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

CWEMF Annual Meeting
Wednesday April 19, 10-11:45

Frank Qian, P.E.
Technical Manager
Woodard & Curran

Paul Shipman, P.E.
Senior Water Resources Engineer
DWR, Division of Planning

Acknowledgements

DWR Water Balance to Water Budget Team

Abdul Khan
Paul Shipman
James Common
George Valente
Todd Hillaire*

Woodard and Curran

Saquib Najmus
Frank Qian

Water Plan Reviewers/Contributors Group

Kamyar Guivetchi
Tito Cervantes
Lew Moeller
Jennifer Stricklin
Chris Montoya*

Alyse Briody
Steve Ewert
Dona Calder
+ Water Supply and Balance Team

CALIFORNIA DEPARTMENT OF WATER RESOURCES

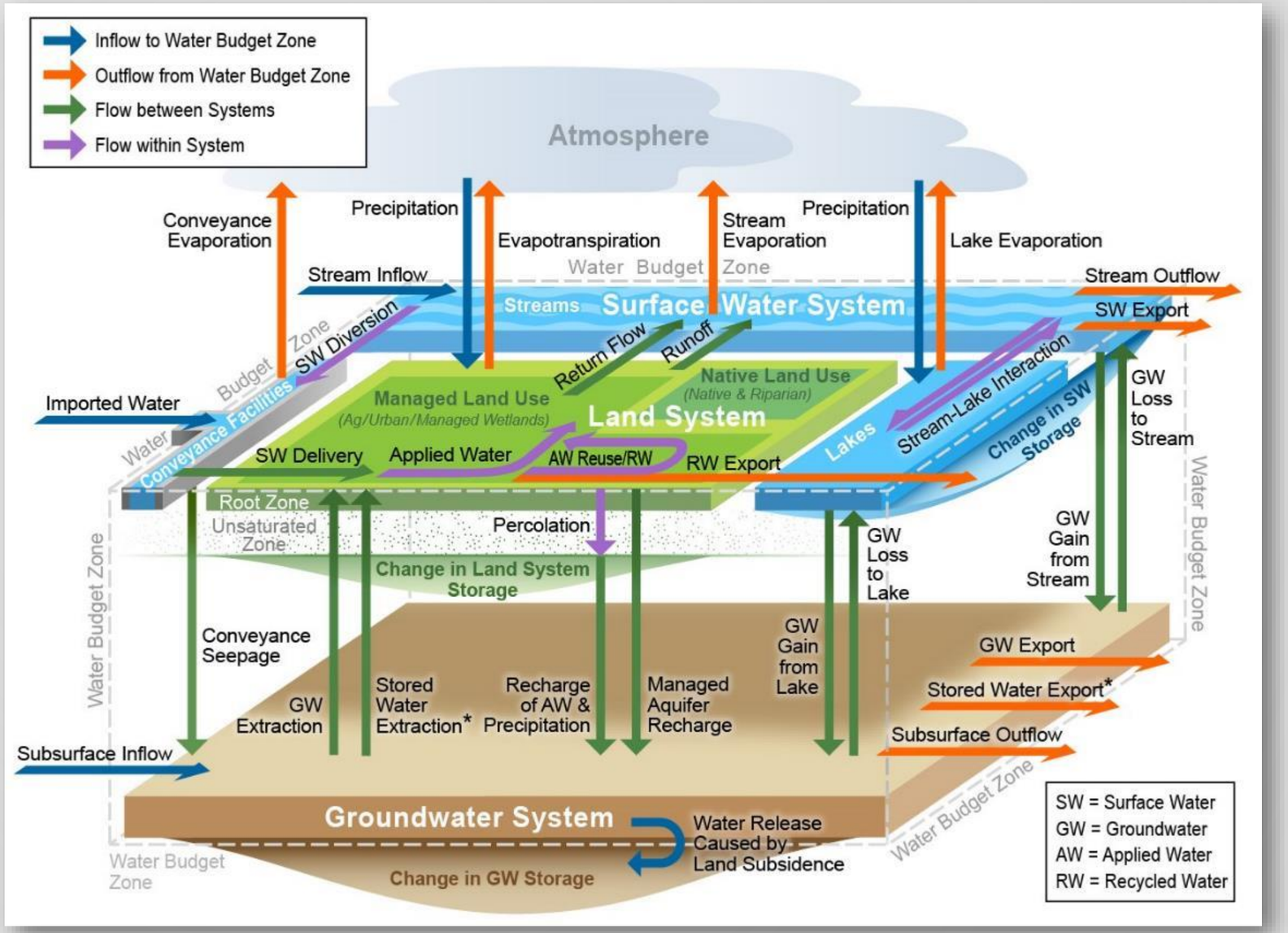
*Now Retired

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.

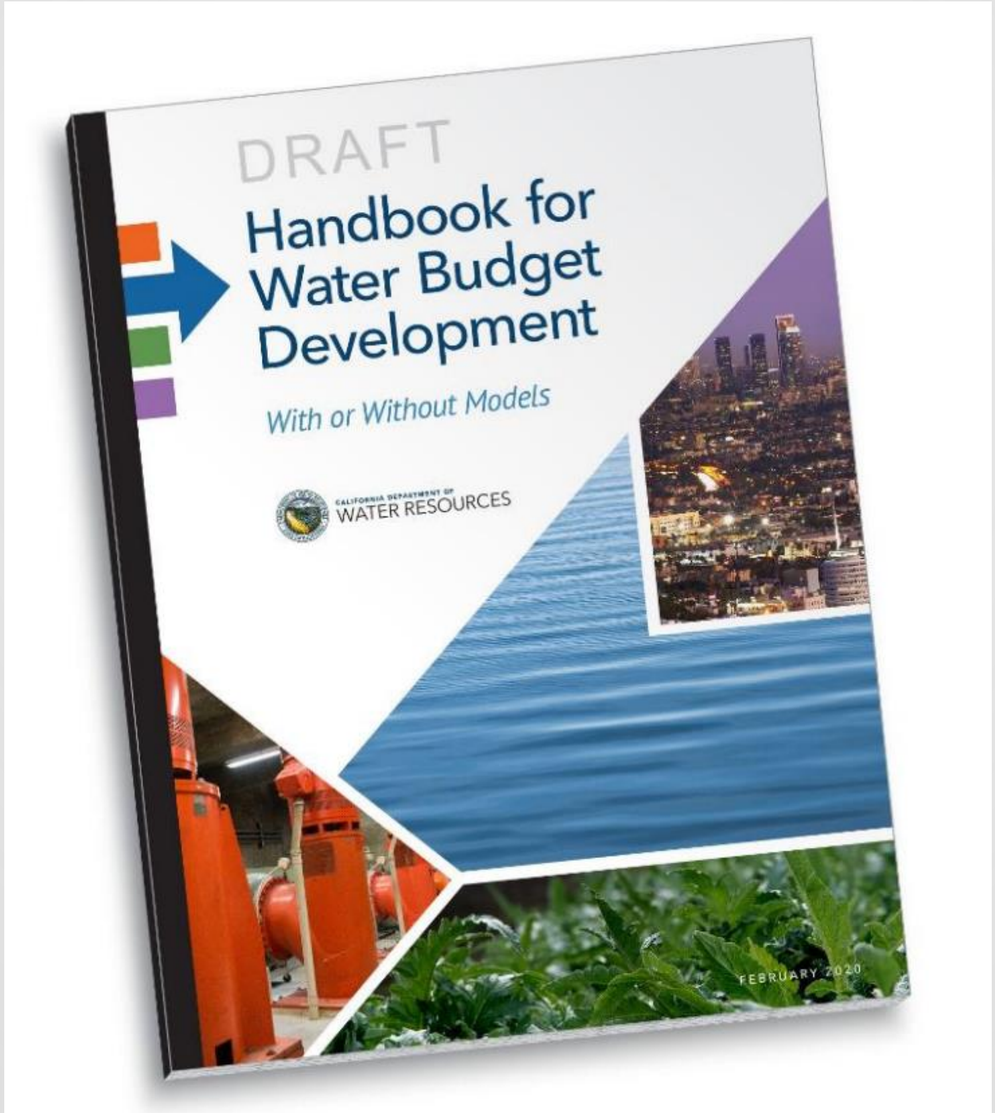
What is a water budget?

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.



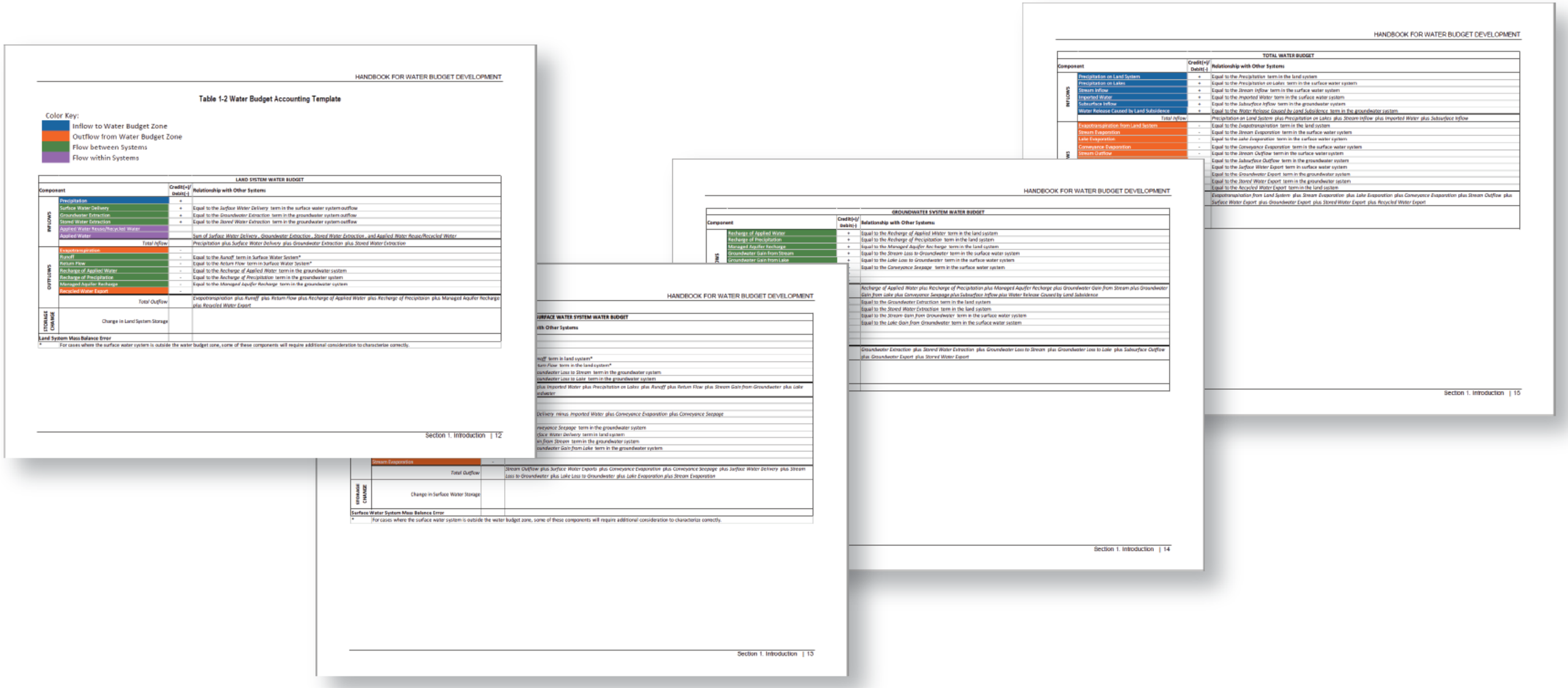
CALIFORNIA DEPARTMENT OF WATER RESOURCES

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



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Water Budget Handbook includes standardized accounting templates for each system.



HANDBOOK FOR WATER BUDGET DEVELOPMENT

Table 1-2 Water Budget Accounting Template

Color Key:
- Inflow to Water Budget Zone
- Outflow from Water Budget Zone
- Flow between Systems
- Flow within Systems

LAND SYSTEM WATER BUDGET			
Component		Credit(+)/ Debit(-)	Relationship with Other Systems
INFLOWS	Precipitation	+	
	Surface Water Delivery	+	Equal to the *Surface Water Delivery* term in the surface water system outflow
	Groundwater Extraction	+	Equal to the *Groundwater Extraction* term in the groundwater system outflow
	Stored Water Extraction	+	Equal to the *Stored Water Extraction* term in the groundwater system outflow
	Applied Water Reuse/Recycled Water		
	Applied Water		Sum of *Surface Water Delivery*, *Groundwater Extraction*, *Stored Water Extraction*, and *Applied Water Reuse/Recycled Water*
	Total Inflow		*Precipitation plus Surface Water Delivery plus Groundwater Extraction plus Stored Water Extraction*
OUTFLOWS	Evapotranspiration	-	
	Runoff	-	Equal to the *Runoff* term in Surface Water System*
	Return Flow	-	Equal to the *Return Flow* term in Surface Water System*
	Recharge of Applied Water	-	Equal to the *Recharge of Applied Water* term in the groundwater system
	Recharge of Precipitation	-	Equal to the *Recharge of Precipitation* term in the groundwater system
	Managed Aquifer Recharge	-	Equal to the *Managed Aquifer Recharge* term in the groundwater system
	Recycled Water Export	-	
	Total Outflow		*Evapotranspiration plus Runoff plus Return Flow plus Recharge of Applied Water plus Recharge of Precipitation plus Managed Aquifer Recharge plus Recycled Water Export*
STORAGE CHANGE	Change in Land System Storage		
Land System Mass Balance Error			

* For cases where the surface water system is outside the water budget zone, some of these components will require additional consideration to characterize correctly.

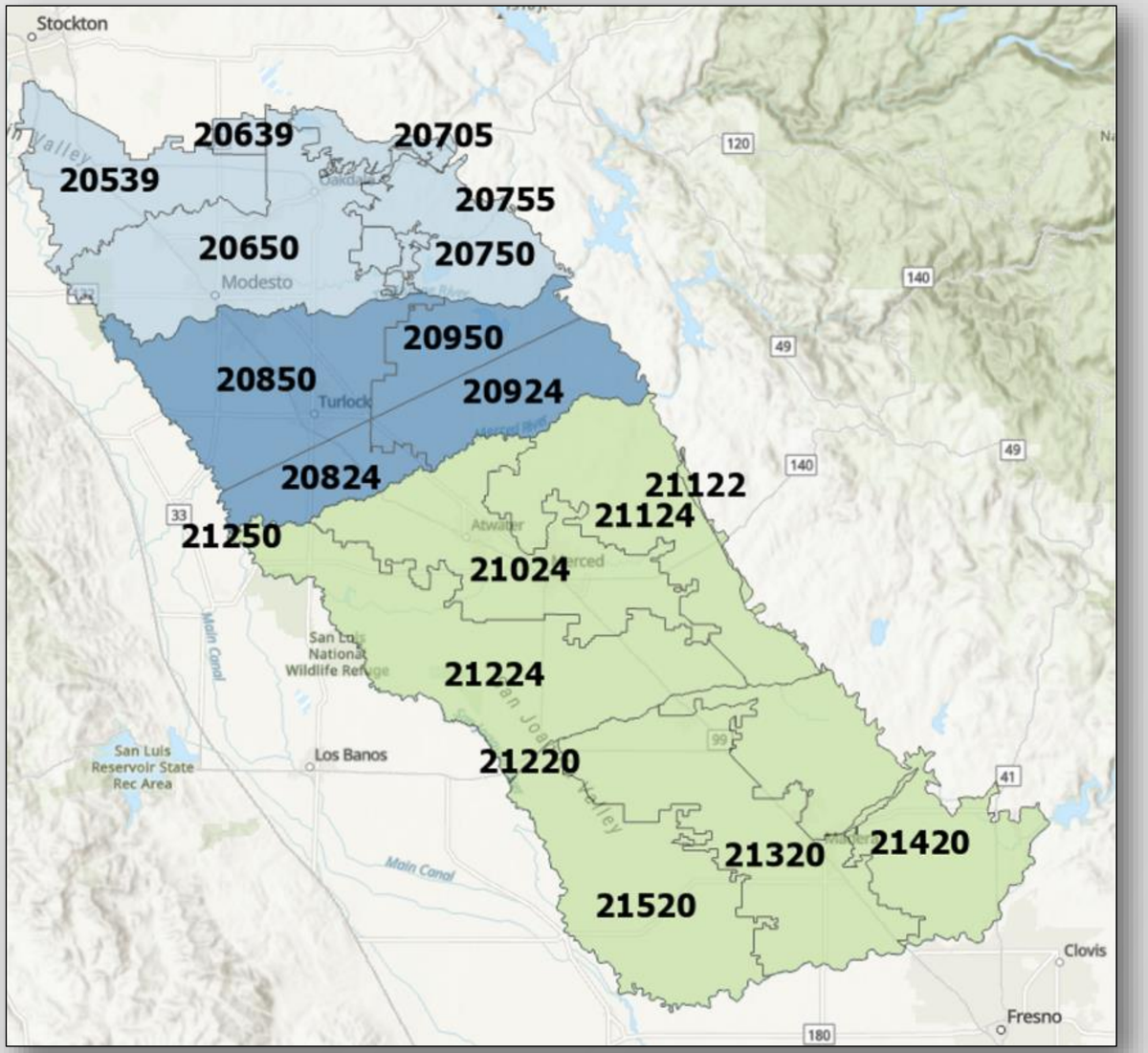
SURFACE WATER SYSTEM WATER BUDGET			
Component		Credit(+)/ Debit(-)	ith Other Systems
			runoff* term in land system*
			turn Flow term in the land system*
			oundwater Loss to Stream term in the groundwater system
			oundwater Loss to Lake term in the groundwater system
			plus *Imported Water plus Precipitation on Lakes plus Runoff plus Return Flow plus Stream Gain from Groundwater plus Lake*
			outflow
			Delivery minus Imported Water plus Conveyance Evaporation plus Conveyance Seepage
			nveyance Seepage term in the groundwater system
			face Water Delivery term in land system
			m from Stream term in the groundwater system
			oundwater Gain from Lake term in the groundwater system
	Stream Evaporation	-	
	Total Outflow		*Stream Outflow plus Surface Water Exports plus Conveyance Evaporation plus Conveyance Seepage plus Surface Water Delivery plus Stream Loss to Groundwater plus Lake Loss to Groundwater plus Lake Evaporation plus Stream Evaporation*
STORAGE CHANGE	Change in Surface Water Storage		
Surface Water System Mass Balance Error			

* For cases where the surface water system is outside the water budget zone, some of these components will require additional consideration to characterize correctly.

GROUNDWATER SYSTEM WATER BUDGET			
Component		Credit(+)/ Debit(-)	Relationship with Other Systems:
	Recharge of Applied Water	+	Equal to the *Recharge of Applied Water* term in the land system
	Recharge of Precipitation	+	Equal to the *Recharge of Precipitation* term in the land system
	Managed Aquifer Recharge	+	Equal to the *Managed Aquifer Recharge* term in the land system
	Groundwater Gain from Stream	+	Equal to the *Stream Loss to Groundwater* term in the surface water system
	Groundwater Gain from Lake	+	Equal to the *Lake Loss to Groundwater* term in the surface water system
			Equal to the *Conveyance Seepage* term in the surface water system
			Recharge of Applied Water plus Recharge of Precipitation plus Managed Aquifer Recharge plus Groundwater Gain from Stream plus Groundwater Gain from Lake plus Conveyance Seepage plus Subsurface Inflow plus Water Release Caused by Land Subsidence
			Equal to the *Groundwater Extraction* term in the land system
			Equal to the *Stored Water Extraction* term in the land system
			Equal to the *Stream Gain from Groundwater* term in the surface water system
			Equal to the *Lake Gain from Groundwater* term in the surface water system
			Groundwater Extraction plus Stored Water Extraction plus Groundwater Loss to Stream plus Groundwater Loss to Lake plus Subsurface Outflow plus Groundwater Export plus Stored Water Export

TOTAL WATER BUDGET			
Component		Credit(+)/ Debit(-)	Relationship with Other Systems
INFLOWS	Precipitation on Land System	+	Equal to the *Precipitation* term in the land system
	Precipitation on Lakes	+	Equal to the *Precipitation on Lakes* term in the surface water system
	Stream Inflow	+	Equal to the *Stream Inflow* term in the surface water system
	Imported Water	+	Equal to the *Imported Water* term in the surface water system
	Subsurface Inflow	+	Equal to the *Subsurface Inflow* term in the groundwater system
	Water Release Caused by Land Subsidence	+	Equal to the *Water Release Caused by Land Subsidence* term in the groundwater system
	Total Inflow		*Precipitation on Land System plus Precipitation on Lakes plus Stream Inflow plus Imported Water plus Subsurface Inflow*
OUTFLOWS	Evapotranspiration from Land System	-	Equal to the *Evapotranspiration* term in the land system
	Stream Evaporation	-	Equal to the *Stream Evaporation* term in the surface water system
	Lake Evaporation	-	Equal to the *Lake Evaporation* term in the surface water system
	Conveyance Evaporation	-	Equal to the *Conveyance Evaporation* term in the surface water system
	Stream Outflow	-	Equal to the *Stream Outflow* term in the surface water system
			Equal to the *Subsurface Outflow* term in the groundwater system
			Equal to the *Surface Water Export* term in surface water system
			Equal to the *Groundwater Export* term in the groundwater system
			Equal to the *Stored Water Export* term in the groundwater system
			Equal to the *Recycled Water Export* term in the land system
			Evapotranspiration from Land System plus Stream Evaporation plus Lake Evaporation plus Conveyance Evaporation plus Stream Outflow plus Surface Water Export plus Groundwater Export plus Stored Water Export plus Recycled Water Export

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



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

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:

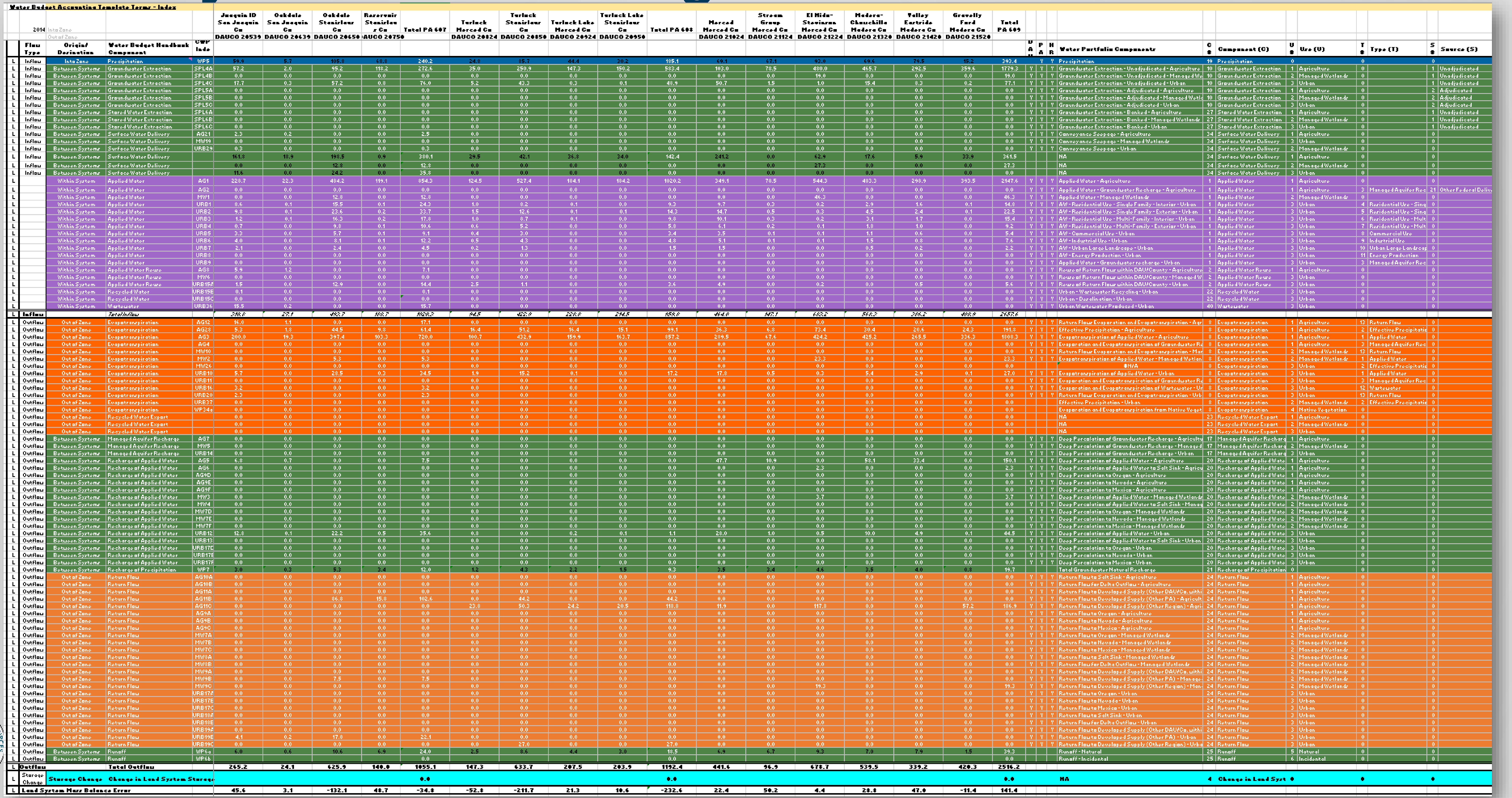
- Colorado River Deliveries: Agriculture.
- Colorado River Deliveries: Managed Wetlands.
- Colorado River Deliveries: Urban.
- …
- Water from Refineries: Agriculture.
- Water from Refineries: Managed Wetlands.
- Water from Refineries: Urban.
- …
- Return Flow from Other DAUCO within PA: Agriculture.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



Land system water budget

	2014	Into Zone			Total PA 607	Total PA 608	Total PA 609
		Out of Zone					
		Between Systems					
LAND SYSTEM WATER BUDGET							
	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	**Storage 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.

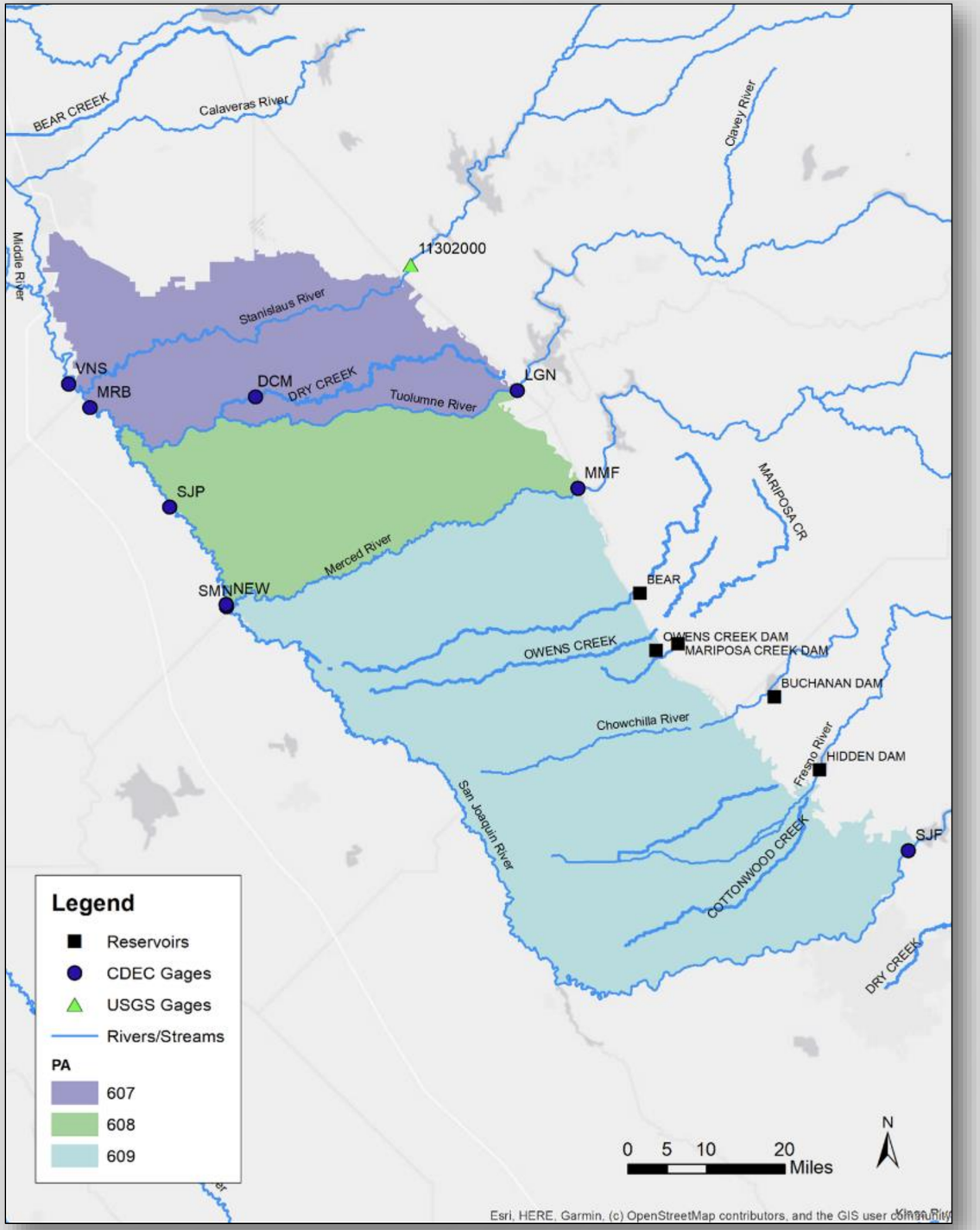
Recommendations for Aligning the Water Budget Accounting Template with Water Plan Data

- 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

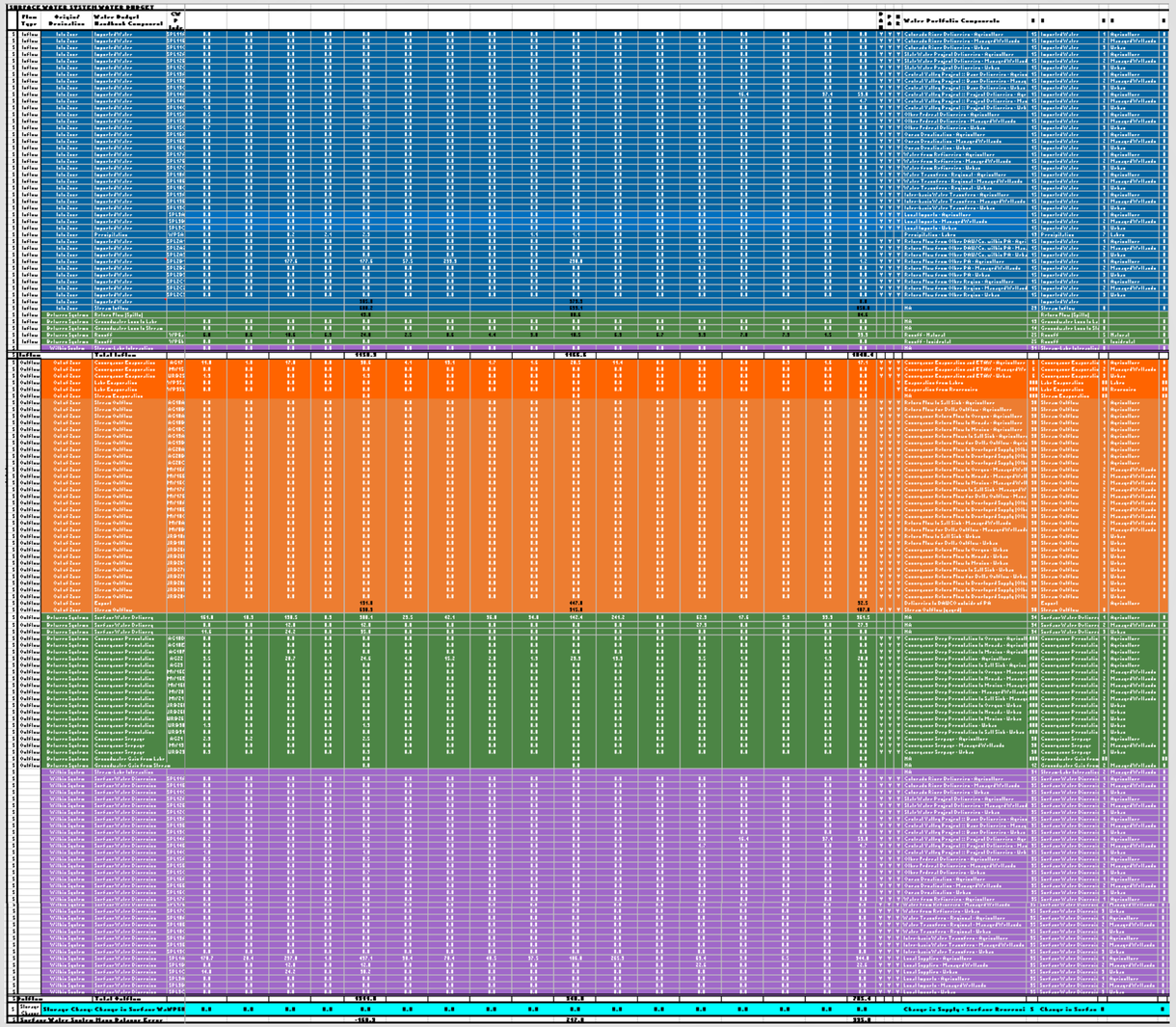
Surface water system water budget

- 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



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Surface water system water budget



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Surface water system water budget

	2014	Into Zone Out of Zone			Total PA 607	Total PA 608	Total PA 609
SURFACE WATER SYSTEM WATER BUDGET							
	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 Water System Mass Balance Error				-160.9	217.8	335.0

CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Recommendations for Improvements to the Water Supply and Balance Data

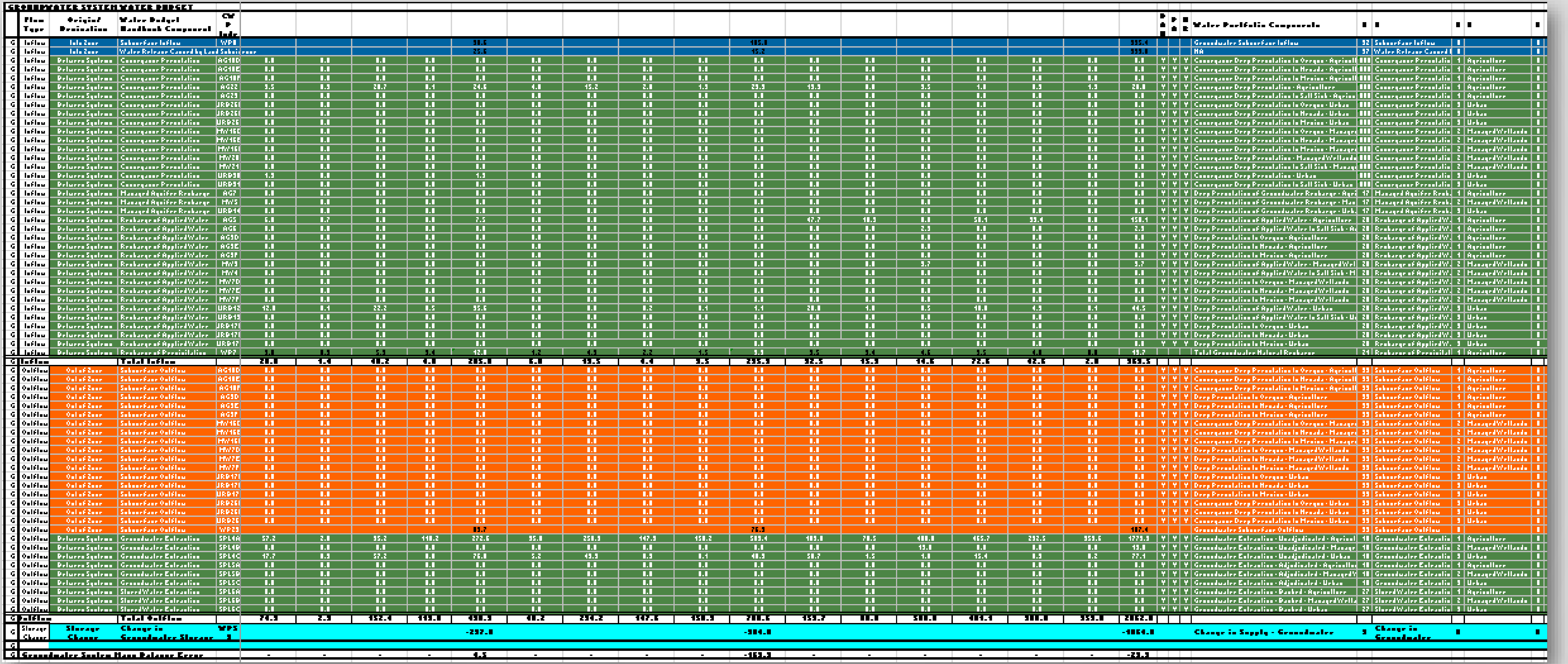
- Boundaries of the water supply and balance data should be revisited to include streams within the area rather than on boundaries when possible.
- Alternatively stream balance sheets could be incorporated into the water supply and balance data.

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



CALIFORNIA DEPARTMENT OF
WATER RESOURCES

Groundwater system water budget

	2014 Into Zone / Out of Zone				Total PA 607	Total PA 608	Total PA 609
GROUNDWATER SYSTEM WATER BUDGET							
	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	Groundwater System Mass Balance 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-Balance-to-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