



Evaluating the Effects of Over Pumping and Drought on Water Supply, Well Production Capacities and Pumping Costs

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Background

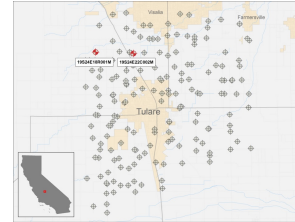
Issue/Study Objective:

- Groundwater decreases from pumping beyond sustainable supply (**groundwater overdraft**).
- Exacerbated during drought conditions (recent drought).

- Evaluate changes in groundwater levels and pumping costs.

Study Area:

- Surrounding Tulare area.
- San Joaquin Valley; Tule SB **Critically Overdrafted (B118) High Priority Basin (SGMA)**
- Availability of DWR well log information and level data.



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Analyses Covered:

1) Well Log Analysis

- **Evaluate trends in impact to wells**; agricultural and domestic.
 - Dist of water levels below top/mid/bot of screened interval.
 - Survey of changing groundwater conditions during drought.



2) Pumping Cost Analysis

- **Estimate trends in pumping costs**; agricultural focus.
 - Pump hydraulics to approximate drawdown from SWL.
 - Pumping costs per acre of agricultural production (drought).



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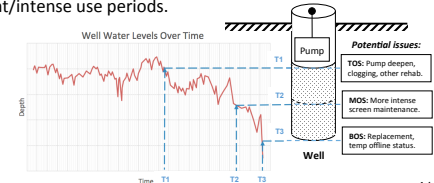
Well Log Analysis

Well Completion Reports (DWR):

- Mixed agricultural (128 wells, 34%) and domestic (247 wells, 66%).
- High/Low pumping rates (gpm) influencing Pumping Water Levels (PWL).
- Top of Screen (TOS), Middle of Screen (MOS), and Bottom of Screen (BOS)

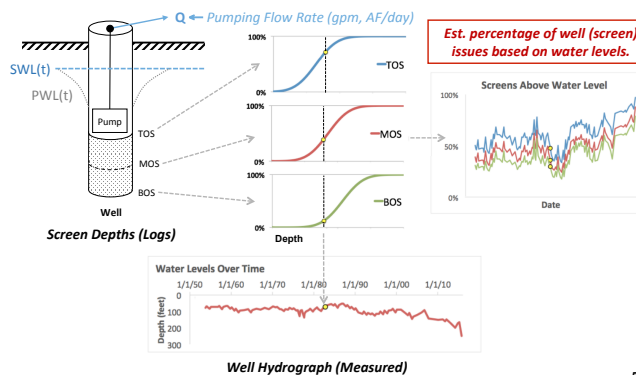
Considerations:

- **Potential well issues depending on levels to TOS/MOS/BOS.**
- Worse during drought/intense use periods.



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Well Log Analysis



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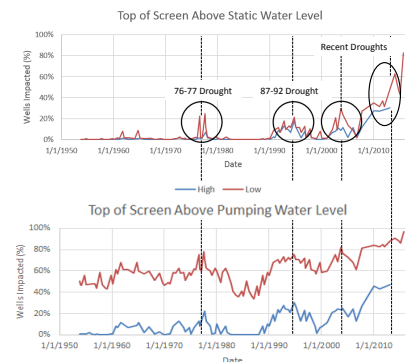
Well Log Analysis

% wells TOS exposed under SWL(t).

1977 Drought: 9 - 26%
1992 Drought: 8 - 21%
Recent Droughts: 11 - 30%
2014 (Latest): 34 - 39% Extended: 80%+

% wells TOS exposed under pumping water conditions.

1977 Drought: 16 - 78%
1992 Drought: 24 - 75%
Recent Droughts: 22 - 81%
2014 (Latest): 43 - 85% Extended: 95%+



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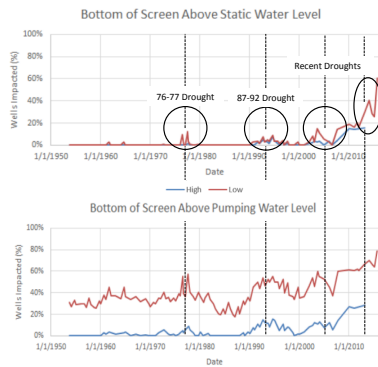
Well Log Analysis

% wells BOS exposed under SWL(t).

1977 Drought: 2 - 11%
 1992 Drought: 1 - 8%
 Recent Droughts: 1 - 16%
2014 (Latest): 16 - 25%
Extended: 55%+

% wells BOS exposed under pumping water conditions.

1977 Drought: 6 - 57%
 1992 Drought: 10 - 55%
 Recent Droughts: 8 - 60%
2014 (Latest): 27 - 66%
Extended: 75%+



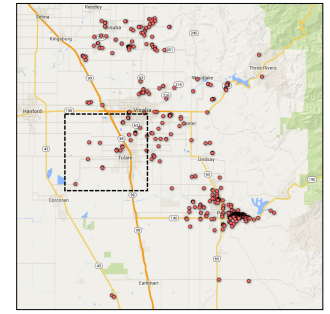
Well Log Analysis

Area Context:

- County of Tulare: Known domestic well issues (889 reported failures).
- 25 wells, 2.8% within study area.
- Issues not specified.
- Does not include rural agricultural or unreported well data.

2014 BOS (High Prob) Data: 16-25%
247 total domestic = 39 to 62 wells

- **Not surprising well issues occurring.**
- **For % at or near TOS levels.**
- **For % below BOS at PWL.**
- More issues reported since 2014.
- 1,505 wells as of June 20, 2016



Source: County of Tulare – Drought Effects Status Update (December 29, 2014)

Pumping Cost Analysis

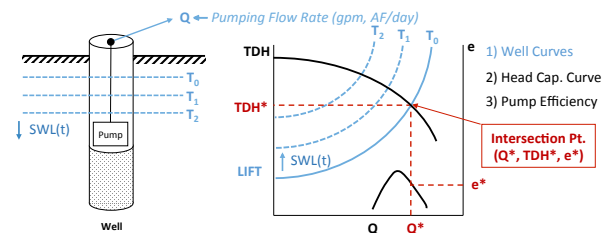
Water Level Considerations:

- Static Water Level (SWL) data; annual measurement hydrograph.
- Pump Total Dynamic Head (TDH) changes with increasing/decreasing SWL.

Pump Considerations:

- Produces water at rate depending on:
 - Total Dynamic Head (TDH) against which the pump operates (combination of lift and pressure).
 - Pump efficiencies.
- Greater lift requirements reduces operational production rates.
- Single-duty point pump, TDH is determined on interplay between the system curve and the pump head-capacity curve – **when curves intersect.**

Pumping Cost Analysis



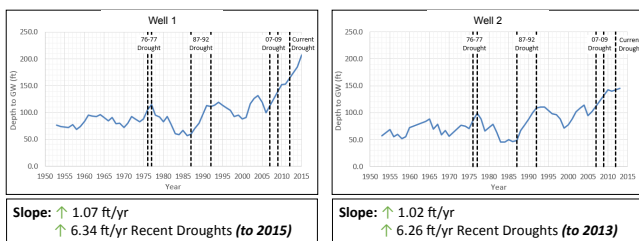
$$kWh = [Q^*(TDH^*) 0.746 \text{ t}] / (3956 e^*)$$

$$COST = kWh \times K_1 \leftarrow \text{Estimate PG\&E/SCE (\$/kWh)}$$

Est. pumping costs from Pumping Water Levels.

Pumping Cost Analysis

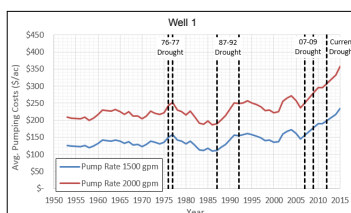
- Two agricultural wells (date extents); pumping rate 1500 – 2000 gpm.
- ETaw of various crops → **Analysis in \$/acre based on \$/kWh rate.**
 - Tulare ID Water Mgmt Plan; update Tulare County Ag. Commissioner



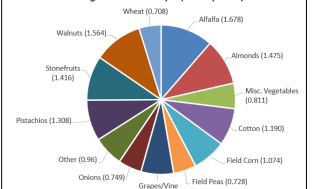
Pumping Cost Analysis

Well No. 1

Average Crop	Year (Condition)	Per Acre Costs	From Baseline	Per AF Costs	From Baseline
	1953 (Baseline):	\$125.83 - \$208.76	---	\$40.20 - \$66.69	---
	1977 Drought:	\$158.26 - \$252.92	↑ \$38.29	\$50.55 - \$ 80.80	↑ \$12.23
	1992 Drought:	\$155.12 - \$248.65	↑ \$34.59	\$49.55 - \$79.44	↑ \$11.05
	2009 Drought:	\$189.43 - \$295.74	↑ \$75.29	\$60.52 - \$94.48	↑ \$24.05
	2015 (Latest):	\$235.03 - \$357.49	↑ \$128.96	\$75.08 - \$114.21	↑ \$41.20



Agricultural Crops (Multipliers)

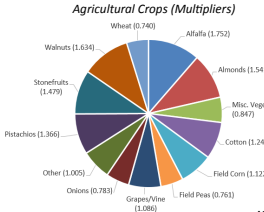
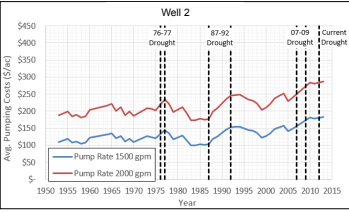


Pumping Cost Analysis

Well No. 2

Average Crop	Year (Condition)	Per Acre Costs	From Baseline	Per AF Costs	From Baseline
	1953 (Baseline):	\$110.11 - \$187.34	--	\$35.17 - \$59.85	--
	1977 Drought:	\$144.46 - \$234.12	↑ \$40.56	\$46.15 - \$74.79	↑ \$12.96
	1992 Drought:	\$153.03 - \$245.80	↑ \$50.69	\$48.89 - \$78.53	↑ \$16.20
	2009 Drought:	\$181.48 - \$284.55	↑ \$84.29	\$57.98 - \$90.91	↑ \$26.93
	2015 (Latest):	\$183.15 - \$286.83	↑ \$86.26	\$58.51 - \$91.63	↑ \$27.56

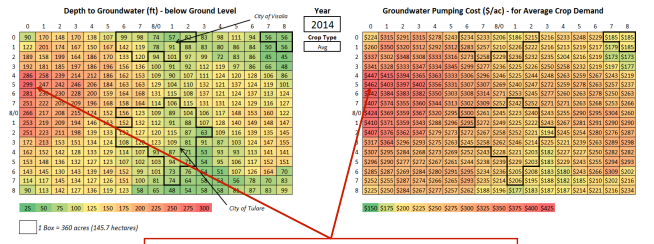
Hydrograph ends 2013, does not capture full drought impacts.



Pumping Cost Analysis

Regional Analysis:

- Distance weighted from well hydrograph (points) to equal spaced nodes.

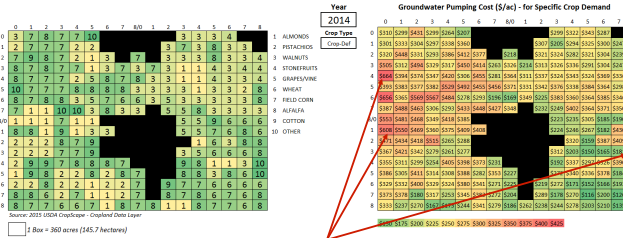


Clear relationship between GW levels and Pumping Costs (Example: 2014 drought conditions).

Pumping Cost Analysis

Regional Analysis:

- Predominant crop demand pattern at nodes (2015 USDA CropScope).



Also demand component influence on pumping costs/crop profitability. (Example: crop demands scatter worse prices).

Conclusions/Assumptions

Conclusions:

- Evaluation approaches holds potential for survey-level quantification of drought impacts on supply well operations – **water level and pumping costs.**
- Employs total depth approach (SWL + s), building on hydraulics and data.
- Quantify increases in levels costs during droughts.
- Additional work needed:
 - Grid Space and Hydrograph Model (e.g., crop profitability).
 - Overstated costs/well issues, but provides useful conditions.

Assumptions:

- Single-duty point pump, not variable speed; *historically constant \$/kWh.*
- Well issues with water levels below screen locations (TOS/BOS shown).
- Characterization of the Well and Head Capacity curves.
- Total reliance on groundwater for supply (surface water unknown).

Continuation/Further Analysis

- **Goal:** provide insight regarding well limitations and pumping cost increases over time – range of historic and projected conditions.
- **Ultimately insight into impacts to well conditions and pumping costs during future droughts.**
 - Pumping costs, if trends extend.
 - Number and type of well issues, if trends extend.
- Incorporate details of surface water and groundwater demands (agricultural and domestic).
- Comparison to reported well issues; County of Tulare data.
- **Sustained pumping costs versus well retrofit/replacement.**