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Development of a Method to Identify Complex Wells and Assess the Accuracy of Basin Withdrawals in Utah

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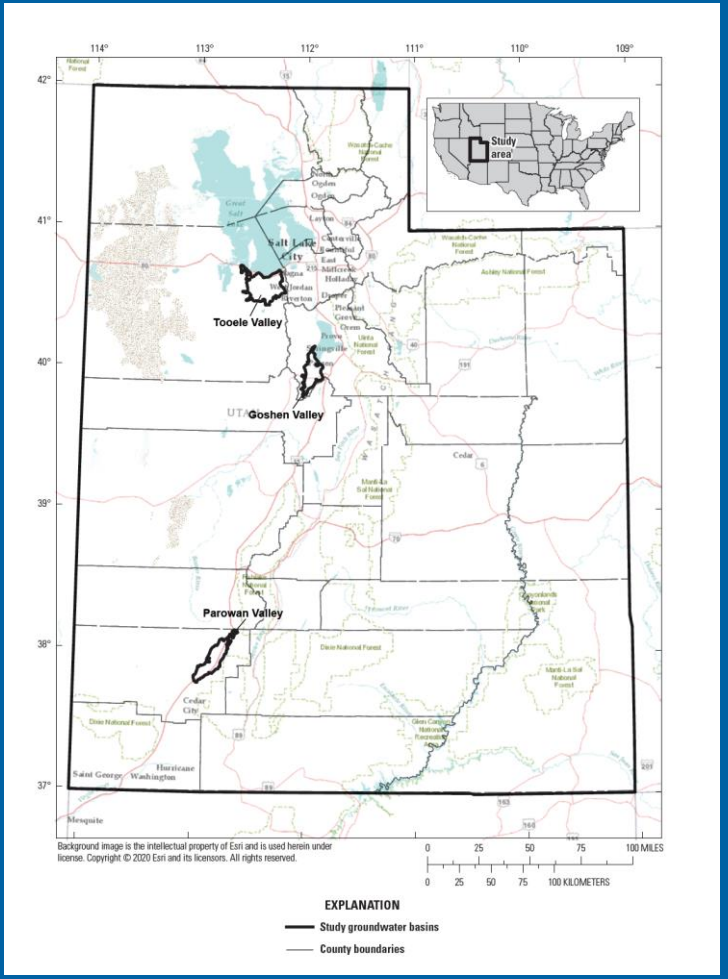
Purpose and Scope

- Test statistical screening method by using existing power consumption coefficients (PCCs) to identify simple and complex wells
- Assess the effectiveness and accuracy of annual groundwater withdrawal estimates and the impact of dedicated flowmeters and complex wells on withdrawal estimates
  - Assess the percent difference among withdrawal calculated using different combinations of PCCs



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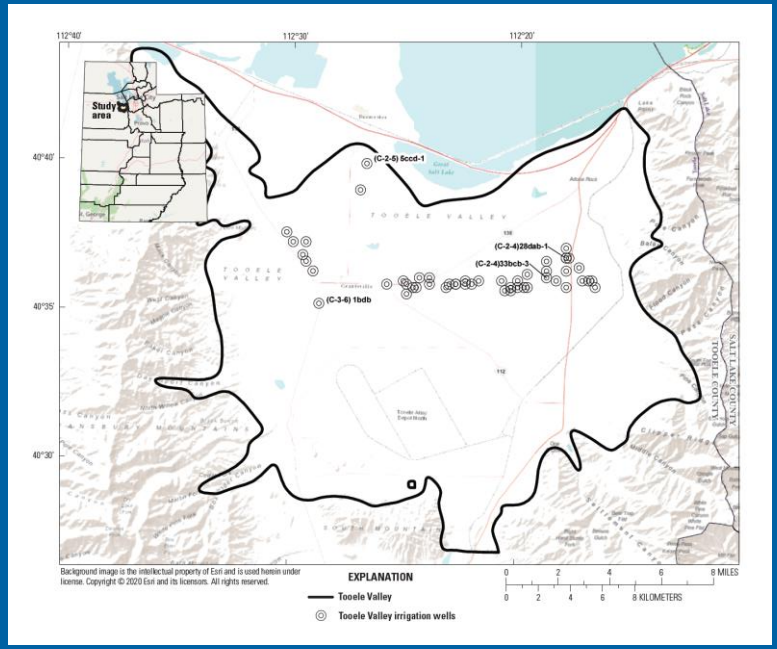
Power Consumption Coefficient (PCC) Background

- Power Consumption Coefficient (PCC)
  - Kilowatt-hours (kWh) required to pump 1 acre-foot of water
  - PCC units acre-ft/1000 kWh
- Field offices measured PCCs since 1960s
- Formula for calculating withdrawal based on PCC:

  withdrawal in acre-feet = PCC/1000*power usage in kWh



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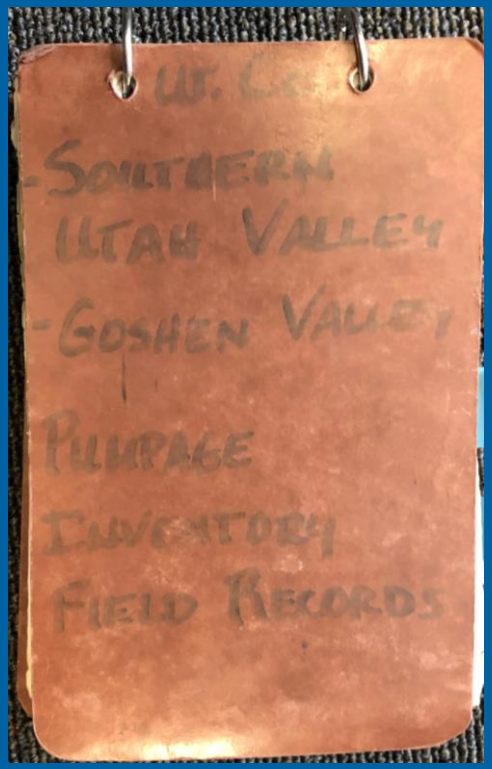
Methods:

- Data entered from field books into an electronic format allowing for data analysis and manipulation
- Statistical analysis of PCC based on variability through time
  - Specifically calculated for each well:
    - Coefficient of Variation (CV)
    - Standard deviation
    - Statistical outliers
    - Mean PCC
    - Median PCC
    - Minimum PCC
    - Maximum PCC



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Simple Well Configuration

Credit: Cory Angeroth

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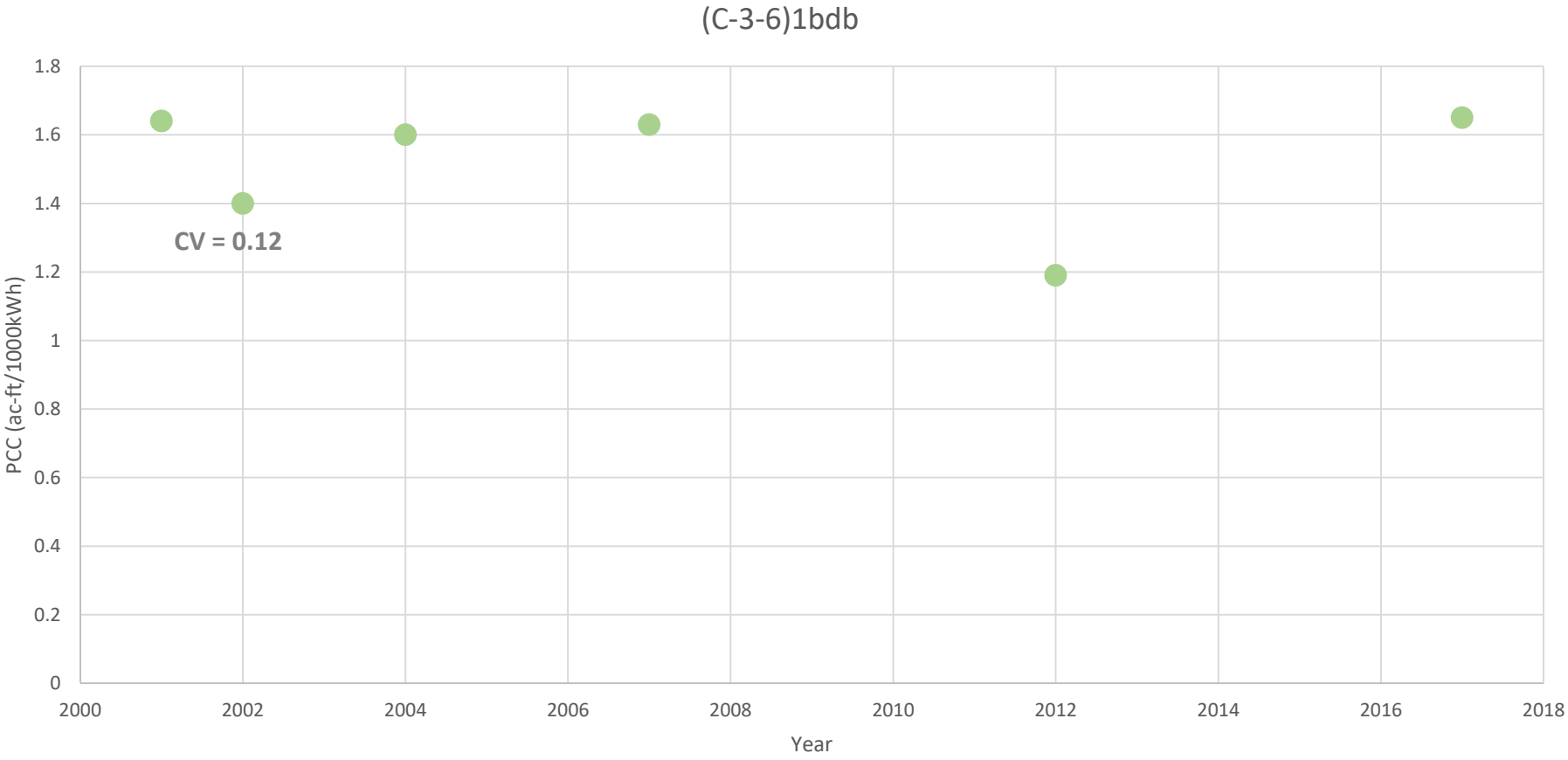
Simple Well—Tooele Valley



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Complex Well Configuration

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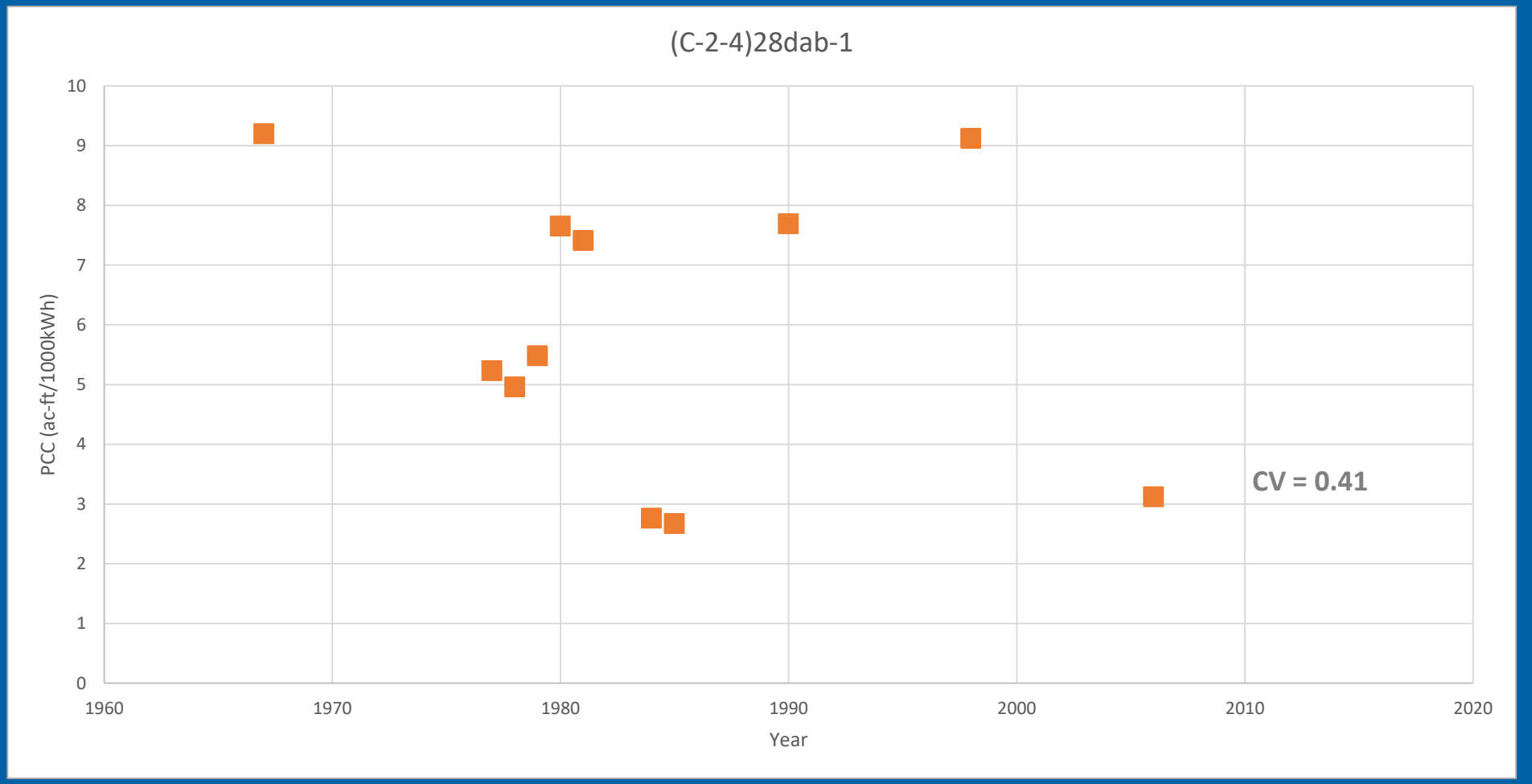
Complex Well—Tooele Valley



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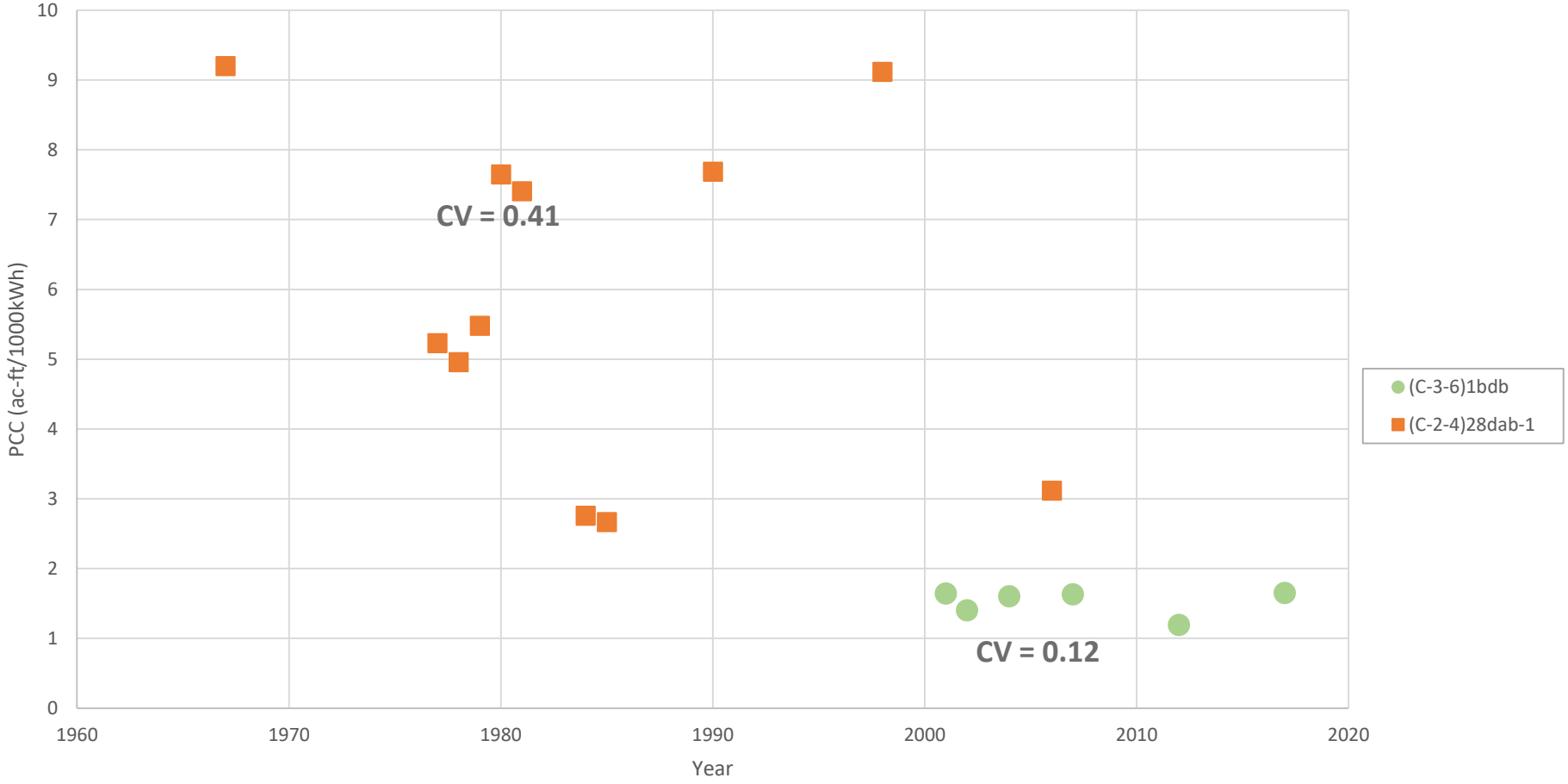
Simple and Complex Wells—Tooele Valley



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Methods:

- **Thresholds for classification of wells based on coefficient of variation (CV):**

Classification		
Simple	Complex	Borderline or ≤ three historical PCCs
<0.2	>0.25	0.20–0.25

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Methods—Classification

Active irrigation wells	Meter type	Wells with dedicated flowmeters	Complex wells	Simple wells	Borderline wells	≤ Three historical measurements	Wells without PCC records
Tooele Valley, Utah							
46	Dedicated flowmeter	0	—	—	—	—	—
	No dedicated flowmeter	46	23	7	1	15	0
Parowan Valley, Utah							
115	Dedicated flowmeter	0	—	—	—	—	—
	No dedicated flowmeter	115	5	47	7	17	39
Goshen Valley, Utah							
30	Dedicated flowmeter	24	8	4	4	8	0
	No dedicated flowmeter	6	—	—	1	5	0

*Active irrigation wells as of 2016

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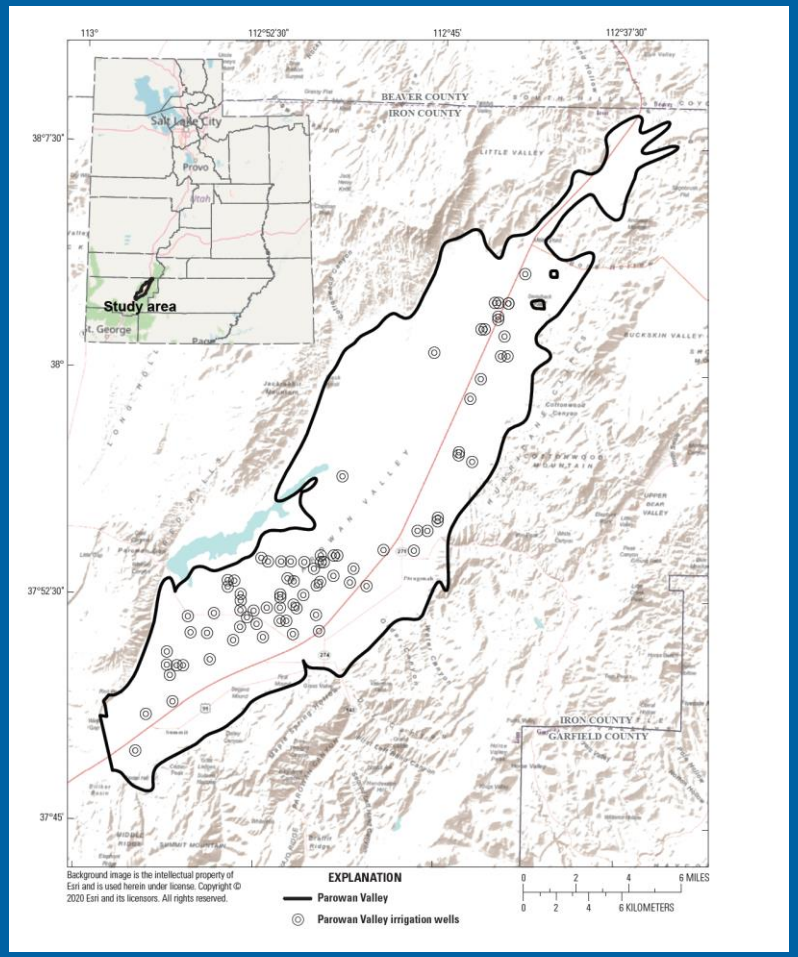
Findings—Basin-wide Withdrawal Estimates

- Compute the annual estimated withdrawal for 3 basins using:
  - Most Recent PCC
  - Maximum PCC
  - Minimum PCC
  - Mean PCC
  - Median PCC



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Findings—Difference between Annual Groundwater Withdrawal Calculated using historical Maximum, Minimum PCC and Most Recently Measured PCC (2016)

Table 6. Calculated groundwater withdrawal using the most recent power consumption coefficients (PCCs), historical minimum PCCs, and historical maximum PCCs in Tooele and Parowan Valleys, Utah, 2016.

[GW, groundwater; acre-ft, acre-foot; %, percent; —, no data]

PCC used to calculate withdrawal	2016 Annual GW withdrawal (acre-ft)	Difference in annual GW withdrawal (acre-ft) from withdrawal calculated with most recently measured PCC[1]	Percent difference in annual GW withdrawal (%) from withdrawal calculated with most recently measured PCC[2]
		Tooele Valley	
Most recent (measured)	5,394	—	—
Minimum	4,074	–1,320	–24
Maximum	8,587	3,193	59
		Parowan Valley	
Most recent (measured)	36,642	—	—
Minimum	32,997	–3,645	–10
Maximum	46,693	10,051	27

[1]The difference between using the most recent PCCs and the minimum or maximum PCCs.

[2]The percent difference between the most recent PCC and the minimum or maximum PCC.

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Findings—Methods for Calculating Withdrawal

Table 7. Method definitions for calculating annual groundwater withdrawal and calculated groundwater withdrawal in Utah, 2016.

[PCC, power consumption coefficient; ≤, less than or equal to; —, no data]

Method number	PCC record(s) used to calculate annual groundwater withdrawal	Estimated annual groundwater withdrawal by basin, in acre-foot		
		Tooele Valley, Utah	Parowan Valley, Utah	Goshen Valley, Utah[1]
Method 1	Most recent (measured)	5,394	36,642	22,646
Method 2	Historical minimum	4,074	32,997	22,433
Method 3	Historical maximum	8,587	46,693	22,688
Method 4	Historical mean	5,962	39,795	22,575
Method 5	Historical median	5,758	39,937	22,576
Method 6	Historical maximum complex, most recent (measured) simple and borderline/wells with ≤ three historical records	7,906	37,510	—
Method 7	Historical maximum complex and borderline/wells with ≤ three historical records, most recent (Measured) simple	8,557	41,283	—
Method 8	Historical minimum complex, most recent (measured) simple and borderline/wells with ≤ three historical records	4,444	35,827	—
Method 9	Historical minimum complex and borderline/wells with ≤ three records, most recent (measured) simple	4,347	34,530	—
Method 10	Valley average	5,693	37,079	22,945
Method 11	Flowmeter	—	—	—

[1]Withdrawal estimated using dedicated flowmeter withdrawal when available and with method indicated for wells without dedicated flowmeters.

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Findings—2016 Tooele Valley Withdrawal Estimates

Table 8. Percent difference between estimated annual groundwater withdrawal calculated using various combinations of historical power consumption coefficients from irrigation wells in Tooele Valley, Utah, 2016.

[GW, groundwater; acre-ft, acre-foot]

Method number	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7	Method 8	Method 9	Method 10	Annual GW withdrawal (acre-ft)
Method 1	0	32	–37	–10	–6	–32	–37	21	24	–5	5,394
Method 2	–24	0	–53	–32	–29	–48	–52	–8	–6	–28	4,074
Method 3	59	111	0	44	49	9	0	93	98	51	8,587
Method 4	11	46	–31	0	4	–25	–30	34	37	5	5,962
Method 5	7	41	–33	–3	0	–27	–33	30	32	1	5,758
Method 6	47	94	–8	33	37	0	–8	78	82	39	7,906
Method 7	59	110	0	44	49	8	0	93	97	50	8,557
Method 8	–18	9	–48	–25	–23	–44	–48	0	2	–22	4,444
Method 9	–19	7	–49	–27	–25	–45	–49	–2	0	–24	4,347
Method 10	6	40	–34	–5	–1	–28	–33	28	31	0	5,693

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Using historical mean or historical median PCCs to calculate withdrawal are close to withdrawal calculated with most recently measured PCCs, and reduce the need for frequent ratings.

Findings—2016 Goshen Valley Withdrawal Estimates for Wells with Flowmeters and 2016 Power Use Records

Table 12. Percent difference between estimated annual groundwater withdrawal calculated using various combinations of historical power consumption coefficients (PCCs) from irrigation wells that have historical PCCs, 2016 power usage, and dedicated flowmeters in Goshen Valley, Utah[1], 2016.

[GW, groundwater; acre-ft, acre-foot]

Method number	Method 1	Method 2	Method 3	Method 4	Method 5	Method 6	Method 7	Method 8	Method 9	Method 10	Method 11	Annual GW withdrawal (acre-ft)
Method 1	0	20	–34	–13	–14	–18	–31	7	19	–2	–9	14,888
Method 2	–17	0	–45	–28	–28	–32	–42	–11	–1	–19	–24	12,370
Method 3	51	81	0	30	30	24	5	61	80	47	37	22,416
Method 4	15	39	–23	0	0	–5	–20	23	38	13	5	17,182
Method 5	16	39	–23	0	0	–5	–20	24	38	13	5	17,241
Method 6	22	47	–19	6	5	0	–15	30	45	19	11	18,135
Method 7	44	73	–4	25	24	18	0	54	72	40	31	21,435
Method 8	–6	13	–38	–19	–19	–23	–35	0	12	–9	–15	13,925
Method 9	–16	1	–44	–27	–28	–31	–42	–10	0	–18	–24	12,477
Method 10	3	23	–32	–11	–11	–16	–29	10	22	0	–7	15,265
Method 11	10	32	–27	–5	–5	–10	–24	18	31	7	0	16,379

[1]This table includes active irrigation wells in Goshen Valley that have historical PCCs, 2016 power usage, and dedicated flowmeters. It excludes 10 active irrigation wells that do not have dedicated flowmeters and 2016 power usage reported.

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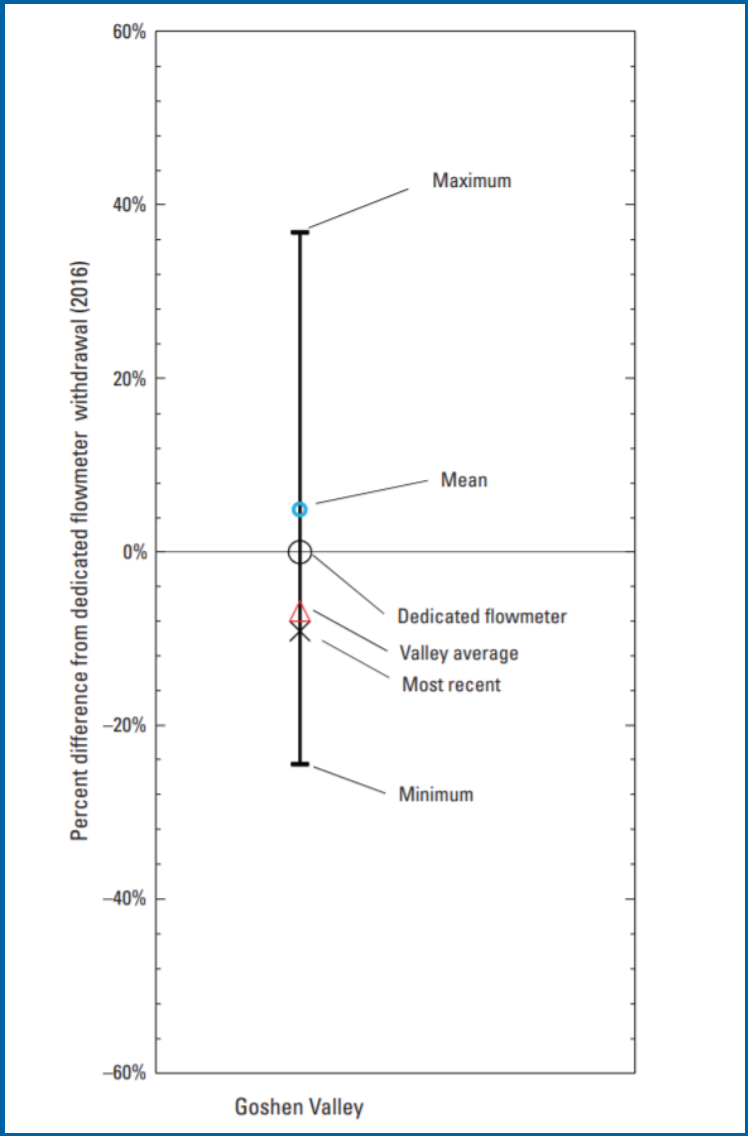
Withdrawal calculated using historical mean (or historical median) PCCs is closer to flowmeter withdrawal than withdrawal calculated using most recently measured PCCs.

Summary—Percent difference between dedicated flowmeter withdrawal and withdrawal calculated with other methods in Goshen Valley, 2016



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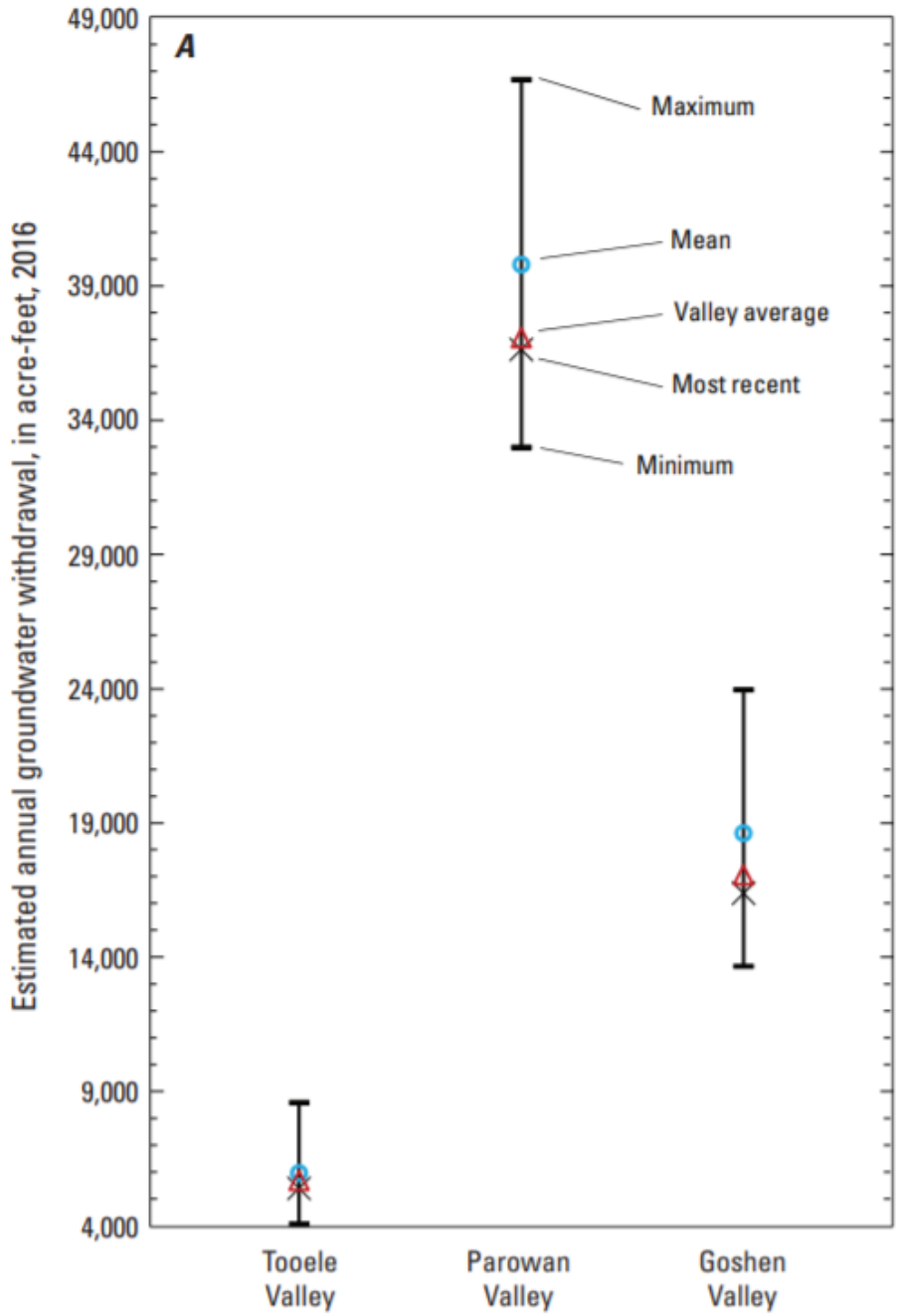
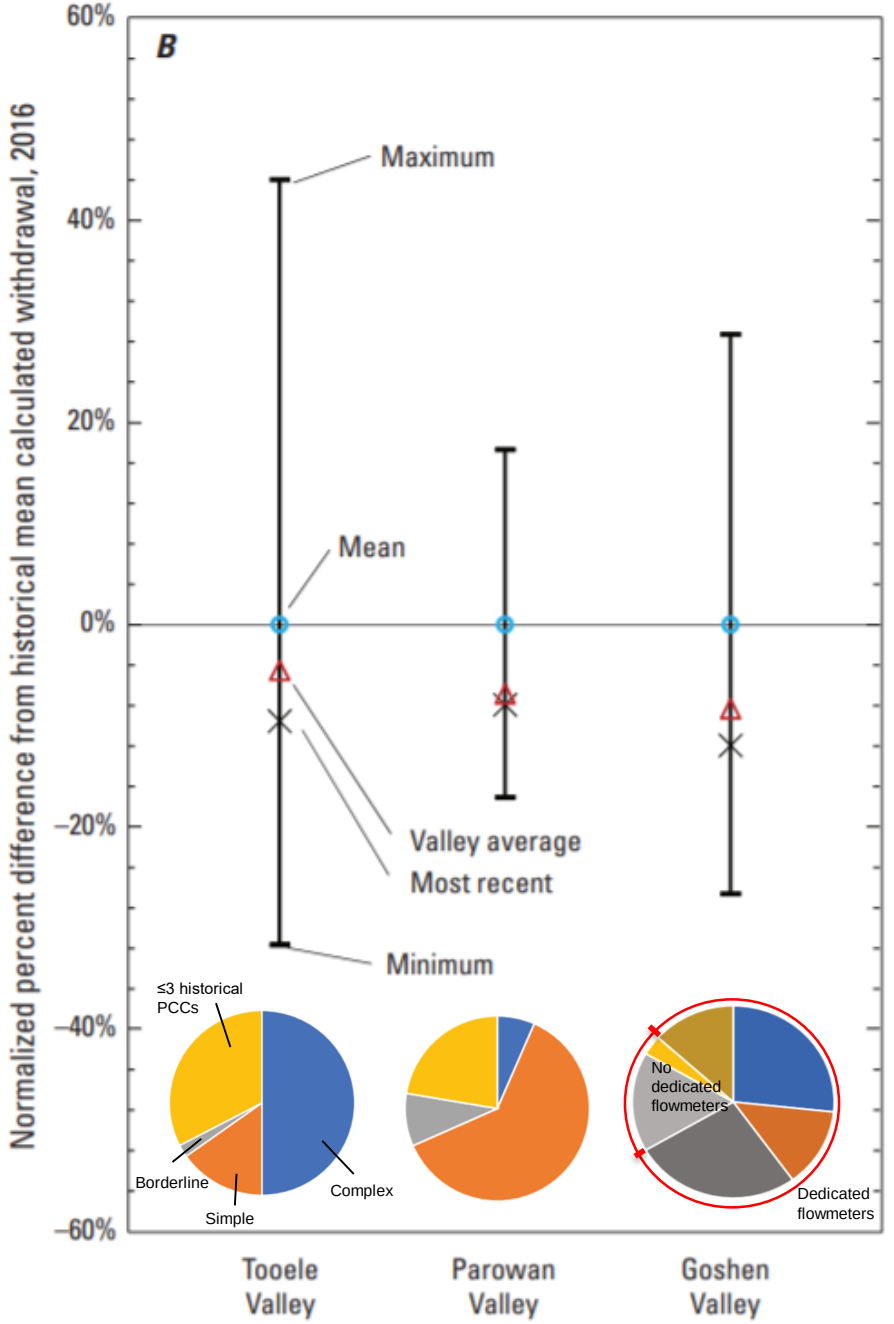
Summary


A
Estimated annual groundwater withdrawal, in acre-feet, 2016
49,000
44,000
39,000
34,000
29,000
24,000
19,000
14,000
9,000
4,000
Maximum
Mean
Valley average
Most recent
Minimum
Tooele Valley
Parowan Valley
Goshen Valley


B
Normalized percent difference from historical mean calculated withdrawal, 2016
60%
40%
20%
0%
–20%
–40%
–60%
Maximum
Mean
Valley average
Most recent
Minimum
≤3 historical PCCs
Borderline
Simple
Complex
No dedicated flowmeters
Dedicated flowmeters
Tooele Valley
Parowan Valley
Goshen Valley

Summary—Future Improvements

- Calculate CV for each well in each basin in Utah
- Determine the percentage of complex wells in each basin
- Field verification of complex wells
- More frequent PCC ratings for complex wells
- Installation of dedicated flowmeters would improve withdrawal estimates

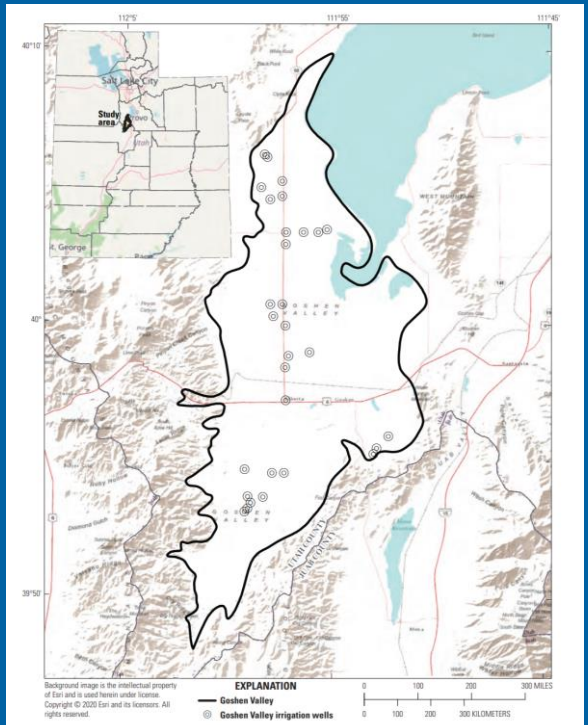


Figure 4. Active irrigation wells in Goshen Valley, Utah.

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Thank you!

Questions?

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