MEMORANDUM

Date: February 20th, 2026

To: Swan Falls Implementation Group

From: Swan Falls Technical Working Group

Subject: Analysis of the necessary ESPA levels required to maintain the minimum flow rate at the Snake River nr Murphy Gage during the low flow period. (Question 5)

Methodology

The Swan Falls Technical Working Group (SFTWG) discussed the approach to provide an answer to the following question posed by the Swan Falls Implementation Group (SFIG):

5. Analysis of the necessary ESPA levels required to maintain the minimum flow rate [3,900 cfs] at the Snake River nr Murphy Gage during the low flow period.

The analysis to answer Question 5 involved three parts. The first was to determine non-Eastern Snake Plain Aquifer (non-ESPA) contributions to the Snake River and consumptive diversion demand from Water District 02 (WD02). The second part was to determine groundwater level locations and minimum fall water levels that would provide adequate flow based on low non-ESPA flow and high consumptive demand scenarios during a single drought year. The third part was to evaluate how much of a buffer in aquifer water levels would be needed to reduce the risk of falling below the minimum streamflow during a multi-year drought.

Consumptive diversion demand refers to the amount of water removed from the Snake River in WD02 that is then consumptively used. Some of the water diverted in WD02 returns to the Snake River through drainage canals or return flows. Consumptive Diversion Demand is described in the Forecast Tool Manual (https://idwr.idaho.gov/wp-content/uploads/sites/2/legal/swan-falls-settlement/20201001-Swan-Falls-Forecast-Manual-Draft-Final.pdf).

Non-ESPA contributions (see Table 1) refer to gaged return flows from the north side of the Snake River and the south side of the Snake River, and four tributary streams: 1) Rock Creek, 2) the Malad River, 3) Salmon Falls Creek, and 4) the Bruneau River. IDWR monitors eleven sites with return flow discharging from the north side of the Snake River and nine sites with discharge from the south side of the Snake River. Ungaged non-ESPA contributions are minor and are expected to be insignificant during the summer low flow period. Historical non-ESPA flows and consumptive demand were analyzed to develop a range of inflow and outflow scenarios based on observed Snake River conditions. Low non-ESPA flow conditions and high consumptive demand were then used to determine the ESPA contributions needed to maintain the minimum flows at the Murphy gage.

Table 1 Non-ESPA Streamflow Contributions to the Snake River from Kimberly to the Murphy Gage.

USGS Gage #	Description	Source
13092747	Rock Creek AB Hwy 30/93 Xing at Twin Falls, ID	USGS
13108150	Salmon Falls Creek nr Hagerman, ID	USGS
13152500	Malad River near Gooding, ID	USGS
13168500	Bruneau River near Hot Spring, ID	USGS
	11 north side Return Flow Sites	IDWR
	9 south side Return Flow Sites	IDWR

* USGS daily discharge found at: https://waterdata.usgs.gov/id/nwis/current/?type=flow
* IDWR daily discharge found at: https://research.idwr.idaho.gov/apps/hydrologic/aquainfo

Part 1: Non-ESPA Streamflow Contributions and Consumptive Demand from WD02

A range of conditions were analyzed for non-ESPA inflow and consumptive diversion demand between 2002 – 2023 for the month of July. Then, a 3-day centered average was calculated for non-ESPA inflow and consumptive demand data to smooth spikes in the data, capture persistent hydrologic conditions, and accurately represent the AADF value. Because the most significant fluctuations in the AADF of the Snake River near Murphy come from non-ESPA flow and irrigation demand, the 3-day average yearly minimum non-ESPA flow best captures the low range of flow contributing to the Swan

Falls AADF that is not sourced from ESPA discharge. Similarly, the 3-day average yearly maximum consumptive demand provides a high range of demand. The net effect on streamflow in the Snake River at Swan Falls was calculated by summing 3-day non-ESPA flow values and deducting 3-day average Consumptive Diversion Demand. For each year from 2002-2023, the minimum value from the 3-day average net non-ESPA flow less average consumptive demand was extracted (Net (cfs), Table 2).

A 3-day centered average was also applied independently to the sum of the non-ESPA inflows and to the Consumptive Diversion Demand to evaluate a worst-case scenario if the lowest non-ESPA inflows observed between 2002-2023 and the highest estimated Consumptive Diversion Demand were to occur during the same 3-day period (i.e. "minimum non-ESPA inflow and maximum demand").

Table 2. 3-day Minimum Non-ESPA Flow and Maximum Consumptive Demand

Year	Non-ESPA (cfs)	Consumptive Demand (cfs)	Net (cfs)	Date of observed min|max
2003	803	1804	-1001	7/4
2007	824	1780	-956	7/1
2002	915	1817	-902	7/12
2013	935	1817	-881	7/25
2014	983	1817	-834	7/16
2005	999	1817	-818	7/21
2022	974	1786	-812	7/9
2004	891	1668	-778	7/28
2012	1035	1804	-769	7/1
2021	958	1727	-768	7/1
2015	1068	1817	-749	7/2
2008	1046	1780	-733	7/12
2006	1083	1792	-709	7/22
2010	1171	1817	-646	7/22
2020	1406	2026	-620	7/15
2016	1227	1817	-590	7/22
2018	1272	1727	-454	7/2
2009	1228	1631	-404	7/22
2019	1522	1549	-27	7/31
2017	1414	1267	147	7/23
2011	1497	1211	285	7/29

minimum non-ESPA inflow and maximum demand	796	2050	-1254	7/3/2003 & 7/14/2020

Six scenarios for the non-ESPA inflow and consumptive demand contribution were considered to evaluate ESPA discharge needed to maintain the minimum streamflow. These scenarios represent different levels of risk of not meeting the minimum streamflow, based on the frequency of historic observations. The risk of not meeting the minimum streamflow occurs when non-ESPA inflows are low and consumptive demand is high. The net difference between non-ESPA inflows and consumptive demand is frequently negative during the summer low-flow season, indicating a portion of the ESPA discharge is being consumed by surface water irrigation in WD02. The scenarios include 80%, 90%, 95%, and 99% exceedance thresholds based on the historic net non-ESPA contribution (Table 3), the minimum net contribution observed in any one year (Table 2, 2003), and the minimum non-ESPA inflow and maximum demand, irrelevant of the same year (Table 2, “minimum non-ESPA inflow and maximum demand”).

Table 3. Net contribution by Percent Exceedance

Percent exceedance	Net (cfs)
80%	**-834**
90%	**-902**
95%	**-956**
99%	**-992**

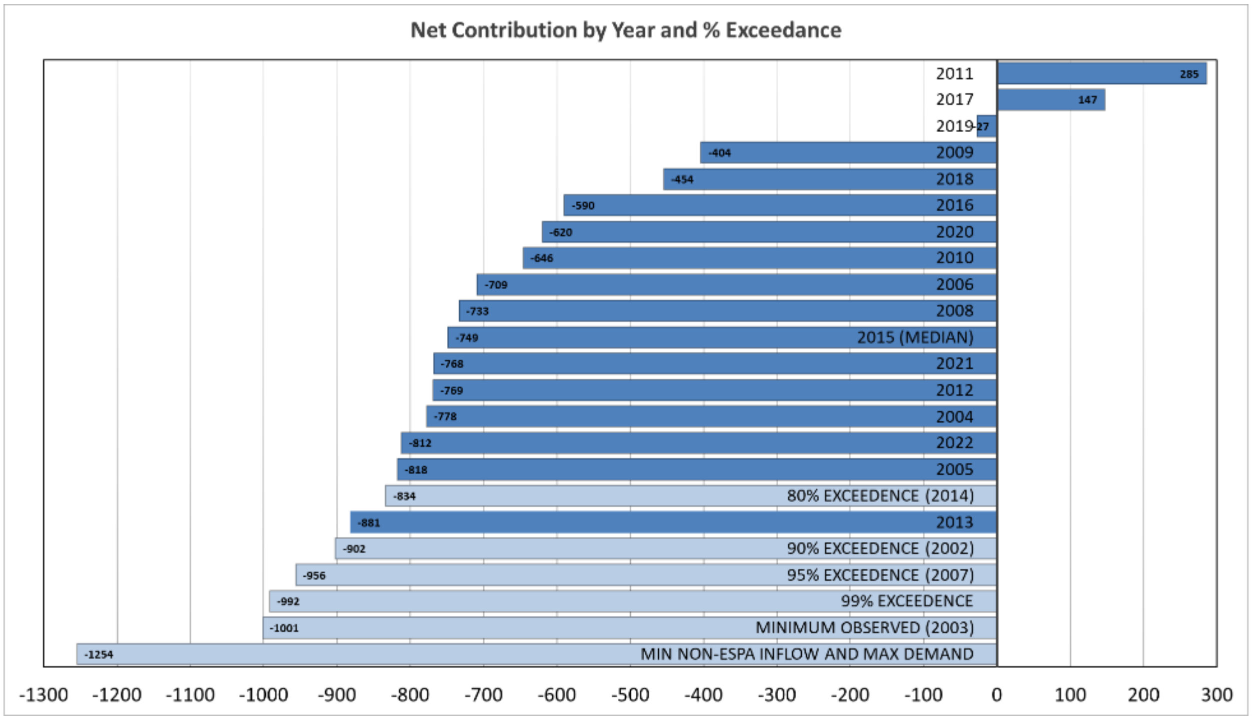


Figure 1. Net Contribution in July by year and Percent Exceedance

The five potential goals for the minimum ESPA contribution needed to meet the summer minimum Swan Falls streamflow of 3,900 cfs are summarized in Table 4.

Table 4. Potential goals for ESPA contribution to minimum streamflow

Scenario	Net non-ESPA contribution (cfs)	ESPA contribution goal (cfs)
80% exceedance	**-834**	**4,734**
90% exceedance	-902	4,802
95% exceedance	-956	4,856
99% exceedance	-992	4,892
minimum observed (2003)	-1,001	4,901
minimum non-ESPA inflow and maximum demand	-1,254	5,154

Part 2. Potential fall water level goals to maintain ESPA contribution to minimum streamflow for a single drought year

IDWR staff propose the implementation of a groundwater level index based on a limited number of indicator wells to facilitate near real-time monitoring of aquifer water level status, support development of aquifer water level goals, and provide a metric for evaluating progress. Potential water level goals to maintain the ESPA contribution to the minimum streamflow at the Snake River near Murphy were analyzed via the following process.

a. Identify a limited number of indicator wells in which water level changes correlate well with ESPA storage changes.

b. Evaluate the relation between the fall water levels in indicator wells with spring water levels and cumulative aquifer storage change.

c. Use fall water levels in a subset of the indicator wells to predict ESPA discharge to the Snake River below Milner during the following summer's low flow period.

d. Develop potential goals for fall water levels using correlation residuals to inform the risk of not meeting the ESPA discharge targets during the following irrigation season.

Part 2a. Identify a limited number of indicator wells in which water level changes correlate well with ESPA storage changes.

IDWR staff calculates the cumulative change in ESPA storage on an annual basis using data from over 400 wells (McVay, 2024[1]). For a given year, the cumulative change in ESPA storage is the difference between the storage of that year and the storage in spring 1912. This evaluation is a valuable indicator of aquifer status that is typically available in July or August following the completion of each year's spring water level data collection, processing, and analysis. Because of the time delay, IDWR staff have identified a more limited network of 37 wells (Figure 2, Attachment C) where water levels can be

[1]McVay, 2024. *ESPA Storage Changes*, presented to Idaho Water Resource Board, August 8, 2024, https://idwr.idaho.gov/wp-content/uploads/sites/2/iwrb/2024/AquiferStabilizationCommitteeMeeting2-24MATERIALS.pdf, pages 1-43.

correlated to the larger storage change analysis completed in July and August. Wells were selected based on location, historic data availability, well use, and the feasibility of installing pressure transducers, data loggers, and telemetry to monitor future water level change. Wells immediately adjacent to known managed recharge sites or hydraulically-connected reaches of the Snake River were not included in the network. The 37 wells can be instrumented with pressure transducers, data loggers, and telemetry to provide a near real-time indication of aquifer status. IDWR is in the process of upgrading equipment at wells monitored by IDWR and working with the USGS and Idaho Power regarding the wells they currently monitor.

For each year from 1980 to 2024, the median water level measured in April, if available, was selected as the representative spring water level for each well. If no observations were available for April, the median water level measured for the month of March, or lastly May was used as the representative spring water level measurement. The spring of 2016 was selected as the datum for normalizing the water levels. Spring 2016 was selected because water level measurements were available for all wells. Using a different year with measurements for all wells would yield similar results. While the spring of 2016 was an observed low level for ESPA aquifer storage, the lowest observed water level in each well occurred in 2015, 2016 or 2023.

Water levels in each well were normalized by calculating the difference in the spring water level from the water level in the spring of 2016. The normalized water levels were then averaged to calculate a spring groundwater index (GWI) that approximates the average change in water level across the ESPA from the spring 2016 datum. Adequate areal coverage required the inclusion of some wells that did not have measurements for all the years between 1980 and 2024. Despite the lack of complete records for all wells, averaging the normalized water levels resulted in a good correlation with the cumulative storage change since 1912 ($R^2 = 0.99$; Figure 3). Hydrographs with normalized spring water levels for each well are provided in Attachment D.

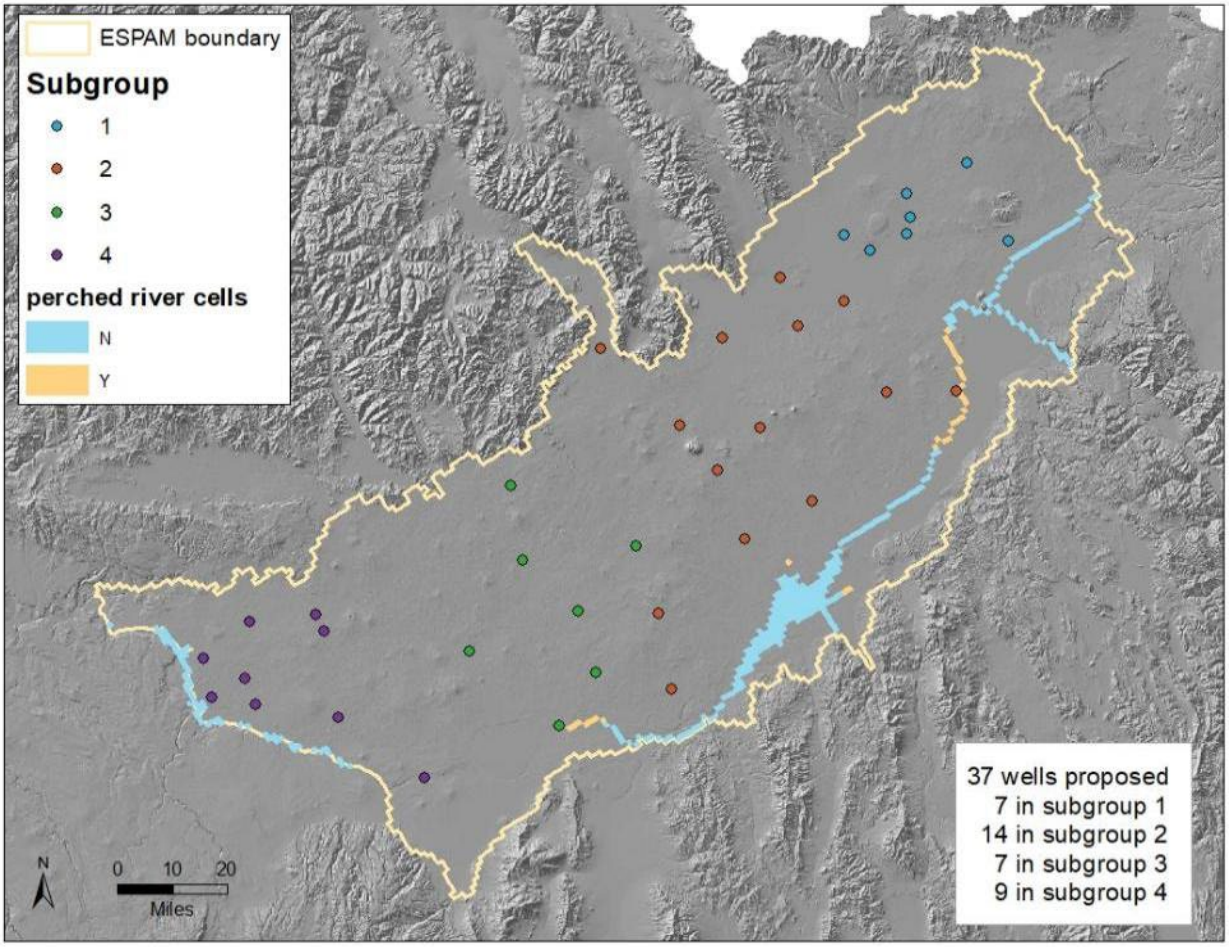


Figure 2. Proposed ESPA wells for near real-time water level status monitoring

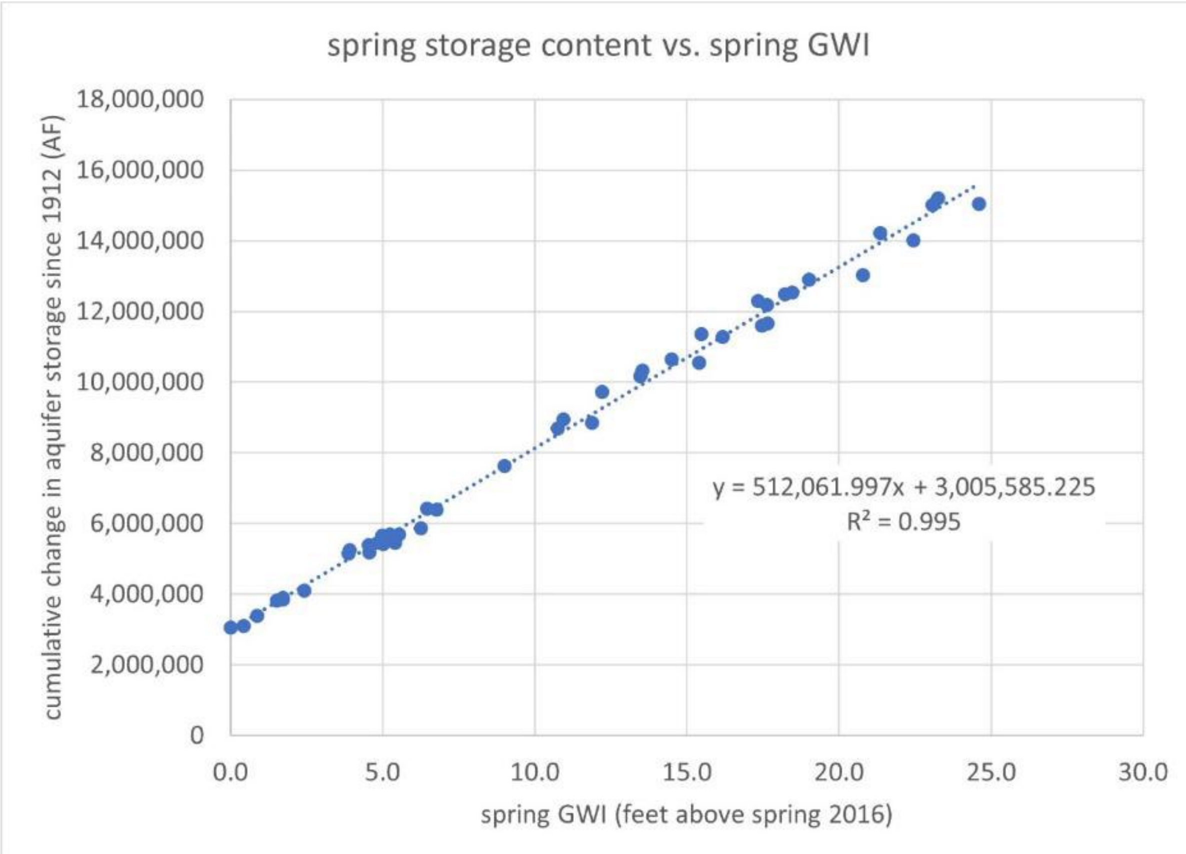


Figure 3. Correlation between cumulative change in ESPA storage calculated from over 400 wells and the spring GWI calculated from 37 network wells

The correlation between historic cumulative change in aquifer storage and the spring GWI is high ($R^2 = 0.99$; Figure 3). Figure 4 illustrates using the correlation in Figure 3 to predict aquifer storage change from the spring GWI and compares the predicted values to the aquifer storage change calculated by IDWR from 1980 to 2024 (45 years). The residual difference between the predicted and calculated aquifer storage varies from +630,000 AF to -470,000 AF with a 5%/95% range of +470,000 AF to -410,000 AF. The mean absolute residual is 210,000 AF. Sources of uncertainty in using the spring GWI to approximate the calculated cumulative aquifer storage change include the following.

- measurement error in water levels used to calculate the spring GWI
- timing of spring water level measurements used to calculate the GWI
- measurement error in water levels used to calculate the aquifer storage content

- timing of spring water level measurements used to calculate the aquifer storage content
- uncertainty in interpolating water level change between measurement locations for calculation of the aquifer storage content
- simplification of using average water level change at 37 locations to approximate interpolated water level change between hundreds of locations

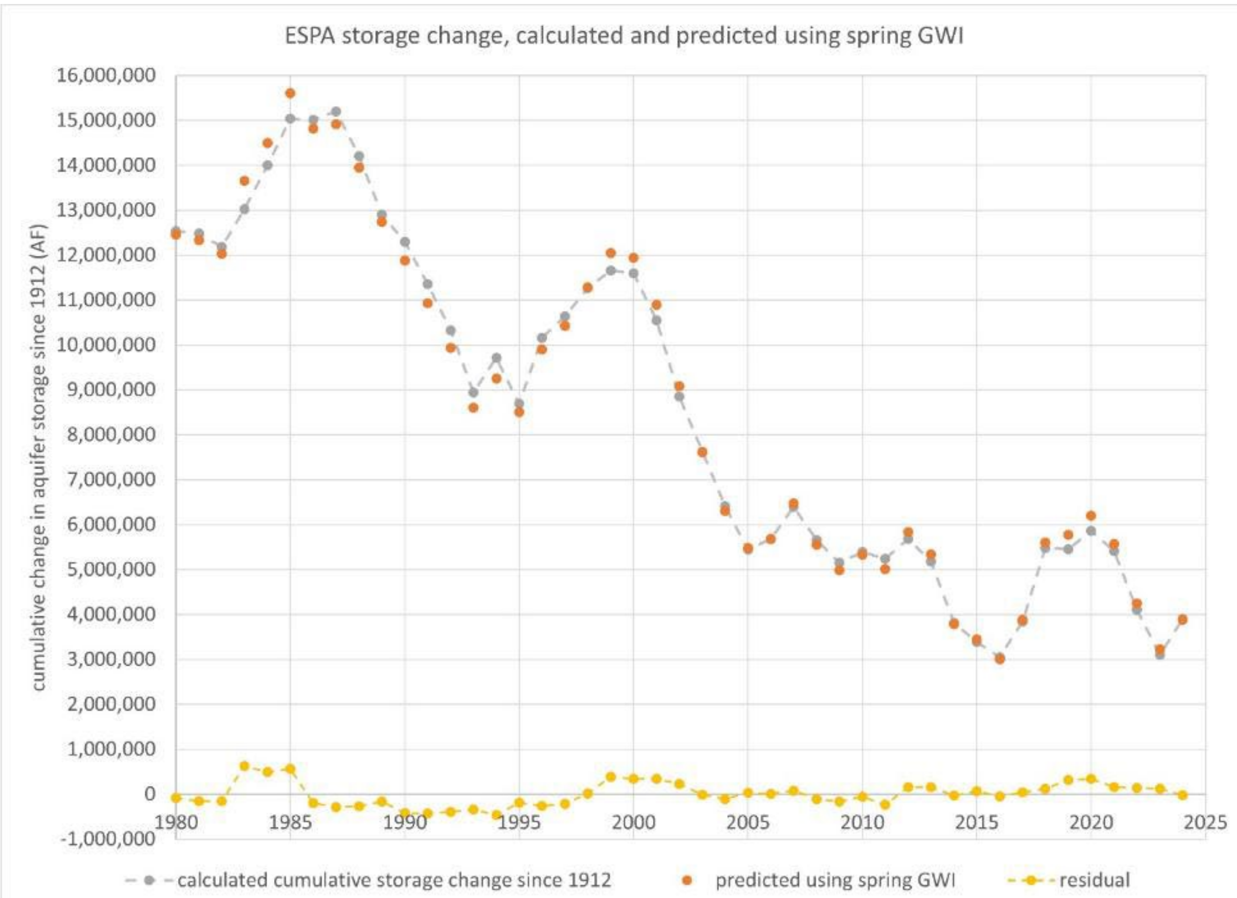


Figure 4. Prediction of spring ESPA storage content using spring GWI

Part 2b. Evaluate the relation between the fall water levels in indicator wells with spring water levels and cumulative aquifer storage change.

For each year from 1980 to 2023, the median water level measured in November, if available, was selected as the representative fall water level for each well. If no observations were available for November, the median water level measured for the month of December, or lastly October, was selected as the representative fall water level measurement. The spring of 2016 was selected as a datum for normalizing the water levels. Water levels in each well were normalized by calculating the difference in the fall water level from the water level in the spring of 2016. Hydrographs with normalized fall water levels for each well are provided in Attachment D. The normalized water levels were then averaged to calculate a fall groundwater index (GWI) that approximates the average change in water level across the ESPA from the spring 2016 datum. The GWI is usually slightly higher in fall than in the following spring but is similar or slightly higher in the spring for a few years (Figure 5). Hydrographs with normalized fall water levels for each well are provided in Attachment D for reference.

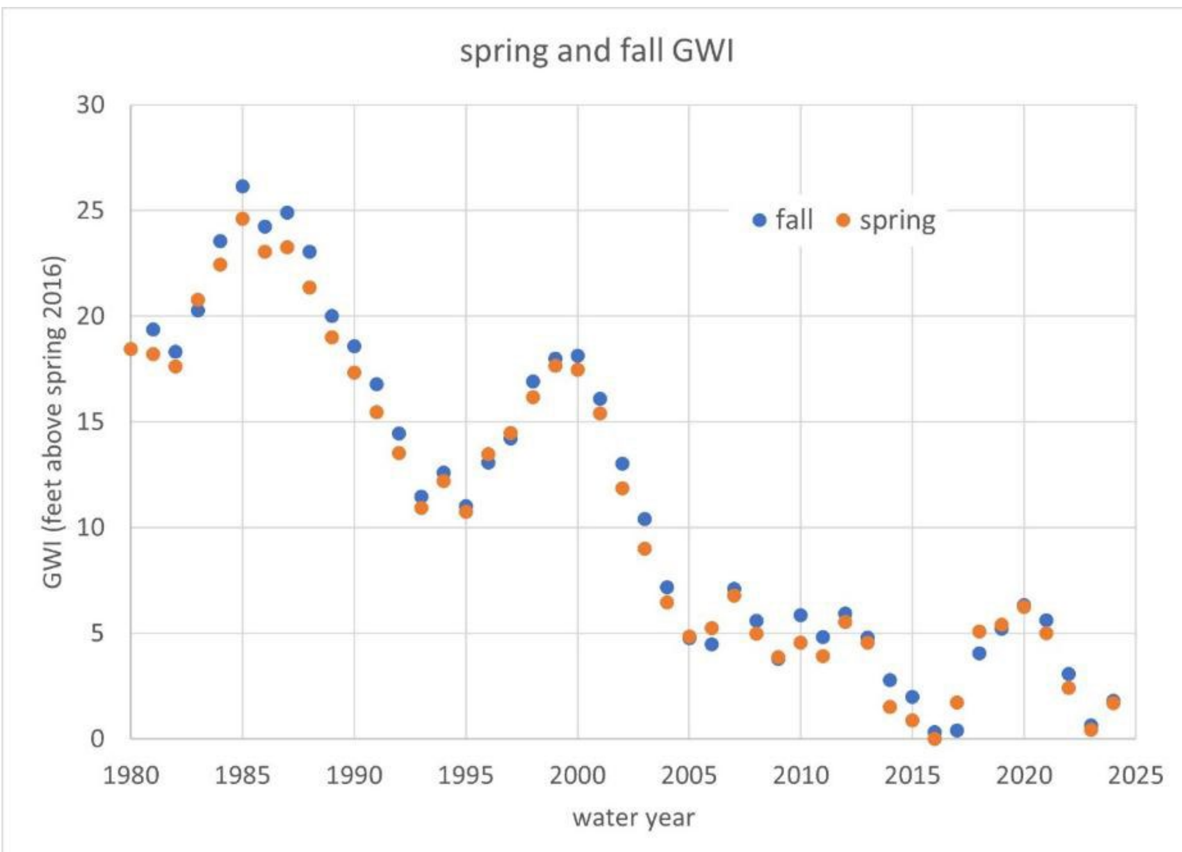


Figure 5. Comparison of spring and fall GWI

As with the spring GWI, adequate areal coverage required the inclusion of some wells that did not have measurements for all the years between 1980 and 2023. Despite the lack of complete records for all wells, averaging the normalized water levels resulted in a good correlation with the cumulative storage change (R^2 = 0.99; Figure 6).

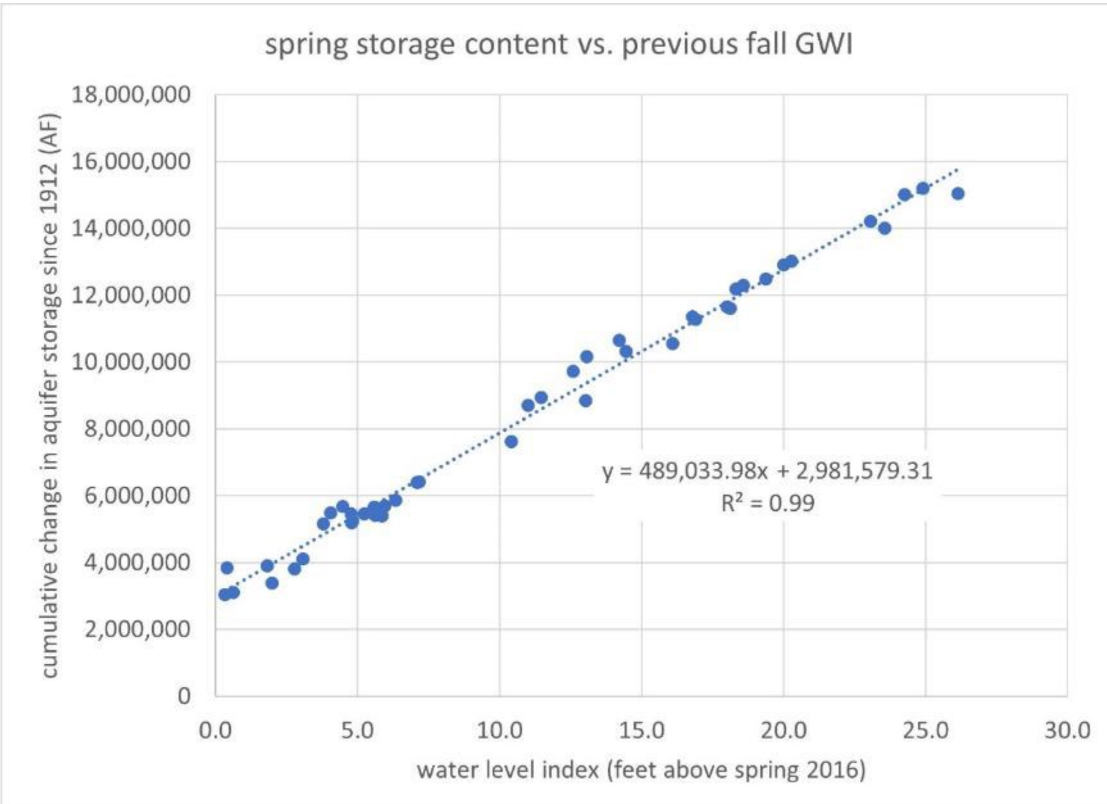


Figure 6. Correlation between cumulative change in ESPA storage calculated from over 400 wells and the fall GWI calculated from 37 network wells

Historic cumulative change in aquifer storage predicted using the linear correlation from Figure 6 is compared to the calculated aquifer storage change in Figure 7. For water years 1981 to 2024 (44 years), residuals vary from +720,000 AF to -790,000 AF with a 5%/95% range of +520,000 AF to -660,000 AF. The mean absolute residual is 290,000 AF. Figure 8 shows the fall prediction residuals plotted with the spring prediction residuals for comparison. Sources of uncertainty in using the fall GWI to predict the cumulative aquifer storage change for the upcoming spring include the following.

- measurement error in water levels used to calculate the fall GWI
- timing of fall water level measurements used to calculate the GWI
- measurement error in water levels used to calculate the aquifer storage content
- timing of spring water level measurements used to calculate the aquifer storage content
- uncertainty in interpolating water level change between measurement locations for calculation of the aquifer storage content
- simplification of using average water level change at 37 locations to approximate interpolated water level change between hundreds of locations
- year-to-year differences in the volume of aquifer recharge occurring between the fall and spring water level measurements

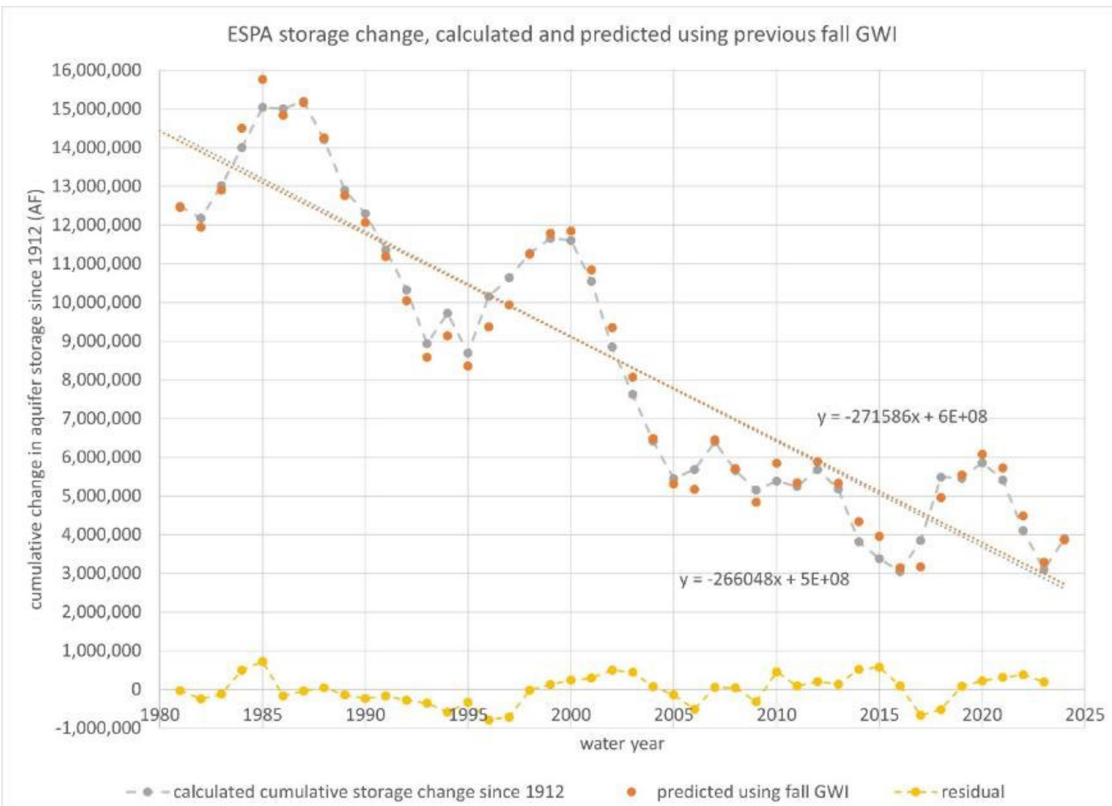


Figure 7. Prediction of spring ESPA storage content using previous fall GWI

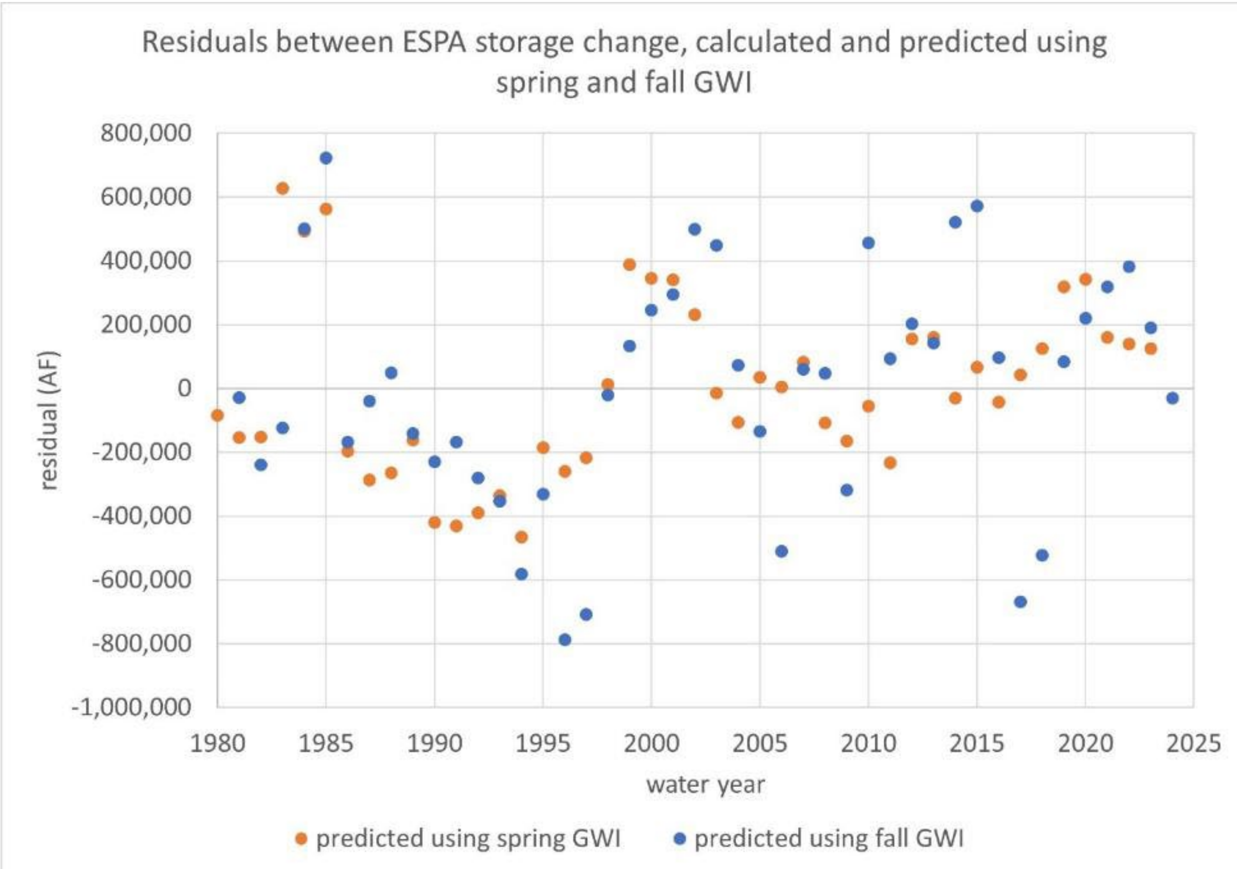


Figure 8. Residuals for spring and fall GWI predictions of spring aquifer storage

Part 2c. Use fall water levels in a subset of the indicator wells to predict ESPA discharge to the Snake River below Milner during next summer's low flow period.

ESPA discharge to the Snake River below Milner occurs from Devil's Washbowl to Bancroft Spring in the reach commonly referred to as Kimberly to King Hill. Monthly reach gains from the ESPA from 1980 through 2023 have been calculated by IDWR staff for calibration of the ESPA groundwater flow model and the Swan Falls Forecast Tool. The correlation between the average July aquifer discharge to the Kimberly to King Hill reach and the previous fall GWI is shown in Figure 9.

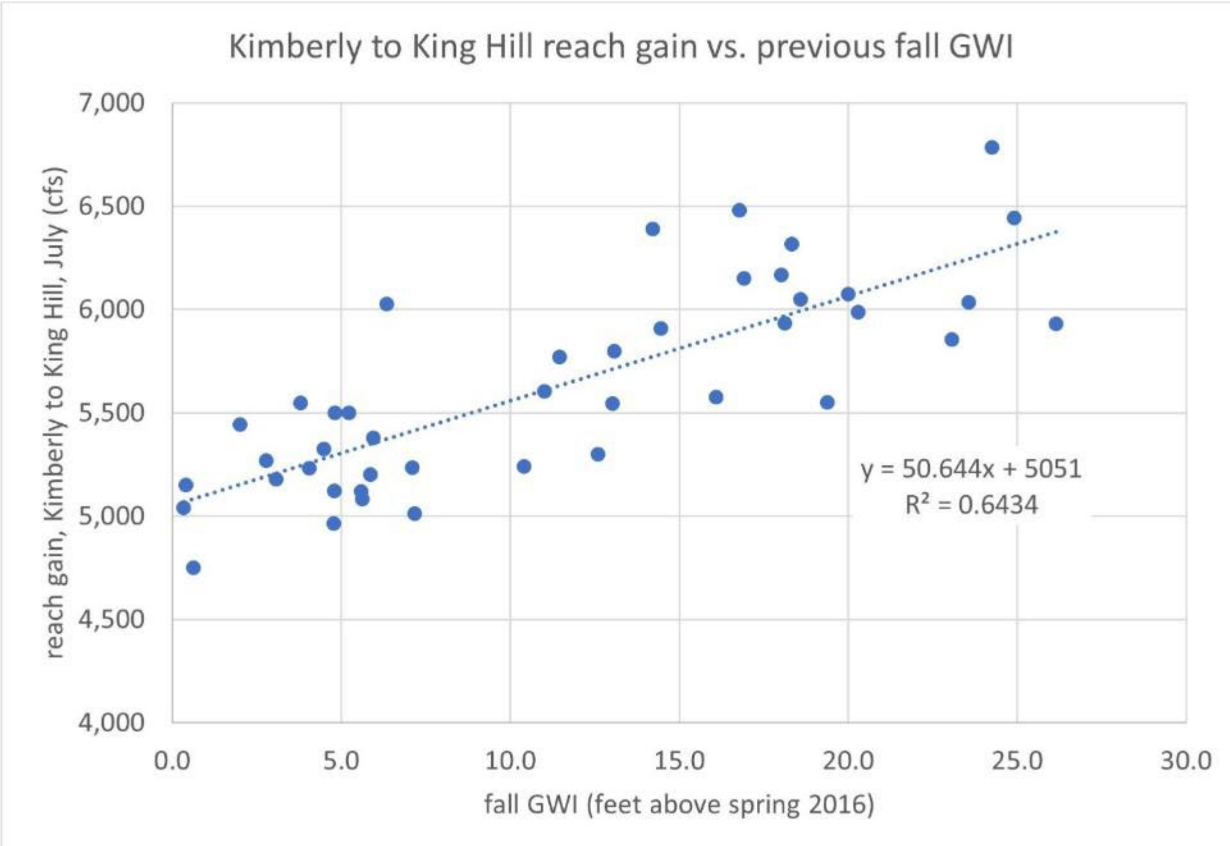


Figure 9. Correlation between ESPA discharge below Milner and Fall GWI calculated from 37 network wells

IDWR staff also correlated the average normalized fall water levels in subgroups 3 and 4 (Figure 2) with the observed Kimberly to King Hill reach gain averaged over the month of July (Figures 9-11). The wells in subgroups 3 and 4 are located west of the Great Rift low transmissivity zone. Water levels west of the Great Rift have a larger impact on aquifer discharge to the Kimberly to King Hill reach than water levels east of the Great Rift.

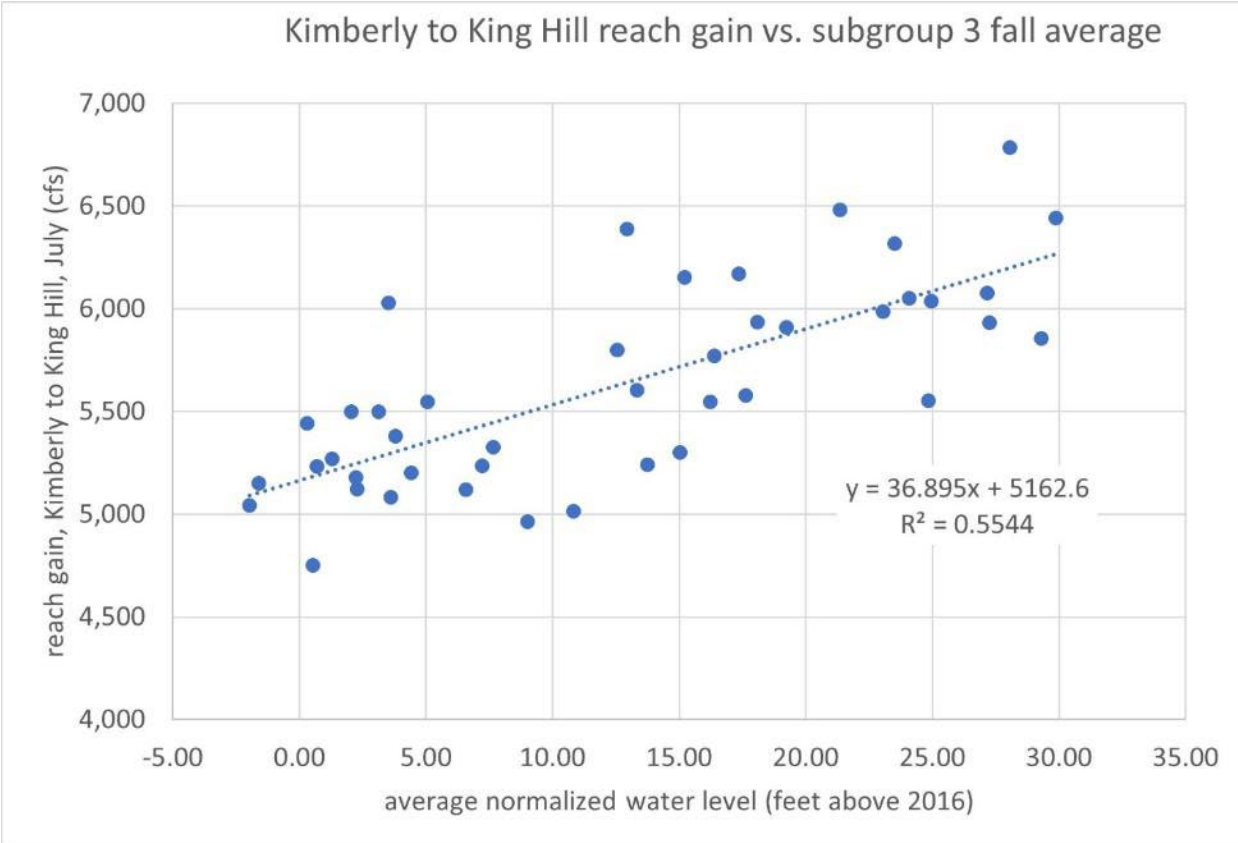


Figure 10. Correlation between ESPA discharge below Milner and subgroup 3 normalized water level average

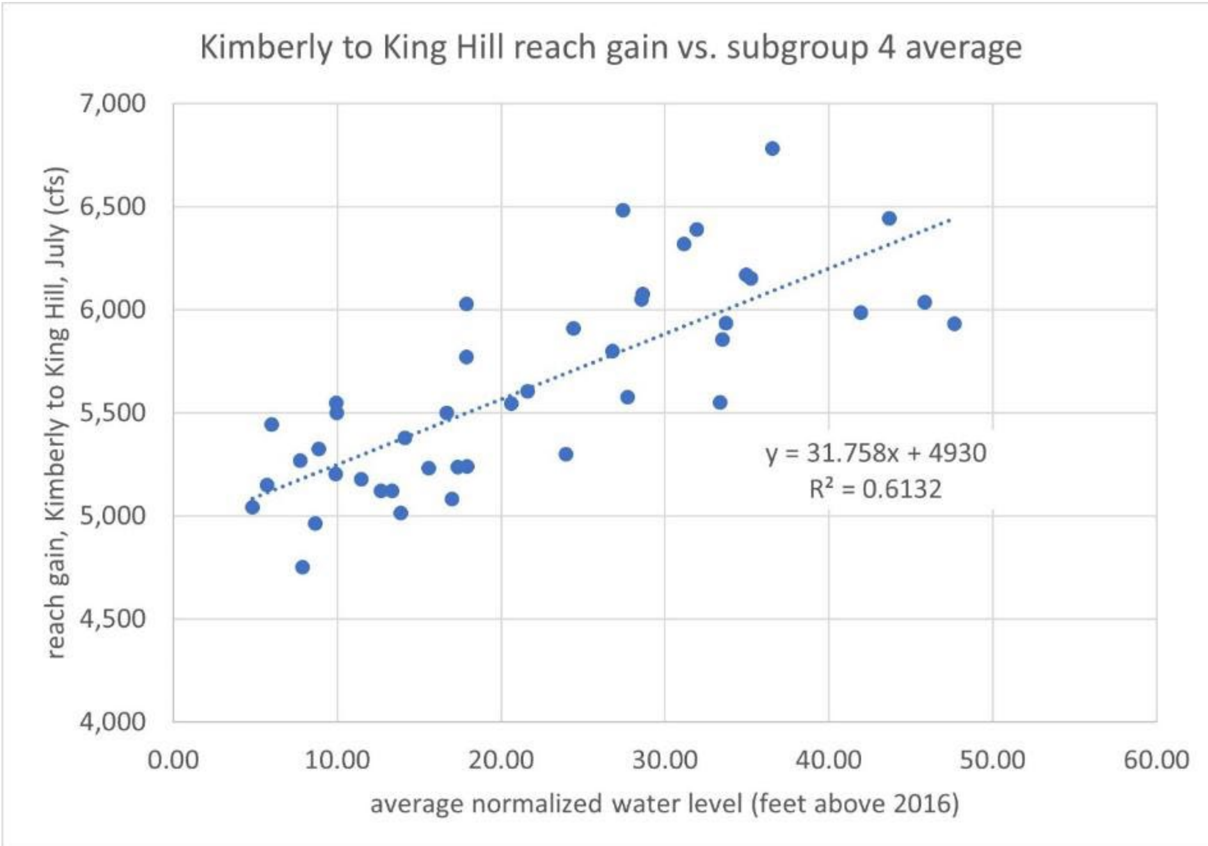


Figure 11. Correlation between ESPA discharge below Milner and subgroup 4 normalized water level average

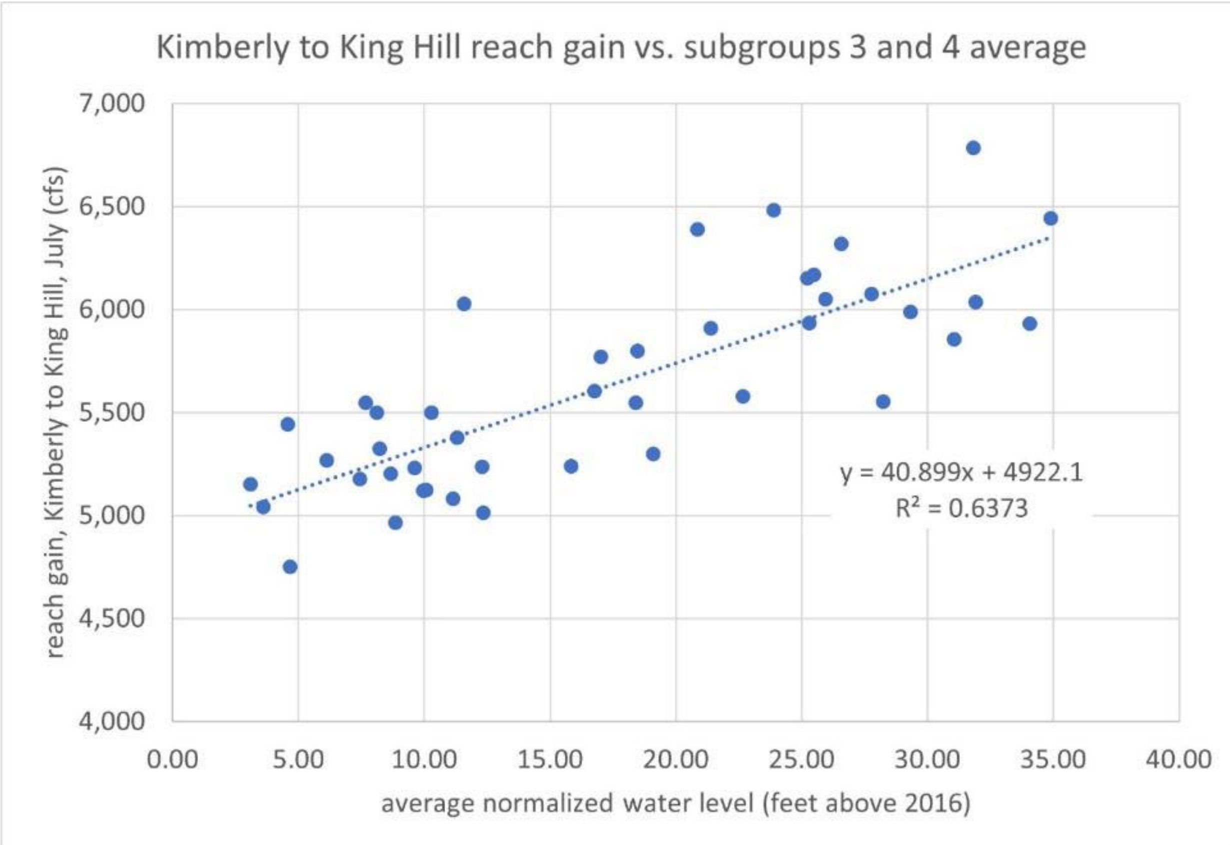


Figure 12. Correlation between ESPA discharge below Milner and subgroups 3 and 4 normalized water level average

The correlation between ESPA discharge below Milner and the average normalized water level in subgroups 3 and 4 is slightly better than the correlation with the average normalized water levels in only subgroup 3 or subgroup 4. The correlation between ESPA discharge below Milner and the average normalized water level in subgroups 3 and 4 is similar to the correlation with the fall GWI, which includes water levels across the ESPA. While the fall GWI could be used to predict aquifer discharge to the Kimberly to King Hill reach, using the average normalized water level for subgroups 3 and 4 is expected to be more resistant to potential changes in the spatial distribution of water use and managed aquifer recharge within the ESPA.

Historic aquifer discharge to the Snake River below Milner predicted using the linear correlation from Figure 12 is compared to the calculated ESPA discharge below Milner in Figure 13. For water years

1981 to 2023 (43 years), the residual difference between the predicted and observed discharge varies from +530 cfs to -630 cfs with a 5%/95% range of +400 cfs to -580 cfs. The mean absolute residual is 230 cfs (approximately 4% of the average discharge). Sources of uncertainty in using the average normalized water level for subgroups 3 and 4 to predict the ESPA discharge to the Snake River below Milner for the upcoming spring include the following.

- measurement error in water levels used to calculate the average normalized water level for subgroups 3 and 4
- timing of fall water level measurements used to calculate the average normalized water level for subgroups 3 and 4
- measurement error in gaged river flow at Kimberly and King Hill, gaged non-ESPA inflows, and reported diversion data contribute to uncertainty in the calculated ESPA discharge to the Snake River below Milner
- for years prior to 2005, estimates of unmeasured return flows added to uncertainty in the reach gain calculation
- simplification of using average water level change at 16 locations to represent the aquifer water level status
- year-to-year differences in aquifer recharge and pumping withdrawals occurring between the fall water level measurements and the following July

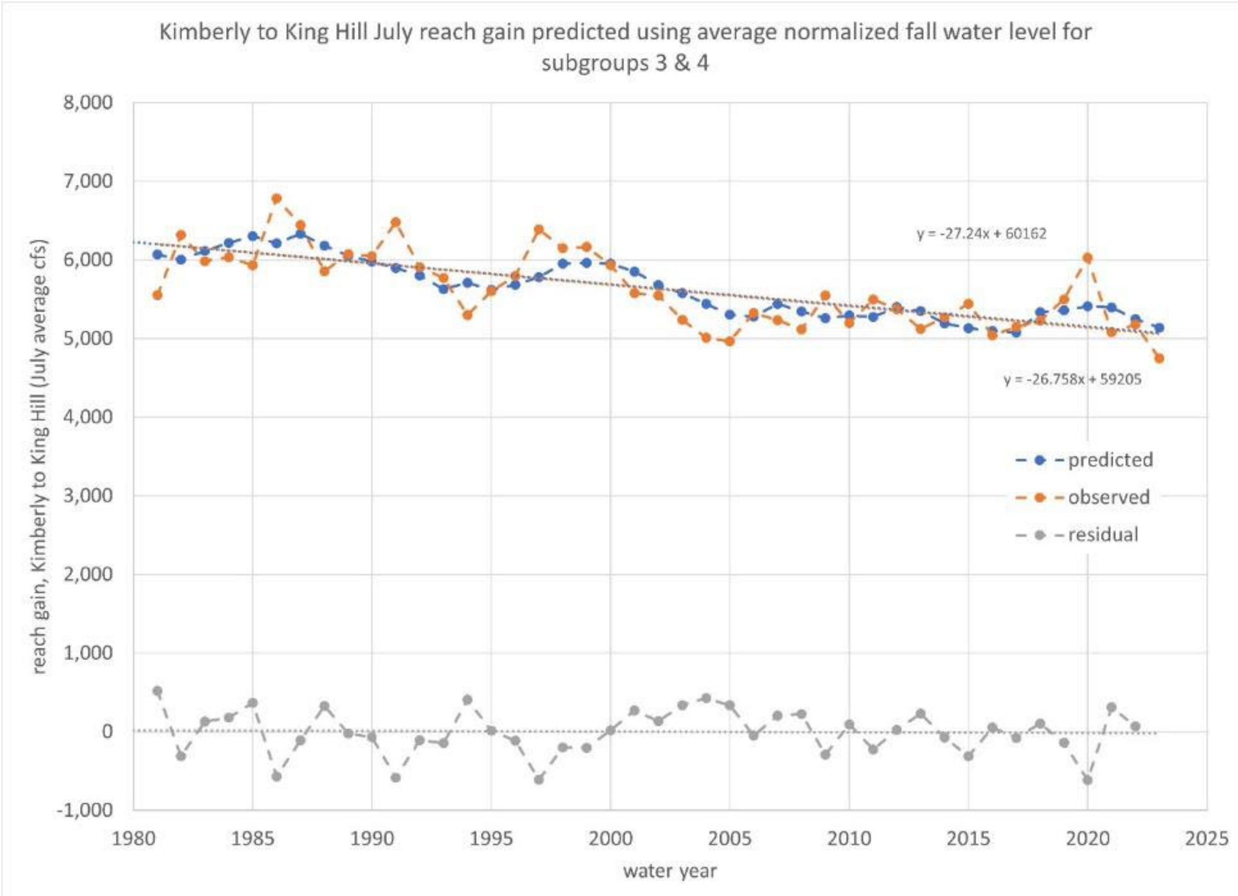


Figure 13. Prediction of average July ESPA discharge to Snake River below Milner using previous fall average normalized water level for subgroups 3 and 4

To evaluate the relative contribution of gage error and reach gain uncertainty to the predictions in Figure 13, a correlation between gaged aquifer discharge to upper Box Canyon and the subgroup 3 and 4 average normalized fall water level was calculated for comparison (Figure 14). Aquifer discharge to upper Box Canyon is measured at a single gage and has lower uncertainty than aquifer discharge to the Kimberly to King Hill reach, which is calculated from multiple gage measurements.

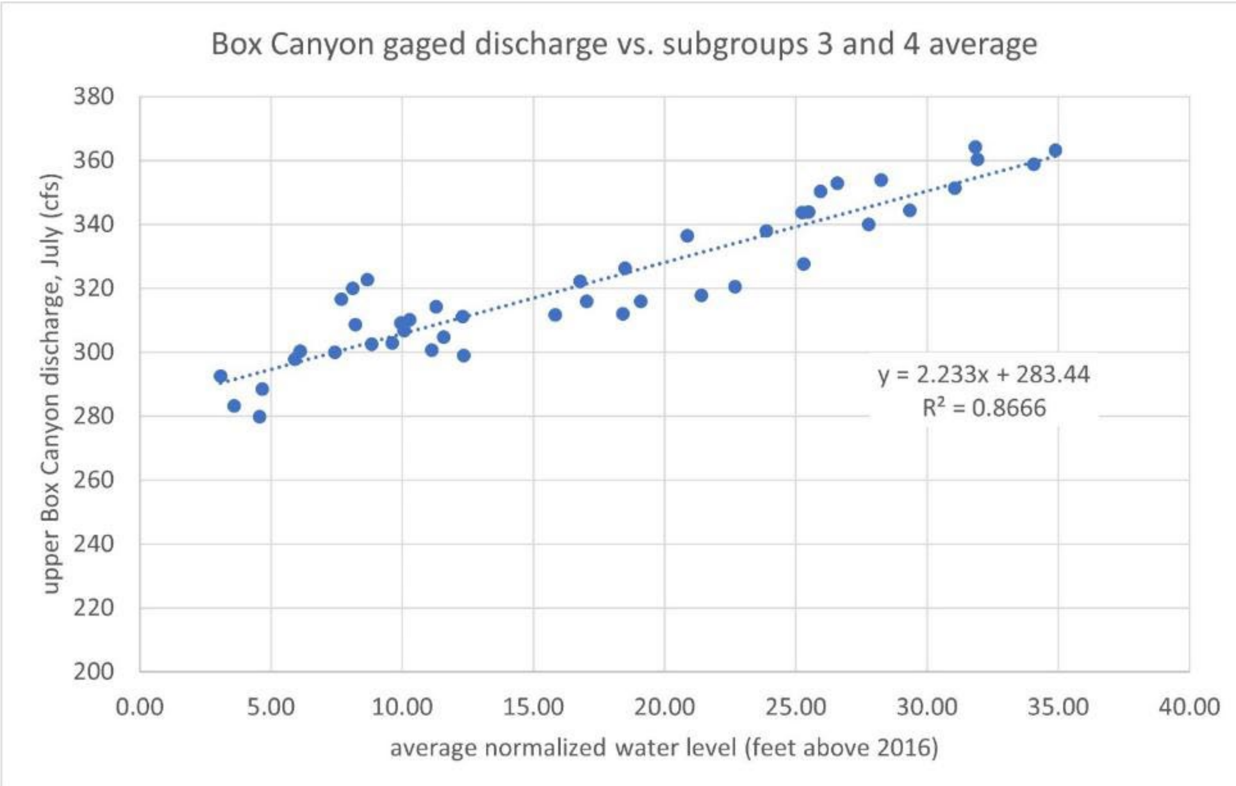


Figure 14. Correlation between upper Box Canyon gaged discharge and previous fall average normalized water level for subgroups 3 and 4

Historic Box Canyon discharge predicted using the linear correlation from Figure 14 is compared to the calculated ESPA discharge below Milner in Figure 15. For water years 1981 to 2024 (44 years), residuals vary from +14 cfs to -20 cfs with a 5%/95% range of +13 cfs to -15 cfs. The mean absolute residual is 6 cfs (approximately 2% of the average discharge).

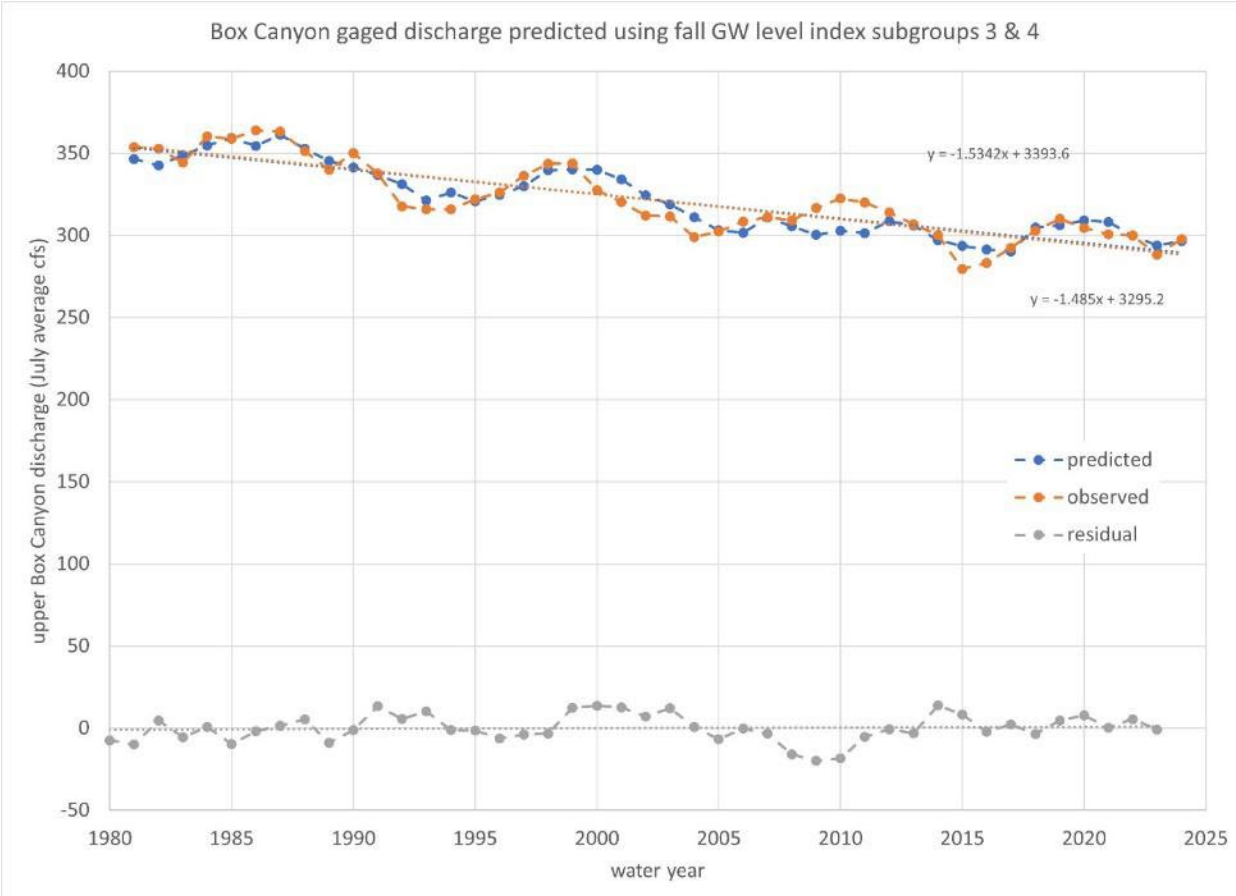


Figure 15. Prediction of average July ESPA discharge to upper Box Canyon using previous fall average normalized water level for subgroups 3 and 4

The square of the correlation coefficient (R^2) represents the proportion of the variance in a dependent variable that can be explained by the independent variable. For aquifer discharge to upper Box Canyon, the correlation indicates approximately 87% of the variance can be explained by the previous fall average normalized water level for subgroups 3 and 4. This result suggests that the fall averaged normalized water level for subgroups 3 and 4 is a good predictor of spring discharge from the ESPA at Box Canyon. For aquifer discharge to the Kimberly to King Hill reach, the correlation indicates approximately 64% of the variance can be explained by the previous fall average normalized water level for subgroups 3 and 4. Measurement errors that contribute to uncertainty in quantifying aquifer discharge to the Kimberly to King Hill reach likely have a large contribution to the difference between these correlations (approximately 23% of the variance). Measurement errors, along with the effects of aquifer stresses that will occur fall and mid-summer, likely have a large contribution to the correlation residuals. While the correlation residuals can be used to qualitatively inform the risk of not meeting the ESPA discharge targets given observed fall water levels, the contribution of reach gain measurement errors on the correlation residuals adds uncertainty to the quantification of risk level.

Part 2d. Develop potential goals for fall water levels using correlation residuals to inform the risk of not meeting the ESPA discharge targets.

Potential goals for average normalized fall water level in the 16 indicator wells in subgroups 3 and 4 (Figure 1) were developed by using the correlation with July ESPA discharge below Milner shown in Figure 11. The correlation residuals provide information regarding the uncertainty in this relationship and how much actual July discharge may differ from the discharge predicted by the correlation. Assuming the purpose of achieving a water-level goal is to reduce the risk of falling below the minimum streamflow, a buffer was added to each of the ESPA contribution goals listed in Table 4. The magnitude of the buffer for each ESPA contribution goal was determined by ranking the ESPA flow prediction residuals and applying the same exceedance percentages that were applied to the non-ESPA inflows.

Table 5. Potential targets for minimum fall normalized subgroup 3 & 4 water level average				
Scenario	**Net non-ESPA contribution (cfs)**	**ESPA contribution goal (cfs)**	**ESPA flow prediction residual (cfs) (predicted July discharge less observed July discharge)**	**Target November subgroup 3 & 4 average normalized water level (ft)**
80% exceedance	-834	4,734	286	> 2.4
90% exceedance	-902	4,802	358	> 5.8
95% exceedance	-956	4,856	401	> 8.2
99% exceedance	-992	4,892	479	> 11.0
minimum observed	-1,001	4,901	525	> 12.3
minimum non-ESPA inflow and maximum demand	-1,254	5,154	525	> 18.5

For reference, the fall 2023 normalized water level average for the 16 wells in subgroups 3 and 4 was 5.9 feet above the spring 2016 level. The potential targets listed in Table 5 range from an average water level of 2.5 feet less than to 12.6 feet above the fall 2023 water level.

The potential targets were also correlated with the fall and spring GWI levels and aquifer storage for the greater ESPA (Table 6).

Table 6. Potential minimum targets for subgroups 3 & 4 correlated with greater ESPA				
Scenario	**Target November subgroup 3 & 4 level(ft)**	**ESPA November GWI (ft)**	**ESPA April GWI (ft)**	**ESPA storage change from 1912 (Sy = 0.075, MAF)**
80% exceedance	> 2.4	> -0.7	> -0.7	> 2.6
90% exceedance	> 5.8	> 2.1	> 1.9	> 4.0
95% exceedance	> 8.2	> 4.0	> 3.8	> 4.9
99% exceedance	> 11.0	> 6.3	> 5.9	> 6.0
minimum observed	> 12.3	> 7.4	> 7.0	> 6.6
minimum non-ESPA inflow and maximum demand	> 18.5	> 12.4	> 11.8	> 9.0

For reference, the fall 2023 GWI for the 37 wells across the ESPA was 1.8 feet above the spring 2016 level. The potential targets listed in Table 6 range from an 2.5 feet below to 10.6 feet above the fall 2023 water level average for the ESPA. Similarly, the spring 2024 normalized water level average for the 37 wells was 1.7 feet above the spring 2016 level and the potential targets range from 2.4 feet below to 10.1 feet above the spring 2024 water level average. The spring 2024 estimated cumulative storage change from 1912 was 3.9 MAF (assuming an average specific yield of 0.075). The potential targets range from a decrease of 1.3 MAF to an increase 5.1 MAF in aquifer storage above the spring 2024 level. Figure 16 illustrates how the potential targets compare with recent historic fall water levels. Figure 17 illustrates how the ESPA storage change correlated with the potential targets compares to the historic ESPA storage change calculated by McVay (2024[1]).

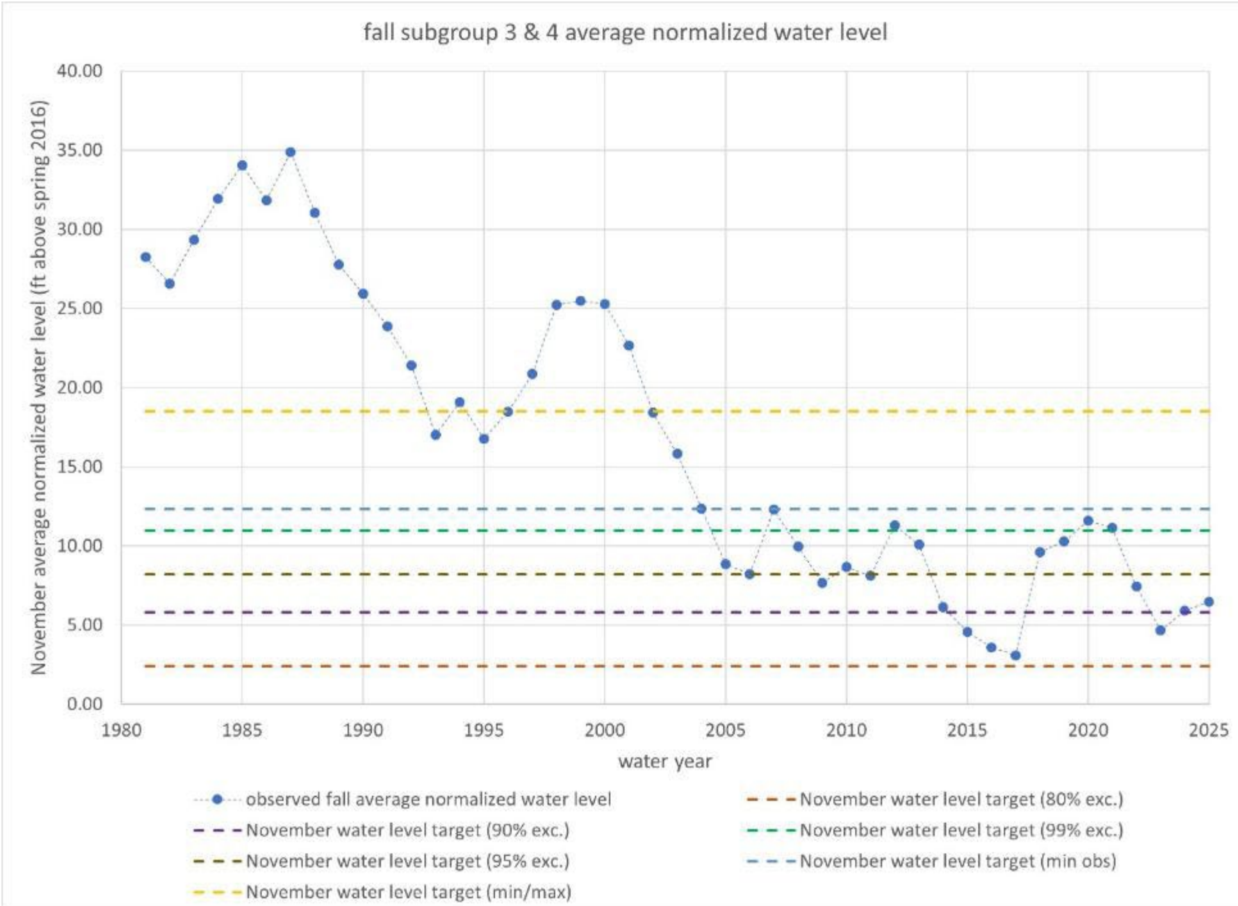


Figure 16. Potential water level targets and historic average normalized fall water level

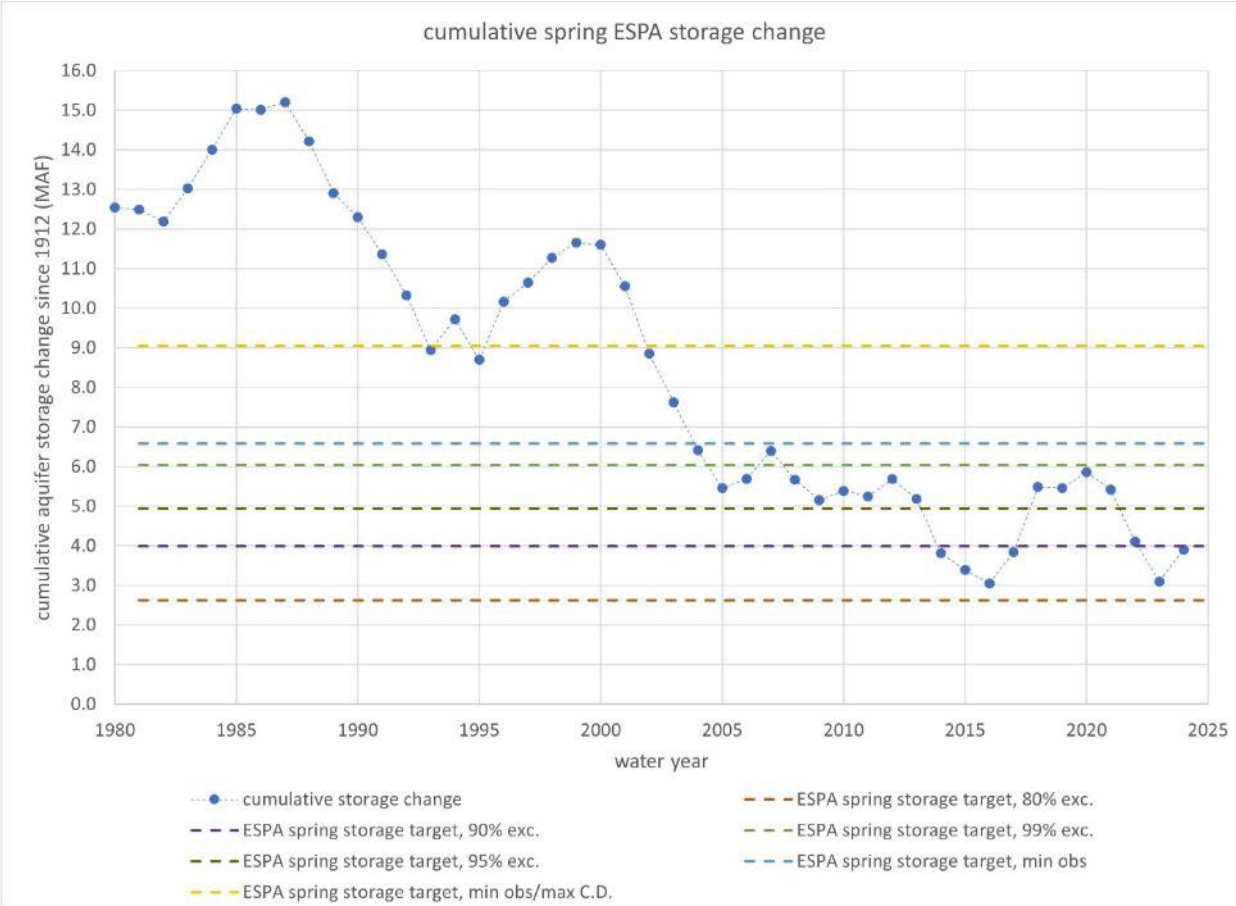


Figure 17. Potential water level targets and historic ESPA storage change

Part 3. Potential water level goals to provide a buffer against falling below the minimum streamflow during a multi-year drought

The potential minimum fall water level targets discussed in Part 2 would need to be met or exceeded every fall to reduce the risk of falling below the minimum streamflow during the following summer. If the aquifer is at the minimum fall water level target and an extreme drought year occurs, extreme changes in water management practices would be needed to meet the fall water level target again in the fall. Because the changes in water management practices that would be needed to maintain a consistent fall water level near a minimum target value are not practical, a buffered target water level could be selected to account for declines in aquifer water levels that are expected to occur during successive drought years. Historic declines in ESPA storage and water levels during multi-year droughts observed between 1980 and 2024 are shown in Table 7. Four multi-year droughts with reductions in ESPA storage of over 2.5 million AF were observed during the last 44 years. The 2020-2022 drought reflects recent changes in aquifer management practices and exhibits average annual declines similar to the long-term average for all drought years.

Table 7. Historic declines in ESPA storage and water levels during recent multi-year droughts

Drought period	Years	subgroups 3&4 fall water level change (ft)	ESPA fall GWI change (ft)	ESPA spring storage change (MAF)
1987 - 1992	6	-17.9	-13.4	-6.3
2000 - 2004	5	-16.4	-13.4	-6.2
2012 - 2015	4	-7.7	-5.6	-2.6
2020 - 2022	3	-6.9	-5.7	-2.7
average change during drought years	18 years	-2.7 ft/yr	-2.1 ft/yr	-1.0 MAF/yr
average change 2020 - 2022	3 years	-3.3 ft/yr	-1.9 ft/yr	-0.9 MAF/yr

A buffer for additional years of drought can be added to the potential targets discussed in Table 6 by multiplying the number of additional years of drought the SFIG would like to buffer against by the average annual change observed during drought years. For example, if the SFIG selects the 90% exceedance target and wants to buffer against a four-year drought period, the target level for the average fall normalized water level in subgroups 3 and 4 would increase from 5.8 feet to 13.9 feet (5.8 feet + 3 x 2.7 feet), the target level for the ESPA fall GWI would increase from 2.1 feet to 8.4 feet (2.1 feet + 3 x 2.1 feet) and the ESPA spring storage volume target would increase from 4.0 MAF to 7.0 MAF (4.0 MAF + 3 x 1.0 MAF) above the estimated 1912 volume. Figures 18 and 19 show the effects of adding buffers to the 90% exceedance target example, with historic fall water level and aquifer storage change shown for context. Similar figures showing examples with buffers applied to each of the five potential minimum targets are provided in Attachment B.

When selecting a target water level and drought buffer combination, it is important to note that some combinations of exceedance scenarios and drought buffer periods yield similar target water levels and storage volumes. This alignment can be observed across multiple combinations in Table 8. For example, the 95% exceedance target (8.2 feet or 4.9 MAF) provides similar protection to the 90% exceedance target with a two-year drought buffer (8.5 feet or 5.0 MAF), illustrating that comparable protection levels can be achieved through different combinations of exceedance scenarios and drought buffer periods.

Table 8. Aquifer head change based on percent exceedance and 2, 3, and 4-year drought scenarios

Scenario	Target Nov subgroup 3 & 4 level (ft)	Target Nov subgroup 3 & 4 level (ft) with 2-year drought	Target Nov subgroup 3 & 4 level (ft) 3-year drought	Target Nov subgroup 3 & 4 level (ft) 4-year drought
80% exceedance	> 2.4	> 5.1	> 7.8	> 10.5
90% exceedance	> 5.8	> 8.5	> 11.2	> 13.9
95% exceedance	> 8.2	> 10.9	> 13.6	> 16.3
99% exceedance	> 11.0	> 13.7	> 16.4	> 19.1
minimum observed	> 12.3	> 15.0	> 17.7	> 20.4
minimum non-ESPA inflow and maximum demand	> 18.5	> 21.2	> 23.9	> 26.6

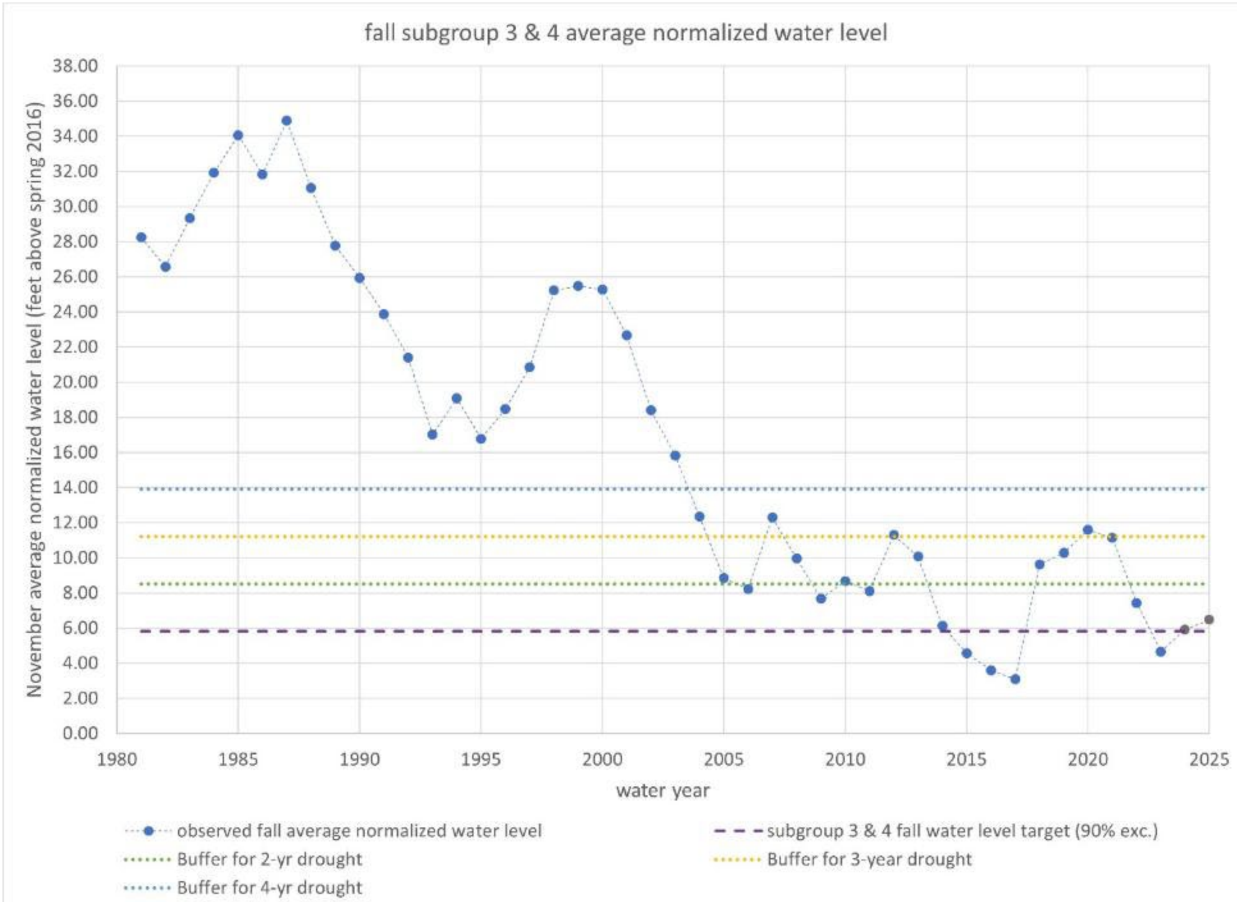


Figure 18. Example of buffering for additional consecutive drought years and historic average normalized fall water level in subgroups 3 and 4

Table 9. Cumulative change in aquifer storage and 2, 3, and 4-year drought scenarios				
Scenario	**ESPA storage change from 1912 (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 2-year drought (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 3-year drought (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 4-year drought (Sy = 0.075, MAF)**
80% exceedance	> 2.6	> 3.6	> 4.6	> 5.6
90% exceedance	> 4.0	> 5.0	> 6.0	> 7.0
95% exceedance	> 4.9	> 5.9	> 6.9	> 7.9
99% exceedance	> 6.0	> 7.0	> 8.0	> 9.0
minimum observed	> 6.6	> 7.6	> 8.6	> 9.6
minimum non-ESPA inflow and maximum demand	> 9.0	> 10.0	> 11.0	> 12.0

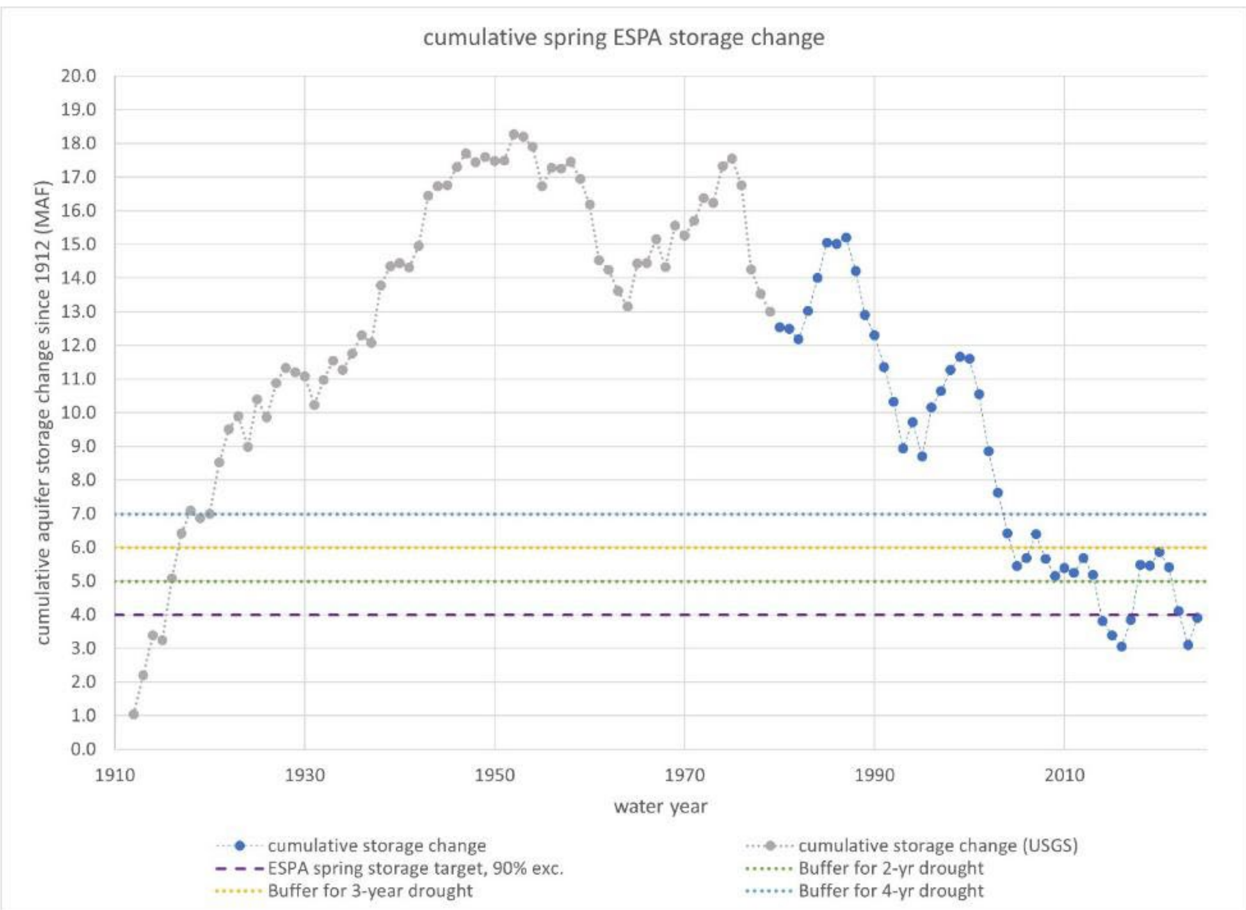


Figure 19. Example of buffering for additional consecutive drought years and historic cumulative change in aquifer storage

Discussion

This analysis provides six examples of potential targets for ESPA discharge and minimum fall aquifer water levels needed to sustain the target discharge during a single-year drought. The analysis of potential targets for ESPA discharge is based on the range of the historic net non-ESPA contributions to Snake River streamflow. The analysis of minimum fall aquifer water levels needed to sustain each potential target is based on the range of water levels and historic ESPA discharge observed between 1980 and 2023. The residual difference between the predicted and observed reach gain represents a combination of the contribution of November through June aquifer stresses (recharge and pumping withdrawals) to summer reach gain and the effects of measurement errors on the correlation between fall water levels and July discharge from the ESPA in the Kimberly to King Hill reach. Potential ESPA discharge targets are shown in Figure 20 with historic and predicted ESPA discharge for comparison.

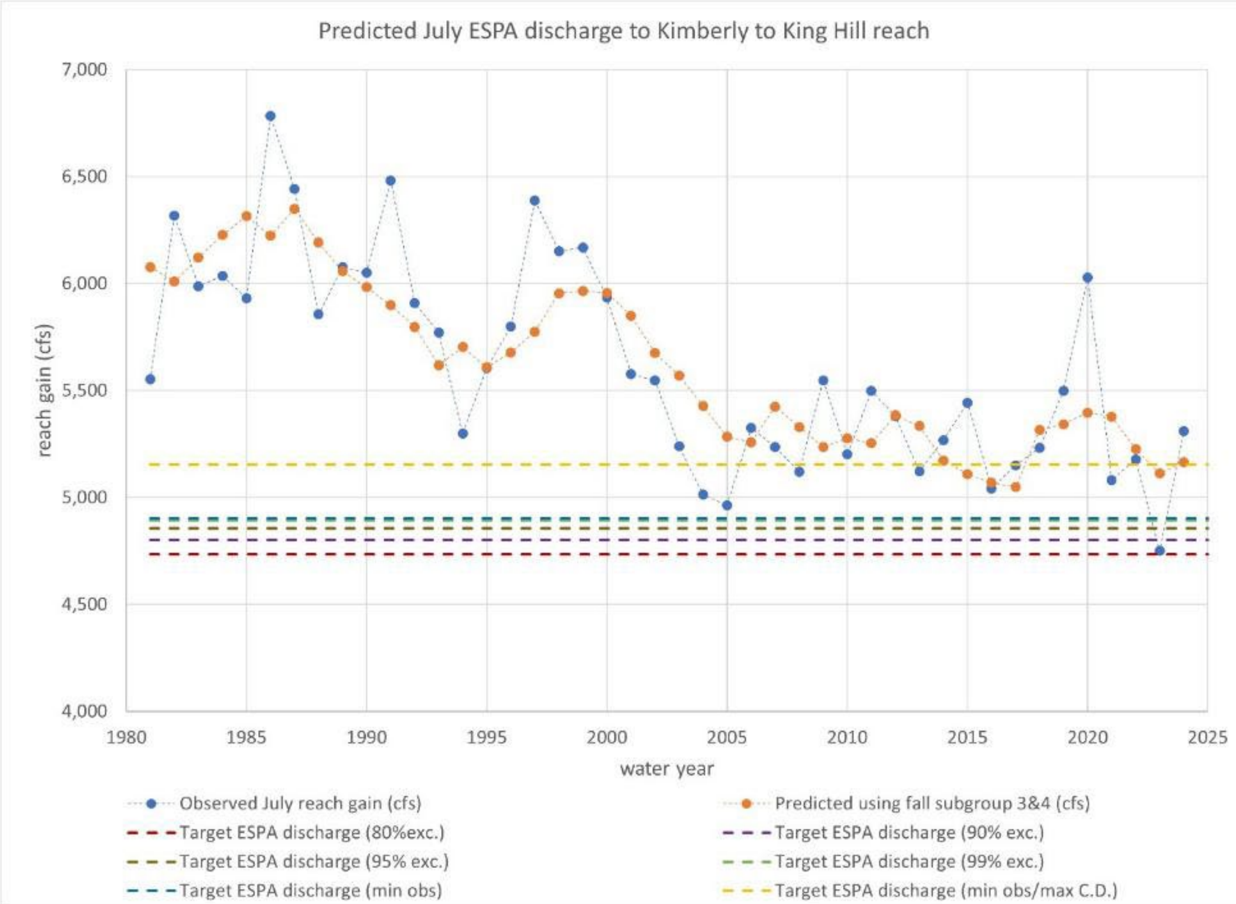


Figure 20. Predicted July discharge and potential ESPA discharge targets

It is difficult to quantify the net risk of not meeting the minimum streamflow at the Snake River near Murphy for a given ESPA water level. For the four potential targets based on exceedance percentiles, the percentiles represent the risk of low non-ESPA contributions, coupled with the same level of risk of the contribution from July ESPA discharge being lower than predicted by correlation with fall water level. If these conditions were completely independent, the overall risk would be the approximate product of their individual risk, effectively the square of the exceedance probability (e.g., for a 10% risk level, $0.10^2 = 0.01$ or 1%). However, these factors are not fully independent because the conditions that would result in lower than average November through June aquifer recharge and higher than average April through June pumping withdrawals are often associated with conditions that would result in lower than average non-ESPA inflows and higher than average non-ESPA consumptive demand. As a result, the true risk likely falls between the exceedance probability itself and this squared value, depending on the degree of correlation.

Table 10 summarizes this range of risk for each water level target based on historic observations of non-ESPA contributions and ESPA discharge.

Table 10. Range of net risk of not meeting the minimum summer streamflow		
Scenario	**Target November subgroup 3 & 4 level(ft)**	**Range of net risk**
80% exceedance	> 2.4	4% to 20%
90% exceedance	> 5.8	1% to 10%
95% exceedance	> 8.2	0.25% to 5%
99% exceedance	> 11.0	0.01% to 1%
minimum observed	> 12.3	very low
minimum non-ESPA inflow and maximum demand	> 18.5	extremely low

Future deviations from the range of historical conditions used to calculate the exceedance values may increase the probability of failing to meet the minimum summer streamflow. Deviations from historic conditions may include (but are not limited to) the following:

- reduction in return flows from the south side and north side of the Snake River
- deviation from climate patterns during the observation periods used in these analyses

Multi-year drought periods will also add to the risk of not meeting the minimum streamflow because it will not be possible to maintain a consistent fall water level in the ESPA without extreme changes in water management. A buffer for additional years of drought can be added to the minimum fall water level targets discussed in Tables 4 and 5 to reduce the risk of falling below the minimum streamflow during multi-year droughts.

Recommendation

There is risk of not meeting the minimum streamflow in the Snake River at Murphy with current ESPA water levels and a single year of low aquifer recharge, low non-ESPA inflows, and high crop consumptive use demand. If ESPA water levels decrease below current levels, there will be an increased risk of falling below the minimum streamflow in subsequent drought years. Any increase in ESPA water levels and aquifer storage will provide some reduction in the risk of falling below the minimum streamflow. The SFTWG has developed a range of potential minimum fall ESPA water level goals that range from slightly below the recent minimum aquifer level to a very conservative increase. For each potential goal, the level of risk described in Table 10 only applies to the upcoming year when the minimum fall water level goal is met or exceeded. Note that the numeric values of the potential average water levels goals are specific to this network of wells and would need to be recalculated using the same methods if the network of wells is modified. Similarly, if an aquifer storage change level is selected as a goal, it should be noted that aquifer storage change is calculated using the average specific yield in the Eastern Snake Plain Aquifer Model (ESPAM) and aquifer storage change goals would need to be recalculated when a new model version is released.

Because it will not be possible to maintain a consistent fall water level without extreme changes in water management, the SFIG could consider adding a buffer to the minimum fall water level targets discussed in Tables 4 and 5 to reduce the risk of falling below the minimum streamflow during multi-year droughts. The buffer magnitude should be based on the length of the multi-year drought the SFIG would like to plan for, and the average observed declines in drought years (summarized in Table 7). Observed water level declines over recent multi-year droughts ranged from 7 to 18 feet for the 16 indicator wells located closest to the Kimberly to King Hill reach of the Snake River and from 6 to 13 feet for 37 wells distributed across the ESPA. Estimated ESPA storage declines over recent multi-year droughts ranged from 2.6 to 6.3 MAF.

Achieving any long-term increase in ESPA water levels is expected to require changes in water management to maintain or increase incidental recharge, increase managed recharge, and/or decrease consumptive use on the Eastern Snake Plain. The technical working group has no recommendation on the selection of a specific water level goal but is available to provide additional technical assistance if requested by the Swan Falls Implementation Group. The SFTWG could also provide assistance with evaluating the risk of the occurrence of multi-year droughts of different lengths based on longer-term historic climate data.

ATTACHMENT A. ANALYSIS OF ADDITIONAL EXCEEDANCE PROBABILITIES AND NET RISK

Table 3a. Net contribution by Percent Exceedance	
Percent exceedance	**Net (cfs)**
50%	**-749**
60%	**-769**
70%	**-812**

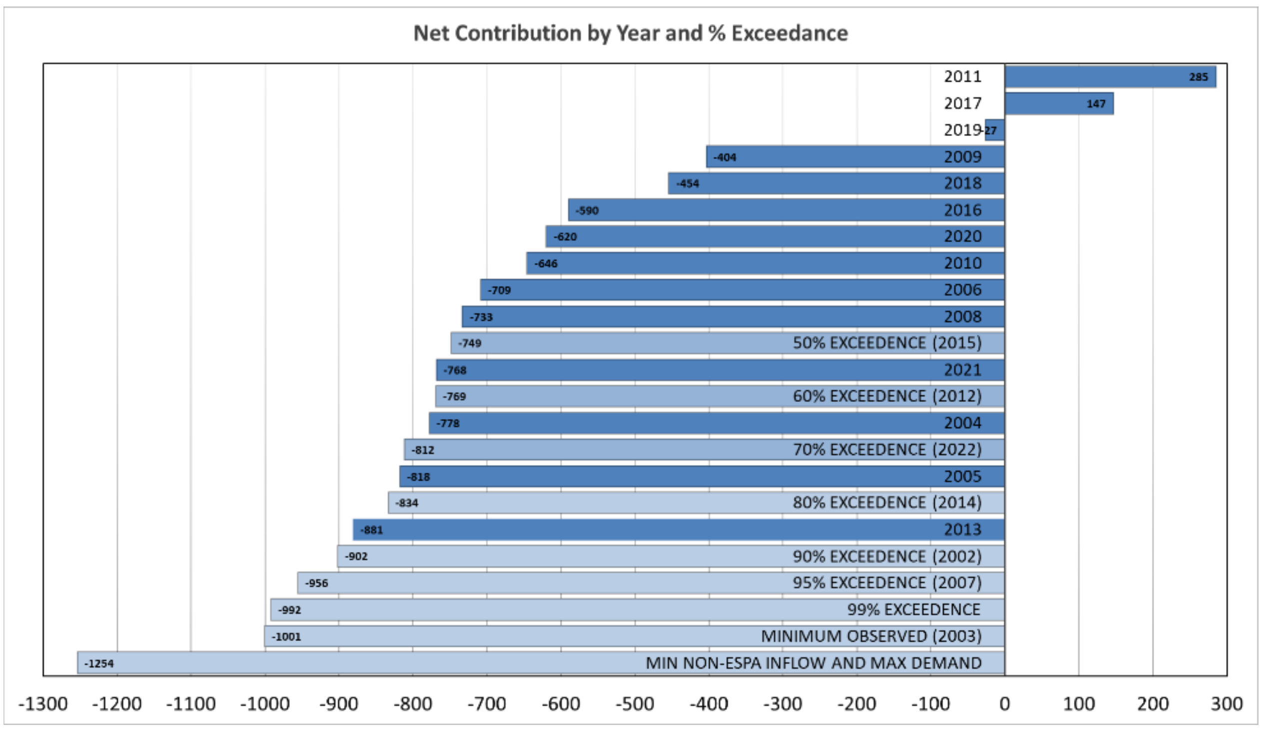


Figure 1a. Net Contribution in July by year and Percent Exceedance

Table 4a. Lower exceedance level targets for ESPA contribution to minimum streamflow		
Scenario	**Net non-ESPA contribution (cfs)**	**ESPA contribution goal (cfs)**
50% exceedance	-749	4,649
60% exceedance	-769	4,669

70% exceedance	-812	4,712

Table 5a. Lower exceedance level targets for minimum fall normalized subgroup 3 & 4 water level average				
Scenario	**Net non-ESPA contribution (cfs)**	**ESPA contribution goal (cfs)**	**ESPA flow prediction residual (cfs) (predicted July discharge less observed July discharge)**	**Target November subgroup 3 & 4 average normalized water level (ft)**
50% exceedance	-749	4,649	6	> -6.5
60% exceedance	-769	4,669	77	> -4.3
70% exceedance	-812	4,712	190	> -0.5

Table 6a. Lower exceedance level targets for subgroups 3 & 4 correlated with greater ESPA				
Scenario	**Target November subgroup 3 & 4 level(ft)**	**ESPA November GWI (ft)**	**ESPA April GWI (ft)**	**ESPA storage change from 1912 (Sy = 0.075, MAF)**
50% exceedance	> -6.5	> -8.0	> -7.7	> -0.9
60% exceedance	> -4.3	> -6.2	> -5.9	> 0.0
70% exceedance	> -0.5	> -3.1	> -3.0	> 1.5

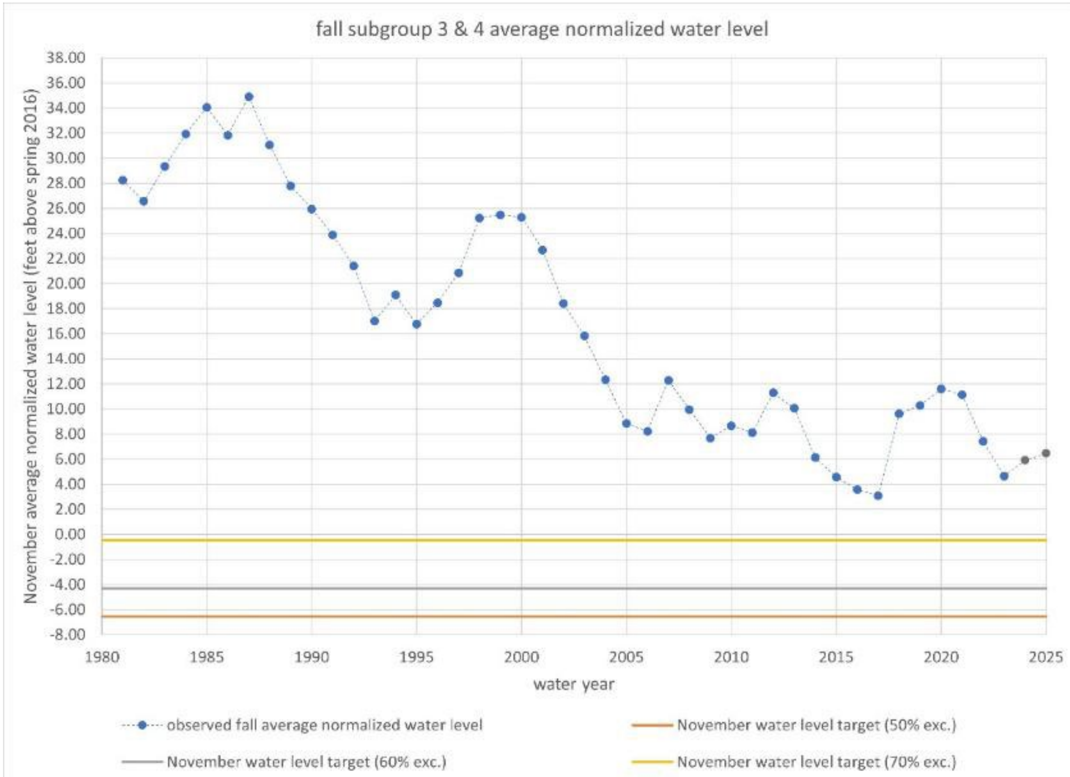


Figure 16a. Potential water level targets (50%, 60%, and 70% exceedance) and historic average normalized fall water level

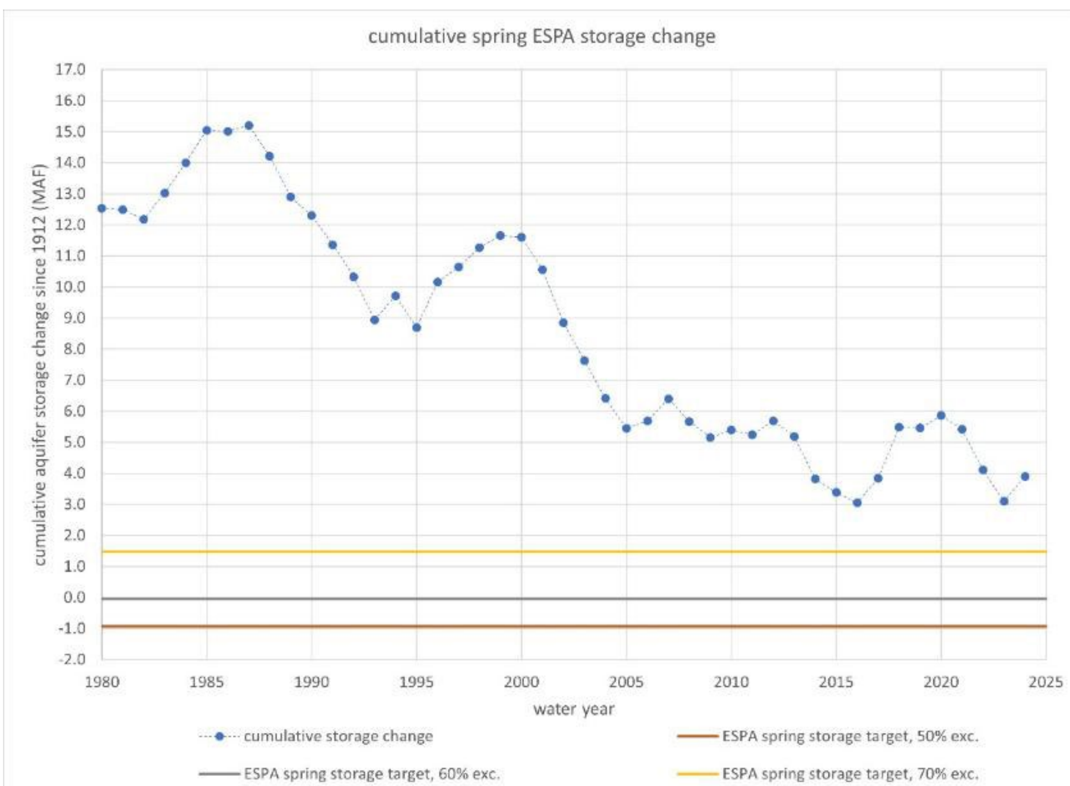


Figure 17a. Potential water level targets (50%, 60%, and 70% exceedance) and historic ESPA storage change

Table 8a. Aquifer head change based on low percent exceedance and 2, 3, and 4-year drought scenarios				
Scenario	**Target Nov subgroup 3 & 4 level (ft)**	**Target Nov subgroup 3 & 4 level (ft) with 2-year drought**	**Target Nov subgroup 3 & 4 level (ft) 3-year drought**	**Target Nov subgroup 3 & 4 level (ft) 4-year drought**
50% exceedance	> -6.5	> -3.8	> -1.1	> 1.6
60% exceedance	> -4.3	> -1.6	> 1.1	> 3.8
70% exceedance	> -0.5	> 2.2	> 4.9	> 7.6

Table 9a. Cumulative change in aquifer storage and 2, 3, and 4-year drought scenarios				
Scenario	**ESPA storage change from 1912 (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 2-year drought (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 3-year drought (Sy = 0.075, MAF)**	**ESPA storage change from 1912 with a 4-year drought (Sy = 0.075, MAF)**
50% exceedance	> -0.9	> 0.1	> 1.1	> 2.1
60% exceedance	> 0.0	> 1.0	> 2.0	> 3.0
70% exceedance	> 1.5	> 2.5	> 3.5	> 4.5

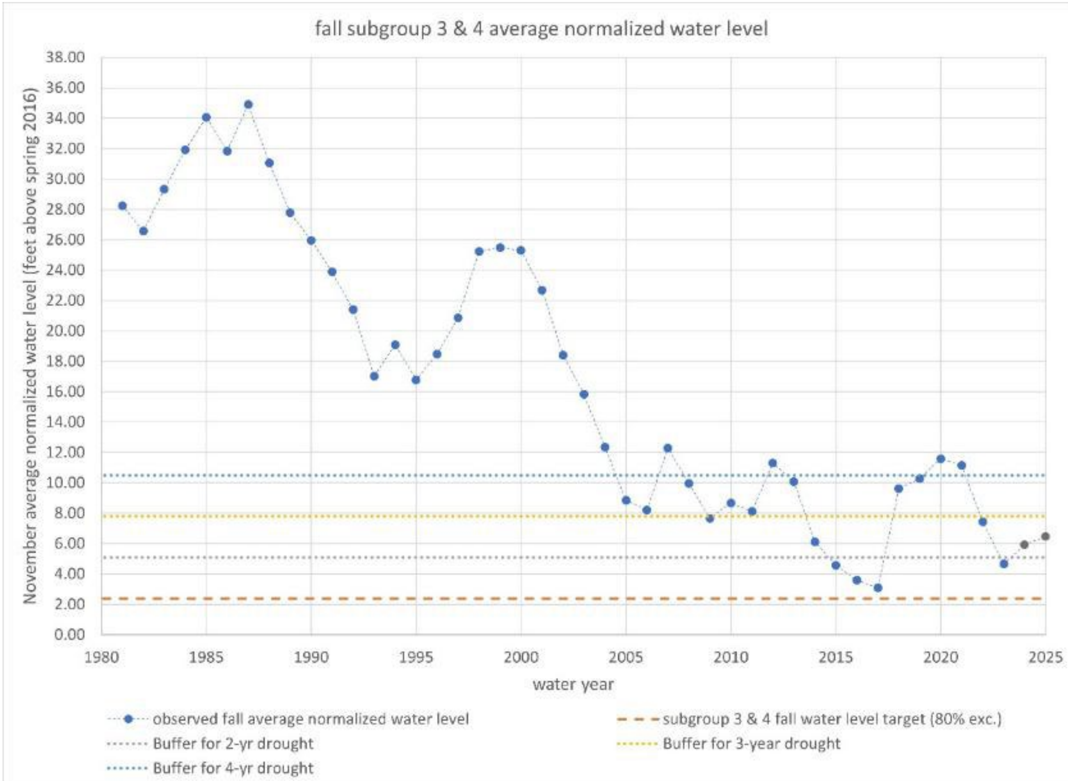
Table 10a. Range of net risk of not meeting the minimum summer streamflow		
Scenario	**Target November subgroup 3 & 4 level(ft)**	**Range of net risk**
50% exceedance	> -0.9	25% to 50%
60% exceedance	> 0.0	16% to 40%
70% exceedance	> 1.5	9% to 30%

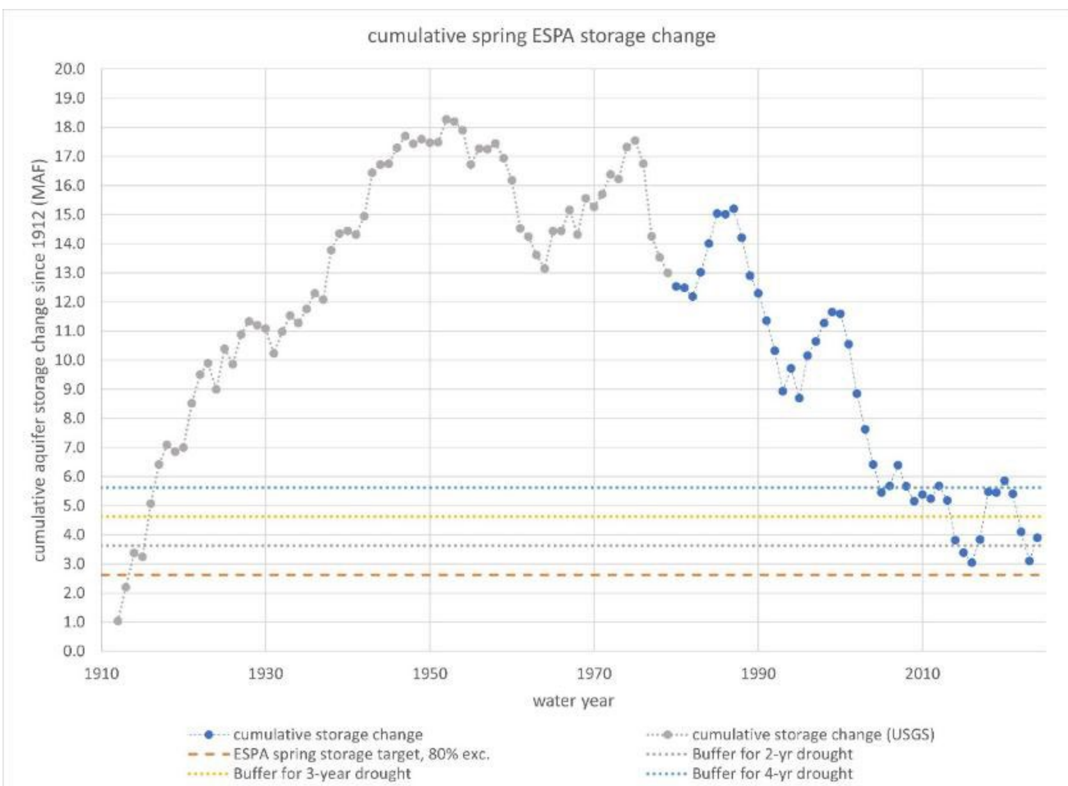
Table 10a2. Range of net risk of not meeting the minimum summer streamflow if Kimberly to King Hill reach gain could be assumed to vary linearly with Box Canyon discharge		
Scenario	**Target November subgroup 3 & 4 level(ft)**	**Range of net risk**
50% exceedance	> -0.9	24% to 49%
60% exceedance	> 0.0	11% to 33%
70% exceedance	> 1.5	3% to 17%
80% exceedance	> 2.4	1% to 8%
90% exceedance	> 5.8	0.3% to 5%
95% exceedance	> 8.2	<1%
99% exceedance	> 11.0	very low
minimum observed	> 12.3	very low
minimum non-ESPA inflow and maximum demand	> 18.5	extremely low

ATTACHMENT B. EXAMPLES OF POTENTIAL WATER LEVEL GOALS

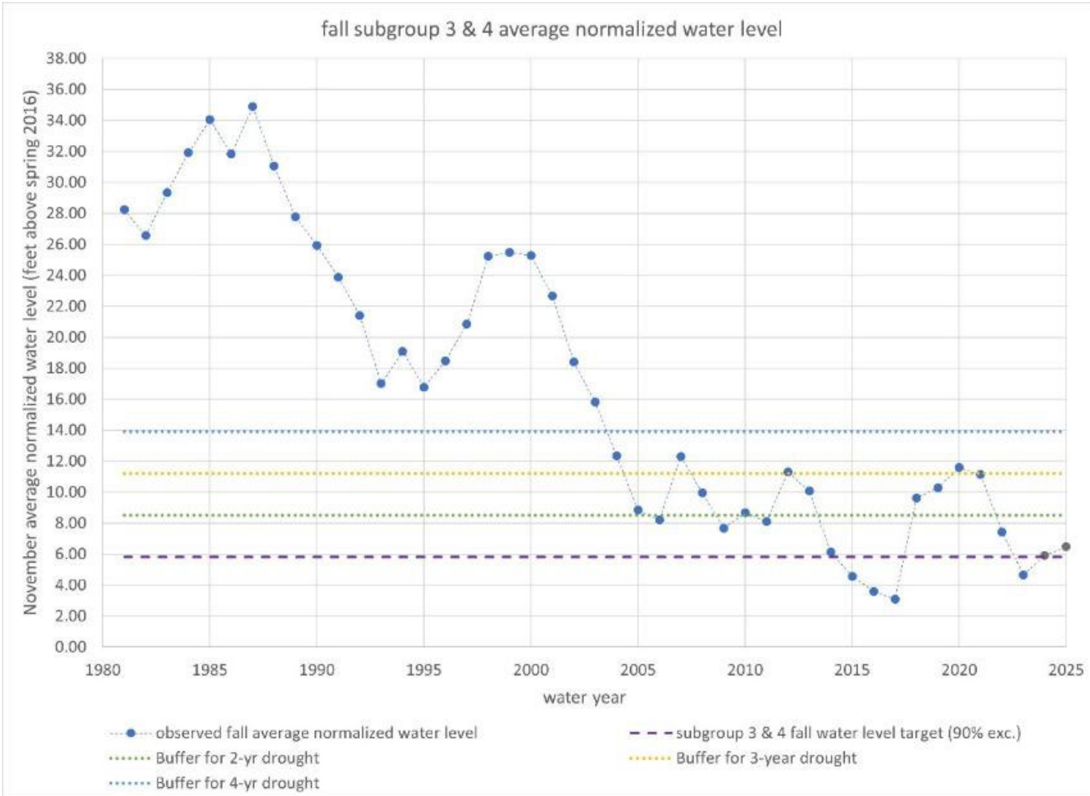
BUFFERED FOR CONSECUTIVE DROUGHT YEARS

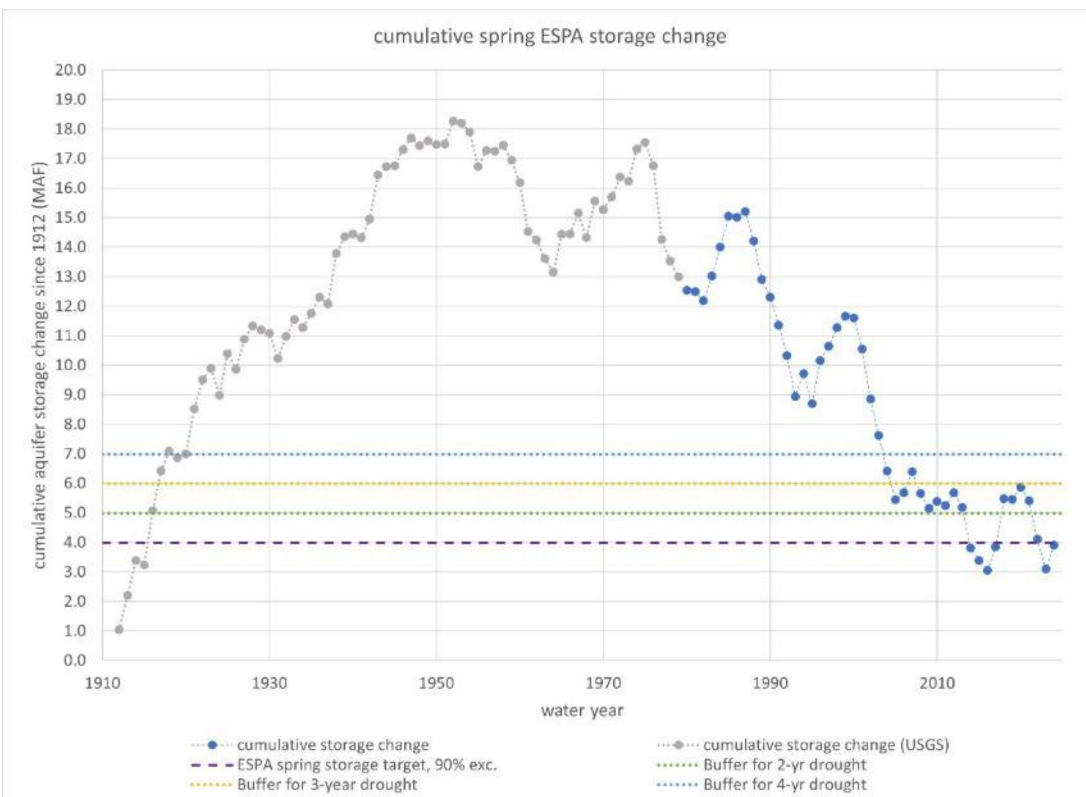
80% EXCEEDANCE TARGET



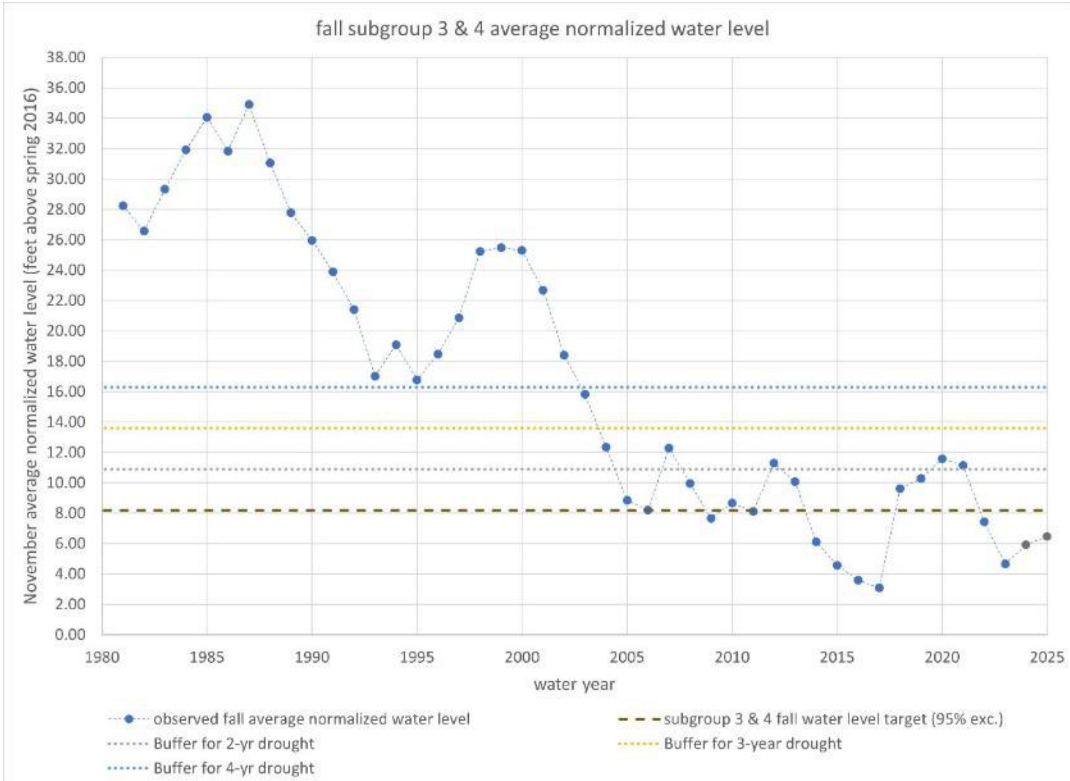


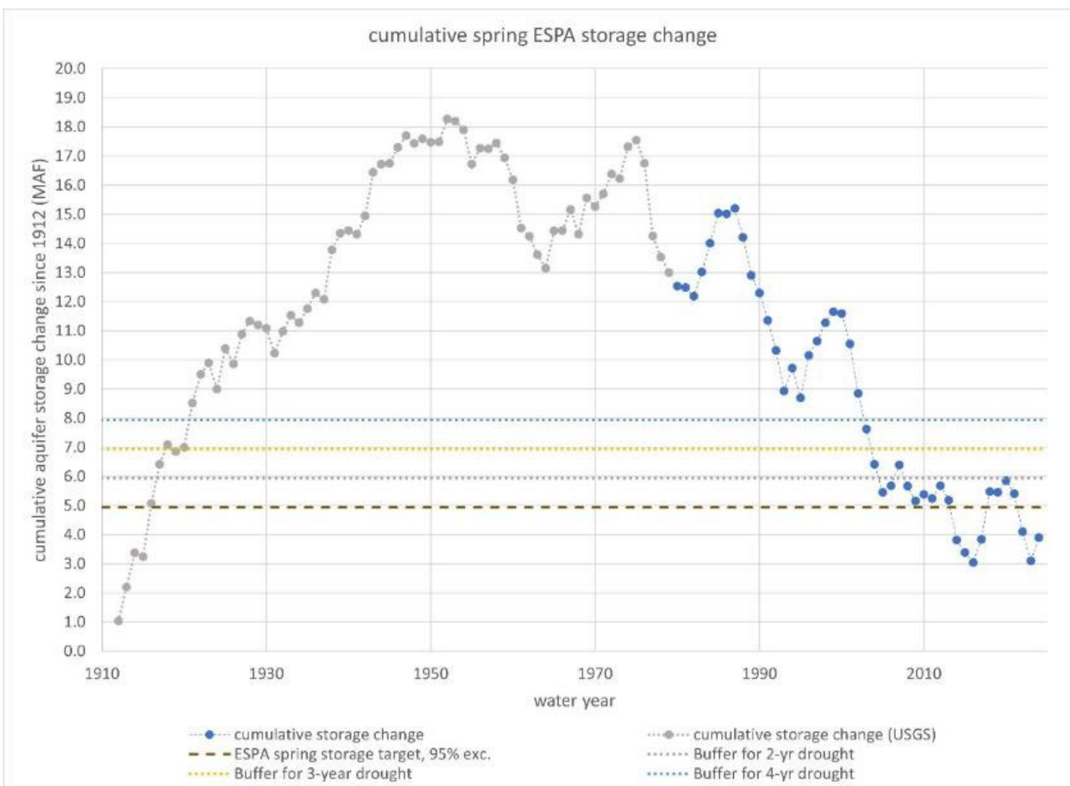
90% EXCEEDANCE TARGET



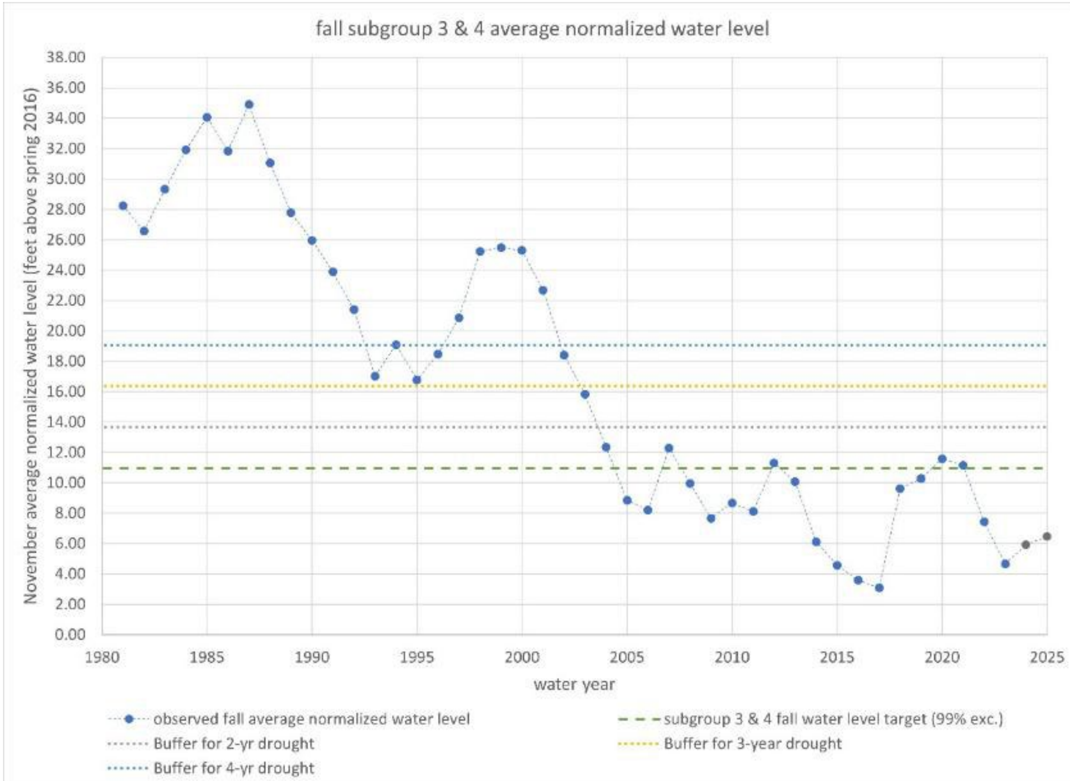


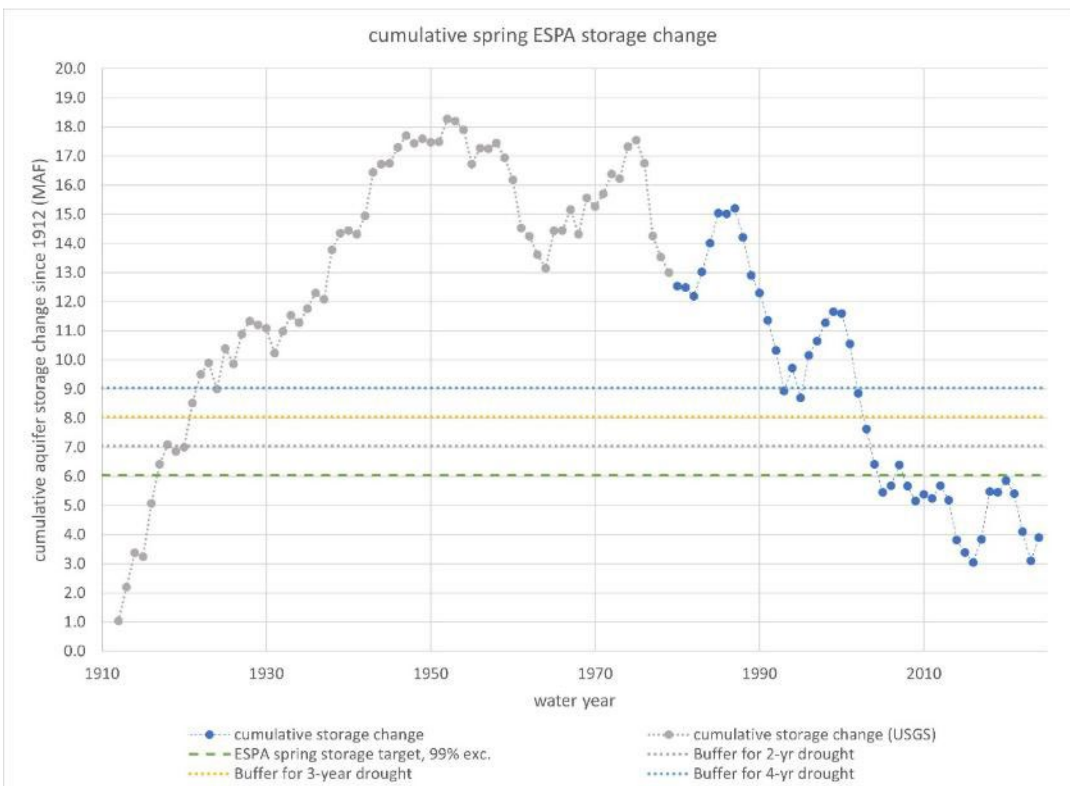
95% EXCEEDANCE TARGET



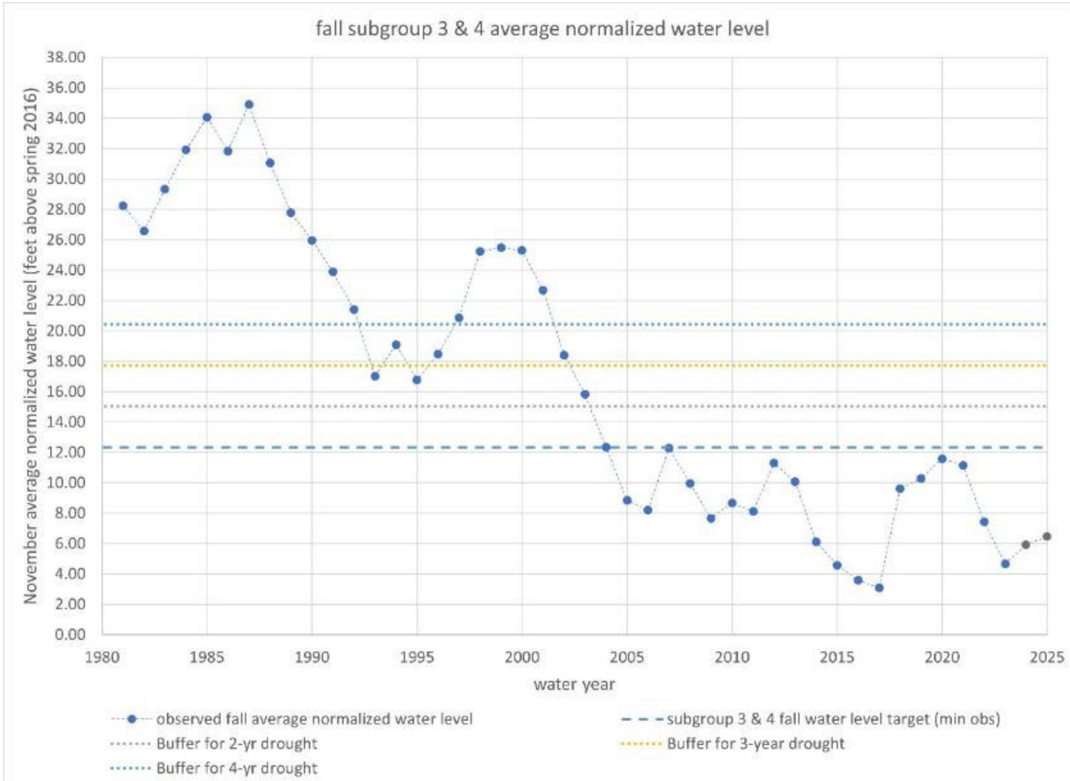


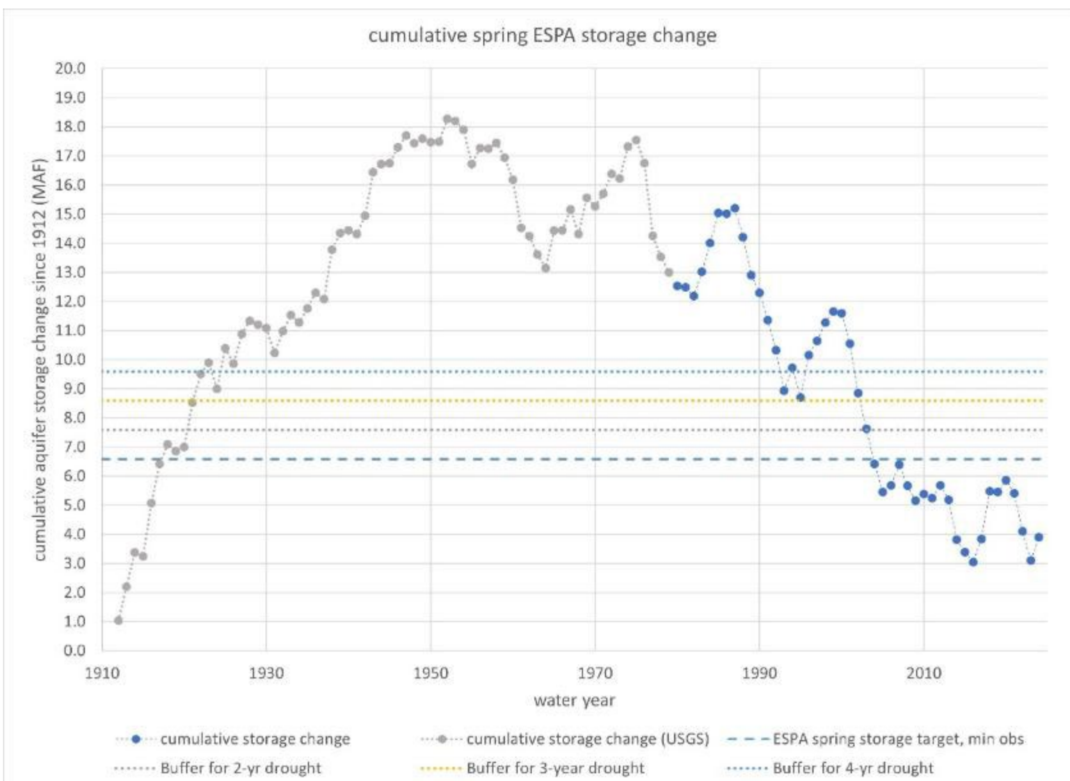
99% EXCEEDANCE TARGET



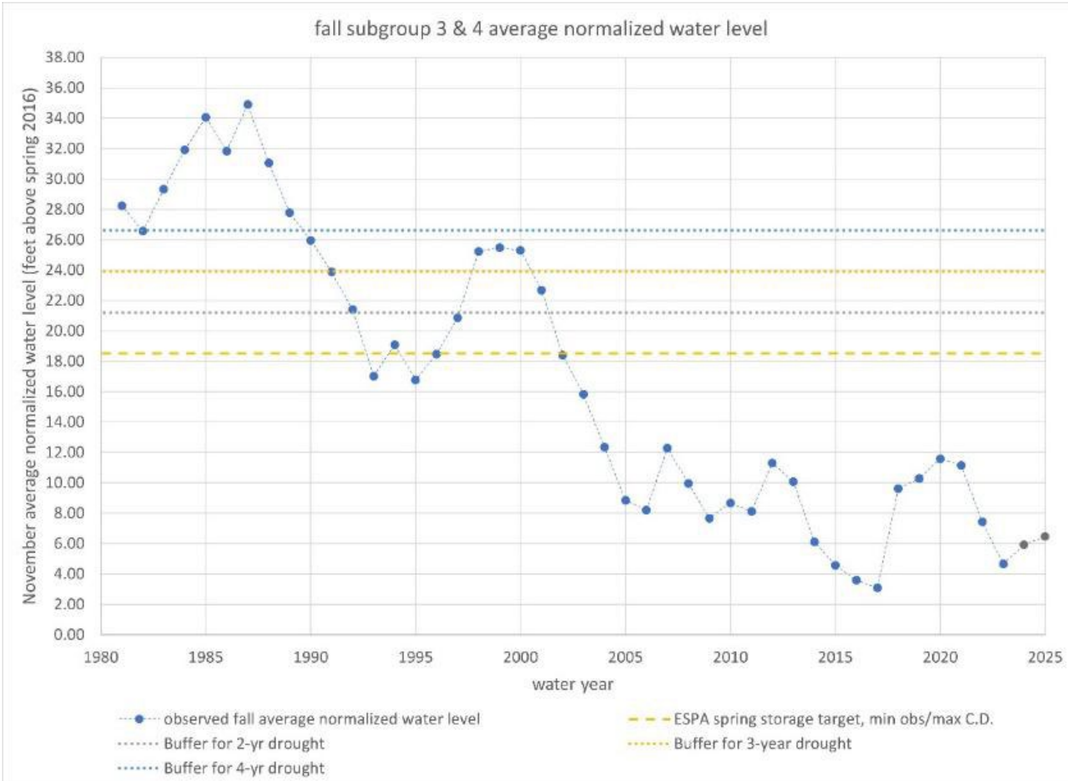


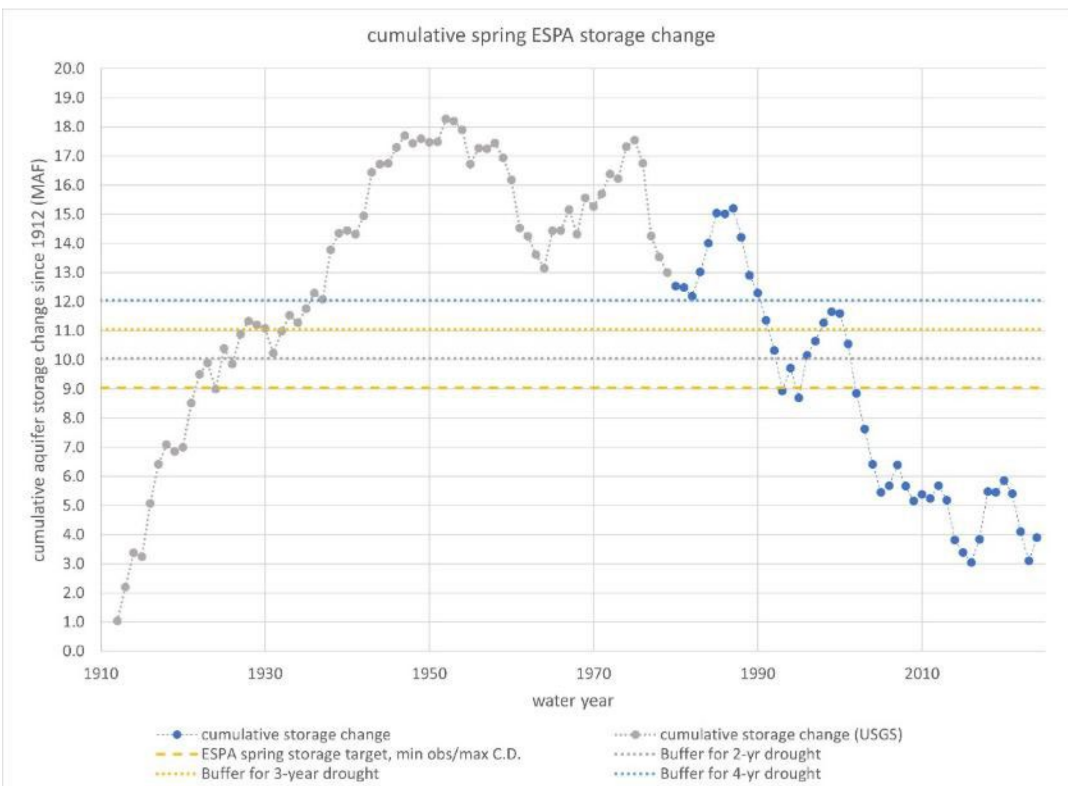
TARGET BASED ON MINIMUM OBSERVED NON-ESPA INFLOW LESS DEMAND





TARGET BASED ON MINIMUM OBSERVED NON-ESPA INFLOW LESS MAXIMUM DEMAND





ATTTACHMENT C. PROPOSED INDICATOR WELLS FOR MONITORING ESPA WATER LEVELS

Subgroup	Station	County	Data
1	07N 34E 04CDC1	JEFFERSON	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	07N 35E 20CBD1	JEFFERSON	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	07N 36E 09BBB3	JEFFERSON	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	07N 39E 16DBB1	FREMONT	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	08N 36E 21DCD1	JEFFERSON	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	09N 36E 33CBB1	CLARK	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
1	09N 38E 05BBA1	CLARK	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	01S 30E 15BCA1	BINGHAM	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	02N 28E 35AAC1	BUTTE	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
2	02N 31E 35DCC1	BINGHAM	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
2	02N 35E 02BBC1	BONNEVILLE	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	02N 37E 02ABA1	BONNEVILLE	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	02S 33E 16ABB1	BINGHAM	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	03S 31E 16CCB1	BINGHAM	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	04N 26E 21ABB1	BUTTE	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	04N 30E 07ADB1	BUTTE	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
2	05N 32E 36ADD1	JEFFERSON	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
2	05N 34E 09BDA1	JEFFERSON	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	05S 28E 26BBD1	POWER	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
2	06N 31E 13DBB1	BUTTE	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
2	08S 28E 01AAA2	POWER	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
3	01S 23E 26CCC1	BLAINE	https://waterdata.usgs.gov/id/nwis/current/?type=gw&group_key=county_cd
3	03S 27E 24DDA1	BLAINE	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
3	04S 24E 06BBC1	MINIDOKA	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
3	05S 25E 22DAD1	MINIDOKA	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
3	06S 22E 28CDD1	LINCOLN	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview

3	07S 26E 14CCC1	BLAINE	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
3	09S 25E 03CAC1	MINIDOKA	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
4	05S 15E 35DBD2	GOODING	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
4	05S 17E 26ACA1	LINCOLN	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
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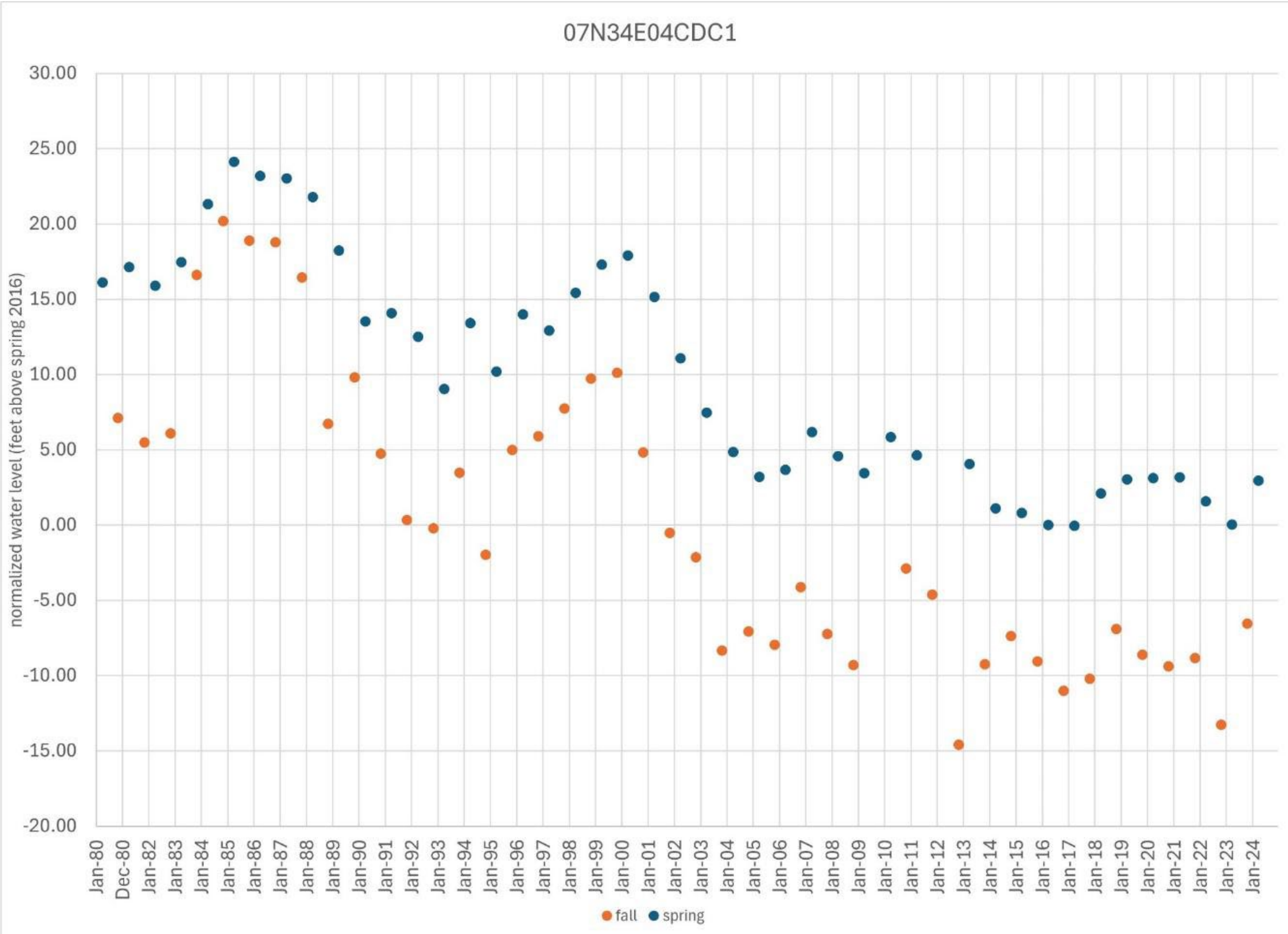
4	08S 16E 19AAA1	GOODING	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
4	08S 18E 35BAC1	JEROME	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview
4	10S 21E 28BCB1	JEROME	https://idwr-groundwater-data.idaho.gov/applications/public.html?publicuser=public#waterdata/stationoverview

ATTACHMENT D. HYDROGRAPHS OF NORMALIZED WATER LEVELS



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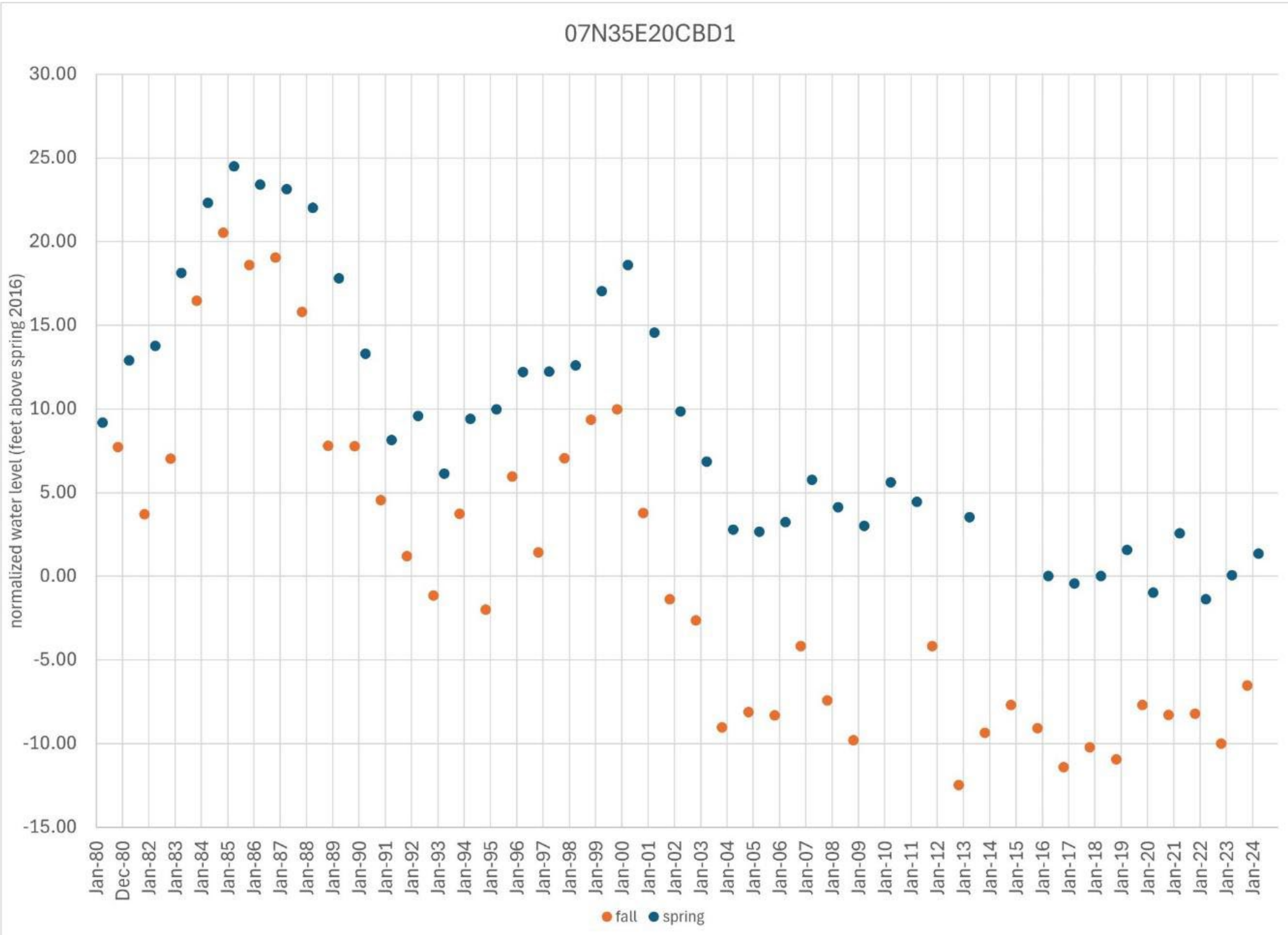
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



07N35E20CBD1
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
-15.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
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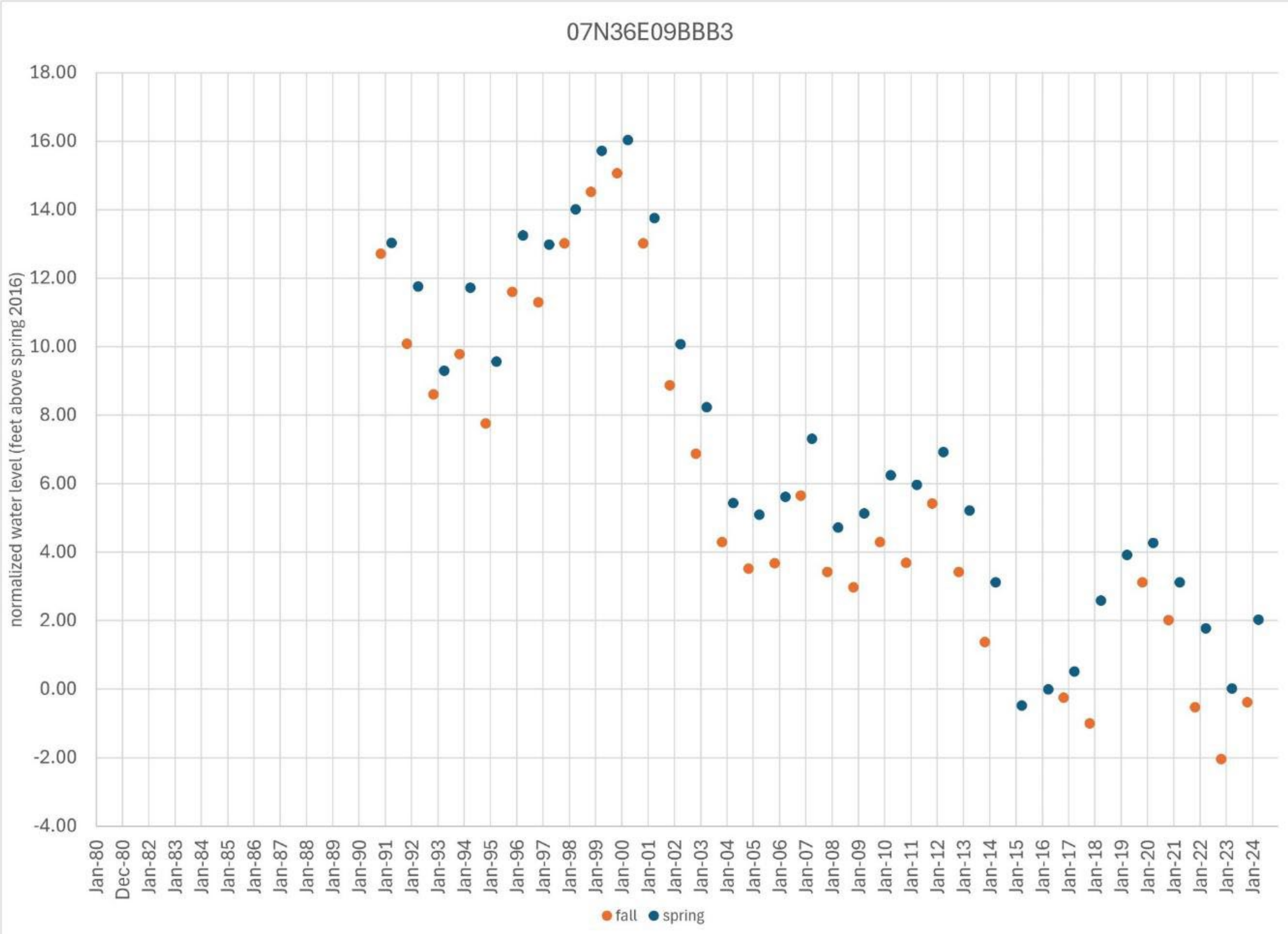
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


07N36E09BBB3
normalized water level (feet above spring 2016)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
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Jan-01
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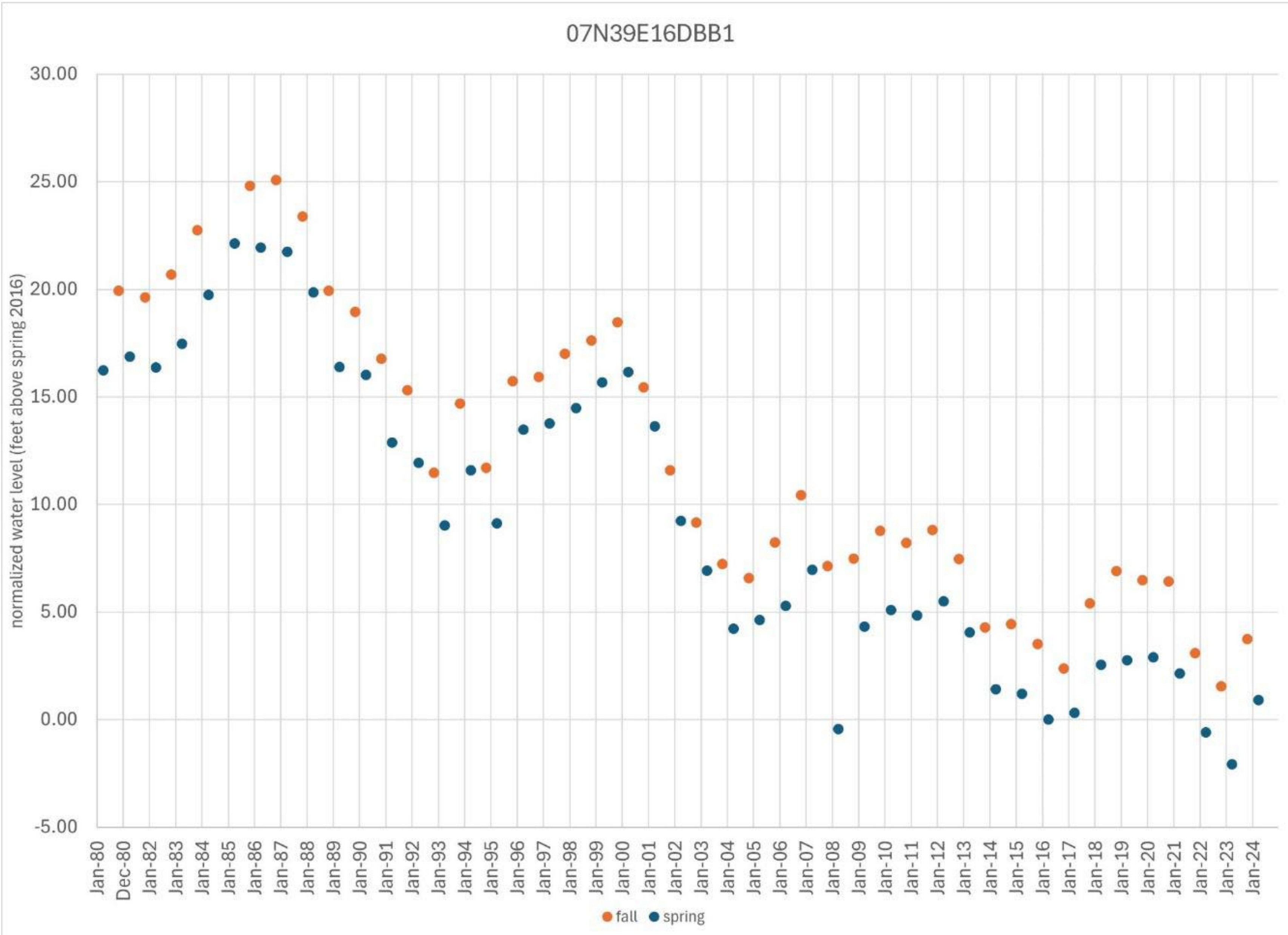
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


07N39E16DBB1
normalized water level (feet above spring 2016)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
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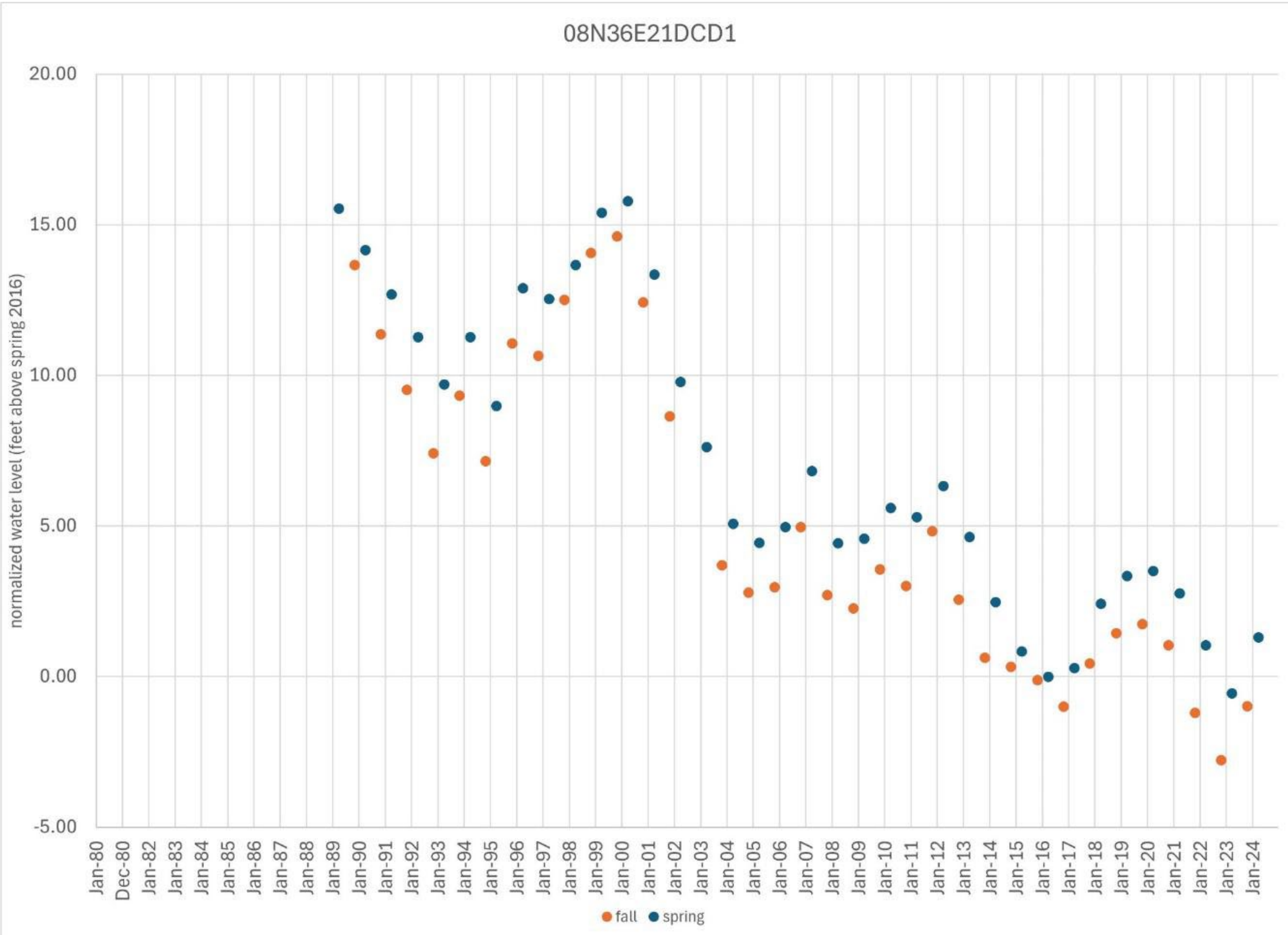
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



08N36E21DCD1
20.00
15.00
10.00
5.00
0.00
-5.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
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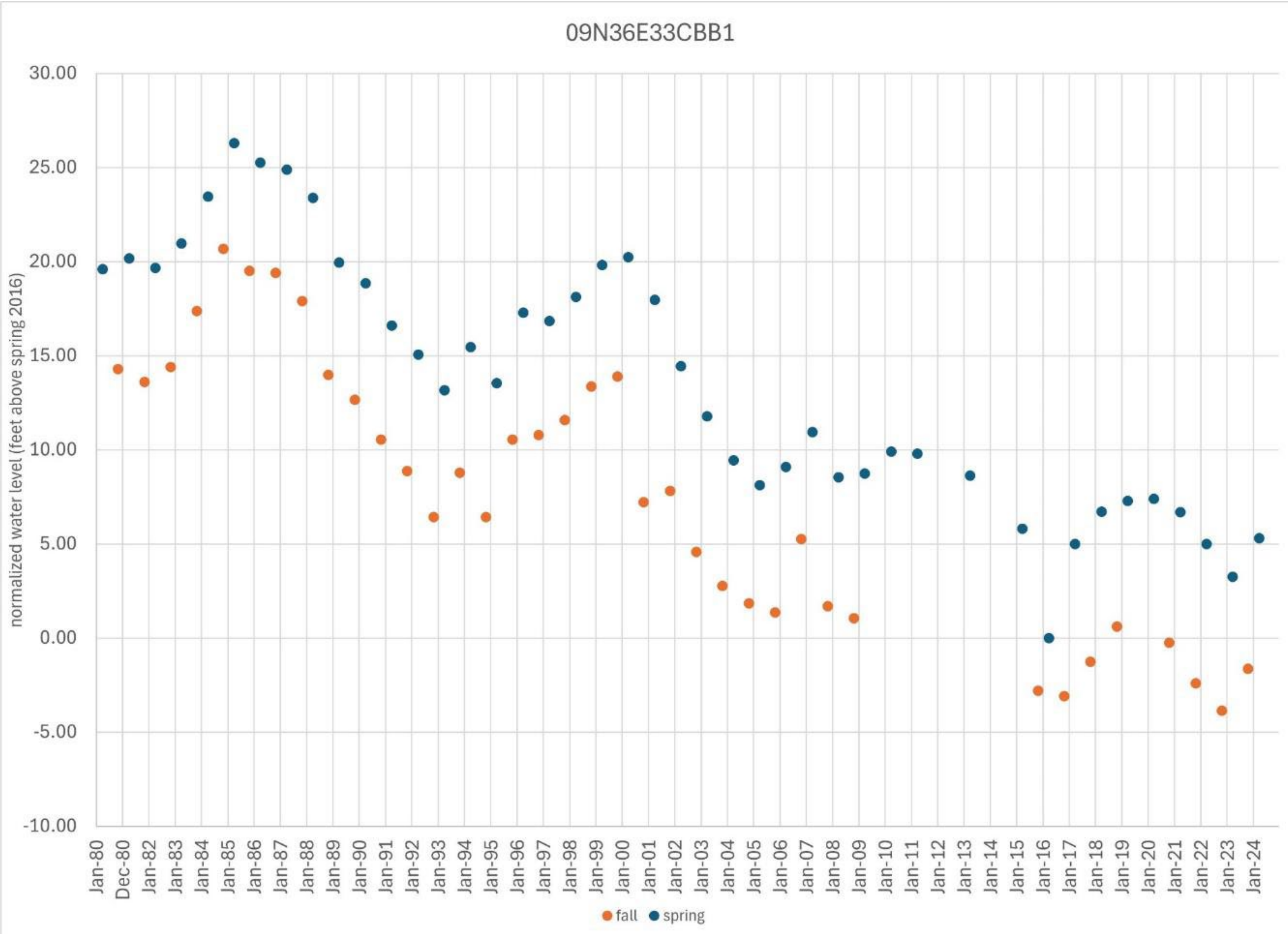
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


09N36E33CBB1
normalized water level (feet above spring 2016)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
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-10.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
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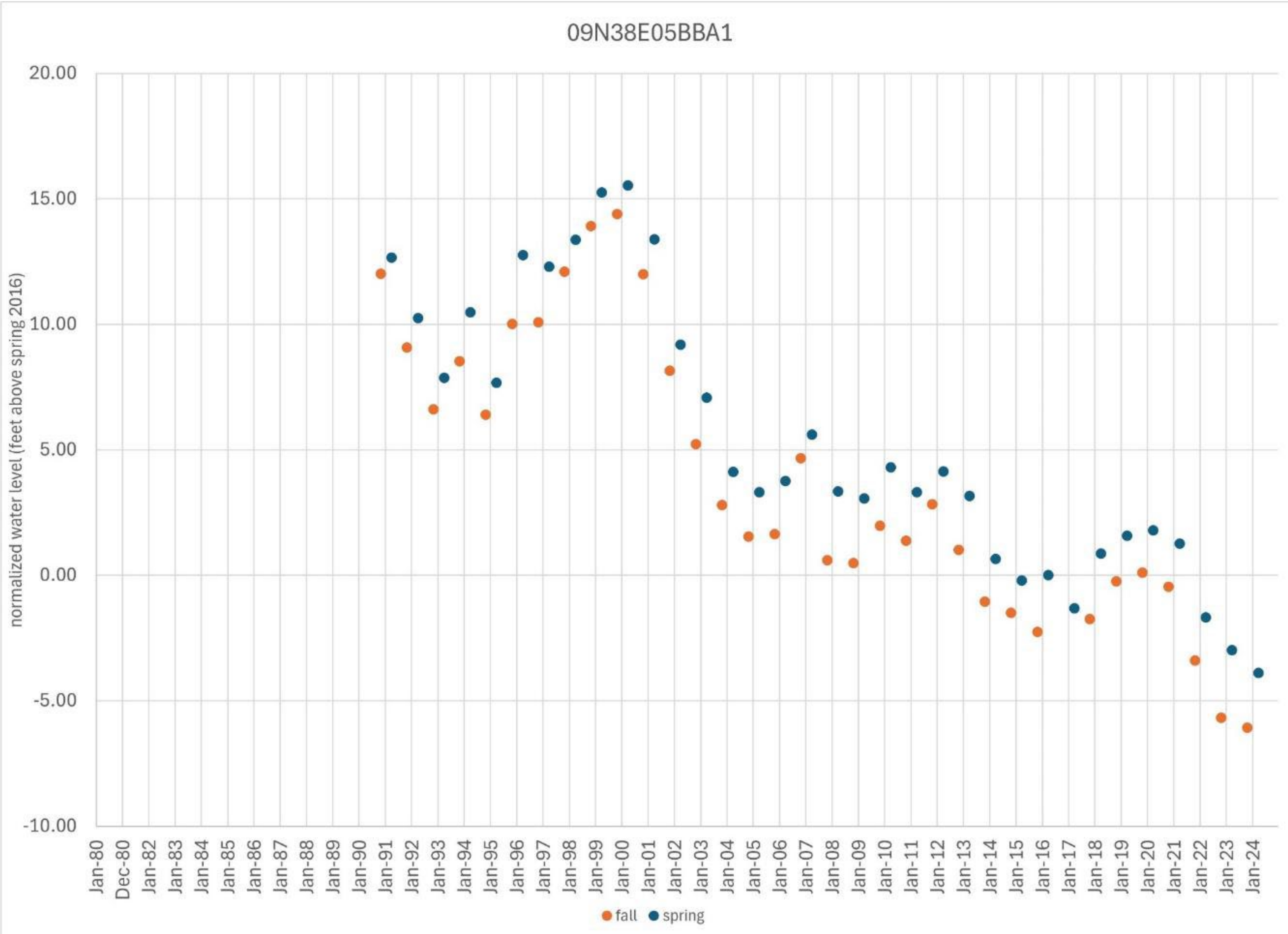
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



09N38E05BBA1
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
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Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring

01S30E15BCA1
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
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Jan-16
Jan-17
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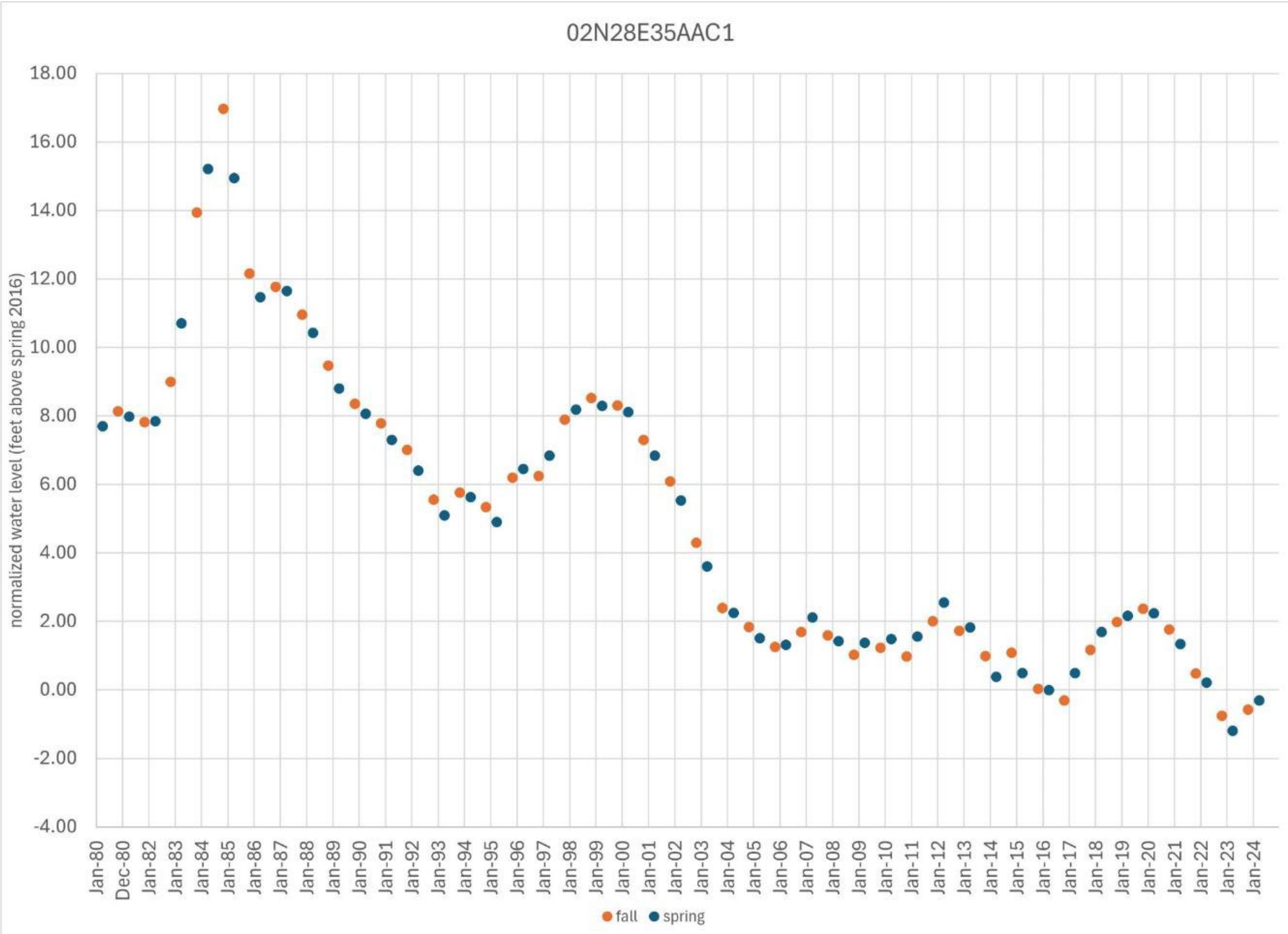
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


02N28E35AAC1
normalized water level (feet above spring 2016)
18.00
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
Jan-80
Dec-80
Jan-82
Jan-83
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Jan-15
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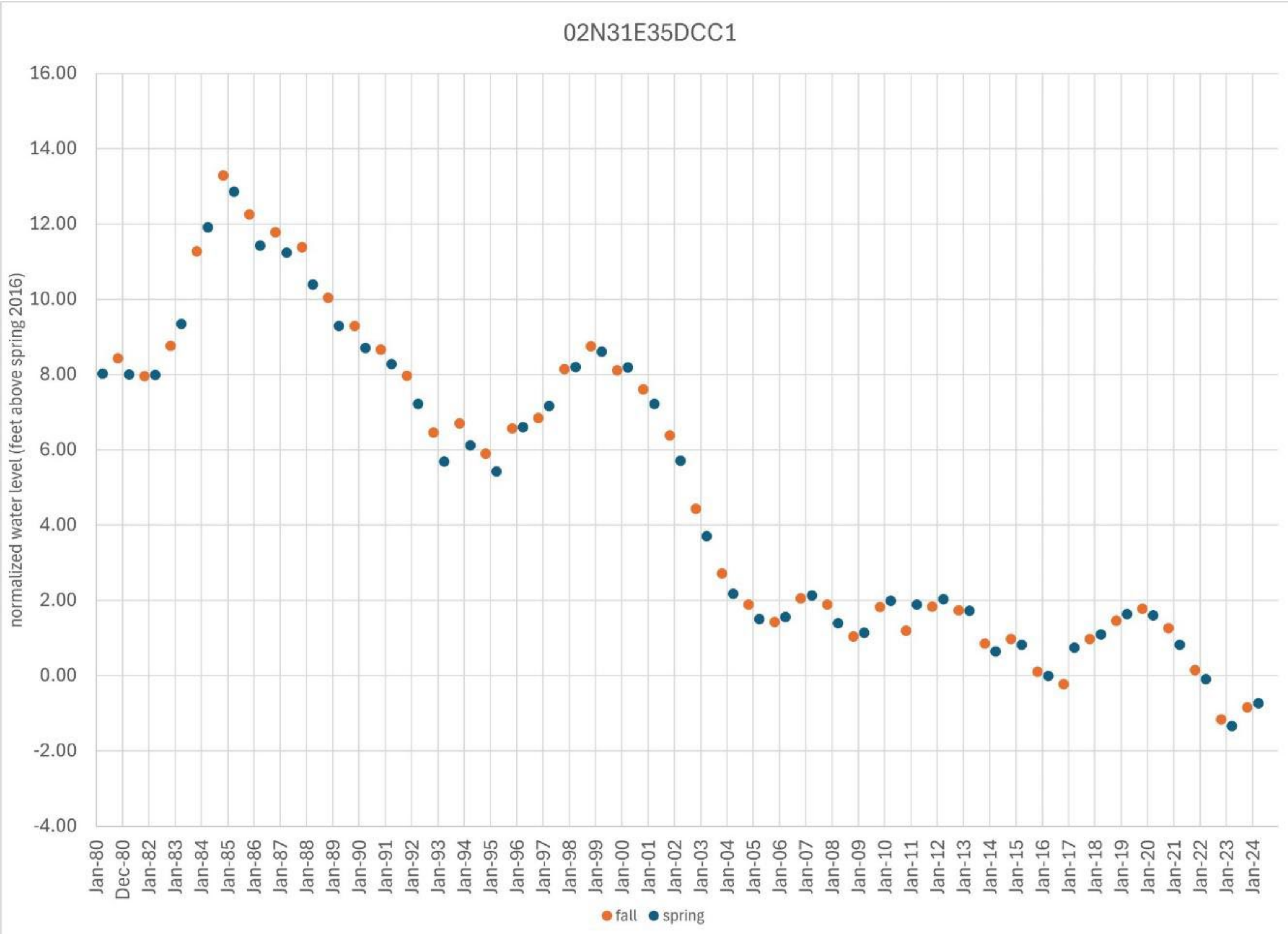
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


02N31E35DCC1
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
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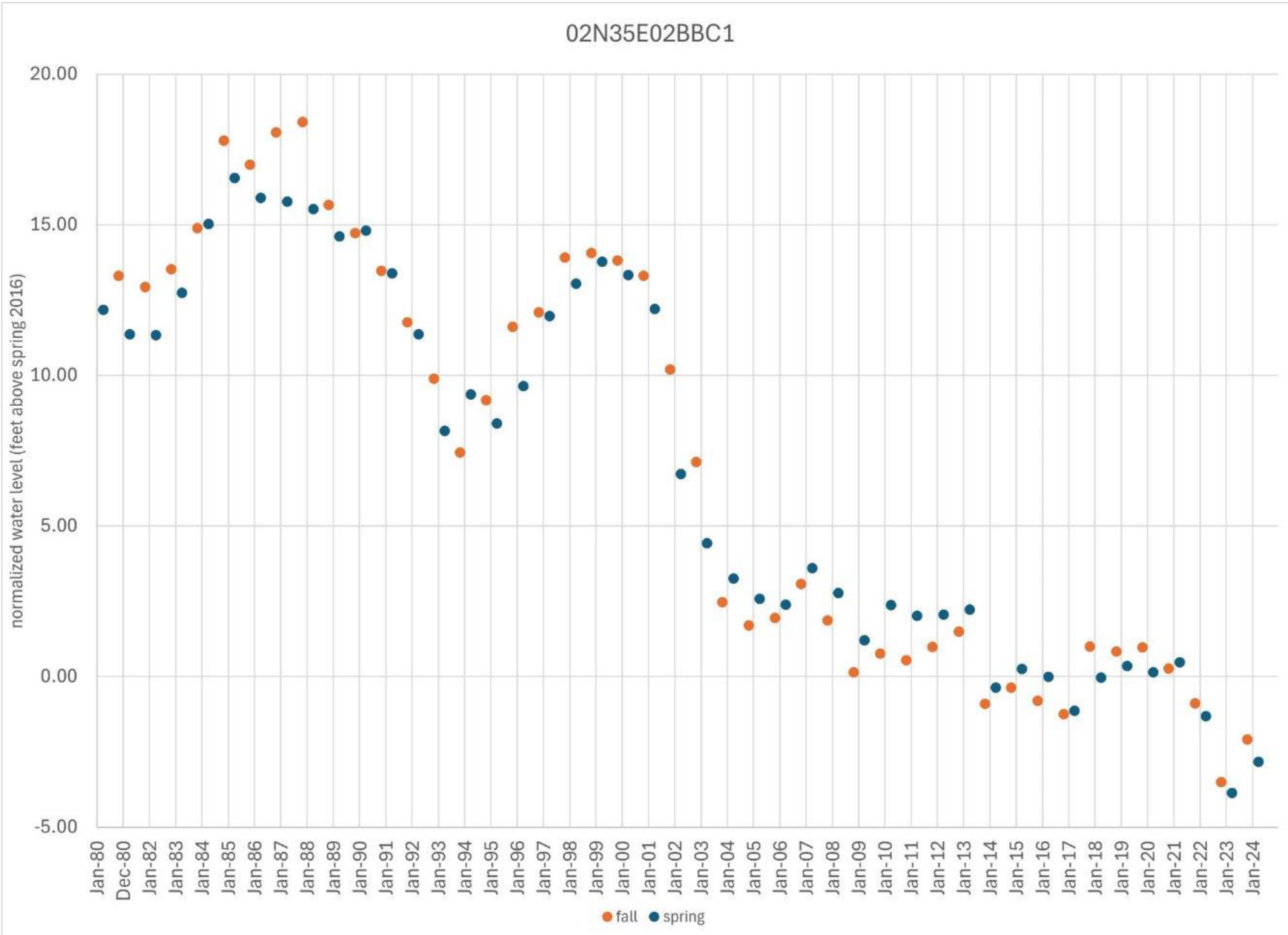
Jan-22
Jan-23
Jan-24
fall
spring


02N35E02BBC1
20.00
15.00
10.00
5.00
0.00
-5.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
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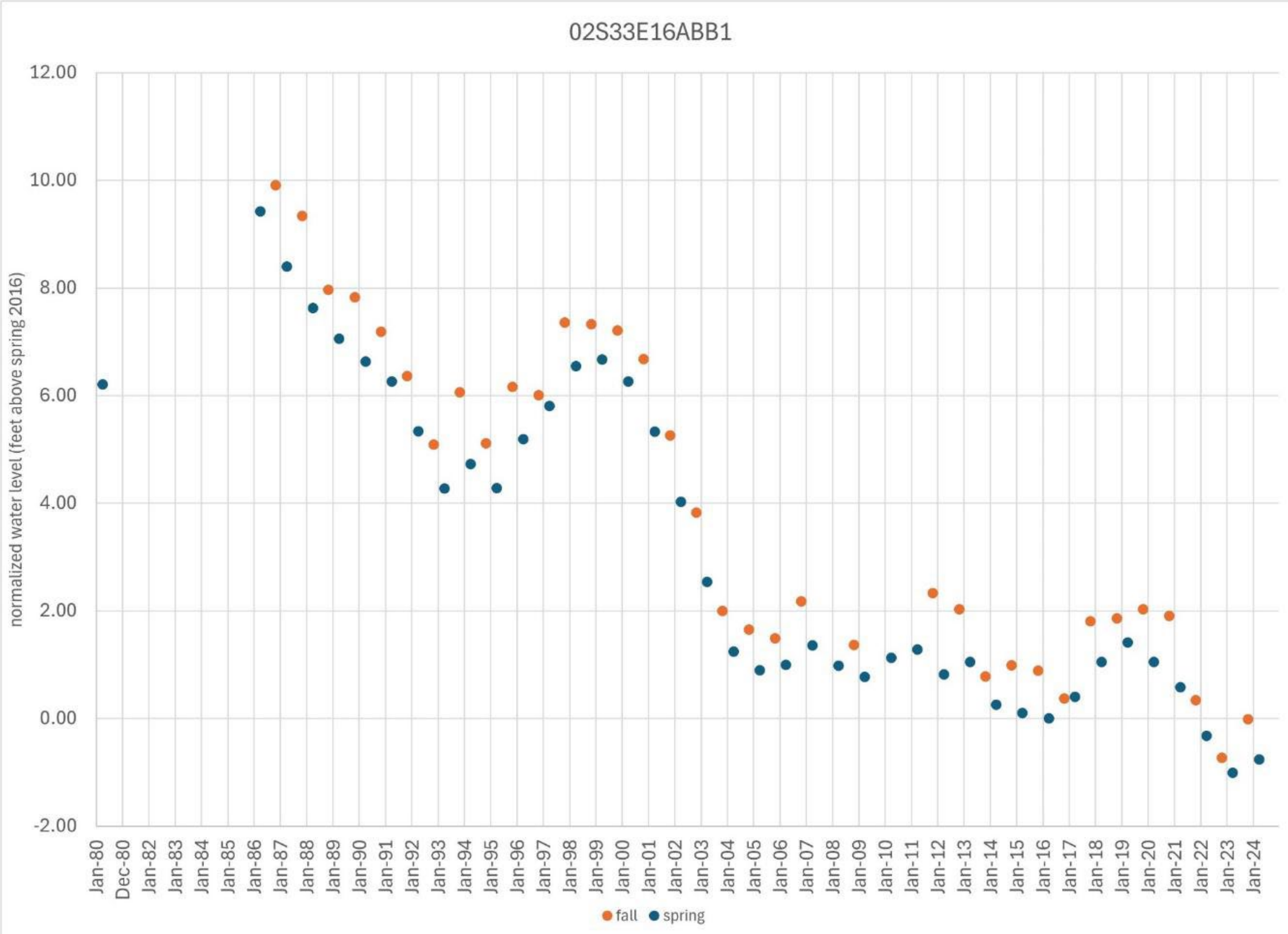
Jan-22
Jan-23
Jan-24
fall
spring



02S33E16ABB1
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
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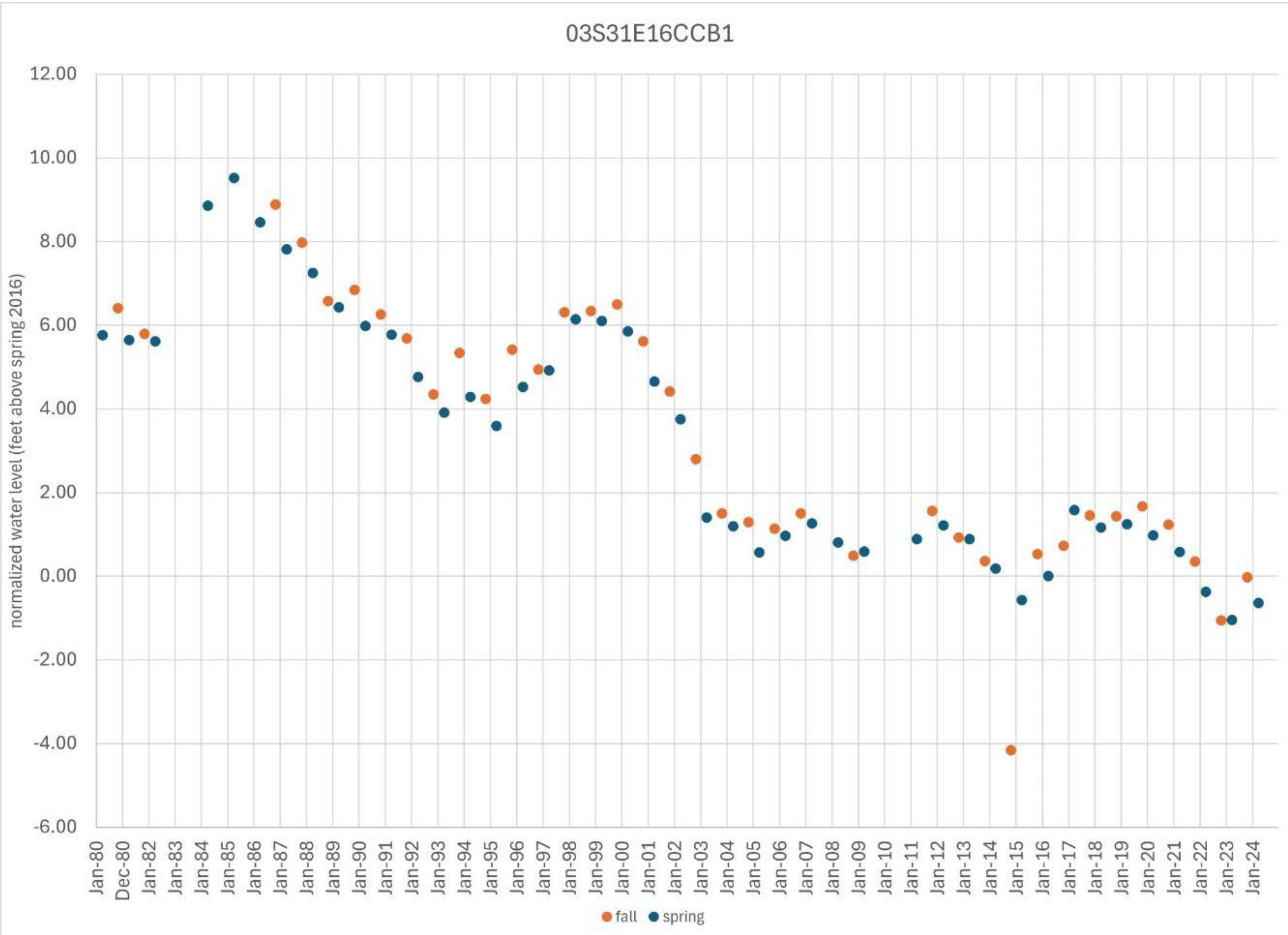
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


03S31E16CCB1
normalized water level (feet above spring 2016)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
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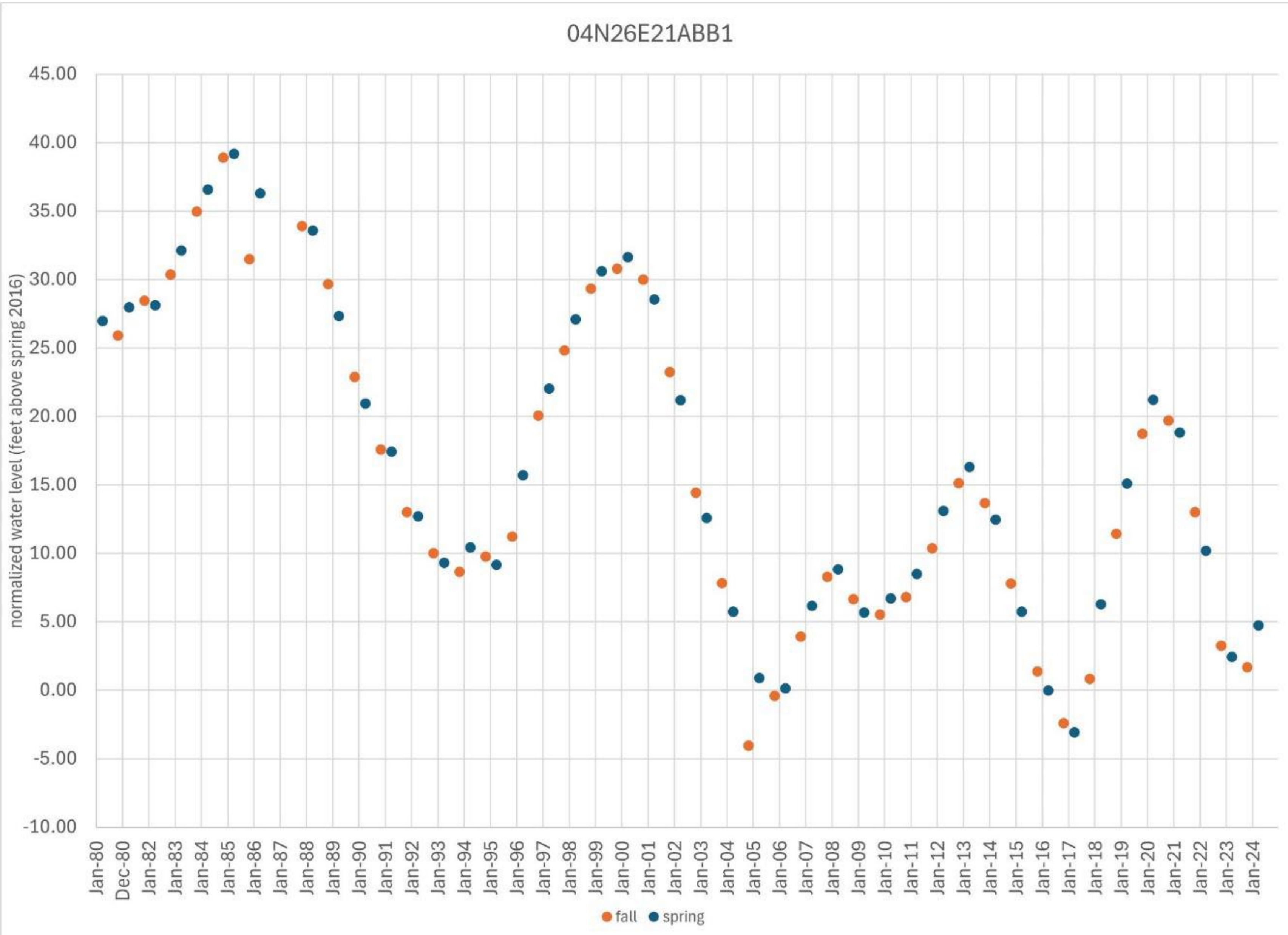
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


04N26E21ABB1
normalized water level (feet above spring 2016)
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
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Jan-00
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Jan-02
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Jan-15
Jan-16
Jan-17
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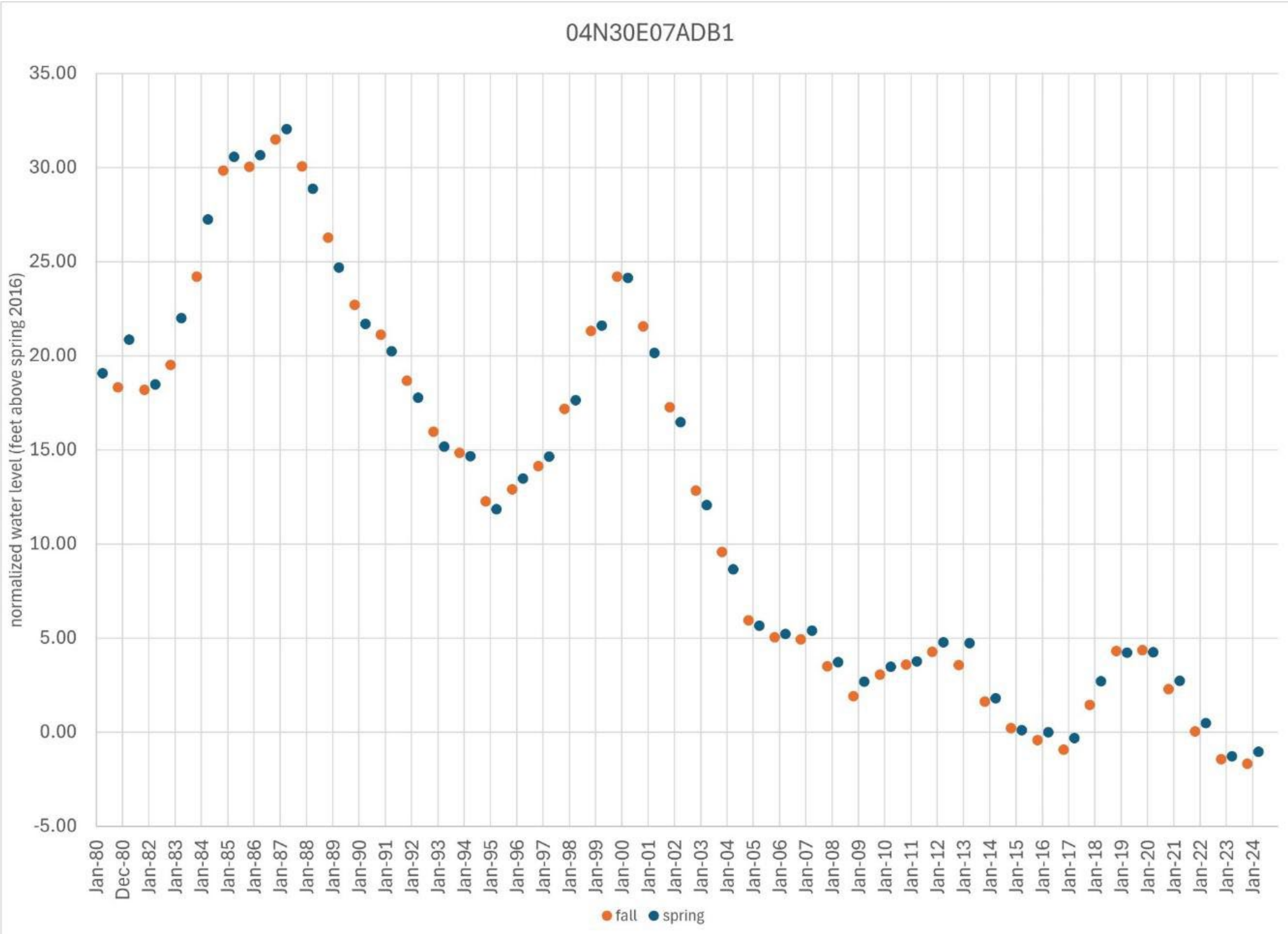
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


04N30E07ADB1
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30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
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Jan-89
Jan-90
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Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
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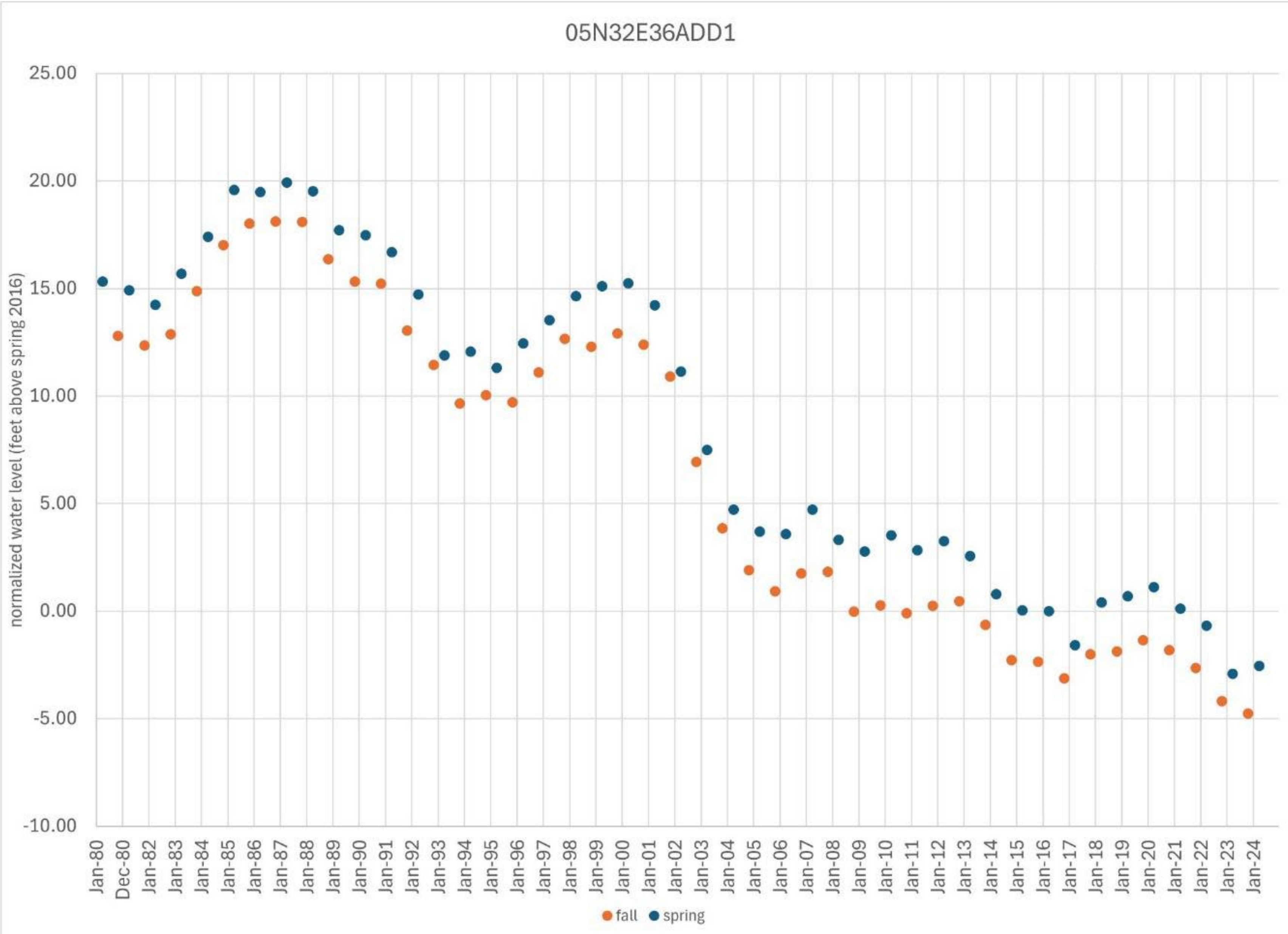
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


05N32E36ADD1
normalized water level (feet above spring 2016)
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
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Jan-89
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Jan-16
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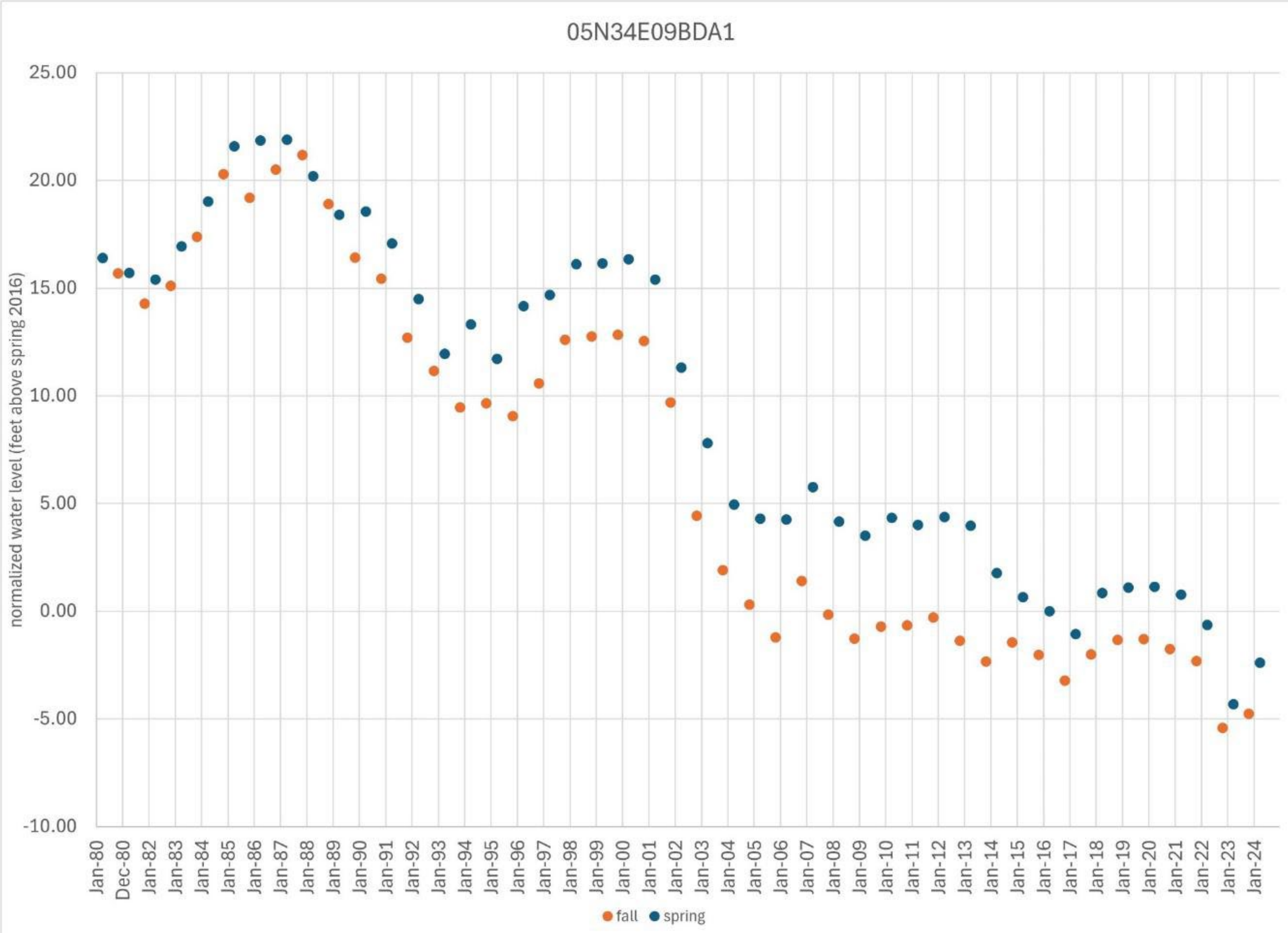
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


05N34E09BDA1
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
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Jan-19
Jan-20
Jan-21
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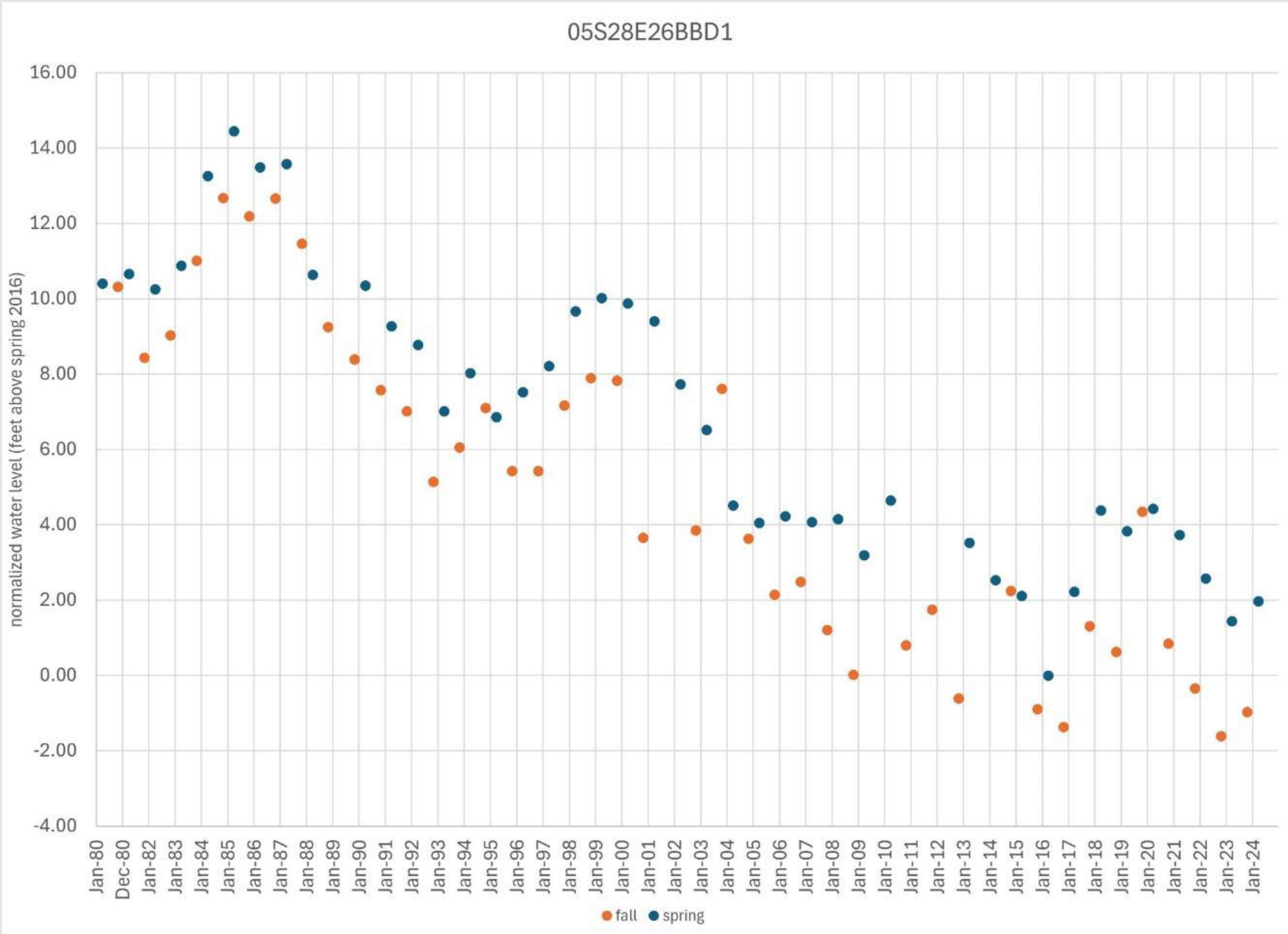
Jan-23
Jan-24
fall
spring


05S28E26BBD1
normalized water level (feet above spring 2016)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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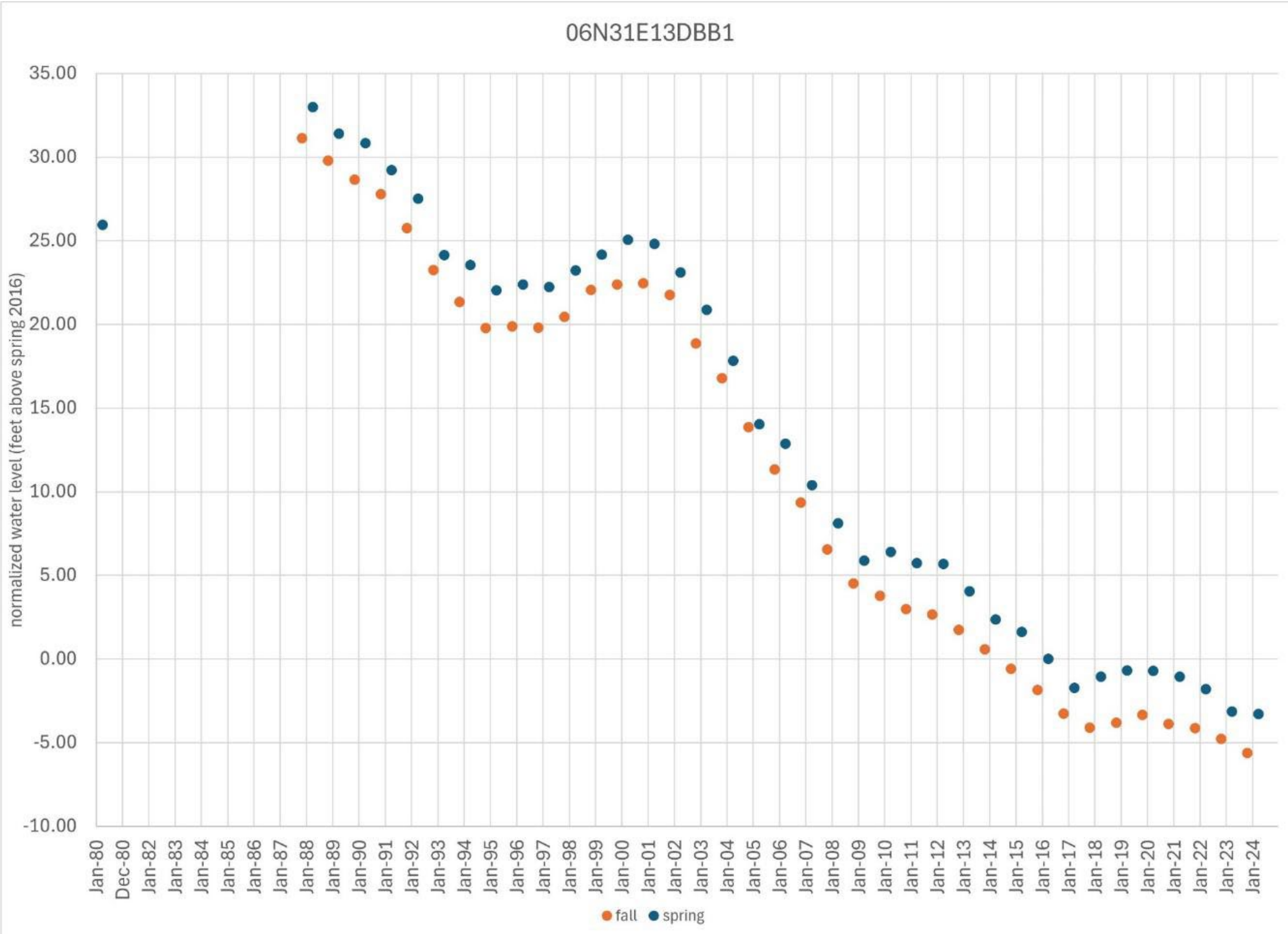
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


06N31E13DBB1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
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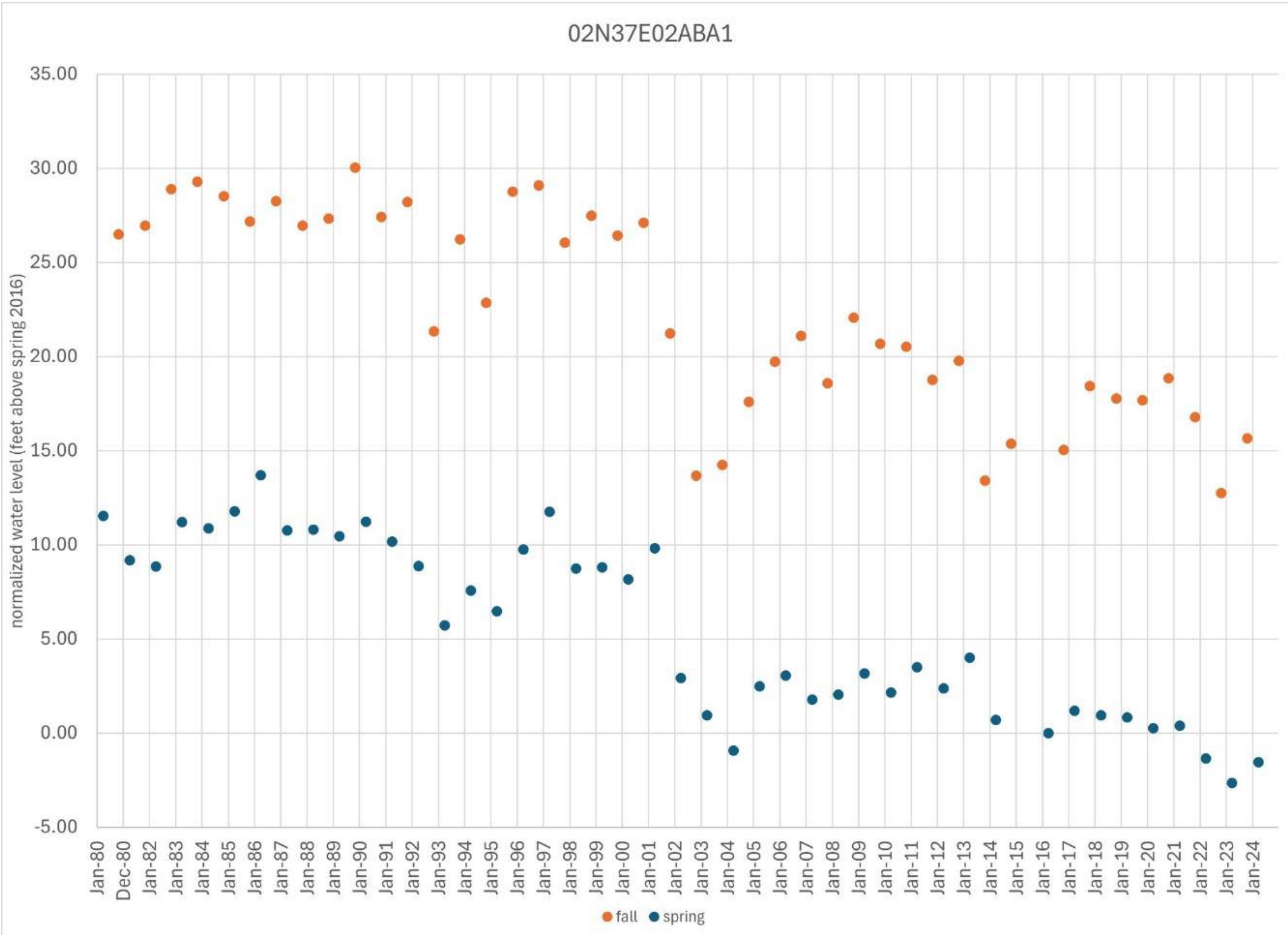
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


02N37E02ABA1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
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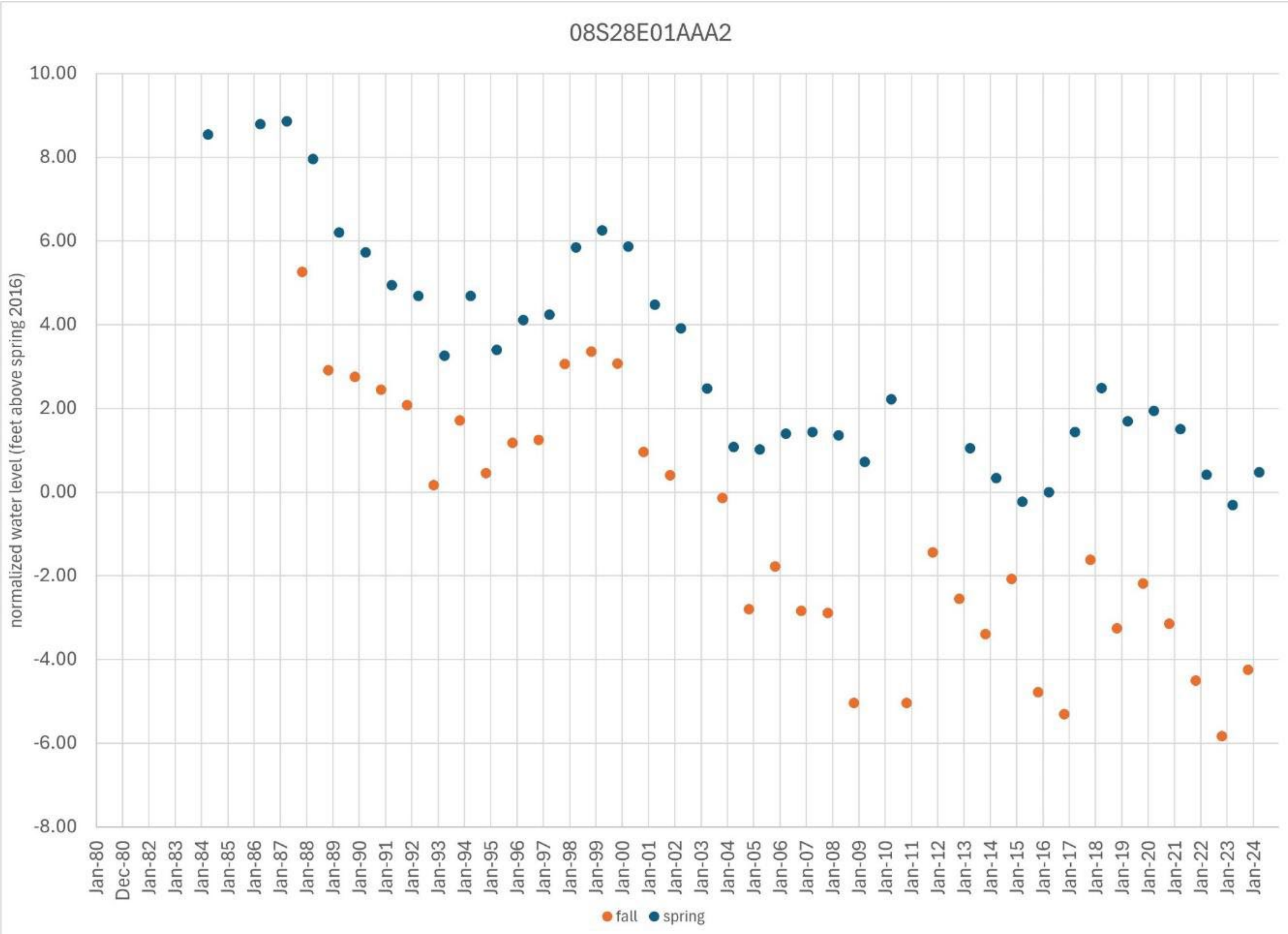
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



08S28E01AAA2
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
-4.00
-6.00
-8.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
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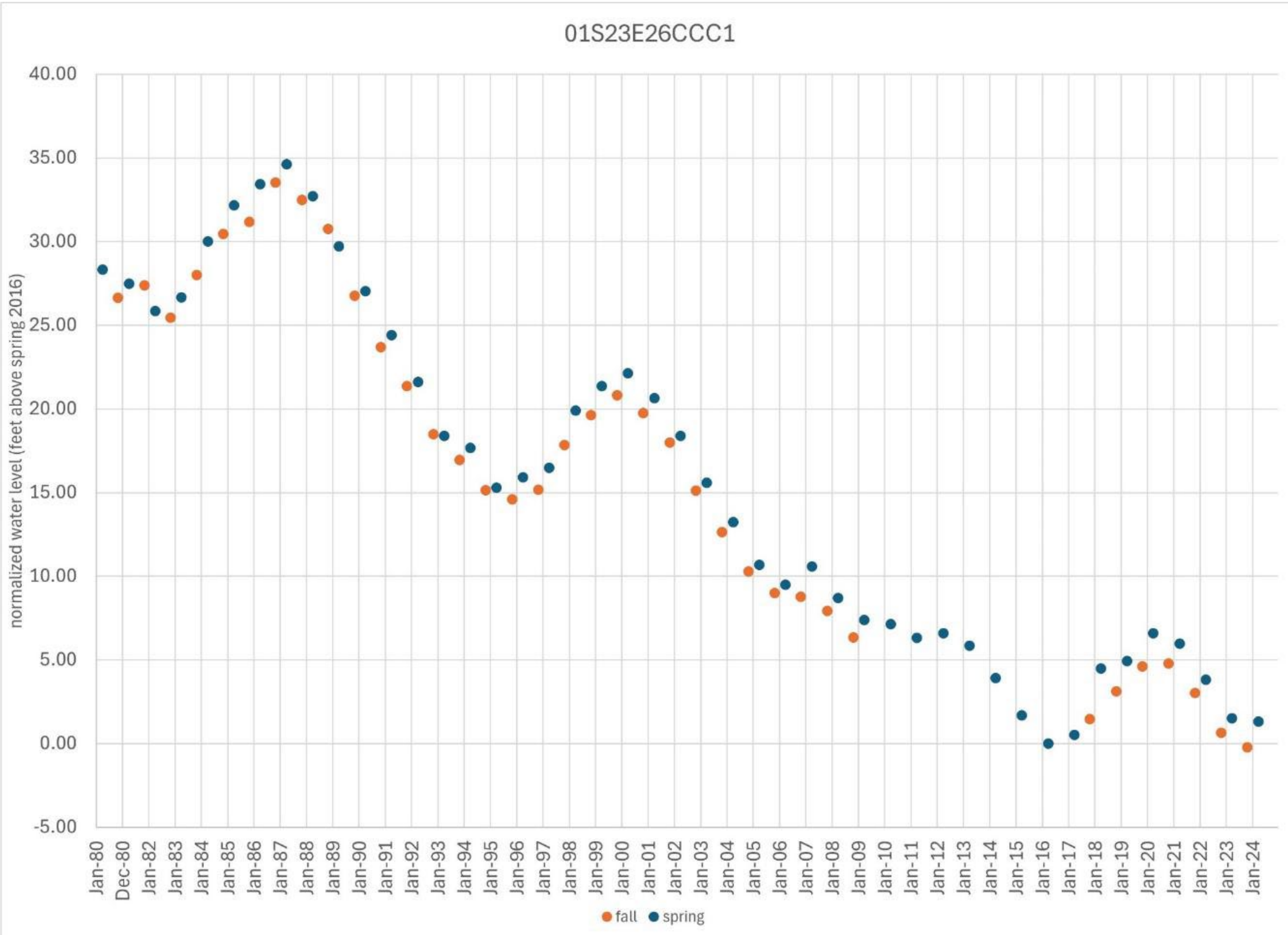
Jan-23
Jan-24
fall
spring


01S23E26CCC1
normalized water level (feet above spring 2016)
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
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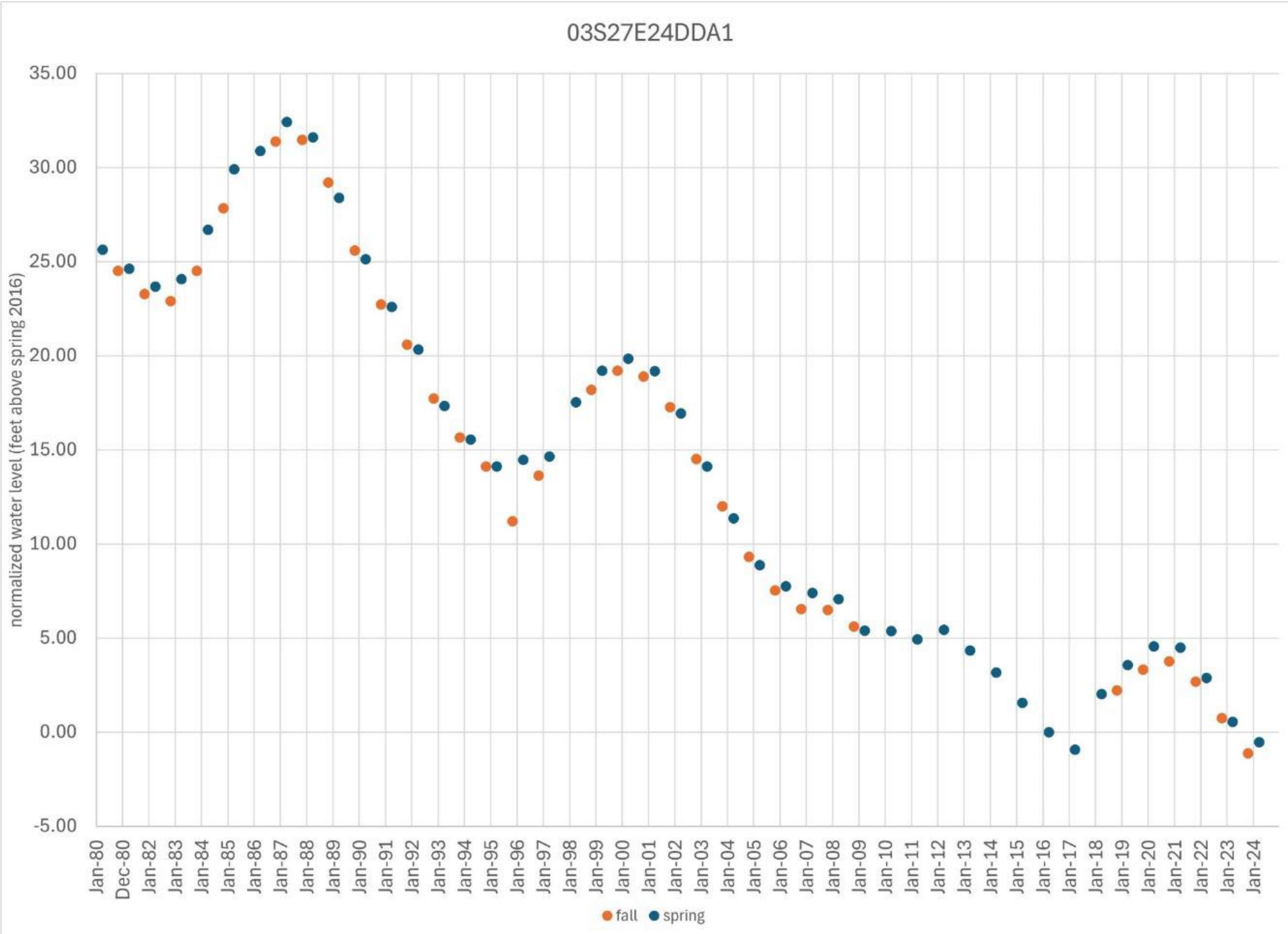
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


03S27E24DDA1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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Jan-15
Jan-16
Jan-17
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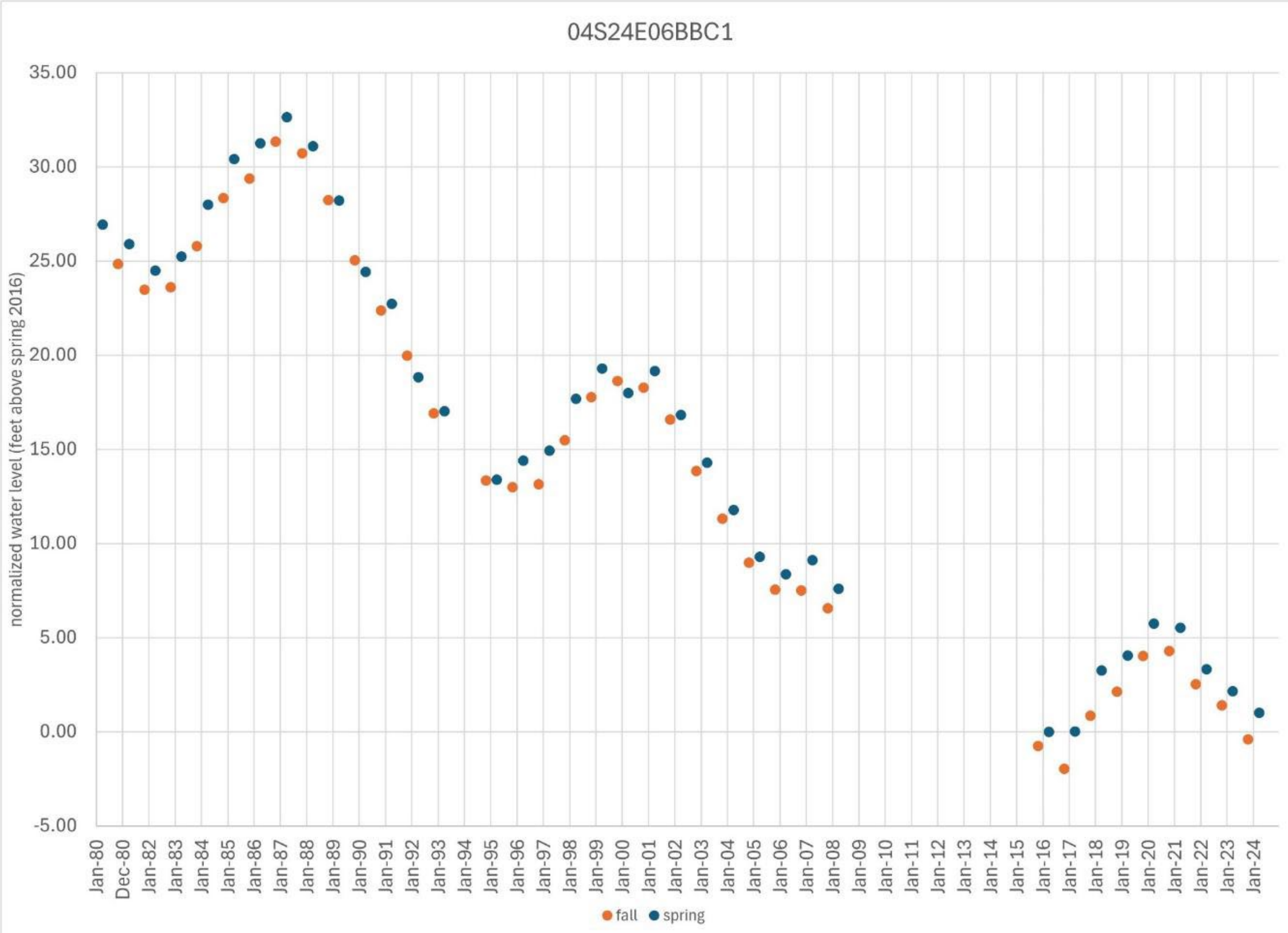
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


04S24E06BBC1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
Jan-05
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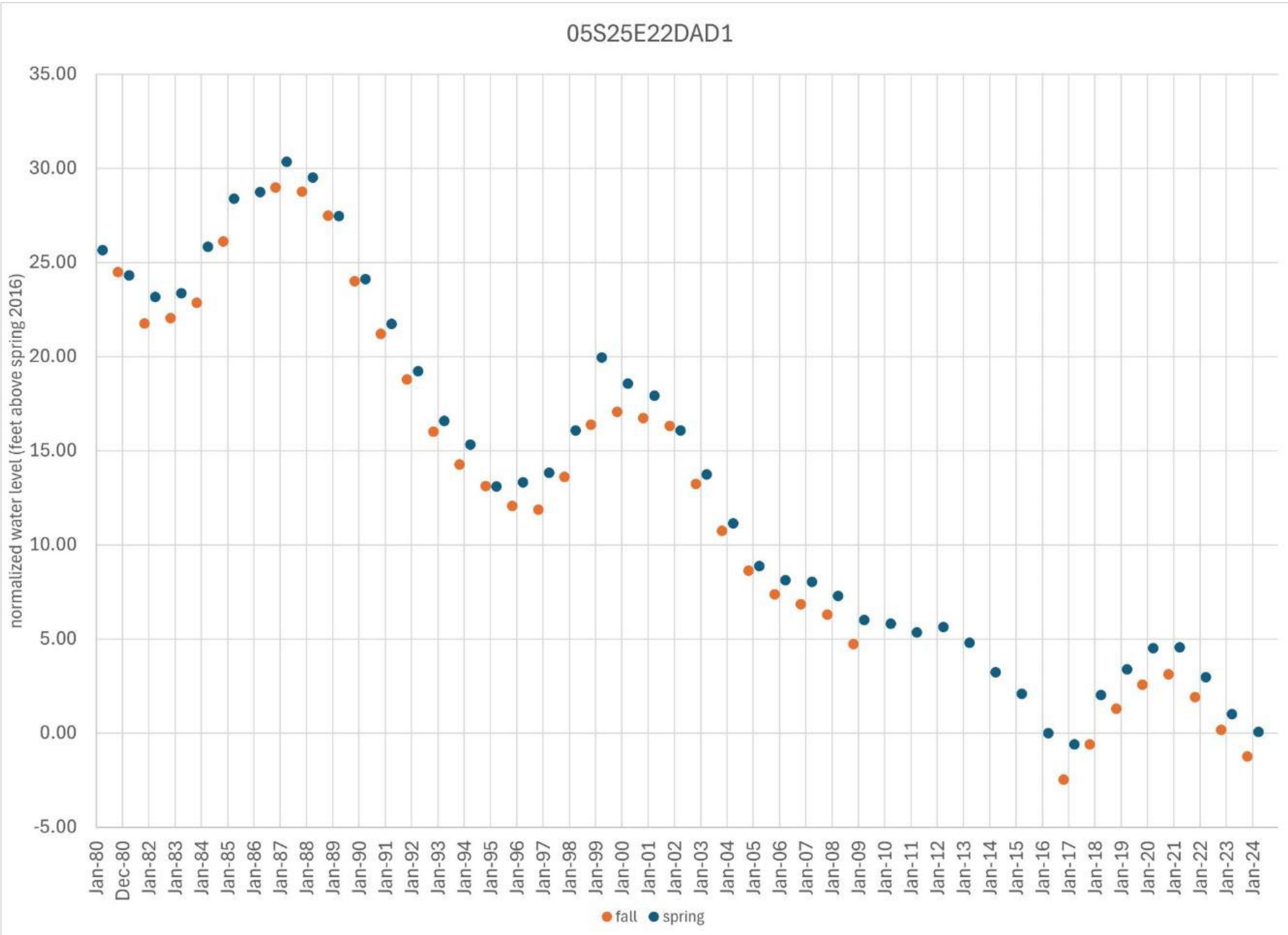
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



05S25E22DAD1
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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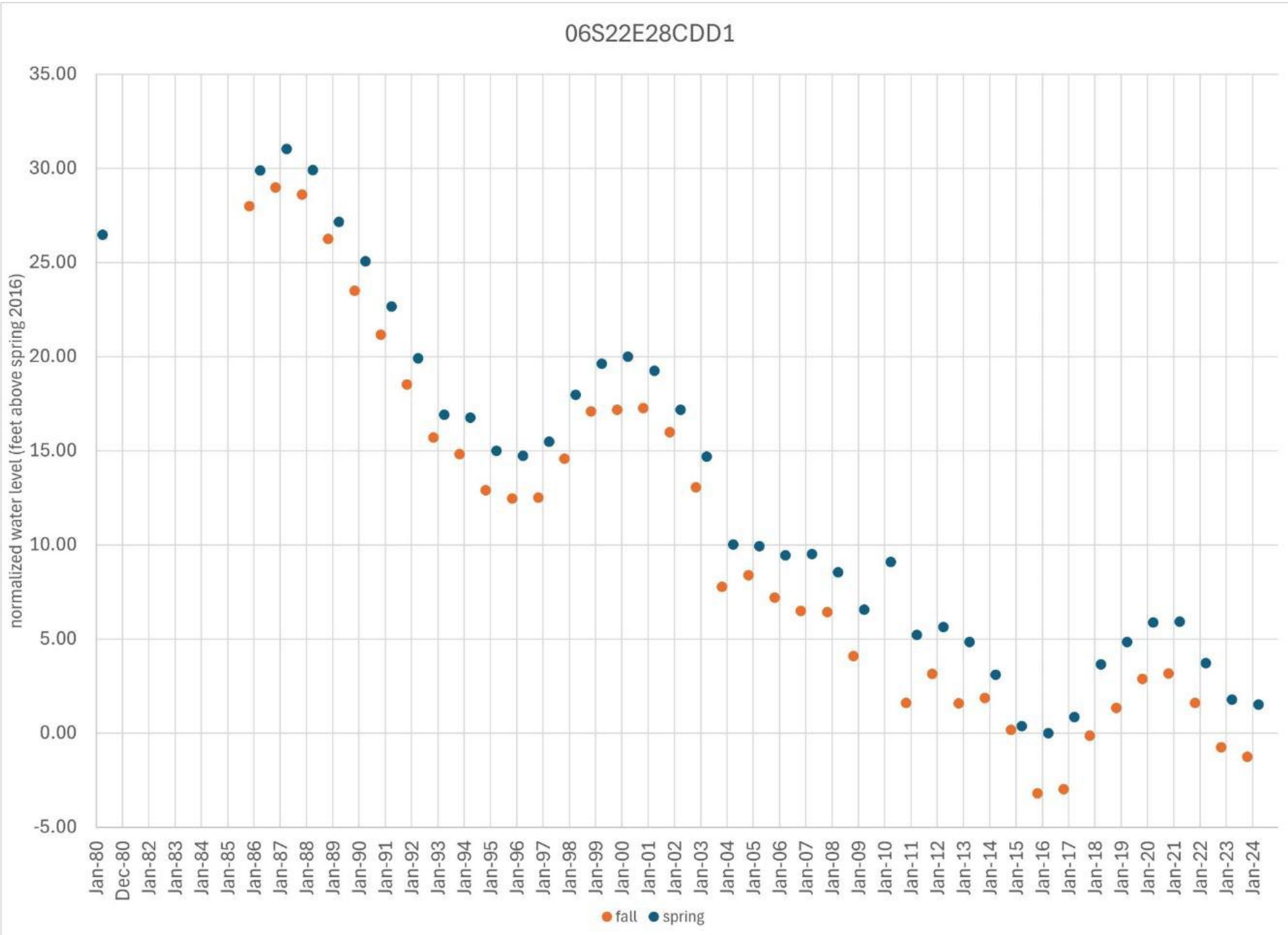
Jan-11
Jan-12
Jan-13
Jan-14
Jan-15
Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


06S22E28CDD1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
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Jan-89
Jan-90
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Jan-94
Jan-95
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Jan-11
Jan-12
Jan-13
Jan-14
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Jan-16
Jan-17
Jan-18
Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


07S26E14CCC1
normalized water level (feet above spring 2016)
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
Jan-87
Jan-88
Jan-89
Jan-90
Jan-91
Jan-92
Jan-93
Jan-94
Jan-95
Jan-96
Jan-97
Jan-98
Jan-99
Jan-00
Jan-01
Jan-02
Jan-03
Jan-04
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Jan-06
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Jan-15
Jan-16
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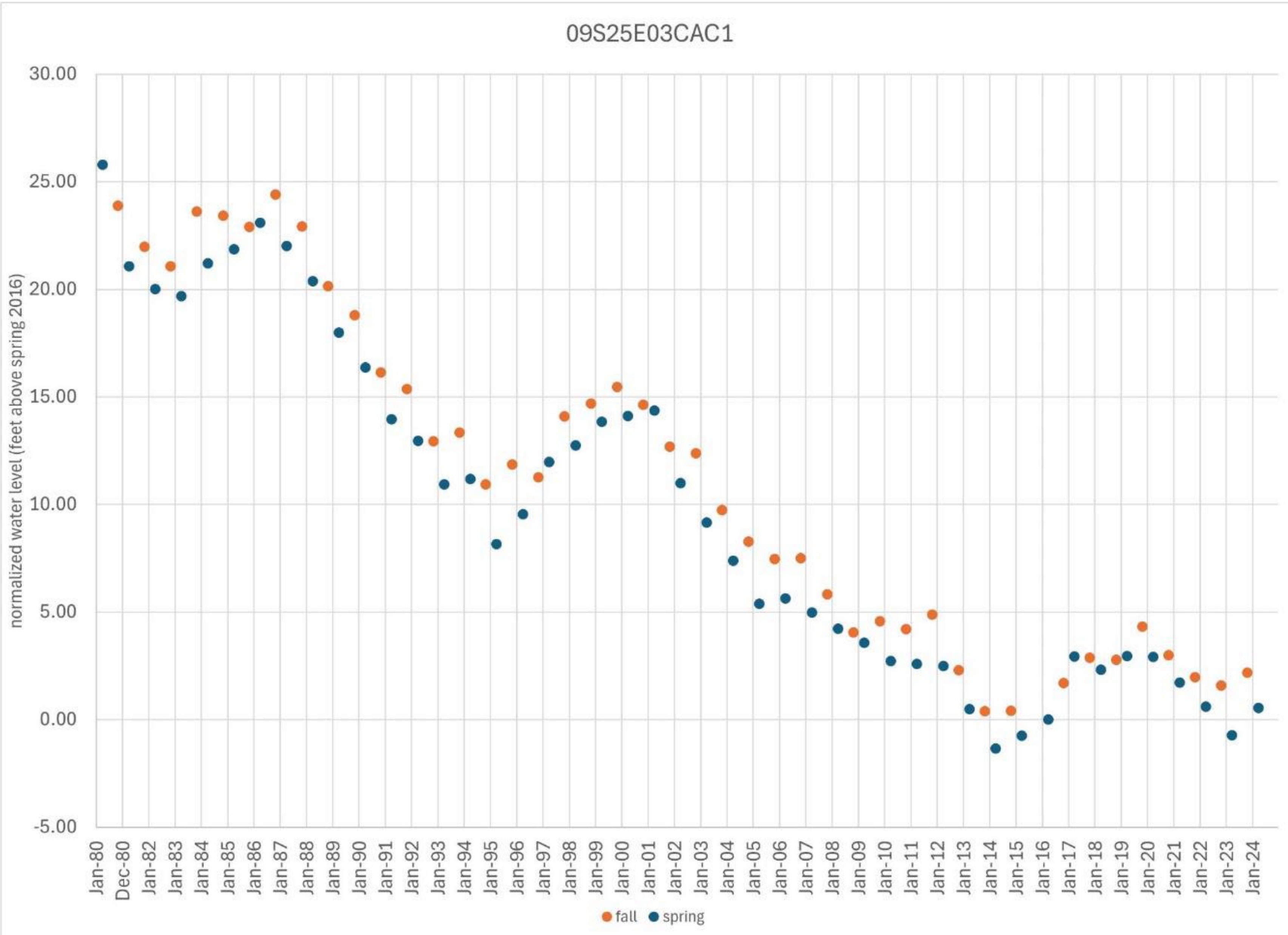
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring



09S25E03CAC1
normalized water level (feet above spring 2016)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
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Jan-89
Jan-90
Jan-91
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Jan-16
Jan-17
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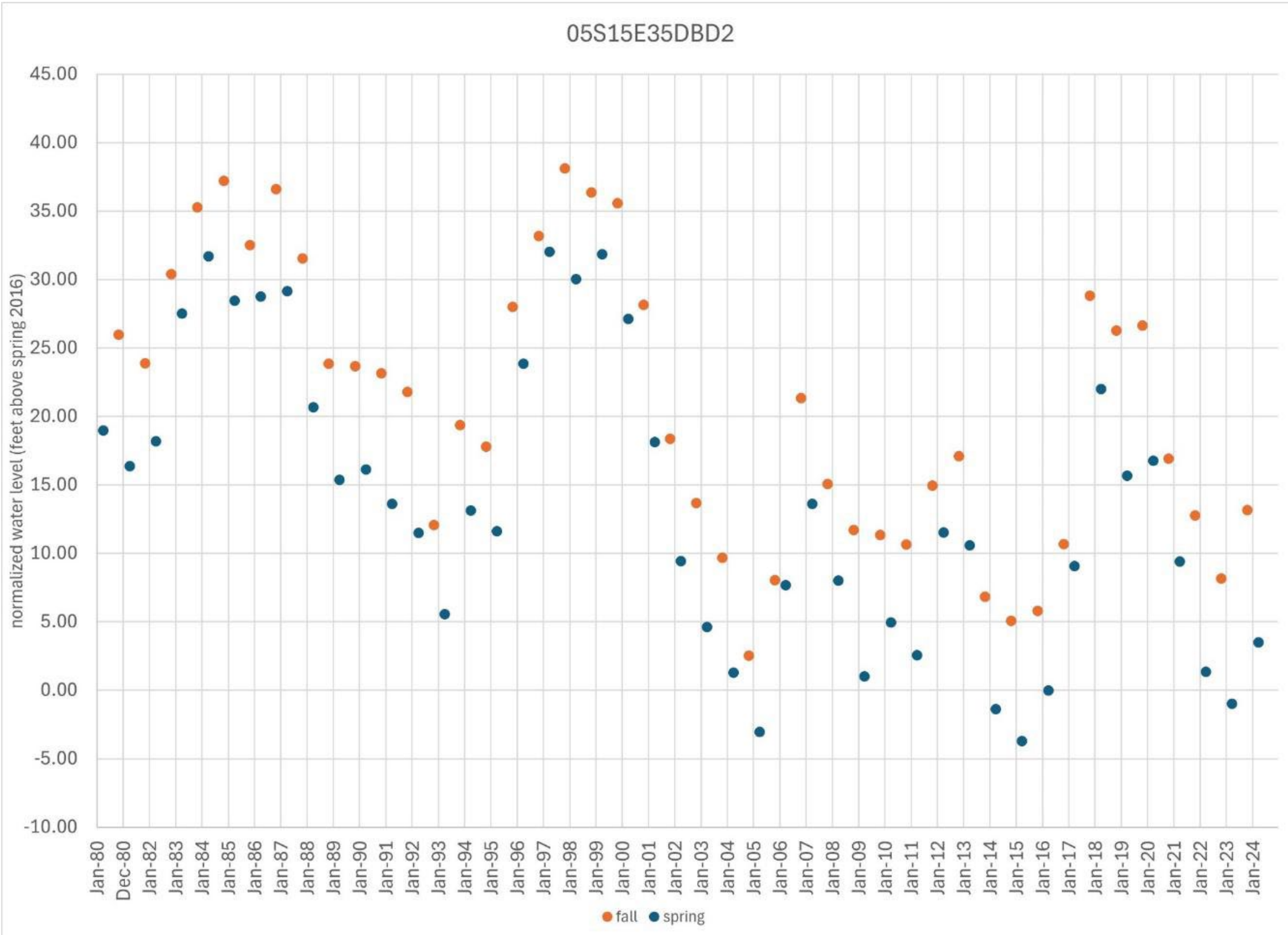
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring


05S15E35DBD2
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
-10.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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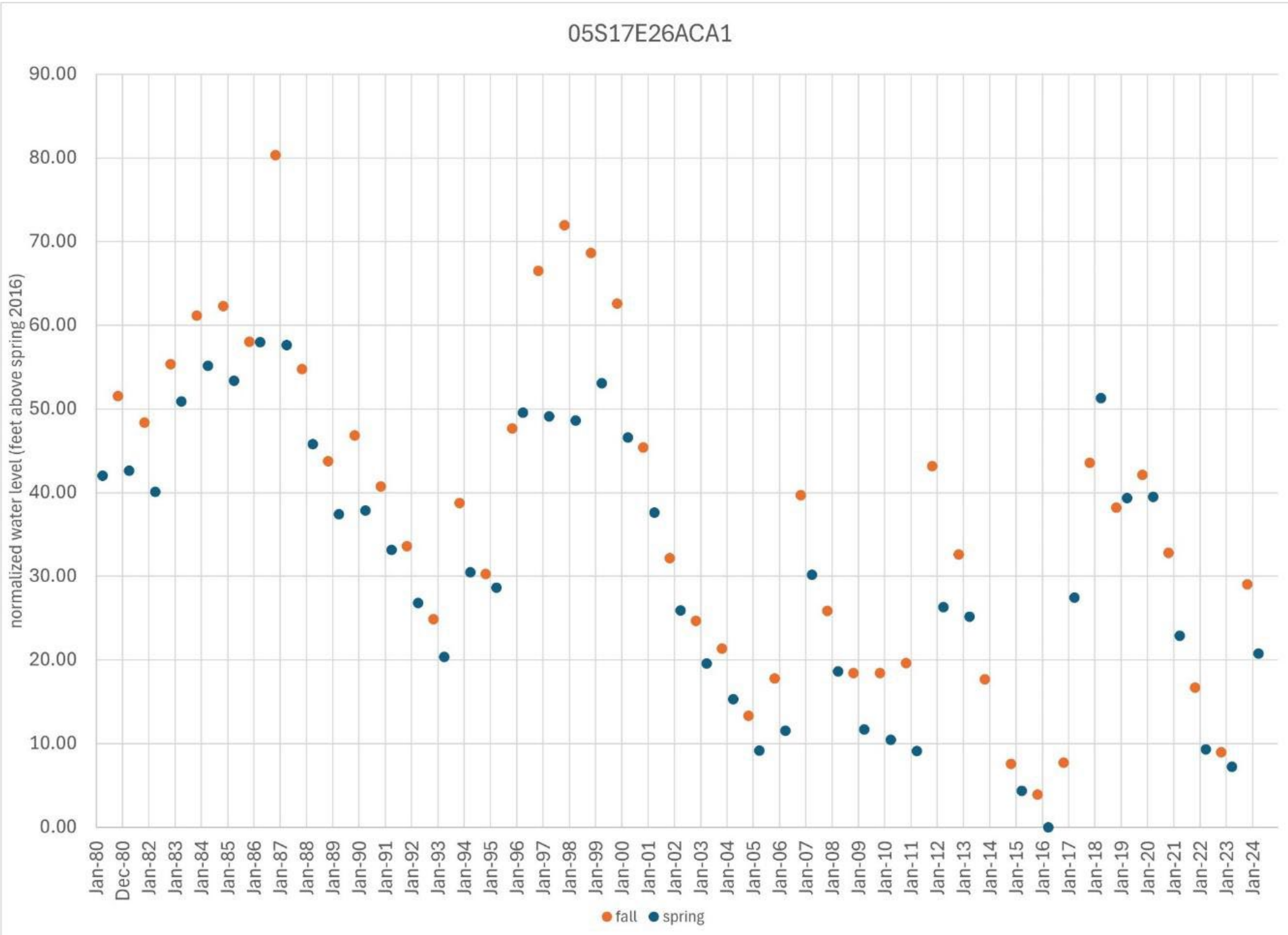
Jan-22
Jan-23
Jan-24
fall
spring


05S17E26ACA1
normalized water level (feet above spring 2016)
90.00
80.00
70.00
60.00
50.00
40.00
30.00
20.00
10.00
0.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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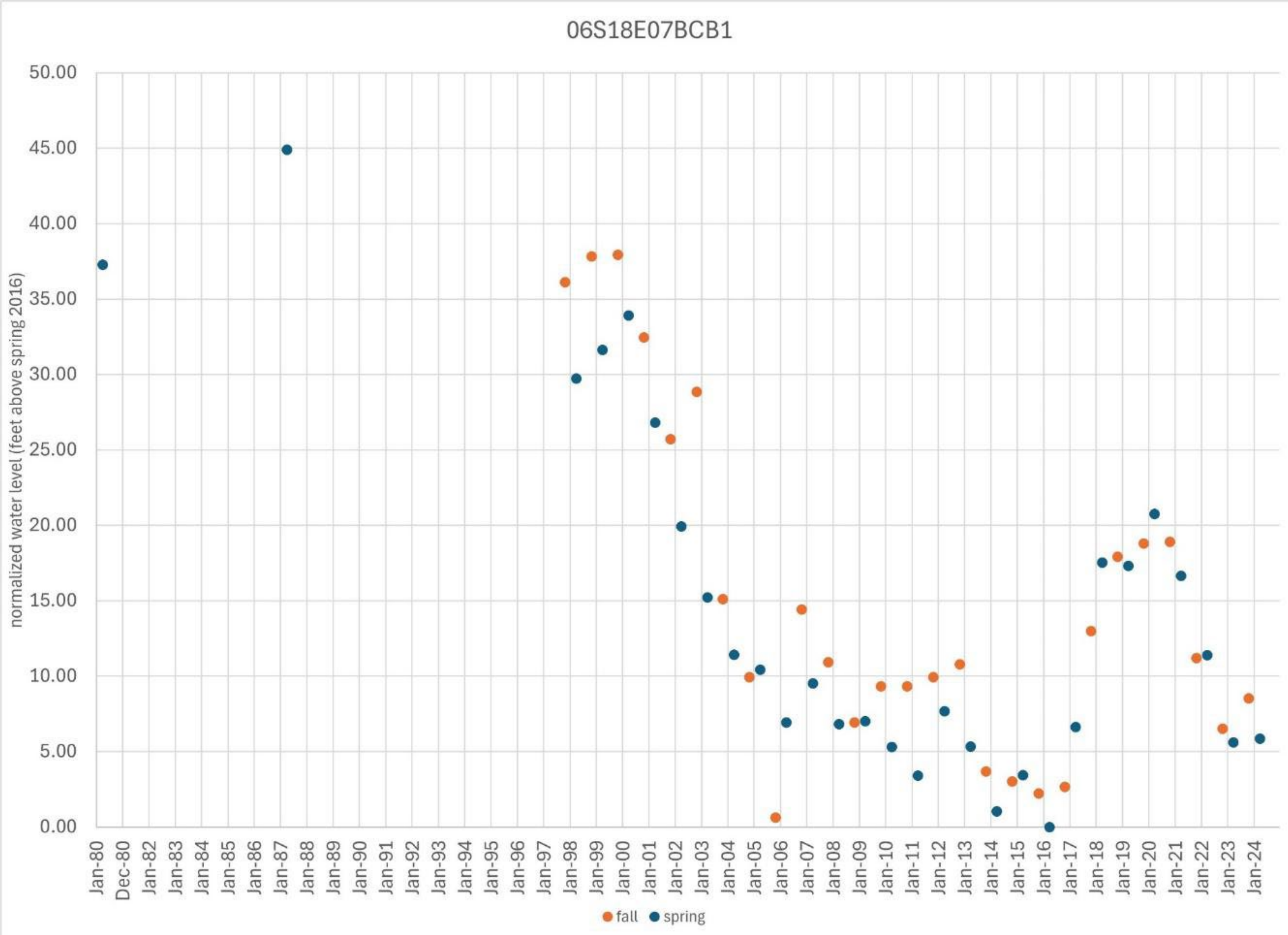
Jan-22
Jan-23
Jan-24
fall
spring


06S18E07BCB1
normalized water level (feet above spring 2016)
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
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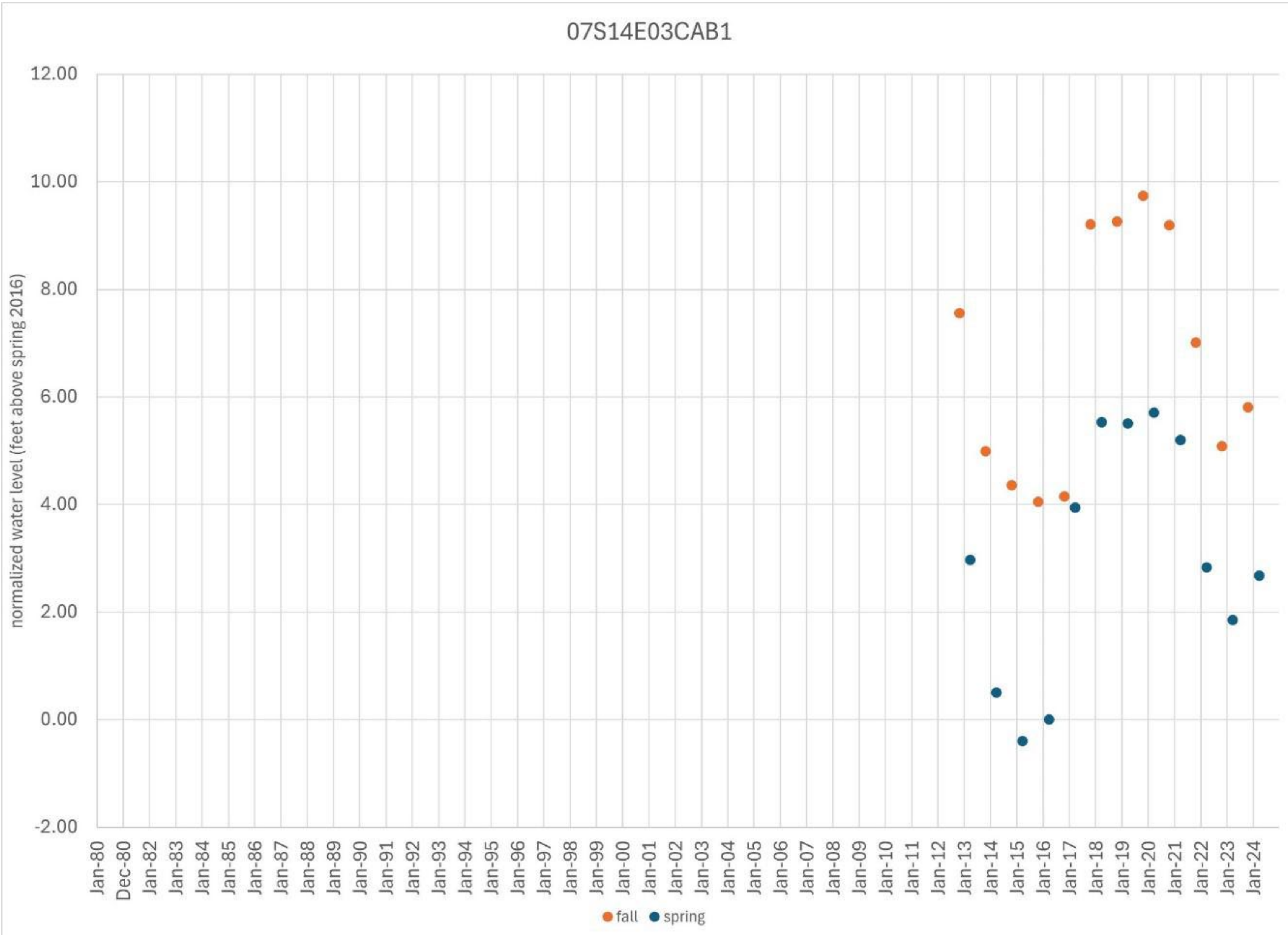
Jan-23
Jan-24
fall
spring


07S14E03CAB1
normalized water level (feet above spring 2016)
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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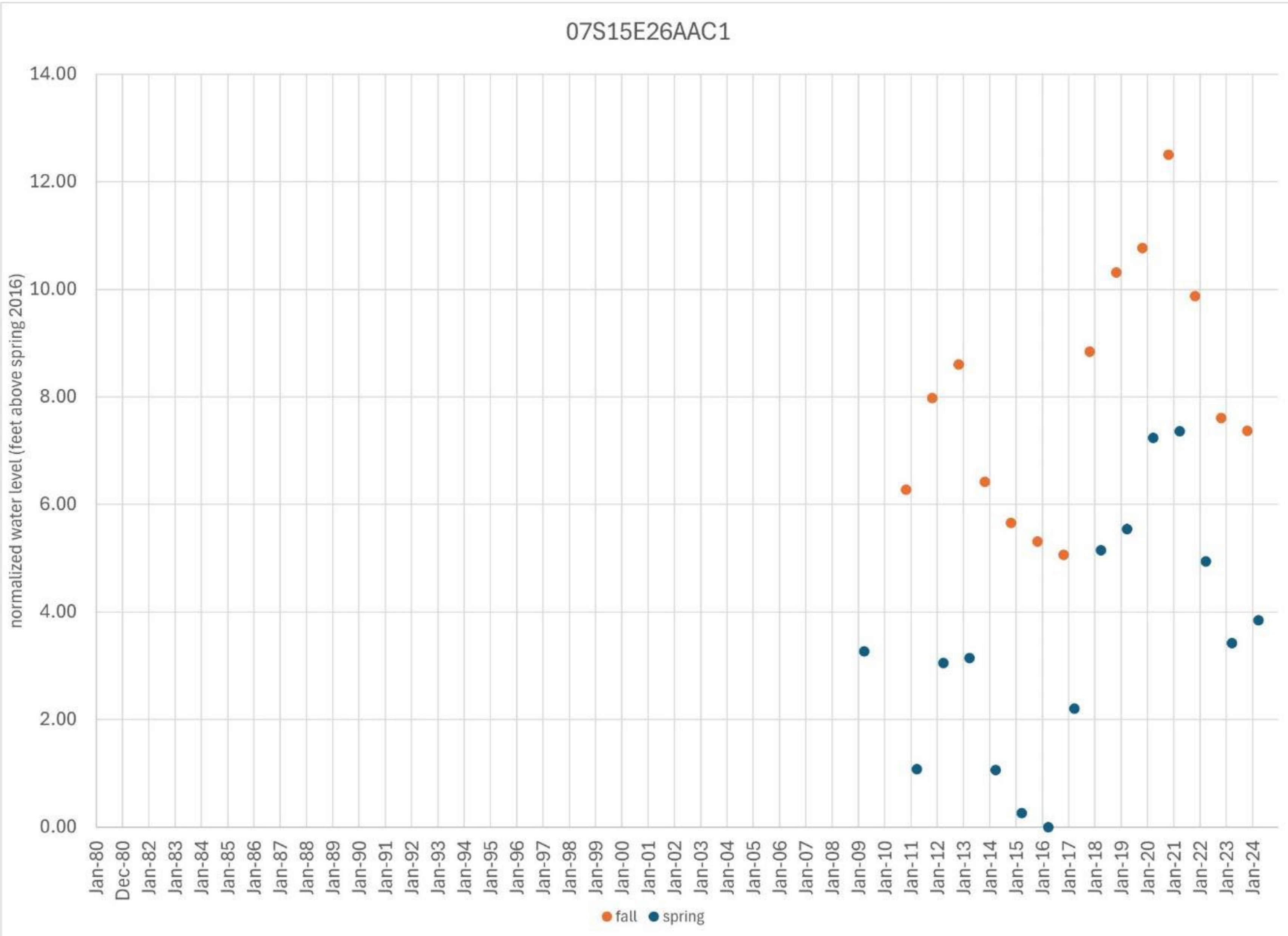
Jan-24
fall
spring



07S15E26AAC1
normalized water level (feet above spring 2016)
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
Jan-80
Dec-80
Jan-82
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Jan-22
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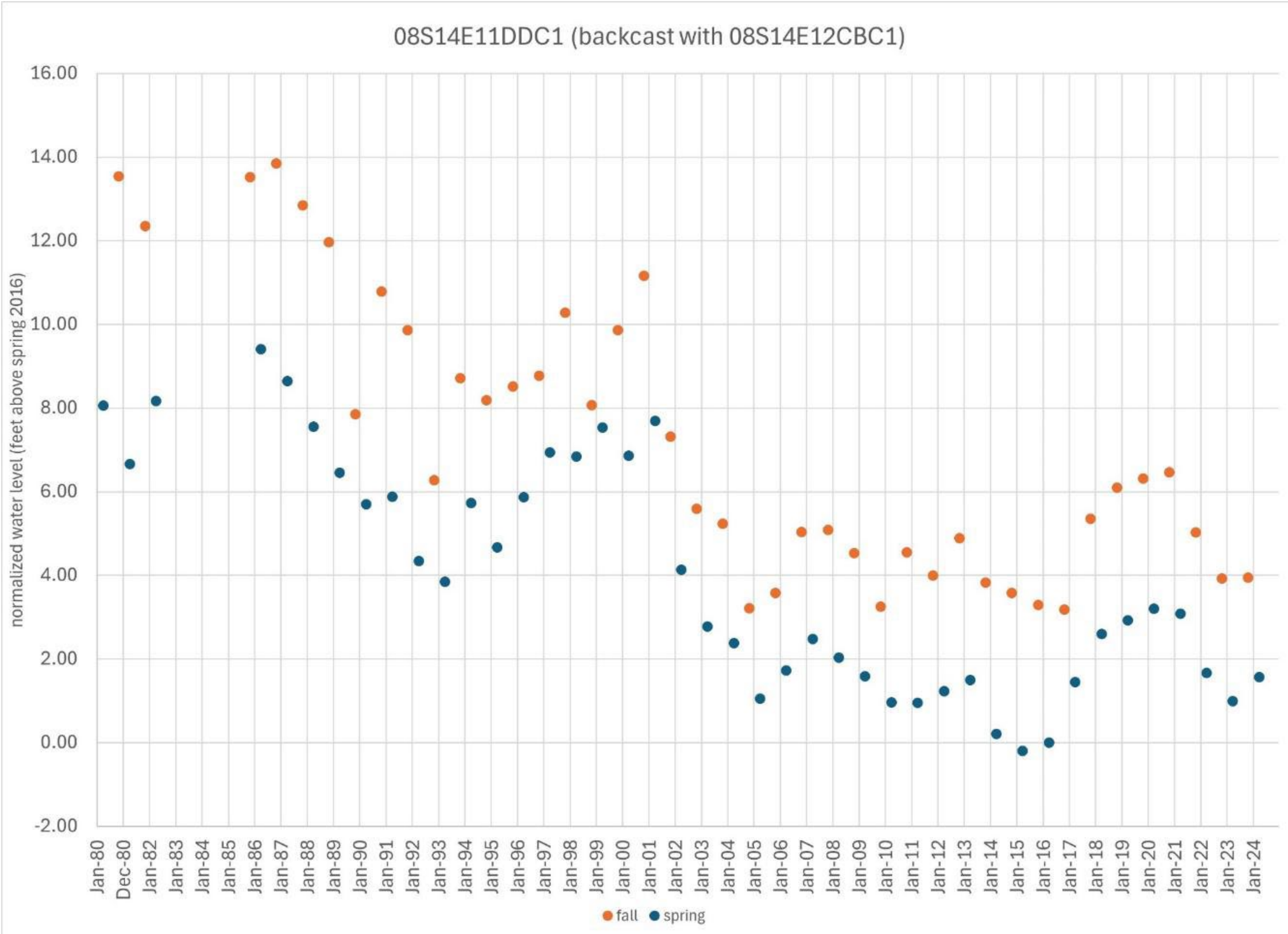
Jan-24
fall
spring


08S14E11DDC1 (backcast with 08S14E12CBC1)
normalized water level (feet above spring 2016)
16.00
14.00
12.00
10.00
8.00
6.00
4.00
2.00
0.00
-2.00
Jan-80
Dec-80
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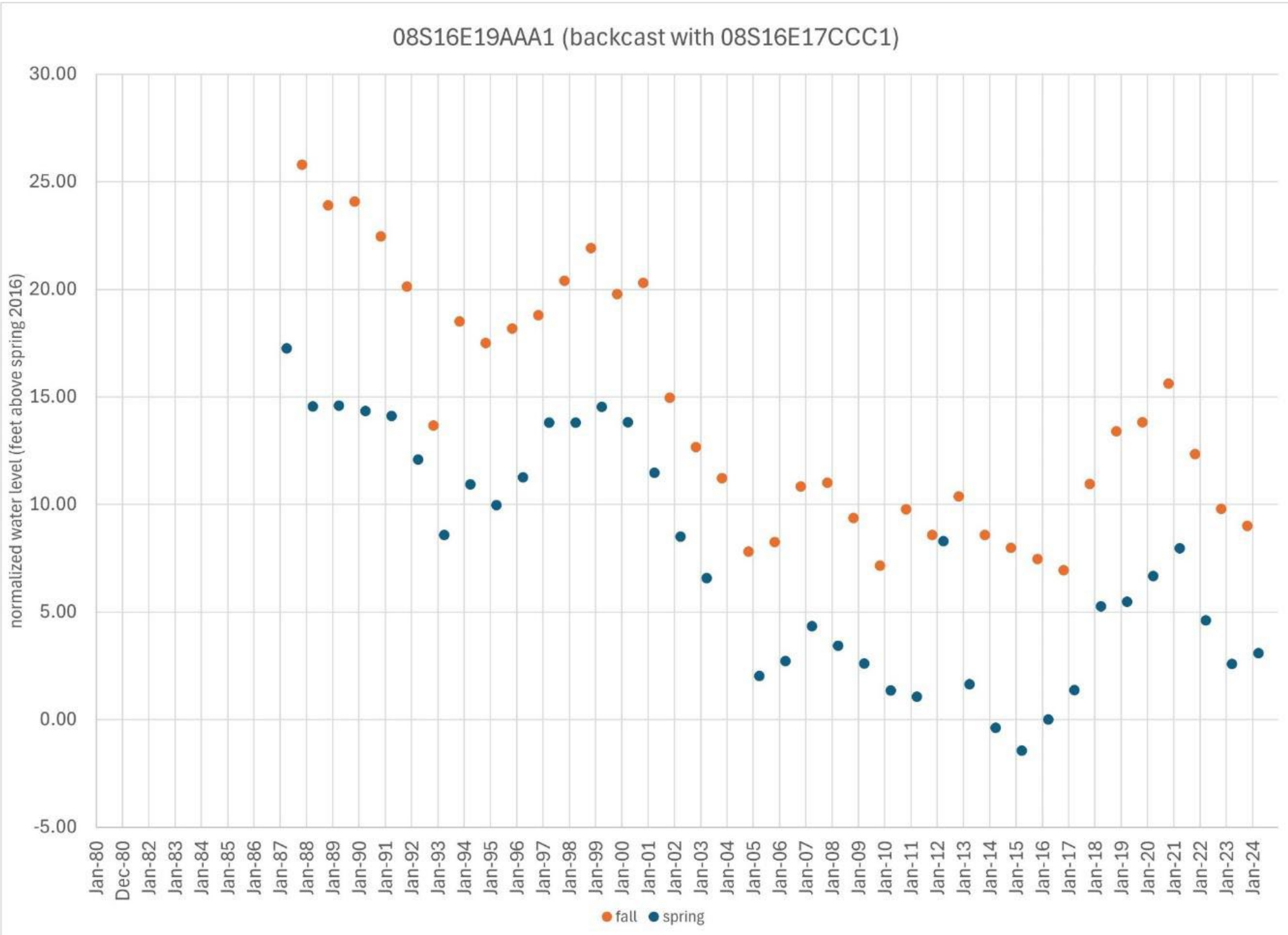
Jan-22
Jan-23
Jan-24
fall
spring


08S16E19AAA1 (backcast with 08S16E17CCC1)
normalized water level (feet above spring 2016)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
-5.00
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
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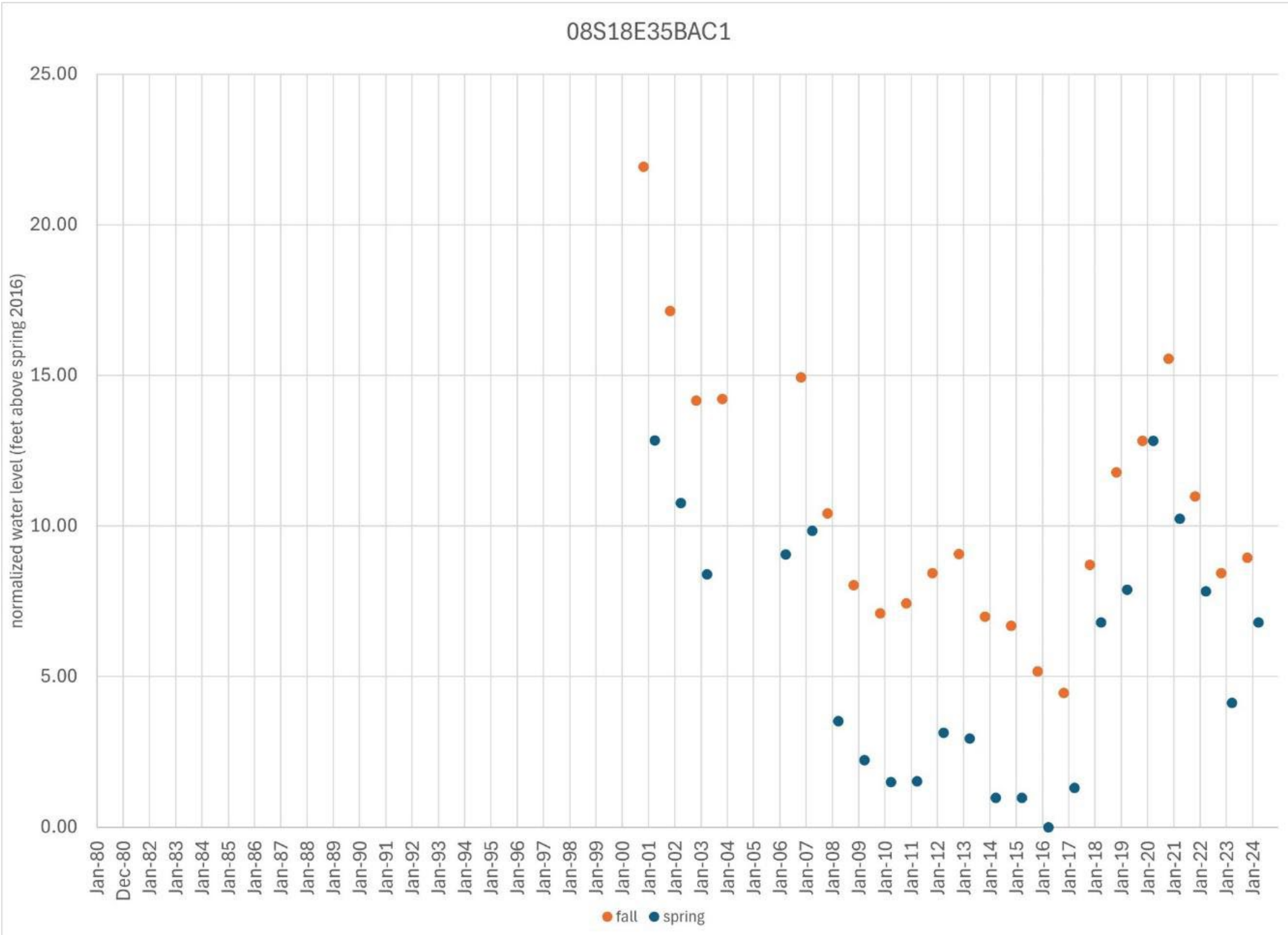
Jan-22
Jan-23
Jan-24
fall
spring


08S18E35BAC1
25.00
20.00
15.00
10.00
5.00
0.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
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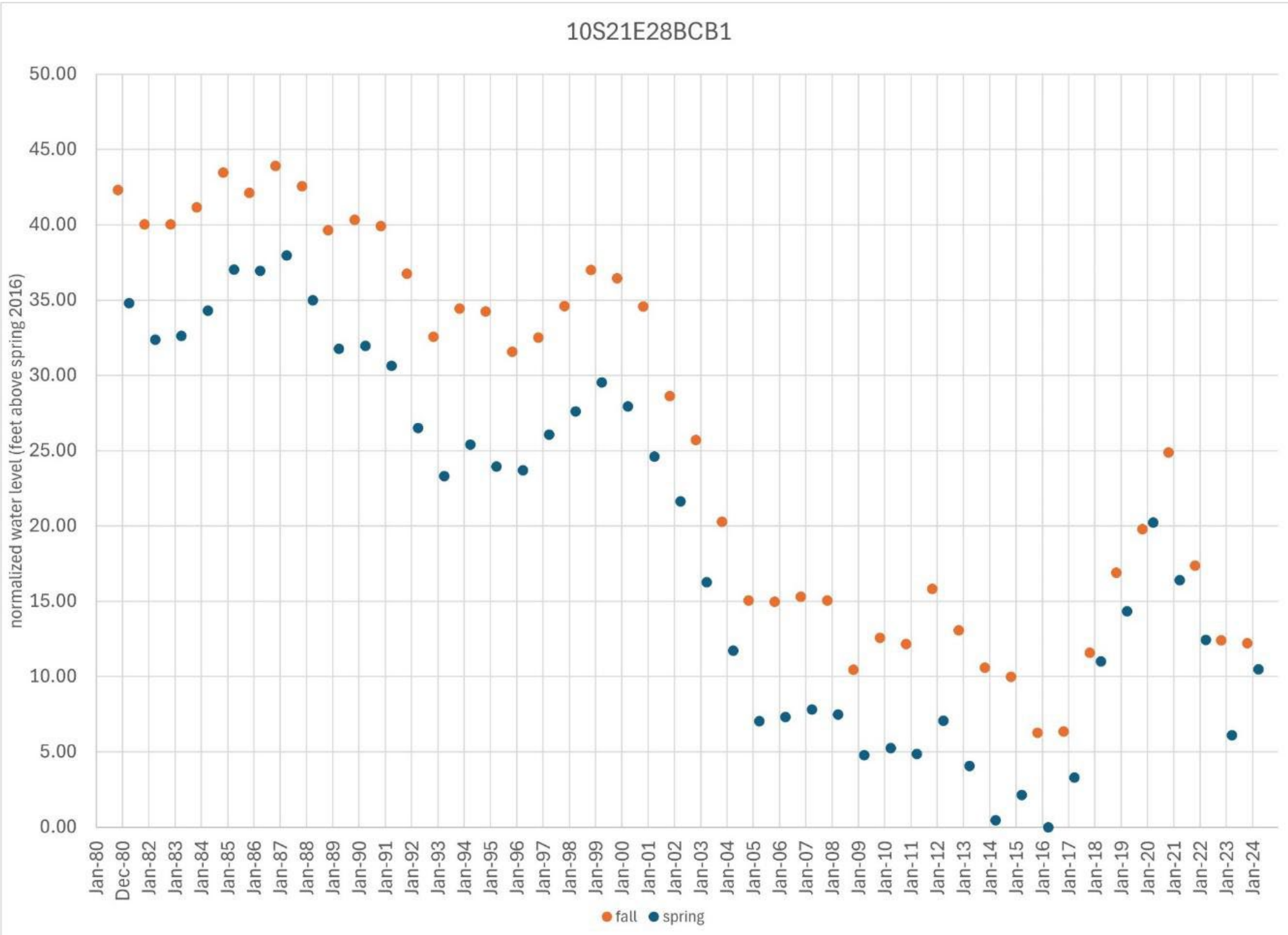
Jan-24
fall
spring


10S21E28BCB1
50.00
45.00
40.00
35.00
30.00
25.00
20.00
15.00
10.00
5.00
0.00
normalized water level (feet above spring 2016)
Jan-80
Dec-80
Jan-82
Jan-83
Jan-84
Jan-85
Jan-86
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Jan-19
Jan-20
Jan-21
Jan-22
Jan-23
Jan-24
fall
spring