Water Budgets

UC DAVIS WATER MANAGEMENT LAB

Union of Concerned Scientists
Science for a Healthy Planet and Safer World

Water Budgets

1. Recap of Groundwater 1.0

2. What is required for a water budget?

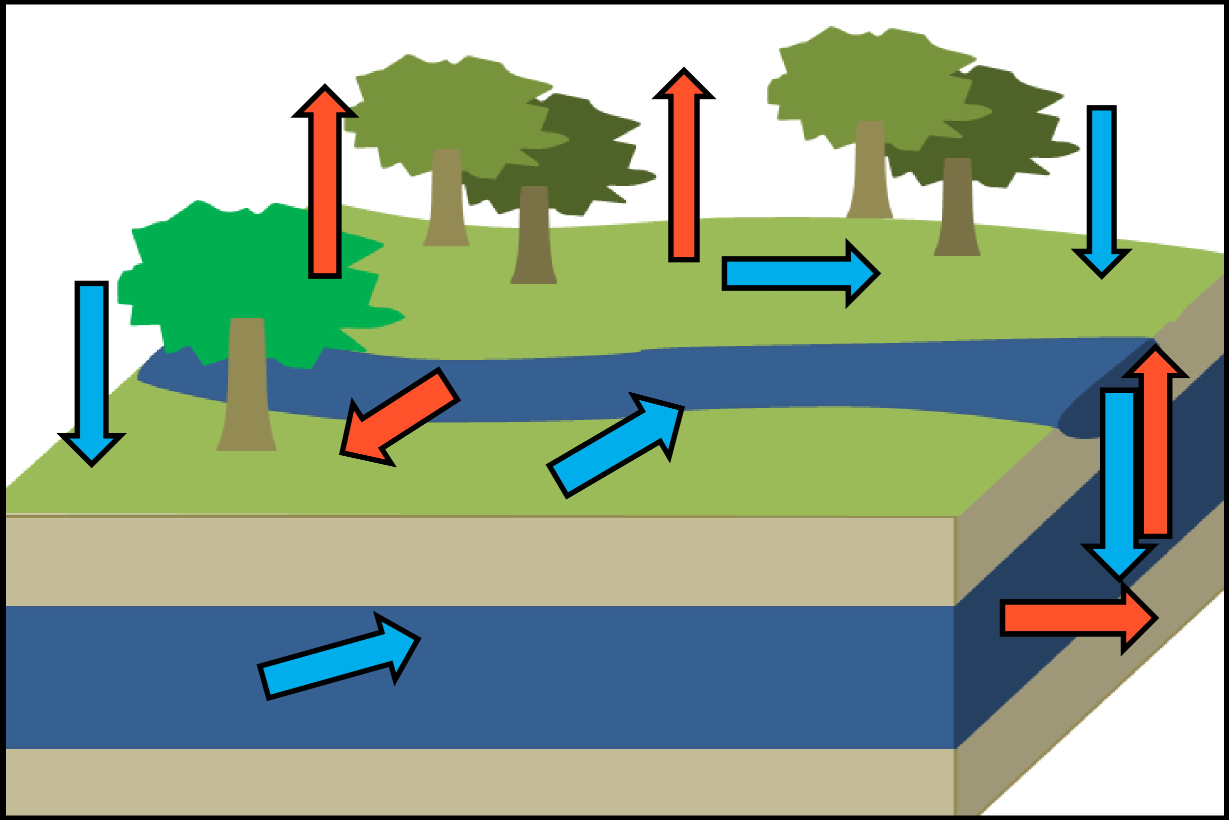
3. How will water budgets be used in GSPs?

4. Factors to consider

5. Practice!

“Conceptual” Water Budget

***Definition**: Accounts for all the water that flows into and out of a project area and accounts for the change of water storage with time*



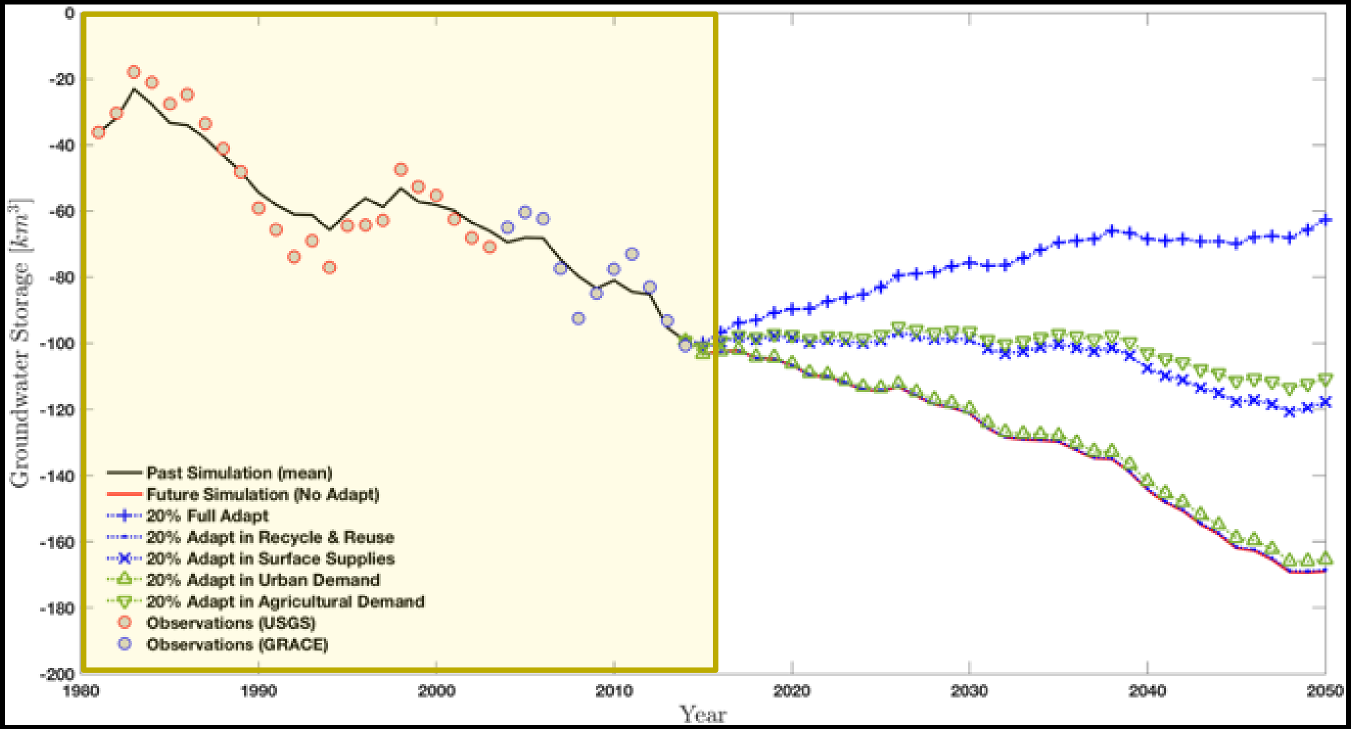
Inflows

Outflows

What can & can't it do?

Goal: calculate the ***change*** in the volume of water in storage underground

Bonus: can be used by water managers to explore different water management "scenarios"



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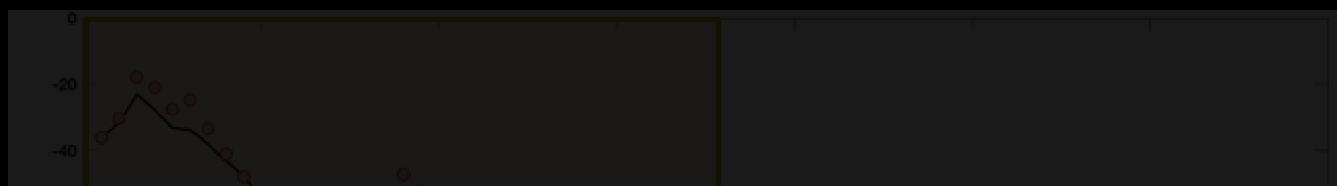
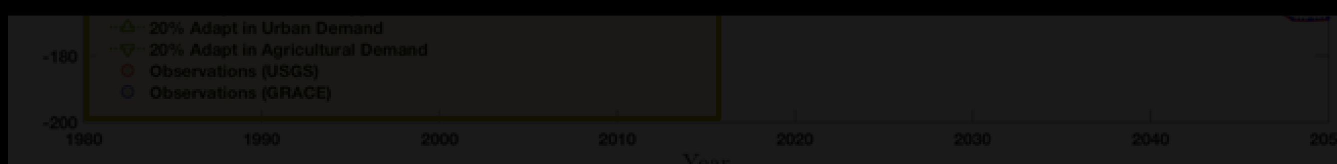


Limitation: accuracy and reliability depends on scale of data, area of interest, etc.

(garbage in → garbage out)



What can & can't it do?

CAN

- describe IF overdraft exists
- WHEN a basin went into overdraft

CANNOT

- provide detailed information on the state of aquifers
- give location-specific groundwater levels
- pinpoint responsible parties
- define extent of undesirable consequences

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What’s required?

Make decisions

Make predictions

Decide on uncertainty

Meet regulations

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How are water budgets used?

1. Track water
2. Prioritize resources
3. Improve communication
4. Estimate vs. measure
5. Understand surface – groundwater
6. Find balance
7. Gauge impact of people, plants, weather, etc.
8. Decide on sustainable pumping rates

How are water budgets used?

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How are water budgets used?

*8. Decide on sustainable pumping rates

Must be careful when well-being of a community is impacted

for example: pumping rate determines acres in production

- **Strawberries — $1.83 billion**
- **Pistachios — $1.5 billion**
- **Tomatoes — $1.33 billion**
- **Walnuts — $1.24 billion**
- **Oranges — $826 million**

(CDFA, 2017)

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Factors to consider

Historic Current Projected

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What happened in the past?

Go back as far as you can

Impact of droughts and floods

Changes in technology

Factors to consider

Historic | Current | Projected

What is happening now?

Measure vs. estimating water use

Relationship with surface water

Factors to consider

Historic Current Projected

<u>What will happen in the future?</u>

More people

Different crops

New climate

Factors to consider

Historic | Current | Projected

For any water budget….

- Uncertainty always matters!!!
  If results are reported in a <u>***range***</u> **so** you can prepare for extremes

- Groundwater storage changes <u>***slowly***</u> and can progress over decades as streams and groundwater systems try to reach equilibrium

Factors to consider

Native vs. non-native water

	Definition	Examples
Native	Percolates into the sub-basin from natural sources	Rainfall, natural stream bed flows, mountain sub-surface inflow
Non-native	Percolates into the sub-basin	Captured floodwater, imported water (Central Valley Project), appropriated water, conveyance losses

Questions

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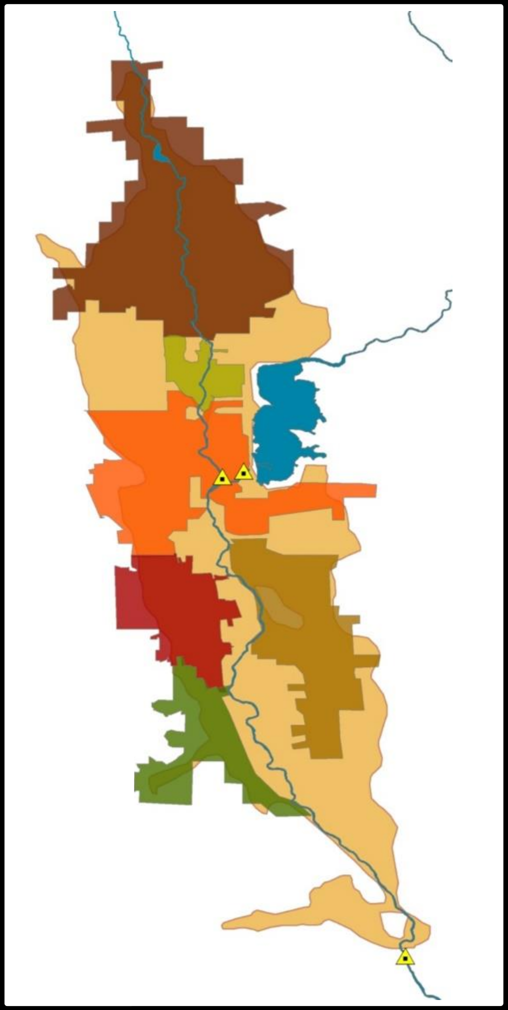
Practice

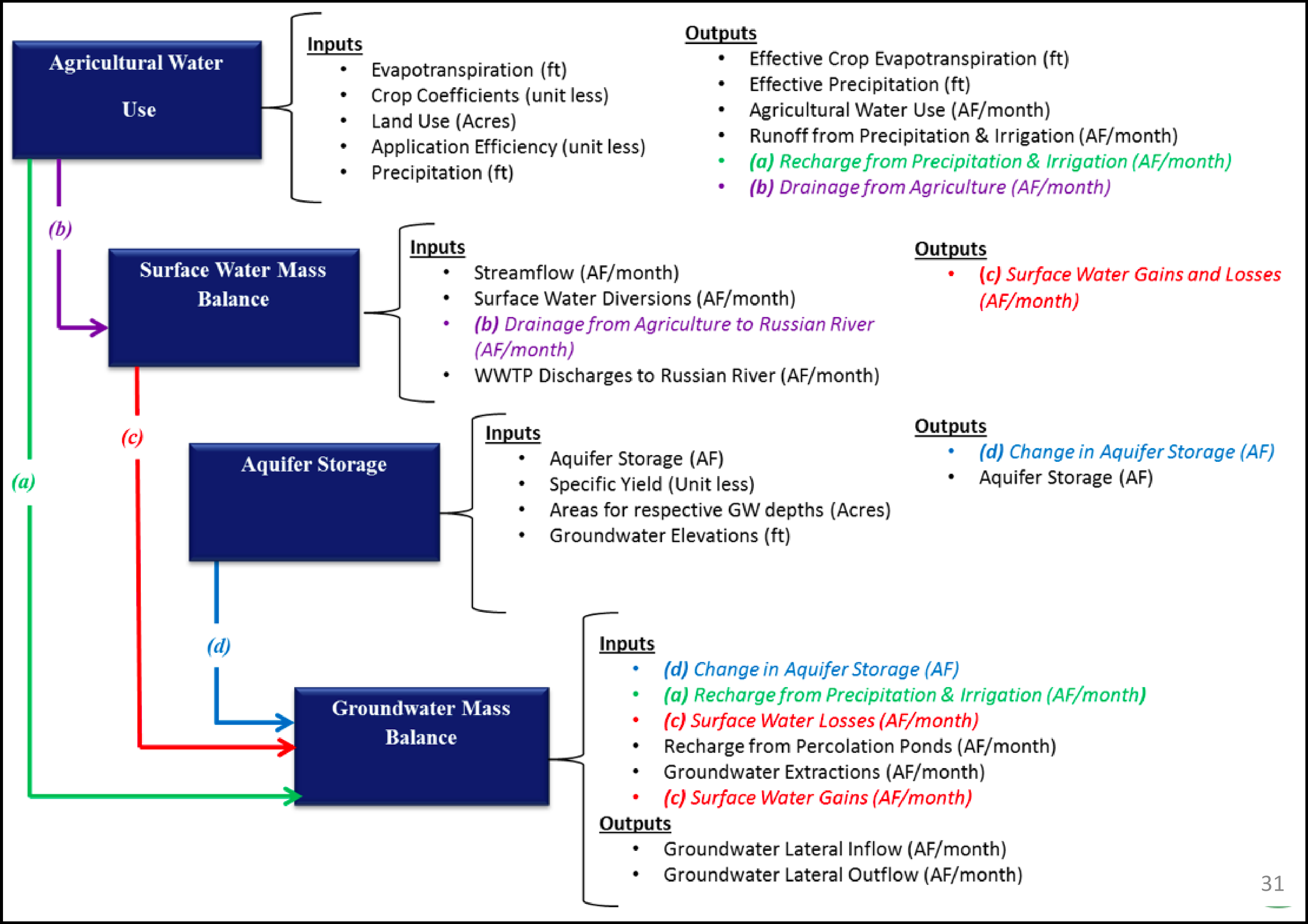
Project Specifications

- Project Boundary: Make Belief Groundwater Basin



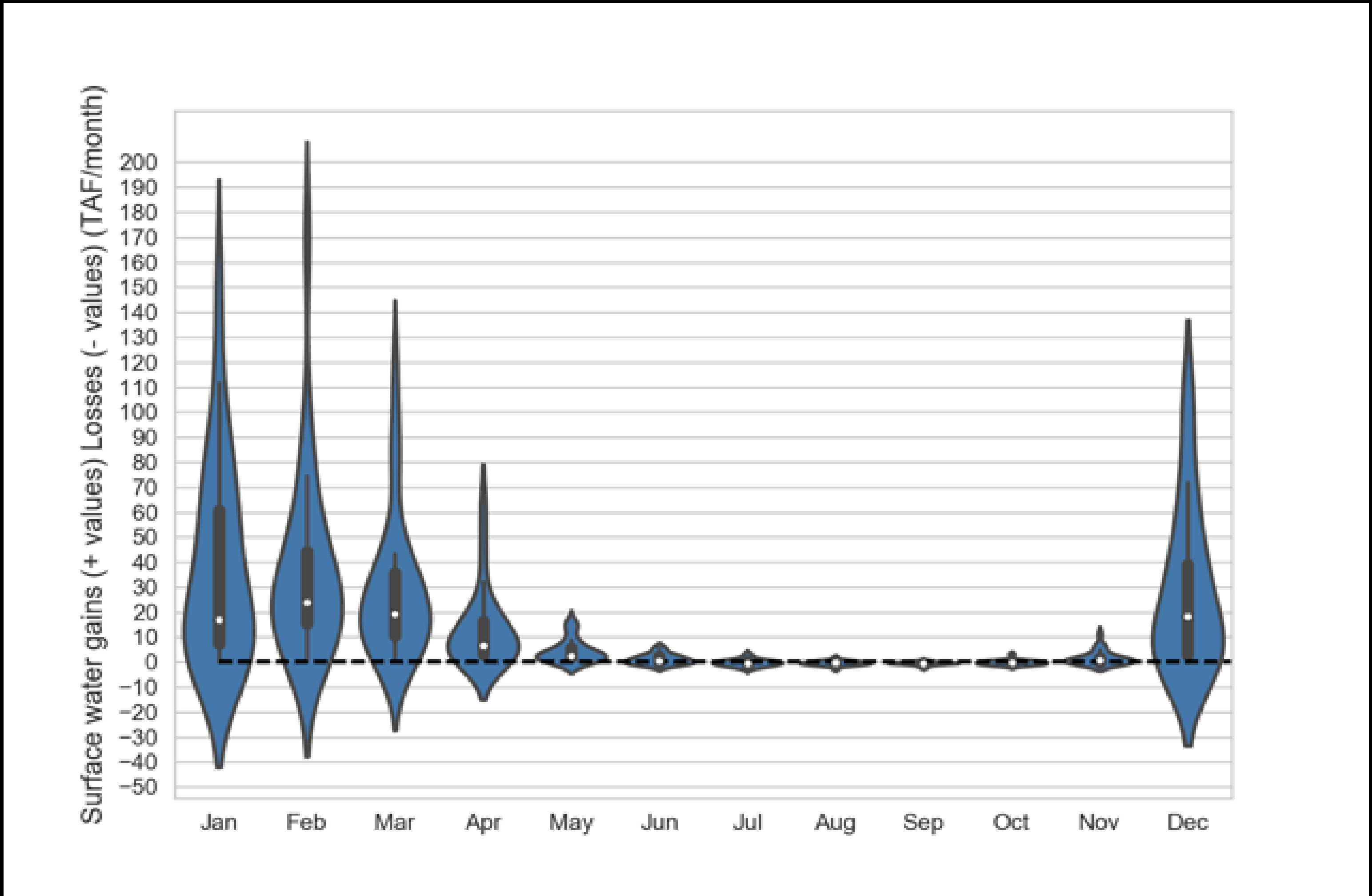
Data
Evapotranspiration
Crop Coefficients
Land Use
Application Efficiency
Precipitation
Stream Flow
City of Ukiah (Water)
RRFC Water Sales
Water Districts (Water)
Private Water Users
Tributary Influence
Evaporation
Specific Yield
Aquifer Storage
Groundwater Elevation Data

Methods

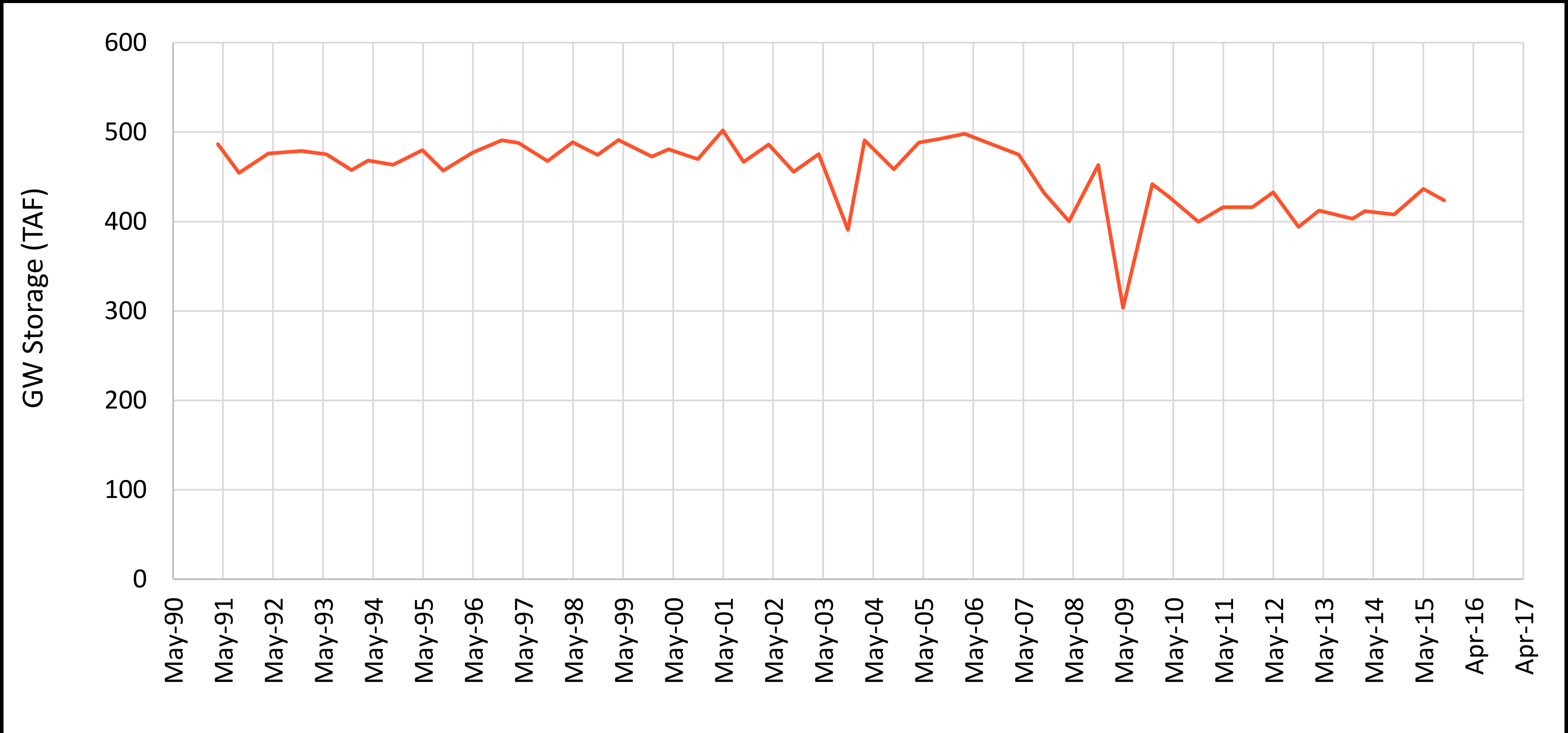


Agricultural Water Use
Inputs
Evapotranspiration (ft)
Crop Coefficients (unit less)
Land Use (Acres)
Application Efficiency (unit less)
Precipitation (ft)
Outputs
Effective Crop Evapotranspiration (ft)
Effective Precipitation (ft)
Agricultural Water Use (AF/month)
Runoff from Precipitation & Irrigation (AF/month)
(a) Recharge from Precipitation & Irrigation (AF/month)
(b) Drainage from Agriculture (AF/month)
(b)
Surface Water Mass Balance
Inputs
Streamflow (AF/month)
Surface Water Diversions (AF/month)
(b) Drainage from Agriculture to Russian River (AF/month)
WWTP Discharges to Russian River (AF/month)
Outputs
(c) Surface Water Gains and Losses (AF/month)
(c)
(a)
Aquifer Storage
Inputs
Aquifer Storage (AF)
Specific Yield (Unit less)
Areas for respective GW depths (Acres)
Groundwater Elevations (ft)
Outputs
(d) Change in Aquifer Storage (AF)
Aquifer Storage (AF)
(d)
Groundwater Mass Balance
Inputs
(d) Change in Aquifer Storage (AF)
(a) Recharge from Precipitation & Irrigation (AF/month)
(c) Surface Water Losses (AF/month)
Recharge from Percolation Ponds (AF/month)
Groundwater Extractions (AF/month)
(c) Surface Water Gains (AF/month)
Outputs
Groundwater Lateral Inflow (AF/month)
Groundwater Lateral Outflow (AF/month)

Results

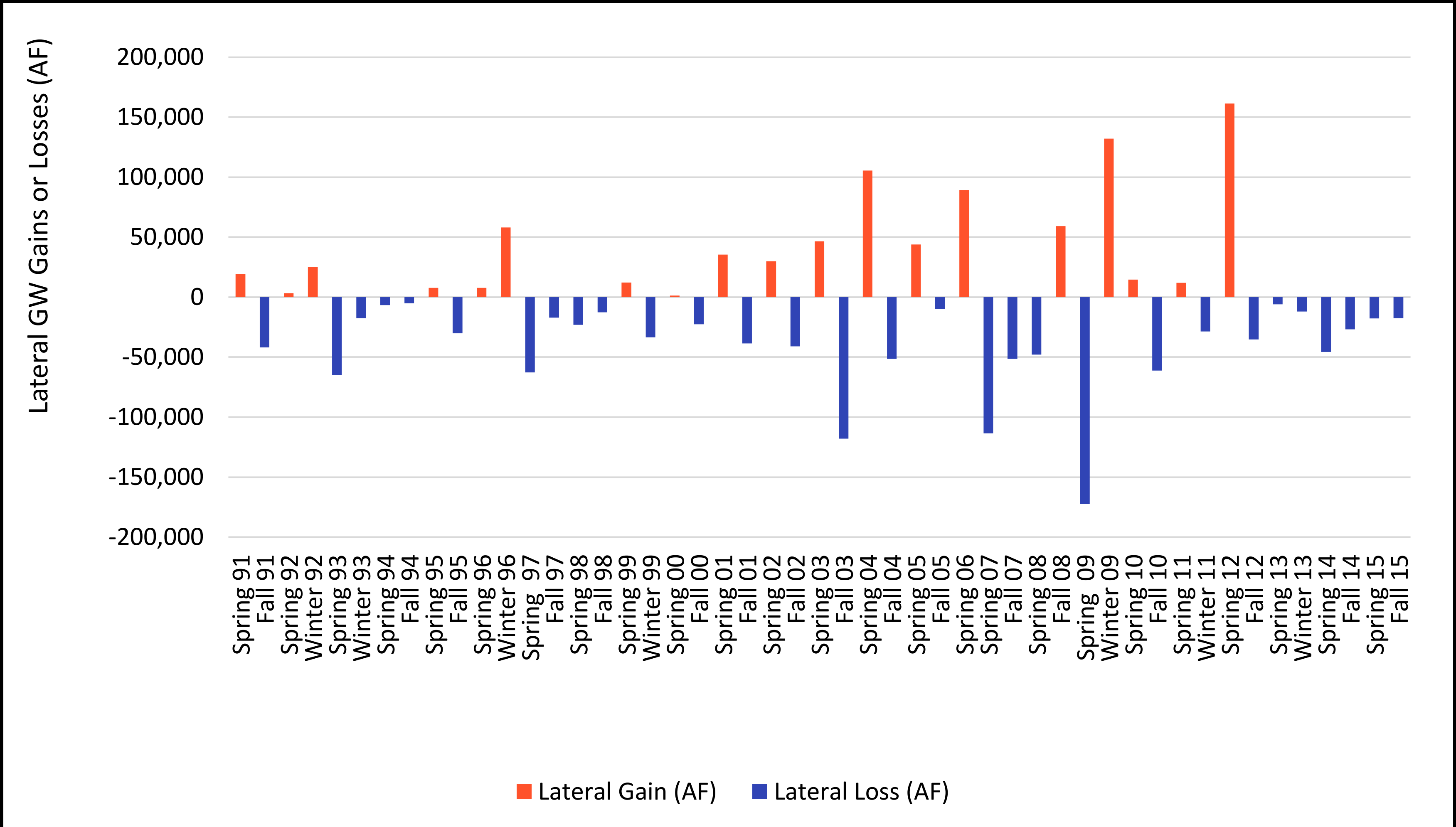

Surface water gains (+ values) Losses (- values) (TAF/month)
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-40
-50
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Results



GW Storage (TAF)
600
500
400
300
200
100
0
May-90
May-91
May-92
May-93
May-94
May-95
May-96
May-97
May-98
May-99
May-00
May-01
May-02
May-03
May-04
May-05
May-06
May-07
May-08
May-09
May-10
May-11
May-12
May-13
May-14
May-15
Apr-16
Apr-17

Results

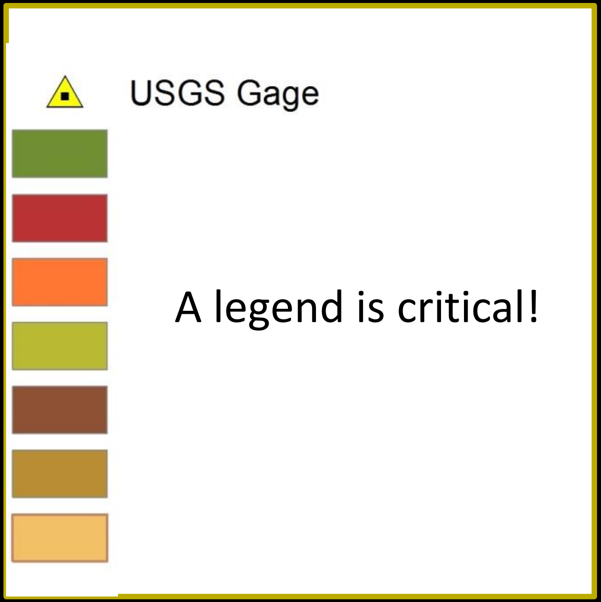


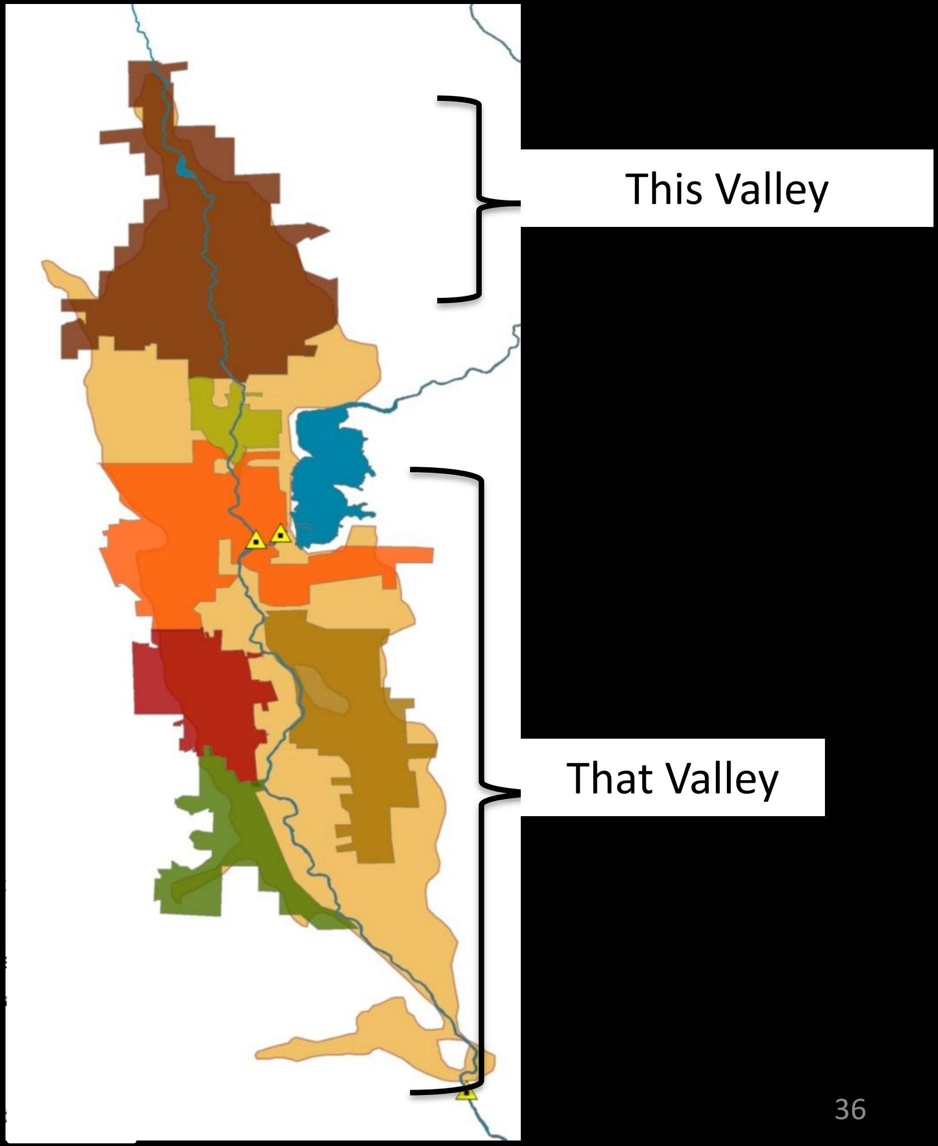
Lateral GW Gains or Losses (AF)
200,000
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
Spring 91
Fall 91
Spring 92
Winter 92
Spring 93
Winter 93
Spring 94
Fall 94
Spring 95
Fall 95
Spring 96
Winter 96
Spring 97
Fall 97
Spring 98
Fall 98
Spring 99
Winter 99
Spring 00
Fall 00
Spring 01
Fall 01
Spring 02
Fall 02
Spring 03
Fall 03
Spring 04
Fall 04
Spring 05
Fall 05
Spring 06
Spring 07
Fall 07
Spring 08
Fall 08
Spring 09
Winter 09
Spring 10
Fall 10
Spring 11
Winter 11
Spring 12
Fall 12
Spring 13
Winter 13
Spring 14
Fall 14
Spring 15
Fall 15
Lateral Gain (AF)
Lateral Loss (AF)

Practice

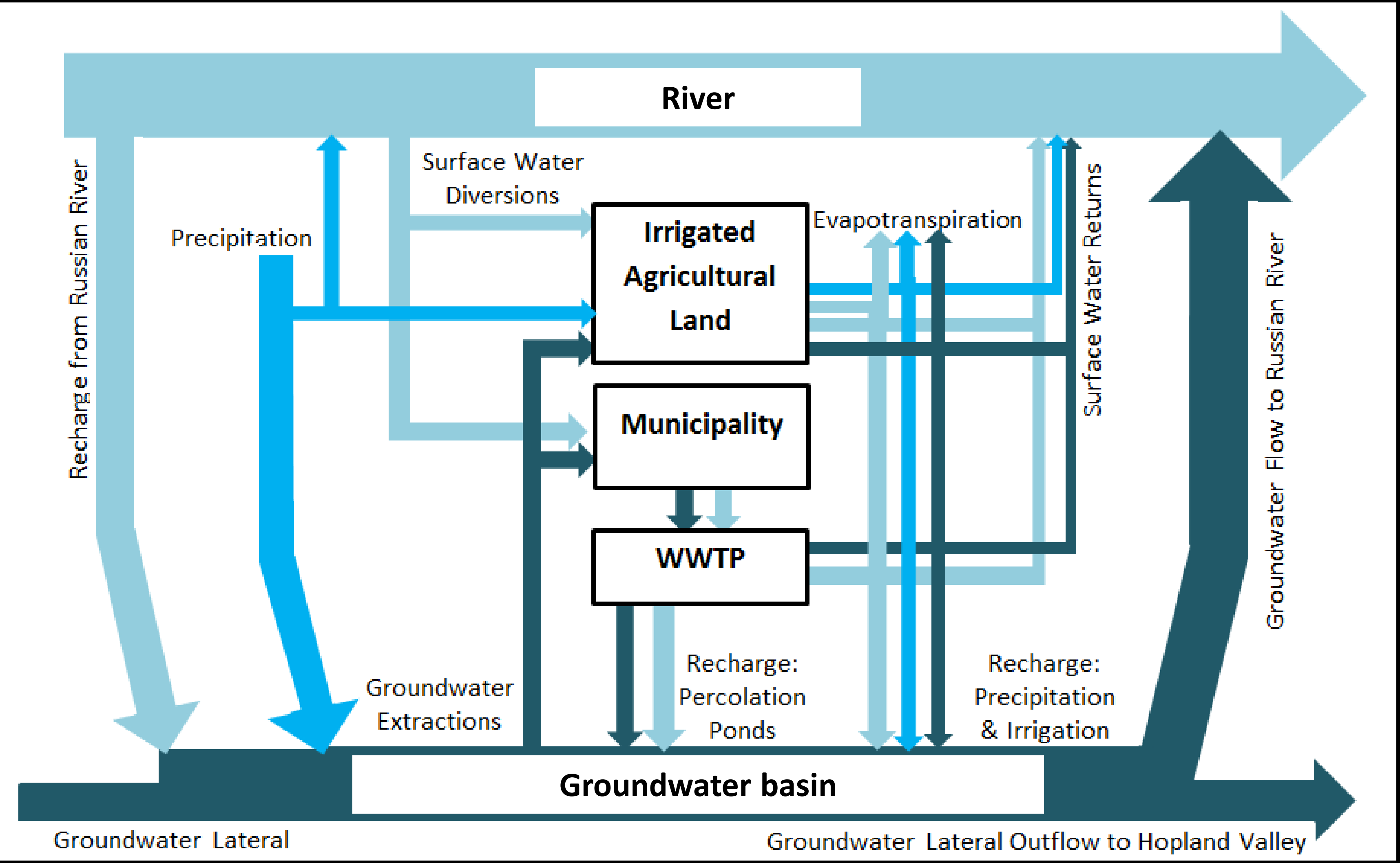
Project Specifications

- Time Period: 1991 - 2015
- Project Boundary: Make Belief Groundwater Basin
  - Consists of This Valley & That Valley





Conceptual model



Surface Water Mass Balance

$$\Delta Storage_t^{SW} = [\,Inflow_t^{SW} - Outflow_t^{SW}\,]\,\Delta t$$

Since there is no reservoir, $\Delta Storage_{\square}^{SW} = 0$ and therefore ,

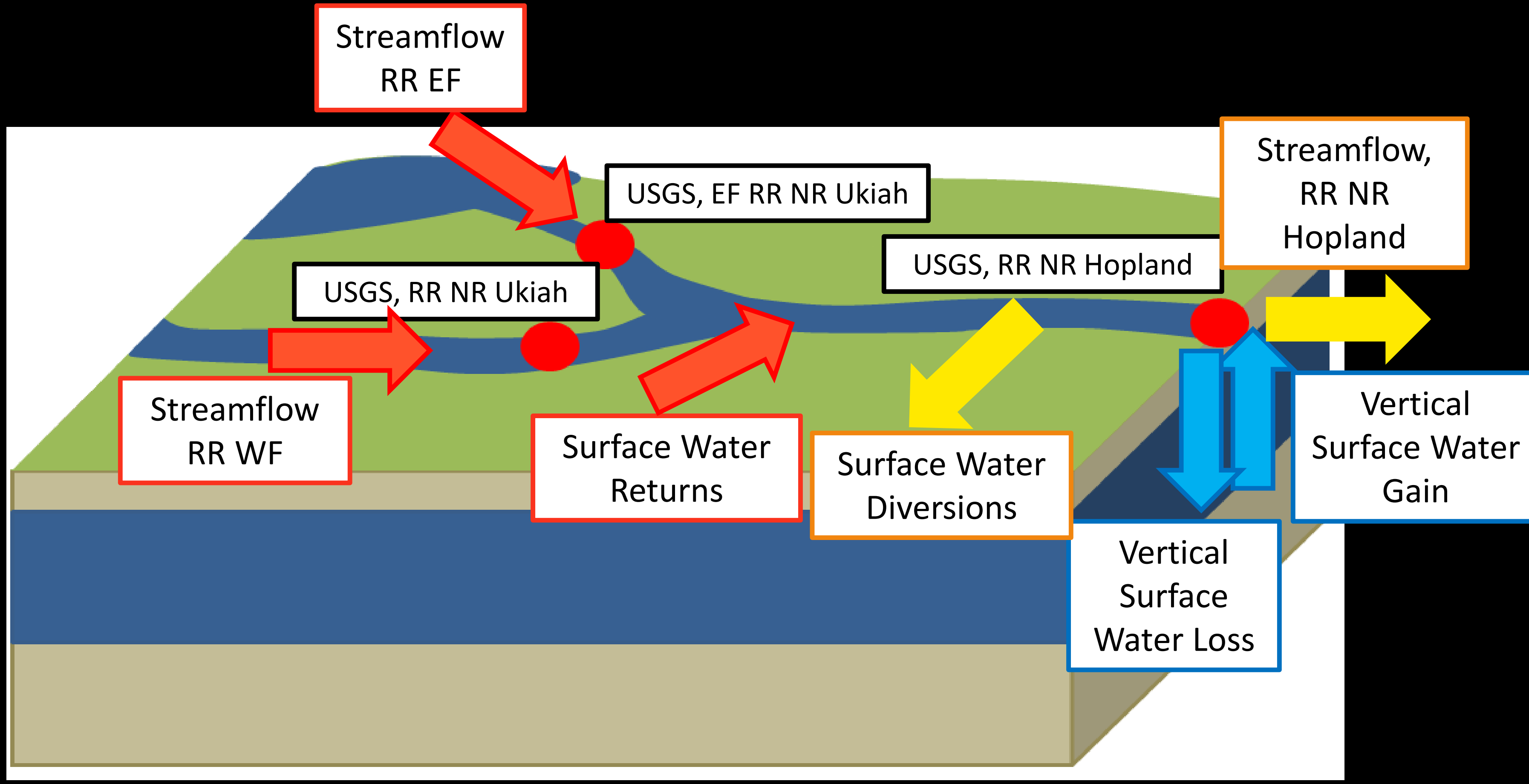
$$Inflow_t^{SW} = Outflow_t^{SW}$$

$$Inflow_t^{SW} = Q_t^{WF} + Q_t^{EF} + Return_t^{SW} + Return_t^{GW} + Gains_t^{SW}$$

$$Outflow_t^{SW} = Q_t^{Hopland} + \sum_{i=1}^{i=1} User_t^{SW,i} + Losses_t^{SW}$$

$$\left[Q_t^{Hopland} + \sum_{i=1}^{i=1} User_t^{SW,i}\right] - [Q_t^{WF} + Q_t^{EF} + Return_t^{SW} + Return_t^{GW}\,] = Gains_t^{SW} - Losses_t^{SW}$$

Surface Water Mass Balance



Groundwater Mass Balance

$$\Delta Storage_t{}^{GW} = [\, Inflow_t{}^{GW} - Outflow_t{}^{GW}]\Delta t$$

Since we have an aquifer,, $\Delta Storage_t{}^{GW} \neq 0$ and therefore ,

$$\boldsymbol{\Delta Storage_t{}^{GW} = [\, Inflow_t{}^{GW} - Outflow_t{}^{GW}]\Delta t}$$

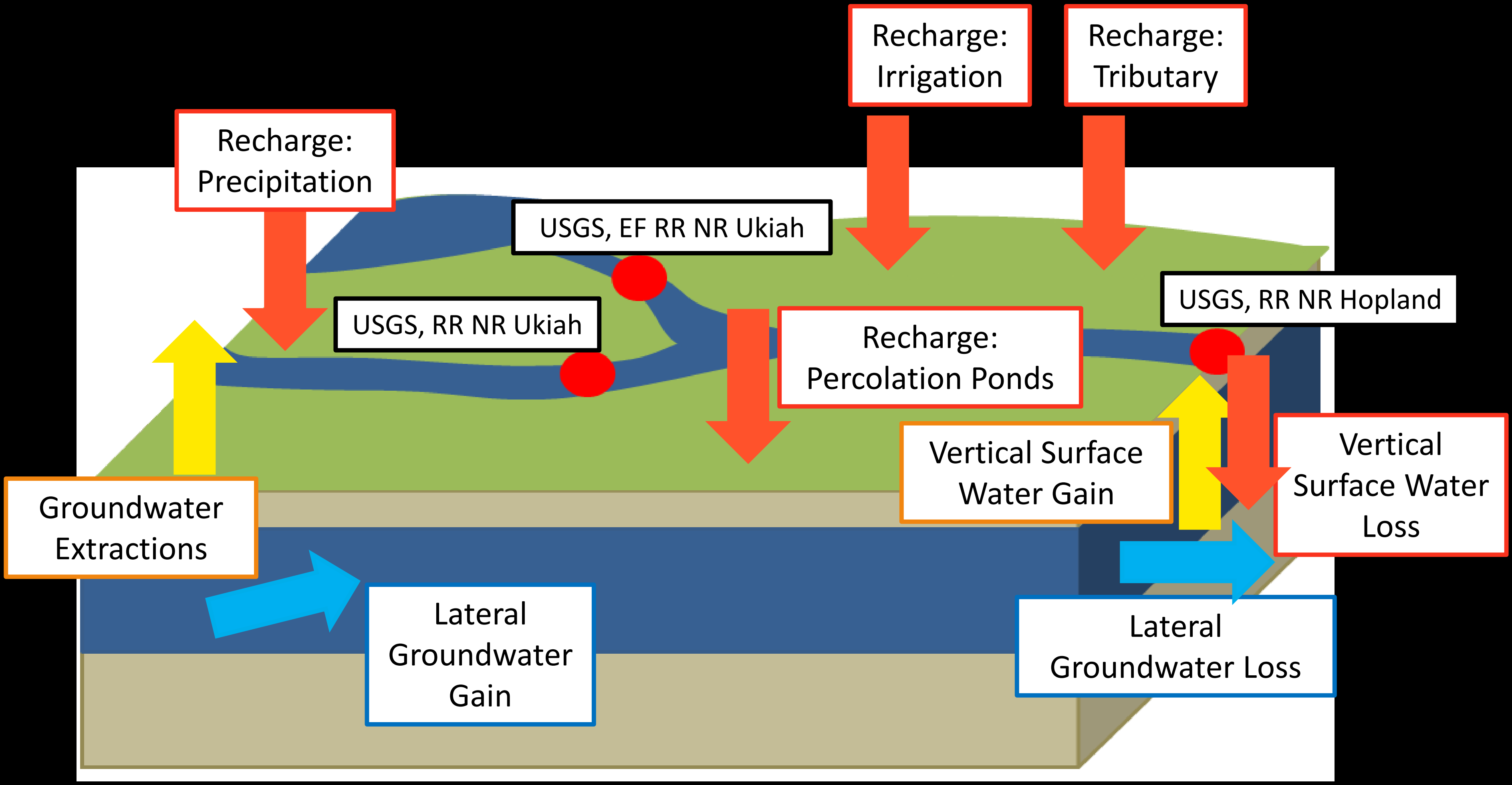
$$\boldsymbol{Inflow_t{}^{GW}} = Recharge_t{}^{Precipitation} + Recharge_t{}^{Irrigation} + Losses_t{}^{SW} + Recharge_t{}^{Percolation\ Ponds} + Recharge_t{}^{Tributary} + \boldsymbol{Gains_t{}^{GW}}$$

$$\boldsymbol{Outflow_t{}^{GW}} = \sum_{i=1}^{i=1} AW_t{}^{GW,crop\ k} + Gains_t{}^{SW} + GE_t{}^{Municipal} + \boldsymbol{Losses_t{}^{GW}}$$

$$\Delta Storage_t{}^{GW} - [Recharge_t{}^{Precipitation} + Recharge_t{}^{Irrigation} + Losses_t{}^{SW} + Recharge_t{}^{Percolation\ Ponds} + Recharge_t{}^{Tributary}] + [\textstyle\sum_{i=1}^{i=1} AW_t{}^{GW,crop\ k} + Gains_t{}^{SW} + GE_t{}^{Municipal}] =$$

$$\boldsymbol{Gains_t{}^{GW} - Losses_t{}^{GW}}$$

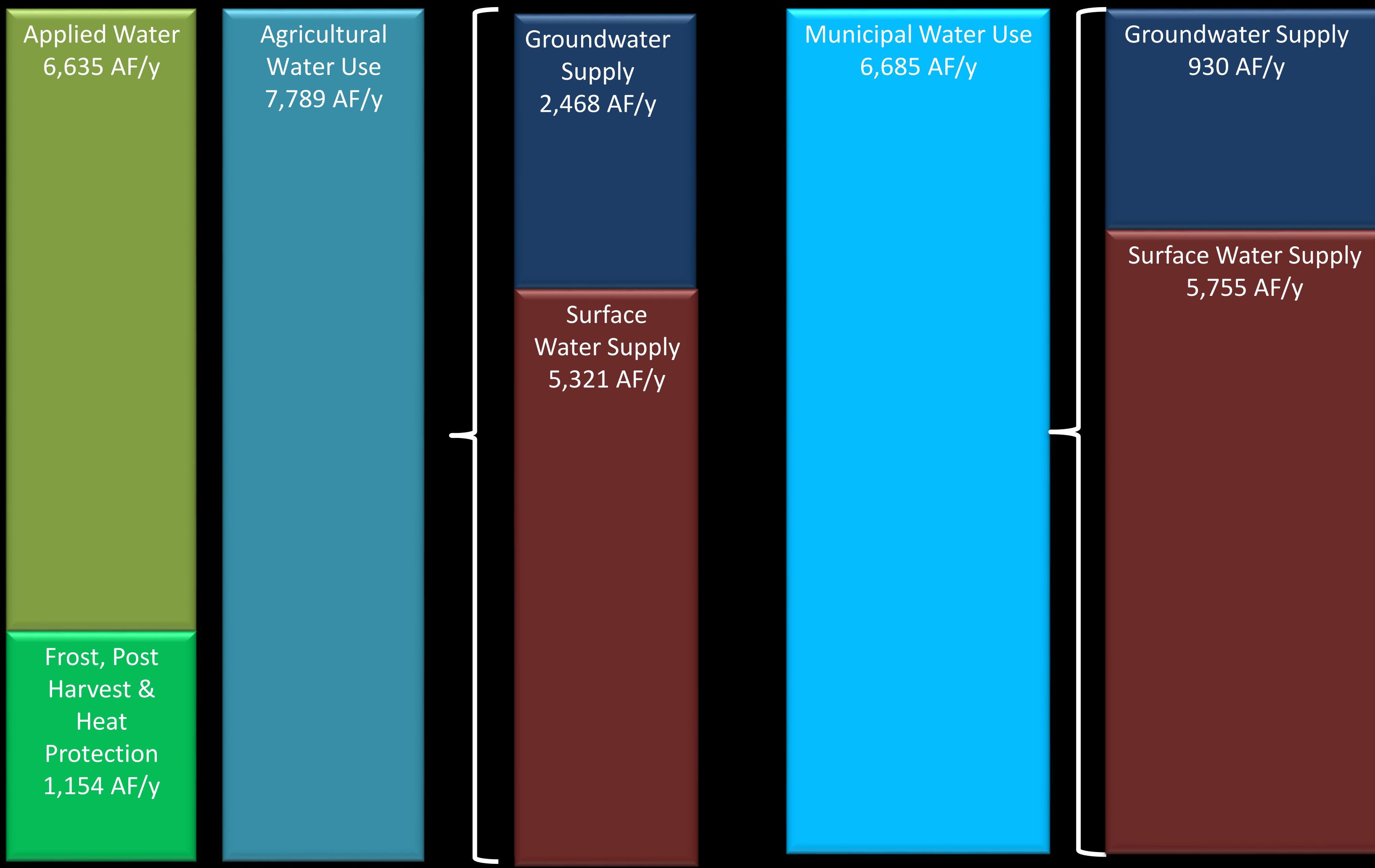
Groundwater Mass Balance



Data & Sources

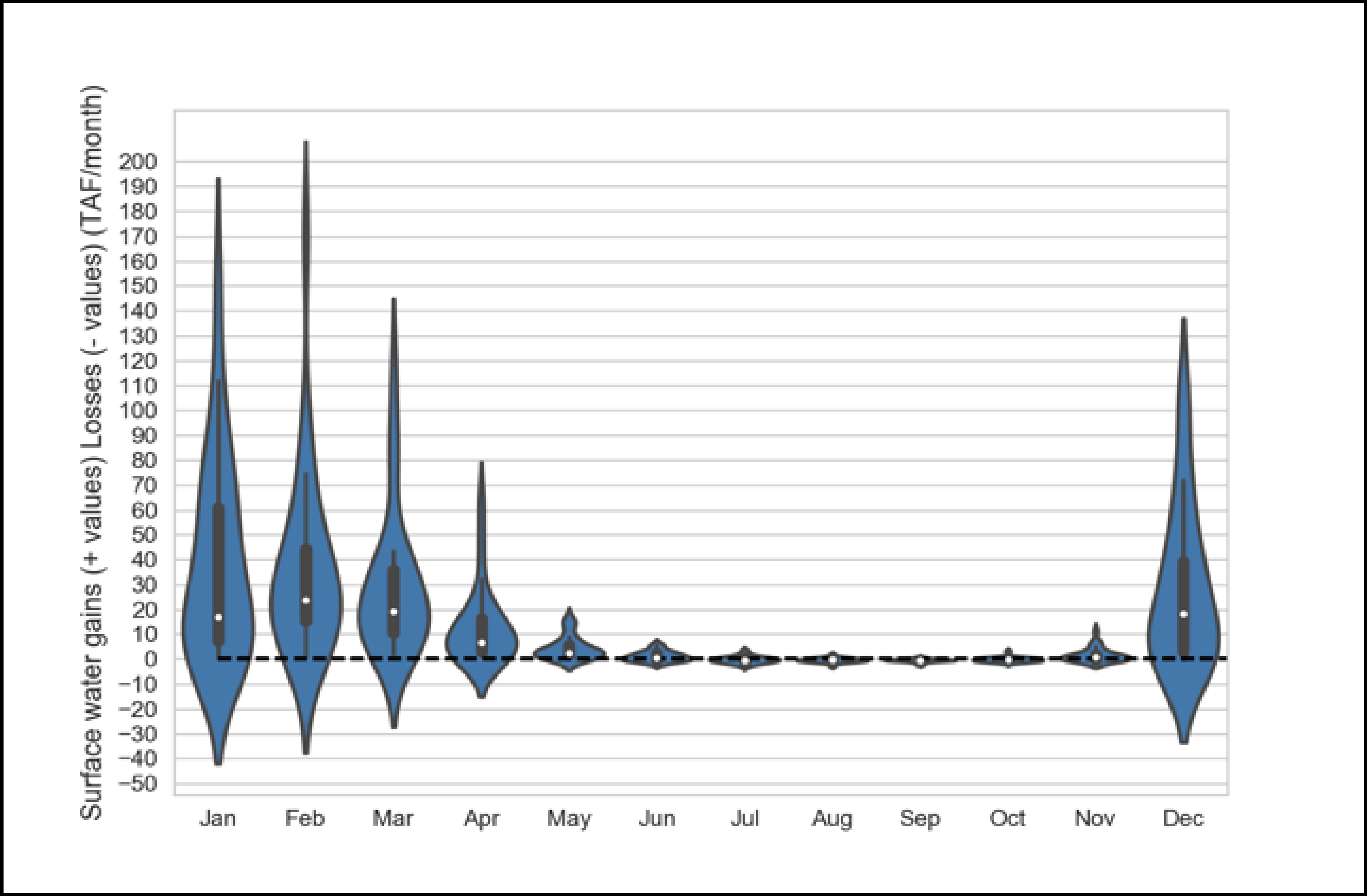
Data	Source
Evapotranspiration	CIMIS
Crop Coefficients	Schwankl et al. (2010)
Land Use	Chuck Morse, Agriculture Commissioner
Application Efficiency	Lewis et al. (2008)
Precipitation	CIMIS & CDEC
Stream Flow	USGS
City of Ukiah (Water)	Sean White , Director of Water & Sewer
RRFC Water Sales	Tamara Alaniz, RRFC General Manager
Water Districts (Water)	Bill Koehler & David Redding, General Managers
Private Water Users	SWRCB
Tributary Influence	Flint et al. (2015)
Evaporation	CDEC
Specific Yield	Bulletin 118
Aquifer Storage	Bulletin 118
Groundwater Elevation Data	DWR

Results



Applied Water
6,635 AF/y
Frost, Post Harvest & Heat Protection
1,154 AF/y
Agricultural Water Use
7,789 AF/y
Groundwater Supply
2,468 AF/y
Surface Water Supply
5,321 AF/y
Municipal Water Use
6,685 AF/y
Groundwater Supply
930 AF/y
Surface Water Supply
5,755 AF/y

Results



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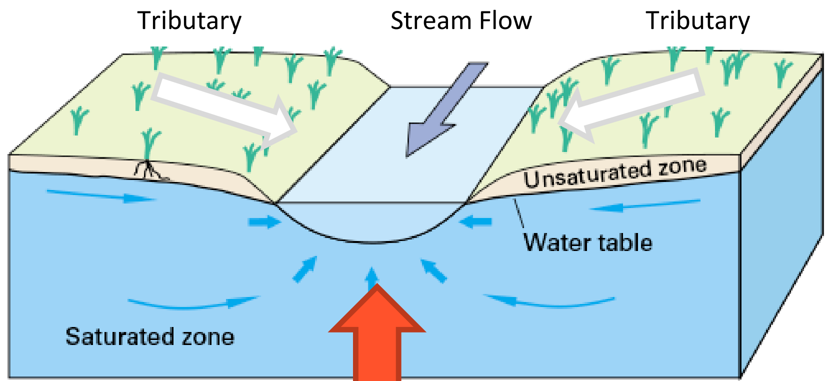
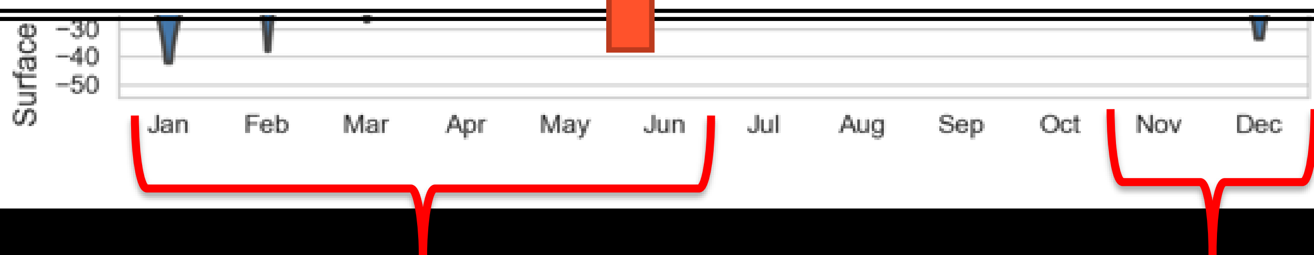
Results

- There are SW-GW Interactions
- The River is a gaining river from Nov to Jun

(+ 18,952 AF/year)

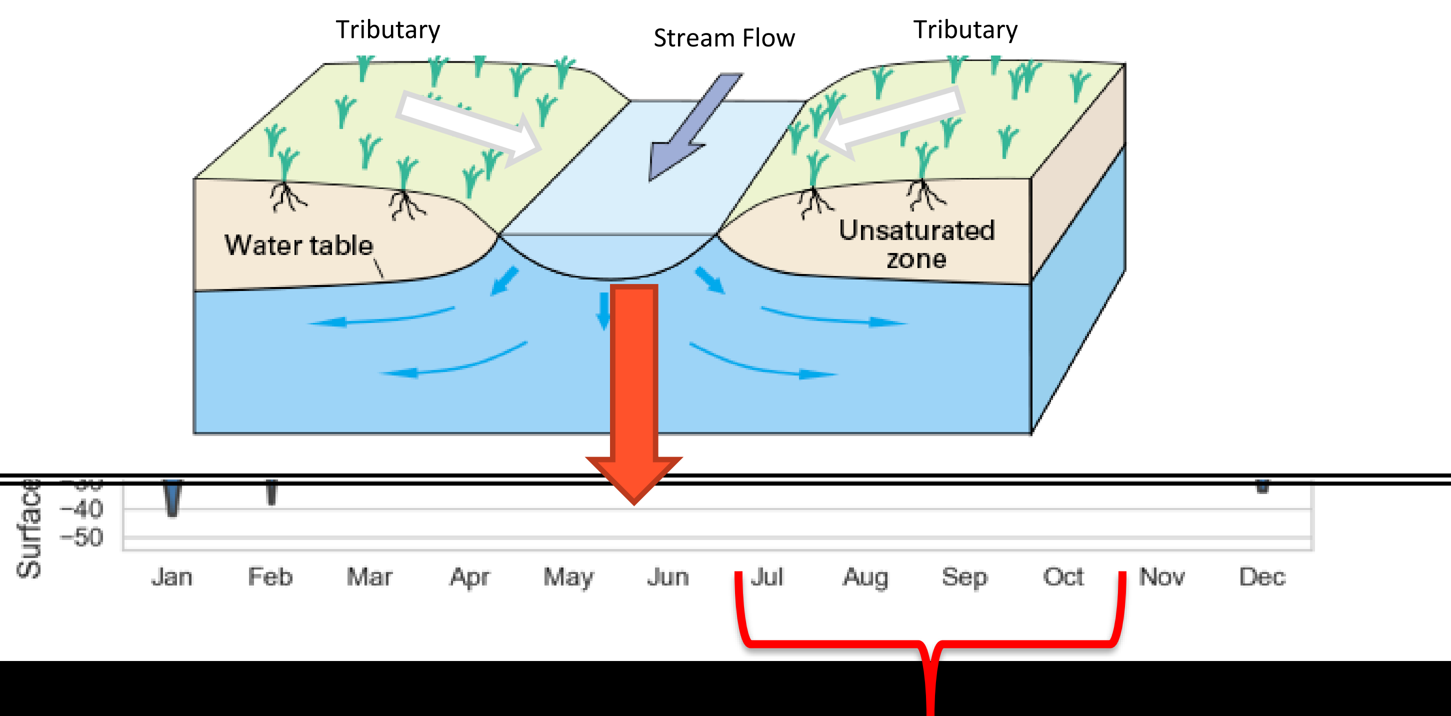


https://www.e-education.psu.edu/earth111/node/938



Results

- The River is a losing river from July to Oct (-393 AF/year)
- Releases from the Lake may recharge the groundwater



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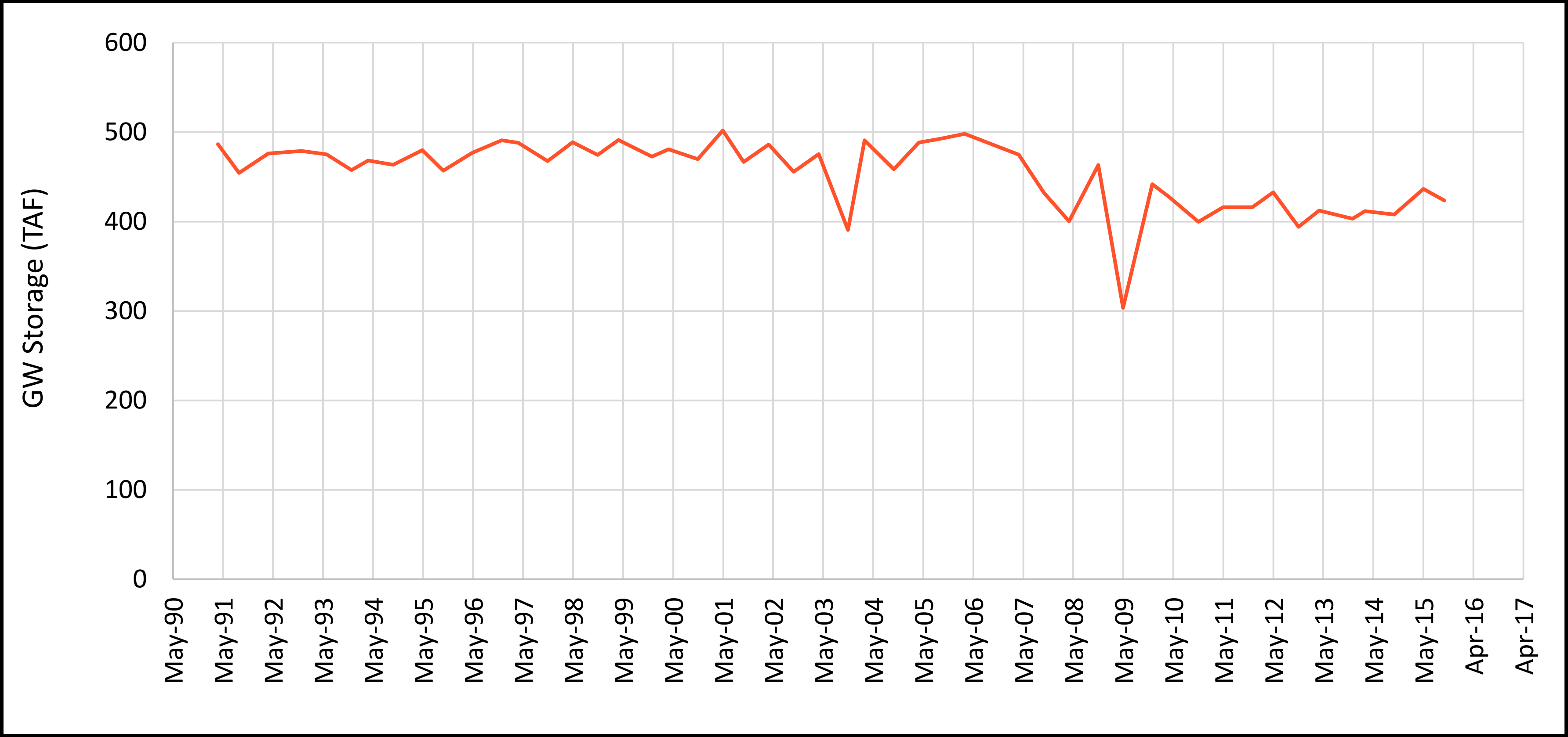
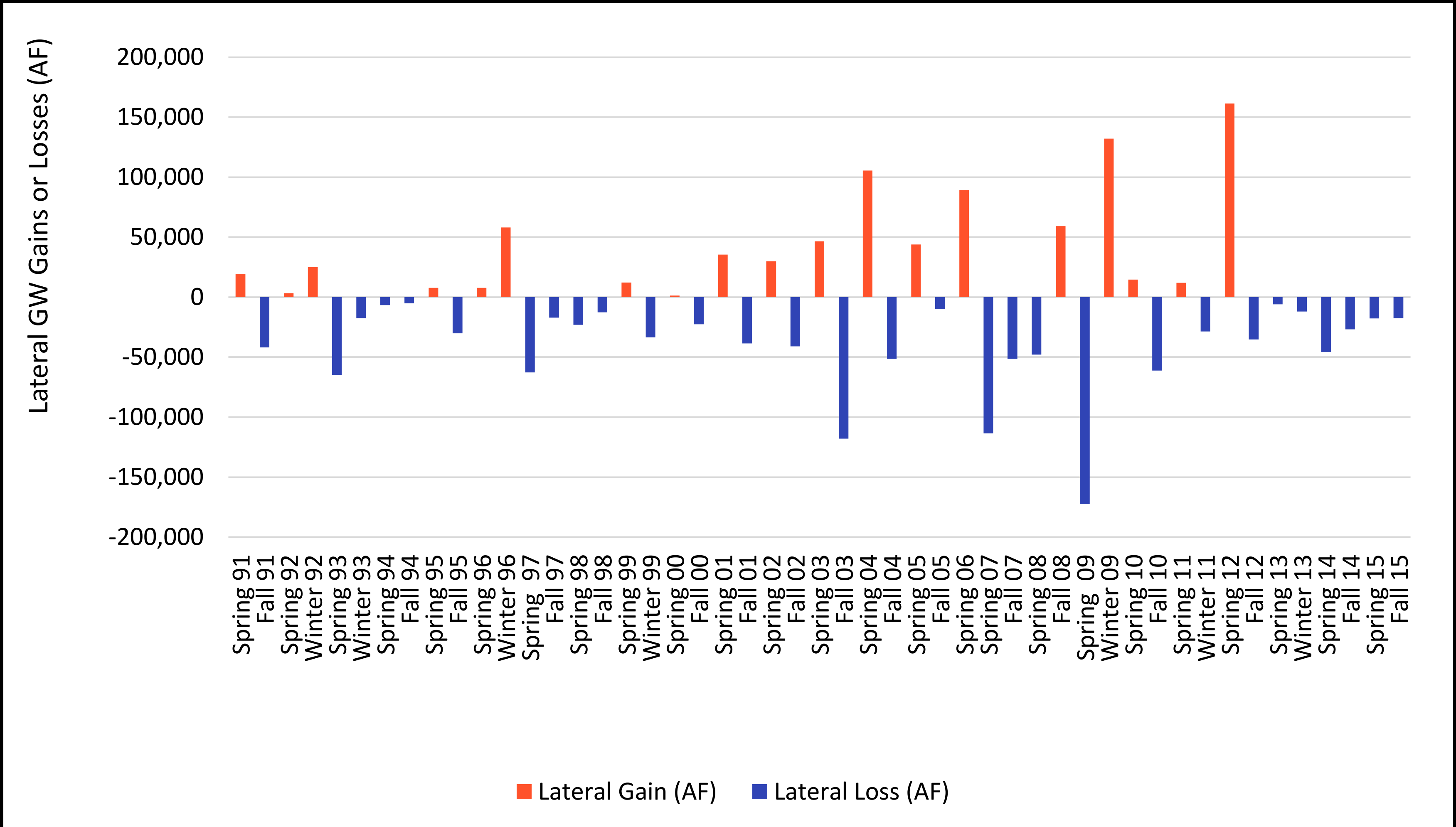


There is a fluctuation of groundwater storage with season, but overall the groundwater **storage is stable**

There are some inconsistencies in the long term water table data, and some questionable data for some years (year 2003 & 2009)

Results



Groundwater lateral movement (losses) occur between basins

Conclusions

Make Belief Groundwater Basin is **not in overdraft**

There are surface water/groundwater interactions

River is a **gaining river** Nov-Jun (+ 18,952 AF/y)

River is a **losing river** July-Oct (- 393 AF/y)

There is connectivity between the groundwater basin and nearby valley

Recommendations to GSA

1. Maintain surface water/groundwater interactions
    - Protect & enhance recharge zones
    - Protect the upper watershed (tributaries)
    - Avoid an increase in groundwater pumping

2. Create protocols for continual water resources management (Good record keeping!!!)

3. Create protocols for continual monitoring of the groundwater tables, streamflow at tributaries, groundwater quality, & land subsidence

4. Placement of a streamflow gauge North of County Water District to improve future water budget calculations

Questions