Appendix 6-M

Platte River Recovery Implementation Program (PRRIP) Surface Water Model

Appendix 6-M contains a technical memorandum describing the modifications made to the surface water model to incorporate two PRRIP projects. The projects included J2 regulating reservoir and Phelps Canal recharge project. Scoring for each project was determined by calculating daily shortages with the project and comparing to daily shortages calculated in the baseline run.

Memo

Date:	Wednesday, December 31, 2014
Project:	COHYST – Amendment 7 (PRRIP Modifications)
To:	Sira Sartori, PRRIP ED Office
From:	HDR
Subject:	COHYST STELLA Model Description and Results for PRRIP Modifications

1.0 Background

This technical memorandum documents the modeling efforts and results completed under COHYST Amendment #7. COHYST Amendment #7 primarily focused on the inclusion of two proposed Platte River Recovery Implementation Program (PRRIP) projects into the STELLA surface water operations model: 1) J2 regulating reservoir; and 2) Phelps Canal recharge project. Further information on the fundamentals of the STELLA surface water operations model can be found in the July 2013 COHYST modeling documentation.

Specific modeling efforts of COHYST Amendment #7 focused on the STELLA surface water operations model only, and included:

- Extension of the current STELLA surface water operations model simulation period (Run 24b_13_21, from the August 2014 workshop) to include the 1947-2010 period,
- Inclusion of the proposed J2 regulating reservoir and associated operating rules into the STELLA model,
- Inclusion of the proposed Phelps Canal recharge project and associated operating rules into the STELLA model, and
- Computation of project scoring based on the reduction in target flow shortages in the central Platte River reach.

2.0 STELLA Model Simulation Extension

The simulation period of the STELLA surface water operations model developed as part of the COHYST 2010 effort extends from 1985 through 2005. As part of the Amendment #7 efforts, the necessary datasets and model inputs were prepared and imported into the STELLA model to extend the simulation period from 1947 through 2010.

2.1 Historic Gage, Diversion, and Return Data

Historical stream gage, canal diversion, and canal return data for 1947-2010 was compiled for each appropriate node in the STELLA model framework. Figure 2.1 illustrates the key stream gages, canal diversions, and canal returns represented in the STELLA model.

8404 Indian Hills Drive, Omaha, NE, 68114 **hdrinc.com**
P (402) 399-1000

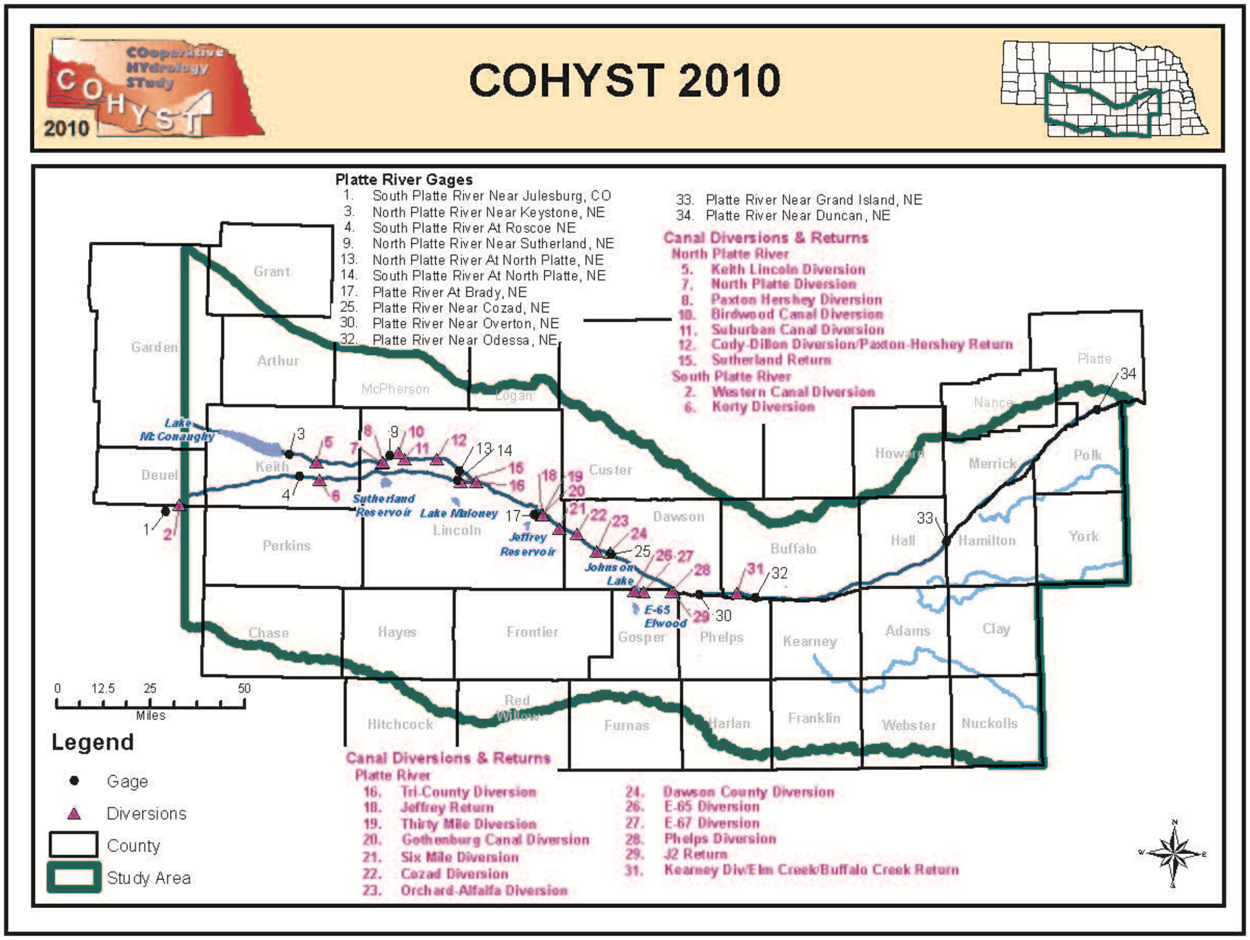


Figure 2.1 Platte River STELLA Nodes

These historic datasets were used in the model to:

- Define the model's upstream boundary condition daily inflows at the Julesburg, CO gage on the South Platte River and the Lewellen, NE gage on the North Platte River.
- Define the daily releases from Lake McConaughy to the North Platte River. *(The operating rules for Lake McConaughy releases contained in the STELLA model are based upon current practices that vary substantially from historic operations. For purposes of this analysis, historic Lake McConaughy releases were used throughout the simulation period).*
- Define the daily flows at the outlet of the J2 Hydropower facility. Flows available for regulation by the proposed PRRIP projects were reset to historic values at the J2 Hydropower outlet to remove effects of varying historic CNPPID system operations and losses and allow a clearer evaluation of the proposed project impacts on reducing shortages.
- Define daily canal diversions for both hydropower and irrigation canal operations.
- Define daily canal returns from those canals with historic return gaging records.

2.2 PRRIP Target Flows

Target flows for the critical habitat reach of the Platte River (Lexington to Chapman) have been established by the Governance Committee of the PRRIP and are included in the Nebraska New Depletions Plan. Target flow values vary throughout the year, as well as annually based on hydrologic condition designation (wet, dry, and normal hydrologic conditions). Annual designations for 1947-2005 were determined by the US Fish and Wildlife Service (USFWS). Annual designations for 2006-2010 were calculated by the PRRIP Office of the Executive Director (ED Office) using USFWS methodologies. Further information on annual hydrologic condition designations can be found in the draft ED Office document *Hydrologic Condition Annual and Periodic Designations*, dated November 1, 2011. The annual hydrologic condition and associated PRRIP target flows were imported into the STELLA model for use in the model operational logic.

2.3 Historic Reach Gains and Losses

In addition to their direct usage in the model as operational inputs during the daily flow routing computations, the historic stream gage, canal diversion, and canal return datasets were used to compute historic daily reach gains/loss values. The calculated daily reach gain/loss values are a lumped quantity that represent the river evaporation and transpiration losses, watershed runoff, ungaged canal returns, and baseflow gains occurring within the reach. The calculated historic daily reach gain/loss values were used to represent these water budget elements in the 1947 to 2010 simulation. Each reach is defined by the main stem gage locations. After the daily values for each reach were imported into the STELLA model, reach gain/loss values are prorated to intermediate nodes within a reach based on sub-reach lengths.

2.4 Monthly RGL Smoothing

During testing of the STELLA model modifications and the proposed project operations, it was noted that large fluctuations in computed daily historic reach gain/loss frequently occurred between reaches, as well as from day to day within a single reach. These fluctuations resulted in artificial oscillations in computed river flows, and subsequent simulated project operations based on those sporadic river flows.

To better represent typical project operations, the daily reach gain/loss values computed for the Cozad-Overton, Overton-Odessa, and Odessa-Grand Island reaches were averaged to determine a daily average for each respective month of the simulation period. Figure 2.2 illustrates a comparison of the daily computed reach gain/loss values with the smoothed average daily by month values. The smoothed reach gain/loss values were used on these three reaches because of their close proximity to the proposed PRRIP projects and the locations for scoring proposed project benefits.

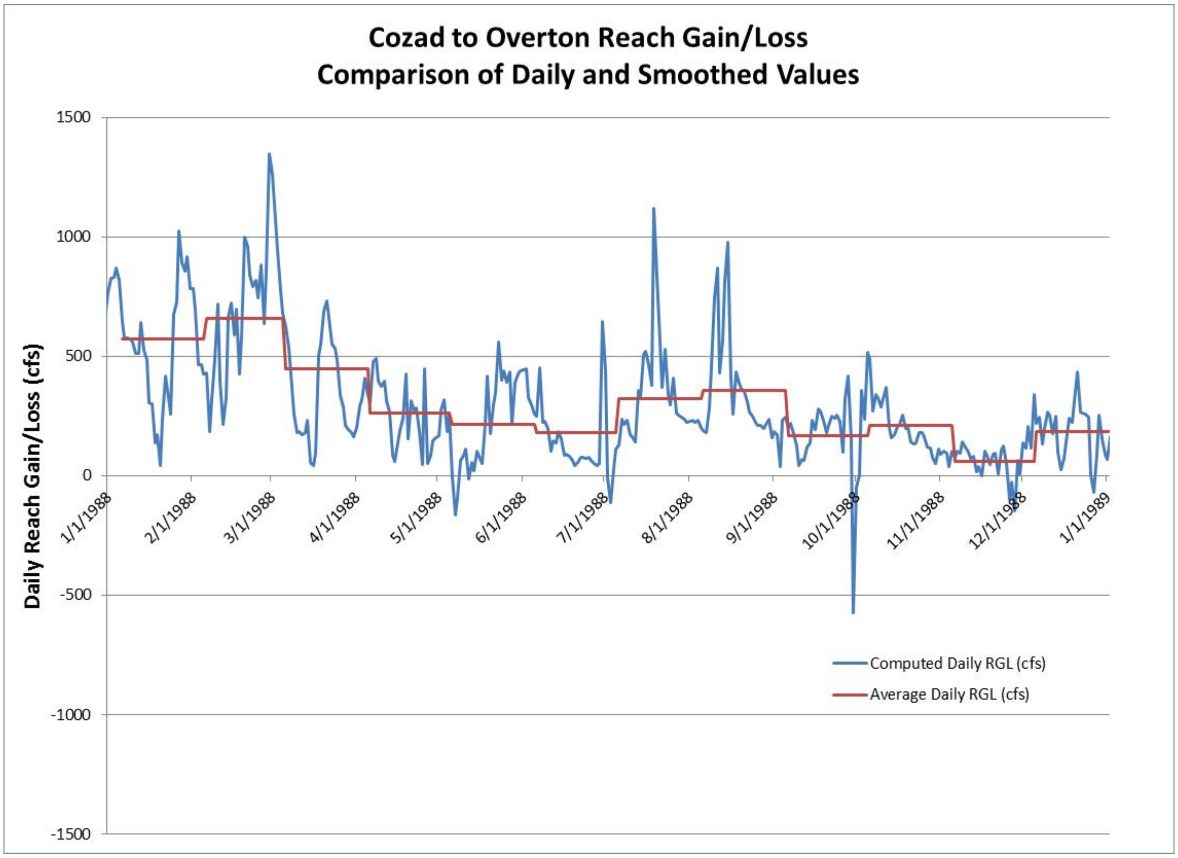


Figure 2.2 Example of Daily and Smoothed Reach Gain/Loss values

3.0 Project Descriptions

3.1 J2 Regulating Reservoir Project

The proposed J2 Regulating Reservoir Project is a two-reservoir system situated adjacent to, and north of the Phelps Canal, south of the Platte River. The two reservoirs would be filled primarily by discharge water from Central Nebraska Public Power and Irrigation District's (CNPPID) J2 Hydropower plant and conveyed to the reservoir through the existing supply canal and Phelps Canal (with expanded canal capacity). The storage capacities of Areas 1 and 2 are 10,473 acre-feet and 3,486 acre-feet, respectively, for total system storage of 13,959 acre-feet.

In general, water from the J2 hydropower discharge will be stored in the J2 Regulating Reservoir during times of excesses to U.S. Fish and Wildlife Service's (USFWS) target flows in the Platte River and released from J2 Regulating Reservoir during times of shortage to target flows. During the irrigation season, the reservoir will also be used to mitigate (hydrocycling) surges to the river associated with J2 Hydropower plant releases by using Area 2 to provide operational flexibility while continuing to provide relatively steady flows to the Phelps Canal.

The project description outlined above, as well as additional background information for the J2 Regulating Reservoir project, can be found in the following PRRIP documentation:

- *J-2 Regulating Reservoir Project Feasibility Study Scoring Update*, February 12, 2012.
- *Conceptual Design Report. J-2 Regulating Reservoir Project*, RJH Consultants, Inc. April 2013

3.2 Phelps Canal Recharge Project

The Phelps Canal Recharge Project is located downstream of the J2 Regulating Reservoir and utilizes excess flows available in the CNPPID system during the non-irrigation season as a water supply. Excesses are diverted into the existing canal, infiltrate into the underlying aquifer and accrete to the Platte River as baseflow gains to reduce shortages to target flows.

The Phelps Canal Recharge Project can be operated as a stand-alone project or in conjunction with the J2 Regulating Reservoir, and has been incorporated into the STELLA model as such.

4.0 Surface Water Model Operations

4.1 Modifications to STELLA Model

The STELLA surface water operations model (Run 24b_13_21) developed as part of the COHYST 2010 effort was modified to include the J2 Regulating Reservoir and the Phelps Canal Recharge projects.

Stocks, flows and connectors were added to the STELLA model framework to represent the J2 Regulating Reservoir and Phelps Canal Recharge Project. Figure 4.1 and Table 4.1 provide a schematic illustration and node description, respectively, of the changes to the STELLA model framework.

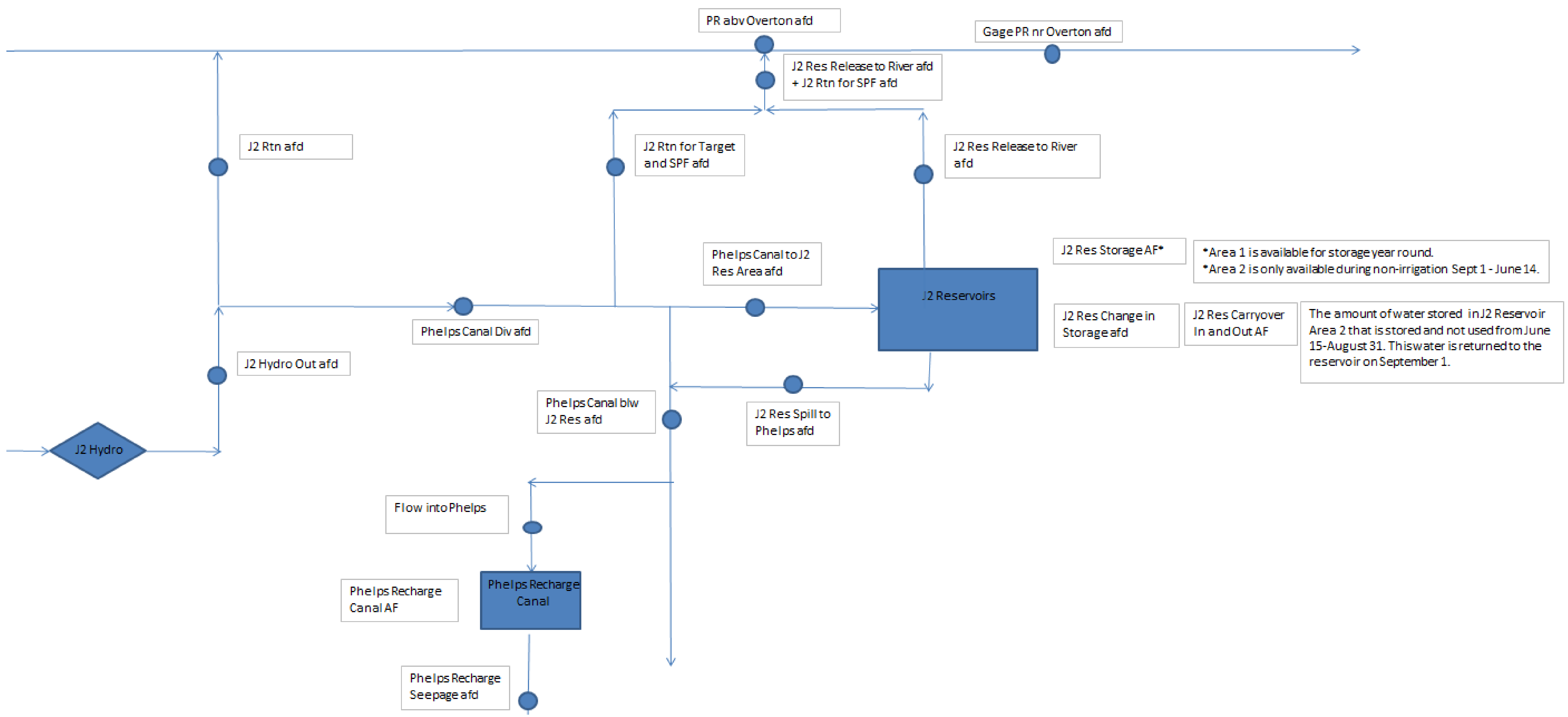


Figure 4.1 Schematic Representation of STELLA Model with J2 Regulating Reservoir and Phelps Canal Recharge Project

Table 4.1: STELLA Node Descriptions

STELLA Node Name	Description
Phelps Est Tot Divs afd	Phelps Estimated Total Diversion (Phelps Demand)
Phelps Canal Div afd	Phelps Canal Diversion
Phelps Canal to J2 Res Area afd	Phelps Canal to J2 Reservoir Area
J2 Storage Area AF	J2 Reservoir Storage Area (includes Areas 1 and/or 2 depending on season)
J2 Res Release to River afd	The amount of water released from J2 Reservoir. (Based on required release for target flows, required spill, or 2000 cfs capacity. Note if J2 is not operating, this value is zero.)
J2 Rtn for Target and SPF afd	Phelps Canal water that bypasses J2 Reservoir Storage Area for Target flow and/or State Protected Flow shortages
J2 Res Back to Phelps Canal	J2 Res Back to Phelps Canal
Phelps Canal blw J2 Res afd	Phelps Canal below J2 Reservoir
Over Odess GI Excess Flow Check	Checks if the Overton, Odessa and Grand Island gages are greater than the Stage Protected Flows and PRRIP Target Flows. (YES or NO)
Maximum SPF Shortage afd	Maximum State Protected Flow Shortage
Shortage at Kearney afd	Shortage at Kearney assuming 406 cfs demand at Kearney
SPF Shortage at Overton afd	State Protected Flow Shortage at Overton
SPF Shortage at Odessa afd	State Protected Flow Shortage at Odessa
SPF Shortage at GI afd	State Protected Flow Shortage at Grand Island
Target Flow Shortage at GI afd	Target Flow Shortage at Grand Island
Gage PR nr Overton afd	River flow at Platte River near Overton gage afd
Gage PR nr Odessa afd	River flow at Platte River near Odessa gage afd
Gage PR nr Kearney afd	River flow at Platte River near Kearney gage afd
Gage PR nr GI afd	River flow at Platte River near Grand Island gage afd
J2 Res Required Release afd	The required amount of flow to be released from the J2 reservoir to meet Target flows at GI
J2 Res Spill to River afd	The amount of water spilled from J2 Reservoir to the River if the reservoir is at maximum capacity
J2 Res Calc Release to River afd	The amount of water calculated to be released from J2 Reservoir if J2 is operating. (Based on required release for target flows, required spill, or 2000 cfs capacity.)
Overton SPF afd	State Protected Flows at Overton
Odessa SPF afd	State Protected Flows at Odessa
GI SPF afd	State Protected Flows at Grand Island
PRRIP Target Flow Grand Island AFD	PRRIP Target Flows at Grand Island based on Wet, Dry, or Normal Year
J2 Hydro Out afd	J2 Hydro Out
J2 rtn afd	Original J2 Return

STELLA Node Name	Description
J2 Carryover AF June 15	Amount of excess water that is stored while Area 2 is offline beginning June 15
J2 Carryover AF September 1	Amount of excess water (captured on June 15) that returns to J2 Reservoir capacity when Area 2 is available on Sept 1
Carryover In and Out	The amount of excess water leaving the reservoir when Area 2 is not available (beginning June 15) or the amount of excess water returning to the J2 reservoir when Area 2 is available again (Sept 1).
Flow into Phelps Recharge Canal afd	Flow into Phelps Recharge Canal afd
Phelps Recharge Canal AF	Phelps Recharge Canal AF
Phelps Recharge Seepage afd	Phelps Recharge Canal Seepage afd
J2 Res Spill to Phelps afd	The amount of excess water from J2 reservoir that can be used for Phelps Recharge canal (when J2 is operating and at capacity).
Select J2 On or Off	Select if J2 Reservoir is operating or not operating
Select Phelps Recharge Canal On or Off	Select if Phelps Recharge Canal is operating or not operating
Select NP & CP Irr Canal Div	Select if North Platte and Central Platte Irrigation Canal Diversions are historic or calculated. This is used in some of the logic to determine if the model is historic or integrated.

4.2 Operating Rule Logic

The operating rule logic in the STELLA model was updated to incorporate the J2 Reservoir and Phelps Recharge Canal projects. The STELLA operating logic allows for the J2 Reservoir and Phelps Recharge projects to be operated independently or in tandem.

As previously mentioned, the COHYST 2010 August Workshop model (Run 24b_13_21) was limited to a simulation period of 1985 through 2005. The previously conducted PRRIP preliminary analysis and scoring of the J2 Regulating Reservoir and Phelps Canal Recharge Project were completed for the simulation period 1947-1994. Prior to extension of the simulation period of the STELLA model, the 1985-2005 model was used to compare STELLA model results for 1985-1994 with the PRRIP results for the overlapping 1985-1994 period. Computed shortages to target flows under baseline and with-project conditions, as well as the temporal distribution of shortages, were evaluated and suitable results were obtained.

The STELLA model can be run using historic value inputs or in the fully integrated mode in conjunction with the groundwater and watershed modeling tools that comprise COHYST 2010. Results from the watershed and groundwater modeling tools were only available for 1985-2005, so the STELLA simulation for 1947-2010 was computed using only historic values.

In the STELLA model, the Interface tab contains all of the ‘knobs’ and ‘sliders’ that are used to adjust operational settings for each respective model run. The red colored buttons are used to toggle the settings of the model to historic or integrated simulation modes. Attachment 1 contains a print out of the Interface tab for 1947-2010 model run. The following sections describe the operational logic associated with the J2 Regulating Reservoir and the Phelps Canal Recharge Project in more detail.

4.2.1 J2 Regulating Reservoir

- The first decision point for the J2 Reservoir project is to determine the amount of water that gets into the Phelps Canal Diversion (Phelps Canal Div afd).
  - o If J2 Reservoir is not operating, no change to the model. The Phelps canal diversion is the minimum of J2 Hydro Out ± reach gain/loss or Phelps Diversion demand.
  - o If J2 Reservoir is operating, the Phelps canal diversion is the minimum of the J2 Hydro Out ± reach gain/loss or the capacity of the Phelps canal (1675 cfs).
- Because the Phelps Irrigation demand will be met before any water can be stored in the J2 Reservoir, the second decision point is the node Phelps Canal below J2 Reservoir (Phelps Canal blw J2 Res afd).
  - o If J2 Reservoir is not operating, then Phelps Canal blw J2 Res is the Phelps Canal Diversion ± reach gain/loss
  - o If J2 Reservoir is operating, the Phelps Canal below J2 Res is the minimum of the Phelps Diversion demand or the Phelps Canal Diversion ± reach gain/loss.
- After the Phelps irrigation demand has been met, the third decision point 3 determines the amount of water that can get into the J2 Reservoir at the node Phelps Canal to J2 Reservoir Area (Phelps Canal to J2 Res Area 2 afd).
  - o If J2 Reservoir is not operating, then no water will go to the J2 Reservoir areas.
  - o If J2 Reservoir is operating, then the Phelps Canal to J2 Reservoir will deliver the water in the Phelps Diversion less the Phelps Demand and less the shortages for State Protected Flows (SPF) or Target flows returned to the river.
- Before the water gets into the J2 Reservoir, the node J2 Rtn for Target and SPF afd returns any water at this point to meet SPF or Target shortages to the river.
  - o If J2 Reservoir is not operating, then no water will go through the J2 Return for SPF.
  - o If J2 Reservoir is operating, then the J2 Return for Target and SPF will deliver the maximum SPF shortage or Target flow shortage back to the river. Therefore, the J-2 reservoir will not be able to store any water coming through Phelps Diversion that will be used to meet a shortage that day.
  - o In order to eliminate circular referencing, the maximum shortage is determined by calculating the maximum SPF and Target flow required that day and subtracting the amount of water in the river at PR blw 30 Mi Rtn afd plus the original J2 Rtn (occurs when flows at Phelps Diversion are in in excess of the 1675 cfs Phelps Canal capacity) plus the RGL in the river from below 30 mile return to PR blw Plum Creek afd – where the water from the J2 Reservoir is returned.
  - o This node has a toggle "Select_SPF_Check_On_or_Off" that can turn this node on or off.
- Maximum SPF and Target Flow afd
  - o This node determines the maximum flow required for SPF or Target flows. The node calculates the maximum of SPF at Overton minus the SPF at Kearney (as Overton is available to meet Kearney), the SPF at Odessa, the SPF at Grand Island, and the Target flow at Grand Island. Note: The Kearney demand (406 cfs) is always less than the State Protected Flow at Overton, therefore the shortage at Overton minus the Kearney shortage term accounts for the Kearney Canal.

- Select Phelps Canal NGL OFF or ON in J2 Res
    - This node allows the user to select if Phelps Canal reach gain/loss from the Phelps headgate to the J2 Reservoir is off or on. The model is currently set to turn these gains/losses off to better match the assumptions that were used in the PRRIP scoring.
- J2 Res Calc Release to River afd
    - Target Flow Shortage for J2 Res Release afd – PRRIP Target Flow less (PR blw 30 Mi Rtn afd plus the computed original J2 Rtn plus the RGL in the river from below 30 mile return to PR abv Overton gage)
    - J2 Res Required Release – Minimum of the Target Flow Shortage for J2 Res Release or the maximum release capacity of 2000 cfs.
    - J2 Res Spill to River afd
        - If the J2 Reservoir storage area is greater than the J2 Reservoir storage capacity, then the J2 Reservoir will spill the amount of water coming into the J2 Reservoir area plus the amount of water above the J-2 Reservoir Storage capacity.
        - If the J2 Reservoir storage area is less than the J2 Reservoir storage capacity, then there will be no spill.
    - J2 Res Spill to Phelps afd - determines the amount of water from the J2 Reservoir that can be delivered to the Phelps Recharge Canal
        - If Phelps Recharge Canal is not operating or if there is a target flow shortage, the spill to Phelps is zero.
        - If the Phelps Recharge Canal is operating and there is no target flow shortage, the J2 Reservoir Spill to Phelps is calculated by using the minimum of the J2 Res Spill to River less the J2 Res Required Release, the Phelps Diversion Rate, or the amount of volume capacity available in the Phelps recharge canal.
    - The J2 Res Calc Release to River is calculated by taking the minimum of (the maximum of the J2 Reservoir required release or J2 Reservoir spill less the spill to Phelps) or the release capacity of 2000 cfs.
- Phelps below E65 (Phelps blw E65 afd)
    - Same logic if J2 Reservoir is or is not operating.
    - Phelps Canal Diversion ± reach gain losses

4.2.2 Phelps Canal Recharge Project

- The Phelps Recharge Canal operates from September 16 – April 15. On April 16, the water in the Phelps Recharge Canal is emptied (Phelps Recharge Canal Flush on April 16).
- The STELLA model is set up to be able to turn the Phelps Recharge Canal on or off independent of the J2 Reservoir.
- The J2 Reservoir Spill to Phelps afd determines the amount of water from the J2 Reservoir that can be delivered to the Phelps Recharge Canal.
    - If Phelps Recharge Canal is not operating or if there is a target flow shortage, the spill to Phelps is zero.
    - If the Phelps Recharge Canal is operating and there is no target flow shortage, the J2 Reservoir Spill to Phelps is calculated by using the minimum of the J2 Res Spill to River less the J2 Res Required Release, the Phelps Diversion Rate, or the amount of volume capacity available in the Phelps recharge canal.
- The Flow into Phelps Recharge Canal afd limits the amount of water that can get into the canal.
    - If Phelps Recharge Canal is off, not operating, or filled to capacity, the flow into Phelps Recharge Canal is zero.

- If J2 Reservoir is operating, the amount of water that can get to the Phelps Recharge canal is the amount of water spilled from the J2 Reservoir to Phelps (J2 Res Spill to Phelps) capped at a capacity of 350 cfs.
- If J2 Reservoir is not operating, and the Shortage Check for Phelps Recharge is >= 0, the flow into Phelps Recharge canal is the minimum of the amount of water in the Phelps Canal, the Phelps Recharge Diversion Rate (capacity of 350 cfs), or the amount of available storage capacity in the Phelps Recharge Canal (capped at 1160 AF).

4.3 Key Assumptions

- Phelps canal capacity above J2 Regulating Reservoir modified to 1,675 cfs
- Phelps canal irrigation demand is served before storing water
- Areas 1 and 2 are modeled as a single area. There are knobs in the model to set the capacities of the J2 Reservoir areas. The knobs were used so they can easily be changed. J2 Reservoir Area 1 was set to 10,473 AF and Area 2 was set to 3,486 AF, for a total of 13,959 AF. Area 1 will be available all year long. Area 2 is only available September 1st through June 14. The end of the day storage volume in Area 2 on June 14 is added back to the storage volume level on September 1.
- For the operational logic in the STELLA model, the PRRIP target flow are compared with river flows at the Platte River abv Overton gage.
- There are several knobs for the Phelps Canal Recharge project.
  - The Phelps Recharge Canal can be selected to be off or on.
  - Phelps canal capacity for recharge was set to 1160 AF.
  - Phelps Recharge Canal Seepage was set to 32 cfs.
  - Phelps Recharge Diversion Rate was set to 350 cfs.
  - Phelps Recharge Canal is operating September 16 – April 15.
- While the framework is included in the model, operational logic for periodically meeting irrigation demands from J2 Regulating Reservoir releases is not currently included in the model.

5.0 Project Scoring

A baseline simulation for the 1947-2010 period was completed without the proposed PRRIP projects in operation. Daily shortages to target flows were computed for the baseline conditions. The same 1947-2010 simulation was then completed with the J2 Regulating Reservoir in operation and daily shortages to target flows computed. Scoring of the model was determined by subtracting the predicted shortages with J2 Regulating Reservoir in operation from the daily shortages computed in the baseline run. The score then quantifies the amount of shortages that are reduced because of the J2 Regulating Reservoir project operations.

The scoring templates are set up to compute scores at Platte River above Overton and at Platte River at Grand Island. The only water that can be credited in the scoring is water that was released through J2 Reservoir.

Table 5.1 illustrates the annual shortages in the baseline and with J2 Regulating Reservoir operations conditions, as well as the computed scoring credit. Table 5.2 provides the same information with both J2 Regulating Reservoir and the Phelps Canal Recharge Project in operation, as well as the annual recharge volumes in the Phelps Canal Recharge Project. Table 5.3 provides a comparison of the annual recharge volume when the Phelps Canal Recharge Project is operated as a stand alone project and in tandem with the J2 Regulating Reservoir.

It is noted that the data presented for the Phelps Canal Recharge Project are raw recharge volumes. A baseflow response function has yet to be applied to these values to determine the gains in the baseflow returns that would ultimately be used to determine the scoring credit of the project.

Table 5.1 Summary of Scoring 1947-2010 (Phelps Canal Recharge OFF)

Year	Baseline Shortages (AF/yr)	J2 ON Shortages (AF/yr)	Score (AF/yr)
1947	184,195	122,680	61,514
1948	162,162	128,597	33,565
1949	404,589	343,431	61,158
1950	473,080	444,434	28,646
1951	390,648	339,571	51,076
1952	343,527	308,878	34,649
1953	218,356	178,152	40,204
1954	270,585	248,881	21,704
1955	276,671	257,677	18,994
1956	367,490	346,215	21,275
1957	280,954	251,977	28,977
1958	454,868	407,848	47,020
1959	143,379	95,271	48,109
1960	642,455	613,245	29,210
1961	246,117	214,065	32,052
1962	454,343	416,722	37,622
1963	198,413	158,368	40,046
1964	216,628	182,167	34,461
1965	562,718	520,349	42,369
1966	489,246	451,286	37,960
1967	541,024	505,236	35,788
1968	513,191	488,739	24,453
1969	461,332	411,763	49,569
1970	351,330	296,651	54,678
1971	170,988	114,781	56,206
1972	307,651	254,397	53,254
1973	66,740	33,384	33,356
1974	355,074	333,641	21,433
1975	447,262	405,845	41,417
1976	117,958	62,119	55,839
1977	462,262	433,764	28,498
1978	540,784	515,438	25,346
1979	523,352	492,112	31,241
1980	263,435	218,141	45,294

Year	Baseline Shortages (AF/yr)	J2 ON Shortages (AF/yr)	Score (AF/yr)
1981	196,031	145,421	50,609
1982	573,765	541,443	32,322
1983	60,206	16,042	44,164
1984	52,692	41,802	10,890
1985	323,818	271,962	51,856
1986	157,862	102,291	55,572
1987	174,772	104,077	70,695
1988	335,238	270,627	64,611
1989	587,936	549,125	38,812
1990	569,351	533,469	35,882
1991	226,607	187,770	38,837
1992	674,127	631,500	42,627
1993	480,998	418,920	62,078
1994	561,777	536,057	25,720
1995	360,373	315,282	45,091
1996	312,990	263,842	49,148
1997	239,951	193,035	46,916
1998	371,434	323,909	47,525
1999	181,108	137,662	43,447
2000	418,116	369,022	49,095
2001	654,723	609,901	44,822
2002	397,664	372,936	24,727
2003	455,027	432,750	22,277
2004	489,050	476,747	12,303
2005	439,215	397,964	41,251
2006	489,424	461,247	28,177
2007	712,993	699,178	13,815
2008	734,254	708,681	25,573
2009	586,226	555,444	30,782
2010	274,433	214,023	60,409
Average Annual	374,921	335,593	39,328

Table 5.2 Summary of Scoring 1947-2010 (Phelps Canal Recharge ON)

Year	Baseline Shortages (AF/yr)	J2 ON Shortages (AF/yr)	Score (AF/yr)	Phelps Recharge Canal
1947	184,195	122,680	61,514	11,038
1948	162,162	128,597	33,565	12,666
1949	404,589	343,431	61,158	4,016
1950	473,080	444,434	28,646	5,155
1951	390,648	339,571	51,076	5,286
1952	343,527	308,878	34,649	8,713
1953	218,356	178,152	40,204	5,857
1954	270,585	248,881	21,704	5,159
1955	276,671	257,677	18,994	4,016
1956	367,490	346,215	21,275	2,140
1957	280,954	251,977	28,977	3,001
1958	454,868	407,848	47,020	1,968
1959	143,379	95,271	48,109	7,760
1960	642,455	613,245	29,210	531
1961	246,117	214,065	32,052	6,826
1962	454,343	416,722	37,622	5,666
1963	198,413	158,368	40,046	5,193
1964	216,628	182,167	34,461	4,651
1965	562,718	520,349	42,369	6,763
1966	489,246	451,286	37,960	2,856
1967	541,024	505,236	35,788	3,377
1968	513,191	488,739	24,453	4,270
1969	461,332	411,763	49,569	5,730
1970	351,330	296,651	54,678	7,144
1971	170,988	114,781	56,206	6,111
1972	307,651	254,397	53,254	8,096
1973	66,740	33,384	33,356	12,348
1974	355,074	333,641	21,433	8,396
1975	447,262	405,845	41,417	5,032
1976	117,958	62,119	55,839	6,047
1977	462,262	433,764	28,498	4,016
1978	540,784	515,438	25,346	0
1979	523,352	492,112	31,241	2,302
1980	263,435	218,141	45,294	7,989
1981	196,031	145,421	50,609	6,435
1982	573,765	541,443	32,322	2,842
1983	60,206	16,042	44,164	13,145
1984	52,692	41,802	10,890	14,552
1985	323,818	271,962	51,856	10,698

Year	Baseline Shortages (AF/yr)	J2 ON Shortages (AF/yr)	Score (AF/yr)	Phelps Recharge Canal
1986	157,862	102,291	55,572	13,824
1987	174,772	104,077	70,695	10,906
1988	335,238	270,627	64,611	5,222
1989	587,936	549,125	38,812	3,889
1990	569,351	533,469	35,882	1,968
1991	226,607	187,770	38,837	5,430
1992	674,127	631,500	42,627	3,445
1993	480,998	418,920	62,078	8,546
1994	561,777	536,057	25,720	1,968
1995	360,373	315,282	45,091	8,304
1996	312,990	263,842	49,148	9,238
1997	239,951	193,035	46,916	10,681
1998	371,434	323,909	47,525	6,821
1999	181,108	137,662	43,447	10,681
2000	418,116	369,022	49,095	2,856
2001	654,723	609,901	44,822	3,462
2002	397,664	372,936	24,727	0
2003	455,027	432,750	22,277	2,334
2004	489,050	476,747	12,303	0
2005	439,215	397,964	41,251	0
2006	489,424	461,247	28,177	0
2007	712,993	699,178	13,815	0
2008	734,254	708,681	25,573	0
2009	586,226	555,444	30,782	4,143
2010	274,433	214,023	60,409	5,349
Annual Average	374,921	335,593	39,328	5,576

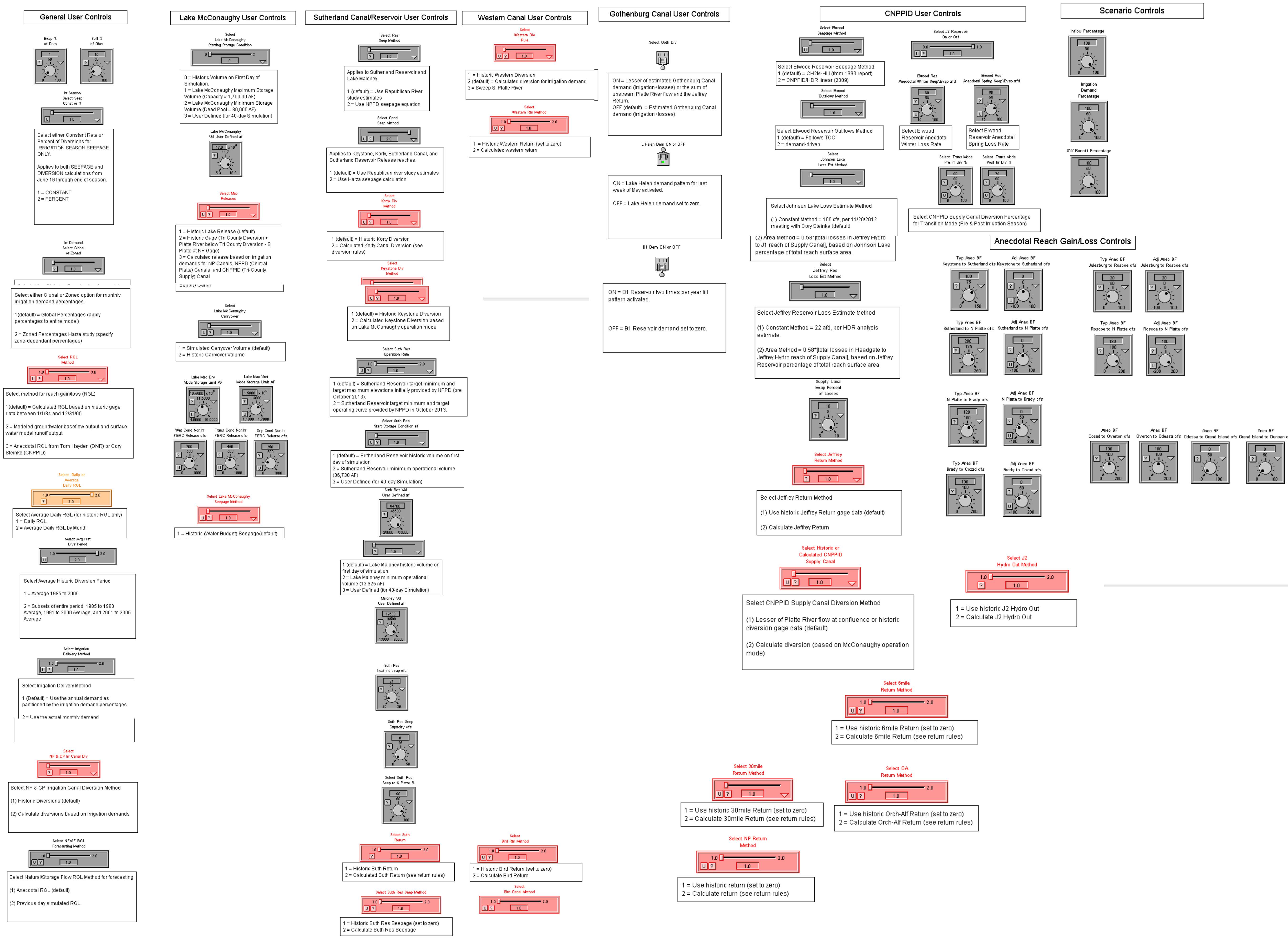
Table 5.3 Phelps Recharge Canal Annual Volumes (AF/year)

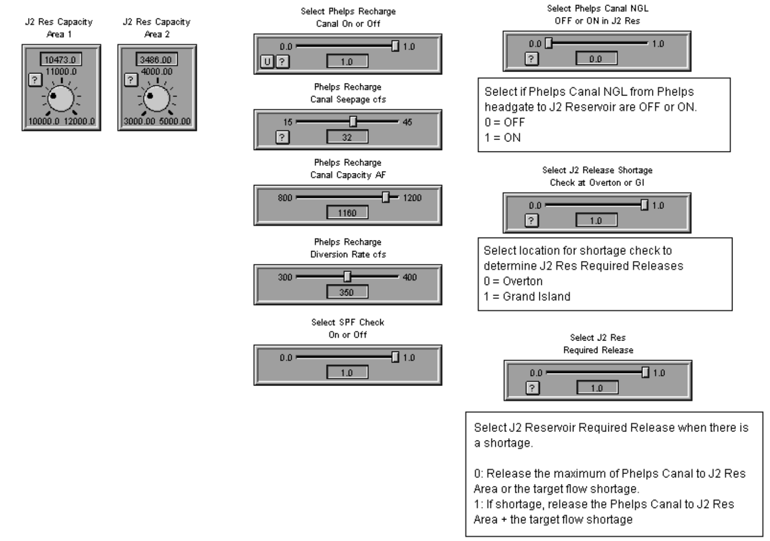
Year	Phelps Recharge Canal with J2 ON	Phelps Recharge Canal with J2 OFF
1947	11,038	15,517
1948	12,666	14,552
1949	4,016	14,489
1950	5,155	14,489
1951	5,286	14,489
1952	8,713	14,552
1953	5,857	14,489
1954	5,159	14,489
1955	4,016	14,489
1956	2,140	14,552
1957	3,001	14,489
1958	1,968	14,489
1959	7,760	14,489
1960	531	14,552
1961	6,826	14,489
1962	5,666	14,489
1963	5,193	14,489
1964	4,651	14,552
1965	6,763	14,489
1966	2,856	14,489
1967	3,377	14,489
1968	4,270	14,552
1969	5,730	14,489
1970	7,144	14,489
1971	6,111	14,489
1972	8,096	14,552
1973	12,348	14,489
1974	8,396	14,489
1975	5,032	14,489
1976	6,047	14,552
1977	4,016	14,489
1978	0	11,888
1979	2,302	15,517
1980	7,989	14,552
1981	6,435	14,489
1982	2,842	14,489
1983	13,145	14,489
1984	14,552	14,552

Year	Phelps Recharge Canal with J2 ON	Phelps Recharge Canal with J2 OFF
1985	10,698	14,489
1986	13,824	14,489
1987	10,906	14,489
1988	5,222	14,552
1989	3,889	14,489
1990	1,968	14,489
1991	5,430	14,489
1992	3,445	14,552
1993	8,546	14,489
1994	1,968	14,489
1995	8,304	14,489
1996	9,238	14,552
1997	10,681	14,489
1998	6,821	11,985
1999	10,681	14,489
2000	2,856	14,552
2001	3,462	12,114
2002	0	13,923
2003	2,334	14,020
2004	0	13,435
2005	0	14,546
2006	0	14,022
2007	0	14,187
2008	0	14,274
2009	4,143	14,489
2010	5,349	13,012
Annual Average	5,576	14,348

Attachment 1

STELLA Interface Menu


General User Controls
Select either Constant Rate or Percent of Diversions for IRRIGATION SEASON SEEPAGE ONLY.
Applies to both SEEPAGE and DIVERSION calculations from June 16 through end of season.
1 = CONSTANT
2 = PERCENT
Select either Global or Zoned option for monthly irrigation demand percentages.
1(default) = Global Percentages (apply percentages to entire model)
2 = Zoned Percentages Harza study (specify zone-dependant percentages)
Select RGL Method
Select method for reach gain/loss (RGL)
1(default) = Calculated RGL based on historic gage data between 1/1/84 and 12/31/05
2 = Modeled groundwater baseflow output and surface water model runoff output
3 = Anecdotal RGL from Tom Hayden (DNR) or Cory Steinke (CNPPID)
Select Daily or Average Daily RGL
Select Average Daily RGL (for historic RGL only)
1 = Daily RGL
2 = Average Daily RGL by Month
Select Average Historic Diversion Period
1 = Average 1985 to 2005
2 = Subsets of entire period; 1985 to 1990 Average, 1991 to 2000 Average, and 2001 to 2005 Average
Select Irrigation Delivery Method
Select Irrigation Delivery Method
1 (Default) = Use the annual demand as partitioned by the irrigation demand percentages.
2 = Use the actual monthly demand
Select NP & CP Irr Canal Div
Select NP & CP Irrigation Canal Diversion Method
(1) Historic Diversions (default)
(2) Calculate diversions based on irrigation demands
Select NFSF RGL Forecasting Method
Select Natural/Storage Flow RGL Method for forecasting
(1) Anecdotal RGL (default)
(2) Previous day simulated RGL
Lake McConaughy User Controls
0 = Historic Volume on First Day of Simulation.
1 = Lake McConaughy Maximum Storage Volume (Capacity = 1,700,00 AF)
2 = Lake McConaughy Minimum Storage Volume (Dead Pool = 80,000 AF)
3 = User Defined (for 40-day Simulation)
Select Mac Releases
1 = Historic Lake Release (default)
2 = Historic Gage (Tri County Diversion + Platte River below Tri County Diversion - S Platte at NP Gage)
3 = Calculated release based on irrigation demands for NP Canals, NPPD (Central Platte) Canals, and CNPPID (Tri-County Supply) Canal
1 = Simulated Carryover Volume (default)
2 = Historic Carryover Volume
Select Lake McConaughy Seepage Method
1 = Historic (Water Budget) Seepage(default)
Sutherland Canal/Reservoir User Controls
Applies to Sutherland Reservoir and Lake Maloney.
1 (default) = Use Republican River study estimates
2 = Use NPPD seepage equation
Applies to Keystone, Korty, Sutherland Canal, and Sutherland Reservoir Release reaches.
1 (default) = Use Republican river study estimates
2 = Use Harza seepage calculation
Select Korty Div Method
1 (default) = Historic Korty Diversion
2 = Calculated Korty Canal Diversion (see diversion rules)
Select Keystone Div Method
1 (default) = Historic Keystone Diversion
2 = Calculated Keystone Diversion based on Lake McConaughy operation mode
1 (default) = Sutherland Reservoir target minimum and target maximum elevations initially provided by NPPD (pre October 2013).
2 = Sutherland Reservoir target minimum and target operating curve provided by NPPD in October 2013.
1 (default) = Sutherland Reservoir historic volume on first day of simulation
2 = Sutherland Reservoir minimum operational volume (36,730 AF)
3 = User Defined (for 40-day Simulation)
1 (default) = Lake Maloney historic volume on first day of simulation
2 = Lake Maloney minimum operational volume (13,925 AF)
3 = User Defined (for 40-day Simulation)
Select Suth Return
1 = Historic Suth Return
2 = Calculated Suth Return (see return rules)
Select Suth Res Seep Method
1 = Historic Suth Res Seepage (set to zero)
2 = Calculate Suth Res Seepage
Western Canal User Controls
Select Western Div Rule
1 = Historic Western Diversion
2 (default) = Calculated diversion for irrigation demand
3 = Sweep S. Platte River
Select Western Rtn Method
1 = Historic Western Return (set to zero)
2 = Calculated western return
Select Bird Rtn Method
1 = Historic Bird Return (set to zero)
2 = Calculate Bird Return
Select Bird Canal Method
Gothenburg Canal User Controls
Select Goth Div
ON = Lesser of estimated Gothenburg Canal demand (irrigation+losses) or the sum of upstream Platte River flow and the Jeffrey Return.
OFF (default) = Estimated Gothenburg Canal demand (irrigation+losses).
L Helen Dem ON or OFF
ON = Lake Helen demand pattern for last week of May activated.
OFF = Lake Helen demand set to zero.
B1 Dem ON or OFF
ON = B1 Reservoir two times per year fill pattern activated.
OFF = B1 Reservoir demand set to zero.
CNPPID User Controls
Select Elwood Reservoir Seepage Method
1 (default) = CH2M-Hill (from 1993 report)
2 = CNPPID/HDR linear (2009)
Select Elwood Reservoir Outflows Method
1 (default) = Follows TOC
2 = demand-driven
Select Elwood Reservoir Anecdotal Winter Loss Rate
Select Elwood Reservoir Anecdotal Spring Loss Rate
Select Johnson Lake Loss Estimate Method
(1) Constant Method = 100 cfs, per 11/20/2012 meeting with Cory Steinke (default)
(2) Area Method = 0.58*[total losses in Jeffrey Hydro to J1 reach of Supply Canal], based on Johnson Lake percentage of total reach surface area.
Select CNPPID Supply Canal Diversion Percentage for Transition Mode (Pre & Post Irrigation Season)
Select Jeffrey Reservoir Loss Estimate Method
(1) Constant Method = 22 afd, per HDR analysis estimate.
(2) Area Method = 0.58*[total losses in Headgate to Jeffrey Hydro reach of Supply Canal], based on Jeffrey Reservoir percentage of total reach surface area.
Select Jeffrey Return Method
Select Jeffrey Return Method
(1) Use historic Jeffrey Return gage data (default)
(2) Calculate Jeffrey Return
Select Historic or Calculated CNPPID Supply Canal
Select CNPPID Supply Canal Diversion Method
(1) Lesser of Platte River flow at confluence or historic diversion gage data (default)
(2) Calculate diversion (based on McConaughy operation mode)
Select J2 Hydro Out Method
1 = Use historic J2 Hydro Out
2 = Calculate J2 Hydro Out
Select 6mile Return Method
1 = Use historic 6mile Return (set to zero)
2 = Calculate 6mile Return (see return rules)
Select 30mile Return Method
1 = Use historic 30mile Return (set to zero)
2 = Calculate 30mile Return (see return rules)
Select OA Return Method
1 = Use historic Orch-Alf Return (set to zero)
2 = Calculate Orch-Alf Return (see return rules)
Select NP Return Method
1 = Use historic return (set to zero)
2 = Calculate return (see return rules)
Scenario Controls
Inflow Percentage
Irrigation Demand Percentage
SW Runoff Percentage
Anecdotal Reach Gain/Loss Controls


J2 Res Capacity Area 1
10473.0
11000.0
10000.0 12000.0
J2 Res Capacity Area 2
3486.00
4000.00
3000.00 5000.00
Select Phelps Recharge Canal On or Off
0.0 1.0
1.0
Phelps Recharge Canal Seepage cfs
15 45
32
Phelps Recharge Canal Capacity AF
800 1200
1160
Phelps Recharge Diversion Rate cfs
300 400
350
Select SPF Check On or Off
0.0 1.0
1.0
Select Phelps Canal NGL OFF or ON in J2 Res
0.0 1.0
0.0
Select if Phelps Canal NGL from Phelps headgate to J2 Reservoir are OFF or ON.
0 = OFF
1 = ON
Select J2 Release Shortage Check at Overton or GI
0.0 1.0
1.0
Select location for shortage check to determine J2 Res Required Releases
0 = Overton
1 = Grand Island
Select J2 Res Required Release
0.0 1.0
1.0
Select J2 Reservoir Required Release when there is a shortage.
0: Release the maximum of Phelps Canal to J2 Res Area or the target flow shortage.
1: If shortage, release the Phelps Canal to J2 Res Area + the target flow shortage

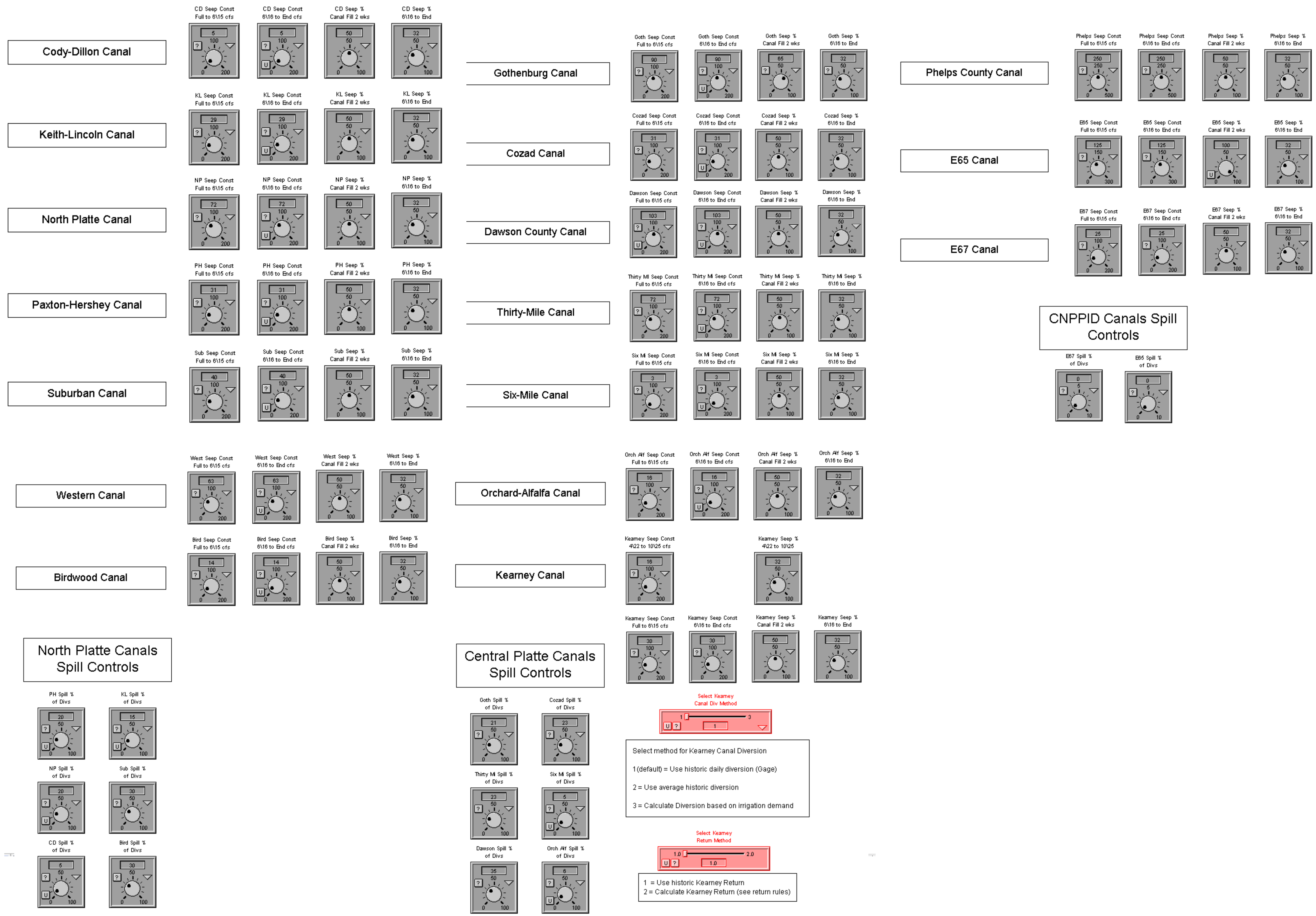
SEEPAGE CALCULATIONS

Estimated total diversions = average historical diversions (based on 1985-1997 data) through June 15. Starting June 16, estimated total demands = (irrigation demands + estimated seepage demand), with applied evaporation factor.

Seepage, for the first two weeks of diversions, is estimated as a percentage of diversions. After the first two weeks, until June 15, seepage is a constant rate based on the assumption that once the canal is filled with water, all diversions prior to the start of irrigation season are lost to seepage, evaporation, and spills.

From June 16 through the end of the irrigation season, the user has the option of choosing a constant rate or percentage factor to estimate seepage. A factor is applied to account for evaporation as a percentage of diversions.

NOTE: The evaporation percentage factor, as well as the constant seepage rates and/or seepage percentage factors for each of the three methods can be varied using the knob controls to the right.



MONTHLY IRRIGATION DEMAND PERCENTAGES

Irrigation demands are prorated, by month, over the irrigation season (June 16 - Sept. 10).

Global Demand % June	Global Demand % July	Global Demand % August	Global Demand % September
7.4	50.0	35.9	6.7

Zone 1 Demand % June	Zone 1 Demand % July	Zone 1 Demand % August	Zone 1 Demand % September
7.4	40.8	45.1	6.7

Zone 2 Demand % June	Zone 2 Demand % July	Zone 2 Demand % August	Zone 2 Demand % September
7.4	40.8	45.1	6.7

Zone 3 Demand % June	Zone 3 Demand % July	Zone 3 Demand % August	Zone 3 Demand % September
7.4	40.8	45.1	6.7

(Each dial: range 0.0 – 100.0)

Select Reservoir Starting Storage Condition/Volume

Select B1 Res Starting Storage Condition: 0.0

Select B1 Res Starting Storage
0 = (default) 0
1 = User Defined (for 40-day Simulation)

B1 Res Vol User Defined af: 100 (range 0 – 100)

Select Elwood Res Starting Storage Condition: 0.0

Select Elwood Res Starting Storage
0 = (default) Target Operating Curve (13,085 AF)
1 = User Defined (for 40-day Simulation)

Elwood Res Vol User Defined af: 10800.0 (range 10800.0 – 39000.0)

Select Funk Lagoon Starting Storage Condition: 0.0

Select Funk Lagoon Starting Storage
0 = (default) 0
1 = User Defined (for 40-day Simulation)

Funk Lagoon Vol User Defined af: 100 (range 0 – 200)

Select Jeff Res Starting Storage Condition: 0.0

Select Jeff Res Starting Storage
0 = (default) 5,237 AF
1 = User Defined (for 40-day Simulation)

Jeff Res Vol User Defined af: 5000 (range 5000 – 6000)

Select Johnson Lake Starting Storage Condition: 0.0

Select Johnson Lake Starting Storage
0 = (default) Johnson Historic Volume
1 = User Defined (for 40-day Simulation)

Johnson Lake Vol User Defined af: 36000 (range 36000 – 42000)

Select Lake Helen Starting Storage Condition: 0.0

Select Lake Helen Starting Storage
0 = (default) 0
1 = User Defined (for 40-day Simulation)

Lake Helen Vol User Defined af: 100 (range 0 – 200)

Select Lake Kearney Starting Storage Condition: 0.0

Select Lake Kearney Starting Storage
0 = (default) 0
1 = User Defined (for 40-day Simulation)

Lake Kearney Vol User Defined af: 100.0 (range 0.0 – 93320.0)