Completing the Water Budget – A mapping of California Water Balance data to a Complete Water Budget

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<u>Acknowledgements</u>

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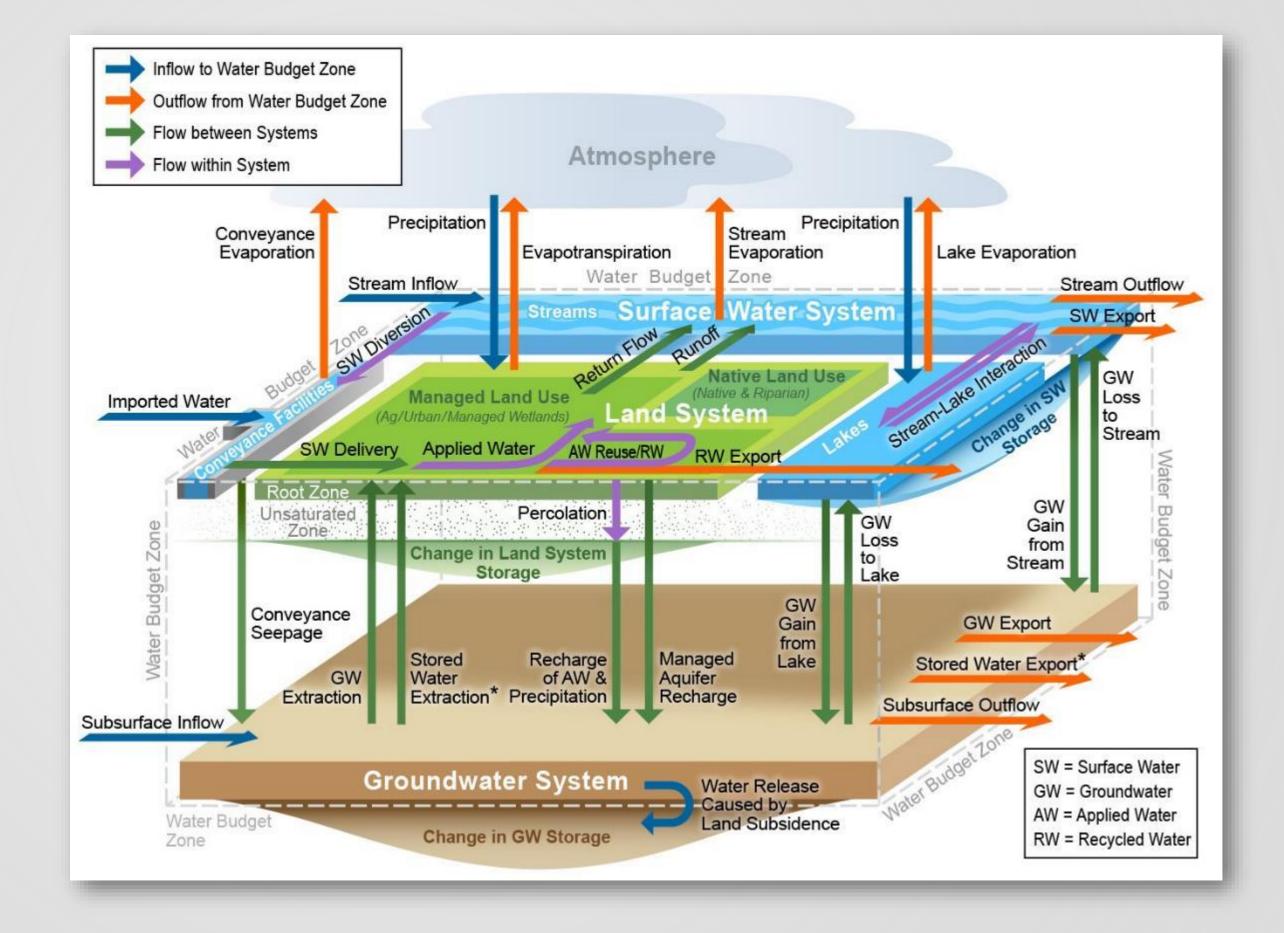
What is a water balance?

Water Plan water balances are simplified water budgets for a water year based on developed water supplies applied to actual uses, and inflows and outflows for a study area that occur above the root zone.



What is a water budget?

Water budget is the systematic and comprehensive accounting of all inflows to and outflows from three interacting systems in a water budget zone: land, surface water, and groundwater.



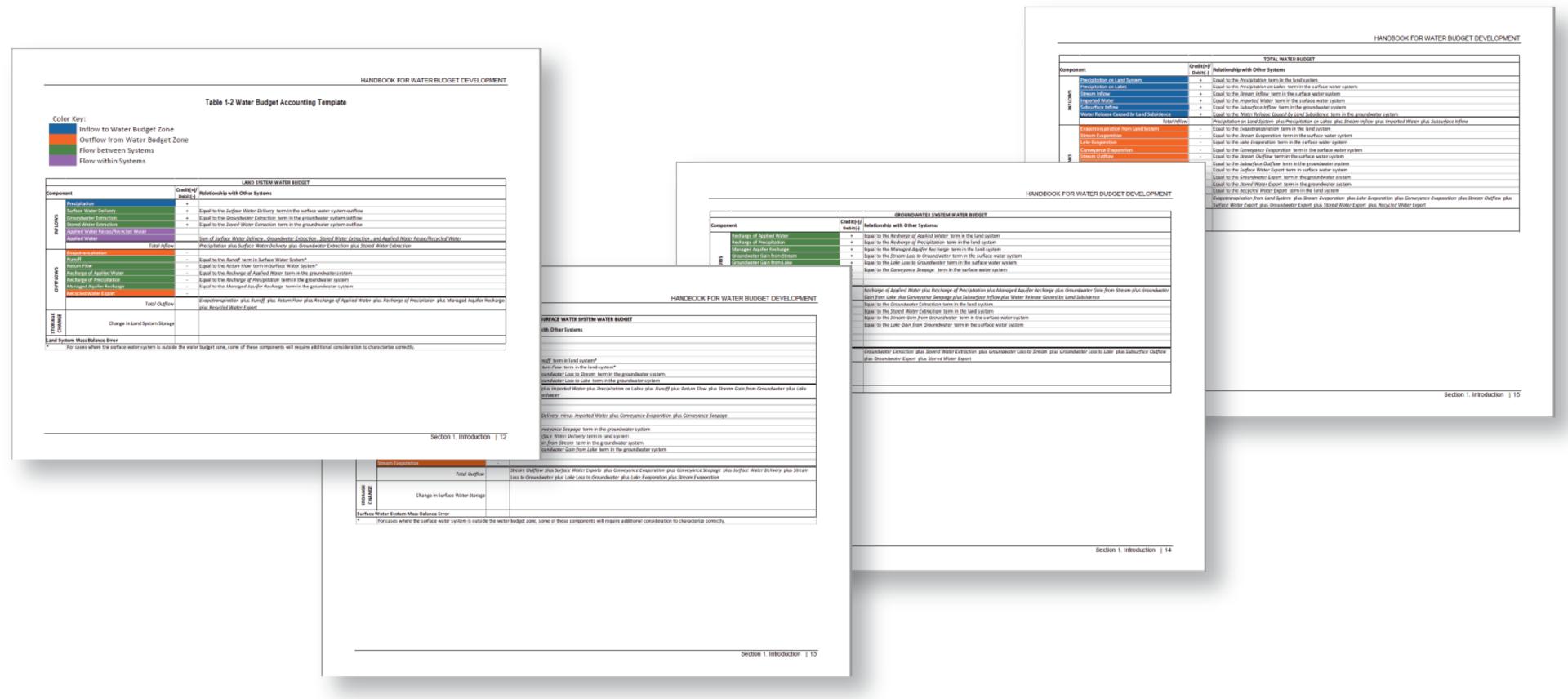


Water Budget Handbook includes a systematic pathway to develop water budgets.



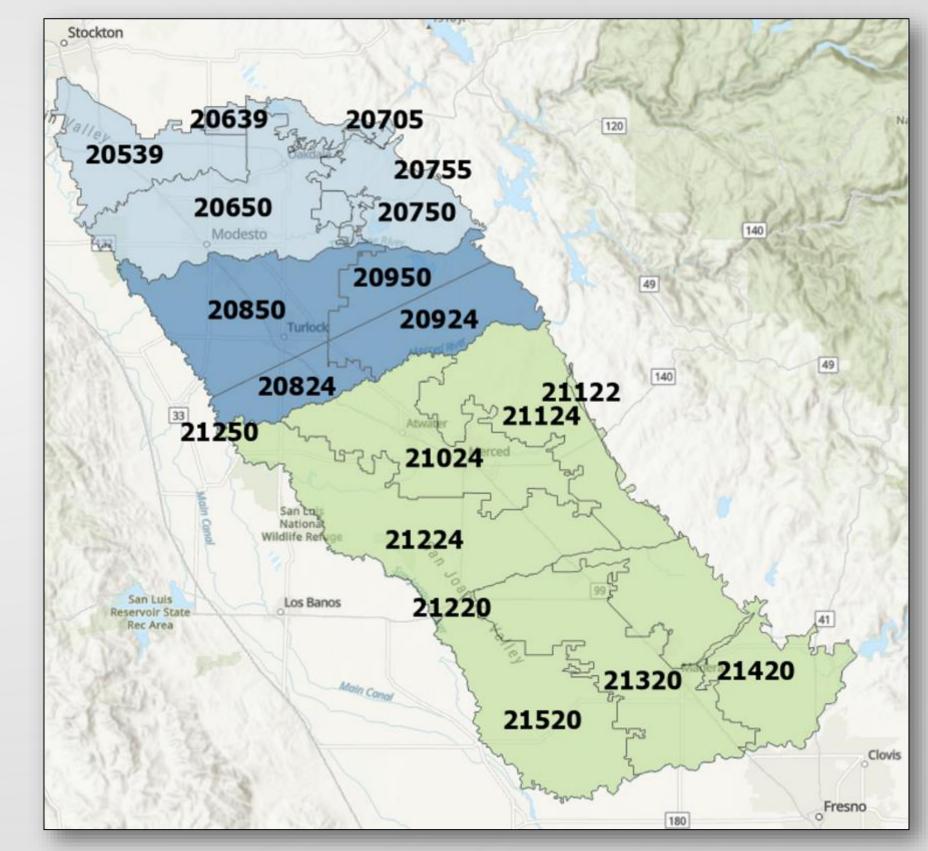


Water Budget Handbook includes standardized accounting templates for each system.



Conducted a pilot study in the Merced area to map water supply and balance terms to water

budget components





Some components map intuitively

Groundwater extraction comprises the following water supply and balance components:

- Groundwater Extraction: Unadjudicated Agriculture.
- Groundwater Extraction: Unadjudicated Urban.
- Groundwater Extraction: Unadjudicated Managed Wetlands.
- Groundwater Extraction: Adjudicated Agriculture.
- Groundwater Extraction: Adjudicated Urban.
- Groundwater Extraction: Adjudicated Managed Wetlands.
- Groundwater Extraction: Banked Agriculture.
- Groundwater Extraction: Banked Urban.
- Groundwater Extraction: Banked Managed Wetlands.



Some components are less intuitive to map.

Imported Water comprises the following water supply and balance components:

- Colorado River Deliveries: Agriculture.
- Colorado River Deliveries: Managed Wetlands.
- Colorado River Deliveries: Urban.
- •
- Water from Refineries: Agriculture.
- Water from Refineries: Managed Wetlands.
- Water from Refineries: Urban.
- •
- Return Flow from Other DAUCO within PA: Agriculture.
- Return Flow from Other DAUCO within PA: Managed Wetlands.
- Return Flow from Other DAUCO within PA: Urban.



LAND SYSTEM

Land system water budget

- System most robustly represented by the water supply and balance data. Most water budget components were available except:
 - Precipitation (used Cal-SIMETAW data)
 - Recharge of Precipitation (estimated)
 - Runoff (estimated)



Land system water budget

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Desi	inetion Com	or Budget Handbunk In ipitation W	/PS 5	9.9	5.7	105.8	68.8	240.2	24.8	85.7	44.4	30.2	185.1	69.1	67.1	93.0	69.6	79.5	15.2	393.4	P H A R Water Pertfelie Compensatr	Component (C)	Ure (U)	T794 (T)	S Seerce
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Betuee	on Systems Groun	nduatorExtraction SP	LSB (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		10 GroundwaterExtraction			2 Adjudi
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Betuee	on Systems Surfa	aco Water Delivery	16	61.8	18.9	198.5 12.8	0.9	380.1	29.5	42.1	36.8	34.0	142.4	241.2	0.0	62.9 27.3	17.6	5.9	33.9	361.5		34 Surface Water Delivery 34 Surface Water Delivery		0	0
Betuee	on Systoms Surfa on Systoms Surfa	aco Water Delivery ace Water Delivery	1	11.6	0.0	24.2	0.0	35.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		0.0	0.0	NA	34 Surface Water Delivery	3 Urban	ů .	
			4G1 22 4G2 (28.7	22.3	484.2	119.1	854.3	124.5	527.4	184.1	184.2	1020.2	349.1	78.5	544.3	483.3	298.9	393.5	2147.6	Y Y Applied Water - Agriculture Y Y Applied Water - Groundwater Recharge - Agriculture		1 Agriculture 1 Agriculture	0 3 Managod Aquifor Ros	0 21 Orbo
Withir	in Systom Applic	iodWator M	1W1 (0.0	0.0	12.8	0.0	12.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.3	0.0	0.0	0.0	46.3 1	Y Y Applied Water - Managed Wetlands	1 Applied Water	2 Managod Wotlandr	0	0
		iodWator UF iodWator UF	RB1 8 RB2 9	9.8	0.1	15.5 23.6	0.1	24.3 33.7	1.0	8.2 12.6	0.1	0.0	9.3 14.3	9.7	0.3	0.2	4.5	2.4	0.1	14.8 Y	Y Y AW-Residential Use-Single Family-Interior-Urban Y Y AW-Residential Use-Single Family-Exterior-Urban	1 Applied Water	3 Urban 3 Urban	4 Residential Use - Sinc 5 Residential Use - Sinc	9 0 9 0
Withir	in System Applic	iod Water UF	RB3 ·	1.2	0.1	16.3	0.2	17.8	1.0	8.7	0.1	0.0	9.8	10.1	0.3	0.2	3.1	1.7	0.0	15.4 1	Y Y AW-Residential Use-Multi-Family-Interior-Usban Y Y AW-Residential Use-Multi-Family-Exterior-Usban	1 Applied Water	3 Urban 3 Urban	6 Residential Use - Mult 7 Residential Use - Mult	t 0
		od Water UF	RB5	3.3	0.0	5.7	0.1	9.1	0.4	3.0	0.0	0.0	3.4	3.5	0.1	0.1	1.1	0.6	0.0	5.4	Y Y AW-Commorcial Uso-Usban	1 Applied Water	3 Urban	8 Commercial Use	
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Withir	in Systom Applia	iodWator UF iodWator UF	RBS (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 1	Y Y AW-Energy Production - Urban	1 Applied Water	3 Urban 3 Urban	11 Energy Production 3 Managed Aquifor Re-	0
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Withir	in System Applic	iodWatorRowo M iodWatorRowo URB	B154 ·	1.5	0.0	12.9	0.0	14.4	2.5	1.1	0.0	0.0	3.6	4.9	0.0	0.2	0.0	0.5	0.0	5.6	Y Y Rouro of Roturn Flour within DAU/County - Managed W Y Y Rouro of Roturn Flour within DAU/County - Urban	2 Applied Water Rewre	3 Urban 3 Urban	0	ő
Withir Withir	in Systom - Rocyc in Systom - Rocyc	cled Water URE	B15E (0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 1	Y Y Urban-Wartowator Rocycling-Urban Y Y Urban-Doralination-Urban	22 Recycled Water 22 Recycled Water	3 Urban 3 Urban	0	0
	in System Waste	ouator UR	RB36 1	15.5 18.6	0.2	0.0 34 83.7	0.0	15.7	0.0	0.0	0.0	0.0 2M.5	0.0 858 F	0.0	0.0 ME/	0.0	0.0 568.3	0.0 386.2	0.0	0.0 1	Y Y Urban Wartowator Produced - Urban	40 Wartowater	3 Urban	0	0
Out		Hoffey atranspiration AC	G12 1	6.0	1.1	0.0	0.0	M2R.3 17.1	94.5 0.0	422.0 0.0	0.0	0.0	0.0	464.0 0.0	0.0	688.2 0.0	0.0	0.0	0.0	2657.6 0.0 Y	Y Y Roturn Flowr Evaporation and Evapotranspiration - Agr	8 Evapotranspiration	1 Agricultura	13 Roturn Flou	0
Out		atranspiration AC atranspiration A	G28 5 4G3 20	5.3 00.0	1.8	44.5 397.4	9.8	61.4 720.0	16.4	51.2 432.9	16.4 159.9	15.1 163.7	99.1 857.2	36.3 289.5	67.6	73.4 424.2	30.4 425.2	20.6	24.3 336.3	191.8 \\ 1808.3 \\	Y Y Effective Precipitation - Agriculture Y Y Evapotranspiration of Apolice Water - Agriculture	8 Evapotranspiration 8 Evapotranspiration	1 Agriculture 1 Agriculture	2 Effective Precipitati 1 Applied Water	ic 0
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Out	tofZone Evapo tofZone Evapo	otranspiration M otranspiration M	1W2 (0.0	0.0	5.3	0.0	5.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	23.3	0.0	0.0	0.0	23.3	Y Y Evapotranspiration of Applied Water - Managed Wetlan	8 Evapotranspiration	2 Managod Wotlandr 2 Managod Wotlandr	1 Applied Water	ő
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Out	tofZone Recyc	cled Water Export		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	NA NA	23 Recycled Water Export 23 Recycled Water Export	1 Agriculture 2 Managed Wetlands	0	0
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	tafZane Retur tafZane Retur		G9A (G9B (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0 1	Y Y Return Flau ta Oregan - Agriculture Y Y Return Flau ta Nevada - Agriculture		1 Agriculture 1 Agriculture		0
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Out	taf Zano Rotur taf Zano Rotur	rn Flau URE	W9C (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.3 0.0	0.0	0.0	0.0	19.3 \\ 0.0 \\	Y Y Roturn Flow to Dovoloped Supply (Other Region) - Man- Y Y Roturn Flow to Oregon - Urban	24 Return Flou 24 Return Flou	2 Managod Wotlandr 3 Urban	0	0
	tafZano Rotur tafZano Rotur	rn Flou URE	B17E (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Y Y Return Flow to Nevada - Urban Y Y Return Flow to Mexico - Urban	24 Roturn Flou 24 Roturn Flou	3 Urban 3 Urban	0	0
Out	tafZano Rotur	rn Fleu URE	B184 (0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Y Y Roturn Flaw to Salt Sink - Urban	24 Roturn Flou	3 Urban	0	0
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	on Systems Runof		P6a (6.0	0.6	10.6	6.9		2.5	8.6	4.4	3.0		6.9	6.7	9.3	7.0	7.9						o o	Ŏ
Betuee	en Systems Runof	off WF	P66 26	5.2	24.1	62E A	140.0	0.0	147.3	633.7	247.5	243.4	0.0	441.6	96.9	674.7	F34 F	334.3			Runaff-Incidental	25 Runaff	6 Incidental	0	0



Land system water budget

LAN	2014 Into Zone Out of Zone Between Systems D SYSTEM WATER BUDGET			Total PA 607	Total PA 608	Total PA 609
	Flow Type Origin/ Desination	Water Budget Handbook Component	CWP Index			
L	Inflow	Total Inflow		1020.3	959.8	2657.6
L	Outflow	Total Outflow		1055.1	1192.4	2516.2
L	Storage Change Change	Change in Land System Storage		0.0	0.0	0.0
L	Land System Mass Balance Error			-34.8	-232.6	141.4



Recommendations for Improvements to the Water Supply and Balance Data

 Precipitation and runoff data available from Cal-SIMETAW should be incorporated into water balances.

Recommendations for Aligning the Water Budget Accounting Template with Water Plan Data

- Clarify accounting of snowpack
- Update the recycled water export to a generic land system export
- Refine conveyance flows and surface water deliveries:
 - Rename existing conveyance seepage component to conveyance recharge component
 - Add a conveyance return flow component for water diverted from surface water system into conveyance facilities but then returns to that system
 - Update the surface water delivery term to account for additional components such as lateral conveyance seepage and imported waste waters
- Revisit wastewater tracking to account for wastewater produced within a region
- Add optional tracking for water used to produce energy

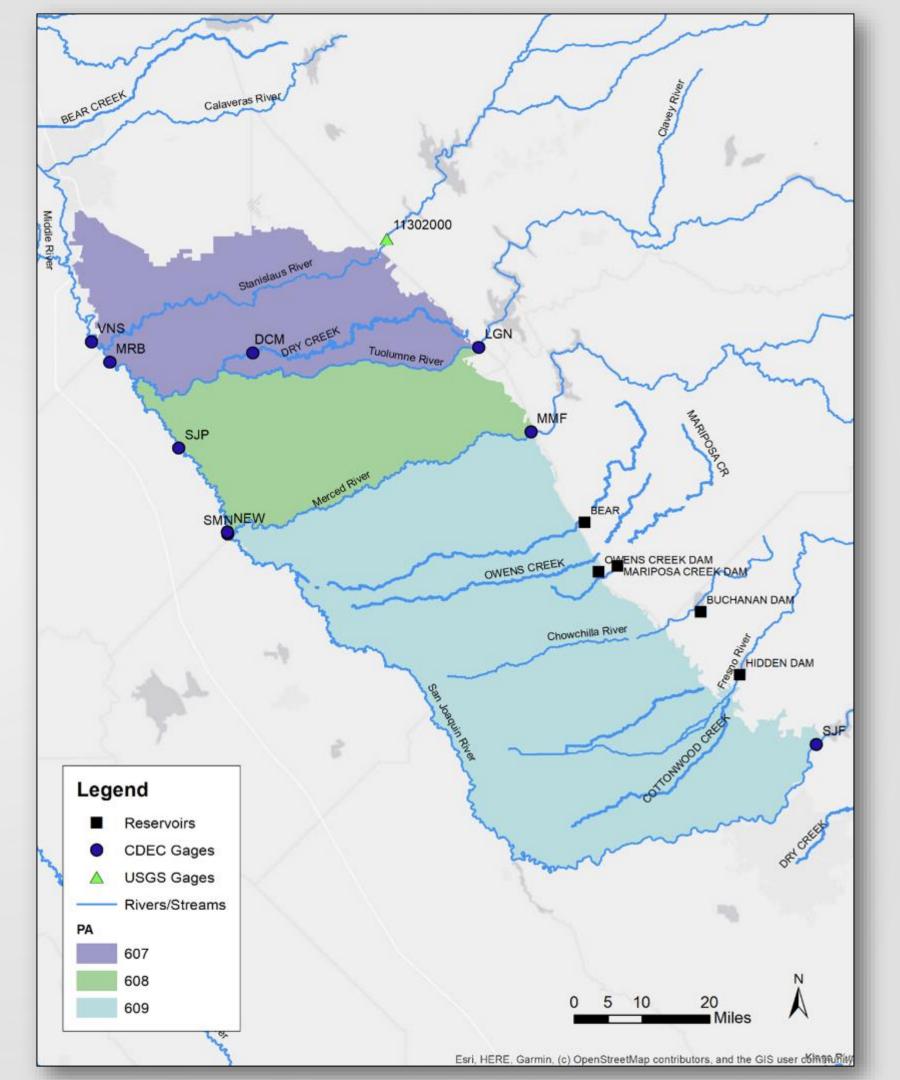


SURFACE WATER SYSTEM

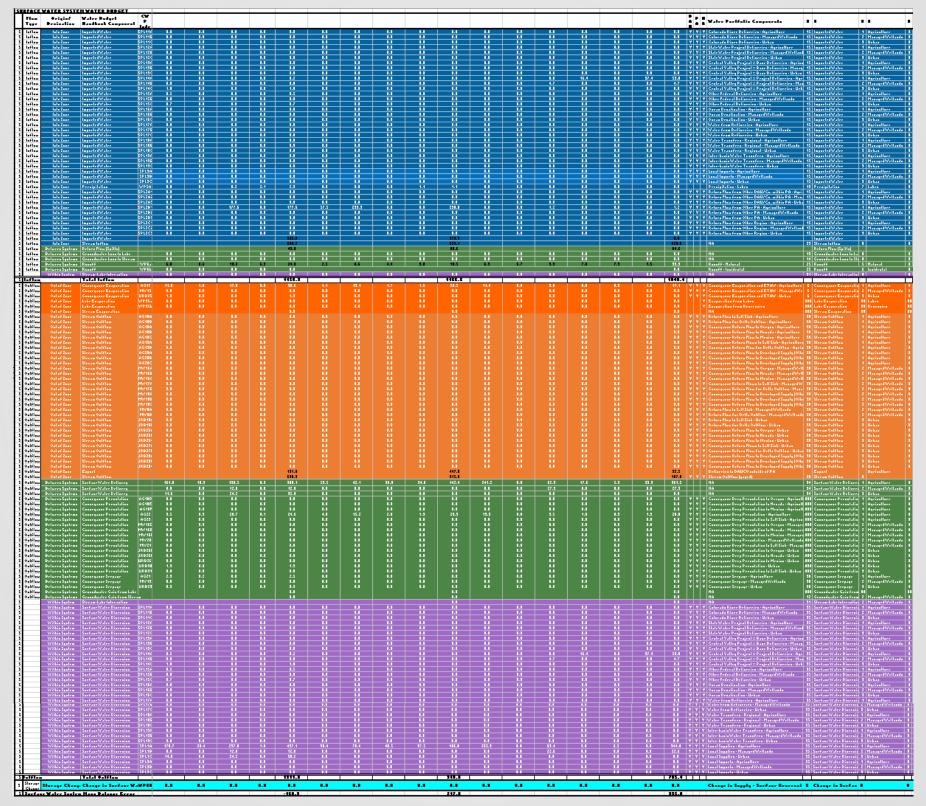
Surface water system water budget

- Rivers on borders of the Planning Areas make it difficult to properly attribute flows
- Many components of the surface water balance are not included as part of the water portfolio or are presented at too coarse a spatial scale to properly trace to the source
- Detailed river balance sheets that are tracked along side of, but not part of, the water supply and balance data were used to complete the water budget





Surface water system water budget





Surface water system water budget

	2014	Into Zone Out of Zone			Total PA 607	Total PA 608	Total PA 609
SUR	FACE WATE	R SYSTEM WATER BUDG	SET				
	Flow Type	Origin/ Desination	Water Budget Handbook Component	CWP Index			
S	Inflow		Total Inflow		1150.9	1166.6	1040.4
S	Outflow		Total Outflow		1311.8	948.8	705.4
S	Storage Change	Storage Change	Change in Surface Water Storage	WP60	0.0	0.0	0.0
S	Surface Wa	ater System Mass Balan	ce Error		-160.9	217.8	335.0



Recommendations for Improvements to the Water Supply and Balance Data

- Boundaries of the water supply and balance data should be revisited to include streams within the area rather than on boundaries when possible.
- Alternatively stream balance sheets could be incorporated into the water supply and balance data.



GROUND WATER SYSTEM

Groundwater system water budget

- Groundwater system data are included in the water supply and balance data, but only when the groundwater system interacts with the land system.
- Water supply and balance data on groundwater were augmented by processing data from C2VSIM FG v1.01 to obtain:
 - Subsurface flow
 - Release of water resulting from subsidence
 - Change in groundwater storage



Groundwater system water budget

HERWATER STATE	EH WATER BURGET																						
	Wales Budgel Bandbank Component	CM																			Waler Parifolia Componenta		
Flow Into Zone	Sakanefane laftan	WPI					38.6					185.8							555.4		Greendwaler Soboorfans Inflow	32 Sebesefase leftes	
Floor Into Zoor	Water Release Cassed by La	and Sabair con-					25.6					45.2							333.8		HA	97 Water Release Caused	T T
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	an Consequent Persolation	AG18F	i.i			1.1	1.1	1.1	1.1	1.1	1.1	· · ·		1.1	i.i	 	1.1	1.1			Y Connegator Deep Prenolation to Hesion · Agrico		
	nn Connegator Persolation	AGZZ	5.5	1.:	28.7	1.1	24.5	4.1	15.2	2.1	1.3	23.5	15.5	1.1	1.5	1.0	1.1	1.1	28.8	YY	Y Connegator Deep Perualalian - Agriculture	IIII Conceganor Percolalis	a 1 Agricullare
	nn Conneganne Pernulation nn Conneganne Pernulation	AG21				+								 		 	-				Y Conneganor Deep Pernulation to Sall Sink - Agric Y Conneganor Deep Pernulation to Oregon - Urban		
	nn Connegator Persolalian	JRP261	1.1			1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1			Y Connegació Deep Prendalina la Henada - Uchan		
	nn Connegator Persolation	URBZE	1.1			1.1	1.1	I.I	1.1	1.1	1.1	1.1	I.I	1.1	1.1	1.1	1.1	1.1			Y Connegator Deep Prevolution to Hesion - Uchan		
	nn Conneganne Pernulation nn Conneganne Pernulation	HT/21EE	1.1				1.1		1	I.I	1:1	1		1.0		1		B.1			Y Conneganne Deep Pernulation to Oregon - Manage Y Conneganne Deep Pernulation to Henada - Manage		
		HWHI	1.1			1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1		4 4	Y Connegative Deep Prenalation to Henium : Hanag	u IIII Conneganne Persolalis	n 2 HanagedWel
efina – Pelaces System	nn Connegator Perculation	HW28	<u> </u>			<u> </u>	1.1	<u> </u>	1.1	<u> </u>	I.I		1.1	<u> !.!</u>	1.1	<u> </u>	1.1				Y Connegació Desp Prendation : Hanaged Welland		
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efina – Pelucca Squica	un Renharge of Applied Waler	AGS	6.1	1.7	111	1.1	7.5	1.1	1.1	1.1	1.1	1.1	47.7	11.3	I.I	58.4	15.4	1.1	151.1	Y Y	Y Deep Perualation of Applied Water - Agriculture	28 Renkarge of Applied W	7. 1 Agricullare
	un Renkarge of AppliedWaler un Renkarge of AppliedWaler		1.1			1.1	1.1	I. I	1.1	1.1	1.1	1.0	1.1	1.1	2.5	1.1	1.1	1.1			Y Deep Persolution of Applied's'aler In Sall Sich - 6 Y Deep Persolution In Oregon - Agriculture	(d. 28 Renharge of Applied') 	
	nn Renharge né Applied Waler		1.1			1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	iii	1.1	1.1	1.1			Y Deep Persolation to Menada - Agriculture	28 Renkarge of Applied W	
	nn Renkarge of Applied Waler		1.1			1.1	1.1	1.1	1.1	1.1	1.1	1.1		1.1		1.1	1.1	1.1			Y Deep Persolation to Menion : Agriculture	21 Renharge of AppliedW	
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	nn Renkarge of AppliedWaler		1.1			1.1	1.1	1.1	1.1	1.1	1.1			1.1		1.1	1.1	1.1			Y Deep Perculation to Henada - Hanaged Wellands		
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	nn Benkarge of AppliedWaler		1.1			1.1	1.1	1.1	1.1	1.1	1.1		1.1	1.1	1.1	1.1	1.1	1.1			Y Deep Persolation to Oregon - University	21 Renkarge of AppliedW	
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	nn Renkaene në Perninitation		1.1	1.3	5.5	3.4	12.8	1.3	4.3	2.2	1.5	1.1	3.5	3.4	1.6	5.5	1.1	1.1			Total Generalizates Halocal Resistance	21 Restares of Persicila	
Flore	Talal laftes		20.0	1.4	48.2	4.8	285.8	E_0	19.5	4.4	9.5	295.9	32.5	15.5	14.6	72.5	42.6	2.1					4 5 1 11
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délan Out of Zone	Schoolfan Onlflan	AG18F	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	8.8	1.1	1.1	1.1	1.1	1.1	1.1	1.1	YY	Y Connegacie Deep Perustation to Mexico - Agrico		
Iffica Out of Zone		AGSD OCER	-:-	1.0	1.0	- !! -	- 1.0	1.1	1.1	1.1	1.1		1.1	1	- !!	1.1	1.1				Y Deep Persolation to Overgon - Agriculture	35 Subserface Outflow	
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Ifles Oal of Zone	Sakara Kara Onliffer	HWHEE	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.0	1.1	1.0	1.1	i.i	1.1			Y Connegació Deep Prendation la Oregon - Hanagi		
Ifles Oal of Zoor		HWHEE	1.1	1.1		1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1				1.1		Y Connegació Deep Prenolation to Henada : Hanag		
Iflew Oal of Zoor Iflew Oal of Zoor		HW/10	-:-	1.0	1.0		- 1.0	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1		1.1			Y Connegative Deep Persolation to Herion - Hanag. Y Deep Persolation to Oregon - Hanaged Wellands		
Ifless Out of Zone	Schoorfeer Oulflee	HW7E	1.1	1.1		1.1	1.1	1.1	1.1	1.1	1.1	8.8	1.1	1.1	1.1	1.1	1.1	1.1			Y Deep Persolation to Henada - Hanaged Wellands		
Ifles Out of Zees		H6/77	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1			Y Deep Perculation to Henion - Hanaged Wellands		
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Ifles Oal of Zoor	_	URB17	1.1	1.1		 ;;	1.1	1.1	- iii	- iii	1.1	1.1	1.1	1.1	1.1	1.1	i.i	- iii	-		Y Deep Persolation to Menion - Union	33 Subserface Oulflow	
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	Sakasefuse Oalflas Sakasefuse Oalflas	WP25					15.7					76.5		 '''		 			107.4		Y Consequence Decy Personal aliana la Henina : Uchan General water School Face Onlifton	33 Sabasefase Oslflau	
	nn Grandwaler Esteasins		57.2	2.1	95.2	118.2	272.6	95.8	258.5	147.5	158.2	585.4	185.8	78.5	411.1	465.7	252.5	959.E			Y Geoodwalee Euleauliou - Unadjudinaled - Ageina		
lélau – Pel <u>uces Systes</u>	nn Grandwaler Esteasinn		1.0				8.8	I .I	1.1	1.1	8.8	I .I	1.1	1.0	13.8	1.0	1.1	1.1			Y Genealwater Cateaution - Unadjudinated - Hanag		
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lélau – Beluees Systes		SPLSB	1.1			1.1	i.i	i.i	i.i	1.1	1.1		i.i	i.i .	i.i	<u> </u>	iii	i.i			Y Gennadualee Euleanlinn - Adjudinaled - Hanaged		
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Groundwater system water budget

		Into Zone Out of Zone			Total PA 607	Total PA 608	Total PA 609
GRO		R SYSTEM WATER BUDG	ET				
	Flow Type	Origin/ Desination	Water Budget Handbook Component	CWP Index			
G	Inflow		Total Inflow		205.8	235.3	969.5
G	Outflow		Total Outflow		438.3	708.6	2062.8
G	Storage Change	Storage Change	Change in Groundwater Storage	WP59	-237.0	-304.0	-1064.0
G							
G	Groundwat	er System Mass Balanc	e Error		4.5	-169.3	-29.3



Recommendations for Improvements to the Water Supply and Balance Data

- Groundwater representation in the water supply and balance data is insufficient.
- Potential sources for additional groundwater information:
 - groundwater sustainability plan annual reports
 - integrated groundwater and surface water models developed for the area of interest.



Recommendations for Improvements to the Water Budget Accounting Template

- Refine the groundwater system in the water budget schematic to account for saline intrusion and potential saline intrusion barriers.
- Refine the groundwater system in the water budget schematic to account for the complex interactions in a multilayered groundwater system.



FUTURE WORK AND RESOURCES

Recommendations for Future Work

The Merced basin pilot study highlighted several challenges for transitioning from water supply and balance data to comprehensive water accounting.

- Expand the Merced basin pilot study using available data from annual reports submitted for GSPs, C2VSim, AWMPs, UWMPs, and other data
- Conduct additional pilot studies that consider regional variability, data availability, and organizational capacity.
- Develop a roadmap for developing basin, watershed, regional, and statewide water budgets.



Resources

- Water Supply and Balance to Water Budget: Merced Basin Pilot Study:
 - https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/California-Water-Plan/Docs/Update2023/Supporting-Documents/Water-Supply-and-Balanceto-Water-Budget---Merced-Basin-Pilot-Study.pdf
- Detailed accounting spreadsheet used for the study:
 - https://data.cnra.ca.gov/dataset/water-balance-to-water-budget-pilot-project-data
- Handbook for Water Budget Development: With or Without Models
 - https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Water-Budget-Handbook.pdf
- Water Budget Handbook Standardized Accounting Templates:
 - https://data.cnra.ca.gov/dataset/water-budget-handbook

