Second Report on the Five-Year Review of Water Availability in the East James Management Unit of the Tulare Aquifer

Scheduled before the Water Management Board October 2025

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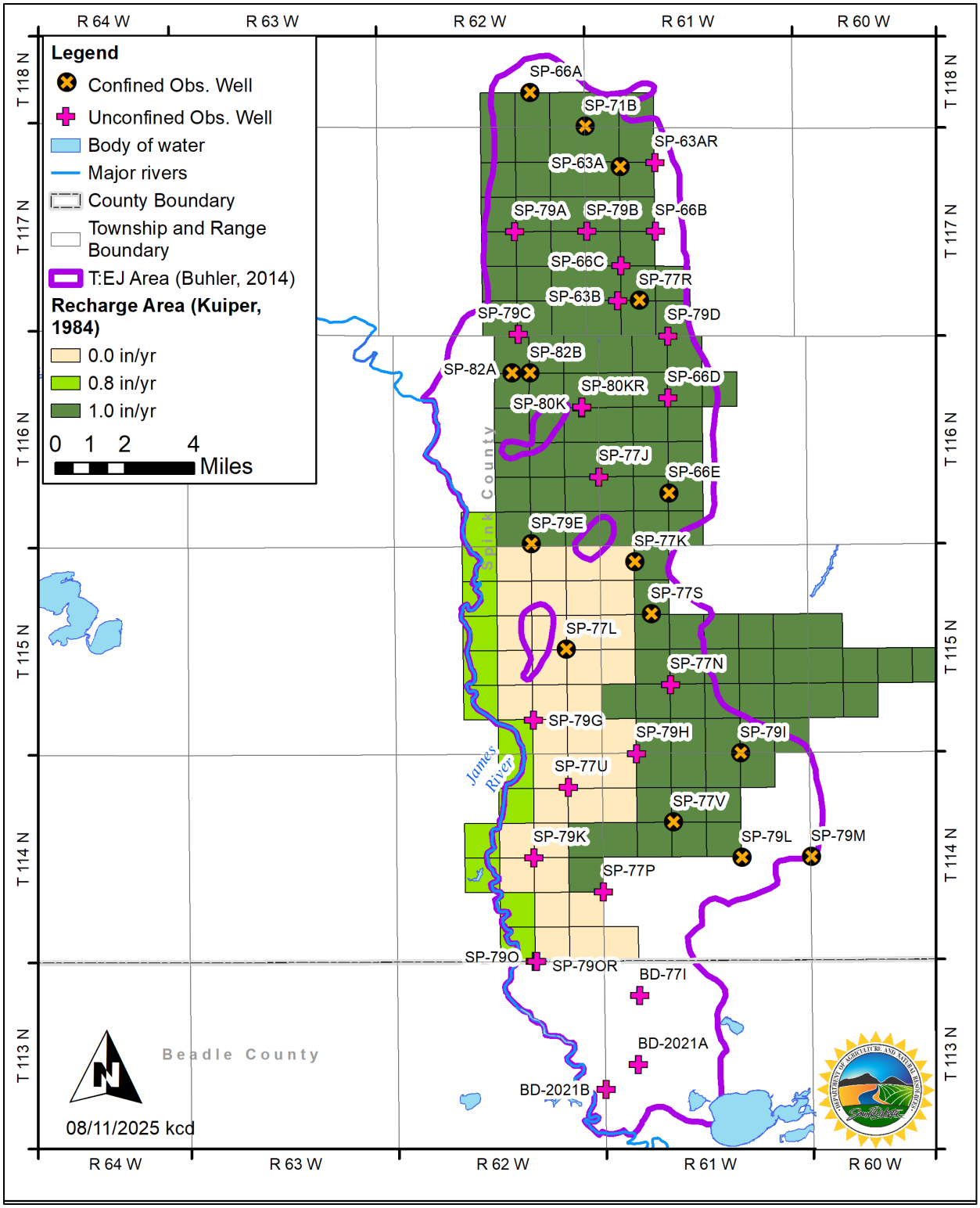

Figure 1: Map of the Tulare: East James aquifer management unit [1], Water Rights observation wells [2], and modeled recharge area from the Kuiper [3] study.

Introduction

In 2013, the South Dakota Water Management Board determined that the East James management unit of the Tulare aquifer was fully appropriated. Subsequently, the South Dakota Legislature provided a process for management of fully appropriated aquifers by enacting South Dakota Codified Law (SDCL) 46-2A-7 through 46-2A-7.7. The Water Management Board met in 2015 to satisfy the requirements provided by that legislation, using technical analysis by Ken Buhler. In 2020, the first 5-year review, as required by the legislation, went before the Water Management Board, using technical analysis by John Farmer. The Board concluded that based on the information available, there was not unappropriated water available for any of the 14 water right permit applications on hold at that time. This report serves as the technical review of the groundwater source, all permits appropriating water from that source, and all held applications from that source as required pursuant to SDCL 46-2A-7.5 for the second 5-year review. There are 14 water right permit applications on hold in the East James management unit as of July 2025.

East James management unit of the Tulare Aquifer (T:EJ) Hydrogeologic Characteristics

The Tulare aquifer is a Quaternary-aged system of sand and gravel layers that were deposited as outwash by meltwater from receding glaciers. The East James management unit is a buried outwash generally lying immediately above the bedrock (a.k.a. basal) east of the James River in Spink and Beadle Counties. Several evaluations of the aquifer extent have been done, with the latest estimate in aerial extent being by Water Rights Staff Engineer Ken Buhler in 2012 [1]. Buhler [1] estimated the area of the aquifer was 123,578 acres. Multiplying the aerial extent by an estimated average saturated thickness of 37 feet [4] and an estimated porosity of 0.15 [5], the estimated storage in the East James management unit is approximately 608,000 acre-feet. Buhler [1] estimated there were 22,477 acres of unconfined area in the aquifer in September of 2011.

Applicable SDCL for Five-Year Reviews of Fully Appropriated Aquifers

Pursuant to SDCL 46-2A-7.5, the Board shall hold a public hearing to review the groundwater source, all permits appropriating water from that source, and all held applications once every five years to determine the availability of unappropriated water. The first five-year review was conducted in 2020, so it is appropriate for another five-year review to be conducted in 2025.

Pursuant to SDCL 46-2A-7.6, if the Board determines that unappropriated water has become available from a fully appropriated aquifer during the five-year review, the Board shall make the unappropriated water available to the applications being held by the Chief Engineer based on priority established in SDCL 46-2A-7.2 and 46-2A-7.4. The Chief Engineer shall process held applications pursuant to SDCL 46-2A until such time as the Board determines the groundwater source again to be fully appropriated. Any remaining applications shall continue to be held by the Chief Engineer for future five-year reviews by the board.

Pursuant to SDCL 46-6-3.1, no application to appropriate groundwater may be approved if, according to the best information reasonably available, it is probable that the quantity of water withdrawn annually from a groundwater source will exceed the quantity of the average estimated annual recharge of the water to the groundwater source. An exception allows water distribution systems to withdraw from groundwater sources older or stratigraphically lower than the

Greenhorn Formation regardless of the results of a hydrologic budget. None of the held applications are a water distribution system as defined in SDCL 46-1-6(17) and the Tulare: East James aquifer is younger and stratigraphically higher than the Greenhorn Formation. Therefore, the Water Management Board must find that recharge to the aquifer exceeds withdrawals to approve any new applications.

Hydrologic Budget

Recharge

Recharge to the Tulare: East James aquifer occurs primarily through infiltration of precipitation where the aquifer is at or near the surface [4], although some recharge may occur from bedrock aquifers that are in contact with the Tulare: East James aquifer and from infiltration of bodies of surface water, if the stage of the surface water is higher than the water table of the aquifer.

Recharge to the Tulare aquifer in Spink and Beadle Counties east of the James River was published by Kuiper in 1984 with a numerical flow model. The Tulare: East James aquifer most corresponds with Model Area B in the Kuiper [3] model. Kuiper [3] used one-mile square cells in a single layer to compare 1968 to 1978 observation well data to 1978 irrigation data. The Kuiper [3] model produced an estimated average annual recharge of 0.76 inches per year.

Hedges, Allen, and Holly [6] used observation well data to determine that the recharge rate to the unconfined portions of the Tulare: East James aquifer is 2.5 inches per year. A regional flow-net analysis of the Tulare: East James aquifer was also performed by Hedges, Allen, and Holly [6] and found the estimated recharge rate was 0.72 inches per year. However, the unconfined and confined portions of the Tulare: East James aquifer were not mapped or otherwise indicated with the Hedges, Allen, and Holly [6] report.

In previous Water Management Board decisions, the Water Management Board has relied upon the 0.76 inches per year of recharge calculated from Kuiper's [3] results. When this recharge was applied over the entire area of the Tulare: East James aquifer at the time, the estimated average annual recharge was approximately 7,950 ac-ft/yr [7]. Given the numerous re-delineations and differences between currently understood aquifer boundaries and the boundaries used in the Kuiper [3] model, the best estimate of recharge which was accepted by the Water Management Board during the first five-year review was 6,800 ac-ft/yr [8], which is the estimated recharge from the Kuiper [3] model without applying the average recharge rate over the re-delineated area. As Farmer [8] indicated in the previous five-year review, the true value of the average annual recharge to the aquifer is likely to be higher than the amount estimated by Kuiper [3], but that value is the best information available.

Discharge

Discharge from the Tulare: East James aquifer occurs through evapotranspiration when the water table is near land surface, flow to surface water bodies when the hydraulic head in the aquifer is higher than the stage of the hydrologically connected surface water, and by domestic and appropriative withdrawals [3] [9] [10].

Domestic self-supply

There are 65 domestic wells on file with the Water Rights Program that are likely to be completed into the Tulare: East James aquifer [10]. Buhler [1] estimated domestic self-supply use based on the average rural use for the rural water systems in the area, a rate of 7,000 gallons per tap per month. Using that same rate of the 65 wells equates to an estimated average annual withdrawal of 17 ac-ft for all domestic self-supply in the aquifer.

Irrigation

There are 96 water rights and permits withdrawing from the Tulare: East James aquifer, which are all for irrigation use, authorized to irrigate a combined total of 16,735 acres. Irrigation reported over the period of record from 1979 through 2024 is shown in Figure 2 [11] [12]. Figure 3 shows the average reported irrigation in inches per irrigated acre and the percentage of irrigated acres per authorized acre over the period of record of 1979 and 1983 through 2024 [12]. Data from 1980 through 1982 was not available. Figure 3 shows that while irrigation water rights in the aquifer have tended to apply fewer inches per acre over time, they are utilizing a higher percentage of their authorized acreage. This may be due to changes in efficiency in irrigation equipment and other factors. Farmer [8] estimated average annual irrigation withdrawal by finding the average reported irrigation per reported acre and multiplying that value and the average rate of utilization (acres irrigated vs acres authorized to irrigate) across all permitted acres.

The average annual application rate in the first five-year review over the period of record of 1979 and 1983 through 2019 was 7.62 inches per irrigated acre. By applying that over the average utilization rate of 78.4% of the authorized acres, Farmer [8] estimated the average annual withdrawal was 8,301 ac-ft/yr. The average application rate over the period of record of 1979 and 1983 through 2024 is 7.58 inches [12]. The average utilization rate from the last five years of record is 81% [12]. Multiplying those numbers by the 16,735 acres authorized [9], the estimated withdrawal following the method Farmer [8] used in the first five-year review is 8,562 ac-ft/yr. All but two of the permits have been inspected and licensed [9]. However, the two permits that are not licensed are 1876A-3, which moves the 272 acres from Water Right No. 1876-3, and 3748A-3, which moves 102 acres and changes the diversion location from Water Right No. 3748-3. Both licenses have fully developed [12], and therefore for the two new permits, no change from previous irrigation patterns is anticipated.

The average reported irrigation can be calculated several other ways, although as Farmer [8] noted in the first five-year review, an average over the entire period of record may bias the average in favor of past irrigation practices and times when there was less development in the aquifer. The irrigation questionnaire summaries add all irrigation rights/permits which reported from the aquifer that year, including permits which are now cancelled, incorporated, or amended [11]. Another way to estimate the average annual withdrawal is to add the average reported withdrawal of each permit authorized to withdraw in the aquifer [12]. This method can still bias the data in favor of past irrigation methods, depending on the period of record chosen, but it removes the influence of multiple years of less development from the estimate. Table 1 shows the average reported irrigation from the two different methods for the period of record of 1979

through 2024 (all data available) and 2015 through 2024 (the last ten years of reports). Further detail of how these numbers were calculated can be seen in Appendix A (p. 13). Of the four values shown in Table 1, the one that is most likely to be the most representative of the average annual irrigation withdrawal from the Tulare: East James aquifer under current irrigation practices is 8,165 ac-ft/yr.

Table 1: Summary of average estimated irrigation withdrawals [11] [12]

Source	Interval	Average (ac-ft/yr)
Irrigation Questionnaire Summaries (Table 2)	1979 - 2024	7,236
	2015 - 2024	8,062
Average by Permit (Table 4, Table 5)	1979 - 2024	8,376
	2015 - 2024	8,165

Summary of Hydrologic Budget

The estimated average annual recharge to the Tulare: East James aquifer is 6,800 ac-ft/yr. However, this estimate is likely to be lower than the true value. The estimated average annual withdrawal in the aquifer from domestic self-supply is 17 ac-ft/yr. The true value of this figure could vary widely from the estimate, but it is a small fraction of the total hydrologic budget. The estimated average annual withdrawal from appropriative water rights (all authorized for irrigation use) is 8,165 ac-ft/yr. Therefore, based on the hydrologic budget, there is not unappropriated water available in the Tulare: East James aquifer.

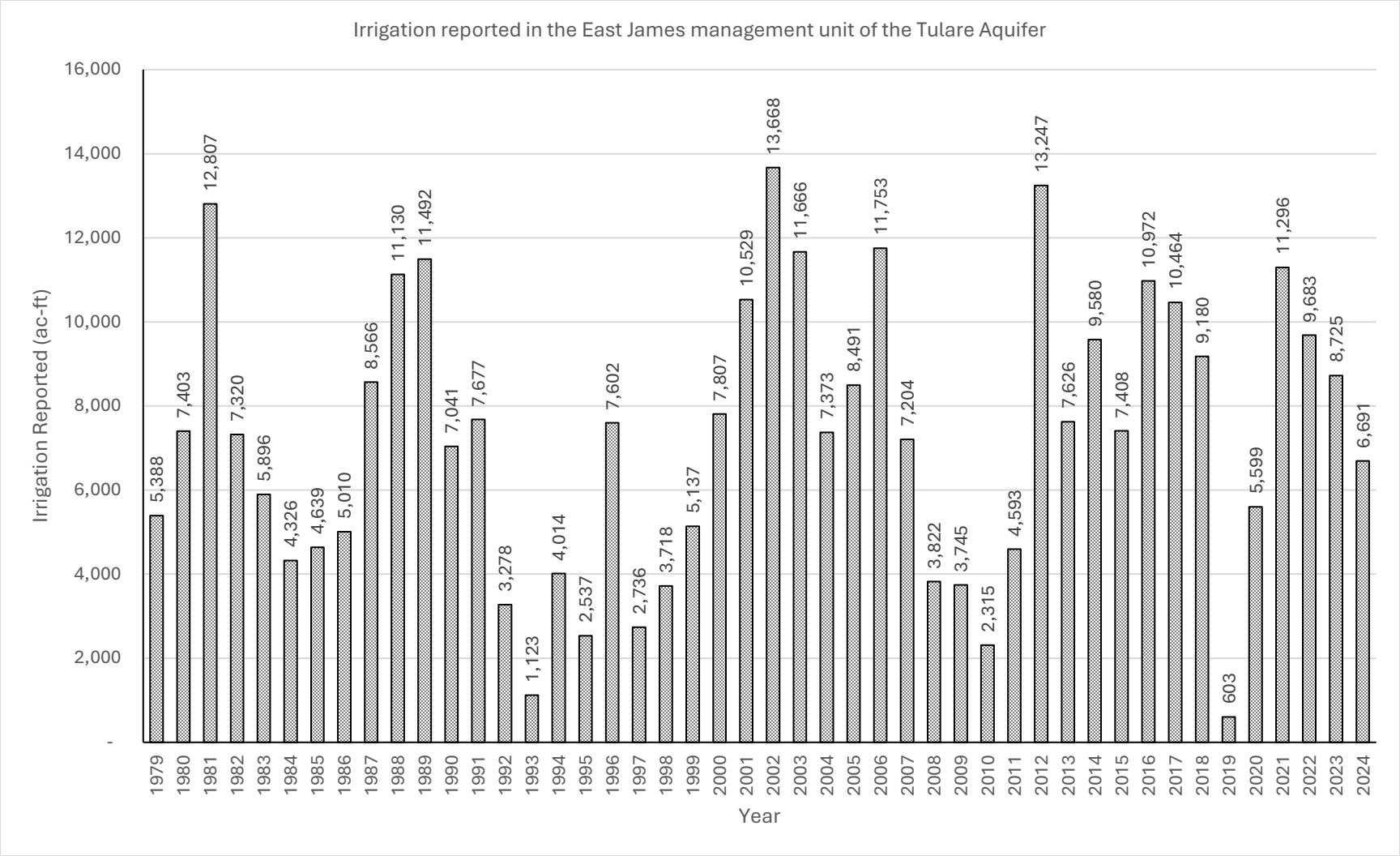

Figure 2: Irrigation Reported in the East James management unit of the Tulare aquifer [11] [12]

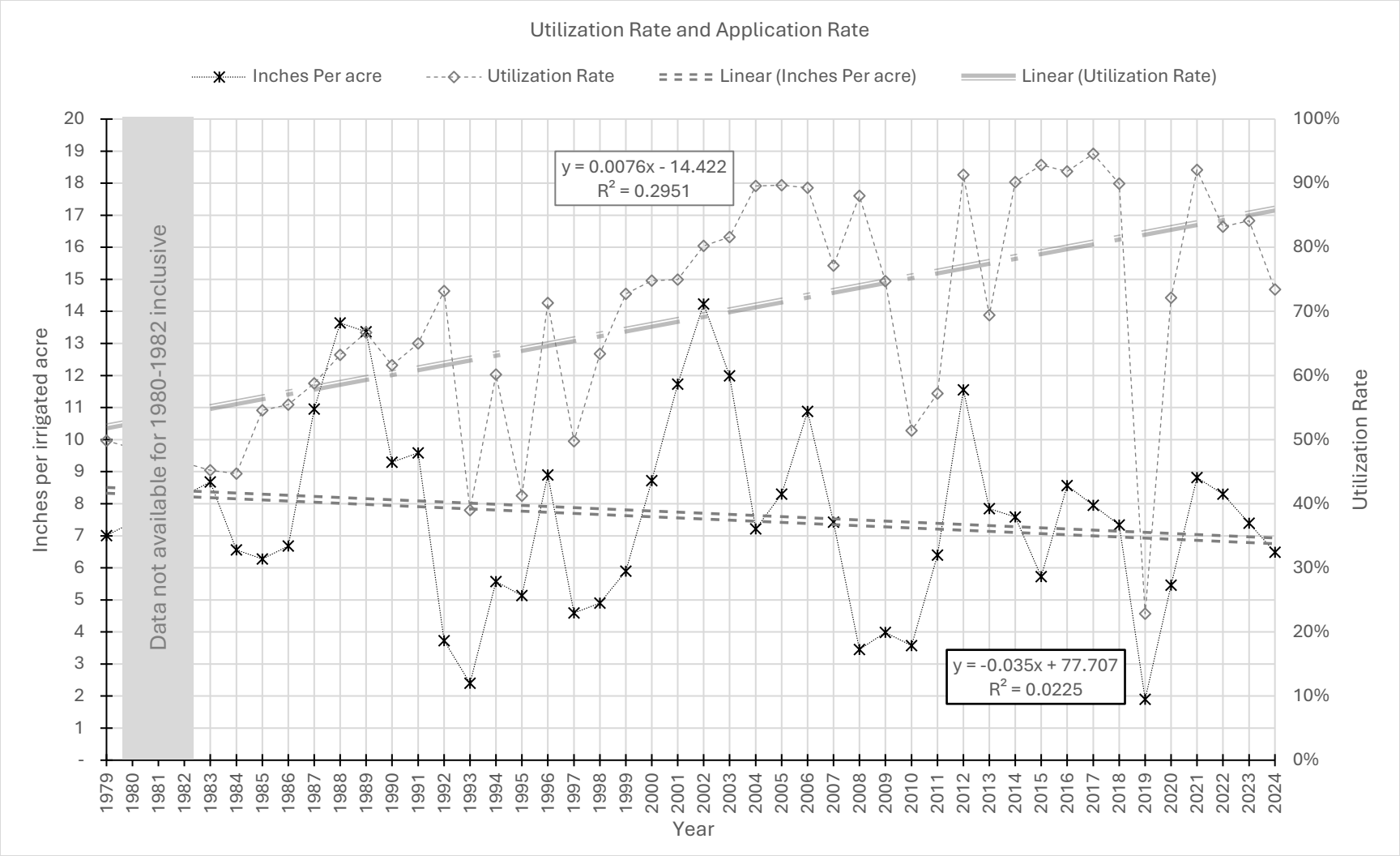

Figure 3: Trends in irrigation water application rate and authorized acreage utilization rate in the Tulare: East James aquifer [12]

Observation Wells

Administrative Rule of South Dakota (ARSD) 74:02:05:07 requires the Water Management Board to consider the record of observation wells to determine that recharge exceeds withdrawals from an aquifer. The Water Rights Program maintains 38 observation wells completed into the Tulare: East James aquifer, although three observation wells, SP-63AR, SP-79OR, and SP-80KR, are intended to be replacements for older wells of the same name, but without the final *R*, pending analysis that they are adequate replacements, so there are effectively 35 unique observation wells completed into the Tulare: East James aquifer. For analysis of the observation wells in this aquifer, the wells were divided into eight groups based on location. Figure 5 (p. 21) shows a map of the eight groups. Figure 6 through Figure 13 (pp. 22-29) show the hydrographs of the observation wells in each group and the elevations of the tops of the aquifer formation [2].

In general, water levels in the aquifer rise during periods of higher-than-average precipitation and decline during periods of lower-than-average precipitation. On average, precipitation in S.D. Climate Division 7 (Figure 14, p. 30) has been increasing over time. In a study done by Hullinger [13], flows in the James River have been increasing over the period of record available back to 1946. If the use in the aquifer remains the same and precipitation and stream flow are increasing, then the water storage in the aquifer should be increasing provided the aquifer is not already at capacity. Indeed, as the period of record of observation wells in the Tulare: East James aquifer continues, a larger percentage of the observation well water levels are above the top of the aquifer. However, the amount of recharge cannot be directly measured from observation well water-level increases in observation wells under confined conditions (i.e. water levels are above the top of the aquifer). Water level fluctuations above the top of the aquifer indicate a change in water pressure in the aquifer, not a change in storage. Higher water pressure in the aquifer will cause the water stored in the aquifer to naturally discharge to other aquifers or surface water features which are in contact with the aquifer. Therefore, recharge to the aquifer is more than withdrawals. Based on observation well analysis, there may be unappropriated water available in the Tulare: East James aquifer, but the amount cannot be known without comprehensive modeling of flows into and out of the aquifer.

Conclusions

1. The estimated average annual recharge to the Tulare: East James aquifer is 6,800 acre-feet per year, based on a model run in 1984.
2. The estimated average annual withdrawal from the Tulare: East James aquifer is 8,182 acre-feet per year.
3. Based on the hydrologic budget, there is not unappropriated water available in the Tulare: East James aquifer.
4. Based on observation well analysis, there may be unappropriated water available in the Tulare: East James aquifer, but the amount cannot be quantified with available information.
5. The creation and maintenance of a new model of the Tulare: East James aquifer to estimate the amount of unappropriated water available is highly recommended.

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Natural Resources Engineer III – DANR Water Rights Program

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[2] SD DANR Water Rights Program, "Observation Wells," SD DANR Water Rights Program, Pierre, South Dakota, 2025.

[3] L. K. Kuiper, "Appraisal of the Water Resources of the Eastern Part of the Tulare Aquifer, Beadle, Hand, and Spink Counties, South Dakota," US Geological Survey, Huron, South Dakota, 1984.

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Glossary

Average (Avg.): a measure of central tendency. In this report, the average is the sum of all values in a set divided by the number of values in that set. Also known as arithmetic average or mean.

Coefficient of Determination (R^2). A measure by which one can assess if a trend line correlates well to the data. As the coefficient of determination approaches 100%, the trend line predicts 100% of the variance in the data set. If the coefficient of determination is 0%, the trend line shows no correlation to variance in data. It is the square of the Pearson correlation coefficient.

Confined. A state of an aquifer or part of an aquifer were water levels in observation wells rise above the top of the aquifer formation. Also known as "artesian" in South Dakota water law.

Minimum (Min.): The smallest value in a set of data.

Maximum (Max.): The largest value in a set of data.

Median: When a set of data is sorted from smallest to largest, the median is the value which falls in the middle.

Standard deviation (St. Dev.): A measure of how much values in a set vary from average. One standard deviation is the amount where, if added or subtracted from the average, approximately 68.2% of the data would fall within that range (Figure 4).

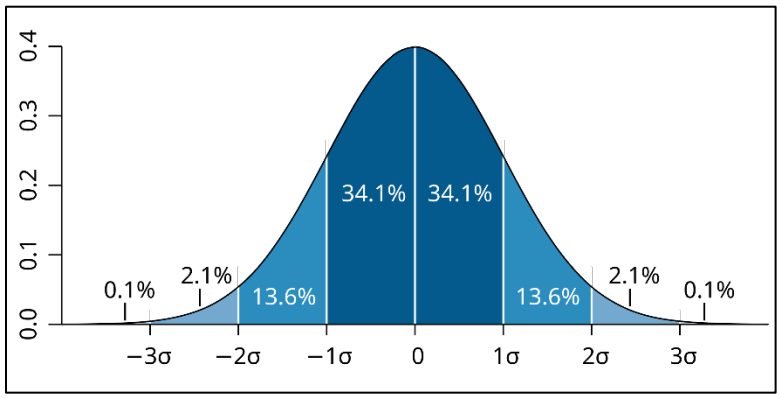

Figure 4: A diagram of a normal distribution and the standard deviations (σ) within it [14].

Unconfined. A state of an aquifer or part of an aquifer where water levels in observation wells are below the top of the aquifer formation. Also known as "water table" in South Dakota water law.

Year:

- **Calendar Year**: January 1 through December 31.
- **Water Year**: October 1 through September 30. The number of a water year corresponds to the larger proportion of the Calendar Year in which the Water Year falls. For example, Water Year 2025 is October 1, 2024 through September 30, 2025. The designation of water year versus calendar year is an attempt to keep climactically related phenomena within the same year designation.

Appendix A: Supplementary Tables

Table 2: Irrigation Reported from 1979 through 2024

Year	No. Licenses	No. Permits	All License/ Permits	Authorized Acres	Reported Irrigation (ac-ft/yr)	Acres Irrigated	Avg. App. Rate for Irr. Acres (in/yr)	Utilization Rate (Irr. Acres/Auth. Acres)
1979	36	53	89	18,530	5,388	9,231	7.00	50%
1980	44	47	91	18,437	7,403	N/A	N/A	N/A
1981	48	46	94	18,553	12,807	N/A	N/A	N/A
1982	47	52	99	19,421	7,320	N/A	N/A	N/A
1983	64	31	95	18,015	5,896	8,149	8.68	45%
1984	65	26	91	17,712	4,326	7,913	6.56	45%
1985	69	17	86	16,246	4,639	8,863	6.28	55%
1986	70	16	86	16,213	5,010	8,993	6.68	55%
1987	70	14	84	15,973	8,566	9,385	10.95	59%
1988	70	11	81	15,493	11,130	9,794	13.64	63%
1989	71	10	81	15,469	11,492	10,318	13.37	67%
1990	73	5	78	14,759	7,041	9,094	9.29	62%
1991	73	6	79	14,787	7,677	9,613	9.58	65%
1992	71	7	78	14,403	3,278	10,541	3.73	73%
1993	71	7	78	14,403	1,123	5,614	2.40	39%
1994	72	5	77	14,375	4,014	8,647	5.57	60%
1995	72	5	77	14,375	2,537	5,928	5.14	41%
1996	72	5	77	14,375	7,602	10,252	8.90	71%
1997	72	5	77	14,375	2,736	7,150	4.59	50%
1998	72	5	77	14,375	3,718	9,111	4.90	63%
1999	72	5	77	14,375	5,137	10,455	5.90	73%
2000	73	4	77	14,369	7,807	10,746	8.72	75%
2001	72	5	77	14,369	10,529	10,772	11.73	75%
2002	72	5	77	14,369	13,668	11,529	14.23	80%
2003	72	3	75	14,313	11,666	11,679	11.99	82%
2004	68	7	75	13,688	7,373	12,259	7.22	90%
2005	67	8	75	13,685	8,491	12,273	8.30	90%
2006	67	13	80	14,523	11,753	12,965	10.88	89%
2007	66	17	83	15,099	7,204	11,648	7.42	77%
2008	66	17	83	15,099	3,822	13,291	3.45	88%
2009	66	16	82	15,099	3,745	11,281	3.98	75%
2010	65	17	82	15,099	2,315	7,765	3.58	51%
2011	64	18	82	15,071	4,593	8,619	6.39	57%
2012	64	18	82	15,071	13,247	13,763	11.55	91%
2013	62	30	92	16,812	7,626	11,666	7.84	69%
2014	62	31	93	16,812	9,580	15,160	7.58	90%
2015	70	20	90	16,727	7,408	15,532	5.72	93%
2016	73	17	90	16,727	10,972	15,363	8.57	92%
2017	78	13	91	16,699	10,464	15,792	7.95	95%
2018	78	13	91	16,699	9,180	15,017	7.34	90%
2019	78	12	90	16,674	603	3,809	1.90	23%
2020	85	10	95	17,065	5,599	12,310	5.46	72%

Appendix A. Table 2 (cont.)

Year	No. Licenses	No. Permits	All License/ Permits	Authorized Acres	Reported Irrigation (ac-ft/yr)	Acres Irrigated	Avg. App. Rate for Irr. Acres (in/yr)	Utilization Rate (Irr. Acres/Auth. Acres)
2021	84	10	94	16,691	11,296	15,370	8.82	92%
2022	84	11	95	16,823	9,683	13,995	8.30	83%
2023	84	11	95	16,823	8,725	14,157	7.40	84%
2024	94	1	95	16,872	6,691	12,385	6.48	73%
1979 through 2024:								
Min.	36	1	75	13,685	603	3,809	1.90	23%
Max.	94	53	99	19,421	13,668	15,792	14.23	95%
Avg.	69	15	85	15,781	7,236	10,888	7.58	70%
2015 through 2024:								
Min.	70	1	90	16,674	603	3,809	1.90	23%
Max.	94	20	95	17,065	11,296	15,792	8.82	95%
Avg.	81	12	93	16,780	8,062	13,373	6.79	80%

Table 3: Summary of irrigation reported statistics per permit

1979-2024 (Table 3)		2015-2024 (Table 4)	
Trend Assessment	Number of Permits	Trend Assessment	Number of Permits
↑↑	3	↑↑	4
↑	3	↑	8
≈	84	≈	73
↓	2	↓	7
↓↓	3	↓↓	2
↑↑ - significant increase; ↑ - moderate increase; ≈ - no significant trend; ↓ - Moderate decrease; ↓↓ - significant decrease			

Calculation methods for Table 4 and Table 5. Calculations done using Microsoft Excel for Microsoft Office 365 (Version 2408 Build 16.0.17928.20572) 64-bit.

1. Average: sum of all reports divided by number of reports.
2. Standard Deviation: STDEV.P([REPORTS]) or STDEV.S([REPORTS]) depending on context.
3. Coefficient of Determination: PEARSON([REPORTS], [RANGE OF YEARS])^2
4. Trend (ac-ft/yr): FORECAST.LINEAR(2025, [REPORTS], [RANGE OF YEARS])-FORECAST.LINEAR(2024, [REPORTS], [RANGE OF YEARS])
5. Trend (% Avg.): Trend (ac-ft/yr) divided by Average.
6. Trend (in/yr): Trend (ac-ft/yr) divided by Licensed Acres.
7. Trend Assessment:

   Significant – Trend (in/yr) minus Average of Trends (in/yr) exceeds two standard deviations.

   Moderate – Trend (in/yr) minus Average of Trends (in/yr) is between one and two standard deviations.

No significant trend – Trend (in/yr) minus Average of Trends (in/yr) is less than one standard deviation.
Increase – Values tend to rise from year to year.
Decrease – Values tend to decline from year to year.

8. Rows starting with **Total** and below are calculated based on the above column, except ***Total Trend (in/yr)***, which is calculated using the same method as the rows for that column using the Total of Trend (ac-ft/yr) and Total Licensed Acres.

Table 4: Irrigation reported statistics per permit (1979-2024)

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
1033A-3	130	33	80	69	2%	1.0	1.29%	0.10	≈
1048-3	160	43	82	73	0%	0.3	0.31%	0.02	≈
1050-3	430	43	225	211	24%	8.3	3.69%	0.23	≈
1071-3	160	43	93	112	0%	-0.6	-0.65%	-0.05	≈
1072-3	160	43	97	130	3%	-1.9	-1.99%	-0.15	≈
1073-3	312	43	137	111	0%	-0.3	-0.19%	-0.01	≈
1120-3	240	43	130	128	13%	3.6	2.80%	0.18	≈
1201A-3	122	12	59	35	10%	3.2	5.38%	0.31	≈
1223-3	131	43	76	66	12%	1.8	2.42%	0.17	≈
1247-3	160	43	86	51	0%	0.1	0.08%	0.01	≈
1312-3	160	43	72	55	3%	0.8	1.09%	0.06	≈
1358B-3	135	6	66	34	32%	11.3	17.08%	1.00	↑↑
1458-3	160	43	68	59	2%	0.7	1.04%	0.05	≈
1504A-3	136	21	33	37	0%	-0.4	-1.14%	-0.03	≈
1504B-3	136	21	58	62	23%	-4.8	-8.33%	-0.43	↓
1700-3	135	43	58	54	0%	0.3	0.50%	0.03	≈
1722A-3	160	8	35	49	25%	-10.8	-31.32%	-0.81	↓↓
1722B-3	80	8	17	17	1%	-0.6	-3.71%	-0.09	≈
1723-3	136	43	56	59	2%	-0.6	-1.13%	-0.06	≈
1724A-3	128	12	92	50	20%	-6.4	-6.98%	-0.60	↓
1876-3	272	43	127	121	1%	1.1	0.87%	0.05	≈
1891-3	262	43	143	120	11%	3.2	2.23%	0.15	≈
1894-3	200	43	53	42	4%	-0.6	-1.20%	-0.04	≈
2208A-3	264	14	105	83	37%	12.6	11.97%	0.57	↑
2235A-3	539	40	265	128	7%	-2.9	-1.08%	-0.06	≈
2236-3	128	43	50	22	1%	0.1	0.29%	0.01	≈
2276-3A	200	42	134	79	11%	-2.1	-1.59%	-0.13	≈
2367-3	124	43	99	75	0%	-0.1	-0.15%	-0.01	≈
2375-3	272	43	135	81	2%	-0.9	-0.67%	-0.04	≈
2418-3	136	43	81	49	4%	0.8	0.98%	0.07	≈
2514-3	132	43	47	46	10%	-1.1	-2.41%	-0.10	≈
2553-3	237	43	155	93	15%	-2.9	-1.87%	-0.15	≈
2561-3	153	43	88	59	37%	-2.8	-3.25%	-0.22	≈
2613-3	130	43	106	155	2%	-1.8	-1.70%	-0.17	≈
2618-3	272	43	107	96	0%	-0.1	-0.10%	0.00	≈

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
3035-3	265	43	68	65	51%	3.7	5.46%	0.17	≈
3056-3	202	43	83	56	17%	-1.9	-2.25%	-0.11	≈
3062-3	140	43	109	103	23%	-3.9	-3.59%	-0.33	≈
3063-3	272	43	93	79	12%	-2.2	-2.34%	-0.10	≈
3114-3	137	43	100	63	20%	2.3	2.25%	0.20	≈
3173-3	136	43	80	71	3%	1.0	1.31%	0.09	≈
3176-3	272	43	99	63	1%	-0.5	-0.49%	-0.02	≈
3178A-3	132	40	152	105	13%	-3.3	-2.20%	-0.30	≈
3178B-3	132	3	60	8	0%	-0.6	-1.07%	-0.06	≈
3179-3	264	43	135	108	2%	-1.2	-0.91%	-0.06	≈
3181-3	232	43	64	37	1%	0.3	0.50%	0.02	≈
3182-3	139	43	45	33	30%	-1.5	-3.26%	-0.13	≈
3189-3	132	43	43	50	11%	-1.3	-3.00%	-0.12	≈
3268-3	140	24	65	65	2%	1.1	1.69%	0.09	≈
3268A-3	110	6	36	20	72%	2.6	7.13%	0.28	≈
3272-3	136	43	113	71	10%	-1.8	-1.60%	-0.16	≈
3378-3	136	43	92	60	4%	-0.9	-0.99%	-0.08	≈
3390-3A	132	42	52	63	0%	-0.3	-0.66%	-0.03	≈
3468-3	272	43	141	72	1%	-0.5	-0.38%	-0.02	≈
3748-3	102	43	60	62	1%	-0.5	-0.86%	-0.06	≈
4158-3	136	43	115	57	15%	1.8	1.54%	0.16	≈
4195A-3	272	18	115	71	6%	3.3	2.84%	0.14	≈
4196-3	190	43	70	62	2%	0.7	1.03%	0.05	≈
4203-3	136	43	74	57	0%	0.0	-0.04%	0.00	≈
4374-3	264	43	56	60	5%	-1.1	-1.96%	-0.05	≈
4375-3	132	43	6	15	22%	-0.6	-9.91%	-0.05	≈
4390-3	128	43	78	64	3%	0.8	1.07%	0.08	≈
4486-3	132	42	74	55	35%	-2.7	-3.63%	-0.24	≈
4586C-3	264	11	259	92	7%	7.5	2.88%	0.34	≈
4612A-3	132	22	70	52	26%	-4.2	-5.96%	-0.38	≈
4714-3	127	42	19	31	0%	0.2	0.87%	0.02	≈
4845-3	136	42	79	48	1%	-0.3	-0.38%	-0.03	≈
5280-3	264	36	113	98	4%	1.9	1.67%	0.09	≈
5529-3	160	34	89	61	1%	0.5	0.52%	0.03	≈
6242A-3	138	23	66	30	2%	-0.7	-1.09%	-0.06	≈
6341-3	262	22	128	76	1%	1.3	0.98%	0.06	≈
6655-3	132	19	72	50	6%	-2.2	-3.03%	-0.20	≈
6656-3	270	19	97	95	10%	-5.4	-5.62%	-0.24	≈
6675-3	100	19	113	38	4%	1.4	1.27%	0.17	≈
6676-3	264	19	251	142	46%	17.6	7.02%	0.80	↑↑
6711A-3	270	18	106	80	1%	-1.5	-1.44%	-0.07	≈
6712A-3	135	16	91	58	5%	-2.8	-3.08%	-0.25	≈
7235A-3	136	12	61	53	7%	-4.1	-6.62%	-0.36	≈
7295-3	120	12	155	58	0%	0.8	0.54%	0.08	≈
7316-3	272	12	206	201	3%	9.6	4.65%	0.42	↑
7348A-3	66	8	52	68	7%	7.9	15.21%	1.44	↑↑

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
7348B-3	135	5	36	50	2%	5.3	14.69%	0.47	↑
7348C-3	104	5	69	69	6%	-12.4	-17.86%	-1.43	↓↓
7348D-3	135	5	89	102	10%	-22.3	-25.00%	-1.98	↓↓
7364-3	135	12	62	32	13%	3.4	5.44%	0.30	≈
7365-3	132	12	3	6	31%	-1.0	-29.72%	-0.09	≈
7366-3	132	12	3	5	36%	-0.9	-27.66%	-0.09	≈
7367-3	132	12	13	20	12%	-2.0	-15.32%	-0.18	≈
7369A-3	154	10	57	29	5%	2.2	3.79%	0.17	≈
7369B-3	132	10	37	28	3%	1.7	4.45%	0.15	≈
7369C-3	130	10	28	28	0%	0.2	0.79%	0.02	≈
7370-3	132	12	6	8	31%	-1.2	-21.24%	-0.11	≈
961-3	320	43	144	136	14%	4.1	2.84%	0.15	≈
970-3	132	43	118	71	17%	2.4	2.01%	0.22	≈
987-3	154	43	87	86	29%	3.7	4.28%	0.29	≈
Total	**16,872**	**2,947**	**8,376**	**6,412**	**--**	**10.5**	**--**	***0.00***	**≈**
Average	178	31	88	67	11%	0.1	-1.28%	-0.01	--
St. Dev.	76		51	38	13%	4.7	7.86%	**0.38**	--
Min.	66	3	3	5	0%	-22.3	-31.32%	-1.98	--
Max.	539	43	265	211	72%	17.6	17.08%	1.44	--
Median	136	43	80	62	5%	-0.3	-0.19%	-0.01	--

Permit Nos. 1876A-3 and 3748A-3 were issued in 2025, so they are not included in this table.

Table 5: Irrigation reported statistics per permit (2015-2024)

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
961-3	320	10	158	136	10%	12.29	8%	0.46	↑
970-3	132	10	164	71	3%	-3.91	-2%	-0.36	≈
987-3	154	10	166	86	12%	-9.62	-6%	-0.75	↓
1033A-3	130	10	78	37	25%	-6.46	-8%	-0.60	≈
1048-3	160	10	63	73	11%	-4.03	-6%	-0.30	≈
1050-3	430	10	297	211	16%	25.01	8%	0.70	↑
1071-3	160	10	81	112	17%	-7.57	-9%	-0.57	≈
1072-3	160	10	66	130	0%	0.90	1%	0.07	≈
1073-3	312	10	123	111	0%	-1.03	-1%	-0.04	≈
1120-3	240	10	136	128	0%	0.06	0%	0.00	≈
1201A-3	122	10	65	35	1%	1.14	2%	0.11	≈
1223-3	131	10	79	66	0%	-0.23	0%	-0.02	≈
1247-3	160	10	89	51	1%	1.48	2%	0.11	≈
1312-3	160	10	94	55	3%	5.83	6%	0.44	↑
1358B-3	135	6	66	34	32%	11.28	17%	1.00	↑↑
1458-3	160	10	78	59	0%	0.61	1%	0.05	≈
1504A-3	136	10	41	37	11%	-4.19	-10%	-0.37	≈
1504B-3	136	10	37	62	53%	-10.05	-27%	-0.89	↓
1700-3	135	10	64	54	11%	4.12	6%	0.37	≈
1722A-3	160	8	35	49	25%	-10.83	-31%	-0.81	↓
1722B-3	80	8	17	17	1%	-0.63	-4%	-0.09	≈
1723-3	136	10	31	59	26%	-6.82	-22%	-0.60	≈
1724A-3	128	10	78	50	0%	-0.33	0%	-0.03	≈
1876-3	272	10	126	121	19%	-14.99	-12%	-0.66	↓
1891-3	262	10	166	120	13%	12.54	8%	0.57	↑
1894-3	200	10	55	42	16%	-5.37	-10%	-0.32	≈
2208A-3	264	10	123	83	40%	20.26	16%	0.92	↑↑
2235A-3	539	10	259	128	10%	12.50	5%	0.28	≈
2236-3	128	10	59	22	8%	3.05	5%	0.29	≈
2276-3A	200	10	98	79	2%	2.86	3%	0.17	≈
2367-3	124	10	43	75	25%	-5.48	-13%	-0.53	≈
2375-3	272	10	115	81	52%	22.41	20%	0.99	↑↑
2418-3	136	10	78	49	7%	-3.81	-5%	-0.34	≈
2514-3	132	10	52	46	1%	-1.37	-3%	-0.12	≈
2553-3	237	10	119	93	2%	1.94	2%	0.10	≈
2561-3	153	10	44	59	19%	-4.20	-10%	-0.33	≈
2613-3	130	10	75	155	2%	-1.89	-3%	-0.17	≈
2618-3	272	10	77	96	17%	-11.01	-14%	-0.49	≈
3035-3	265	10	141	65	0%	1.03	1%	0.05	≈
3056-3	202	10	45	56	12%	-4.58	-10%	-0.27	≈
3062-3	140	10	58	103	12%	3.32	6%	0.28	≈
3063-3	272	10	46	79	13%	-4.53	-10%	-0.20	≈
3114-3	137	10	132	63	2%	3.51	3%	0.31	≈
3173-3	136	10	73	71	55%	-12.19	-17%	-1.08	↓
3176-3	272	10	109	63	11%	-7.05	-6%	-0.31	≈

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
3178A-3	132	10	102	105	13%	-8.80	-9%	-0.80	↓
3178B-3	132	3	60	8	0%	-0.64	-1%	-0.06	≈
3179-3	264	10	118	108	16%	-12.32	-10%	-0.56	≈
3181-3	232	10	85	37	2%	2.59	3%	0.13	≈
3182-3	139	10	20	33	1%	0.29	1%	0.02	≈
3189-3	132	10	39	50	22%	-4.66	-12%	-0.42	≈
3268-3	140	1	56	65	N/A	N/A	N/A	N/A	N/A
3268A-3	110	5	43	20	13%	3.16	7%	0.34	≈
3272-3	136	10	72	71	31%	8.39	12%	0.74	↑
3378-3	136	10	65	60	0%	-0.77	-1%	-0.07	≈
3390-3A	132	10	37	63	63%	-12.47	-33%	-1.13	↓
3468-3	272	10	149	72	7%	-5.96	-4%	-0.26	≈
3748-3	102	10	19	62	27%	-5.11	-27%	-0.60	≈
4158-3	136	10	159	57	0%	-1.22	-1%	-0.11	≈
4195A-3	272	10	132	71	1%	-3.60	-3%	-0.16	≈
4196-3	190	10	82	62	0%	0.38	0%	0.02	≈
4203-3	136	10	74	57	4%	-2.94	-4%	-0.26	≈
4374-3	264	10	48	60	52%	-13.40	-28%	-0.61	≈
4375-3	132	10	1	15	16%	0.48	42%	0.04	≈
4390-3	128	10	84	64	3%	-2.92	-3%	-0.27	≈
4486-3	132	10	39	55	24%	-4.59	-12%	-0.42	≈
4586C-3	264	10	266	92	3%	5.61	2%	0.26	≈
4612A-3	132	10	40	52	37%	-6.50	-16%	-0.59	≈
4714-3	127	10	20	31	0%	-0.88	-4%	-0.08	≈
4845-3	136	10	79	48	0%	0.03	0%	0.00	≈
5280-3	264	10	131	98	1%	2.17	2%	0.10	≈
5529-3	160	10	81	61	6%	5.31	7%	0.40	↑
6242A-3	138	10	64	30	17%	4.64	7%	0.40	↑
6341-3	262	10	136	76	2%	-4.47	-3%	-0.20	≈
6655-3	132	10	59	50	11%	-5.93	-10%	-0.54	≈
6656-3	270	10	70	95	14%	-8.95	-13%	-0.40	≈
6675-3	100	10	126	38	11%	-5.03	-4%	-0.60	≈
6676-3	264	10	337	142	1%	-2.71	-1%	-0.12	≈
6711A-3	270	10	101	80	16%	-13.29	-13%	-0.59	≈
6712A-3	135	10	75	58	2%	2.06	3%	0.18	≈
7235A-3	136	10	57	53	6%	-4.27	-8%	-0.38	≈
7295-3	120	10	160	58	0%	-1.53	-1%	-0.15	≈
7316-3	272	10	222	201	0%	3.65	2%	0.16	≈
7348A-3	66	8	52	68	7%	7.94	15%	1.44	↑↑
7348B-3	135	5	36	50	2%	5.30	15%	0.47	↑
7348C-3	104	5	69	69	6%	-12.37	-18%	-1.43	↓↓
7348D-3	135	5	89	102	10%	-22.27	-25%	-1.98	↓↓
7364-3	135	10	68	32	1%	1.15	2%	0.10	≈
7365-3	132	10	2	6	50%	-0.84	-42%	-0.08	≈
7366-3	132	10	2	5	58%	-0.96	-41%	-0.09	≈
7367-3	132	10	9	20	5%	-1.12	-12%	-0.10	≈

Permit No.	Acres	No. Reports	Average (ac-ft/yr)	St. Dev. (ac-ft/yr)	R^2	Trend (ac-ft/yr)	Trend (% Avg.)	Trend (in/yr)	Trend Assessment
7369A-3	154	10	57	29	5%	2.16	4%	0.17	≈
7369B-3	132	10	37	28	3%	1.66	4%	0.15	≈
7369C-3	130	10	28	28	0%	0.22	1%	0.02	≈
7370-3	132	10	6	8	63%	-2.18	-38%	-0.20	≈
Total	**16,872**	**904**	**8,165**	**6,380**	**--**	**-111.58**	**--**	***-0.01***	**≈**
Average	178	10	86	67	13%	-1.19	-4%	-0.12	--
St. Dev.	76		61	38	16%	7.58	13%	**0.51**	--
Min.	66	1	1	5	0%	-22.27	-42%	-1.98	--
Max.	539	10	337	211	63%	25.01	42%	1.44	--
Median	136	10	73	61	8%	-0.99	-2%	-0.09	--

Permit Nos. 1876A-3 and 3748A-3 were issued in 2025, so they are not included in this table.

Appendix B: Observation Well Hydrographs

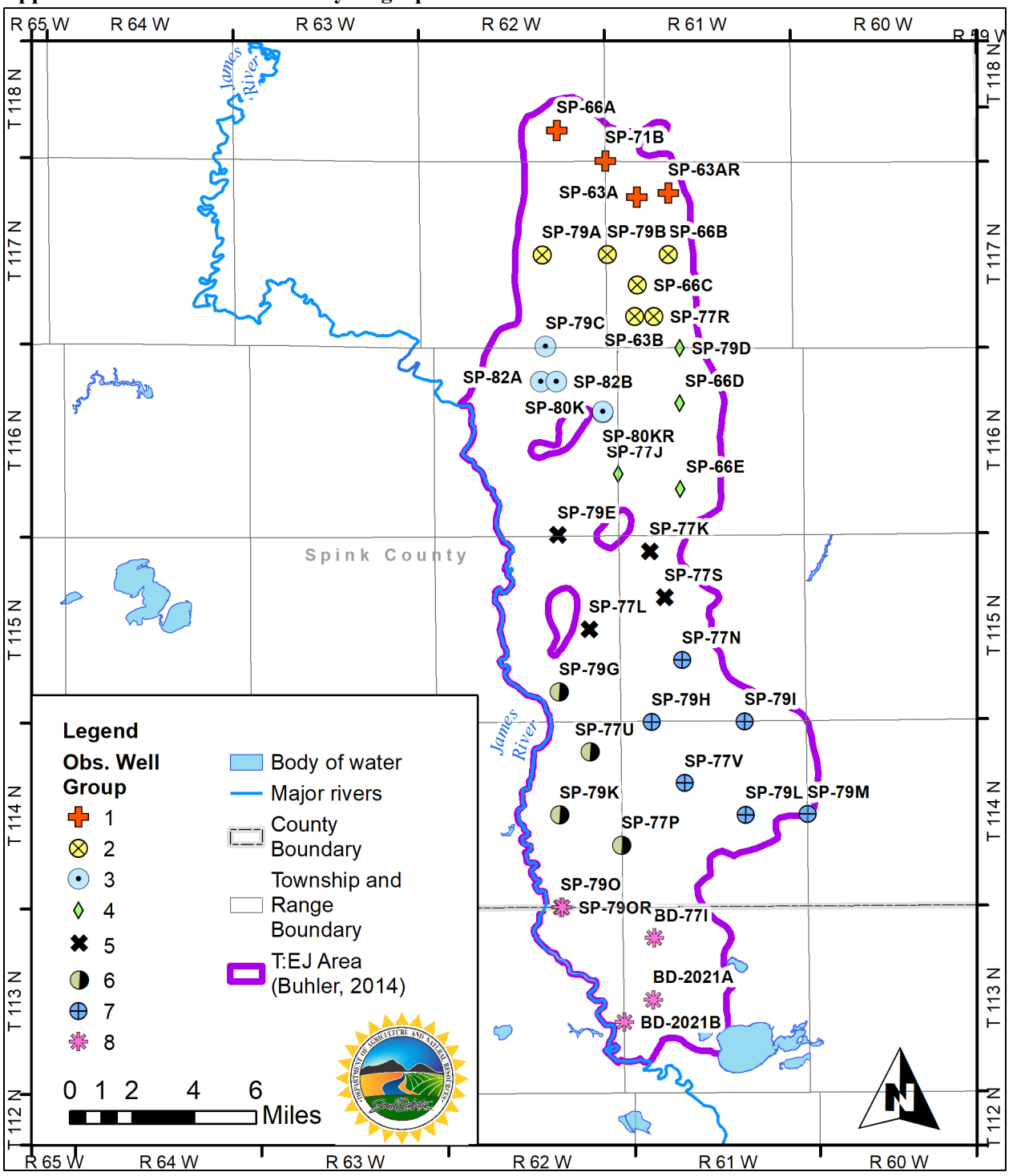

Figure 5: Map of groups of observation wells in T:EJ [2]

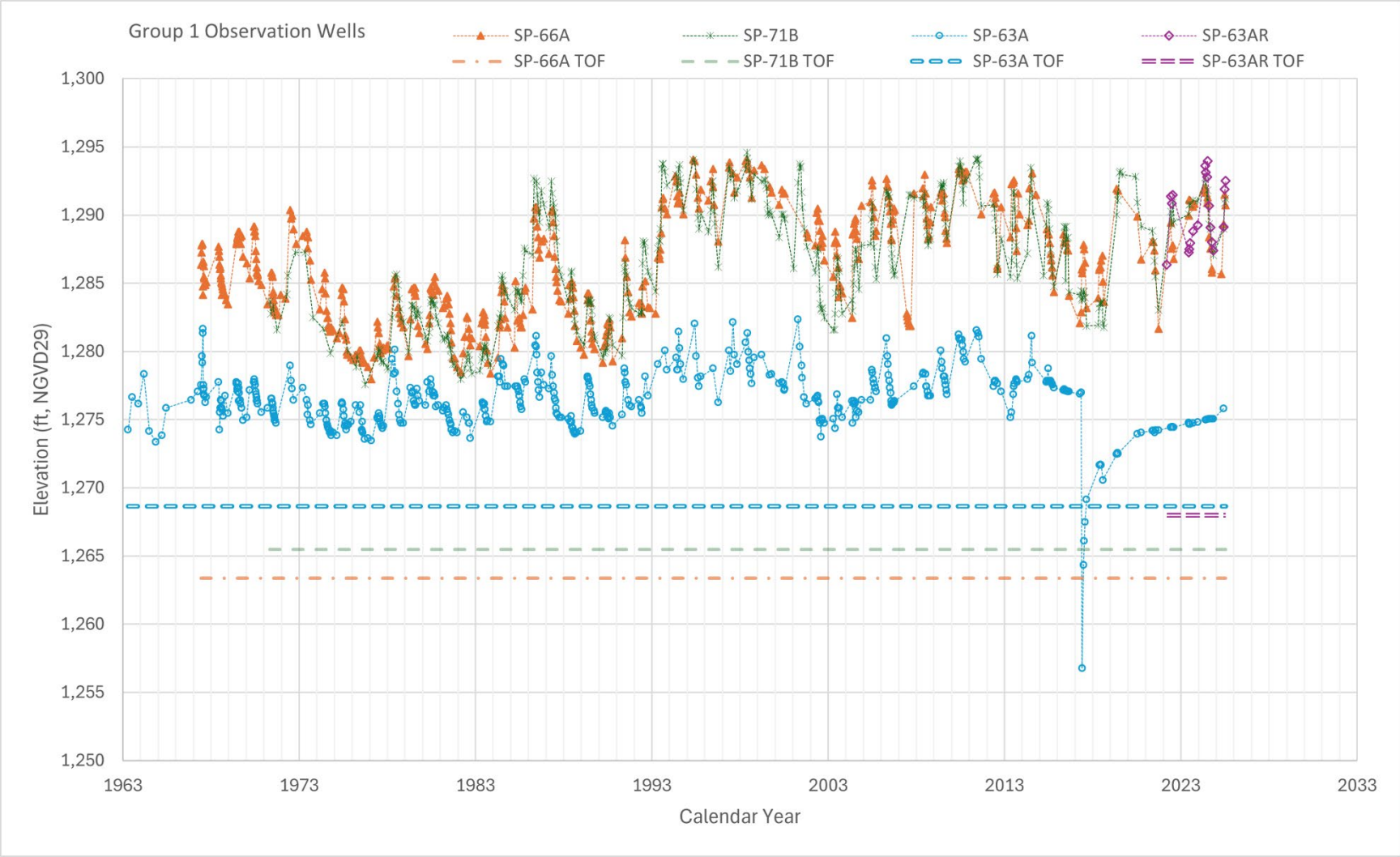

Figure 6: Observation well water level elevations and formation top (TOF) elevations for Group 1 [2]

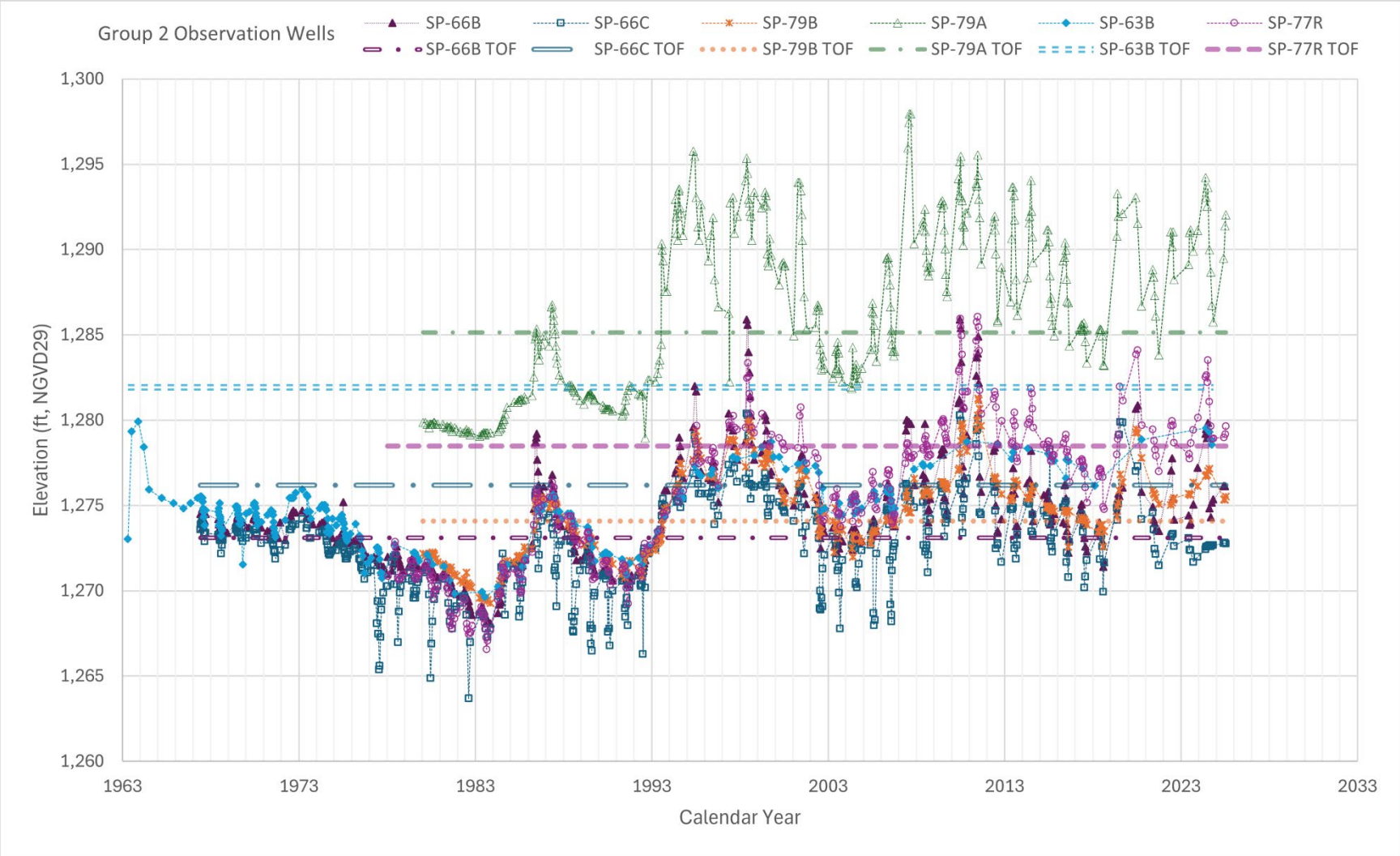

Figure 7: Observation well water level elevations and TOF elevations for Group 2 [2]

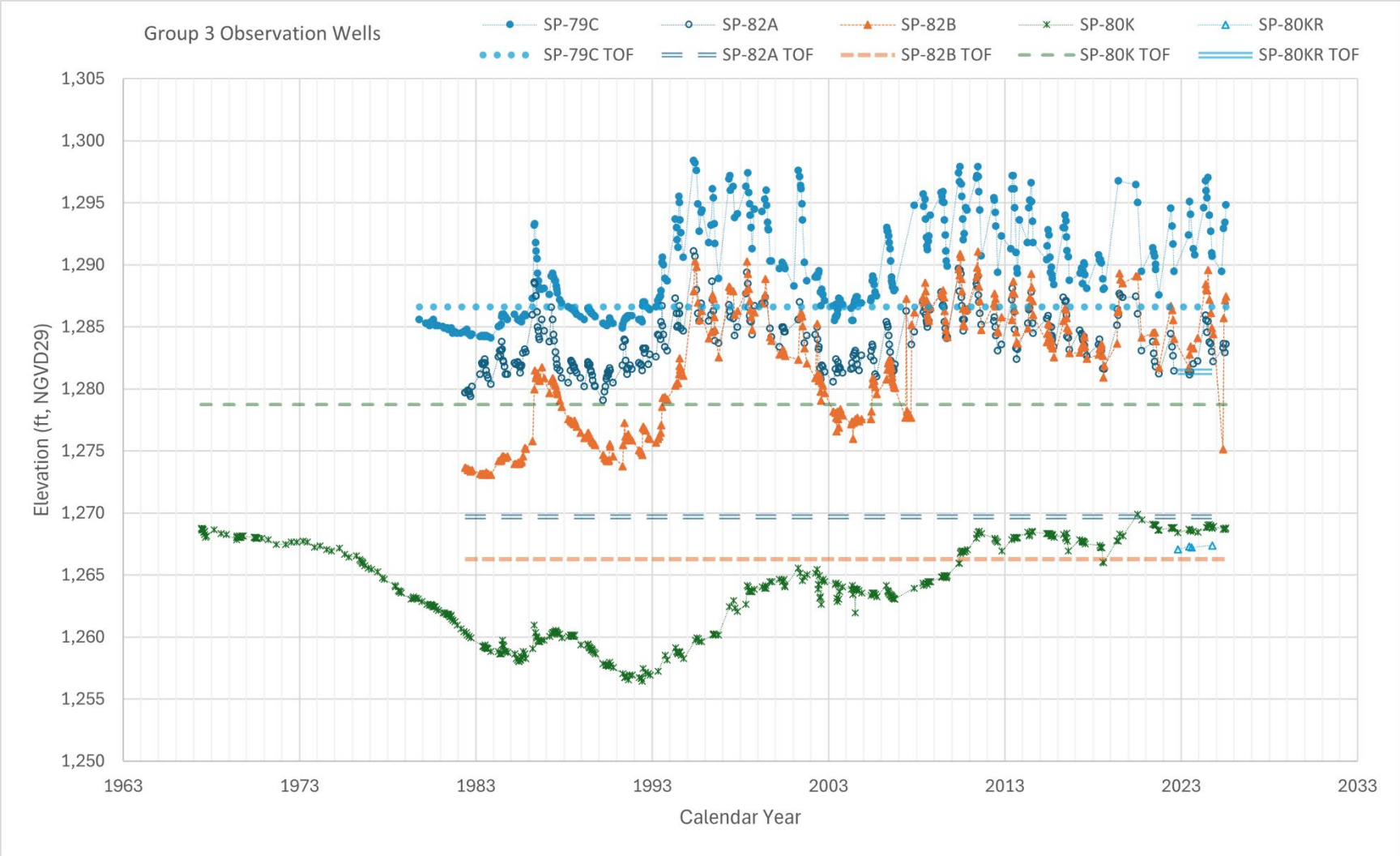

Figure 8: Observation well water level elevations and TOF elevations for Group 3 [2]

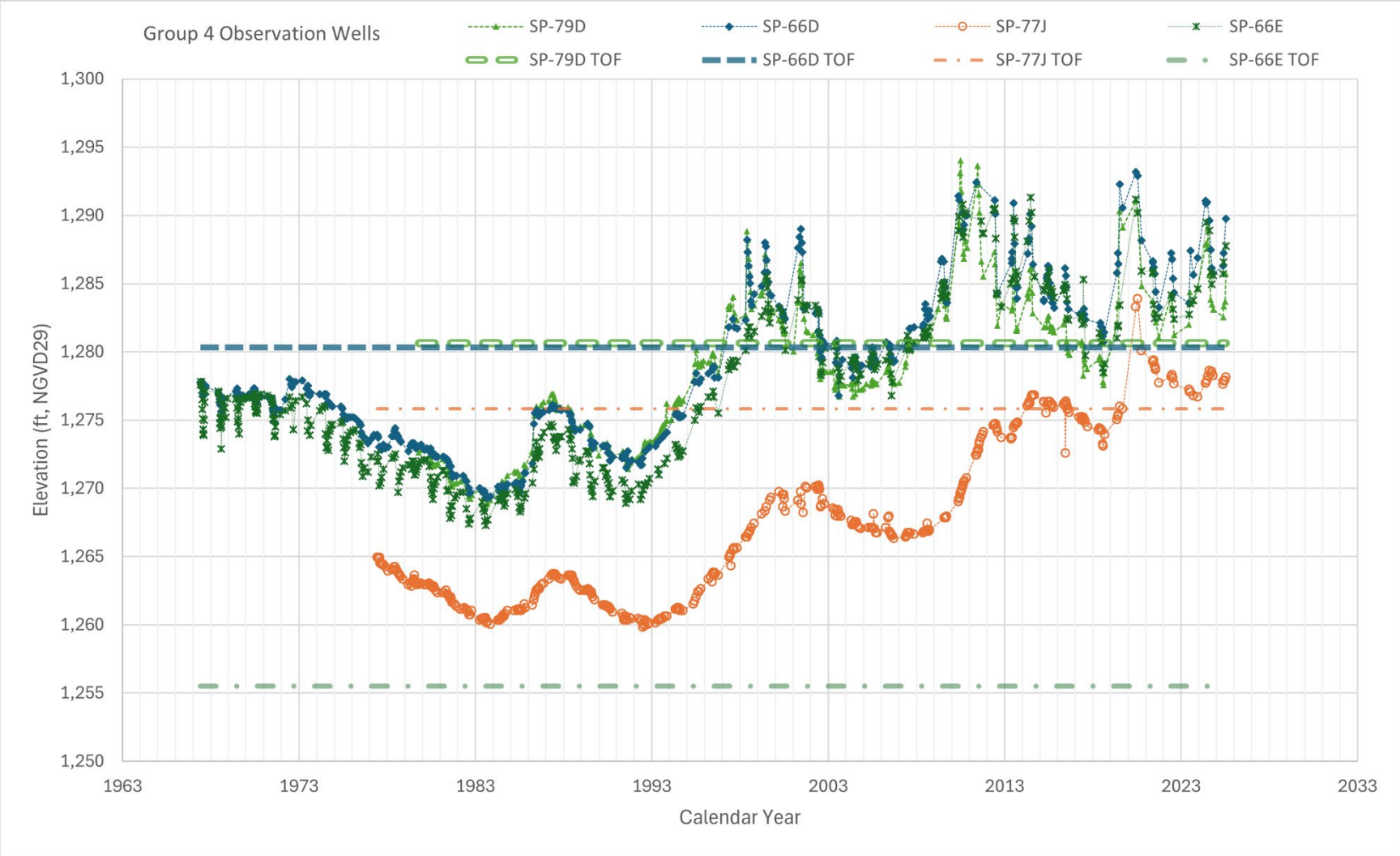

Figure 9: Observation well water level elevations and TOF elevations for Group 4 [2]

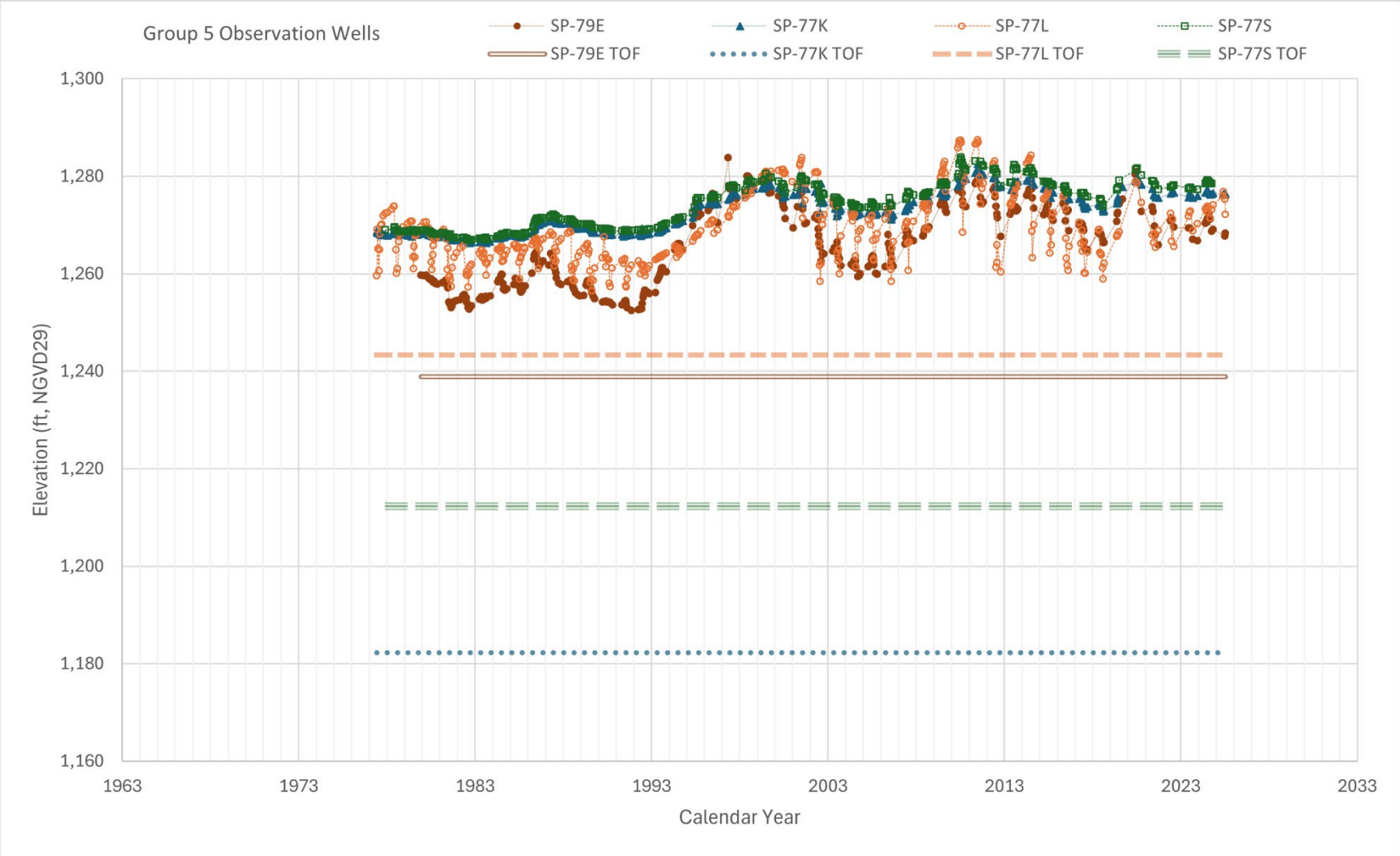

Figure 10: Observation well water level elevations and TOF elevations for Group 5 [2]

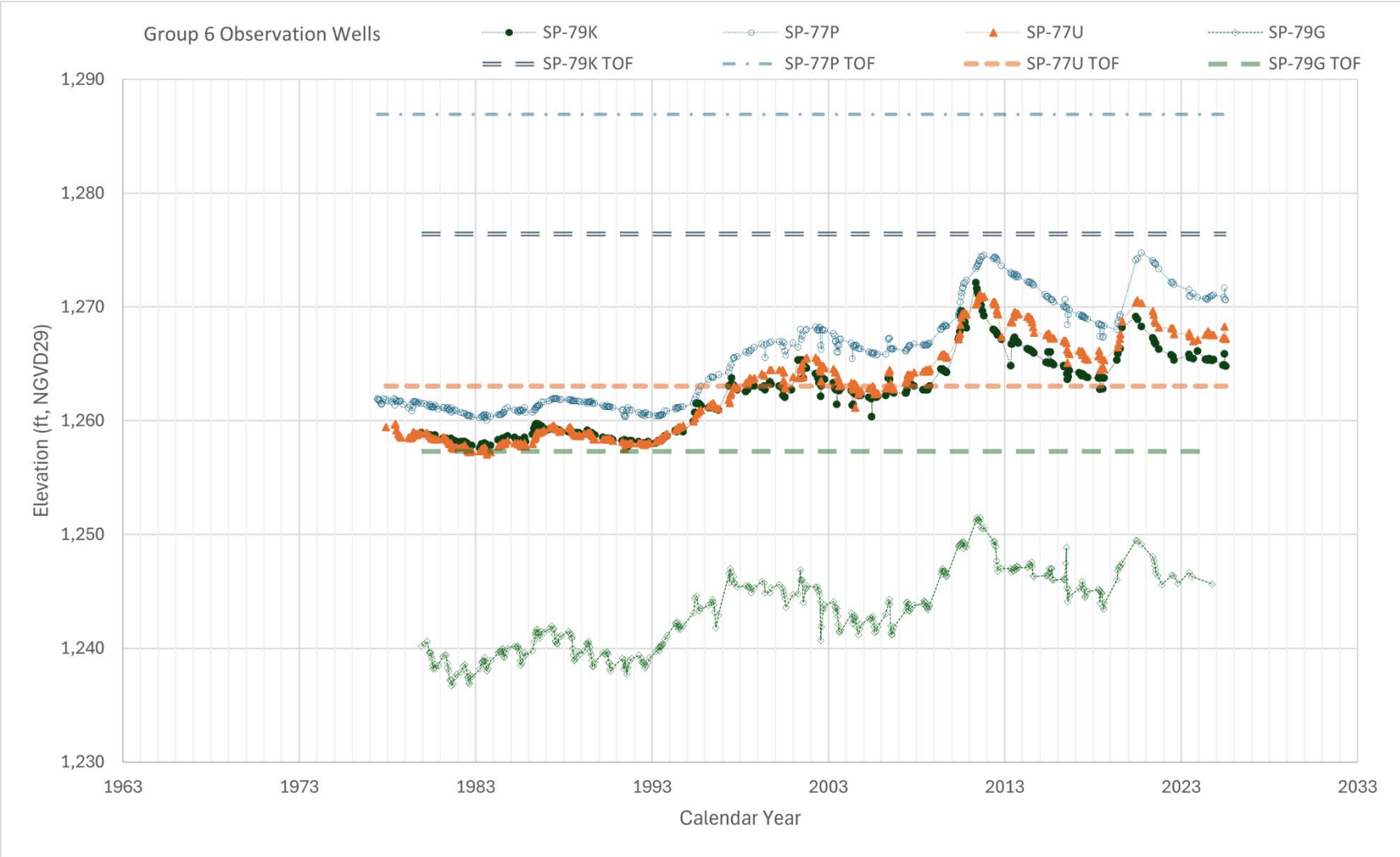

Figure 11: Observation well water level elevations and TOF elevations for Group 6 [2]

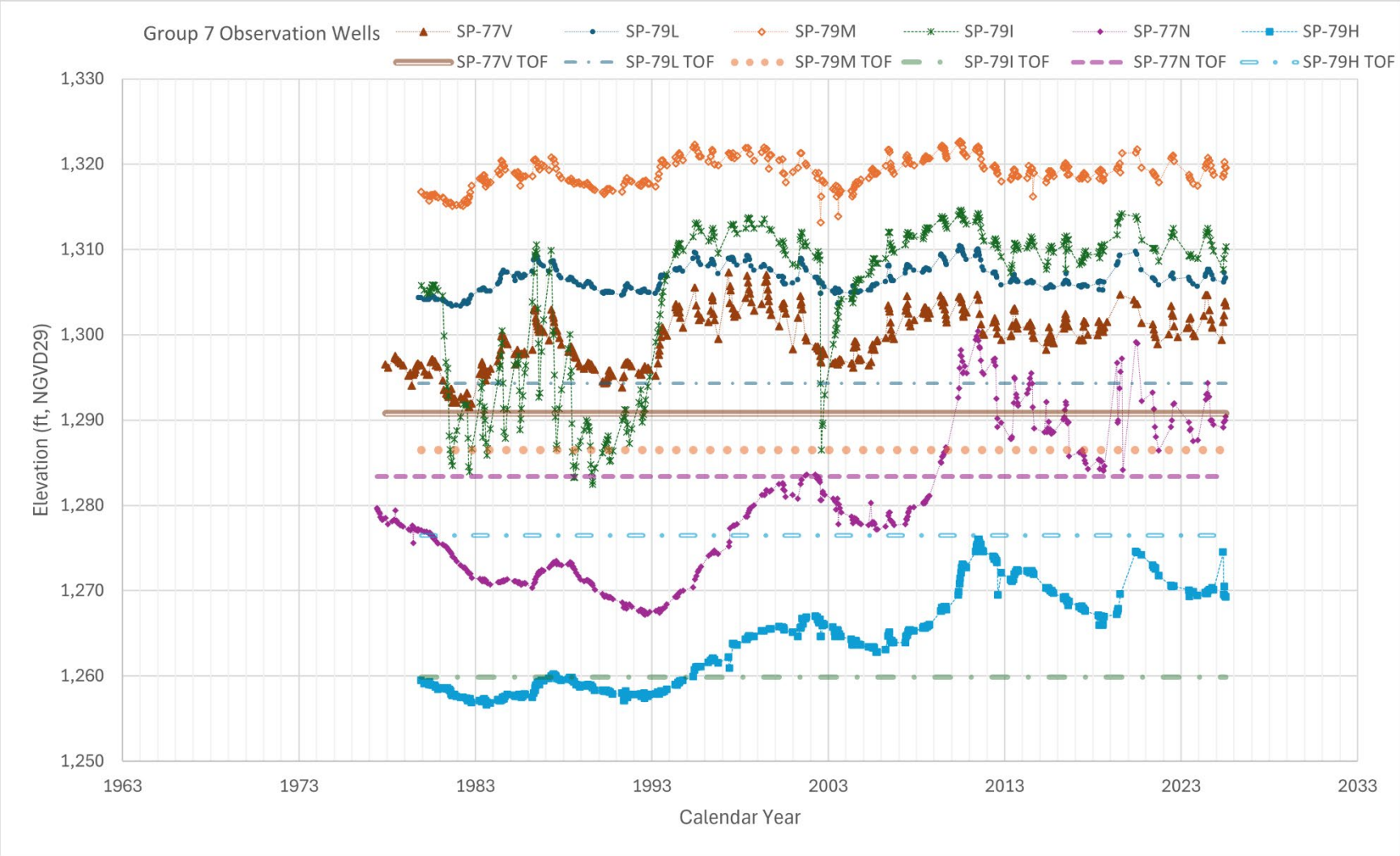

Figure 12: Observation well water level elevations and TOF elevations for Group 7 [2]

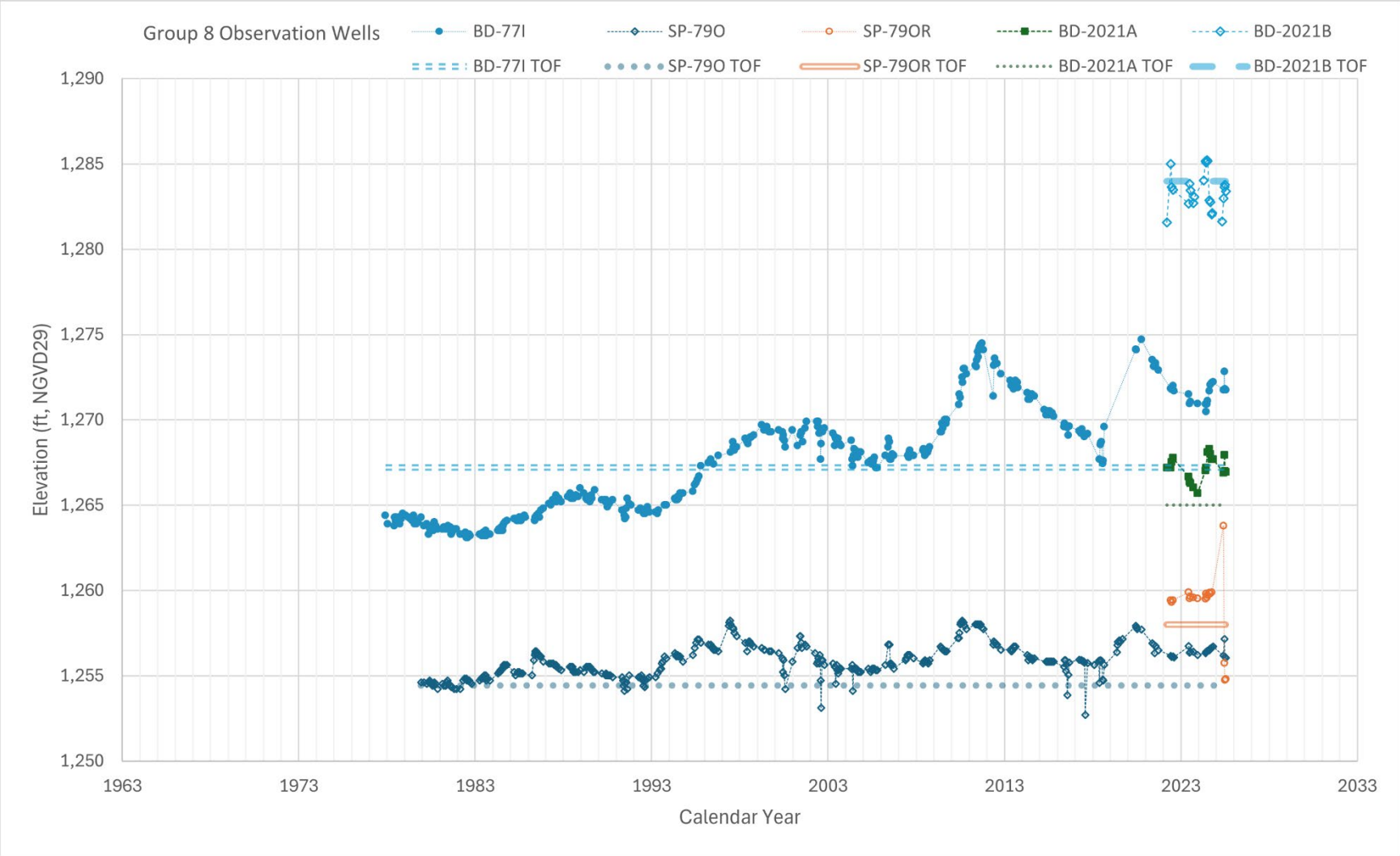

Figure 13: Observation well water level elevations and TOF elevations for Group 8 [2]

Appendix C: Climactic Data

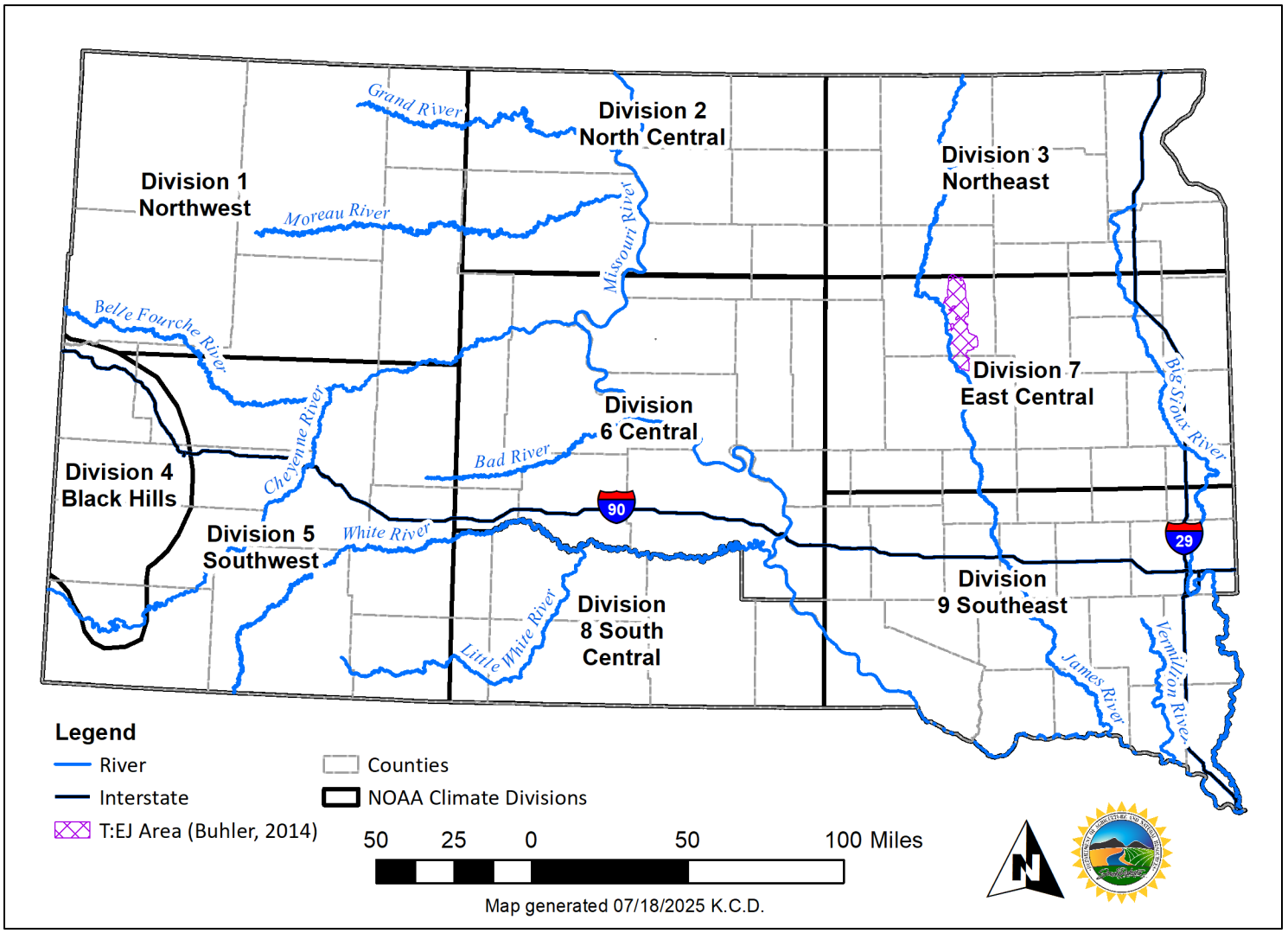

Figure 14: Map of NOAA Climate Divisions in South Dakota [15]

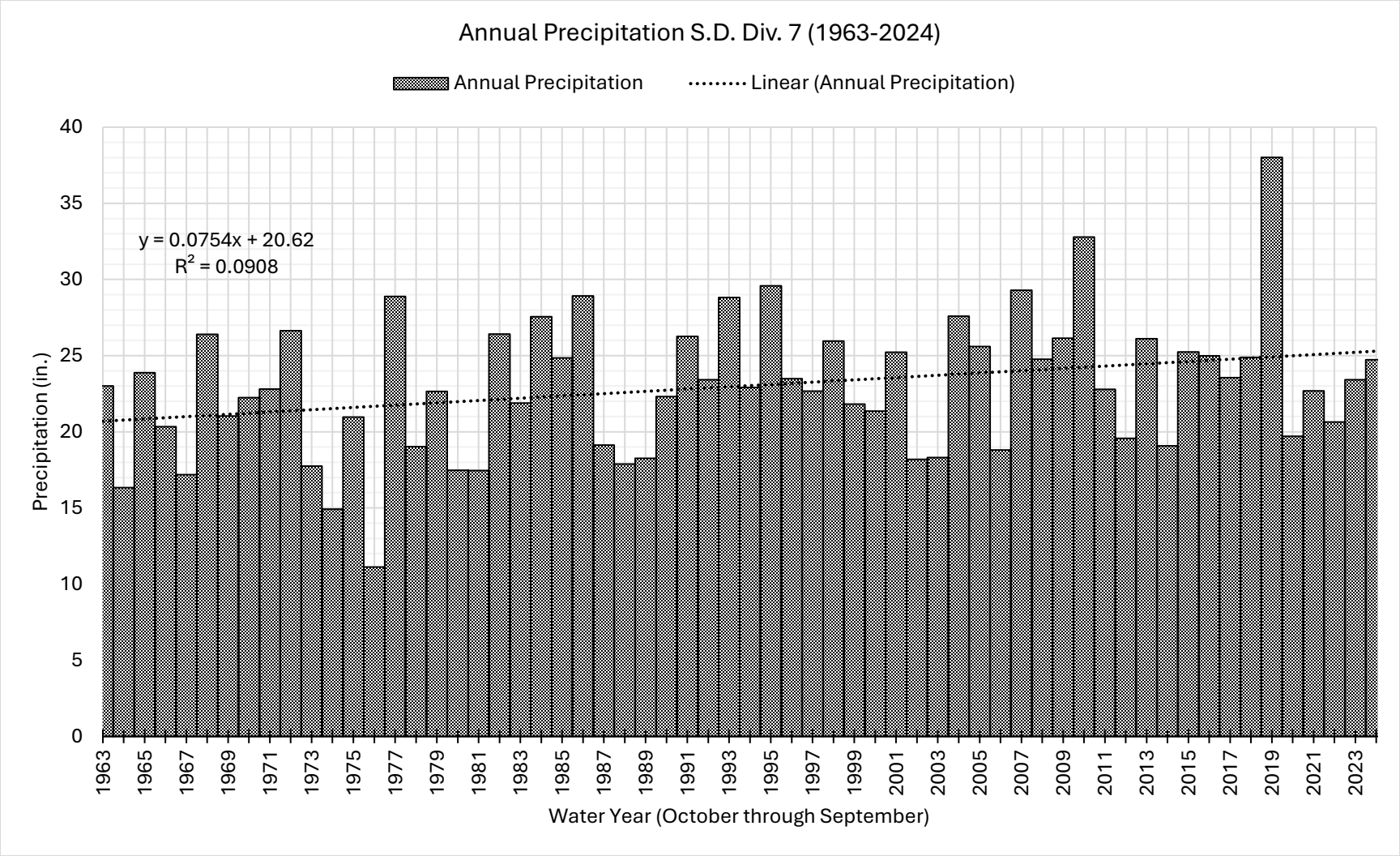

Figure 15: Annual precipitation for South Dakota Climate Division 7 from 1963 through 2024. The average from the 1900-2000 period of record was 21.6 inches [15].

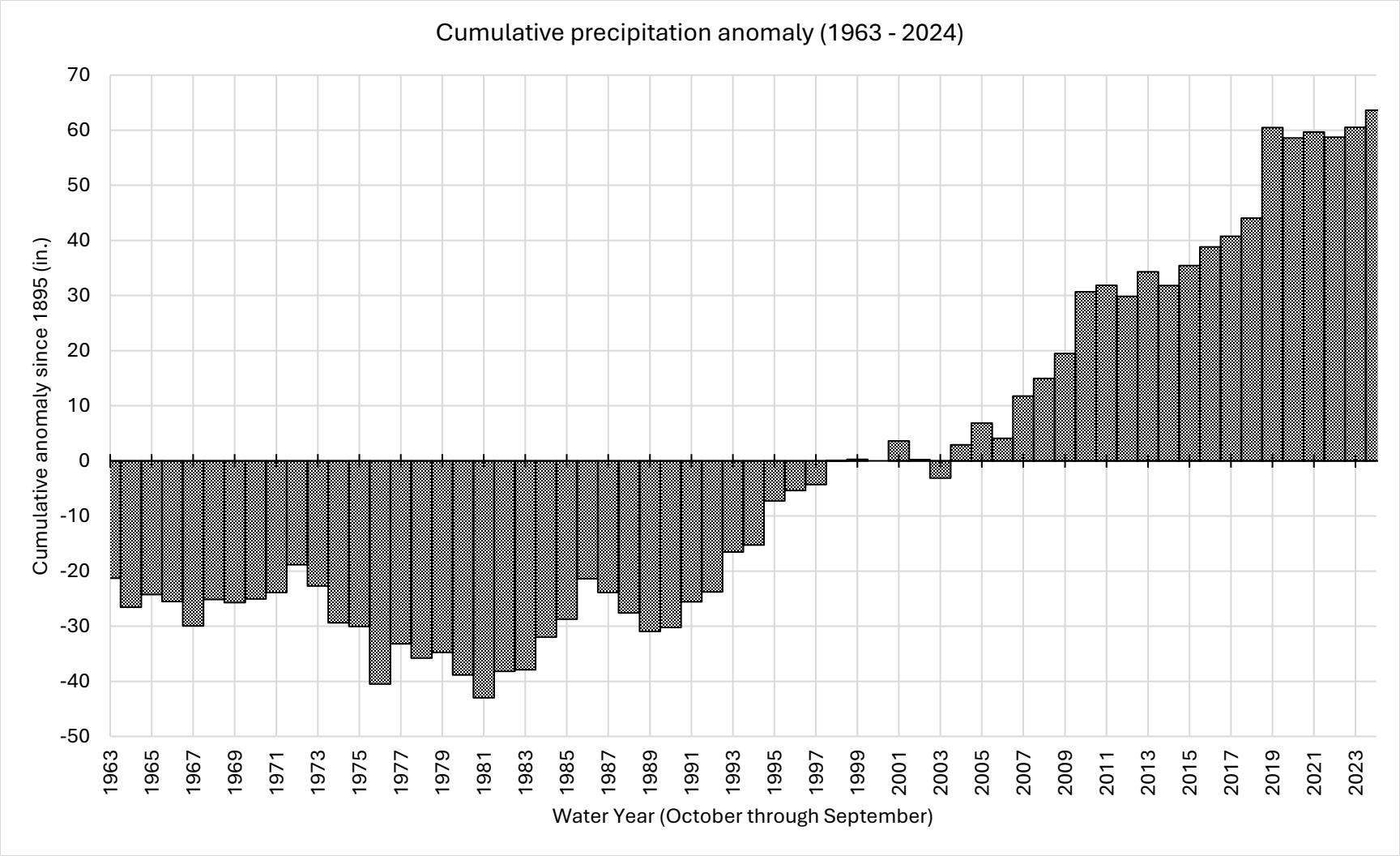

Figure 16: Cumulative Precipitation Anomaly from 1963 through 2024 [15]

Table 6 Annual Precipitation data for South Dakota Climate Division 7 (East Central) [15]

Water Year	Precip. (in)	Anomaly (in)	Cumulative Anom. (in)	Water Year	Precip. (in)	Anomaly (in)	Cumulative Anom. (in)	Water Year	Precip. (in)	Anomaly (in)	Cumulative Anom. (in)	Water Year	Precip. (in)	Anomaly (in)	Cumulative Anom. (in)
1895	17.98	-3.62	-3.62	1928	18.48	-3.12	18.71	1961	20.15	-1.45	-28.79	1994	22.9	1.30	-15.26
1896	26.44	4.84	1.22	1929	20.88	-0.72	17.98	1962	27.72	6.12	-22.67	1995	29.59	7.99	-7.27
1897	25.23	3.63	4.84	1930	19.5	-2.10	15.88	1963	23	1.40	-21.27	1996	23.49	1.89	-5.38
1898	16.83	-4.77	0.07	1931	15.72	-5.88	10.00	1964	16.33	-5.27	-26.54	1997	22.67	1.07	-4.31
1899	19.55	-2.05	-1.98	1932	18.57	-3.03	6.97	1965	23.88	2.28	-24.26	1998	25.96	4.36	0.04
1900	26.93	5.33	3.35	1933	13.92	-7.68	-0.71	1966	20.34	-1.26	-25.53	1999	21.81	0.21	0.25
1901	23.83	2.23	5.57	1934	14.9	-6.70	-7.42	1967	17.19	-4.41	-29.94	2000	21.35	-0.25	0.00
1902	21.09	-0.51	5.06	1935	19.92	-1.68	-9.10	1968	26.4	4.80	-25.14	2001	25.23	3.63	3.63
1903	23.13	1.53	6.59	1936	14.45	-7.15	-16.25	1969	21.03	-0.57	-25.71	2002	18.18	-3.42	0.21
1904	18.19	-3.41	3.18	1937	18.49	-3.11	-19.36	1970	22.24	0.64	-25.07	2003	18.3	-3.30	-3.10
1905	28.95	7.35	10.53	1938	20.22	-1.38	-20.75	1971	22.81	1.21	-23.87	2004	27.59	5.99	2.89
1906	27.66	6.06	16.58	1939	17.96	-3.64	-24.39	1972	26.63	5.03	-18.84	2005	25.59	3.99	6.88
1907	18.43	-3.17	13.41	1940	18.55	-3.05	-27.44	1973	17.74	-3.86	-22.70	2006	18.8	-2.80	4.08
1908	27.38	5.78	19.19	1941	21.28	-0.32	-27.76	1974	14.92	-6.68	-29.38	2007	29.29	7.69	11.76
1909	23.21	1.61	20.80	1942	26.74	5.14	-22.62	1975	20.96	-0.64	-30.03	2008	24.77	3.17	14.93
1910	14.57	-7.03	13.77	1943	21.76	0.16	-22.47	1976	11.12	-10.48	-40.51	2009	26.15	4.55	19.48
1911	20.63	-0.97	12.79	1944	26.35	4.75	-17.72	1977	28.89	7.29	-33.22	2010	32.79	11.19	30.67
1912	19.61	-1.99	10.80	1945	21.37	-0.23	-17.95	1978	19.03	-2.57	-35.79	2011	22.78	1.18	31.85
1913	19.16	-2.44	8.36	1946	26.59	4.99	-12.96	1979	22.65	1.05	-34.74	2012	19.57	-2.03	29.81
1914	28.51	6.91	15.27	1947	21.48	-0.12	-13.09	1980	17.48	-4.12	-38.87	2013	26.11	4.51	34.32
1915	24.45	2.85	18.11	1948	22.89	1.29	-11.80	1981	17.46	-4.14	-43.01	2014	19.07	-2.53	31.79
1916	23.6	2.00	20.11	1949	18.4	-3.20	-15.00	1982	26.42	4.82	-38.19	2015	25.24	3.64	35.43
1917	19.26	-2.34	17.77	1950	19.38	-2.22	-17.22	1983	21.89	0.29	-37.90	2016	24.99	3.39	38.82
1918	23.98	2.38	20.15	1951	24.79	3.19	-14.03	1984	27.55	5.95	-31.96	2017	23.56	1.96	40.77
1919	24.97	3.37	23.52	1952	14.79	-6.81	-20.85	1985	24.84	3.24	-28.72	2018	24.89	3.29	44.06
1920	27.81	6.21	29.72	1953	25.21	3.61	-17.24	1986	28.92	7.32	-21.40	2019	38.02	16.42	60.48
1921	22.85	1.25	30.97	1954	18.57	-3.03	-20.27	1987	19.12	-2.48	-23.88	2020	19.71	-1.89	58.59
1922	19.76	-1.84	29.13	1955	17.49	-4.11	-24.38	1988	17.88	-3.72	-27.60	2021	22.69	1.09	59.67
1923	19.98	-1.62	27.51	1956	22.86	1.26	-23.12	1989	18.26	-3.34	-30.95	2022	20.64	-0.96	58.71
1924	22.74	1.14	28.64	1957	24.58	2.98	-20.15	1990	22.31	0.71	-30.24	2023	23.42	1.82	60.53
1925	15.46	-6.14	22.50	1958	15.27	-6.33	-26.48	1991	26.26	4.66	-25.58	2024	24.72	3.12	63.65
1926	19.16	-2.44	20.06	1959	19.36	-2.24	-28.72	1992	23.41	1.81	-23.77	2025	12.34	-9.26	54.39
1927	23.37	1.77	21.83	1960	22.99	1.39	-27.33	1993	28.82	7.22	-16.55	Water Year 2025 ends September 30			