Verde River Watershed Report Card

METHODOLOGY

December 2025

Contents

Goals and Objectives

The Verde River Watershed Report Card (WRC) was developed to track the condition of water, habitat, and communities within the Verde River Watershed. The report card is intended to identify problem areas requiring restoration or conservation, and to serve as an outreach tool for managers and organizers to highlight key issues when communicating conservation and restoration to the public.

The report card was co-developed with stakeholders from around the Verde River Watershed. The selection of indicators reflects stakeholders' values for the Verde, with an emphasis on those values perceived as under threat. Some of the key threats identified included land-use changes, groundwater pumping, resource overuse, climate change, and human pollution. The vitality of communities within the watershed was also identified as an integral component of watershed health.

The Verde River Watershed Report Card is an assessment of watershed condition. The report card team recognizes numerous improvements to the report card indicators, data sources, and methods. Improvements can be made as the process is repeated for future report cards without jeopardizing the ability to track change in watershed condition over time.

Region Determination

A watershed is defined by the topography of the land — it includes all areas where surface water drains into a common outlet, such as the Verde River. To support meaningful analysis, the Verde River Watershed was divided into regions based on geographic features, geology, hydrography (e.g., water-flow patterns), and stakeholder input.

The regions were delineated to align with stakeholders' conceptual models of the watershed developed during the planning process and to support consistent evaluation over time. For results to be precise and useful, each region should include enough sampling sites; adequate spatial coverage is necessary to ensure reliable analysis and tracking of ecological conditions.

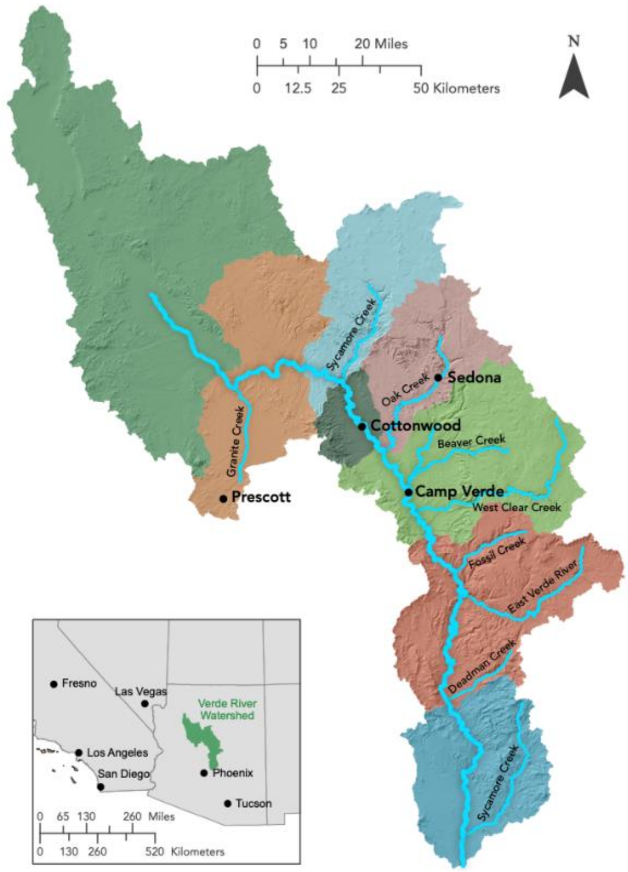

Figure 1: Seven regions of the Verde River Watershed

To maintain consistency and integrate national standards, regions were defined using U.S. Geological Survey 12-digit hydrologic unit codes (HUC12s), which delineate watershed boundaries. Each watershed is typically divided into upstream and downstream segments that are hydrologically connected to the Verde River.

In total, seven regions were identified:

1. **Big and Little Chino**
2. **Upper Verde**
3. **Upper Verde Valley**
4. **Oak Creek** — a major tributary treated as a separate sub-watershed due to its distinct flow and ecological dynamics
5. **Lower Verde Valley**
6. **Wild and Scenic**
7. **Lower Verde**

Water from each region flows into the Verde River and contributes to downstream hydrologic regions. To support analysis and grading, custom polygon shapefiles were created for each region using selected data and mapping criteria established during the project.

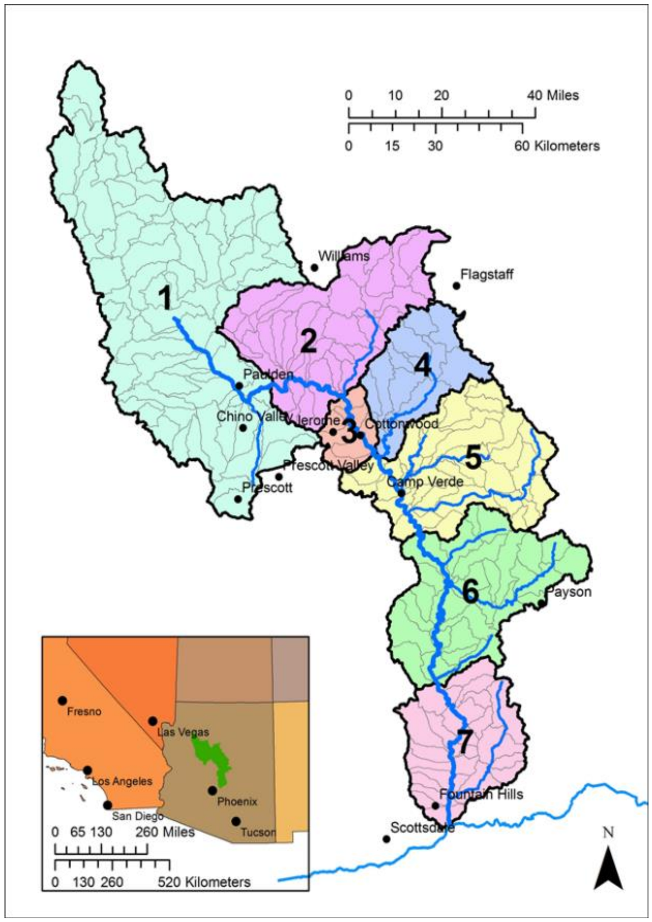

Figure 2: Seven regions were created by combining HUC12 watersheds.

The second significant factor used to identify watershed regions was the integration of human geography by use of population distribution. Census Bureau data were employed for regions, which should be represented not only by the watersheds' physical boundaries but also by patterns of human settlement. These data are available at the census block level, a small geographical unit whose size scales with population density. Nevertheless, many such census blocks may span multiple watershed boundaries, making it difficult to attribute their populations directly to specific hydrologic regions.

To address this problem, population data were downscaled using 2016 urban imperviousness data from the National Land Cover Dataset (NLCD). This data type represents impervious surfaces, such as buildings and roadways. People do not live on roads; therefore, the data were filtered to exclude road areas. All other impervious surfaces were considered potential sites of residence. The population of each census block was then allocated proportionally to the other impervious grid cells (at 30-m resolution). Through this approach, population data were precisely matched to hydrologic regions, and the region definition accounted for human geography. It also allowed for more accurate weighting of social indicators across the watershed.

Indicators and Thresholds

The indicators used in the report card were baseflow, depth to groundwater, water quality index, water quality certainty, macroinvertebrates, upland condition index, riparian birds, native fish, affordable housing, unemployment, education, healthcare, digital engagement, civic engagement, recreation access, visitor satisfaction, and recreation planning (Figure 3). Since the 2020 version, groundwater Best Management Practices (BMPs), surface water BMPs, and turbidity were removed as indicators due to insufficient data. In 2025, the fish indicator methodology was revised to consider only native fish.

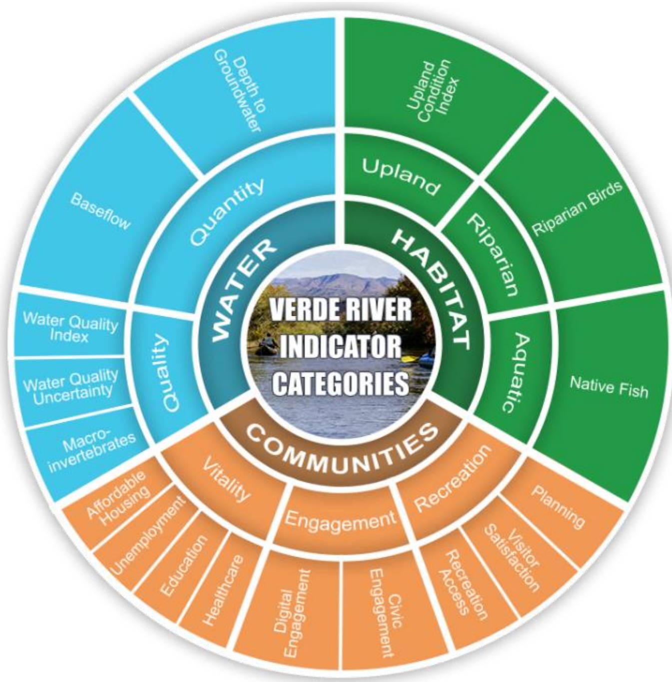

Figure 3: Verde River Watershed Report Card indicator wheel.

Once these indicators were identified, targets or thresholds for each indicator were developed. Establishing targets for each indicator can be done by using pre-existing standard thresholds from the scientific literature or by determining acceptable management goals. A threshold ideally indicates a tipping point at which current knowledge predicts an abrupt change in ecosystem condition. Thus, from the perspective of selecting meaningful, health-related thresholds, this is the point beyond which prolonged exposure to unhealthy conditions elicits a negative response for the environment or human health. For example, prolonged exposure to water quality below the criteria thresholds elicits negative responses in aquatic systems, either by compromising an organism's biotic functions (e.g., reduced reproduction) or by causing mortality.

More generally, thresholds are agreed-upon values or ranges that indicate that an ecosystem is moving away from a desired state toward an undesirable endpoint. Recognizing that many managed ecosystems face multiple, broad-scale stressors, another perspective is to define a threshold as the level of impairment that an environment can sustain before resulting in significant (or perhaps irreversible) damage.

When selecting thresholds, it is important to recognize that many are already available and that thresholds likely exist for the chosen indicator. A good place to start looking for existing thresholds and goals is in other report card methods or scientific reports and publications.

One way to develop threshold values, if none exist, is to relate them to management goals. These goals can then guide the selection of appropriate indicators. Even with agreed-upon thresholds, there remains the question of how best to apply these thresholds in management and governance contexts. Recognizing this challenge, thresholds can still be used effectively to track ecosystem change and to define achievable management goals for the restoration, preservation, and conservation of an ecosystem. If threshold values are clearly defined and justified, they can be updated in light of new research or management goals and can provide an important focus for the discussion and implementation of ecosystem management. Alternatively, if stressors are correctly identified and habitats are appropriately classified, multiple attributes (indicators) of the biological community should discriminate, in predictable and significant ways, between the least- and most-impaired habitat conditions. Reference communities can then be characterized using these data, which in turn can be used to develop threshold values.

For the Verde, there were several scoring methods that were applied for report card indicators, including:

1. **Pre-determined thresholds and scoring.** For some indicators, the data provider had already assigned a rating to the observations or results. These may have been measured against a region-specific desired condition or by another method. This method was used when the assessment methods were from an accepted source and followed generally accepted practices. In some cases, only one threshold was provided; in these cases, the fraction of data meeting that threshold was used to generate a score.
2. **Comparison against a baseline condition.** For some indicators, a baseline condition could be established. For example, water quantity was graded relative to the mean and standard deviation of 7-day low-flow conditions since 2006. These statistics (mean and standard deviation) were used to calculate a z-score, a quantitative measure of how many standard deviations a value lies above or below the mean, for the most recent year of data for each gauge. The z-score was then divided into five categories that represented grades A through F.

Description	z-score	Grade
Substantially above national average	1.5 – 2.5	A
Above national average	0.5 – 1.5	B
Near national average	-0.5 – 0.5	C
Below national average	-1.5 – -0.5	D
Substantially below national average	-2.5 – -1.5	F

Table 1: Z-score grade scale

3. **Comparison to a national average.** For the economic indicators, the basin was graded against the national average. As in #2 above, a z-score was used; however, here the mean and standard deviation were calculated from county-level data across the country. The table above shows how the z-scores were translated into grades.

All measurements were standardized to a 0–100 scale to enable thematic aggregation of individual indicators up to the indicator categories and spatial aggregation from regions to the entire watershed. Scores were distributed in equal increments to facilitate aggregation. It is important to note that the scoring scheme is not a reflection of a "curve" or a lenient grading system. The report card team (in consultation with diverse stakeholders) determined through data analysis what data values represented good and bad grades. Those were translated into the final scoring scheme and distributed on the 0–100 scale in 20-point increments. Therefore, final scores were given a grade as follows:

Letter Grade	Mean Percentile Score
A+	95 to 100
A	85 to 94
A-	80 to 84
B+	75 to 79
B	65 to 74
B-	60 to 64
C+	55 to 59
C	45 to 54
C-	40 to 44
D+	35 to 39
D	25 to 34
D-	20 to 24
F	0 to 19

Table 2: Verde Watershed Report Card grade scale

Water

Water indicators track both the quantity and quality of water in the watershed.

Water Quantity

Indicator: Baseflow

Indicator importance:

Baseflow is the flow in the river when it is not influenced directly by rain or snow and when it is most closely tied to flows from connected springs and aquifers. This indicates the impacts of drought, climate change, and groundwater pumping. The Verde River is one of the last perennial rivers in the Southwestern United States, supporting one of the rarest forests in the world, the Fremont Cottonwood-Goodding Willow gallery forest. Without adequate flows, the Verde will not be able to support healthy ecosystems.

Data source:

United States Geological Survey (USGS), accessed via the web interface at https://waterdata.usgs.gov/nwis

Calculation method:

Like all rivers, the discharge of the Verde River fluctuates rapidly in response to precipitation and snow-melt events. Baseflow is the term used to describe the flow during periods of low discharge (stream flow) between precipitation events. Baseflow is generally sustained by groundwater inputs along the length of the river and its tributaries. Perennially flowing springs are particularly important to the Verde discharge in the upper Verde.

The full annual cycle of Verde discharge includes periods of generally high flow, with regular precipitation and runoff inputs, and periods of generally low flow during seasonally dry periods. Based on stakeholder discussions, it was determined that June generally has the lowest discharge. June follows several months of warm temperatures. Evaporation and transpiration from vegetation have significantly dried the landscape, and snowmelt discharge has already occurred. June also precedes the summer monsoon season, which begins in July-August. Therefore, this indicator uses U.S. Geological Survey (USGS) discharge data for June.

There were long-term USGS gauge stations in five of the seven reporting regions (Table 3). The data used were observations from May and June over the entire period of record. The 7-day low flow (minimum flow) was calculated for each 7-day period ending on the focal day in June. The 7-day low-flow was used because it is relatively insensitive to short-term precipitation-related discharge peaks of duration less than a week. The mean 7-day low flow for June was calculated and used as an indicator of baseflow conditions.

Baseline conditions were established for each gauge, against which each measurement of the June mean 7-day low flow could be compared. Discharge at each gauge is unique, based on its position in the watershed. Baseline conditions for each gauge were established separately. An inspection of time series for each gauge indicated that baseflow has declined for decades (Figure 4).

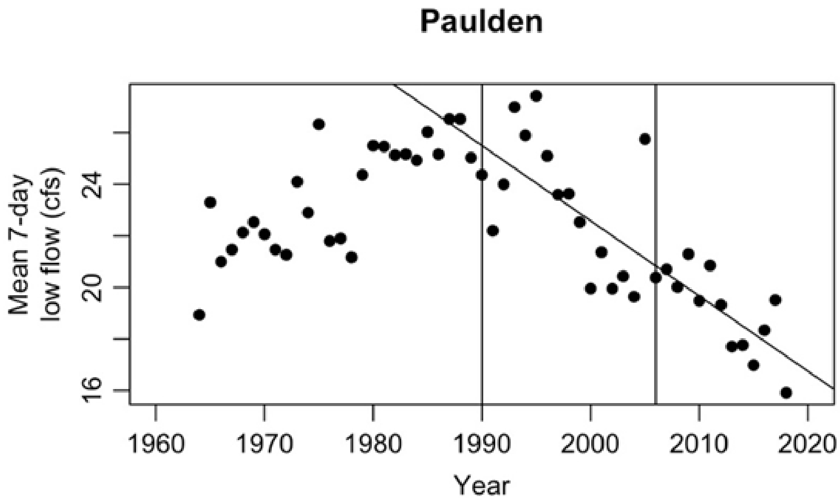

Figure 4: June mean 7-day low flow at Paulden gauge with a trendline fitted to data since 1990. The period since 2006 was adopted as the baseline period.

Stakeholders were generally comfortable stating that, if the current baseflow could be maintained, conservation efforts would be successful. The mean and standard deviation of the June mean 7- day low flow were calculated between 2006 and 2018 and used as the baseline for each gauge (Table 3). We used these statistics to calculate a z-score for each June mean 7-day low flow and adopted a yearly grading period. We scaled the z-score to the range -2.5 to 2.5, corresponding to grades from F to A. Therefore, when the 2-year June mean 7-day low flow exceeded the baseline mean, the region received a grade above 50%. Likewise, when the 2-year June mean 7-day low flow was below the baseline mean, the region received a grade below 50%.

June low flow (CFS)			
Gauge Name	**Region**	**Baseline Mean**	**Baseline StdDev**
Paulden	2	19.1	1.6
Clarkdale	3	61.9	3.4
Oak Creek Sedona	4	27.3	1.4
Camp Verde	5	51.1	13.2
Tangle Creek	6	84.9	18.0

Table 3: Gauges and baseflow baseline

Indicator: Depth to Groundwater

Methods followed those from 2020, see the Technical Memorandum in Appendix 1.

Water Quality

Indicator: Water Quality Index

Indicator importance:

Suitable water quality in the Verde Watershed is essential to the communities, flora, and fauna that depend upon it.

Data Source:

The Arizona Department of Environmental Quality (ADEQ) provided a Geographic Information System (GIS) layer of reaches within the Verde Watershed that have been assessed for water quality. The layer included stream names, segment IDs, assessment determinations, mileage, and impairment information. The data used are from the most recent approved ADEQ assessment.

Calculation Method:

The water quality index (WQI) was calculated as the percentage of stream miles assessed that met state standards. ADEQ has determined whether each stream segment meets state standards.

In QGIS, we used the intersect tool to add the appropriate region field to the "Assessed Streams" layer and to overlay the Verde Zones (regions) layer. We then used the field calculator to calculate the mileage for each reach within each region. The miles for each region were then totaled. This resulted in the Total Assessed Miles portion of the calculation. To calculate the Miles Attaining Standards, the same data were filtered to include only reaches labeled "1 Supporting All Uses." The mileage was then totaled by region again. This data was then input into the following formula:

$$WQ\ Index = \left(\frac{Miles\ Attaining\ Standards}{Total\ Assessed\ Miles}\right) * 100$$

Where:

- **Miles Attaining Standards** refers to the total length of stream reaches that fully comply with state-designated water quality standards, designated "1 Supporting All Uses".
- **Total Assessed Miles** include all stream miles evaluated with a status (Supporting All Uses, Supporting Some Uses, Inconclusive, Not Attaining TMDL Complete, and Impaired).

The product of this equation was converted to letter grades (Table 2).

Indicator: Water Quality Certainty

Indicator importance:

When examining water quality throughout the watershed, it is important to understand the certainty of these scores. High water quality certainty scores enable practitioners to rely on data while deciding on environmental and resource management projects and policies.

Data Source:

The data used in this section were provided by the ADEQ. The ADEQ provided a layer of assessed streams in Arizona. They also provided a layer of flow regimes within the state. The most recent data available were used.

Calculation Method:

Water quality certainty measures the amount of stream miles that have been assessed using ADEQ's assessment methods compared to the total stream miles eligible for assessment within the watershed.

ADEQ provided a layer of assessed streams in the Verde Watershed and a layer of flow regimes. It was determined that only perennial and intermittent stream types would be included in this exercise; therefore, the flow-regime layer was filtered to show only these stream types. In QGIS, we used the intersect tool to overlay the region layer onto the flow-regime layer. Then the mileage of each reach by region was calculated in the field calculator and added as a field. These mileages were summed by region and entered into the equation below as "Total Watershed Miles".

To determine the total assessed miles, we clipped the assessed streams layer to only show perennial and intermittent streams that have been assessed. Then we used the intersect tool to overlay the region layer and calculated the miles, as above. These mileages were summed by region and entered into the equation below.

$$WQ\ Certainty = \left(\frac{Total\ Assessed\ Miles}{Total\ Watershed\ Miles}\right) * 100$$

Where:

- **Total assessed miles** refers to the cumulative length of stream miles (perennial and intermittent) evaluated and assigned a status (Attaining, Impaired, or Inconclusive).
- **Total watershed miles** represents the total length of all perennial and intermittent stream miles within each region, including both assessed and unassessed areas.

The product of this equation was converted to letter grades (Table 2).

It is important to note that the streamflow layer includes streams designated as ephemeral, undetermined, or null. These streams were excluded from scoring at ADEQ's recommendation. Currently, only perennial and intermittent streams are federally protected under the Waters of the

United States (WOTUS) rules. Some ephemeral streams are included in the assessed layer and were excluded from that calculation to ensure consistency.

Indicator: Macroinvertebrates

Indicator importance:

Benthic macroinvertebrates are freshwater animals living in rivers and streambeds. These organisms are effective indicators of stream health because they do not move frequently and reflect population changes in response to environmental stressors. The changes observed in macroinvertebrate populations directly reflect alterations in water quality, habitat conditions, and ecosystem stability, making them essential for assessing aquatic health in the Verde River Watershed.

Data Source:

Macroinvertebrate survey data provided by ADEQ.

Calculation Method:

The provided data were the results of 2019 surveys of stream benthic (bottom-dwelling) macroinvertebrate species. Based on the survey results, ADEQ calculated an Index of Biotic Integrity (IBI) for each survey site. This methodology is intended to use the last five years of survey data. Surveys completed in the last five years and not included in the 2020 scoring were from 2019 only. No surveys have been conducted since 2019. Regions 1, 3, and 7 had no surveys completed in the timeframe and were excluded from scoring.

For each station, we typically identify the most recent survey that met ADEQ's criteria for sample validation. This was unnecessary since there was only one survey per station in this dataset. Data were only used if the sample met the following criteria: the sample was made (1) during the spring index period (Warm-water sites: April-May; Cold-water sites: May-June), (2) in riffle habitat, (3) in a perennial stream, (4) on mixed substrates (not bedrock or travertine dominant), and (5) during baseflow conditions. When these criteria were not met, survey results were flagged and removed from the analysis

The IBI values were scaled to match the report card scoring methodology. The IBI values were provided on a 0-100 scale, with values greater than 50 representing “Meets criteria”, values 40–49 representing “Inconclusive”, and values below 40 representing “Violates”. We rescaled these values so that scores of 75 and above received an A (80%) and scores of 40 and below received an F (20%) (Table 4). The IBI values were organized by reporting regions and were averaged within each region.

IBI values	WRC score
75	80 % (A)
40	20 % (F)

Table 4: Macroinvertebrates (IBI) grade scale

With an average IBI value for each region, it was then converted to a WRC score using the formula:

$$WRC\ Score = (1.7143x) - 48.571$$

Habitat

Habitat indicators assess habitat quality for plants and animals in the watershed across three habitat types: uplands, riparian, and aquatic.

Upland

Indicator: Upland Condition Index

Indicator importance:

Healthy rivers are supported by healthy land. The upland condition index uses indicators from the U.S. Forest Service (USFS) Watershed Condition Framework (WCF) to assess how upland areas in each region function as expected in the absence of human activities.

Data Source:

The United States Department of Agriculture Forest Service Watershed Condition Framework (USFS 2011): https://www.fs.usda.gov/biology/resources/pubs/watershed/maps/Watershed_Condition_Framework2011FS977.pdf

The data were updated in 2025 to calculate the upland condition index score.

Calculation Method:

The WCF is a 12-indicator system that evaluates aquatic and terrestrial habitat properties. The WCF assessments encompass all HUC12 watersheds within USFS-managed lands. The shapefile structure contains data attributes corresponding to 12 indicators (USFS 2011). The WCF evaluates each watershed using three possible rankings for its twelve indicators. Of the 12 indicators, the first five (water quality, water quantity, aquatic habitat, aquatic biota, and riparian/wetland vegetation) address aquatic conditions. These scores were excluded from the upland habitat score. Seven additional indicators cover the connected terrestrial physical components (roads and trails, soils) and terrestrial biological elements (fire regime or wildfire, forest cover, rangeland vegetation, terrestrial invasive species, forest health) were used for this analysis.

WCF Score	WCF Rating	WRC Score	Grade
1	Functioning	100 %	A
1.5	Functioning at Risk	75%	B
2	Functioning at Risk	50 %	C
2.5	Not Functioning	25%	D
3	Not Functioning	0 %	F

Table 5: Upland grade scale

We used the WCF shapefile to retrieve these seven terrestrial indicators for analysis. Each indicator received a score and grade from 1 (Functioning or 100%) to 3 (Not Functioning or 0%) (Table 5). Each HUC12 received its watershed score by averaging multiple weights according to WCF technical guidelines, which gave physical measures three times more importance (75%) than biological indicators (25%). All HUC12s that intersected USFS-managed lands had information available. In certain areas, no forest habitat existed, so the WCF entered no data for the forest cover indicator. The physical and biological scores were aggregated to each reporting region by calculating area-weighted averages based on each HUC12 area. Only available areas with natural forests and WCF classification were included when applying the weight-based calculations for the area averages.

WCF scores were scored linearly based on Table 2 with the following equation:

$$\text{WRC Score} = (-50 * \text{WCF Score}) + 150$$

Riparian

Indicator: Riparian Birds

Indicator importance:

The Verde River Watershed is home to one of the rarest forests on earth, the Fremont Cottonwood-Goodding Willow Gallery Forest. Formed at the river's connection to its desert surroundings, these forests, when healthy, support an incredible diversity of bird species. To measure riparian forest health, we compared the current number of bird species in a region to a list of species expected to nest in the riparian area of the region.

Data Source:

eBird data, requested as a Basic Dataset download from ebird.org

Calculation Method:

The same list of 91 bird species used in the 2020 Watershed Report Card was used for this indicator in 2025. However, scientific names were updated to reflect the current taxonomy, resulting in the removal of two invalid subspecies and the revision of three scientific names. Locations for sensitive species, such as the southwestern willow flycatcher (*Empidonax traillii extimus*) and bald eagle (*Haliaeetus leucocephalus*), are not provided by eBird and, therefore, we removed these two species/subspecies from our analysis. In future years, eBird data could be used alongside other datasets, such as those from the Arizona Game and Fish Department, to include these species in indicator calculations. For the 2025 Watershed Report Card, we used a final list of 86 birds for our analysis (Appendix 2).

For each species, a breeding season was identified, generally from March to May and from July to August. Using eBird data from 2023 and 2024, we assessed which species from the list of expected bird species (Appendix 2) were observed within each watershed region during their respective breeding season. We then divided the number of species detected in each region by the total number of species in the full list and converted the result to a percentage. The percentage of breeding birds recorded versus the full list of expected species was the final score used for this indicator.

Aquatic

Indicator: Native Fish

Indicator importance:

Native fish depend on a functioning aquatic habitat. To measure aquatic health in the Verde River Watershed, we used native fish species richness (the number of different native fish species in a given area). We selected this metric for this indicator rather than the "abundance" of native fish because of the limited number of fish surveys conducted during the examined timeframes and the lack of standardized sampling across the surveys. In short, estimates of native fish abundance could not be calculated due to insufficient surveys and bias introduced by different sampling methods, which prevented reliable comparisons across datasets (e.g., due to variation in sampling time, location, and effort level).

Data Source:

We referenced agency fish surveys that sampled within one or more of the seven regions during 2015-2019 (to calculate the 2020 WRC using the updated methodology) and 2020-2024 (for the 2025 WRC). Fish survey documents reviewed included 16 Arizona Game and Fish Department (AZGFD) fish survey reports, eight Gila River Basin Native Fish Monitoring (Bureau of Reclamation (BOR) / Marsh & Associates) survey reports, one USFS eDNA fish survey report, one U.S. Fish and Wildlife Service Recovery Plan, and one USFS fisheries report. For additional information on the data and references used, see Appendix 3.

Calculation Method:

To score the health of fish species native to the Verde River Watershed, we first determined the number of native fish species historically found (as recently as the twentieth century) in each of the seven watershed regions. These counts were derived from federal and State of Arizona agency documents and websites and serve as the baseline for scoring the health of native fish in each region. Our assessment of historical native fish distributions throughout the Verde River Watershed was vetted by fish biologists from Stillwater Sciences, AZGFD, and the BOR.

We focused on 13 fish species native to the Verde River Watershed, as identified in our literature review. However, it came to our attention that Gila chub and headwater chub were recently deemed to be the same species as roundtail chub by the American Fisheries Society. Therefore, our final list included 11 fish species native to the Verde River Watershed (Table 6). For the Big and Little Chino, Oak Creek, and Lower Verde regions, there were nine native fish species determined to be historically found in each region. In the Upper Verde region, 10 native fish species were historically documented. For the Upper Verde Valley, Lower Verde Valley, and Wild and Scenic regions, 11 native fish species were identified as historically occurring in each region.

SPECIES CODE	COMMON NAME	SCIENTIFIC NAME	Big and Little Chino	Upper Verde	Upper Verde Valley	Oak Creek	Lower Verde Valley	Wild and Scenic	Lower Verde
AGCH	Longfin Dace	Agosia chrysogaster	X	X	X	X	X	X	X
PACL	Desert Sucker	Pantosteus [Catostomus] clarkii	X	X	X	X	X	X	X
CAIN	Sonora Sucker	Catostomus insignis	X	X	X	X	X	X	X
GIRO	Roundtail Chub	Gila robusta	X	X	X	X	X	X	X
MEFU	Spikedace	Meda fulgida	X	X	X	X	X	X	
ONGI	Gila Trout	Oncorhynchus gilae	X	X	X	X	X	X	X
POOC	Gila Topminnow	Poeciliopsis occidentalis occidentalis			X	X	X	X	X
PTLU	Colorado Pikeminnow	Ptychocheilus lucius		X	X		X	X	X
RHOS	Speckled Dace	Rhinichthys osculus	X	X	X	X	X	X	X
TICO	Loach minnow	Tiaroga cobitis	X	X	X		X	X	
XYTE	Razorback Sucker	Xyrauchen texanus	X	X	X	X	X	X	X
		TOTAL # HISTORICAL NATIVE SPECIES	9	10	11	9	11	11	9

Table 6: Native fish species in the Verde watershed regions.

We examined surveys and reports to determine the presence or absence of native fish species in each of the seven regions for each 5-year period. Only fish found during surveys were counted; we did not include records of stocked fish that were not found in surveys. Exact locations of surveys and sampled fish within a region were determined by cross-referencing Global Positioning System (GPS) coordinates and sampling maps from surveys and reports with the boundaries of the watershed's seven regions. The presence or absence of native fish species observed during sampling in each of the seven regions was recorded in a Microsoft Excel file. When the surveys reported sampled fish locations in the NAD83 / UTM zone 12N coordinate system, we used an online coordinate converter (epsg.io) to convert the coordinates to the WGS 84 coordinate system for compatibility with Google Earth.

After reviewing all available fish surveys and reports noted above, letter-grade scores were calculated for each region based on the percentage of historical native fish species found in surveys conducted during each five-year period 2015-2019 for the 2020 WRC and 2020-2024 for the 2025 WRC.

Communities

Community indicators are tools used to measure and track quality of life across a region, covering factors such as health, education, economic stability, and social well-being. In this report, the community indicator focuses specifically on conditions in and around the Verde River watershed. These indicators are valuable because they capture a wide range of interactions between people, the economy, the healthcare system, education, and the environment.

Vitality

Indicator: Affordable Housing

Indicator importance:

Housing cost burden—defined as households spending more than 30 percent of their income on housing—is a standard metric for assessing housing affordability. High cost-burden rates are associated with an increased risk of housing instability and limited access to necessities, including healthcare, education, transportation, and food. Comparing the watershed's cost-burden rate to the national average provides context for evaluating local housing pressures. The housing-affordability indicator was calculated in four stages: data extraction, regional aggregation, percentage computation, and linear scoring.

Data Source:

American Community Survey (ACS) table B25106 (5-year estimates: 2019-2023)

Calculation Method:

First, the ACS B25106 table was filtered to include only Census tracts whose GEOIDs intersect the 7 regions of the Verde River Watershed. Within each region, all ACS variables for households allocating 30 percent or more of their income on housing were summed to determine the count of burdened households. Total households were summed separately for each region to serve as the denominator for percentage calculations. Unburdened households, allocating <30% of income towards housing, were then computed by subtracting burdened households from total households, and the percentage of unburdened households was derived for each region. Percentages of total unburdened households were then linearly scaled with the following formula:

$$Score = \frac{(\%\ Unburdened - 50)}{50}$$

Scores below 0 were set to 0, and scores above 1 were capped at 1. The resulting numeric scores were subsequently mapped to letter grades following the broader report-card rubric (Table 2).

Linear scaling is used to transform the raw percentage of unburdened households into a standardized 0–1 (or 0–100) score for comparison across regions and with national benchmarks.

WRC Score	Affordable Housing Percent Rates
100% (A)	100%
0% (F)	50%

Table 7: Affordable housing scale

Indicator: Unemployment

Indicator Importance:

Employment is a key indicator of a community's overall economic health. A region's unemployment rate captures the share of working-age residents who want a job but cannot find one, indicating how well local labor markets match people to paid work. Persistent unemployment erodes household income, strains public-assistance programs, and is linked to poorer physical and mental-health outcomes, higher crime, and lower student achievement. Because joblessness disproportionately affects younger adults, people of color, and rural communities, this indicator also sheds light on underlying inequities in opportunity and social mobility. Tracking unemployment within the Verde Watershed—and benchmarking it against state and national averages—therefore helps stakeholders gauge the inclusiveness and resilience of the local economy.

Data Source:

American Community Survey (ACS) table B23025 (5-year estimates: 2019-2023)

Calculation Method:

The ACS table, B23025 "Employment Status for the Population 16 Years and Over", was downloaded at the census block-group level. Block groups intersecting the Watershed's regional boundaries were retained; a block group spanning more than one watershed region was therefore listed under each intersected region. For each region, two ACS variables were summed:

1) B23025_003E (Estimated total labor force): includes the ACS estimate of the civilian labor force—that is, all residents aged sixteen and older who are either employed or counted as unemployed under Bureau of Labor Statistics rules and excludes anyone on active-duty military service.
2) B23025_005E (Estimated unemployed): isolates the subset of that civilian labor force who are officially classified as unemployed: people who had no paid work during the reference week and have actively searched for a job within the past four weeks or are on temporary layoff awaiting recall.

The regional unemployment rate was then computed as:

$$Unemployment\ Rate = \frac{Unemployed}{Labor\ Force}$$

Rates were then linearly transformed so that 3% ("full employment") maps to a perfect score of 1 and 15 percent (severe economic stress) maps to zero:

$$WRC\ Score\ = max\ (0, min\ (\ 1, \frac{0.15 - RATE}{0.12}\ ))$$

WRC Score	Unemployment Rates
80% (A)	3%
20% (F)	15%

Table 8: Unemployment scale

Any values below 3 percent are capped at 1; values above 15 percent are floored at 0. The 3–15% window preserves continuity with the 2020 report card and aligns with Bureau of Labor Statistics guidance, in which 3% is often cited as the lower bound of natural unemployment and 15% signals acute local distress. Lastly, numeric scores were converted to letter grades using the grading rubric (Table 2).

Indicator: Education

Indicator importance:

The children of the Verde River Watershed are its future. To measure whether children have adequate educational opportunities, we examined the high school graduation rate in each region.

Data Source:

Arizona Department of Education, Four-Year Graduation Rate Data. (2022) https://www.azed.gov/accountability-research/data

National Center for Education Statistics - https://nces.ed.gov/ccd/elsi/tableGenerator.aspx?savedTableID=651540 (able to develop a list of AZ schools with Latitude and longitude within the watershed that offer 12th grade)

Calculation Method:

To identify high schools within the watershed and by region, we used the National Center for Education Statistics, which provides a list of Arizona schools with GPS coordinates. Using those GPS coordinates, we clipped the list within each region. The school list was then filtered to include only high schools and online high schools. We then obtained graduation rates for each school from the Arizona Department of Education.

The data analysis relied on high school graduation rates in the Verde River Watershed. Each school's graduation rate was scored based on the threshold recommendation provided by stakeholders. The thresholds were a graduation rate of 90%, corresponding to an A grade (80% score), and a graduation rate of 70%, corresponding to an F grade (20% score) (Table 9).

WRC Score	High School graduation rates
80% (A)	90%
20% (F)	70%

Table 9: High school graduation scale

Graduation rates reflect the percentage of students who graduate within four years of entering high school. The schools were organized by watershed region, and the graduation rate scores were averaged. The average graduation rate for each region, it was then converted to a WRC score using the formula:

$$WRC\ Score = (3 * Graduation\ Rate - 190)$$

The scoring process excluded Region 2 because no high schools are located within that region.

Indicator: Healthcare

Indicator Importance:

Health-insurance coverage—the share of residents enrolled in any public or private plan—is considered a structural determinant of health. Coverage functions as a gateway to primary care, preventive screenings, and financial risk protection; when it is lacking, people are more likely to delay treatment, experience unmanaged chronic conditions, and incur medical debt. Because gaps in coverage often mirror broader patterns of social stratification (e.g., income, race, rurality), the indicator also provides insight into local dimensions of health equity and social inclusion. Comparing the Verde Watershed's insured-population share with the national average, therefore, contextualizes how effectively the region's health-care institutions and labor markets are meeting residents' basic access needs.

Data source:

American Community Survey (ACS) table B27010 (5-Year Estimates: 2019-2023)

Calculation Method

The ACS table B27010, "Type of Health Insurance Coverage by Age", was downloaded at the block-group level and filtered to include only block groups whose GEOIDs intersect the regional watershed boundaries; the same block group may appear in more than one region if it spans multiple regions. For each watershed region, the ACS variables representing individuals without health insurance coverage were summed to obtain the total number of uninsured individuals. All population columns in B27010 were summed separately to give the region's estimated total population. The count of insured residents was derived by subtracting uninsured individuals from the total population. The proportion insured for each region was then calculated:

$$\%\ Insured = \frac{(Insured\ Individuals)}{(Total\ Population)} \times 100$$

To place regional results on a 0–1 scale that aligns with the report-card framework, insured percentages were linearly transformed between 60 percent (baseline) and 100 percent (ideal) using:

$$Score = \frac{(\%\, Insured - 60)}{40}$$

The 60 percent anchor follows the precedent set in the 2020 methodology, to align with the statewide insurance rate at the time—estimated at 82 percent by Future of Arizona—so that Arizona's average would fall near the middle of the 60 to 100 percent scoring range, providing a consistent point of reference for regional comparison. Under this scheme, a region matching the statewide average receives a C, while lower or higher coverage levels fall proportionally below or above that midpoint. Scores below 0 are set to 0, and scores above 100 are capped at 100; the resulting numeric values are then translated into letter grades using the report-card rubric.

WRC Score	Insured rates
100% (A)	100%
0% (F)	60%

Table 10: Insured rate scale

Engagement

Indicator: Digital Engagement

Indicator importance:

For many people, the digital world is an important means of learning about and experiencing the Verde River. To capture this type of engagement, we compared the number of times water-related topics in a given area were searched for on Google using Google Trends data.

Data Source:

Google Trends (https://trends.google.com)

Calculation Method:

The digital engagement indicator is based on results from Google Trends queries. Google Trends provides weekly scores for search terms that are scaled between 0 to 100, relative to the most popular search term in the set of terms included. Four search terms were identified from each watershed region based on (mostly aquatic) place names (Table 11). In some cases, the search term was a prominent feature of the region (e.g., Oak Creek), whereas in others it was a large lake, park, or other feature (e.g., Bartlett Lake). Since scores are relative only to the search term within that set, we included Verde River as a search term in each region, for a total of five search terms per region. This allowed us to standardize and compare scores across regions. The search for each term yielded weekly data for the past 2 years (reporting period: July 1, 2023 to June 30, 2025).

To standardize all scores for comparison across regions, each search term value was divided by the corresponding "Verde River" value for the same week and multiplied by 100. This makes the Verde River the common baseline across regions and scales, thereby making all scores relative to it. So, for instance, if "Oak Creek" had half the score of "Verde River", it would get a standardized score of 50. Values over 100 would indicate search terms with higher interest than the Verde River and those less than 100 would indicate search terms with lower interest than the Verde River within the reporting period.

These standardized scores were then averaged for each search term and each region over the two-year reporting period. Each region was then scored using the top three-performing search terms. The average (of the top three scores) for each region was then rescaled using min-max scaling to fall between 0 and 100 to give us the final scores for each region.

It's important to keep in mind that this approach compares search terms for each region relative to the other regions. This essentially pits each region against each other and does not try to establish a critical threshold for the Google Trends results. This is necessary because the Google Trends results are unitless and the values depend on the range of values for the search terms used in each search. In this way, differences between the regions (search terms) are preserved and extremely high scores for one search term (e.g., Oak Creek) will drive scores in the other regions down. Therefore, decreases in scores may indicate either decreased interest in that term or increased interest in another search term.

Additionally, there could be another (unidentified) search term for some of these regions that would perform better (return a higher value in Google Trends). We attempted to limit this concern by identifying multiple search terms for each region selected by stakeholders. We suggest reviewing search terms regularly to determine if another term might be more appropriate.

Search Terms	Region
Verde River	0
Goldwater Lake	1
Lynx Lake	1
Watson Lake	1
Granite Creek	1
Sycamore Canyon	2
Perkinsville	2
Bear Siding	2
Upper Verde Wildlife Area	2
Dead Horse Ranch State Park	3
Tuzigoot National Monument	3
Tapco	3
Tavasci	3
Oak Creek	4
Slide Rock State Park	4
Red Rock State Park	4
Crescent Moon	4
Wet Beaver Creek	5
West Clear Creek	5
Rockin' River	5
Montezuma Castle	5
Fossil Creek	6
Sheep Bridge	6
Tonto Natural Bridge State Park	6
East Verde River	6
Bartlett Lake	7
Horseshoe Lake	7
Phon D Sutton	7
Needle Rock	7

Table 11: Search terms used to represent each region

Indicator: Civic Engagement

Indicator Importance:

For the river to persist over the long term the communities who depend on it must be invested in its health. To assess the extent to which local governments are engaging in conversations about water-related issues, we examined the number of times water-related topics appeared in regular meeting minutes of local governments.

Data Sources:

Regular meeting minutes collected from municipal and county government websites from 2023 and 2024 (Appendix 4).

Swanwick, R.H., Read, Q.D., Guinn, S.M. et al. Dasymetric population mapping based on US census data and 30-m gridded estimates of impervious surface. Sci Data 9, 523 (2022). https://doi.org/10.1038/s41597-022-01603-z

Calculation Method:

The goal of this indicator was to measure the engagement of local governments throughout the watershed on conservation topics. Similar to the digital engagement indicator, we used the occurrence of place names with conservation meaning to indicate engagement. (Table 11).

To quantify civic engagement, we use regular meeting minutes collected from the websites of municipal and county governments in the watershed (Appendix 4). Data were summarized for jurisdiction populations for incorporated municipalities (i.e., cities and towns) and unincorporated county communities within each region (i.e., populations residing in unincorporated areas of the county).

We aggregated data from all meetings in 2023 and 2024. In total, we searched 1,214 documents with the number of documents per jurisdiction ranging from 24 to 54 over the two year period. We searched each document (meeting minutes) for occurrences of all 30 of the search terms in Table 11, plus the term “watershed” and recorded the number of documents containing at least one instance of each search term for each jurisdiction. Since we graded only on the presence of a search term within the meeting minutes, if a search term occurred one time then the government got credit for that mention and no more credit for discussing the term many times in the same meeting. In future Watershed Report Cards, it may be more informative to use the abundance of these terms, rather than only occurrence.

We then identified the three highest performing search terms for each civic group and calculated the mean mention rate across these three terms. Mean mention rate was calculated as the average number of documents containing a search term divided by the total number of documents searched. The mean mention rate was then scaled to fall between 0 and 100 using min-max scaling.

We then used a 30-m resolution dasymetric population raster to determine the proportion of each jurisdiction's population within each watershed region (Swanick et al., 2022). This dataset used 2020 Census block data, alongside the National Land Cover Database, which identifies impervious surfaces, to assign populations only to areas that are impervious and not roads. This results in a finer-scale resolution of where the population within each jurisdiction resides so we could accurately assign them to a specific watershed region. For the next Watershed Report Card, it is suggested to develop an updated layer using the code provided in Swanick et al. 2022 to recreate an up-to-date population layer. Such a layer could be used on any other indicators requiring population data as well.

Using these data, we summed the total population within each region that falls within each assessed jurisdiction (e.g., total population of Cottonwood within each watershed region) by intersecting the watershed regions layer with each jurisdiction and each county, and then using zonal statistics to sum the population within each jurisdiction/county/region combination (e.g., the population of Sedona within Yavapai County in region 4, the population of Sedona in Coconino County in region 4).

We then calculated the total population within each county and in each region (e.g., the population of Yavapai County within each watershed region) by intersecting Arizona counties with the watershed region and using zonal statistics to sum populations within each count/region combination (e.g., Coconino County population within region 1, Coconino County population within region 2).

Finally, to calculate the population residing in unincorporated areas for each county and region, the total population of all incorporated areas within a watershed region and county was subtracted for the total population within that county and watershed region.

We then calculated the proportion of the total assessed population that each jurisdiction accounts for. The scaled scores were then weighted by this proportion and then summed to give the final score for each watershed region.

When summing up to the watershed-level, we found the proportion of the total population within the watershed that lived within each watershed region. We then weighted the regional scores by that proportion and summed them for an overall watershed score.

Recreation

Indicator: Recreation Access

Indicator Importance

While remote areas within the watershed offer opportunities for solitude and immersion in nature, it is equally important that residents have access to outdoor recreation close to their homes. Proximity to recreational opportunities has been linked to a range of physical, mental, and social benefits, particularly in more developed or densely populated areas. The recreation access indicator was developed to evaluate the equitable distribution of outdoor recreational opportunities across the watershed, with a focus on the percentage of residents who live near accessible recreation sites.

For this indicator, it is important to include all types of recreation and a diverse range of activities to ensure that access to recreation is available to everyone, regardless of social or economic status or physical ability. Recreation types include trails and trailheads, remote wilderness, established federal forest and park sites, and municipal/county parks.

Data Source:

U.S.D.A. Forest Service Recreation Opportunities Map (https://data.fs.usda.gov/geodata/edw/datasets.php?dsetParent=Recreation)

Arizona State Parks and Trails Statewide Trailhead Map (https://www.arcgis.com/home/item.html?id=ce4e69a454ad492692e89301414757ec)

Arizona State Parks and Trails Park Locations Map (https://www.arcgis.com/home/item.html?id=2bdcb0d8c38d4c639b07920944419697)

Calculation method

The recreation access indicator was developed by first consolidating spatial data from three primary sources: U.S. Forest Service Recreation Opportunities, Arizona State Parks and Trails (ASPT) locations, and Arizona recreation sites. The latter two sources were provided directly from ASPT staff. Through continued partnership, we contacted ASPT staff to obtain the most current shapefile (ASPT has a shapefile on their website, but it was not the most up-to-date version). These data sets were downloaded or received in 2025. We also used the shapefile produced during the 2020 Watershed Report Card, which shows trailheads within the watershed. The point data used represents only areas with managed recreation access, which is required for responsible recreation. While access to recreation sites promotes the local economy and community health, it is also important to manage recreational impacts and provide designated access points. Therefore, unmanaged access points were excluded from our analysis (e.g., public lands without a designated access point or areas where a trail was within 3 miles, but a trailhead was not).

All features in these four datasets consist of point features only. Therefore, some larger areas, such as city parks, are represented by a single point, which will likely lead to errors when measuring local households within the 3-mile radius, resulting in an underestimate of the population within 3 miles of these parks. These errors are likely to be higher with larger parks or recreation areas. However, because the USFS and ASPT datasets were used in the last WRC and are available only as point features, we sought to be consistent with prior efforts. Future WRC efforts may consider using datasets containing polygon features for recreation opportunities, such as those available in the Protected Area Database developed and managed by the US Geological Survey (USGS 2024).

To analyze the population in each watershed region residing within 3 miles of a recreation opportunity, we first merged the points from all four shapefiles into a single shapefile in QGIS and then buffered each point by 3 miles. The buffer results were aggregated into a single feature representing all areas within the watershed that are within 3 miles of a recreation opportunity. This feature was intersected with the watershed regions to produce a final shapefile of all areas within each region that are within 3 miles of a recreational opportunity. This step also ensured that we considered only areas within the watershed boundary.

We then used zonal statistics to calculate the proportion of the population in each watershed region located within 3 miles of a recreation opportunity. We divided the population within 3 miles of a recreation opportunity in each region by the region's total population to calculate the proportion of the regional population within 3 miles of a recreation opportunity. These proportions were multiplied by 100 to obtain percentages, which served as the raw scores for each watershed region.

$$Raw\ Score = \frac{Pop.within\ 3\ miles\ of\ Rec}{Total\ regional\ pop} * 100$$

Standards for this indicator are few; American Trails has set a goal of providing a trail network within 3 miles of 90% of Americans by 2020. We adopted this goal but extended it to any recreational opportunity (not just trails) and graded it such that, if a region achieved the goal, it would receive an ‘A’. Therefore, we scored linearly from 50% (score = 0) to 100% (score = 100) of the population within 3 miles of a recreation opportunity, placing the 90% goal at a score of 80 (i.e., the transition from B to A).

WRC Score	Raw Score
100% (A)	100%
0% (F)	50%

Table 12: Recreation access scale

Literature Cited

U.S. Geological Survey (USGS) Gap Analysis Project (GAP), 2024, Protected Areas Database of the United States (PAD-US) 4.1: U.S. Geological Survey data release, https://doi.org/10.5066/P96WBCHS.

Indicator: Visitor Satisfaction

Indicator Importance

The Verde River Watershed attracts thousands of visitors annually and is known for its excellent recreational opportunities. Using the U.S. Forest Service's National Visitor Use Monitoring Survey, we measured the proportion of people who were satisfied with their experience on Forest Service lands.

Data Source

U.S. Forest Service – National Visitor Use Monitoring (NVUM) surveys for:

- Tonto National Forest (2016)
- Prescott National Forest (2022)
- Coconino National Forest (2020)
- Kaibab National Forest (2020)

Calculation Method

NVUM surveys employed a five-point rating scale that ranged from (1) Very Satisfied, (2) Somewhat Satisfied, (3) Somewhat Dissatisfied, (4) Very Dissatisfied, or (5) Neither. Results that were Very Satisfied or Somewhat Satisfied passed (scoring 100%), while those that were Somewhat Dissatisfied, Very Dissatisfied, or Neither failed (scoring 0%). The 0–100% scores for each National Forest were weighted by area to produce a score for each region.

WRC Score	Survey Results
100% (A)	(1) Very Satisfied, (2) Somewhat Satisfied
0% (F)	(3) Somewhat Dissatisfied, (4) Very Dissatisfied, or (5) Neither

Table 13: Visitor satisfaction scale

Indicator: Recreation Planning

Indicator Importance

Sustainable recreation requires careful planning. For this indicator, we assessed the quality of recreation plans for land management agencies in the watershed that allow public recreation on their lands.

Data Source

Prescott National Forest - https://www.fs.usda.gov/main/prescott/landmanagement/planning
Kaibab National Forest - https://www.fs.usda.gov/detail/kaibab/landmanagement/planning/?cid=stelprdb5106605
Coconino National Forest - https://www.fs.usda.gov/main/coconino/landmanagement/planning
Tonto National Forest - https://www.fs.usda.gov/main/tonto/landmanagement/planning
US National Park Service - https://home.nps.gov/moca/getinvolved/planning.htm
Arizona State Parks - https://azstateparks.com/scorp
Arizona State Trust Land - does not exist

Calculation Method

The analysis of recreation planning focused on seven land managers with recreation control rights within the watershed: Tonto National Forest, Prescott National Forest, Coconino National Forest, Kaibab National Forest, Arizona State Lands Department, Arizona State Parks, and U.S. National Park Service. This analysis includes the Arizona State Lands Department, although it differs from federal agencies' operations in that the public obtains recreational access through permit purchases. We recognize that a large amount of recreation planning occurs at smaller spatial scales. The purpose of this metric was not to assess individual local plans but rather to evaluate the context in which they are developed. The evaluation scored the following factors:

1. **Existence and Ease of Access:** All points (20) went to agencies that made their recreation plans accessible online, but the complete absence of formal plans yielded zero (0) points.
2. **Date since Last Update:** Agencies received 20 points if they updated their plans in 2025. Two points were deducted each year after 2025 until the plan reached 10 years, at which point the score became 0.
3. **Needs Assessment**: Good recreation plans should describe the jurisdiction's recreation needs in the context of past planning and anticipated future conditions. Plans receive full credit (20) when they address the existing planning context. Plans receive a 0 if not addressed.
4. **Public Participation:** Public participation in plan development is a critical component of developing sustainable recreation plans that align with the community's needs. Public participation in plan-making processes earned 20 rating points, and plans without public involvement scored 0 points.
5. **Desired Conditions:** The types and intensity of recreation that a given location can support often vary throughout a jurisdiction. Plans that explicitly recognized this fact and established site-specific desired recreation conditions were given 20 points.

The 0–100 scores for each entity were weighted by area to produce a regional score.

Appendices

Appendix 1 – Depth to Groundwater Technical Memo

TECHNICAL MEMORANDUM

DATE:	June 20, 2024
TO:	Selena Pao and Travis Buck, The Nature Conservancy; Tracy Stephens, Friends of the Verde River
FROM:	Esther Adelstein and Christian Braudrick, Stillwater Sciences
SUBJECT:	Verde River Watershed Report Card Groundwater Level Indicator Methodology

The Verde River Watershed is an important source of water for residents and biota of central Arizona. The University of Maryland Center for Environmental Science, Friends of the Verde River, and The Nature Conservancy (UMCES et al. 2020) developed a report card for a wide array of indicators to assess watershed health in three categories: habitat, communities, and water. Baseflow was used to evaluate water quantity in 2020, and the authors of the report card would like to include groundwater levels as an additional indicator for water quantity. Groundwater is a critical source for perennial flow in the Verde River and water supply for communities in the Verde River Watershed.

To support this objective, Stillwater Sciences, in consultation with The Nature Conservancy and Friends of the Verde River, developed groundwater level indicator grading methodology for the water quantity category of the Verde River Watershed Report Card (WRC). The groundwater level indicator grading methodology was developed with the goal of quantifying different groundwater level conditions throughout the watershed, ranging from undesirable (a grade of "F") to desirable (a grade of "A"). This methodology was used to calculate the 2020 WRC groundwater level indicator grades and is intended to be used for updated grades in 2025 and 2030. The methodology and 2020 WRC groundwater level indicator grades are described below.

Background

The Verde River WRC tracks the condition of water quantity, quality, and management, habitat, and communities within the Verde River Watershed. The report card provides a letter grade for each of 20 indicators in seven watershed regions, listed from north to south: (1) Big and Little Chino, (2) Upper Verde, (3) Upper Verde Valley, (4) Oak Creek, (5) Lower Verde Valley, (6) Wild and Scenic, and (7) Lower Verde (UMCES et al. 2020, Figure 1-1).

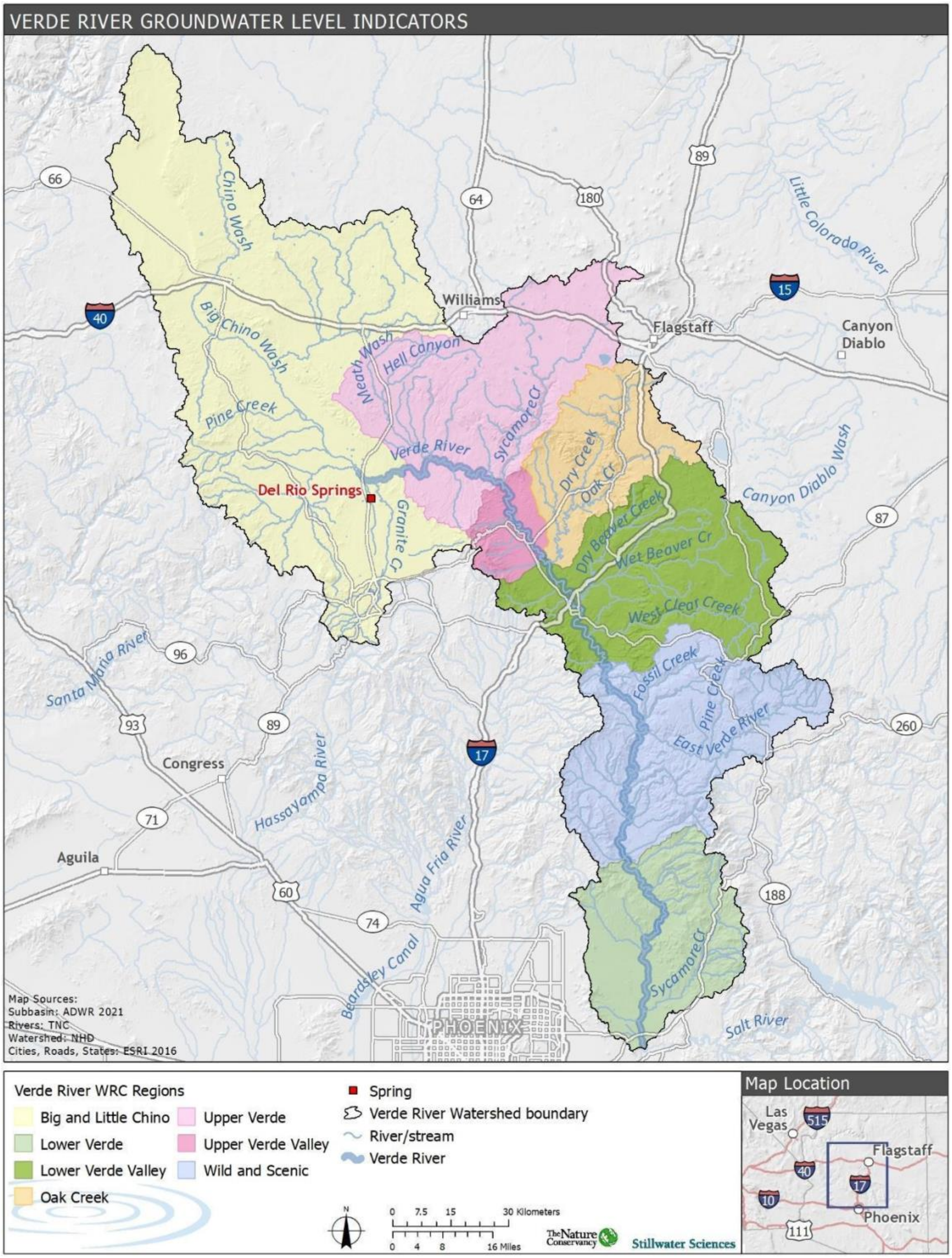

Figure 0-1. Map of Verde River watershed and WRC regions.

Hydrology and Hydrogeology

The Verde River is a tributary of the Salt River in the Colorado River Watershed. The majority of the Verde River Watershed's 6,615-square-mile area is located in Yavapai County, Arizona, and the watershed extends from the Hualapai Reservation in the north to just east of the city of Mesa at the confluence with the Salt River (Figure 1-1). A series of ephemeral washes in the Prescott-Chino Valley area and the Big Chino Wash drainage comprise its headwaters region. The Verde River is perennial from a group of springs near the mouth of Granite Creek to the confluence with the Salt River; historically, the perennial reach began approximately five miles upstream at Del Rio Springs (Figure 1-1). Groundwater discharge in the upper Verde Valley contributes to baseflow throughout the Verde River (Haney et al. 2008, Wirt et al. 2005).

Population growth and groundwater development in the Verde River Watershed has accelerated since 1980 (Haney et al. 2008). Prior to 1980, agricultural groundwater pumping, particularly in the Big and Little Chino region, altered the hydrology of the area compared with predevelopment conditions. Agricultural pumping has decreased from historical levels, but pumping for domestic use has increased (Blasch et al. 2006, Bills et al. 2007). Modeling indicates that groundwater pumping in the upper and middle watershed (Big and Little Chino, Upper Verde, Upper Verde Valley, Oak Creek, and Lower Verde Valley regions) has resulted in depletion of Verde River flows, reducing baseflow by about 10,000 acre-feet per year at the downstream end of the Verde Valley (Garner et al. 2013).

The Verde River Watershed is located in the Transition Zone structural province between the relatively undeformed Colorado Plateau province and the Basin and Range province, which underwent severe deformation during Tertiary-period tectonic uplift, rifting, and extension (Wirt et al. 2005, Blasch et al. 2006). The Coconino Plateau sub-province, a component of the Colorado Plateau, covers approximately 2,500 square miles in the northern portion of the watershed. The sub-province reaches Big Black Mesa in the Big and Little Chino region, occupying just under half the region's area. Farther south, it extends to the Mogollon Rim over the northeastern halves of the Upper Verde and Lower Verde Valley regions and most of the Oak Creek region. The remainder of the basin is within the Transition Zone, characterized by mountainous regions of crystalline and consolidated sedimentary rocks with alluvium-filled basins deformed by faulting, uplift, and volcanic activity (Blasch et al. 2006).

The following sections describe the primary aquifers[1] in each WRC region.

Big and Little Chino Region

The majority of the Big and Little Chino Region overlies the Verde River groundwater basin. The northwestern end of the region overlies part of the Peach Springs basin, and the southern end of the region overlies part of the Prescott Active Management Area (AMA)[2] (ADWR 2021). There are three major aquifers in the Big and Little Chino Region: the Big Chino basin-fill aquifer, the Little Chino basin-fill aquifer, and the Redwall-Muav (Paleozoic carbonate) aquifer beneath the Coconino Plateau. The basin-fill aquifers are productive and highly heterogeneous. Alluvial deposits (including a fine-grained playa deposit) and buried volcanic units comprise the Big Chino basin-fill aquifer. Groundwater discharges from the Big Chino near Paulden, where the basin is bounded by highly permeable basalts and underlain by the moderately permeable Redwall-Muav aquifer. The Big Chino Fault forms the northeastern edge of the valley. The Big Chino basin-fill aquifer is hydraulically connected to the Redwall-Muav aquifer

[1] Saturated water-bearing geologic units.

[2] The 1980 Arizona Groundwater Code designated areas with heavy reliance on groundwater as AMAs. AMAs are subject to regulation of groundwater extraction.

beneath the Coconino Plateau, with groundwater exchange potentially occurring at the bottom of the basin-fill aquifer, through alluvial fans along the base of Big Black Mesa (the upthrown side of the Big Chino Fault), or through fractures in the Big Chino fault zone (Wirt et al. 2005).

The Little Chino basin-fill aquifer is a complex sequence of alluvial and volcanic deposits with both confined and unconfined groundwater conditions and a maximum thickness of over 700 ft. Several units produce artesian[3] flow. Buried plugs of volcanic material restrict subsurface flow of groundwater and contribute to discharge from the Little Chino basin-fill at Del Rio Springs. The basin-fill aquifer reaches thicknesses of over 1,200 ft (Blasch et al. 2006).

On the Coconino Plateau, groundwater occurs primarily in units of the Redwall-Muav aquifer, the overlying C aquifer (an extensive sequence of saturated units between the Redwall-Muav and younger volcanic units), and in perched zones within alluvium and the volcanic units that cap the plateau (Bills et al. 2007).

Upper Verde, Upper Verde Valley, and Lower Verde Valley

The Upper Verde, Upper Verde Valley, and Lower Verde Valley regions are located within the Verde River groundwater basin. The primary aquifers in these regions are the Redwall-Muav aquifer of the Coconino Plateau and basin-fill sediment. The Tertiary Verde Formation, which consists of fluviolacustrine deposits interbedded with gravel and basalt flows, is the primary basin-fill water-bearing unit. This formation is up to 2,000 feet thick in some areas of the basin. The lacustrine deposits include several limestone facies, which may be confined by sandstone and mudstone facies. The Verde Formation is overlain by a thin (<70 feet) layer of highly permeable Quaternary alluvium, which yields water to shallow wells (Blasch et al. 2006).

Oak Creek

The Oak Creek region is located within the Verde River groundwater basin. Wells in this region produce from both the Redwall-Muav aquifer and the Middle and Upper Supai Group (the deepest units of the C aquifer). The Redwall-Muav aquifer is approximately 250 feet thick in this region (Blasch et al. 2006, Bills et al. 2007).

Wild and Scenic

The Wild and Scenic region overlies the Verde River groundwater basin. The Verde mainstem in the Wild and Scenic region is much less developed than upstream reaches and its hydrogeology not as well studied. Most wells in this region are in Payson, approximately 20 miles east of the river. Payson relies heavily on a fractured Proterozoic granite aquifer for its water supply, while wells in the Strawberry and Pine area, northwest of Payson, tap the Redwall-Muav aquifer (Parker et al. 2005).

Lower Verde

The northeastern half of the Lower Verde region overlies the Verde River groundwater basin, while the southwestern half overlies the Phoenix AMA. In the Lower Verde region, downstream of Bartlett Dam, wells are clustered at Fountain Hills, where the regional aquifer is composed of two units: the shallow

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[3] Groundwater confined under pressure that will rise above the top of the aquifer when tapped by a well.

floodplain aquifer and underlying conglomerate unit. The two units are connected only locally and are generally separated by silt and the Pemberton Clay Formation. Artesian conditions have been observed in wells reaching the deeper unit (Slotnicki et al. 2003), suggesting that the units are disconnected in parts of the subarea.

Groundwater Data

To evaluate groundwater level conditions in each of the WRC regions, we used publicly available data from the Arizona Department of Water Resources (ADWR) Groundwater Site Inventory (GWSI) to assess changes in groundwater elevation through time. The methods used to assess the data are described below.

Data Sources

The GWSI is ADWR's repository for statewide groundwater data and includes well location and groundwater elevation data (ADWR 2021). GWSI wells within the WRC regions were identified in a geographic information system (GIS) (Figure 2-1). Water level data were downloaded from the GWSI[4] for all ADWR groundwater basins that overlap the watershed (Peach Springs, Prescott AMA, Verde River, and Phoenix AMA basins). The WRC scoring considers both discrete water level measurements (typically collected on a quarterly, semiannual, or annual basis) and automated water level measurements (typically collected four times per day at 33 GWSI wells in the Verde River Watershed). The majority of wells with automated water level measurements are located in the Big and Little Chino area. Daily average automated water level measurements are used for WRC scoring.

Well Selection

WRC grading for the groundwater level indicator is based on comparison of groundwater level conditions during the report card period to baseline groundwater level conditions. Following the baseflow indicator methodology, the groundwater level indicator defines the baseline period as Water Year (WY) 2006 through WY 2018. The WRC baseflow indicator baseline period was determined by stakeholder input during development of the WRC (UMCES et al. 2020). The report card period is defined as the two most recent complete water years at the time of report card scoring. However, because the 2020 report card scores are calculated retroactively and a report card period of WYs 2018 and 2019 would overlap with the baseline period, WYs 2019 and 2020 were selected as the report card period for the 2020 WRC.

Of the GWSI wells within the Verde River Watershed, only wells with four or more static water level[5] measurements during the baseline period and one or more static water level measurements during the report card period were selected for WRC grading. The selected wells are shown on Figure 2-1. The number of selected wells per region ranges from 10 wells in the Lower Verde region to 137 wells in the Big and Little Chino region (Table 2-1). The selected wells represent about eight percent of the wells in the watershed. The record for most selected wells begins in the 1990s. Approximately 25% of selected wells have data prior to 1975, and the oldest record is from 1938. The period of record for approximately 20% of wells begins after 2000.

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[4] https://app.azwater.gov/gwsi/SearchGWSI.aspx

[5] The elevation of the water table under normal, non-pumping conditions. Static water level measurements are indicated by blank *REMARK_CODE* field in the GWSI (ADWR 2021)

Table 0-1. Number of GWSI and selected wells by WRC region.

WRC Region ID	WRC Region	Number of GWSI wells	Number of GWSI wells selected for 2020 WRC
1	Big and Little Chino	884	137
2	Upper Verde	197	11
3	Upper Verde Valley	305	13
4	Oak Creek	436	18
5	Lower Verde Valley	686	22
6	Wild and Scenic	248	19
7	Lower Verde	101	10
-	*Total*	*2,857*	*230*

Data Gaps

Figure 2-1 illustrates spatial gaps in GWSI coverage, as well as in coverage of selected wells. Notable spatial gaps are along the Verde River in the Wild and Scenic and Upper Verde regions.

While the GWSI contains well depth and/or perforated interval for a limited number of wells, the aquifer in which most wells are screened is unknown. Additionally, the aquifers are highly heterogeneous, so a single well cannot be assumed to represent conditions throughout a particular aquifer. Ranges and trends in groundwater elevations may vary among aquifers and are likely affected by pumping. Each WRC region encompasses multiple aquifers with a wide range of groundwater elevations observed at wells within each region (Figure 2-2). The range of groundwater levels for the entire period of record (including years prior to baseline) varies between approximately one foot to over 100 feet in some regions.

There are also temporal data gaps. Water level measurements are not collected every year at all wells, and there are multi-year gaps during the baseline period at some wells.

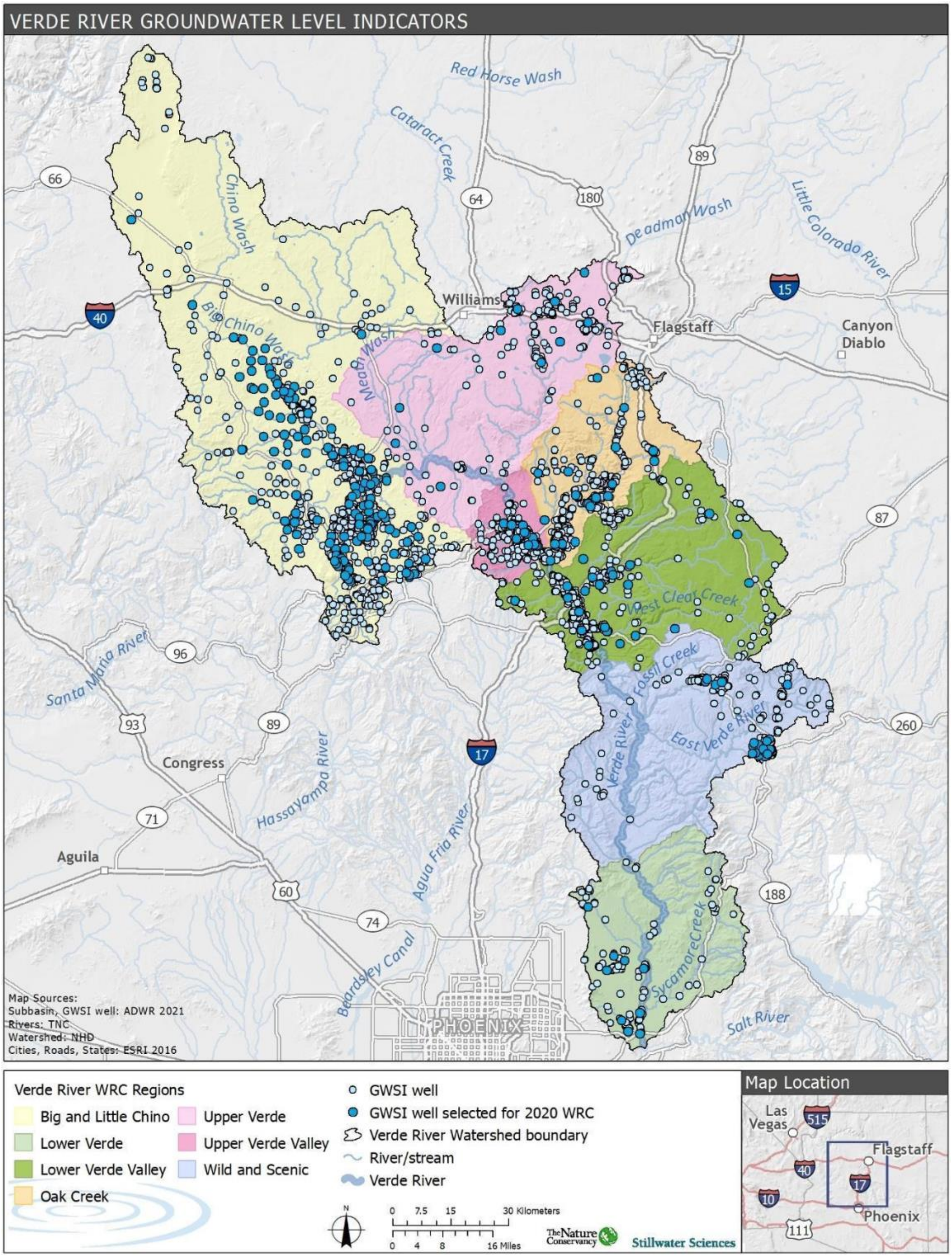

Figure 0-2. Map of Verde River WRC regions, ADWR GWSI wells, and ADWR GWSI wells selected for 2020 WRC grading based on data availability.

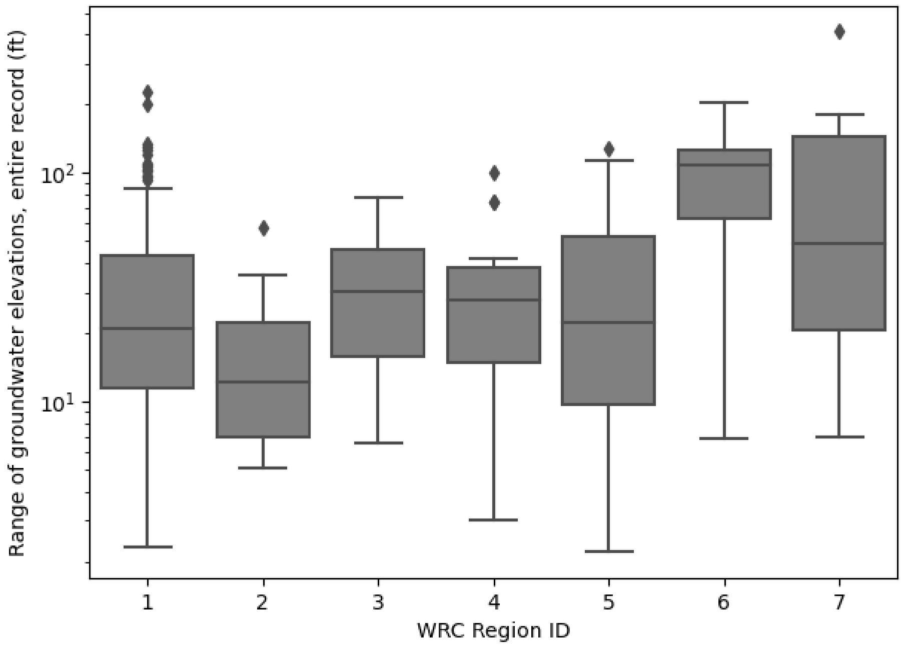

Figure 0-3. Box-and-whisker plots of the range of groundwater elevations at each well within a WRC region. The upper and lower boundaries of the boxes denote the 75th and 25th percentiles, respectively, and the horizontal lines within the boxes denote the median. Whiskers denote 1.5 times the interquartile range. Diamonds denote outliers (1.5 times the interquartile range above the third quartile or below the first quartile).

Grading Methodology

The goal of WRC grading is to quantify groundwater level conditions ranging from undesirable (grade "F") to desirable (grade "A") for each region of the Verde River Watershed (Table 3-1). Groundwater level conditions for each letter grade are based on comparison of groundwater elevation magnitudes in the baseline and report card periods, rather than trends. Groundwater levels may not change monotonically over the baseline and/or report card periods, so the magnitude and direction of a linear trend may vary depending on the period over which the trend is calculated. Measurement frequency is too low at most GWSI wells for robust trend analysis over multiple time periods.

Table 0-2. Summary of groundwater level conditions by letter grade.

Letter Grade	Groundwater Level Conditions
A	• Stable groundwater elevation • Report card elevation above baseline range
B	• Report card elevation in upper baseline range
C	• Report card elevation in middle baseline range
D	• Report card elevation in lower baseline range
F	• Report card elevation below baseline range

Ideally, groundwater data would be tied to individual aquifers for each region. However, due to gaps in spatial coverage and well perforation data, there is not enough information to aggregate wells by aquifer and set groundwater elevation thresholds by aquifer or WRC region. Wells are instead graded individually, and the grades are aggregated by WRC region following the procedure below.

Data availability at each GWSI well in the Verde River Watershed is evaluated using the criteria outlined in Section 2.2: four or more measurements in the baseline period and one or more measurements in the report card period are required for grading.

The distribution of groundwater elevations during the baseline period is evaluated for each well that meets the criteria in Step 1.

The percentile score of the median groundwater elevation during the report card period compared to the baseline distribution is computed, giving a score between 0 and 100 for each well that meets the criteria in Step 1, unless:

> the report card median is below the baseline 90th percentile but within one foot of the baseline 90th percentile. In this case, groundwater elevation is considered stable and the well receives a score of 90, regardless of percentile.

The scores for wells that meet the criteria in Step 1 are averaged by WRC region to compute a score for each region.

The average score is converted to a letter grade.

Figure 3-1 shows an example of a well where the report card median is the 0th percentile of the baseline distribution and receives a score of 0. Figure 3-2 shows an example of a well with stable groundwater elevation that receives a score of 90.

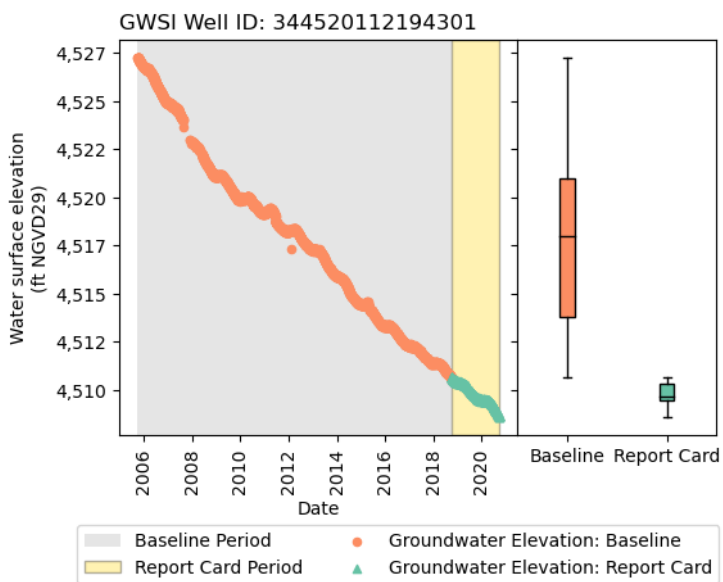

Figure 0-4. 2020 WRC grading analysis for GWSI Well 344520112194301. The percentile score of the Report Card period median compared to the Baseline period distribution is 0, and the well score is 0. Data prior to the baseline period are omitted from plots and scoring.

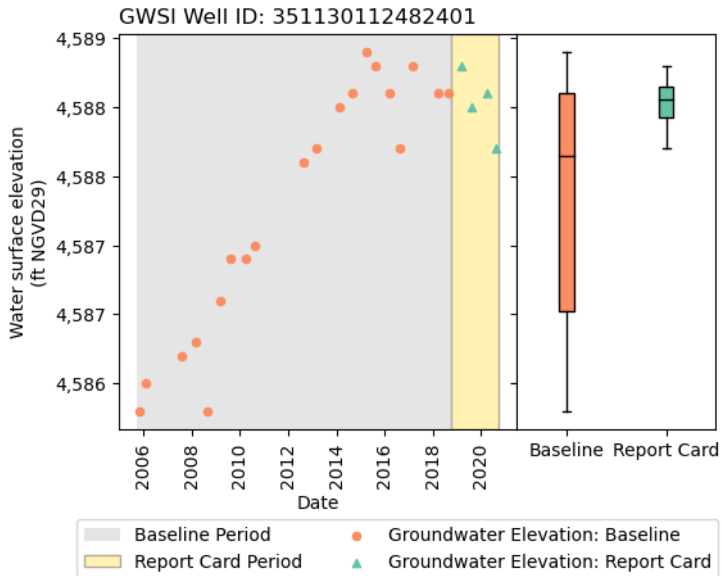

Figure 0-5. 2020 WRC grading analysis for GWSI Well 351130112482401. The percentile score of the Report Card period median compared to the baseline period distribution is 65. The median report card elevation was within one foot of the 90th percentile baseline elevation, so the well receives an adjusted score of 90, consistent with approximately stable groundwater levels from 2013 through 2020. Data prior to the baseline period are omitted from plots and scoring.

The score for a WRC region is calculated as the mean of well scores for wells within the region. All wells are weighted equally in this calculation, with no adjustments based on number of measurements at each well. The overall watershed score is calculated as the mean of the seven regional mean scores, so all regions have equal weight regardless of number of wells. Scores are equated to letter grades using the rubric in Table 3-2.

Table 0-3. Equating percentile scores to letter grades for each region.

Letter Grade	Mean Percentile Score
A+	95 to 100
A	85 to 94
A-	80 to 84
B+	75 to 79
B	65 to 74
B-	60 to 64
C+	55 to 59
C	45 to 54
C-	40 to 44
D+	35 to 39
D	25 to 34
D-	20 to 24
F	0 to 19

2020 Report Card Results

Table 4-1 shows 2020 WRC scores and grades by region. Baseline and report card period data and scores for individual wells are presented in Appendix A and Appendix B, respectively. The 2020 WRC indicates that groundwater levels in WYs 2019 and 2020 are generally in the lower end of baseline ranges (WYs 2006 through 2018) in the Big and Little Chino and Lower Verde regions, within baseline ranges in the Upper Verde, Upper Verde Valley, Oak Creek, and Lower Verde Valley regions, and in the upper end of the baseline range in the Wild and Scenic region.

As described in Section 2.3 and shown on Figure 2-1, there is a gap in well coverage along the Verde River in the Wild and Scenic region, with WRC wells in the region clustered near Payson. The Wild and Scenic region's "B-" grade indicates that groundwater levels are generally in the upper end of the baseline range near Payson, which may reflect recharge from Payson's Green Valley Park water reclamation project. The project has recharged approximately 400 acre-feet per year, roughly 25% of Payson's municipal water use, to the fractured granite aquifer since the project was completed in 1998 (Joiner and Eden 2020). The region's grade may not accurately capture groundwater level conditions closer to the Verde River mainstem.

Table 0-4. 2020 WRC scores and letter grades.

WRC Region ID	WRC Region	Letter Grade	Mean Score	Number of GWSI Wells Selected for WRC	Standard Error of Well Scores
1	Big and Little Chino	D	32	137	3.1
2	Upper Verde	C+	57	11	9.9
3	Upper Verde Valley	C+	55	13	10.1
4	Oak Creek	C	50	18	6.8
5	Lower Verde Valley	C	48	22	7.4
6	Wild and Scenic	B-	62	19	6.8
7	Lower Verde	D	27	10	7.2
-	*Overall*	*C*	*47*	*230*	*5.1*[a]

[a] Overall standard error calculated using a sample size of 7 WRC regions as opposed to total wells because the overall score is the mean of the 7 watershed scores.

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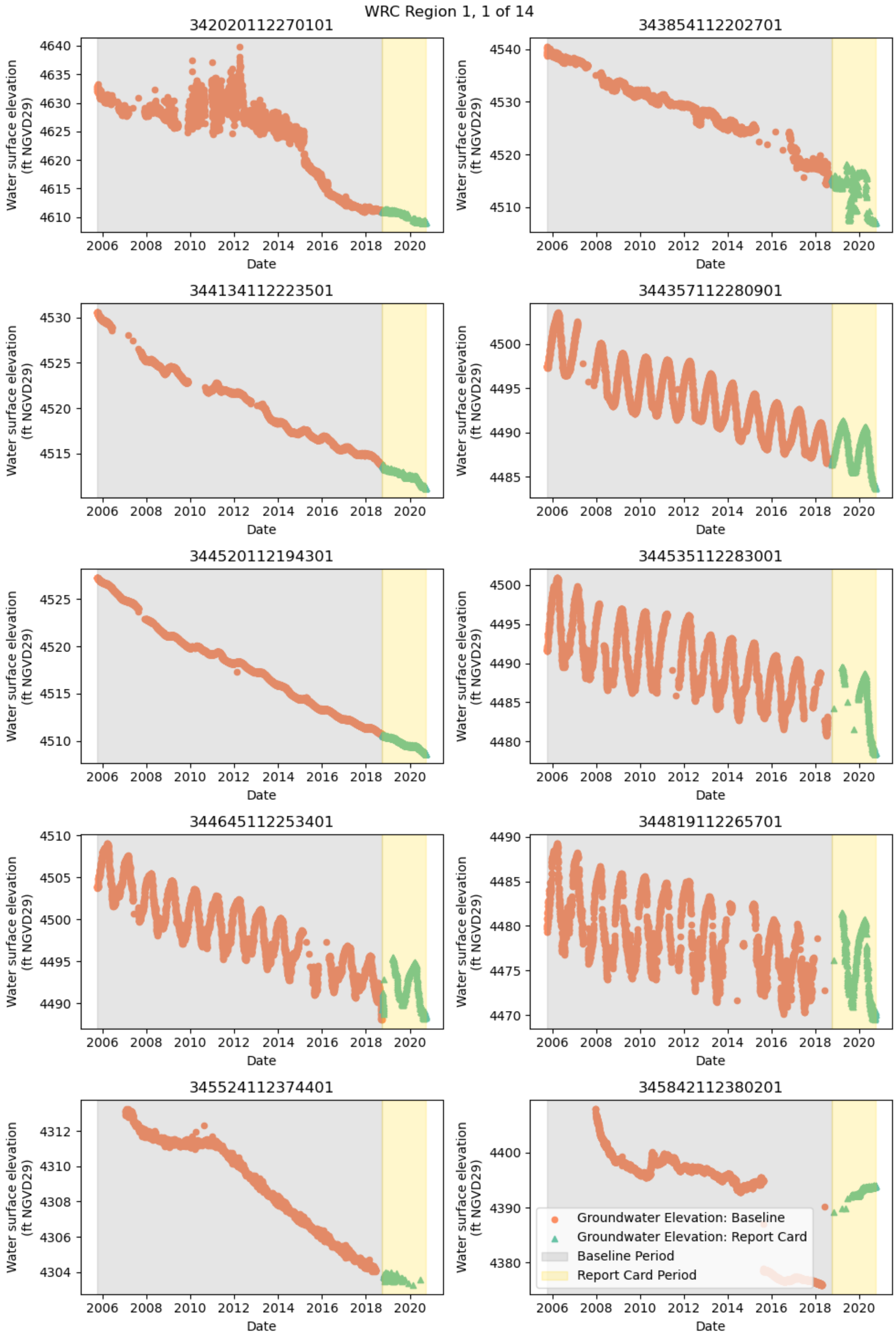
Memo Appendices

Appendix A

2020 Verde Watershed Report Card

Well data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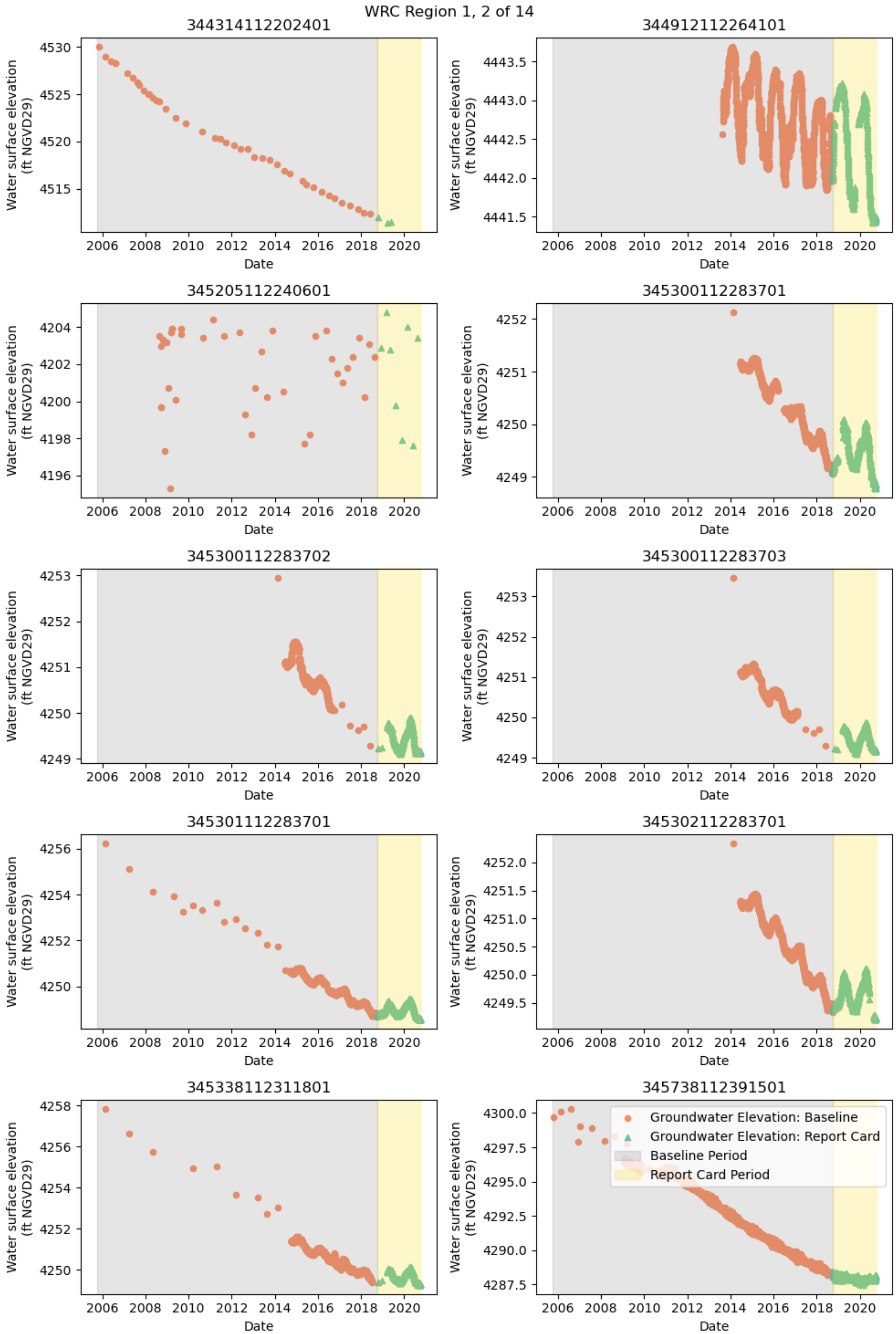
Groundwater Elevation: Report Card
Baseline Period
Report Card Period



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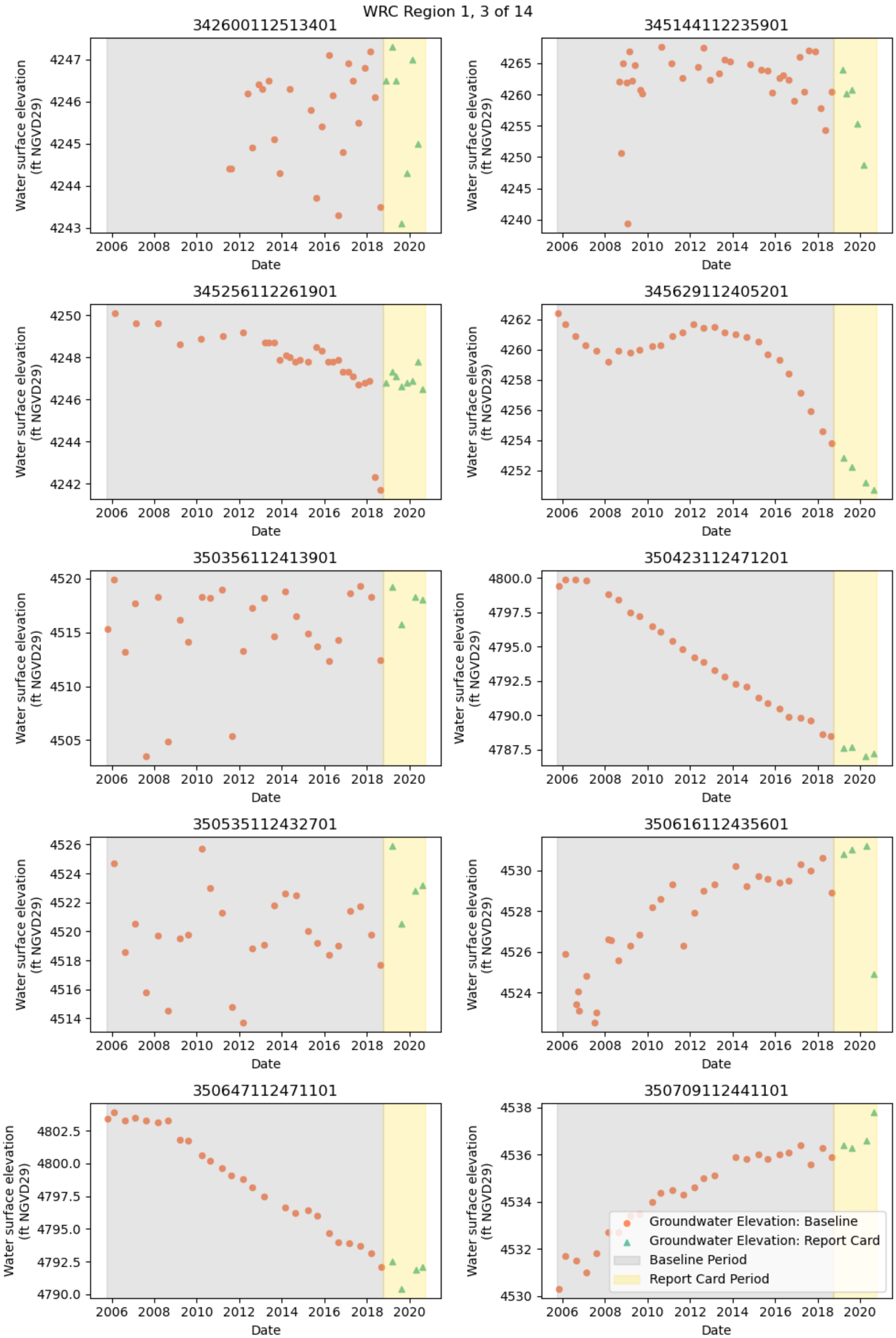
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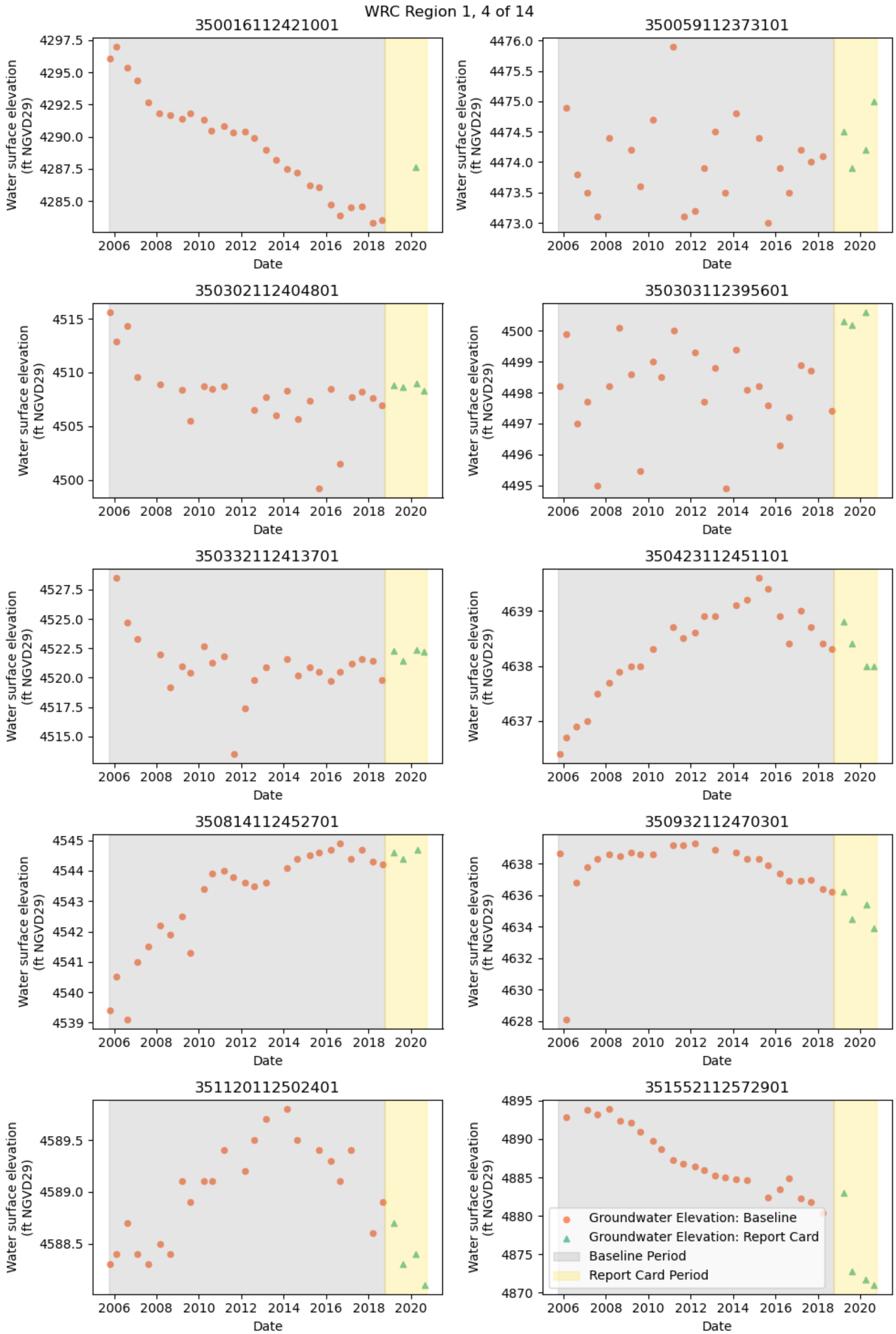
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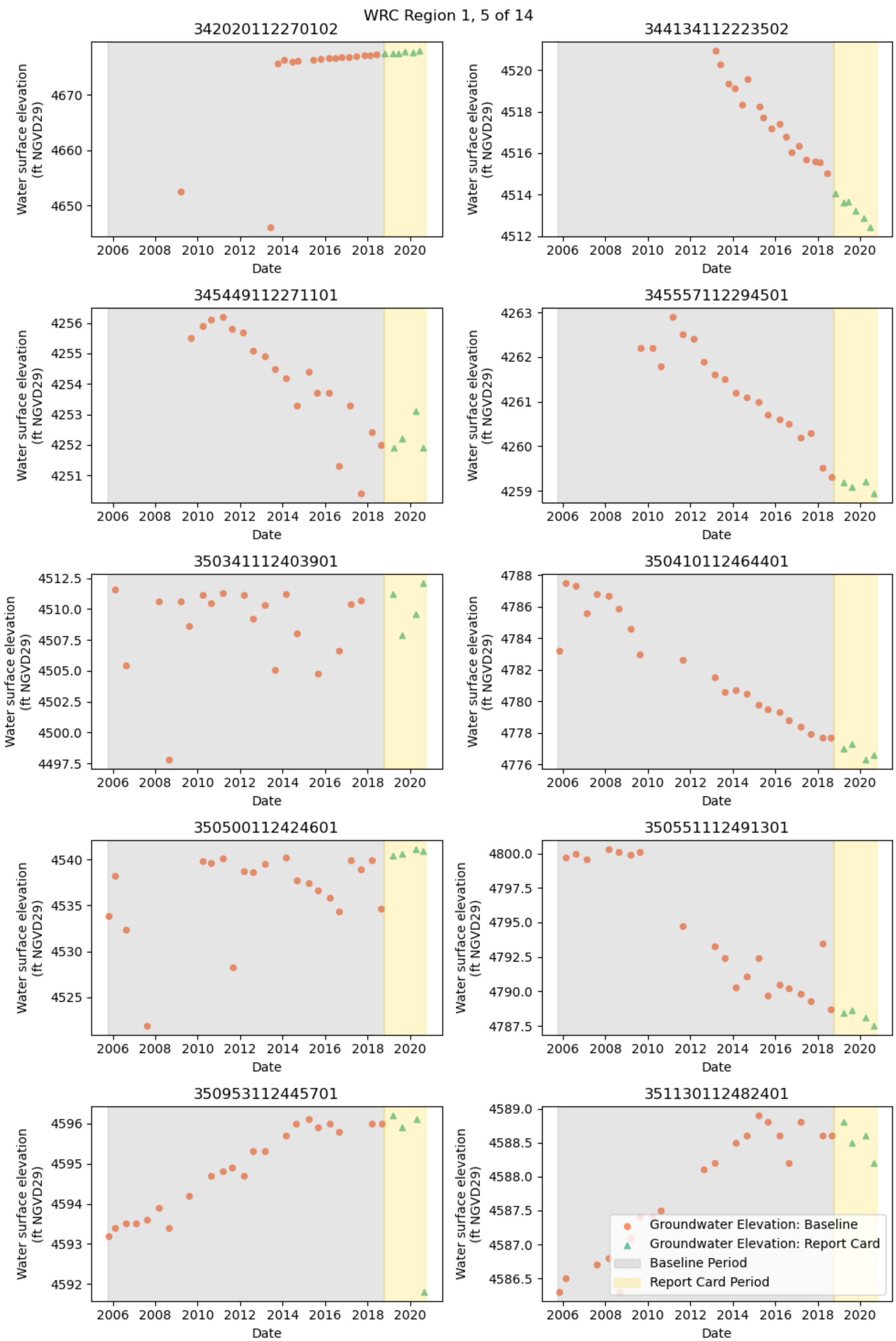
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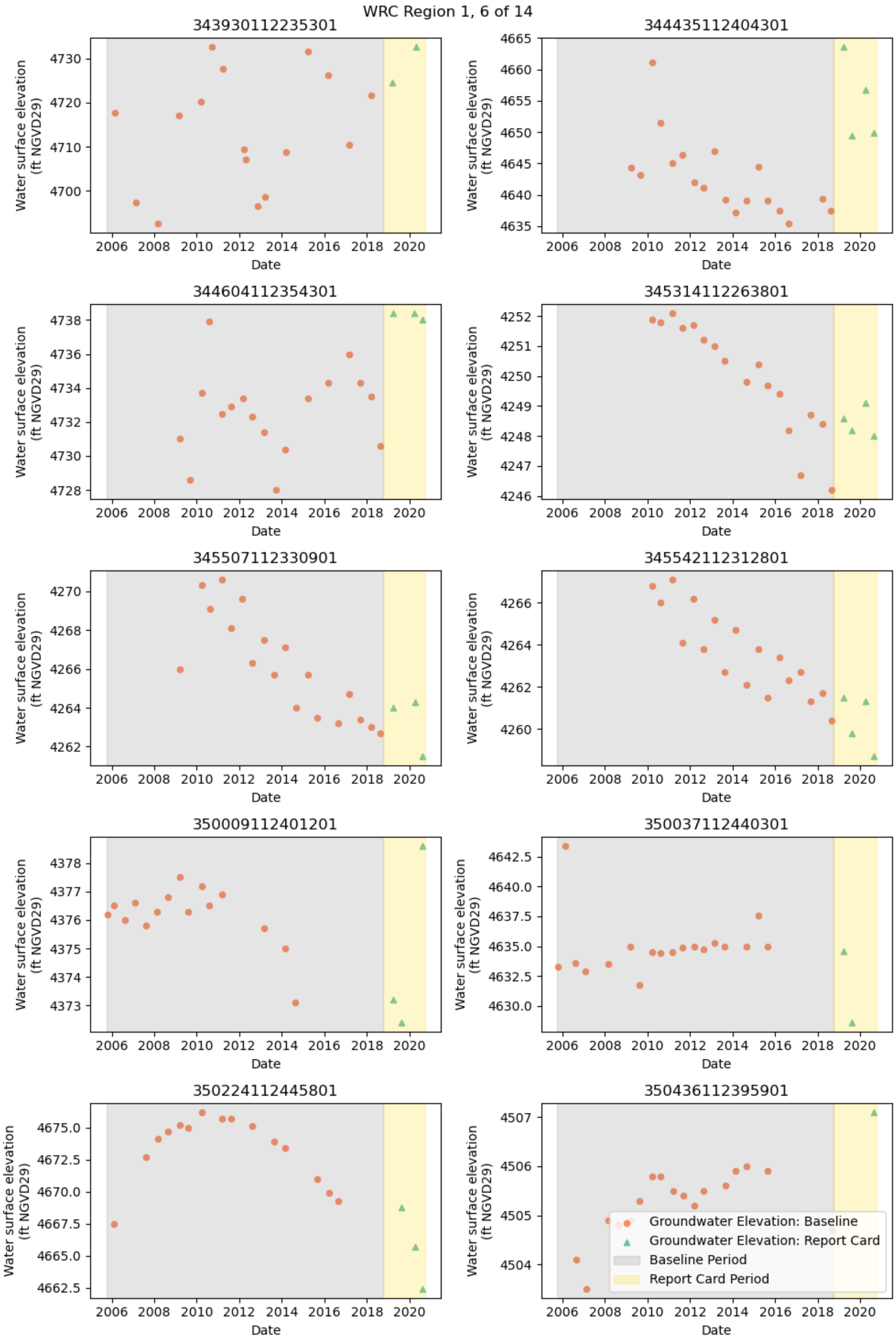
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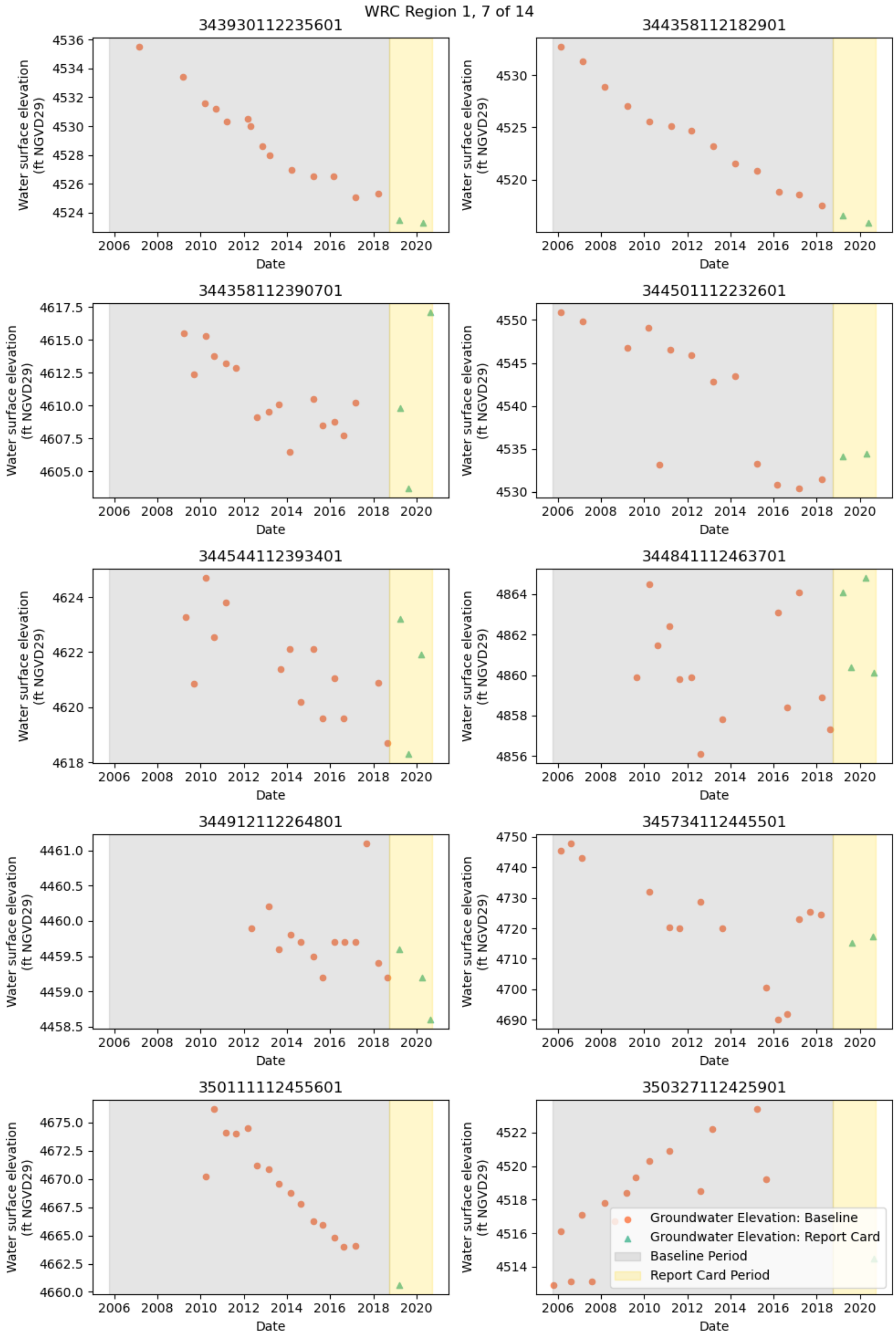

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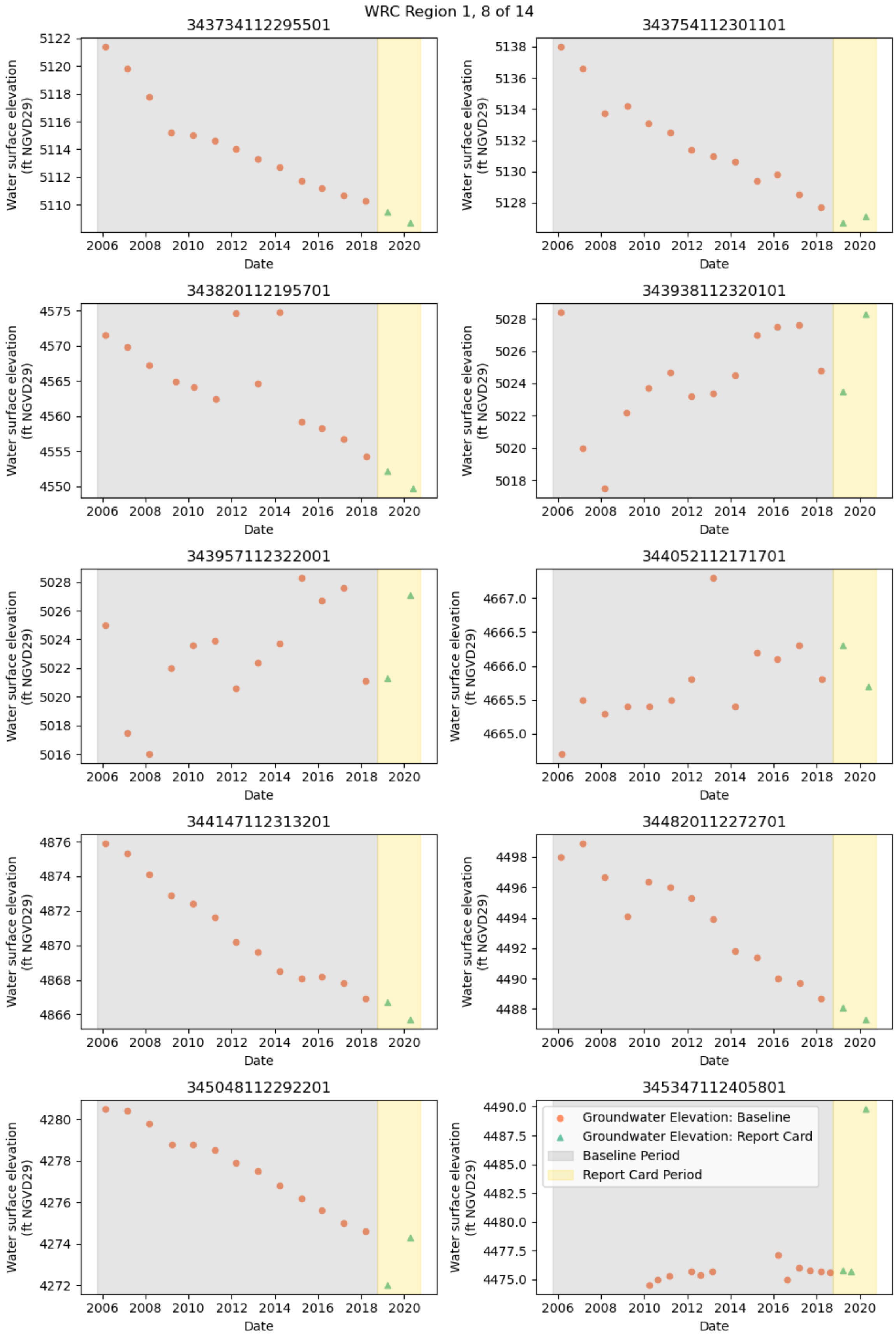
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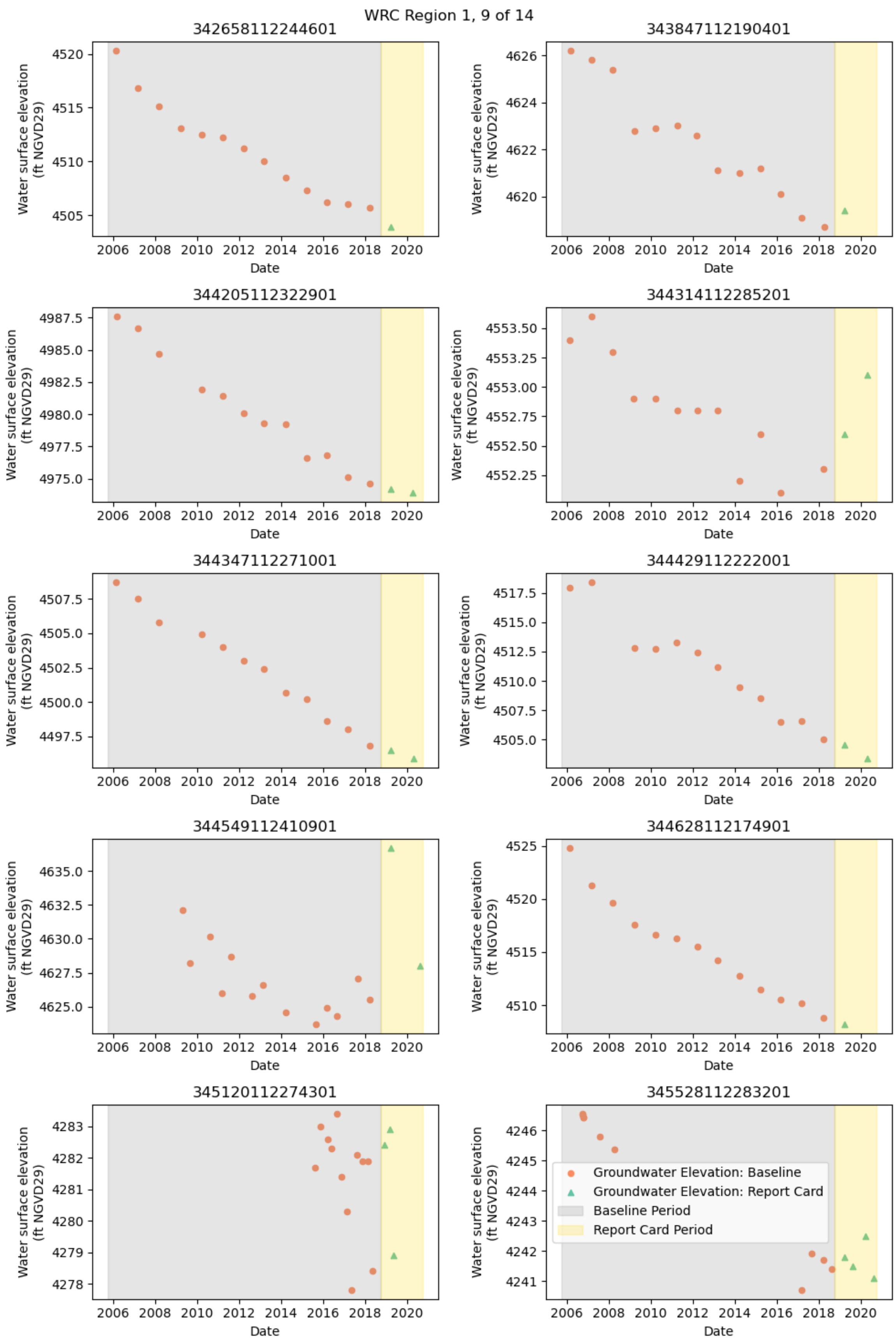
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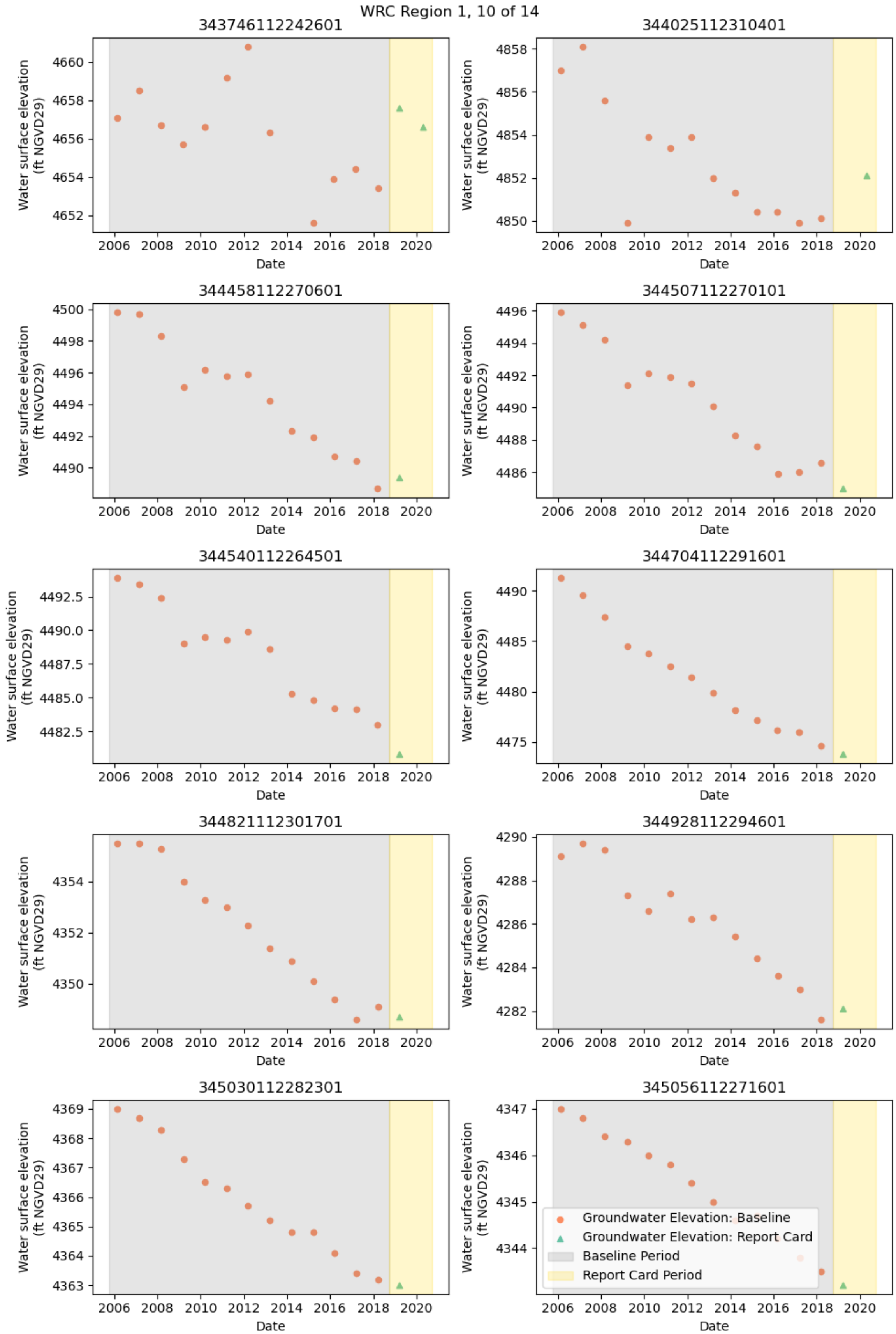
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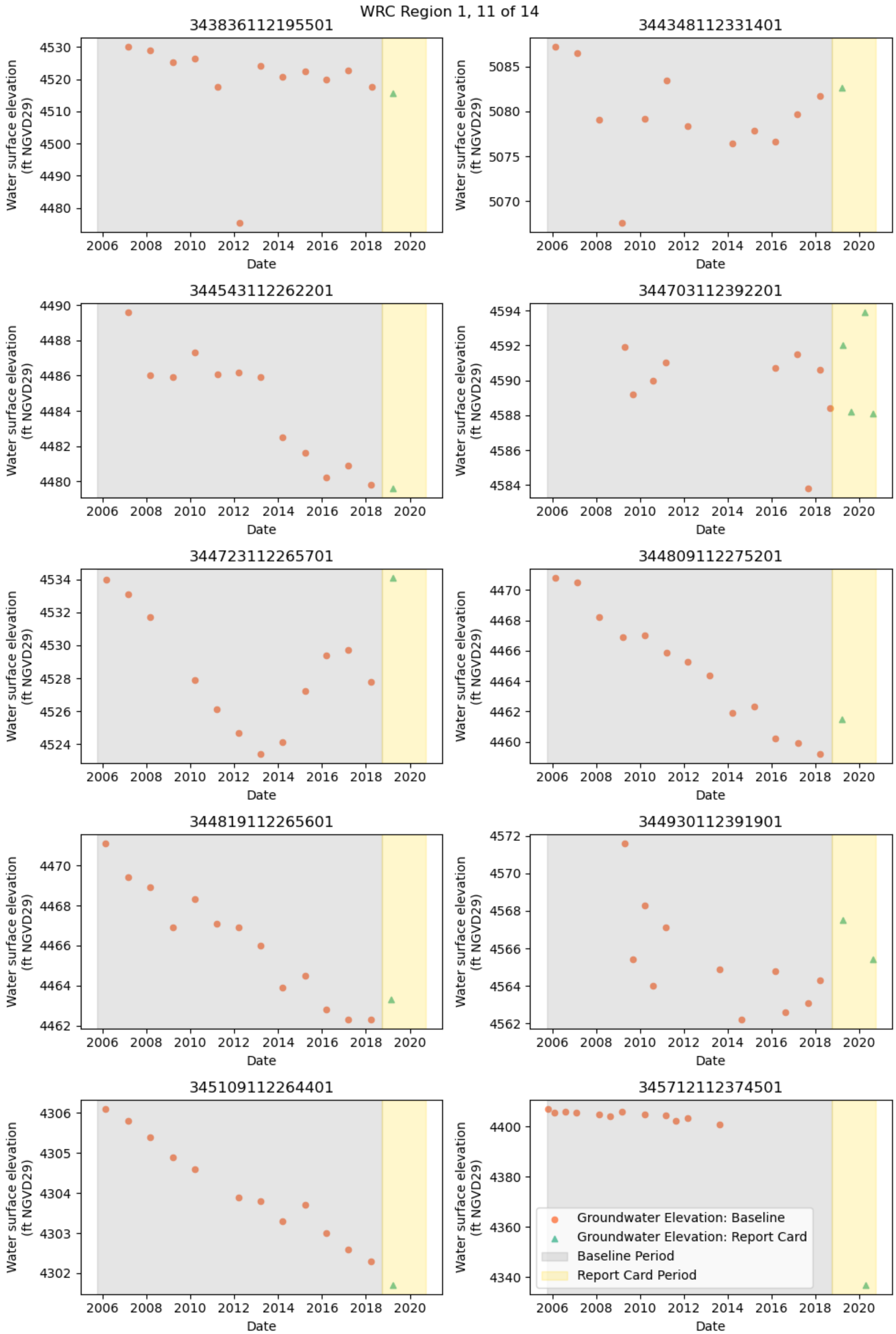
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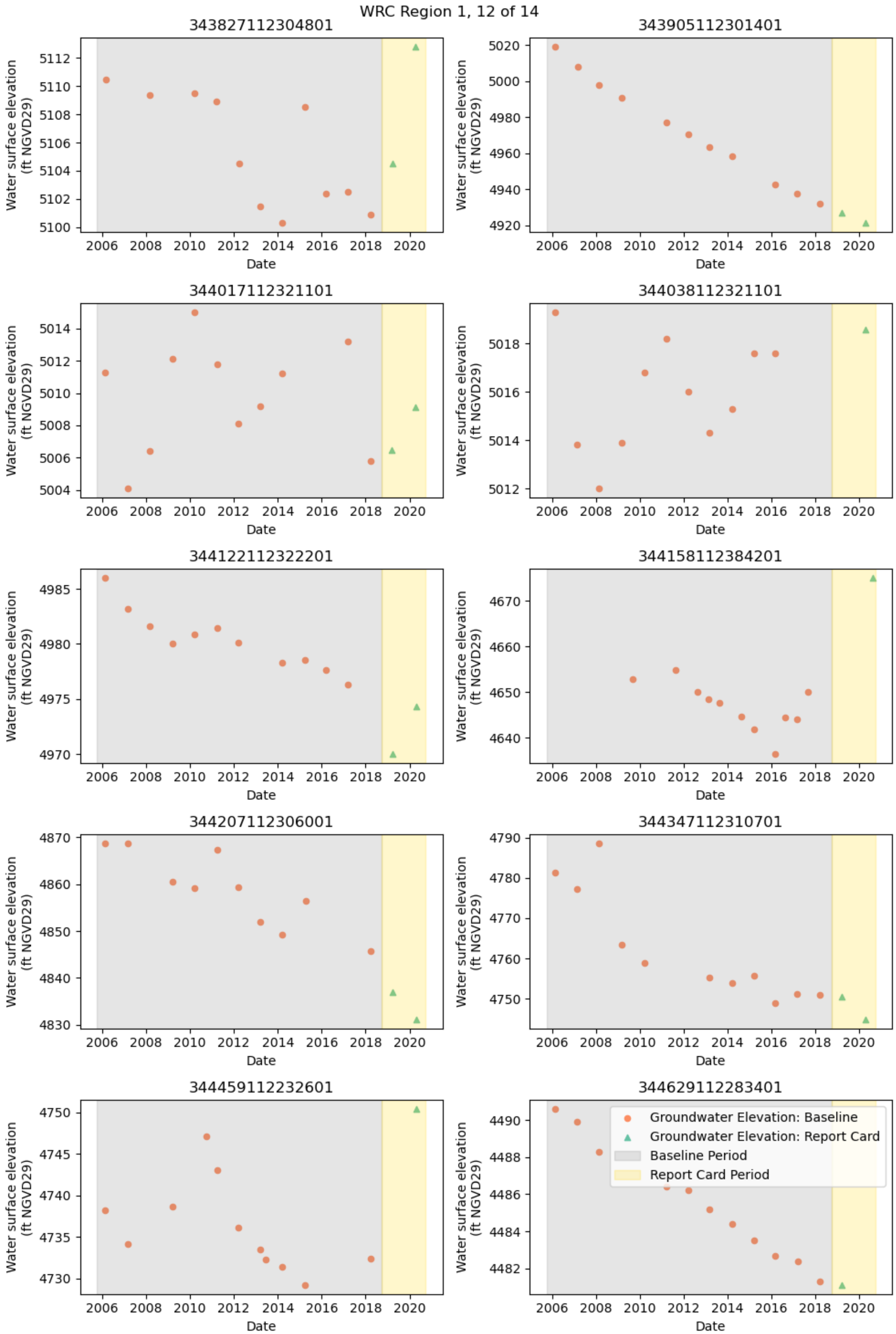
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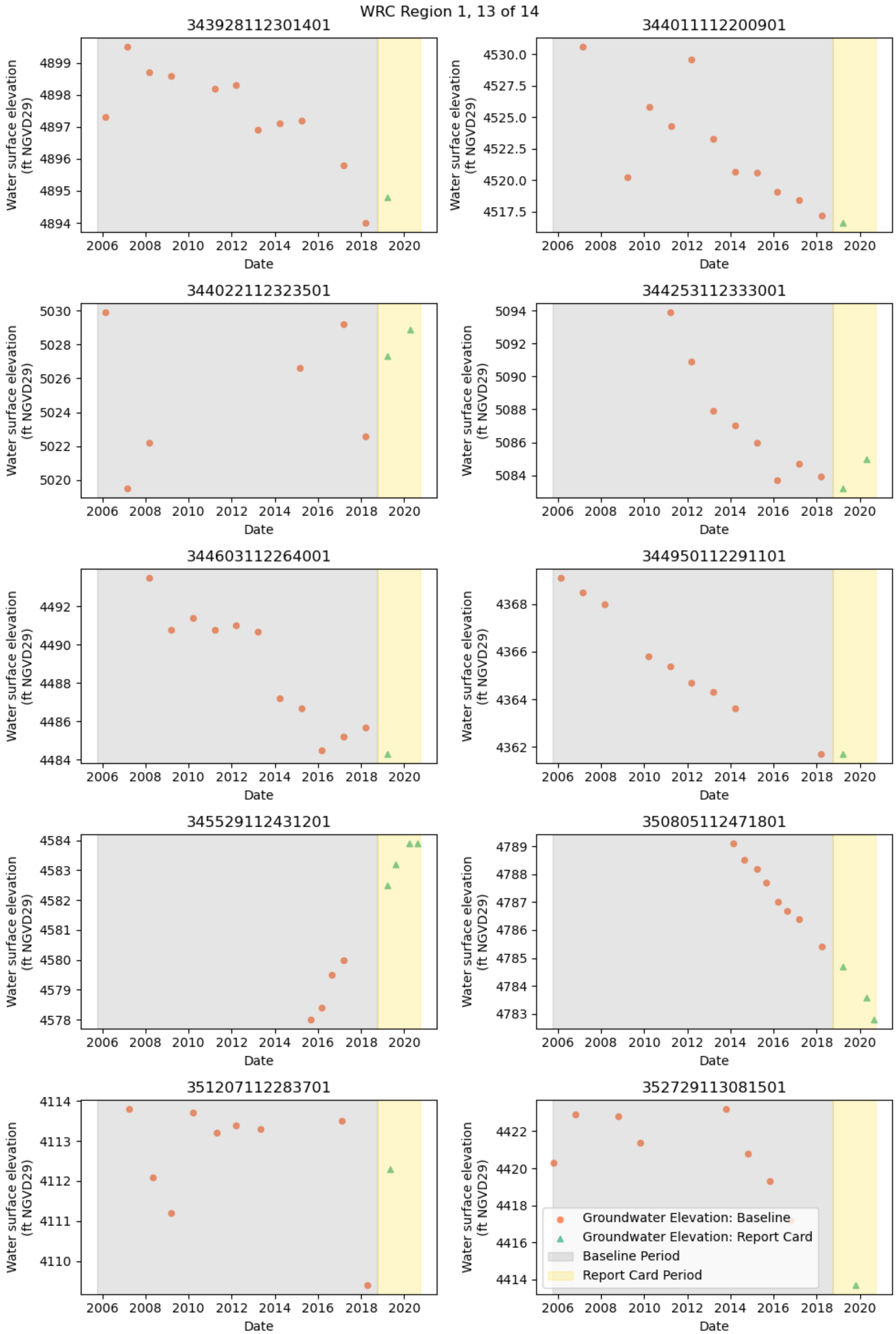
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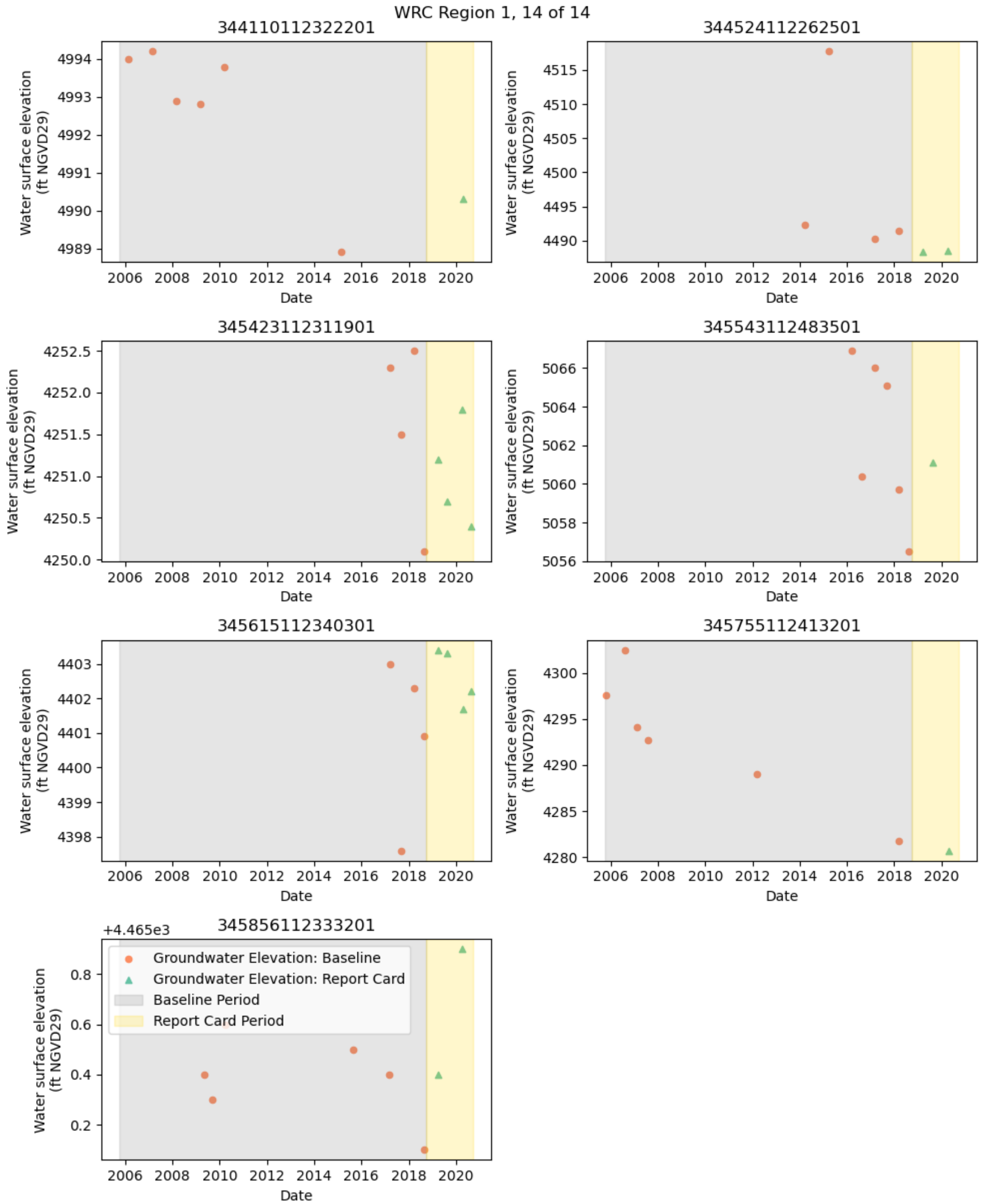
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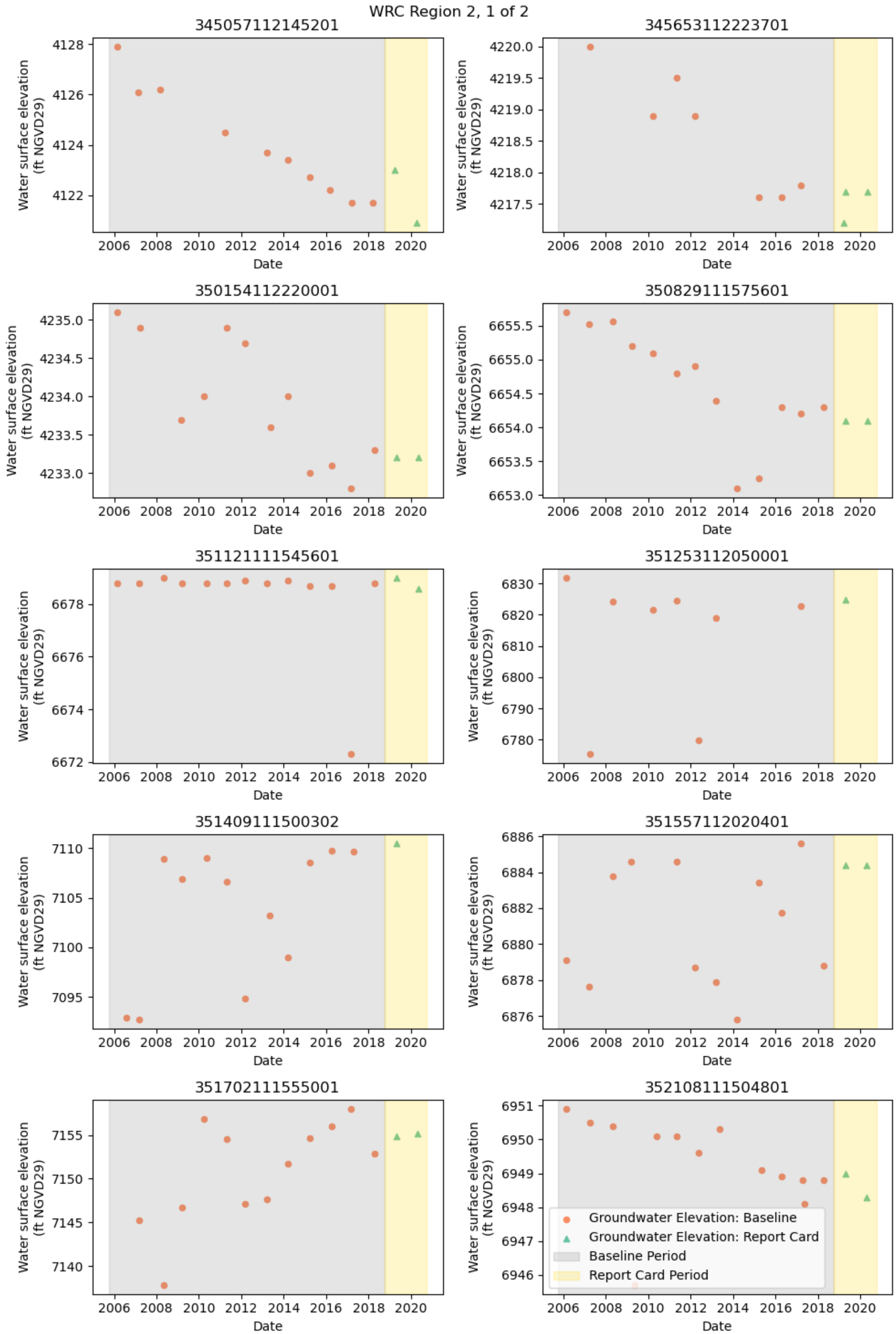
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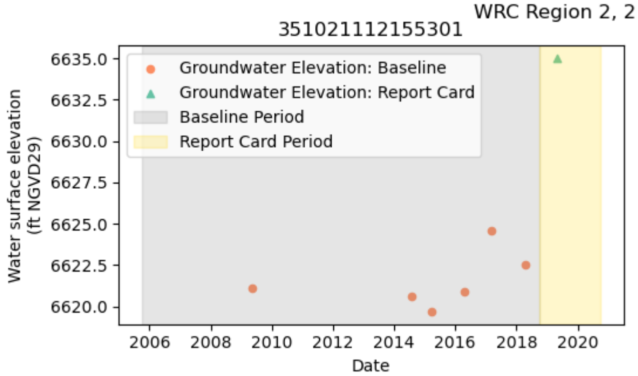
Report Card Period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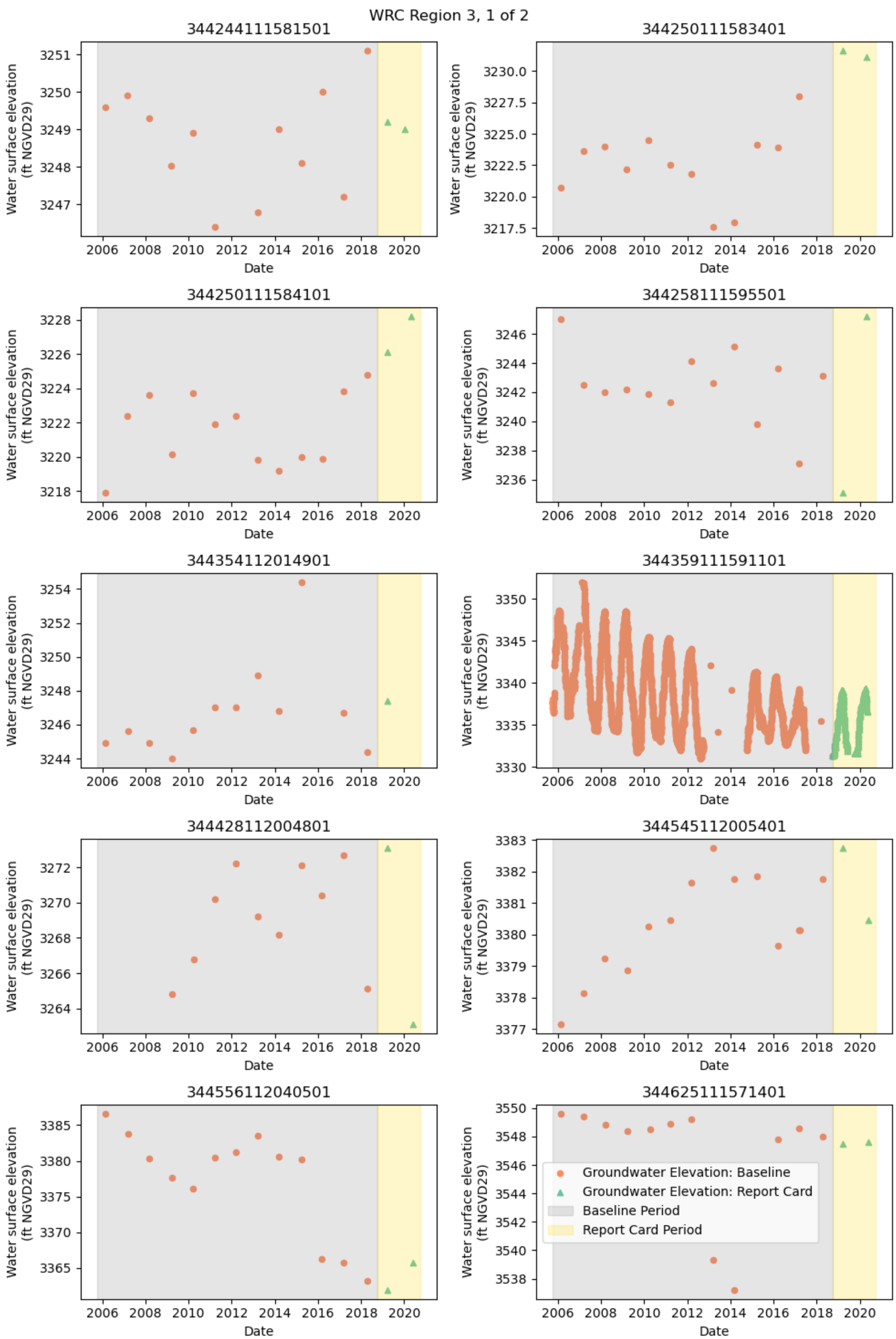
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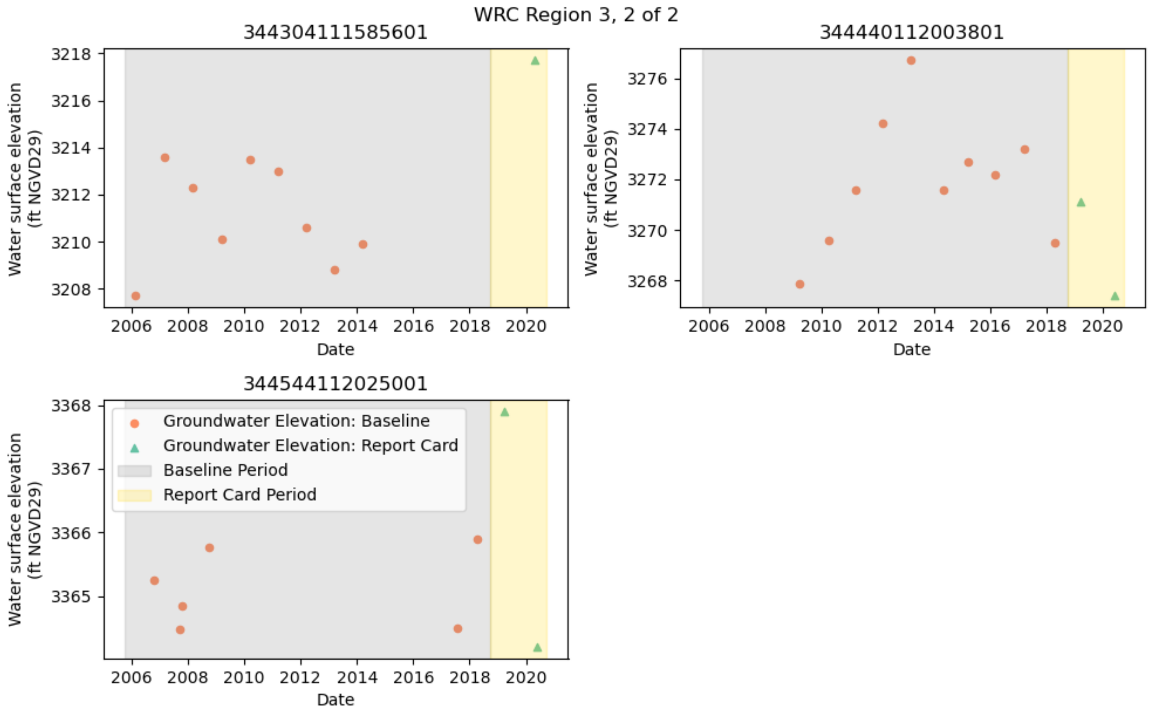
Report Card Period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(ft NGVD29)
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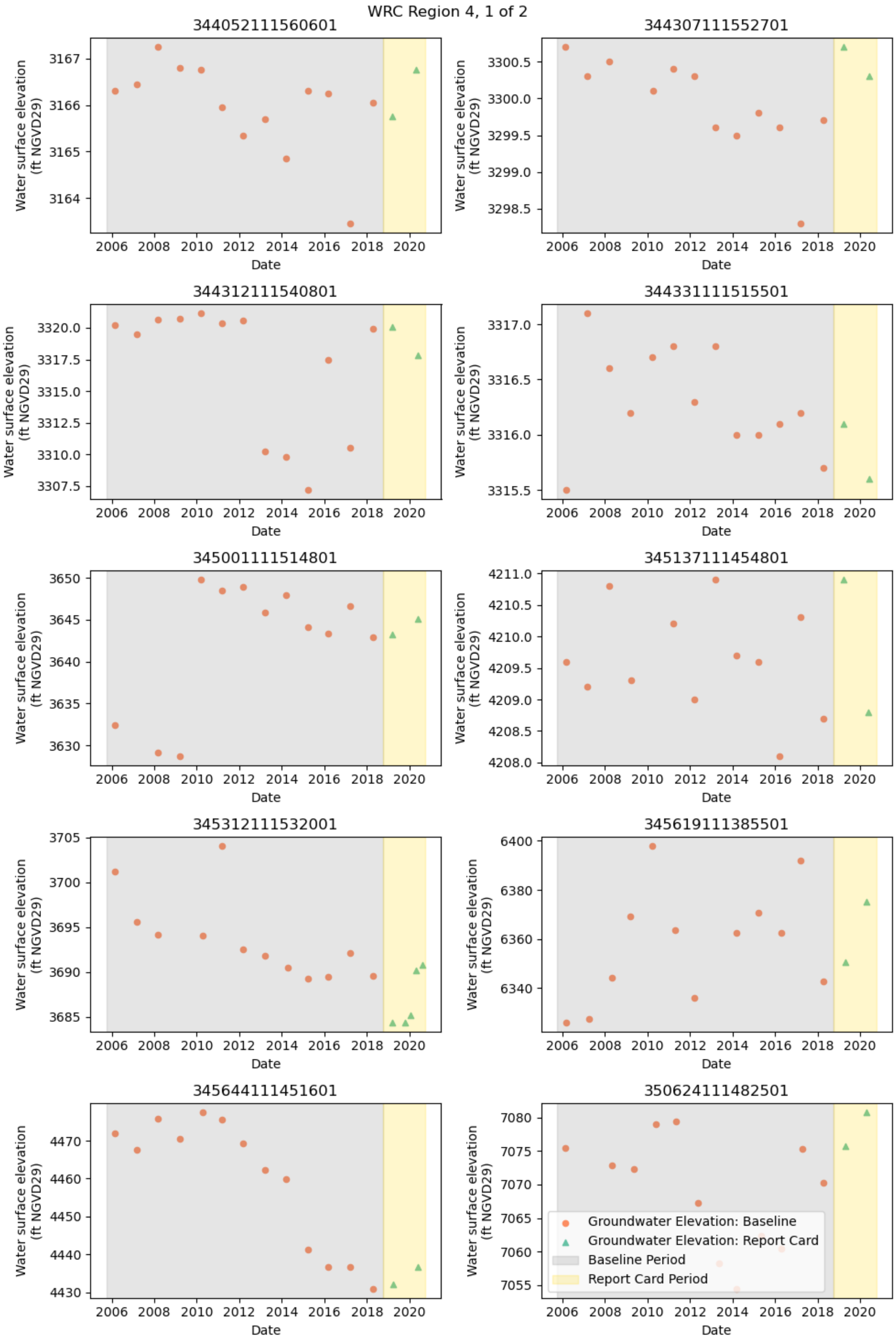
Baseline Period
Report Card Period


WRC Region 4, 1 of 2
344052111560601
344307111552701
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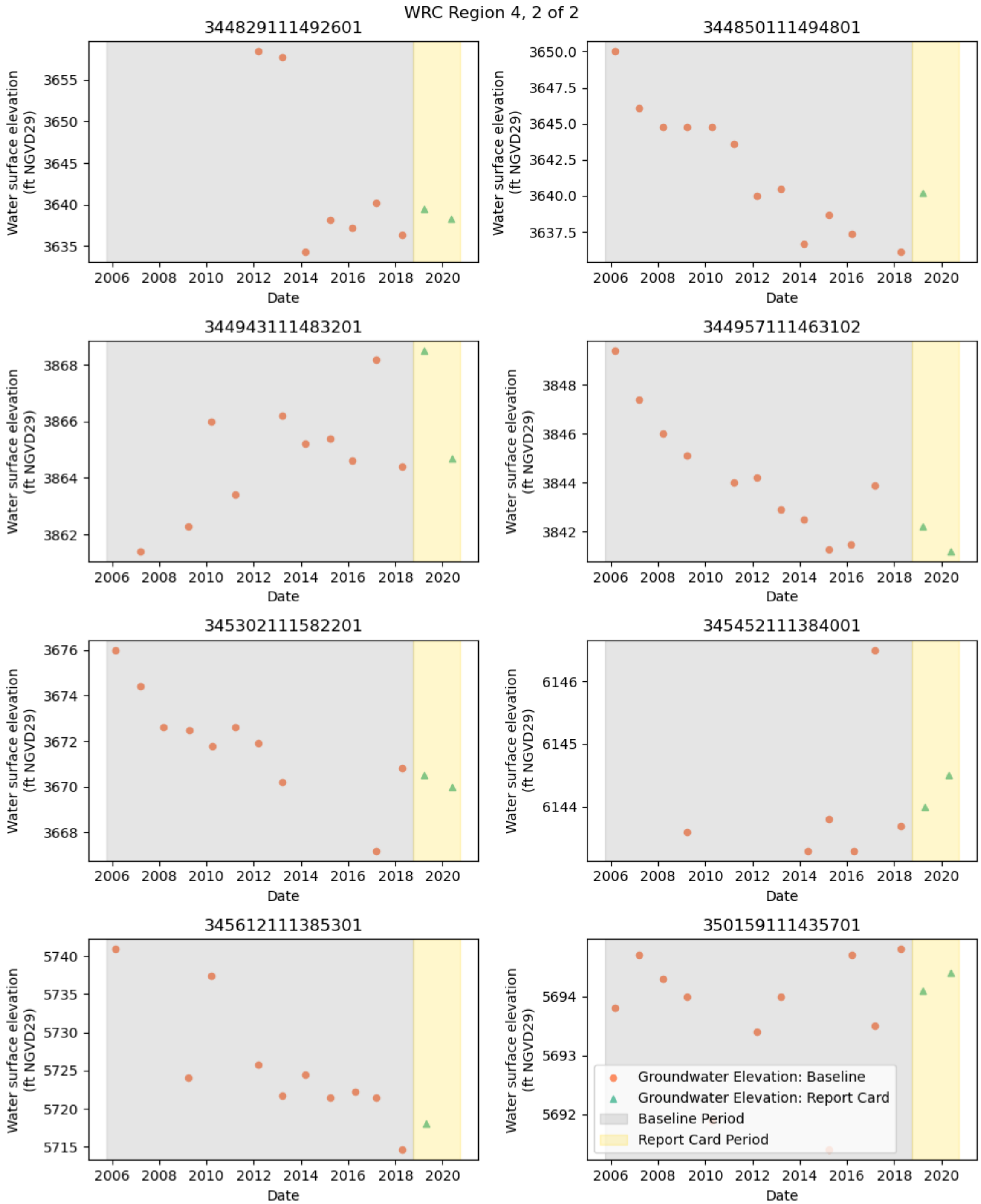
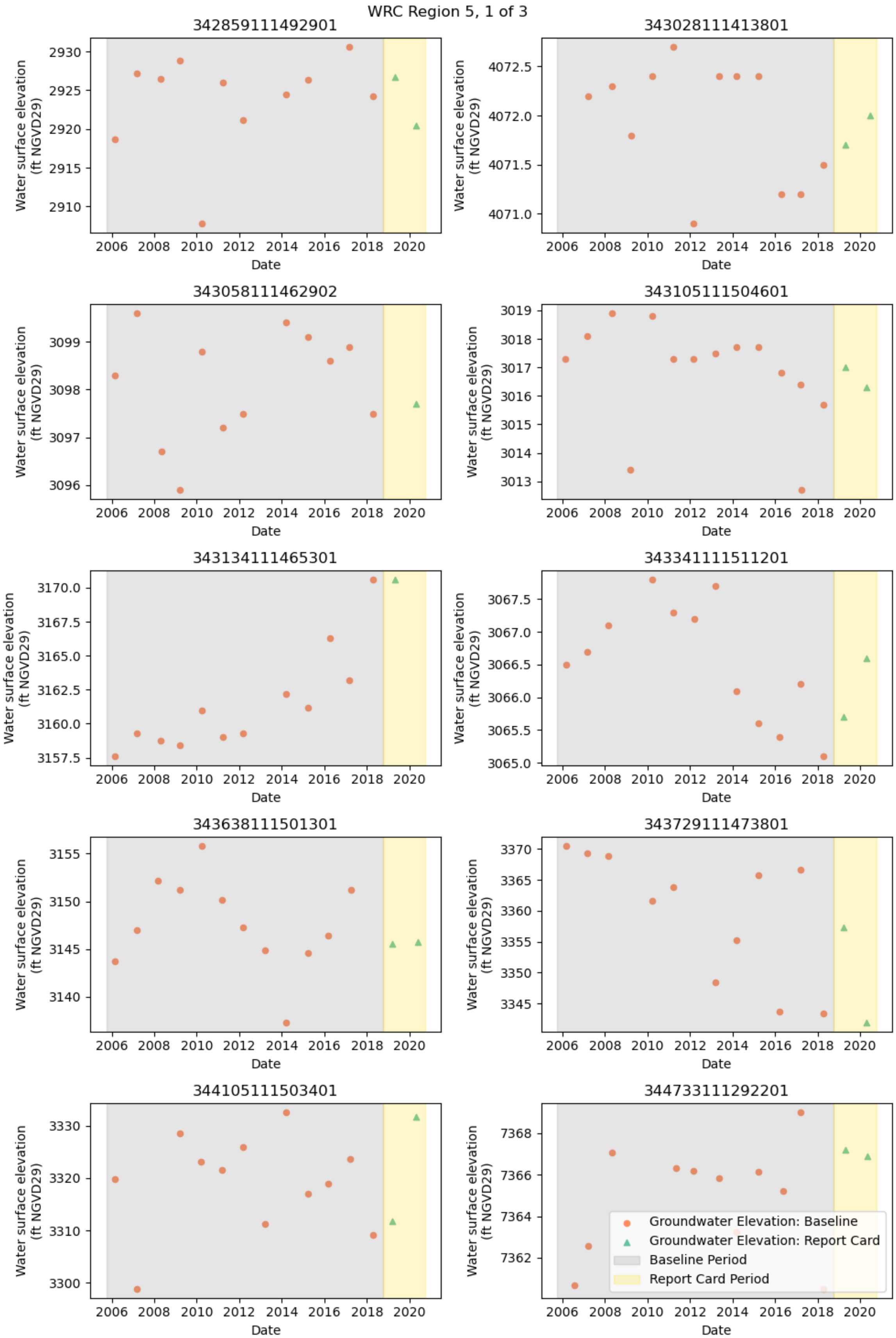
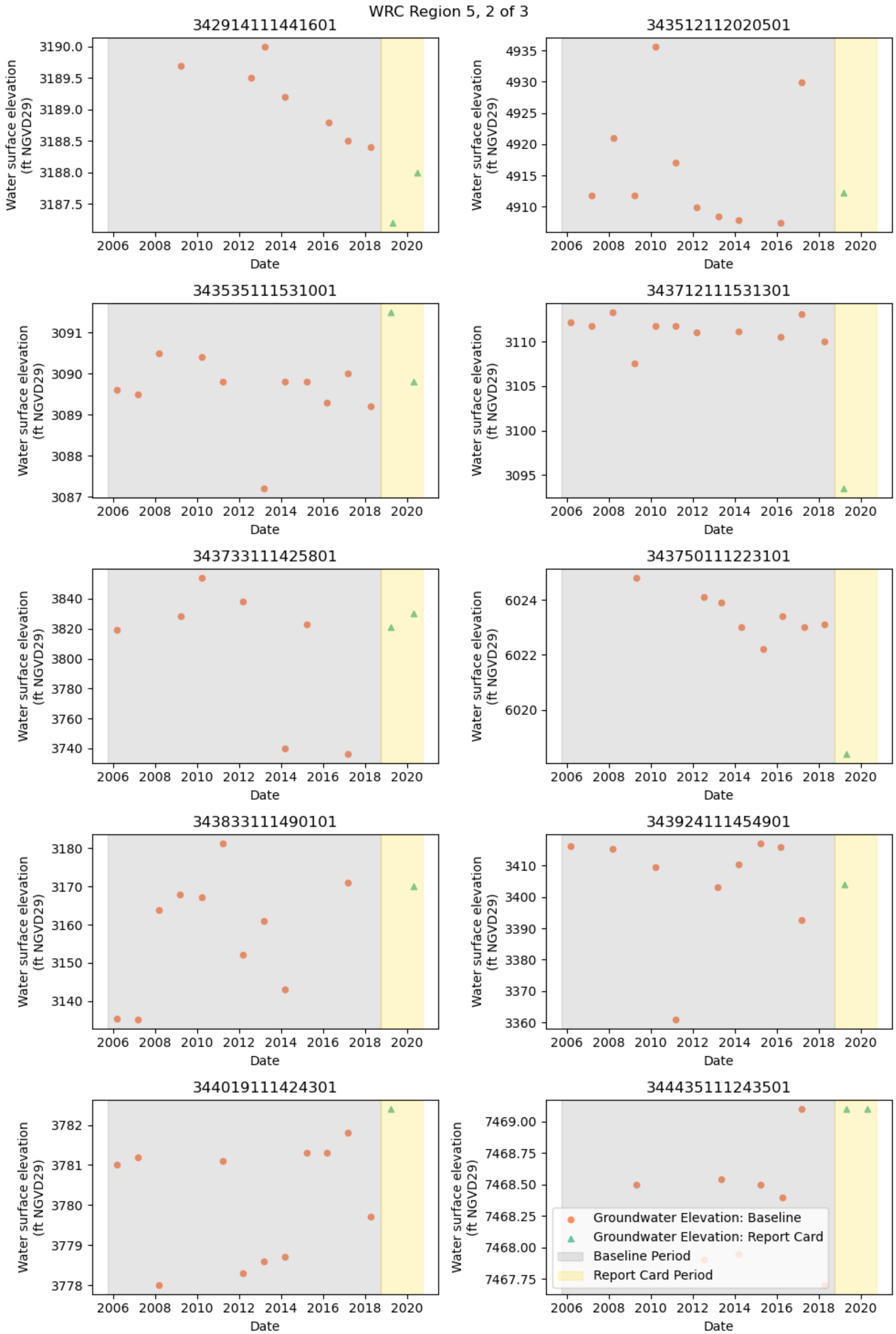
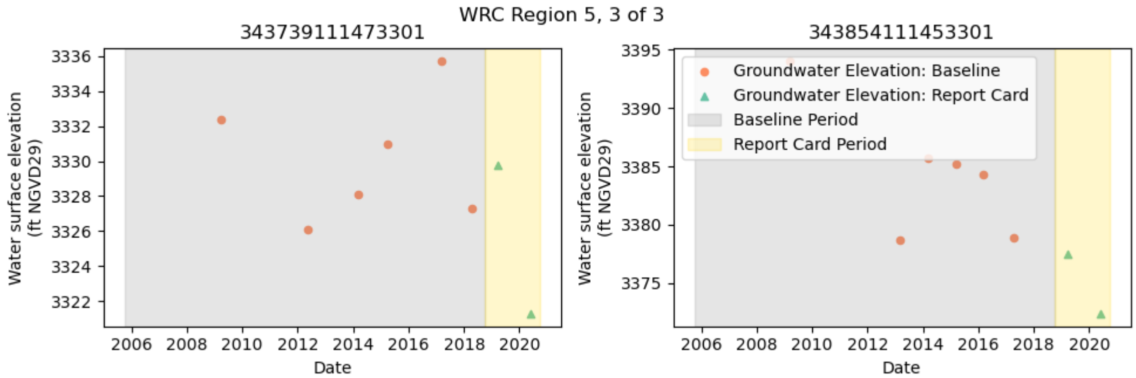
344331111515501
345001111514801
345137111454801
345312111532001
345619111385501
345644111451601
350624111482501
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period

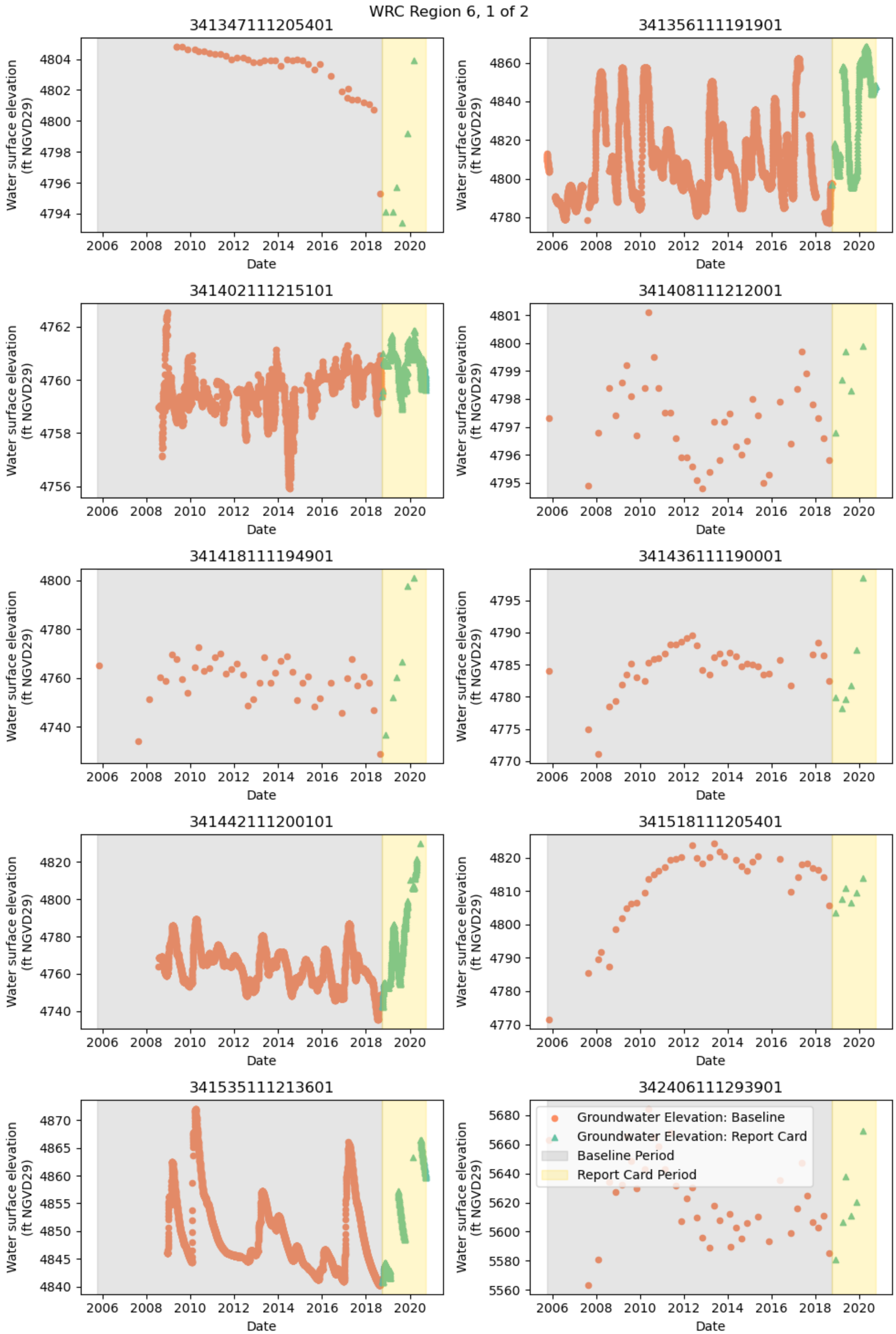

WRC Region 4, 2 of 2
344829111492601
344850111494801
344943111483201
344957111463102
345302111582201
345452111384001
345612111385301
350159111435701
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period

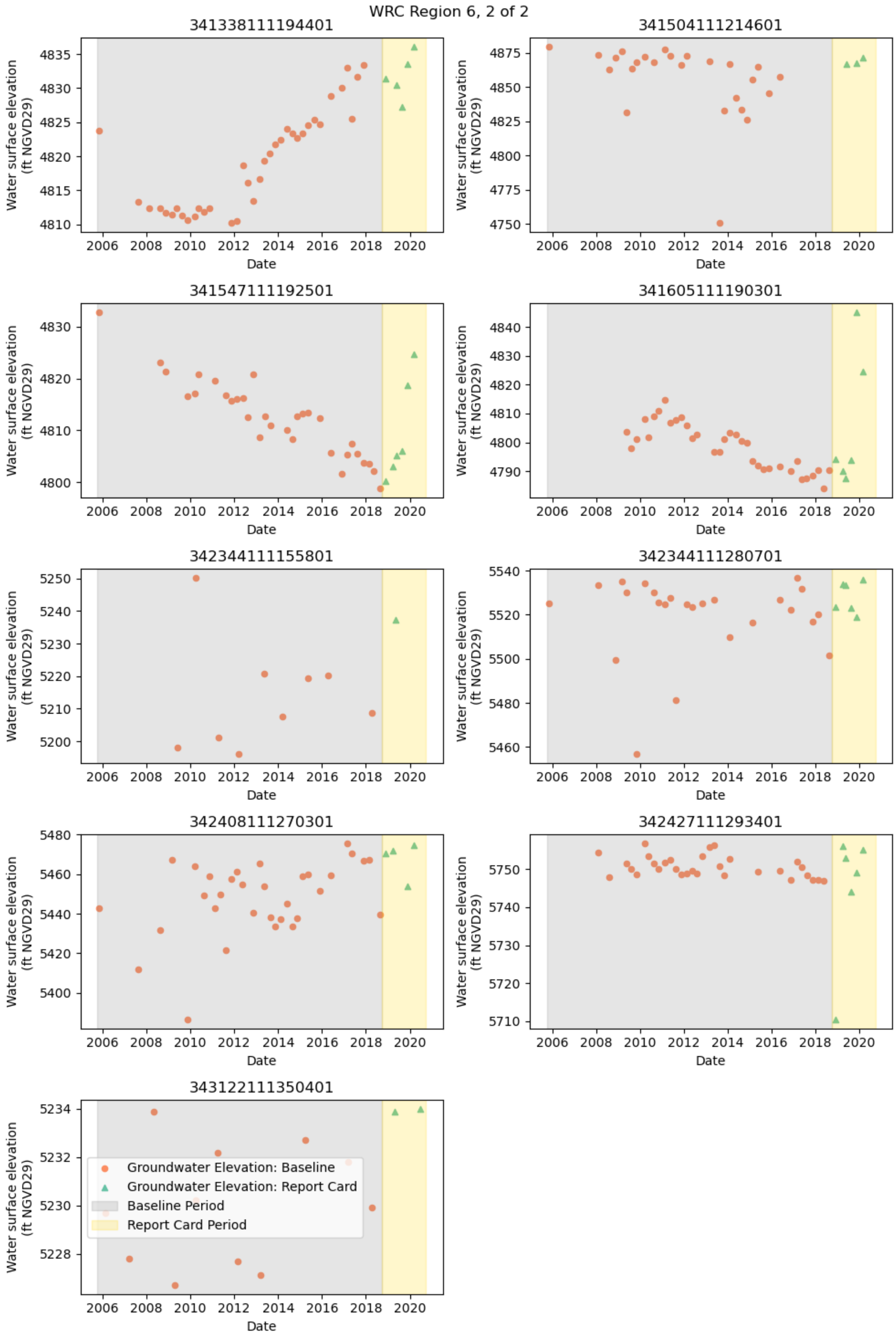

WRC Region 5, 1 of 3
342859111492901
343028111413801
343058111462902
343105111504601
343134111465301
343341111511201
343638111501301
343729111473801
344105111503401
344733111292201
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period

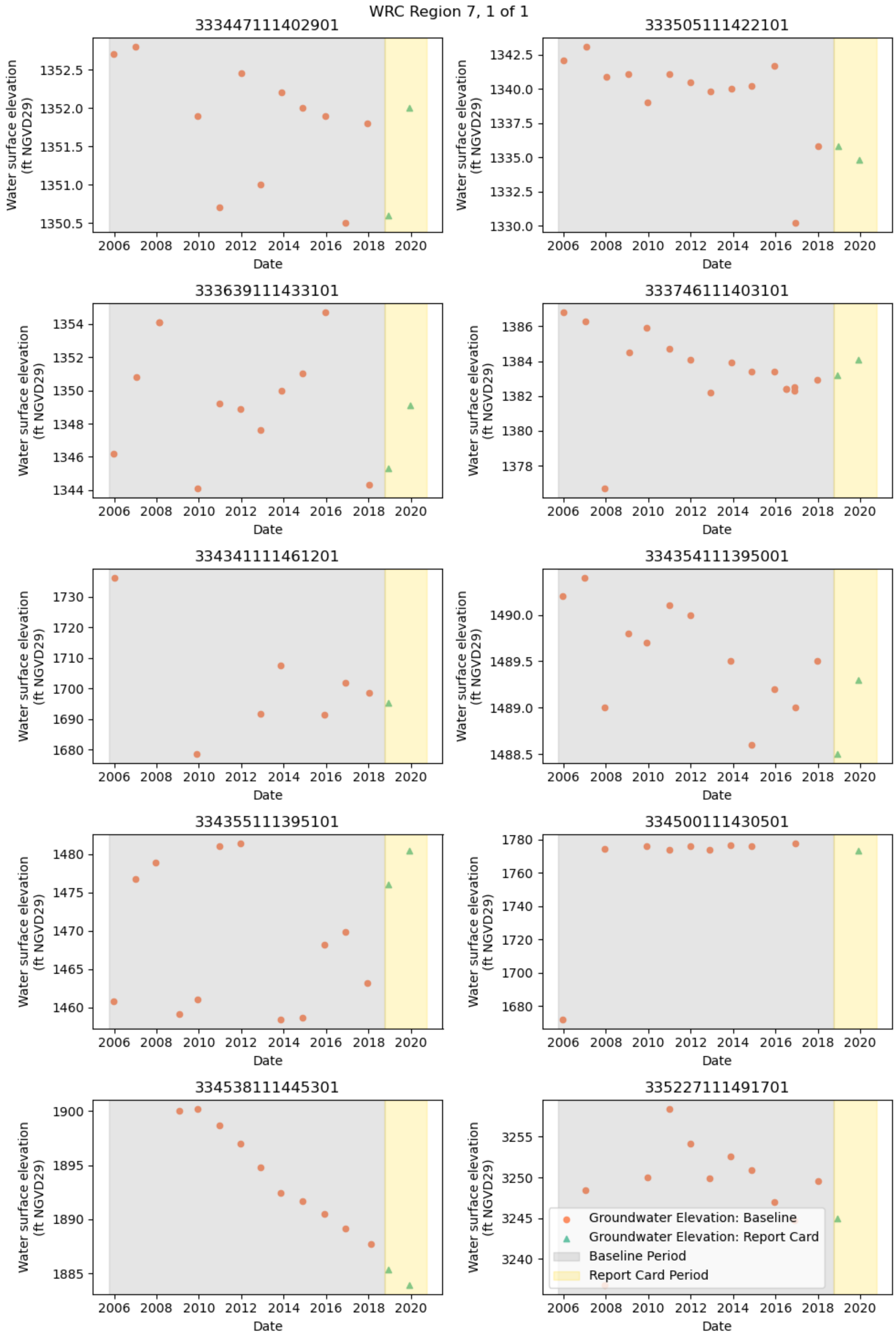

WRC Region 5, 2 of 3
342914111441601
343512112020501
343535111531001
343712111531301
343733111425801
343750111223101
343833111490101
343924111454901
344019111424301
344435111243501
Water surface elevation
(ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period



WRC Region 5, 3 of 3
343739111473301
343854111453301
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period


WRC Region 6, 1 of 2
341347111205401
341356111191901
341402111215101
341408111212001
341418111194901
341436111190001
341442111200101
341518111205401
341535111213601
342406111293901
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period


WRC Region 6, 2 of 2
341338111194401
341504111214601
341547111192501
341605111190301
342344111155801
342344111280701
342408111270301
342427111293401
343122111350401
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period



WRC Region 7, 1 of 1
333447111402901
333505111422101
333639111433101
333746111403101
334341111461201
334354111395001
334355111395101
334500111430501
334538111445301
335227111491701
Water surface elevation (ft NGVD29)
Date
Groundwater Elevation: Baseline
Groundwater Elevation: Report Card
Baseline Period
Report Card Period

Appendix B

2020 Verde Watershed Report Card

Individual well scores

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	345615112340301	4	4	75	90	1
1	345529112431201	4	4	100	100	0
1	345423112311901	4	4	25	25	0
1	344524112262501	4	2	0	0	0
1	345856112333201	6	2	100	100	0
1	344110112322201	6	1	16	16	0
1	344022112323501	6	2	66	66	0
1	345755112413201	6	1	0	0	0
1	345543112483501	6	1	50	50	0
1	344253112333001	8	2	25	25	0
1	350805112471801	8	3	0	0	0
1	352729113081501	8	1	0	0	0
1	344703112392201	9	4	44	44	0
1	351207112283701	9	1	33	33	0
1	344950112291101	9	1	11	11	0
1	345528112283201	10	4	20	20	0
1	344207112306001	10	2	0	0	0
1	344122112322201	11	2	0	0	0
1	343905112301401	11	2	0	0	0
1	344347112310701	11	2	0	0	0
1	343827112304801	11	2	63	63	0
1	344930112391901	11	2	72	72	0
1	344459112232601	11	1	100	100	0
1	344011112200901	11	1	0	0	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	344038112321101	11	1	90	90	1
1	344017112321101	11	2	27	27	0
1	343928112301401	11	1	9	9	0
1	344629112283401	11	1	0	0	0
1	344603112264001	11	1	0	0	0
1	344158112384201	11	1	100	100	0
1	344348112331401	12	1	75	75	0
1	343836112195501	12	1	8	8	0
1	344314112285201	12	2	58	90	1
1	344205112322901	12	2	0	0	0
1	344429112222001	12	2	0	0	0
1	345347112405801	12	3	83	83	0
1	344543112262201	12	1	0	0	0
1	345712112374501	12	1	0	0	0
1	344723112265701	12	1	100	100	0
1	345120112274301	12	3	75	90	1
1	343746112242601	12	2	75	75	0
1	345109112264401	12	1	0	0	0
1	344347112271001	12	2	0	0	0
1	344507112270101	13	1	0	0	0
1	344458112270601	13	1	7	7	0
1	344501112232601	13	2	38	38	0
1	344821112301701	13	1	7	7	0
1	344147112313201	13	2	0	0	0
1	342658112244601	13	1	0	0	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	344820112272701	13	2	0	0	0
1	344540112264501	13	1	0	0	0
1	344704112291601	13	1	0	0	0
1	344052112171701	13	2	69	69	0
1	344358112182901	13	2	0	0	0
1	344809112275201	13	1	23	23	0
1	344819112265601	13	1	23	23	0
1	344549112410901	13	2	100	100	0
1	344841112463701	13	4	69	69	0
1	343820112195701	13	2	0	0	0
1	343754112301101	13	2	0	0	0
1	344025112310401	13	1	53	53	0
1	343938112320101	13	2	69	69	0
1	345056112271601	13	1	0	0	0
1	343734112295501	13	2	0	0	0
1	345048112292201	13	2	0	0	0
1	345030112282301	13	1	0	0	0
1	343957112322001	13	2	69	69	0
1	344928112294601	13	1	7	7	0
1	344628112174901	13	1	0	0	0
1	344912112264801	13	3	11	11	0
1	343847112190401	13	1	15	15	0
1	343930112235601	14	2	0	0	0
1	345734112445501	14	2	21	21	0
1	344544112393401	14	3	57	57	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	344358112390701	15	3	40	40	0
1	350111112455601	15	1	0	0	0
1	350327112425901	15	1	20	20	0
1	350224112445801	15	3	0	0	0
1	350009112401201	15	3	6	6	0
1	343930112235301	16	2	87	87	0
1	342020112270102	16	6	100	100	0
1	345314112263801	17	4	23	23	0
1	350436112395901	17	1	100	100	0
1	344604112354301	17	3	100	100	0
1	344134112223502	17	6	0	0	0
1	344435112404301	18	4	94	94	0
1	345542112312801	18	4	5	5	0
1	350037112440301	18	2	0	0	0
1	345507112330901	18	3	33	33	0
1	345557112294501	19	4	0	0	0
1	345449112271101	19	4	15	15	0
1	350341112403901	19	4	52	52	0
1	351130112482401	20	4	65	90	1
1	350551112491301	20	4	0	0	0
1	350500112424601	21	4	100	100	0
1	350953112445701	22	4	88	90	1
1	350410112464401	22	4	0	0	0
1	350059112373101	22	4	68	68	0
1	351120112502401	23	4	8	8	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	350302112404801	23	4	78	78	0
1	351552112572901	23	4	0	0	0
1	350932112470301	24	4	4	4	0
1	350332112413701	24	4	83	83	0
1	342600112513401	24	7	81	90	1
1	350303112395601	25	3	100	100	0
1	350423112451101	25	4	36	36	0
1	350535112432701	26	4	92	92	0
1	350423112471201	26	4	0	0	0
1	350709112441101	26	4	100	100	0
1	350814112452701	26	3	88	90	1
1	350647112471101	26	4	0	0	0
1	350016112421001	27	1	37	37	0
1	350356112413901	27	4	62	62	0
1	345629112405201	27	4	0	0	0
1	350616112435601	29	4	100	100	0
1	345256112261901	29	8	13	13	0
1	345144112235901	34	5	17	17	0
1	345205112240601	40	8	52	52	0
1	344314112202401	42	3	0	0	0
1	345300112283702	807	570	0	0	0
1	345300112283703	981	570	0	0	0
1	345338112311801	1386	566	4	4	0
1	345300112283701	1441	631	9	9	0
1	345301112283701	1468	737	8	8	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
1	345302112283701	1581	666	8	8	0
1	344912112264101	1875	653	39	39	0
1	345738112391501	3243	721	0	0	0
1	345842112380201	3798	420	28	28	0
1	344134112223501	3848	737	0	0	0
1	344819112265701	3878	568	18	18	0
1	343854112202701	4018	681	0	0	0
1	342020112270101	4143	664	0	0	0
1	345524112374401	4147	245	0	0	0
1	344535112283001	4148	344	15	15	0
1	344645112253401	4364	592	3	3	0
1	344357112280901	4473	737	7	7	0
1	344520112194301	4627	737	0	0	0
2	351021112155301	6	1	100	100	0
2	345653112223701	7	3	28	28	0
2	351253112050001	8	1	87	87	0
2	345057112145201	10	2	20	20	0
2	351702111555001	12	2	75	75	0
2	350154112220001	12	2	25	25	0
2	351557112020401	12	2	75	75	0
2	351409111500302	12	1	100	100	0
2	350829111575601	13	2	15	15	0
2	351121111545601	13	2	53	90	1
2	352108111504801	13	2	15	15	0
3	344544112025001	6	2	100	100	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
3	344304111585601	9	1	100	100	0
3	344428112004801	10	2	30	30	0
3	344440112003801	10	2	10	10	0
3	344244111581501	12	2	58	58	0
3	344625111571401	12	2	16	16	0
3	344354112014901	12	1	83	83	0
3	344250111583401	12	2	100	100	0
3	344250111584101	13	2	100	100	0
3	344258111595501	13	2	15	15	0
3	344556112040501	13	2	7	7	0
3	344545112005401	14	2	64	64	0
3	344359111591101	3430	462	34	34	0
4	345452111384001	6	2	83	83	0
4	344829111492601	7	2	57	57	0
4	345302111582201	10	2	20	20	0
4	345612111385301	10	1	10	10	0
4	344943111483201	10	2	90	90	0
4	350159111435701	11	2	63	90	1
4	344957111463102	11	2	18	18	0
4	344307111552701	12	2	91	90	1
4	345001111514801	12	2	50	50	0
4	350624111482501	12	2	83	83	0
4	345312111532001	12	5	0	0	0
4	345619111385501	12	2	58	58	0
4	345137111454801	12	2	66	66	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
4	344850111494801	12	1	41	41	0
4	344312111540801	13	2	38	38	0
4	344331111515501	13	2	15	15	0
4	345644111451601	13	2	7	7	0
4	344052111560601	13	2	53	90	1
5	343739111473301	6	2	0	0	0
5	343854111453301	6	2	0	0	0
5	342914111441601	7	2	0	0	0
5	343733111425801	7	2	57	57	0
5	343750111223101	8	1	0	0	0
5	344435111243501	8	2	100	100	0
5	343924111454901	9	1	33	33	0
5	343512112020501	10	1	60	60	0
5	343833111490101	10	1	80	80	0
5	343535111531001	11	2	100	100	0
5	344019111424301	11	1	100	100	0
5	343729111473801	11	2	27	27	0
5	343712111531301	11	1	0	0	0
5	344733111292201	11	2	81	81	0
5	342859111492901	11	2	27	27	0
5	343058111462902	12	1	41	41	0
5	343134111465301	12	1	100	100	0
5	343638111501301	12	2	33	33	0
5	343341111511201	12	2	33	33	0
5	344105111503401	12	2	58	58	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
5	343028111413801	12	2	41	90	1
5	343105111504601	14	2	28	28	0
6	342344111155801	9	1	88	88	0
6	343122111350401	11	2	100	100	0
6	341504111214601	25	3	56	56	0
6	342344111280701	25	6	72	72	0
6	342427111293401	31	6	61	61	0
6	341547111192501	31	6	22	22	0
6	342408111270301	32	4	96	96	0
6	341605111190301	34	6	38	38	0
6	341338111194401	36	5	91	91	0
6	341347111205401	38	6	0	0	0
6	341518111205401	39	6	28	28	0
6	341436111190001	39	6	10	10	0
6	342406111293901	40	6	47	47	0
6	341408111212001	42	5	88	88	0
6	341418111194901	42	6	66	66	0
6	341402111215101	3376	680	97	97	0
6	341535111213601	3552	346	66	66	0
6	341442111200101	3745	485	69	69	0
6	341356111191901	4139	657	90	90	0
7	334341111461201	7	1	42	42	0
7	334500111430501	9	1	11	11	0
7	334538111445301	10	2	0	0	0
7	335227111491701	11	1	18	18	0

WRC Region	GWSI Well ID	Count Baseline Measurements	Count Report Card Measurements	Percentile Score	Percentile Score with Stable Adjustment	Stable adjustment applied? 1 = True, 0 = False
7	333447111402901	11	2	27	27	0
7	333639111433101	12	2	25	25	0
7	334355111395101	12	2	75	75	0
7	334354111395001	12	2	8	8	0
7	333505111422101	13	2	7	7	0
7	333746111403101	16	2	56	56	0

Appendix 2 – Riparian Bird Species List

Common Name	Scientific Name	Breeding Season Start	Breeding Season End
Abert's Towhee	*Melozone aberti*	March	August
Acorn Woodpecker	*Melanerpes formicivorus*	April	August
American Barn Owl	*Tyto furcata*	April	July
American Kestrel	*Falco sparverius*	March	August
Anna's Hummingbird	*Calypte anna*	February	August
Ash-throated Flycatcher	*Myiarchus cinerascens*	March	August
Bell's Vireo	*Vireo bellii*	March	August
Belted Kingfisher	*Megaceryle alcyon*	April	July
Bewick's Wren	*Thryomanes bewickii*	March	August
Black Phoebe	*Sayornis nigricans*	March	July
Black-chinned Hummingbird	*Archilochus alexandri*	March	August
Black-crowned Night-heron	*Nycticorax nycticorax*	April	July
Black-tailed Gnatcatcher	*Polioptila melanura*	March	August
Blue Grosbeak	*Passerina caerulea*	May	September
Blue-gray Gnatcatcher	*Polioptila caerulea*	April	August
Bridled Titmouse	*Baeolophus wollweberi*	March	August
Broad-billed Hummingbird	*Cynanthus latirostris*	March	July
Bronzed Cowbird	*Molothrus aeneus*	May	August
Brown-crested Flycatcher	*Myiarchus tyrannulus*	April	August
Brown-headed Cowbird	*Molothrus ater*	April	August
Bullock's Oriole	*Icterus bullockii*	April	August
Bushtit	*Psaltriparus minimus*	March	August
Canyon Towhee	*Melozone fusca*	March	September
Canyon Wren	*Catherpes mexicanus*	March	August
Cassin's Kingbird	*Tyrannus vociferans*	April	August
Cliff Swallow	*Petrochelidon pyrrhonota*	March	August
Common Black Hawk	*Buteogallus anthracinus*	March	August
Common Ground-Dove	*Columbina passerina*	April	August
Common Merganser	*Mergus merganser*	March	July
Common Raven	*Corvus corax*	March	July
Common Yellowthroat	*Geothlypis trichas*	April	August
Cooper's Hawk	*Astur cooperii*	March	September
Crissal Thrasher	*Toxostoma crissale*	March	July
Elf Owl	*Micrathene whitneyi*	March	July
Eurasian Collared-Dove	*Streptopelia decaocto*	March	September
European Starling	*Sturnus vulgaris*	March	July
Gambel's Quail	*Callipepla gambelii*	March	September
Gila Woodpecker	*Melanerpes uropygialis*	March	August

Great Blue Heron	*Ardea herodias*	March	September
Great Horned Owl	*Bubo virginianus*	February	June
Great-tailed Grackle	*Quiscalus mexicanus*	March	September
Greater Roadrunner	*Geococcyx californianus*	March	September
Green Heron	*Butorides virescens*	April	August
Harris's Hawk	*empidonax traillii extimus*	January	June
Hooded Oriole	*Icterus cucullatus*	April	August
House Finch	*Haemorhous mexicanus*	March	August
House Sparrow	*Passer domesticus*	February	August
Hutton's Vireo	*Vireo huttoni*	March	August
Indigo Bunting	*Passerina cyanea*	April	August
Juniper Titmouse	*Baeolophus ridgwayi*	April	August
Ladder-backed Woodpecker	*Dryobates scalaris*	March	August
Lazuli Bunting	*Passerina amoena*	May	August
Lesser Goldfinch	*Spinus psaltria*	March	September
Loggerhead Shrike	*Lanius ludovicianus*	February	July
Lucy's Warbler	*Leiothlypis luciae*	April	July
Mallard	*Anas platyrhynchos*	April	September
Mexican Duck	*Anas diazi*	April	September
Mississippi Kite	*Ictinia mississippiensis*	April	August
Mourning Dove	*Zenaida macroura*	March	September
Northern Cardinal	*Cardinalis cardinalis*	March	August
Northern Flicker	*Colaptes auratus*	April	July
Northern Mockingbird	*Mimus polyglottos*	March	August
Northern Rough-winged Swallow	*Stelgidopteryx serripennis*	March	July
Phainopepla	*Phainopepla nitens*	March	July
Red-tailed Hawk	*Buteo jamaicensis*	February	August
Red-winged Blackbird	*Agelaius phoeniceus*	April	August
Say's Phoebe	*Sayornis saya*	March	July
Song Sparrow	*Melospiza melodia*	April	July
Spotted Towhee	*Pipilo maculatus*	April	August
Summer Tanager	*Piranga rubra*	April	August
Turkey Vulture	*Cathartes aura*	April	August
Verdin	*Auriparus flaviceps*	February	August
Vermilion Flycatcher	*Pyrocephalus rubinus*	March	August
Violet-green Swallow	*Tachycineta thalassina*	April	July
Western Kingbird	*Tyrannus verticalis*	April	August
Western Screech-owl	*Megascops kennicottii*	March	July
Western Wood-Pewee	*Contopus sordidulus*	May	August

White-breasted Nuthatch	*Sitta carolinensis*	March	August
White-winged Dove	*Zenaida asiatica*	March	September
Wild Turkey	*Meleagris gallopavo*	April	August
Willow Flycatcher	*Empidonax traillii*	May	August
Wood Duck	*Aix sponsa*	March	July
Yellow Warbler	*Setophaga petechia*	April	August
Yellow-billed Cuckoo (Western DPS)	*Coccyzus americanus*	June	September
Yellow-breasted Chat	*Icteria virens*	April	August
Zone-tailed Hawk	*Buteo albonotatus*	March	August

Appendix 3 – Native Fish Data and Reference

Fish surveys and reports used to find presence or absence of native fish species in the seven regions that comprise the Verde River Watershed Report Card:

AZGFD Fish Surveys:

Cole, Kassandra. Verde River Bartlett Lake to Box Bar Summary Report May 10, 2023. Phoenix, AZ: Arizona Game and Fish Department, 2023.

Cole, Kassandra and Amberle Jones. Verde River – Childs to Sheep Bridge Survey Report September 15-19, 2023. Phoenix, AZ: Arizona Game and Fish Department, 2024.

Cummins, Gregg. Verde River: Beasley Flats-Childs Fish Survey Report June 2015. Phoenix, AZ: Arizona Game and Fish Department, 2015.

Cummins, Gregg. Verde River: Granite Creek – Verde Ranch Fish Survey Report June 2016. Phoenix, AZ: Arizona Game and Fish Department, 2016.

Cummins, Gregg. Verde River: Beasley Flats-Childs Fish Survey Report June 2018. Phoenix, AZ: Arizona Game and Fish Department, 2018.

Cummins, Gregg. Verde River: Tuzigoot-Beasley Flats Fish Survey Report July 31, 2018. Phoenix, AZ: Arizona Game and Fish Department, 2018.

Cummins, Gregg. Verde River: Perkinsville-Sycamore Creek Fish Survey Report July-August 2019. Phoenix, AZ: Arizona Game and Fish Department, 2019.

Cummins, Gregg. Verde River: Granite Creek- Verde Ranch Fish Survey Report June 2019. Phoenix, AZ: Arizona Game and Fish Department, 2019.

Cummins, Gregg. Verde River: Verde Ranch- Perkinsville Fish Survey Report July 2019. Phoenix, AZ: Arizona Game and Fish Department, 2019.

Jackson, Nate and Matt Chmiel. Verde River: Perkinsville-Sycamore Creek Fish Survey Report June 13-15, 2023. Phoenix, AZ: Arizona Game and Fish Department, 2023.

Jaeger, Jake. Verde River Fish Survey Report September 14-18, 2015. Phoenix, AZ: Arizona Game and Fish Department, 2015.

Kaitchuck, Jason and Matt Chmiel. Verde River: Tuzigoot-Beasley Flat Fish Survey Report July 31, 2021. Phoenix, AZ: Arizona Game and Fish Department, 2021.

Kaitchuck, Jason and Matt Chmiel. Verde River: Beasley Flat-Childs Fish Survey Report June 2021. Phoenix, AZ: Arizona Game and Fish Department, 2021.

Rinker, Matthew and Scott Rogers. Oak Creek Fish Monitoring Report June 2022. Phoenix, AZ: Arizona Game and Fish Department, 2022.

Stites, Andy and Matt Chmiel. Verde River: Granite Creek-Verde Ranch Fish Survey June 2022. Phoenix, AZ: Arizona Game and Fish Department, 2022.

Stites, Andy and Matt Chmiel. Verde River: Verde Ranch - Perkinsville Fish Survey July 12-14, 2022. Phoenix, AZ: Arizona Game and Fish Department, 2022.

Gila River Basin Native Fish Monitoring (BOR / Marsh & Associates) surveys:

https://usbr.gov/lc/phoenix/biology/azfish/pdf/2015%20Report%20FINAL%20(Appendices%20added).pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/2016%20Final%20Report%20%20(Appendices%20added).pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/2017FinalReportwithAppendix.pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/GRBMP2018.pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/GRBMP2019.pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/GRBMP2020.pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/GRBMP2022.pdf

https://usbr.gov/lc/phoenix/biology/azfish/pdf/GRBMP2023.pdf

US Forest Service Fish Surveys and Fisheries Reports:

Agyagos, Janie. Red Rock Ranger District Fisheries Program FY11-FY24. Unpublished Microsoft Word File, 2024.

Jackson, Leonard. Environmental DNA results for samples collected by the USFS, 2021-2022. Unpublished Microsoft Excel File, 2022.

US Fish and Wildlife Service Recovery Plans:

U.S. Fish and Wildlife Service. 2022. Revised Recovery Plan for Gila trout (Oncorhynchus gilae). U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, New Mexico. 185 pages.

Literature supporting historical native fish distributions in the Verde River Watershed:

https://www.fws.gov/species/longfin-dace-agosia-chrysogaster

https://awcs.azgfd.com/species/fish/agosia-chrysogaster

https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=639

https://www.fws.gov/species/desert-sucker-catostomus-clarkii

https://awcs.azgfd.com/species/fish/catostomus-clarkii

https://www.fws.gov/species/sonora-sucker-catostomus-insignis

https://awcs.azgfd.com/species/fish/catostomus-insignis

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/fsbdev3_018488.pdf

https://www.fws.gov/species/roundtail-chub-gila-robusta

https://awcs.azgfd.com/species/fish/gila-robusta

https://nas.er.usgs.gov/queries/FactSheet.aspx?SpeciesID=3197

https://www.fws.gov/species/spikedace-meda-fulgida

https://awcs.azgfd.com/species/fish/meda-fulgida

https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=570 https://ecos.fws.gov/docs/recovery_plan/Revised%20Recovery%20Plan%20for%20the%20Gila%20trout%20(2022)%20Signed.pdf

https://www.fws.gov/species/gila-trout-oncorhynchus-gilae

https://awcs.azgfd.com/species/fish/oncorhynchus-gilae

https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=905

https://www.fws.gov/species/gila-topminnow-poeciliopsis-occidentalis

https://awcs.azgfd.com/species/fish/poeciliopsis-occidentalis-occidentalis

https://nas.er.usgs.gov/queries/FactSheet.aspx?speciesID=866

https://www.fws.gov/species/colorado-pikeminnow-ptychocheilus-lucius

https://ecos.fws.gov/docs/recovery_plan/20230804_FinalRP_Colorado%20pikeminnow_v4_AMMsigned.pdf

https://ecosphere-documents-production-public.s3.amazonaws.com/sams/public_docs/species_nonpublish/3022.pdf

https://www.fs.usda.gov/rm/boise/AWAE/projects/fish_cattle/Colorado%20pikeminnow.pdf

https://awcs.azgfd.com/species/fish/ptychocheilus-lucius

https://www.fs.usda.gov/rm/boise/AWAE/projects/fish_cattle/Colorado%20pikeminnow.pdf

https://www.fws.gov/species/speckled-dace-rhinichthys-osculus

https://www.fws.gov/sites/default/files/documents/2024-05/ecological-risk-screening-summary-speckled-dace.pdf

https://nas.er.usgs.gov/queries/factsheet.aspx?SpeciesID=640

https://www.fws.gov/species/loach-minnow-tiaroga-cobitis

https://www.federalregister.gov/documents/2010/10/28/2010-26477/endangered-and-threatened-wildlife-and-plants-endangered-status-and-designation-of-critical-habitat

https://www.fws.gov/species/razorback-sucker-xyrauchen-texanus

https://awcs.azgfd.com/species/fish/xyrauchen-texanus

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5342134.pdf

https://awcs.azgfd.com/conservation-opportunity-areas/aquatic/verde-river-sullivan-dam-to-hell-canyon

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5349799.pdf

https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3821423.pdf

https://www.fs.usda.gov/rm/boise/AWAE/labs/awae_flagstaff/publications/rinne_stefferud_verderivernativefish.pdf

Literature supporting only one species of chub, Gila robusta (roundtail chub) in the Verde River Watershed:

https://www.northernarizonagazette.com/2016/09/12/fisheries-experts-reclassify-native-fish-species/

https://fisheries.org/2017/09/taxonomy-of-gila-in-the-lower-colorado-river-basin-of-arizona-and-new-mexico/

https://meridian.allenpress.com/copeia/article-abstract/106/2/279/196621/Classification-Success-of-Species-within-the-Gila

https://www.nature.com/articles/s41598-023-41719-9

Appendix 4 – Civic Engagement Municipalities

Entity Name	Website for meeting minutes
Camp Verde	https://www.campverde.az.gov/departments/town-clerk/agendas-minutes/town-council/-toggle-allpast
Chino Valley	https://www.chinoaz.net/611/Agendas-Minutes-Videos
Clarkdale	https://clarkdale.az.gov/129/Agendas-Minutes
Coconino County	https://www.coconino.az.gov/AgendaCenter
Cottonwood	https://cottonwoodaz.gov/129/Agendas-Minutes
Flagstaff	https://public.destinyhosted.com/agenda_publish.cfm?mt=ALL&get_month=7&get_year=2025&countDownload=&downloadFile=&id=35247&loc=&term=N
Fountain Hills	https://destinyhosted.com/agenda_publish.cfm?id=36868
Gila County	https://www.gilacountyaz.gov/government/clerk_of_the_board/meeting_agendas_results_and_minutes.php
Jerome	https://jerome.az.gov/meeting-minutes
Maricopa County	https://www.maricopa.gov/324/Board-of-Supervisors-Meeting-Information
Payson	https://www.paysonaz.gov/government/town-council/town-council-meetings-and-agendas
Prescott	https://prescott-az.gov/prescott-city-clerk/council-meetings/
Prescott Valley	https://www.prescottvalley-az.gov/government/town_council/meeting_agendas_minutes.php
Scottsdale	https://ww2.scottsdaleaz.gov/council/meeting-information/agendas-minutes/archived-agendas-minutes
Sedona	https://www.sedonaaz.gov/your-government/departments/city-clerk/council-commissions-committees-boards/city-council/meetings-agendas-packets-minutes
Williams	https://www.williamsaz.gov/government/meetings/city_council
Yavapai County	https://www.yavapaiaz.gov/County-Government/Meetings/Meeting-Notices