Water Budget Outline

- Introduction to water budget (WB)
- WB requirements under SGMA
- Historical WB
- Current WB
- Predictive WB Scenario A (Baseline)
- Predictive WB Scenario B (Wet – Moderate Warming Climate)
- Predictive WB Scenario C (Dry – Extreme Warming Climate)
- Sustainability Overview
- Sustainable Yield of the Basin

Water Budget - Introduction

Water is moved, stored and exchanged between atmosphere, land surface and subsurface (Hydrologic cycle).

**Water Budget:**
Accounting of the total groundwater and surface water entering and leaving a basin.

Water Budget – Accounting Structure

- Basin’s Water Budget
  - Divided into “accounting centers” for water budget accounting
  - Surface Water System (SWS) Budget
  - Groundwater System (GWS) Budget
  - Land Surface System Budget
  - Stream System Budget

Water Budget – Components

- An outflow from one system can be an inflow to another system
- Land Surface System and Stream System are in balance (total inflows = total outflows)
- For Groundwater System:
  - Inflow – Outflow = Change in Storage
SGMA WB Requirements

Historical Water Budget

Historical Data for Model Development

<table>
<thead>
<tr>
<th>Data Type</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate data</td>
<td>USGS Basin Characterization Model</td>
</tr>
<tr>
<td>Land use data</td>
<td>DWR land use surveys and aerial imagery analysis (LandID)</td>
</tr>
<tr>
<td>GW pumping by Municipal &amp; public systems</td>
<td>SWRCB annual reporting database (unavailable data were estimated based on available information)</td>
</tr>
<tr>
<td>Instream diversions</td>
<td>SWRCB Water Rights Management System (unavailable data were estimated based on available information)</td>
</tr>
</tbody>
</table>

SGMA WB Requirements

Historical Water Budget

Water budget shall quantify the following (GSP Regulation §354.18(b))

- Total surface water entering and leaving the Basin by water source type
- Inflow to the Groundwater System by water source type
- Outflows from the Groundwater System by water use sector
- The change in the annual volume of groundwater in storage between seasonal high conditions.
- If overdraft conditions occur, a quantification of overdraft over a period of years during which water year and water supply conditions approximate average conditions.
- The water year type associated with the annual supply, demand, and change in groundwater stored.
- An estimate of sustainable yield for the basin.

Analysis Period

- 1988 to 2019 (32 years)
- Selected after evaluation of precipitation records and Big Valley water year (WY) type classification
- WY type was determined using weighted annual precipitations (DWR 2021)

<table>
<thead>
<tr>
<th>Water Year Type</th>
<th>Number of Years (1988-2019)</th>
<th>Percentage Total Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical (C)</td>
<td>3</td>
<td>9%</td>
</tr>
<tr>
<td>Above Normal (AN)</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>Below Normal (BN)</td>
<td>4</td>
<td>13%</td>
</tr>
<tr>
<td>Wet (W)</td>
<td>9</td>
<td>28%</td>
</tr>
<tr>
<td>Dry (D)</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>Deep (DP)</td>
<td>12</td>
<td>38%</td>
</tr>
</tbody>
</table>

Historical Water Budget – Land Surface System

- Major inflows
  - Precipitation
  - Groundwater uptake
- Major outflows
  - Surface Runoff
  - Evapotranspiration
  - Deep percolation

WB strongly influenced by annual precipitation
**Historical Water Budget – Stream System**

- Major inflows
  - Stream inflow
  - Surface runoff
  - Stream gain

- Major outflows
  - Stream outflow
  - Stream loss

**Historical Water Budget – Groundwater System**

- Major inflows
  - Deep percolation
  - Hillside subsurface inflow
  - Stream leakage

- Major outflows
  - Groundwater uptake
  - Agricultural pumping
  - Domestic pumping

**GWS budget summary**

- Average annual storage change: +100 AFY (an increase)
- Cumulative storage over 32-year period: +6,000 AF (increase equivalent to 0.25 acre-feet per acre across the basin)
- Annual storage change ranges from a decrease of 7,400 AF to an increase of 10,700 AF
- Storage increases in wet years; decreases in dry years
- No historical overdraft conditions
- Decrease of storage during dry years is due to removal of temporary surplus of groundwater

**Current Water Budget – Evaluated Periods**

- Regulations do not specify a time period for “current water budget”
- Evaluated water budgets for several recent periods
  - Recent 1 year (2019)
  - Recent 1 year (2018)
  - Recent 4 years (2016-2019)
  - Recent 6 years (2014-2019)
  - Recent 10 years (2010-2019)
- Inflows and outflows widely vary between these periods
- Recent 6 years (2014-2019) was selected as the representative “Current Water Budget”
  - This period includes two wet years, two above-normal years, a dry year, and a critical year
  - Current budget reasonably representative of recent conditions, but not necessarily representative of any longer-term average conditions

**Current Water Budget – Land Surface System**

- Budgets are highly variable between 1-year periods mainly due to precipitation variability
  - Annual rainfall: 23.6 inches in 2018, 53.3 inches in 2019
  - Variability lower for multi-year periods
  - 6-year period (2014-2019) is a reasonable representation of current water budget
Projected Scenario A – Land Surface System Budget

- Groundwater pumping ↑12% (↑1,100 AFY)
- Changes in all other water budget components ↑2%, except 10% increase of stream diversions due to 100 AFY increase.

Projected Scenario A – Groundwater System Budget

- GWS budget summary
  - Average annual storage change close to zero
  - Cumulative storage change over 53-year period: -2,200 AF (a decrease) (decrease equivalent to 0.09 acre feet per acre across the Basin)
  - Annual storage change ranges from a decrease of 8,400 AF to an increase of 10,600 AF (consistent with historical budget)
  - No projected overdraft conditions
Projected Scenario B – Land Surface System Budget

Average projected volumes in comparison to Scenario A averages:
- Precipitation ↑29% (↑20,500 AFY)
- Greater year to year variability
- Groundwater uptake ↑21% (↑2,300 AFY)
- Runoff ↑24% (↑3,700 AFY)
- Deep percolation ↑24% (↑3,700 AFY)
- ET ↑4% (↑1,900 AFY)

Projected Scenario B – Groundwater System Budget

- Deep percolation ↑24% (↑3,700 AFY)
- Subsurface inflow from hillsides ↑21% (↑2,300 AFY)
- Stream leakage ↓71% (↓3,100 AFY)
- Deep percolation ↑24% (↑3,700 AFY)
- ET ↑4% (↑1,900 AFY)
- Other components consistent with Scenario A

Projected Scenario B – Stream System Budget

- Stream inflow ↑35% (↑25,100 AFY)
- Stream gain ↑16% (↑900 AFY)
- Runoff ↑30% (↑17,400 AFY)
- Stream outflow ↑37% (↑19,800 AFY)
- Stream loss ↓11% (↓40,500 AFY)

Projected Scenario B – Groundwater System Budget

GWS budget summary
- Average annual storage change close to zero
- Cumulative storage change over 53-year period: 1,500 AF (an increase)
- Annual storage change ranges from a decrease of 9,200 AF to an increase of 9,200 AF
- No projected overdraft conditions

Projected Scenario C – Land Surface System Budget

Average projected volumes in comparison to Scenario A averages:
- Groundwater pumping ↓8% (↓1,000 AFY)
- Stream outflow ↓7% (↓200 AFY)
- Stream leakage ↓5% (↓200 AFY)
- Stream inflow ↓7% (↓7,400 AFY)
- Stream gain ↓10% (↓300 AFY)
- Deep percolation ↑81% (↑2,500 AFY)
- Other components consistent with Scenario A

Projected Scenario C – Stream System Budget

- Stream inflow ↓7% (↓40,500 AFY)
- Stream gain ↓10% (↓300 AFY)
- Stream outflow ↓5% (↓300 AFY)
- Other components consistent with Scenario A
Projected Scenario C – Groundwater System Budget

Average projected volumes in comparison to Scenario A averages:

- Stream leakage ↑5% (↑200 AFY)
- Ag. pumping ↑10% (↑700 AFY)
- All other components consistent with Scenario A (changes ≤100 AFY)

Uncertainty of Estimated Water Budgets

<table>
<thead>
<tr>
<th>Water Budget Component</th>
<th>Data Source</th>
<th>Estimated Uncertainty (%)</th>
<th>Description of Uncertainty</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater Inflow</td>
<td>Measurement</td>
<td>15%</td>
<td>Typical accuracy for calculated groundwater pumping</td>
</tr>
<tr>
<td>Stream Leakage</td>
<td>Calculation</td>
<td>20%</td>
<td>Typical uncertainty for calculated groundwater pumping</td>
</tr>
<tr>
<td>Agriculture Uptake</td>
<td>Calculation</td>
<td>20%</td>
<td>Typical uncertainty for calculated groundwater pumping</td>
</tr>
<tr>
<td>Deep Percolation</td>
<td>Calculation</td>
<td>20%</td>
<td>Typical uncertainty for calculated groundwater pumping</td>
</tr>
<tr>
<td>Subsurface Inflow</td>
<td>Calculation</td>
<td>20%</td>
<td>Typical uncertainty for calculated groundwater pumping</td>
</tr>
<tr>
<td>Storage Change</td>
<td>Calculation</td>
<td>20%</td>
<td>Typical uncertainty for calculated groundwater pumping</td>
</tr>
</tbody>
</table>

Sustainability Overview

- In 2014, the state passed the Sustainable Groundwater Management Act – SGMA
- SGMA requires groundwater to be managed by local public agencies called Groundwater Sustainability Agencies – GSAs
- GSAs are responsible to ensure a groundwater basin is managed sustainably
- Sustainable management is conducted through the Groundwater Sustainability Plan - GSP

GWS budget summary

- Average annual storage change: -300 AFY (a decrease)
- Cumulative storage change over 53-year period: -15,200 AF (a decrease)
  (decrease equivalent to 0.62 acre-feet per acre across the Basin)
- Annual storage change ranges from a decrease of 9,400 AF to an increase of 6,600 AF
  (for comparison Scenario A range: decrease of 8,400 AF to increase of 10,600 AF)
- Multi-year dry periods with declining GW storage occur, but no projected overdraft conditions

Sustainability Goal

- A single sustainability goal for the basin
- Achieved within 20-years of GSP implementation
- Maintained without causing undesirable results
Sustainable Yield – GSP Requirements

Sustainable Yield (CWC Section 30721[w])

“The maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result.”

- GSP Regulations require the GSP quantify the sustainable yield for the Basin
- Regulations do not specify a methodology to estimate sustainable yield
- Historical and projected model results were used to estimate sustainable yield for Big Valley Basin

Sustainable Yield – Calculation

| Scenario | Groundwater System Water Budget Components | Simulated Scenario and Average Annual Volume (AFY) | Under all considered scenarios:
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total GW Extraction (uptake + pumping)</td>
<td>Total GW Extraction (uptake + pumping)</td>
</tr>
<tr>
<td></td>
<td>Groundwater Pumping</td>
<td>Groundwater Uptake</td>
</tr>
<tr>
<td></td>
<td>(-27,100)</td>
<td>(-28,500)</td>
</tr>
</tbody>
</table>

Estimated Sustainable Yield using the most extreme scenario (Scenario C)

Sustainable yield = Total GW Extraction – GW Storage Change

- Total GW Extraction ranges from -27,000 to -30,000 AFY (wet year)
- Total GW Extraction ranges from -27,000 to -30,000 AFY (wet year)
- Total GW Storage Change ranges from -300 to 200 AFY (wet year)

Estimated Sustainable Yield = 29,000 AFY

Estimated Sustainable Yield Range = 22,000 to 36,000 AFY

For comparison, DWR Bulletin 118 estimates: Storage capacity of Big Valley Basin = 225,000 AF

Estimated Sustainable Yield = 29,000 AFY

Estimated sustainable yield is consistent with the sustainability goal for the Basin

True sustainable yield can be higher because maximum possible volume of GW extraction was not simulated

Estimated sustainable yield will be reviewed as the Basin implements the GSP

Sustainable Yield – Summary

Stream Leakage Characteristics

- Narrow range (4,500 AFY to 5,200 AFY) for historical, projected Scenario A and projected Scenario C.
- Relatively lower (1,400 AFY) for projected Scenario B due to increased gain and decreased loss under assumed wet climate.
- Year to year variability within each scenario indicates strong influence of precipitation on stream flow and leakage.
- Groundwater pumping seems to have a less effect on stream flow and leakage.
- Widespread significant and unreasonable stream depletion conditions are not expected at sustainable yield of 29,000 AFY.