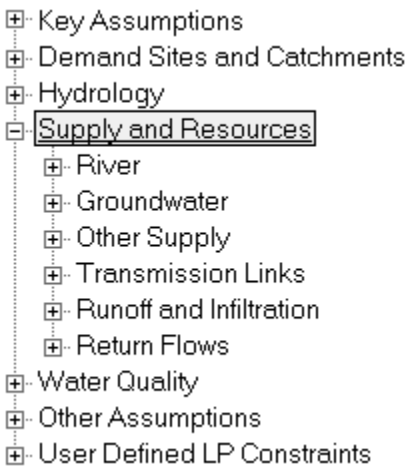
Chapter 6 Supply and Resources

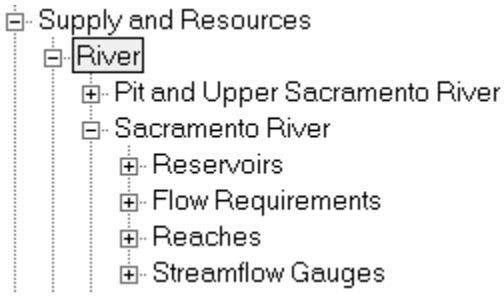
The *Supply and Resources* branch of the SacWAM data tree includes parameters relevant to transmission arcs, rivers and diversions, groundwater, runoff and infiltration, return flows, and other water supply elements including valley floor inflows, *Streamflow Gauges*, and *Reservoirs*. The *River* branch of the WEAP tree includes manmade channels and tunnels (*diversion* arcs, documented in Section 6.2) as well as natural streams and rivers (Section 6.1). Refer to Table 6-12 for location information of datasets relating to these parameters.

For clarity, this chapter is organized using headings that mimic the data tree in the WEAP software. It is recommended that the user navigate to the parameter of interest using the navigation pane (in Word check the "Navigation Pane" box in the "View" banner). Screenshots of the WEAP interface for each parameter are provided where possible to help the user understand where parameters are entered into the model.



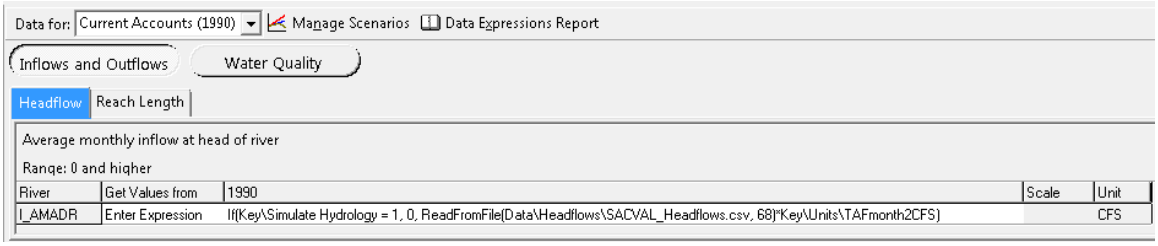
6.1 River

Both river objects (representing natural streams) and diversions objects (representing canals, tunnels, and aqueducts) appear in the WEAP tree under 'River'. However, parameterization of river and diversion objects differ. Diversions are discussed under Section 6.2. The definition of river objects occurs at multiple levels. 'Inflows and Outflows' are defined for each river (the 'Water Quality' feature is not used in SacWAM). Additionally, a River may contain reservoirs, flow requirements, reaches, and streamflow gauges.



6.1.1 Inflows and Outflows

6.1.1.1 *Headflow*



SacWAM can run in two modes with respect to upper watershed hydrology. The first mode uses WEAP catchment objects to simulate snow accumulation, snow melt, and rainfall runoff processes. The creation of the catchments is described in Chapter 4 and Chapter 5. The second uses timeseries data of historical unimpaired flows developed by DWR to represent flows from the upper watersheds into the stream network. The model user can choose between these two methods of simulation using the parameter *Key\Simulate Hydrology.*

The WEAP "Headflow" is the inflow to the first node on a stream. Headflow can be specified either as originating from a WEAP catchment object, or with values directly input using the Read from File Method. Historical streamflow data were obtained for the Sacramento Valley Hydrologic Region from DWR, and for the San Joaquin Hydrologic Region from Reclamation. The data are stored in the csv file *Data>Headflows>SacVal_Headflows* as monthly timeseries data. The first row in this file denotes the name of the timeseries data used in SacWAM. Inflow names contain the prefix "I_" followed by a five or six letter string. The five letter string is an acronym for inflows to reservoirs or lakes. The six letter string denotes the river followed by the river mile. For example, I_SHSTA represents the inflow to Lake Shasta, and I_NFY029 represents inflow to the North Fork Yuba River at RM 29. Table 6-1 lists all historical inflows used in SacWAM and their average annual flow.

Table 6-1 Upper Watershed Inflows

Inflow Arc	Description	Type[1]	Av. Annual Flow (TAF)[2]
I_ALD001	Alder Creek near Whitehall	Stream inflow	28
I_ALMNW	Lake Almanor and Mountain Meadows Reservoir	Reservoir inflow	728
I_AMADR	Amador Reservoir	Reservoir inflow	29
I_ANT011	Antelope Creek near Red Bluff	Stream inflow	101
I_ANTLP	Antelope Reservoir	Reservoir inflow	33
I_BCC014	Big Chico Creek near Chico	Stream inflow	101
I_BCN010	Bear Creek (North) near Millville	Stream inflow	60
I_BKILD	Bucks Island Lake	Stream inflow	20
I_BLKBT	Black Butte Lake	Local reservoir inflow	205
I_BOWMN	Bowman Lake	Reservoir inflow	93
I_BRC003	Bear Creek above Holsten Chimney	Stream inflow	34
I_BRR023	Camp Far West Reservoir	Local reservoir inflow	93
I_BRYSA	Lake Berryessa	Reservoir inflow	362
I_BTC048	Butte Creek	Stream inflow	245
I_BTL006	Battle Creek near Cottonwood	Stream inflow	351
I_BTVLY	Butt Valley Reservoir	Reservoir inflow	75
I_BUKSL	Bucks Lake	Reservoir inflow	85
I_CAPLS	Caples Lake	Reservoir inflow	27
I_CCH053	Cache Creek above Rumsey	Stream accretion	55
I_CLR011	Clear Creek near Igo	Stream accretion	46
I_CLR025	Whiskeytown Lake	Reservoir inflow	285
I_CLRLK	Clear Lake	Reservoir inflow	436
I_CLV026	Calaveras River at Bellota	Stream inflow	8
I_CMBIE	Combie Reservoir	Local reservoir inflow	31
I_CMCHE	Camanche Reservoir	Local reservoir inflow	11
I_CMP001	Camp Creek at mouth	Stream inflow	12
I_CMP012	Camp Creek at Camp Creek Diversion Tunnel	Stream inflow	32
I_CMPFW	Camp Far West Reservoir	Local reservoir inflow	16
I_COW014	Cow Creek near Millville	Stream inflow	420
I_CSM035	Cosumnes River at Michigan Bar	Stream accretion	305
I_CWD018	North Fork and Middle Fork Cottonwood Creek near Olinda	Stream inflow	298
I_DAVIS	Lake Davis	Reservoir inflow	26
I_DCC007	Duncan Canyon Creek	Stream inflow	28
I_DEE023	Deer Creek	Stream inflow	33
I_DER001	Deer Creek near Smartville	Stream accretion	29
I_DER004	Deer Creek at Wildwood Dam	Stream accretion	33
I_DHC001	Dry Creek and Hutchinson Creek	Stream inflow	54
I_DRC012	Deer Creek near Vina	Stream inflow	231
I_DSC035	Dry and Sutter creeks	Stream inflow	65
I_ELD027	Elder Creek near Paskenta	Stream inflow	68
I_ELIMP	Echo Lake Conduit	Inter-basin import	2
I_ENF011	East Branch of North Fork Feather River near Rich Bar	Stream accretion	52
I_ENGLB	Englebright Reservoir	Stream inflow	147
I_EPARK	East Park Reservoir inflow	Reservoir inflow	66
I_FOLSM	Folsom Lake	Local reservoir inflow	249
I_FRDYC	Fordyce Lake	Reservoir inflow	87
I_FRMAN	Lake Frenchman	Reservoir inflow	23
I_FRMDW	French Meadows Reservoir	Reservoir inflow	114
I_GRZLY	Grizzly Creek	Stream inflow	52
I_HHOLE	Hell Hole Reservoir	Local reservoir inflow	207
I_HON021	South Fork Honcut Creek near Bangor	Stream inflow	24
I_ICEHS	Ice House Reservoir	Reservoir inflow	56
I_INDVL	Indian Valley Reservoir	Reservoir inflow	111
I_JKSMD	Jackson Meadows Reservoir	Reservoir inflow	76
I_JNKSN	Jenkinson Lake	Reservoir inflow	17

Table 6-1 Upper Watershed Inflows cont.

Inflow Arc	Description	Type[1]	Av. Annual Flow (TAF) [2]
I_KSWCK	Sacramento River below Keswick Dam	Stream accretion	175
I_LBEAR	Lower Bear Reservoir	Reservoir inflow	73
I_LCC038	Little Chico Creek near Chico	Stream inflow	22
I_LDC029	Little Dry Creek	Stream inflow	26
I_LGRSV	Little Grass Valley Reservoir	Reservoir inflow	78
I_LJC022	Littlejohn and Rock Creek at Farmington Reservoir	Reservoir inflow	52
I_LKVLY	Lake Valley Reservoir	Reservoir inflow	9
I_LNG000	Long Creek Canyon at mouth	Stream inflow	74
I_LOONL	Loon Lake	Reservoir inflow	22
I_LOSVQ	Los Vaqueros Reservoir	Reservoir inflow	1
I_LST007	Sly Creek Reservoir	Reservoir inflow	75
I_LWSTN	Lewiston Lake	Local reservoir inflow	23
I_MERLC	Merle Collins Reservoir	Reservoir inflow	48
I_MFA001	Middle Fork American River near Auburn local inflow	Stream accretion	245
I_MFA023	Middle Fork American River near Foresthill	Stream accretion	0
I_MFA036	Middle Fork American River at Interbay Diversion Dam	Stream accretion	51
I_MFF073	Middle Fork Feather River near Potola	Stream accretion	115
I_MFF019	Middle Fork Feather River near Merrimac	Stream accretion	962
I_MFM010	Middle Fork Mokelumne near West Point	Stream inflow	47
I_MFY013	Middle Fork Yuba River above Our House Diversion Dam	Stream accretion	152
I_MLC006	Mill Creek near Los Molinos	Stream inflow	217
I_MNS000	Minor northeast streams	Stream inflow	237
I_MOK079	Mokelumne River at Mokelumne Hill	Stream accretion	70
I_MSH015	Marsh Creek	Stream inflow	14
I_NBLDB	New Bullards Bar Reservoir	Local reservoir inflow	402
I_NFA022	North Fork American River at North Fork Dam local inflow	Stream accretion	219
I_NFA054	North Fork American River	Stream inflow	353
I_NFF027	North Fork Feather River at Pulga	Stream accretion	754
I_NFM006	North Fork Mokelumne below Tiger Creek Reservoir	Stream accretion	13
I_NFY029	North Fork Yuba River below Goodyears Bar	Stream inflow	539
I_NHGAN	New Hogan Reservoir	Reservoir inflow	154
I_OGN005	Oregon Creek at Log Cabin Diversion Dam	Stream inflow	53
I_OROVL	Lake Oroville	Local reservoir inflow	282
I_PARDE	Pardee Reservoir	Local reservoir inflow	11
I_STMPY	Stumpy Meadows Reservoir	Reservoir inflow	22
I_PLM001	Plum Creek Inflow	Stream inflow	7
I_PYN001	Paynes Creek and Sevenmile Creek	Stream inflow	53
I_RLLNS	Rollins Reservoir natural inflow	Local reservoir inflow	160
I_RUB001	Local Inflows to Rubicon River	Stream accretion	100
I_RBCON	Rubicon Lake	Reservoir Inflow	75
I_RVPHB	Round Valley and Philbrook lakes	Reservoir inflow	20
I_SCOTF	Scotts Flat Reservoir	Local reservoir inflow	33
I_SCW008	South Fork Cottonwood Creek near Olinda	Stream inflow	178
I_SFA021	South Fork American River near Placerville	Stream accretion	107
I_SFA035	South Fork American River near Camino	Stream accretion	171
I_SFA056	South Fork American River at Kyburz	Stream inflow	247
I_SFD003	South Fork Deer Creek at Wildwood Dam	Stream inflow	8
I_SFF008	South Fork Feather at Enterprise	Stream accretion	21
I_SFF011	South Fork Feather River at Ponderosa Dam	Stream accretion	94
I_SFM006	South Fork Mokelumne near West Point	Stream inflow	56
I_SFR005	South Fork Rubicon River Inflow	Stream inflow	80
I_SFY007	South Fork Yuba River at Jones Bar	Stream accretion	207
I_SGRGE	Stony Gorge Reservoir	Local reservoir inflow	165
I_SHSTA	Shasta Lake	Reservoir inflow	5,667
I_SILVR	Silver Lake	Reservoir inflow	26

Table 6-1 Upper Watershed Inflows contd.

Inflow Arc	Description	Type[1]	Av. Annual Flow (TAF)[2]
I_SLT009	Slate Creek at Slate Creek Diversion Dam	Stream inflow	141
I_SLTSP	Salt Springs Reservoir	Reservoir Inflow	332
I_SPLDG	Lake Spaulding	Local reservoir inflow	306
I_THM028	Thomes Creek at Paskenta	Stream inflow	217
I_TRNTY	Trinity Reservoir (Claire Engle Lake)	Reservoir inflow	1,267
I_UNVLY	Union Valley Reservoir	Reservoir inflow	168
I_WBF006	West Branch Feather River near Yankee Hill	Stream accretion	69
I_WBF015	West Branch Feather River at Miocene Diversion Dam	Stream accretion	148
I_WBF030	West Branch Feather River at Hendricks Diversion Dam	Stream accretion	96
I_WLF013	Wolf Creek at Tarr Ditch Diversion Dam	Stream inflow	19

Notes:
[1] Reservoir inflow = total natural inflow to reservoir or lake.
Local reservoir inflow = natural inflow to reservoir or lake from a portion of watershed adjacent to the water body.
Stream inflow = natural flow/unimpaired flow at stream location.
Stream accretion = accretion to stream or river between upstream inflow location and this location.
[2] Flows averaged over Water Years 1922-2009.
Key: TAF = thousand acre-feet

Only in limited cases are streamflow records available over the entire period of simulation. For the majority of streams, historical timeseries data have been extended using various statistical methods assuming stationarity over the historical period. Methods used to develop each inflow are summarized in Table 6-2. These methods are as follows:

- Direct gauge measurement: Stream gauge data exist at the watershed outflow point for water years 1922 through 2009.
- Streamflow correlation: Stream gauge data exist at the watershed outflow point for only a limited period between water years 1922 and 2009. Gauge data are extended through linear correlation of annual flows with streamflow records from adjacent watersheds. Double mass plots of monthly flows are used to check that a constant (and linear) relationship exists between the dependent and independent variables. Annual synthetic flows are disaggregated to a monthly time step based on the cumulative fraction of annual runoff that has occurred by the end of month, while attempting to preserve the shape of the hydrograph of the dependent watershed.
- Proportionality: No gauge data exist for the watershed. It is assumed that runoff is proportional to the product of drainage area and average annual precipitation depth over the watershed.[9] Outflow is determined through association of the watershed with a similar, but gauged watershed and the use of multiplicative factors representing the ratio of watershed areas and ratio of precipitation depths.
- Mass balance: Typically, this method is used when watersheds have significant storage regulation. Reservoir operating records of dam releases and reservoir storage, together with estimated reservoir evaporation, are used to estimate inflows to the reservoir.

[9] Determined using PRISM data of the 30-year average annual precipitation for 1971-2000 (PRISM, 2013).

Table 6-2 Data Sources and Calculation Methods for Upper Watershed Inflows

SacWAM Inflow	Observed Period	Agency	Gauge ID	Flow Correlation	Propor-tionality	Mass Balance
I_ALMMW	10/21 - present	USGS	11399500			●
I_AMADR	–	–	–		●	
I_ANT011	10/40 - 09/82[2]	USGS	11379000	●		
I_ANTLP	10/30 - 09/93	USGS	11401500	●		●
I_BCC014	10/21 - 09/86	USGS	11384000	●		●
I_BCN010	10/59 - 09/67	USGS	11374100	●		
I_BKILD	11/90 - present	USGS	11428400	●		●
I_BLKBT	01/53 - present	USACE	Res. Report of Operations	●		●
I_BOWMN	02/27 - present	USGS	11416500	●		
I_BRC003	10/98 - present	USGS	11451715	●	●	
I_BRR023	–	–	–	●	●	●
I_BRYSA	01/57 - present	Reclamation	Res. Report of Operations	●		●
I_BTC048	10/30 - present	USGS	11390000			●
I_BTL006	10/40 - 09/61	USGS	11376500	●		
I_BTL006	10/61 - present	USGS	11376550			
I_BTVLY	10/36 - present	USGS	11400500	●	●	
I_BUKSL	10/80 - present	USGS	11403530	●		●
I_CAPLS	10/22 - 09/92	USGS	11437000	●		●
I_CCH053	10/60 - present	USGS	11451760	●	●	●
I_CLR011	10/40 - present	USGS	11372000	●		●
I_CLR025	10/64 - present	Reclamation	Res. Report of Operations	●	●	
I_CLRLK	10/44 - present	USGS	11451000			●
I_CLV026	–	–	–		●	
I_CMBIE	–	–	–	●	●	●
I_CMCHE	–	–	–		●	
I_CMP001	10/56 - 09/04	USGS	11333000	●		
I_CMP012	10/49 - 09/54	USGS	11331500	●	●	
I_CMPFW				●	●	●
I_COW014	10/49 - present	USGS	11374000	●	●	
I_CSM035	10/21 - present	USGS	11335000			●
I_CWD018	09/71 - 09/86	USGS	11375810	●		
I_DAVIS	10/25 - 09/80, 12/67 - present	USGS, DWR	11391500, Res. Report of Operations	●	●	
I_DCC007	09/60 - present	USGS	11427700	●		●
I_DEE023	10/60 - 09/77	USGS	11335700	●	●	
I_DER001	10/35 - present	USGS	1418500			
I_DER004	–	–	–		●	
I_DHC001	–	–	–		●	
I_DRC012	10/21 - present	USGS	11383500	Data for all years		
I_DSC035	10/61 - 09/70, 10/35 - 09/41	USGS, USGS	11326300, 11327000	●	●	
I_ELD027	10/48 - present	USGS	11379500	●		
I_ELIMP	08/23 - present	USGS	11434500	●		
I_ENF011	10/50 - 09/60	USGS	11403000	●		●

Table 6-2 Data Sources and Calculation Methods for Upper Watershed Inflows, contd.

SacWAM Inflow	Observed Period	Agency	Gauge ID	Flow Correlation	Propor-tionality	Mass Balance
I_ENGLB	10/21 - 09/41, 10/41 - present	USGS, USGS	11418000, 11419000	●		●
I_EPARK	10/21 - present	Reclamation	Res. Report of Operations			●
I_FOLSM	10/21 - present, 02/55 - present	USGS, Reclamation	USGS Res. Report of Operations			●
I_FRDYC	07/66 - present	USGS	11414100	●		●
I_FRMAN	10/65 - present	DWR	Res. Report of Operations	●		●
I_FRMDW	10/64 - present	USGS	11427500	●		●
I_GRZLY	10/85 - present	USGS	11404300	●		●
I_HHOLE	10/85 - present	USGS	11428800	●		●
I_HON021	10/50 - 09/86	USGS	11407500	●		
I_ICEHS	10/1923 - present	USGS	11441500	●		●
I_INDVL	10/74 - present	USGS	11451300	●		●
I_JKSMD	10/26 - present	USGS	11407900	●		●
I_JNKSN	10/46 - 09/54	USGS	11332500	●		
I_KSWCK	10/38 - present	USGS	11370500			●
I_LBEAR	–	–	–		●	
I_LCC038	02/59 - present	DWR	A04910	●		●
I_LCC039	02/59 - 09/93	DWR	A04280			
I_LDC029	–	–	–		●	
I_LGRSV	10/63 - present	USGS	11395030	●		●
I_LJC022	10/51 - 09/95	USACE	multiple data sources	●		●
I_LKVLY	–	–	–		●	
I_LNG000	10/66 - 09/92	USGS	11433100	●	●	●
I_LOONL	10/62 - present	USGS	11429500	●		●
I_LOSVQ	10/97 - present	CCWD		●		
I_LST007	10/73 - present	USGS	11396000	●		●
I_LWSTN	10/21 - present	USGS	11525500	●		●
I_MERLC	10/63 -present	BVID	Res. Report of Operations	●		●
I_MFA001	10/21 - 09/85	USGS	11433500	●		●
I_MFA036	10/65 - present	USGS	11427770	●		●
I_MFF019	10/51 - 09/86	USGS	11394500	●		
I_MFF073	10/68 - 09/80	USGS	11329100	●		●
I_MFM010	10/21 - present	USGS	11317000			
I_MFY013	10/68 - present	USGS	11408870			●
I_MLC006	10/28 - present	USGS	11381500	●		
I_MNS000	–	–	–		●	
I_MOK079	10/27 - present	USGS	11319500			●
I_MSH015	04/53 - 09/83	USGS	11337500			
I_NBLDB	10/66 - 09/40	USGS	11413520	●		●
I_NFA022	10/21 - 09/41, 10/41 - present	USGS, USGS	11426500, 11427000		●	●
I_NFA054	10/21 - 09/41, 10/41 - present	USGS, USGS	11426500, 11427000		●	●
I_NFF027	10/21 - present	USGS	11404500	●		●
I_NFM006	09/84 - present	USGS	11316700	●		●

Table 6-2 Data Sources and Calculation Methods for Upper Watershed Inflows, contd.

SacWAM Inflow	Observed Period	Agency	Gauge ID	Flow Correlation	Propor-tionality	Mass Balance
I_NFY029	10/30 - present	USGS	11413000	●	●	
I_NHGAN	10/63 - present	USACE	Res. Report of Operations	●		●
I_OGN005	10/21 – 09/69, 09/68 - present	USGS, USGS	11409500	●	●	●
I_OROVL	10/21 - present, 10/67 - present	USGS, DWR	11407000, Res. Report of Operations			●
I_PARDE	–	–	–	●	●	●
I_PLM001	10/22 - 09/39	USGS	11440500	●		
I_PYN001	10/49 - 09/66	USGS	11377500	●	●	
I_RBCON	10/91 - present	USGS	11427960	●		●
I_RLLNS	04/50 - present	USGS	11422500	●	●	●
I_RUB001	10/58 – 09/84	USGS	11433200	●		●
I_RVPHB	–	–	–	●	●	●
I_SCOTF	–	–	–		●	●
I_SCW008	12/76 - 09/86	USGS	11375870	●		
I_SFA021	10/64 - present	USGS	11444500	●		●
I_SFA035	10/22 - present	USGS	11443500	●		●
I_SFA056	10/22 - present	USGS	11439500	●		●
I_SFD003	–	–	–		●	
I_SFF008	10/21 - 09/66	USGS	11397000	●		●
I_SFF011	10/21 - 09/66	USGS	11397000	●		●
I_SFM006	10/21 - present	USGS	11317000	●		
I_SFR005	10/62 - present	USGS	11430000	●		●
I_SFY007	10/40 - present	USGS	11417500	●		
I_SGRGE	11/28 - present	Reclamation	Res. Report of Operations			●
I_SHSTA	10/25 - 09/42 01/44 - present	USGS, Reclamation	11369500, Res. Report of Operations		●	●
I_SILVR	10/22 - present	USGS	11436000	●		●
I_SLT009	10/60 - present	USGS	11413300	●		●
I_SLTSP	10/27 - present	USGS	11314500	●		●
I_SPLDG	12/65 - present	USGS	11414250	●		●
I_STMPY	04/46 - 09/60	USGS	11432500	●		
I_THM028	10/21 - 09/96	USGS	11382000	●		
I_TRNTY	10/21 - present, 10/61 - present	USGS, Reclamation	11525500, Res. Report of Operations	●		●
I_UNVLY	10/61 - present	USGS	11441002			
I_WBF006	10/30 - 09/63	USGS	11406500	●	●	●
I_WBF015	10/30 - 09/63	USGS	11406500	●	●	●
I_WBF030	10/30 - 09/63	USGS	11406500	●	●	●
I_WLF013	–	–	–	●	●	●

Key: cfs=cubic feet per second; DWR=California Department of Water Resources; PG&E=Pacific Gas and Electric; USGS=United States Geological Survey; WBA=Water Budget Area

6.1.1.2 *Fraction Diverted*

The fraction diverted for rivers is only applicable to the Old River and is discussed in Section 7.2.5.2 in Chapter 7 on Other Assumptions.

6.1.2 Reservoirs

The following sections apply to the majority of the reservoirs in SacWAM. However, Camino Reservoir, Caples Lake, Chili Bar Reservoir, Silver Lake, Slab Creek Reservoir, Farmington Reservoir, Rock Creek Reservoir, Clifton Court Forebay, and Lake Amador are not operated in the model and therefore bear blank expressions for many of the parameters. The purpose of these reservoirs in SacWAM is solely to orient SacWAM users when viewing the schematic.

The San Luis Reservoir is represented by two reservoirs: CVP_San Luis and SWP_San Luis in order to represent and simulate the CVP and SWP share of the facility. Operations of San Luis Reservoir is discussed in detail in the Other Assumptions chapter, Section 7.2.1.

6.1.2.1 *Reservoir Evaporation*

For SacWAM a user-defined set of parameters was added to the model in order to calculate the reservoir evaporation. These parameters are located in the Reservoir Evaporation tab of the Reservoirs interface. The calculation of reservoir evaporation is made using the Modified Hargreaves Equation (Droogers and Allen, 2002):

D*0.0013*(So)*(Tave[C] +17.0)*(Tmax[C]-Tmin[C]-0.0123*P [mm])^0.76 Equation 6-1

where:

D = days in the time step;

So = extra-terrestrial solar radiation;

Tave = average temperature for the time step;

Tmax = maximum temperature for the time step, 1.4 x Tave;

Tmin = minimum temperature for the time step, 0.6 x Tave.

Precipitation, Tave, Tmin, and Tmax

Precipitation and average temperature values are taken from the catchments in which the reservoirs are located.

Latitude

Latitudes for each reservoir were determined using GIS.

Reference Evap

The reference evaporation is calculated using Equation 3-2.

JDay

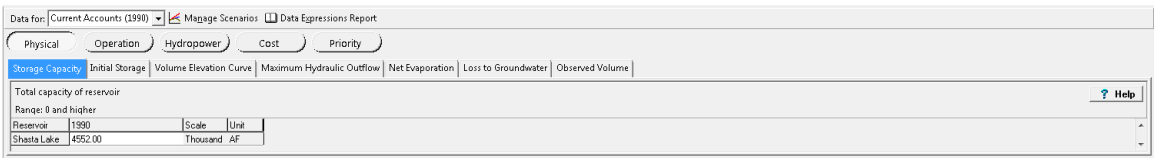
JDay stands for Julian Day. The default values in WEAP are the middle day of the month as counted by the Julian calendar, where January 1 is 1, January 31 is 31, February 1 is 32…and December 31 is 365 (in a non-leap year).

del, dr, ws, and *So*

Solar declination (*del*), the relative distance between Earth and the sun (*dr*), the sunset hour angle (*ws*), and solar radiation (*So*) are affect the reference evaporation expression; all use default WEAP expressions.

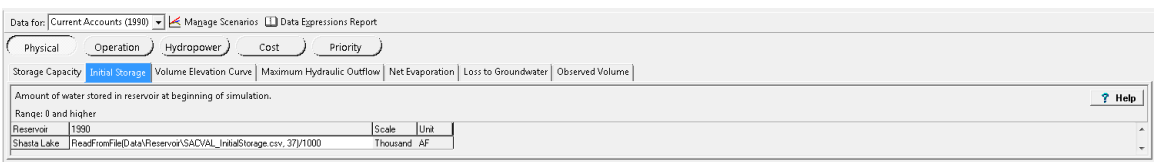
6.1.2.2 *Physical*

Storage Capacity



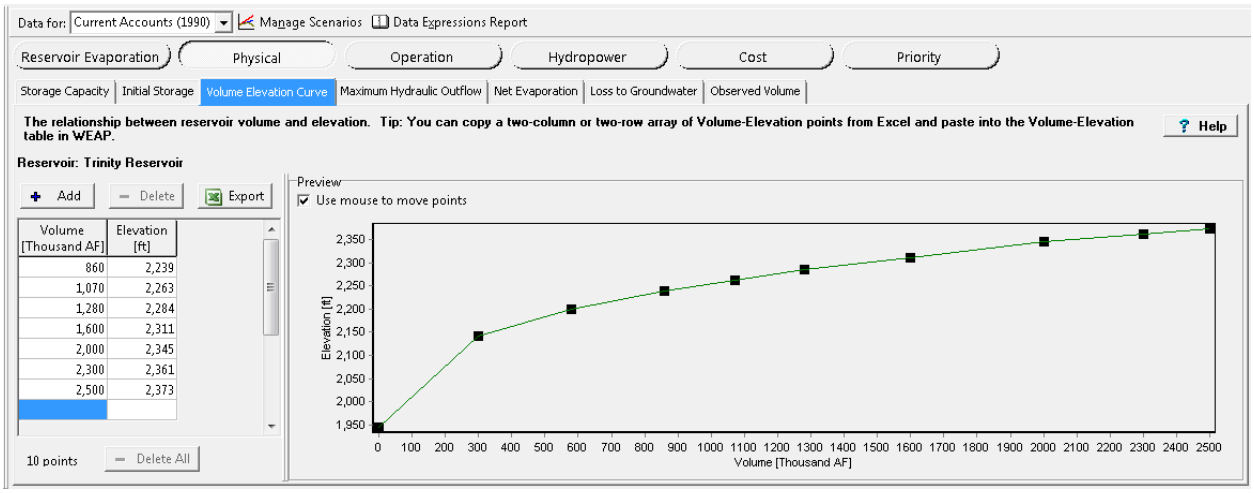
Storage Capacity data for reservoirs were obtained from CDEC (DWR, 2014d). They are given in TAF in SacWAM (*Supply and Resources\Rivers\Reservoirs\Physical\Storage Capacity*). For more information, see **reservoir storage capacity**.

Initial Storage



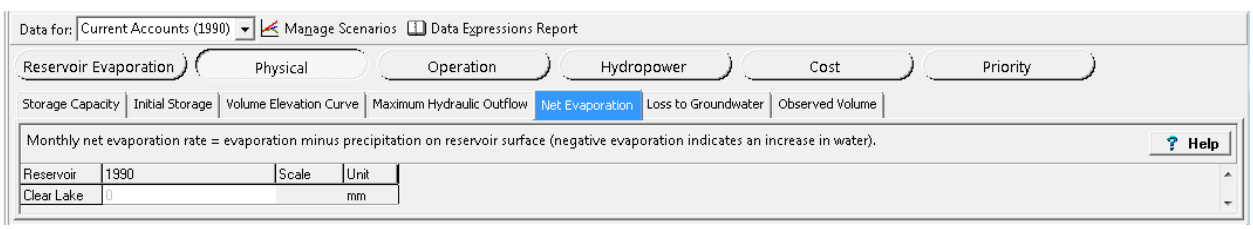
Initial Storage data for reservoirs were obtained from CDEC and represent historical October 1 storage volumes (DWR, 2014d). These values are given in TAF (*Supply and Resources\Rivers\Reservoirs\Physical \Initial Storage*). For more information, see **reservoir storage capacity**.

Volume Elevation Curve



Volume Elevation Curve data for reservoirs were obtained from a variety of sources. They relate reservoir volume in TAF to reservoir water surface elevation in feet (*Supply and Resources\Rivers\Reservoirs\Physical\Volume Elevation Curve*). This information is used to calculate the reservoir area for use in simulating reservoir evaporation. For complete data, see **volume elevation curve**.

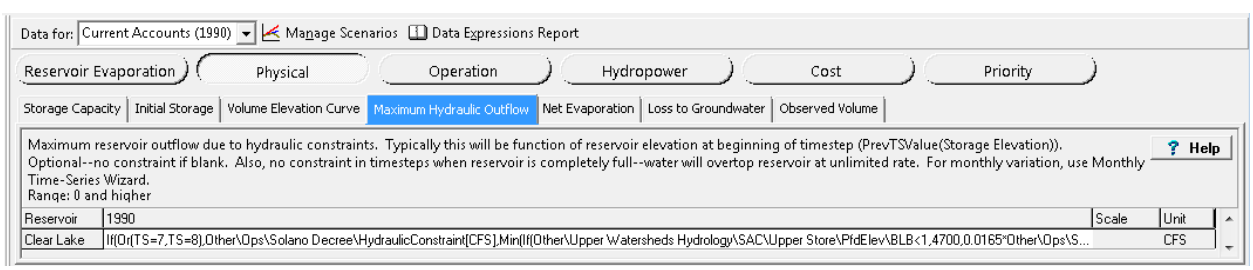
Net Evaporation



This parameter is used to simulate evaporation from the water surface of the reservoir.

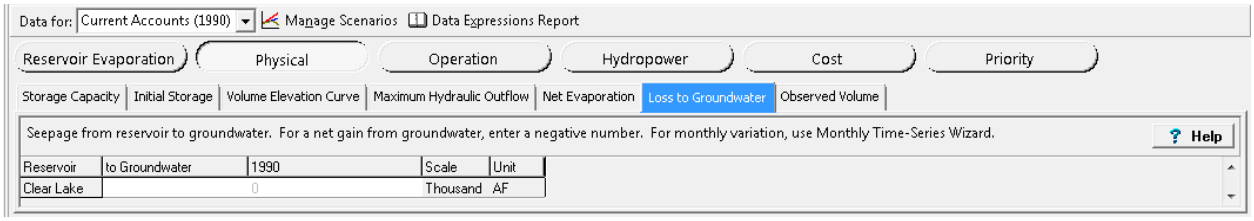
In WEAP this parameter is often treated as the net of evaporation and precipitation that occurs on the reservoir surface. However, in SacWAM the catchments contain the area of the reservoirs and therefore account for the precipitation that falls on the reservoir. For this reason, the Net Evaporation parameter only contains the estimated reference evaporation calculated in the *Reference Evap* parameter under the Reservoir Evaporation tab.

Maximum Hydraulic Outflow



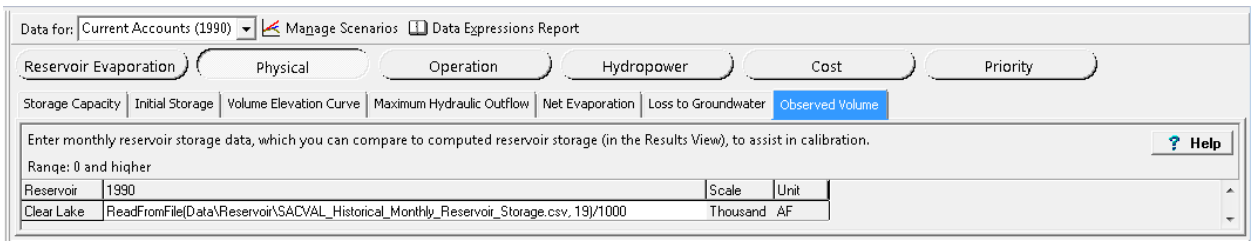
This parameter restricts the flow of water out of a reservoir. In SacWAM this has been implemented on Clear Lake as part of the Solano Decree logic, on Whiskeytown reservoir, and on Los Vaqueros reservoir.

Loss to Groundwater



No reservoir losses to groundwater are simulated in SacWAM.

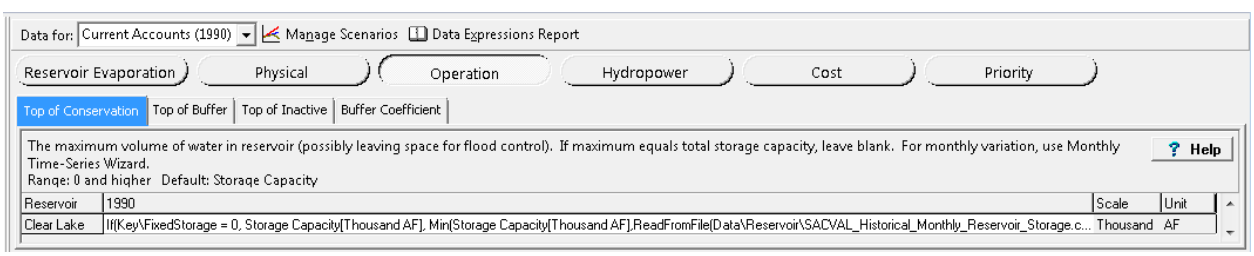
Observed Volume



Historical *Observed Volumes* for reservoirs are read from the file Data\Reservoir\SACVAL_Historical_Monthly_Reservoir_Storage.csv stored in the WEAP model directory. The data were taken from CDEC and can be found in **reservoir storage capacity**.

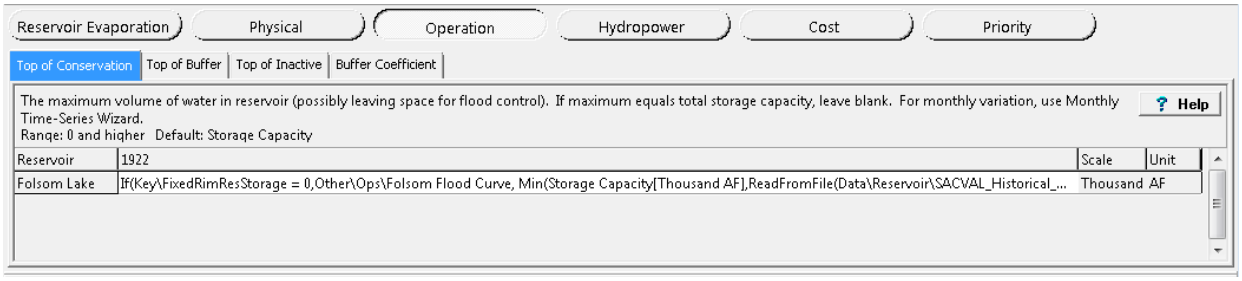
6.1.2.3 *Operation*

The operations of reservoirs, tunnels, and canals in the upper watersheds have been kept relatively simple and do not fully reflect the complexity that exists in the operations of this infrastructure in the real system. This relatively simple approach was implemented as the operations of the upper watershed infrastructure is buffered by the large volume of storage available in the rim reservoirs. For now, the operations of the reservoirs and diversions (tunnels, canals) is set equal to the average monthly storage or flow.



Average monthly storage values (1970-2009) were loaded into Top of Conservation and Top of Inactive. These parameters force the reservoir to maintain operations at a given average monthly value, and can be turned off and on using the *Simulate Operations* Key Assumption. These average monthly values are derived from CDEC (DWR, 2014d) or USGS data.

Top of Conservation



The top of conservation parameter is used to place an upper limit on the conservation storage in a reservoir. In SacWAM, reservoirs are divided into "Rim" reservoirs (Table 6-3) or "Upper Watershed" reservoirs (Table 6-4). Generally, the "Rim" reservoirs are the terminal reservoirs on their respective streams. These reservoirs have a switch controlled by the Key Assumption *FixedRimResStorage* that allows the user to set the monthly storage in these reservoirs equal to the historical record. This is useful for calibration purposes. The "Upper Watershed" reservoirs are largely hydropower reservoirs located upstream from the terminal reservoirs. In SacWAM the user can opt to have the storage in these reservoirs set equal to the 1970-2009 average monthly value of storage. This allows for a simple representation of the hydropower operations that occur in these reservoirs. This setting is through the Key Assumption *FixedUpperResStorage*. For more information, see **reservoir storage capacity**.

Table 6-3. Rim Reservoirs

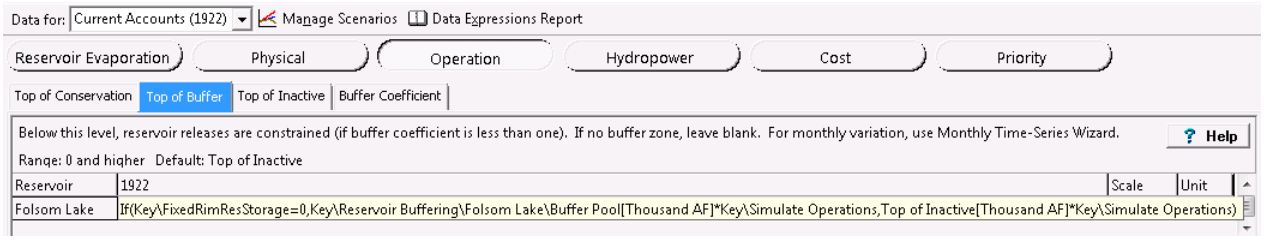
Shasta Lake	Oroville Reservoir
New Bullards Bar Reservoir	Folsom Lake
Pardee Reservoir	Camanche Reservoir
Trinity Reservoir	New Hogan Reservoir
Black Butte Reservoir	Whiskeytown Reservoir
Keswick Reservoir	Lake Natoma
Clear Lake	Lewiston Lake
Lake Berryessa	Thermalito Afterbay
Camp Far West	Jenkinson Lake
East Park Reservoir	Stony Gorge Reservoir
Indian Valley Reservoir	Englebright Reservoir
Los Vaqueros Reservoir	

Table 6-4. Upper Watershed Reservoirs Constrained to Average Historical Storage

Rollins Reservoir	Lake Combie
Frenchman Lake	Scotts Flat
Sly Creek Reservoir	French Meadows
Jackson Meadows Reservoir	Lake Spaulding
Little Grass Valley	Bowman Lake
Lake Fordyce	Union Valley Reservoir
Ice House Reservoir	Hell Hole Reservoir
Loon Lake Reservoir	Lake Almanor
Butt Valley	Bucks Lake
Lake Davis	Merle Collins Reservoir

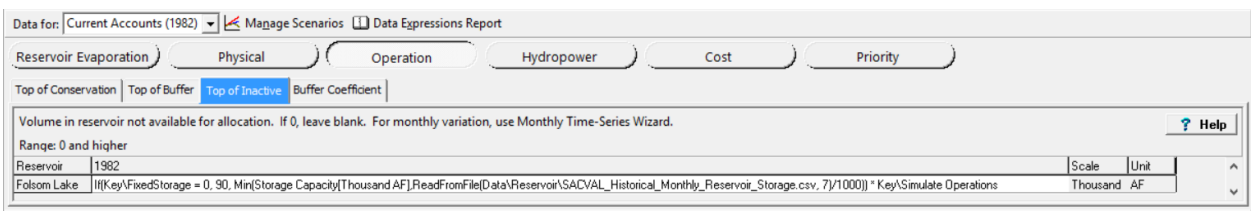
Top of conservation for Shasta varies from year to year depending on hydrologic conditions. Therefore, when the (i.e. *FixedRimResStorage*=0), Top of Conservation values are read from a file of CalSim II data that reflect the historical conditions.

Top of Buffer



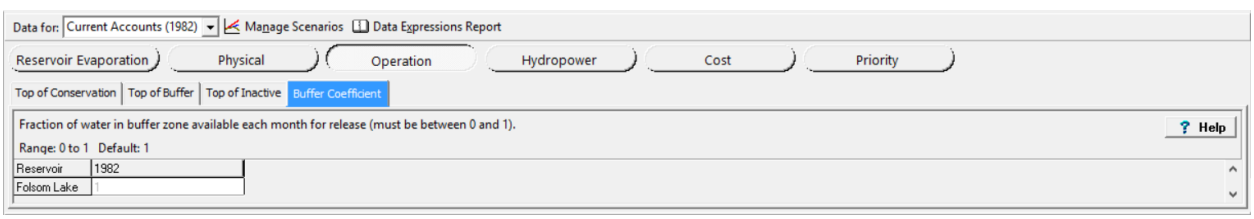
The top of buffer parameter is used to set the upper limit of the buffer pool. If the reservoir is operating in the buffer pool then the reservoir will release only the volume of water available multiplied by the buffer coefficient. For the major rim reservoirs, expressions have been added to the Top of Buffer parameter that allow the user to set buffer pool volumes. These values are set in *Key Assumptions\Reservoir Buffering* (see Section 9.11).

Top of Inactive



The top of inactive parameter is used to specify the upper limit of the dead pool storage. Similar to the top of conservation, some reservoirs have this parameter constrained to average historical storage in order to simulate operations (Table 6-3). The remainder have a fixed volume of dead pool storage. For more information, see **reservoir storage capacity**.

Buffer Coefficient



The buffer coefficient parameter is used to specify the fraction of the buffer pool that is available to meet demands. Similar to Top of Buffer, there is an option to set this parameter for the major rim reservoirs using the in *Key Assumptions\Reservoir Buffering* (see Section 9.11).

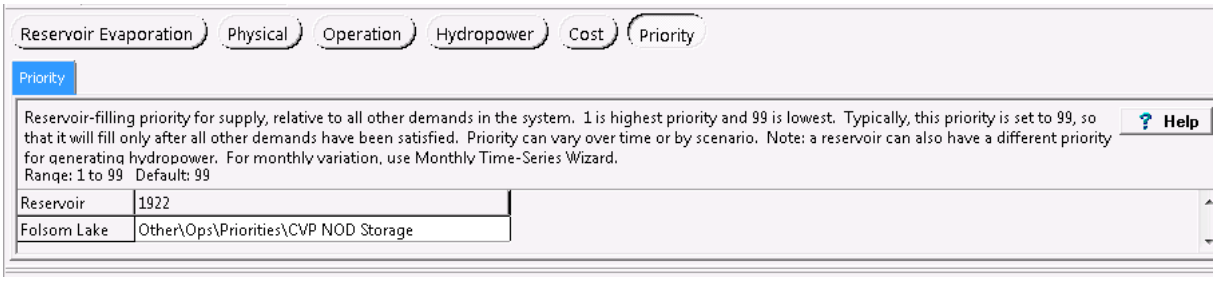
6.1.2.4 *Hydropower*

The *Hydropower* WEAP feature is not used in SacWAM.

6.1.2.5 *Cost*

The *Cost* WEAP feature is not used in SacWAM.

6.1.2.6 *Priority*



Priorities for reservoirs, demand sites and catchments, and flow requirements are discussed in the Other Assumptions chapter, Section 7.2.1. Demand priorities are assigned to reservoirs for water storage as well as to other consumptive and non-consumptive (i.e. flow requirement) demands. These priorities are also considered relative to the rest of the demand priority structure (Section 7.2.1), such that WEAP will prefer to store water if the storage priority is higher (i.e. has a lower numeric value) than another demand. When releasing water from storage to meet downstream demands, WEAP will release first from reservoirs with lower demand priority. Also, if reservoirs share the same demand priority, then WEAP will attempt to balance these reservoirs as a percentage of their potential storage (i.e. top of conservation storage). Priority values for reservoirs in SacWAM are primarily defined relative to Demand Groups described in Table 7-29. Expressions of reservoir priority and their associated values are presented in Section Table 6-5.

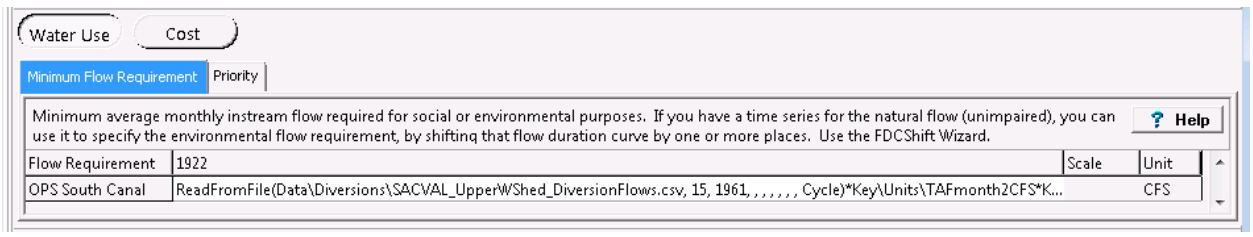
Table 6-5. SacWAM Reservoir Priority Structure

Reservoir	River	Priority	Expression
SWP San Luis Reservoir	SWP San Luis Conveyance	56,52	SWP SOD Storage ab/bw Rule Curve
Clifton Court Forebay	Old River	52	SWP SOD Storage bw Rule Curve
Oroville Reservoir	Feather River	52	SWP NOD Storage
Thermalito Afterbay	Power Canal	52	SWP NOD Storage
CVP San Luis Reservoir	CVP San Luis Conveyance	54,45	CVP SOD Storage ab/bw Rule Curve
Folsom Lake	American River	53	CVP NOD Storage
Keswick Reservoir	Sacramento River	53	CVP NOD Storage
Lake Natoma	American River	53	CVP NOD Storage
Shasta Lake	Sacramento River	53	CVP NOD Storage
Whiskeytown Reservoir	Clear Creek	53	CVP NOD Storage
Lewiston Lake	Trinity River	21	CVP NOD Storage - 25
Trinity Reservoir	Trinity River	21	CVP NOD Storage - 25
Los Vaqueros Reservoir	Kellogg Creek	14	Urban NonProject + 1
Black Butte Reservoir	Stony Creek	12	NonProject Trib Storage
Camanche Reservoir	Mokelumne River	12	NonProject Trib Storage
Camp Far West	Bear River	12	NonProject Trib Storage
Clear Lake	Cache Creek	12	NonProject Trib Storage
East Park Reservoir	Little Stony Creek	12	NonProject Trib Storage
Englebright Reservoir	Yuba River	12	NonProject Trib Storage
Farmington Reservoir	Littlejohns Creek	12	NonProject Trib Storage
Indian Valley Reservoir	North Fork Cache Creek	12	NonProject Trib Storage
Lake Berryessa	Putah Creek	12	NonProject Trib Storage
New Bullards Bar Reservoir	Yuba River	12	NonProject Trib Storage
New Hogan Reservoir	Calaveras River	12	NonProject Trib Storage
Stony Gorge Reservoir	Stony Creek	12	NonProject Trib Storage
Pardee Reservoir	Mokelumne River	11	NonProject Trib Storage - 1
EBMUD Terminal Reservoirs	Mokelumne Aqueduct	9	
PGandE Upper Watershed Reservoirs	North Fork Mokelumne River	6	Upper Watershed Reservoirs + 1
Bowman Lake	Canyon Creek	5	Upper Watershed Reservoirs
Camino Reservoir	Silver Creek	5	Upper Watershed Reservoirs
Caples Lake	Caples Creek	5	Upper Watershed Reservoirs
Chili Bar Reservoir	South Fork American River	5	Upper Watershed Reservoirs
French Meadows	Middle Fork American River	5	Upper Watershed Reservoirs
Hell Hole	Rubicon River	5	Upper Watershed Reservoirs
Ice House	South Fork Silver Creek	5	Upper Watershed Reservoirs
Jackson Meadows Reservoir	Middle Fork Yuba River	5	Upper Watershed Reservoirs
Jenkinson Lake	Sly Park Creek	5	Upper Watershed Reservoirs
Lake Almanor	North Fork Feather River	5	Upper Watershed Reservoirs
Lake Amador	Jackson Creek	5	Upper Watershed Reservoirs
Lake Combie	Bear River	5	Upper Watershed Reservoirs
Lake Fordyce	Fordyce Creek	5	Upper Watershed Reservoirs
Lake Spaulding	South Fork Yuba River	5	Upper Watershed Reservoirs
Little Grass Valley Reservoir	South Fork Feather River	5	Upper Watershed Reservoirs
Loon Lake	Gerle Creek	5	Upper Watershed Reservoirs
Merle Collins Reservoir	French Dry Creek	5	Upper Watershed Reservoirs
Rock Creek Reservoir	Wise Canal	5	Upper Watershed Reservoirs
Rollins Reservoir	Bear River	5	Upper Watershed Reservoirs
Scotts Flat Reservoir	Deer Creek Yuba	5	Upper Watershed Reservoirs
Silver Lake	Silver Fork American	5	Upper Watershed Reservoirs
Slab Creek Reservoir	South Fork American River	5	Upper Watershed Reservoirs
Sly Creek Reservoir	Lost Creek	5	Upper Watershed Reservoirs
Union Valley Reservoir	Silver Creek	5	Upper Watershed Reservoirs

Key: ab=above; bw=below; CVP=Central Valley Project; IFR=instream flow requirement; NOD=north of Delta; SOD=south of Delta; SWP=State Water Project; SWRCB=State Water Resources Control Boar

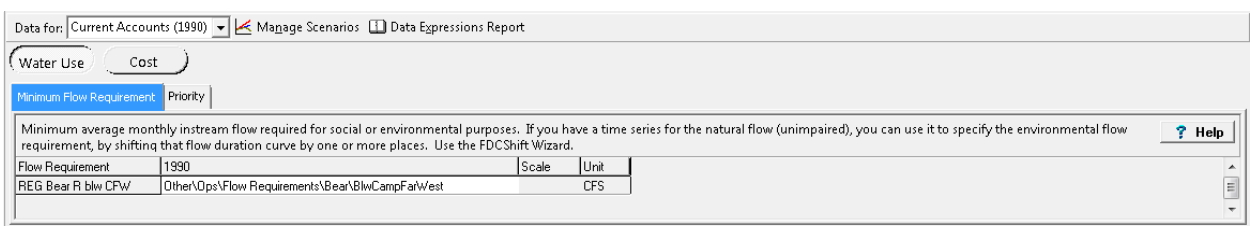
When demands sites or catchments are connected to more than one supply source, the order of withdrawal is determined by supply preferences. Similar to demand priorities, supply preferences are assigned a value between 1 and 99, with lower numbers indicating preferred water sources. The assignment of these preferences usually reflects some combination of economic, environmental, historic, legal, and political realities. In general, multiple water sources are present when the preferred water source is insufficient to satisfy all of an area's water demands. WEAP treats the additional sources as supplemental supplies and will draw from these sources only after it encounters a capacity constraint (expressed as either a maximum flow volume or a maximum percent of the demand) associated with the preferred water source. In general, SacWAM is set up such that surface water is given preference over pumping groundwater.

6.1.3 Flow Requirements



6.1.3.1 *Water Use*

Minimum Flow Requirement



In the upper watersheds, flow requirements are used to drive the simulation of water transfers via tunnels and canals. These flow requirements differ from regulatory requirements and are designated with an "OPS" in their name. Regulatory requirements have a "REG" in their name.

A *Minimum Flow Requirement* (MFR) has been specified for some rivers. Flow requirements that are regulatory in nature are named using the prefix "REG." REG parameters reference rules in the *Other\Ops* section of WEAP and are documented in Chapter 7.

A second type of flow requirement is used to drive simulated operations of upstream reservoirs, or diversions through tunnels, canals, and pipelines. These flow requirements, which are operational in nature, are designated using the prefix "OPS." In the upper watersheds, OPS flow requirements are typically set equal to the average monthly flows from 1970 to 2009. For more detail see **upper watershed diversion flows**.

A third type of flow requirement is the "SWRCB" type. These were added to SacWAM to allow model users to set and test new regulatory flow requirements where the flow requirement is specified as a

fraction of the unimpaired flow. For more details on how to use the SWRCB-type flow requirements, see Section 9.3.

Priority

Priorities for flow requirements, demand sites and catchments, and reservoirs are discussed in Chapter 7 on Other Assumptions, Section 7.2.4.

6.1.3.2 *Cost*

The WEAP *Cost* feature for Flow Requirements is not used in SacWAM.

6.1.4 Reaches

6.1.4.1 *Inflows and Outflows*

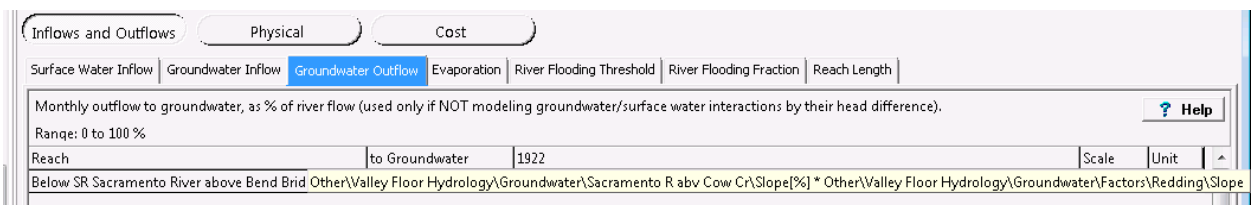
Surface Water Inflow

The WEAP *Surface Water Inflow* feature is not used in SacWAM.

Groundwater Inflow

The *Groundwater Inflow* feature is used to simulate surface water groundwater interactions.

Groundwater Outflow



The *Groundwater Outflow* feature is used to simulate surface water groundwater interactions.

Evaporation

The *Evaporation* WEAP feature is not used in SacWAM.

River Flooding Threshold

The *River Flooding Feature* WEAP feature is not used in SacWAM.

River Flooding Fraction

The *River Flooding Fraction* WEAP feature is not used in SacWAM.

Reach Length

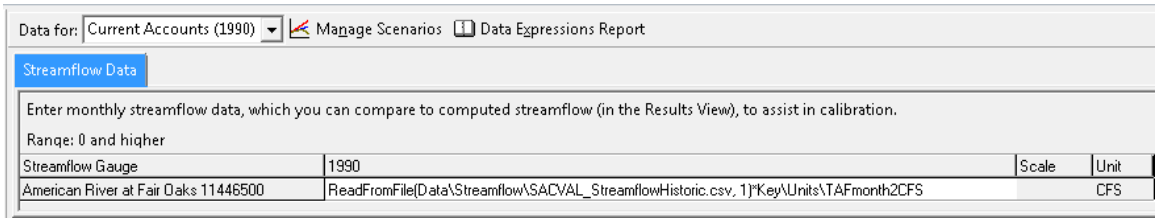
6.1.4.2 *Physical*

The *Physical* WEAP feature is not used in SacWAM.

6.1.4.3 *Cost*

The *Cost* WEAP feature is not used in SacWAM.

6.1.5 Streamflow Gauges



Streamflow gauges are used to provide comparisons between simulated and observed values of flow. In SacWAM, observed data are read from a SACVAL_StreamflowHistoric.csv file located in Data\Streamflow within the model area directory.

6.1.5.1 *Streamflow Data*

Streamflow gauge data are used in SacWAM to assess model performance. In some cases the streamflow gauge objects in the model represent computed full natural flows or estimates of unimpaired flows. To differentiate between actual observed flow data, full natural flows, and estimated unimpaired flows each gauge has been given a prefix of either HIS, FNF, or EST.

Historical

Historical streamflow data were obtained from the USGS Current Water Data for the Nation website (USGS, 2014), DWR's Water Data Library (DWR, 2014c), DWR's CDEC (DWR, 2014d) and by contacting DWR directly.

Historical streamflow data are saved in a csv file and contained in the SacWAM directory (Data\Streamflow\SACVAL_StreamflowHistoric.csv*)* with the exception of gauges without any infrastructure upstream, for which streamflow data are identical to inflow arc data (Table 6-6). For more information regarding streamflow data, refer to the **streamflow gauges**.

Table 6-6. SacWAM Streamflow Gauges and Corresponding Inflow Arcs

Streamflow gauge	Inflow arc
HIS Antelope Ck nr Red Bluff 11379000	I_ANT011
HIS Battle Creek nr Cottonwood 11376550	I_BTL006
HIS Bear Ck nr Millville	I_BCN010
HIS Big Chico Ck nr Chico 11384000	I_BCC014
HIS Clear Lake Inflows	I_CLRLK
HIS Cottonwood Ck nr Olinda 11375810	I_SCW008
HIS COW014	I_COW014
HIS Deer Ck nr Vina 11383500	I_DRC012
HIS Dry Creek	I_DSC035
HIS East Park Res Inflow	I_EPARK
HIS Elder Ck nr Paskenta 11379500	I_ELD027
HIS Farmington Res Inflow	I_LJC022
HIS Fordyce Res Inflow	I_FRDYC
HIS Indian Valley Res inflow	I_INDVL
HIS Jackson Meadows Res Inflow	I_JKSMD
HIS Lake Berryessa Inflow	I_BRYSA
HIS Little Dry Ck	I_LDC029
HIS Little Grass Valley Res Inflow	I_LGRSV
HIS Los Vaqueros Reservoir Inflow	I_LOSVQ
HIS Mill Ck nr Los Molinos 11381500	I_MLC006
HIS New Hogan Res Inflow	I_NHGAN
HIS NF Yuba bw Goodyears Bar 11413000	I_NFY029
HIS Paynes and Sevenmile Cks 11377500	I_PYN001
HIS SF Cottonwood Ck nr Olinda 11375870	I_SCW018
HIS Shasta Lake Inflow	I_SHSTA
HIS Thomes Ck at Paskenta 11382000	I_THM028
HIS Trinity Res Inflow	I_TRNTY

Key: bw=below; Ck=Creek; nr=near; Res=Reservoir.

Full Natural Flow

SacWAM gauges that represent full natural flows—the calculated flow that would be in the river without any upstream infrastructure—are designated with the prefix FNF and are equal to the sum of upstream inflow arc flows with exceptions noted in Table 6-7.

Table 6-7. Full Natural Flow Gauges Not Calculated as Sum of Upstream Inflow Arcs

Gauge	Data source
FNF American at Fair Oaks	California Data Exchange Center station AMF
FNF Camanche Res Inflow	I_CMCHE + FNF Mokelumne at Mokelumne Hill + I_PARDE
FNF Cosumnes at Michigan Bar	California Data Exchange Center station CSN
FNF Feather at Oroville	California Data Exchange Center station FTO
FNF Mokelumne at Mokelumne Hill	California Data Exchange Center station MKM and USGS 11394500
FNF Mokelumne at Pardee	FNF Mokelumne at Mokelumne Hill + I_PARDE
FNF Whiskeytown Res Inflow	I_CLR025

Key: FNF=full natural flow; Res=Reservoir.

Estimated

[22 stream gauge expressions look at SACVAL_StreamflowHistoric.csv or SACVAL_Headflows.csv to get EST values.]

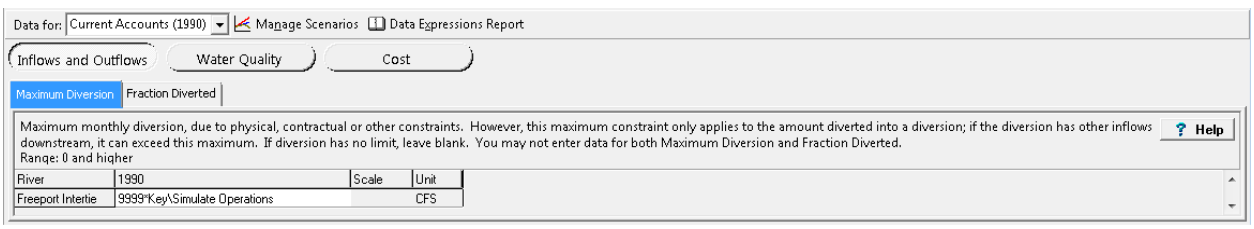
6.2 Diversion

Diversion arcs typically represent man-made conveyance facilities, including canals, pipelines, and hydropower penstocks. They are represented by orange arcs in the SacWAM schematic. In the WEAP data tree "Diversions" are aggregated with "Rivers." However, some of the diversion properties differ from rivers.

In the upper watersheds, the operation of this infrastructure is achieved using flow requirements to demand monthly average values based on water years 1970-2009, similar to the approach used for reservoir storage. If in the future a more sophisticated representation of the operations rules is needed for these infrastructure, they can be modified

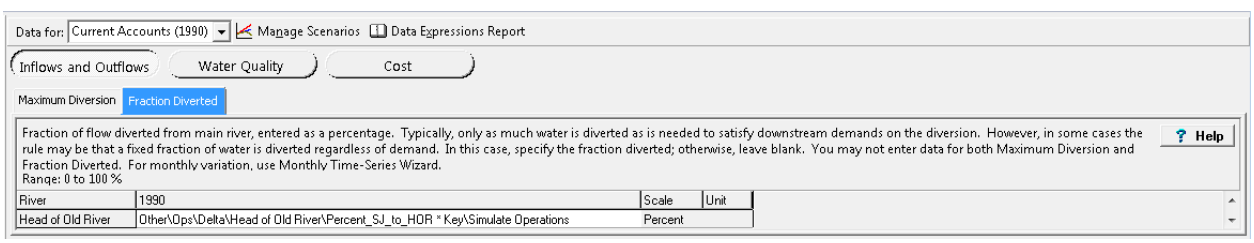
6.2.1 Inflows and Outflows

6.2.1.1 *Maximum Diversion*



The maximum diversion parameter is used to limit the flow through a diversion arc. In SacWAM this parameter is used to restrict flow to a canal or pipeline's physical limit. See **maximum diversions** for more information.

6.2.1.2 *Fraction Diverted*



No values were entered except for Other\Ops\Delta\Head of Old River\Percent_SJ_to_HOR * Key\Simulate Operations for Head of Old River.

6.2.2 Water Quality

The WEAP *Water Quality* feature for diversions is not used.

6.2.3 Cost

The WEAP *Cost* feature for diversions is not used.

6.2.4 Reaches

6.2.4.1 *Inflows and Outflows*

Surface Water Inflow

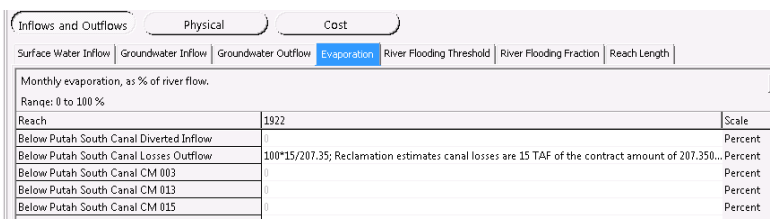
This parameter is meant to reflect monthly values of surface water inflow beyond that from catchments or tributaries. The following inflow reaches use headflow values when Simulate Hydrology is turned off (See Section 9.4).

- Below I_ALMMW
- BelowI_BTVLY Headflow
- BelowI_DAVIS Headflow

Groundwater Inflow and Groundwater Outflow

Some *Reaches* include expressions for groundwater inflow and outflow. These parameters are controlled through *Other Assumptions* and explained in Section 7.3.4.

Evaporation



Reclamation estimates canal losses by evaporation are 15 TAF of the contract amount of 207.350 TAF. This amounts to over 7%. This is the only Reach in the model for which an evaporation value is entered.

6.2.4.2 *Maximum Diversion*

In the upper watersheds the tunnel and canals are constrained to have a flow no larger than the average monthly flow. These expressions for these parameters are in **maximum diversions**. The values are found in **upper watershed diversion flows**.

6.2.4.3 *Fraction Diverted*

This parameter was not used in the upper watersheds.

6.3 Groundwater

SacWAM includes ten groundwater basins, each basin represented using a groundwater object on the WEAP schematic. Inflows and outflows to and from the groundwater basins include deep percolation from natural, agricultural, and refuge areas represented by the demand unit catchment objects, return flows from urban demand sites, seepage losses on surface water distribution systems represented by losses to groundwater on transmission links and groundwater pumping to meet demands in the catchments and demand sites. The groundwater nodes also interact with the stream network through the *Groundwater Inflow* and *Groundwater Outflow* parameters on stream reaches. Details of the groundwater simulation are presented in Section 3.3.

6.3.1.1 *Deep Percolation*

In order to simulate deep percolation from irrigation and rainfall, an analysis was conducted to determine which groundwater basin receives recharge from each DU. The aggregated **groundwater basins** were intersected with the SacWAM DUs to produce the **groundwater basin intersection** shapefile. This intersection determined the percentage of each DU within one or more groundwater basins. The post-intersection processing is documented in the **gw basins spreadsheet**.

The information in the groundwater basin intersection shapefile was used to specify the destination of infiltration links (dashed blue line) from catchments and return flow links (solid red line) from urban demand demand sites. If the DU overlaid multiple groundwater basins, the relative proportions determined by the the spatial intersection described above were used to disaggregate the flows. A listing of each agricultural, agricultural, urban, and refuge DU and their respective links to groundwater basins is provided in Table 6-8,

Table 6-9, and Table 6-10.

Where the percentage of a DU that lies within a groundwater basin is less than or equal to 10%, the infiltration or runoff link is not represented on the schematic and proportions were recalculated with the groundwater basin portions less than or equal to 10% omitted from the total area.

6.3.1.1 *Groundwater Pumping*

Similar to deep percolation, the information in the **groundwater basin intersection** shapefile was used to determine the sources of groundwater for agricultural catchments and urban demand nodes Table 6-8, Table 6-9, and Table 6-10). Agricultural and refuge DUs all have at least one groundwater source in SacWAM. Urban DUs are either supplied entirely by groundwater, or conjunctively use surface water and groundwater.

For all DUs, the minimum and maximum amount of groundwater pumping were constrained as follows. Additional details regarding the parameter values are provided in Chapter 4 and Chapter 6.

The minimum amount of groundwater pumping for a DU is set by constraining the maximum percentage of the demand that can be met by surface water. This constraint was calculated based on an analysis of the areal extent of surface water delivery infrastructure. For instance, if 60% of a DU's cropped area overlaps a surface water delivery service area then the maximum percentage of the demand that can be met by surface water was set to 60% which translates into a minimum groundwater pumping constraint of 40%. This constraint was set in the *Maximum Flow Percent of Demand* parameter (see below) for the transmission link that connects a catchment or demand site to a surface water source. In the cases where a DU has more than one surface supply, a UDC was created that restricted the total surface water supply to a fraction of the total water requirement. The fraction is calculated using 1-*Minimum Groundwater Pumping Factor.* For more information see Section 8.13.

The maximum amount of groundwater pumping is specified using the *Maximum Flow Percent of Demand* parameter on transmission links that connect catchments and demand sites to ground water sources. These parameter values were derived by analysis of county land use surveys (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a).

Table 6-8. Deep Percolation Destinations and Groundwater Sources for Agricultural Demand Units

Demand Unit	Deep Percolation to Groundwater Basin(s)	Groundwater Source(s)
A_02_NA	Redding (100%)	Redding (100%)
A_02_PA	Redding (100%)	Redding (100%)
A_02_SA	Redding (100%)	Redding (100%)
A_03_NA	Redding (100%)	Redding (100%)
A_03_PA	Redding (100%)	Redding (100%)
A_03_SA	Redding (100%)	Redding (100%)
A_04_06_NA	Red Bluff Corning (100%)	Red Bluff Corning (100%)
A_04_06_PA1	Red Bluff Corning (100%)	Red Bluff Corning (100%)
A_04_06_PA2	Red Bluff Corning (100%)	Red Bluff Corning (100%)
A_04_06_PA3	Red Bluff Corning (35%); Colusa (65%)	Red Bluff Corning (35%); Colusa (65%)
A_05_NA	Red Bluff Corning (100%)	Red Bluff Corning (100%)
A_07_NA	Colusa (100%)	Colusa (100%)
A_07_PA	Colusa (100%)	Colusa (100%)
A_08_NA	Red Bluff Corning (14%); Colusa (86%)	Red Bluff Corning (14%); Colusa (86%)
A_08_PA	Colusa (100%)	Colusa (100%)

A_08_SA1	Colusa (100%)	Colusa (100%)
A_08_SA2	Colusa (100%)	Colusa (100%)
A_08_SA3	Colusa (100%)	Colusa (100%)
A_09_NA	Butte (100%)	Butte (100%)
A_09_SA1	Butte (100%)	Butte (100%)
A_09_SA2	Butte (100%)	Butte (100%)
A_10_NA	Butte (100%)	Butte (100%)
A_11_NA	Sutter Yuba (15%); Butte (85%)	Sutter Yuba (15%); Butte (85%)
A_11_SA1	Butte (100%)	Butte (100%)
A_11_SA2	Butte (100%)	Butte (100%)
A_11_SA3	Butte (100%)	Butte (100%)
A_11_SA4	Sutter Yuba (100%)	Sutter Yuba (100%)
A_12_13_NA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_12_13_SA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_14_15N_NA1	Sutter Yuba (100%)	Sutter Yuba (100%)
A_14_15N_NA2	Sutter Yuba (100%)	Sutter Yuba (100%)
A_14_15N_NA3	Sutter Yuba (100%)	Sutter Yuba (100%)
A_14_15N_SA	Sutter Yuba (87%); Butte (13%)	Sutter Yuba (87%); Butte (13%)
A_15S_NA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_15S_SA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_16_NA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_16_PA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_16_SA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_17_NA	Sutter Yuba (50%); Butte (50%)	Sutter Yuba (50%); Butte (50%)
A_17_SA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_18_19_NA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_18_19_SA	Sutter Yuba (100%)	Sutter Yuba (100%)
A_20_25_NA1	Yolo Solano (81%); Colusa (19%)	Yolo Solano (81%); Colusa (19%)
A_20_25_NA2	Yolo Solano (100%)	Yolo Solano (100%)
A_20_25_PA	Yolo Solano (100%)	Yolo Solano (100%)
A_21_NA	Yolo Solano (39%); Colusa (61%)	Yolo Solano (39%); Colusa (61%)
A_21_PA	Yolo Solano (38%); Colusa (62%)	Yolo Solano (38%); Colusa (62%)
A_21_SA	Yolo Solano (81%); Colusa (19%)	Yolo Solano (81%); Colusa (19%)
A_22_NA	American (100%)	American (100%)
A_22_SA1	American (100%)	American (100%)
A_22_SA2	American (100%)	American (100%)
A_23_NA	American (100%)	American (100%)
A_24_NA1	American (100%)	American (100%)
A_24_NA2	American (100%)	American (100%)

Table 6-8. Deep Percolation Destinations and Groundwater Sources for Agricultural Demand Units cont.

Demand Unit	Deep Percolation to Groundwater Basin(s)	Groundwater Source(s)
A_24_NA3	American (100%)	American (100%)
A_26_NA	American (100%)	American (100%)
A_50_NA1	Delta (100%)	Delta (100%)
A_50_NA2	Delta (100%)	Delta (100%)
A_50_NA3	Delta (100%)	Delta (100%)
A_50_NA4	Delta (100%)	Delta (100%)
A_50_NA5	Delta (100%)	Delta (100%)
A_50_NA6	Delta (100%)	Delta (100%)
A_50_NA7	Delta (100%)	Delta (100%)
A_60N_NA1	Cosumnes (100%)	Cosumnes (100%)
A_60N_NA2	Cosumnes (72%); American (28%)	Cosumnes (72%); American (28%)
A_60N_NA3	Eastern San Joaquin (56%); Cosumnes (44%)	Eastern San Joaquin (56%); Cosumnes (44%)
A_60N_NA4	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_60N_NA5	Eastern San Joaquin (24%); Cosumnes (76%)	Eastern San Joaquin (24%); Cosumnes (76%)
A_60S_NA	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_60S_PA	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_61N_PA	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_61N_NA1	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_61N_NA2	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
A_61N_NA3	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)

Table 6-9. Deep Percolation Destination and Groundwater Sources for Urban Demand Units

Demand Unit	Return Deep Percolation to Groundwater Basin(s)[10]	Groundwater Source(s)
U_02_NU	Redding (100%)	Redding (100%)
U_02_PU	None	None
U_02_SU	None	Redding (100%)
U_03_NU	Red Bluff Corning (100%)	Red Bluff Corning (100%)
U_03_PU	None	Redding (100%)
U_03_SU	None	Redding (100%)
U_04_06_NU	Red Bluff Corning (79%), Colusa (21%)	Red Bluff Corning (79%), Colusa (21%)
U_05_NU	Red Bluff Corning (100%)	Red Bluff Corning (100%)
U_07_NU	Colusa (100%)	Colusa (100%)
U_08_NU	Red Bluff Corning (12%), Colusa (88%)	Red Bluff Corning (12%), Colusa (88%)
U_09_NU	Butte (100%)	Butte (100%)
U_10_NU1	None	Red Bluff Corning (62%); Butte (38%)
U_10_NU2	Butte (100%)	Butte (100%)
U_11_NU1	None	None
U_11_NU2	Butte (100%)	Butte (100%)
U_12_13_NU1	None	Sutter Yuba (100%)
U_12_13_NU2	Sutter Yuba (100%)	Sutter Yuba (100%)
U_14_15N_NU	None	None
U_15S_NU	None	Sutter Yuba (100%)
U_16_NU	Sutter Yuba (100%)	Sutter Yuba (100%)
U_16_PU	None	Sutter Yuba (100%)
U_17_NU	Sutter Yuba (100%)	Sutter Yuba (100%)
U_18_19_NU	Sutter Yuba (100%)	Sutter Yuba (100%)
U_20_25_NU	None	None
U_20_25_PU	None	Yolo Solano (100%)
U_21_NU	Sutter Yuba (13%); Colusa (87%)	Sutter Yuba (13%); Colusa (87%)
U_21_PU	None	None
U_22_NU	American (100%)	American (100%)
U_23_NU	American (100%)	American (100%)
U_24_NU1	None	American (100%)
U_24_NU2	None	American (100%)
U_26_NU1	None	American (100%)
U_26_NU2	None	American (100%)
U_26_NU3	None	American (100%)
U_26_NU4	None	American (100%)
U_26_NU5	None	American (100%)
U_26_NU6	American (100%)	None
U_26_PU1	None	American (100%)
U_26_PU2	None	American (100%)
U_26_PU3	None	American (100%)
U_26_PU4	None	American (100%)
U_26_PU5	None	American (100%)
U_60N_NU1	None	Eastern San Joaquin (61%), Cosumnes (39%)
U_60N_NU2	American (84%), Cosumnes (16%)	None
U_60N_PU	Cosumnes (100%)	None

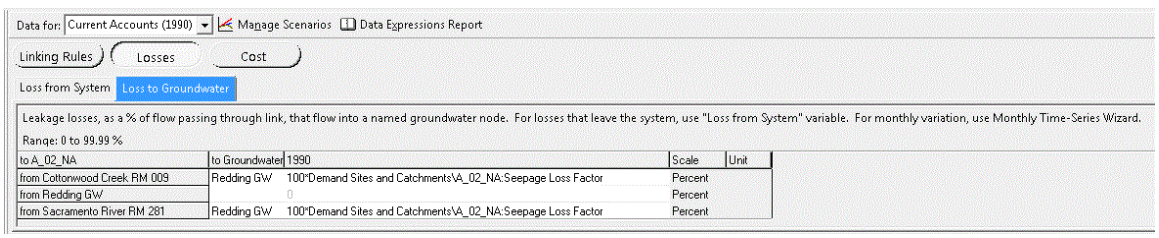
[10] Unlike agricultural and refuge lands which are represented by a single catchment object, urban areas are represented by both a catchment and demand site object. Consequently, an urban DU can have a return flow to a groundwater basin(s) from the demand site in addition to runoff from the catchment object.

Demand Unit	Return Deep Percolation to Groundwater Basin(s)[10]	Groundwater Source(s)
U_60S_NU1	None	Eastern San Joaquin (100%)
U_60S_NU2	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
U_61N_NU1	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)
U_61N_NU2	Eastern San Joaquin (100%)	Eastern San Joaquin (100%)

Table 6-10. Groundwater Sources and Runoff for Refuge Demand Units

Demand Unit	Runoff Deep Percolation to Groundwater Basin(s)	Groundwater Source(s)
R_08_PR	Colusa (100%)	Colusa (100%)
R_09_PR	Butte (100%)	Butte (100%)
R_11_PR	Butte (100%)	Butte (100%)
R_17_NR	Butte (100%)	Butte (100%)
R_17_PR1	Butte (100%)	Butte (100%)
R_17_PR2	Sutter Yuba (100%)	Sutter Yuba (100%)

6.3.1.2 *Seepage Loss to Groundwater*



$$Loss\ to\ Groundwater\ (\%) = f_{sp}\ *\ 100$$

The *Loss to Groundwater* parameter is specified on each transmission link (the *Supply and Resources\Transmission Link\Demand Unit\Loss to Groundwater* branch in the data tree) that connects a catchment or demand site to a surface water source. As indicated in the above equation, *Loss to Groundwater* is defined as the *Seepage Loss Factor* indicated on the DU level multiplied by 100 to obtain a percentage (see 4.4.2.1 - Seepage Loss Factor for more detail about how *Seepage Loss Factor* values were determined). As shown above, in addition to the percentage of transmission flow lost to groundwater, the receiving groundwater basin must also be specified. To determine which groundwater basin a surface transmission link loses water to, the following rules were implemented:

- If a DU overlies one groundwater basin as determined by the **groundwater basin intersection**, that groundwater basin is specified as the basin to which the transmission link loses water.
- If a DU overlies two or more groundwater basins as determined by the **groundwater basin intersection** and has one surface water transmission link, it was assumed the loss to groundwater infiltrates to the groundwater basin that underlies the larger proportion of the DU.
- If a DU overlies two or more groundwater basins as determined by the **groundwater basin intersection** and has multiple surface water transmission links, the loss to groundwater was split between the groundwater basins where the groundwater basin comprises 35% or more of the DU.

6.3.1.3 *Stream – Aquifer Interaction*

Interaction between streams and aquifers is simulated in the SacWAM using factors derived by SWRCB staff from the C2VSim groundwater model. These loss and gain factors were derived from a C2VSim

model run in which the land use was kept constant at the level of development for water year 2009, the most recent year available in C2VSim. The model run consisted of an ensemble of results based on multiple 5 year runs in which the initial conditions were reset every 5 years to the state of the groundwater system simulated by the historical C2VSim model run for the end of water year 2009. The model was run for 88 years in this manner. The idea behind this approach is that future management of the Valley's groundwater will not result in long-term trends of storage loss or gain, therefore the groundwater heads were reset every 5 years to match the recent historical past. From the ensemble run, monthly stream flow and seepage to groundwater were recorded for each C2VSim stream reach. These values were regressed and the resulting slope and intercept of the linear regression expression were used to specify the Groundwater Inflow and Groundwater Outflow on stream reaches that were designated to have stream-aquifer interactions. In general, the most downstream SacWAM reach on a corresponding C2VSim reach was selected to represent the stream-aquifer interactions for the entire C2VSim reach. For example, on Cow Creek, which is a single stream reach in C2VSim, the stream-aquifer interactions in SacWAM were set to occur on the reach called "Below SR Cow Creek," which is the last stream reach before the confluence with the Sacramento River.

The parameters used to characterize the stream-aquifer interactions are provided in Table 6-11. The slope was entered into the *Groundwater Outflow* parameter as a percent and represents the percentage of the streamflow that flows to the aquifer. The intercept was entered into the *Groundwater Inflow* parameter and represents the flow from the aquifer to the stream reach. This information is provided in the **groundwater functions** spreadsheet. During calibration of the valley floor hydrology these parameters were further adjusted to mimic the overall behavior of C2VSim (see Appendix B).

Table 6-11. Stream-Aquifer Parameters Derived from C2VSim

C2VSim Reach #	SacWAM Reach Name	Description	Slope (%)	Intercept (cfs)	Basin	Slope Adjustment Factor
25	Below I_CLV026 Inflow	Calaveras R	18.07	0.00	Eastern San Joaquin	1.7
27	Below Mokelumne River RM 050	Mokelumne R	14.00	0.00	Cosumnes	1.0
27	Below Mokelumne River RM 035	Mokelumne R	14.00	0.00	Eastern San Joaquin	1.0
29	Below SR Cosumnes River	Cosumnes R	0.36	0.00	American	
29	Below I_DEE023 Inflow	Cosumnes R	0.36	0.00	Cosumnes	1.0
32	Below SR Sacramento River above Bend Bridge Gauge	Sacramento R abv Cow Ck	0.66	62.65	Redding	1.4
33	Below SR Cow Creek	Cow Ck	3.17	10.95	Redding	1.4
34	Below Bear Creek Inflow	Sacramento R blw Cow Ck	0.22	46.60	Redding	1.4
35	Below SR Cottonwood Creek	Cottonwood Ck	1.22	1.06	Redding	0.6
36	Below Battle Creek RM 006	Battle Ck	3.44	29.50	Redding	1.0
37	Below SWRCB Sac AB Bend Bridge	Sacramento R blw Battle Ck	0.18	55.18	Red Bluff Corning	1.4
37	Below Battle Creek Inflow to Sacramento RM 269	Sacramento R blw Battle Ck	0.18	55.18	Redding	1.4
38	Below I_PYN001 Inflow	Paynes Ck	1.76	17.76	Red Bluff Corning	1.0
39	Below Sacramento River RM 240	Sacramento R blw Paynes Ck	0.15	77.33	Red Bluff Corning	1.4
40	Below SR Antelope Creek	Antelope Ck	1.43	22.29	Red Bluff Corning	1.0
41	Below Catchment Inflow Node 94	Sacramento R blw Antelope Ck	0.11	25.50	Red Bluff Corning	1.4
42	Below I_ELD027 Inflow	Elder Ck	9.42	14.27	Red Bluff Corning	1.0
43	Below Mill Creek RM 006	Mill Ck	1.87	8.89	Red Bluff Corning	1.0
44	Below McClure Creek Inflow to Sacramento River RM 225	Sacramento R blw Mill Ck	0.15	29.52	Red Bluff Corning	1.4
45	Below SR Thomes Creek	Thomes Ck	9.40	4.41	Red Bluff Corning	0.7
46	Below Catchment Inflow Node 99	Sacramento R blw Thomes Ck	0.14	22.96	Red Bluff Corning	1.4
47	Below Deer Creek RM 005	Deer Ck	1.45	3.33	Red Bluff Corning	1.0
48	Below Catchment Inflow Node 104	Sacramento R blw Deer Ck	0.29	37.20	Red Bluff Corning	1.4
49	Below Constant Head Orifice Outflow	Stony Ck	6.09	0.00	Colusa	2.8
49	Below SR Stony Creek	Stony Ck	6.09	0.00	Red Bluff Corning	2.8
50	Below Catchment Inflow Node 106	Big Chico Ck	0.31	0.02	Butte	1.0
50	Below Catchment Inflow Node 105	Big Chico Ck	0.31	0.02	Red Bluff Corning	1.0
51	Below Sacramento River RM 159	Sacramento R blw Big Chico Ck	2.08	232.61	Butte	0.9
51	Below SR Sacramento River above Butte City Gauge	Sacramento R blw Big Chico Ck	2.08	232.61	Colusa	1.4
52	Below A_11_SA3 Runoff	Butte Ck	14.75	0.00	Butte	0.9
53	Below OPS Navigation Control Point	Sacramento R abv CBD	0.96	72.76	Colusa	1.4
53	Below Sacramento River RM 109	Sacramento R abv CBD	0.96	72.76	Sutter Yuba	1.4
55	Below Colusa Basin Drainage Canal CM 049	Upr Colusa Basin Drain	5.84	127.19	Colusa	1.0
56	Below SR Colusa Basin Drain Above Outfall Gates Gauge	Lwr Colusa Basin Drain	14.91	272.87	Colusa	1.0
57	Below Sutter Bypass Floodflow Inflow	Sacramento R blw CBD	0.31	14.54	Colusa	1.4
57	Below Sutter Bypass Inflow to Sacramento RM 085	Sacramento R blw CBD	0.31	14.54	Sutter Yuba	1.4

Table 6-11. Stream-Aquifer Parameters Derived from C2VSim cont.

C2VSim Reach #	SacWAM Reach Name	Description	Slope (%)	Intercept (cfs)	Basin	Slope Adjustment Factor
58	Below A_17_NA Runoff	Sutter Bypass	4.99	58.71	Sutter Yuba	0.55
59	Below Feather River RM 039	Feather R abv Yuba R	1.91	95.50	Butte	1.0
59	Below Feather River RM 045	Feather R abv Yuba R	1.91	95.50	Sutter Yuba	1.0
60	Below Yuba River RM 003	Yuba R	0.99	0.00	Sutter Yuba	1.0
61	Below Feather River RM 014	Feather R abv Bear R	2.15	53.36	Sutter Yuba	1.0
62	Below SR Bear River	Bear R	5.57	0.00	American	2.0
62	Below Dry and Hutchinson Creeks Inflow	Bear R	5.57	0.00	Sutter Yuba	2.0
64	Below REG Verona	Feather R blw Sutter Bypass	2.06	176.31	American	1.0
64	Below Feather River RM 007	Feather R blw Sutter Bypass	2.06	176.31	Sutter Yuba	1.0
65	Below Sacramento River RM 074	Sacramento R blw Feather R	1.01	0.00	American	1.4
65	Below Natomas East Main Drain Inflow	Sacramento R blw Feather R	1.01	0.00	Yolo Solano	1.4
66	Below REG American IFR	American R	1.50	0.00	American	1.3
67	Below Georgiana Slough fr Sacramento River RM 029 Outflow	Sacramento R blw American R	0.62	0.00	Delta	1.4
68	Below Cache Creek RM 030	Cache Ck	32.11	2.95	Colusa	0.7
68	Below SR Cache Creek above Yolo Gauge	Cache Ck	32.11	2.95	Yolo Solano	0.7
69	Below REG Lower Putah Diversion Dam	Putah Ck	9.71	0.00	Yolo Solano	3.3

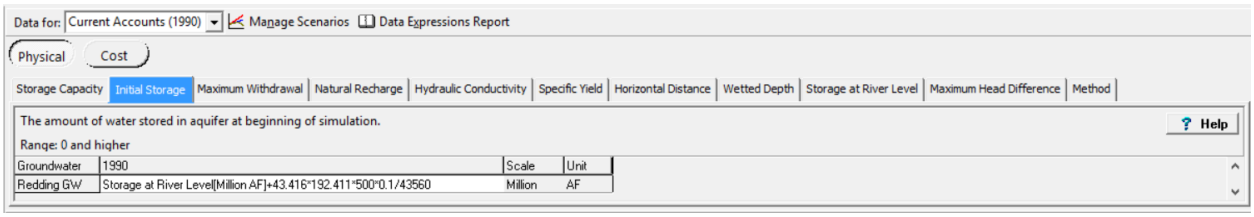
Key: abv=above, blw=below; CBD=Colusa Basin Drain; cfs=cubic feet per second; Ck=Creek; CM=Canal Mile; fr=from; R=River; RM=River Mile; SR=surface return.

6.3.2 Physical

6.3.2.1 *Storage Capacity*

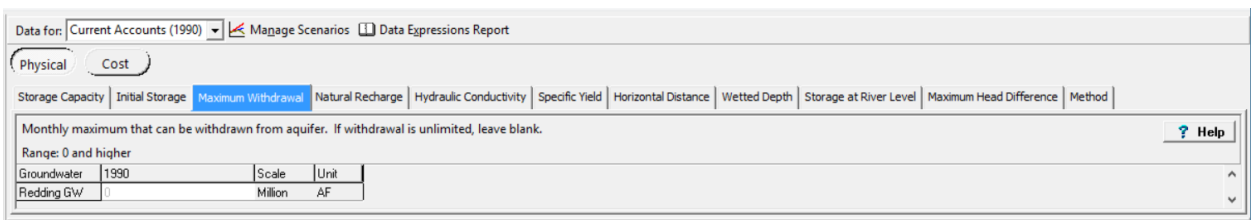
The storage capacity parameter is used to specify the total volume of available storage in a groundwater aquifer. In SacWAM, this parameter has been left blank which means the capacity is unlimited.

6.3.2.2 *Initial Storage*



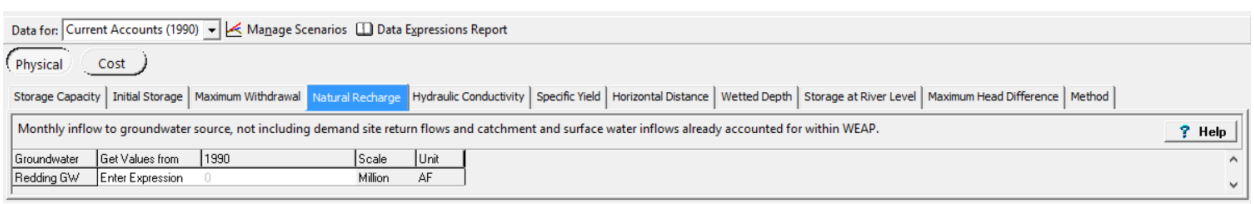
This parameter sets the initial storage in the aquifer. For all aquifers this value was arbitrarily set to 30 million AF.

6.3.2.3 *Maximum Withdrawal*



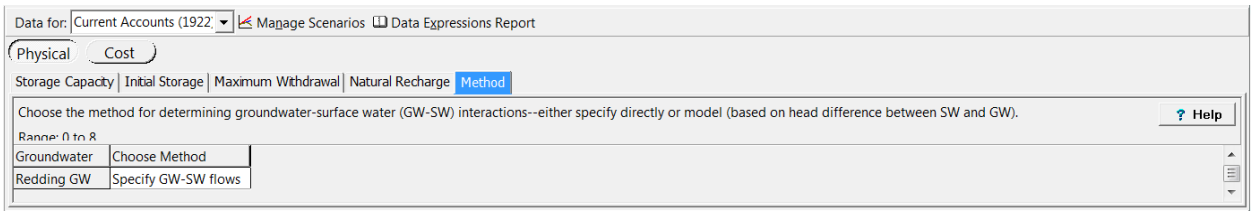
This parameter restricts the amount of water that can be withdrawn from the aquifer in a time step. In SacWAM this parameter was left blank making it unrestricted.

6.3.2.4 *Natural Recharge*



This parameter is used to specify recharge to the aquifer. This parameter is blank. In SacWAM aquifer recharge is simulated as deep percolation from catchments, return flows from demand sites, and seepage from transmission links.

6.3.2.5 *Method*



For each groundwater basin, the method for simulating stream-groundwater interaction is set to "Specify GW-SW flows."

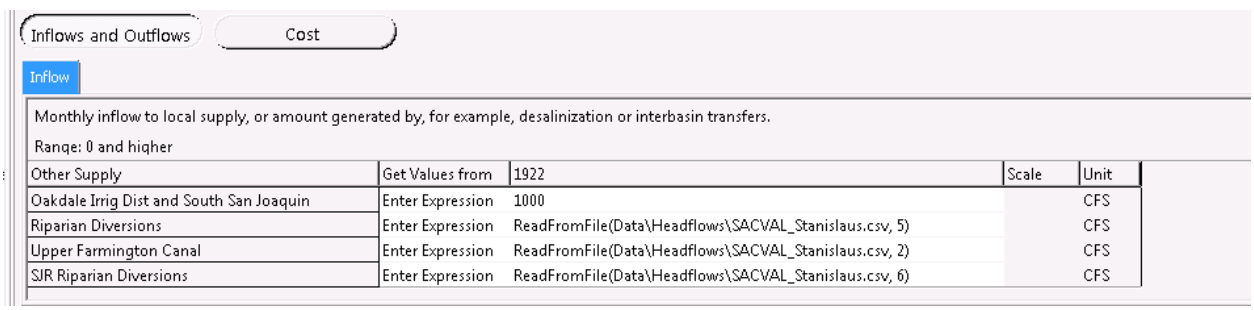
6.3.3 Cost

The *Cost* feature under *Groundwater* is not used in SacWAM.

6.4 Other Supply

The use of the 'Other Supply' object in SacWAM is limited to the San Joaquin Valley. It provides water to lands on the southern boundary of the model domain located between the Calaveras and Stanislaus rivers, east of the San Joaquin River. The Other Supply represents: (1) water that is diverted from the Stanislaus River and flows into the Calaveras watershed, and (2) water used by riparian diverters along the San Joaquin River that extract their water upstream from Vernalis. It is assumed that these supplies are sufficient to meet the water demands of the local water users.

6.4.1 Inflows and Outflows



Other Supply	Get Values from	1922	Scale	Unit
Oakdale Irrig Dist and South San Joaquin	Enter Expression	1000		CFS
Riparian Diversions	Enter Expression	ReadFromFile(Data\Headflows\SACVAL_Stanislaus.csv, 5)		CFS
Upper Farmington Canal	Enter Expression	ReadFromFile(Data\Headflows\SACVAL_Stanislaus.csv, 2)		CFS
SJR Riparian Diversions	Enter Expression	ReadFromFile(Data\Headflows\SACVAL_Stanislaus.csv, 6)		CFS

The Other Supply inflow was set to 1,000 cubic feet per second (cfs) to ensure that there is sufficient water to meet Oakdale ID demands.

6.4.2 Cost

The *Cost* feature under *Other Supply* is not used in SacWAM.

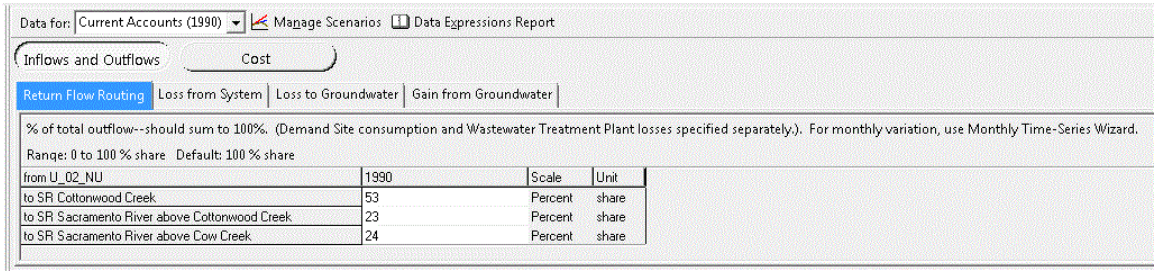
6.5 Return Flows

6.5.1 Inflows and Outflows

6.5.1.1 *Return Flow Routing*

In addition to surface runoff fractions that are specified for urban catchments (dashed blue line in WEAP), return flow percentages from urban demand sites must be specified for return flow links (solid

red line in WEAP). These are entered under the *Supply and Resources\Return Flows\Demand Site\Inflows and Outflows\Return Flow Routing* branch of SacWAM (below). Return flows were determined using the surface **returns intersection**, except where there are known WWTPs.



6.5.1.2 *Loss from System*

The *Loss from System* feature under Inflows and Outflows is not used in SacWAM.

6.5.1.3 *Loss to Groundwater*

The *Loss to Groundwater* feature under Inflows and Outflows is not used in SacWAM.

6.5.1.4 *Gain from Groundwater*

The *Gain from Groundwater* feature under Inflows and Outflows is not used in SacWAM.

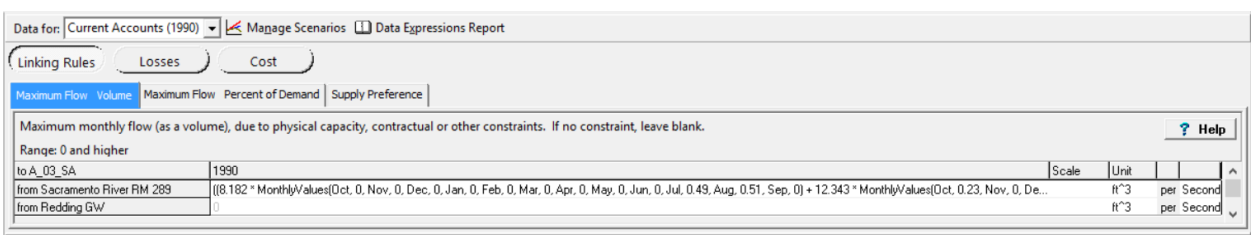
6.5.2 Cost

The *Cost* feature under *Return Flows* is not used in SacWAM.

6.6 Transmission Links

6.6.1 Linking Rules

6.6.1.1 *Maximum Flow Volume*



The **maximum flow volume** parameter is used to restrict the total volume of water that can flow through a transmission link. In SacWAM, this parameter is used to restrict flows according to water rights and contract limits. A sample expression is presented below for a CVP settlement contractor:

((8.182 * MonthlyValues(Oct, 0, Nov, 0, Dec, 0, Jan, 0, Feb, 0, Mar, 0, Apr, 0, May, 0, Jun, 0, Jul, 0.49, Aug, 0.51, Sep, 0)

+ 12.343 * MonthlyValues(Oct, 0.23, Nov, 0, Dec, 0, Jan, 0, Feb, 0, Mar, 0, Apr, 0.11, May, 0.14, Jun, 0.29, Jul, 0, Aug, 0, Sep, 0.23))

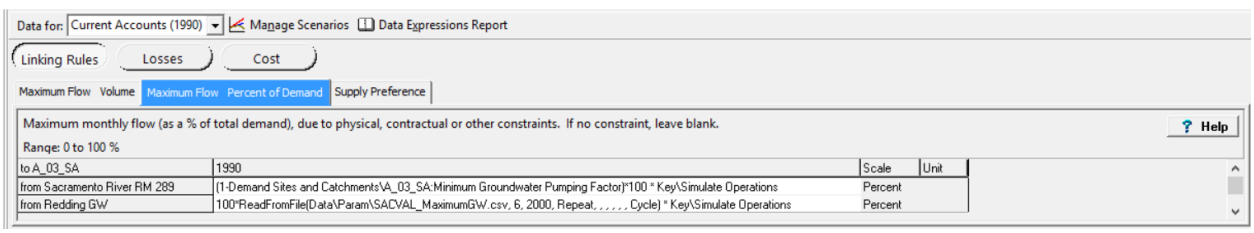
* *Key\Units\TAFmonth2CFS*

* *Other\Ops\CVP Allocations\Shasta_Crit*

+ 9999 * MonthlyValues(Oct, 0, Nov, 1, Dec, 1, Jan, 1, Feb, 1, Mar, 1, Apr, 0, May, 0, Jun, 0, Jul, 0, Aug, 0, Sep, 0))

In this expression, the first block of information contains the contract amount (8.182 TAF) for the critical months (July and August) multiplied by the monthly portion of the contract that can be diverted during the peak months. The second block of information contains the full contract amount for the non-peak months (12.343 TAF) for the non-peak months multiplied by the monthly portion of the contract that can be diverted during the non-peak months. In the actual contract, only the total April – October (8.182+12.343) and July and August (8.182) volumes are specified. In SacWAM, the monthly proportions are based on average monthly water demands. The third block is a unit conversion from TAF to cfs. The fourth block implements an allocation based on Shasta critical years. The fifth block allows diversions (up to the full water demand) from November to March, as water rights outside of the irrigation season specified in the CVP contracts have not currently been quantified for SacWAM.

6.6.1.2 *Maximum Flow Percent of Demand*

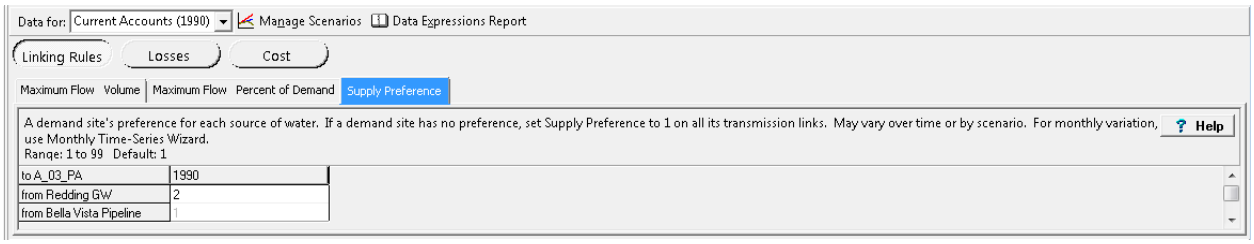


The **maximum flow percent of demand** is used to restrict the flow through a particular transmission link to a percent of the demand in the destination catchment or demand site. In SacWAM this parameter is used to implement various restrictions:

1. For transmission links that transport water from a groundwater source to a catchment or demand site, the maximum groundwater pumping fraction is entered in this parameter. These values were calculated by analysis of the county land use surveys (DWR, 1994a-b, 1995a-b, 1996, 1997b, 1998a-c, 1999a-b, 2000a) and determined by summing the total area in a DU that is served by groundwater only and groundwater and surface water.
2. For transmission links that transport water from surface water to agricultural catchments, the maximum percent of demand that can be met by surface water is defined as one minus the minimum groundwater pumping factor (see Minimum Groundwater Pumping Factor in Section 4.4).
3. For urban DU demand sites, this parameter is used to specify the maximum fraction of the demand that can be served by surface water. This forces a certain level of groundwater pumping representing capacity, operational constraints and other factors.
4. For demand sites outside of the valley floor, this parameter is used to restrict total deliveries if water allocations are not at 100%. For example this is utilized for demands south of the Delta.

All parameters in maximum flow percent of demand are multiplied by a factor called *Key\Simulate Operations*. This factor has a value of zero when the model is run in the unimpaired mode. This setting forces the model to have zero flow on the transmission links. For more details see Section 9.7.

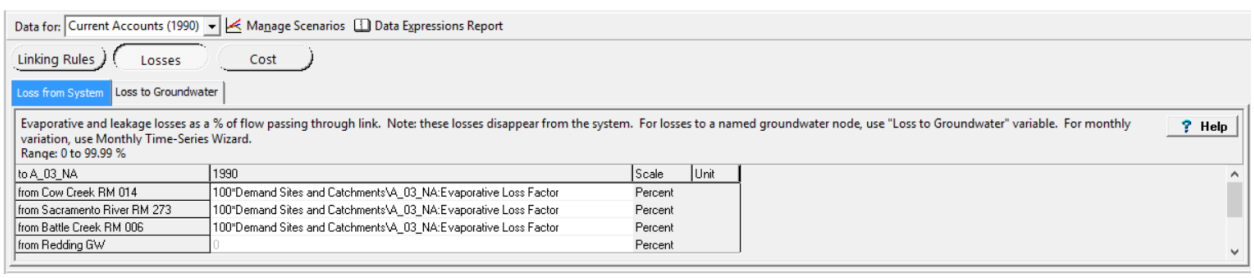
6.6.1.3 *Supply Preference*



Supply preference is used in determining the preference order for supplies in the case where a catchment or demand site has more than one supply. Most commonly this situation arises when a catchment or demand site is connected to a surface water supply and a groundwater supply. In SacWAM, the assumption is that surface water is used preferentially, and therefore given a preference value of "1", and ground water is the second preference with a preference value of "2". There are some cases in which a catchment has more than one surface water supply. In these cases the supply preferences were ranked based on information from water supply contracts.

6.6.2 Losses

6.6.2.1 *Loss from System*



The *Loss from System* parameter specifies the fraction of water from the delivery system that is lost through evaporation. This parameter is specified using the *Evaporative Loss Factor* described in Section 4.4.

6.6.2.2 *Loss to Groundwater*

Data for: Current Accounts (1990) | Manage Scenarios | Data Expressions Report

Linking Rules | Losses | Cost

Loss from System | Loss to Groundwater

Leakage losses, as a % of flow passing through link, that flow into a named groundwater node. For losses that leave the system, use "Loss from System" variable. For monthly variation, use Monthly Time-Series Wizard.
Range: 0 to 99.99 %

to A_03_NA	to Groundwater	1990	Scale	Unit
from Cow Creek RM 014	Redding GW	100*Demand Sites and Catchments\A_03_NA:Seepage Loss Factor	Percent	
from Sacramento River RM 273	Redding GW	100*Demand Sites and Catchments\A_03_NA:Seepage Loss Factor	Percent	
from Battle Creek RM 006	Redding GW	100*Demand Sites and Catchments\A_03_NA:Seepage Loss Factor	Percent	
from Redding GW		0	Percent	

The *Loss to Groundwater* parameter specifies the fraction of water lost from delivery canals to the underlying groundwater through seepage. This parameter is specified using the Seepage Loss Factor described in Section 4.4.

6.6.3 Cost

The *Cost* feature is not used in SacWAM.

6.7 Runoff and Infiltration

6.7.1 Inflows and Outflows

6.7.1.1 *Surface Runoff Fraction for Agricultural Catchments*

Data for: Current Accounts (1990) | Manage Scenarios | Data Expressions Report

Inflows and Outflows | Cost

Surface Runoff Fraction

Runoff to each surface water node, as a percent of total runoff. Sum of all runoff shares must = 100%. For monthly variation, use Monthly Time-Series Wizard.
Range: 0 to 100 % share

from A_02_NA	1990	Scale	Unit
to SR Cottonwood Creek	84	Percent	share
to SR Sacramento River above Keswick Gauge	16	Percent	share

The surface runoff fraction is used to divide the runoff from a catchment object among different receiving surface water bodies. For agricultural catchments, these percentages can be found in Table 3-5 as described in Section 3.7.1.

6.7.1.2 *Surface Runoff Fraction for Urban Catchments*

Data for: Current Accounts (1990) | Manage Scenarios | Data Expressions Report

Inflows and Outflows | Cost

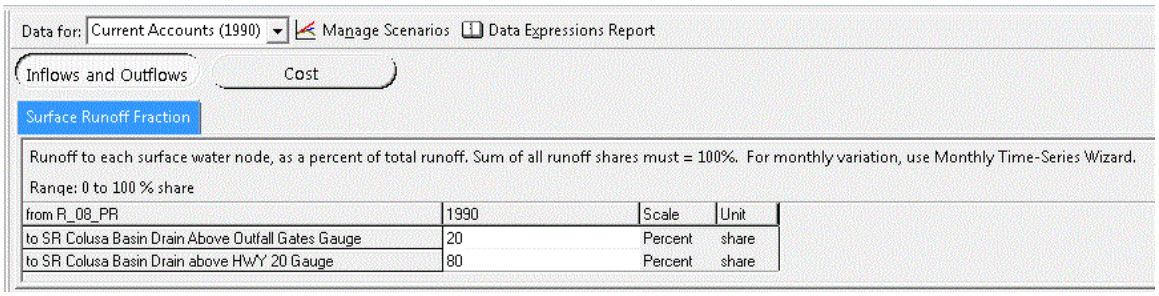
Surface Runoff Fraction

Runoff to each surface water node, as a percent of total runoff. Sum of all runoff shares must = 100%. For monthly variation, use Monthly Time-Series Wizard.
Range: 0 to 100 % share

from U_02_NU_0	1990	Scale	Unit
to SR Cottonwood Creek	53	Percent	share
to SR Sacramento River above Cottonwood Creek	23	Percent	share
to SR Sacramento River above Cow Creek	24	Percent	share

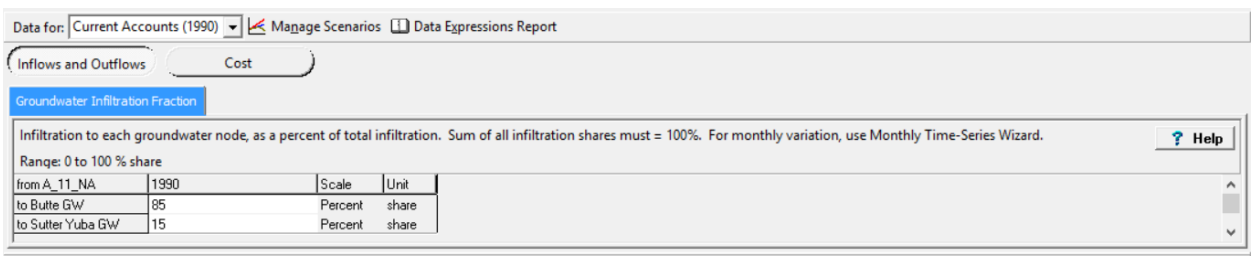
Surface runoff from urban catchments is divided using the values in Table 3-5 and Section 3.7.1.

6.7.1.3 *Surface Runoff from Refuge Catchments*



Surface runoff from refuge catchments is treated in a similar manner to that from agricultural catchments. Their specified percentages are listed in Table 3-5.

6.7.1.4 *Groundwater Infiltration Fraction*



The groundwater infiltration fraction specifies the fraction of the total deep percolation that flows to a particular receiving groundwater basin. This is used when a DU overlies more than one groundwater basin. The fractions entered in this parameter for agricultural, urban, and refuge DUs are described in Section 3.3 and provided in Table 6-8, Table 6-9, and Table 6-10.

6.7.2 Cost

The *Cost* features under *Runoff and Infiltration* are not used in SacWAM.

6.8 Operations Rules

The operations of reservoirs, tunnels, and canals in the upper watersheds have been kept relatively simple and do not fully reflect the complexity that exists in the operations of this infrastructure in the real system. This relatively simple approach was implemented as the operations of the upper watershed infrastructure is buffered by the large volume of storage available in the rim reservoirs. For now, the operations of the reservoirs and diversions (tunnels, canals) is set equal to the average monthly storage or flow.

6.8.1 Diversion Operations

The operations of reservoirs, tunnels, and canals in the upper watersheds have been set equal to the average monthly values based on water years 1970-2009. For more detail see Sections 6.1 and 6.2.

6.9 Data Directory

Table 6-12 provides location information in the 2014_WB_WEAP data directory for the datasets referenced in Chapter 6.

Table 6-12. File Location Information for Supply and Resources

Referenced Name	File Name	File Location*
maximum diversions	Maximum Diversion.xlsx	Rivers\Diversions
maximum flow percent of demand	Maximum Flow Percent of Demand.xlsx	Transmission_Links
maximum flow volume	Maximum Flow Volume.xlsx	Transmission_Links
reservoir storage capacity	SACVAL_SR_Riv_Res_Storage.xlsx	Rivers\Reservoirs
returns intersection	sac_val_returns_intersection.shp	GIS\Hydrology
streamflow gauges	SACVAL_SR_Riv_Streamflow_Gauges.xlsx	Rivers\Streamflow_Gauges
supply preference	Supply Preference.xlsx	Transmission_Links
upper watershed diversion flows	SACVAL_UpperWShed_DiversionFlows.xlsx	Rivers\Diversions
valley floor inflows	SACVAL_SR_Riv_Inflows.xlsx	Rivers\Historical_Inflows
volume elevation curve	SACVAL_SR_Riv_Res_Vol_Elev.xlsx	Rivers\Reservoirs

*Files located at Data\ Supply_and_Resources \... except for GIS files (GIS\...).

This page intentionally left blank