diversion:

SF_PR_blw_30_mi_Div_afd = MAX(SF_PR_blw_Jeff_Rtn_afd-SF_30_mi_Canal_afd-SF_Goth_Canal_afd,0)

NF_PR_blw_30_mi_Div_afd = MAX(PR_blw_30_Mi_Div_afd-SF_PR_blw_30_Mi_Div_afd,0)

Logic & Assumptions:

- Storage water is the storage water in the river above 30-mile/Gothenburg Diversion minus the storage water diverted into 30-mile canal and Gothenburg Canal
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

6-Mile Diversion:

SF_6_Mi_Canal_afd = IF (NF_PR_blw_30_Mi_Div_afd + (Reach_Length_%_Platte_R_blw_30_Mi_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) < Dawson_NF_App_Demand_Check_afd) THEN Six_Mi_Canal_afd ELSE MAX(Six_Mi_Canal_afd - (NF_PR_blw_30_Mi_Div_afd + (Reach_Length_%_Platte_R_blw_30_Mi_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) - Dawson_NF_App_afd_Demand_Check),0)

NF_6_Mi_Canal_afd = Six_Mi_Canal_afd-SF_6_Mi_Canal_afd

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- If the natural flow in the river is not sufficient to satisfy the Dawson natural flow appropriation, then no natural flow is diverted and the total diversion at 6-mile Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the Dawson natural flow appropriation, then the storage water at 6-mile Canal is calculated by subtracting the amount of natural flow in the river below 30-mile and the Dawson natural flow appropriation from the total diversion at 6-mile Canal.
- Natural flow at 6-mile Canal is the difference between the total diversion at 6-mile Canal and the storage water diverted at 6-mile Canal.

Platte River below 6-mile Diversion:

SF_PR_blw_6_Mi_Div_afd = MAX(SF_PR_blw_30_Mi_Div_afd-SF_6_Mi_Canal_afd,0)
NF_PR_blw_6_Mi_Div_afd = MAX(PR_blw_6_Mi_Div_afd-SF_PR_blw_6_Mi_Div_afd,0)

Logic & Assumptions:

- Storage water is the storage water in the river above 6-mile Diversion minus the storage water diverted into 6-mile canal
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Cozad Diversion:

SF_Cozad_Canal_afd = IF (NF_PR_blw_6_Mi_Div_afd +
(Reach_Length_%_Platte_R_blw_6_Mi_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) < Dawson_NF_App_Demand_Check_afd)
THEN Cozad_Div_afd
ELSE MAX(Cozad_Div_afd - (NF_PR_blw_6_Mi_Div_afd +
(Reach_Length_%_Platte_R_blw_6_Mi_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) - Dawson_NF_App_Demand_Check_afd),0)
NF_Cozad_Canal_afd = Cozad_Div_afd-SF_Cozad_Canal_afd

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- If the natural flow in the river is not sufficient to satisfy the Dawson natural flow appropriation, then no natural flow is diverted and the total diversion at Cozad Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the Dawson natural flow appropriation, then the storage water at Cozad Canal is calculated by subtracting the amount of natural flow in the river below 6-mile and the Dawson natural flow appropriation from the total diversion at Cozad Canal.
- Natural flow at Cozad Canal is the difference between the total diversion at Cozad Canal and the storage water diverted at Cozad Canal.

Platte River below Cozad Diversion:

SF_PR_blw_Cozad_Div_afd = MAX(SF_PR_blw_6_Mi_Div_afd-SF_Cozad_Canal_afd, 0)
NF_PR_blw_Cozad_Div_afd = MAX(PR_blw_Cozad_Div_afd-SF_PR_blw_Cozad_Div_afd,0)

Logic & Assumptions:

- Storage water is the storage water in the river above Cozad Diversion minus the storage water diverted into Cozad canal
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Orchard-Alfalfa Diversion:

SF_Orch_Alf_Canal_afd = IF (NF_PR_blw_Cozad_Div_afd +
(Reach_Length_%_Platte_R_blw_Cozad_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) < Dawson_NF_App_Demand_Check_afd)
THEN Orch_Alf_Canal_afd
ELSE MAX(Orch_Alf_Canal_afd - (NF_PR_blw_Cozad_Div_afd +
(Reach_Length_%_Platte_R_blw_Cozad_Div_to_Dawson_Cnl*Anec_BF_Brady_to_Cozad_cfs*1.98) - Dawson_NF_App_Demand_Check_afd),0)
NF_Orch_Alf_Canal_afd = Orch_Alf_Canal_afd-SF_Orch_Alf_Canal_afd
Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.

- If the natural flow in the river is not sufficient to satisfy the Dawson natural flow appropriation, then no natural flow is diverted and the total diversion at Orchard-Alfalfa Canal is all storage water.
- If the natural flow in the river is sufficient to satisfy the Dawson natural flow appropriation, then the storage water at Orchard-Alfalfa Canal is calculated by subtracting the amount of natural flow in the river below Cozad and the Dawson natural flow appropriation from the total diversion at Orchard-Alfalfa Canal.
- Natural flow at Orchard-Alfalfa Canal is the difference between the total diversion at Orchard-Alfalfa Canal and the storage water diverted at Orchard-Alfalfa Canal.

Platte River below Orchard-Alfalfa Diversion:

SF_PR_blw_Orch_Alf_Div_afd = MAX(SF_PR_blw_Cozad_Div_afd-SF_Orch_Alf_Canal_afd, 0)
NF_PR_blw_Orch_Alf_Div_afd = MAX(PR_blw_OA_Div_afd-SF_PR_blw_Orch_Alf_Div_afd,0)

Logic & Assumptions:

- Storage water is the storage water in the river above OA Diversion minus the storage water diverted into OA canal
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Dawson Diversion:

SF_Dawson_Canal_afd = Dawson_Div_afd-NF_Dawson_Canal_afd
NF_Dawson_Canal_afd = MIN(Dawson_NF_App_Demand_Check_afd, Dawson_Div_afd)

Logic & Assumptions:

- The App Demand Check node limits the natural flow appropriation to the irrigation season.
- Storage water at Dawson Canal is the difference between the total diversion at Dawson Canal and the natural flow diverted at Dawson Canal.
- Natural flow at Dawson Canal is capped at the Dawson natural flow appropriation.

Platte River below Dawson Diversion:

SF_PR_blw_Dawson_afd = IF PR_blw_Dawson_afd =0 THEN 0
ELSE MIN(MAX(SF_PR_blw_Orch_Alf_Div_afd-SF_Dawson_Canal_afd, 0), PR_blw_Dawson_afd)
NF_PR_blw_Dawson_Div_afd = MAX(PR_blw_Dawson_afd-SF_PR_blw_Dawson_afd,0)

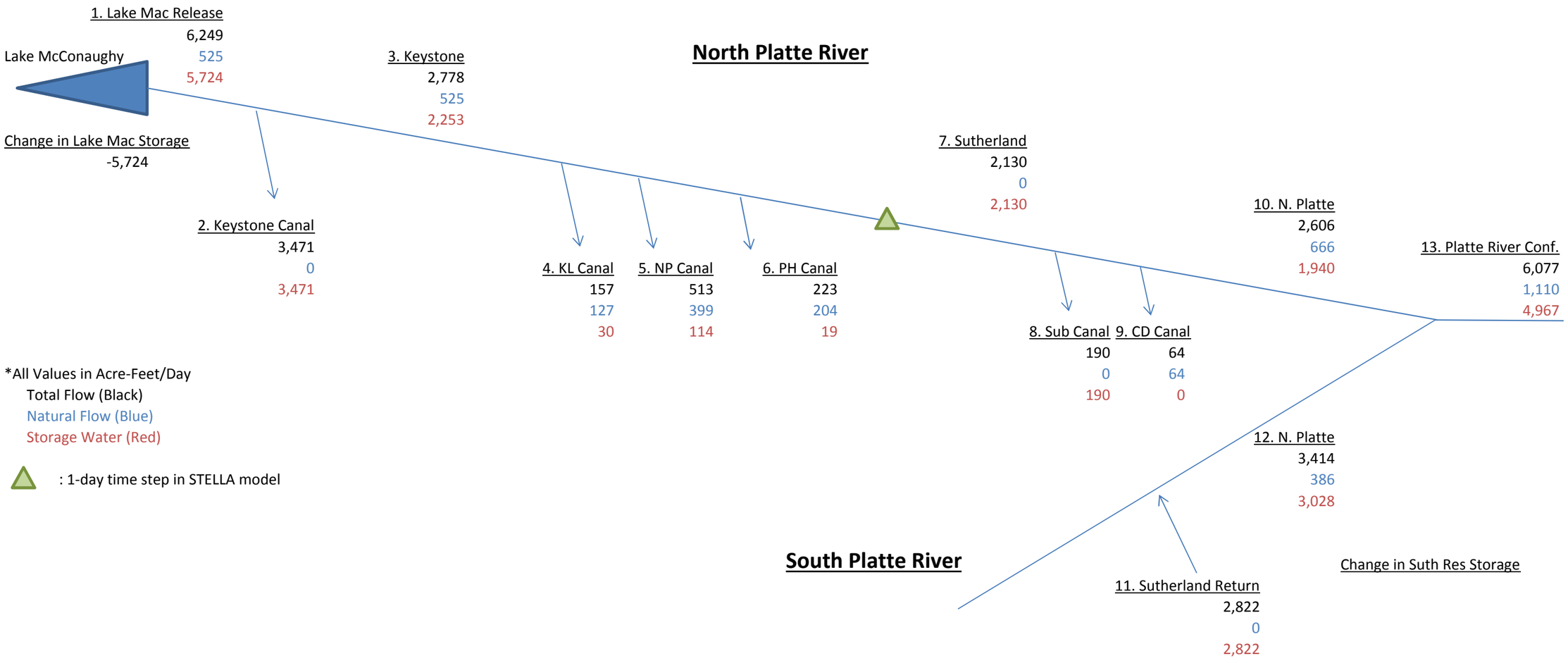
Logic & Assumptions:

- Storage water is the storage water in the river above Dawson minus the storage water diverted into Dawson canal
- Natural flow is the difference between the calculated flow in the river and the calculated storage water in the river.
- Assumes that the reach gain/loss assigned only to the natural flow.

Appendix 2– Schematic of Water Coloring

In order to see how the priorities are used in the Stella model calculations, the following schematic shows each node where natural flow and storage water are calculated. The schematic begins at the upstream end of the model and presents daily values for the natural flow, storage water and total water to the most downstream end of the model. This schematic presents a way to see the logic described in Appendix 1 put into action within the Stella model.

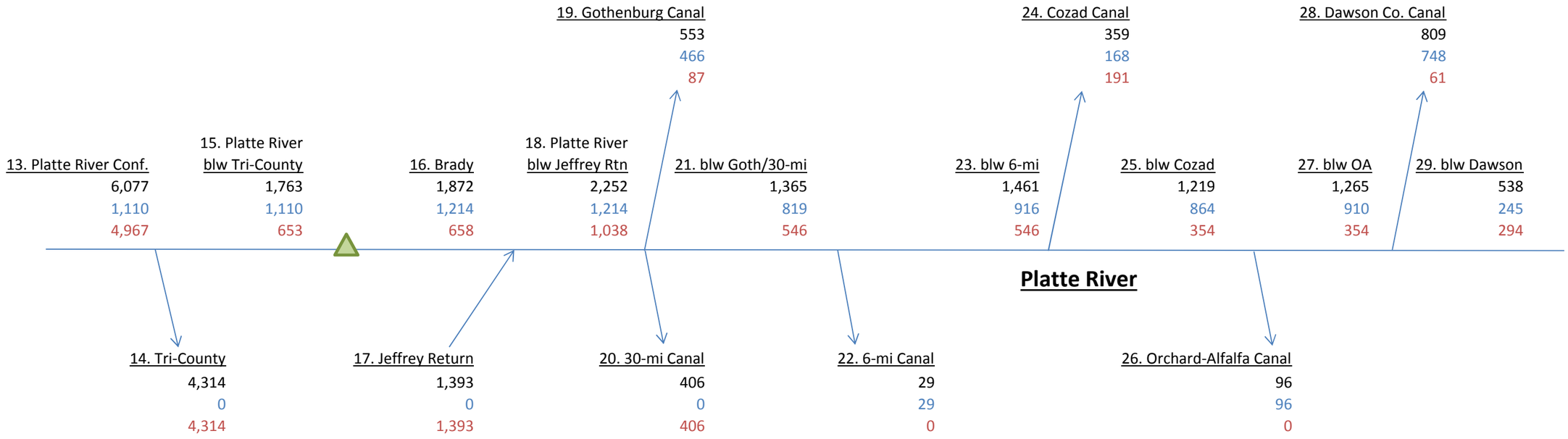
Input Start Date (at Lake McConaughy): 7/1/2001
Simulation Day: 6392



*All Values in Acre-Feet/Day
Total Flow (Black)
Natural Flow (Blue)
Storage Water (Red)

: 1-day time step in STELLA model

Start Date (at Lake McConaughy): 7/1/2001



*All Values in Acre-Feet/Day

Total Flow (Black)

Natural Flow (Blue)

Storage Flow (Red)

: 1-day time step in STELLA model

The schematic shows daily values in acre-feet/day for July 1, 2001. Below are calculations for the values that are on the schematic. Each point on the schematic is numbered to match the numbering used below.

1. Lake McConaughy
    a. Demand on Lake Mac = 6,249 afd
    b. Lake Mac Storage Change = -5,724 afd.
        i. This represents net change in storage using inflows, outflows and reservoir losses – seepage and evap.
        ii. Positive = increase in storage
        iii. Negative = decrease in storage
    c. The natural flow is not sufficient to satisfy the demand so storage water is needed to meet the demand (with Mac/Ogal Release).
    d. Storage water = Lake Mac Storage Change = 5,724 afd
    e. Natural flow = Demand – Lake Mac Storage Change = 6,249 + -5,724 = 525 afd

2. Keystone Canal
    a. Total Diversion = 3,471 afd (Keystone Diversion Capacity = 3,471 afd)
    b. Natural flow = 0 afd
    c. Storage water = 3,471 (assumes storage water will only be sent down the river if it exceeds the Keystone Diversion capacity)

3. North Platte River nr Keystone
    a. Total Flow = Lake Mac Release Total – Keystone Canal Total = 6,249 afd – 3,471 afd = 2,778 afd
    b. Natural flow = Natural flow released from Lake Mac – Natural flow diverted at Keystone Canal = 525 – 0 = 525 afd
    c. Storage water = Storage water released from Lake Mac –Storage water diverted at Keystone Canal = 5,724 – 3,471 = 2,253 afd

4. KL Canal
    a. Total Diversion = 157 afd. Minimum of water in the river or KL Estimated Total Diversion.
    b. Natural flow = 127. Checks that the natural flow in the river (127 afd) can satisfy NP natural flow appropriation (399 afd). It cannot, so no natural flow is diverted.
    c. Storage water = Total diversion because natural flow doesn't satisfy NP natural flow appropriation = 30 afd.

5. NP Canal
    a. Total Diversion = 513 afd. Minimum of water in the river or NP Estimated Total Diversion.
    b. Natural flow = 399 afd. Capped at NP natural flow appropriation (399 afd).
    c. Storage water = Total diversion – natural flow = 513 afd – 399 afd = 114 afd.

6. PH Canal
    a. Total Diversion = 223 afd. Minimum of water in the river or PH Estimated Total Diversion.
    b. Natural flow = 204 afd. Capped at PH natural flow appropriation (204 afd).
    c. Storage water = Total diversion – natural flow = 223 afd – 204 afd = 19 afd.

7. North Platte River near Sutherland
    a. Total Flow = Total Flow at Keystone + NGLs – KL Canal Total Flow – NP Canal Total Flow – PH Canal Total Flow = 2,778 afd + NGLs – 157 afd – 513 afd – 223 afd = 2,130 afd.
    b. Natural flow = Total Gage flow – Storage Water = 2,242 afd – 2,242 afd = 0 afd.
    c. Storage water = Minimum of (Storage water at NP nr Keystone – KL Storage Water – NP Storage Water – PH Storage Water = 2,253 afd – 30 afd – 114 afd – 19 afd = 2,090 afd) or Total flow = 2,090 afd

8. Suburban Canal
    a. Total Diversion = 190 afd.
    b. Natural flow = 0 afd. Checks that the natural flow in the river (0 afd) can satisfy CD natural flow appropriation (115 afd). It cannot, so no natural flow is diverted.
    c. Storage water = Total diversion because natural flow doesn't satisfy CD natural flow appropriation = 190 afd.

9. CD Canal
    a. Total Diversion = 64 afd. Minimum of water in the river or NP estimated total diversion.
    b. Natural flow = 64 afd. Minimum of water in diversion or CD natural flow appropriation (115 afd).
    c. Storage water = Total diversion – natural flow = 64 afd – 64 afd = 0 afd.

10. North Platte River at North Platte
    a. Total Flow = 2,606 afd.
    b. Natural flow = Gaged flow – storage water = 2,606 afd – 1,940 afd = 666 afd.
    c. Storage water = Storage water at Sutherland – Sub storage water – CD storage water = 2,130 afd -190 afd – 0 afd = 1,940 afd.

11. Sutherland Return
    a. Total Flow = 2,822 afd.
    b. Natural flow = Total flow – storage water = 2,822 afd – 2,822 afd = 0 afd.
    c. Storage water = Storage water diverted at Keystone minus system NGLs minus Sutherland Reservoir Change in Storage = 3,471 afd – NGLs – (116) afd = 2,822 afd.

12. South Platte River at North Platte
    a. Total Flow = 3,414 afd.
    b. Natural flow = Gaged flow – storage water = 3,414 afd – 3,028 afd = 386 afd.
    c. Storage water = storage water at Sutherland Return - NGLs = 3,028 afd.

13. Platte River blw the NPR/SPR Confluence
    a. Total Flow = 6,077 afd.
    b. Natural flow = NPR natural flow + SPR natural flow = 666 afd + 386 afd + NGL = 1,110 afd.
    c. Storage water = NPR storage water + SPR storage water = 1,940 afd + 3,028 afd = 4,967 afd.

14. Tri-County Diversion
    a. Total Flow = 4,314 afd.
    b. Natural flow = Maximum of (Tri-County Diversion – Storage water at Platte River Conf = 4,314 afd – 4,967 afd = -653 afd, or 0 afd) = 0 afd.
    c. Storage water = Total Diversion – Natural Flow = 4,314 afd – 0 afd = 4,314 afd.

15. Platte River blw Tri-County
    a. Total Flow = Total flow at PR Conf – Total at Tri-County Div = 6,077 afd – 4,314 afd = 1,763 afd.
    b. Natural flow = Natural flow at PR Conf – Natural flow at Tri-County Div =

1,110 afd – 0 afd = 1,110 afd.

c. Storage water = Storage water at PR Conf – Storage water at Tri-County Div = 4,967 afd – 4,314 afd = 653 afd.

16. Platte River below Brady
    a. Total Flow = 1,872 afd.
    b. Natural flow = Total Gage flow – Storage water at PR blw Brady = 1,872 afd – 658 afd = 1,214 afd.
    c. Storage water = Minimum of Storage water at Tri-County Div (lagged 2 days) or Total Gage flow = 658 afd.

17. Jeffrey Return
    a. Total Return Flow = 1,393 afd.
    b. Natural flow = Minimum of Jeffrey Rtn total flow or natural flow at Tri-County Diversion (lagged 1 day) = 0 afd.
    c. Storage water = Total Rtn flow – natural flow = 1,393 afd – 1,393 afd = 0 afd.

18. Platte River blw Jeffrey Return
    a. Total Flow = 2,252 afd.
    b. Natural Flow = Total flow – storage water = 2,252 afd – 1,038 afd = 1,214 afd.
    c. Storage Water = Storage water at Jeff Rtn + Storage water at PR blw TriCo Div (lagged 2 days) = 1,038 afd.

19. Gothenburg Canal
    a. Total Diversion = 553 afd
    b. Natural Flow = Total diversion – storage water = 553 afd – 87 afd = 466 afd.
    c. Storage Water = 87 afd. Checks that the natural flow in the river (1,214 afd) can satisfy Dawson natural flow appropriation (748 afd). It can, so storage water is calculated by taking the maximum of Gothenburg Diversion minus the amount of natural flow in the river below Jeff Rtn minus the Dawson NF Appropriation from Gothenburg Diversion or zero.

20. 30-mile Canal
    a. Total Diversion = 406 afd
    b. Natural Flow = Total diversion – storage water = 406 afd – 0 afd = 406 afd
    c. Storage Water = 0 afd. Checks that the natural flow in the river (1,214 afd) can satisfy Cozad, Six-Mile, Orchard-Alfalfa and Dawson natural flow appropriations (466 afd + 48 afd + 167 afd + 748 afd = 1429 afd). It cannot so storage water is calculated by taking the maximum of 30-mile Diversion minus the amount of natural flow in the river below Jeff Rtn minus the Gothenburg NF minus the Cozad, Six-Mile, Orchard-Alfalfa and Dawson natural flow appropriations or zero.

21. Platte River below Gothenburg/30-mile
    a. Total Flow = Total flow Platte River blw Jeff Rtn – Total flow Goth canal – Total flow 30-mile canal + NGLs = 1,365 afd
    b. Natural Flow = Total flow – storage water = 1,365 afd – 546 afd = 819 afd
    c. Storage Water = Platte River blw Jeff Rtn Storage water – Gothenburg Div storage water – 30-mile storage water = 1,038 afd - 87 afd - 406 afd = 546 afd

22. 6-mile Canal
    a. Total Diversion = 29 afd
    b. Natural Flow = Total diversion – storage water = 29 afd – 0 afd = 29 afd
    c. Storage Water = 0 afd. Checks that the natural flow in the river (819 afd) can satisfy Dawson natural flow appropriation (748 afd). It can so storage water is calculated by taking the maximum of 6-mile Diversion minus the amount of natural flow in the river below Goth/30-mi minus the Dawson natural flow appropriations or zero.

23. Platte River below 6-mile
    a. Total Flow = 1,461 afd
    b. Natural Flow = Total flow – storage water = 1,461 afd – 546 afd = 916 afd
    c. Storage Water = 546 afd. Maximum of storage water PR blw Goth/30-mi minus storage water 6-mile canal plus NGLs or zero.

24. Cozad Canal
    a. Total Diversion = 359 afd
    b. Natural Flow = Total diversion – storage water = 359 afd – 191 afd = 168 afd.
    c. Storage Water = 191 afd. Checks that the natural flow in the river (916 afd) can satisfy Dawson natural flow appropriation (748 afd). It can, so storage water is calculated by taking the maximum of Cozad Diversion minus the amount of natural flow in the river below 6-mi minus the Dawson natural flow appropriations or zero.

25. Platte River below Cozad
    a. Total Flow = PR blw 6-mi – Cozad Canal + NGLs = 1,461 afd – 359 afd +NGLs = 1,219 afd.
    b. Natural Flow = Total flow – storage water = 1,461 afd – 354 afd = 864 afd.
    c. Storage Water = 354 afd. Storage water PR blw 6-mi minus Cozad Div storage water = 546 afd – 191 afd = 354 afd.

26. Orchard-Alfalfa Canal
    a. Total Diversion = 96 afd
    b. Natural Flow = Total diversion – storage water = 96 afd – 0 afd = 96 afd.
    c. Storage Water = 0 afd. Checks that the natural flow in the river (864 afd) can satisfy Dawson natural flow appropriation (748 afd). It can, so storage water is calculated by taking the maximum of OA Diversion minus the amount of natural flow in the river below Cozad minus the Dawson natural flow appropriations or zero.

27. Platte River below Orchard-Alfalfa
    a. Total Flow = 1,265 afd
    b. Natural Flow = Total flow – storage water = 1,265 afd – 354 afd = 910 afd
    c. Storage Water = 354 afd. Storage water PR blw Cozad minus OA storage water = 354 afd – 0 afd = 354 afd.

28. Dawson County Canal
    a. Total Diversion = 809 afd
    b. Natural Flow = 748 afd. Capped at Dawson natural flow appropriation (748 afd).
    c. Storage Water = Total diversion – natural flow = 809 afd – 748 afd = 61 afd

29. Platte River below Dawson
    a. Total Flow = 538 afd
    b. Natural Flow = Total flow – storage water = 538 afd – 294 afd = 245 afd
    c. Storage Water = 294 afd. Maximum of storage water at PR blw OA minus Dawson Canal storage water or zero. = 354 afd – 61 afd = 294 afd