Current Conceptual Model of Recharge in the Butte Basin

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What is a Conceptual Model?

Set of hypotheses as to how, where, when, and why recharge occurs in your study area or subbasin.
Groundwater Recharge

- Defined: Downward flow of water reaching the water table
- Difficult to measure and to estimate. Inherent uncertainty in any method
- Best to use multiple lines of evidence to understand and estimate
Potential Recharge Processes

- Over a broad area
  - Precipitation, irrigation (i.e. applied water)
Potential Recharge Processes

- Over a broad area
  - Precipitation, irrigation (i.e. applied water)
- At a specific location
  - Rivers, streams, bodies of water
- Managed aquifer recharge
  - Ponding, field flooding, In-lieu

Dependent on the connectivity to the aquifer system
Fractured Rock vs. Alluvial Groundwater Basins

Aquifer dynamics - How groundwater moves in, out, and through the system

Harter and Rollins 2008: ANR Publication 3497
Recharge is Dependent on Aquifer Characteristics

“Layer Cake” aquifer stratigraphy depict continuous layers

Image Credit: Rick Cramer, Burns & McDonnell

Image Credit: USGS Circular 1376
Recharge is Dependent on Aquifer Characteristics

From Ehman and Edwards (2014)

Image Credit: Rick Cramer, Burns & McDonnell

Image Credit: Dr. Graham Fogg
Multiple Studies to Better Understand Butte County Groundwater

- Lower Tuscan Aquifer Investigation, 2013
- Stable Isotope Recharge Study, 2017
- Water Budget Development
  - Water Inventory & Analysis Report, 2016
- Groundwater Level Monitoring, ongoing
Lower Tuscan Aquifer Investigation, 2013

New Monitoring Wells

Infiltration

Isotope Analysis

Measuring Stream Flow
What We Learned

- Recharge from streams crossing Tuscan outcrop in canyon reaches is minimal or at least comparatively small
  - Likely broad areal recharge
- Significant recharge potential of shallow alluvial aquifer to deeper Lower Tuscan aquifer materials
- Tuscan Formation characteristics variable
- Significant leakage through aquitards separating other aquifer zones
- Recommendations for future studies
  - More stable isotope sampling and analysis
Stable Isotope Recharge Project

Background:

- Stable Isotopes of Oxygen and Hydrogen
  Naturally occurring components of water that can be used to identify likely sources of groundwater recharge

- Primary study goal
  to develop better understanding of overall recharge mechanisms and sources in general area of Butte Creek
Stable Isotope Recharge Project

Surface Water & Groundwater Samples
Stable Isotope Recharge Project

Recharge Water Source Regions

Groundwater Basin

Fractured Rock
Strong Spatial Component to Recharge

North Area

- Groundwater in shallow and intermediate zones (<400 ft bgs) sourced from Upper Watershed (UW)

- Suggests recharge from stream channels of Butte Creek or the Sacramento R. as they flow across the valley floor

- Deep zone sourced from Lower Foothills (LF) or mixture of UW and LF

- Suggests combination of direct recharge from the LF and likely downward migration of groundwater from the shallower zones driven by pumping
Strong Spatial Component to Recharge

East Area

- Recharge source at all depths is likely a combination of Valley Floor rainfall and runoff within local streams and creeks from the westernmost part of the Lower Foothills.

- The intermediate and deep intervals in the east area may also receive some recharge from direct percolation in the Lower Foothills immediately adjacent to the Valley Floor.

- Evaporated water signature in shallow/intermediate zones indicates some degree of delay between timing of rainfall and recharge.
Strong Spatial Component to Recharge

South Area

- Shallow domestic well (<100 ft deep) shows evidence of recharge from irrigation water.

- All other depth intervals of the other monitoring wells suggest groundwater sourced from rainfall on eastern edge of Valley Floor or lowest elevations of the Lower Foothills.

- Suggests recharge to these aquifer intervals occurs at the outcrop of the Tuscan Formation or through local alluvial fans and other sedimentary material directly overlying the Lower Tuscan Formation.
Conclusions

- There is no single source of groundwater recharge throughout Butte County.
- Different parts of the basin are recharged from one or more of the following sources:
  - Rainfall on the Lower Foothills (North and East Areas, intermediate and deep zones);
  - Butte Creek (North Area shallow wells);
  - Sacramento River (North Area shallow zones);
  - Local rainfall on the valley floor (East Area shallow and South Area);
  - Irrigation water (shallowest portion of South Area);
Geologic formations control flow paths (structure and layering)
- Permeable zones within an aquifer unit
- Vertical connectivity

Stable isotopes help confirm connections
- Within a geologic unit, between geologic units
- Between recharge sources and wells

Stable isotopes do not identify the specific pathways of recharge
Stable isotopes do not identify the rate of recharge
Water Budget... show me the numbers

Image Credit: DWR Water Budget BMP
How?...Butte Basin Groundwater Model

- Integrated groundwater-surface water model
- Originally developed in 1990s, updated in 2008 and ongoing
- Used to develop water budgets in Water Inventory & Analysis Report, 2016
- Can be used to estimate complete groundwater-surface system budgets
Groundwater Level Data

- Contour Maps
- Multi-completion monitoring wells
Groundwater Recharge is difficult to measure and estimate.

Butte County has employed a variety of approaches.

Stable Isotope Study suggests:
- Butte Creek, Sacramento River important recharge sources to upper portions of the basin (<400 ft) in their vicinity. Pumping may cause some mixing to deeper depths.
- Rainfall on Lower Foothills and Valley Floor important recharge source to all depth intervals in the East and South areas.
  - Specifics of how and where recharge occurs is unknown.
- Evidence of irrigation water recharging only the shallowest portion (<100 ft) of the groundwater system in the South area.

Water Budgets will help:
- Estimate contribution and rate of recharge of different recharge sources.
- Indicate their relative importance to guide future studies/data collection.
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