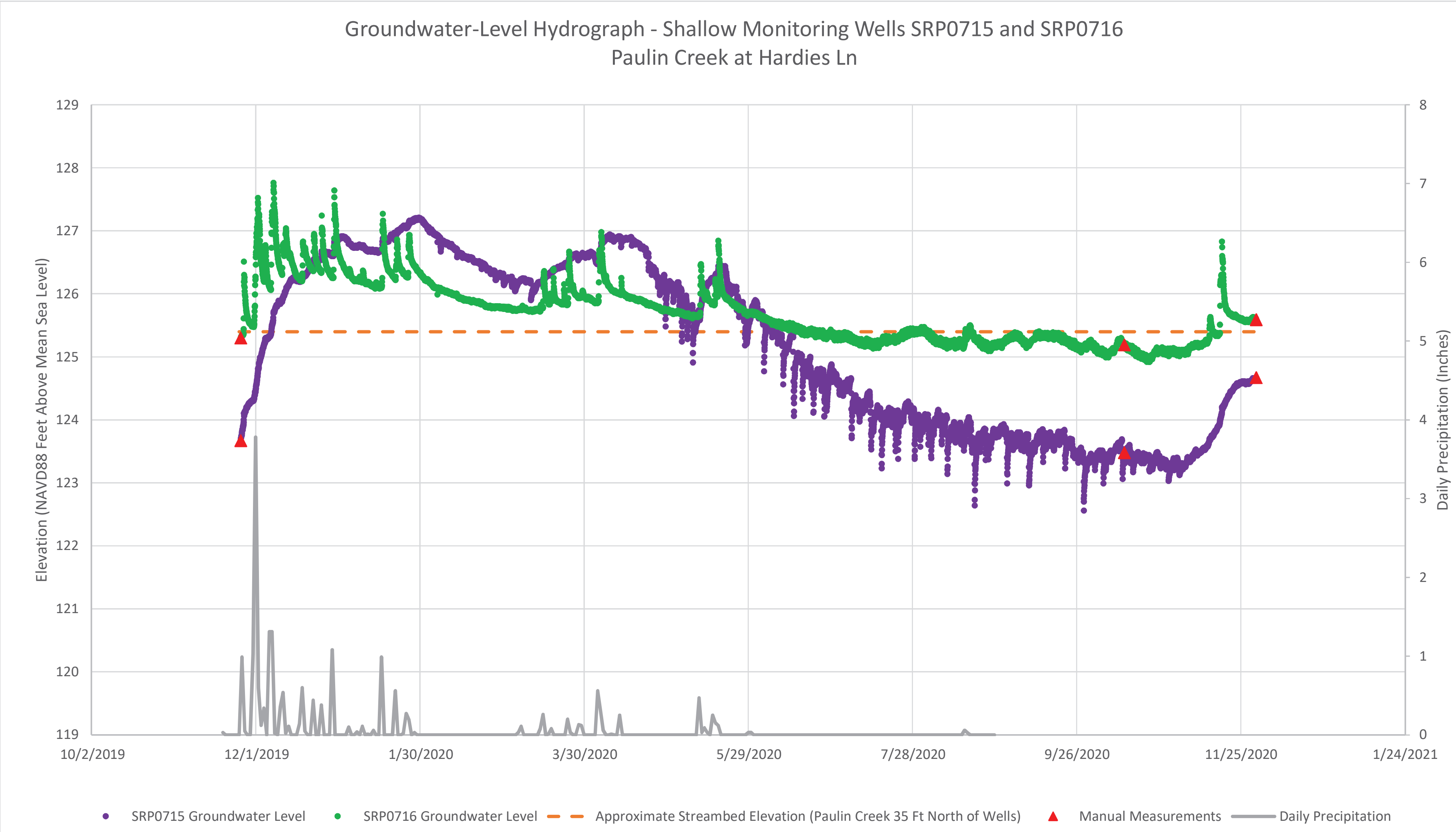


Groundwater-Level Hydrograph - Shallow Monitoring Wells SRP0715 and SRP0716
Paulin Creek at Hardies Ln
Elevation (NAVD88 Feet Above Mean Sea Level)
Daily Precipitation (Inches)
129
128
127
126
125
124
123
122
121
120
119
8
7
6
5
4
3
2
1
0
10/2/2019
12/1/2019
1/30/2020
3/30/2020
5/29/2020
7/28/2020
9/26/2020
11/25/2020
1/24/2021
SRP0715 Groundwater Level
SRP0716 Groundwater Level
Approximate Streambed Elevation (Paulin Creek 35 Ft North of Wells)
Manual Measurements
Daily Precipitation

Identification and Mapping
Groundwater Dependent Ecosystems Workgroup
Meeting Summary

Date/Time: Tuesday, July 7, 2020 | 1:00 p.m. - 3:00 p.m.
Location: https://csus.zoom.us/j/99011901938
Contact: Sam Magill, Practitioner Work Group Facilitator
Email: s.magill@csus.edu | Phone: (831) 251-4127

MEETING SUMMARY

Welcome and Introductions / Agenda and Meeting Schedule Review

Sam Magill, Work Group Facilitator walked through the agenda for the day and reminded the participants of the focus of the workgroup:

a. Description of existing datasets, model tools and preliminary mapping efforts
b. Discuss process for integration of datasets for developing Potential GDE Maps
c. Discussion of data gaps

Marcus Trotta, Hydrogeologist, welcomed the group and conveyed his appreciation for the attendees participating in the work group. He mentioned the input from this group will feed into the second Ecosystems work group.

Sam Magill then suggested a round of introductions.

Sustainable Groundwater Management Act (SGMA) Update and Need for Identification of Groundwater Dependent Ecosystems

Objective: Provide brief overview of SGMA requirements, update on GSP development, and need for GDE identification

Marcus Trotta started with a high-level overview of SGMA and mentioned the three steps of compliance:

1. Form GSA by June 30, 2017
2. Develop GSP by January 31, 2022
3. Achieve sustainability 20 years after adoption of plan

Failure to meet any of the deadlines, triggers intervention by the State Water Resources Control Board.

There is one Groundwater Sustainability Plan in development for each of the three basins, Petaluma Valley, Santa Rosa Plain, and Sonoma Valley. The three agencies were formed in June 2017 and have been working on their GSP since then. Sonoma Water is leading the technical work on each of the plans with support from different consultants, the Advisory Committee, and the Board.

Trotta gave an overview of the main points for GDE Mapping:

- Focus on ecosystems that can be affected by groundwater conditions and management are within jurisdiction of the GSAs
- Utilize available statewide and local datasets to develop best available information
- Consider using “indicator” species and/or grouping of GDWs with similar characteristics/habitat needs
- Prioritize GDEs for consideration in developing SMCS for surface water depletion (separate workgroup)

Questions/Discussion

Dusterhoff – Is there a state defined definition for GDE that basins are following to determine what we consider GDEs or is it basin dependent and the scientists in the basin define what GDEs are?

> Trotta – The Definition under SGMA is that GDEs are ecological communities of species that depend on groundwater emerging from aquifers or groundwater occurring near the surface (i.e. areas of shallow groundwater, could be roots of vegetation are able to tap into groundwater to support their growth). The state through its partnership with the Nature Conservancy has developed initial indicators of groundwater dependent ecosystems. They encourage GSAs to use that information as well as local information. So, there are state guidance and suggestions, but how they are mapped out within each basin is up to the local GSA.
>
> Magill – That would include low lying wetlands not directly connected to existing surface water sources?
>
> Trotta – It could, provided there is a connection with groundwater for those wetlands.

Trowbridge – For this discussion, are we narrowing our focus to groundwater dependent ecosystems but can be impacted by the GSA? The SRP GSA only covers groundwater in the Santa Rosa Plain, but if the water is coming from the Mayacamas, no amount of management change in the Santa Rosa Plain is going to change that. Also, vernal pools, they fill through rainwater but could become groundwater. How does that fit in?

> Trotta – Vernal pools that are primarily perched features, rainwater that perches on low permeability layer, they do eventually contribute to groundwater. In terms of their dependency on groundwater, I wouldn’t categorize them as being dependent on groundwater. We would want to focus on groundwater dependent ecosystems connected with aquifers that the GSA would have control over managing. For areas that are outside the basins, the GSA’s jurisdiction is limited to those basin areas. They are required to demonstrate their Groundwater Sustainability Plan will not affect neighboring groundwater basins. In terms of upstream areas, we have been including information from those up lying adjoining areas in the contributing watershed in the basin. The GSA

could support projects that enhance conditions in those areas but that don't have direct control of groundwater use or anything that would affect groundwater conditions in those areas.

Marcus Trotta gave a high-level introduction overview of existing datasets for preliminary mapping of potential groundwater dependent ecosystems. Andy Rich talked about their work in identifying interconnected surface water in the basins. Definition in the GSP Regulations as 'surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.' Our approach to identifying the interconnect surface water is dependent on the information we have for the basins Santa Rosa Plain and Sonoma Valley. For Sonoma Valley, we have a lot of observed data using seepage run monitoring results. For Santa Rosa Plain, we are much more dependent on model results from the USGS flow model developed for the SRP in 2014. We are currently updating the model, but the results presented here are from 2014.

Questions

Rogers – Just for clarification on interconnected definition: SGMA defines 'interconnected surface water' as 'surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted.'

Rogers – It seems like some of the graphs, figures and analyses in the presentation, focus on the percent of time when stream reach is gaining, but losing streams are interconnected surface water also, based on the definition.

Rich – Good point, we need to reconsider a little more.

Rohde – Are there shallow groundwater data prior to 2016? Using groundwater data from 2016 to characterize groundwater conditions in the basin is technically past the SGMA date. Also, it's important to understand inter-annual groundwater fluctuations across multiple water year types (i.e., dry, wet, average).

Trotta – Yes, we have initially contoured 2016, as it represented the largest dataset of observed groundwater levels at the time. We can evaluate earlier years as well. Additionally, each point (well) on those maps has a time series of groundwater levels that can be examined if certain areas are of interest.

Rohde - Fantastic! The depth-to-groundwater maps look very nice. The lidar ground elevation data makes a difference and is much better than interpolating depth to groundwater measurements between wells.

Dusterhoff – Would you see a different story in a dry period versus a wet period?

Rich – Certainly, as the groundwater system dries during a dry period. Based on observed data, you should see a decrease amount of interconnected surface water. The point raises the question of when is the best time to do the analysis?

Dusterhoff – You are doing the best you have with the funding you have to collect the data. Story can be skewed by the time data is retrieved. How do you plan on acknowledging drier periods versus wetter periods?

Rich – For the simulated data from Santa Rosa Plain, which is focused from 2000 to 2010, I don't think we are capturing too biased climate period. With the observed data, much of it is from the last five years which is a drier period. But, given the difficulty in replicating some of the observed data, it is hard to have data that reflects not so dry conditions.

Gaffney – Will the data be available once peer reviewed and completed? Will the recording of the meeting and presentation be available too?

Magill – Yes, we will make the presentations available. The meeting is also being recorded and there will be a meeting summary that can be shared.

Trotta – We can provide you all copies of the figures that we are presenting either as a packet or through a file share site, I know some of these can be hard to view on Zoom. We also have draft write-ups for how we developed the Interconnected Surface Water maps.

Gaffney - I am wondering about underlying "raw" data, specifically GIS data.

Rich – As there are a lot of GIS data, I think it would be better to have an offline discussion, we are happy to share the information.

Marcus Trotta then showed Santa Rosa Plain, Petaluma Valley and Sonoma Valley preliminary maps from the Nature Conservancy of groundwater dependent ecosystems, draft Steelhead streams maps and draft vegetation-related potential groundwater dependent ecosystem maps before handing over to Melissa Rohde, from the Nature Conservancy for comment, and to David Cook and Patrick Lei, both from Sonoma Water.

Melissa Rohde mentioned the map is basically a starting point and much of the map features are taken from aerial imagery, there been lots of expert review and ground truthing, maps of springs and other hydrologic features. In order to know the ecosystems are related to groundwater, it is important to look at the depth of groundwater. In most parts of the state there often isn't good data of shallow groundwater. Absence of evidence isn't evidence of absence! It is important to ensure that our groundwater data network is dense enough to pick up what the conditions are in the eco systems and to validate if they are groundwater dependent. These species are typically known to use groundwater, but the species are opportunistic and can use other sources of water, so it is important to make sure there is groundwater there.

David Cook said they wanted to find an indicator species that would represent groundwater dependent species throughout the three basins. Initially we focused on fish and amphibians and we were also looking for a solid data set. Through that process we found that steelhead are quite well distributed throughout the basins, and we had detailed data sets. Unfortunately, there wasn't one single dataset used for all three basins. For Petaluma and Sonoma Valley, we used a 2005 report from Leidy, this was supplemented with information from Sonoma Water. For Santa Rosa Plain, we had a good dataset from the Coastal Monitoring Program, along with in-house data from the Shawn Chase database. We put all the steelhead bearing streams on maps, excluded anything outside of the three basins and included any stream further downstream from a section that was identified as steelhead habitat. That is how we arrived at our process to get the steelhead layer.

Patrick Lei – We relied heavily on the Sonoma Veg Map and focused on communities with strong riparian composition such as willow and cottonwood, or species that may rely on groundwater in some parts of the year, such as oak. One limitation of maps is depth of groundwater. We probably will not include vernal pools in the final maps because we don't think there is much of a groundwater connection, but where there is, we would include it.

Questions

Trowbridge – How are the maps of groundwater dependent ecosystems going to inform SGMA? Are we expecting the maps to change over time as groundwater management changes or are we going to monitor attributes of these communities that we would expect to change with groundwater management? It seems like what is driving the maps is development.

> Trotta – The way that groundwater dependent ecosystems are written into SGMA and requirements related to them in the groundwater sustainable plan regulations that DWR has established, is related to identifying their occurrence and distribution and taking them into consideration during the development of GSP and SMC, establishing how much groundwater lowering can occur in the basin before there are impacts in the basin or how much surface depletion there is before there are impacts. I am envisioning the mapping based on our existing available data sets will be utilized by the second workgroup that would be focused on what are the minimum thresholds set for surface water depletion in the basin. Are there certain areas that should be prioritized more than others? Are there areas where there should be a focus on monitoring? Going forward, I would expect the maps to change over time as new information is developed. How does the distribution of these groundwater dependent ecosystems match up with where higher densities of groundwater pumping are occurring in the basins?
>
> Lee – Related to that concept of previous development and how it affects this. Things about the seepage and springs around, there are lots of places in the watershed where early in the history of the area, they were found and developed where there are stock ponds in the hills now, where the original seepage would have been. Now they are characterized by ponds more than whatever vegetation we are looking for otherwise.

Lee – Another question about the Veg map, there are lots of places on the developmental property, there is spring activity under forested cover, would that be one area of data gap? I guess you can't see through the upper canopy to see the lower plants.

> Lei – I agree with you, that would be one example of a data gap. We do have limitations, In the early discussion before putting the map together we talked about seepage and springs but decided to keep those out of this map.
>
> Lee – If we want to talk about those kinds of places that are not showing up in your analyses at this point, that is where local knowledge can come in.
>
> Trotta – Seepage and springs that may be missed by the veg mapping, could be picked up in the maps Andy Rich went through. It may not capture all of them but could give an insight. Also, maps that have been developed by USGS that include seepage and springs, that we could also incorporate.

Rohde – When you create the GDE map, it would be great to see how the Sonoma Veg data overlap with the NC dataset. It would be helpful to see which vegetation are added under the Sonoma veg database that weren't originally available in the NC dataset.

Trotta – What we see as some of the next steps is going to be integration of different data sets. We can produce various maps that highlight the differences between the maps or show where we are intersecting data. We will make sure the data is clearly shown on the next set of maps.

Sam Magill said staff would be very interested to hear if there are other existing data sources that should be included for the Groundwater Sustainability Plan, and what additional data collection is recommended for the implementation phase of the GSP.

Rogers – I have a question about the steelhead distribution maps – were those generated from records current steelhead distribution or were they taken from steelhead critical habitat maps? Some areas that probably don't have steelhead, might not have steelhead because of stream flow depletion impacts. How was that dynamic factored in the map making?

Cook – It is based on current information, doesn't account for any impact on groundwater. It was the most accurate data set we could find. Something up for discussion – how do you define what steelhead stream?

Rogers – What is the data here? What is the timeline? In more recent years, steelhead have been absent due to decrease in stream flow. Since the Leidy study was completed, Yulupa creek has dried considerably and has a significant passage barrier. I wouldn't consider it a steelhead stream currently, but it could become one again. Are we looking to restore past conditions through this or maintain existing GDEs as of a certain dateline?

Trotta – Ultimately it would be a GSA Board decision. No need to correct or address issues before GSA was enacted in 2017 – it is not a requirement of SGMA. Many GSPS have held it as a baseline in their criteria. We are aware of the baseline; it will depend on the costs and priorities of the GSA in complying with SGMA. At a minimum they would support to restore conditions to improve fisheries and other ecosystems in their plans. Whether it would be built into the criteria would be up for discussion.

Gaffney – Definitely, there is an opportunity for continued collaborative data collection and local refinement. When we developed the Sonoma Veg Map program, the intention was to create a fine scale veg map for the million-acre county that aligned with the CDFW MCV standards. There is a significant opportunity to continually refine with local data via this process, as well as through I-naturalist, stream maintenance program etc. Ag & Open Space has developed additional data sets related to future potential riparian habitat based on physical attributes and processes.

There are also relatively accurate maps for the main stem Russian (alluvial reaches) that document riparian and land use cover from 1940-1942, 1990. Combined with modeled outputs for where riparian "could" exist based on fluvial-geomorphic processes, this could contribute to this initiative one more potential gap (please forgive my ignorance of the constraints of this process): multi-benefit criteria such as agricultural use (such as rangelands) that are compatible with GW sustainability, biological diversity, etc. Since Ag & Open Space is a potential tool for protecting these areas (via conservation easements) it would be helpful to understand how you are looking at this (or if it is outside the realm of this effort).

Rich – Regarding the comment of the main stem of the Russian River, none of the three basins covers the main stem of the Russian River so, it won't be directly useful here, but it is interesting information

Trowbridge – To piggyback on Karen Gaffney's historic data, we have been working on a historical ecology map. We wouldn't want the GSA to be beholden to restoring it, we are working on a vision for restoration and it does seem like the historical ecology would be indicative of groundwater and how groundwater used to be in the basin, so it would provide valuable baseline information about groundwater even if some of the ecology has changed.

Trotta – What is the timeframe for that work?

Dusterhoff – It is a two-part project. Part 1 is developing restored landscape vision and Part is using the vision to identify several restoration concepts. The vision was completed in April; we are in the process of making some updates, but it is a public document now. Restoration plan will be done by February 2021. Here is the link for Laguna de Santa Rosa Restoration Vision:
https://www.sfei.org/sites/default/files/biblio_files/Restoration%20Vision%20for%20the%20Laguna%20de%20Santa%20Rosa%20SFEI%20041520%20med%20res.pdf

Gaffney – Am I mistaken that the Ukiah reach of Russian River is not a high or medium priority basin? The middle Reach looks to be involved too.

Trotta – It is a medium priority basin and there is a GSA creating a plan for that basin in Mendocino county. We aren't directly involved in the development of that plan. The data sources you mention would most likely be of interest to that GSA, I can put you in contact with consultants working with GSA in that area.

Magill to Trotta – Should meeting participants send additional information to staff between meetings?

Trotta – Yes, that would be helpful; we will discuss offline, maybe a single point of contact or file share location would be best.

Lee – In terms of existing data sources to be included – there are local and anecdotal knowledge of data that exists out there. In terms of another data source, we at the Ecology Center, have installed 11 stream gauges in upper Sonoma creek in the last two years. Having the continuous data that can be used in an upstream and downstream fashion, is another potential data source that could be valuable and is available. Also, we recently installed a series of temperature loggers around the watershed for the dry season. In terms of additional data collection to be recommended, seeing more of the continuous stream flow data around the different watersheds beyond the USGS gauges is available, and could be valuable moving forward.

Pennington – Great work. I was thinking about other species of concern and endangered species. You chose steelhead but it does seem there are other species that are dependent on having water in the summer and into the fall, when the streams are most sensitive to groundwater depletion. I would recommend looking at species such as freshwater shrimp and where they existed historically. Think about steelhead passed through these streams but aren't necessarily there when the groundwater dependent ecosystems are sensitive to groundwater depletion.

David Cook – We can look at other species. The reason we selected steelhead is that it encompasses species that are most sensitive in the summertime. Steelhead streams, we are really talking about juvenile steelhead and they encapsulate all the amphibians such as CA giant salamander, etc. that need perennial water. Fresh water shrimp distribution is so patchy that there are no known occurrences within the three basins. It doesn't encapsulate enough to be of value for this kind of type of analysis.

Pennington – What about the possibility of using multiple species?

David Cook – We may add additional section in the streams. In general, when you look at the basins, lots of amphibians are outside the basin.

Rohde – We also need to consider how other state and federal listed species are impacted by groundwater. Here is a document that identifies what protected status species are likely reliant on groundwater in California:
https://groundwaterresourcehub.org/public/uploads/pdfs/Critical_Species_LookBook_web.pdf
This is an effort that Rick Rogers (NOAA), Briana Seepy (DFW), Xeronimo Castaneda (Audabon), and I have put together.

Review Meeting Action Items

Sam Magill restated the action items from the meeting:

- Data sharing – staff to discuss offline how to share additional data, meeting summary, and other meeting materials
- Discussion for staff how to share raw data
- Marcus Trotta to connect Karen Gaffney to the GSA for the Ukiah reach of the Russian River

Next Steps and Planning for Meeting #2

Objective: Discuss next steps for planning workgroup meeting #2.

Marcus Trotta said he will look at file share, take input received today and make any refinements and revisions to maps. He will develop a GIS process to integrate surface water maps to species and veg maps with the goal of having the information and those maps for a second meeting. Then we can determine if we need a third meeting or not. Would like a discussion of the importance of understanding their habitat needs including critical time periods. We are probably looking at the second or third week of August for the next meeting for this group. Sam Magill will reach out to you.

We proposed the other workgroup would meet on the tail end of this one. We will look at the overall schedule, it may make sense to have the two groups overlap a little to do some work in tandem with this workgroup.

Marcus Trotta and Andy Rich thanked the group for participating and said the comments were very helpful.

Attendees:

Andres Ticlavilca, National Marine Fisheries Service
Karen Gaffney, Ag & Open Space Preservation District
Melissa Rohde, The Nature Conservancy
Rick Rogers, National Marine Fisheries Service
Robert Pennington, Permit Sonoma
Scott Dusterhoff, San Francisco Estuary Institute
Steve Lee, Sonoma Ecology Center
Wendy Trowbridge, Santa Rosa de Laguna Foundation

Staff/Presenters

Marcus Trotta, Sonoma Water
Andy Rich, Sonoma Water
David Cook, Sonoma Water
Patrick Lei, Sonoma Water
David Manning, Sonoma Water
Ann DuBay, Sonoma Water
Simone Peters, Sonoma Water (recorder of meeting notes)

Facilitator

Sam Magill, Sacramento State University – Consensus and Collaboration Program

SANTA ROSA PLAIN • PETALUMA VALLEY • SONOMA VALLEY
GROUNDWATER
SUSTAINABILITY AGENCIES

IDENTIFICATION AND MAPPING OF GROUNDWATER DEPENDENT ECOSYSTEMS

Workgroup Meeting #1

July 7, 2020

MEETING AGENDA

1. Welcome and Introductions
2. Agenda Review
3. Sustainable Groundwater Management Act (SGMA) Update and Need for Identification of GDEs
   - SGMA overview
   - Groundwater Sustainability Plan (GSP) status and schedule
   - How will identified GDEs be used in the GSPs
   - Proposed process for mapping GDEs
   - Questions/Discussion
4. Existing Datasets for Preliminary Mapping of Potential GDEs
   - Indicators of GDEs (iGDE) maps (The Nature Conservancy)
   - Draft Steelhead streams maps (Sonoma Water)
   - Draft Vegetation-related GDE maps (Sonoma Water)
   - Draft Interconnected Surface Water maps (Sonoma Water)
   - Draft Depth-to-Groundwater (DTW) maps for shallow unconfined aquifer system (Sonoma Water)
   - Discussion of Data Gaps
5. Next Steps and Planning for Meeting #2
6. Review Action Items
7. ADJOURN

Required Steps to Groundwater Sustainability

Step one
Form Groundwater Sustainability Agency
June 30, 2017
- Complete

Step two
Develop Groundwater Sustainability Plan
January 31, 2022

Step three
Achieve Sustainability
20 years after adoption of plan*

* DWR may grant up to two, five-year extensions on implementation upon showing of good cause and progress

Failure to meet any of these deadlines triggers intervention by the State Water Resources Control Board

Sustainable Management Criteria

Sustainable Management Criteria (SMCs) are defined locally based on ***basin conditions*** to avoid *significant and unreasonable* ***Undesirable Results*** for SGMA ***Sustainability Indicators***.

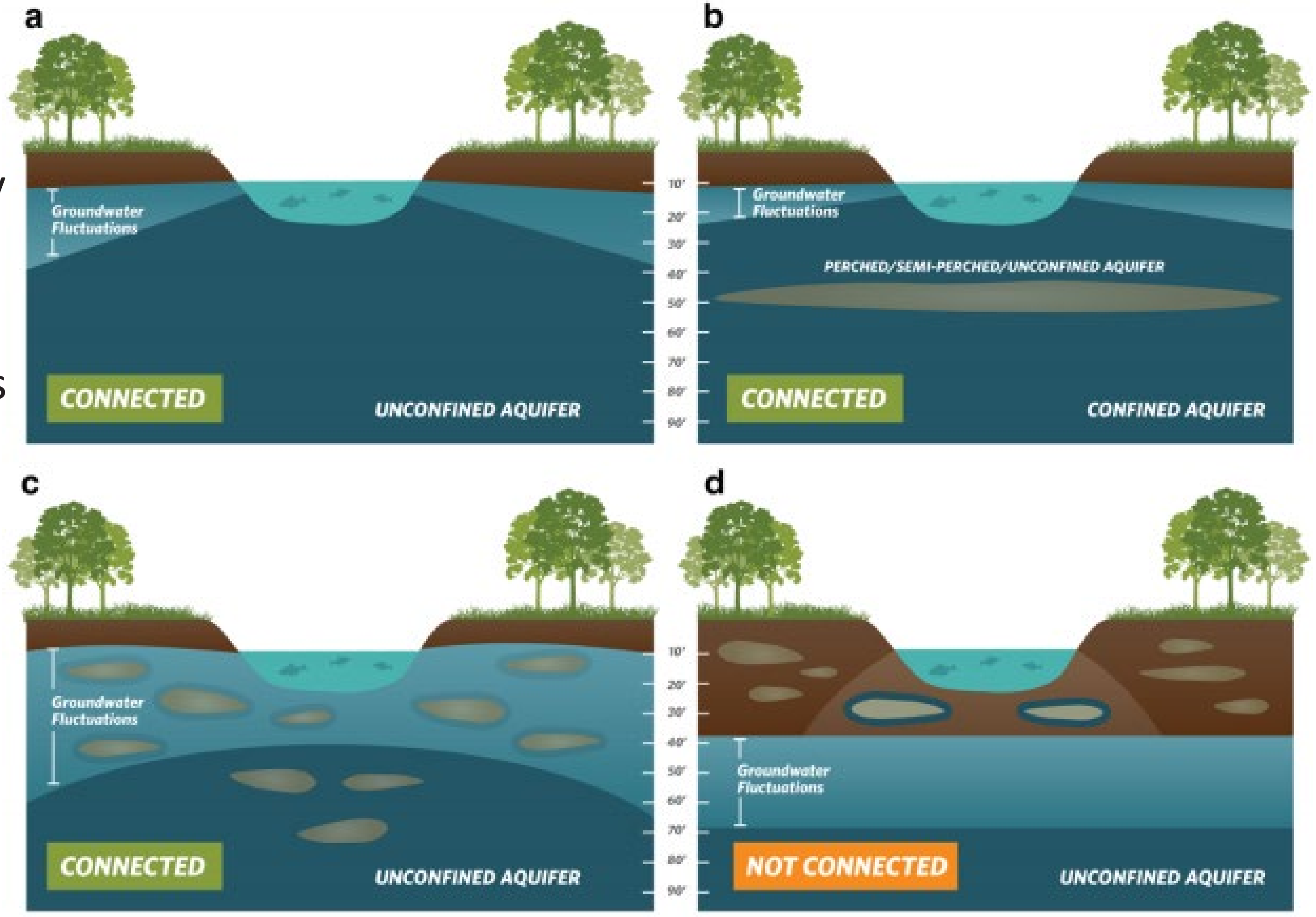
Iterative Process which will involve significant stakeholder engagement, modeling of future climate, growth, and projects and actions

Sustainability Indicators

- Lowering Groundwater Levels
- Seawater Intrusion
- Reduction of Storage
- Land Subsidence
- Degraded Quality
- Surface Water Depletion

Proposed Approach for GDE Mapping

- Focus on ecosystems that can be affected by groundwater conditions and management and are within jurisdiction of GSAs
- Utilize available statewide and local datasets to develop best available information
- Consider using "indicator" species and/or grouping of GDEs with similar characteristics/habitat needs
- Prioritize GDEs for consideration in developing SMCs for Surface Water Depletion (separate workgroup)



https://groundwaterresourcehub.org/

Source: The Nature Conservancy, Identifying GDEs Under SGMA Best Practices for using the NC Dataset, 2019

Focus of Workgroup Meetings

Meeting 1 - *July 7*

a. Background and Focus of Workgroup
b. Description of existing datasets, model tools and preliminary mapping efforts
c. Discuss process for integration of datasets for developing Potential GDE Maps
d. Discussion of data gaps

Technical Work between Meetings 1 and 2

a. Completion and refinement of maps based on Workgroup input
b. Develop initial information to support characterizing habitat needs and ecological value for potential grouping of GDEs

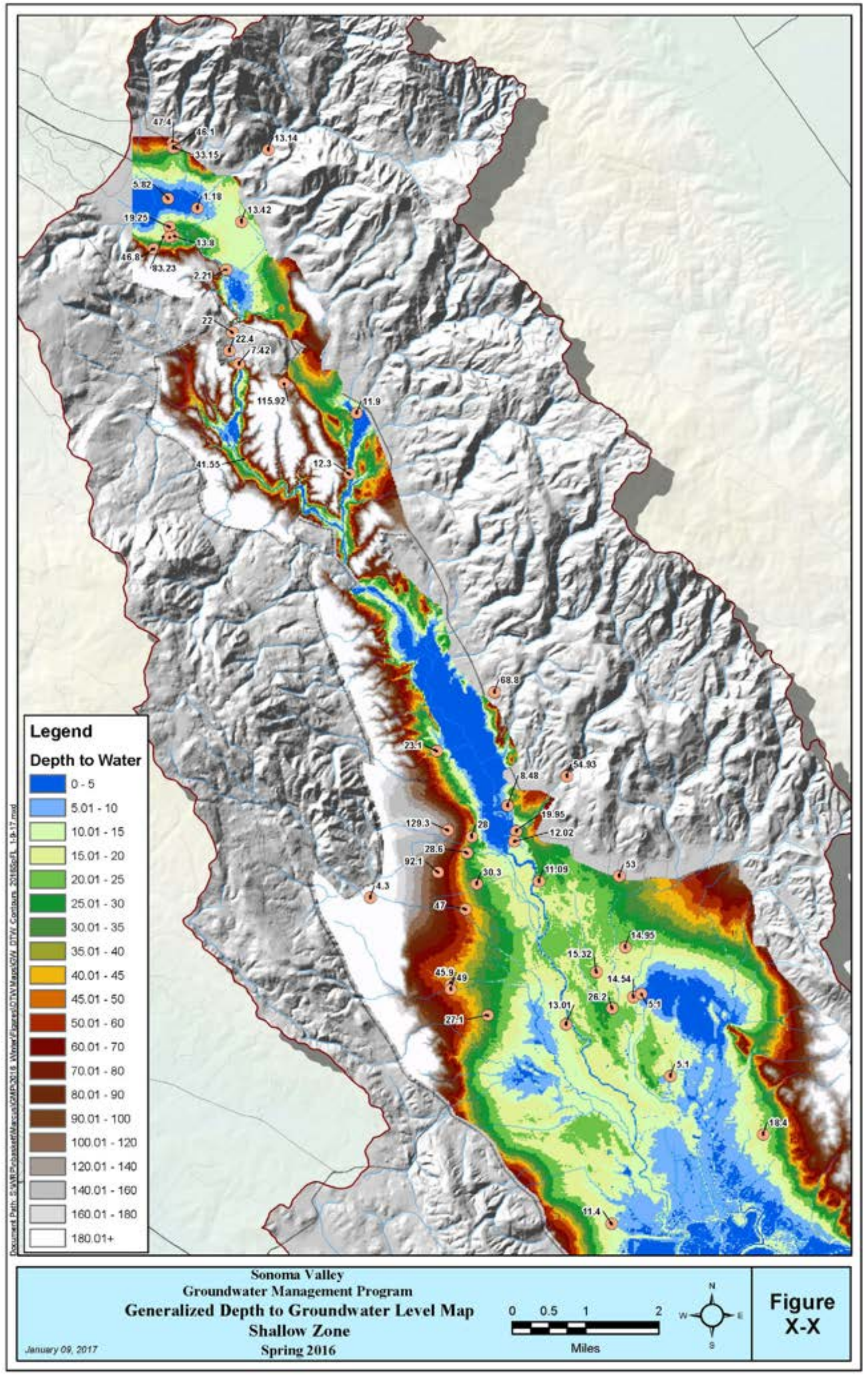
Focus of Workgroup Meetings

Meeting 2 (and 3?) - *August?*

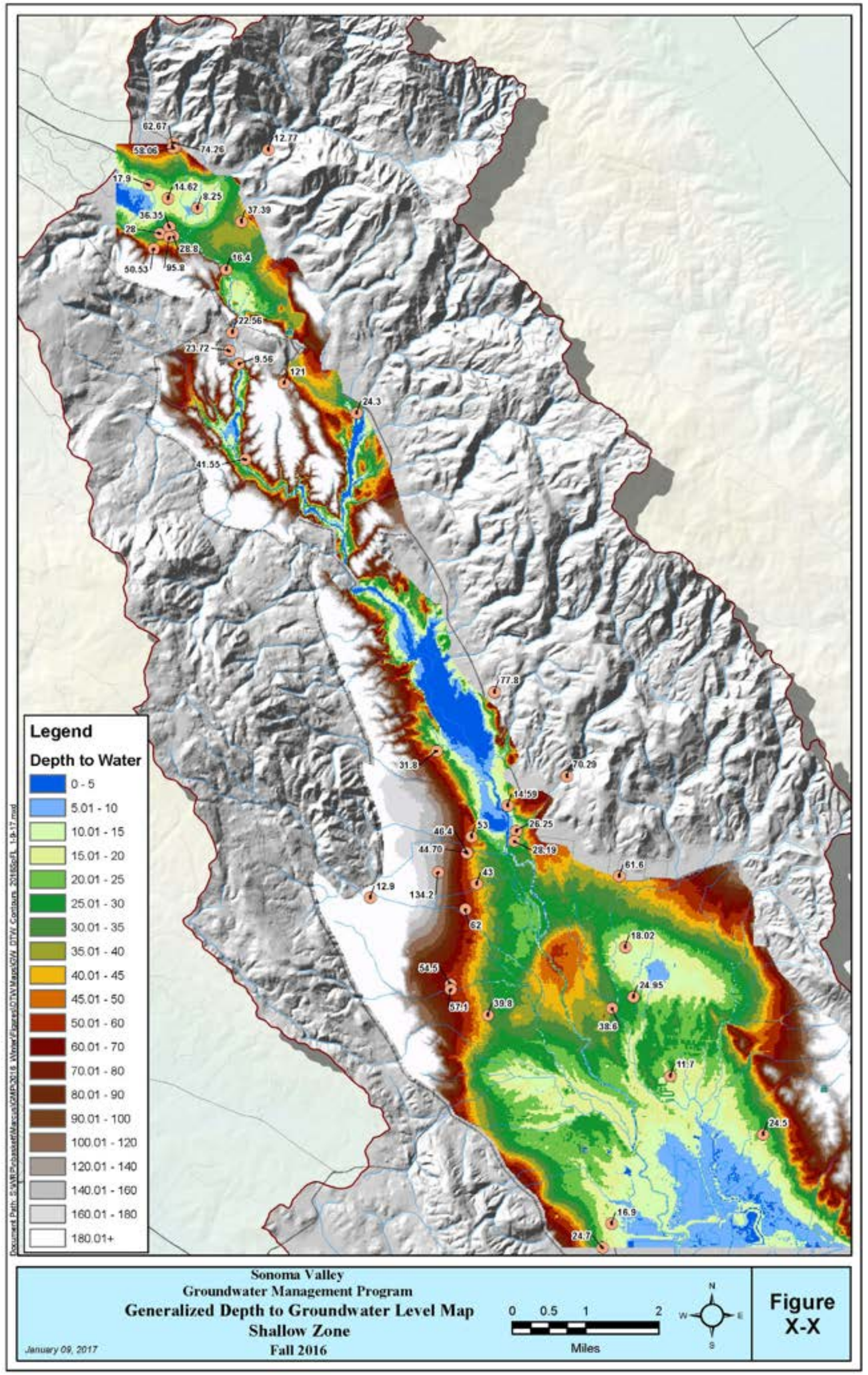
a. Review/discuss new maps and map revisions based on Meeting 1
b. Characterizing GDEs
    - General habitat needs (flow, temperature, critical time periods etc)
    - Group individual GDEs into GDE communities based on locations, habitat needs, connection to groundwater, density/amount of groundwater pumping etc. (as applicable)
    - Relative ecological value of each GDE community
    - Develop "priority" species/communities whose needs would cover others if they are met?

Hydrologic Datasets and Tools

- Draft Depth-to-Groundwater (DTW) maps for shallow unconfined aquifer system
  - Initial maps for Santa Rosa Plain and Sonoma Valley
  - Under development for Petaluma Valley
- Draft Interconnected Surface Water (ISW) maps
  - Initial maps for Santa Rosa Plain and Sonoma Valley
  - Petaluma Valley to be developed following completion of USGS integrated hydrologic model

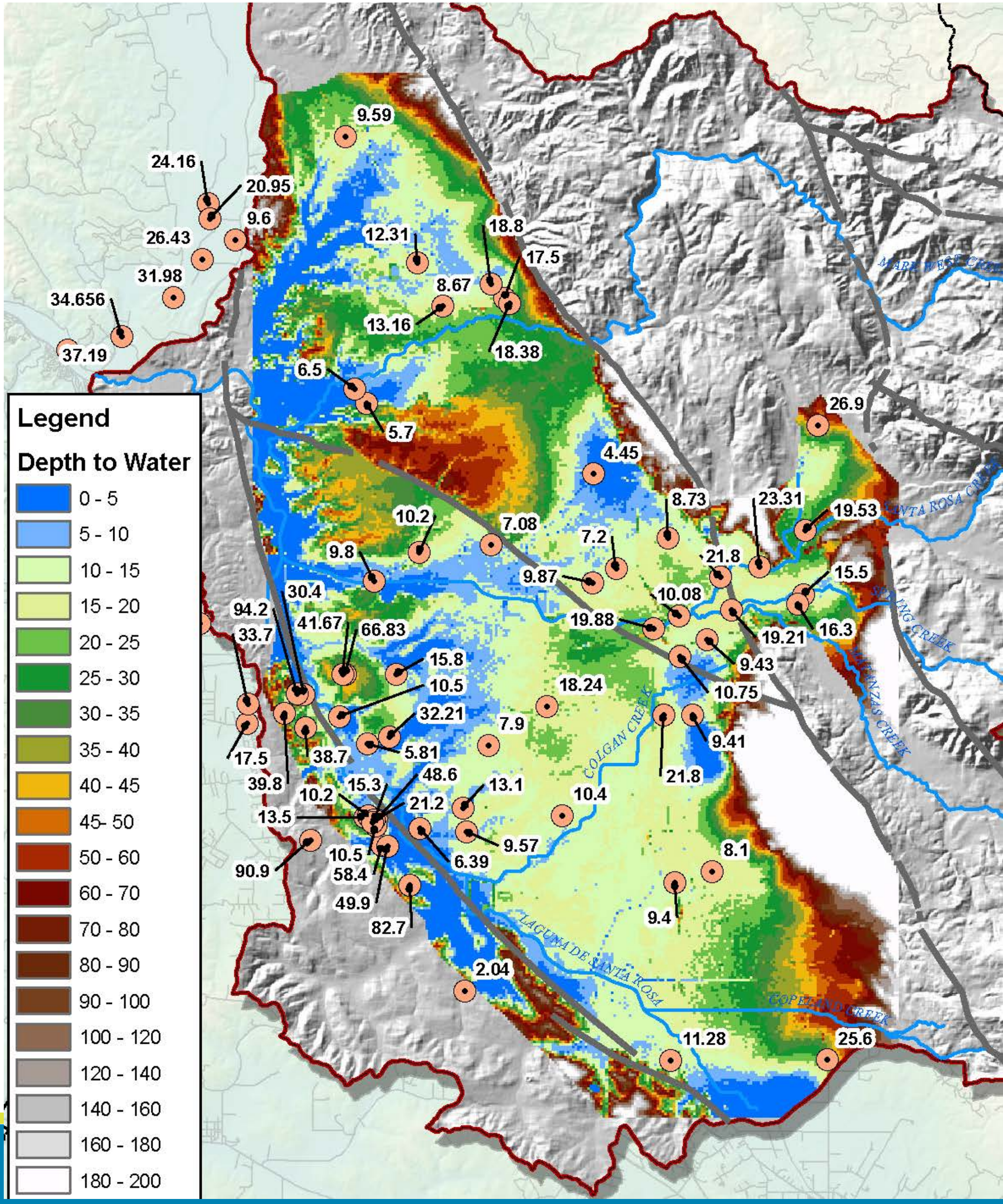


Depth-to-Groundwater Maps for Shallow Unconfined Aquifer System: Sonoma Valley – Spring and Fall 2016

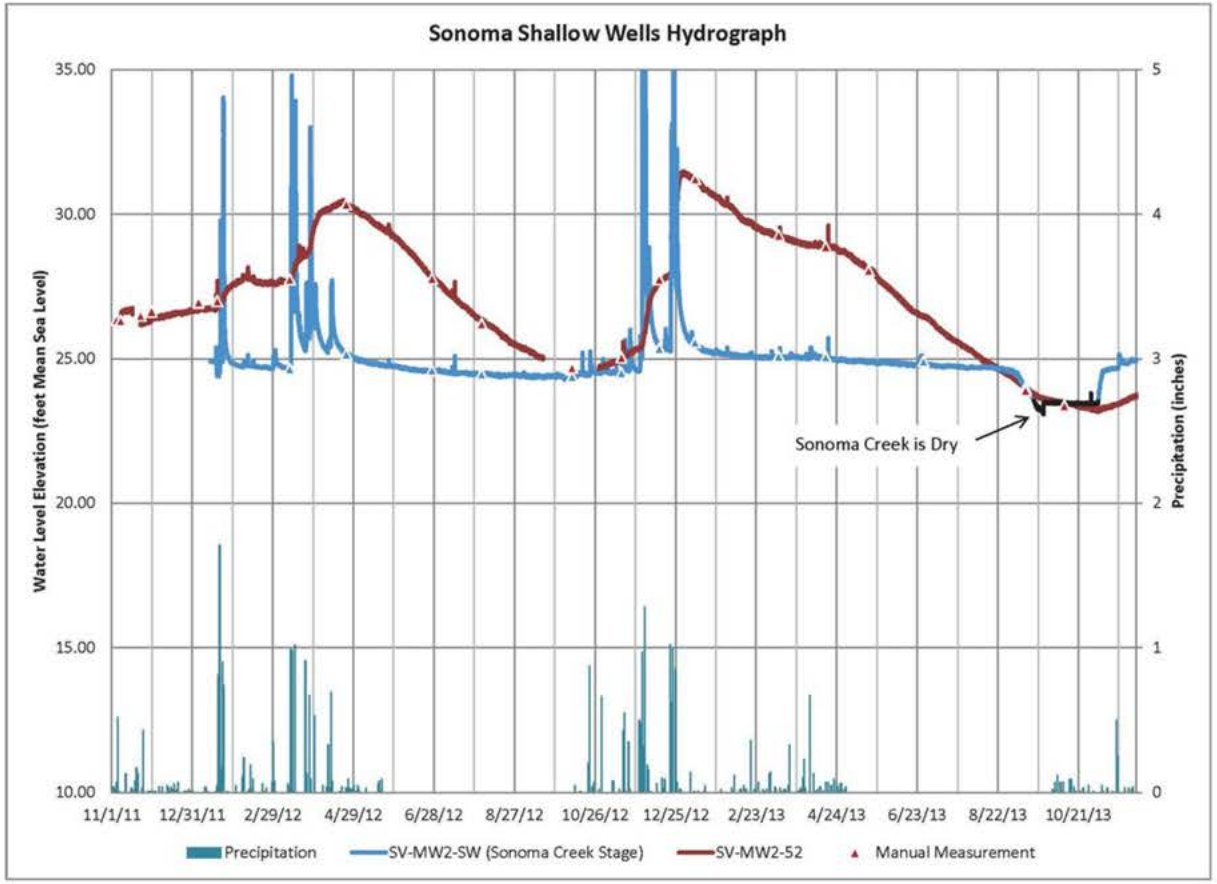


Depth-to-Groundwater Maps for Shallow Unconfined Aquifer System: Santa Rosa Plain – Spring 2015

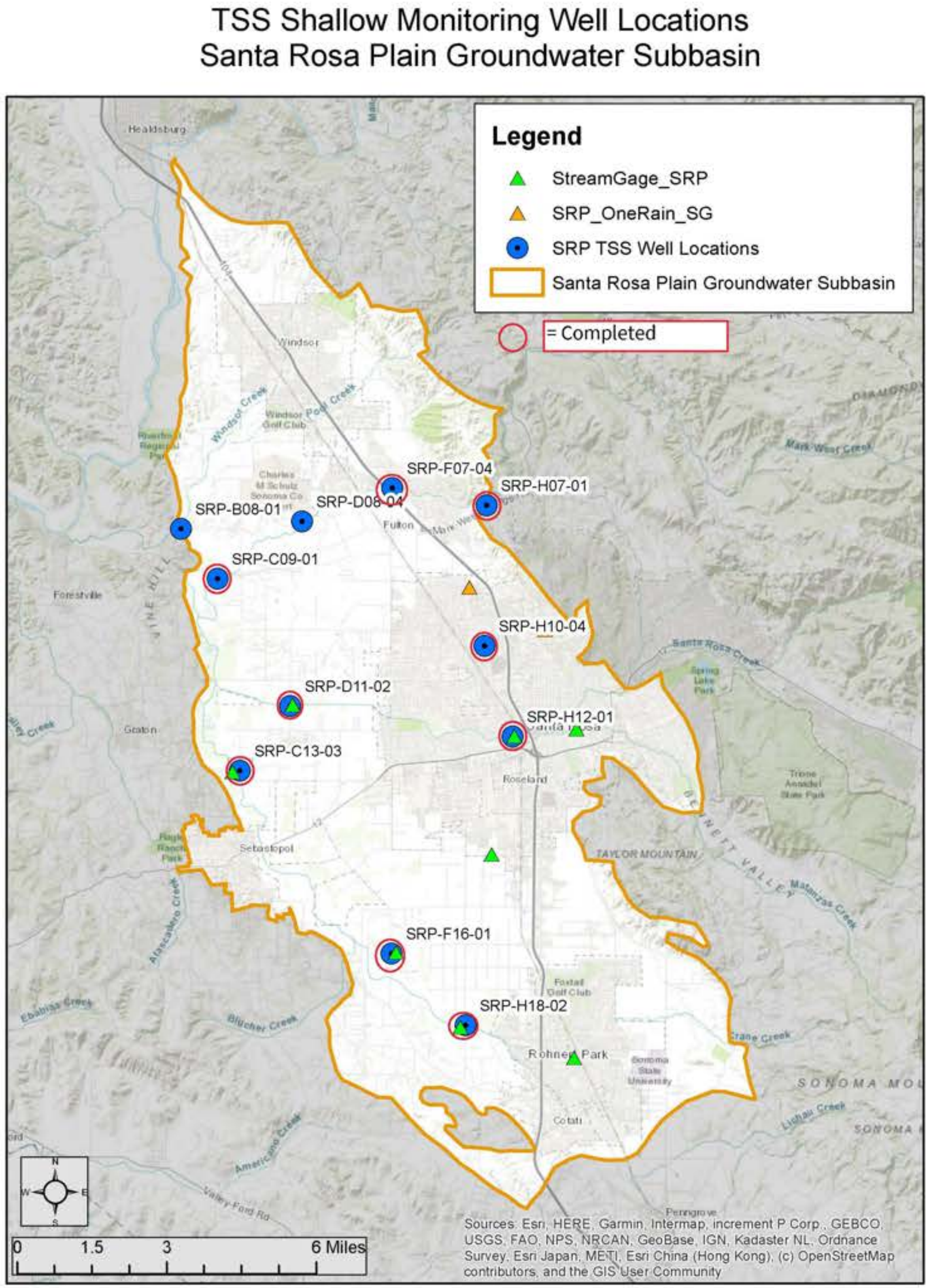
- Consider seasonal fluctuations and temporal trends



Additional Data Sources: Paired Shallow Monitoring Wells with Stream Gauges



*Note: Gaps in data occur when pressure transducer is temporarily out of service or removed for sampling



Interconnected Surface Water – Requirements and Approach

Defined in the GSP Regulations as ***surface water that is hydraulically connected at any point by a continuous saturated zone to the underlying aquifer and the overlying surface water is not completely depleted*** (DWR, 2016).

Define with available data/existing tools using multiple lines of evidence (tools and datasets vary for each basin)

Sonoma Valley Approach

(1) results of seepage run monitoring;

(2) frequency of observed or measured streamflow;

(3) comparison of interpolated groundwater levels within the shallow aquifer system and streambed elevations; and

(4) high frequency groundwater level observations from shallow monitoring wells located near streams.

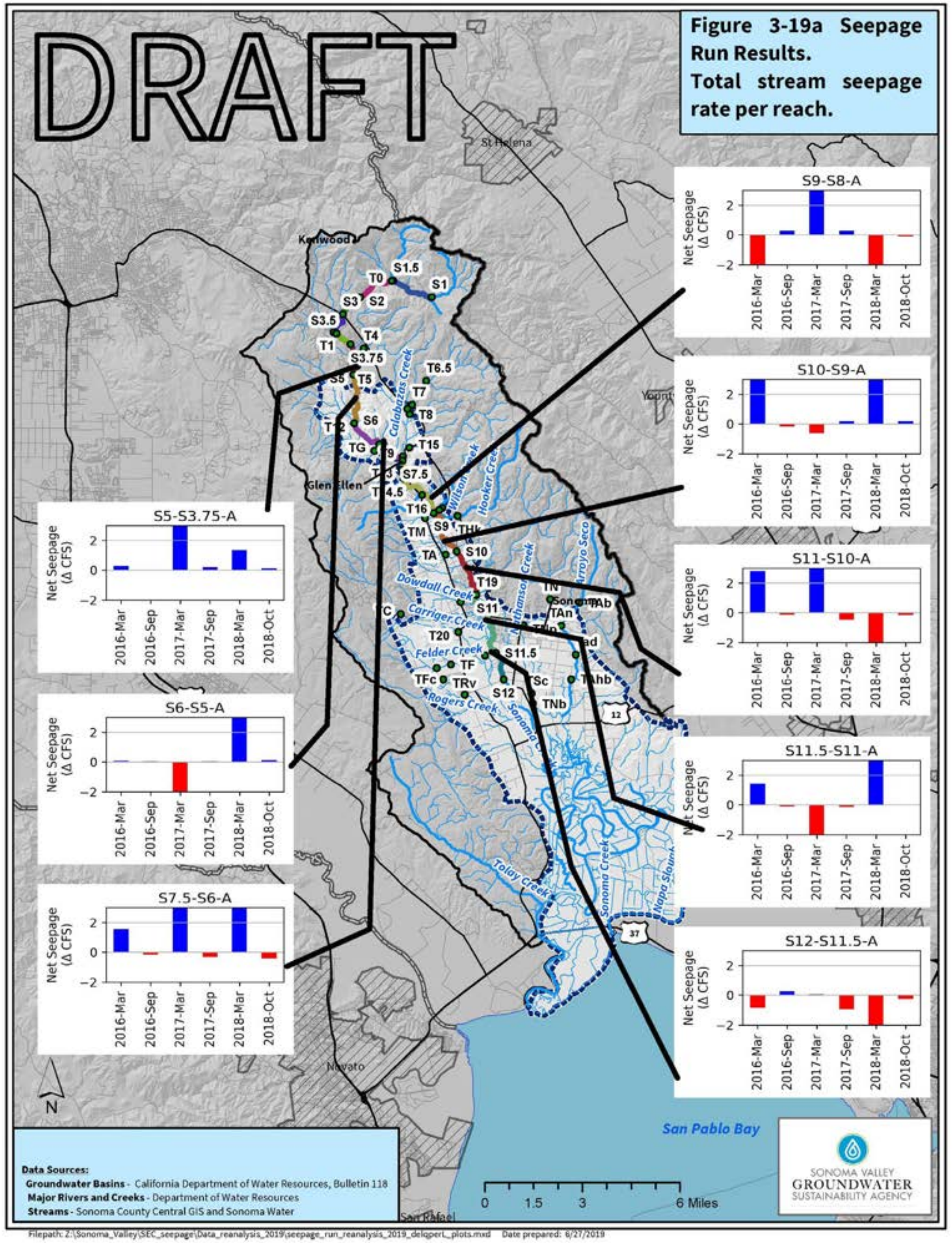
Did not use modeled interactions

Santa Rosa Plain Approach

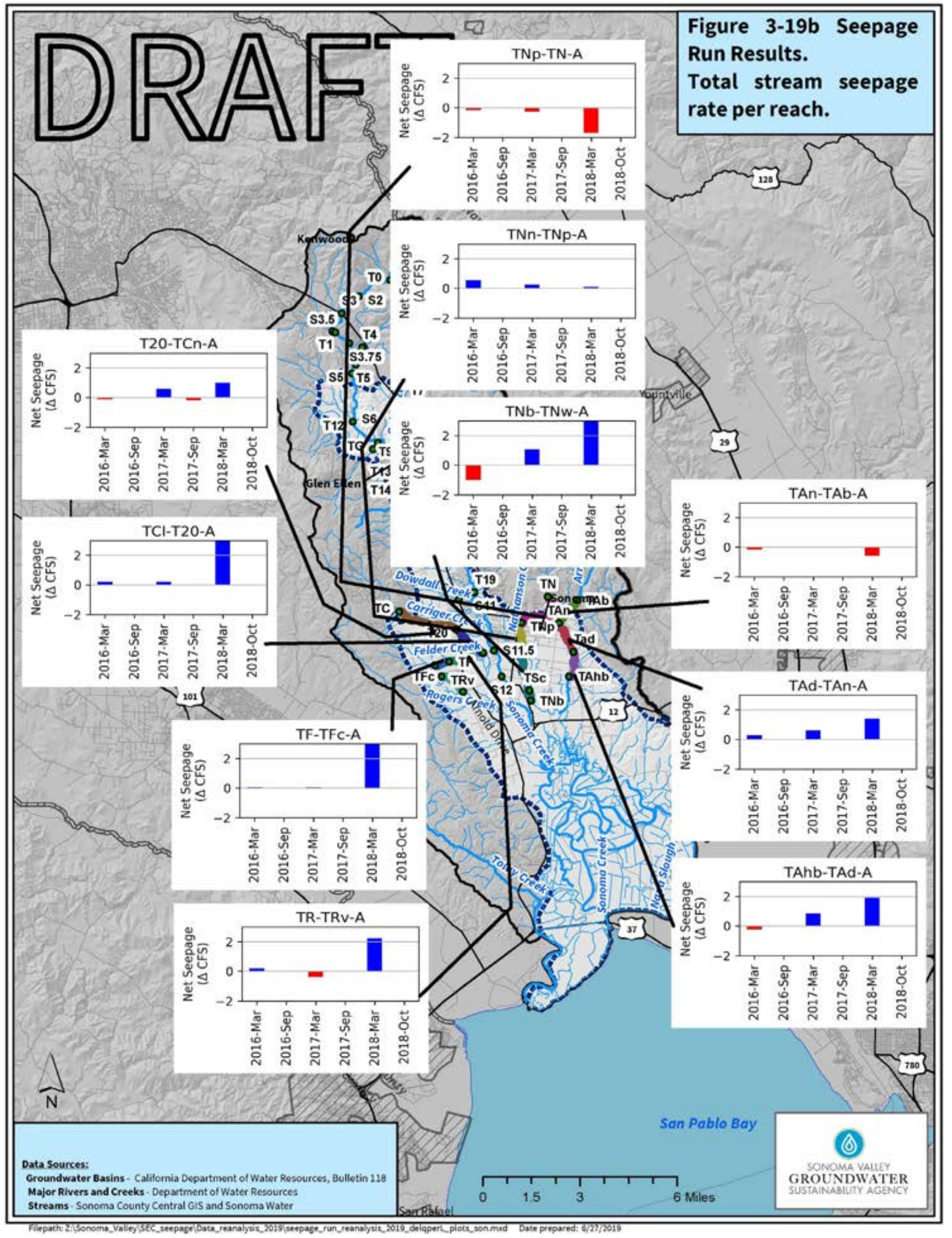
1) measured groundwater level and streambed elevation differences
2) modeled output derived from Wolfenden et al (2014)
   - Percent of time stream is gaining
   - Median streamflow
   - Surface leakage

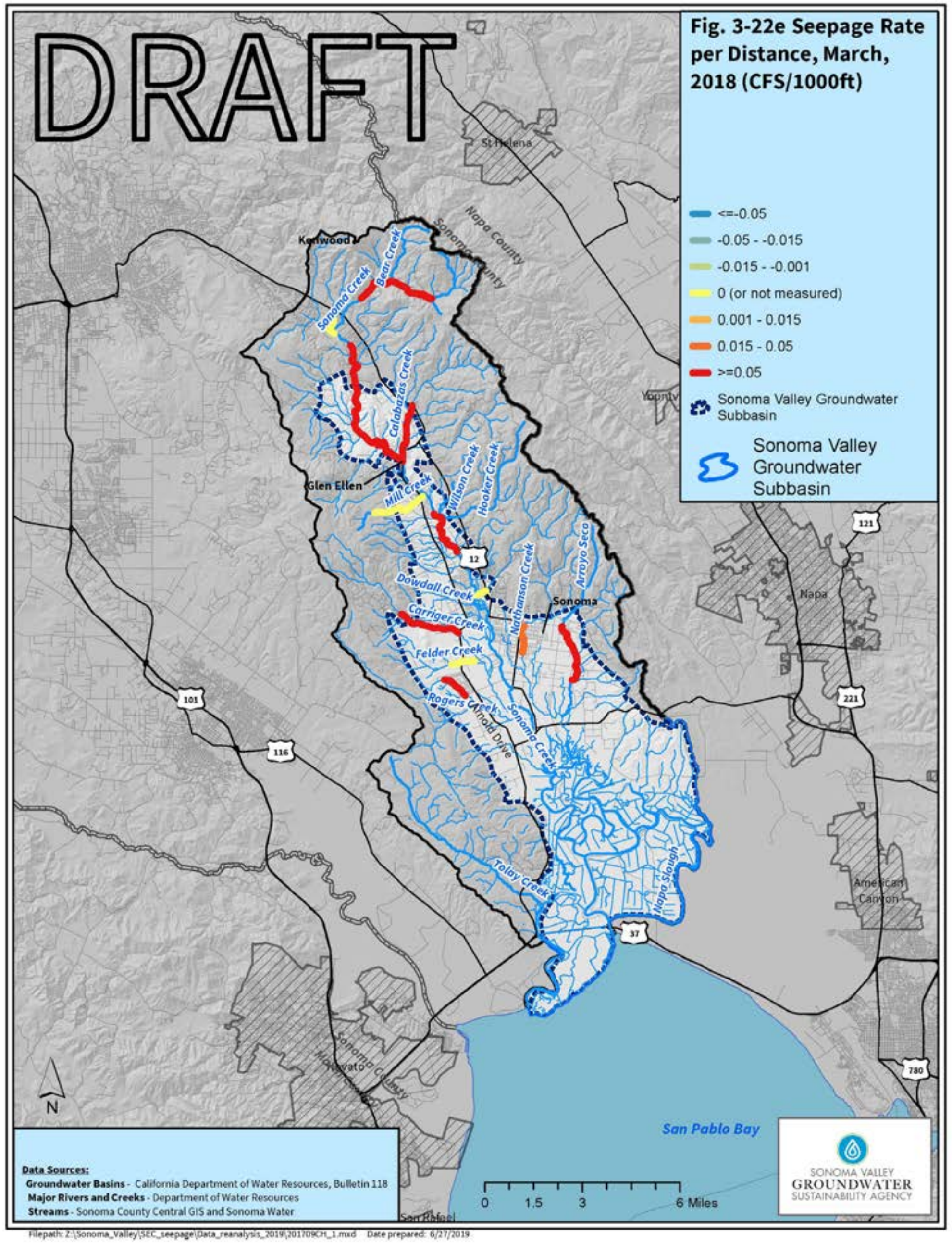
Additional information used in the assessment:

- streamflow seepage exchange through differential gaging
- baseflow separation of observed streamflow records

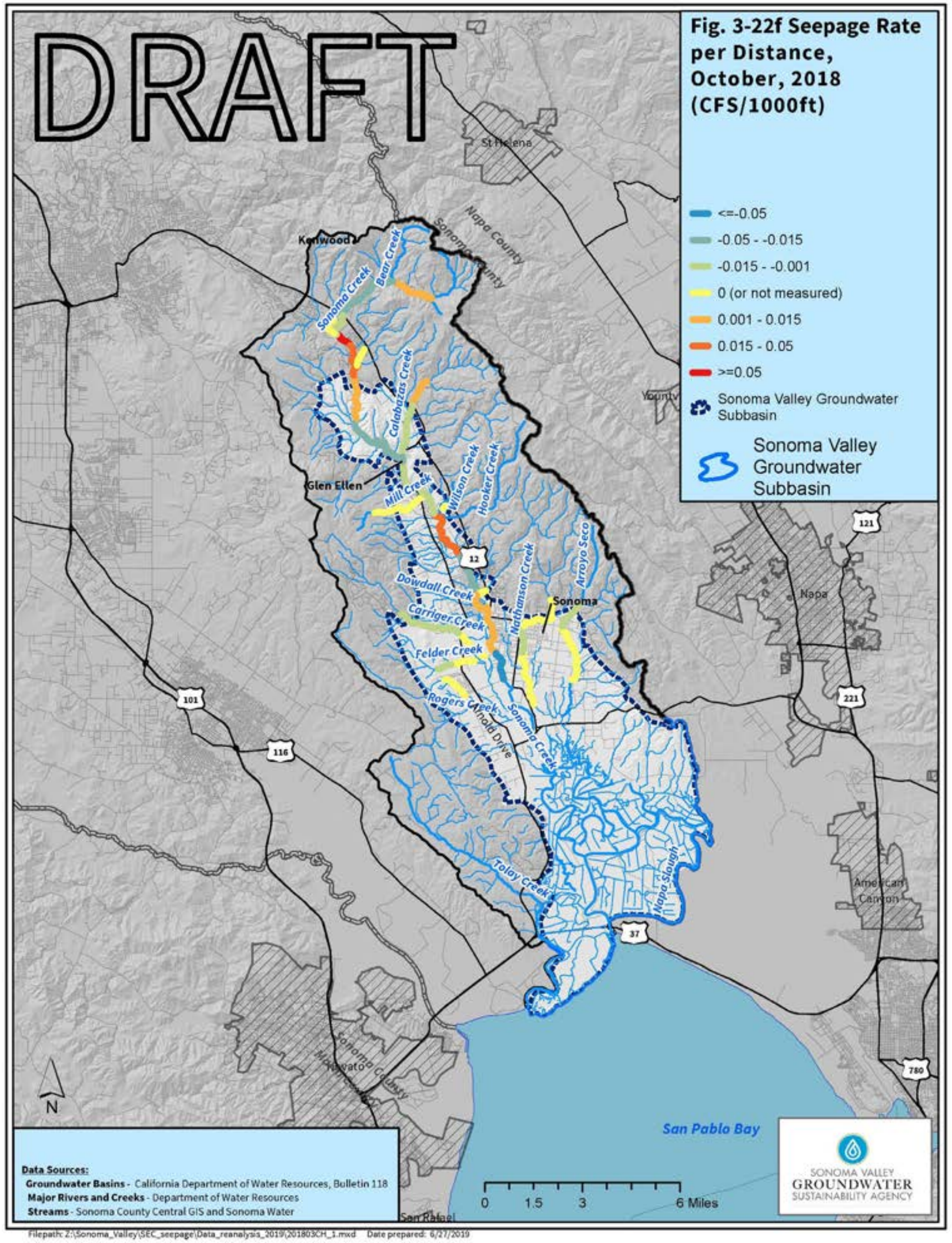


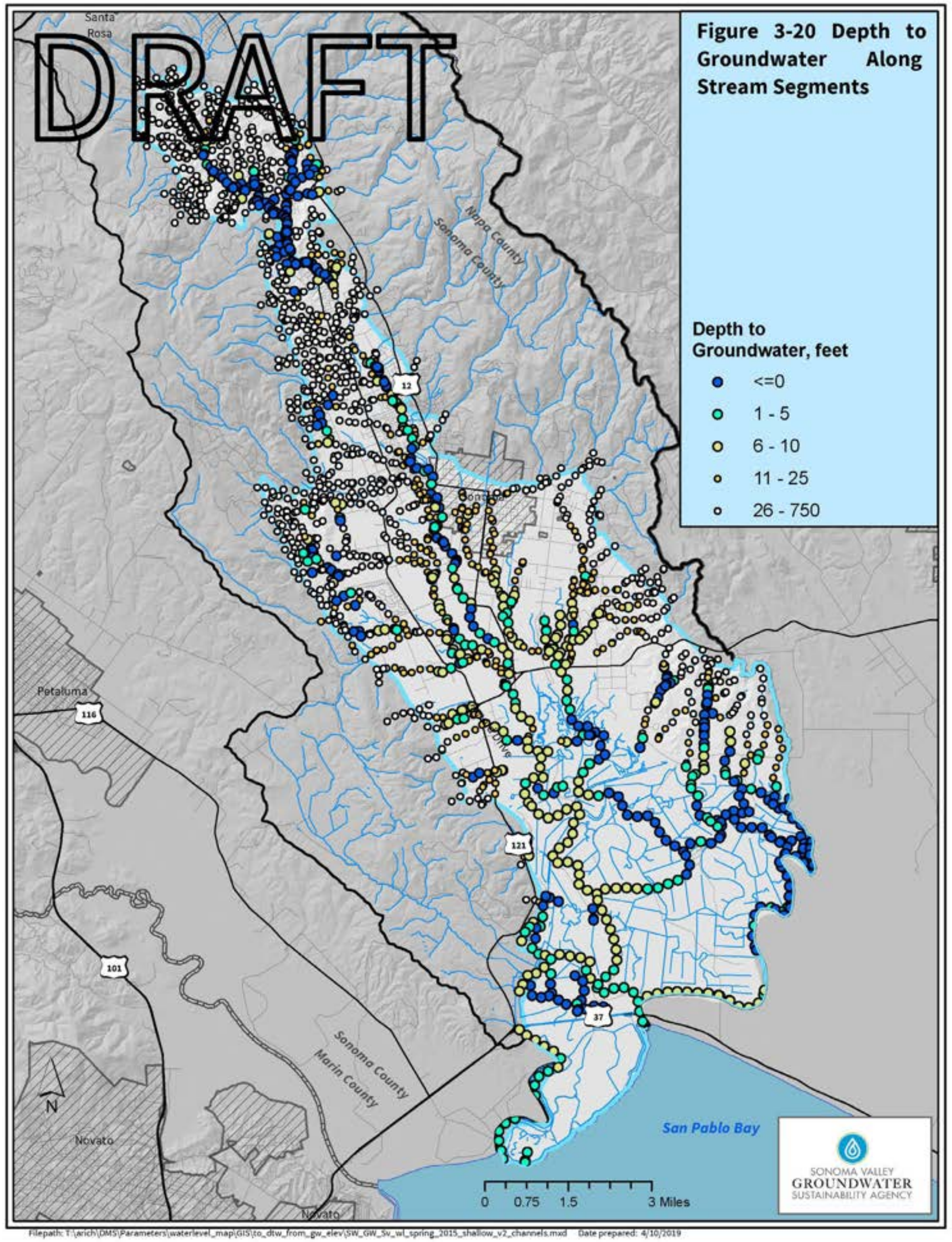
Sonoma Valley Seepage Runs: Total Seepage Rate per Reach



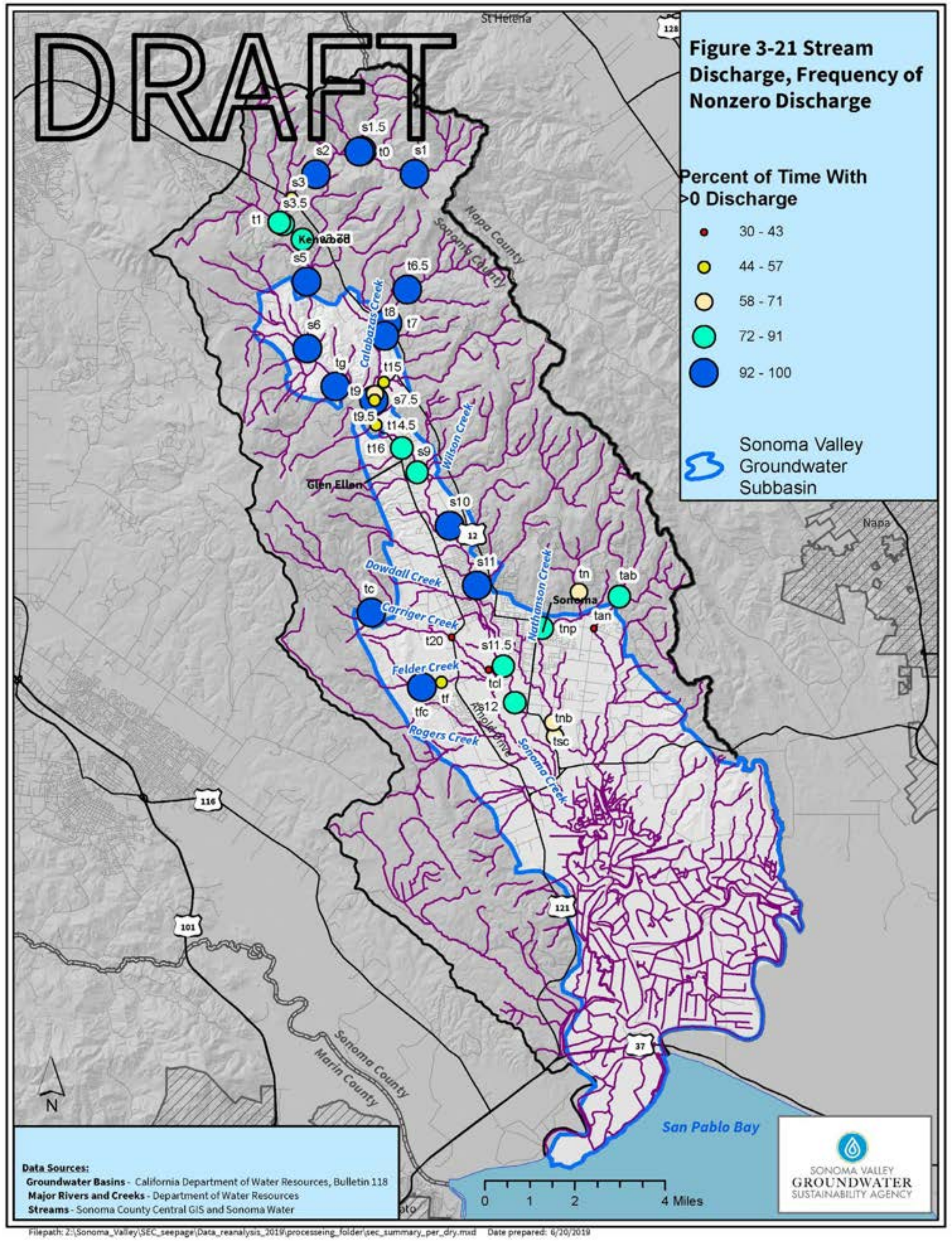


Sonoma Valley Seepage Runs: Total Seepage Rate Distance





Sonoma Valley Depth to Groundwater along Stream Segments & Frequency of Nonzero Discharge



Sonoma Valley Interconnected Surface Water Map

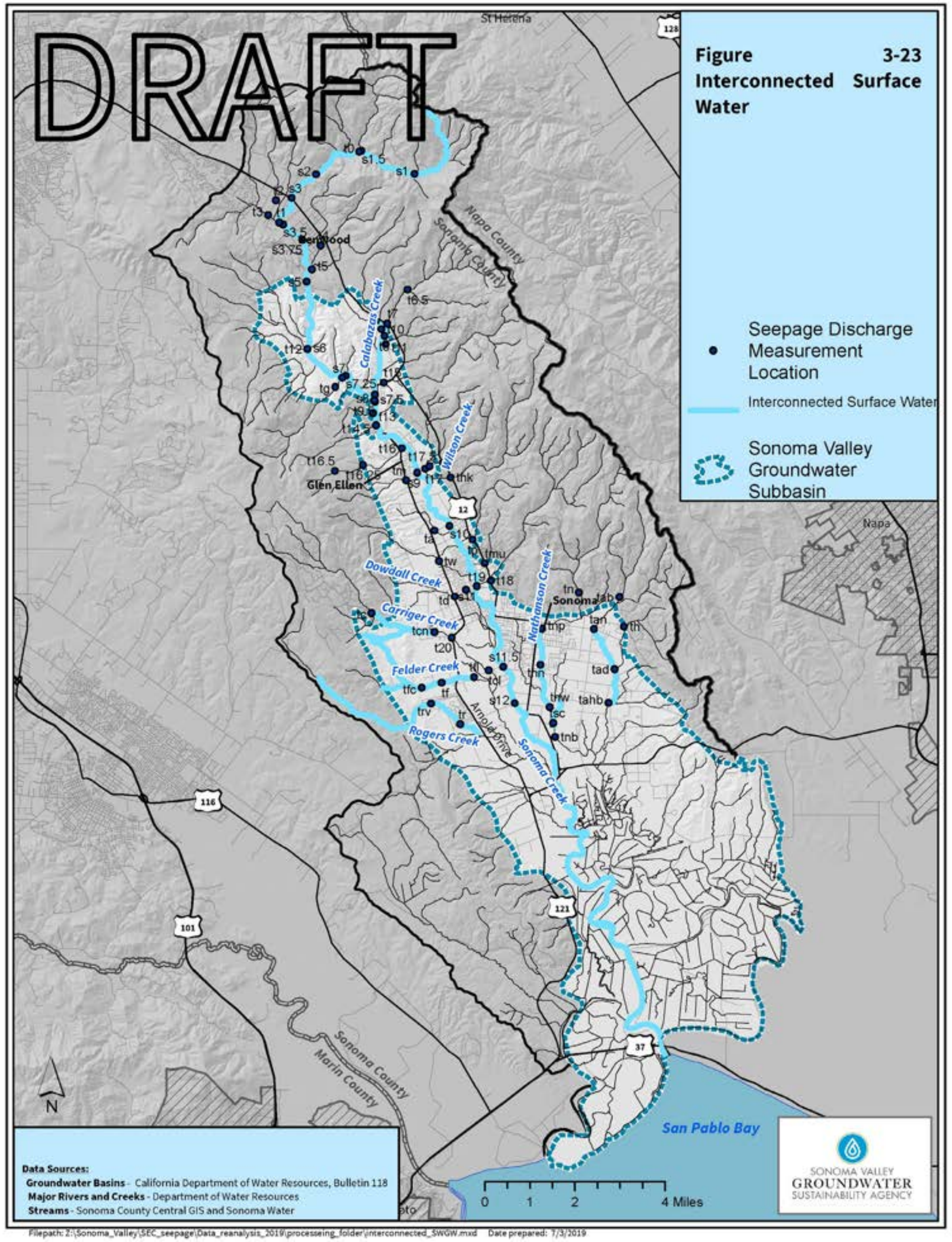


Figure 3-18b Percent of time Stream is Gaining, from 2000 to 2010

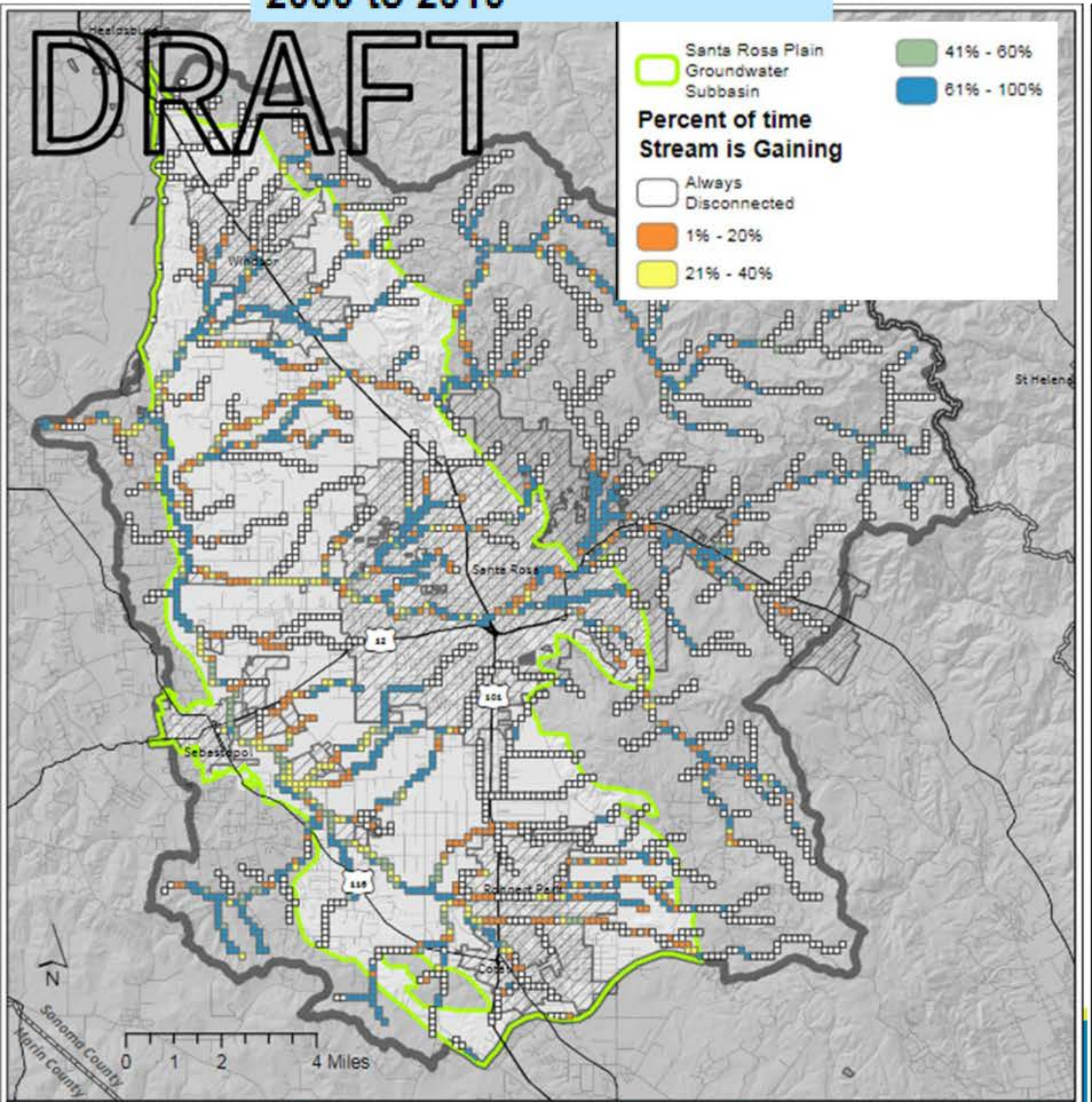


Figure 3-18a Depth to Water Along Stream Channels, Spring 2015

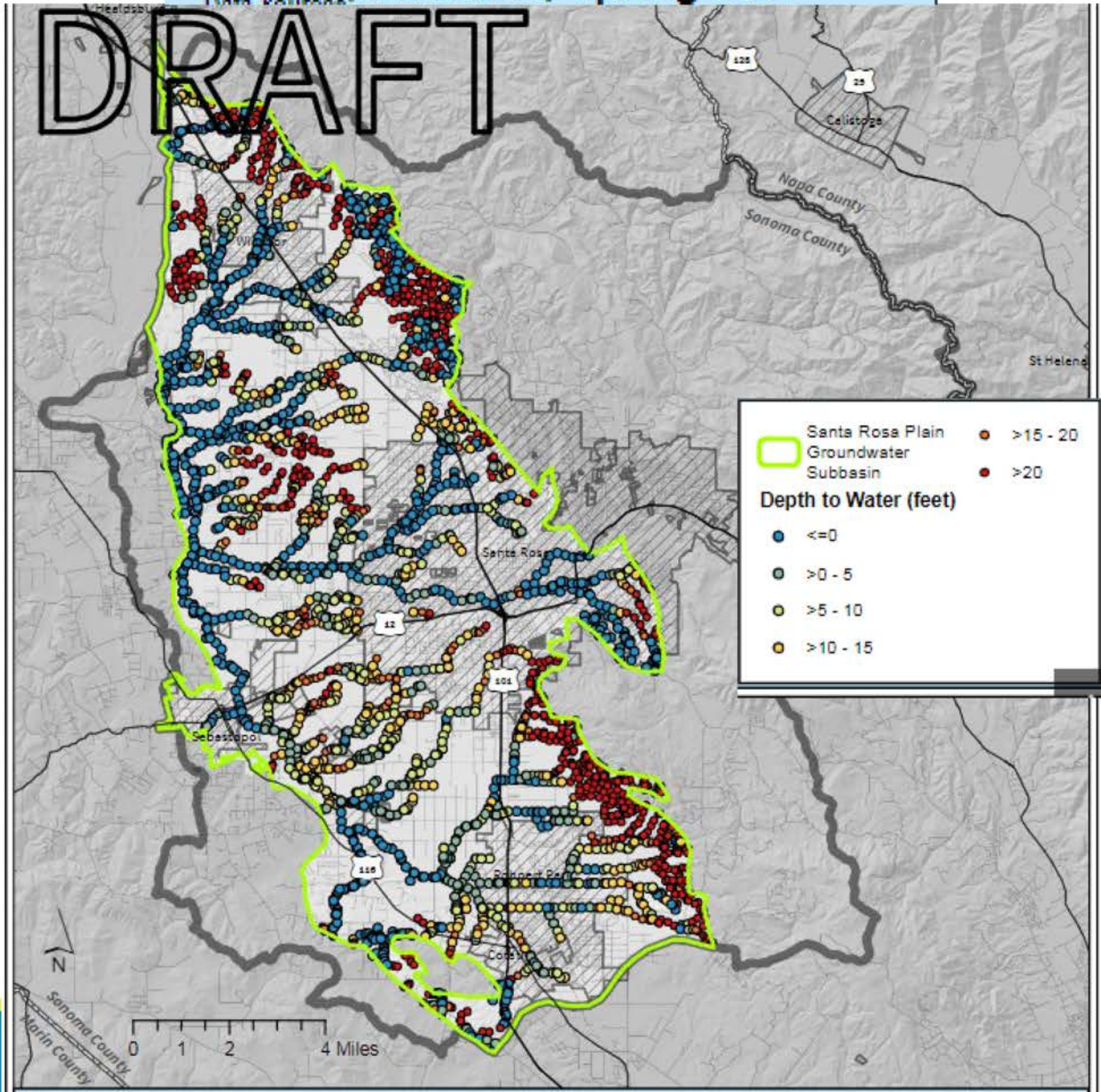


Figure 3-18d Surface Leakage, 2006

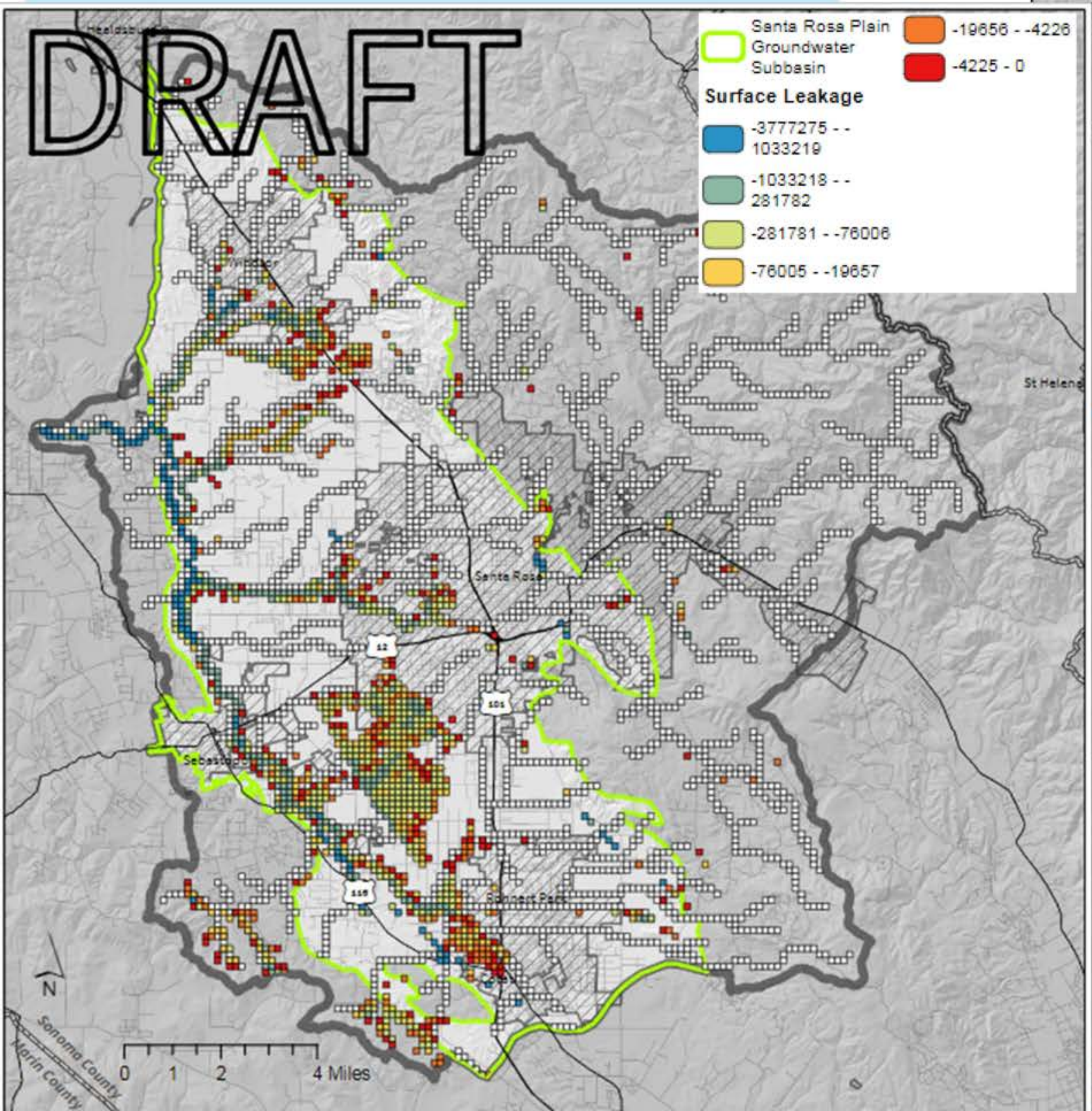
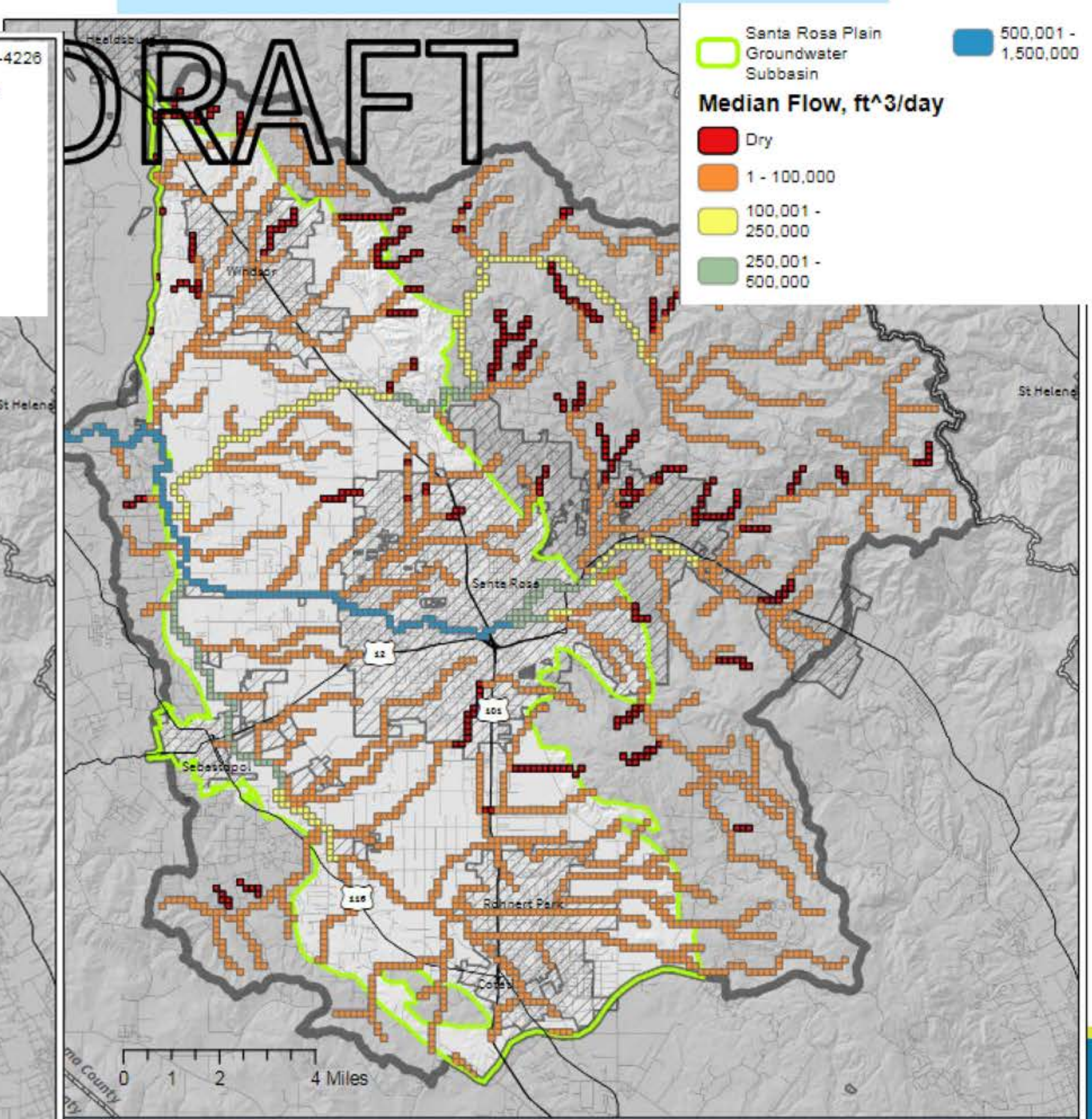
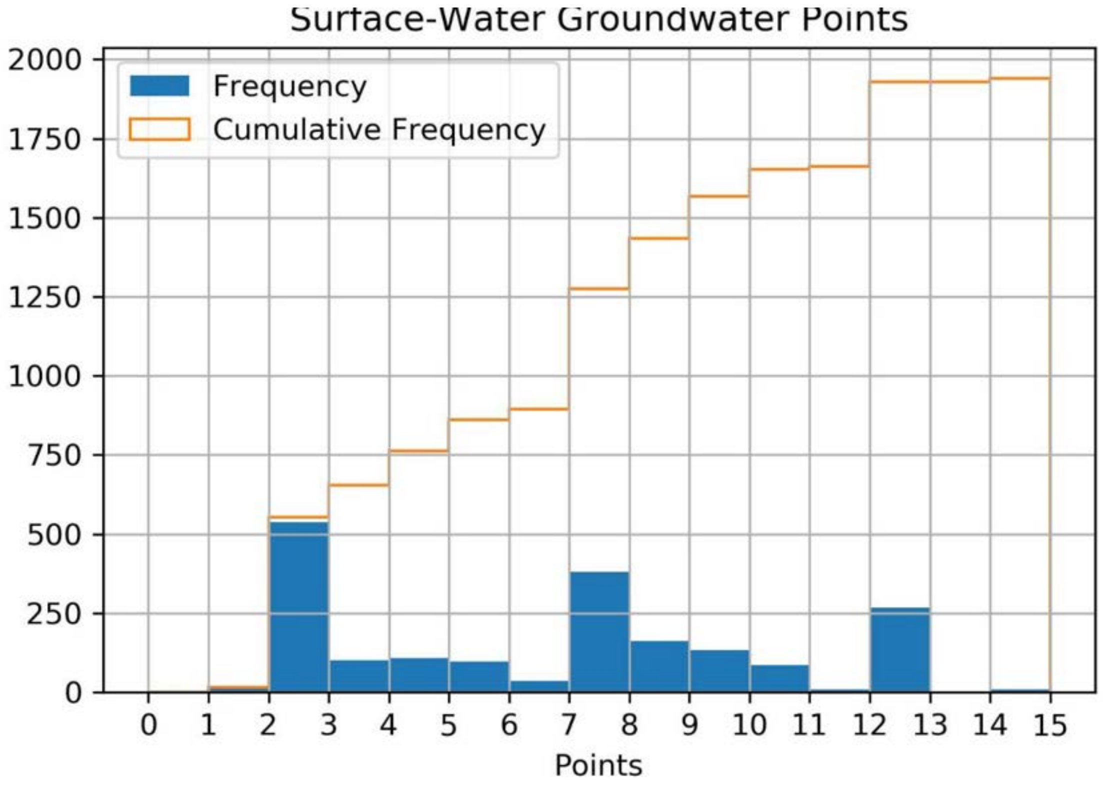


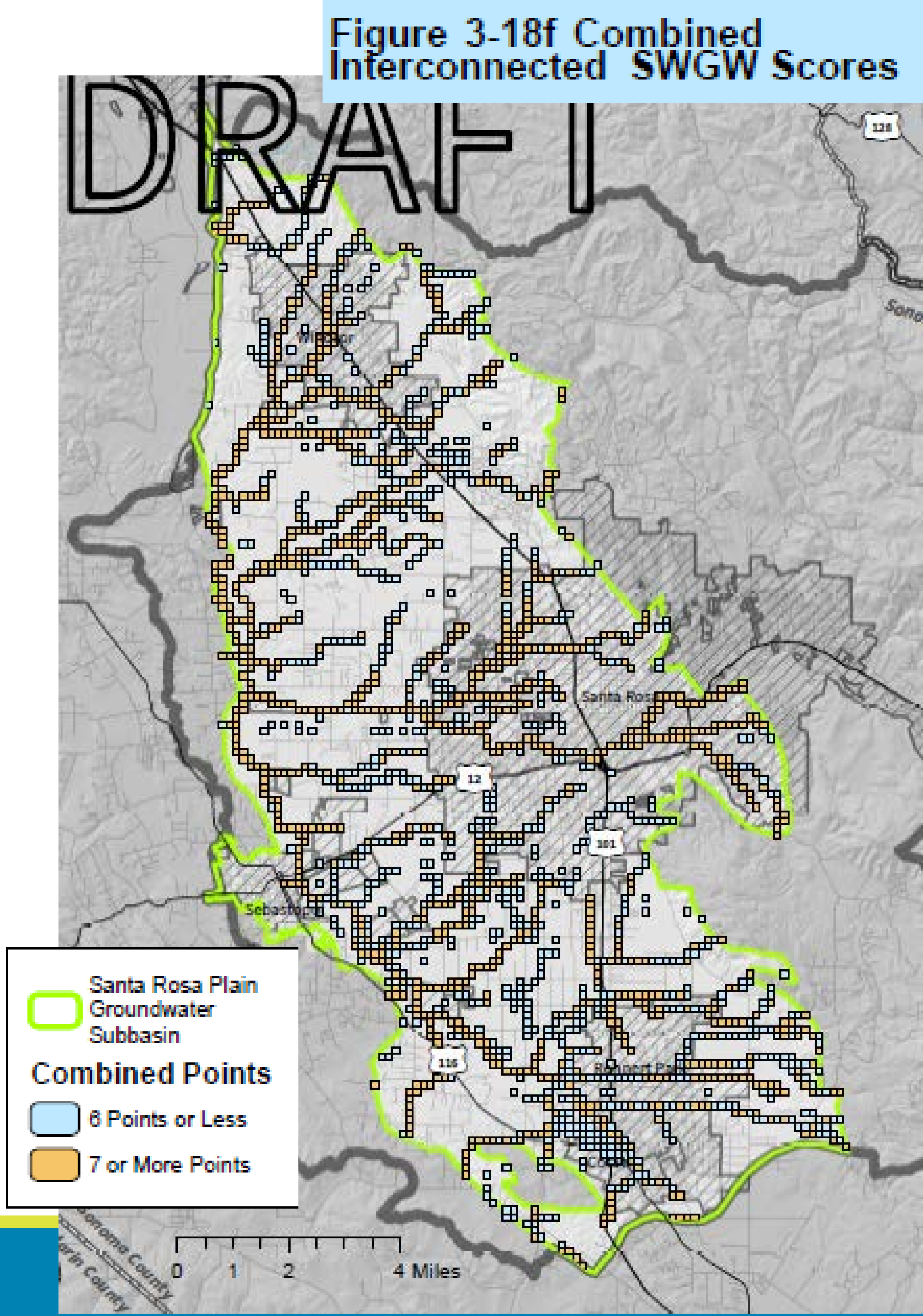
Figure 3-18c Median Flow, from 2000 to 2010



Santa Rosa Plain Interconnected Surface Water Mapping:

- Initial selection of Interconnected Surface Water based on Stream Reaches with 7 or more points (orange –colored cells



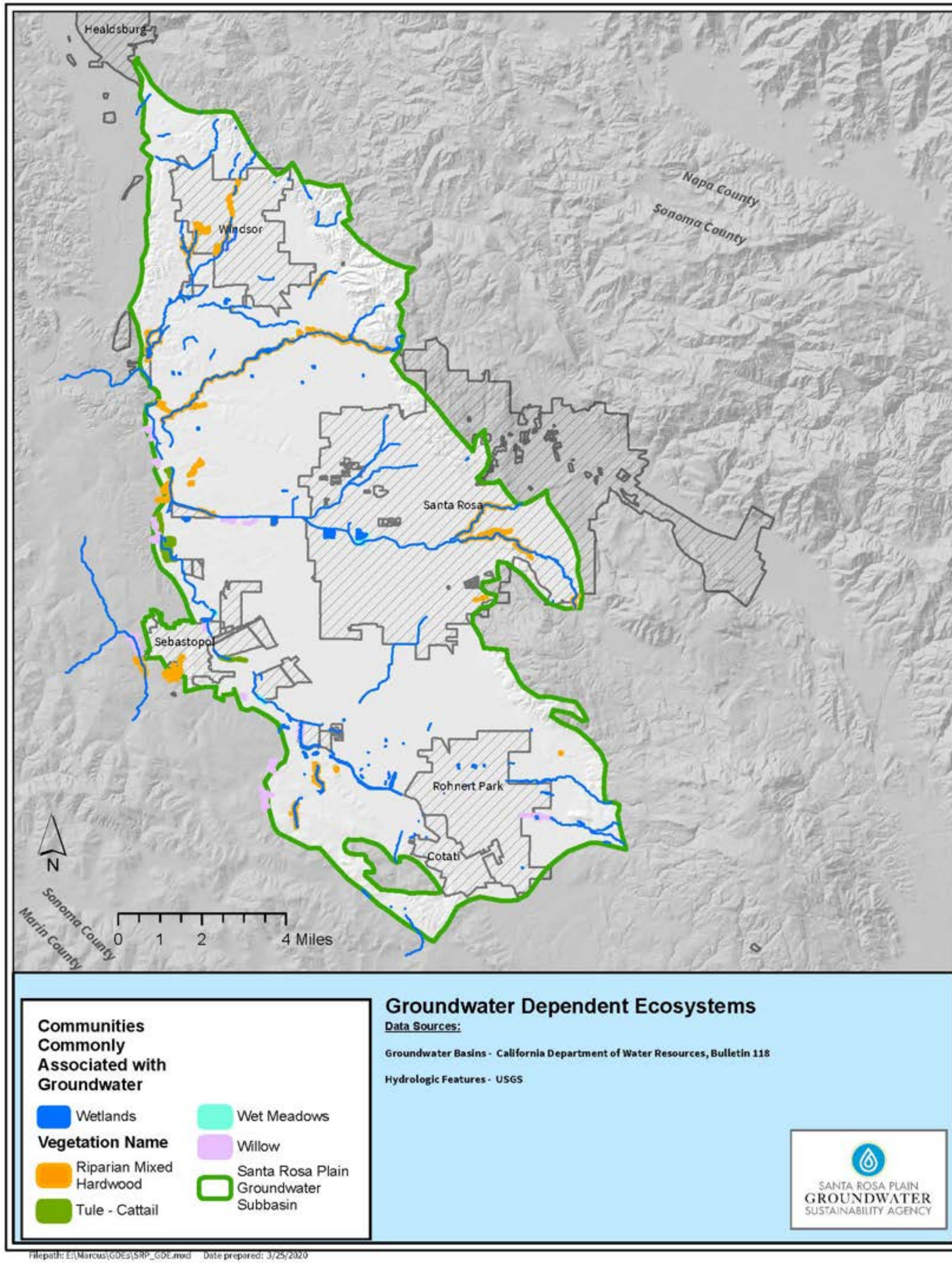


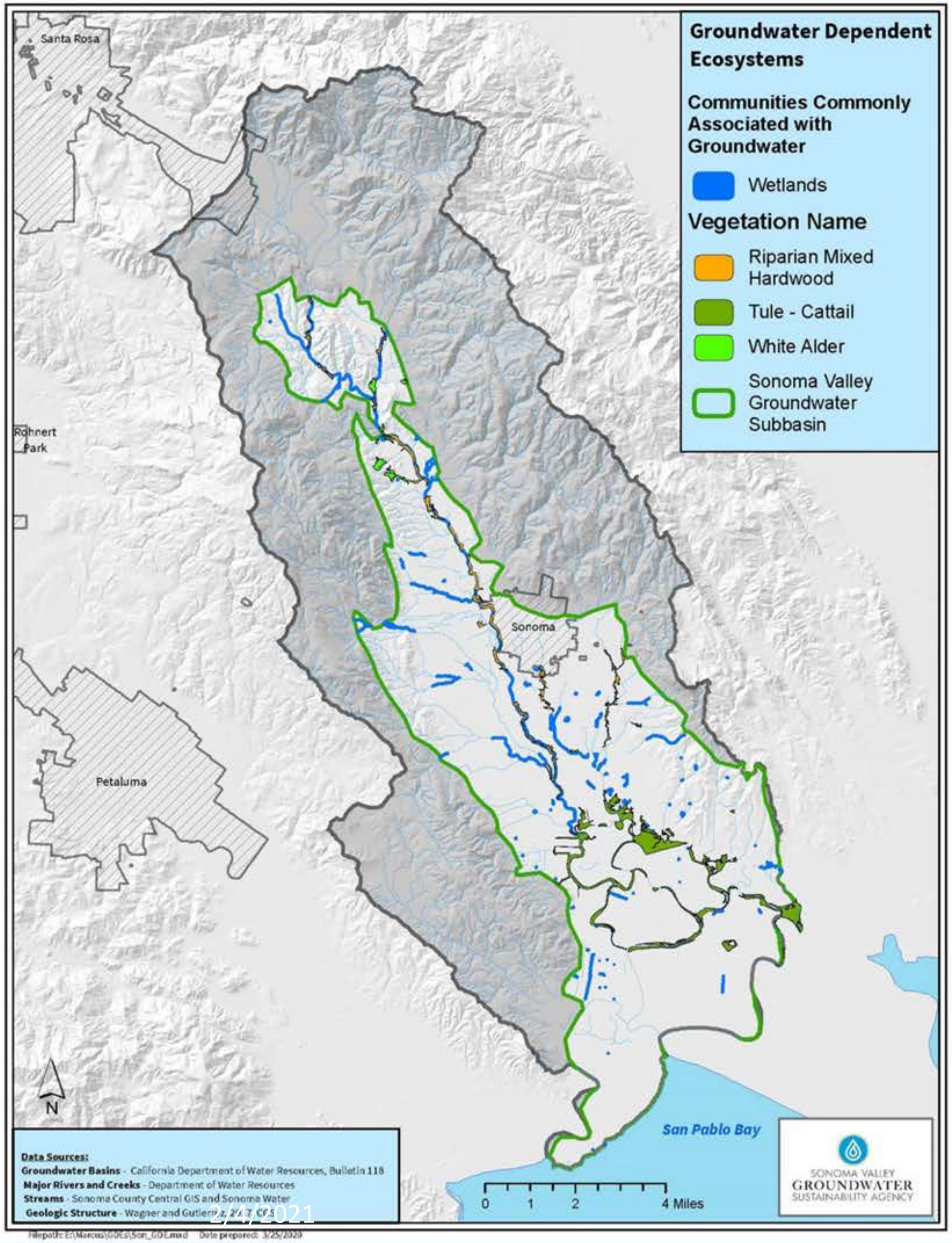
Preliminary GDE Mapping

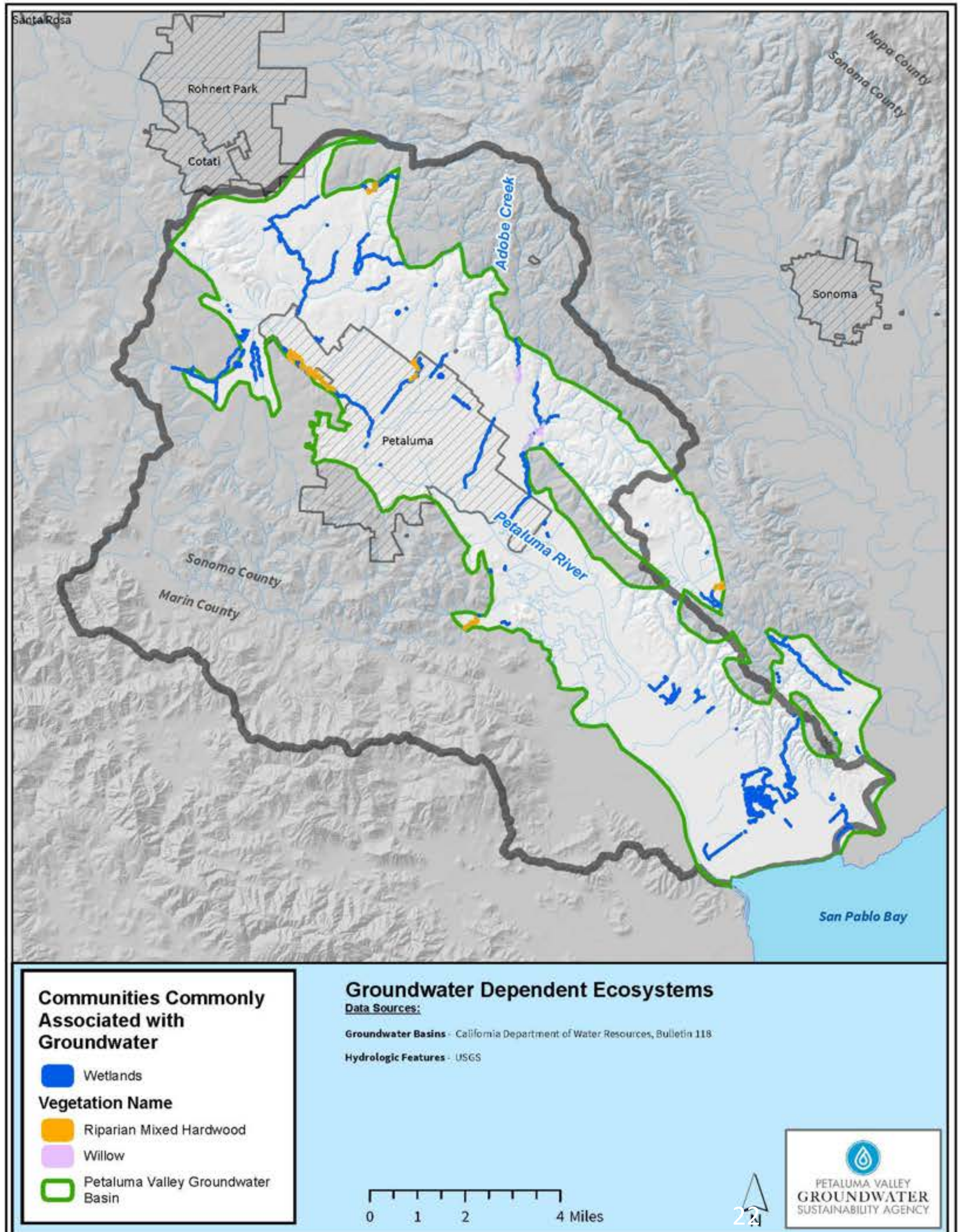
- Indicators of GDEs (iGDE) maps (The Nature Conservancy)
- Draft Steelhead streams maps (Sonoma Water)
- Draft Vegetation-related potential GDE maps (Sonoma Water)

Indicators of GDEs (iGDEs) Mapping (TNC):

- Natural Communities Commonly Associated with Groundwater (NC Dataset).
- https://gis.water.ca.gov/app/NCDatasetViewer/

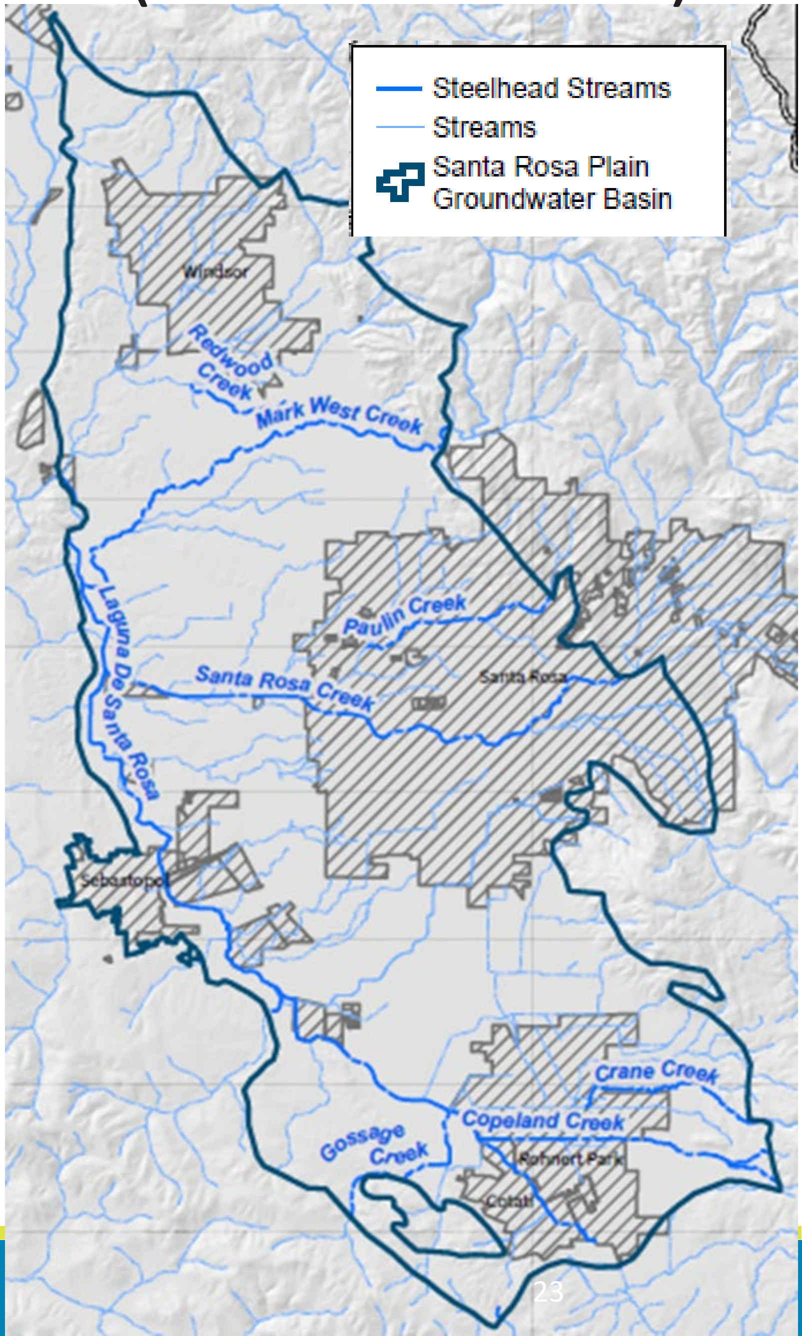



Groundwater Dependent Ecosystems
Communities Commonly Associated with Groundwater
Wetlands
Vegetation Name
Riparian Mixed Hardwood
Tule - Cattail
White Alder
Sonoma Valley Groundwater Subbasin
Santa Rosa
Rohnert Park
Petaluma
Sonoma
San Pablo Bay
N
0 1 2 4 Miles
Data Sources:
Groundwater Basins - California Department of Water Resources, Bulletin 118
Major Rivers and Creeks - Department of Water Resources
Streams - Sonoma County Central GIS and Sonoma Water
Geologic Structure - Wagner and Gutierrez
SONOMA VALLEY GROUNDWATER SUSTAINABILITY AGENCY
Date prepared: 3/25/2020

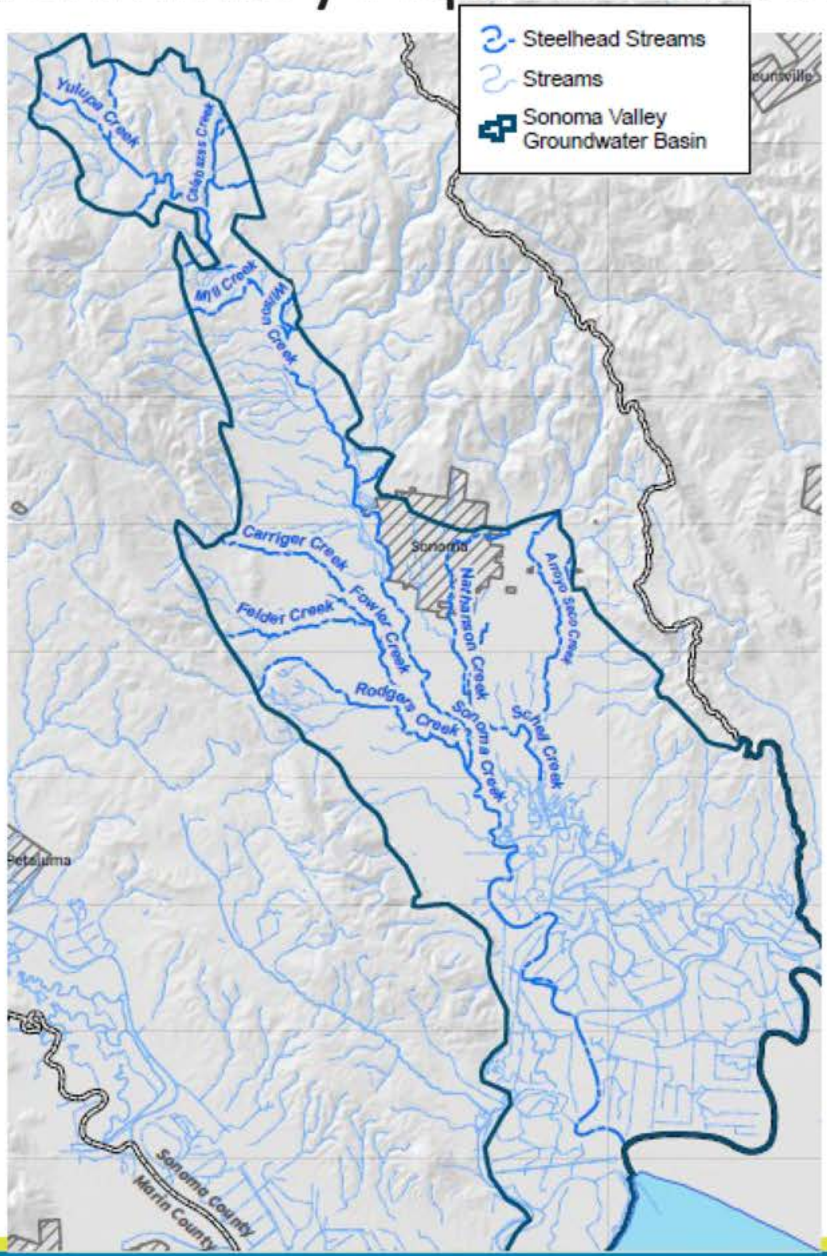

Santa Rosa
Rohnert Park
Cotati
Adobe Creek
Sonoma
Napa County
Sonoma County
Petaluma
Petaluma River
Sonoma County
Marin County
San Pablo Bay
Communities Commonly Associated with Groundwater
Wetlands
Vegetation Name
Riparian Mixed Hardwood
Willow
Petaluma Valley Groundwater Basin
Groundwater Dependent Ecosystems
Data Sources:
Groundwater Basins - California Department of Water Resources, Bulletin 118
Hydrologic Features - USGS
0 1 2 4 Miles
PETALUMA VALLEY GROUNDWATER SUSTAINABILITY AGENCY
Date prepared: 3/25/2020

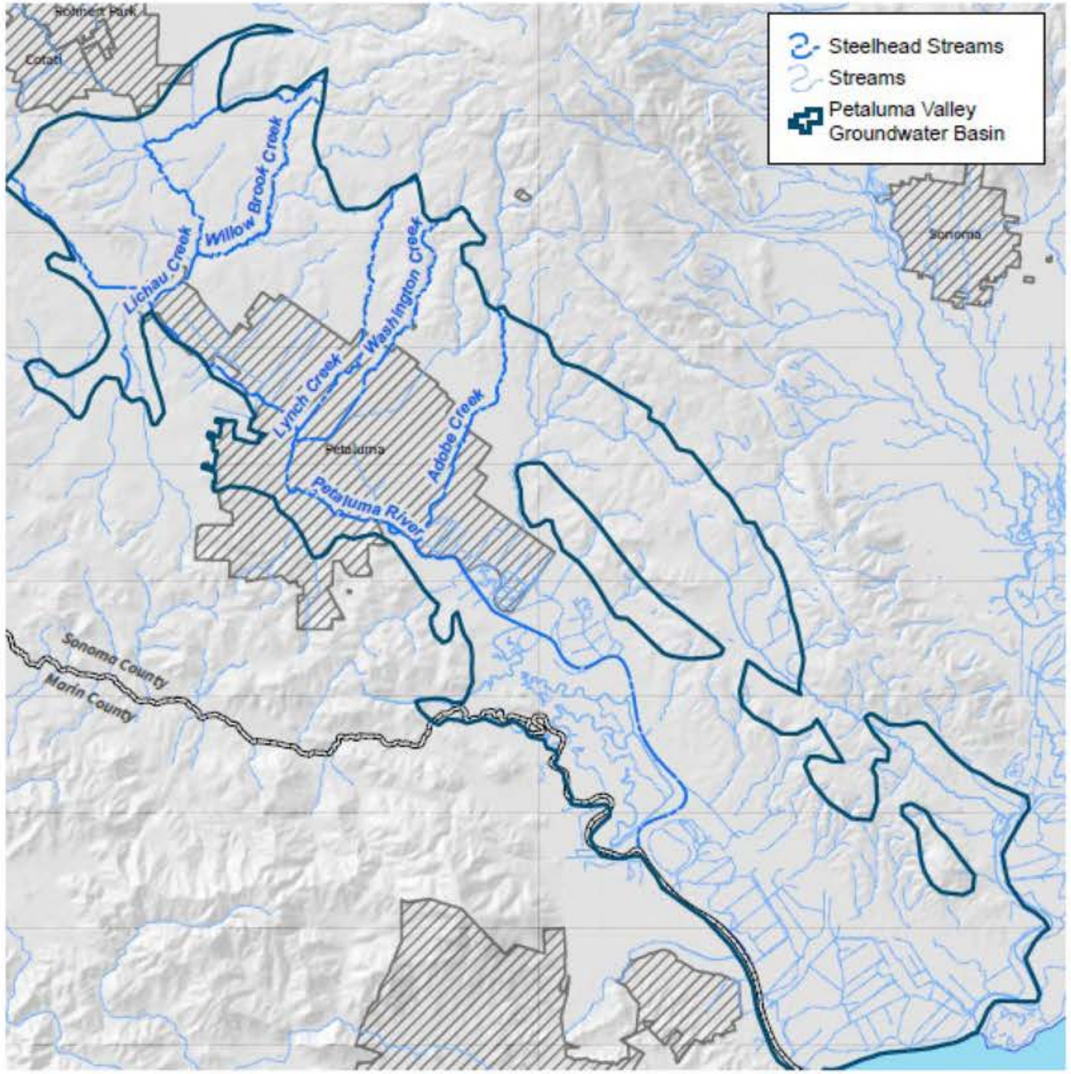
Preliminary Aquatic Groundwater Dependent Species (Sonoma Water)

- Steelhead used as priority indicator species to cover all groundwater dependent species
- Source documents used to identify steelhead streams in three ground water basins
  - Petaluma and Sonoma Ground Water Basins
    - Leidy, R.A., G.S. Becker, B.N. Harvey. 2005. Historical distribution and current status of steelhead/rainbow trout (*Oncorhynchus mykiss*) in streams of the San Francisco Estuary, California. Center for Ecosystem Management and Restoration, Oakland, CA.
    - Stream Maintenance Program (SMP). Sonoma Water steelhead habitat evaluation database.
  - Santa Rosa Plain Ground Water Basin
    - Coastal Monitoring Program (CMP). Habitat evaluation for salmonids conducted by Sonoma Water and approved by NMFS and CDFW.
    - Shawn Chase database. Sonoma Water in-house database of known occurrences of steelhead in the Russian River watershed.
- Assumptions
  - Connecting stream reaches downstream of steelhead creeks included in steelhead GDE.



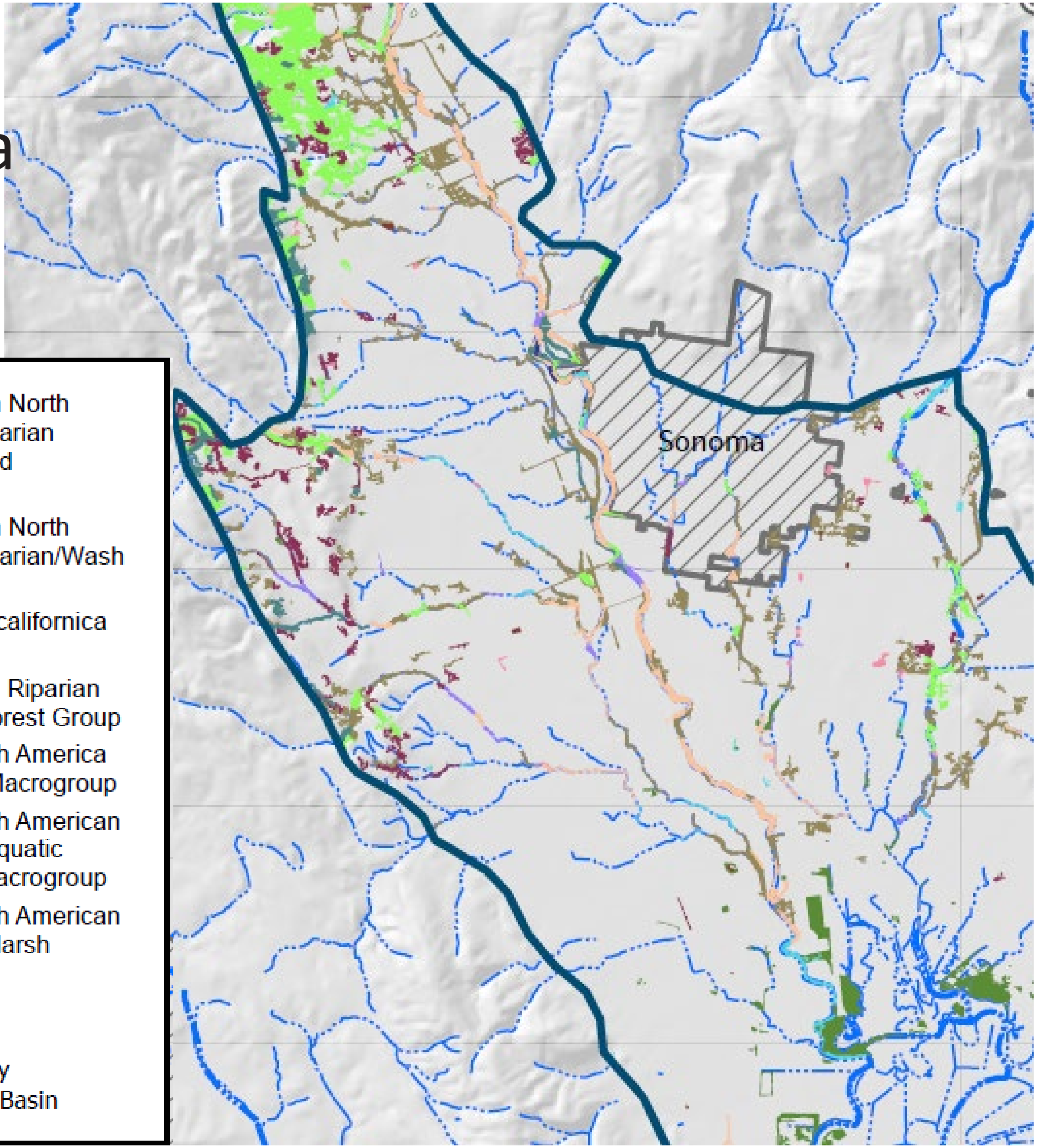
Preliminary Aquatic Groundwater Dependent Species (Sonoma Water)





Preliminary mapping of vegetation associated with groundwater (Sonoma Water): - Sonoma Valley Example

- Primary data source: Sonoma Veg Map
- Focus on communities with strong riparian composition (willows and cottonwoods) or species that may rely on groundwater some parts of year (oaks)



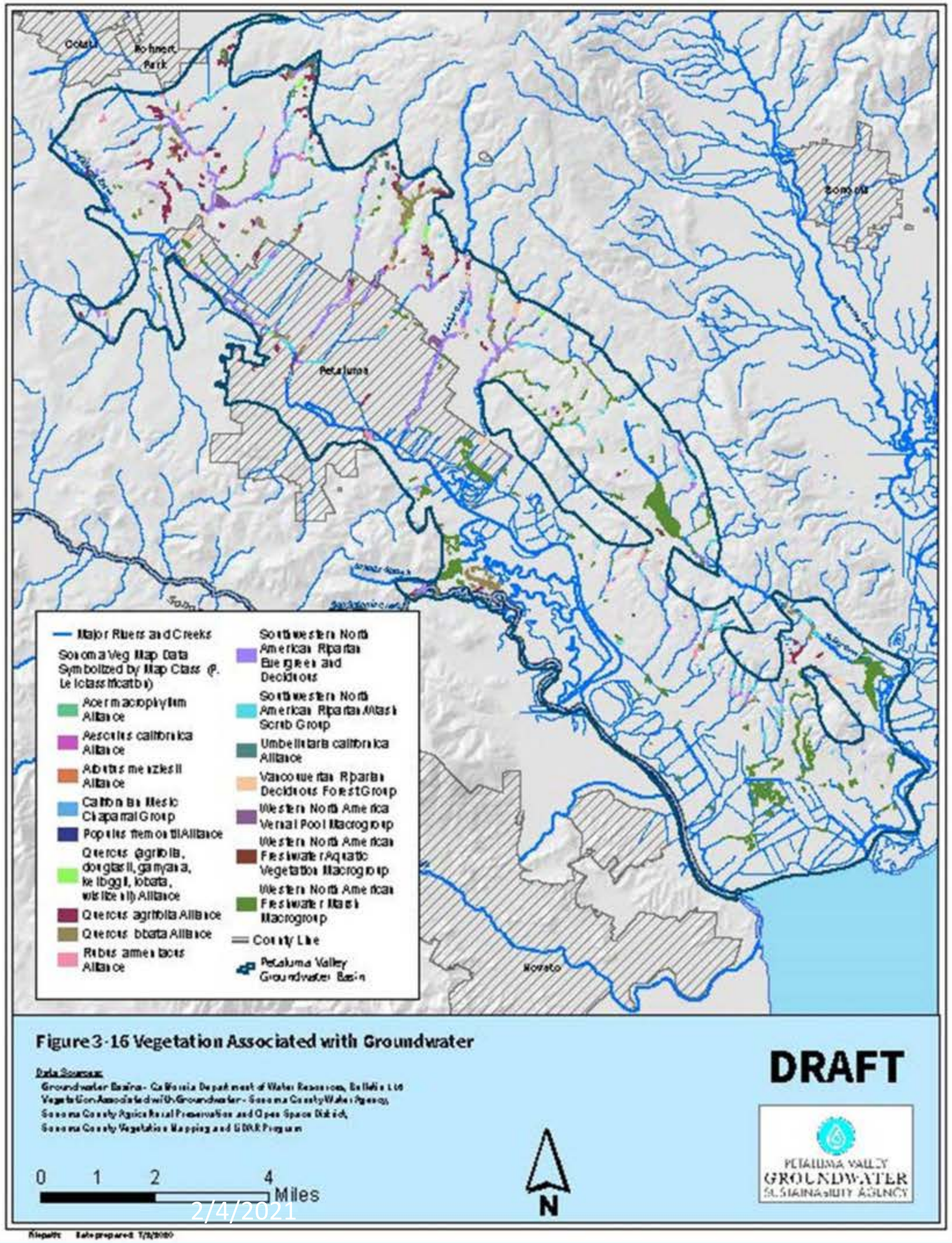


Figure 3-16 Vegetation Associated with Groundwater

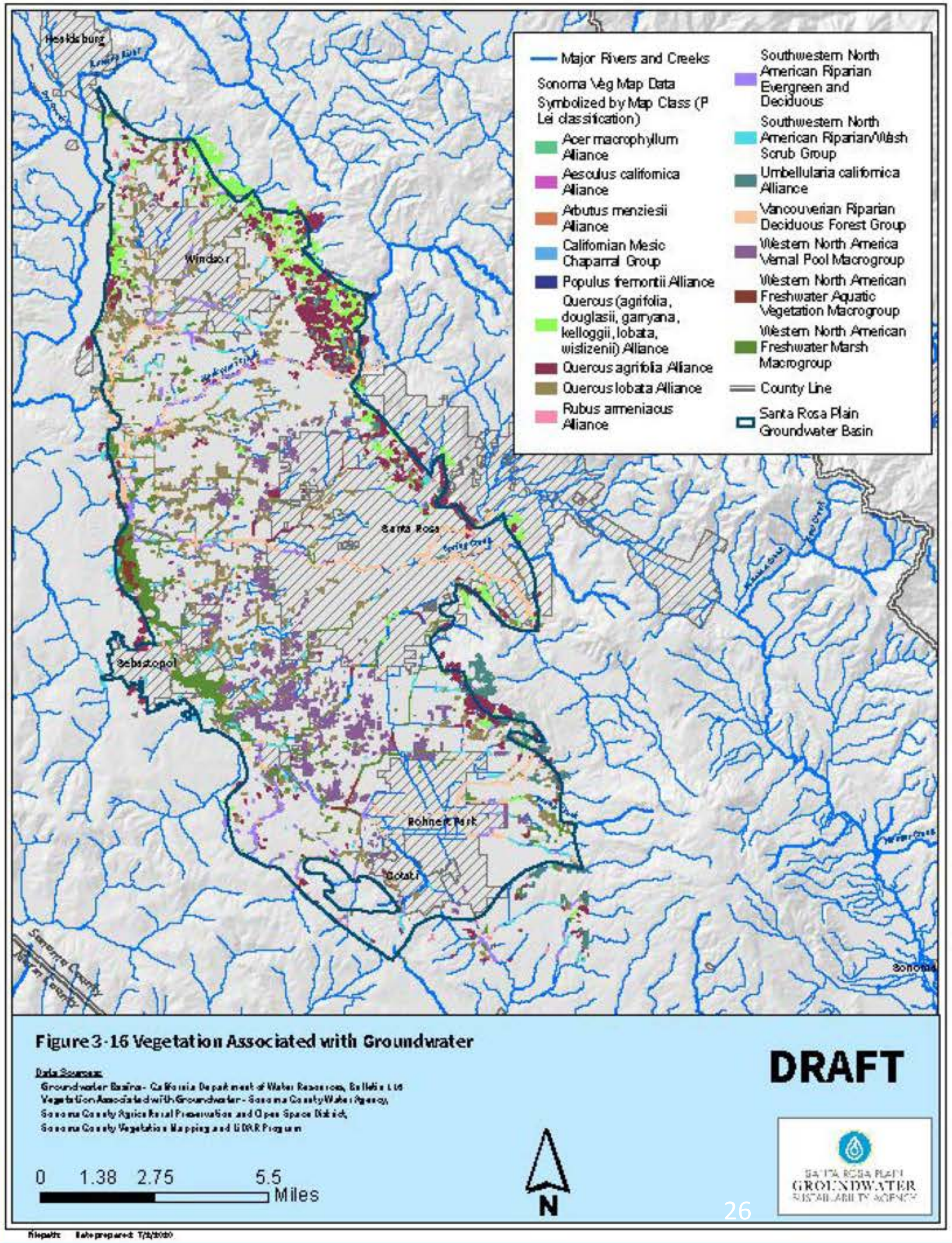
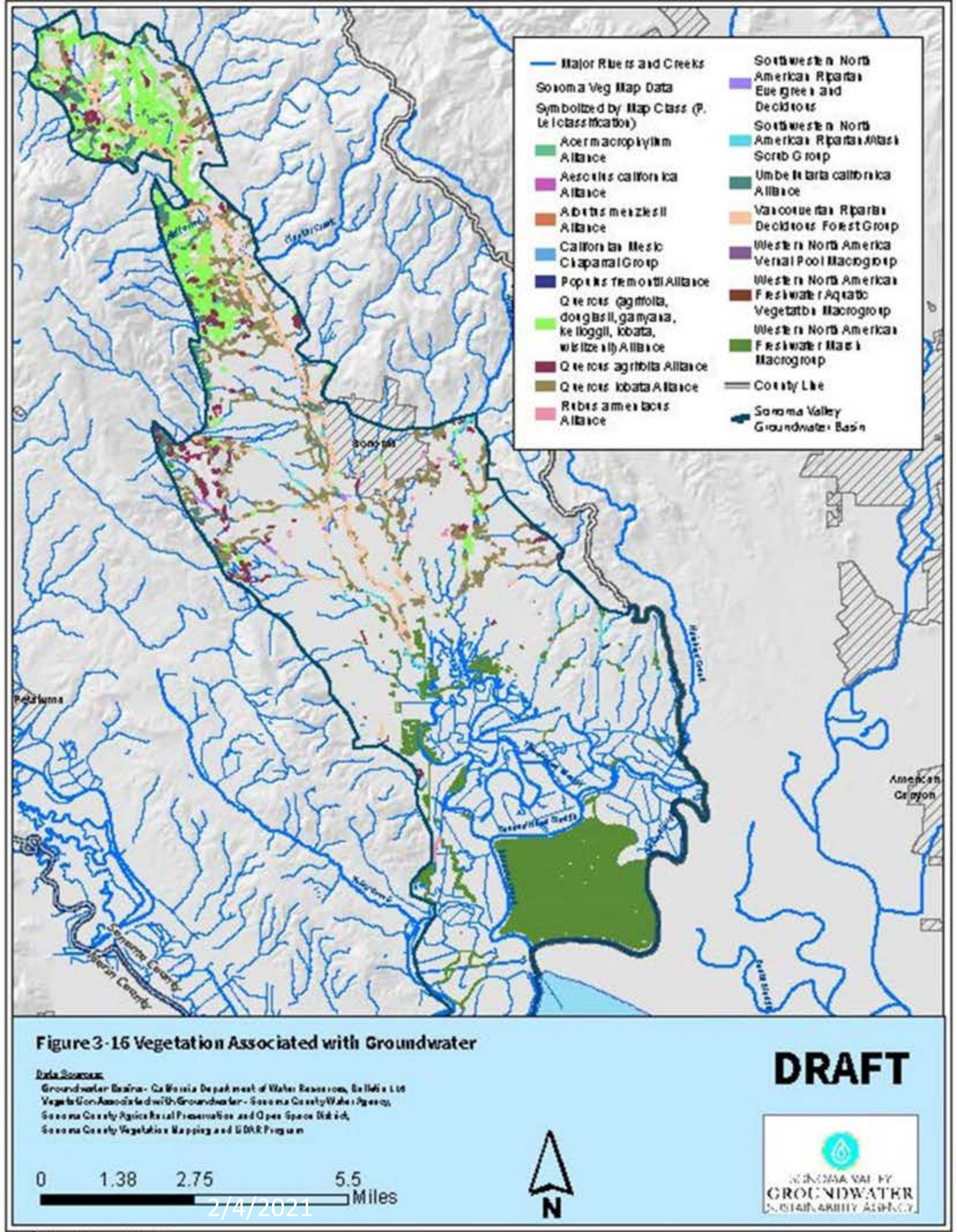


Figure 3-16 Vegetation Associated with Groundwater


Major Rivers and Creeks
Sonoma Veg Map Data
Symbolized by Map Class (P. Lei classification)
Acer macrophyllum Alliance
Aesculus californica Alliance
Arbutus menziesii Alliance
Californian Mesic Chaparral Group
Populus fremontii Alliance
Quercus (agrifolia, douglasii, garryana, kelloggii, lobata, wislizeni) Alliance
Quercus agrifolia Alliance
Quercus lobata Alliance
Rubus armeniacus Alliance
Southwestern North American Riparian Evergreen and Deciduous
Southwestern North American Riparian/Wash Scrub Group
Umbellularia californica Alliance
Vancouverian Riparian Deciduous Forest Group
Western North America Vernal Pool Macrogroup
Western North American Freshwater Aquatic Vegetation Macrogroup
Western North American Freshwater Marsh Macrogroup
County Line
Sonoma Valley Groundwater Basin
Sonoma
Petaluma
American Canyon
Sonoma County
Marin County
Figure 3-16 Vegetation Associated with Groundwater
Data Sources:
Groundwater Basins - California Department of Water Resources, Bulletin 118
Vegetation Associated with Groundwater - Sonoma County Water Agency,
Sonoma County Agricultural Preservation and Open Space District,
Sonoma County Vegetation Mapping and LiDAR Program
DRAFT
0 1.38 2.75 5.5 Miles
N
SONOMA VALLEY GROUNDWATER SUSTAINABILITY AGENCY

Questions/Discussion

Discussion of Data Gaps

1. Are there other existing data sources that should be included for GSP?
2. What additional data collection is recommended for implementation phase of GSP?

Identification and Mapping
Groundwater Dependent Ecosystems Workgroup
Meeting Notes

Date/Time: Thursday, November 19, 2020 | 2:30 p.m.
Location: https://csus.zoom.us/j/87923439778
Contact: Sam Magill, Practitioner Work Group Facilitator
Email: s.magill@csus.edu | Phone: (831) 251-4127

MEETING SUMMARY

Welcome and Introductions / Agenda and Meeting Schedule Review

Sam Magill, Work Group Facilitator welcomed the group then ran through the day's agenda. He mentioned this meeting was the last one scheduled for the group, but staff would consider an additional meeting if needed.

Marcus Trotta welcomed the group and said there are some revisions and updates to the mapping that he wanted to share and receive input. He also was looking forward to hearing thoughts on prioritizing the GDEs' to help focus development of Sustainable Management Criteria and future monitoring of the GSA, future data collections, studies, and approaches of the implementation phase of the GDE.

Update on Groundwater Dependent Ecosystem (GDE) Mapping Process

Marcus Trotta presented updated maps for sensitive aquatic species and vegetation and then presented draft integrated preliminary GDE maps. Patrick Lei, Sonoma Water, explained that three data sources are used to create the maps: 1) Sonoma Vegetation Map; interconnected surface water data; and depth to water threshold <30 feet. The analyses (presented by Marcus Trotta) help make sure we encompass areas that could potentially have groundwater within 30 feet. The maps have been shared with the Nature Conservancy and compared with their maps; there are some slight differences.

Questions/Comments

Rogers (chat) – What do the green stream channels signify in the Petaluma Valley map? Are those where riparian corridors exist but no sensitive aquatic species? I don't see the same on the other maps.

> Patrick Lei – I think we are seeing an artifact of the mapping; the orders and layers of the maps.

Wendy Trowbridge (chat) – The assumption here is that vegetation is an innocent victim of groundwater decline. How would the GSA deal with a situation where warmer summer conditions lead to an increase in evapotranspiration and the vegetation causes a decline in groundwater? It could create a difficult situation for the GSA.

> Trotta – Good question. That is something that will have to be considered and factored in. We will be developing 50-year projected model scenarios that will incorporate a climate future. It is something we could look at with the models and is factored into the SMC if it looks like a significant issue.

Magill – Maybe it is something we could flag for the Interconnect Surface Water work group.

Maxfield (chat) – How will diversions of surface water be factored in?

Trotta (chat) - Surface water diversions will need to be considered when developing the SMC for surface water depletion. I don't think they necessarily come in to play for GDE mapping.

Robert Pennington (chat) – Is this monitoring for GDE mapping or monitoring for SMC criteria?

Trotta (chat) – Monitoring for GDE mapping, although there could very well be overlap with SMC criteria.

Steve Rogers – For groundwater dependent vegetation, it seems the 30-foot threshold is specific to the rooting depth of oaks, but oaks have some of the deepest rooting systems of groundwater dependent vegetation species. Probably there are other shallower root species. Do they address other species besides oaks? It seems 30 feet wouldn't take into consideration other species.

Trotta – The 30 feet threshold is intended for consideration in mapping the potential presence of GDEs in the basin to be somewhat conservative.

Lei – We are trying to filter out eco systems that currently are not within 30 feet and probably not dependent on groundwater. It is a conservative model.

Rogers – I see now it is used for mapping vegetation and won't be used for management criteria for vegetation.

Lei – My understanding is that that is the next step.

Rogers – Makes sense.

Steven Lee – Looking at Sonoma Valley, there is one tributary, Stewart Creek off Calabasas, that might be underrepresented. It is a tributary that has Steelhead. It looks like Stewart Creek isn't listed on the map.

Trotta – Stewart Creek was included in the Steelhead mapping that David Cook did.

Lee – I don't think so.

Rob Pennington – Are there Steelhead present in the alluvial basin part of the groundwater basin or are they present in the upper watershed?

Lee – They have probably been cut off alluvially during the dry season months. I want to raise the issue, maybe it is intentionally left off the map.

Trotta – It looks like it is one of the streams filtered out through looking at the interconnected surface water. That stream isn't mapped as being interconnected surface water. We can follow up with David Cook.

Lee – What is the criteria for the delineation?

Trotta – If it isn't interconnected surface water, groundwater is below the streambed throughout the year and isn't contributing to the flow of water in that creek.

Lee – I recently did some temperature monitoring. Based on the way temperature data look, it seems there is a connection with groundwater feeding it.

Lee – In the areas identified less than 30 feet to the groundwater, it looks like the channels themselves, it doesn't seem to get wide beyond the channel area. Some monitoring I have done recently shows the groundwater is shallow southeast of Calabasas Creek, 500 yards or so off the creek.

Trotta – It would be great to see any additional data you have.

Melissa Rohde – Could you elaborate more why saltmarshes aren't included?

Lei – We have been working under the assumption of tidally influenced rather than groundwater influenced. If we think it could be groundwater influenced, we should include saltwater marsh and aquatic. The map classes we have been working on from the beginning didn't include saltwater marsh.

Rohde – It is worth considering, these ecosystems are defined as being dependent on groundwater near the earth's surface. If it is about using groundwater and is groundwater dependent, the species don't use multiple sources of water simultaneously at different times of the year. If the saltwater marsh areas were impacted by pumping there could be an inadvertent impact on the ecosystem if connected to groundwater.

Lei – If anyone has further questions about why some habitats were included or excluded from the maps, let me know, and I can get them added to the maps. I look forward to hearing your input.

Preliminary Data Gaps/Recommendations on Future Data Collection

Marcus Trotta presented a slide with questions about recommendations for additional data collection and studies and asked the group for input.

1) *Are there additional monitoring needs for surface/groundwater interaction to better understand CDEs?*
2) *Are field verification surveys required to confirm maps?*
3) *Are there certain GDE parameters that should be considered?*
4) *How should any recommended studies/monitoring be prioritized for GSP implementation?*

Rogers – Are you planning on getting people together to discuss this?

Trotta – It would be good to get initial ideas here on types of monitoring and prioritization of locations for monitoring, etc. The Surface Water Depletion workgroup will also have a discussion on monitoring related to surface water depletion.

Rogers – My suggestion would be to put in monitoring that would best inform the modelling effort.

Andy Rich – All the models that we are developing are data rich, there could be some improvement, such as the data collected by the Ecology Center of surface water - groundwater interactions.

Lee – Basically we have most of the important creeks included in this. The question is what other areas aren't included? In terms of data gaps, when using vegetation mapping as a basis for the analysis, it seems underneath the canopy of other tree species that would indicate groundwater dependent eco-systems that wouldn't show up in those, I am thinking of seeps. Most areas I am thinking of are higher up in the watershed.

Trowbridge – I would be curious to hear how other GSAs have dealt with vernal pools. Clearly, there are perched aquifers, but water does flow out of vernal swells. And seepage runs. Also, another pitch for the importance of measuring evapotranspiration.

Rohde – With regards to vernal pools, they are not generally included in the mapping. If the groundwater that the eco-systems are accessing and not connected to a principal aquifer it is not groundwater dependent in the context of SGMA. We have a GDE pulse we put together that includes satellite data from the last 35 years for mapped polygons, it doesn't include data from your mapping. It would be good for us to talk about how you could do that. How to update the GDE pulse with recent data. Maybe we could give you the code.

Trowbridge – It seems like some of the differences between Sonoma Water's vegetation mapping and the TNC's vegetation maps in Santa Rosa Plain are related to perched aquifers associated with vernal pools.

Rohde – My understanding is the hydrogeology of the area is mostly unconfined aquifers. Can you explain the hydrogeology of the basin?

Trotta – The shallow groundwater conditions in the central portions of the plain, the shallow aquifer system is primarily unconfined. It is interesting the oaks are coinciding with areas of vernal pools.

Rohde – Is the groundwater essentially at the surface because of vernal pools or are the vernal pools there because the groundwater is at the surface?

Trotta – The vernal pools are superficial features that fill from precipitation in areas where the shallowest soils are sufficiently low permeability that allows for the formation of the vernal pools rather than filled by seasonal high groundwater fluctuations.

Rohde – When we are mapping the eco systems, one of the challenges is that we have a poor understanding of the shallow aquifer systems and the perched clay lands. SGMA is about adaptive management. If the vernal pools are driven by precipitation and surface run-off, under SGMA they wouldn't have to be categorized as groundwater dependent eco systems. We don't have data to prove that, so I think we should keep vernal pools in and address it as we move forward.

Pennington – Are there ideas for the SMC of the non-stream GDEs? What would the monitoring network look like? Will we have the monitoring such that it improves the mapping will make much difference in the end in terms of evaluating impacts of GDEs?

Trotta – I think it will for some of the next upcoming topics. If we had some areas that were higher priorities, maybe it would help identify monitoring needs.

Pennington – So you are thinking of using water levels for the GDE's sustainable management criteria.

Rich – It could be useful for identifying data gaps in the future.

Rohde – In general the non-riparian vegetation types should be considered when you are establishing SMC for chronic lowering of groundwater levels. You would have to define what an Undesirable Result looks like for that accounting for all the other beneficial users that rely on groundwater levels in the basin.

Trowbridge – I would encourage more monitoring. It seems like much of the Santa Rosa Plain where there are vernal pools are underlined by clay layers. I wonder if much of the riparian vegetation along the creeks isn't groundwater dependent on the deep groundwater so much as dependent on the shallow groundwater in the same way the vernal pools are. I don't think we have the information to say one way or another.

Trotta – When we look at the areas that have been mapped, we limited it to segments that have been mapped as interconnected surface water. Based on that data, those segments are connected to the shallow aquifer system. With all the clay in the Santa Rosa Plain, the continuity and degree of the connection is variable. We don't have a fine scale subsurface portion of the aquifer system to differentiate that. That is why the streams are made as interconnected.

Trowbridge – I think Santa Rosa Creek is interconnected. I wonder about some of the other smaller creeks that run by vernal pools, the lower parts of Copeland for example.

Trotta – Sounds like an area for future investigation and monitoring.

Pennington – In terms of what would be helpful, more shallow monitoring wells near streams would be useful for answering that question. I agree with the seepage runs, very useful. My knowledge of the stream gauging network is that it is quite good, I am not sure if there is a gauge is the upper end of Mark West Creek near Wikiup/Larkfield. Maybe one there would be useful. For Sonoma Creek, Sonoma Ecology Center would be able to advise.

Lee – We have three gauges in Sonoma Creek and a whole series of additional ones we have been trying to answer similar questions with other funding. Having more gauges and tracking more tributary flows would be an additional useful support. Steven Lee showed examples of stream temperature monitoring that he had done in the summer around the watershed. Temperature can be used as additional data to help inform this topic.

Rohde – I attended an fascinating session on groundwater dependent eco systems. There is interesting research being done using thermal imagery to map springs. There is some utility of using temperature to fill in data gaps.

Trotta – We have been using temperature as a tracer for groundwater-surface water interaction for years. It is a robust tool that can be used. In most applications it is usually more a focused study versus basin wide. New technology is coming out, it is worth considering.

GDE Grouping and Prioritization

Marcus presented a slide with guiding questions for the group and asked for initial input on the topics.

1) *Do we need to prioritize different GDEs?*
2) *How do we assign value to different vegetation classes?*
3) *Are there certain streams or stream reaches that should be prioritized for focusing SMC development and monitoring?*
4) *How do we select areas for additional monitoring?*

Questions/Comments

Rohde – Have you thought of grouping them into units first based on hydrogeologic setting? Associating polygons that are near each other and sharing same groundwater conditions – similar processes, easier to rank and monitor them?

Trotta – I have thought about it but not about how to implement it. It would be good to identify areas that have document groundwater level declines. Otherwise grouping based on hydrogeology could be a little challenging. The Bulletin 118 basins' mapping is similar hydrogeology in terms of superficial units, it may be difficult to parse them out that way.

Rohde – Well maybe not by hydrogeology but by location and habitat type? That would be my approach.

Rich – I think we could use some of the sub areas that were developed for the models. Some are based on hydrogeology and other groupings that might be helpful.

Trowbridge – One concern I have is that trees are a lagging indicator of groundwater depletion. What would be constrained are smaller trees and regeneration, and smaller vegetation. By using mature trees, you will miss the signal until it is too late.

Rohde – Yes, I echo Trowbridge's point. We need to maintain groundwater levels to ensure saplings survive. It is critical to ensuring the forests remain intact in the long term. It is key that groundwater needs to support spawning in future.

Lee – I appreciate the prioritization examples. Maybe there is a bit of a logic gap here. By choosing Steelhead streams we selected for high priority streams off the bat. But there are other streams that aren't Steelhead streams but that are fed by springs and have bugs and ecological value and are dependent on groundwater. Maybe they aren't the high value ones, but they are groundwater dependent eco systems that have been selected in the process.

Pennington – In terms of David Manning's assessment, the most sensitive GDE are the streams, riparian vegetation, and then the oak woodland. My feeling for the oak woodland is that their rooting depths can change significantly, probably a little more resilient and cover a large area. Also, in terms of Steelhead streams, once the streams have been mapped, it would probably be good to stop labeling them as Steelhead streams. There is a framework, CA Environmental Flows Framework that relates different flow criteria and beneficial uses and functions.

Rohde – My colleague, Julie Zimmerman is co-leading that effort, if you are interested, I can put you in touch with her. I second the eco-system approach.

Trotta – We have been moving away from calling them Steelhead streams or Steelhead maps and changing it to Aquatic streams and maps. It is a change you will see going forward.

Pennington – In terms of grouping by stream, it would be useful to group them by what periods/seasons the different species exist in the streams.

Marcus Trotta said staff would send out the questions and PDFs of the maps for the group to review and consider and provide input, especially on prioritization of grouping. When staff receives your input, we will make additional adjustments and develop a draft narrative for the Advisory Committee and Surface Water Depletion workgroup. If needed, we can schedule another meeting to discuss remaining issues.

Marcus Trotta closed with a slide indicating next steps including: initial draft narrative describing process and how mapping will be used in GSP; develop draft assignment of ecological value; share maps and approach with Surface Water Depletion SMC workgroup; and compile list of prioritized recommended data collection activities.

Review Meeting Action Items

Marcus Trotta, Andy Rich and Rob Pennington thanked the attendees for their time, thoughts and interest.

Melissa Rohde asked if there would be a meeting on SMC for groundwater levels regarding groundwater dependent eco systems. Marcus Trotta said there is a separate workgroup meeting to discuss Interconnected Surface Water SMC. He said it would be great to get any thoughts from this group for developing the SMC for lowering groundwater levels and added that maybe we can loop this group into the discussions with the Advisory Committee.

Rob Pennington asked if draft SMC on chronic lowering of groundwater levels already been developed in all the basins.

Trotta – There have been some initial drafts of our proposed methodology, we are currently working on it and plan to bring it to the Advisory Committee in January.

Pennington – In discussions so far, have there been any conversations about the ecosystem?

Trotta – Most of the discussions have been about maintaining groundwater levels within or above historical ranges and making sure they stay above nearby wells. We did say we would revisit the SMC with information from groundwater eco system mapping but there hasn't been discussion yet on how it would be incorporated.

Attendees:

Jessie Maxfield, CA Department of Fish & Wildlife
Melissa Rohde, The Nature Conservancy (joined 3:10)
Rick Rogers, National Marine Fisheries Service
Robert Pennington, Permit Sonoma
Steve Lee, Sonoma Ecology Center
Wendy Trowbridge, Santa Rosa de Laguna Foundation

Staff/Presenters

Marcus Trotta, Sonoma Water
Andy Rich, Sonoma Water
Patrick Lei, Sonoma Water
Simone Peters, Sonoma Water (recording meeting notes)

Facilitator

Sam Magill, Sacramento State University – Consensus and Collaboration Program

SANTA ROSA PLAIN • PETALUMA VALLEY • SONOMA VALLEY

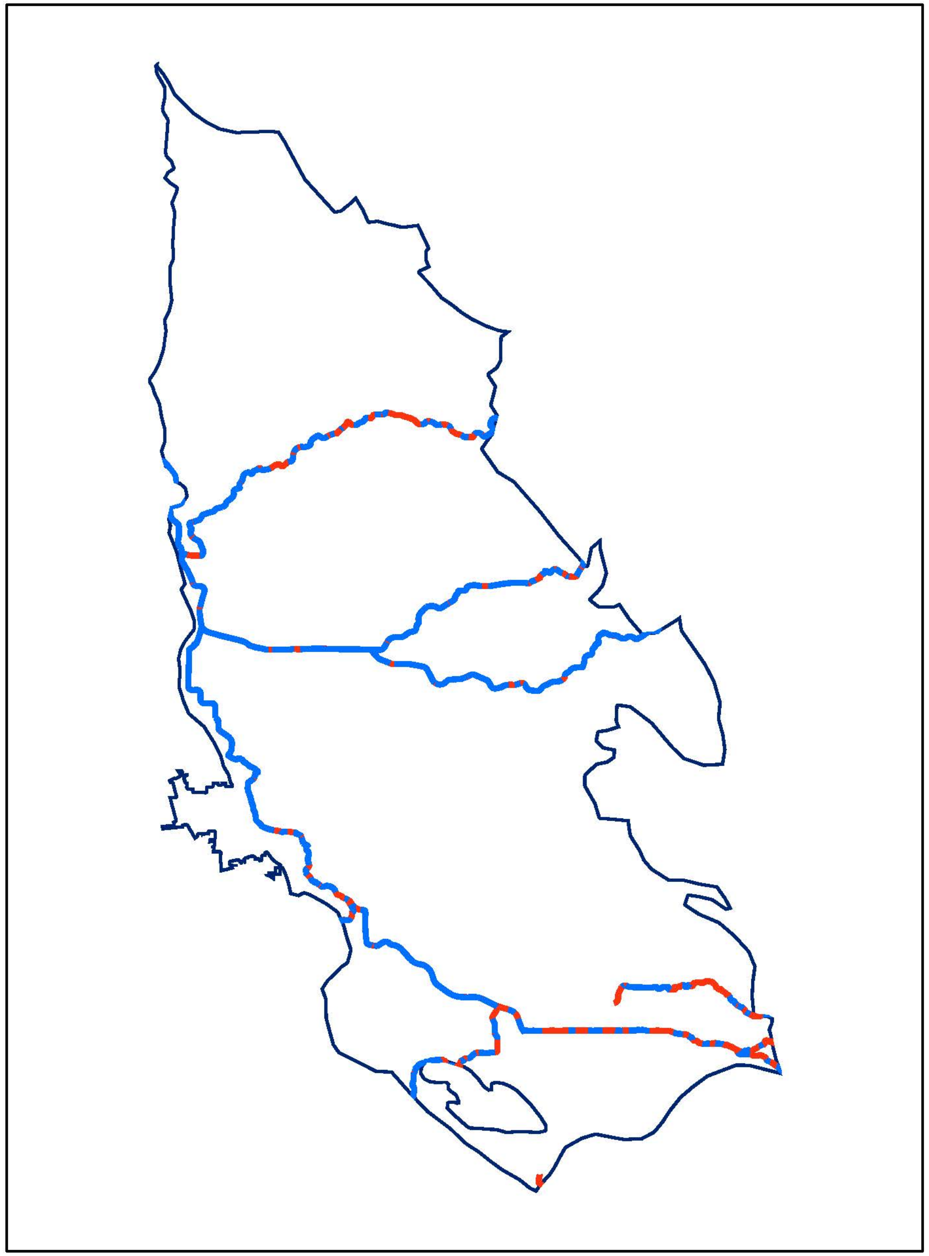
GROUNDWATER

SUSTAINABILITY AGENCIES

IDENTIFICATION AND MAPPING OF GROUNDWATER DEPENDENT ECOSYSTEMS

Workgroup Meeting #3

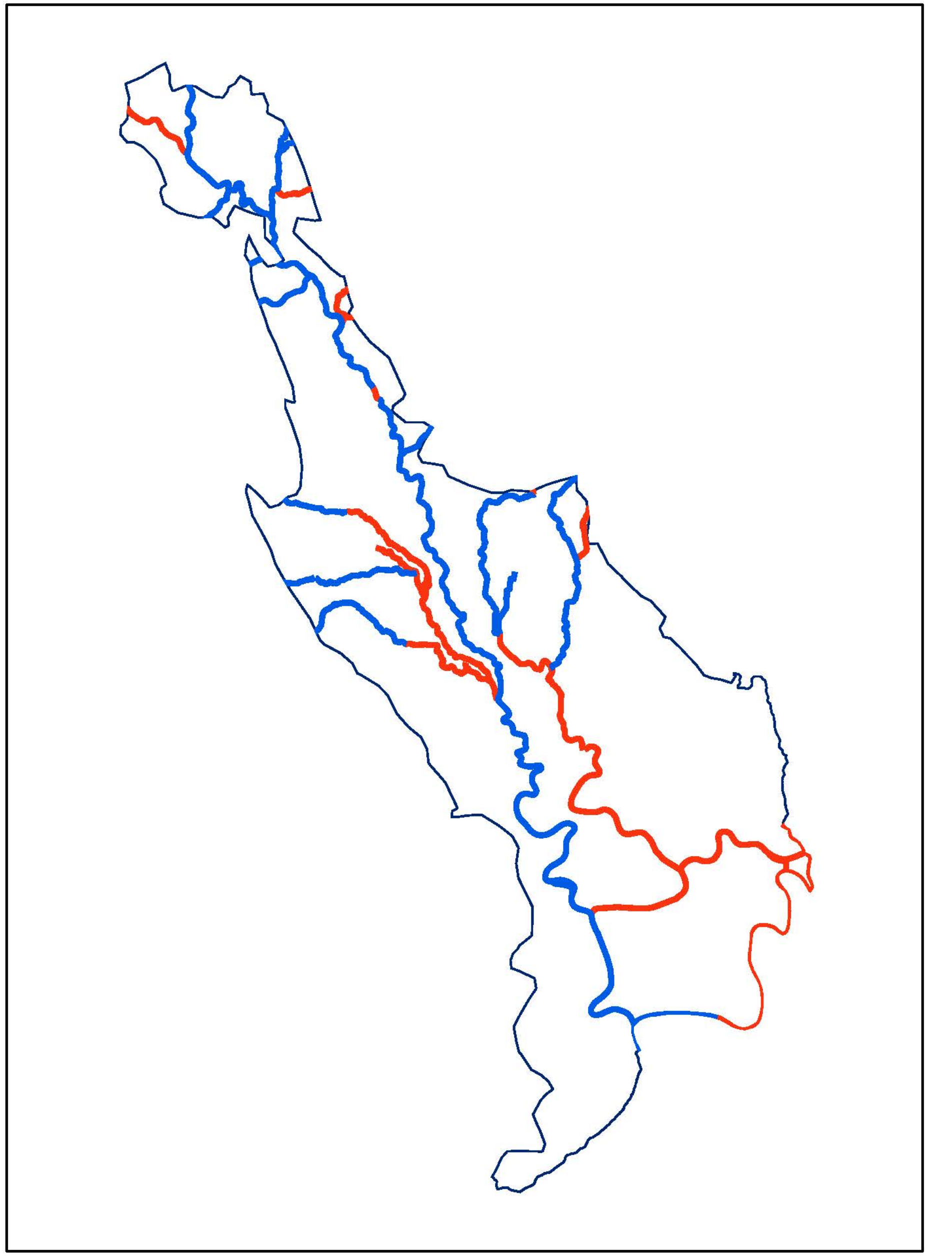
November 19, 2020



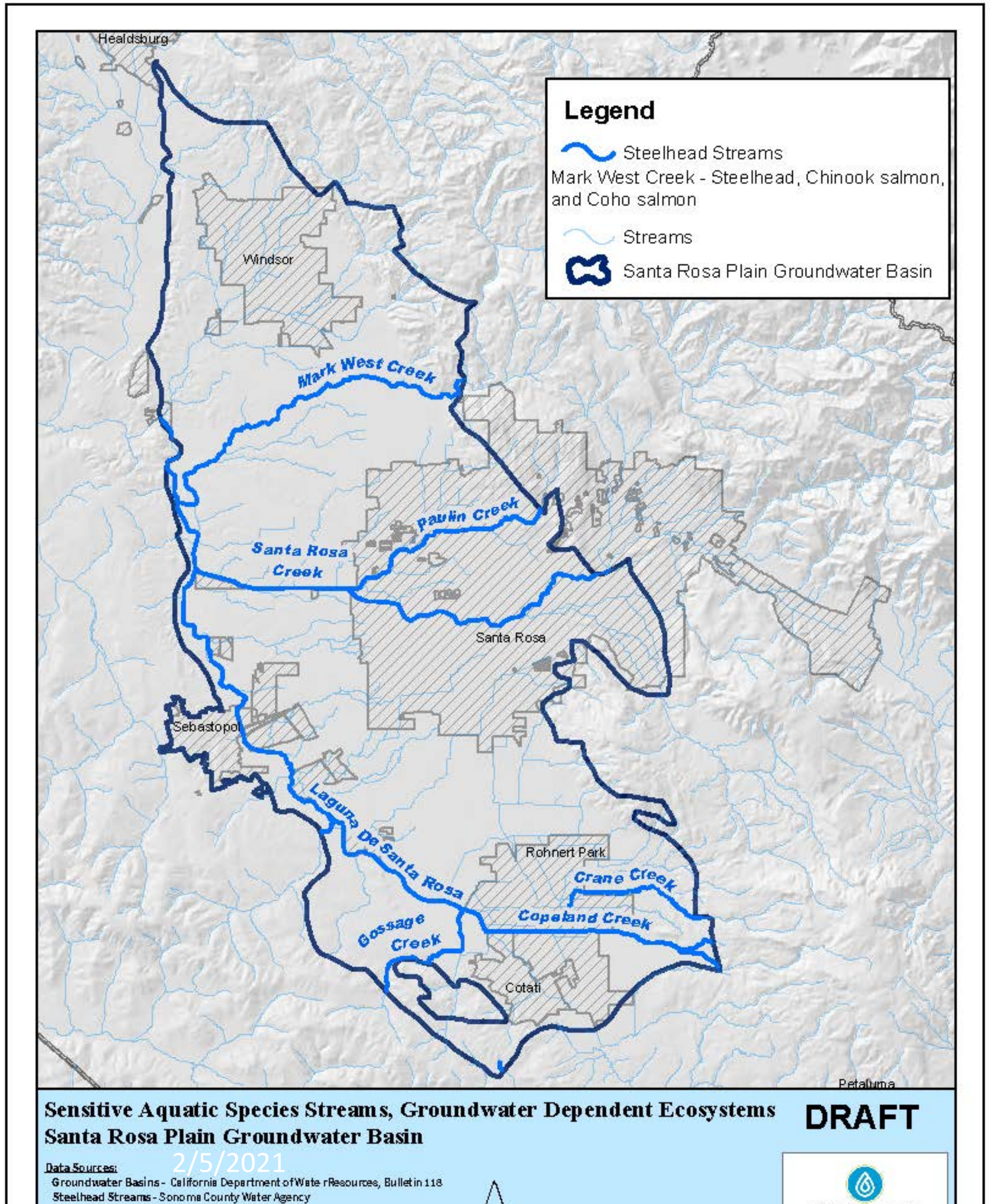
Sensitive Aquatic Species GDE Mapping Process (SRP and SV*)

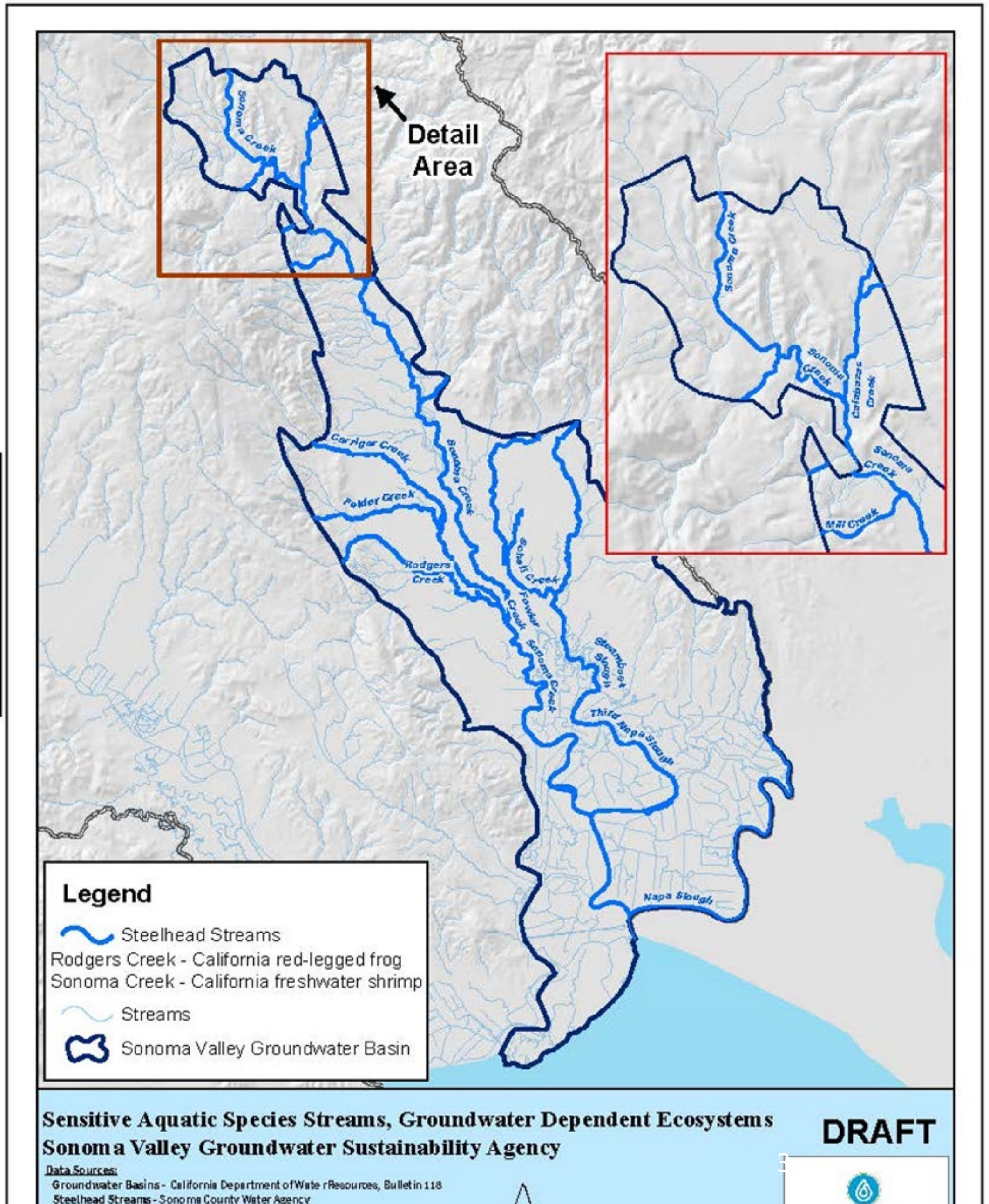
If any segment of a Sensitive Aquatic Species stream (**red**) intersects with mapped interconnected surface water (**blue**), entire reach of stream downstream of interconnected portion included as Sensitive Aquatic Species GDE.

*Petaluma Valley Interconnected Surface Water Mapping is pending completion



Updated Preliminary Aquatic Groundwater Dependent Species

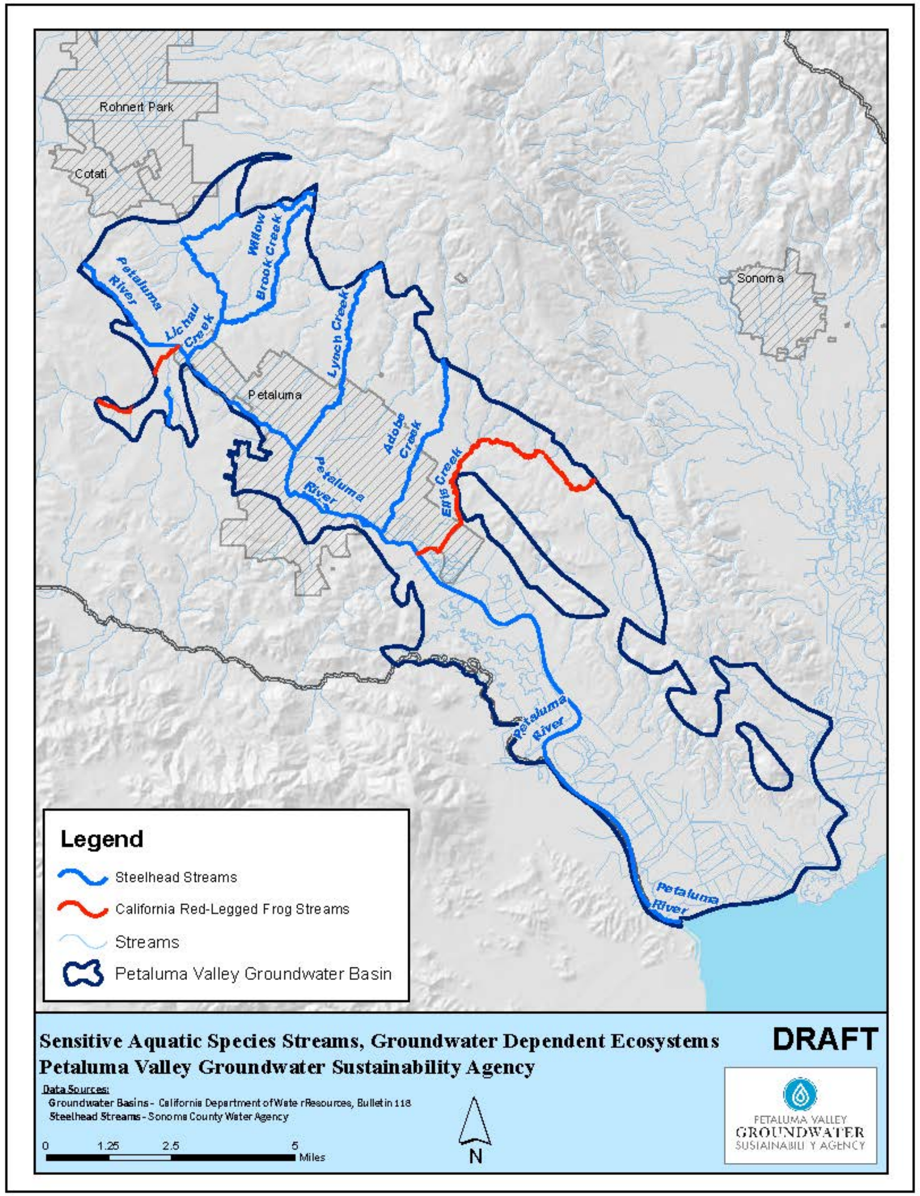




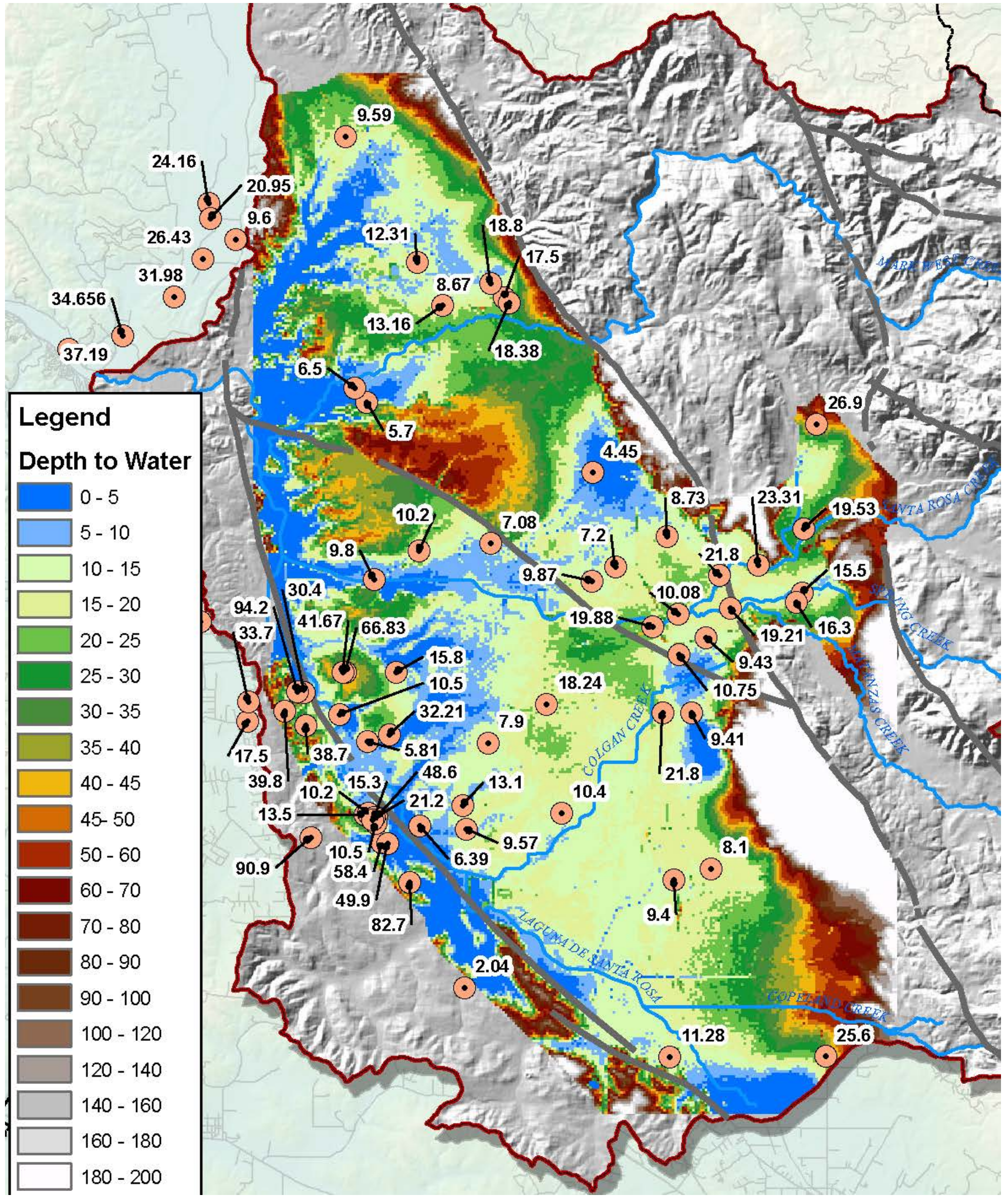
np

n

Updated Preliminary Aquatic Groundwater Dependent Species

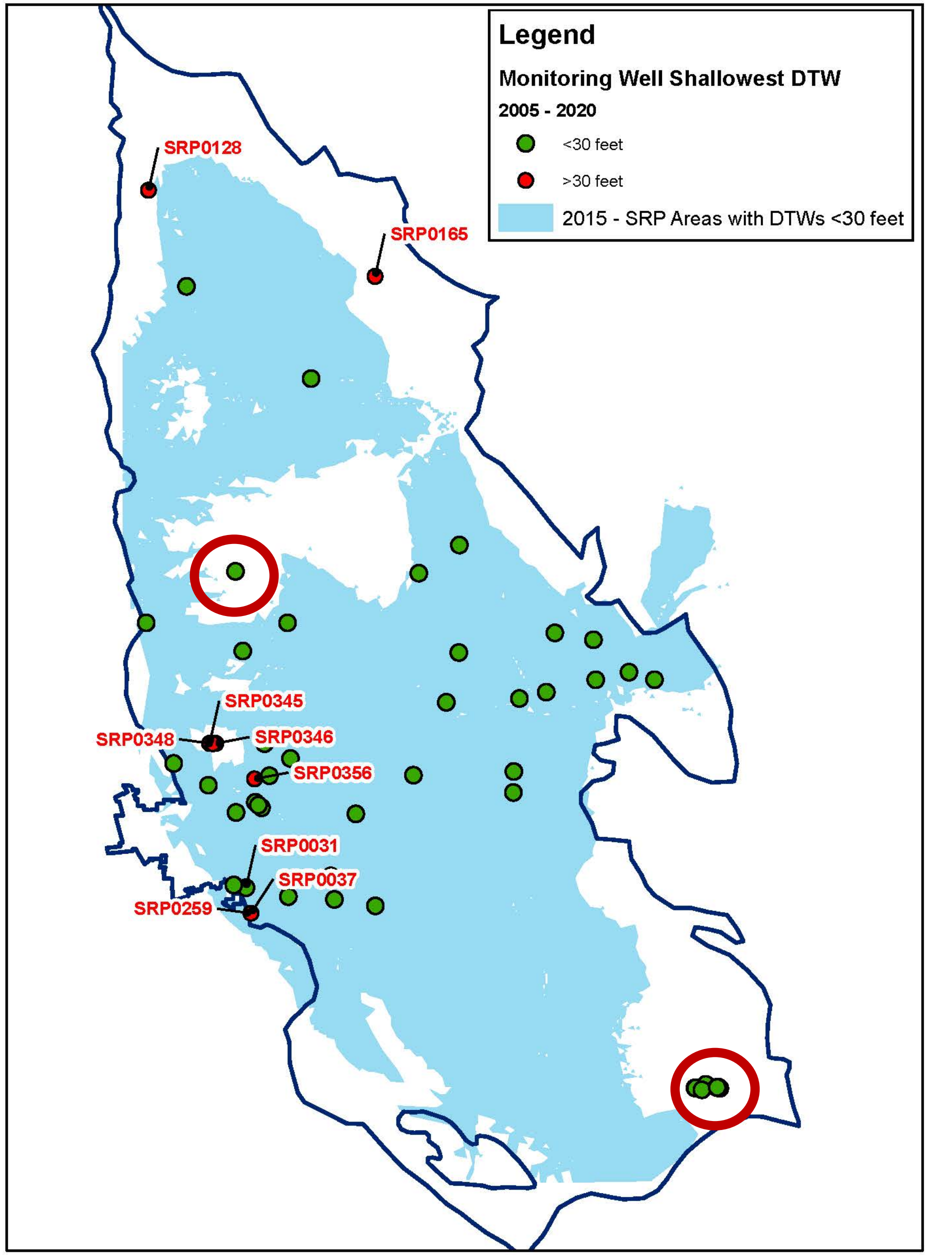


Petaluma Valley (draft pending mapping of ISW)

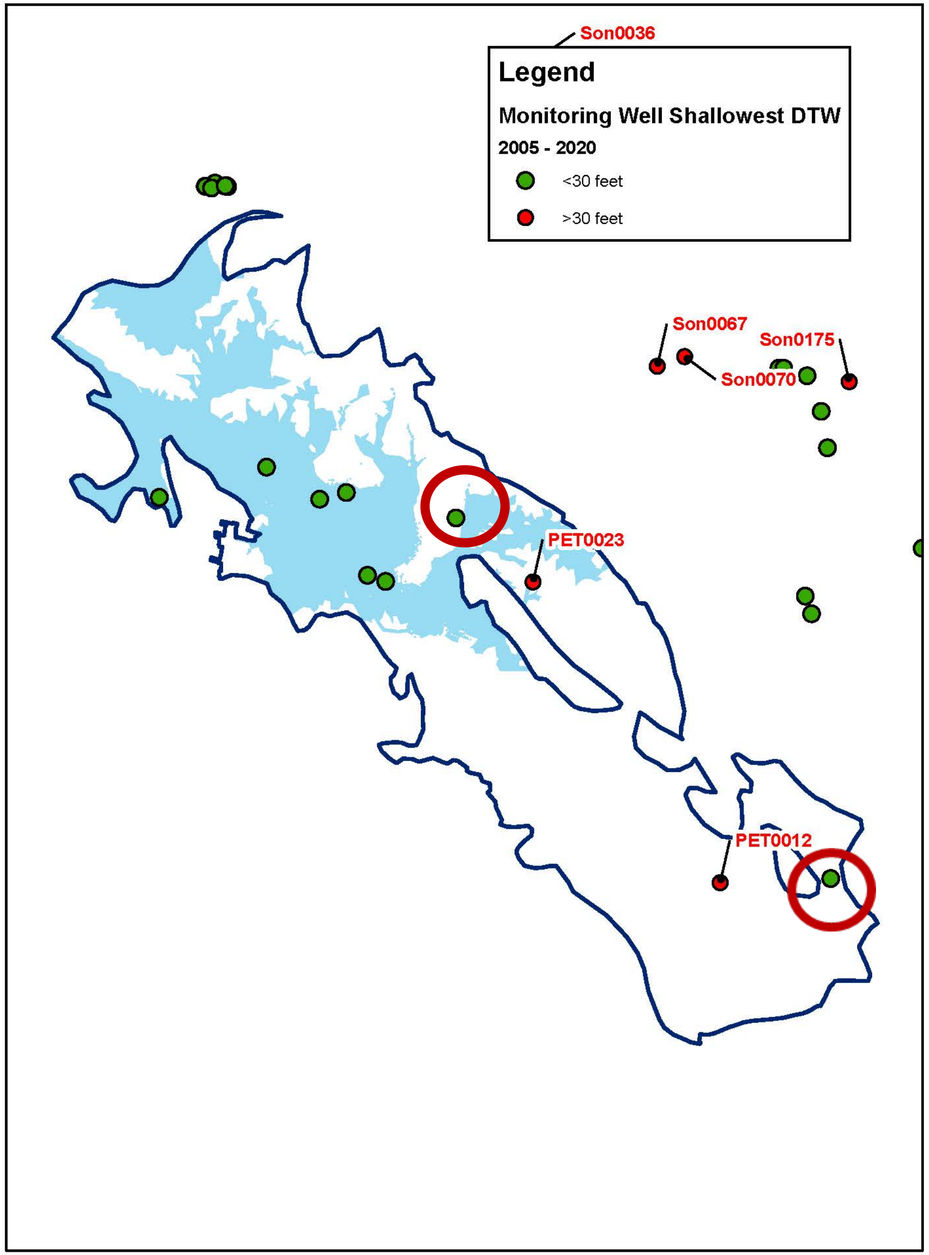


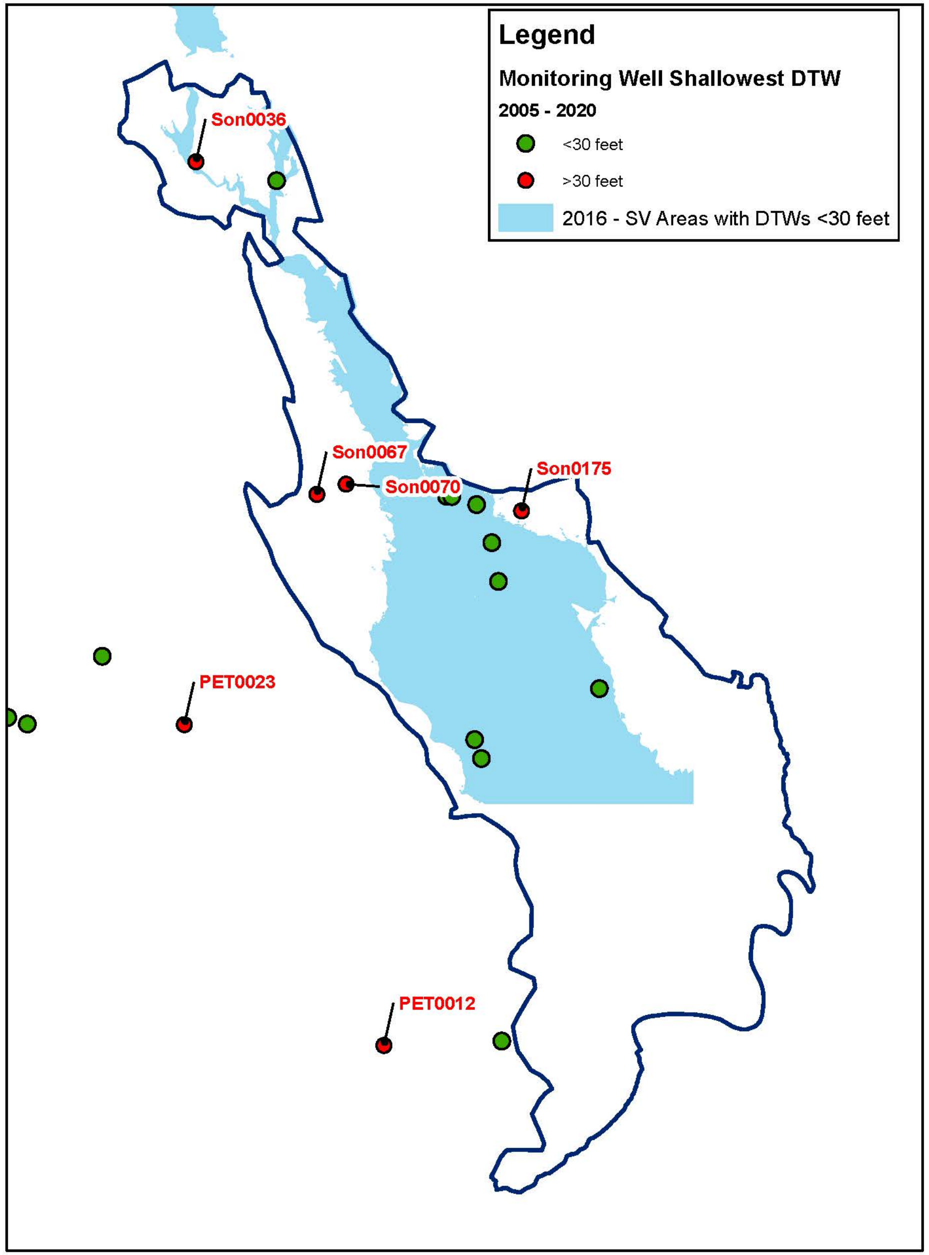
Vegetation Mapping Update (DTW maps)

- Analyzed all availab groundwater-level data from 2005-202 for shallowest deptl to water on record for each well
- Identified a few are for further investigation and modification

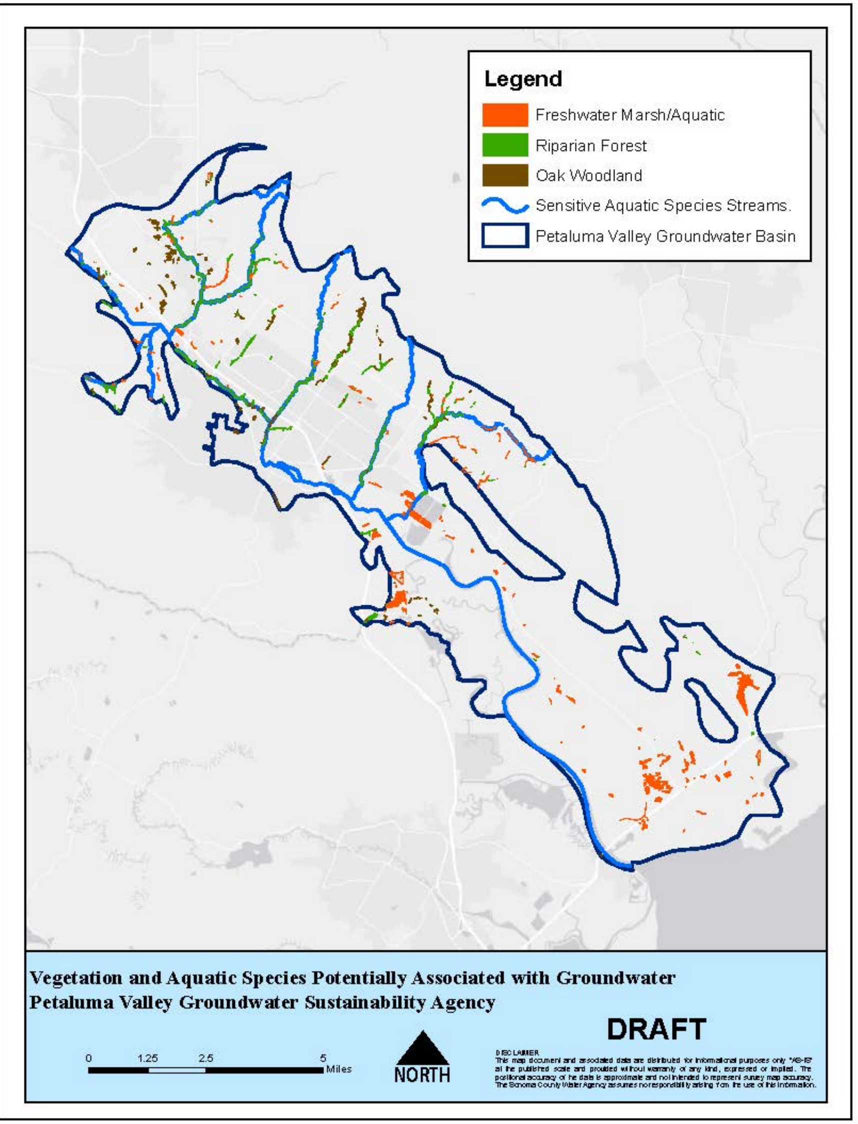


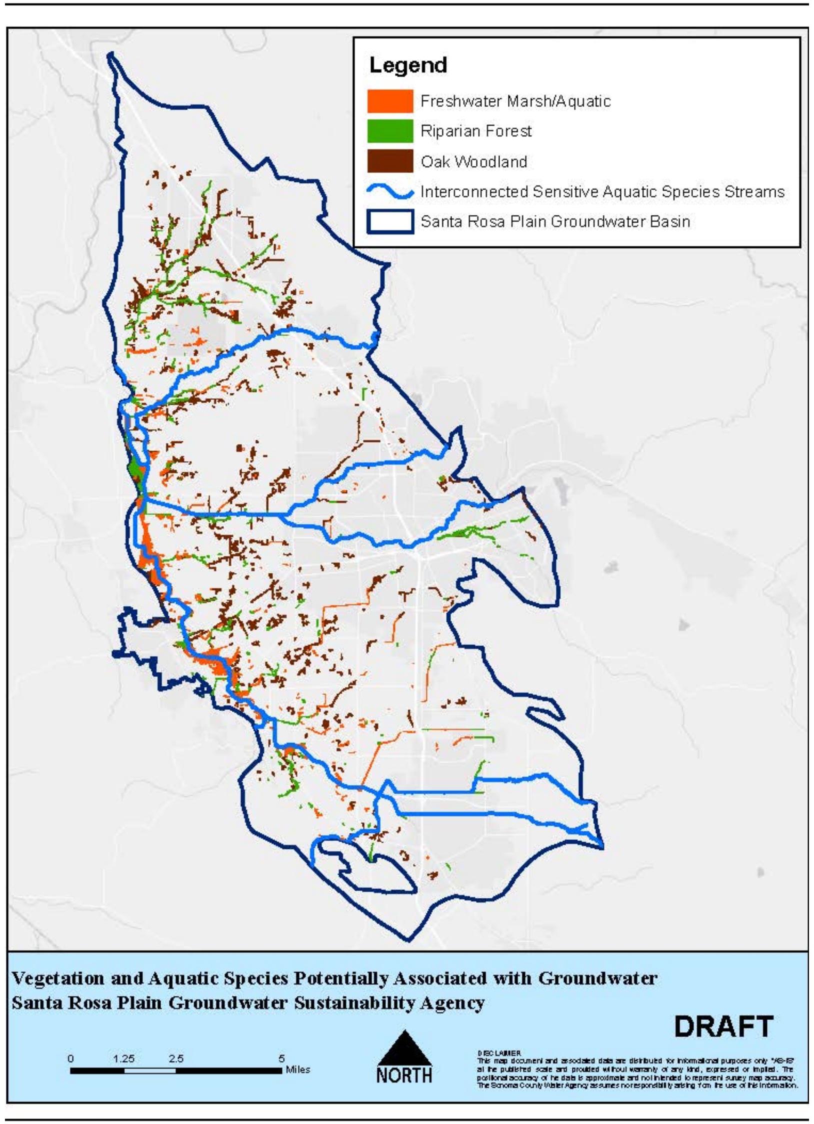
Vegetation Mapping Update (DTW maps)

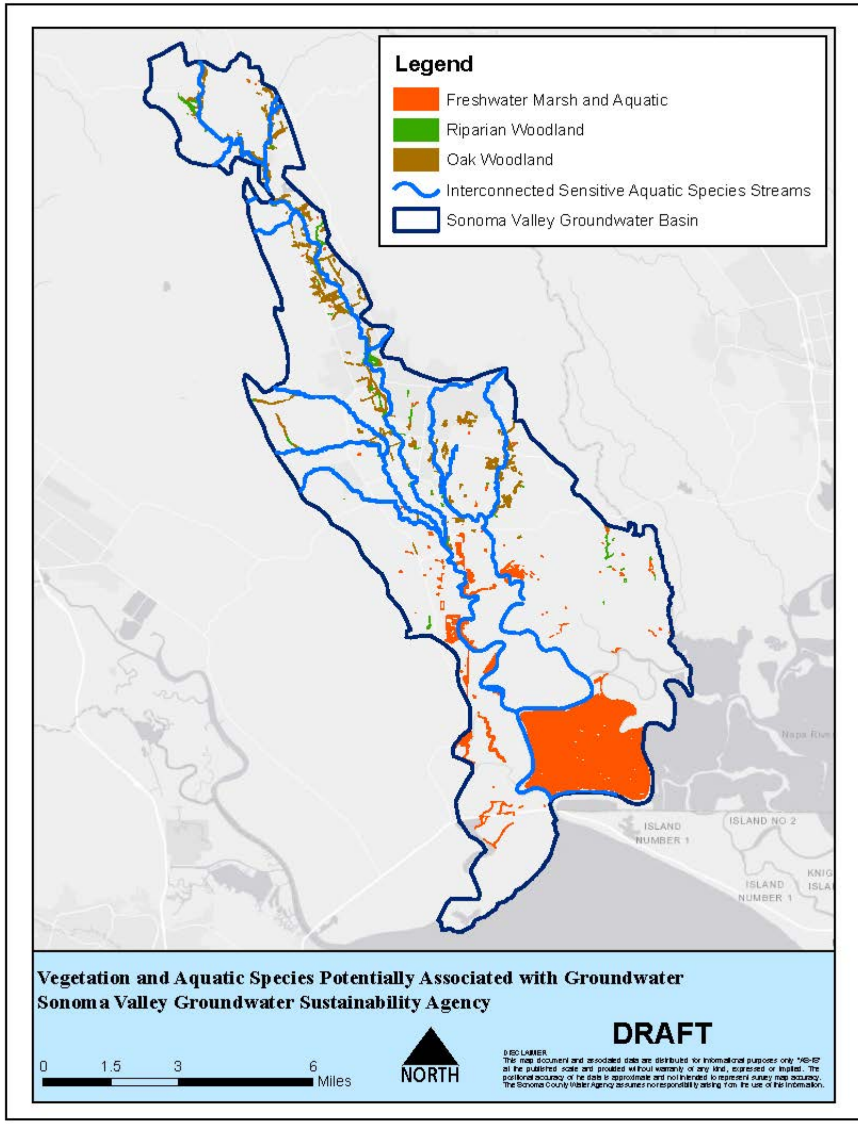


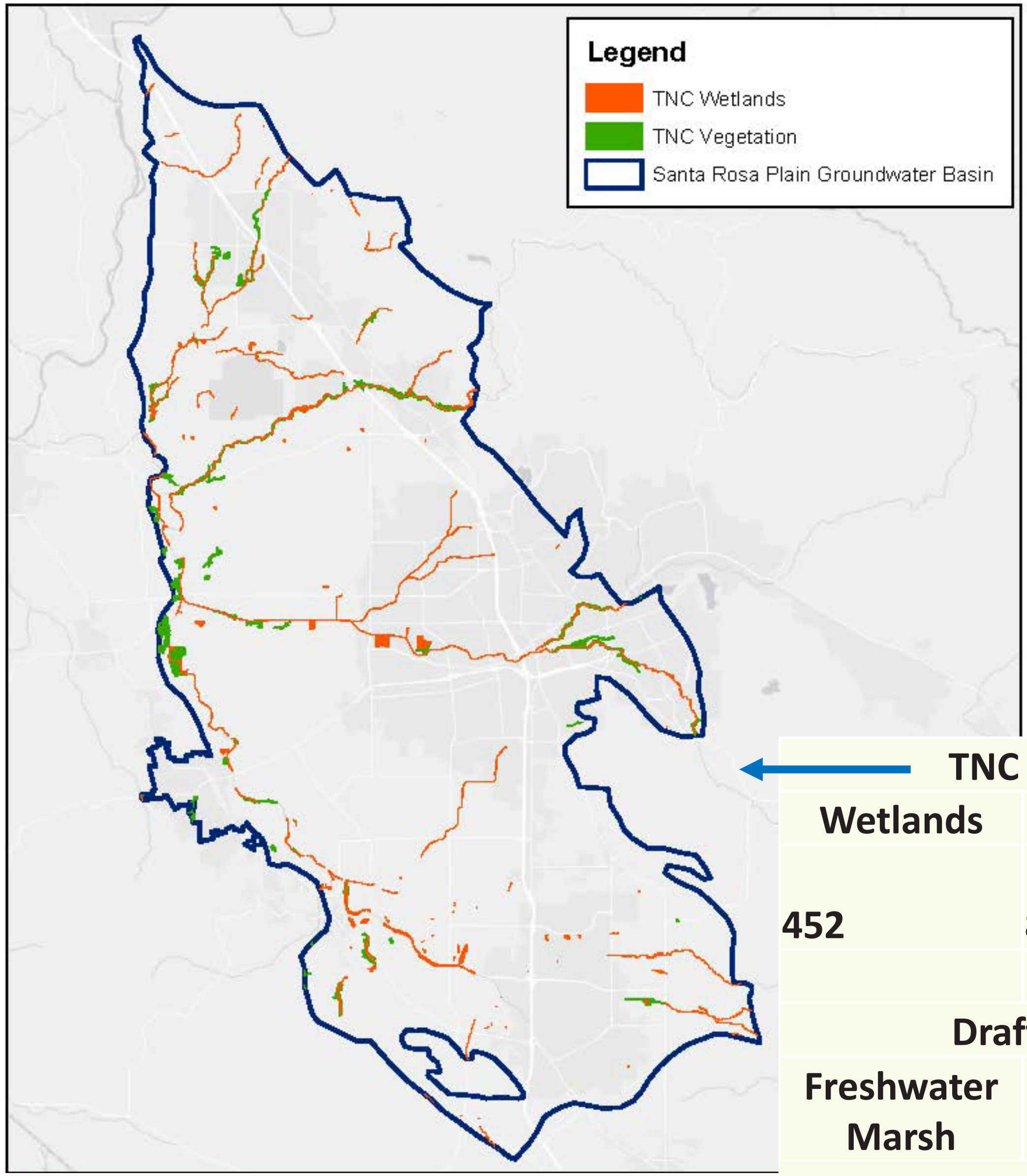


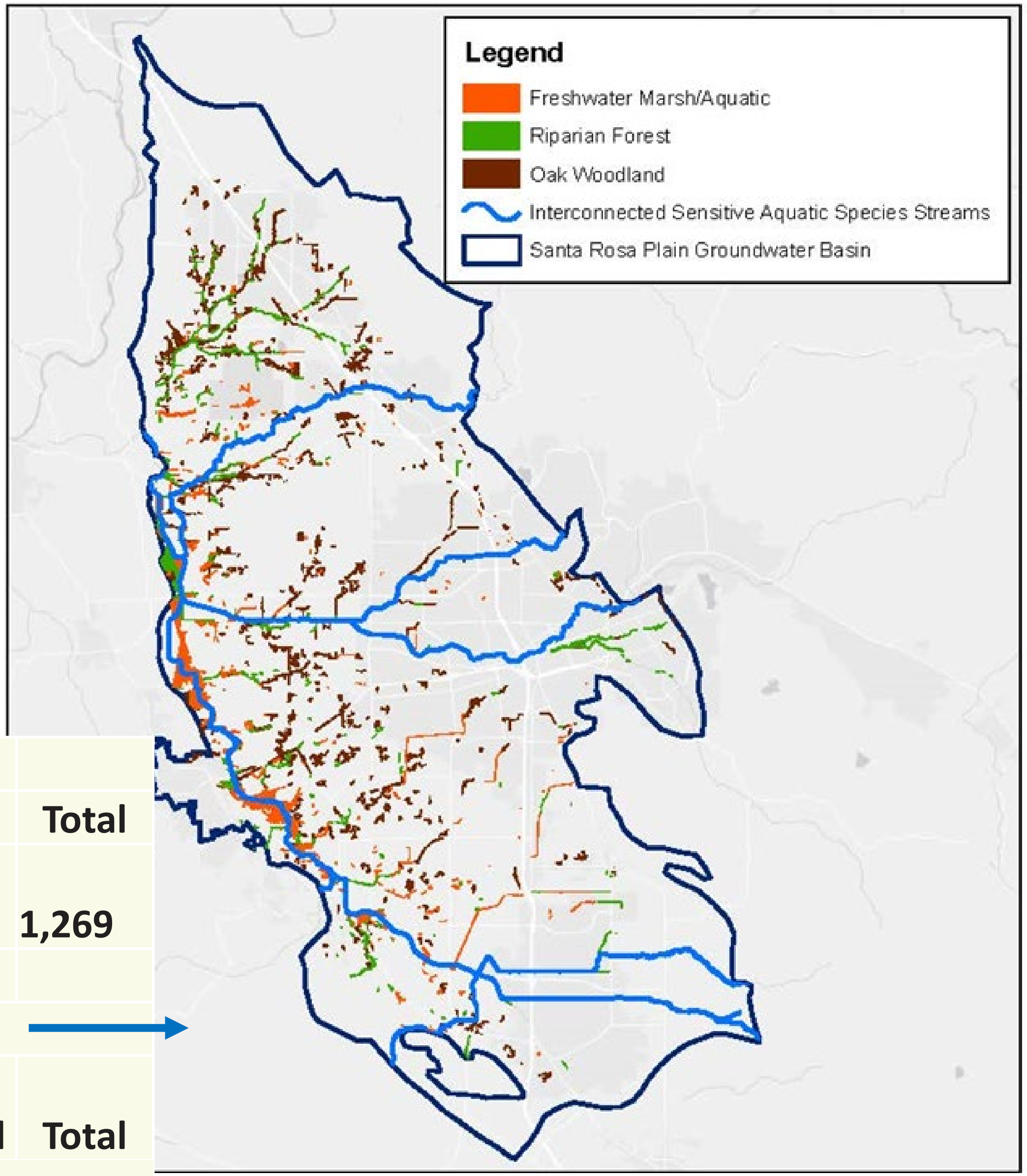
Draft Integrated Preliminary GDE Maps



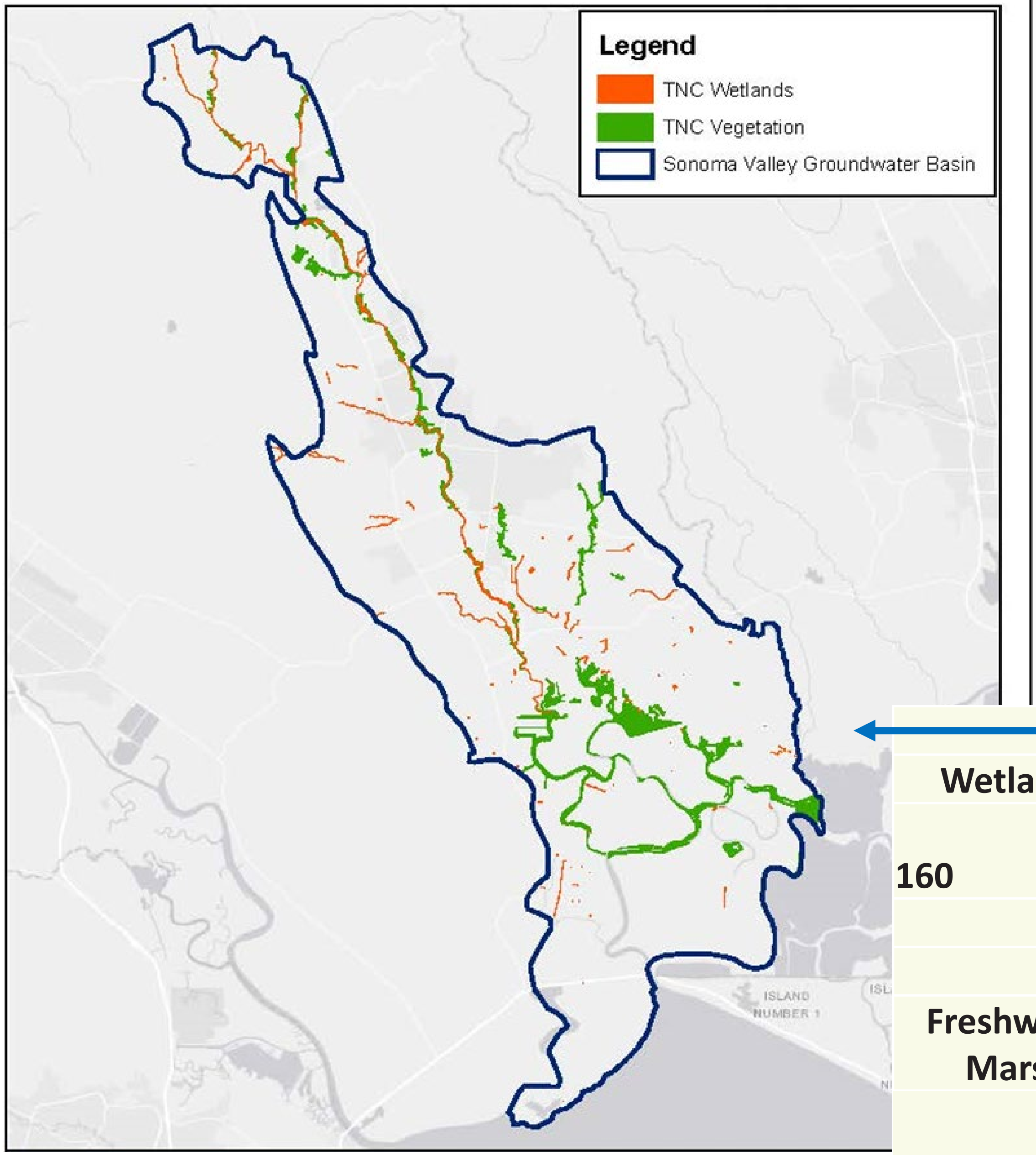




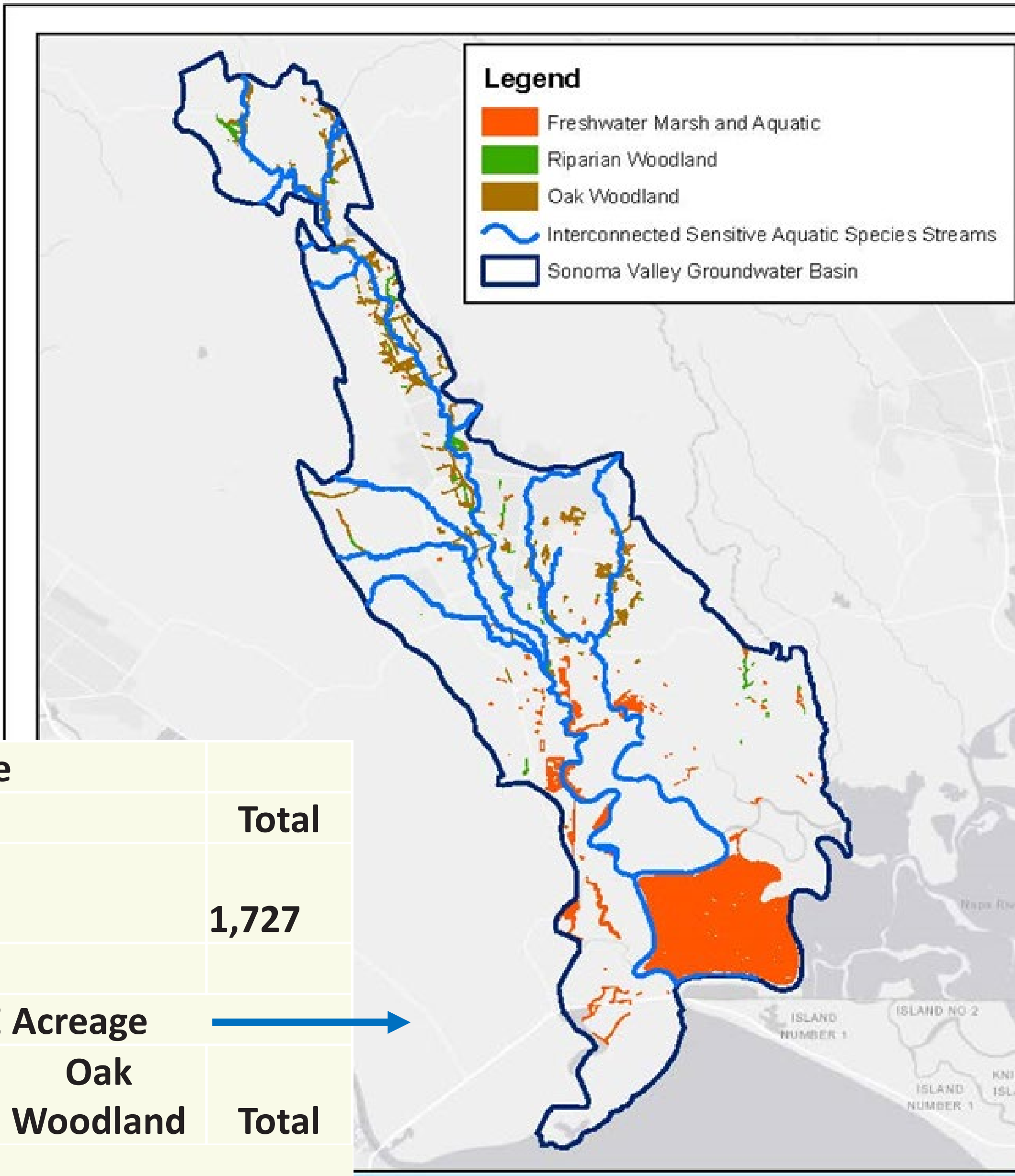


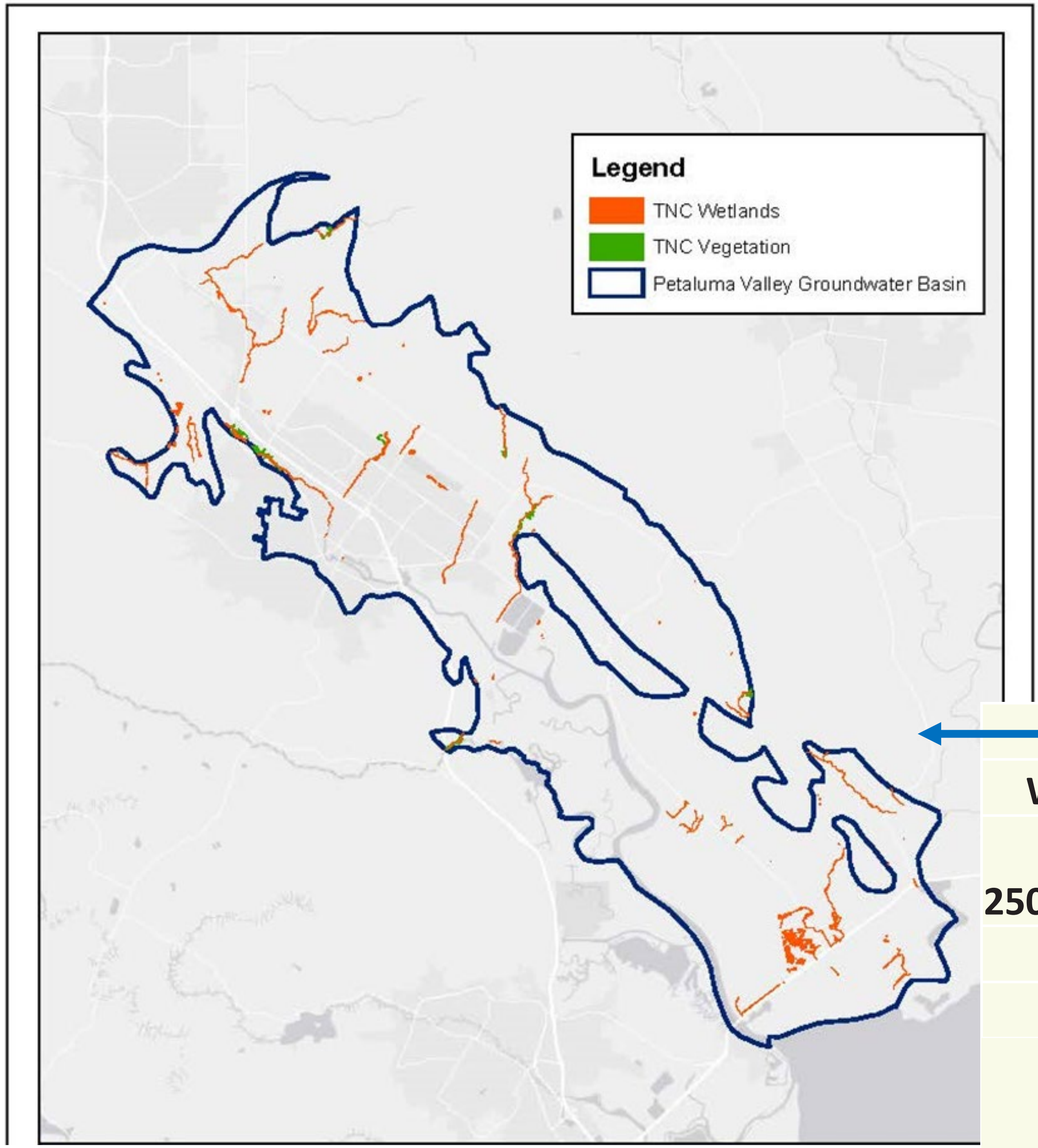


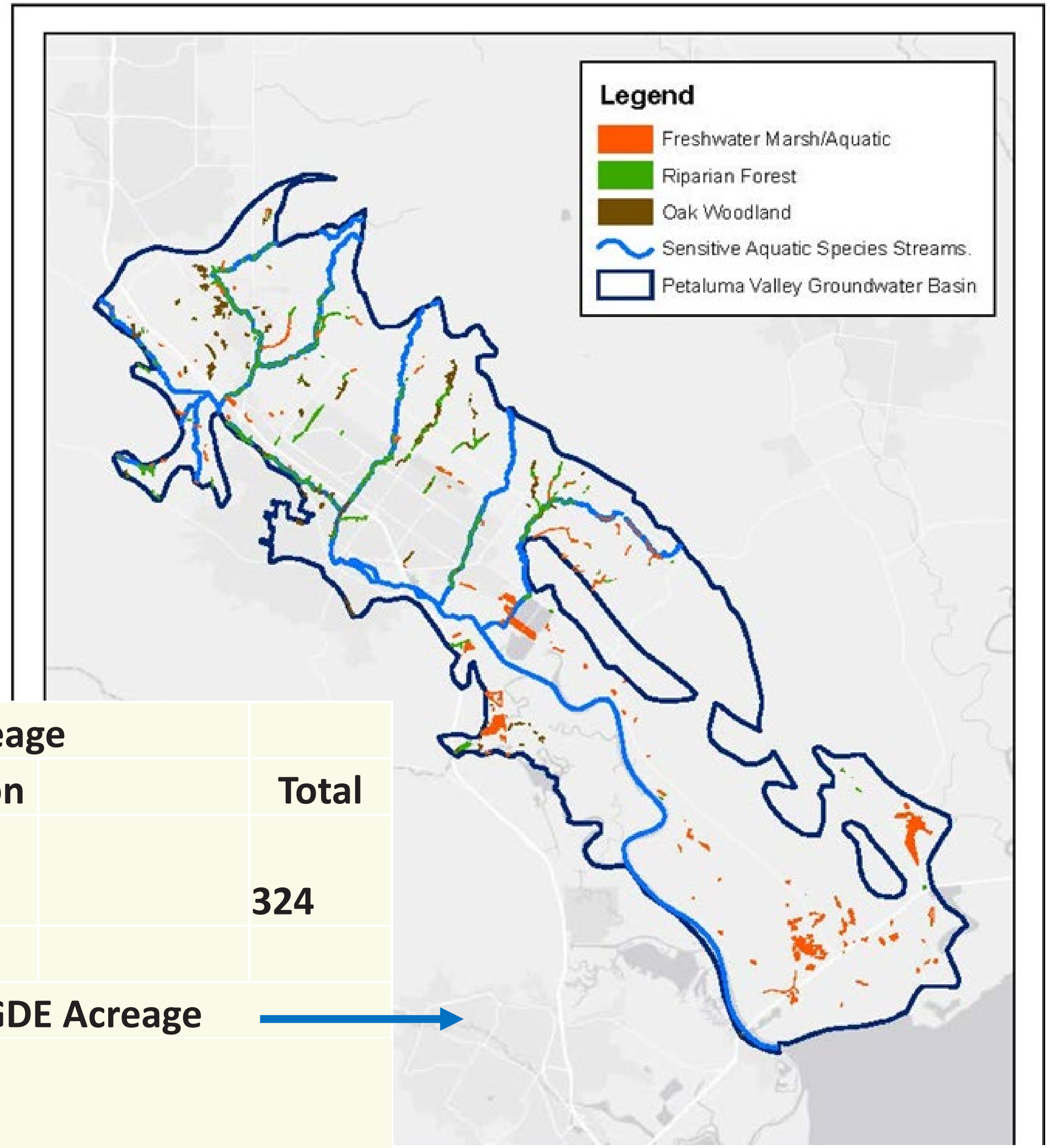
TNC iGDE Acreage			
Wetlands	Vegetation		Total
452	817		1,269
Draft Prelim GDE Acreage			
Freshwater Marsh	Riparian Forest	Oak Woodland	Total
952	1,152	1,710	3,813



TNC iGDE Acreage			
Wetlands	Vegetation		Total
160	1,567		1,727
Draft Prelim GDE Acreage			
Freshwater Marsh	Riparian Forest	Oak Woodland	Total
	556	880	1,644







TNC iGDE Acreage			
Wetlands	Vegetation		Total
250	74		324
Draft Prelim GDE Acreage			
431	299	172	903

Recommendations for Additional Data Collection/Studies for GSP Implementation

- Are there additional monitoring needs for surface/groundwater interaction to better understand GDEs?
  - Shallow monitoring wells, stream gauges, seepage runs, etc.
- Are field verification surveys required to confirm maps?
- Are there certain GDE parameters that should be considered?
  - Rooting depths, Normalized Difference Vegetation Index (NDVI), etc.
- How should any recommended studies/monitoring be prioritized for GSP implementation?

Grouping/Prioritization of GDEs

- Do we need to prioritize different GDEs?
  - Steelhead/special status species?
  - Oak woodland vs. riparian?
- How do we assign value to different vegetation classes?
- Are there certain streams or stream reaches that should be prioritized for focusing SMC development and monitoring?
- How do we select areas for additional monitoring?

TNC Guidance for Assigning Ecological Value

High Ecological Value

- All or part of the GDE unit has been designated as having important significance by environmental agencies, by other laws, in international agreements, or by local GSA stakeholders
- Contains species that are entirely dependent on groundwater (obligate) for their survival, are extremely sensitive to environmental characteristics provided by groundwater, or are rare or unique.
- Contains species or ecological communities that are vulnerable to slight to moderate changes in groundwater discharge or groundwater levels that would result in a substantial change in their distribution, species composition, and/or health.

TNC Guidance for Assigning Ecological Value

Moderate Ecological Value

- The species or ecological communities within the GDE are not legally protected but may have been designated as a beneficial use and/or as having important significance by environmental agencies, local conservation plans, or local stakeholders.
- Contains mostly species that are partially dependent on groundwater (facultative).
- Contains species or ecological communities that are somewhat vulnerable to slight to moderate changes in groundwater discharge or groundwater levels that would result in some change(s) in their distribution, species composition, and/or health.

TNC Guidance for Assigning Ecological Value

Low Ecological Value

- The species or ecological communities within the GDE are not legally protected and have not been designated as having important significance by other environmental agencies, local conservation plans, or local stakeholders.
- Contains only species that are partially dependent on groundwater (facultative).
- Contains species or ecological communities that are not vulnerable to slight to moderate changes in groundwater discharge or water tables, resulting in minimal change(s) in their distribution, species composition, and/or health.

Next Steps

- Initial draft narrative describing process and how mapping will be used in GSP
- Develop draft assignment of ecological value
- Share maps and approach with Surface Water Depletion SMC Workgroup
- Compile list of prioritized recommended data collection activities

.

Appendix 4-D
Development of Sustainable Management Criteria of Interconnected Surface Water – Santa Rosa Plain

Development of Sustainable Management Criteria for Depletion of Interconnected Surface Water

Santa Rosa Plain Groundwater Sustainability Plan

Determination of Sustainable Management Criteria (SMCs) for depletion of interconnected surface water (ISW) by groundwater pumping is based on a methodology that uses shallow groundwater level (GWL) measurements as a proxy for surface water depletion by pumping at dedicated shallow monitoring wells installed at representative monitoring point (RMP) locations adjacent to ISW. The use of GWLs as a proxy for a rate or volume of surface water depletion relies on correlation between surface water depletion by pumping and shallow GWLs at RMP locations that is demonstrated using model simulations. Quantifying surface water depletion due to pumping is a challenge because (1) it cannot be measured directly and (2) the influence of surface water depletion by pumping is often obscured by other factors, such as precipitation and runoff, diversions, evapotranspiration, and natural groundwater/surface-water interactions. The specific approach for setting SMCs at individual RMP locations varies depending on historical GWL data availability at RMP locations or from adjacent wells. For some RMP locations, especially those with limited data, future changes to SMCs for this sustainability indicator will likely be needed as more data become available.

1 Selection of Depletion of Interconnected Surface Water RMPs

Groundwater elevations from 9 shallow monitoring wells located near streams in the Santa Rosa Plain are equipped with high frequency monitoring provided by dedicated pressure transducers. These monitoring wells provide location-specific groundwater level data on the distribution and timing of surface water-groundwater interconnectivity in the Subbasin (Figs. 1–2). Streambed elevations near each monitoring well were obtained from LiDAR datasets to compare with groundwater elevations and assess interconnectedness, as not all shallow wells have stream-surface water measurements near enough to assess the presence of gaining or losing conditions. One of the locations has multiple wells completed at different depths within the shallow aquifer system (SRP0715 and SRP0716; located along Santa Rosa Creek). Monitoring well SRP0716 was considered most representative for assessing interconnected surface water conditions for the shallow principal aquifer system at this location. Six of the 9 shallow monitoring wells were included as RMPs based on observed interconnection at these locations (Table 1). Two of the 9 locations were not included as RMPs due to lack of observed interconnection. Additional details of shallow monitoring wells near streams are included in Section 5.3 of the GSP.

2 Methodology for Demonstrating Correlation between Groundwater Levels and Surface Water Depletion

SGMA regulations define the metric for depletion of ISW as a volume or rate of surface water depletion by groundwater pumping. Since direct measurement of depletion of ISW by groundwater pumping is not possible, SGMA allows groundwater elevations to be used as a proxy for the volume or rate of depletion of ISW, provided significant correlation between groundwater elevations and depletion of ISW can be demonstrated. The methodology outlined below relies on groundwater modeling to demonstrate the correlation between shallow GWLs and depletion of ISW.

2.1 Modeling Framework for Isolating Impacts of Groundwater Pumping on Streamflow

Even though depletion of ISW by groundwater pumping cannot be measured directly, the volume or rate of depletion can be estimated with model simulations. To isolate the impact of depletion of ISW by groundwater pumping, a sensitivity approach was used by subtracting simulated streamflow outputs from two scenarios simulated with the Santa Rosa Plain Integrated Hydrologic Model. The general procedure is derived from Barlow and Leake (2012)[1] and is illustrated in Steps 1–2 in Fig. 3:

1. Simulate (a) a historical baseline scenario, which includes historical groundwater pumping, and (b) an identical historical baseline scenario, but remove historical groundwater pumping, i.e., a no-pumping scenario.
2. At each time step, subtract historical baseline simulated streamflow outputs from no-pumping scenario at each RMP location.

The resulting streamflow volume is an estimate of ISW depletion from groundwater pumping that occurred at all ISW locations upstream of each RMP location at each time step (e.g., as illustrated in Step 2 in Fig. 3). In effect, the volume of ISW depletion is the amount of additional streamflow volume at each RMP location if historical groundwater pumping had not occurred. Of course, the no-pumping scenario is outside the bounds of real-world conditions and is not presented as an aspirational goal for the basin, but instead provides a means to estimate the relative magnitude of ISW depletion over time and across locations. Simulated differences in streamflow for pumping and no-pumping scenarios are shown for all RMPs in Figs. 4–10.

While the Santa Rosa Plain Integrated Hydrologic Model offers a robust platform to evaluate potential impacts of surface water depletion by groundwater pumping, there are significant uncertainties related to this approach. Namely, the no-pumping scenario outlined above is a substantial simplification that (1) does not differentiate between wells accessing surface water underflow from wells accessing groundwater and does not account for potential changes in surface water demand that may occur in the absence of groundwater pumping, and (2) simulates conditions outside of the calibrated range of the model. These additional uncertainties compound the uncertainties and simplifications inherent to the calibrated model itself. Despite these limitations, this analysis is especially useful for evaluating the relative magnitudes of surface water depletion between RMPs and through time.

2.2 Demonstrating Correlation between Groundwater Levels and Surface Water Depletion at RMP Locations

To evaluate the correlation between surface water depletion from groundwater pumping and shallow groundwater levels at RMP locations, this methodology focused on a 15-year simulation period from 2004–2018 representing recent historical groundwater pumping conditions in the basin. Surface water depletion was estimated at each RMP location as the percent decrease in minimum monthly simulated streamflow during the July-September period at the corresponding SFR cell for each year during 2004–2018. The corresponding shallow groundwater level was estimated as the minimum monthly simulated groundwater level in model layer 1 at each RMP location during the July–September period for each year. Correlation was determined with linear regression and evaluated using the coefficient of

---

1

determination (R-squared). R-squared values greater than 0.60 were determined to be sufficiently correlated. R-squared values for each RMP location are summarized in Table 1. Correlation between surface water depletion from groundwater pumping and shallow groundwater levels is illustrated in Step 3 in Fig. 3 and is shown for each RMP location in Figs. 11–17.

Two RMP locations (SRP0713, SRP0714; Figs. 15–16) showed poor simulated correlation between surface water depletion from groundwater pumping and shallow groundwater levels (R-squared values less than 0.60). Groundwater-level proxy SMC values were still set for these RMP locations because poor correlation at these sites was attributed to poor process representation in the model at these RMP locations rather than insufficient hydrologic connection between surface water and shallow groundwater levels. Shallow groundwater levels at these sites are close to the streambed elevation and show response to fluctuations in surface water stage, indicating hydrologic connection between surface water and shallow groundwater levels. As outlined in subsequent Section 3.3, future improvements in the model will focus on improving process representation at these RMP locations.

3 Methodology for Determining Minimum Thresholds and Measurable Objectives for Depletion of Interconnected Surface Water at RMPs

Prior to setting SMCs for individual RMP locations, basin-wide yearly estimates of surface water depletion by groundwater pumping were assessed by evaluating surface water depletion at the basin's outlet (USGS gage 1146800, Mark West Creek at Mirabel Heights; Fig. 1–2), thereby aggregating all surface water depletion that occurs upstream within the SRP basin. Daily average simulated streamflow for pumping/no-pumping scenarios at the basin outlet are shown in Fig. 18, and annual dry-season surface water depletion estimates for 2004–2018 are shown for the basin outlet in Fig. 19.

Based on input from the Depletion of Interconnected Surface Water Work Group, as well from the SRP Advisory Committee and Board, it was determined that MT values at RMP locations should be sufficiently protective so as to not exceed the average, basin-wide, dry-season (July–September) surface water depletion from pumping that occurred during the three years with the greatest depletion over the 2004–2018 evaluation period. As shown in Fig. 19, the three years with the greatest simulated depletion were 2014, 2015, and 2016. Accordingly, the resultant MT is more protective than if the MT were chosen to reflect the single year with the greatest depletion.

The methodology for setting MT values using groundwater-level proxies relies on the correlation between simulated surface water depletion from groundwater pumping and simulated shallow groundwater levels at each RMP location (Figs. 11–17). To set the groundwater-level proxy MT value equivalent to the average dry-season surface water depletion from pumping that occurred during 2014–2016, the average percentile ranking of simulated groundwater levels during 2014–2016 is first determined at each RMP location (e.g., 10^{th} percentile groundwater level for RMP SRP0709; Fig. 12). These values are summarized for each RMP location in Table 1.

3.1 Methodology for Determining Groundwater-Level Minimum Thresholds at RMP Locations

3.1.1 Substituting Groundwater-Level Minimum Threshold Percentile Ranking Value from Adjacent Well(s)

To set the groundwater-level proxy MT value at each RMP location, the method relies on evaluating the resultant percentile ranking for each RMP (Table 1) using available observed historical dry-season low groundwater levels during 2004–2020. However, the dedicated shallow monitoring wells at RMP locations were installed in fall 2019, so there is presently insufficient data to directly evaluate the percentile-ranking of historical dry-season groundwater levels at these dedicated wells. Instead, the MT percentile ranking is evaluated at an adjacent well with a longer period of record, and the resultant MT value is then translated to the dedicated RMP well using the position of the MT value relative to measured 2019 and 2020 dry-season groundwater levels (i.e., match points). This procedure is illustrated in Step 4 in Fig. 3. For locations with multiple adjacent wells, the average position of the MT value for those multiple wells relative to 2019 and 2020 dry-season groundwater levels is used. MT values for RMP wells that use the match-point methodology are summarized in Table 1 and are shown in Figs. 20–36. The relationship between RMP wells and adjacent wells that use the match-point methodology is given in Tables 2–6.

3.1.2 Determining Groundwater-Level Minimum Threshold from Approximate Streambed Elevation

For RMP wells that do not have adjacent wells with a sufficiently long period of record to use as a substitute MT, groundwater-level proxy MT values were set at an elevation to maintain the observed local gradient between groundwater levels and streambed elevation, so as to maintain historical gaining/losing conditions. For RMP SRP0714, the MT value was set as 1 ft. above the approximate streambed elevation, so as to maintain observed gaining conditions (Table 1; Fig. 35). Similarly, for RMP SRP0716, the MT value was set to 1 ft. below the observed streambed elevation, so as to maintain observed interconnection (Table 1; Fig. 36).

3.2 Methodology for Determining Groundwater-Level Measurable Objectives at RMP Locations

Based on input from the Depletion of Interconnected Surface Water Work Group, as well as from the SRP Advisory Committee and Board, it was determined that MO values at RMP locations should maintain the observed average dry-season surface water depletion from pumping that occurred during the years with available observations during 2004–2020. Accordingly, MO values at each RMP are set to reflect average dry-season observed groundwater levels during the years with available observations during 2004–2020. MO values for each RMP are summarized in Table 1 and are shown in Figs. 20–36.

3.2.1 Transferring Groundwater-Level Measurable Objective Percentile Ranking Value from Adjacent Wells

Since the dedicated shallow monitoring wells at RMP locations were installed in fall 2019, there is limited data to directly estimate the average dry-season groundwater levels during 2004–2015 at these dedicated wells. Similar to setting MT values, the groundwater-level proxy MO value at each RMP location relies on evaluating the average dry-season groundwater level at an adjacent well with a longer period of record, and then translating the MO value to the dedicated RMP well using the position of the

MO value relative to measured 2019 and 2020 dry-season groundwater levels (i.e., match points). For locations with multiple adjacent wells, the average position of the MO value for those multiple wells relative to 2019 and 2020 dry-season groundwater levels is used. MO values for RMP wells that use the match-point methodology are summarized in Table 1 and are shown in Figs. 20–34. The relationship between RMP wells and adjacent wells that use the match-point methodology is given in Tables 2–6. For RMP locations without adjacent well data (SRP0714 and SRP0716), the MO is set as the average of 2019 and 2020 dry-season groundwater levels at the dedicated RMP well (Table 1; Figs. 35–36).

3.3 Future Methodology for Determining Groundwater-Level Minimum Thresholds and Measurable Objectives at RMP Locations with Sufficient Groundwater Level Period of Record

Once a sufficient period of record of groundwater level observations is established at each dedicated RMP monitoring well (i.e., at or before the 5-year update), the methodology for setting MT and MO values will be modified to establish the MT and MO approaches directly to observed groundwater levels at each dedicated RMP well, rather than relying on adjacent wells with a longer period of record. Additionally, the groundwater level percentile ranking for each RMP location may be modified once improvements are made to the model that more accurately simulate groundwater/surface-water interactions and depletion of interconnected surface water by groundwater pumping.

4 Figures

4.1 Site Overview

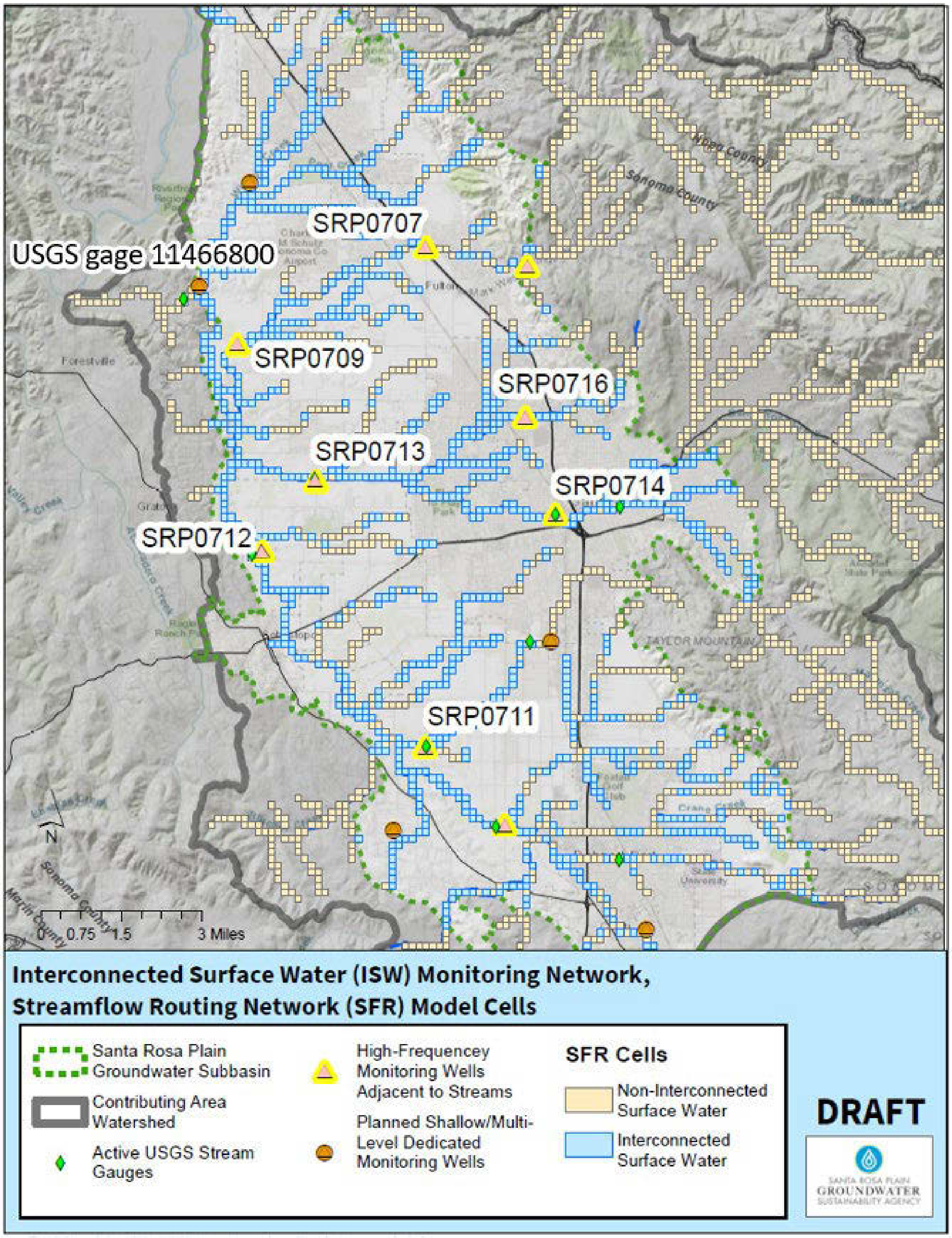


Figure 1: Santa Rosa Plain depletion of interconnected surface water RMP locations along with streamflow routing network cells identified as interconnected surface water.

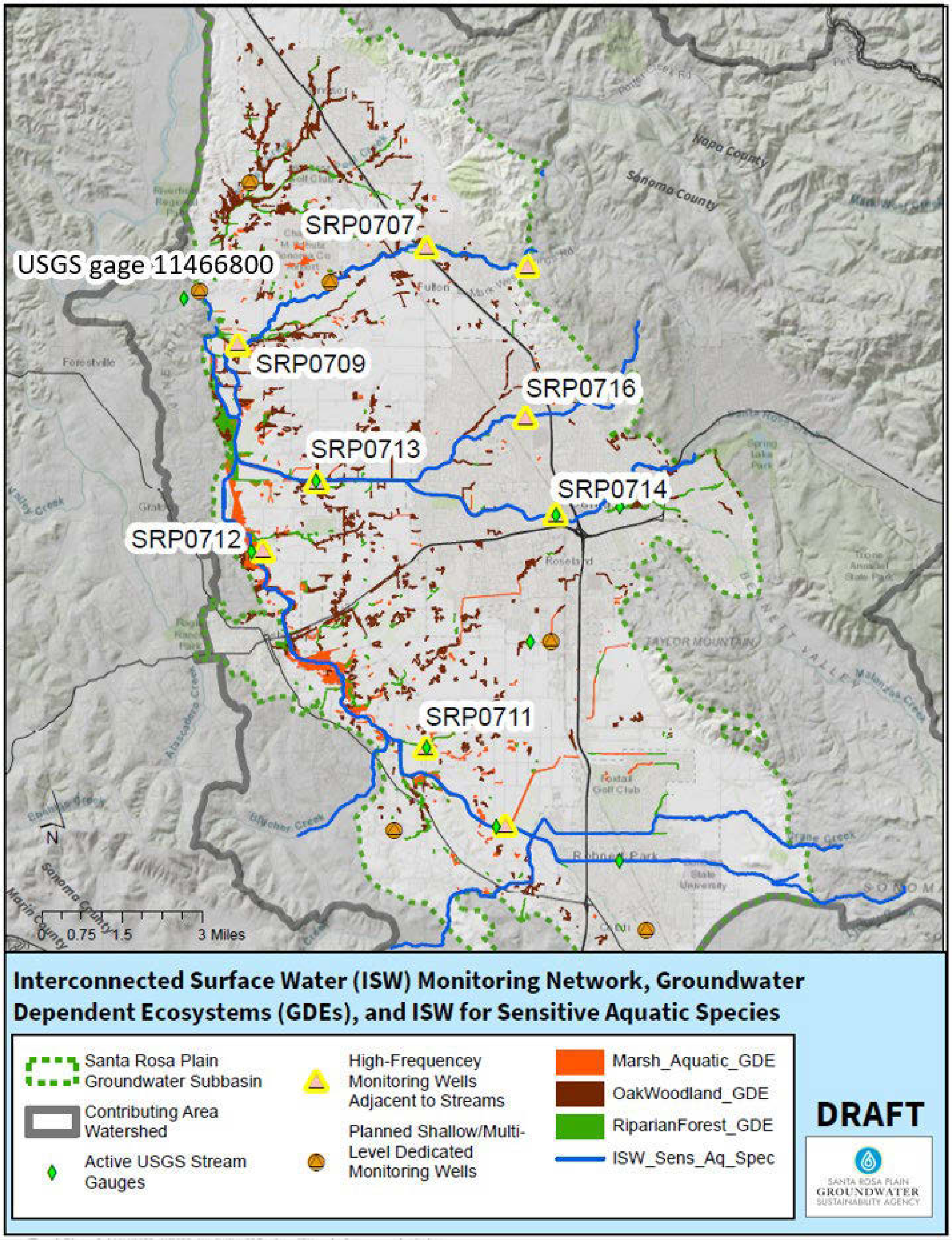


Figure 2: Santa Rosa Plain depletion of interconnected surface water RMP locations along with mapped GDE locations.

4.2 Methodology Overview

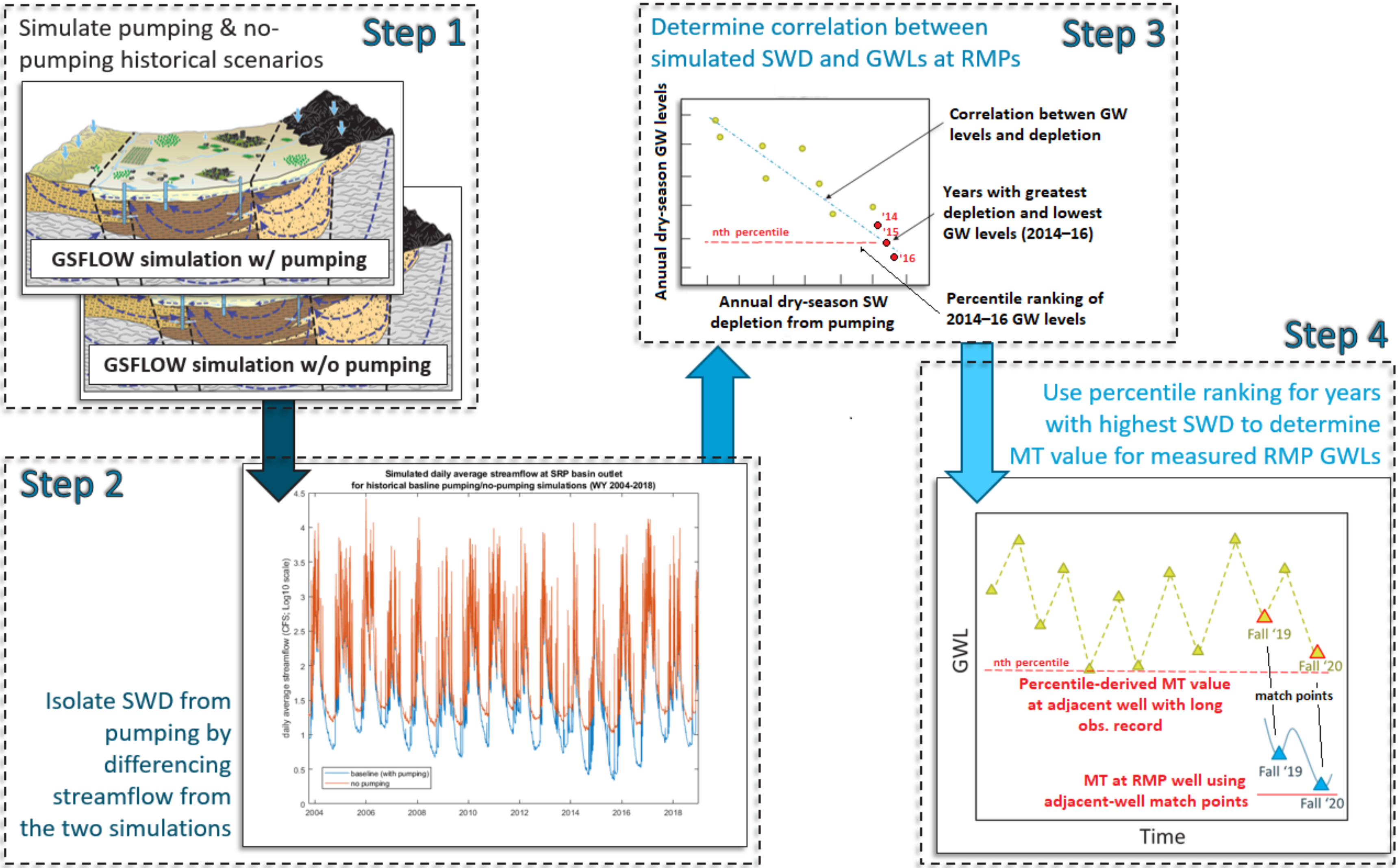


Figure 3: Methodology conceptualization for establishing depletion of interconnected surface water SMCs.

4.3 Simulated Reductions in Streamflow due to Pumping

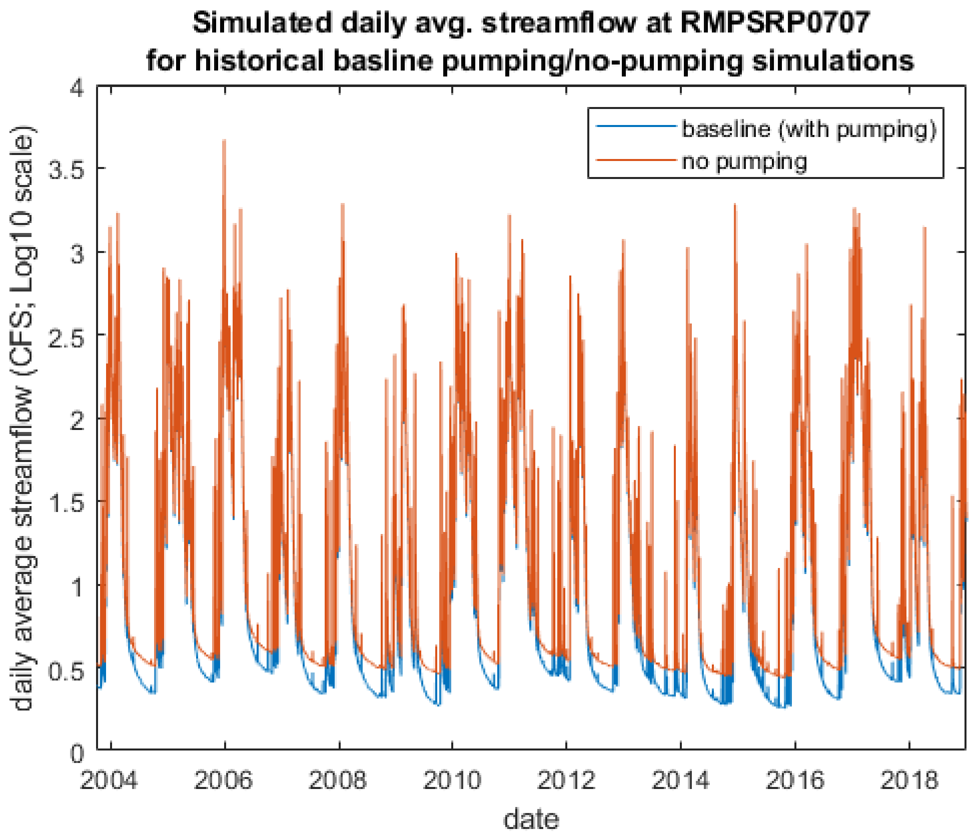


Figure 4: Differences in simulated streamflow at RMP SRP0707 during 2004–2018.

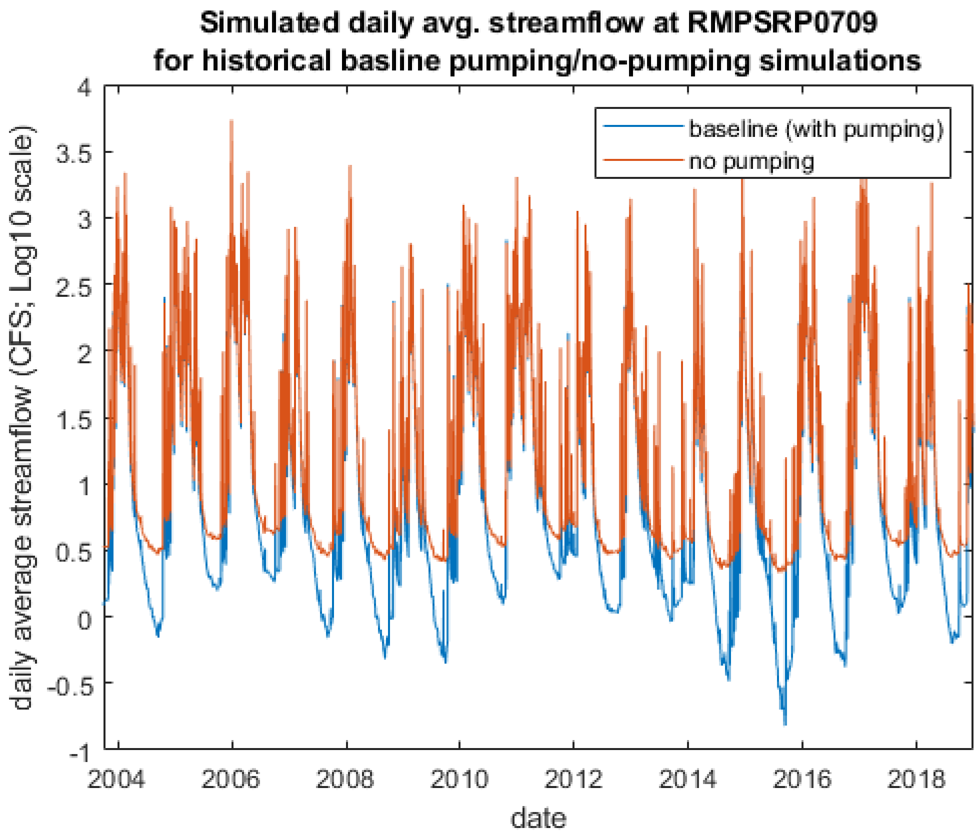


Figure 5: Differences in simulated streamflow at RMP SRP0709 during 2004–2018.

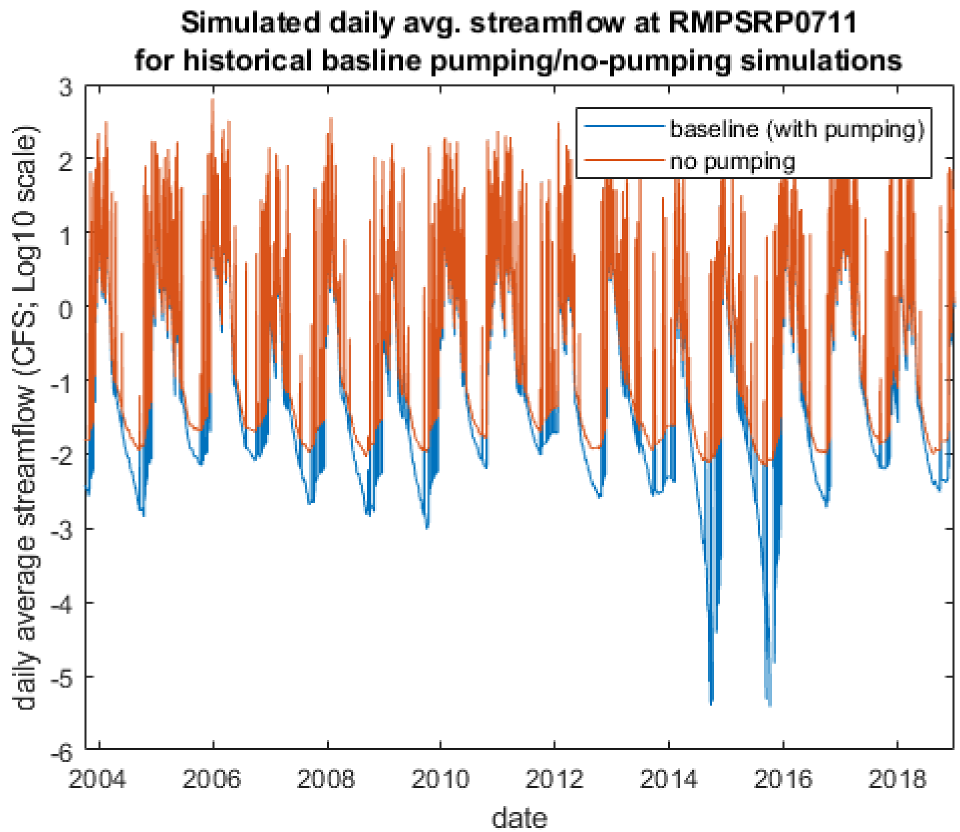


Figure 6: Differences in simulated streamflow at RMP SRP0711 during 2004–2018.

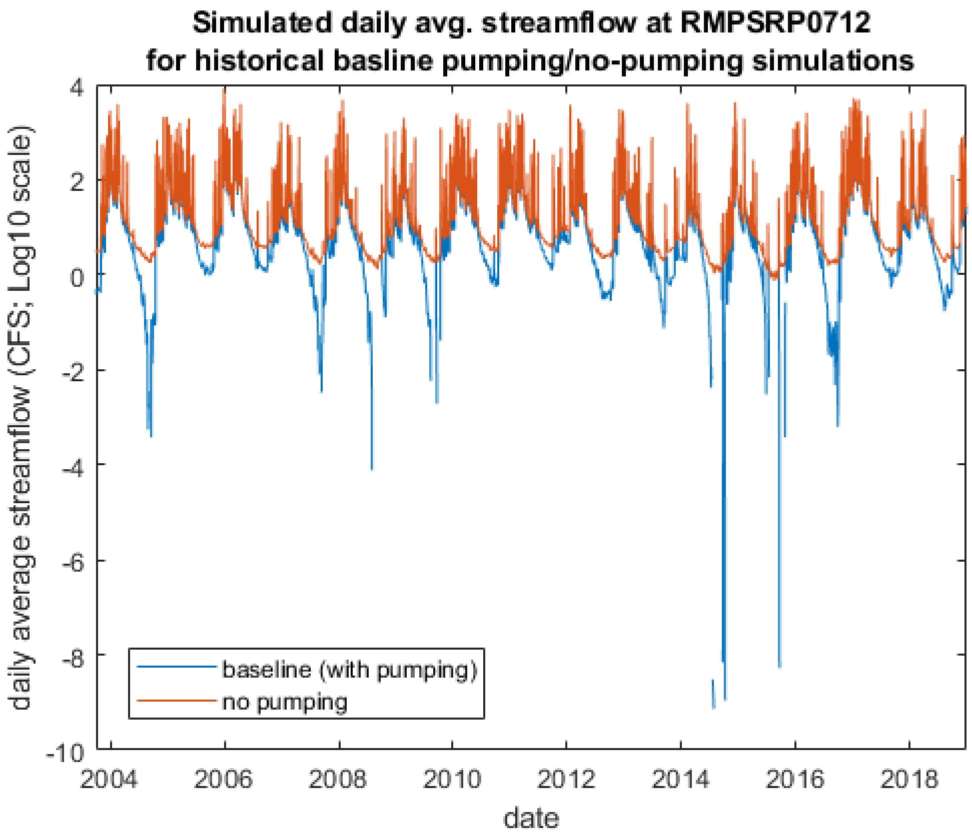


Figure 7: Differences in simulated streamflow at RMP SRP0712 during 2004–2018.

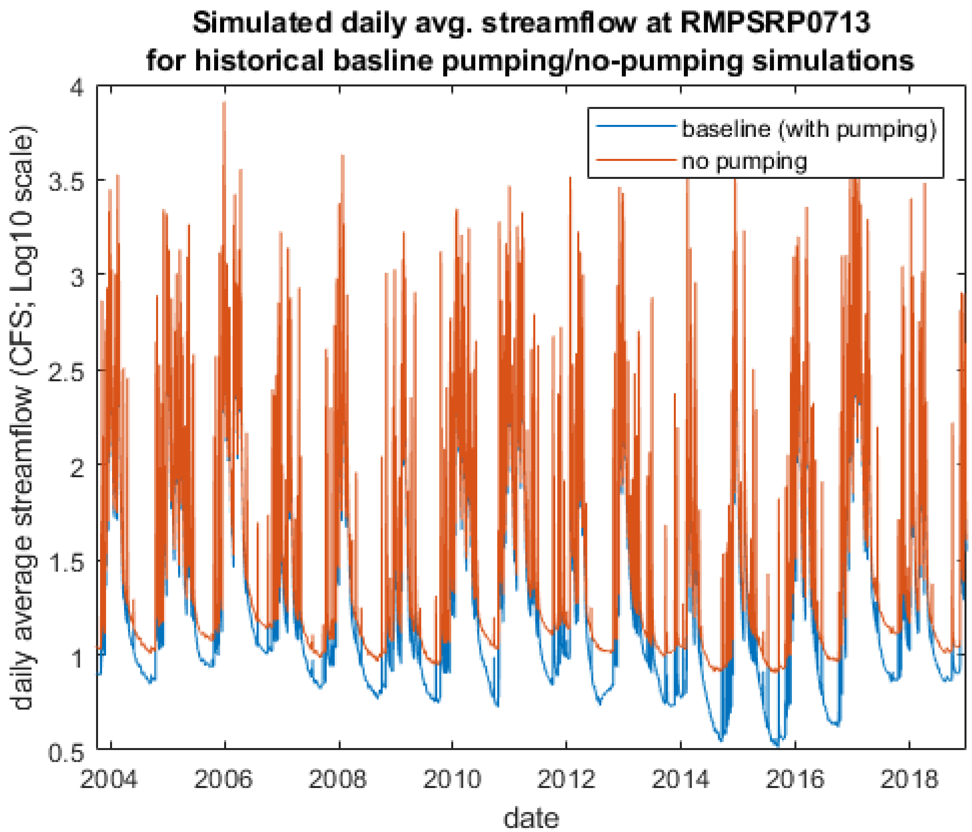


Figure 8: Differences in simulated streamflow at RMP SRP0713 during 2004–2018.

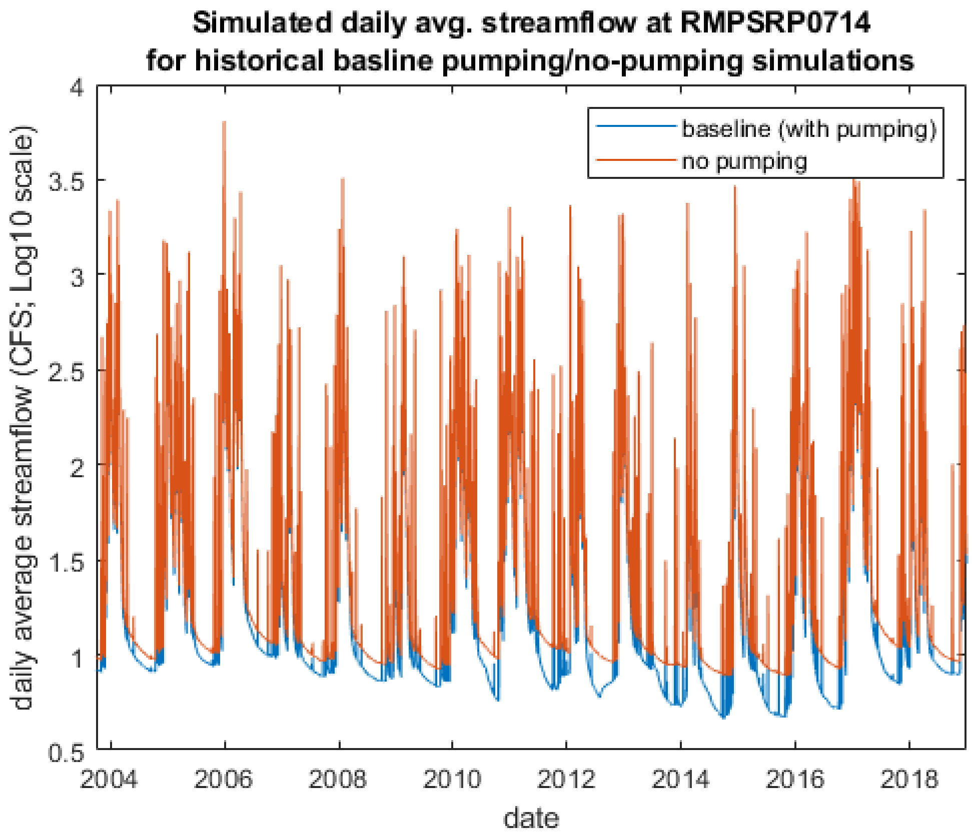


Figure 9: Differences in simulated streamflow at RMP SRP0714 during 2004–2018.

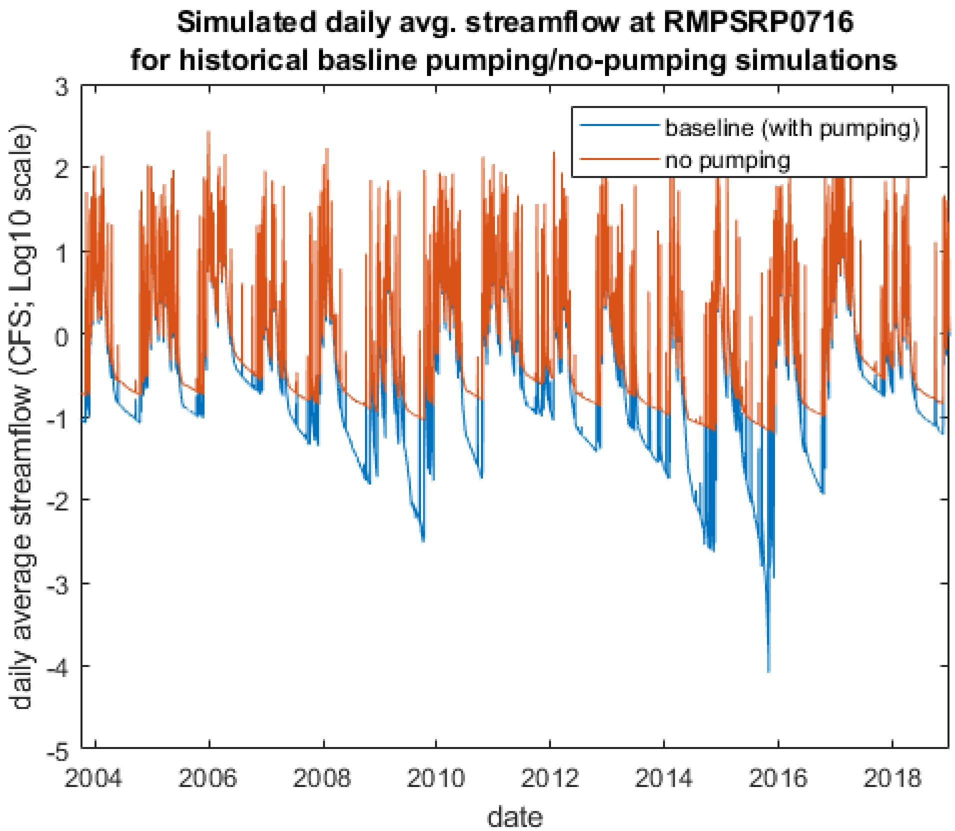


Figure 10: Differences in simulated streamflow at RMP SRP0716 during 2004–2018.

4.4 Simulated Correlation between Surface Water Depletion and Groundwater Levels

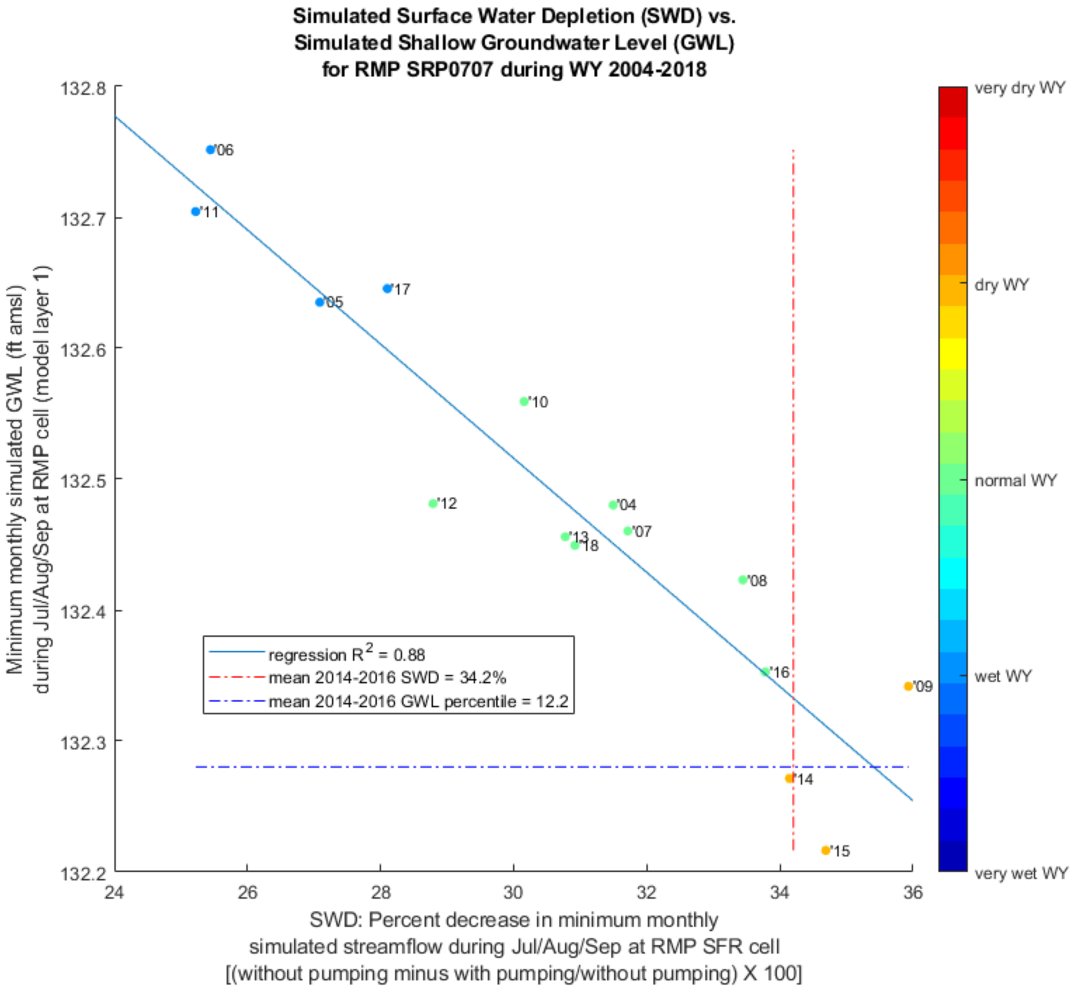


Figure 11: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0707 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

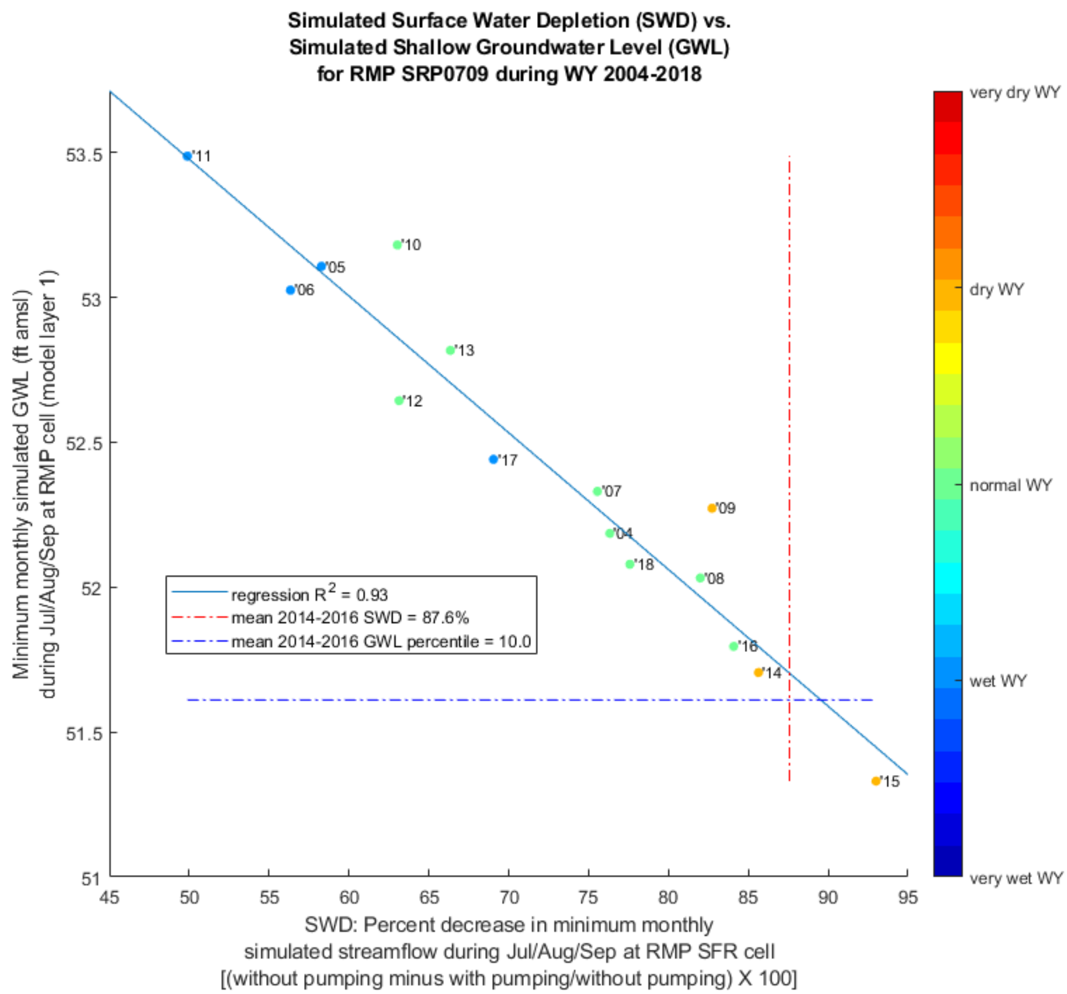


Figure 12: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0709 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

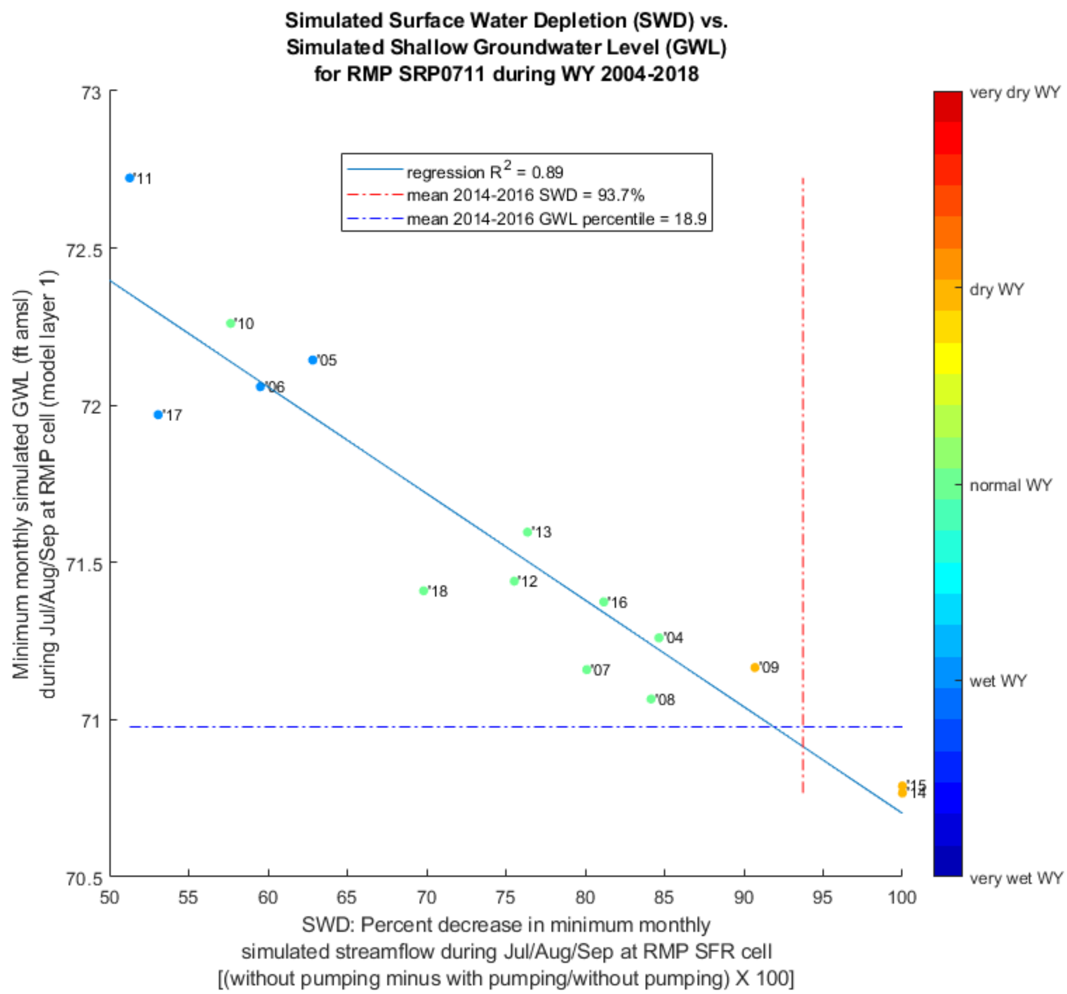


Figure 13: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0711 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

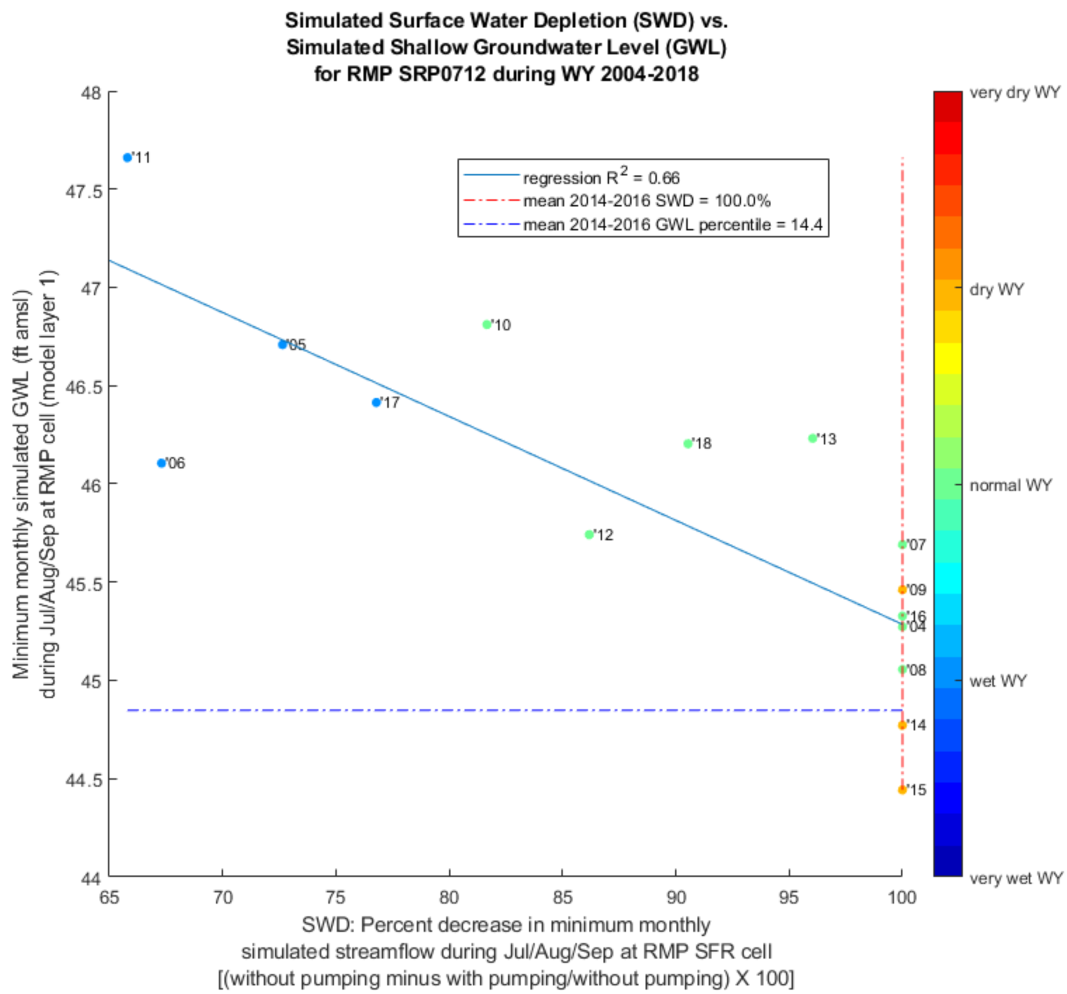


Figure 14: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0712 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

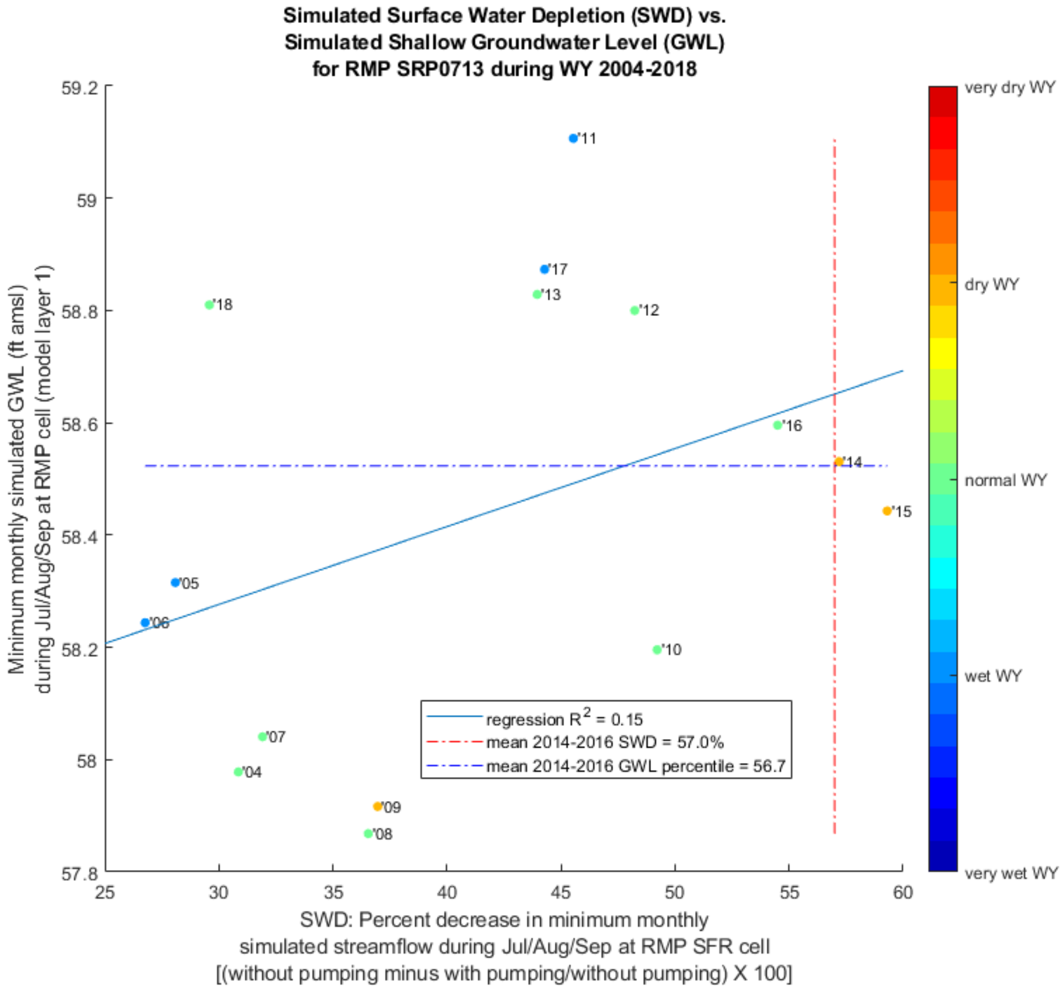


Figure 15: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0713 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

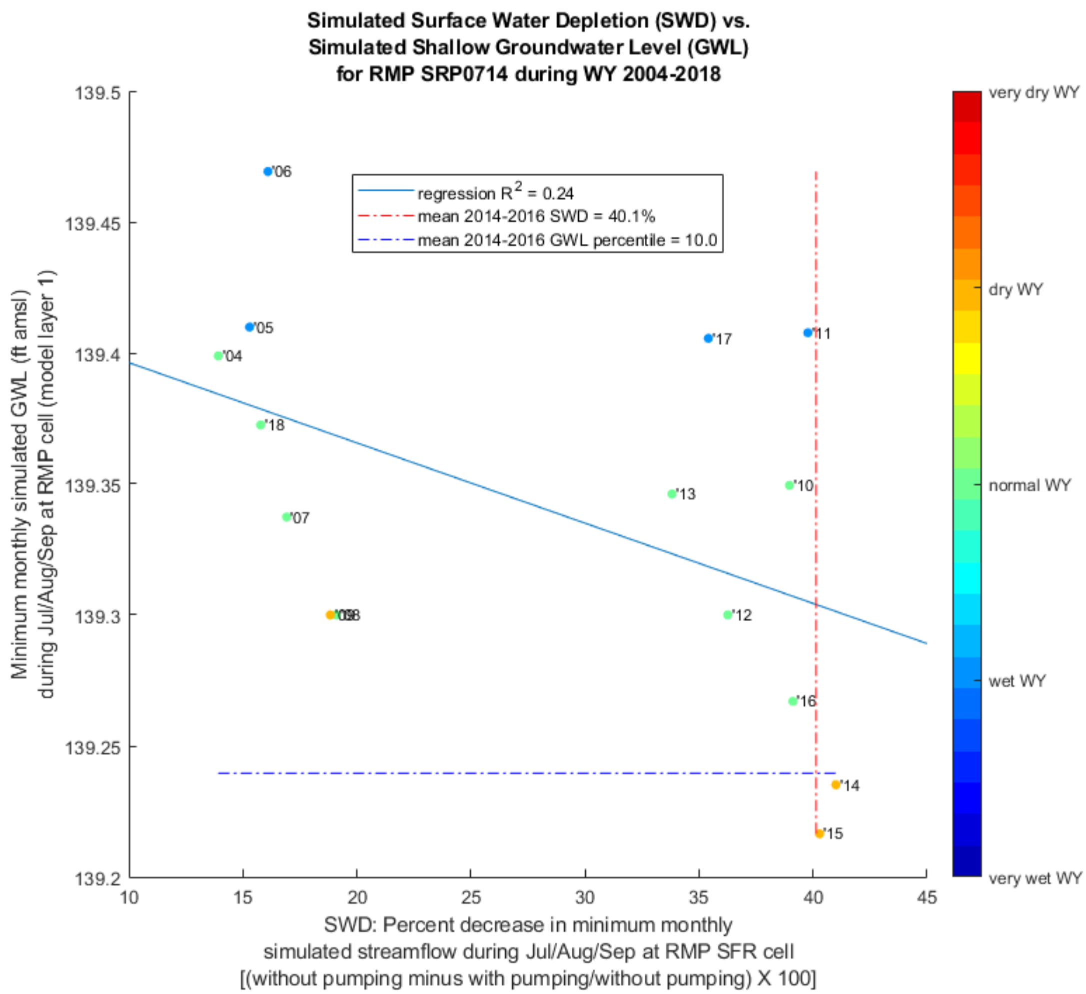


Figure 16: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0714 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

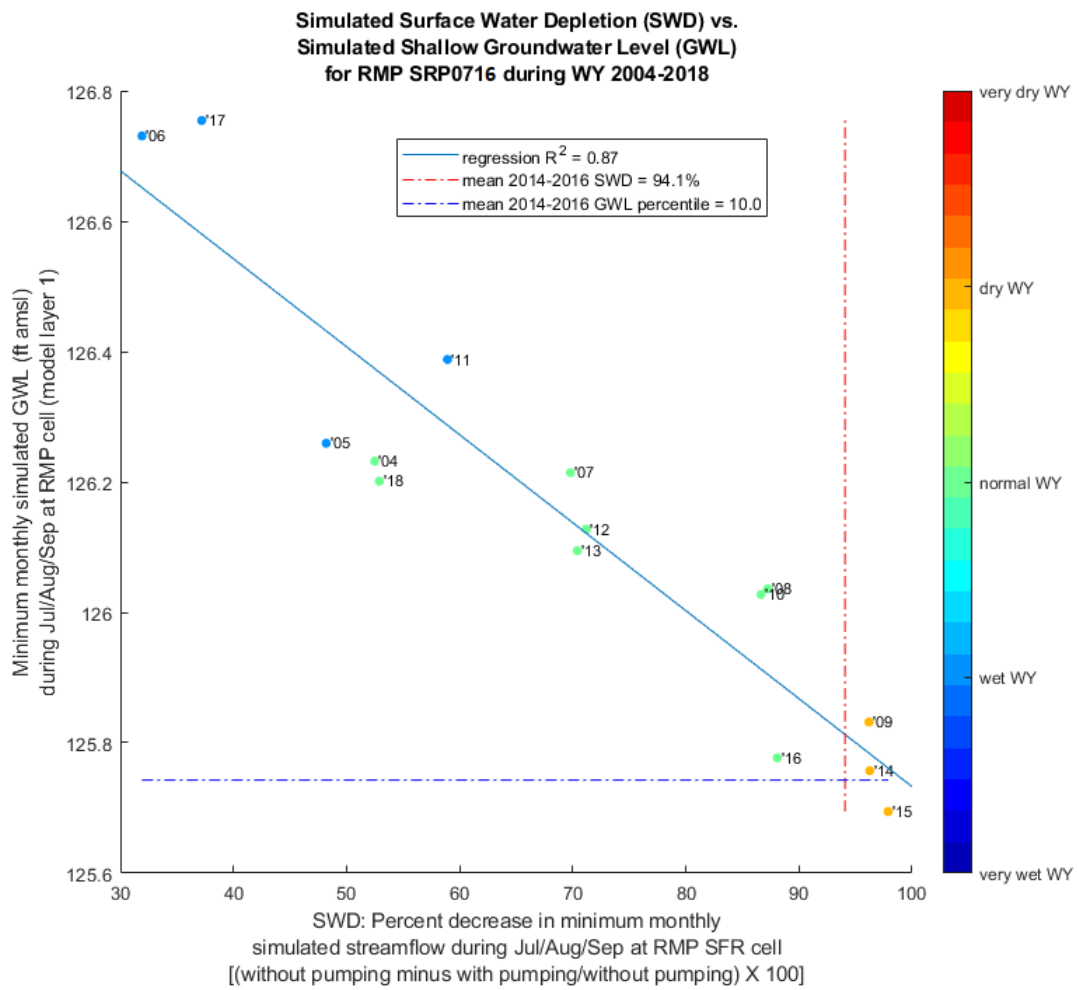


Figure 17: Correlation between simulated dry-season surface water depletion and simulated dry-season shallow groundwater levels at RMP SRP0716 during 2004–2018, along with the average groundwater-level percentile ranking for 2014–2016.

4.5 Simulated Surface Water Depletion at the Basin Outlet

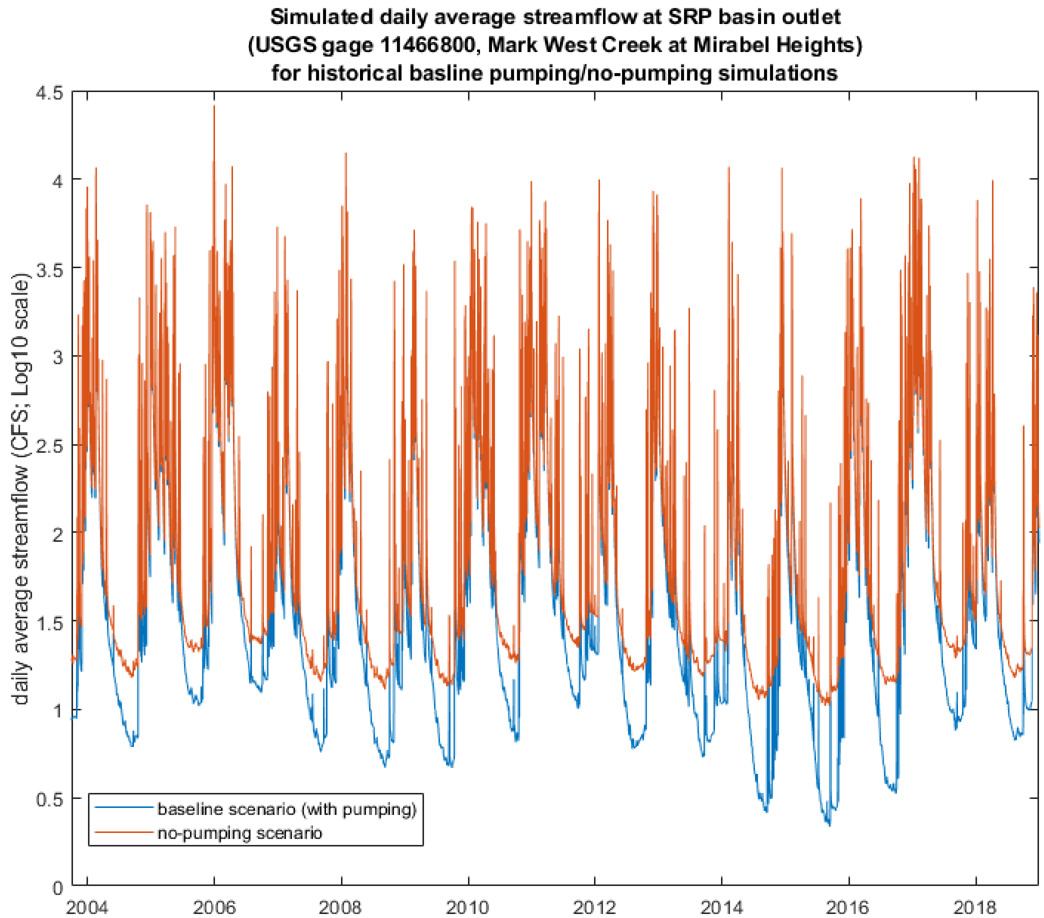


Figure 18: Differences in simulated streamflow at the Santa Rosa Plain basin outlet on Mark West Creek during 2004–2018.

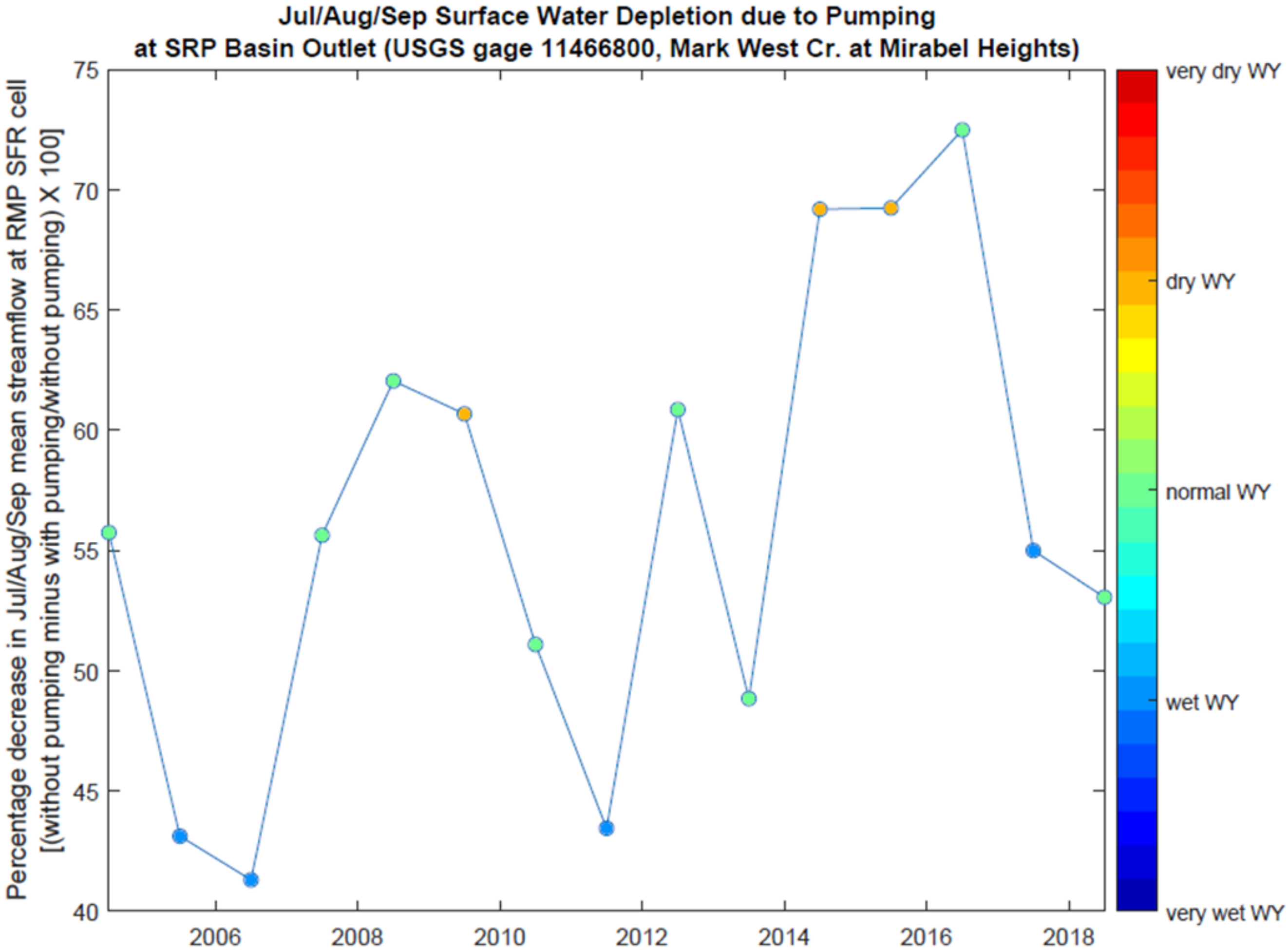


Figure 19: Annual estimated dry-season depletion of interconnected surface water at the Santa Rosa Plain basin outlet during 2004–2018.

4.6 Minimum Thresholds and Measurable Objectives at RMP Locations

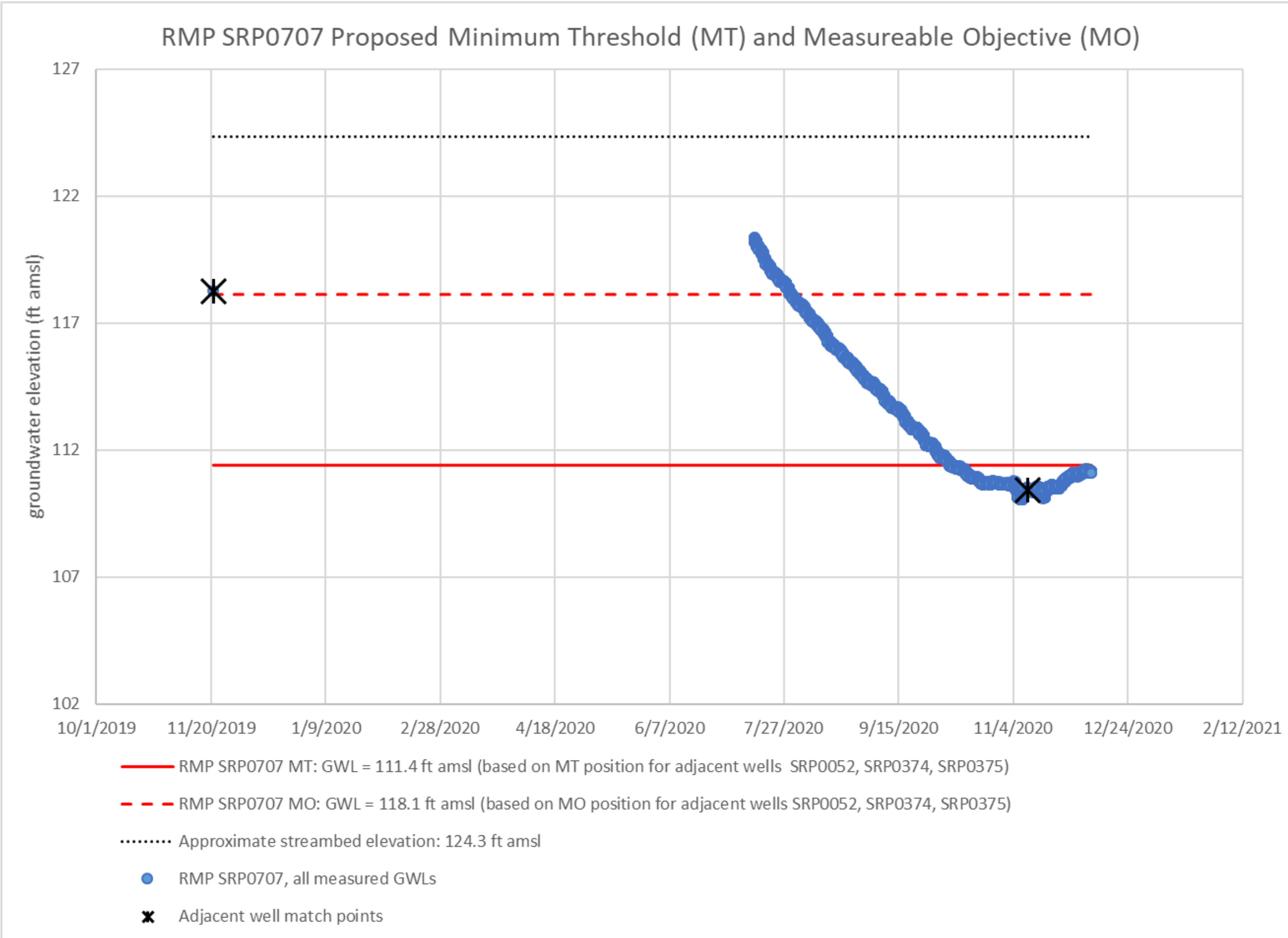


Figure 20: Measured groundwater levels at RMP SRP0707, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

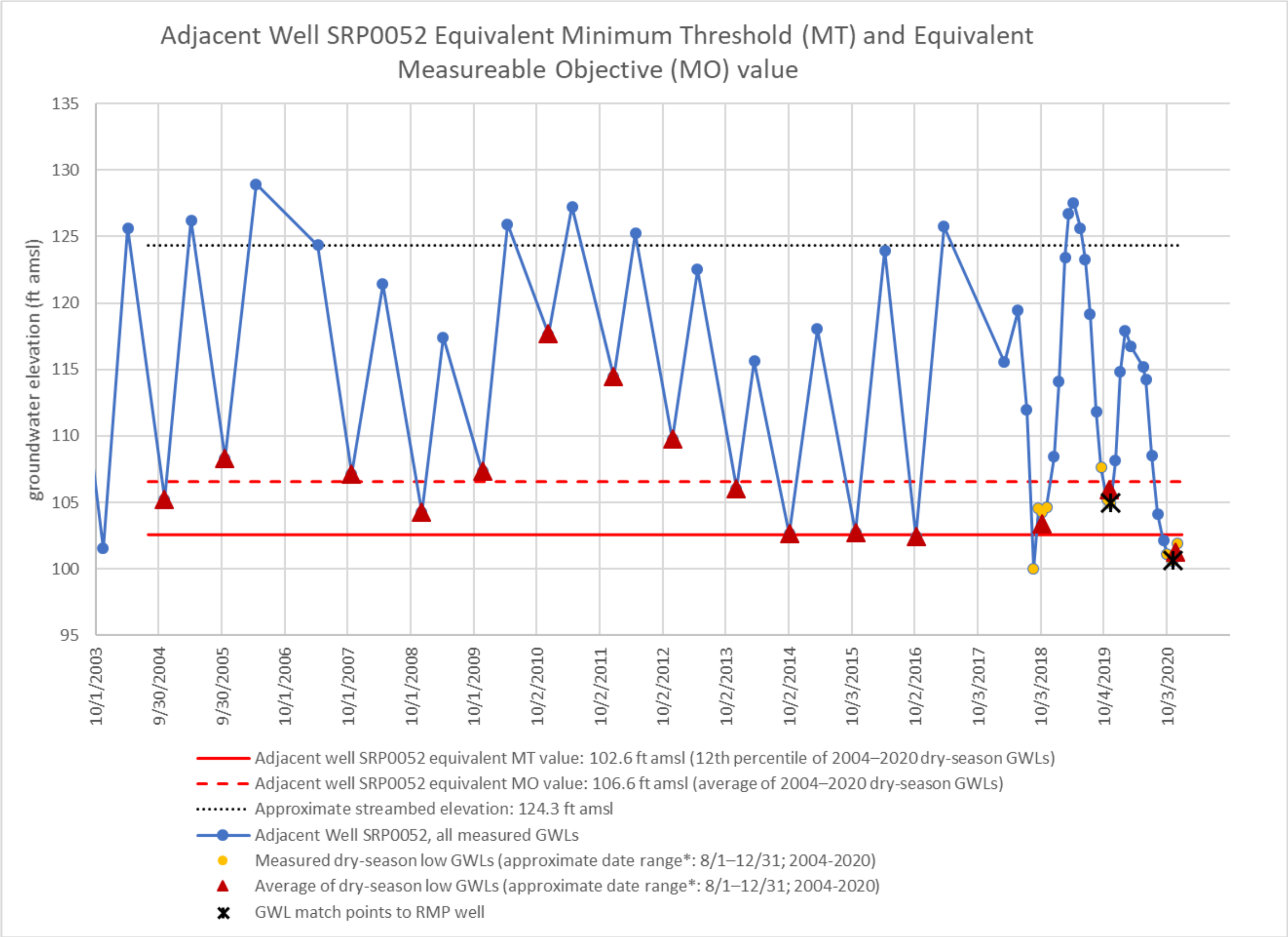


Figure 21: Measured groundwater levels at SRP0052, an adjacent well to RMP SRP0707, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

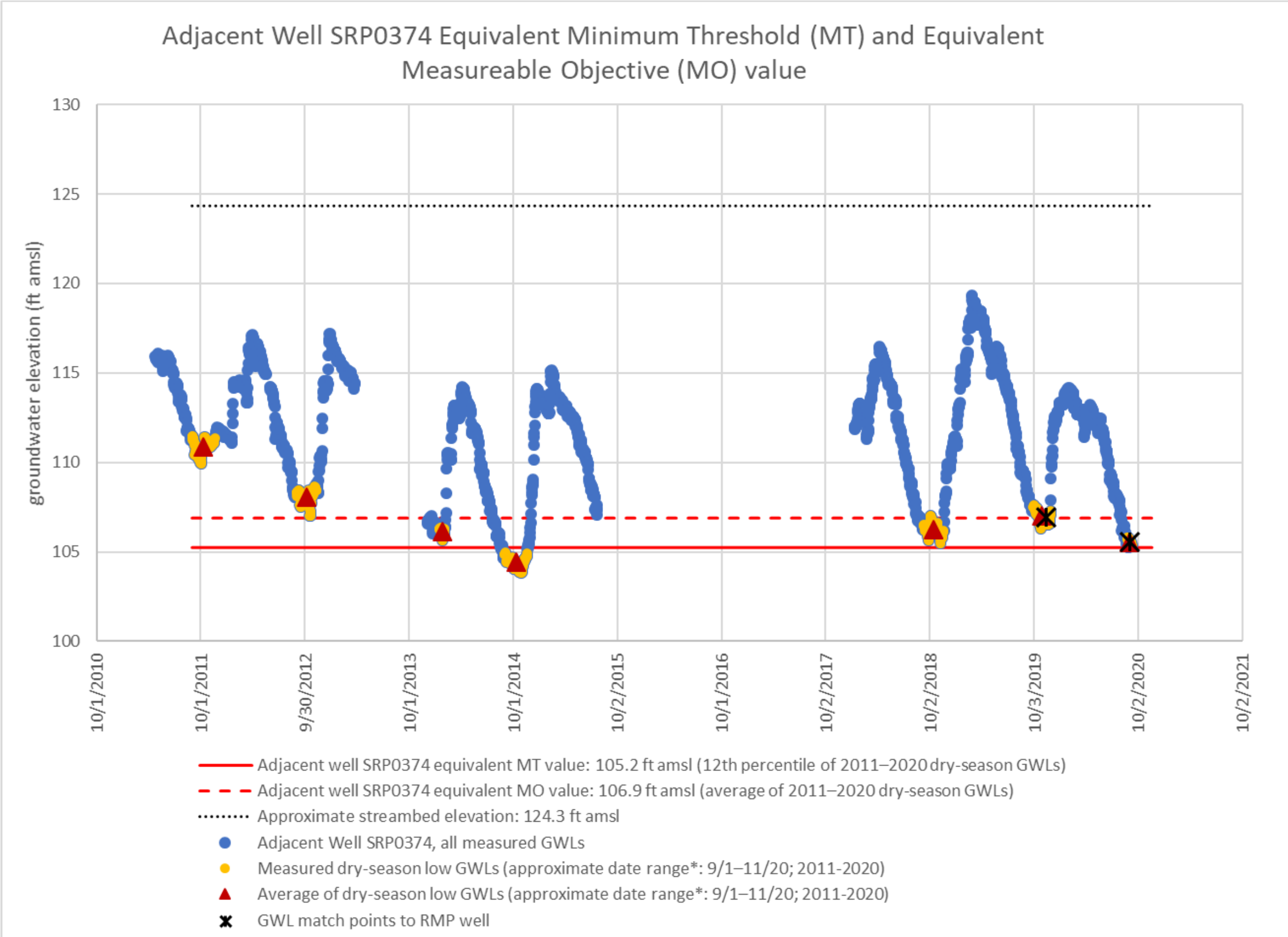


Figure 22: Measured groundwater levels at SRP0374, an adjacent well to RMP SRP0707, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

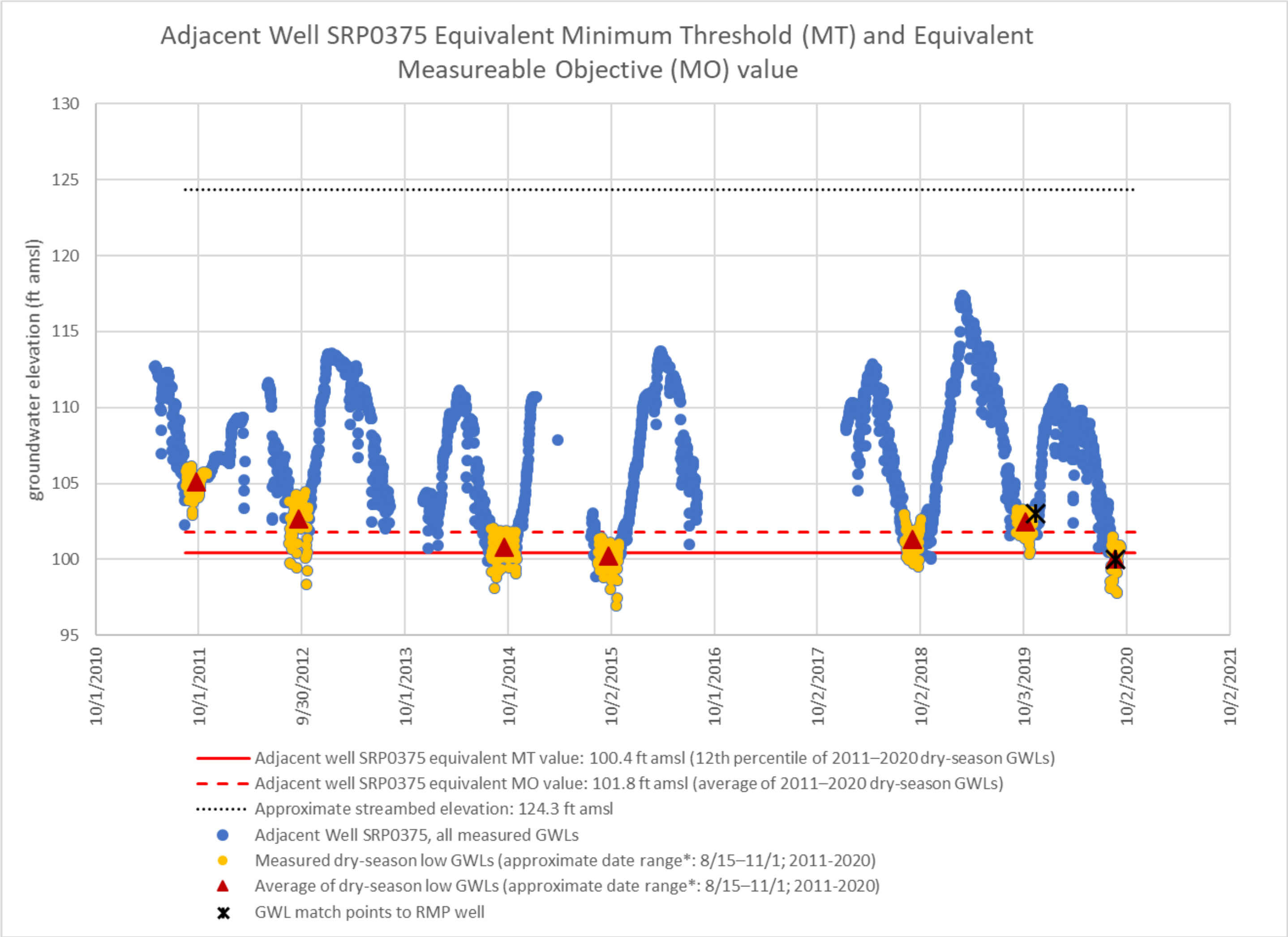


Figure 23: Measured groundwater levels at SRP0375, an adjacent well to RMP SRP0707, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

---

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

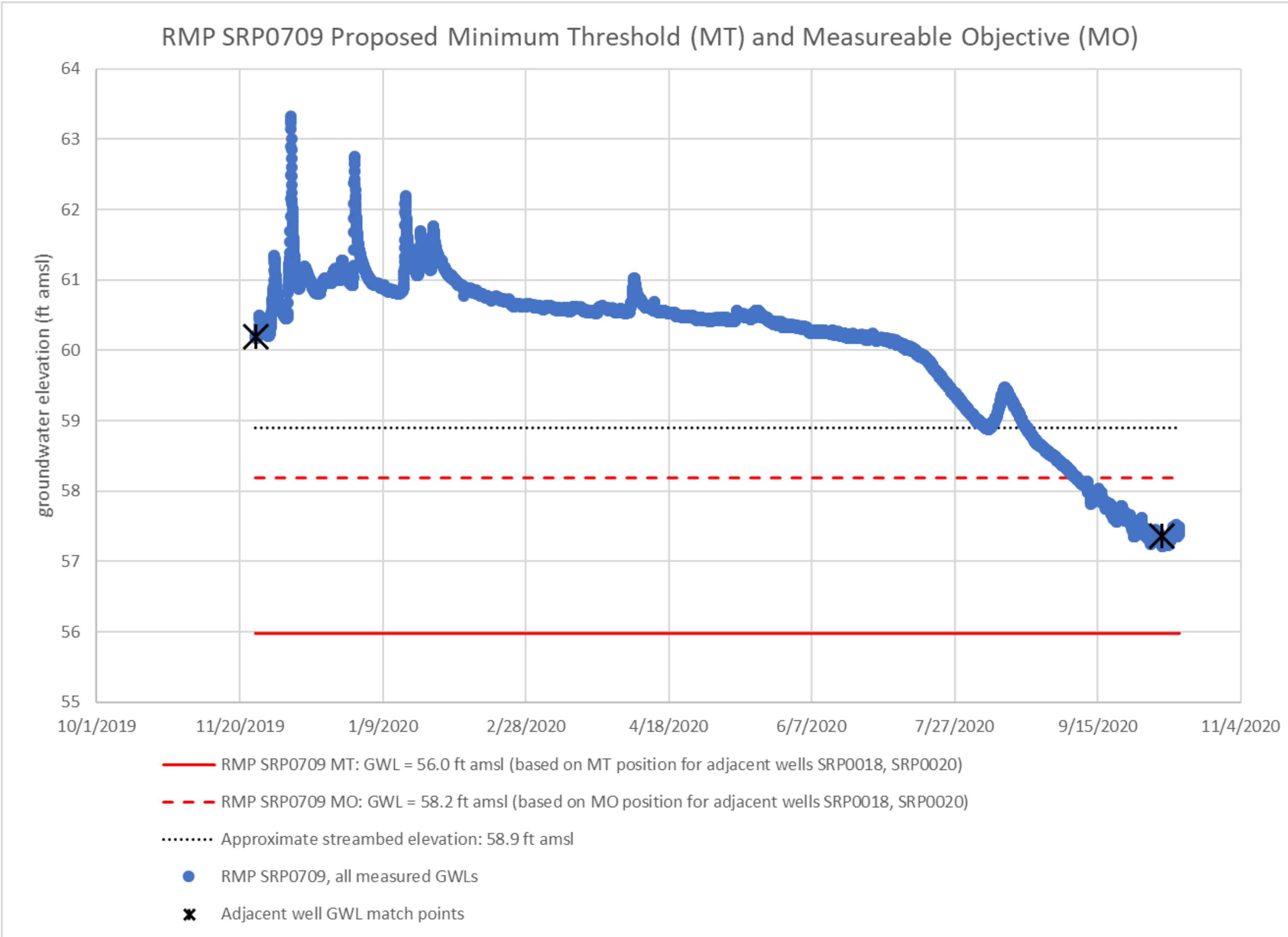


Figure 24: Measured groundwater levels at RMP SRP0709, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

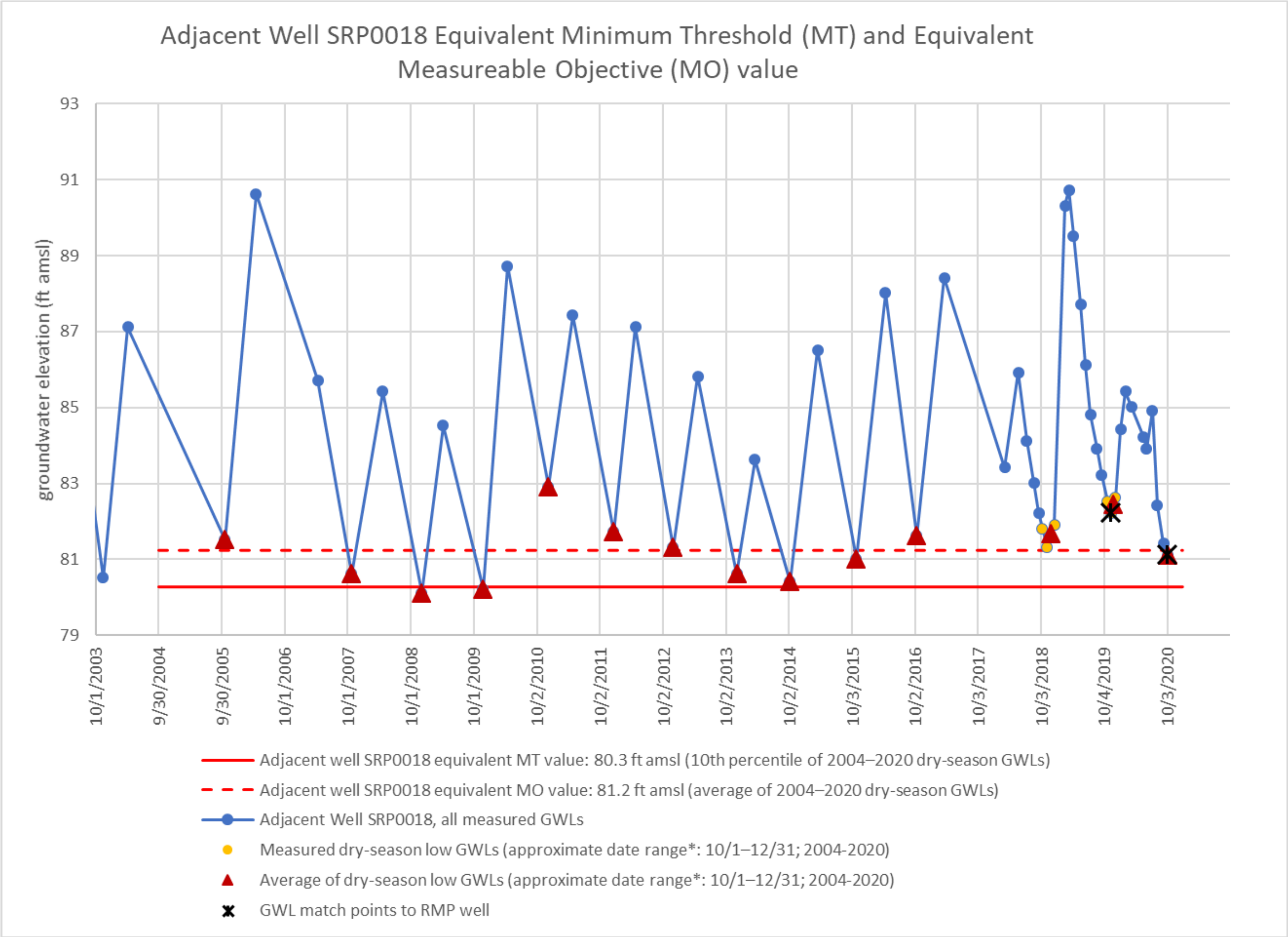


Figure 25: Measured groundwater levels at SRP0018, an adjacent well to RMP SRP0709, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

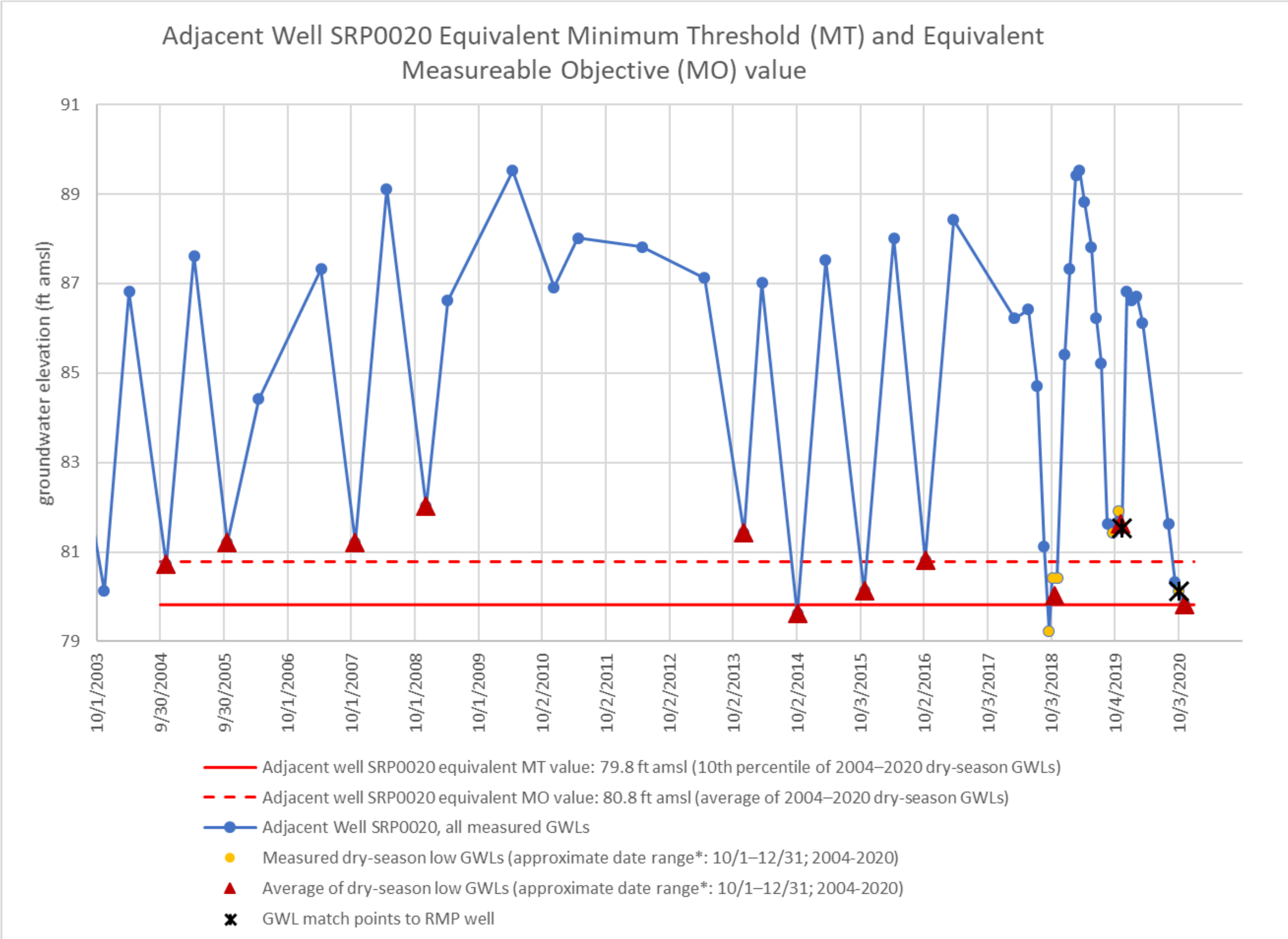


Figure 26: Measured groundwater levels at SRP0020, an adjacent well to RMP SRP0709, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

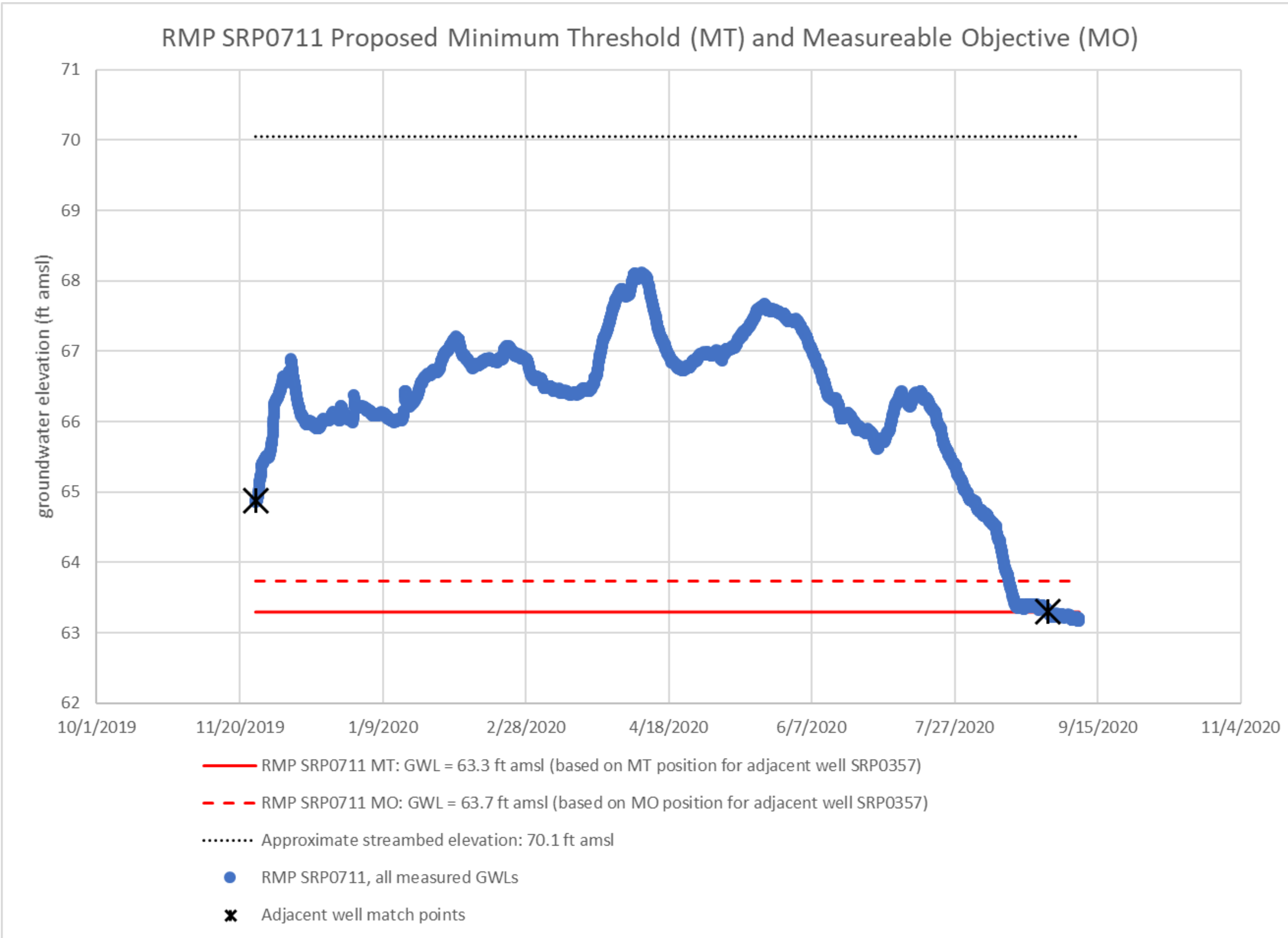


Figure 27: Measured groundwater levels at RMP SRP0711, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

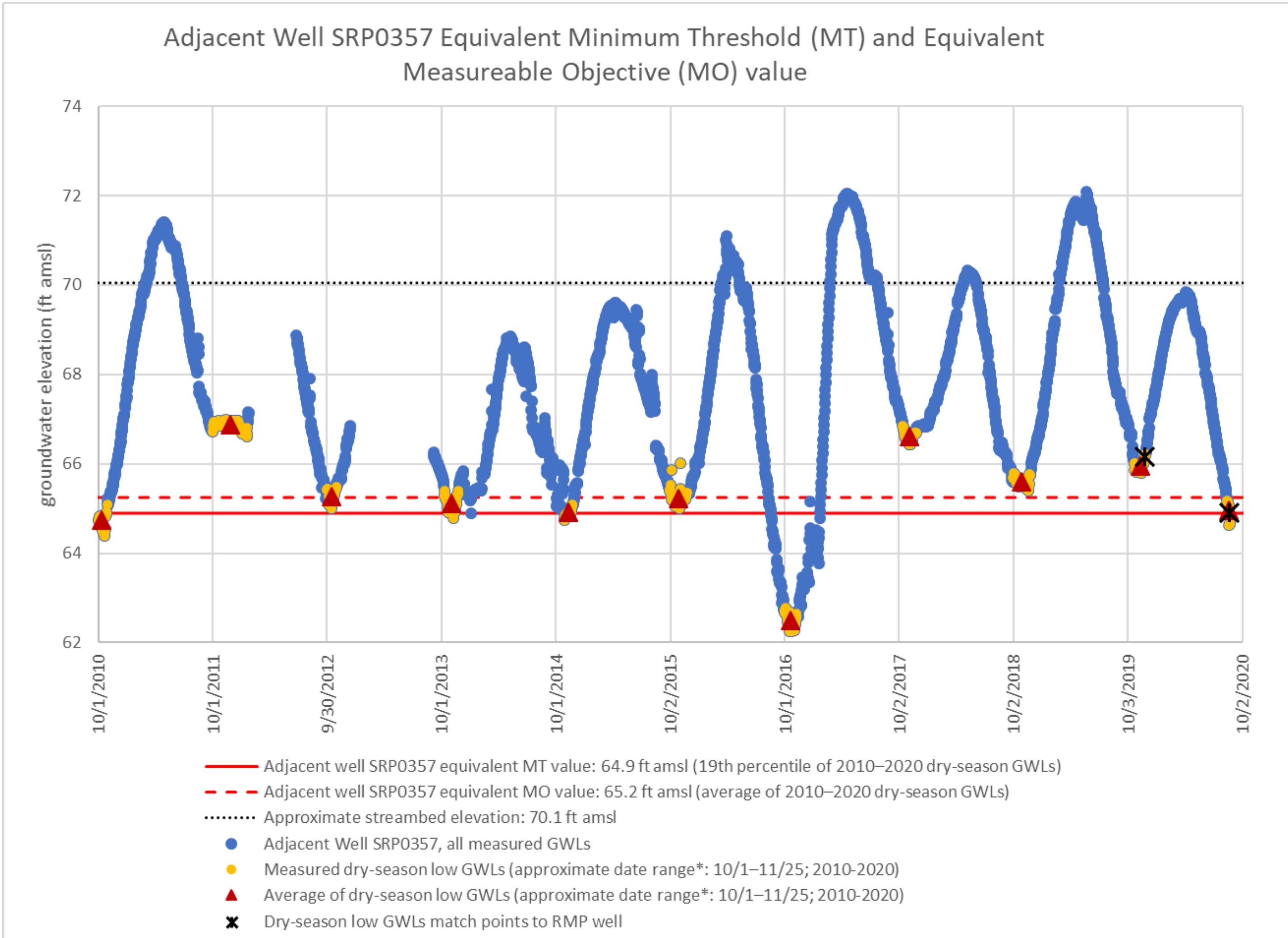


Figure 28: Measured groundwater levels at SRP0357, an adjacent well to RMP SRP0711, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

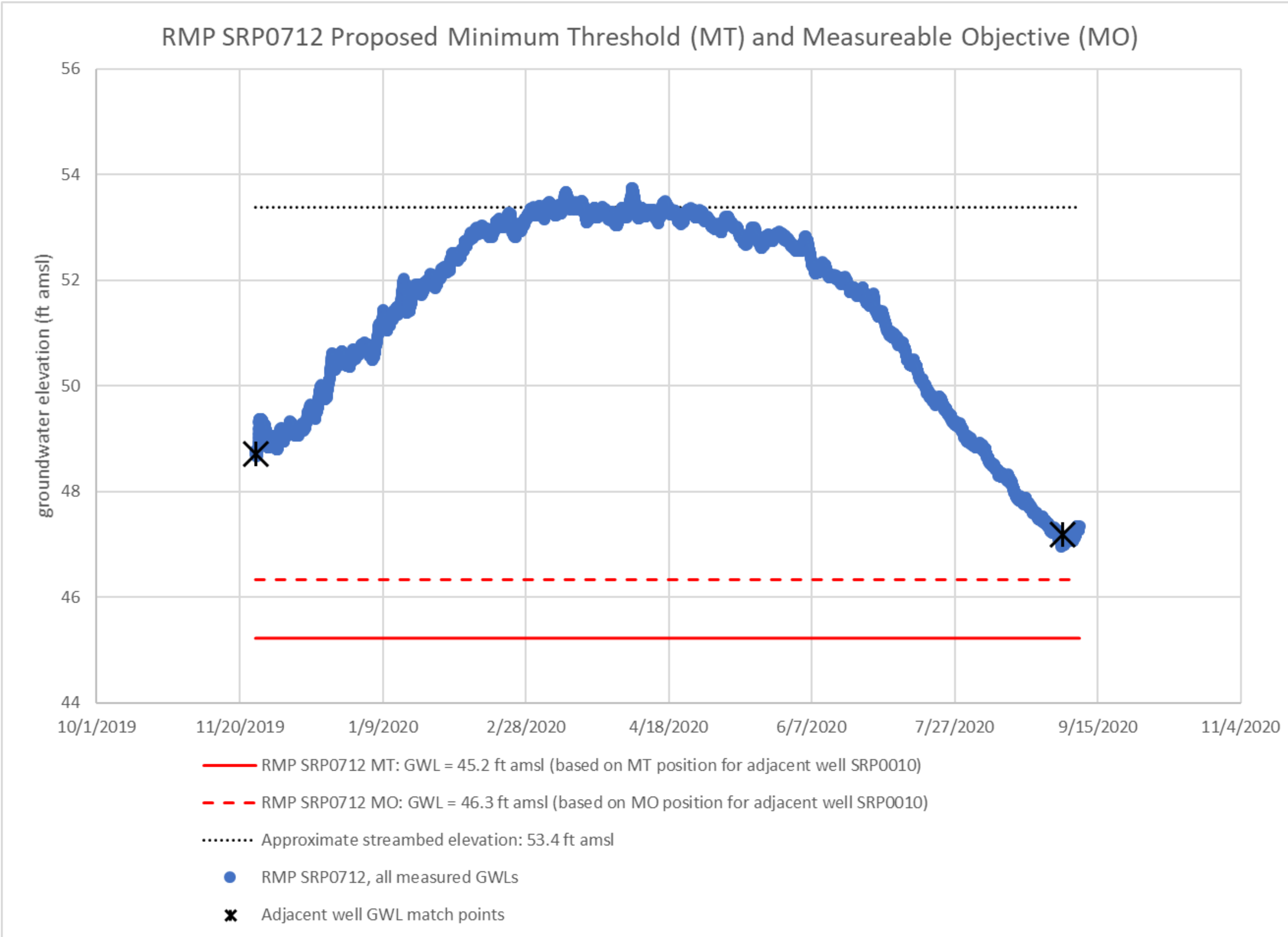


Figure 29: Measured groundwater levels at RMP SRP0712, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

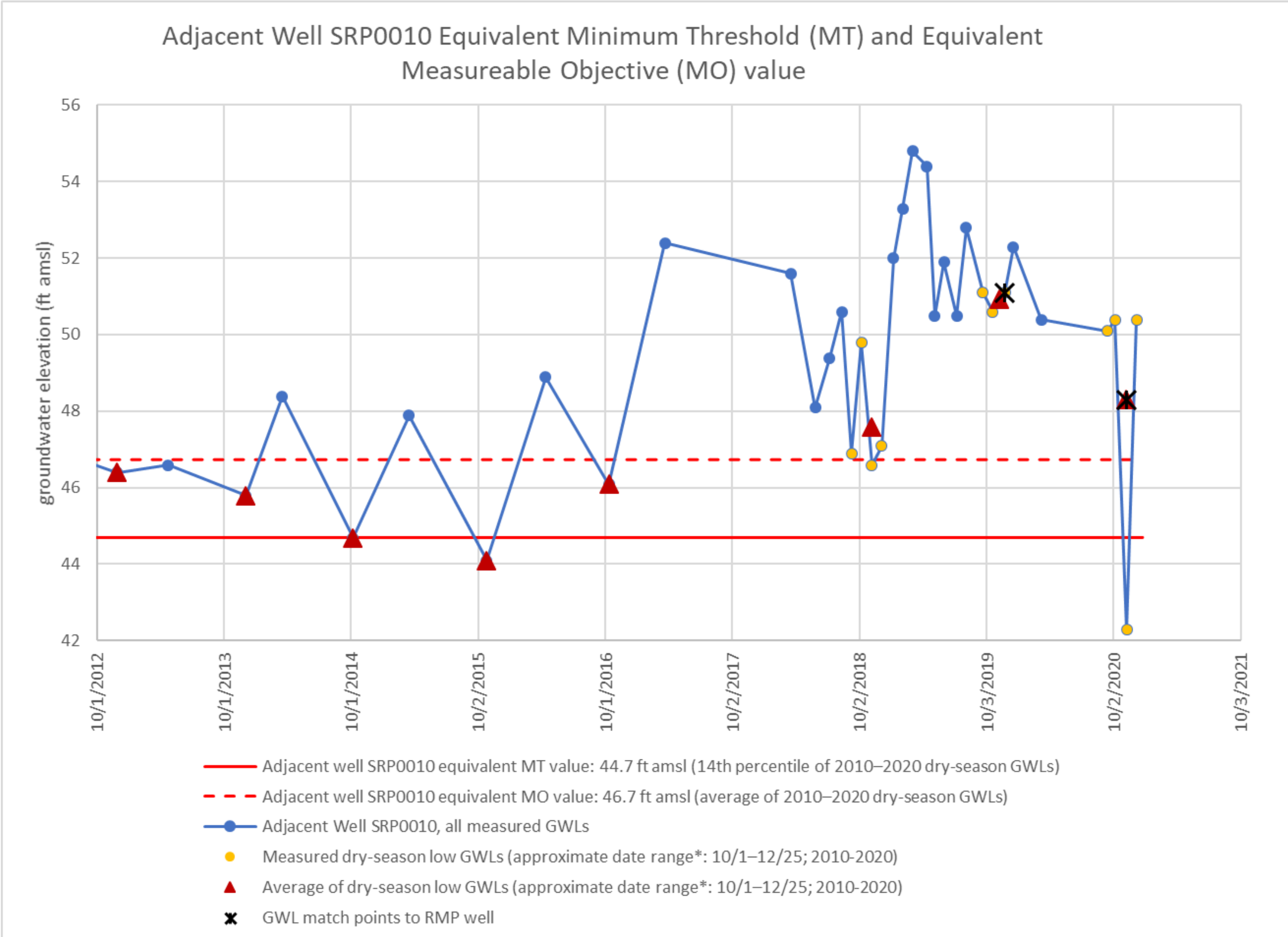


Figure 30: Measured groundwater levels at SRP0010, an adjacent well to RMP SRP0712, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.

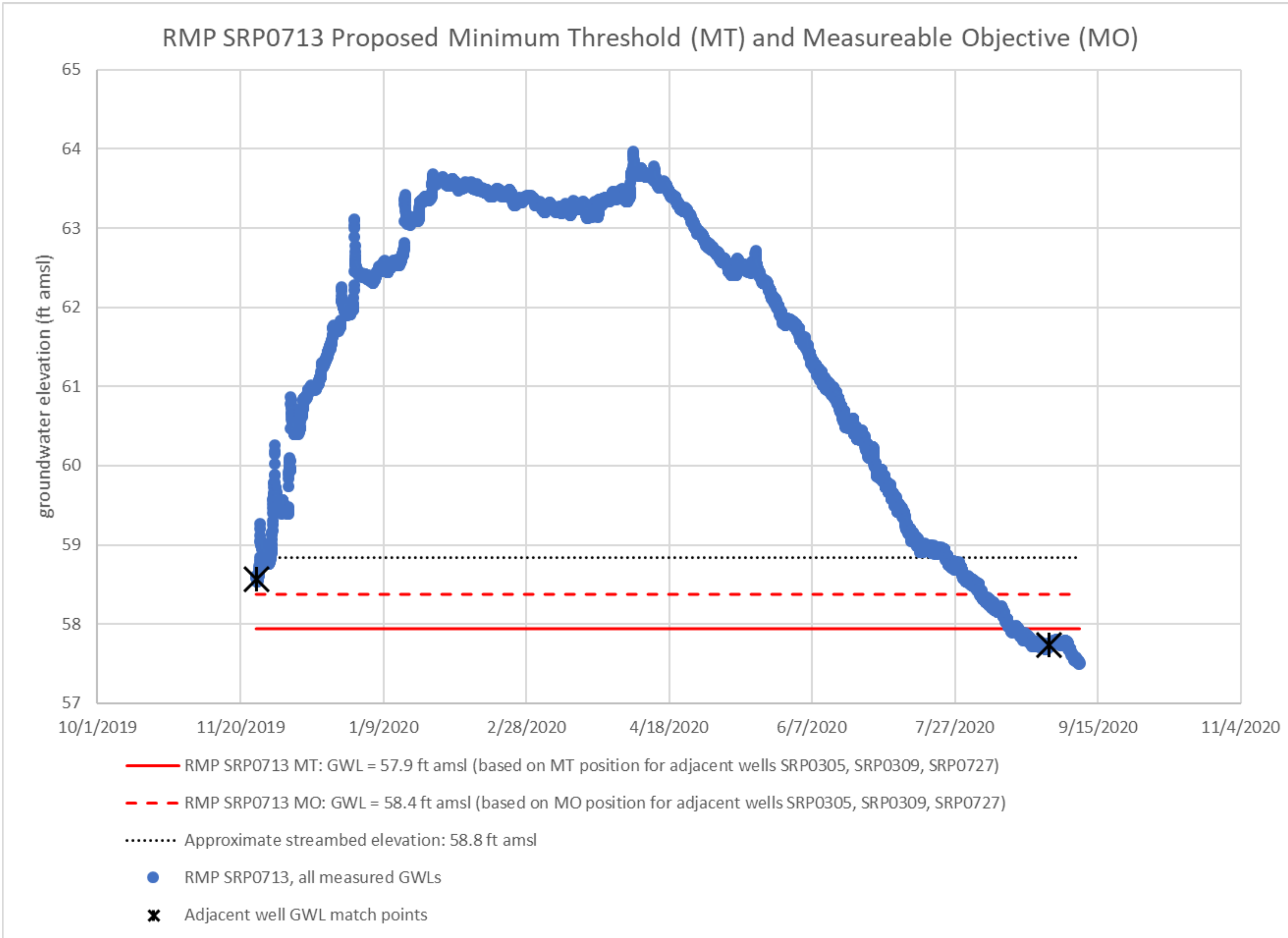


Figure 31: Measured groundwater levels at RMP SRP0713, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

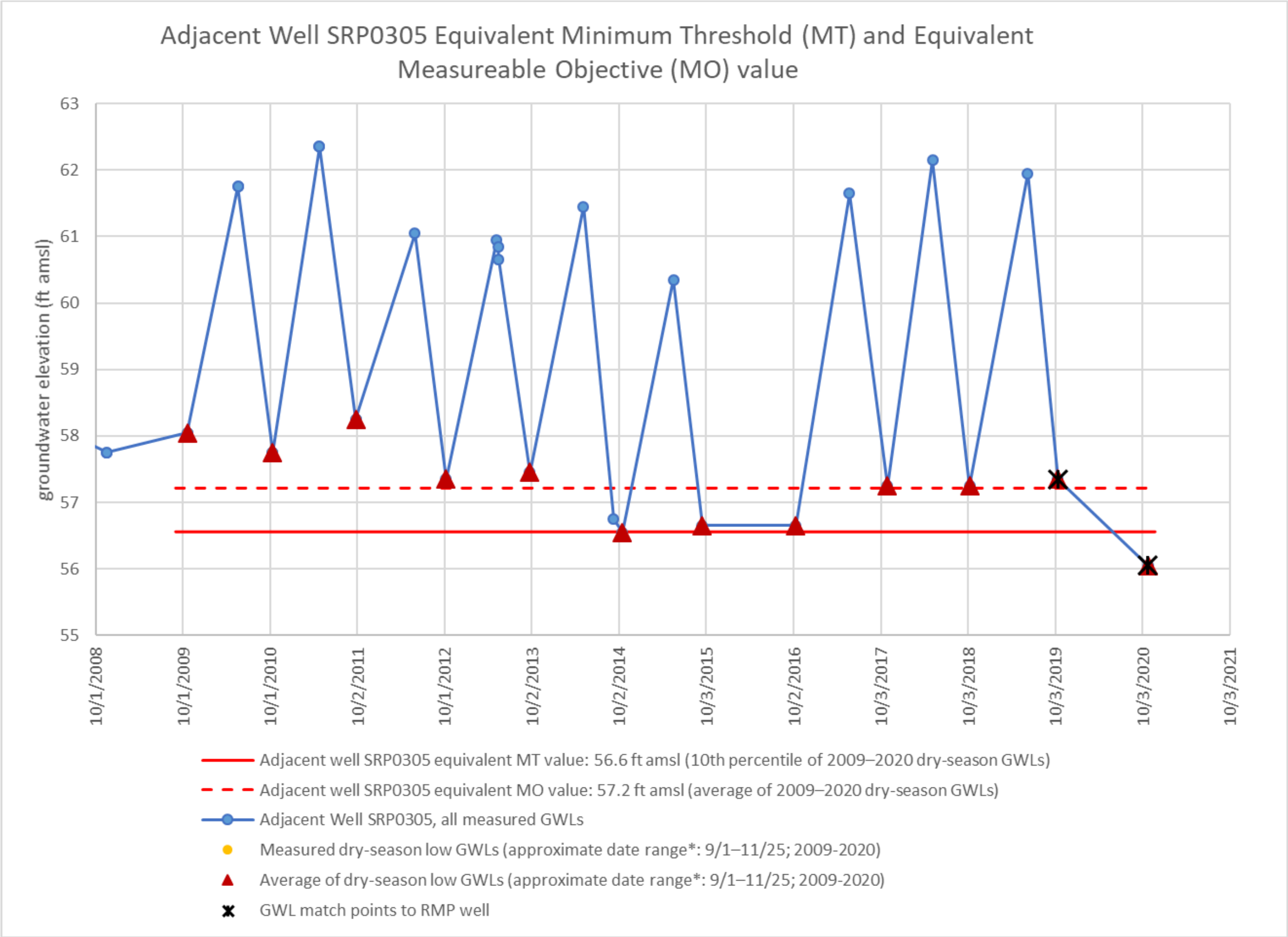


Figure 32: Measured groundwater levels at SRP0305, an adjacent well to RMP SRP0713, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

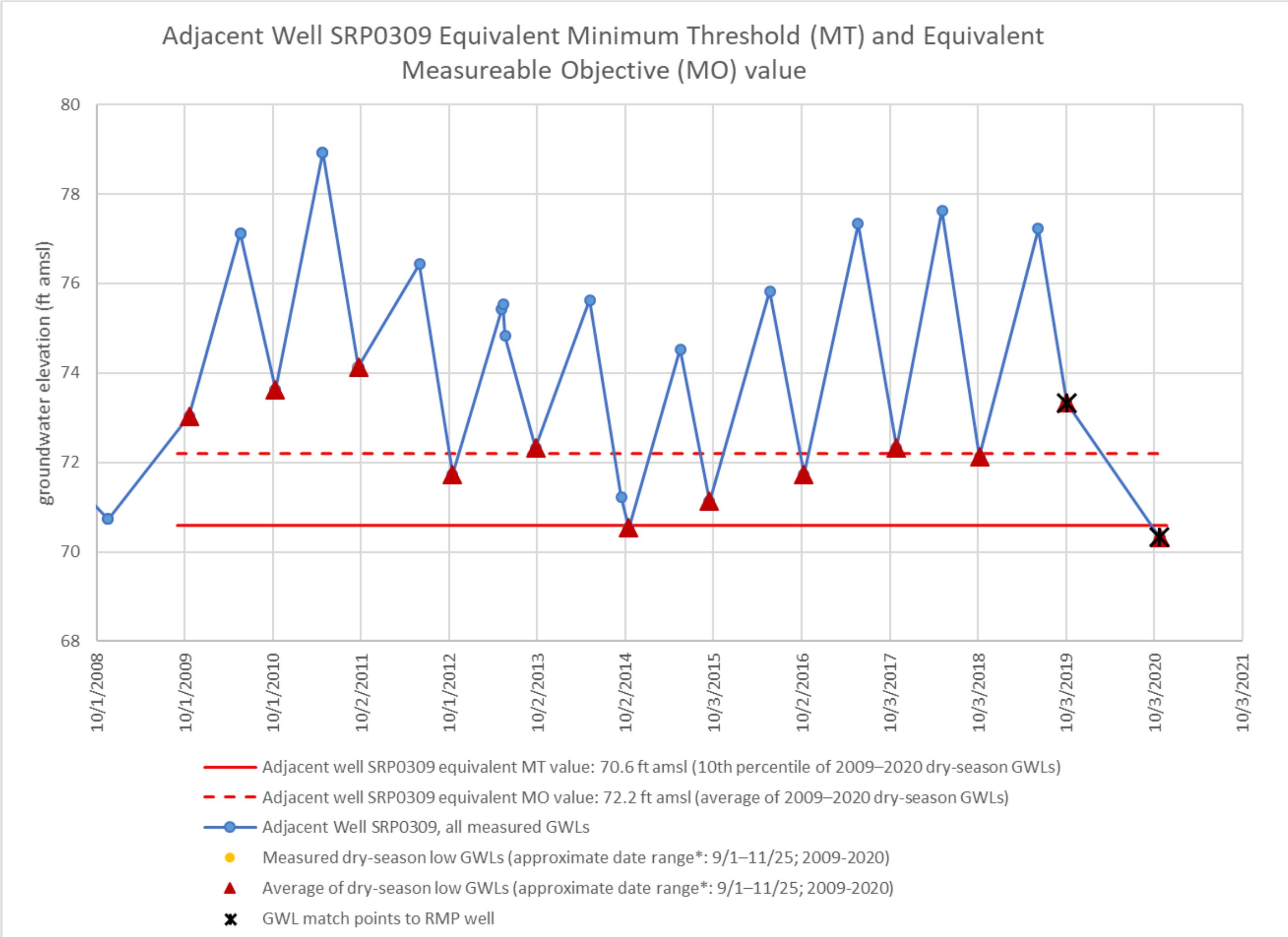


Figure 33: Measured groundwater levels at SRP0309, an adjacent well to RMP SRP0713, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

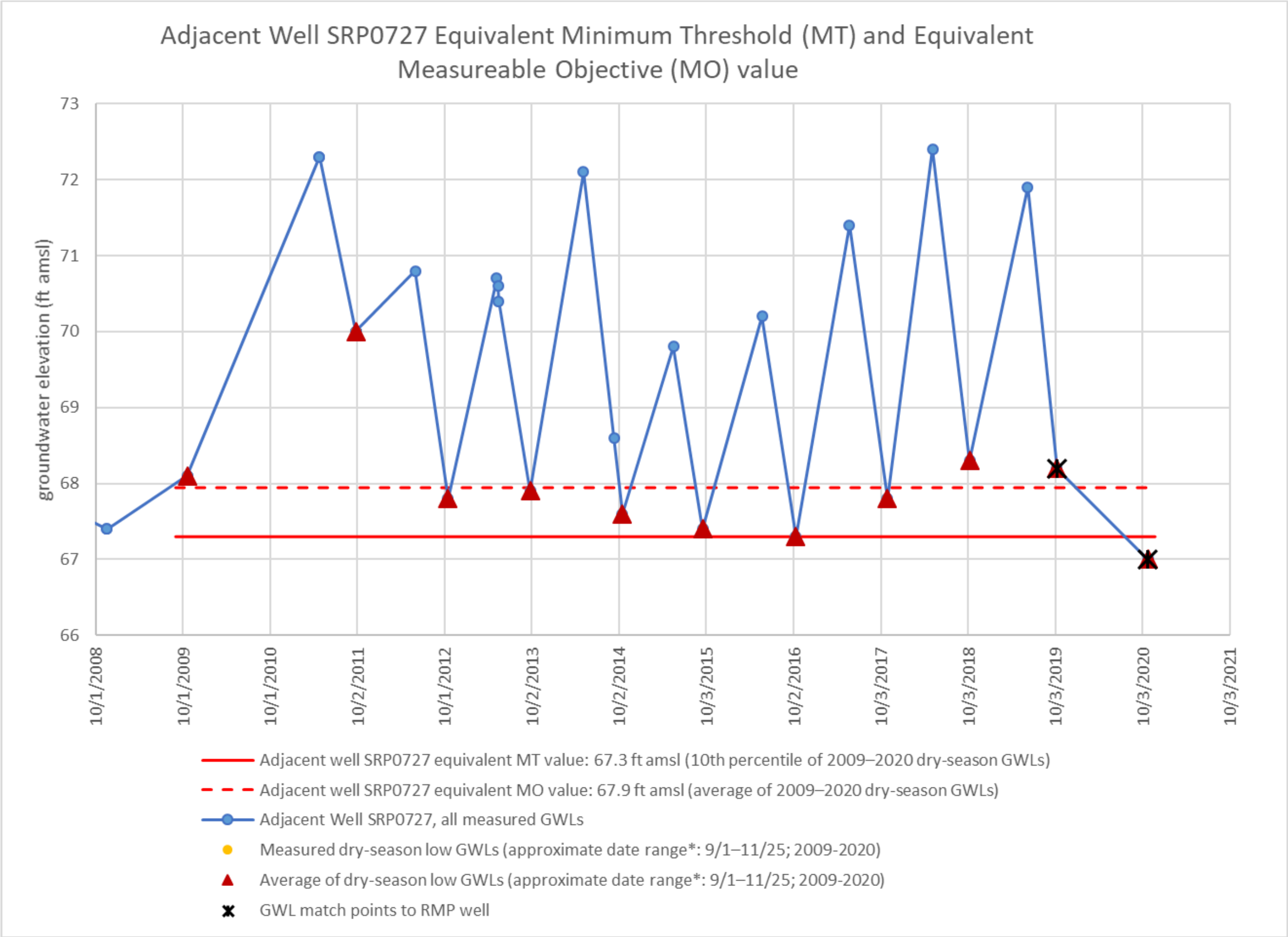


Figure 34: Measured groundwater levels at SRP0727, an adjacent well to RMP SRP0713, along with Minimum Threshold and Measureable Objective groundwater level proxy values for depletion of interconnected surface water by groundwater pumping.*

---

* Note that the approximate date range may have been manually adjusted to capture the true dry-season minimum groundwater levels

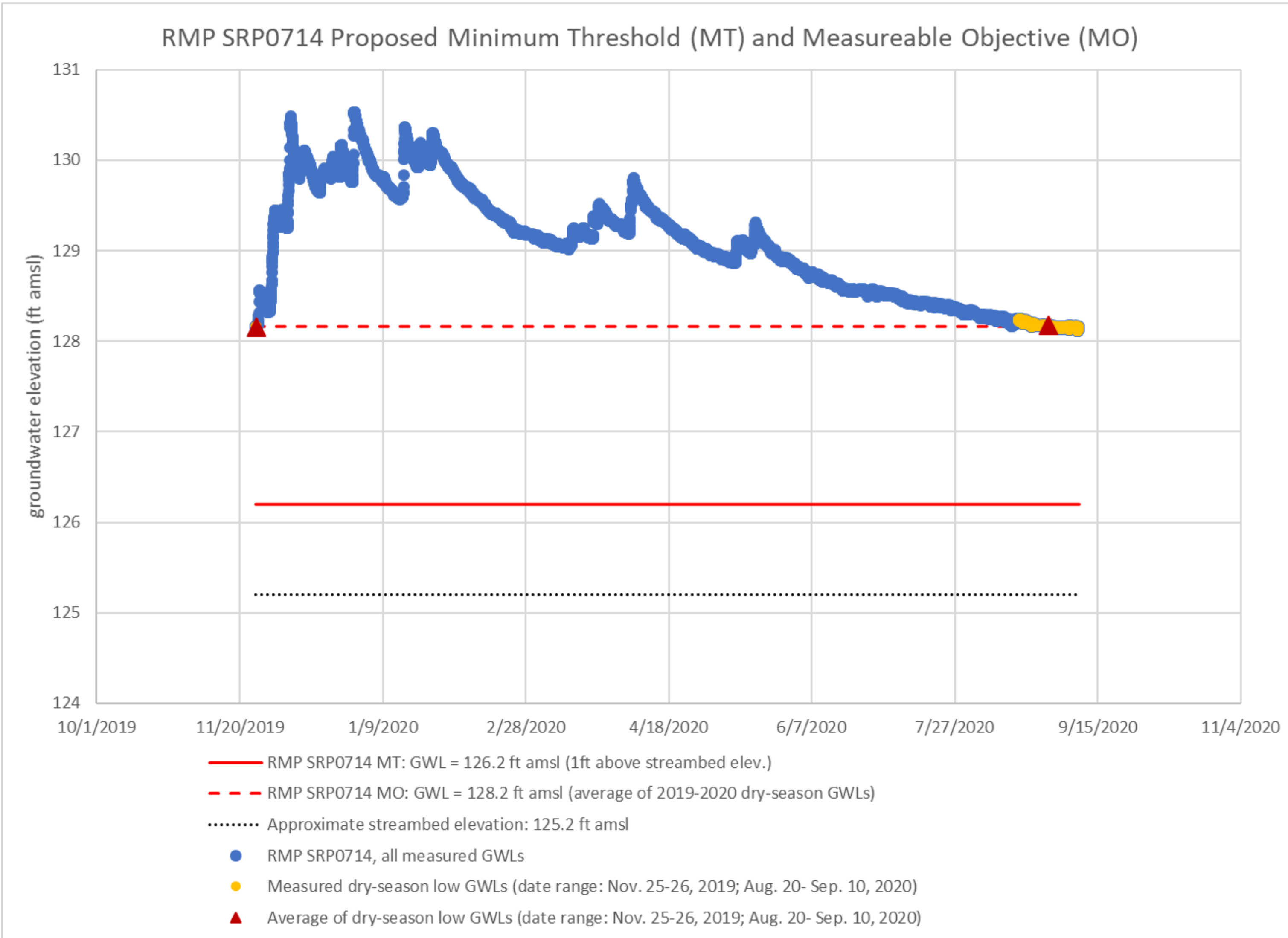


Figure 35: Measured groundwater levels at RMP SRP0714, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

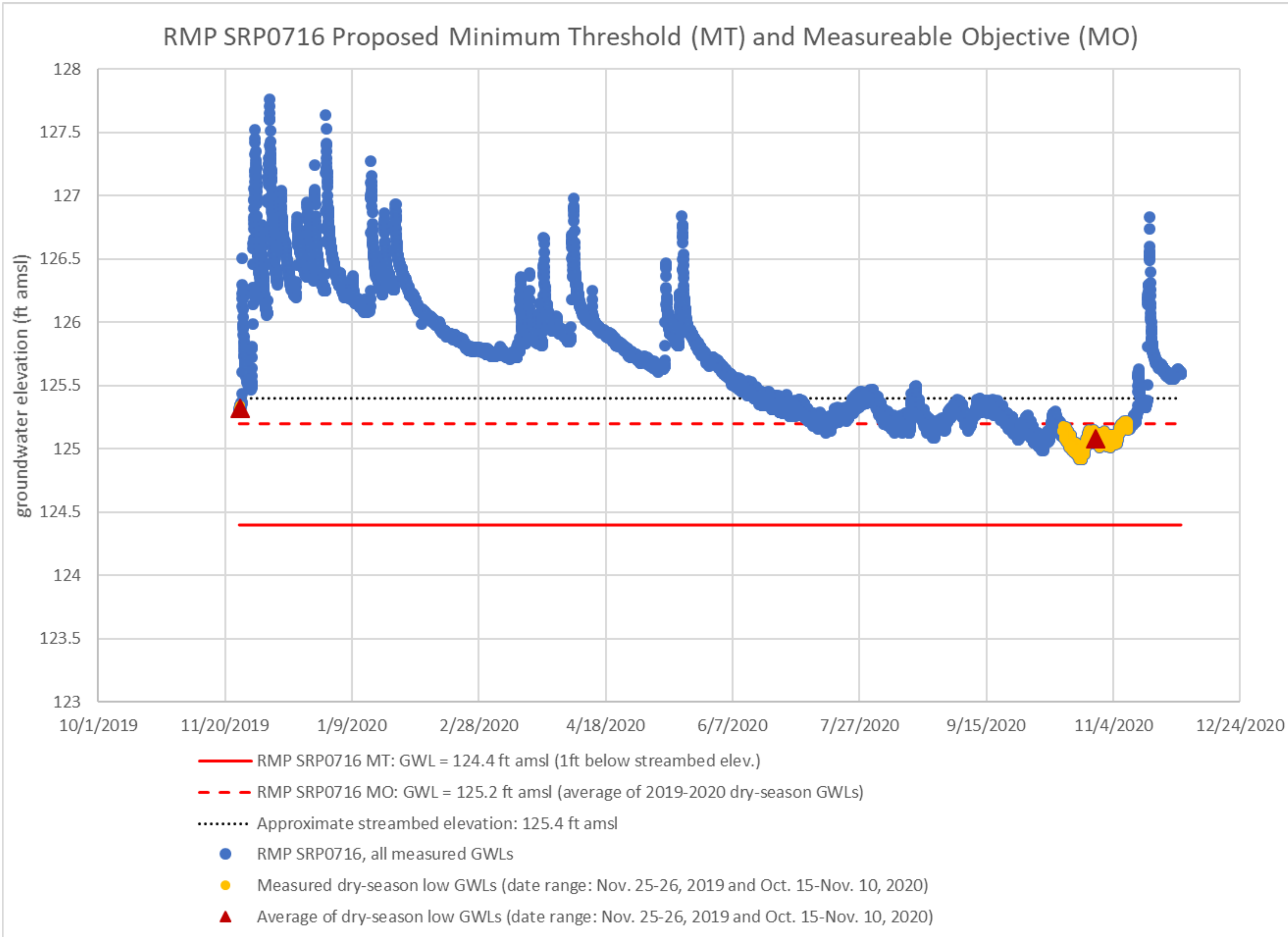


Figure 36: Measured groundwater levels at RMP SRP0714, along with Minimum Threshold and Measureable Objective groundwater level proxies for depletion of interconnected surface water by groundwater pumping.

5 Tables

5.1 Summary Table

Table 1: Summary table depletion of interconnected surface water SMCs at RMP locations.

RMP Well	Proposed MT (ft amsl)	Proposed MO (ft amsl)	MT Method	Number of Adjacent Wells Used	Simulated 2004–2018 SWD-GWL Correlation (R-squared)	Simulated Mean 2014–2016 GWL Percentile Ranking
SRP0707	111.4	118.1	adjacent-well match point	3	0.88	12.2
SRP0709	56.0	58.2	adjacent-well match point	2	0.93	10.0
SRP0711	63.3	63.7	adjacent-well match point	1	0.89	18.9
SRP0712	45.2	46.3	adjacent-well match point	1	0.66	14.4
SRP0713	57.9	58.4	adjacent-well match point	3	< 0.60	56.7*
SRP0714	126.2	128.2	1 ft. above streambed elevation	---	< 0.60	10.0
SRP0716	124.4	125.2	1 ft. below 2020 dry-season low GWL	---	0.87	10.0

notes:

*Median 10th-percentile substituted due to poor SWD-GWL correlation at RMP SRP0713.

RMP: Representative Monitoring Point

MT: Minimum Threshold

MO: Measurable Objective

GWL: Groundwater Level

SMC: Sustainable Management Criteria

5.2 RMP Adjacent Well Information

Table 2: Summary of adjacent well information used to establish SMCs with the match-point methodology for RMP SRP0707.

RMP SRP0707 Adjacent Well(s)						
RMP Well	**Adjacent Well**	**MT position relative to 2nd match point (units = 2019-2020 match-point difference)**	**MO position relative to 2nd match point (units = 2019-2020 match-point difference)**	**Distance and Direction of Adjacent Well from RMP Well**	**Adjacent Well Depth (ft bls)**	**Adjacent Well Screened Interval (ft bls)**
SRP0707	SRP0052	0.45	1.38	3200 ft N	95	?
	SRP0374	-0.21	0.99	4800 ft W	60	40–60
	SRP0375	0.13	0.59	4800 ft W	140	120–140
		0.12	0.98	**<-- Avg. MT & MO position relative to 2nd match point**		
		111.4	118.1	**<-- Avg. calculated MT and MO at RMP well (ft amsl)**		

Table 3: Summary of adjacent well information used to establish SMCs with the match-point methodology for RMP SRP0709.

RMP SRP0709 Adjacent Well(s)						
RMP Well	**Adjacent Well**	**MT position relative to 2nd match point (units = 2019-2020 match-point difference)**	**MO position relative to 2nd match point (units = 2019-2020 match-point difference)**	**Distance and Direction of Adjacent Well from RMP Well**	**Adjacent Well Depth (ft bls)**	**Adjacent Well Screened Interval (ft bls)**
SRP0709	SRP0018	-0.76	0.11	7200 ft NE	89	?
	SRP0020	-0.21	0.47	7600 ft E	110	?
		-0.49	0.29	**<-- Avg. MT & MO position relative to 2nd match point**		
		56.0	58.2	**<-- Avg. calculated MT and MO at RMP well (ft amsl)**		

Table 4: Summary of adjacent well information used to establish SMCs with the match-point methodology for RMP SRP0711.

RMP SRP0711 Adjacent Well(s)						
RMP Well	**Adjacent Well**	**MT position relative to 2nd match point (units = 2019-2020 match-point difference)**	**MO position relative to 2nd match point (units = 2019-2020 match-point difference)**	**Distance and Direction of Adjacent Well from RMP Well**	**Adjacent Well Depth (ft bls)**	**Adjacent Well Screened Interval (ft bls)**
SRP0711	SRP0357	0.00	0.28	5150 ft NW	80	60-80
		0.00	0.28	**<-- Avg. MT & MO position relative to 2nd match point**		
		63.3	63.7	**<-- Avg. calculated MT and MO at RMP well (ft amsl)**		

Table 5: Summary of adjacent well information used to establish SMCs with the match-point methodology for RMP SRP0712.

RMP SRP0712 Adjacent Well(s)						
RMP Well	**Adjacent Well**	**MT position relative to 2nd match point (units = 2019-2020 match-point difference)**	**MO position relative to 2nd match point (units = 2019-2020 match-point difference)**	**Distance and Direction of Adjacent Well from RMP Well**	**Adjacent Well Depth (ft bls)**	**Adjacent Well Screened Interval (ft bls)**
SRP0712	SRP0010	-1.28	-0.56	2850 ft S	110	?
		-1.28	-0.56	**<-- Avg. MT & MO position relative to 2nd match point**		
		45.2	46.3	**<-- Avg. calculated MT and MO at RMP well (ft amsl)**		

Table 6: Summary of adjacent well information used to establish SMCs with the match-point methodology for RMP SRP0713.

RMP SRP0713 Adjacent Well(s)						
RMP Well	Adjacent Well	MT position relative to 2nd match point (units = 2019-2020 match-point difference)	MO position relative to 2nd match point (units = 2019-2020 match-point difference)	Distance and Direction of Adjacent Well from RMP Well	Adjacent Well Depth (ft bls)	Adjacent Well Screened Interval (ft bls)
SRP0713	SRP0309	0.09	0.62	4700 ft NE	42	10–40
	SRP0305	0.39	0.90	320 ft NE	42	10–40
	SRP0727	0.25	0.79	5400 ft E	28	?
		0.24	0.77	**<-- Avg. MT & MO position relative to 2nd match point**		
		57.9	58.4	**<-- Avg. calculated MT and MO at RMP well (ft amsl)**		

.

Appendix 5-A
Monitoring Protocols

Appendix 5-A

Monitoring Protocols
Santa Rosa Plain Groundwater Subbasin

In accordance with the GSP Regulations, monitoring protocols have been established for the Santa Rosa Plain Groundwater Subbasin monitoring networks. The following monitoring protocols, intended to ensure the quality and consistency of data, are adapted from DWR's BMPs for Monitoring Protocols, Standards and Sites (DWR 2016).

General Well Monitoring Information

- Long-term access agreements should be maintained for each monitoring site. Access agreements should include year-round site access to allow for increased monitoring frequency. At the time of GSP submittal, some sites included in the monitoring networks for GSP implementation may lack or have outdated access agreements. A Subbasin-wide inventory of access agreement status and efforts to standardize access agreements will be conducted in the early phases of GSP implementation.

- Each monitoring site shall have unique identifier and documentation should include a general written description of the site location, date established, access instructions and point of contact (if necessary), type of information to be collected, latitude, longitude, and elevation. Each monitoring location should also track all modifications to the site in a modification log. This information is stored in the Data Management System (DMS).

- Groundwater elevation data from Spring and Fall semi-annual measurement events will form the basis of Basin-wide potentiometric surface maps and should approximate conditions at a discrete period in time. Therefore, all groundwater-level measurements for the semi-annual events should be collected within as short a time as possible, preferably within a 1-to-2-week period.

- Depth to groundwater must be measured relative to an established Reference Point (RP) on the well casing. The RP is usually identified with a permanent marker, paint spot, or a notch in the lip of the well casing. By convention in open casing monitoring wells, the RP reference point is located on the north side of the well casing. If no mark is apparent, the person performing the measurement should measure the depth to groundwater from the north side of the top of the well casing.

- The elevation of the RP of each well must be surveyed to the North American Vertical Datum of 1988 (NAVD88), or a local datum that can be converted to NAVD88. The elevation of the RP must be accurate to within 0.5 foot. It is preferable for the RP elevation to be accurate to 0.1 foot or less. At the time of GSP submittal, some sites included in the monitoring networks for

GSP implementation lack sufficient RP survey data. Information related to this data gap, including plans to address it, is included in Section 5 of this GSP.

- Depth to groundwater must be measured to an accuracy of 0.1 foot below the RP. It is preferable to measure depth to groundwater to an accuracy of 0.01 foot. Air lines and acoustic sounders may not provide the required accuracy of 0.1 foot. While the GSA recognizes that acoustic sounders may not produce data as accurate as that produced by electronic sounding tape or steel tape, for certain privately owned wells in voluntary monitoring programs, an acoustic sounder may be used if requested by the well owner or deemed the only feasible measurement device. For all groundwater-level measurements, the measurement device type shall be noted.

Groundwater-Level Measurement and Field Data Recording Protocols

- The sampler should remove the appropriate cap, lid, or plug that covers the monitoring access point listening for pressure release. If a release is observed, the measurement should follow a period of time to allow the water level to equilibrate. For measuring wells that are under pressure, multiple measurements should be collected to ensure the well has reached equilibrium such that no significant changes in water level are observed. Every effort should be made to ensure that a representative stable depth to groundwater is recorded. If a well does not stabilize, the quality of the value should be appropriately qualified as a questionable measurement. In the event that a well is artesian, site-specific procedures should be developed to collect accurate information and be protective of safety conditions associated with a pressurized well.

- Measure depth to water in the well using procedures appropriate for the measuring device. A typical measuring device should be an electronic sounding tape (electronic water-level meter) capable of 0.01-foot accuracy unless conditions at a particular well require an alternate type of measuring device. Equipment must be operated and maintained in accordance with manufacturer's instructions. Groundwater levels should be measured to the nearest 0.01 foot relative to the RP.

- The sampler should calculate the groundwater elevation as:

  GWE = RPE – DTW

  Where:
  GWE = Groundwater Elevation
  RPE = Reference Point Elevation
  DTW = Depth to Water

  The sampler must ensure that all measurements are in consistent units of feet, tenths of feet, and hundredths of feet. Measurements and RPEs should not be recorded in feet and inches.

- The sampler should record the well identifier, date, time (24-hour format), RPE, height of RP above or below ground surface, DTW, GWE, and comments regarding any factors that may influence the depth to water readings such as weather, nearby irrigation, flooding, potential for tidal influence, or well condition. If there is a questionable measurement or the measurement cannot be obtained, it should be noted. Standardized field forms should be used for all data collection.

- The sampler should replace any well caps or plugs and lock any well buildings or covers.

- The water-level meter and/or any other downhole equipment should be decontaminated after measuring each well.

- All data should be entered into the DMS as soon as possible. Care should be taken to avoid data entry mistakes and the entries should be checked by a second person for quality assurance.

Pressure Transducer Protocols

Pressure transducers with dataloggers are used in many dedicated monitoring wells and inactive supply wells in the Santa Rosa Plain Groundwater Subbasin monitoring networks to record groundwater-level, temperature, and conductivity data. The following monitoring protocols apply to the use of pressure transducers:

- When installing pressure transducers, care must be exercised to ensure that the data recorded by the transducers is confirmed with hand measurements.

- The sampler must use an electronic water-level meter and follow the protocols listed above to measure the groundwater level and calculate the groundwater elevation in the monitoring well to properly program and reference the pressure transducer installation. It is recommended that transducers record pressure or measured groundwater level to conserve data capacity; groundwater elevations can be calculated at a later time after downloading.

- The sampler must note the well identifier, the associated transducer serial number, transducer range, transducer accuracy, and cable serial number.

- Transducers must be able to record groundwater levels with an accuracy of at least 0.1 foot. Professional judgment should be exercised to ensure that the data being collected is meeting the monitoring objectives and that the instrument is capable. Consideration of the battery life, data storage capacity, range of groundwater level fluctuations, and natural pressure drift of the transducers should be included in the evaluation.

- The sampler must note whether each pressure transducer uses a vented or non-vented cable for barometric compensation. If non-vented units are utilized, they must be properly corrected for natural barometric pressure changes. This requires the consistent logging of barometric pressure to coincide with measurement intervals.

- Follow manufacturer specifications for installation, calibration, data logging intervals, battery life, correction procedure (if non-vented cables used), and anticipated life expectancy to assure that monitoring objectives are being met for the GSP.
- Secure the cable to the well head with a well dock or another reliable method. Mark the cable at the elevation of the reference point with tape or a permanent marker to allow for estimates of future cable slippage.

- Manual groundwater-level measurements should be collected in accordance with the procedures outlined above at least semi-annually to confirm the accuracy of transducer data and monitor for electronic drift or cable movement.

- The data should be downloaded as necessary (at least semi-annually) to ensure no data is lost and entered into the Data Management System following established protocols as soon as possible. Data collected with non-vented data logger cables should be corrected for atmospheric barometric pressure changes, as appropriate. After the sampler is confident that the transducer data have been safely downloaded and stored, the data should be deleted from the data logger to ensure that adequate data logger memory remains.

Protocols for Installation of New Monitoring Wells

It is anticipated that several new dedicated monitoring wells will be installed to fill data gaps during GSP implementation. The design, installation, and documentation of new monitoring wells must consider the following:

- Construction consistent with California Well Standards as described in Bulletins 74-81 and 74-90, and local permitting agency standards of practice.

- Logging of borehole cuttings under the supervision of a California Professional Geologist and described consistent with the Unified Soil Classification System methods according to ASTM standard D2487-11.

- Written criteria for logging of borehole cuttings for comparison to known geologic formations, principal aquifers and aquitards/aquicludes, or specific marker beds to aid in consistent stratigraphic correlation within and across basins, to the extent feasible.

- Geophysical surveys of boreholes to aid in consistency of logging practices, when funding allows. Methodologies should include resistivity, spontaneous potential, spectral gamma, or other methods as appropriate for the conditions. Selection of geophysical methods should be based upon the opinion of a professional geologist or professional engineer and address the objectives for the specific borehole and characterization needs.

- Ensure that the drilling contractor submits State well completion reports according to the requirements of §13752. Well completion report documentation should include geophysical logs, detailed geologic log, and formation identification as attachments, if available.

Groundwater Quality Monitoring Protocols

In general, the GSP relies on water quality data generated through existing programs. In some cases, it may be necessary to collect additional water quality data to support monitoring programs or evaluate specific projects. The USGS National Field Manual for the Collection of Water Quality Data (USGS, 2018) should be used to guide the collection of reliable data.

While specific groundwater sampling protocols vary depending on the constituent being sampled for, the protocols listed below provide guidance which is applied to all groundwater quality sampling.

- Prior to sampling, the sampler must contact the laboratory to schedule laboratory time, obtain appropriate sample containers, and clarify any sample holding times or sample preservation requirements.

- Each well used for groundwater quality monitoring must have a unique identifier. This identifier should appear on the well housing or the well casing to avoid confusion.

- In the case of wells with dedicated pumps, samples should be collected at or near the wellhead. Samples should not be collected from storage tanks, at the end of long pipe runs, or after any water treatment.

- The sampler should clean the sampling port and/or sampling equipment and the sampling port and/or sampling equipment must be free of any contaminants. The sampler must decontaminate sampling equipment between sampling locations or wells to avoid cross-contamination between samples.

- The groundwater elevation in the well should be measured following the protocols described above.

- For any well not equipped with low-flow or passive sampling equipment, an adequate volume of water should be purged from the well to ensure that the groundwater sample is representative of ambient groundwater and not stagnant water in the well casing. Purging three well casing volumes is generally considered adequate. Professional judgment should be used to determine the proper configuration of the sampling equipment with respect to well construction such that a representative ambient groundwater sample is collected. If pumping causes a well to be evacuated (go dry), document the condition and allow well to recover to within 90% of original level prior to sampling.

- Field parameters of pH, electrical conductivity, and temperature should be collected for each sample. Field parameters should be evaluated during the purging of the well and should stabilize prior to sampling. Other parameters, such as oxidation-reduction potential (ORP), dissolved oxygen (DO - in situ measurements preferable), or turbidity, may also be useful for meeting monitoring objectives and assessing purge conditions. All field instruments should be calibrated daily and evaluated for drift throughout the day.

- Sample containers should be labeled prior to sample collection. The sample label must include: sample ID (often well ID), sample date and time, sample personnel, sample location, preservative used, and analytes and analytical method.

- Samples should be collected under laminar flow conditions. This may require reducing pumping rates prior to sample collection.

- All samples requiring preservation must be preserved as soon as practically possible, ideally at the time of sample collection. Ensure that samples are appropriately filtered as recommended for the specific analyte. Entrained solids can be dissolved by preservative leading to inconsistent results of dissolve analytes. Specifically, samples to be analyzed for metals should be field-filtered prior to preservation; do not collect an unfiltered sample in a preserved container.

- Samples should be chilled and maintained at 4 °C to prevent degradation of the sample. The laboratory's Quality Assurance Management Plan should detail appropriate chilling and shipping requirements.

- Samples must be transported under chain of custody documentation to the appropriate laboratory promptly to avoid violating holding time restrictions.

- Instruct the laboratory to use reporting limits that are equal to or less than applicable Sustainable Management Criteria values or regional water quality objectives/screening levels.

Protocols for Measuring Streamflow

Monitoring of streamflow is necessary for incorporation into water budget analysis and for use in evaluation of stream depletions associated with groundwater extractions. The use of existing streamflow monitoring locations is incorporated into the Subbasin's monitoring networks to the greatest extent possible.

Establishment of new streamflow discharge sites should consider the existing network and the objectives of the new location. Professional judgment should be used to determine the appropriate permitting that may be necessary for the installation of any monitoring locations along surface water bodies. Regular frequent access will be necessary to these sites for the development of ratings curves and maintenance of equipment.

To establish a new streamflow monitoring station special consideration must be made in the field to select an appropriate location for measuring discharge. Once a site is selected, development of a relationship of stream stage to discharge will be necessary to provide continuous estimates of streamflow. Several measurements of discharge at a variety of stream stages will be necessary to develop the ratings curve correlating stage to discharge. The use of Acoustic Doppler Current Profilers (ADCPs) can provide accurate estimates of discharge in the correct settings. Professional judgment must be exercised to determine the appropriate methodology. Following development of the ratings curve a simple stilling well and pressure transducer with data logger can be used to evaluate stage on a frequent basis.

Streamflow measurements should be collected, analyzed, and reported in accordance with the procedures outlined in USGS Water Supply Paper 2175, Volume 1. – Measurement of Stage Discharge and Volume 2. – Computation of Discharge (Rantz and others, 1982). This methodology is currently used by both the USGS and DWR for existing streamflow monitoring throughout the State.

Protocols for Monitoring Land Subsidence

Evaluating and monitoring inelastic land subsidence can utilize multiple data sources to evaluate the specific conditions and associated causes. At the time of GSP submittal, the GSA generally relies on existing Interferometric Synthetic Aperture Radar (InSAR) data and data from continuous GPS (CGPS) stations. Subsidence can also be estimated from numerous other techniques including: level surveying tied to known stable benchmarks or benchmarks located outside the area being studied for possible subsidence; installing and tracking changes in borehole extensometers; or obtaining data from static GPS surveys or Real-Time-Kinematic (RTK) surveys. No standard procedures exist for collecting data from the potential subsidence monitoring approaches. However, an approach may include:

Identification of Land Subsidence Conditions

- Evaluation of existing regional long-term leveling surveys of regional infrastructure, i.e., roadways, railroads, canals, and levees.

- Inspection of existing County and State well records where collapse has been noted for well repairs or replacement.

- Determining if significant fine-grained layers are present such that the potential for collapse of the units could occur should there be significant depressurization of the aquifer system.

- Inspection of geologic logs and the hydrogeologic conceptual model to aid in identification of specific units of concern.

- Analysis of regional remote-sensing information such as InSAR.

- Review of seismic related data and records that might explain land subsidence observations.

- Review of groundwater elevation measurements and trends in Representative Monitoring Points (established as part of groundwater-level Sustainable Management Criteria) and other nearby wells being monitored, including an assessment as to whether groundwater levels are below historical lows or exceeding Minimum Thresholds.

- Evaluation of known or estimated groundwater pumping patterns within the vicinity of any observed potential land subsidence.

Monitor regions of suspected subsidence where potential exists

- Establish CGPS network to evaluate changes in land surface elevation.

- Establish leveling surveys transects to observe changes in land surface elevation.

- Establish extensometer network to observe land subsidence. Extensometer design should be based on local conditions, professional judgement, and monitoring objectives.

Standards and guidance documents for collecting data for land subsidence monitoring include:

- GPS and Leveling surveys must follow surveying standards set out in the California Department of Transportation's Caltrans Surveys Manual (California Department of Transportation, various dates).

- Instruments installed in borehole extensometers must follow the manufacturer's instructions for installation, care, and calibration.

References

- California Department of Transportation, various dates. *Caltrans Surveys Manual*.
- California Department of Water Resources (DWR). 2016. *Best Management Practices for the Sustainable Management of Groundwater, Monitoring Protocols, Standards, and Sites*. December
- Rantz, S.E., and others, 1982. *Measurement and computation of streamflow*; U.S. Geological Survey, Water Supply Paper 2175.
- U.S. Geological Survey, 2018, *Preparations for water sampling*: U.S. Geological Survey Techniques and Methods, book 9, chap. A1.

.

Appendix 5-B
Comparative Hydrographs – Chronic Lowering of Groundwater Levels Representative Monitoring Points

Figure 5--B-1. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-1

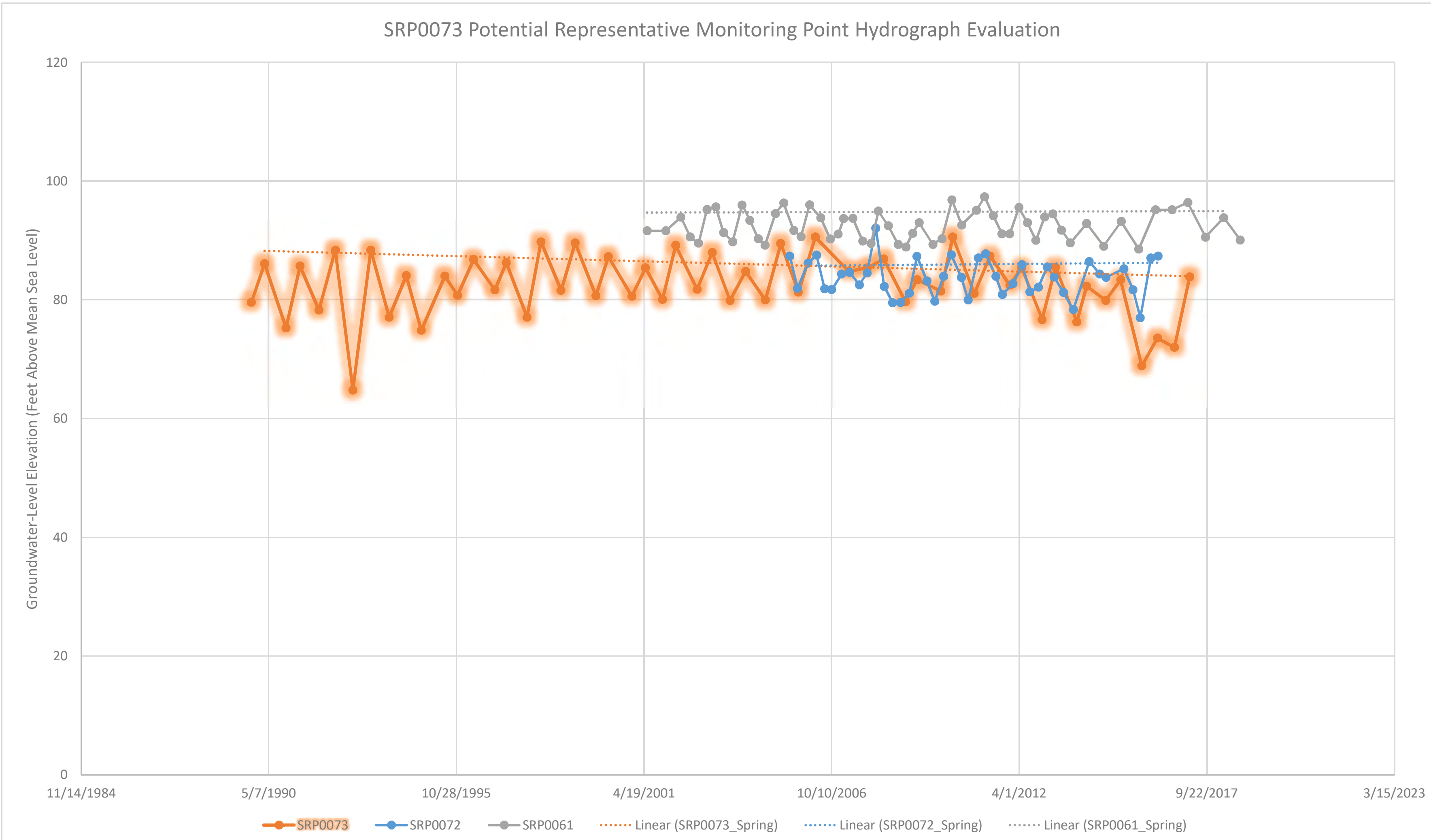


Figure 5-B-2. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-2

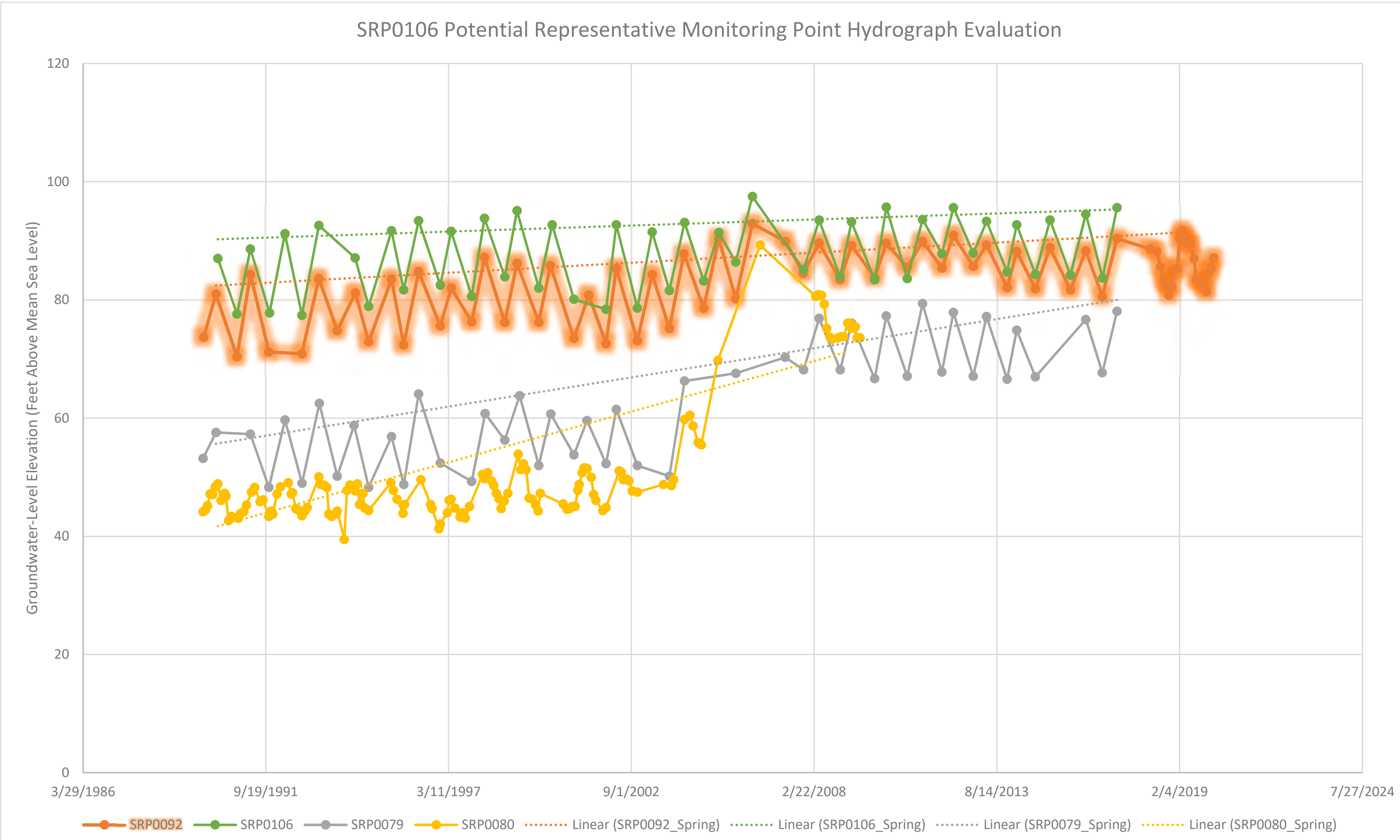


Figure 5-B-3. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-3

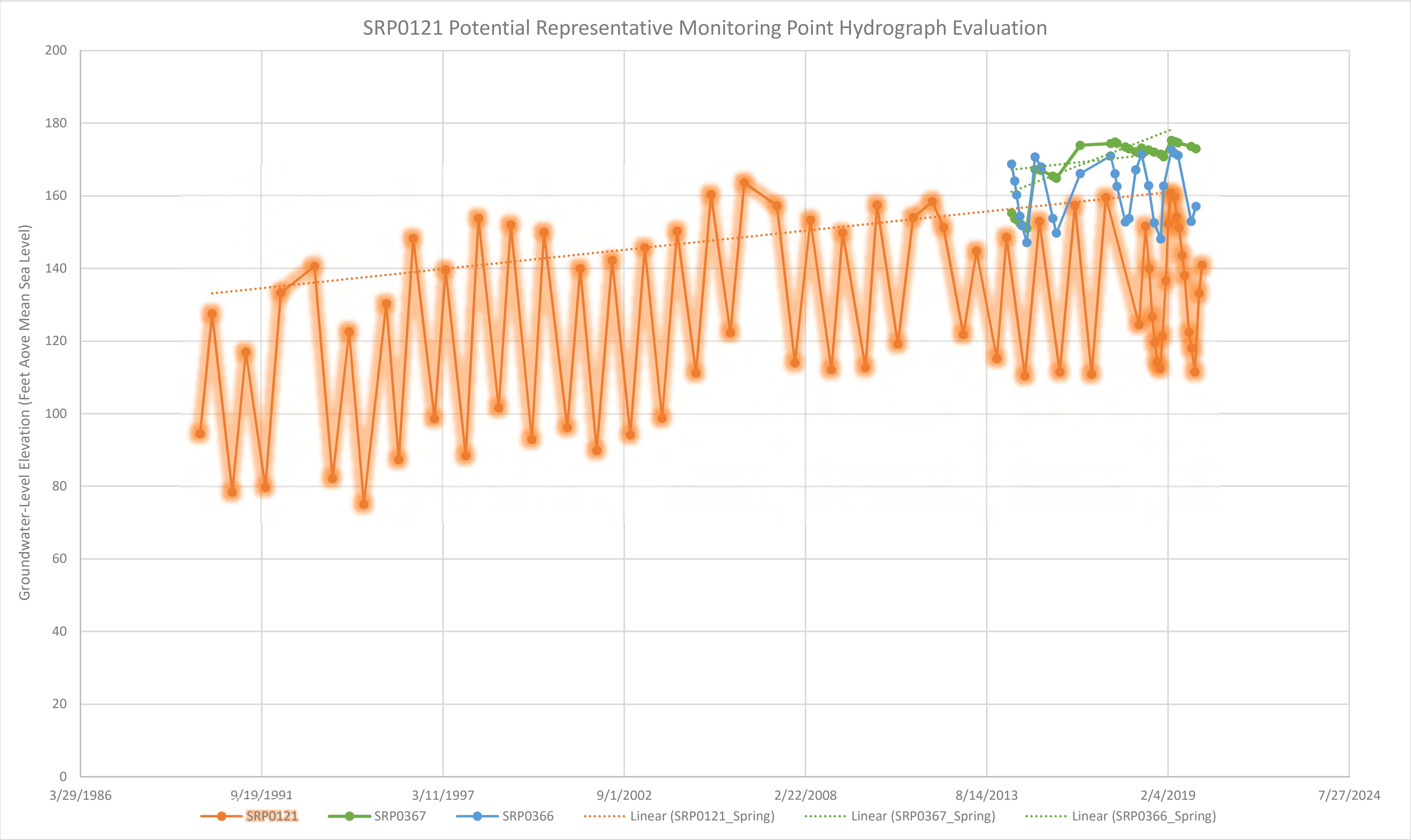


Figure 5-B-4. Groundwater level
elevation in feet above mean sea level.
Data from 1989 to 2018.

Figure 5-B-4

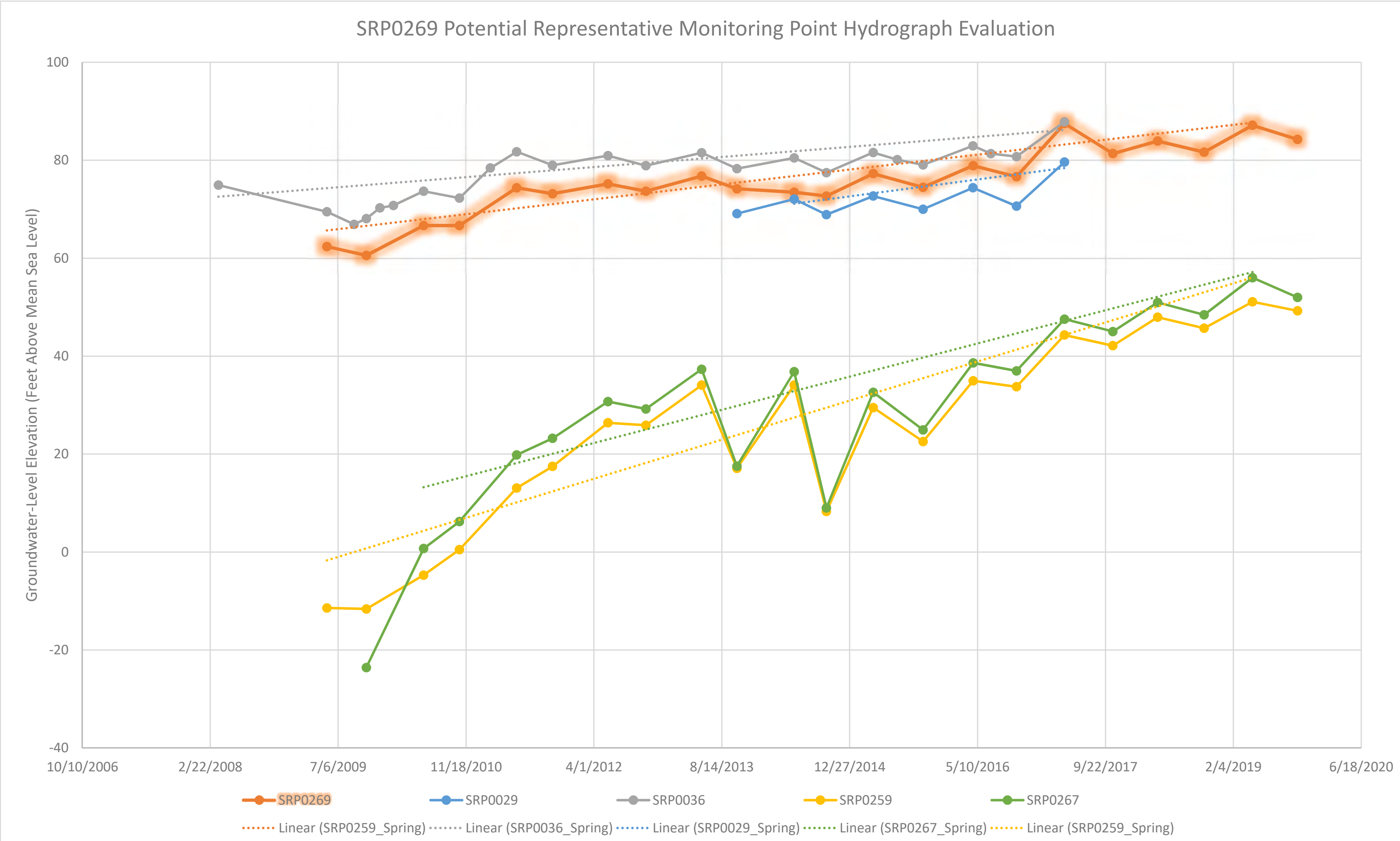


Figure 5-B-5. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-5

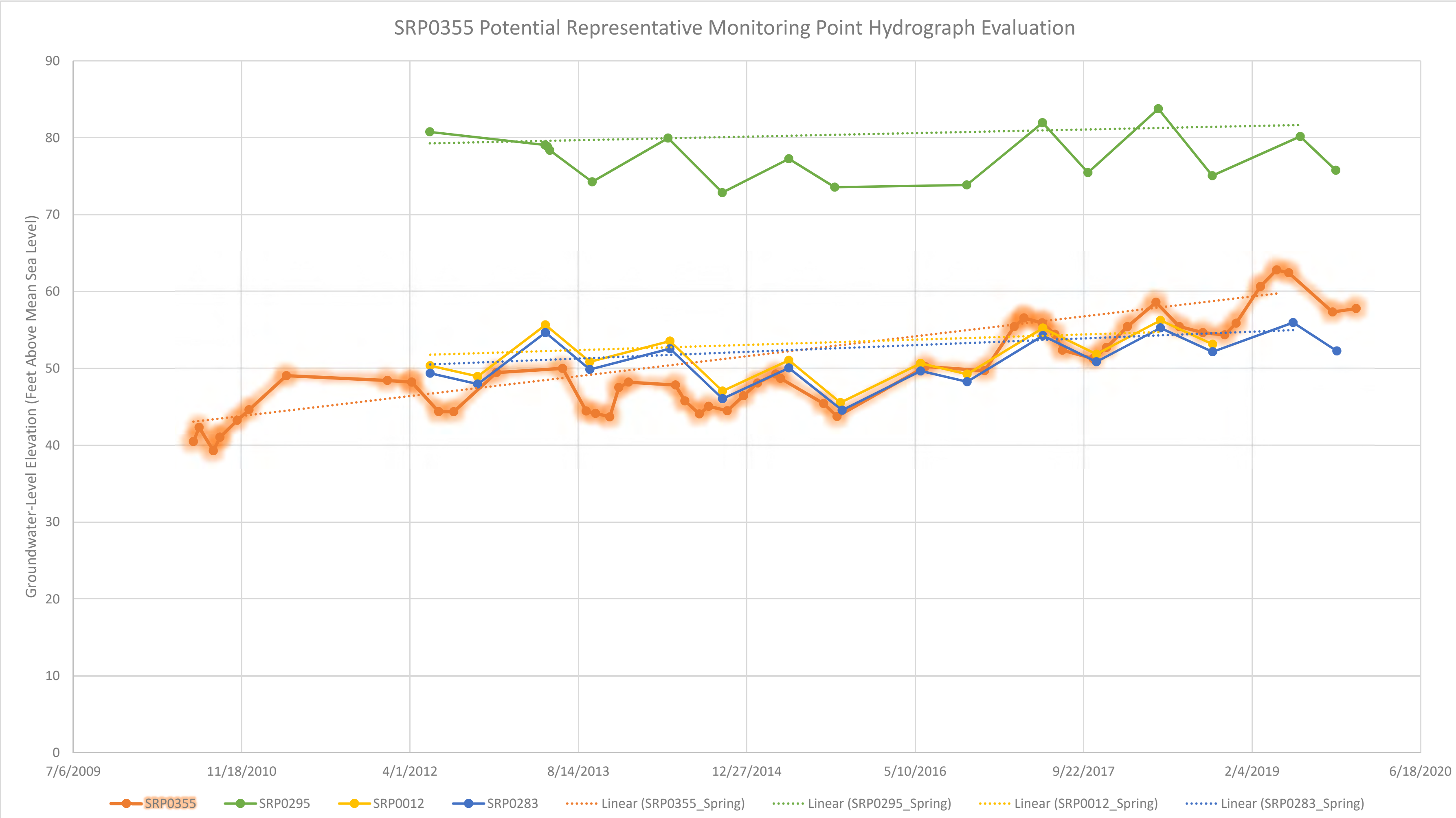


Figure 5-B-6. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-6

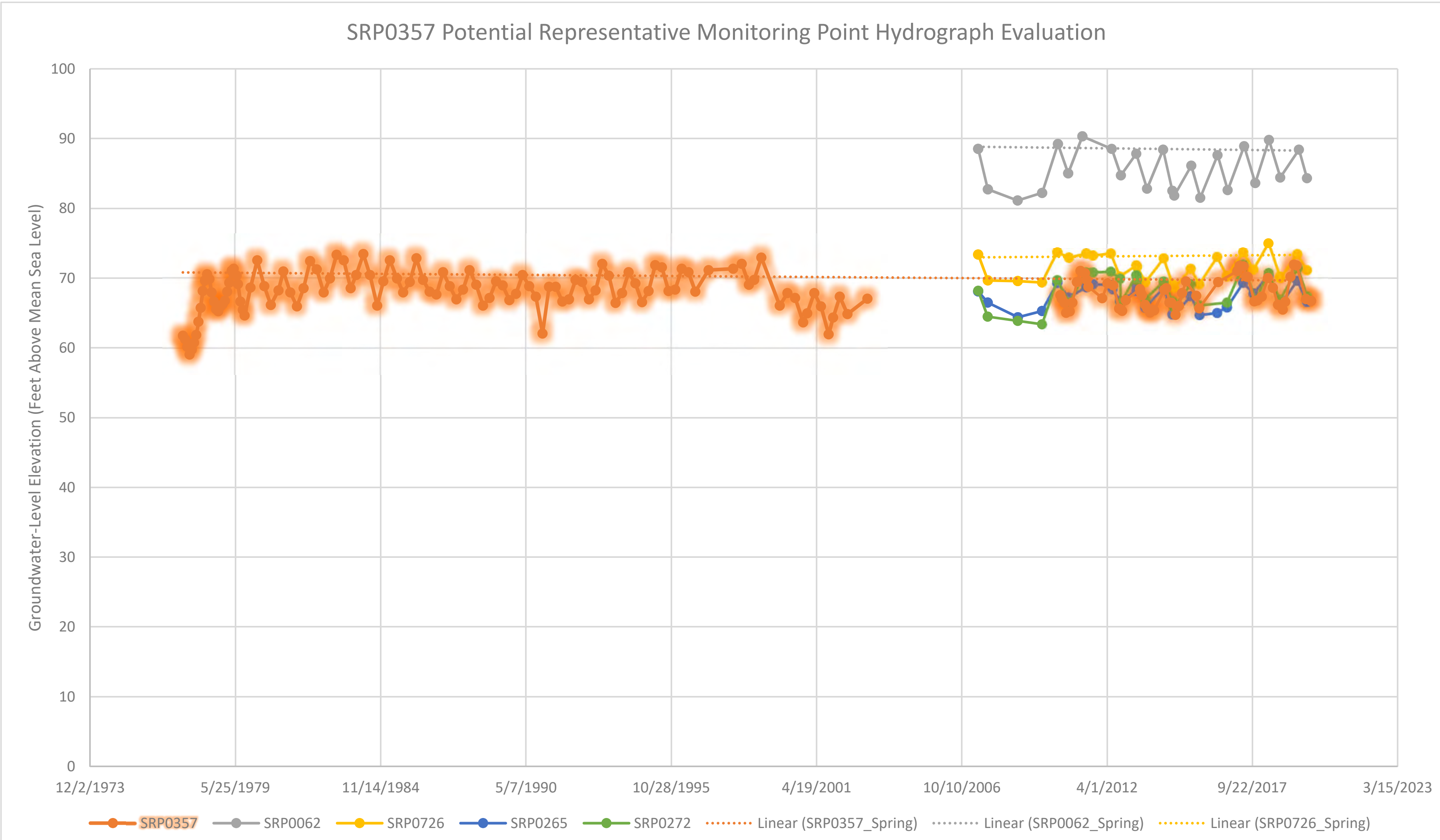


Figure 5-B-7. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-7

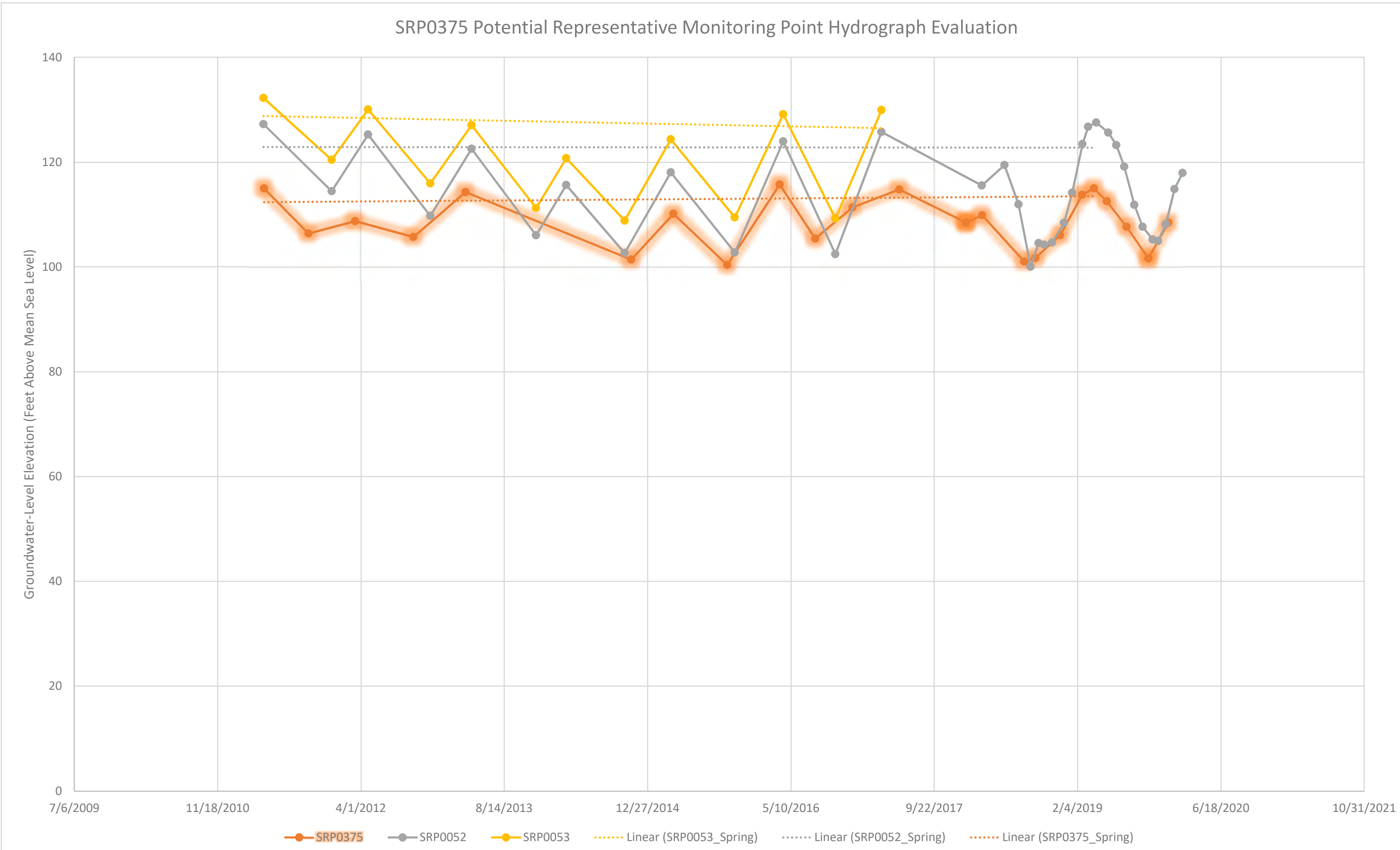


Figure 5-B-8. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-8

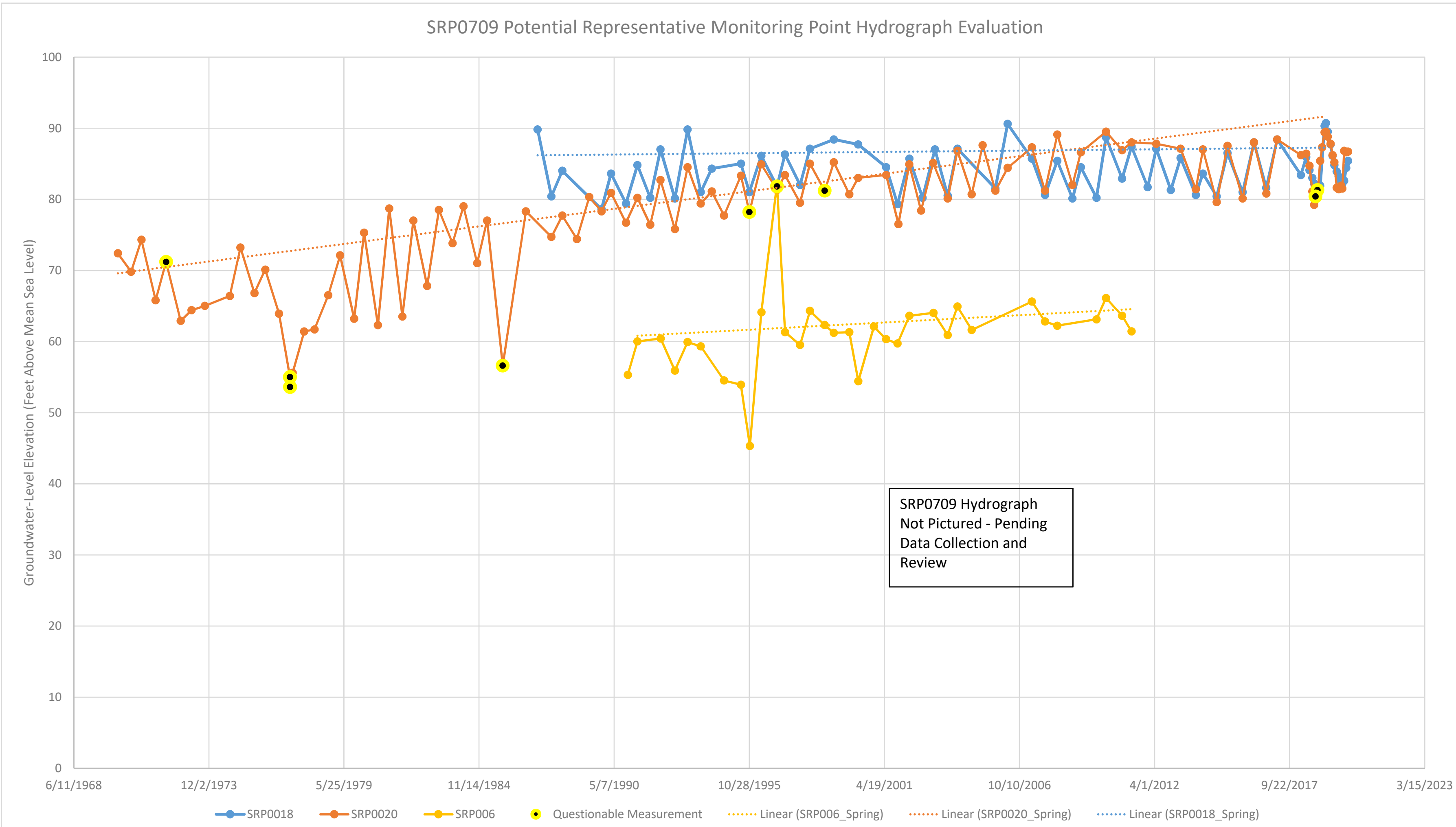


Figure 5-B-9 Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-9

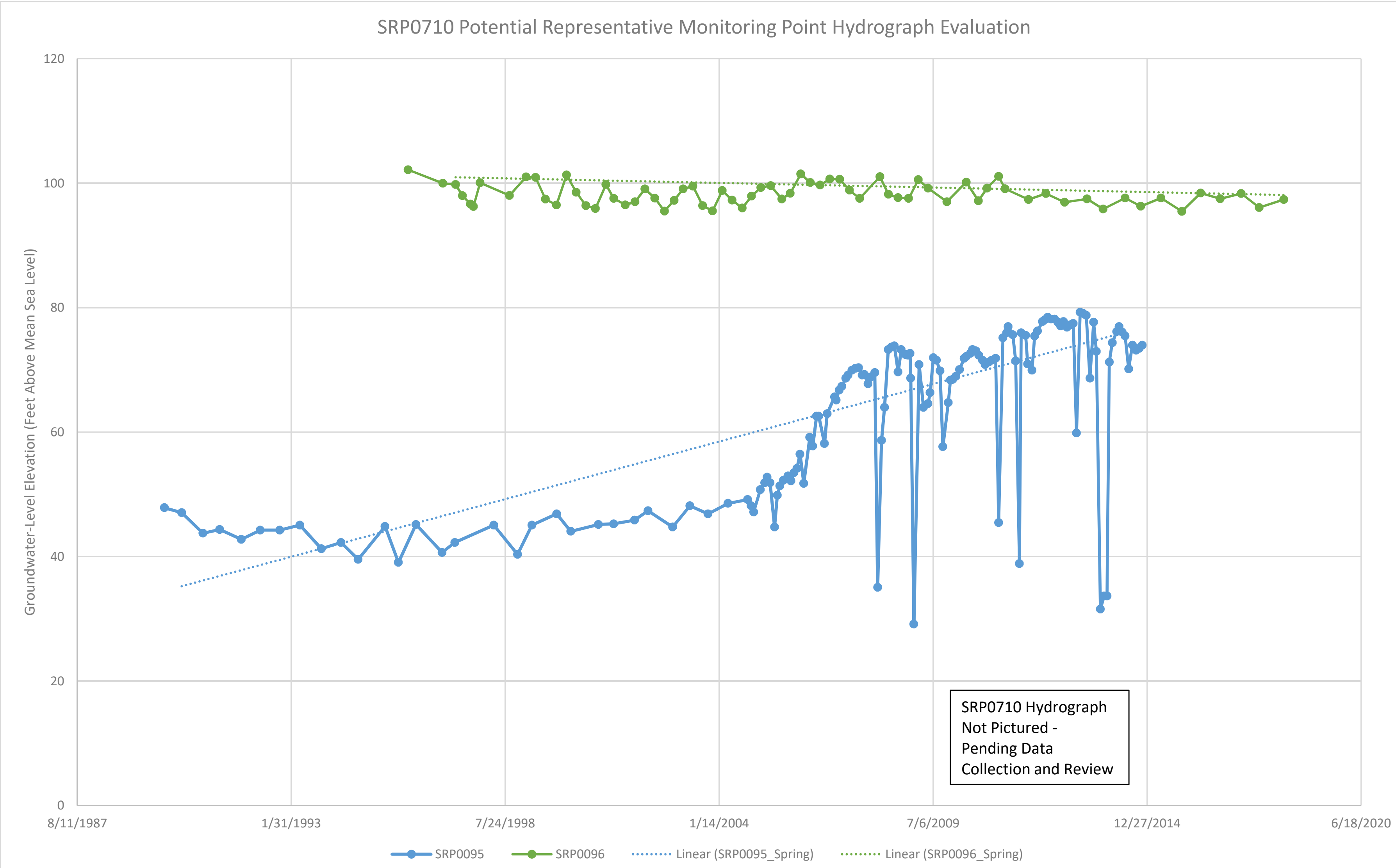


Figure 5-B-10 Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-10

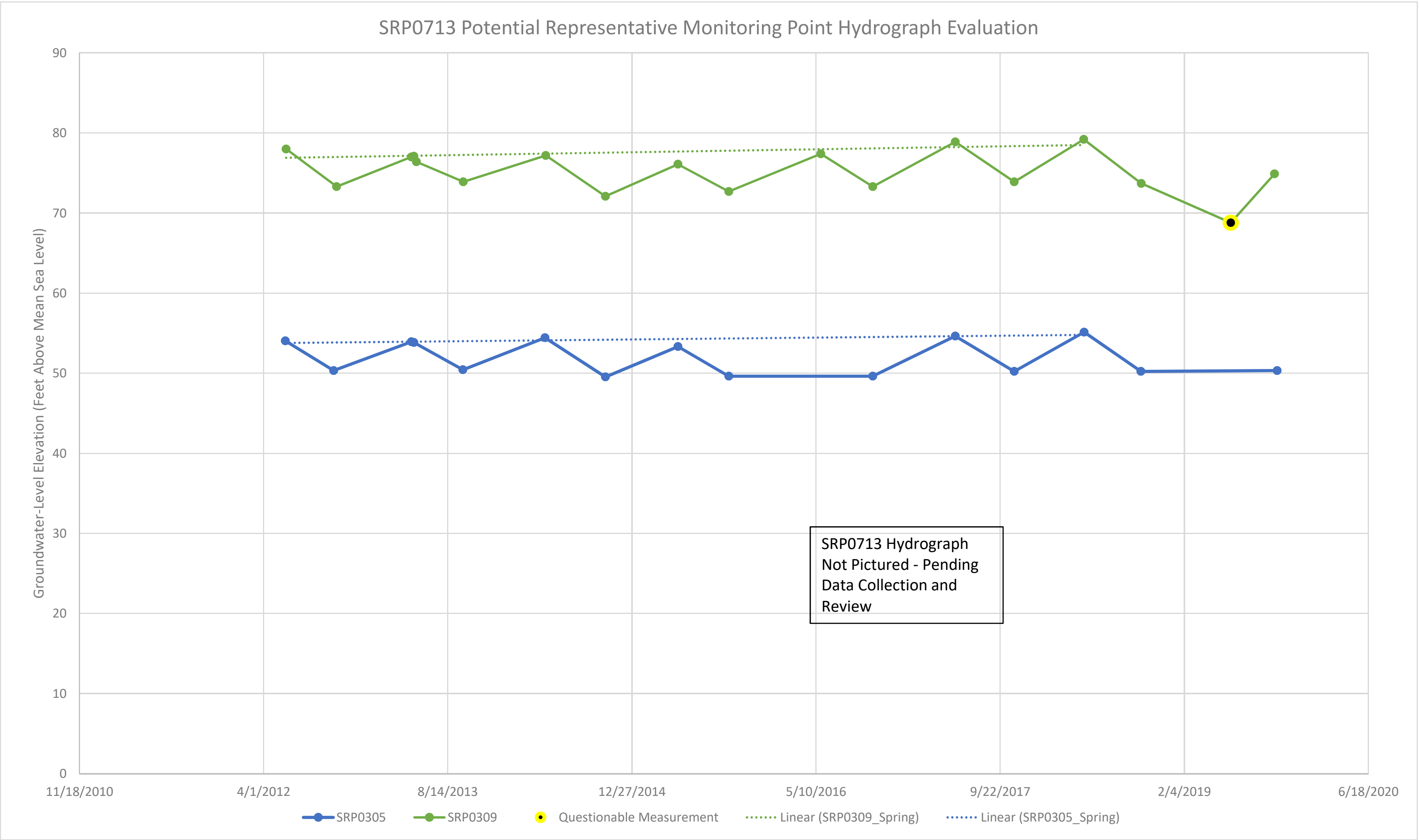


Figure 5-B-11. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-11

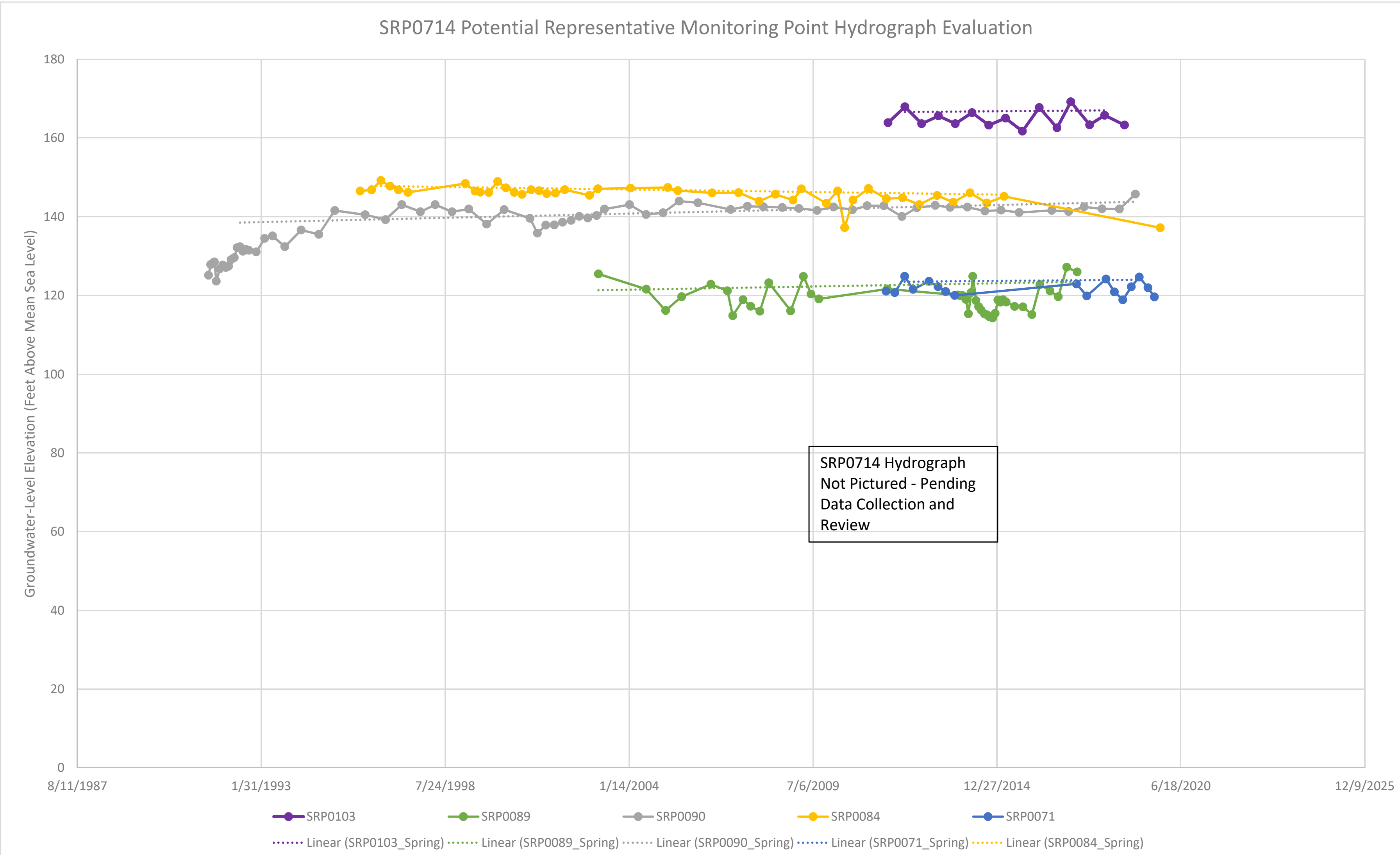


Figure 5-B-12. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-12

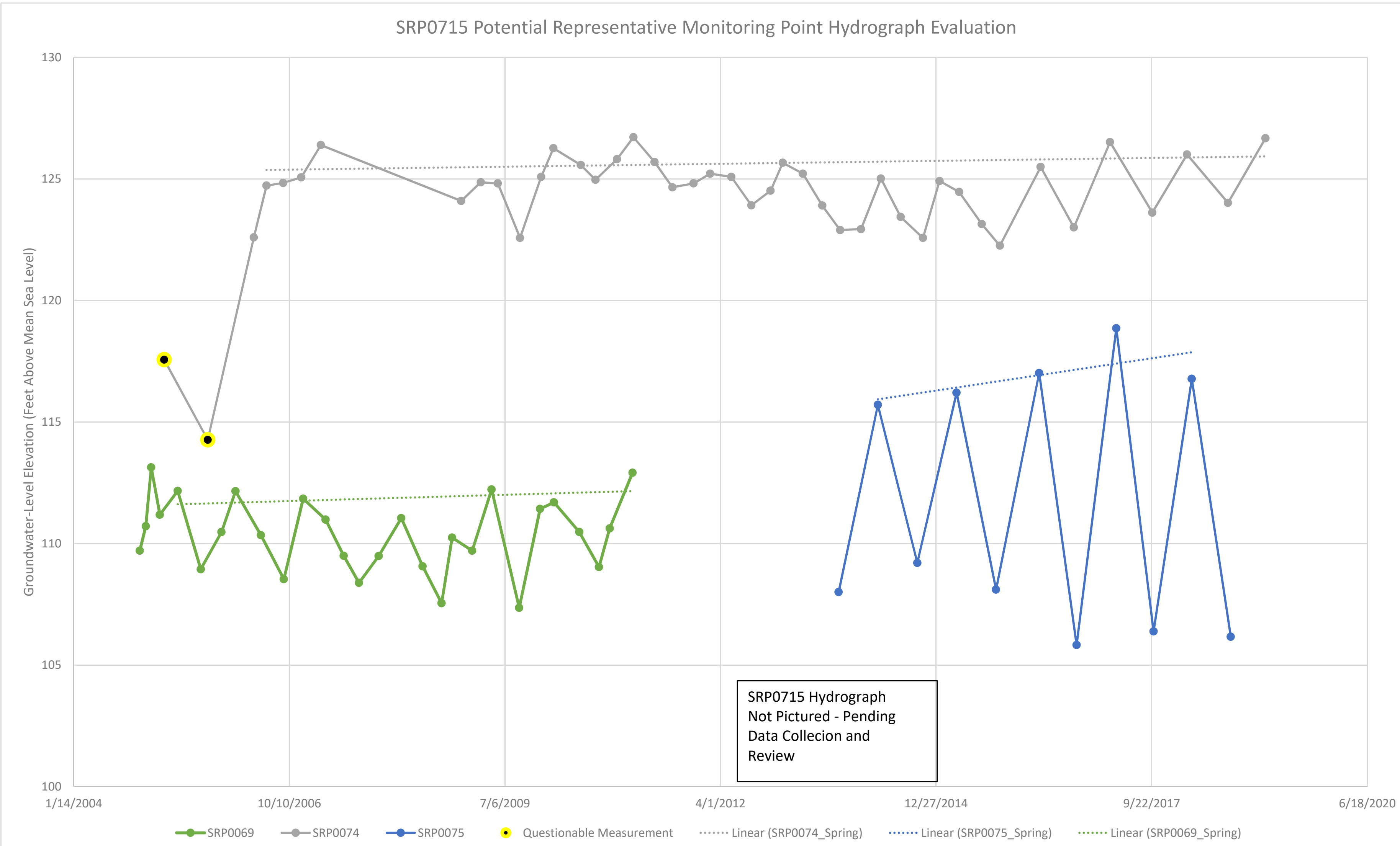


Figure 5-B-13. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-13

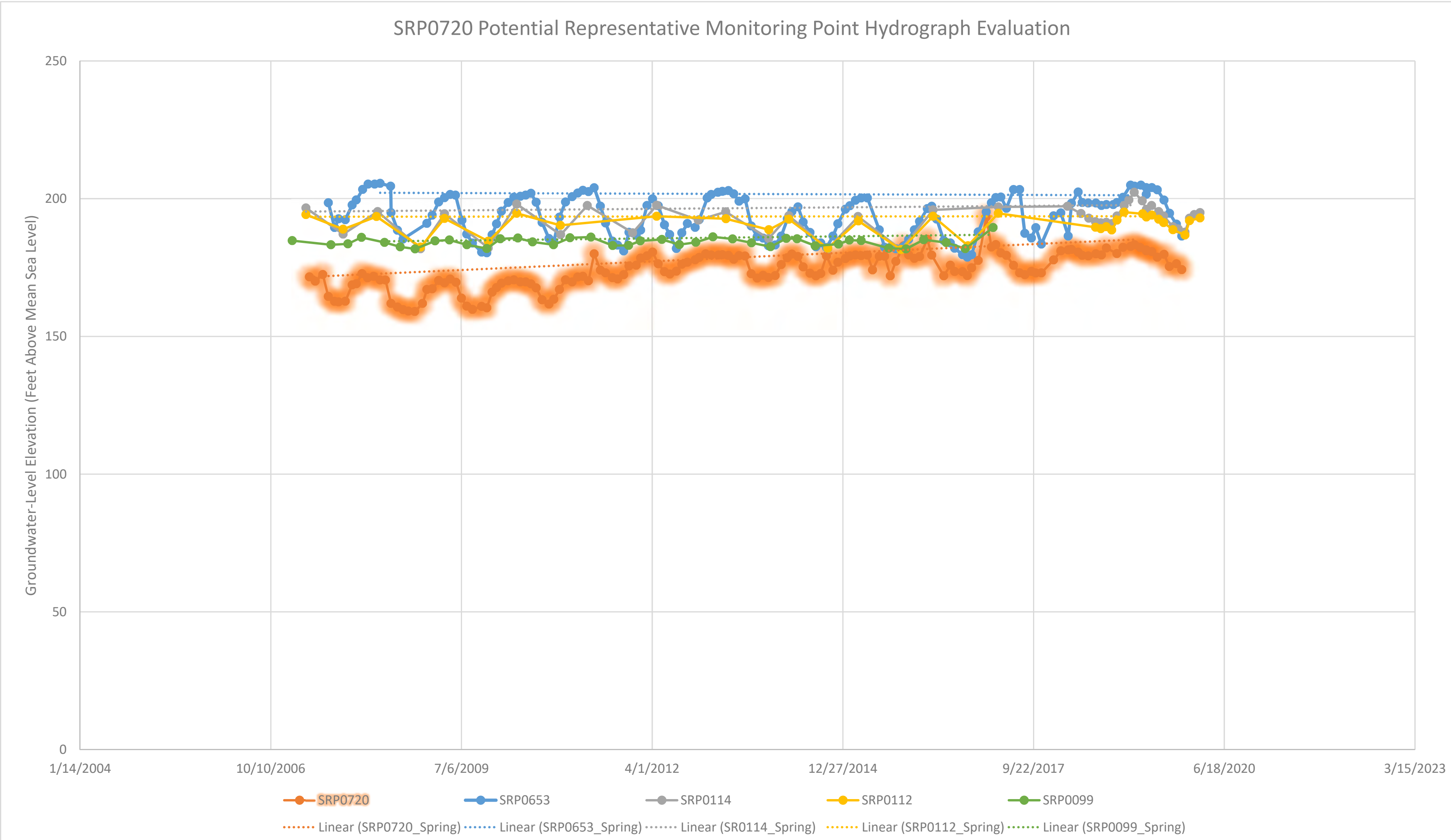


Figure 5-B-14. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-14

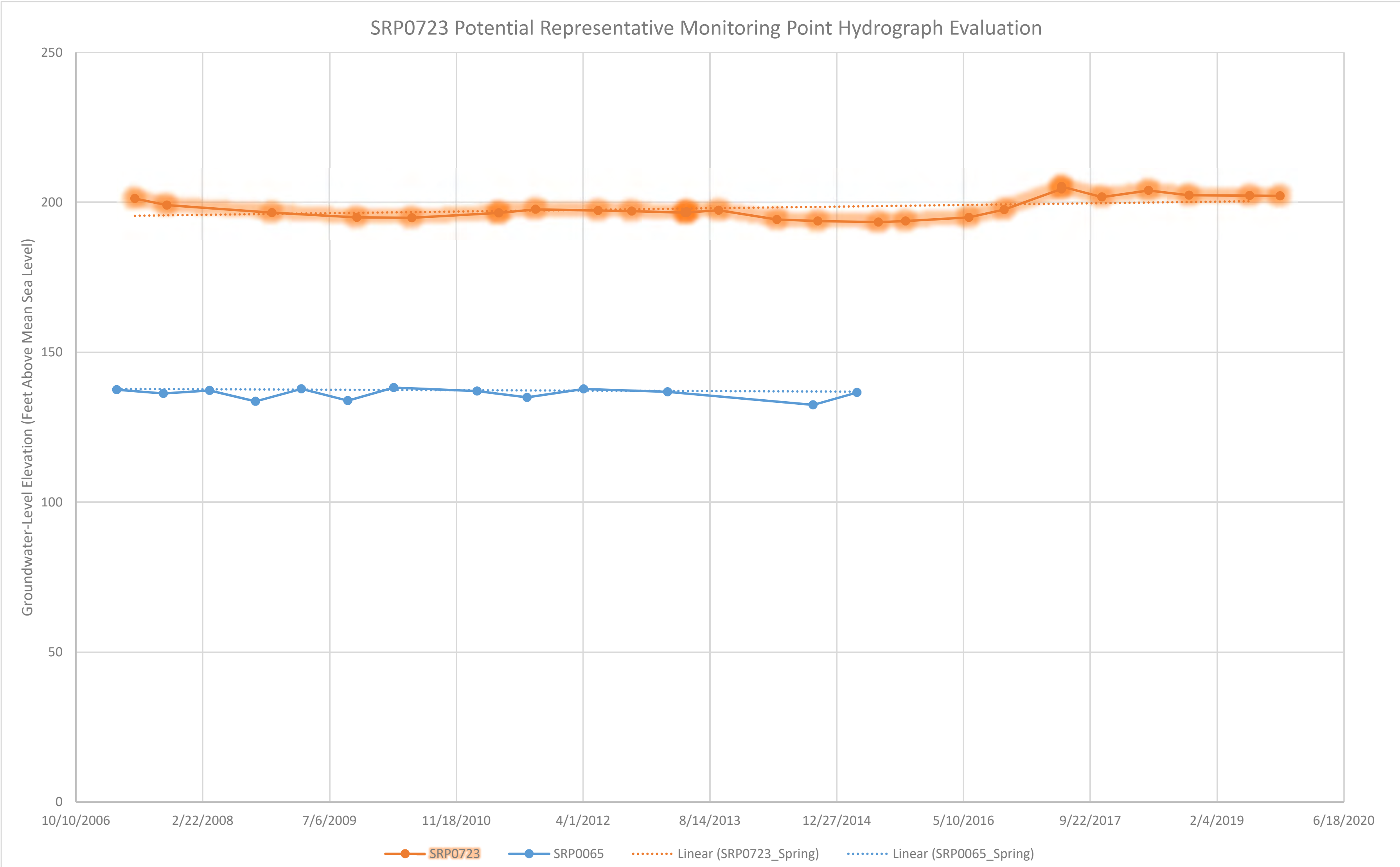


Figure 5-B-15. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-15

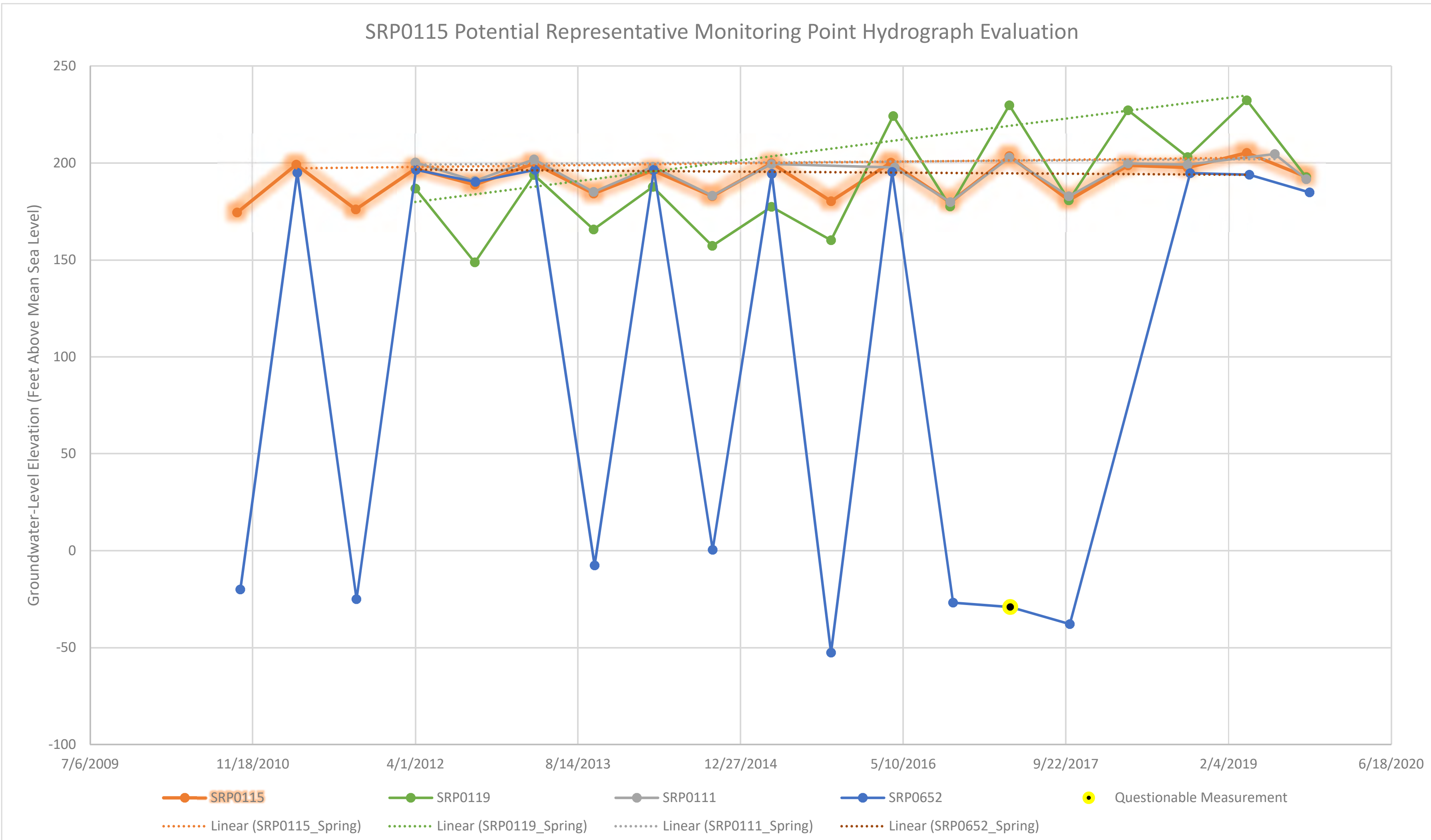


Figure 5-B-16. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-16

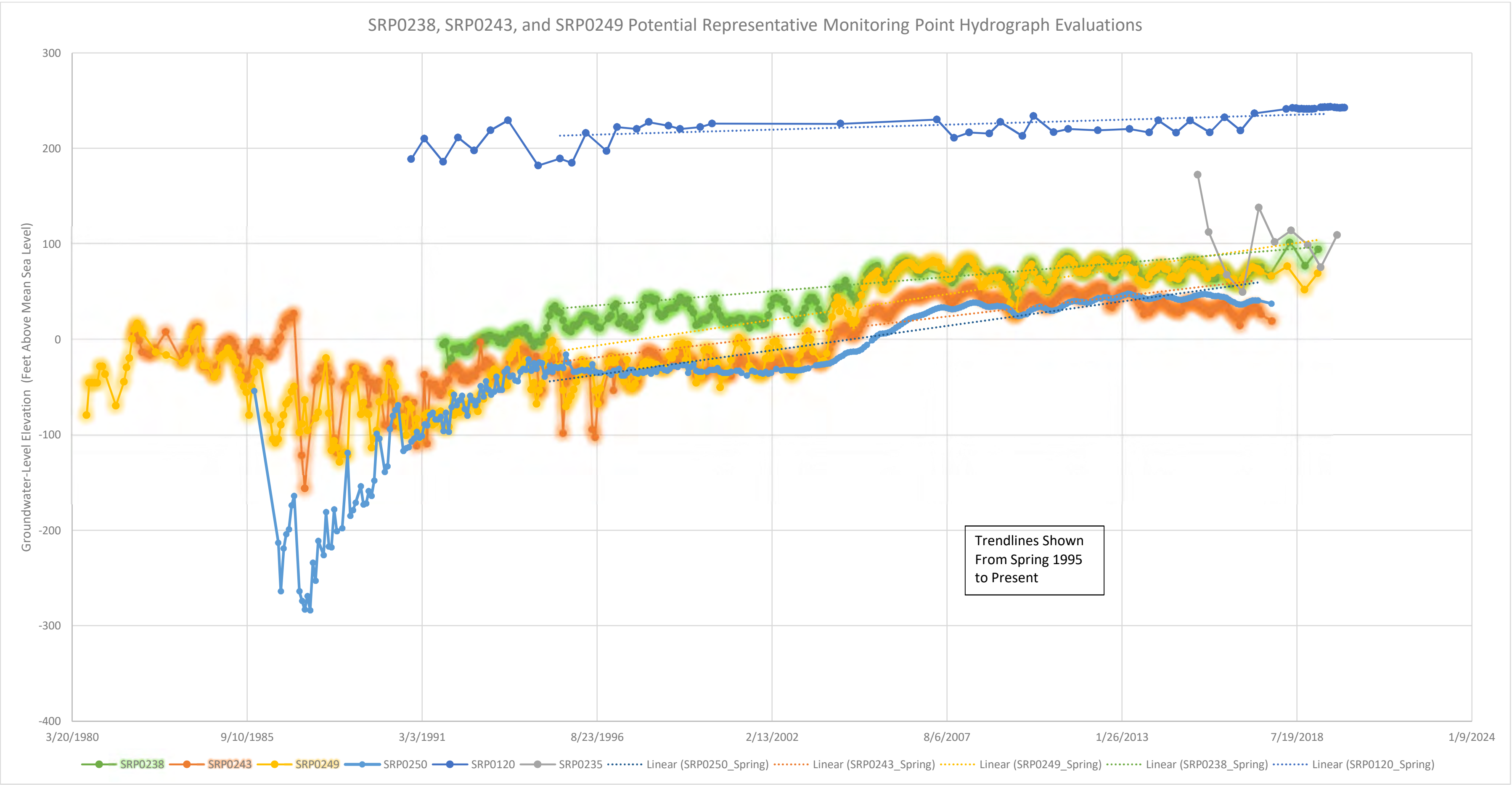


Figure 5-B-17. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-17

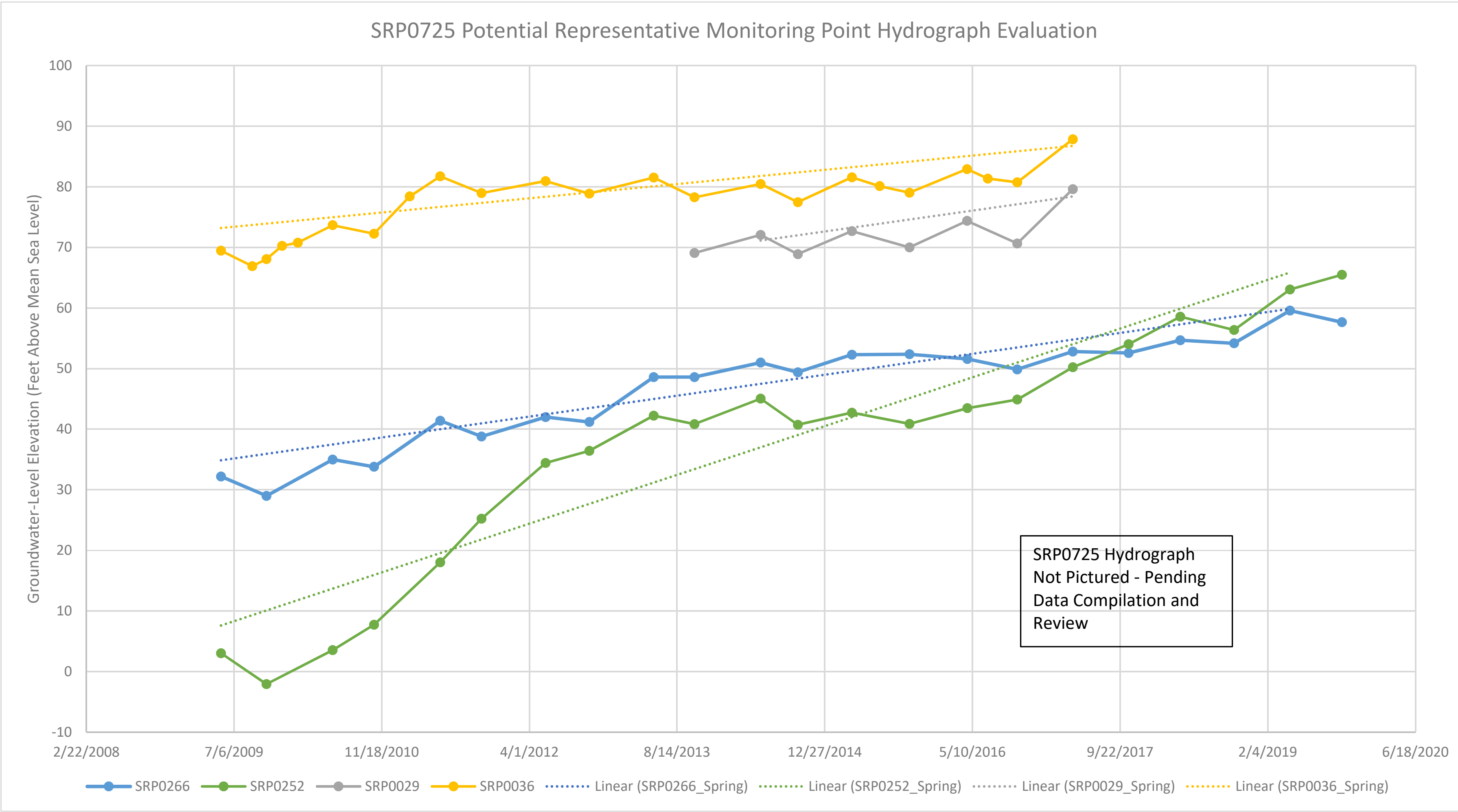


Figure 5-B-18. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-18

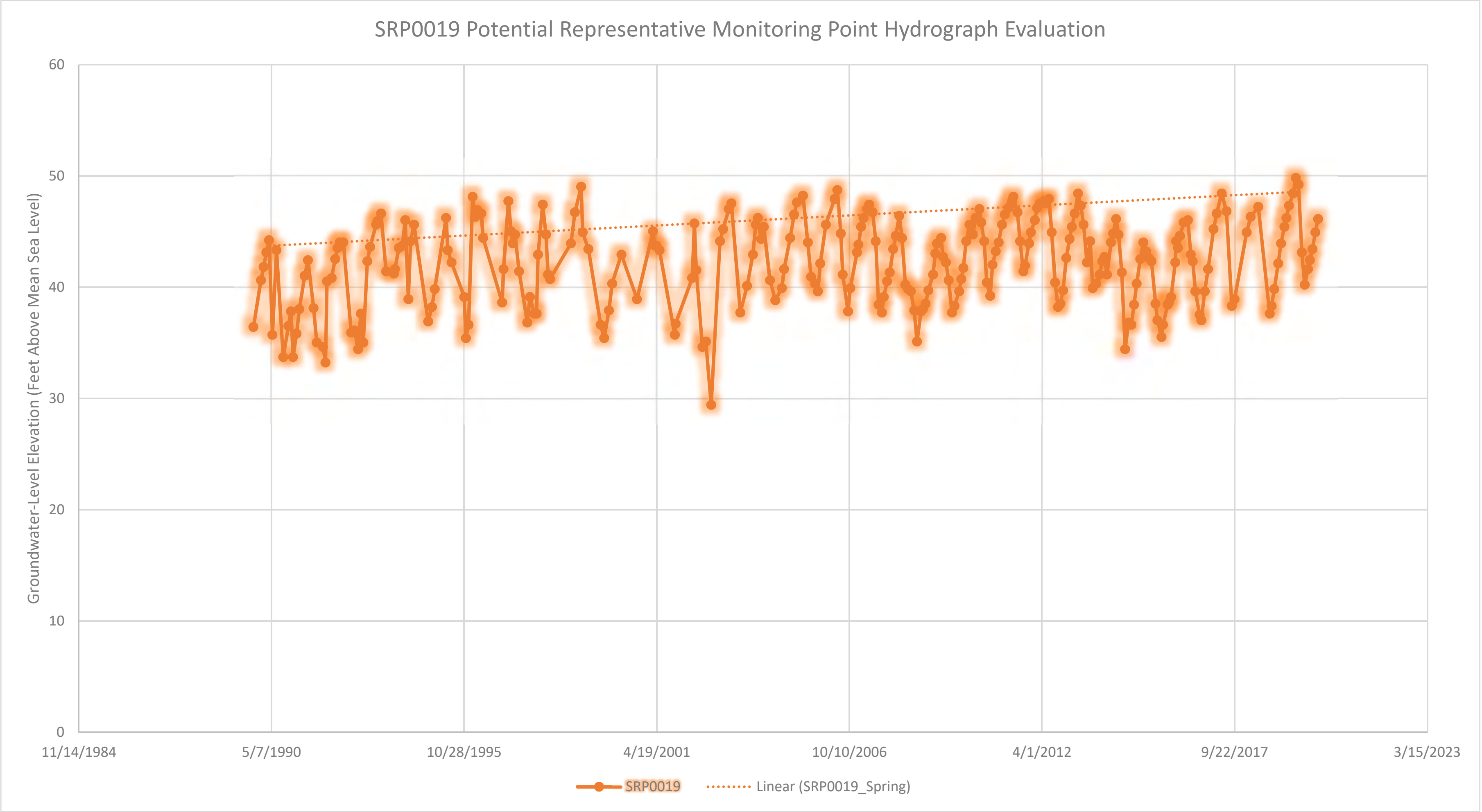


Figure 5-B-19. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-19

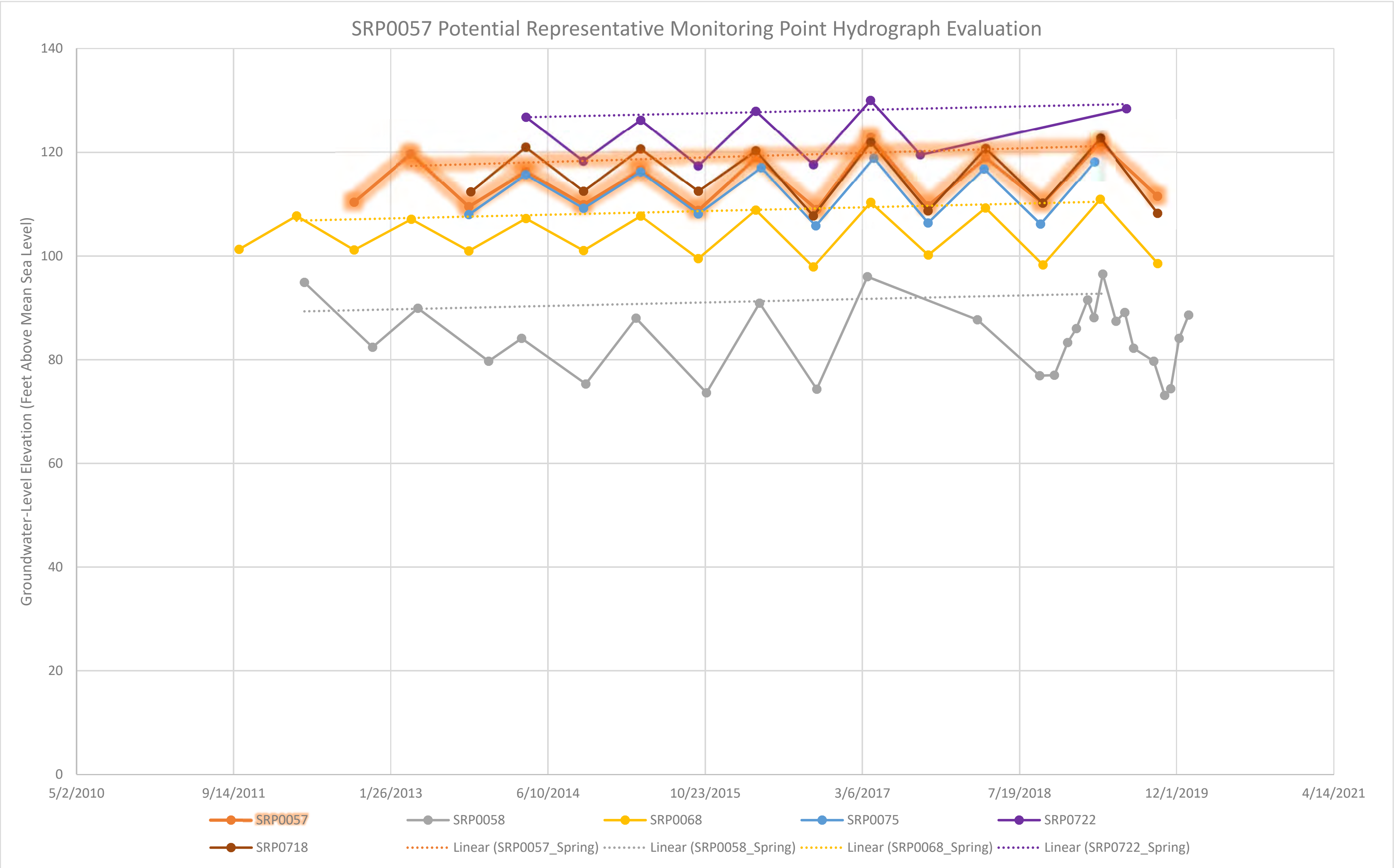


Figure 5-B-20. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

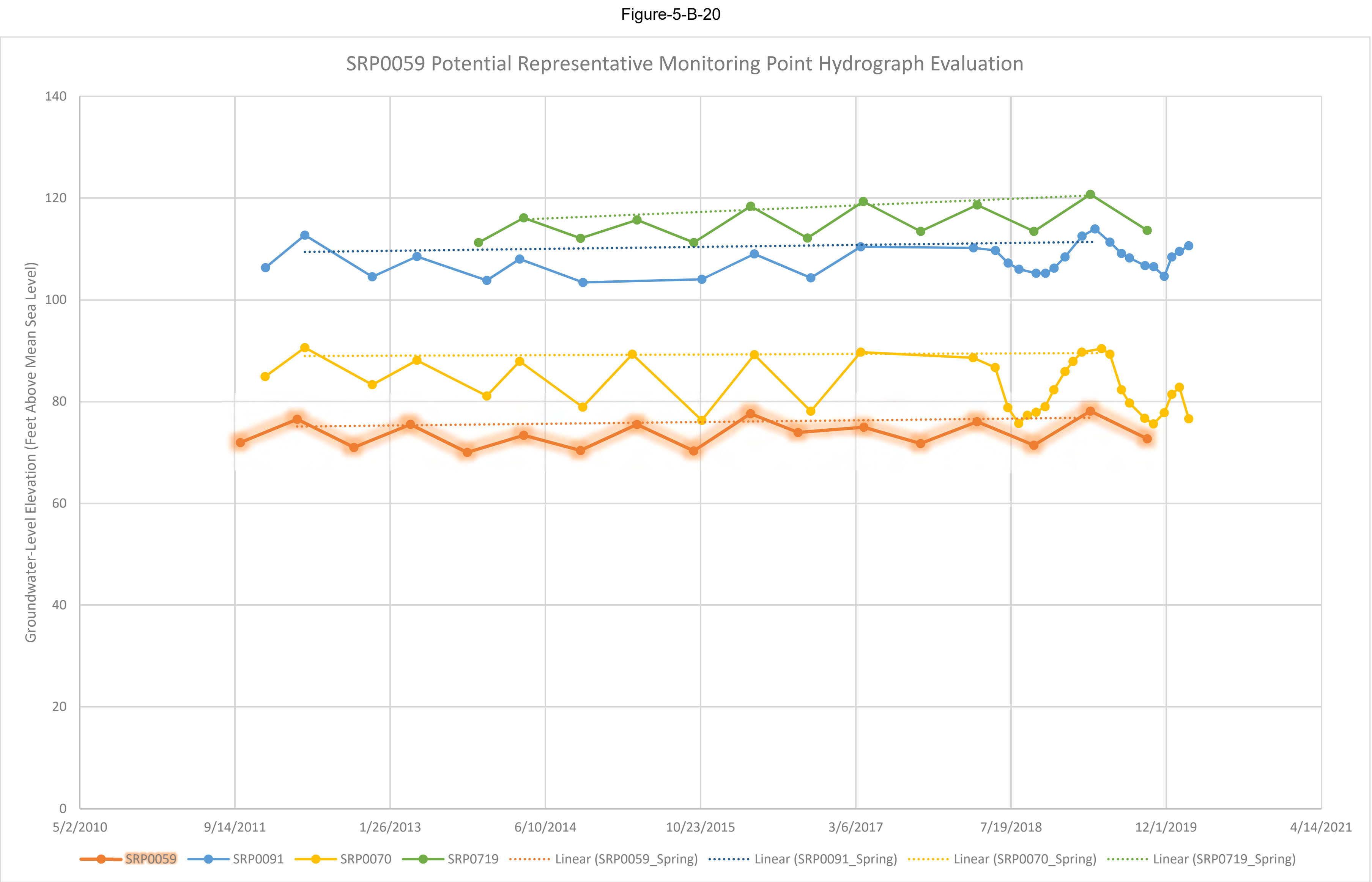


Figure 5-B-21. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-21

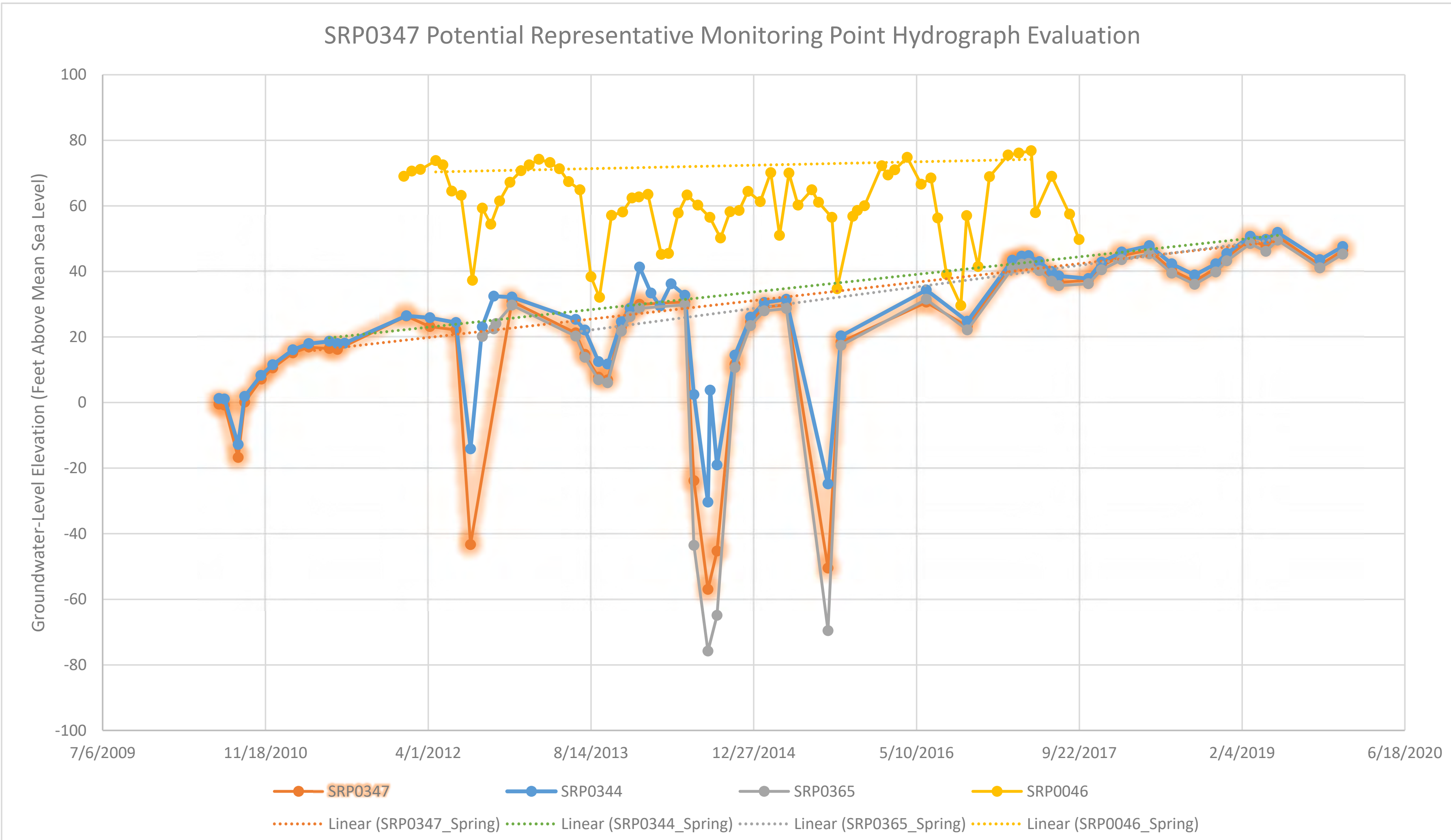


Figure 5-B-22. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

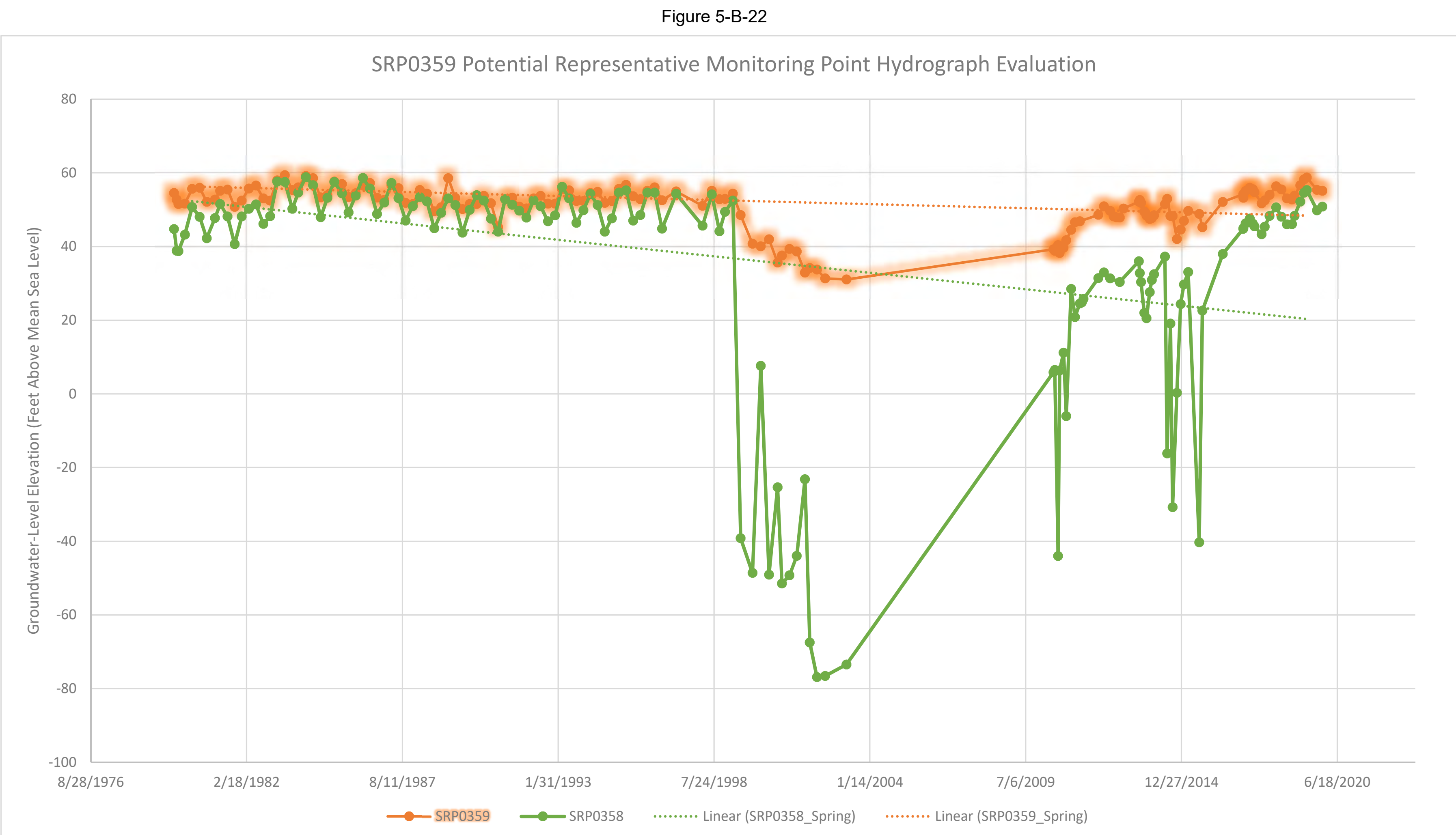
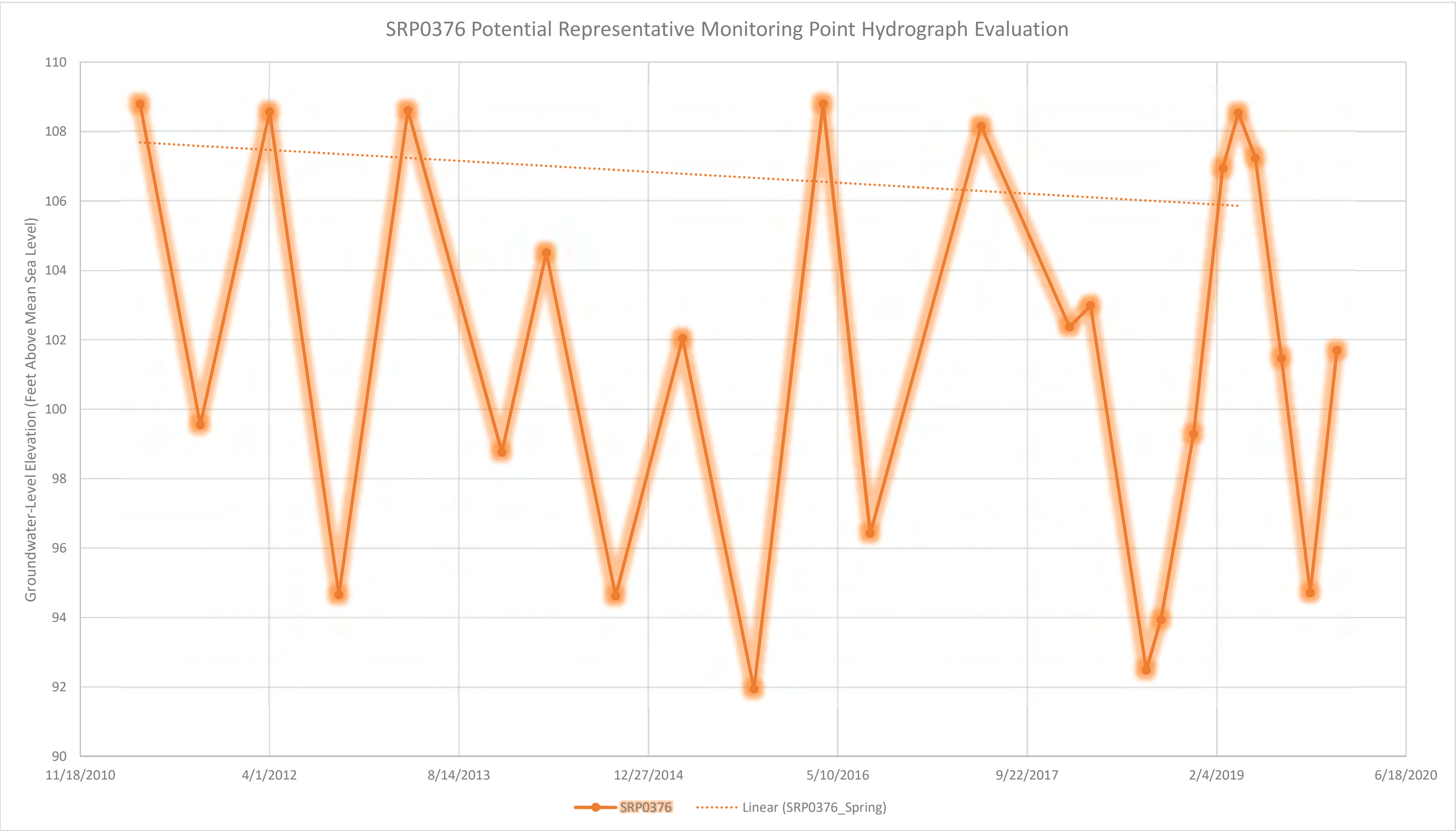


Figure 5-B-23. Groundwater level elevation in feet above mean sea level. Data from 1989 to 2018.

Figure 5-B-23



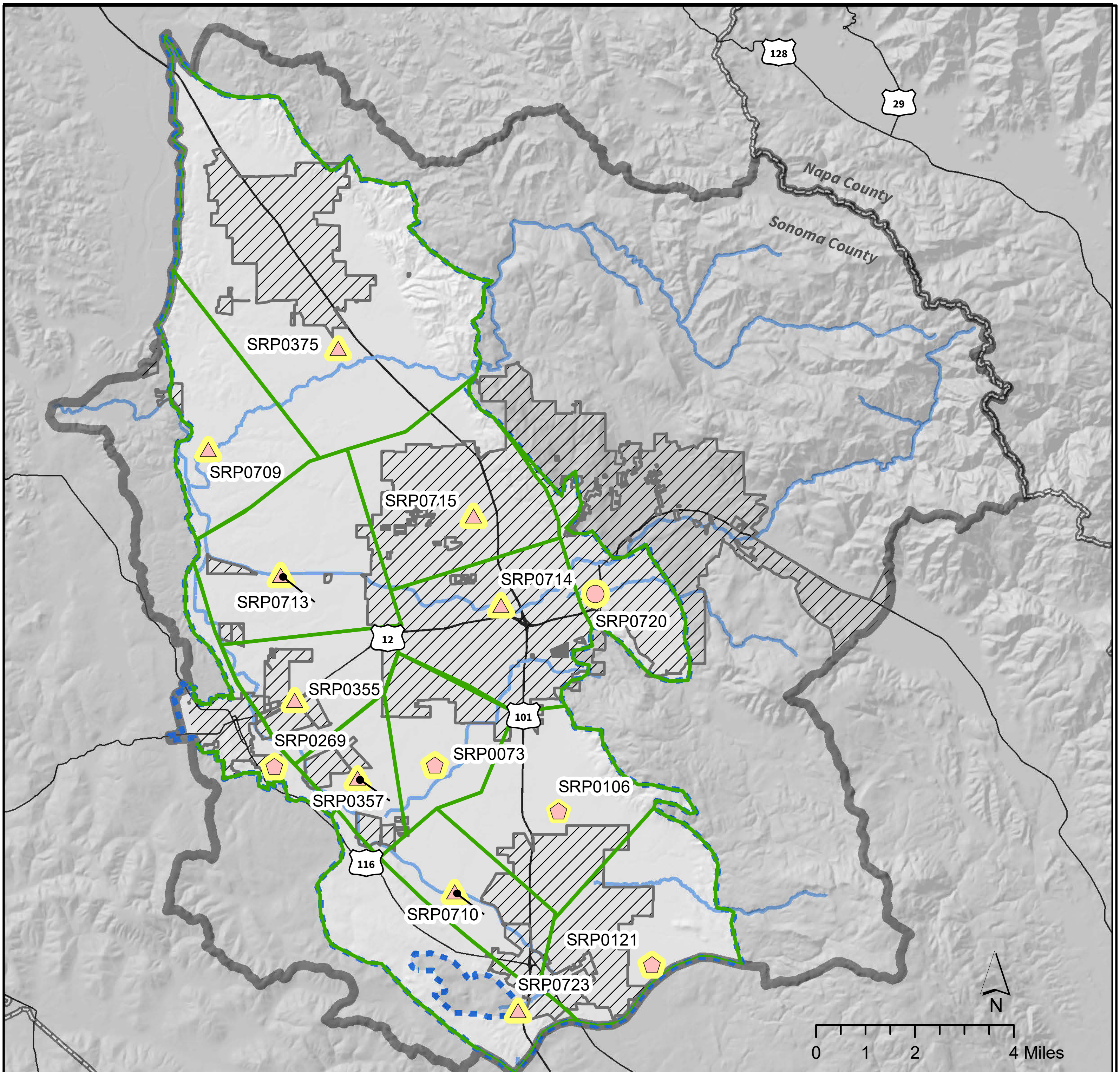


Figure 5-B-24

RMPs for Chronic Lowering of Groundwater Levels with Vicinity Areas used for Supply Well Statistic Calculations - Shallow Aquifer System

SANTA ROSA PLAIN GROUNDWATER SUSTAINABILITY AGENCY

Filepath: T:\mbuttress\SGMA Monitoring Networks\Santa Rosa Plain\SRP_Potential_RMPs_Shallow.mxd Date prepared: 11/5/2021

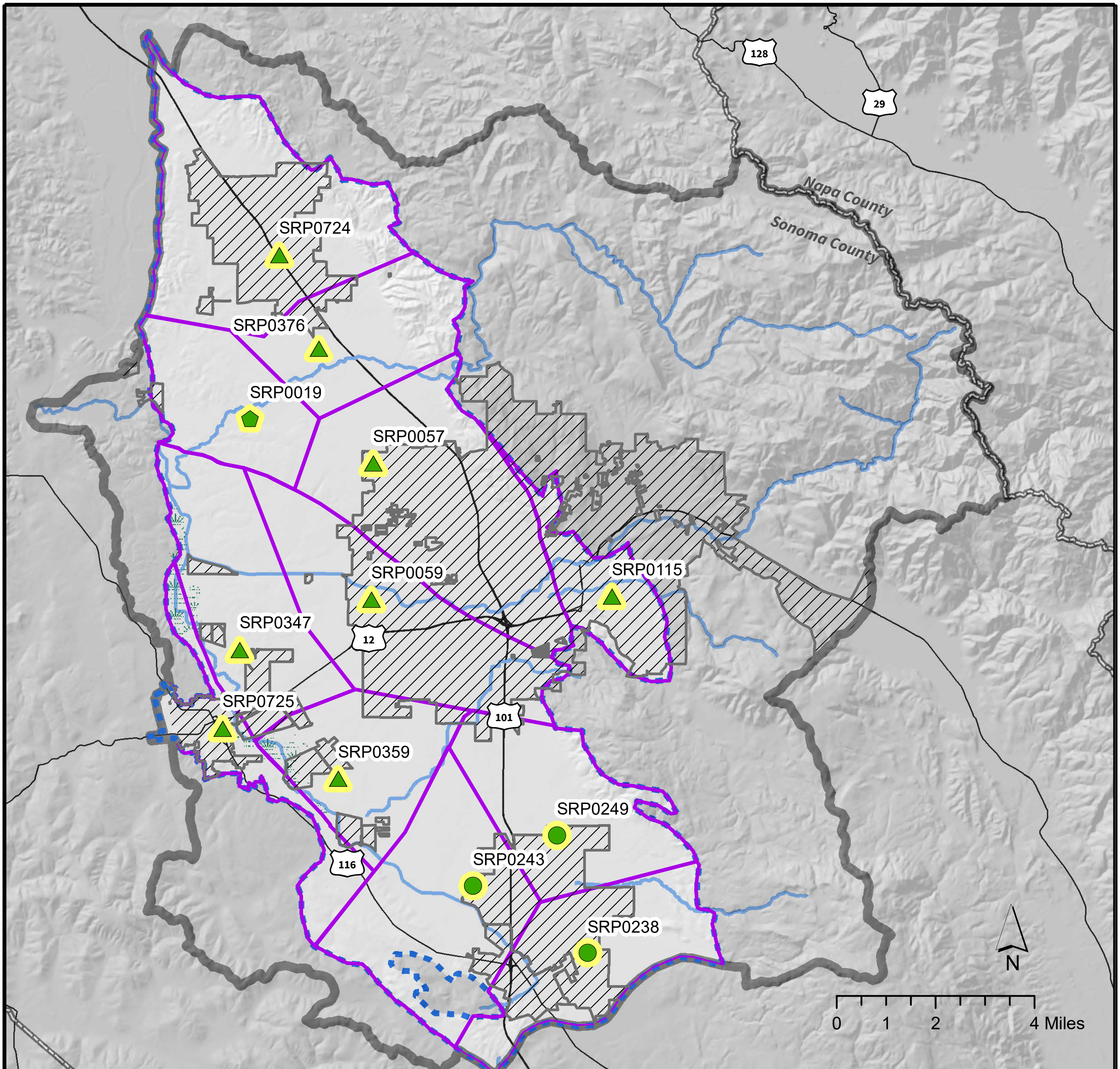


Figure 5-B-25

RMPs for Chronic Lowering of Groundwater Levels with Vicinity Areas used for Supply Well Statistic Calculations - Deep Aquifer System

RMPs - Dedicated Monitoring Wells	RMP Vicinity Areas/Santa Rosa Plain Groundwater Subbasin
RMPs - Municipal Supply Wells	Contributing Area Watershed
RMPs - Private Supply Wells	Major Rivers and Creeks
	City Footprints

SANTA ROSA PLAIN GROUNDWATER SUSTAINABILITY AGENCY

Filepath: T:\mbuttress\SGMA Monitoring Networks\Santa Rosa Plain\SRP_Potential_RMPs_Deep.mxd Date prepared: 11/5/2021

Table 5-B-1
Representative Monitoring Points for Chronic Lowering of Groundwater Levels with Supply Well Statistics - Shallow Aquifer System
Santa Rosa Plain Groundwater Subbasin

Data Management System ID						Data Record															
Station Name	Station Number	Type of Well	Well Depth (ft BTOC)	Screened Interval(s) (ft BTOC)	Current Monitoring Frequency	From	Until	Addditional Information	TOC Elevation* (ft MSL)	BOC Elevation* (ft MSL)	Well Owner	Well Screened in Single Aquifer?	Total Shallow Supply Wells in Vicinity Area[1]	98th Percentile Shallowest Supply Well in Vicinity Area[2] (ft BGS)	98th Percentile Shallowest Well with 10 ft Buffer Elev. at RMP (ft MSL)	95th Percentile Shallowest Supply Well in Vicinity Area[2] (ft BGS)	95th Percentile Shallowest Well with 10 ft Buffer Elev. at RMP (ft MSL)	90th Percentile Shallowest Supply Well in Vicinity Area[2] (ft BGS)	90th Percentile Shallowest Well with 10 ft Buffer Elev. at RMP (ft MSL)	Average Depth of Shallow Supply Wells in Vicinity Area[2] (ft BGS)
SRP0710	SRP-H18-02_Stony	Observation	45.5	35-45	Hourly	11/21/2019	Present	Laguna de Santa Rosa at Stony Point Rd.	89.02	43.52	SRPGSA	Yes	120	56	43.02	56	43.02	64	35.02	130
SRP0709	SRP-C09-01_River Rd	Observation	33.5	23-33	Hourly	11/25/2019	Present	Mark West Creek at River Rd.	70.39	36.89	SRPGSA	Yes	178	52	28.39	57	23.39	60	20.39	112
SRP0713	SRP-D11-02_Willow	Observation	45.5	25-45	Hourly	11/25/2019	Present	Santa Rosa Creek at Willowside Rd.	71.44	25.94	SRPGSA	Yes	490	48	33.44	52	29.44	60	21.44	110
SRP0714	SRP-H12-01_Pierson	Observation	51.5	41-51	Hourly	11/25/2019	Present	Santa Rosa Creek at Pierson St.	151.56	100.06	SRPGSA	Yes	424	44	117.56	48	113.56	52	109.56	91
SRP0715	SRP-H10-04_Hardies	Observation	40.5	30-40	Hourly	11/25/2019	Present	Paulin Creek at Hardies Ln.	136.34	95.84	SRPGSA	Yes	514	40	106.34	47	99.34	50	96.34	89
SRP0355	SCWA_SEB_MW_07	Observation	90	70-90	Hourly	2/14/2008	Present		81.46	-8.54	SCWA	Yes	390	45	46.46	50	41.46	58	33.46	102
SRP0357	SCWA_TODD_RED	Observation	80	60-80	Hourly	6/1/1977	Present		79.05	-0.95	SCWA	Yes	206	40	49.05	52	37.05	60	29.05	101
SRP0375	SCWA_Airport_MW_02	Observation	140	120-140	Hourly	4/29/2011	Present	385117N1227863W001, SRP-E07-02	121.6	-18.4	SCWA	Yes	821	50	81.6	59	72.6	64	67.6	114
SRP0720	Hoen Well	Municipal	115	?	Monthly	4/1/2005	11/8/2019		194.58	79.58	City of Santa Rosa	Yes	169	48	156.58	50	154.58	56	148.58	102
SRP0723	MW-114	Observation	?	?	Semi-Annual	5/30/2007	10/10/2019		223.29	Unknown	City of Santa Rosa	Yes	514	44	189.29	53	180.29	60	173.29	122
SRP0073	SRP-G15-01	Unknown	80	?	Semi-Annual	11/3/1989	3/21/2017	06N08W04Q001M	93.78	13.78	Private	Yes	252	40	63.78	44	59.78	55	48.78	103
SRP0106	SRP-J16-01	Unknown	90	?	Monthly	10/3/1989	2/9/2021	06N08W12M001M	101.6	11.6	Private	Yes	512	48	63.6	56	55.6	60	51.6	106
SRP0121	SRP-L19-01	Unknown	150	?	Monthly	11/9/1989	2/13/2020	06N07W30R001M	178.57	28.57	Private	Yes	150	65	123.57	78	110.57	84	104.57	149
SRP0269	WGFH-08	Unknown	160	100-160	Semi-Annual	5/23/2009	10/13/2019	383889N1228088W001	90.77	-69.23	Private	Yes	129	52	48.77	60	40.77	70	30.77	138

Notes
ft BTOC - Feet Below Top-of-Casing
TOC Elevation - Top-of-Casing Elevation
BOC Elevation - Bottom-of-Casing Elevation
* - Accuracy of Well Casing Elevation Data Varies. Top-of-Casing Elevations to be Surveyed in Accordance with SGMA Requirements.
ft MSL - Feet Above Mean Sea Level
ft BGS - Feet Below Ground Surface
1: Only Wells with Known Total Depth Used in Calculations. This Represents Only a Subset of All Supply Wells in the Subbasin
2: Statistics Calculated Using Only Supply Wells With Total Depths of 40 Feet or Greater
SCWA - Sonoma County Water Agency
SRPGSA - Santa Rosa Plain Groundwater Sustainability Agency

Table 5-B-2
Representative Monitoring Points for Chronic Lowering of Groundwater Levels with Supply Well Statistics - Deep Aquifer System
Santa Rosa Plain Groundwater Subbasin

Data Management System ID						Data Record																
Station Name	Station Number	Type of Well	Well Depth (ft BTOC)	Screened Interval(s) (ft BTOC)	Monitoring Frequency	From	Until	Addditional Information	TOC Elevation* (ft MSL)	BOC Elevation* (ft MSL)	Well Owner	Well Screened in Single Aquifer?	Total Deep Supply Wells in Vicinity Area[1]	Shallowest Deep Zone Supply Well in Vicinity Area[2] (ft BGS)	98th Percentile Shallowest Deep Zone Supply Well in Vicinity Area[3] (ft BGS)	98th Percentile Shallowest Well with 50 ft Buffer Elev. at RMP (ft MSL)	95th Percentile Shallowest Deep Zone Supply Well in Vicinity Area[3] (ft BGS)	95th Percentile Shallowest Well with 50 ft Buffer Elev. at RMP (ft MSL)	90th Percentile Shallowest Deep Zone Supply Well in Vicinity Area[3] (ft BGS)	90th Percentile Shallowest Well with 50 ft Buffer Elev. at RMP (ft MSL)	Average Depth of Deep Supply Wells in Vicinity Area (ft BGS)
SRP0359	SCWA_TODD_WHITE	Observation	257	237-257	Hourly	8/2/1979	Present		79.05	-177.95	SCWA	Yes	79	250	252	-122.95	252	-122.95	260	-130.95	411
SRP0347	SCWA_OCC_MW_04	Observation	300	?	Hourly	6/28/2010	Present		95.4	-204.6	SCWA	Unknown	152	211	231	-85.6	231	-85.6	250	-104.6	414
SRP0376	SCWA_Airport_MW_03	Observation	360	340-360	Hourly	4/25/2011	Present	CASGEM ID: 385117N1227863W002, SRP-E07-03	121	-239	SCWA	Yes	98	208	208	-37	245	-74	249	-78	450
SRP0115	SRP-K12-04	Observation	870	500-860	Sub-Daily	4/22/2010	Present	MARTHA WAY	215.71	-654.29	City of Santa Rosa	Yes	81	240	240	25.71	240	25.71	255	10.71	415
SRP0057	SRP-F09-02	Observation	360	200-350	Sub-Daily	5/20/2011	Present	NORTHWEST VILLAGE	141.57	-218.43	City of Santa Rosa	Yes	155	220	250	-58.43	263	-71.43	276	-84.43	457
SRP0059	SRP-F12-01	Observation	694	199-684	Sub-Daily	5/20/2011	Present	PLACE TO PLAY	101.32	-592.68	City of Santa Rosa	No	133	212	213	-61.68	225	-73.68	250	-98.68	418
SRP0238	SRP-K19-01	Municipal	380	130-380	Sub-Daily	11/1/1991	Present	CASGEM ID: 383350N1226841W001, RP Well 37	128.18	-251.82	City of Rohnert Park	No	232	230	230	-51.82	243	-64.82	250	-71.82	444
SRP0249	SRP-J17-01	Municipal	462	302-462	Sub-Daily	9/1/1980	Present	CASGEM ID: 383694N1226960W001, RP Well 17	103.35	-358.65	City of Rohnert Park	Yes	183	230	250	-96.65	250	-96.65	290	-136.65	441
SRP0243	SRP-H18-01	Municipal	582	258-582	Sub-Daily	3/1/1982	Present	CASGEM ID: 383544N1227271W001, RP Well 24	90.74	-491.26	City of Rohnert Park	Yes	307	219	224	-83.26	230	-89.26	243	-102.26	384
SRP0724	Windsor_Bluebird	Municipal	765	695-745	NM	NM	NM	BLUEBIRD WELL	118.75	-646.25	Town of Windsor	Yes	197	208	216	-47.25	225	-56.25	240	-71.25	406
SRP0725	Sebastopol Well #5	Municipal	528	138-528	Sub-Daily	2/1/2007	Present		85.14	-442.86	City of Sebastopol	No	215	219	220	-84.86	227	-91.86	240	-104.86	308
SRP0019	SRP-D08-02	Unknown	1048	?	Monthly	3/16/1976	2/5/2020	08N09W36P001M	93.62	-954.38	Private	Unknown	123	221	235	-91.38	250	-106.38	255	-111.38	461

Notes
ft BTOC - Feet Below Top-of-Casing
TOC Elevation - Top-of-Casing Elevation
BOC Elevation - Bottom-of-Casing Elevation
* - Accuracy of Well Casing Elevation Data Varies. Top-of-Casing Elevations to be Surveyed in Accordance with SGMA Requirements.
ft MSL - Feet Above Mean Sea Level
ft BGS - Feet Below Ground Surface
1: Only Wells with Known Total Depth Used in Calculations. This Represents Only a Subset of All Supply Wells in the Subbasin
2: Shallowest Supply Well with More than Half of Screened Interval Below 200 feet BGS
3: Determined by Calculating the 98th Percentile (from Deepest to Shallowest) of the Total Depth Values for all Supply Wells with More than Half of Screened Interval Below 200 feet BGS within a Vicinity Area
SCWA - Sonoma County Water Agency
NM - Not Currently Monitored

.

Appendix 6-A
Simulation of Projects and Management Actions for the Santa Rosa Plain Groundwater Sustainability Plan

Appendix 6-A

Simulation of Projects and Management Actions for the Santa Rosa Plain Groundwater Sustainability Plan

Table of Contents

Tables

Figures

1 INTRODUCTION

The purpose of this appendix is to describe the modifications to the future baseline predictive groundwater model used to simulate potential projects and management actions (PMAs). The proposed PMAs for the Santa Rosa Plain Subbasin are selected to address areas experiencing groundwater level declines and potential undesirable results. The various PMAs are intended to prevent undesirable results from occurring. PMAs for the Santa Rosa Plain subbasin include reductions in rural-domestic pumping, reductions of vineyard consumptive use, aquifer storage and recovery (ASR) and managed aquifer recharge (MAR) of surface water diversions.

2 PROJECT ASSUMPTIONS FOR FUTURE SIMULATIONS

PMAs are divided into three model simulations: Group 1, Group 2 and Group 3. Each PMA simulation builds upon the future baseline simulation (GSP Water Budget, Section 3) by adding water conservation measures and supplemental supply. The future baseline scenario runs from water year 2021 through water year 2070 and uses the SRPHM numerical flow model with projected land use changes, population growth and climate change. Climate change is simulated using the RCP8.5 scenario of the HadGEM2-ES climate model. To observe the incremental improvements from adding additional water management measures, each successive PMA builds upon the previous simulation, i.e., Group 3 contains all the PMAs in Group 1 and Group 2, and Group 2 simulations include Group 1 PMAs.

2.1 Description of Projects

2.1.1 Group 1

The Group 1 project scenario builds upon the future baseline scenario by adding reductions in water use for rural domestic water users and reductions in vineyard consumptive use.

The Group 1 scenario simulates the impacts of a 20% reduction in all rural domestic use and a 10% reduction in consumptive use for all vineyards, both beginning in 2025.

2.1.2 Group 2

The Group 2 projects implement .

Group 2: The Group 2 scenario builds upon the assumptions used for the Group 1 scenario but also includes stormwater capture for managed aquifer recharge (MAR). Figure 1 shows the location of the Group 2 projects along the lower Mark West Creek. MAR locations were selected based on identifying simulated irrigated agricultural model cells principally downslope of the diversion location selected. There are 184 model cells, or 1,840 acres, that receive equal amounts of diverted water. A 200 AF diversion that is engineered to infiltrate over 1,840 acres of a month results in an infiltration rate of 0.04 inches per day. Such a rate would likely be feasible for a managed aquifer recharge project (Beganskas and Fisher, 2017; Dahlke et al,). Conceptually the diverted water would be recharged via flooding of the vineyards. The amount of stormwater available for diversion was calculated by:

1. Calculating the 90th percentile flow for the diversion location based on simulated monthly streamflow.
2. If a given winter month (December – March) exceeded the 90th percentile flows, 20% of the flow could be collected as stormwater. Diversion volumes were limited to 200 AF per month, or about 3.3 CFS, to incorporate engineering and diversion limitations.

Figure 2 shows the simulated discharge at the diversion location along with the diversions and cumulative diversions for the 50-year simulation period. A total of 12,000 AF are diverted and recharged during the simulation period. The average annual stormwater diversion for Mark West Creek is approximately 240 AFY. From WY 2021 to WY 2052 about 10,400AF of water is diverted and recharged, whereas for the last 17 years only 1,700AF is water diverted. A five-year period starting in WY 2052 experiences zero diversions, followed by a period 10-year period of either zero or 200AFY of diversions (Figure 3).

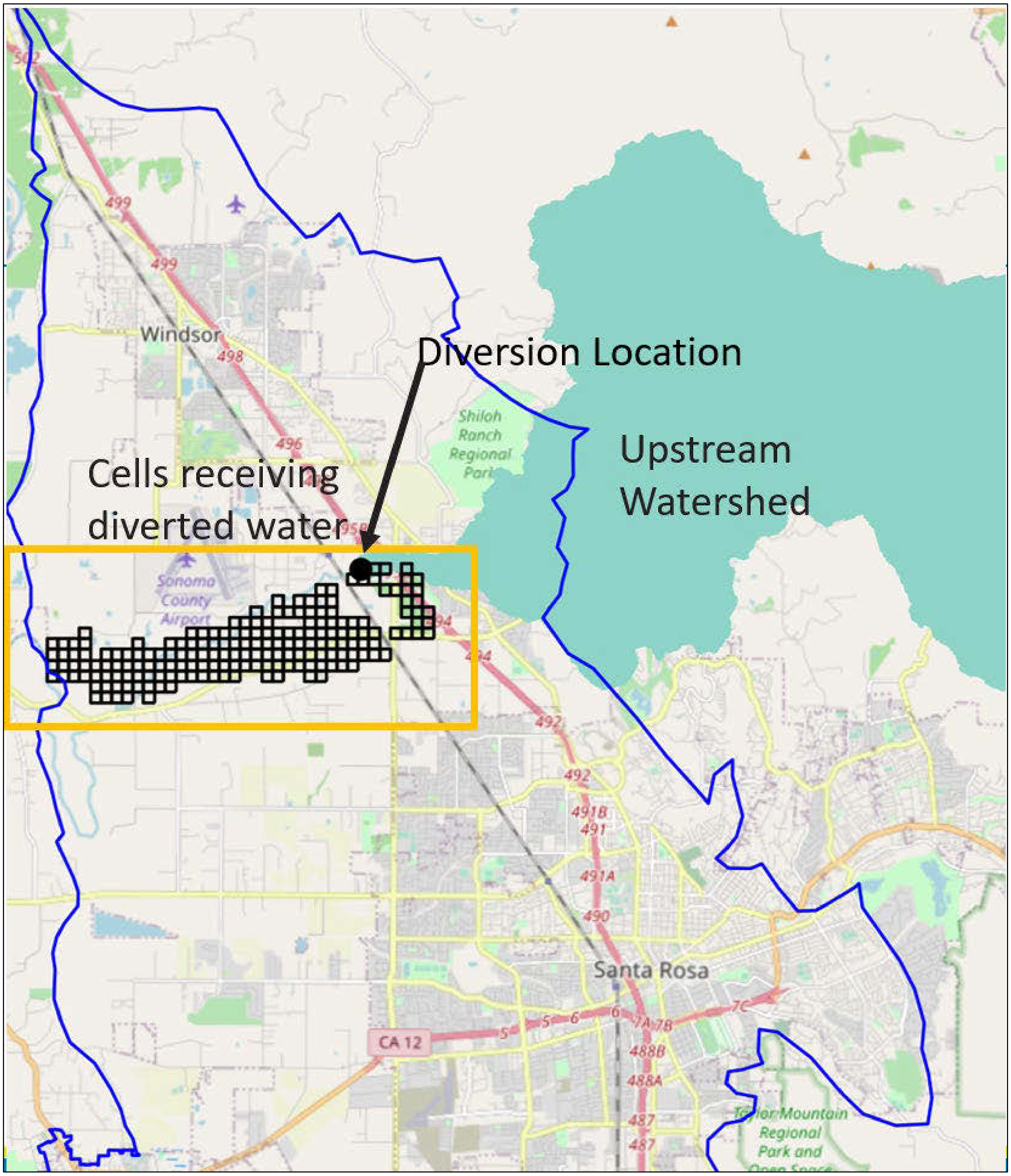


Figure 1. Group 2 Scenario Model PMA Locations

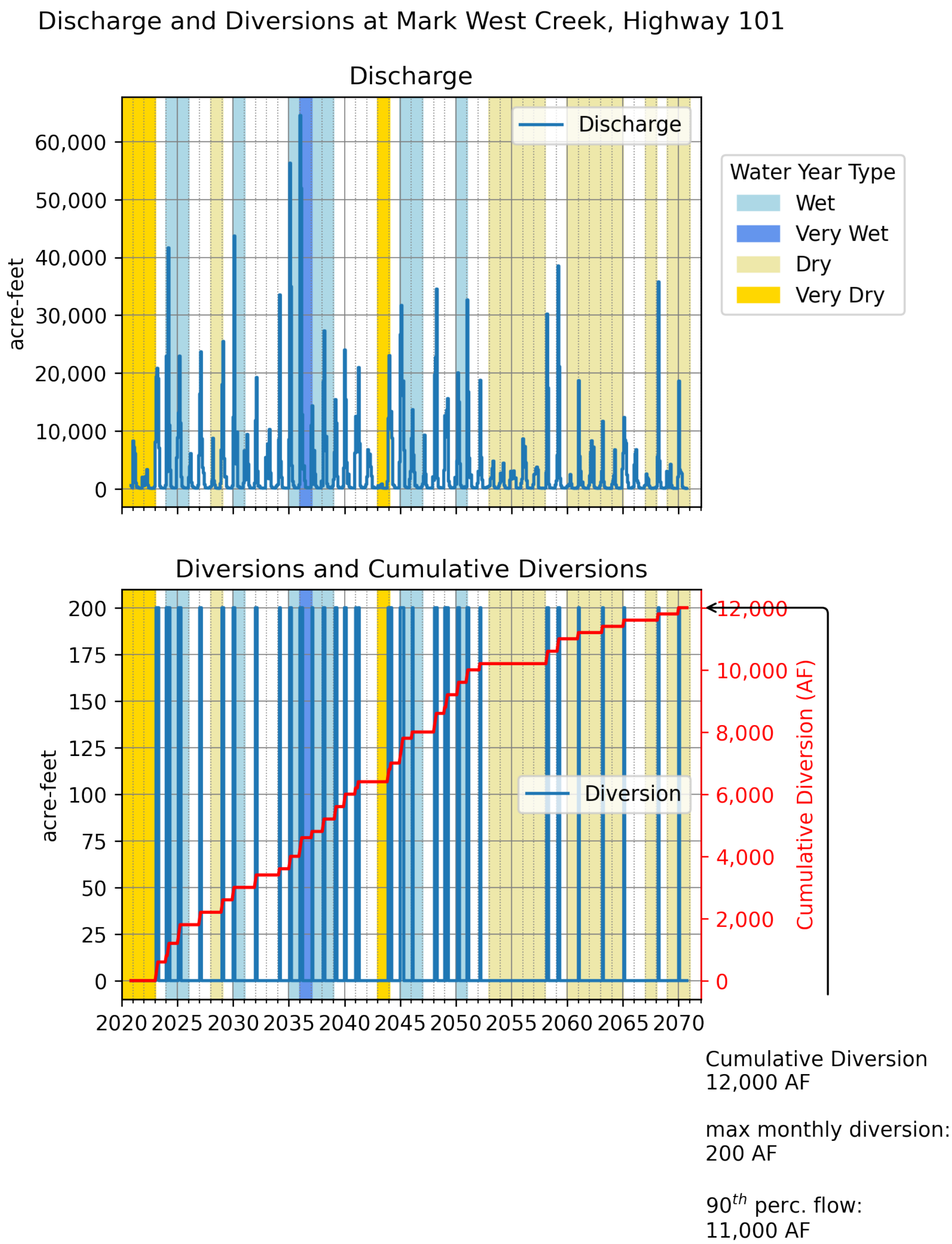
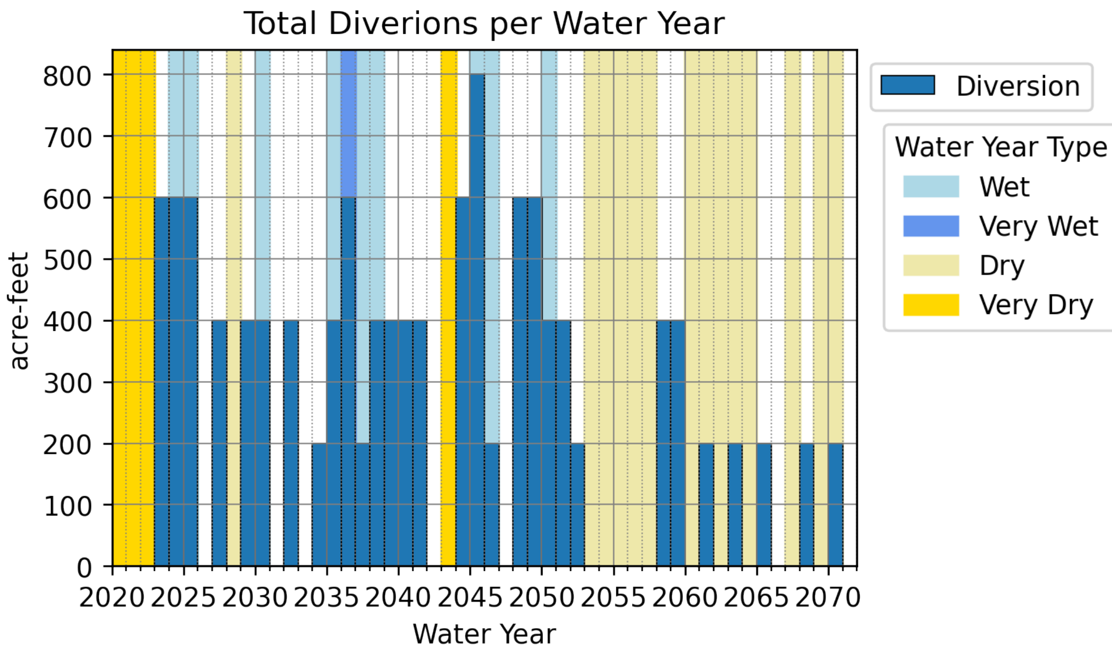


Figure 2. Monthly Diversion and Stormwater Capture in Group 2 Simulation



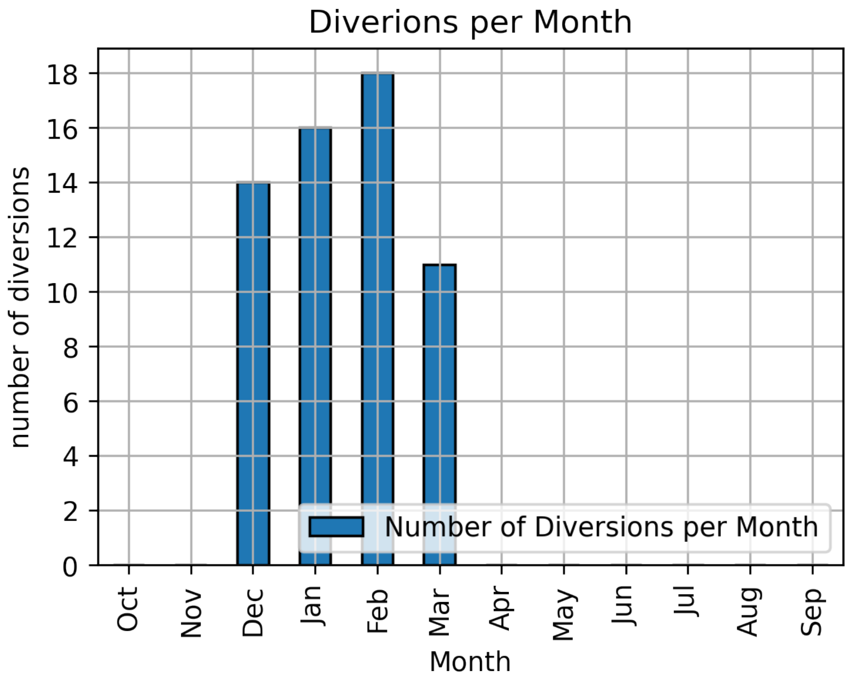


Figure 3 Total Yearly Diversions and Diversions Per Month, Group 2 Scenario

2.1.3 Group 3

Aquifer storage and recovery projects are implemented in the Group 3 scenario. There are 5 wells that are used for the project (Figure 4). They are assumed to receive Russian River water and will inject continuously from November to April. Injection will occur at wells belonging to the Sonoma County Water Agency, City of Santa Rosa, Town of Windsor, Rohnert Park, and City of Cotati. Once the wells are online, yearly injection will total 940AFY, with the well belonging to the Sonoma County Water Agency accounting for 53% of the total. Recovery of injected water will occur via normal operations simulated in the Projected Baseline Simulation.

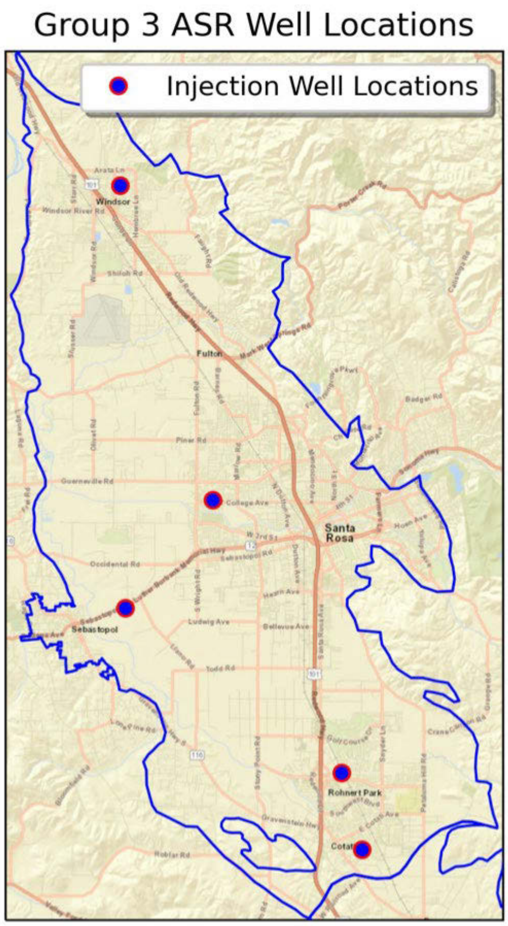


Figure 4 Location of Injection Wells for Group 3 Scenario

2.2 Implementation of Projects in Model

In each PMA scenario, each type of project is implemented in the model in the same way.

Crop Consumptive Use: Crop consumptive use reductions are simulated by reducing crop coefficients (K_c) by 10% during the growing season, beginning in water year 2025. This has the effect of lowering the potential evapotranspiration. As a result, the AG package calculates lower groundwater pumping to meet crop demand.

Rural Domestic Pumping: Rural domestic pumping reductions are simulated by rescaling specified pumping rates. From WY 2025 until the end of the simulation, the rural domestic pumping rates are reduced by 20%. These declines in water use are assumed to occur via reductions in outdoor water use only. Because indoor water does not decline, septic return flows are assumed to remain the same as those of the Projected Baseline simulation.

Stormwater Manager Aquifer Recharge: In the Group 2 scenario, MAR of stormwater is simulated by adding water to the soil zone. The stormwater is recharged to the soil zone by adding it to the external water source option in the Precipitation and Runoff Module System component of GSFLOW. Water applied to the soil zone may be consumed by evapotranspiration or it may be lost through runoff or other soil zone processes, instead of becoming recharge to the underlying groundwater system. The diverted water is applied evenly to each of the model cells for the period in which the water was diverted.

Aquifer Storage and Recovery: The Group 3 scenario simulates ASR injection at both new and existing wells. Injection is simulated using the Multi-Node, Drawdown-Limited Well Package (MNW1) package. Table 1 lists the ASR wells for the Group 3 simulation and how the well is simulated in the model.

Table 1. ASR Well Simulation Method

Well	Model Layer(s)	Existing Well
Sonoma County Water Agency	6, 7	yes
Town of Windsor	4	no
Santa Rosa	4	no
Rohnert Park	4, 5, 6	yes
City of Cotati	3, 4, 5	yes

3 SIMULATION RESULTS

This section contains an overview of key water budget components, hydrographs of representative monitoring point (RMP) wells and projected groundwater elevation benefits.

3.1 Simulated Project Yields

Table 2 shows the simulated project yields for each simulation, for each project category. Volumes added by each project are added to the previous simulation.

Table 2. Simulated Project Yields

Project	Group 1	Group 2	Group 3
Reduce Crop Consumptive Use	Averages 1,200 AFY less agricultural pumping than baseline simulation	Same as Group 1	Same as Group 1
Reduce Rural Domestic Pumping	Averages 600 AFY less pumping than the baseline simulation	Same as Group 1	Same as Group 1
Stormwater Managed Aquifer Recharge	None	Average deliveries of 240 AFY	Same as Group 2
Aquifer Storage and Recovery	None	None	940 AFY

3.2 Groundwater Budget

Each simulation contains the PMAs used in the previous simulation – Group 2 simulations include PMAs from Group 1, and Group 3 simulations include PMAs from Group 1 and Group 2. As a result of this sequential modeling process, each simulation shows a progressive improvement in storage change over the simulation. Figure 5 shows cumulative change in storage for the future baseline, Group 1, Group 2 and Group 3 scenarios. Table 3 shows the average annual change in storage for each for the four simulations, rounded to the nearest 100 AFY. Implementation of each Scenario causes a reduction in total groundwater storage decline. Group 1 results in the greatest reduction in total storage decline. Despite the injection of 940 AFY in Group 3, there is only minor benefit to groundwater storage in this scenario. This occurs because a number of fluxes offset the increased inflows. Group 3 groundwater budget shows reduced groundwater recharge, increased groundwater ET, increased stream leakage, and increased surface leakage, compared to Group 2.

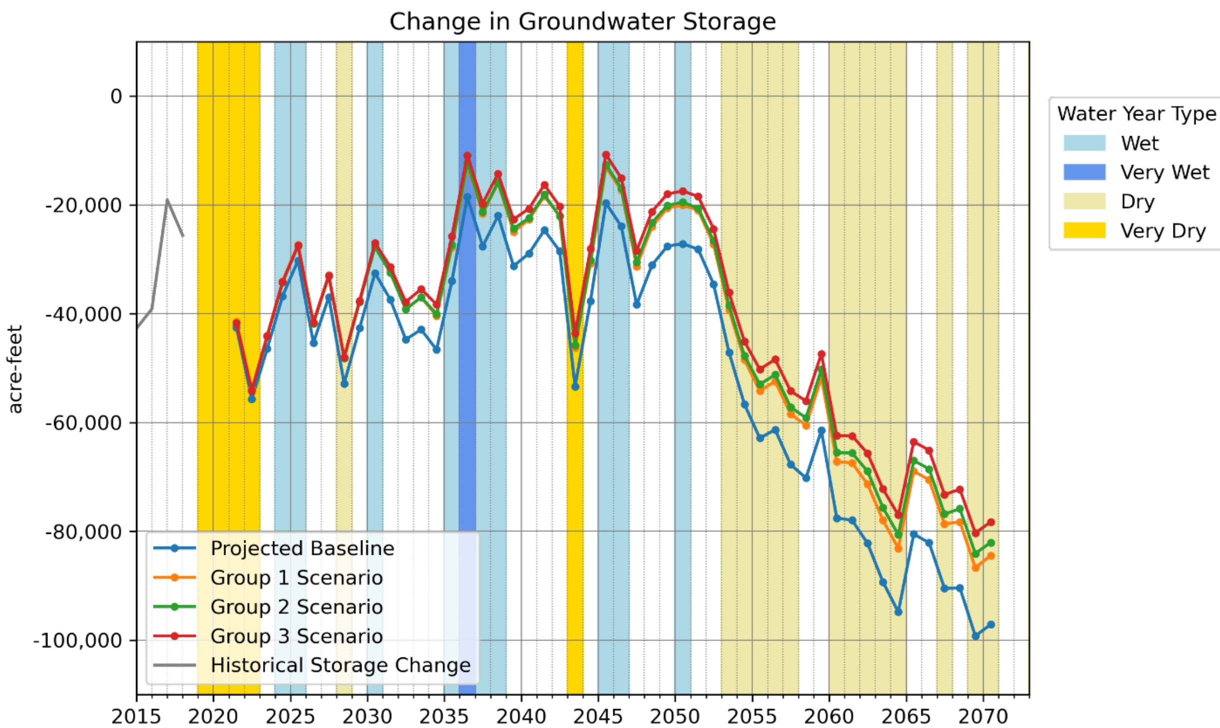


Figure 5. Projected Annual Cumulative Change in Storage for Model Scenarios

Table 3. Average change in groundwater storage for each scenario by period.

Average annual change in groundwater storage (AFY)	Baseline	Group 1	Group 2	Group 3
2021 – 2070	-1,400	-1,200	-1,100	-1,100

Figure 6 shows the impact of each project scenario on net stream leakage. Table 4 shows average annual net stream leakage for each simulation. Negative values indicate net leakage from surface water to groundwater, positive values indicate net leakage from groundwater to surface water. Results show that with Group 1, Group 2, and Group 3 projects, there is a projected reduction in net streamflow depletion due to reduced pumping and increased recharge. Group 2 is slightly more negative than Group 1 likely due to increased runoff to streams and greater stream leakage to groundwater. Figure 7 shows the impact of Group 2 projects on summertime streamflow in the Group 2 project area. Along lower Mark West creek summertime discharges increase up to 10% more than the Baseline due to the implementation of Group 2 projects.

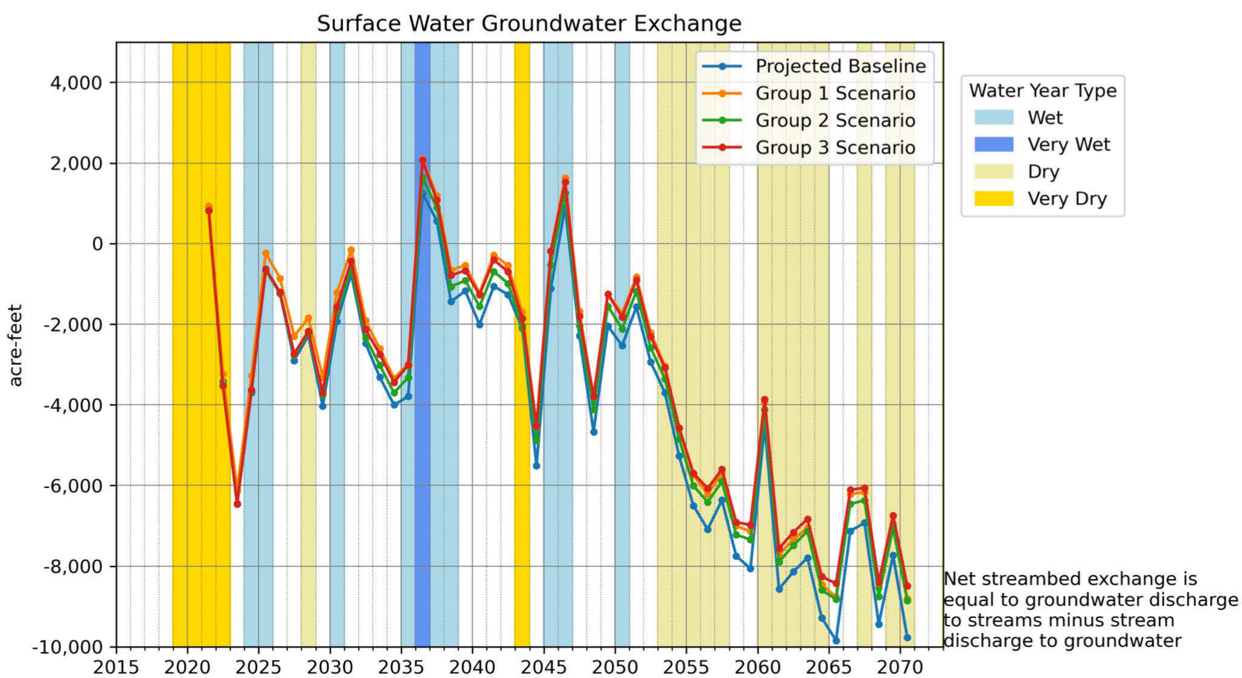


Figure 6. Impact of PMA's on Net Streambed Exchange

Table 4. Average annual net stream leakage by period

Mean Net Stream Leakage (AFY)	Baseline	Group 1	Group 2	Group 3
2021 – 2070	-4,100	-3,400	-3700	-3,400

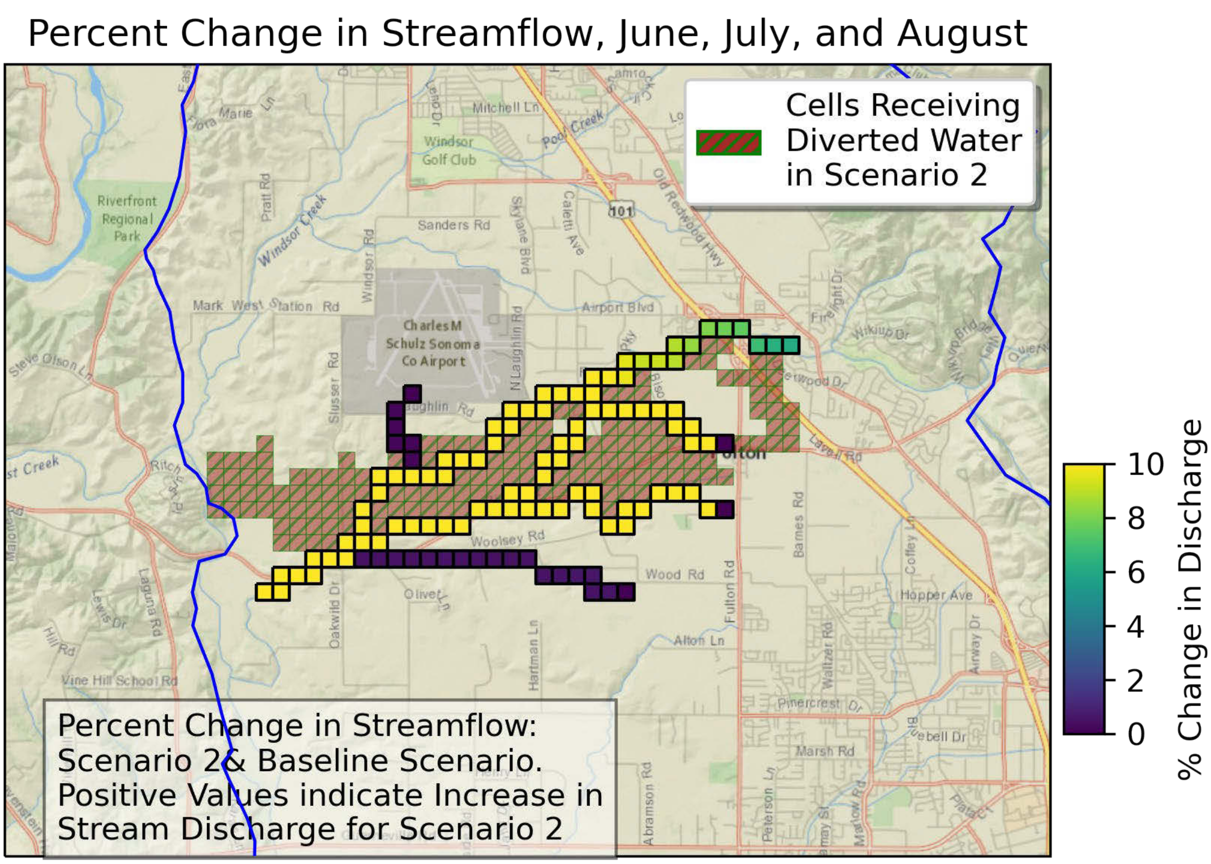


Figure 7 Change in Summer Streamflow Due to Implementation of Group 2

Figure 8 shows the groundwater pumpage for each of the scenarios by water use sector.

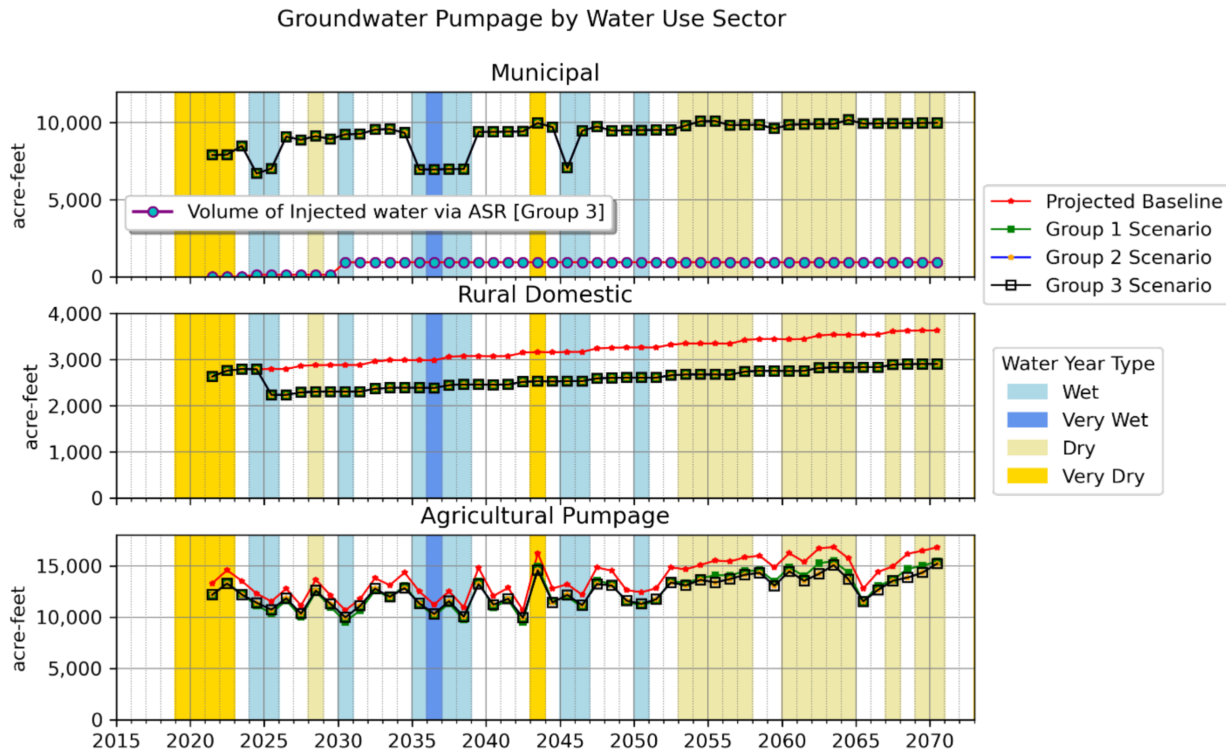


Figure 8 Groundwater Pumpage by Water Use Sector for all Scenarios

3.3 Groundwater Elevations

Simulated monthly water levels for Santa Rosa Plain were compared to equivalent measured monthly water levels for the most recent part of the historical record (usually 2017-2018). The difference between measured and simulated water levels during those most recent years were then averaged to derive an offset for each RMP well. The offset was applied to the future simulated dataset to generate a dataset of adjusted projected annual water levels for the future. All projected water levels shown in hydrographs in this appendix are annual average water levels.

For each simulation, adjusted projected water levels at RMP wells (Figure 9) were compared against measurable objectives (MO) and minimum thresholds (MT). Figure 10 shows an example water level hydrograph for the shallow RMP Well SRP0106. The groundwater elevation of the baseline and all group scenarios for SRP0106 is above the MT for the entire projected water budget period.

Figure 11 shows an example water level hydrograph for deep RMP Well SRP0376. In this case, the baseline scenario RMP first experiences MT exceedances in the mid 2030's, and then continuously starting in 2043. Primarily through the implementation of the Group 1 PMA's, the SRP0376 RMP does not begin to experience MT exceedances until 2052, at which point exceedances occur continuously until 2070.

Appendix 6-A-1 shows hydrographs for each scenario for the remaining shallow and deep RMP wells and the corresponding MO and MT for that well.

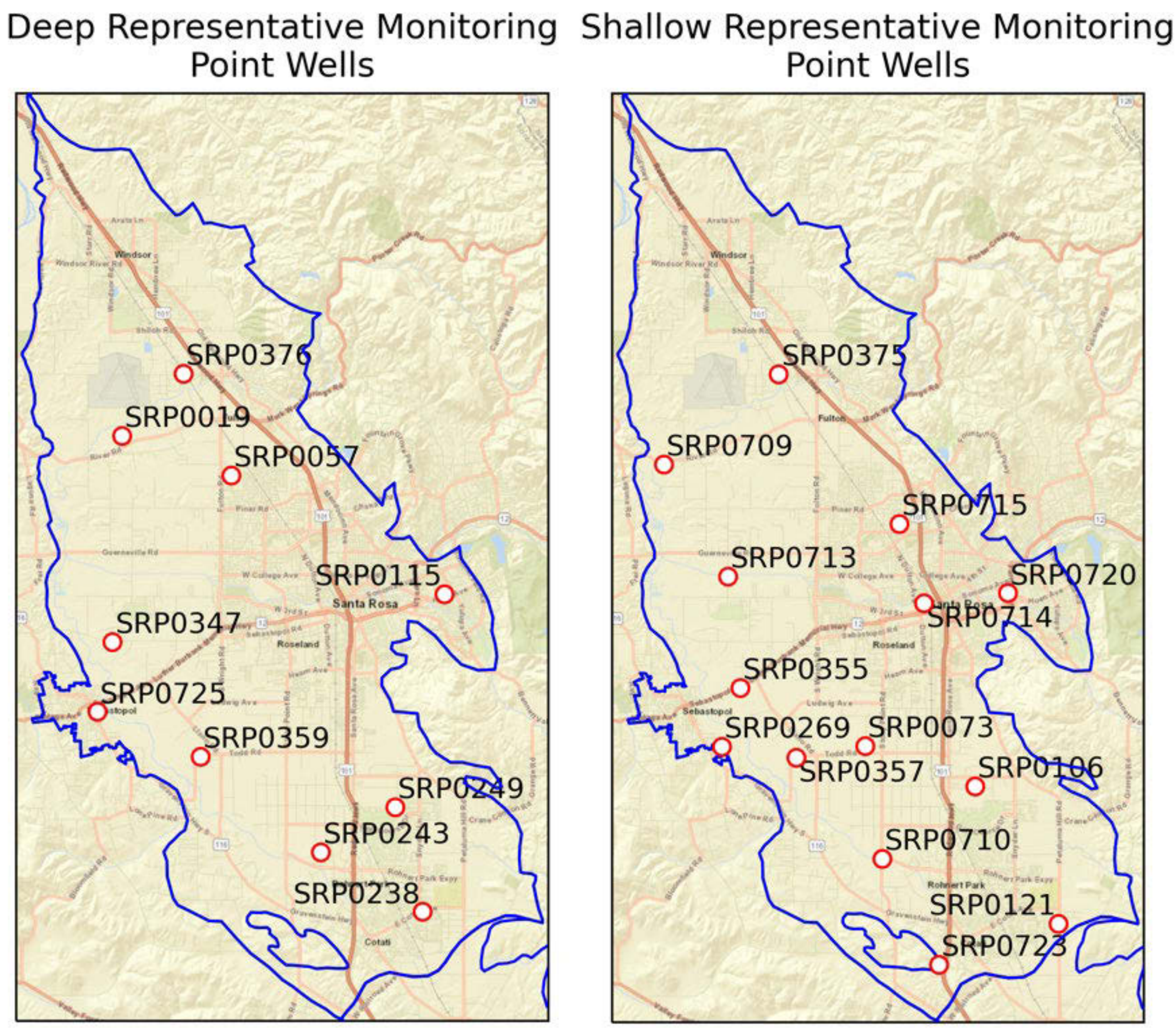


Figure 9 Representative Monitoring Point locations

.

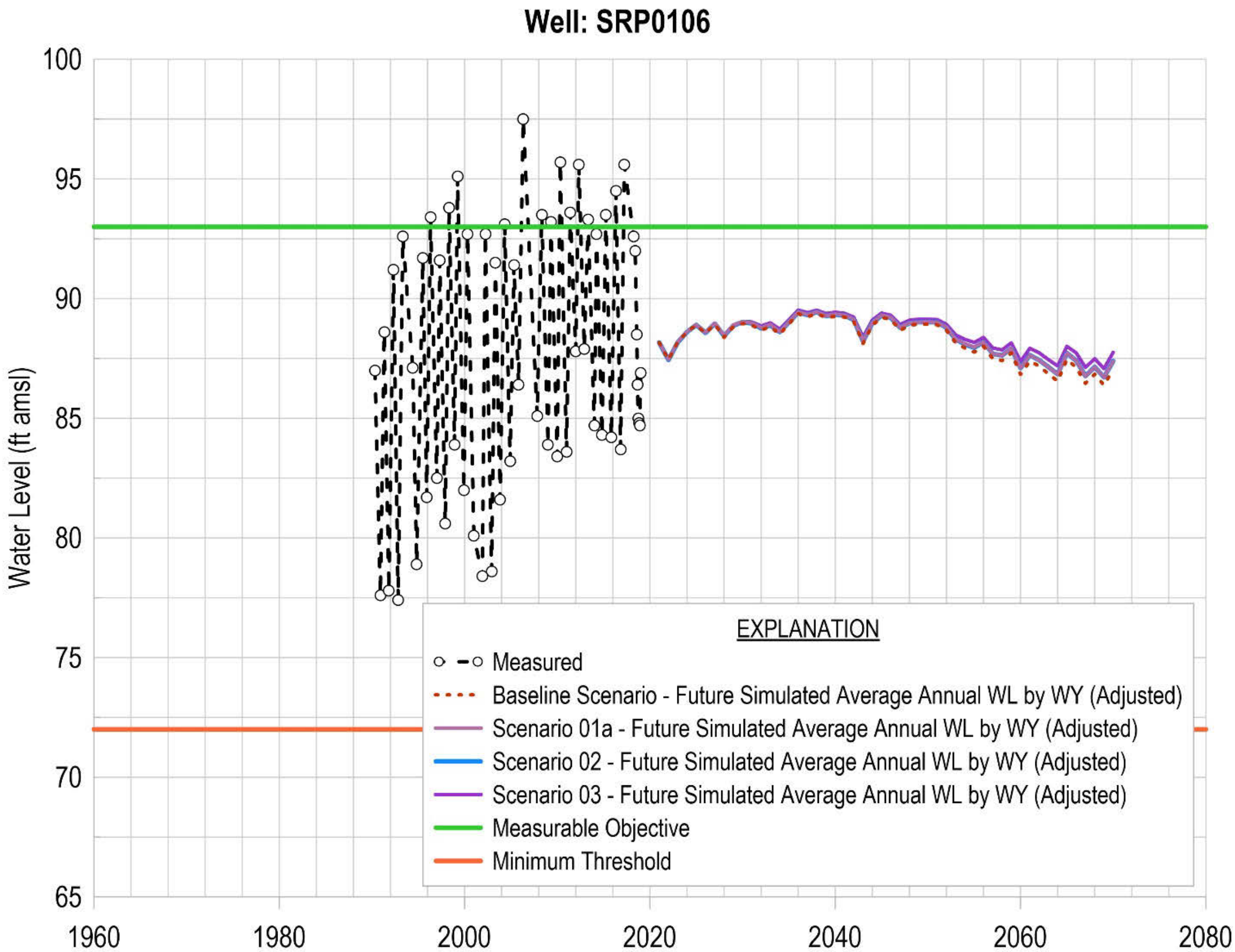


Figure 10. Water Level Hydrograph for Shallow RMP Well SRP0106

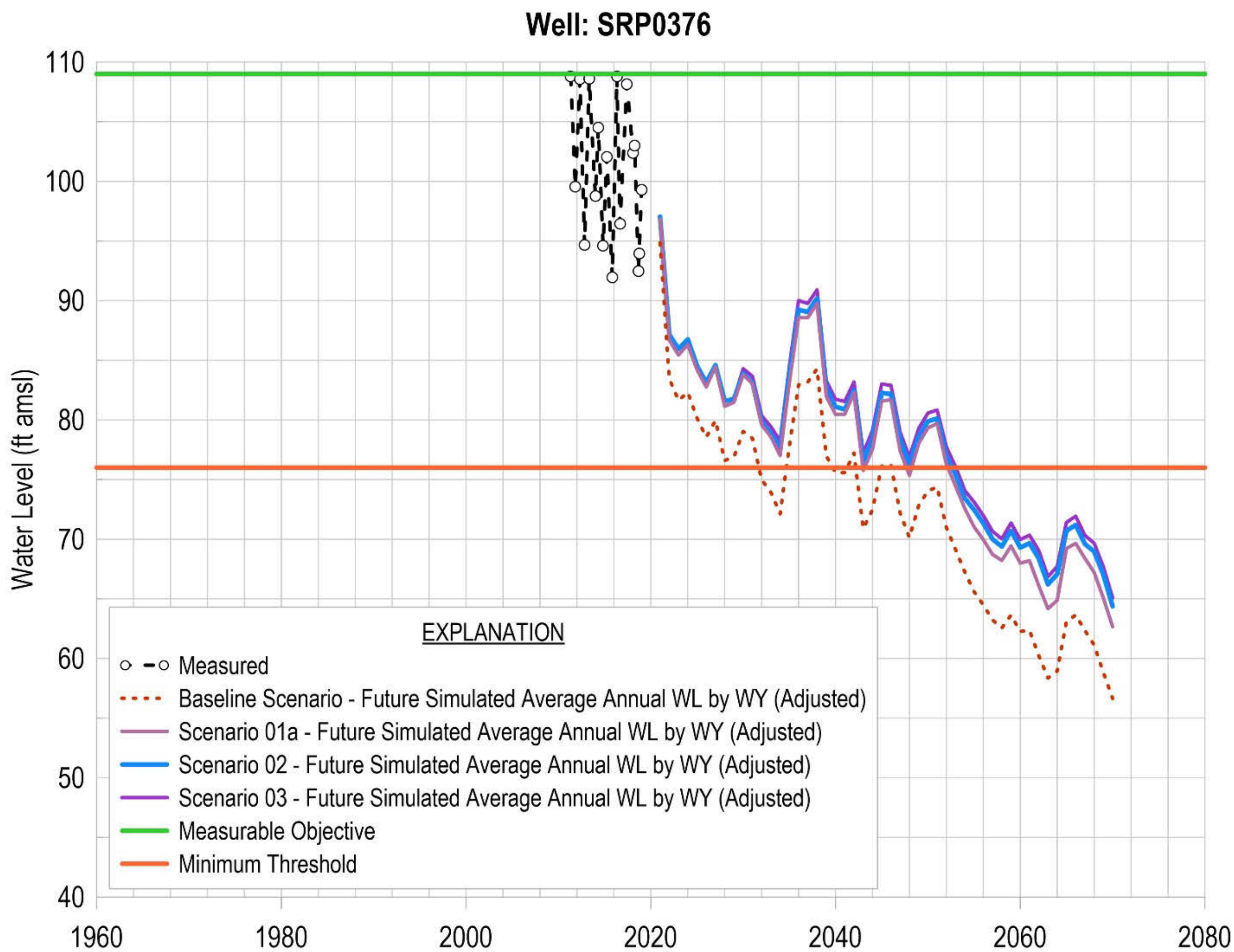


Figure 11. Water Level Hydrograph for Deep RMP Well SRP0376

Table 5 and Table 6 display the number of years where water levels are below the minimum threshold for shallow and deep RMP wells, respectively. These values are summarized in Table 7. The number of MT exceedances for each well depth category and scenario are plotted in Figure 12 and Figure 13. As additional projects are added for each simulation, the number of years with MT exceedances decreases for each time period. Implementation of Group 1 results in greatest decline in MT exceedances, whereas implementation of Group 3 results in a minimal decrease of MT exceedances, changing from 19 to 18 exceedances, compared to Group 2.

Table 5. Number of Years with Water Levels Below Minmum Threshold for Shallow RMP Wells

RMP Well	Baseline		Group 1		Group 2		Group 3	
	2021 - 2040	2041-2070	2021 - 2040	2041-2070	2021 - 2040	2041-2070	2021 - 2040	2041-2070
SRP0121	0	0	0	0	0	0	0	0
SRP0720	0	0	0	0	0	0	0	0
SRP0269	0	0	0	0	0	0	0	0
SRP0355	0	0	0	0	0	0	0	0
SRP0723	0	0	0	0	0	0	0	0
SRP0073	0	0	0	0	0	0	0	0
SRP0106	0	0	0	0	0	0	0	0
SRP0357	0	0	0	0	0	0	0	0
SRP0375	0	4	0	0	0	0	0	0
SRP0709	0	0	0	0	0	0	0	0
SRP0710	0	0	0	0	0	0	0	0
SRP0713	0	0	0	0	0	0	0	0
SRP0714	0	0	0	0	0	0	0	0
SRP0715	0	0	0	0	0	0	0	0

Table 6. Number of Years with Water Levels Below Minimum Threshold for Deep RMP Wells

RMP Well	Baseline		Group 1		Group 2		Group 3	
	2021 - 2040	2041-2070	2021 - 2040	2041-2070	2021 - 2040	2041-2070	2021 - 2040	2041-2070
SRP0238	0	0	0	0	0	0	0	0
SRP0243	0	0	0	0	0	0	0	0
SRP0249	0	0	0	0	0	0	0	0
SRP0347	0	0	0	0	0	0	0	0
SRP0359	0	0	0	0	0	0	0	0
SRP0019	0	16	0	4	0	0	0	0
SRP0115	0	0	0	0	0	0	0	0
SRP0376	4	27	0	20	0	18	0	17
SRP0724	0	0	0	0	0	0	0	0
SRP0725	0	0	0	0	0	0	0	0
SRP0057	0	15	0	2	0	1	0	1

Table 7 Summary of Waterlevel exceedances by depth and period

		Number of years with projected WL below MT	
	Depth	**Deep**	**Shallow**
Period	**Scenario**		
2021 - 2040	**Scenario - Baseline**	4	0
	Scenario - Group 1	0	0
	Scenario - Group 2	0	0
	Scenario - Group 3	0	0
2040 - 2070	**Scenario - Baseline**	58	4
	Scenario - Group 1	26	0
	Scenario - Group 2	19	0
	Scenario - Group 3	18	0

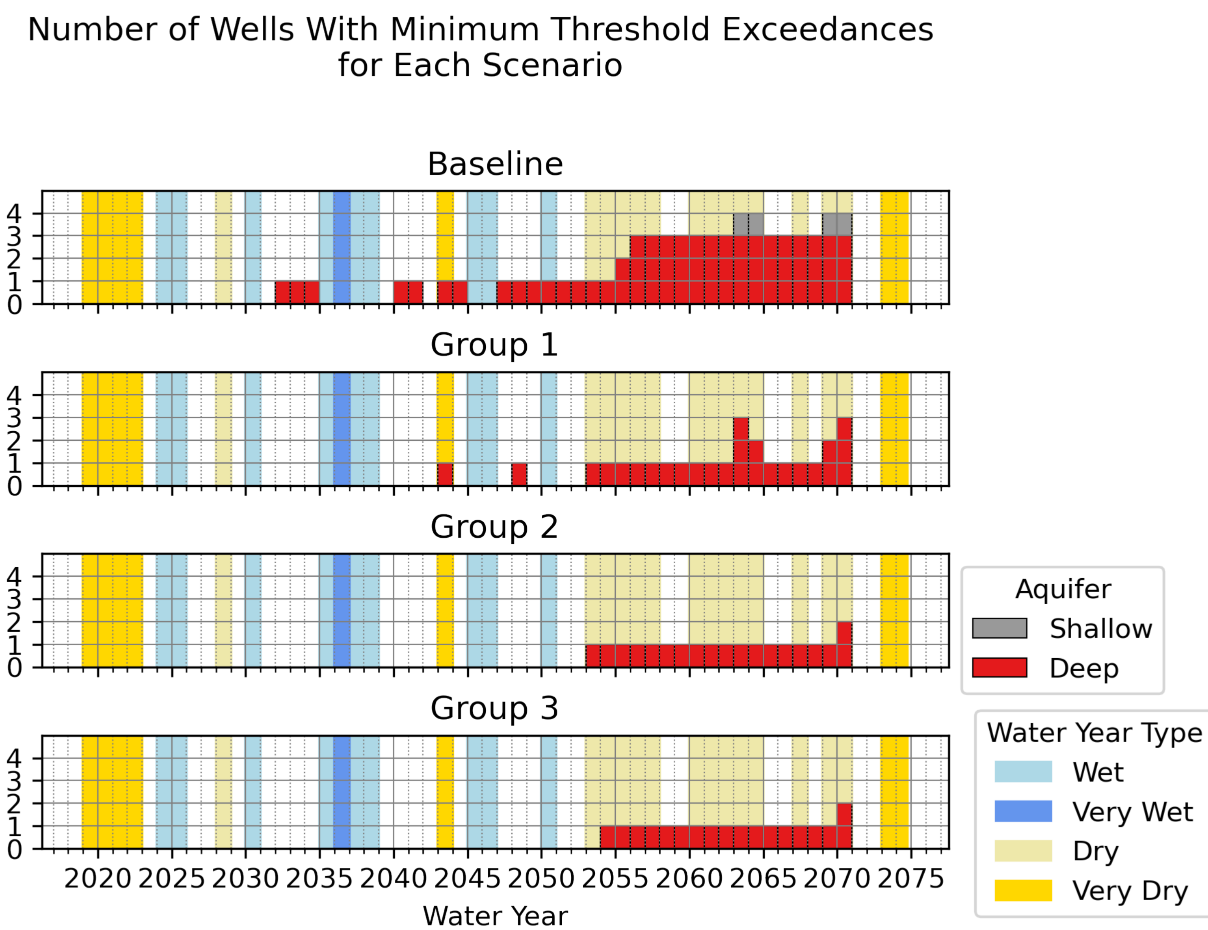


Figure 12. Number RMP of Wells Below Minimum Threshold

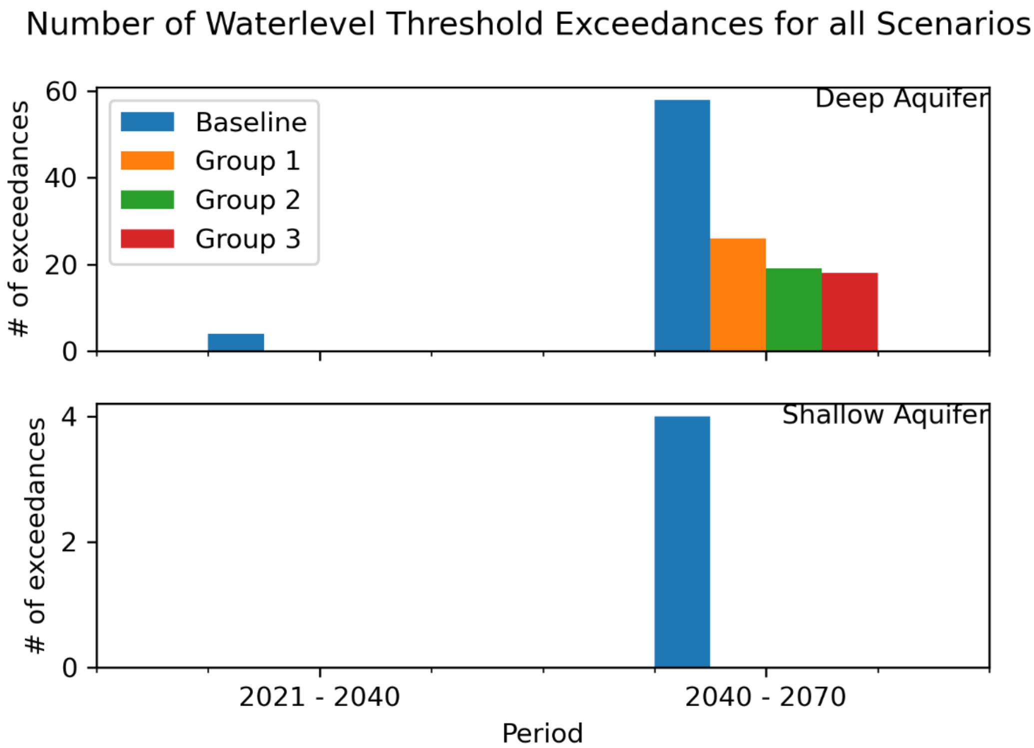


Figure 13 Number of Waterlevel Exceedances for all Scenarios

Each simulation was evaluated for undesirable results. Undesirable results are defined to occur when projected water levels at 30% of RMP wells fall below the MT for three consecutive years. For the shallow aquifer this occurs when 4 out of the 14 wells concurrently have MT exceedances, while for the deep aquifer this occurs when 3 out of the 11 wells concurrently have MT exceedances.

In the baseline scenario, undesirable results do not occur in the shallow aquifer but do occur in the deep aquifer from WY 2059 to WY 2070 (Figure 14). Undesirable results do not occur in the Group 1, Group 2, or Group 3 scenarios for either aquifer.

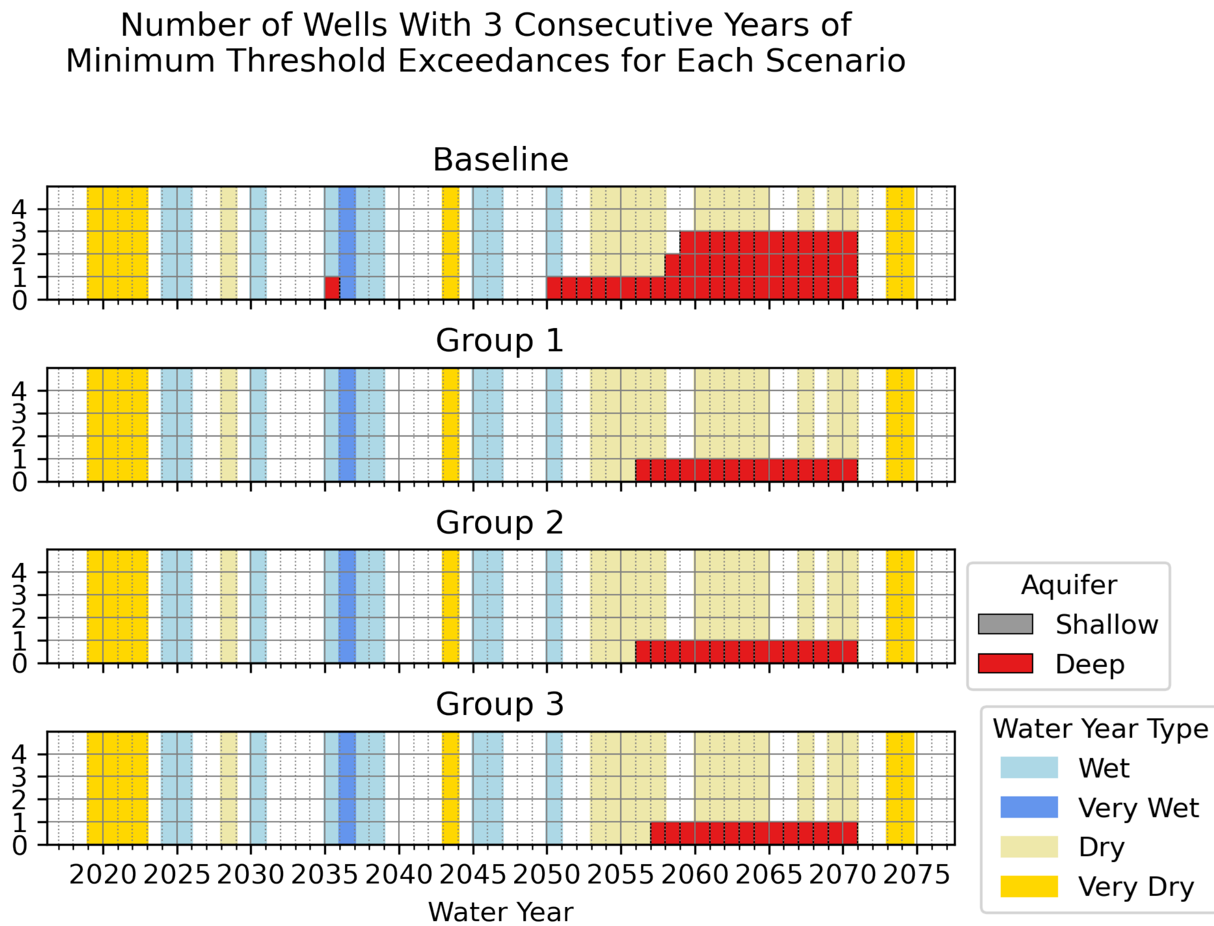


Figure 14. Number of Wells Below Minimum Threshold for Three Consecutive Years for RMP Wells. Undesirable results occur when 30% of RMP's experience Minimum Threshold exceedances for three consecutive years

3.3.1 Changes in Simulated Groundwater Elevation for Group 1, Group 2 and Group Scenarios

This section shows the projected changes in groundwater elevation between the baseline and the group scenarios. The maps are presented in the following order: shallow waterlevel differences at WY 2040 (Figure 15, Figure 16, and Figure 17), deep waterlevel differences at WY 2040 (Figure 18, and Figure 19, and Figure 20), shallow waterlevel differences at WY 2070 (Figure 21, Figure 22, and Figure 23), and deep waterlevel differences at WY 2070 (Figure 24, Figure 25, and Figure 26). Figure 15, Figure 16, and Figure 17 demonstrate that the implementation of the three PMA's have little effect on shallow waterlevels at WY 2040. Deep waterlevels do benefit from the implementation of the PMA's (Figure 18, and Figure 19, and Figure 20). The Group 1 shows positive changes generally northeast of the Trenton Ridge. The Group 2 scenario shows the smallest areal change in groundwater levels, with little benefit when compared to Group 1. The Group 3 scenario shows areas of positive waterlevel changes in the same areas as Group 1 and 2, but also in the southern portion of the subbasin, from the City of Cotati to the northern border of the Rohnert Park. The shallow waterlevel changes at WY 2070 show little benefit due to the implementation of the PMA's (Figure 21, Figure 22, Figure 23), similar to the WY 2040 water level differences. The deep aquifer at WY 2070 shows similar but expanded patterns as the deep aquifer in WY 2040 (Figure 24, Figure 25, and Figure 26). For Group 1 and Group 2 the waterlevel benefits are concentrated around the area northeast of the Trenton Ridge Fault. The Group 3 scenario shows expanded benefits in the both the area northeast of the Trenton Ridge Fault and much of the southern third of the subbasin.

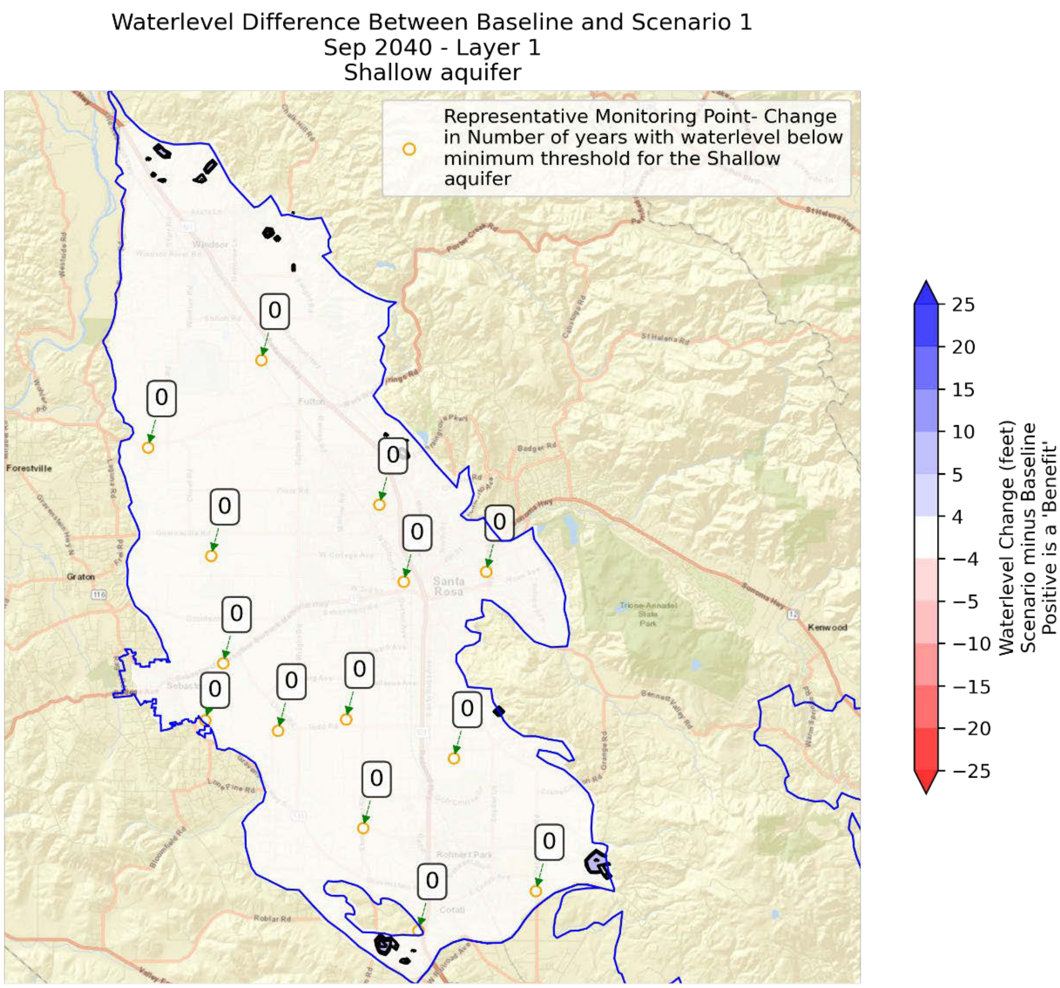


Figure 15. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2040 for Group 1 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

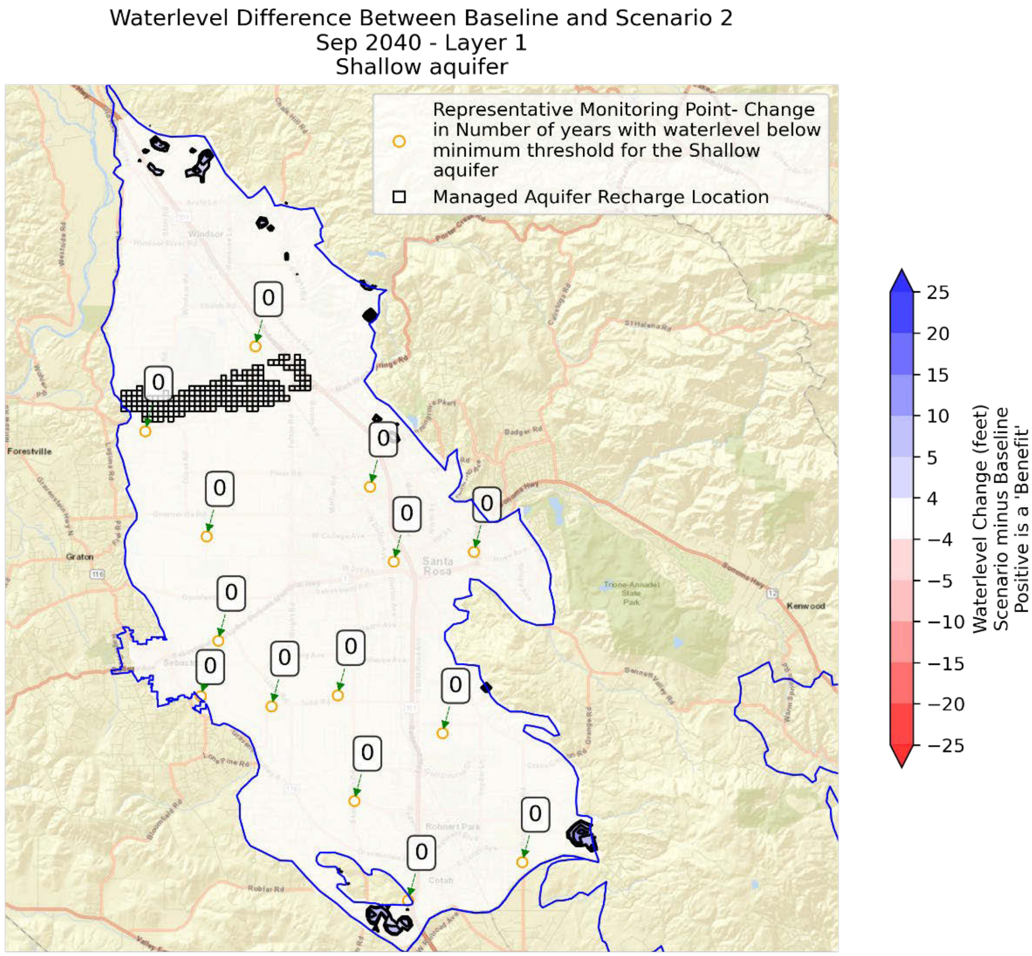


Figure 16. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2040 for Group 2 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

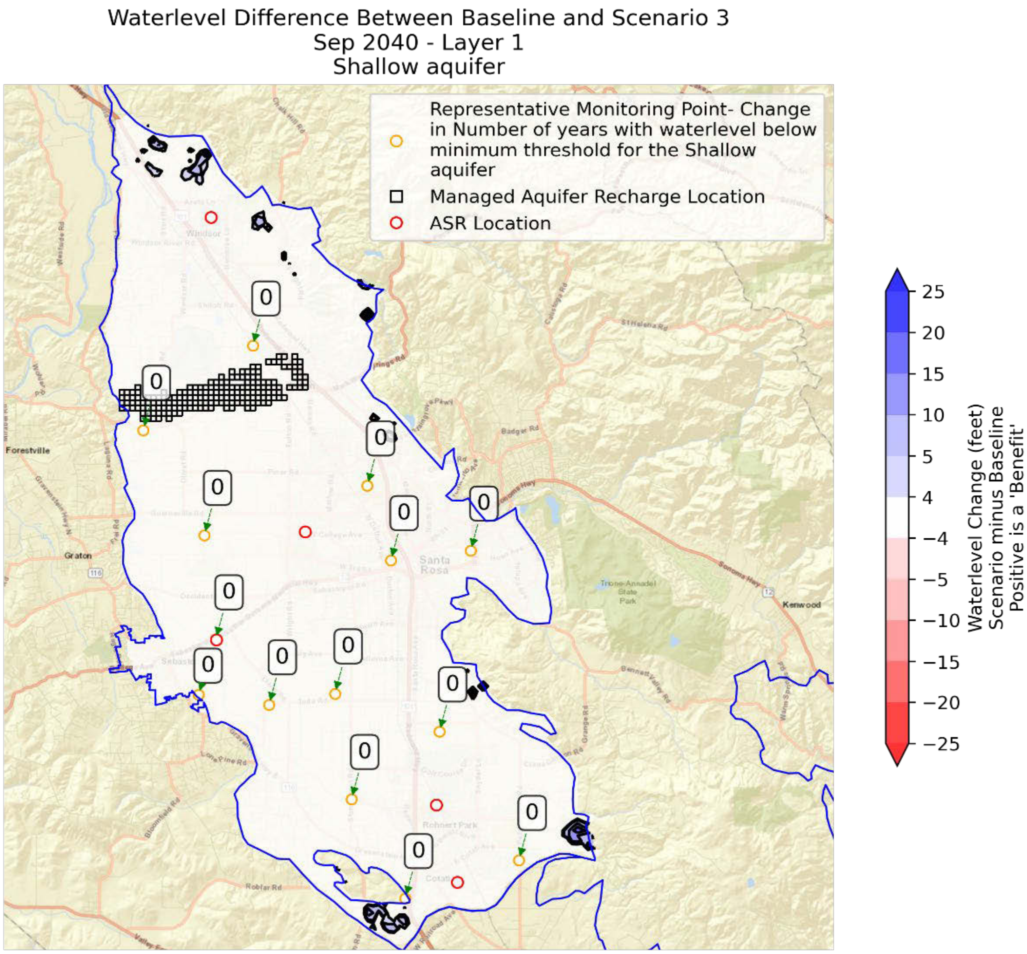


Figure 17. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2040 for Group 3 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

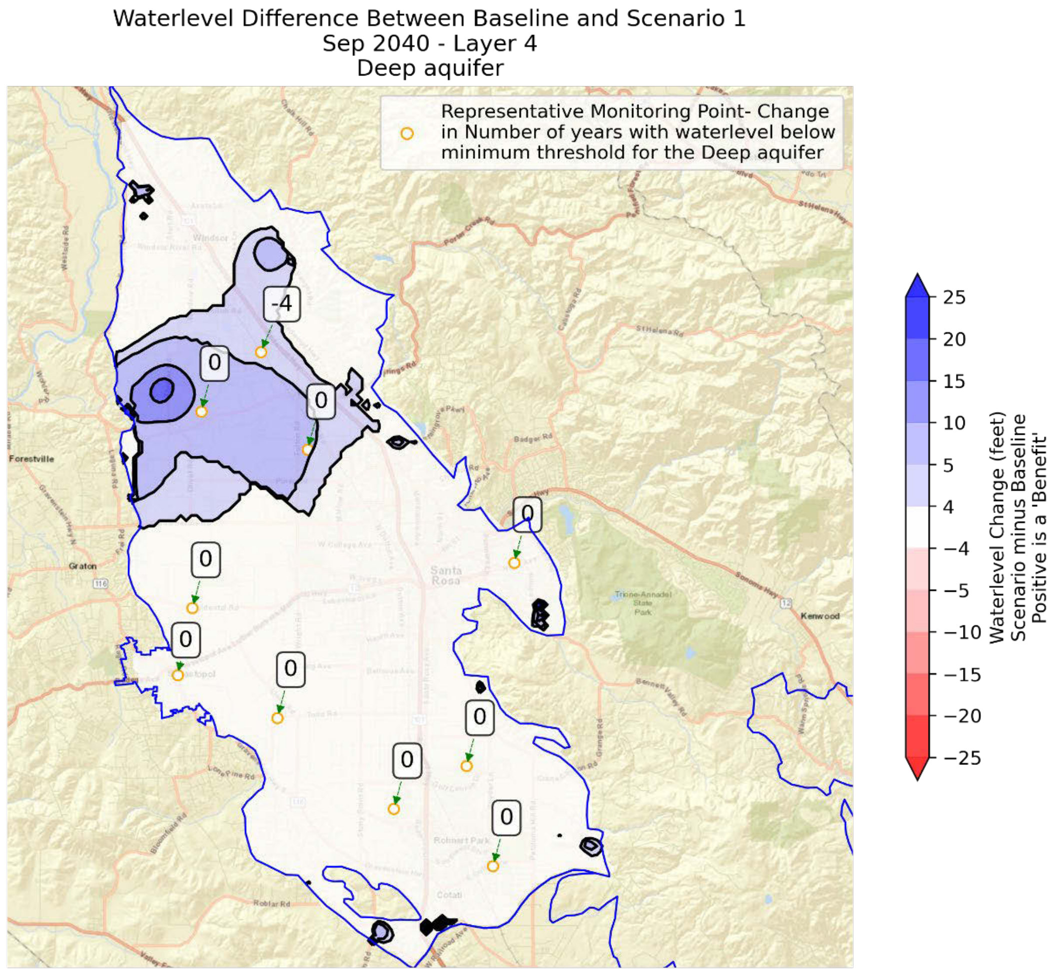


Figure 18. Projected Deep Aquifer Groundwater Elevation Benefit in September 2040 for Group 1 PMA’s Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

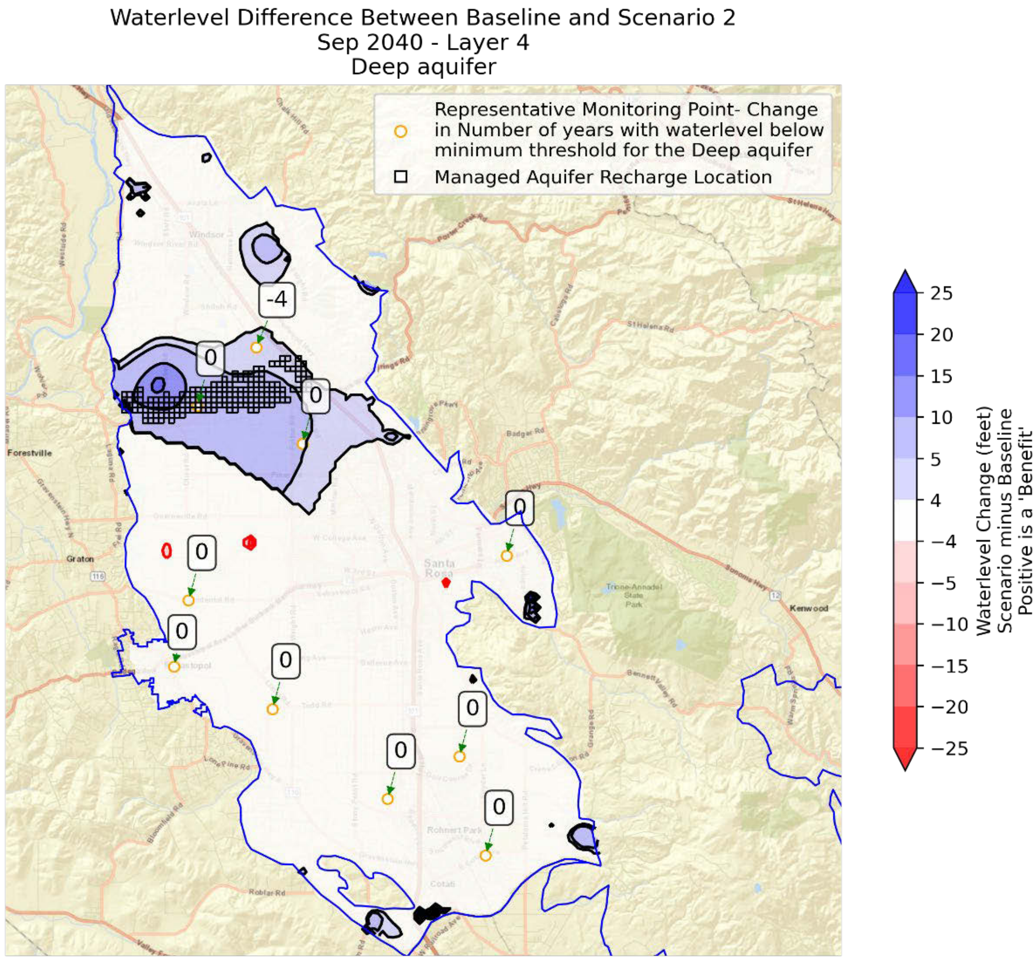


Figure 19. Projected Deep Aquifer Groundwater Elevation Benefit in September 2040 for Group 2 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

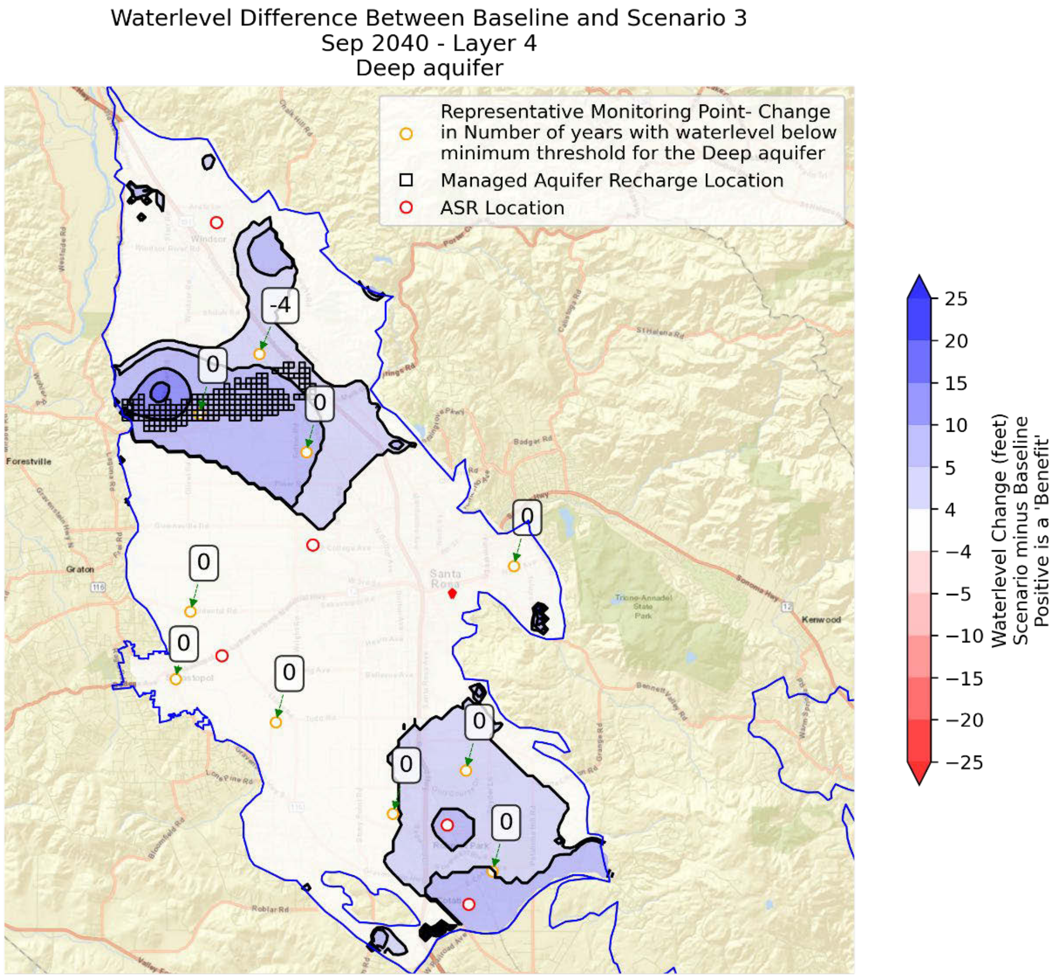


Figure 20. Projected Deep Aquifer Groundwater Elevation Benefit in September 2040
for Group 3 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

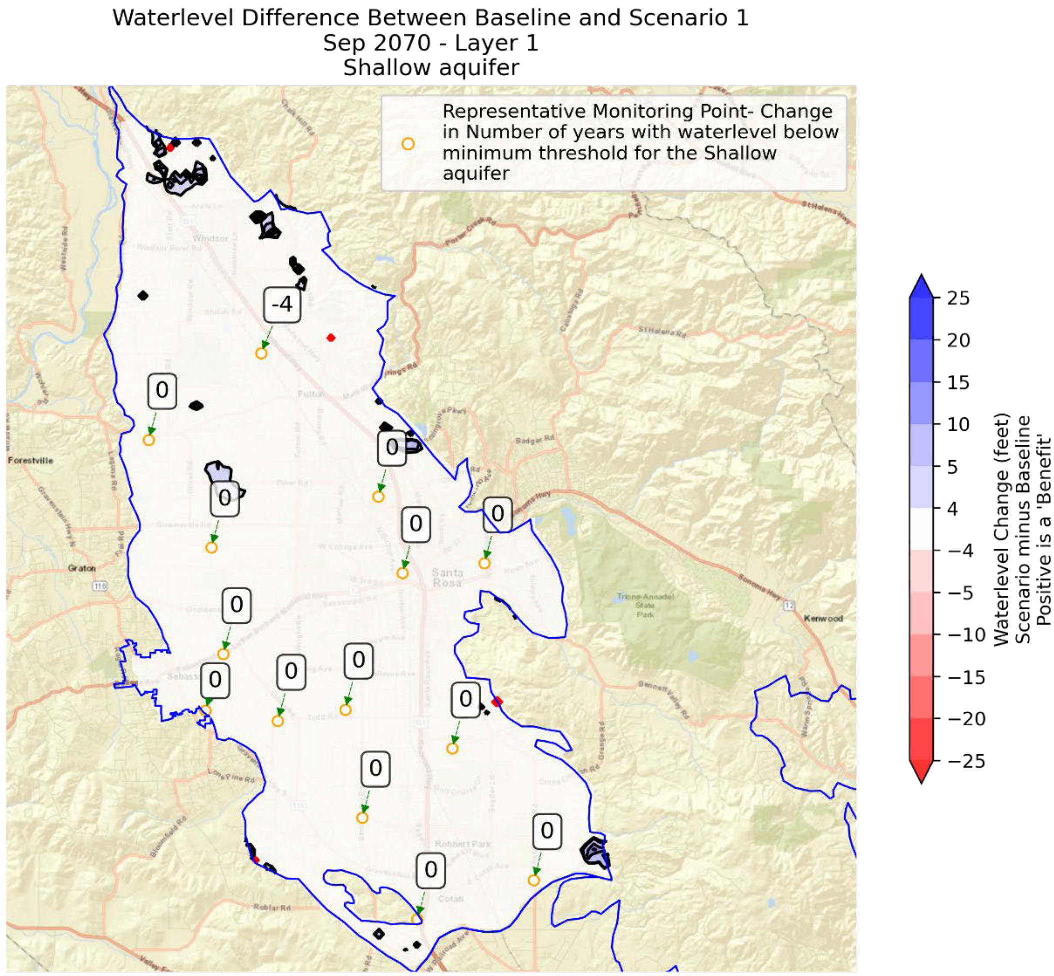


Figure 21. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2070 for Group 1 PMA’s Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

Waterlevel Difference Between Baseline and Scenario 2
Sep 2070 - Layer 1
Shallow aquifer

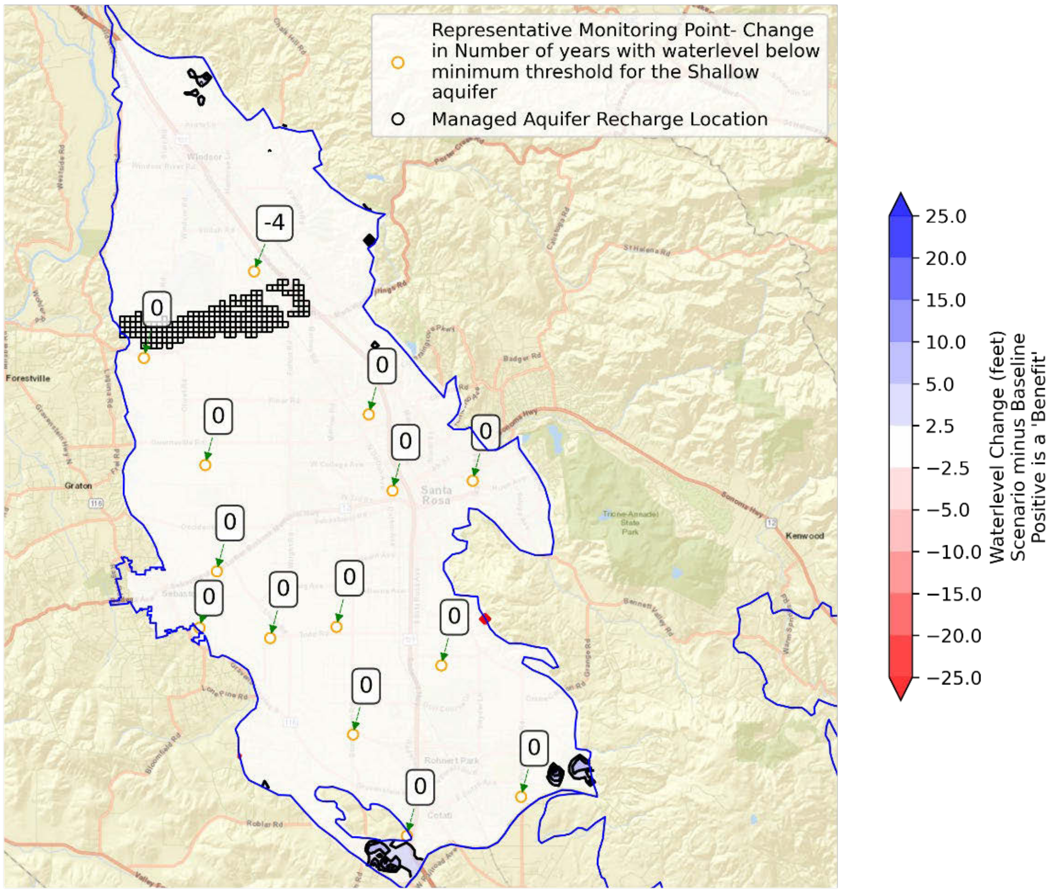


Figure 22. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2070 for Group 2 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

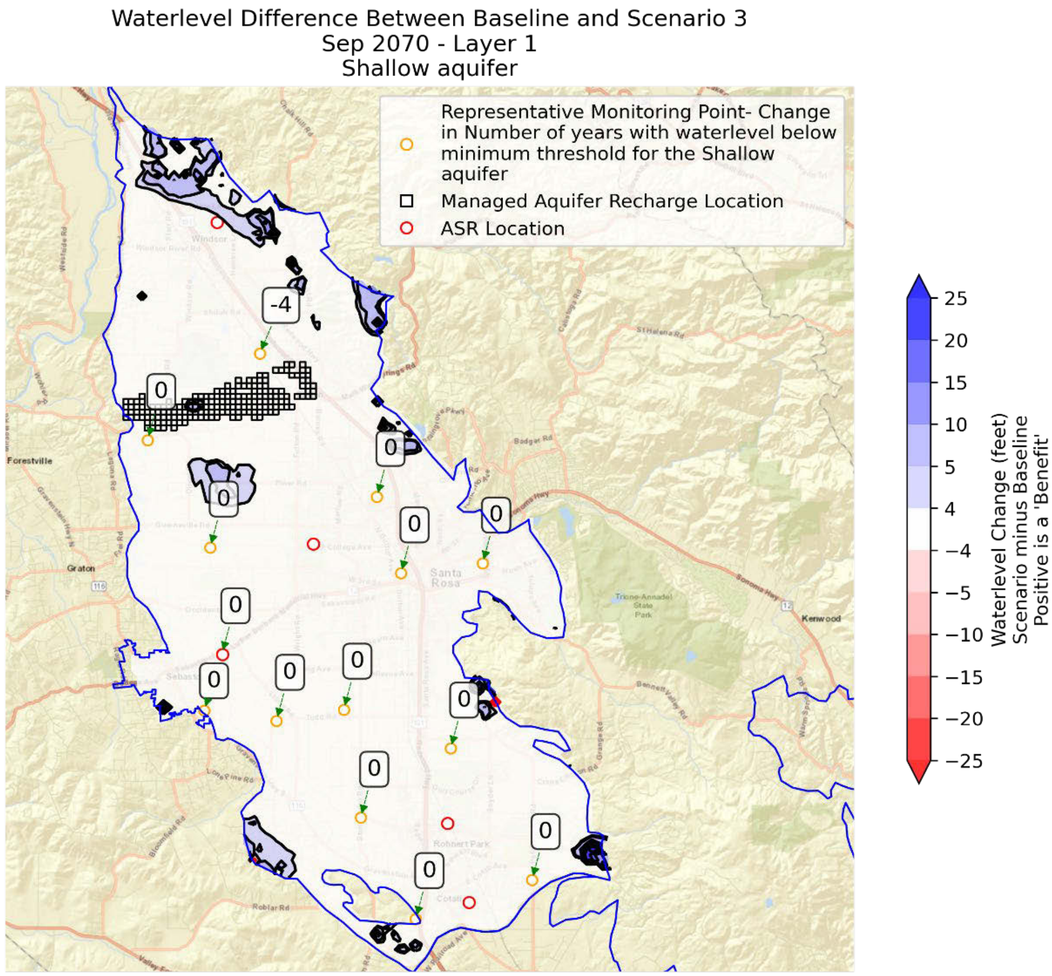


Figure 23. Projected Shallow Aquifer Groundwater Elevation Benefit in September 2070 for Group 3 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

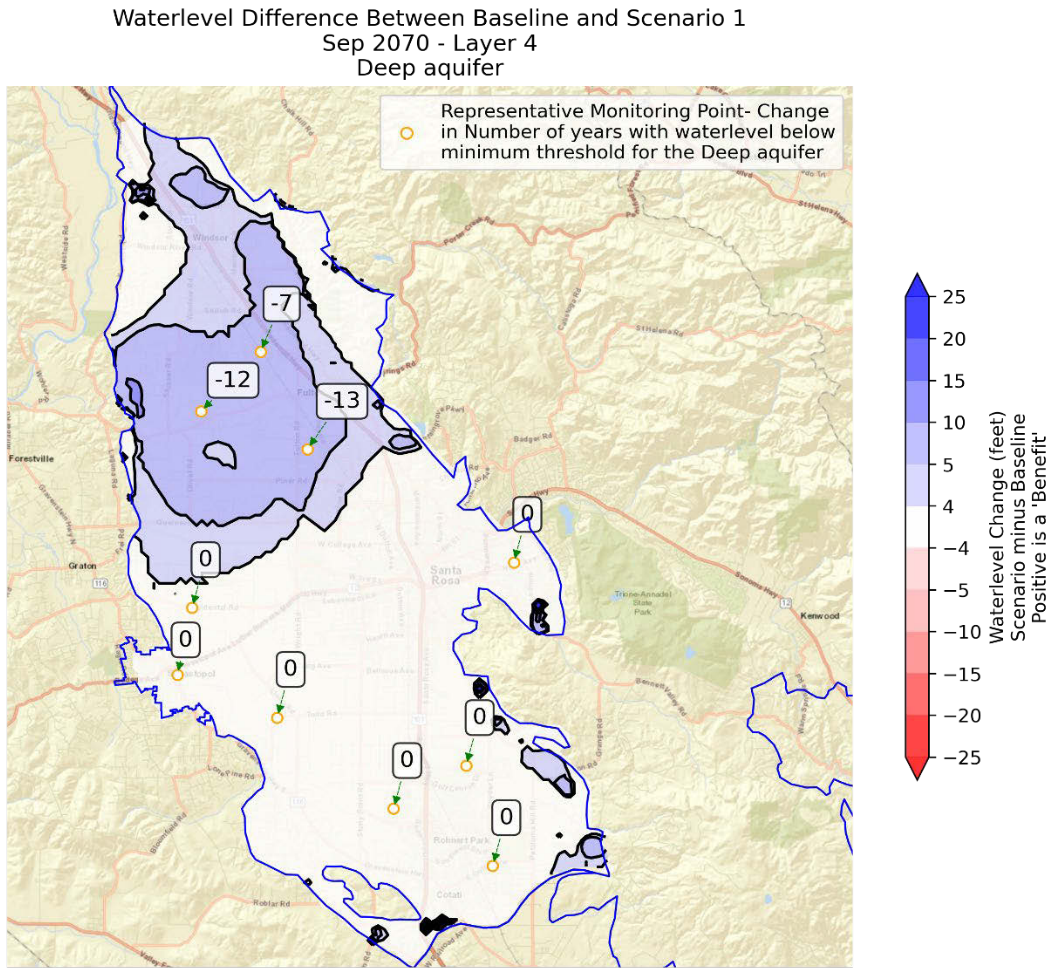


Figure 24. Projected Deep Aquifer Groundwater Elevation Benefit in September 2070 for Group 1 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

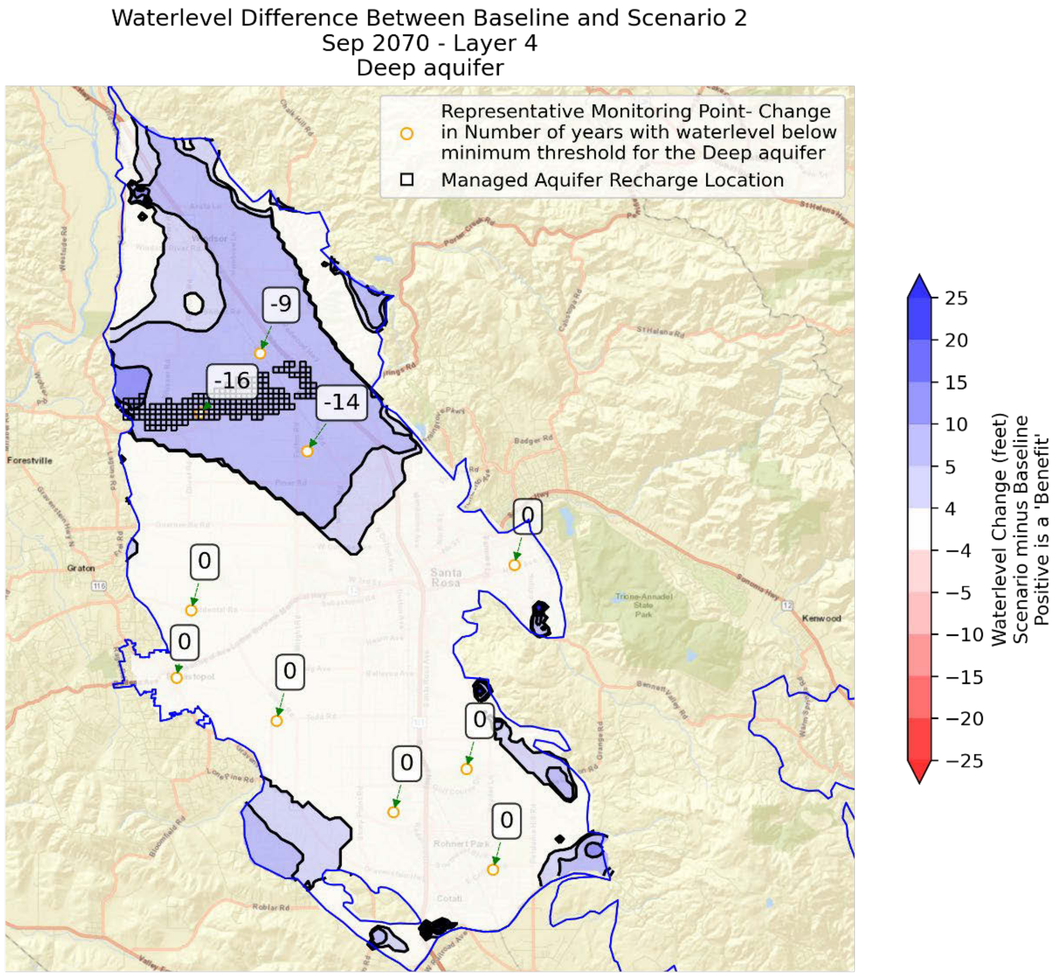


Figure 25. Projected Deep Aquifer Groundwater Elevation Benefit in September 2070 for Group 2 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

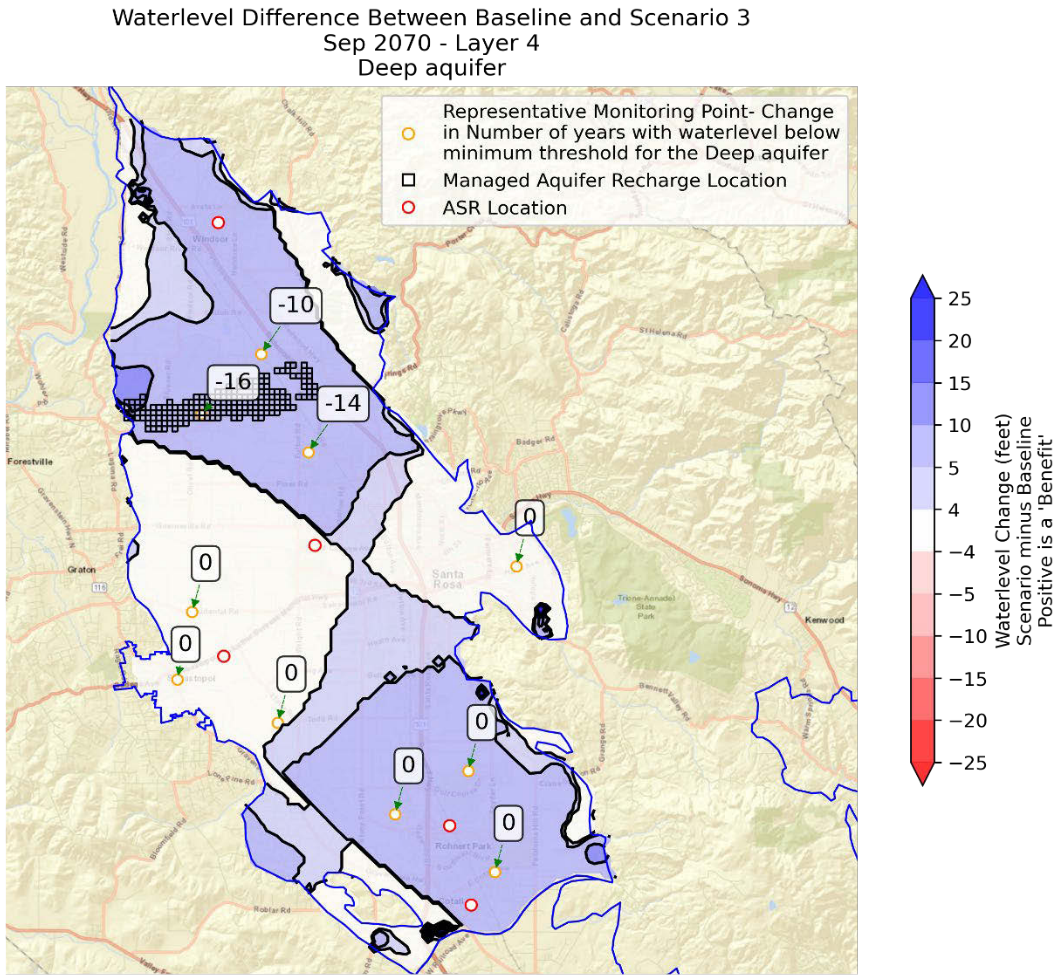


Figure 26. Projected Deep Aquifer Groundwater Elevation Benefit in September 2070 for Group 3 PMA's Versus Baseline. Positive Changes Outlined in Black, Negative Changes Outlined in Red

3.3.2 Actual Simulated Waterlevels For Group 1, Group 2, and Group 3 Scenarios

The following figures show the actual simulated waterlevels at each referenced time and depth, for each scenario. They are the corresponding simulated waterlevels used to calculate waterlevel differences and changes in MT exceedances in Figure 15 to Figure 26. The maps are presented in the following order: shallow waterlevel at WY 2040 (Figure 27, Figure 28, Figure 29, and Figure 30), deep waterlevel at WY 2040 (Figure 31, Figure 32, Figure 33, and Figure 34), shallow waterlevel at WY 2070 (Figure 35, Figure 36, Figure 37, and Figure 38), and deep waterlevel at WY 2070 (Figure 39, Figure 40, Figure 41 and Figure 42).

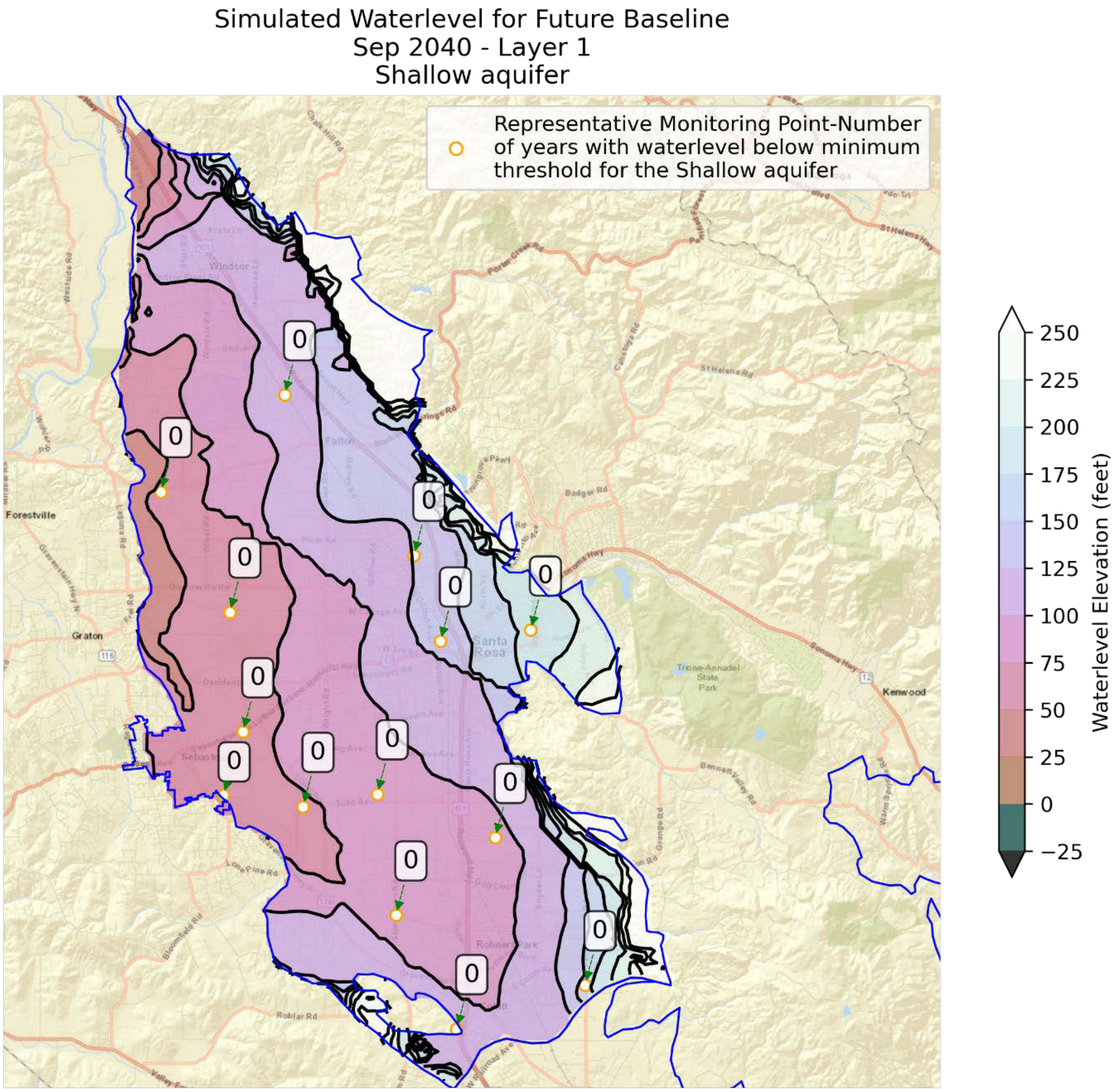


Figure 27 Actual Simulated Waterlevels for the Shallow Aquifer for the Future Baseline, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

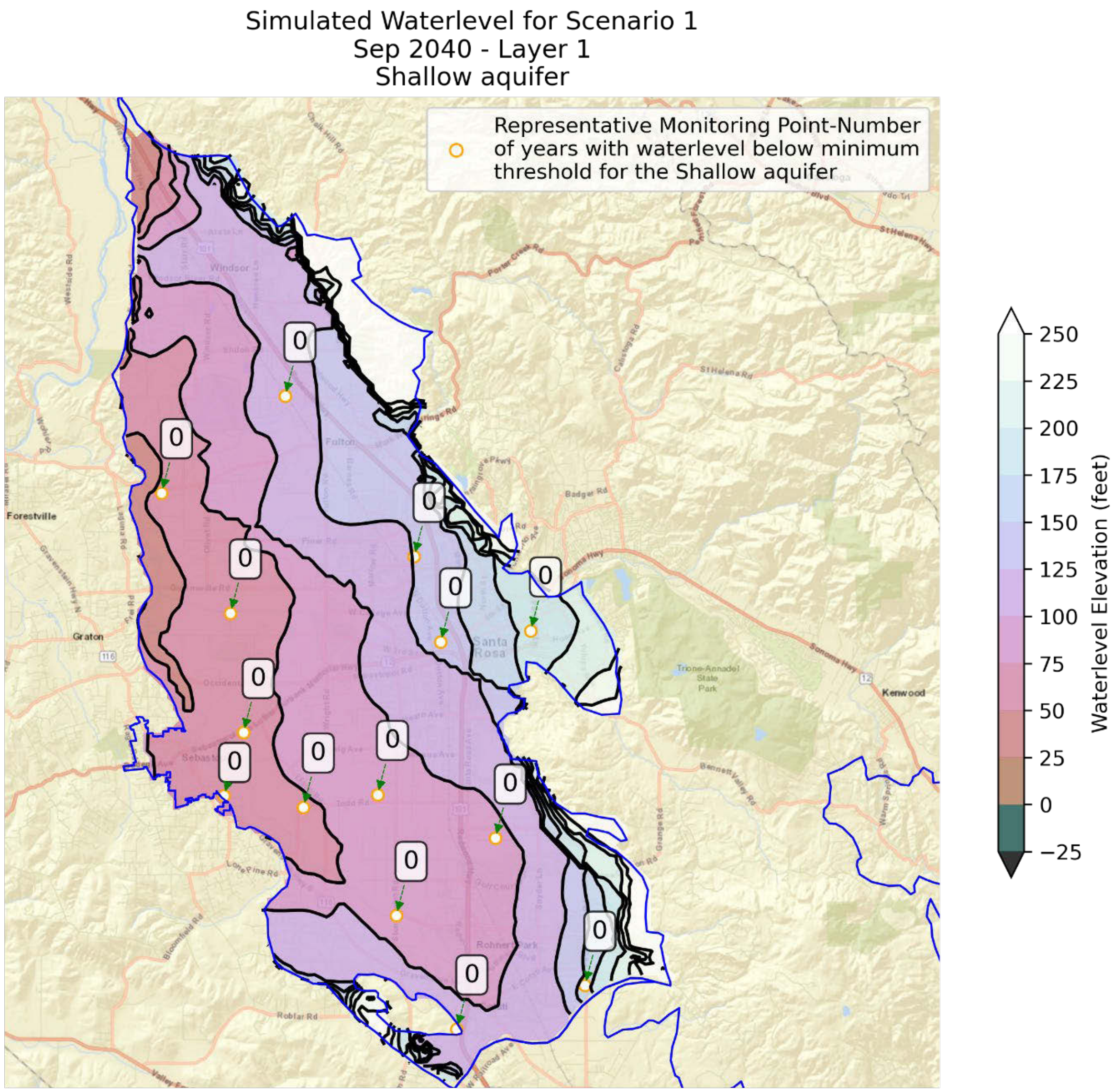


Figure 28 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 1, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

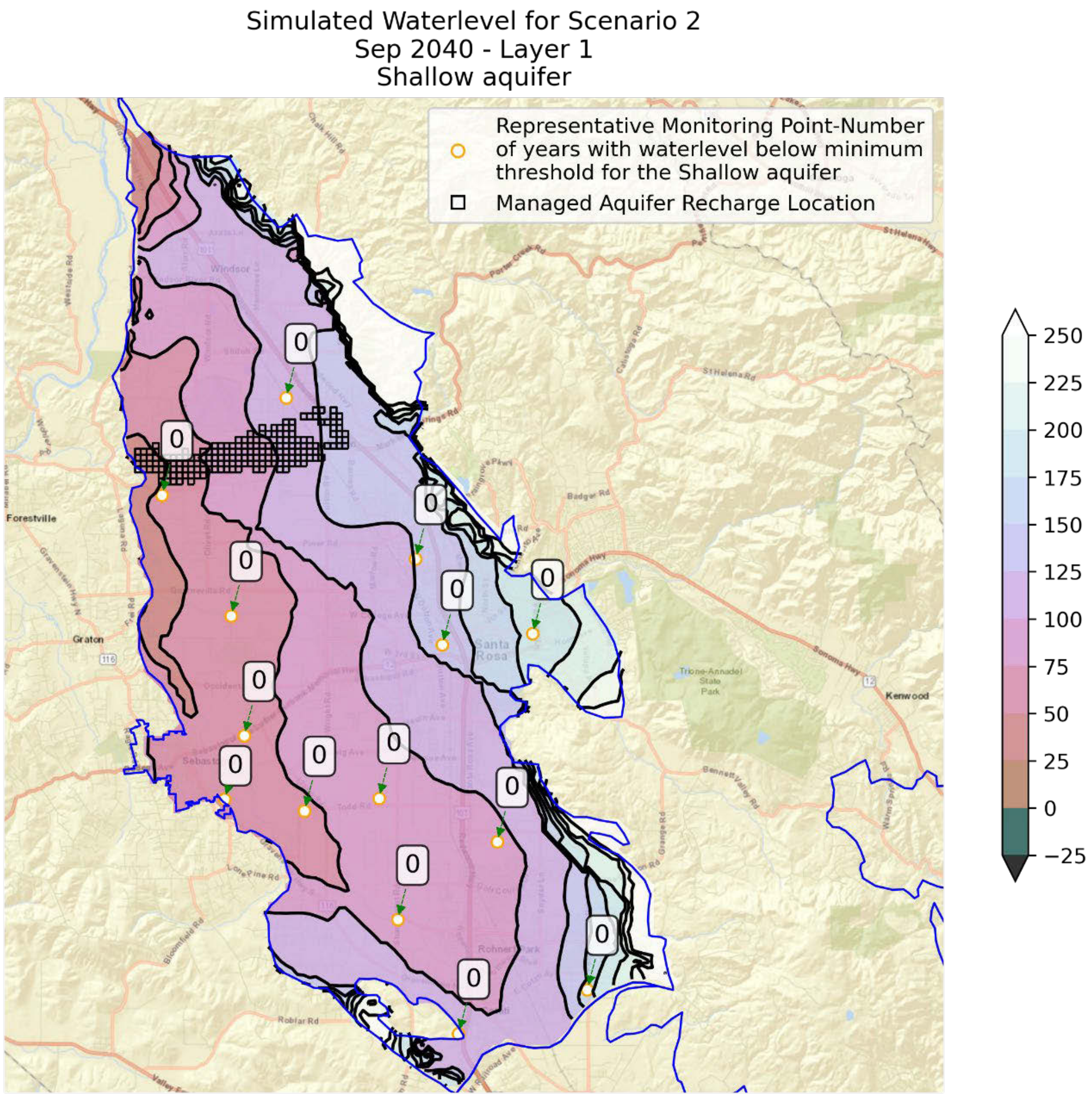


Figure 29 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 2, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

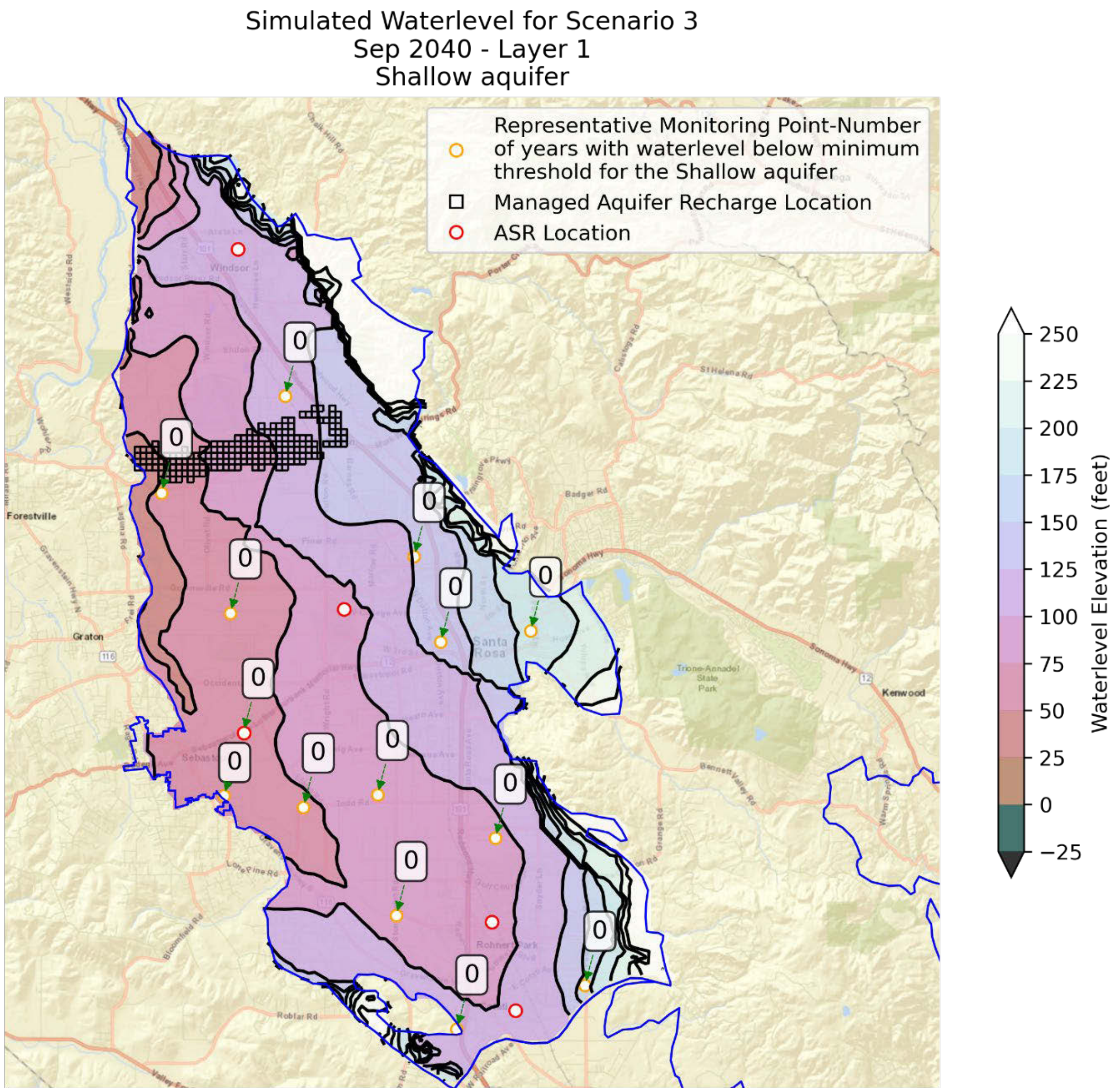


Figure 30 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 3, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

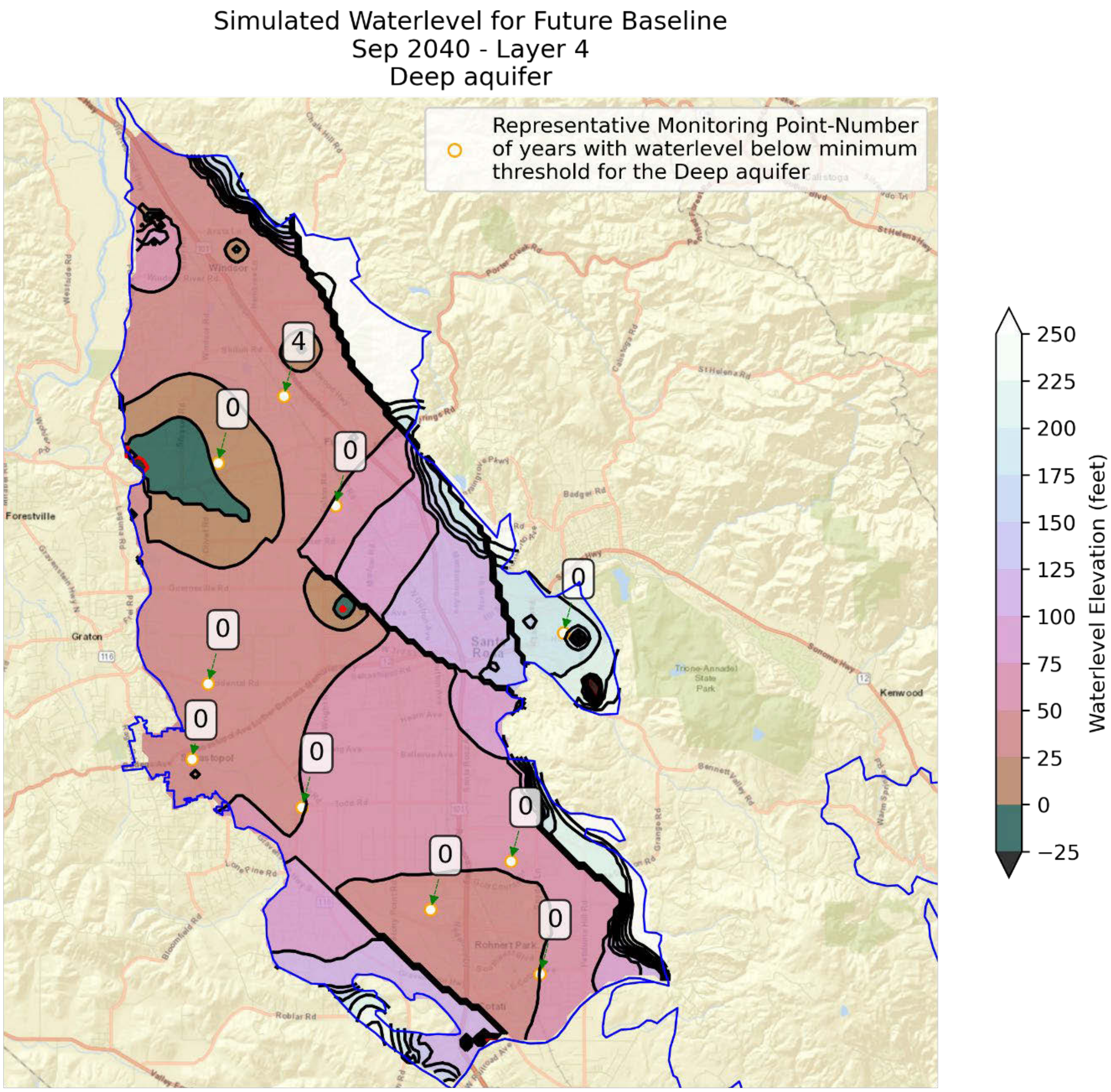


Figure 31 Actual Simulated Waterlevels for the Deep Aquifer for the Future Baseline, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

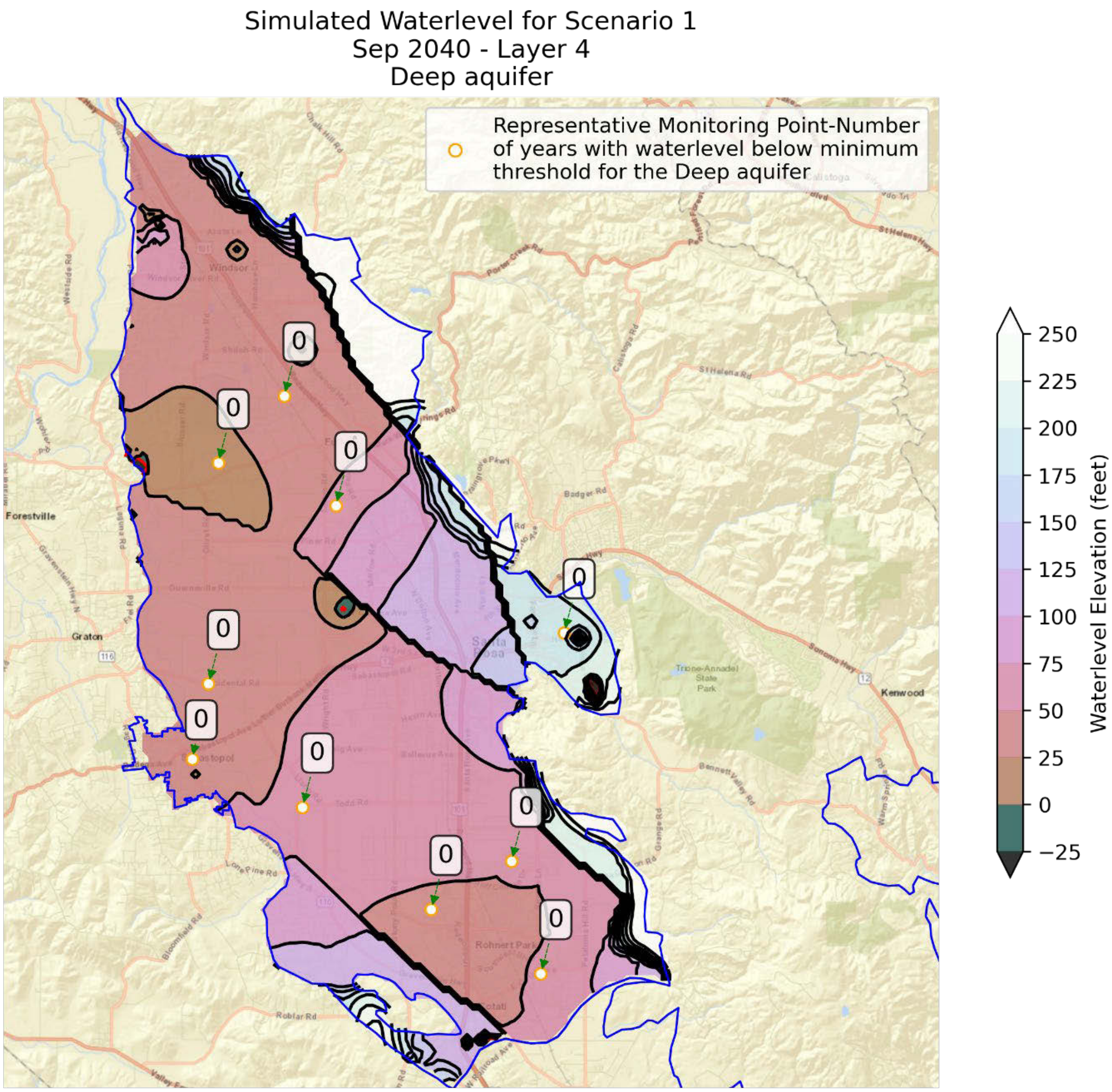


Figure 32 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 1, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

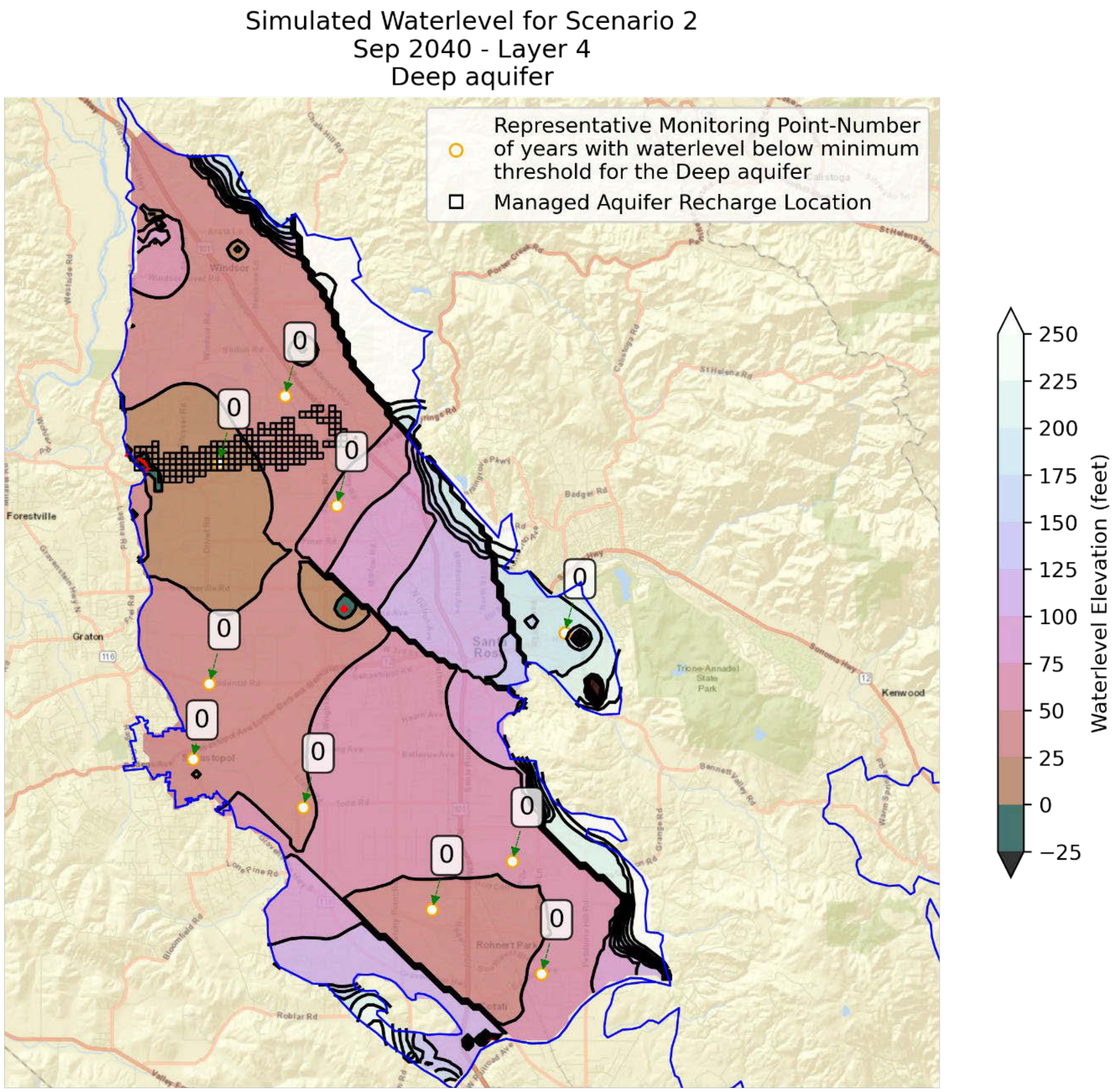


Figure 33 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 2, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

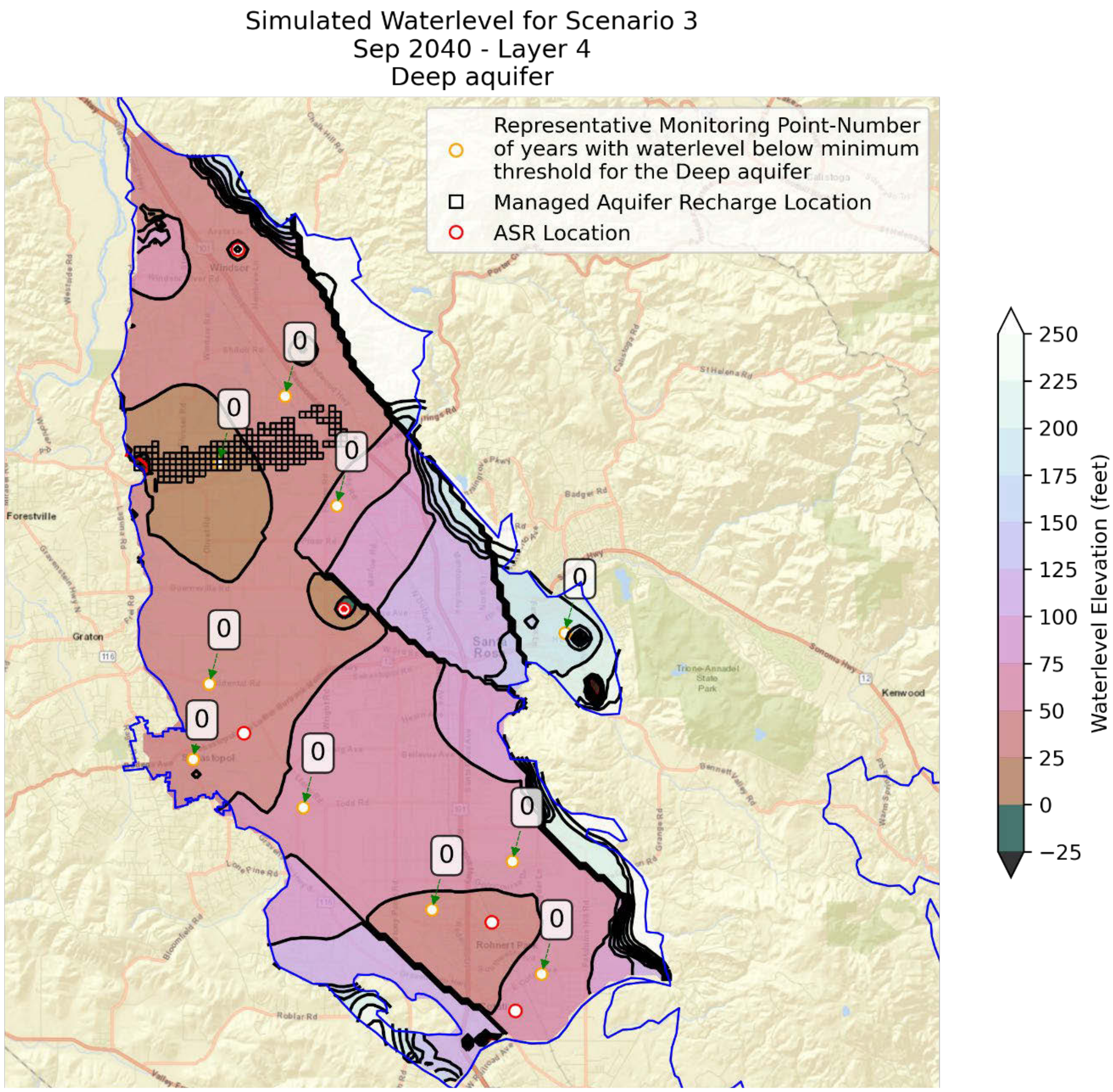


Figure 34 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 3, Sep 2040. Positive Values Outlined in Black, Negative Values Outlined in Red

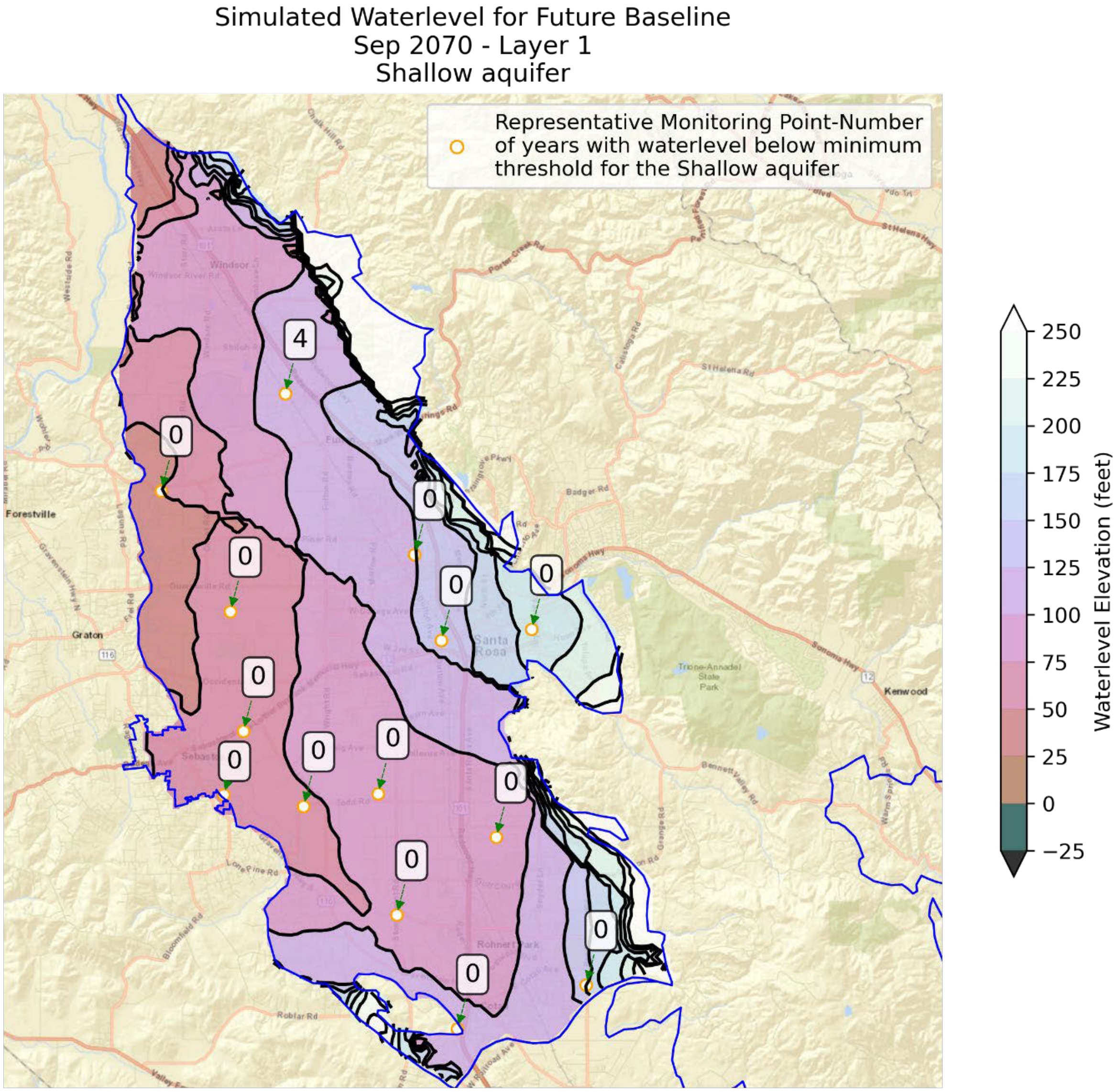


Figure 35 Actual Simulated Waterlevels for the Shallow Aquifer for the Future Baseline, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

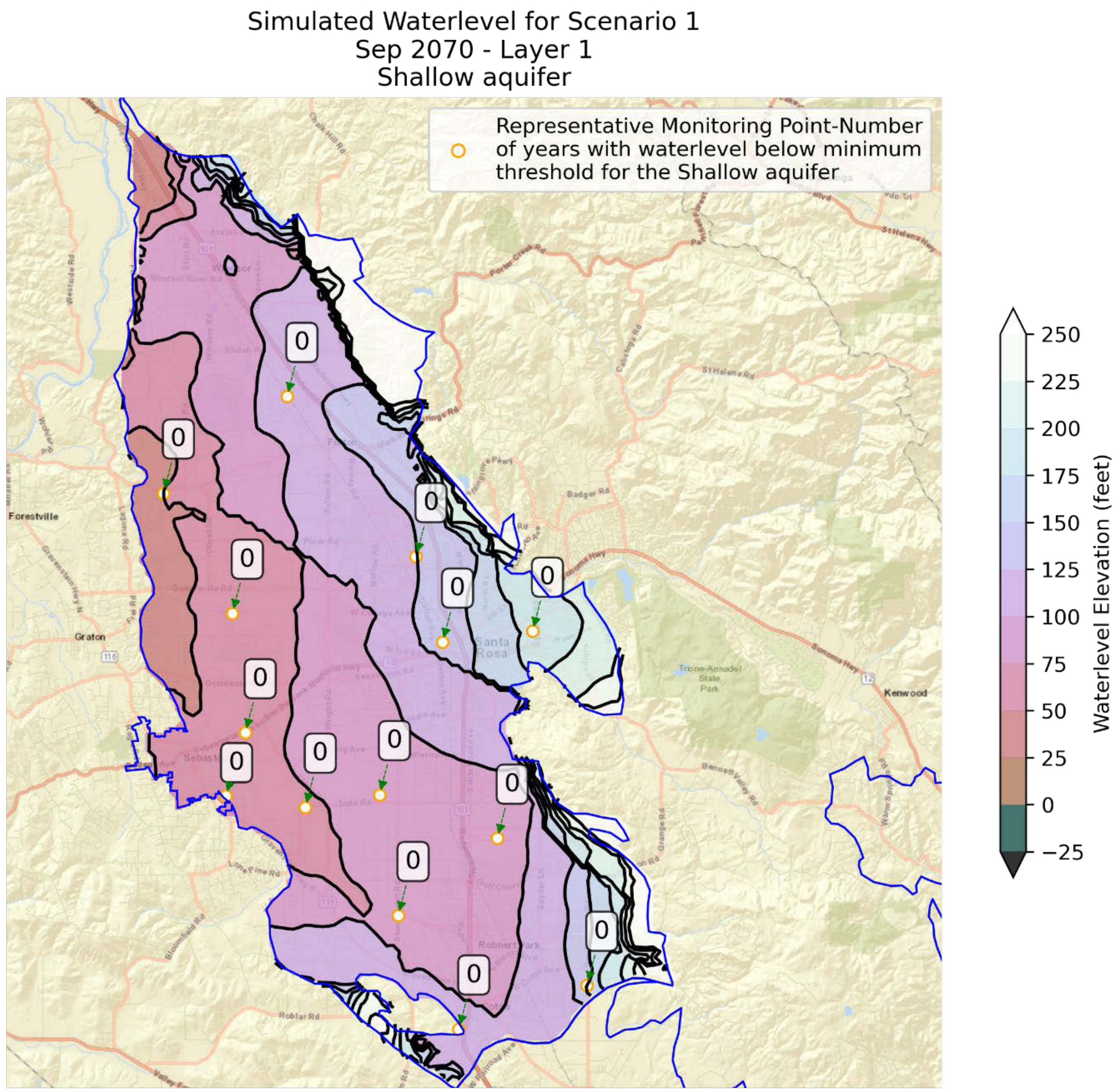


Figure 36 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 1, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

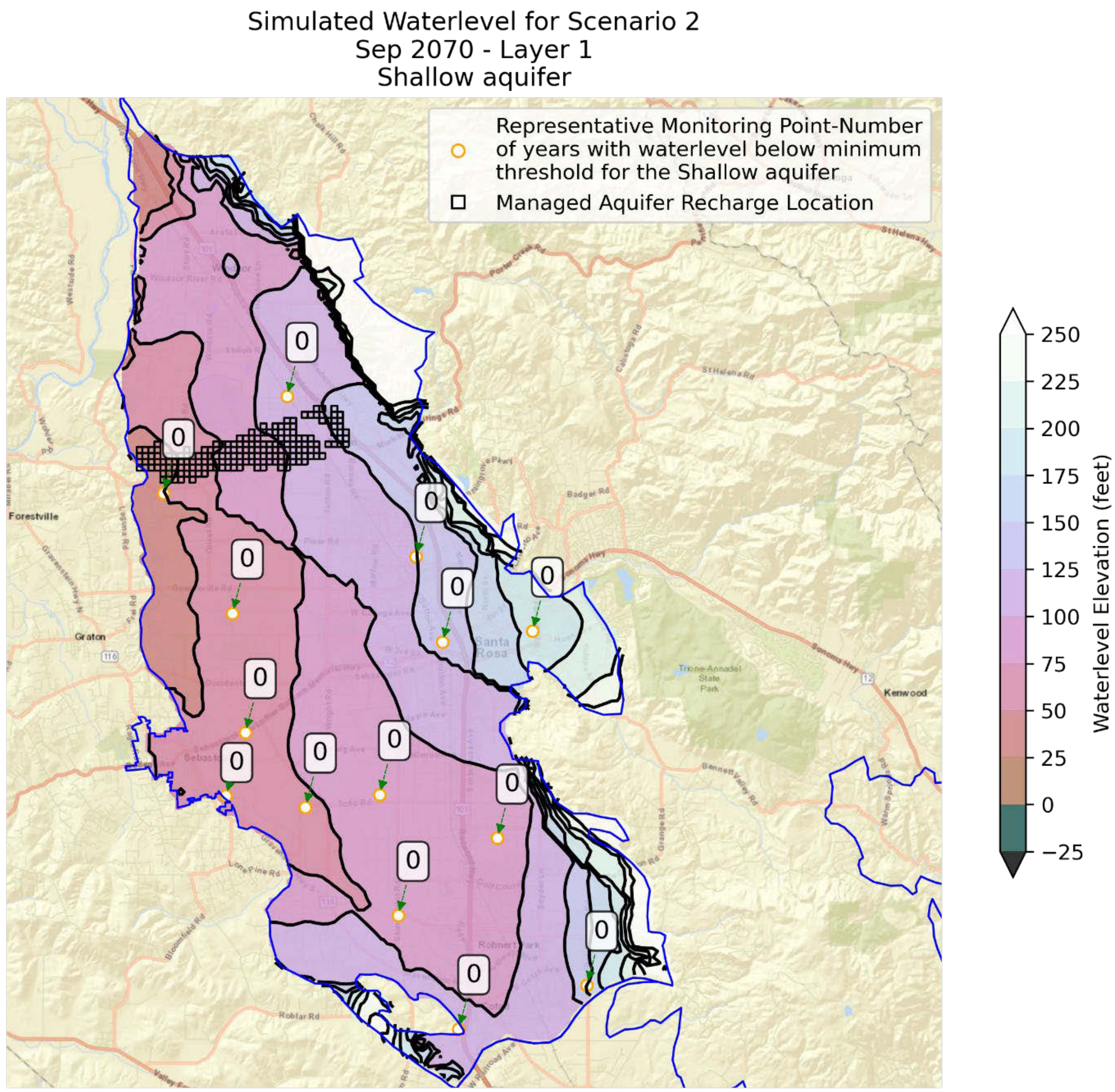


Figure 37 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 2, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

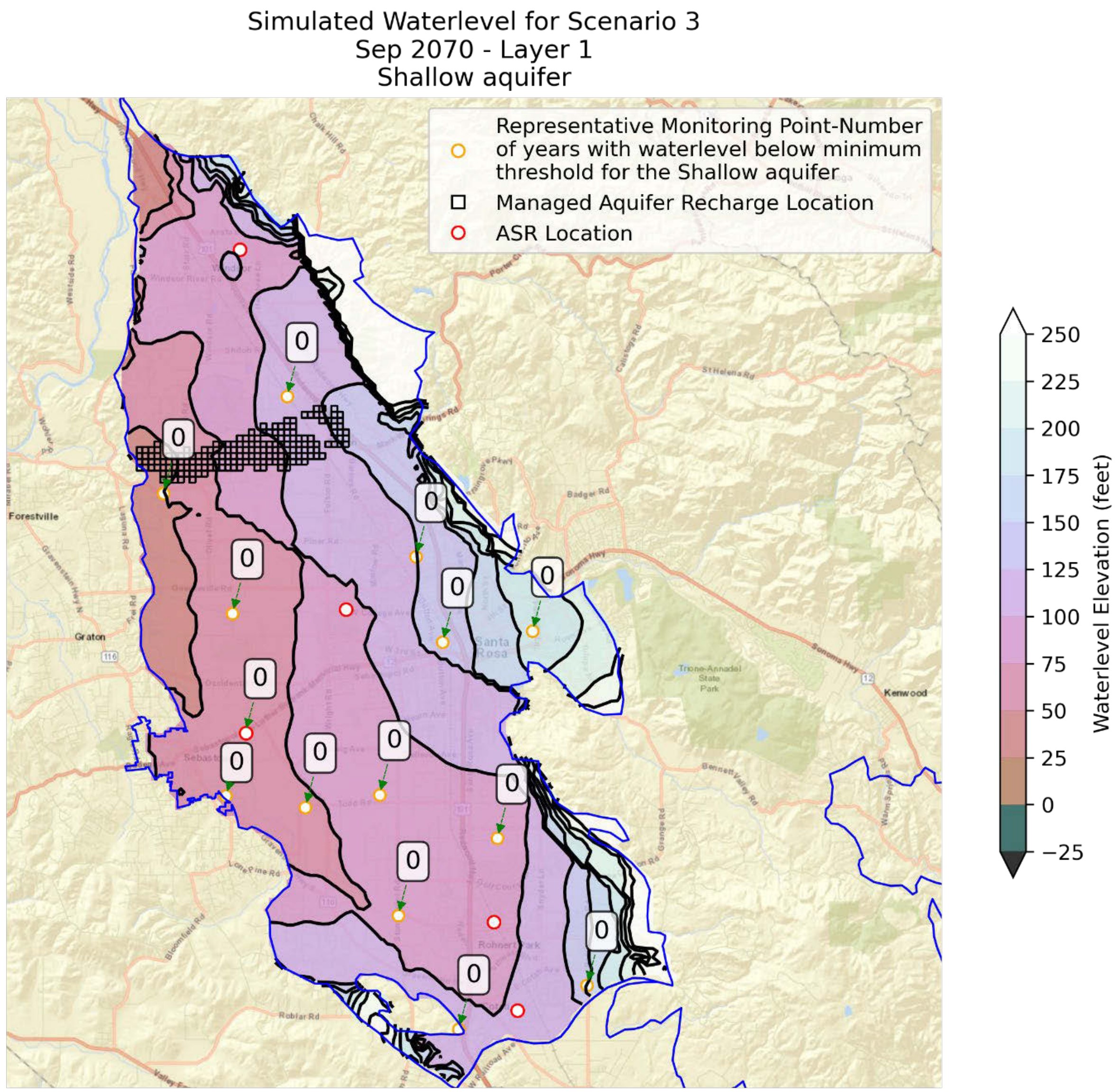


Figure 38 Actual Simulated Waterlevels for the Shallow Aquifer for Scenario 3, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

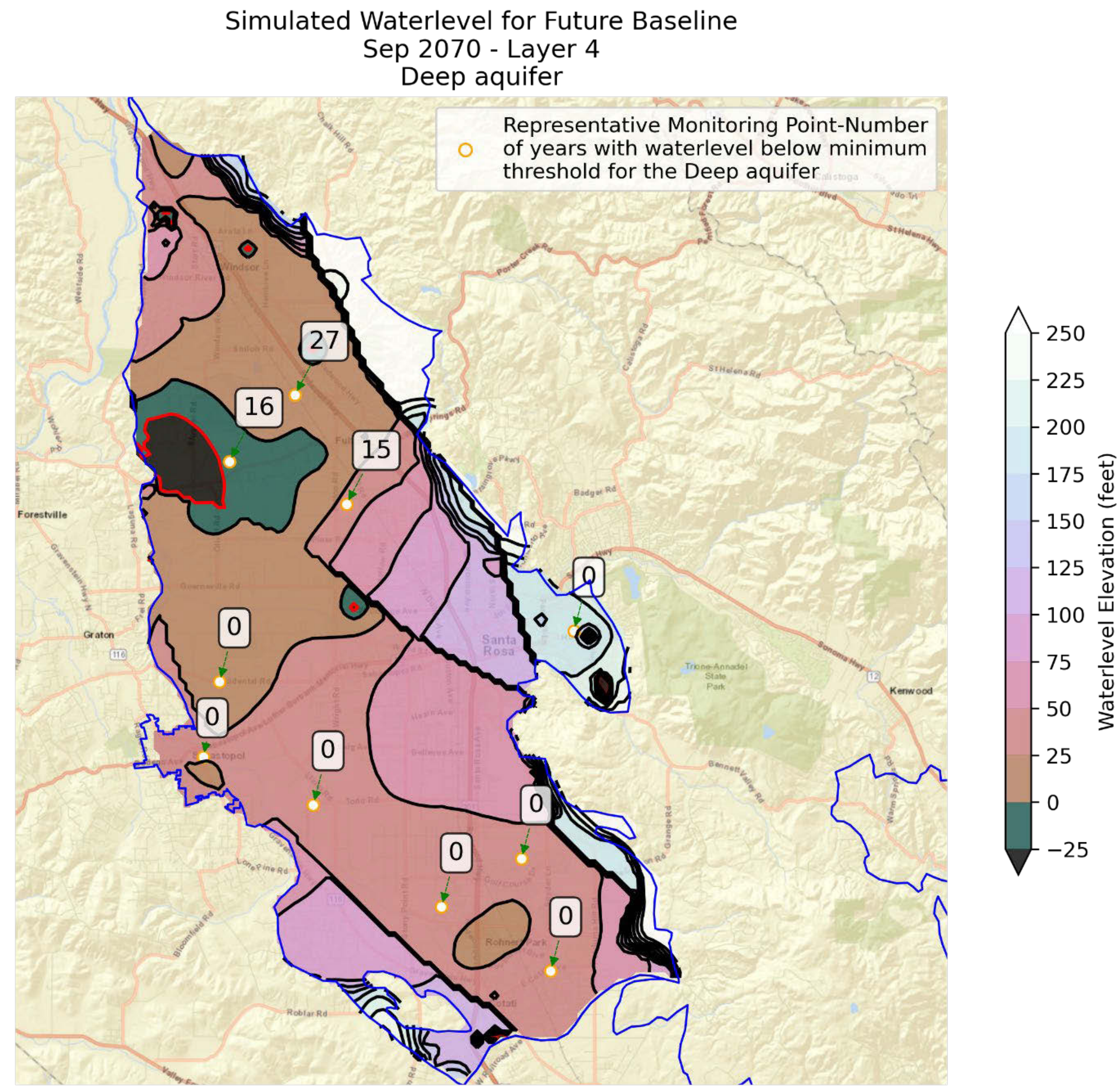


Figure 39 Actual Simulated Waterlevels for the Deep Aquifer for the Future Baseline, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

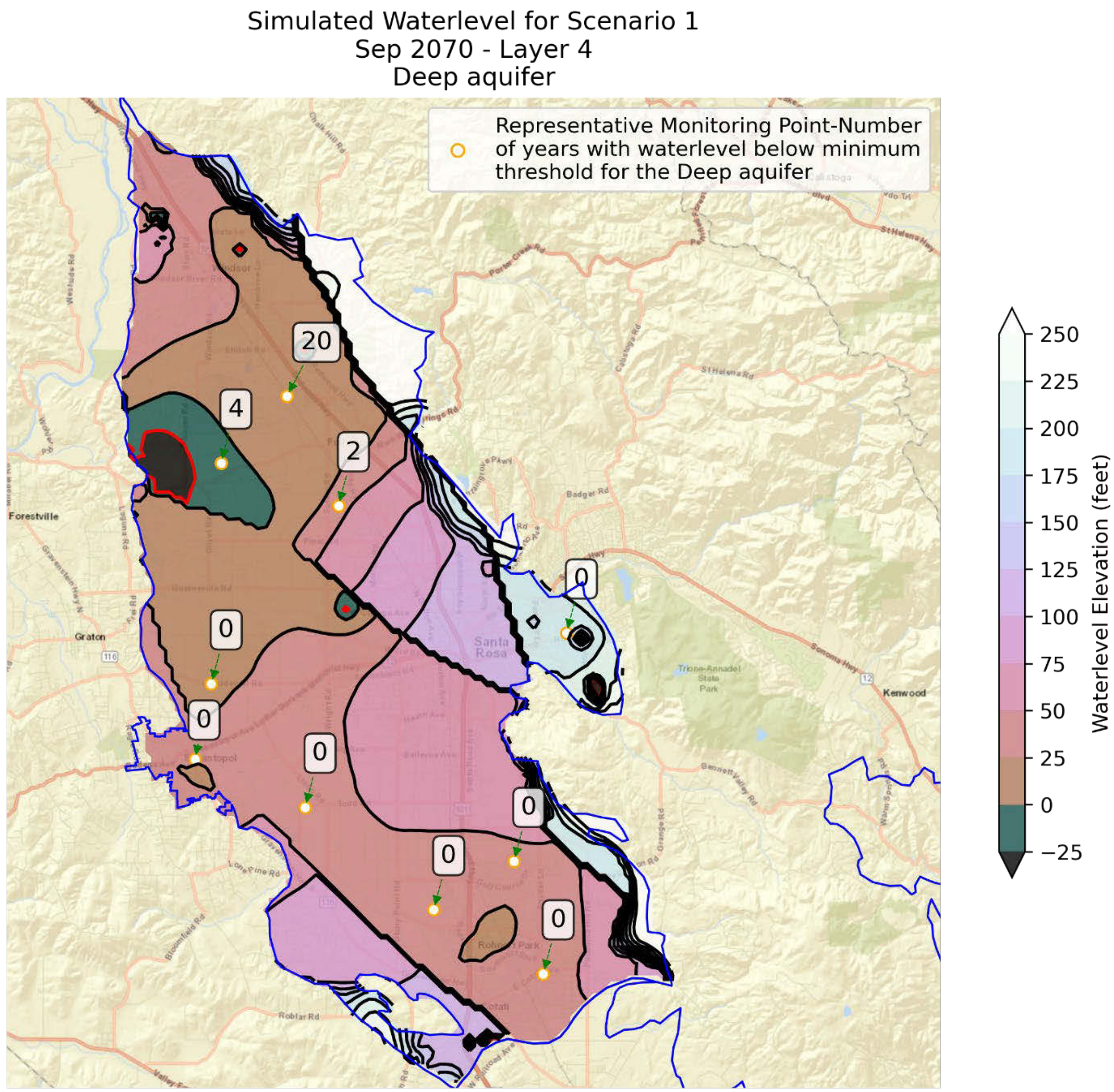


Figure 40 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 1, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

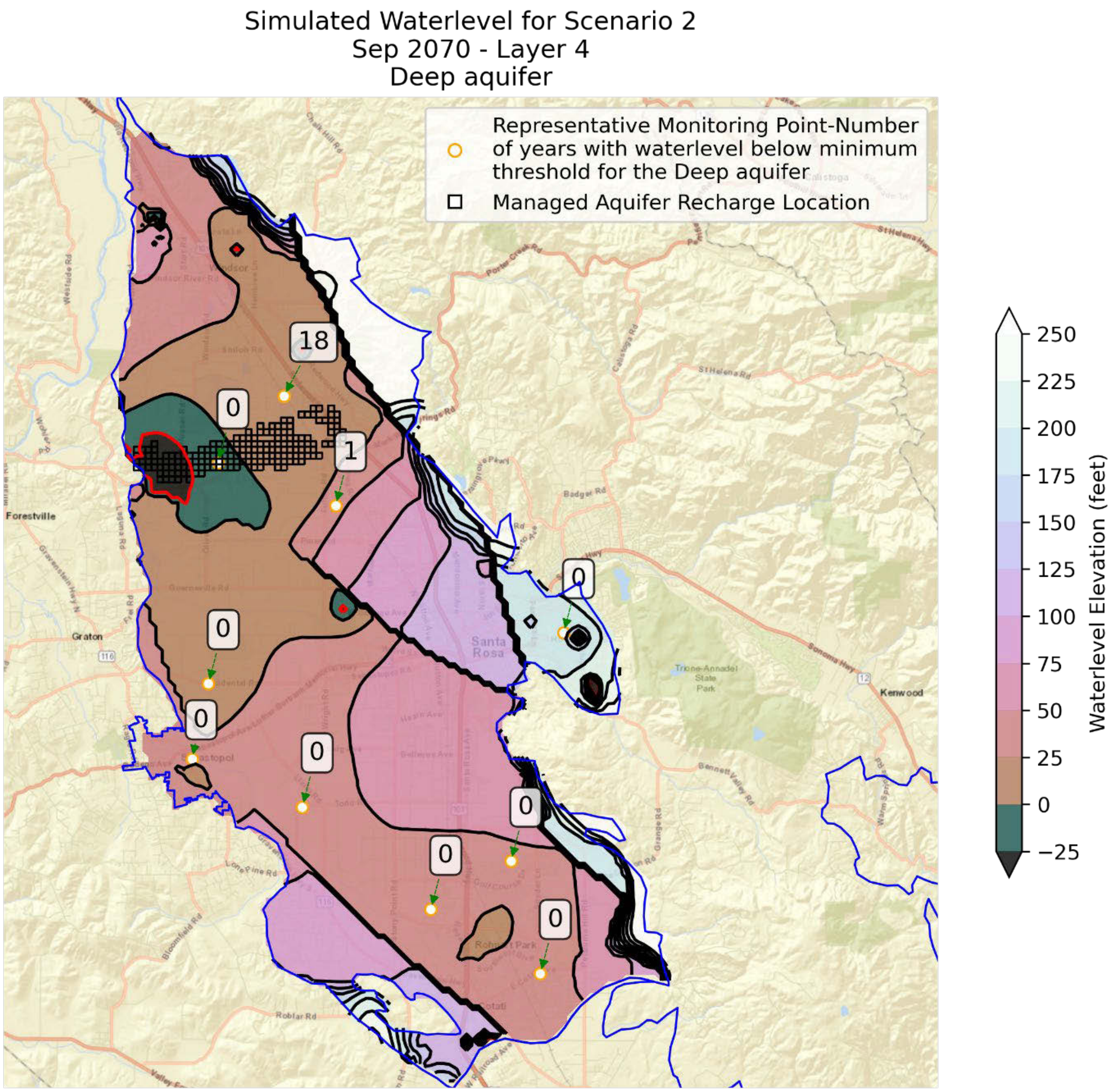


Figure 41 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 2, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

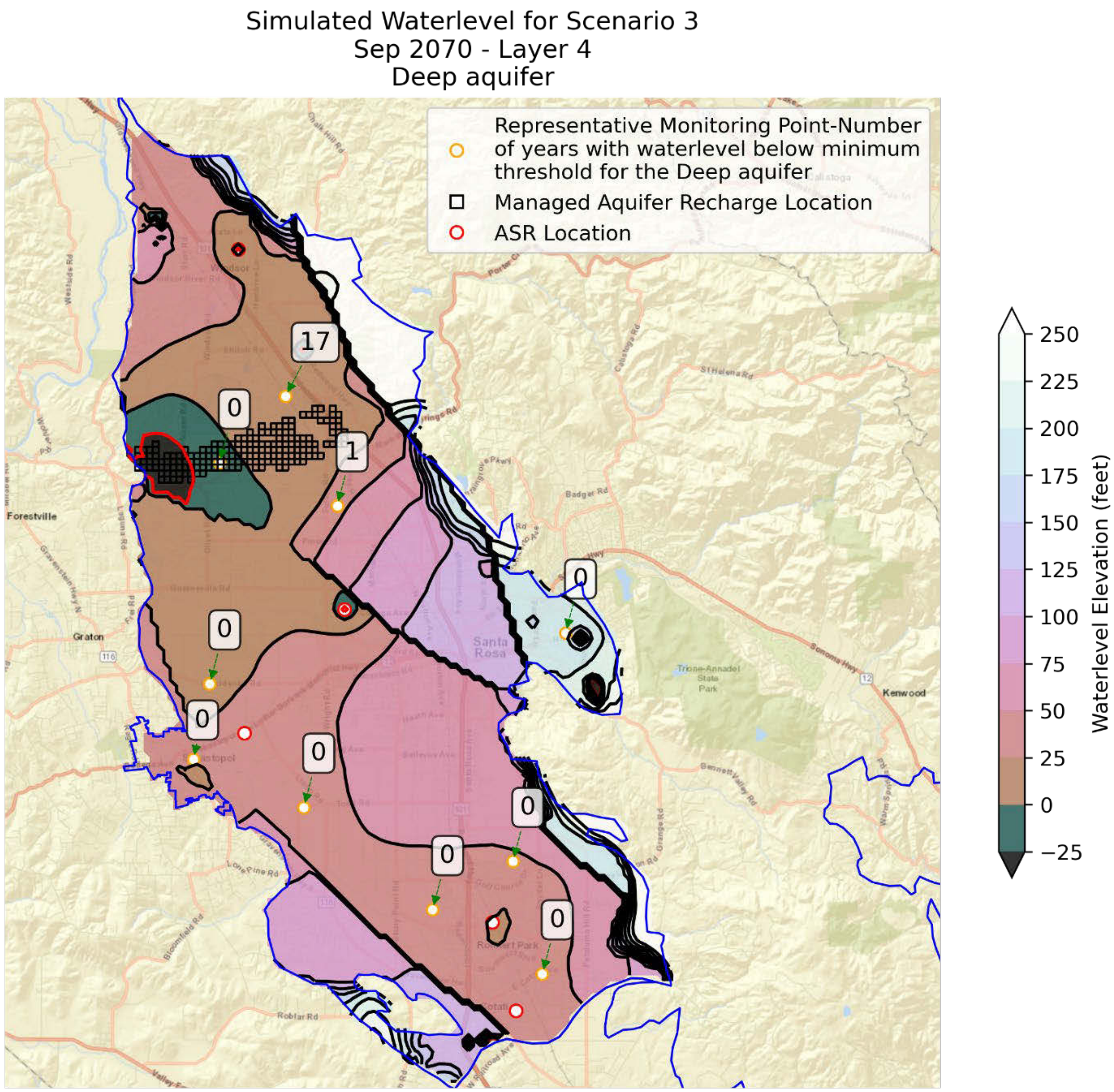


Figure 42 Actual Simulated Waterlevels for the Deep Aquifer for Scenario 3, Sep 2070. Positive Values Outlined in Black, Negative Values Outlined in Red

4 CONCLUSIONS

The Group 1, Group 2 and Group 3 project scenarios improve groundwater conditions and reduce the number of MT exceedances. Implementation of Group 1, 2 and 3 prohibit the occurrence of undesirable results. Each successive scenario shows improvement in the number of MT exceedances. Each successive group also shows improvement in the rate of groundwater storage decline. The baseline change in groundwater storage is -1,400 AFY but improves to -

1,100 in the Group 3 Scenario. The Group 1 and Group 3 show positive improvements in groundwater elevation for the deep aquifer. The Group 2 project does not cause significant improvement in groundwater elevations compared to Group 1 but does increase summertime discharge in the lower Mark West Creek area by 10%. Group 3 shows small improvement in MT exceedance and causes improvements to the areal coverage of the groundwater elevation benefits, especially in the southern third of the Subbasin. Additional data collection and project conceptualization during early phases of GSP implementation will help refine these scenarios.

5 References

Beganskas S, Fisher A.T., Coupling distributed stormwater collection and managed aquifer recharge: Field application and implications, Journal of Environmental Management, Volume 200, 2017, Pages 366-379

.

Appendix 6-B
Simulated Waterlevel Hydrographs from the Simulation of Projects and Management Actions

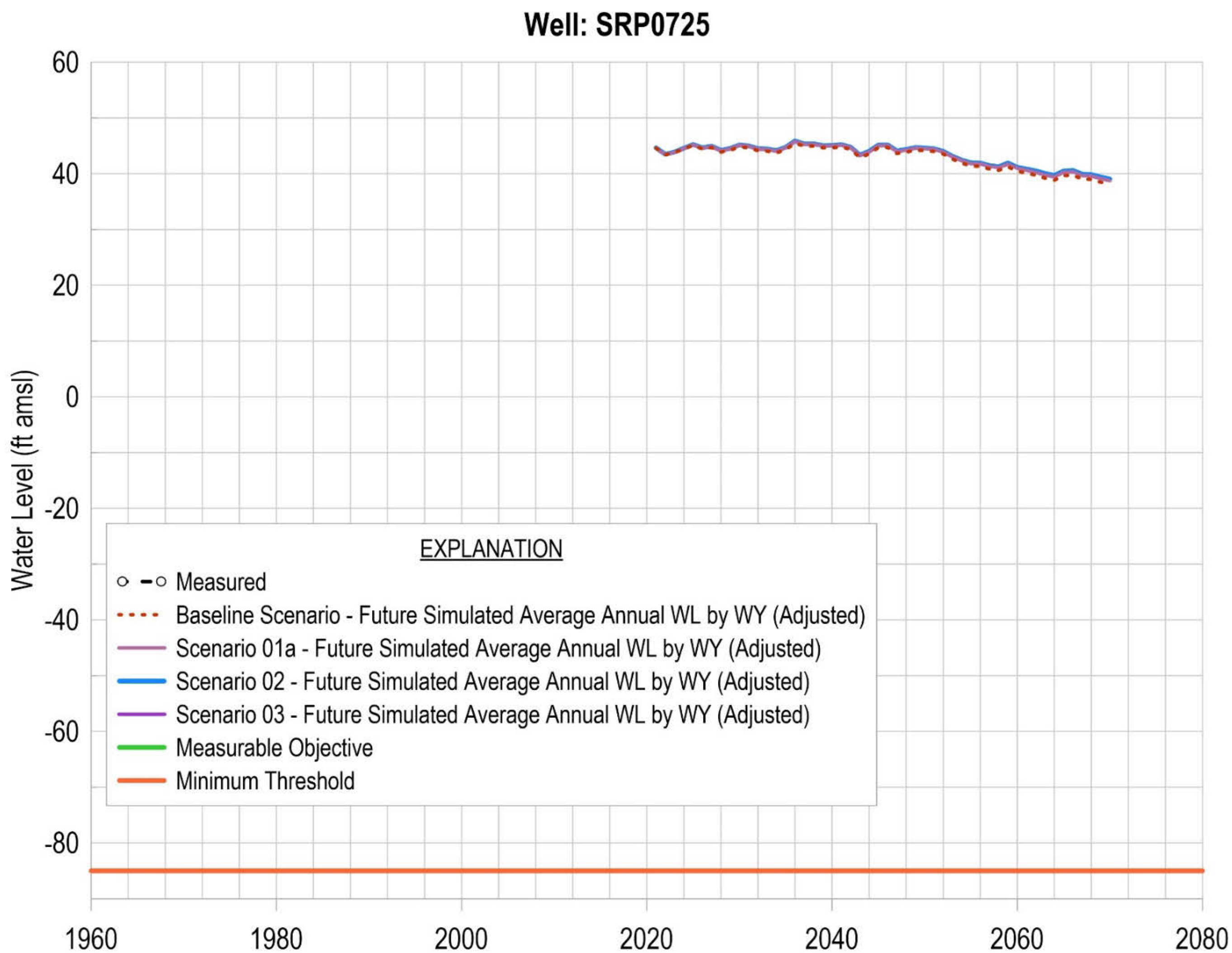


Figure 1 Waterlevel Hydrograph for SRP0725

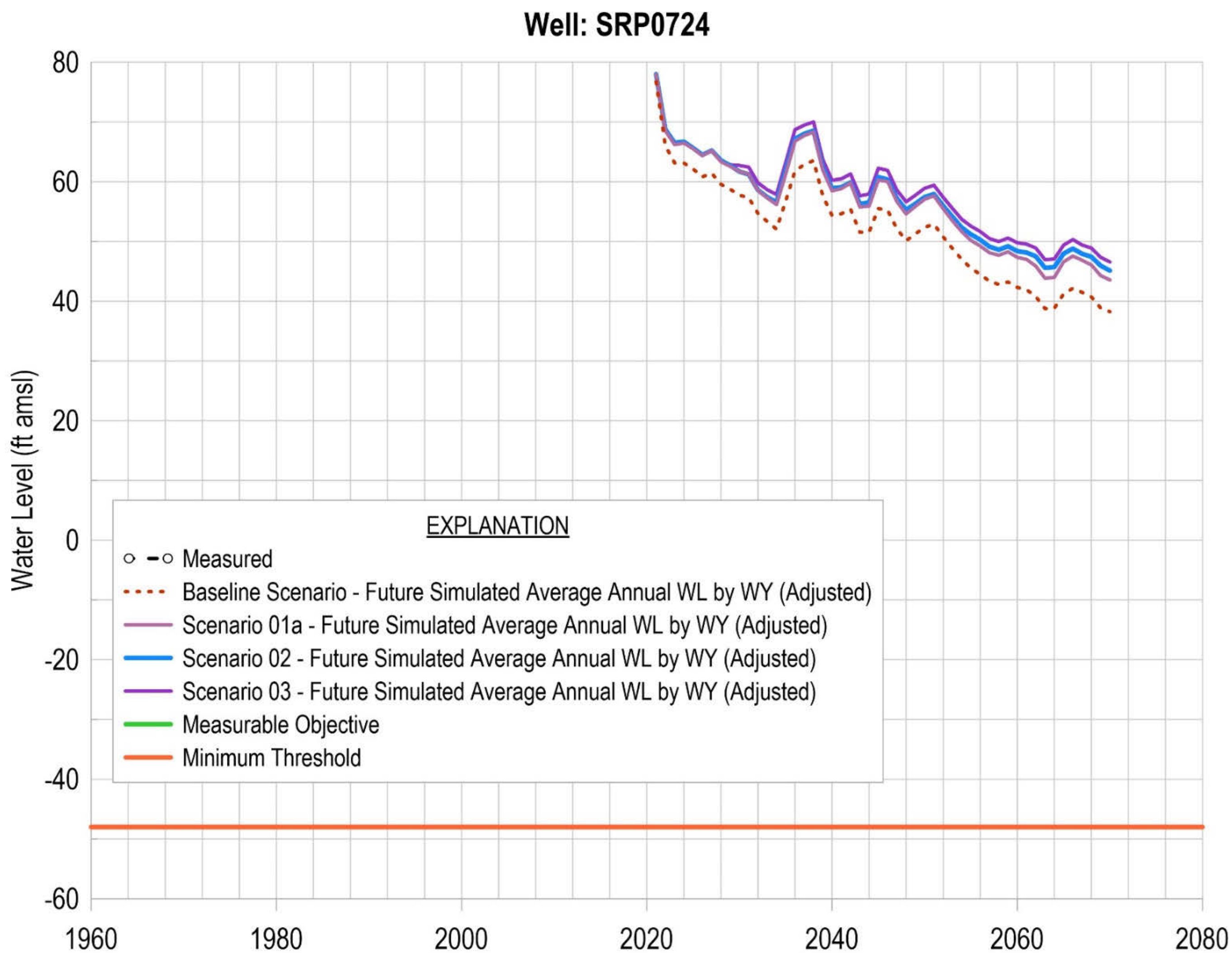


Figure 2 Waterlevel Hydrograph for SRP0724

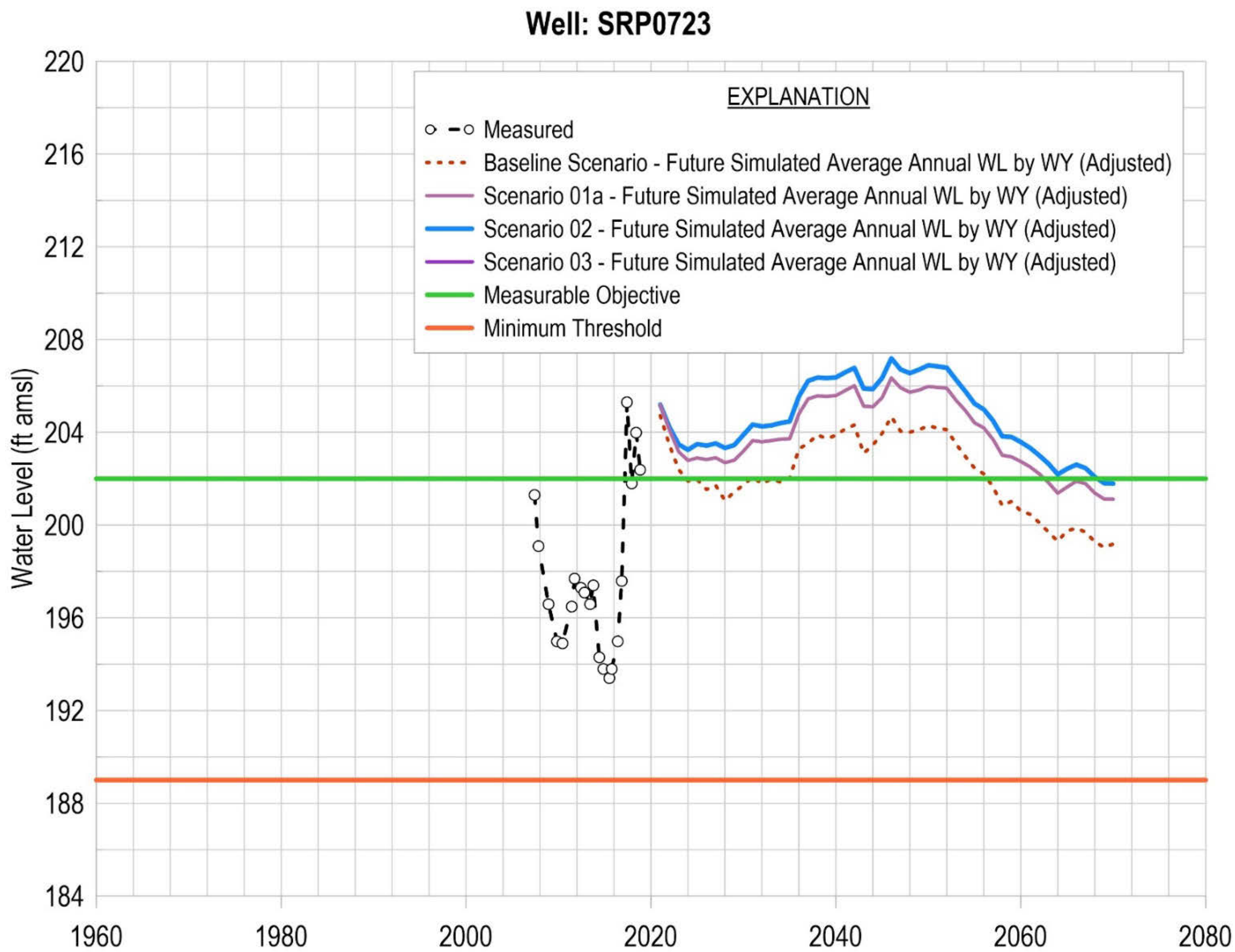


Figure 3 Waterlevel Hydrograph for SRP0723

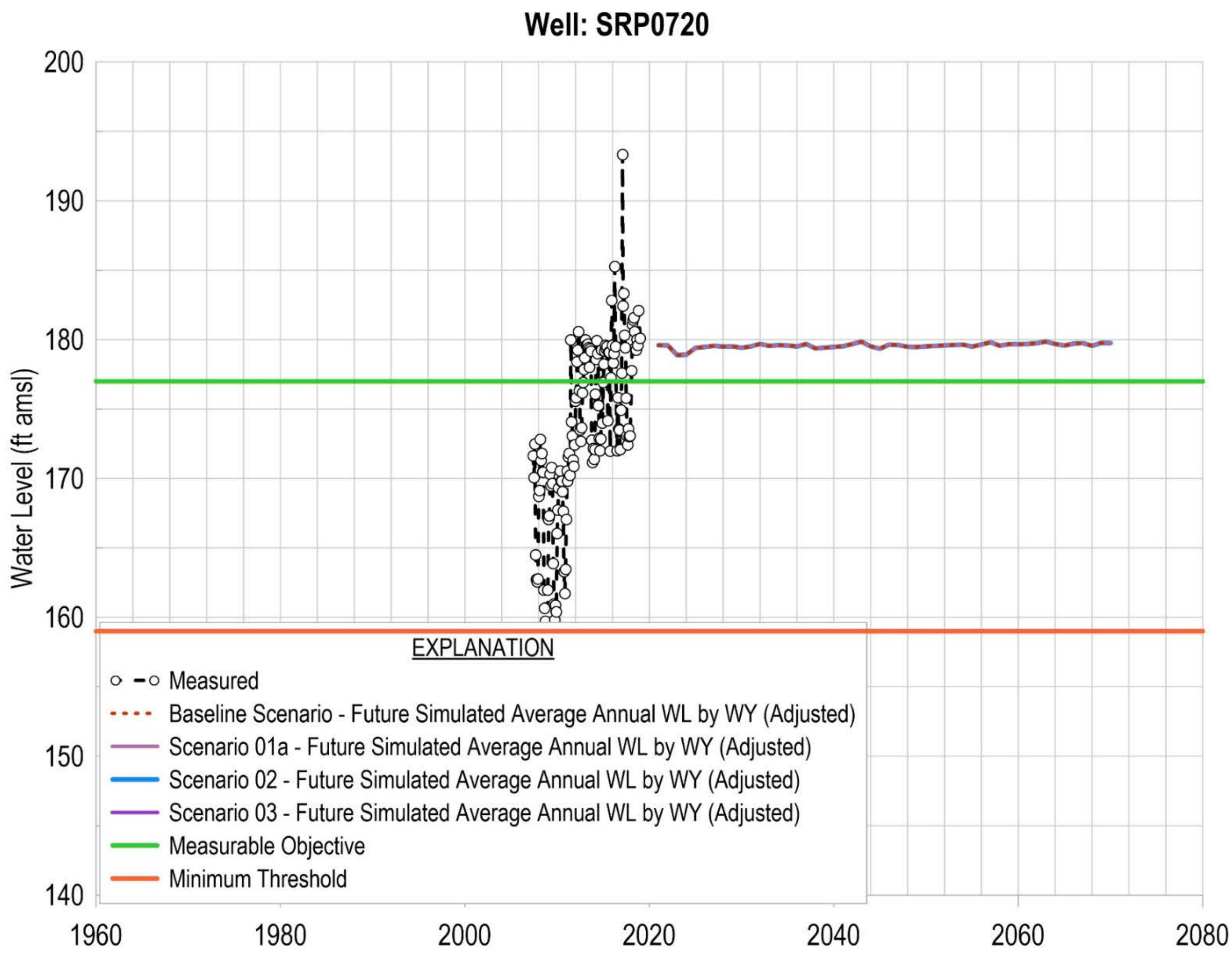


Figure 4 Waterlevel Hydrograph for SRP0720

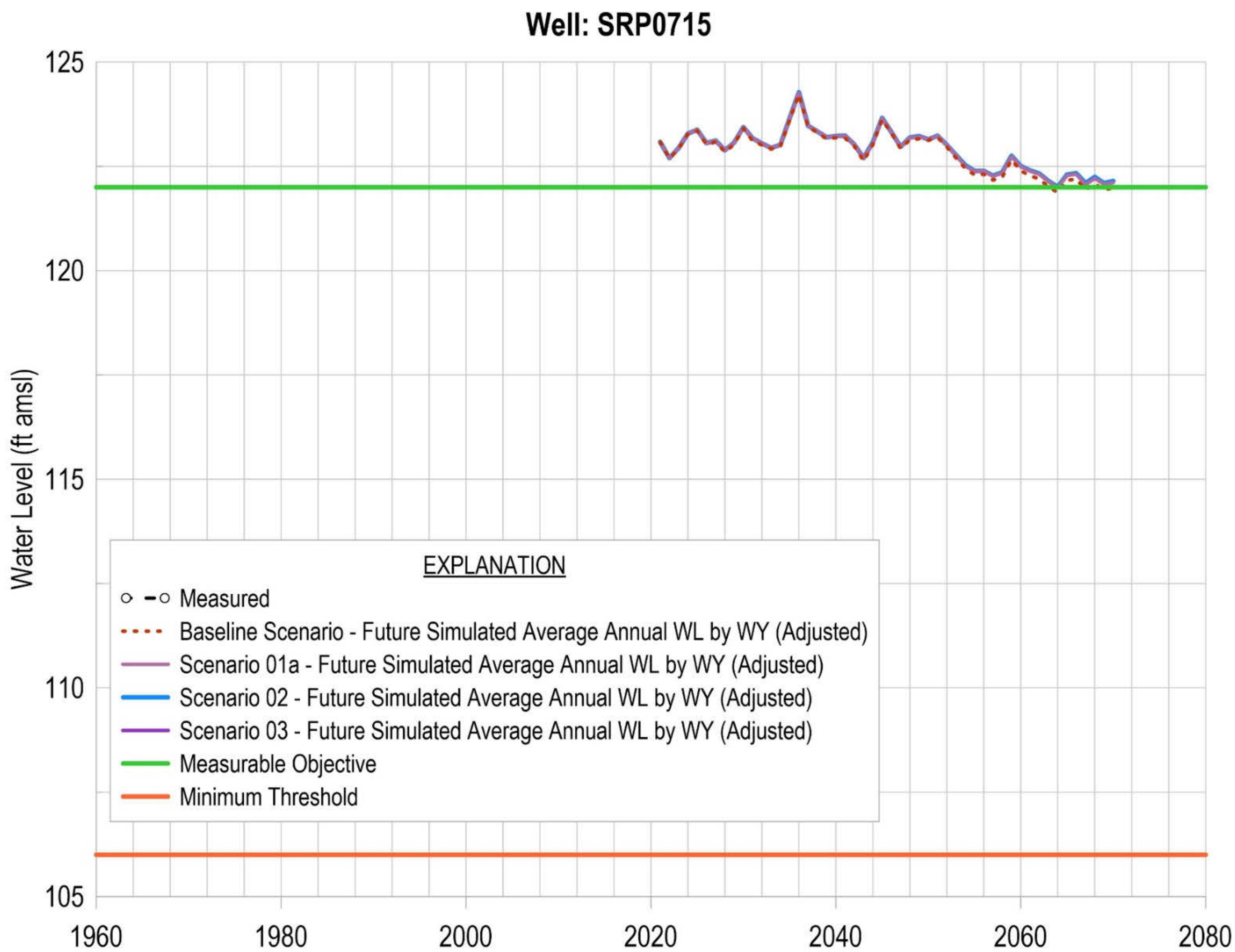


Figure 5 Waterlevel Hydrograph for SRP0715

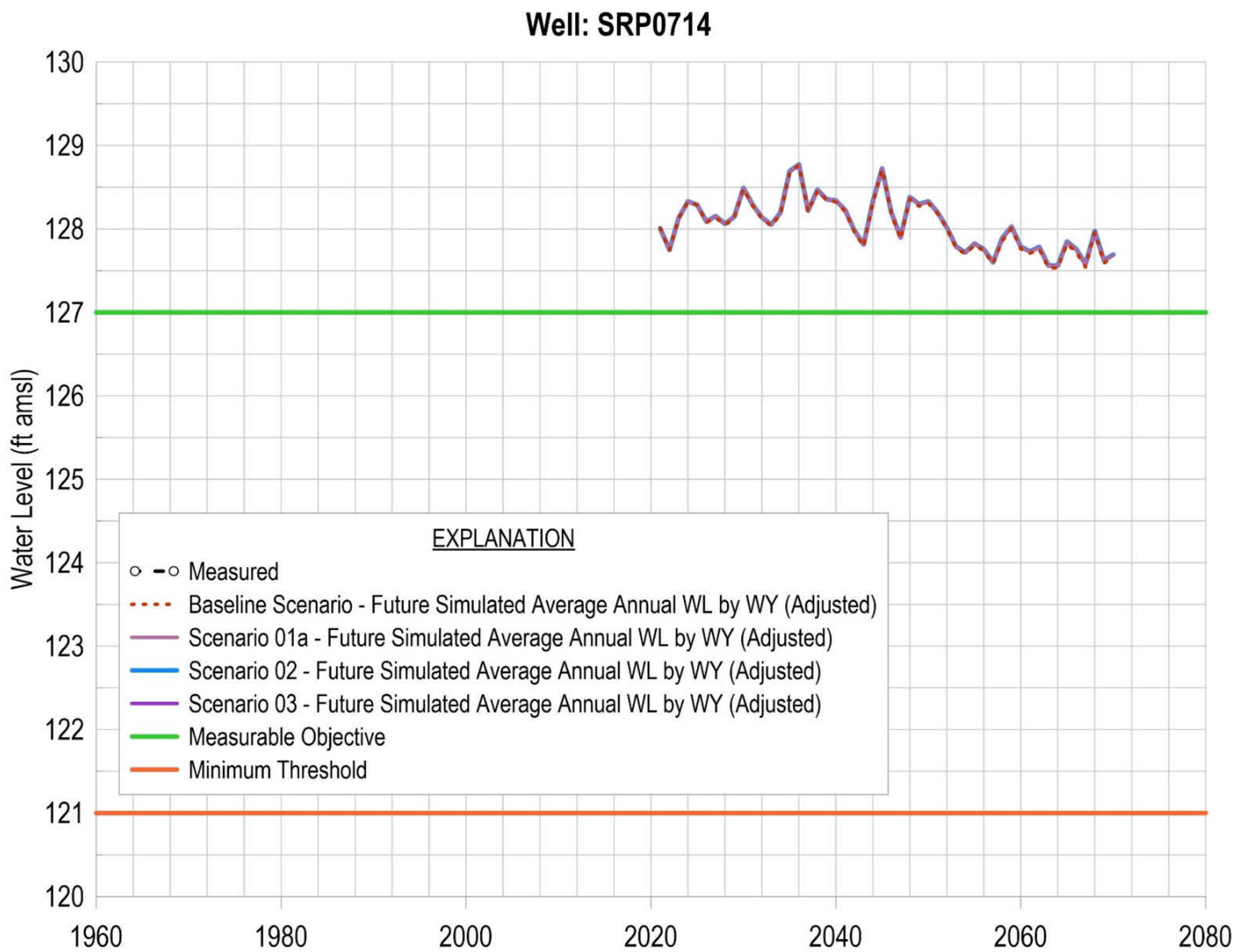


Figure 6 Waterlevel Hydrograph for SRP0714

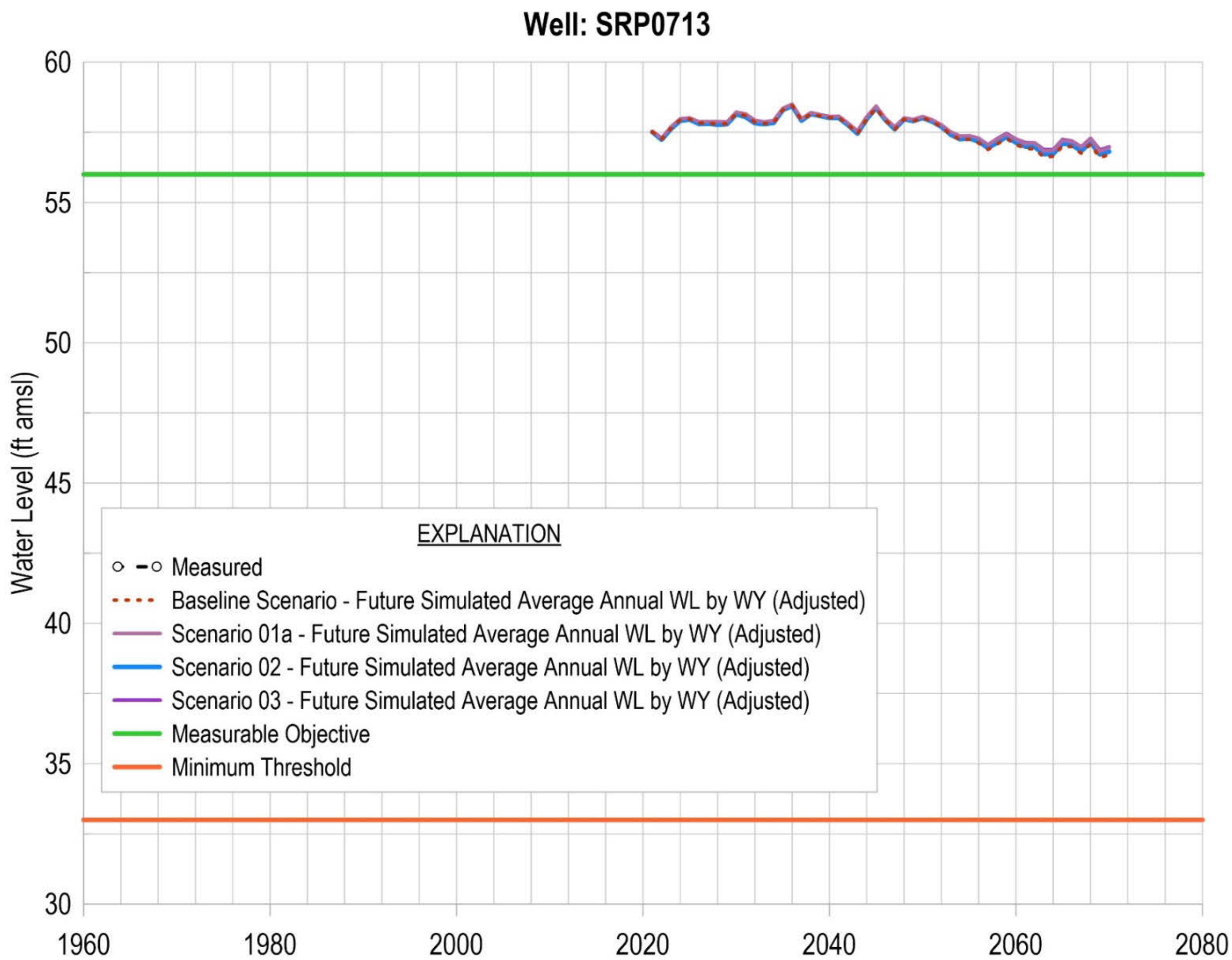


Figure 7 Waterlevel Hydrograph for SRP0713

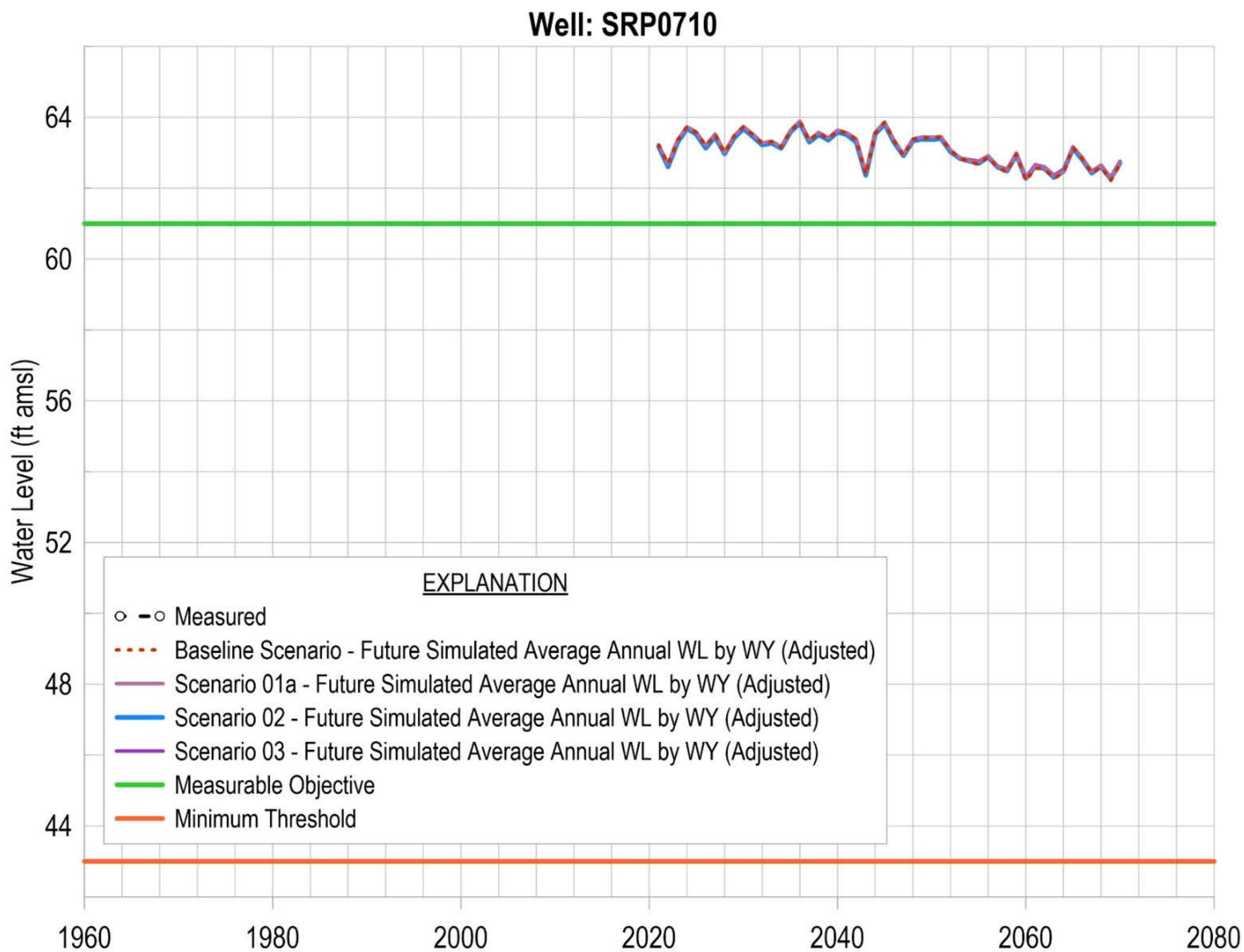


Figure 8 Waterlevel Hydrograph for SRP0710

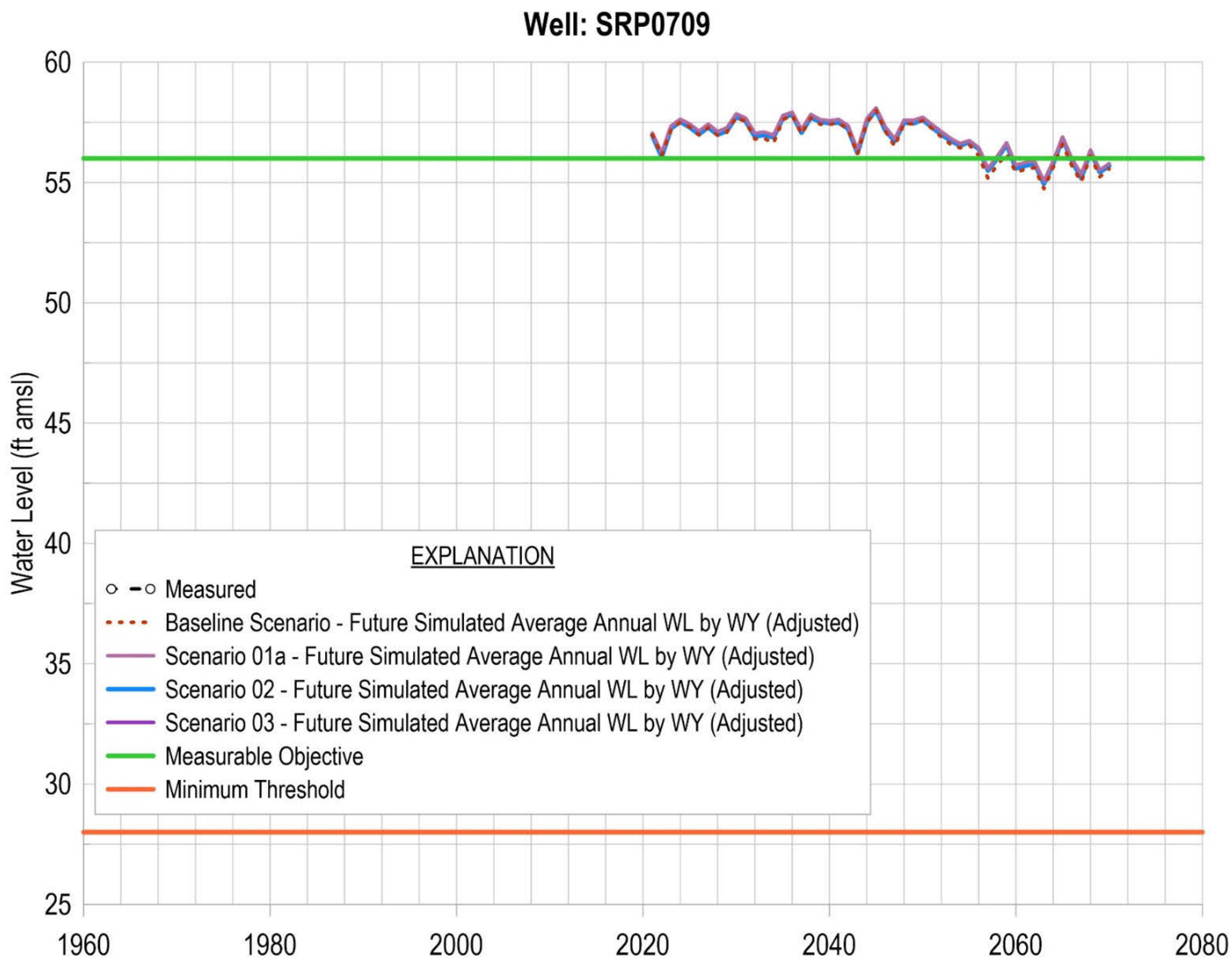


Figure 9 Waterlevel Hydrograph for SRP0709

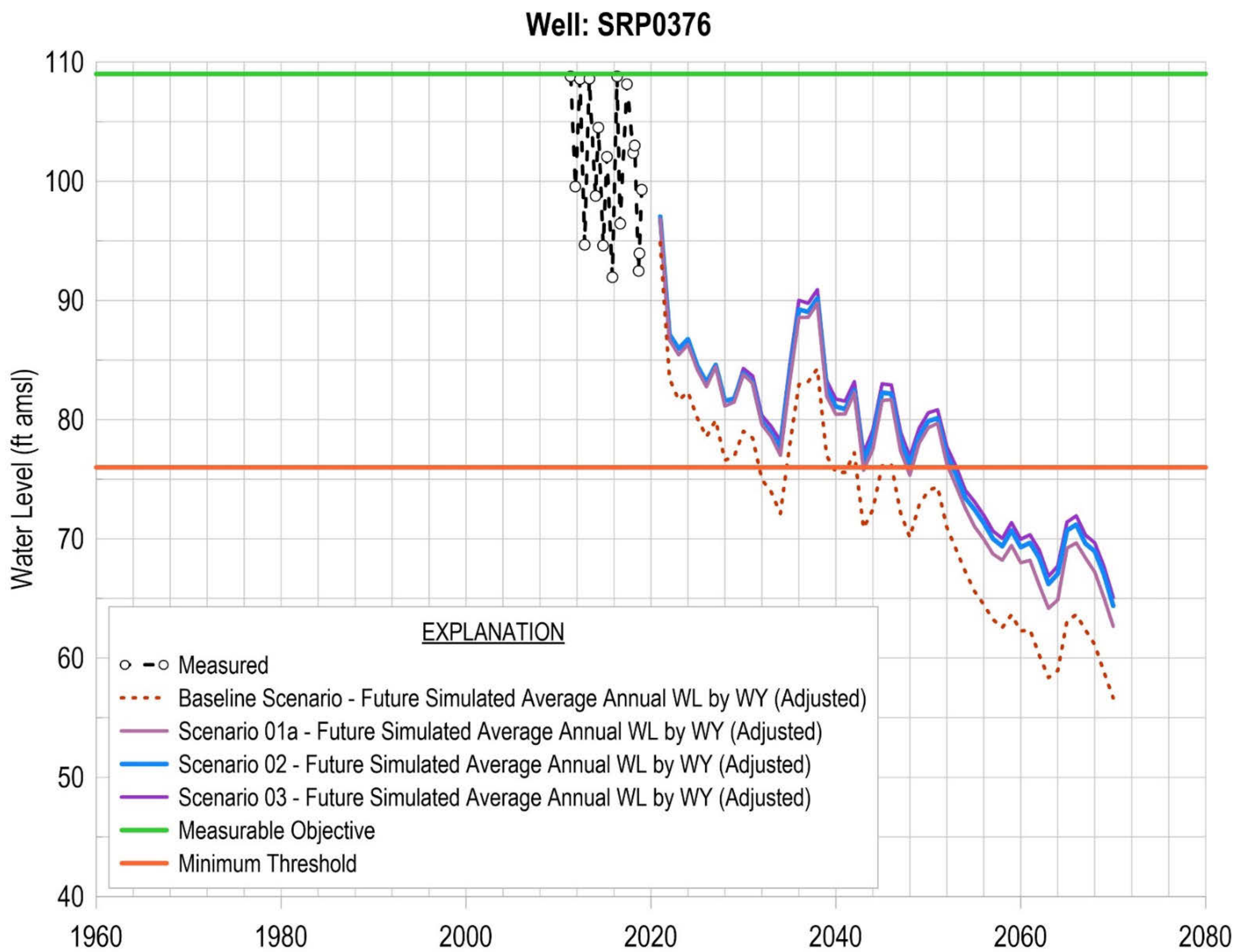


Figure 10 Waterlevel Hydrograph for SRP0376

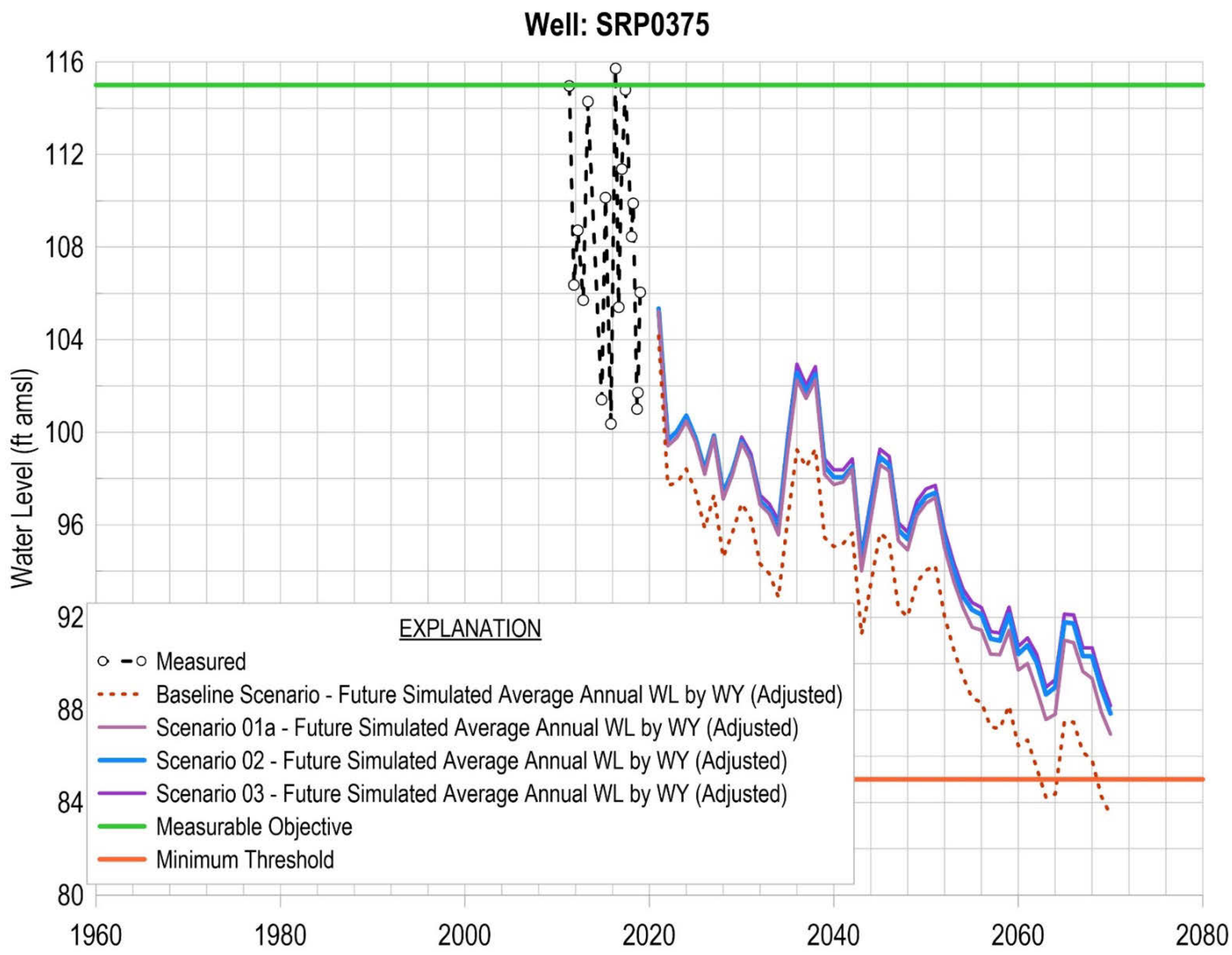


Figure 11 Waterlevel Hydrograph for SRP0375

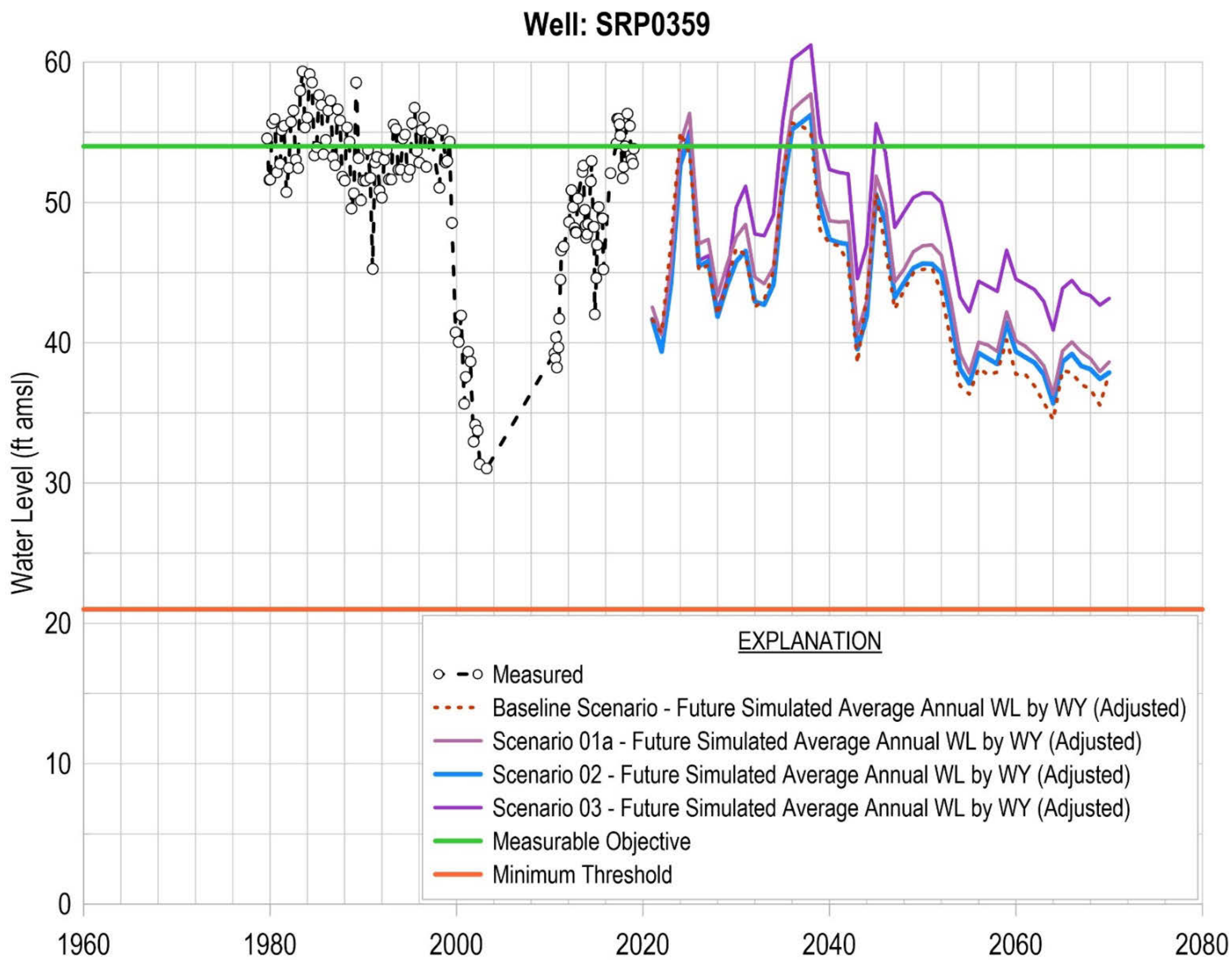


Figure 12 Waterlevel Hydrograph for SRP0359

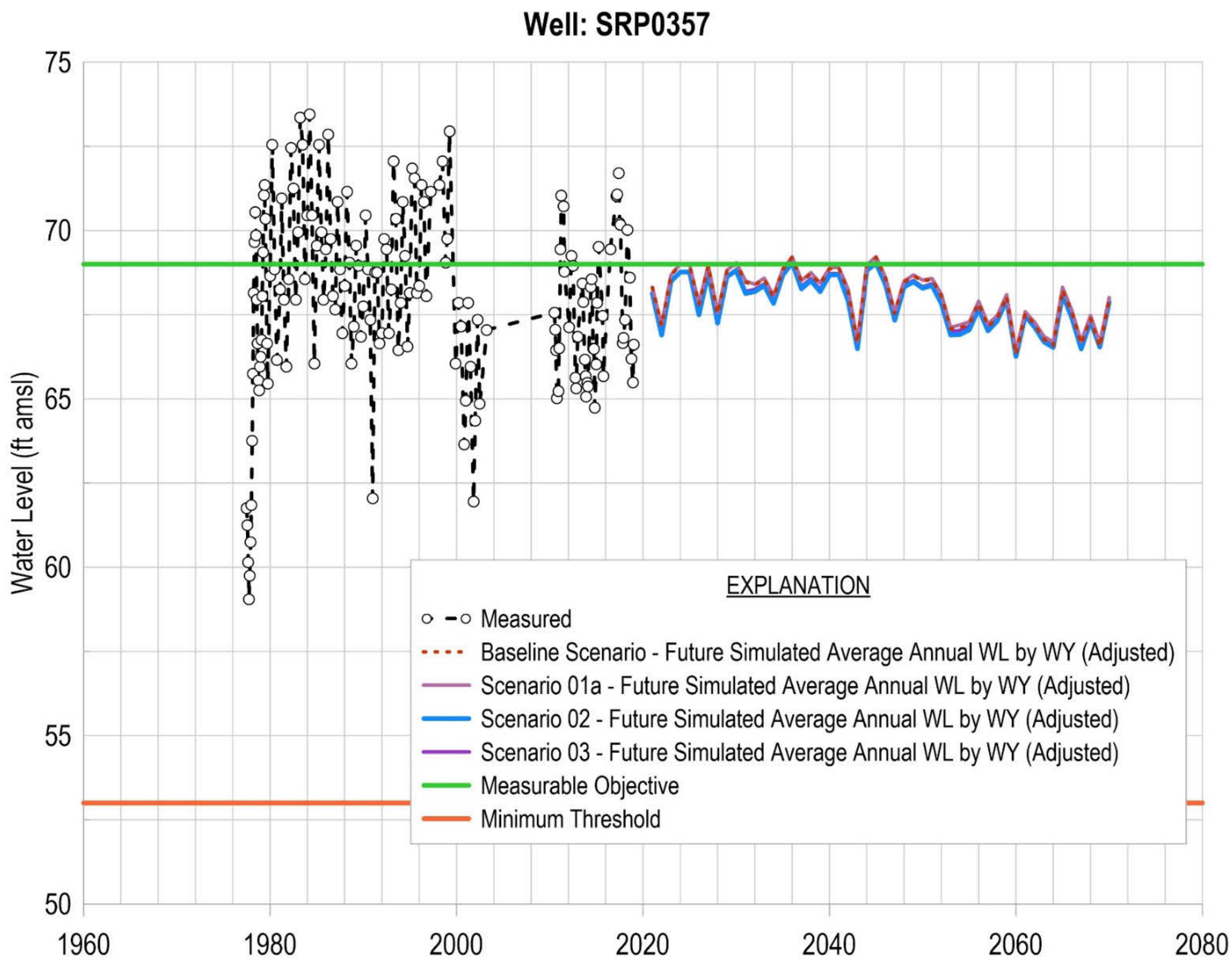


Figure 13 Waterlevel Hydrograph for SRP0357

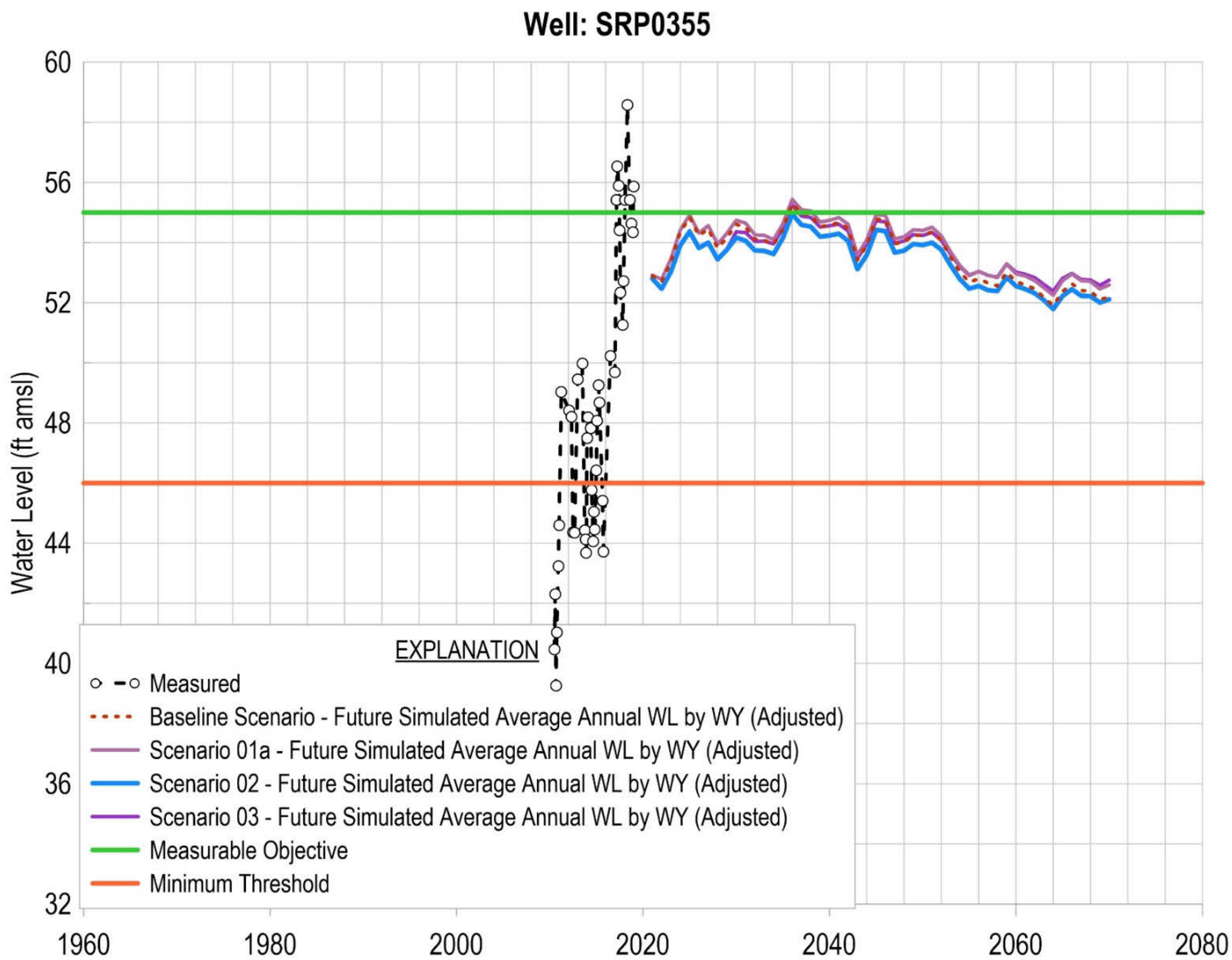


Figure 14 Waterlevel Hydrograph for SRP0355

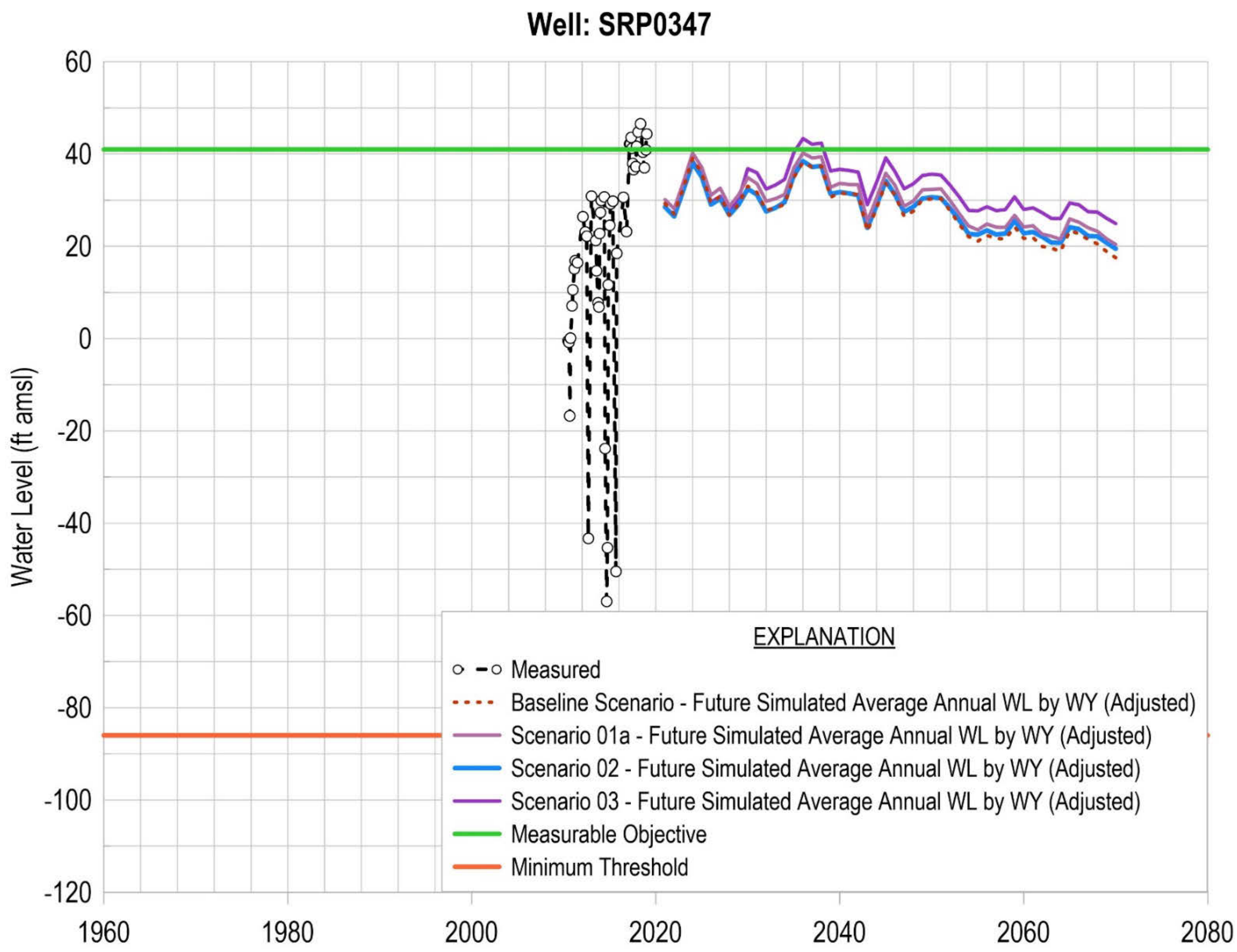


Figure 15 Waterlevel Hydrograph for SRP0347

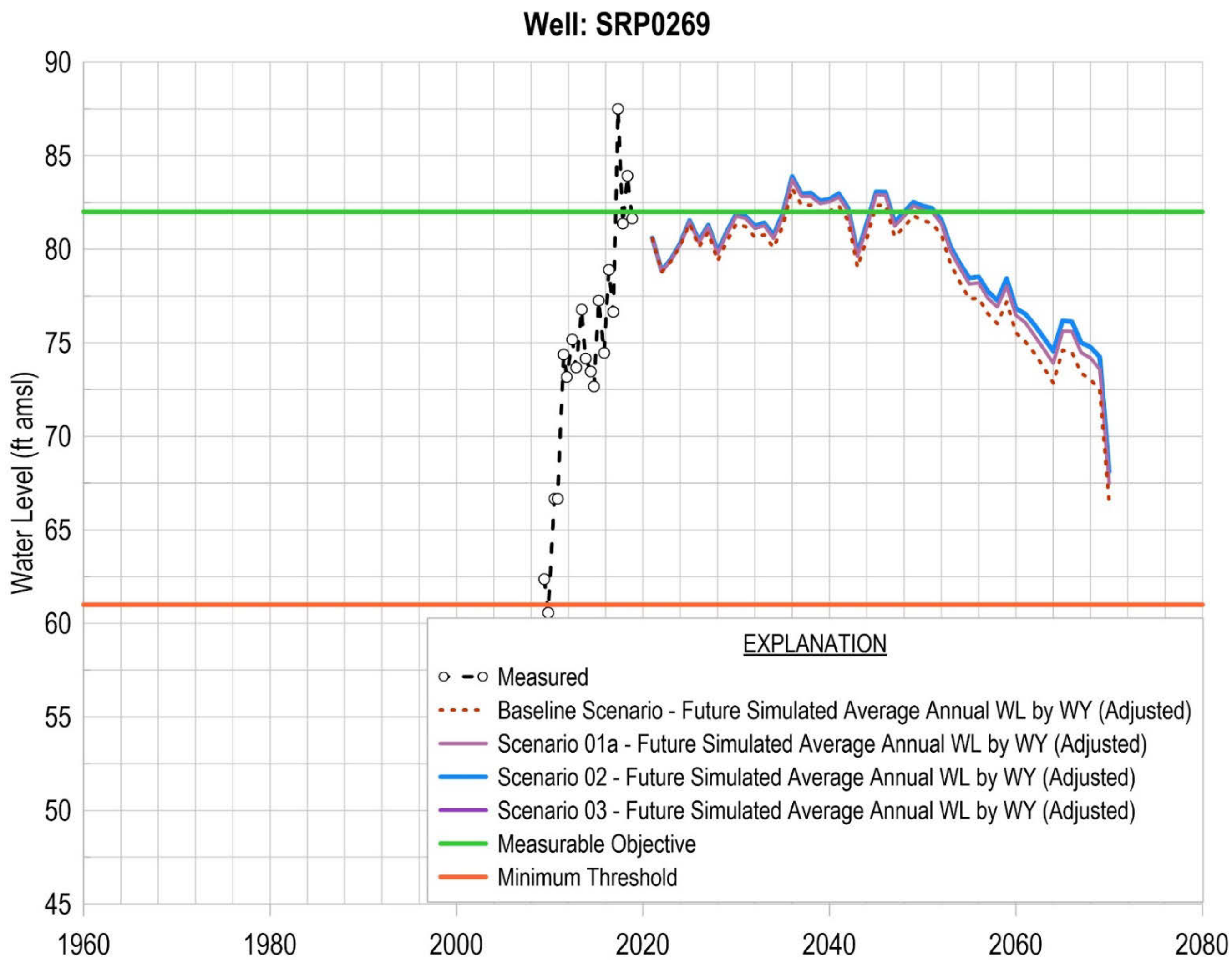


Figure 16 Waterlevel Hydrograph for SRP00269

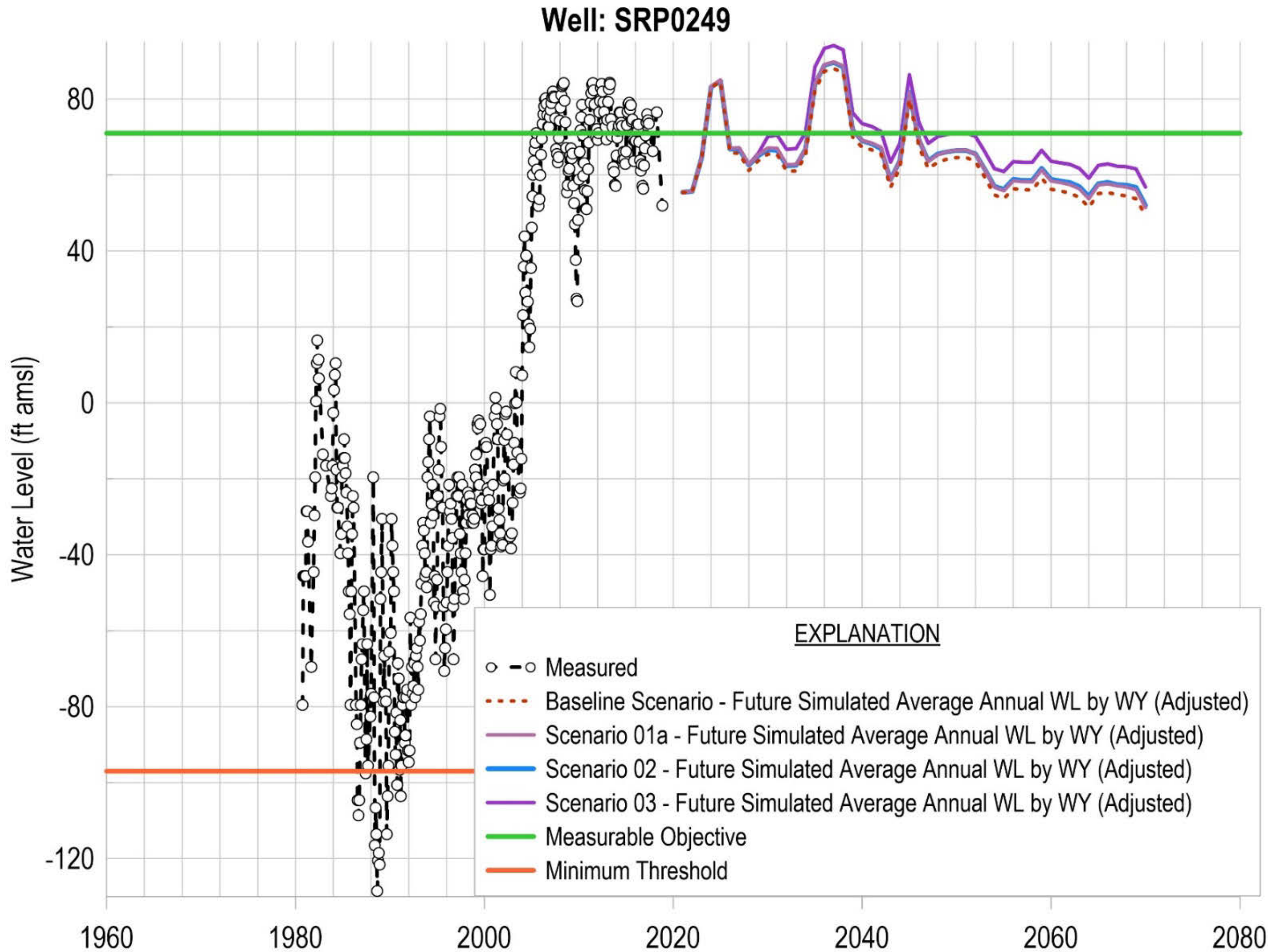


Figure 17 Waterlevel Hydrograph for SRP00249

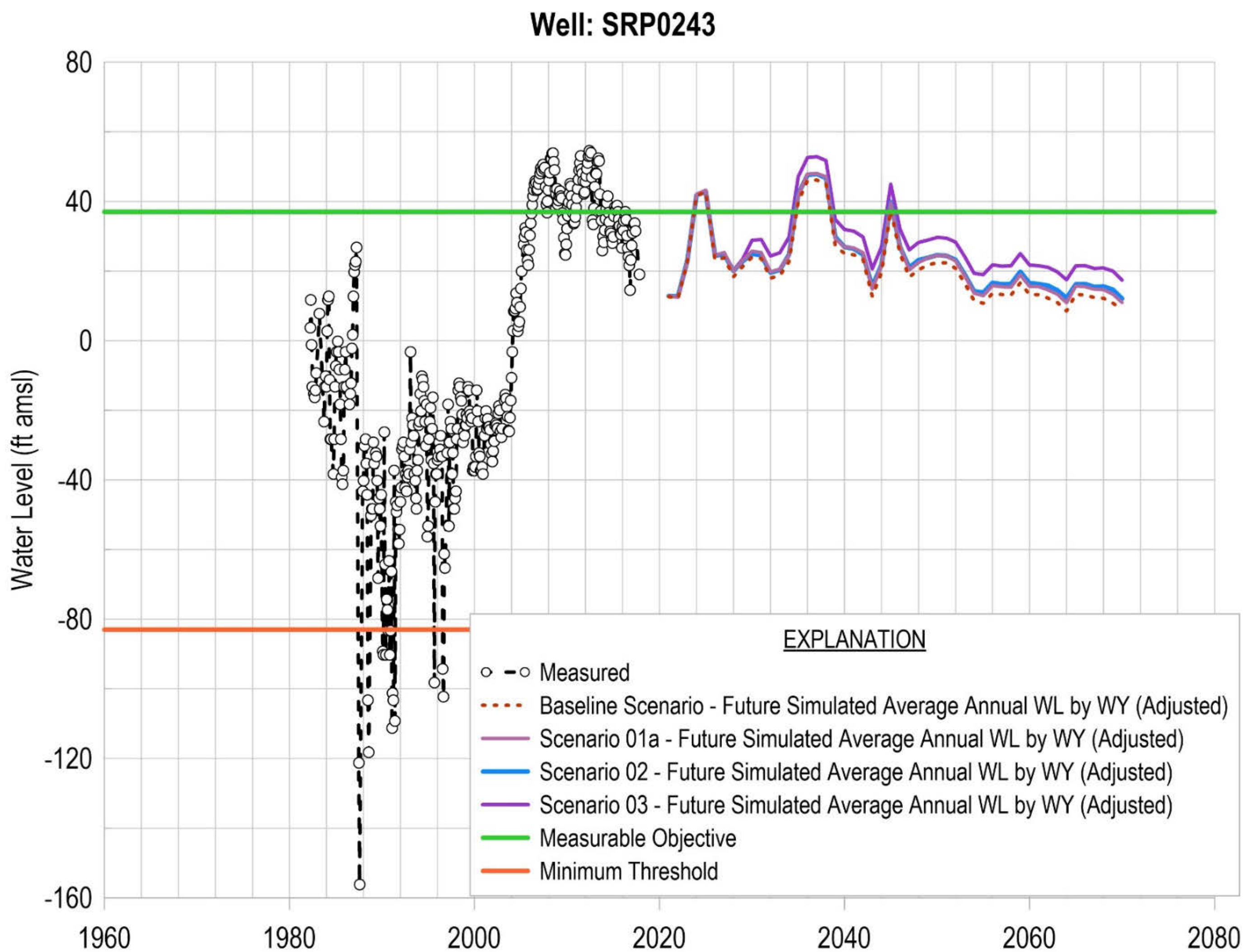


Figure 18 Waterlevel Hydrograph for SRP00243

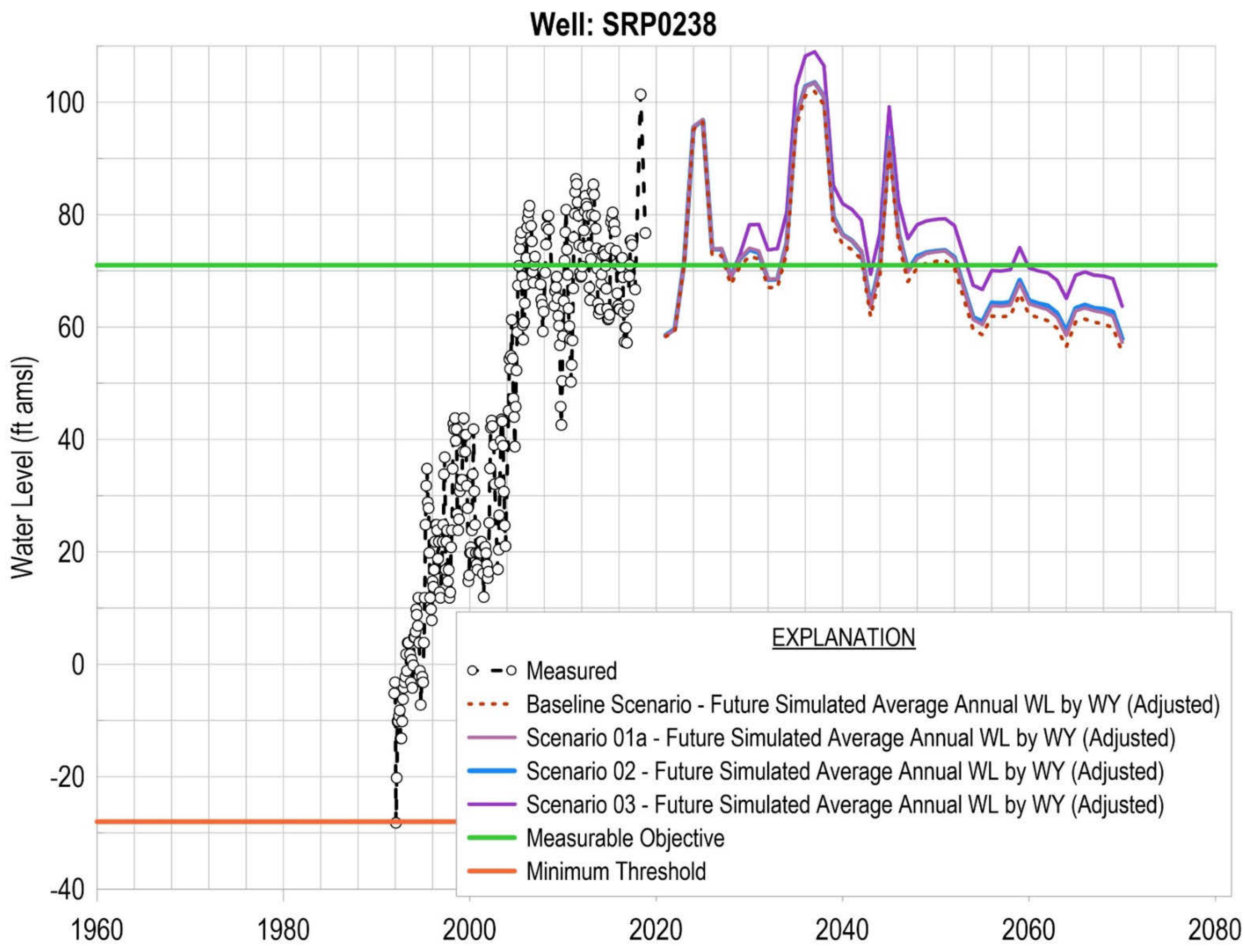


Figure 19 Waterlevel Hydrograph for SRP0238

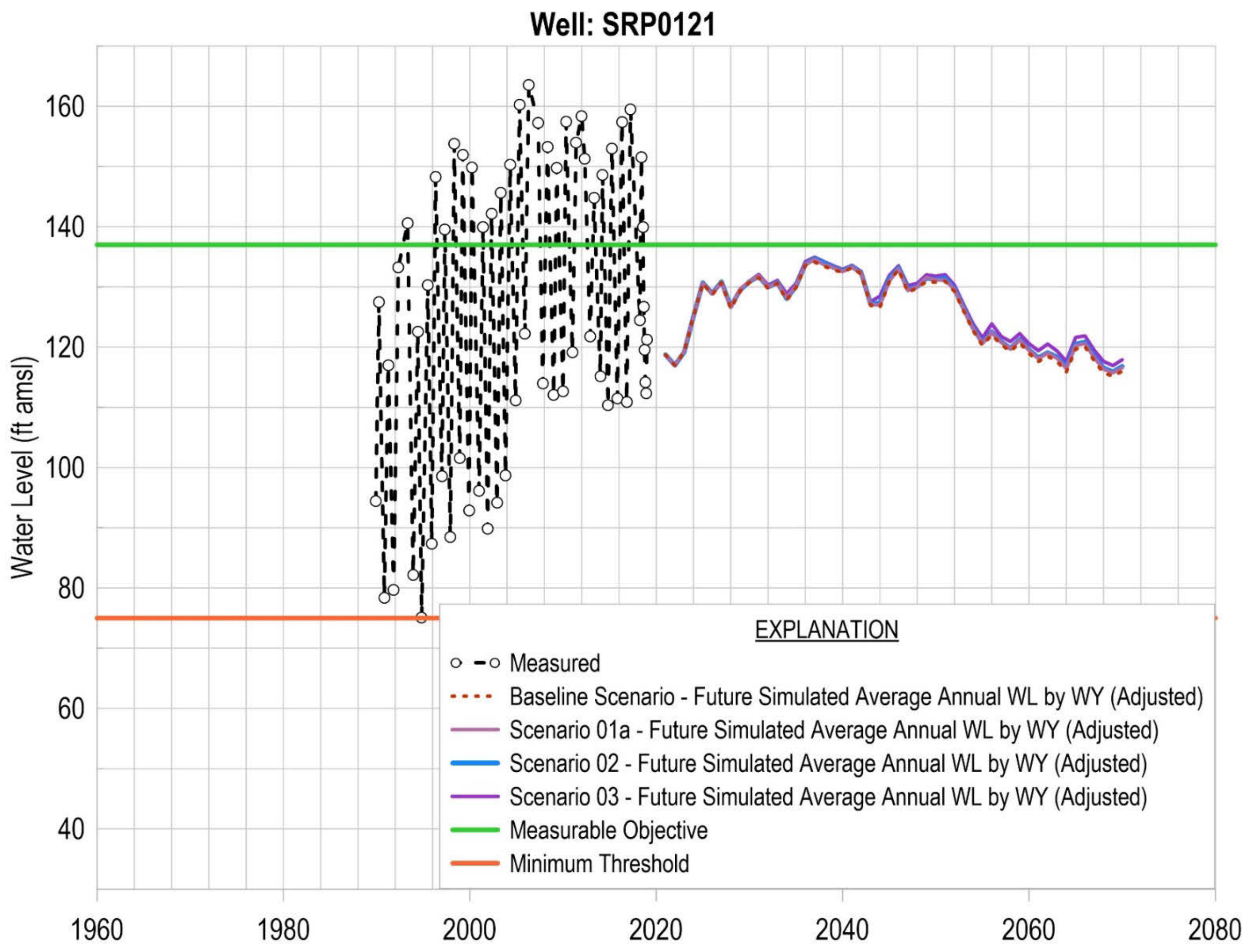


Figure 20 Waterlevel Hydrograph for SRP0121

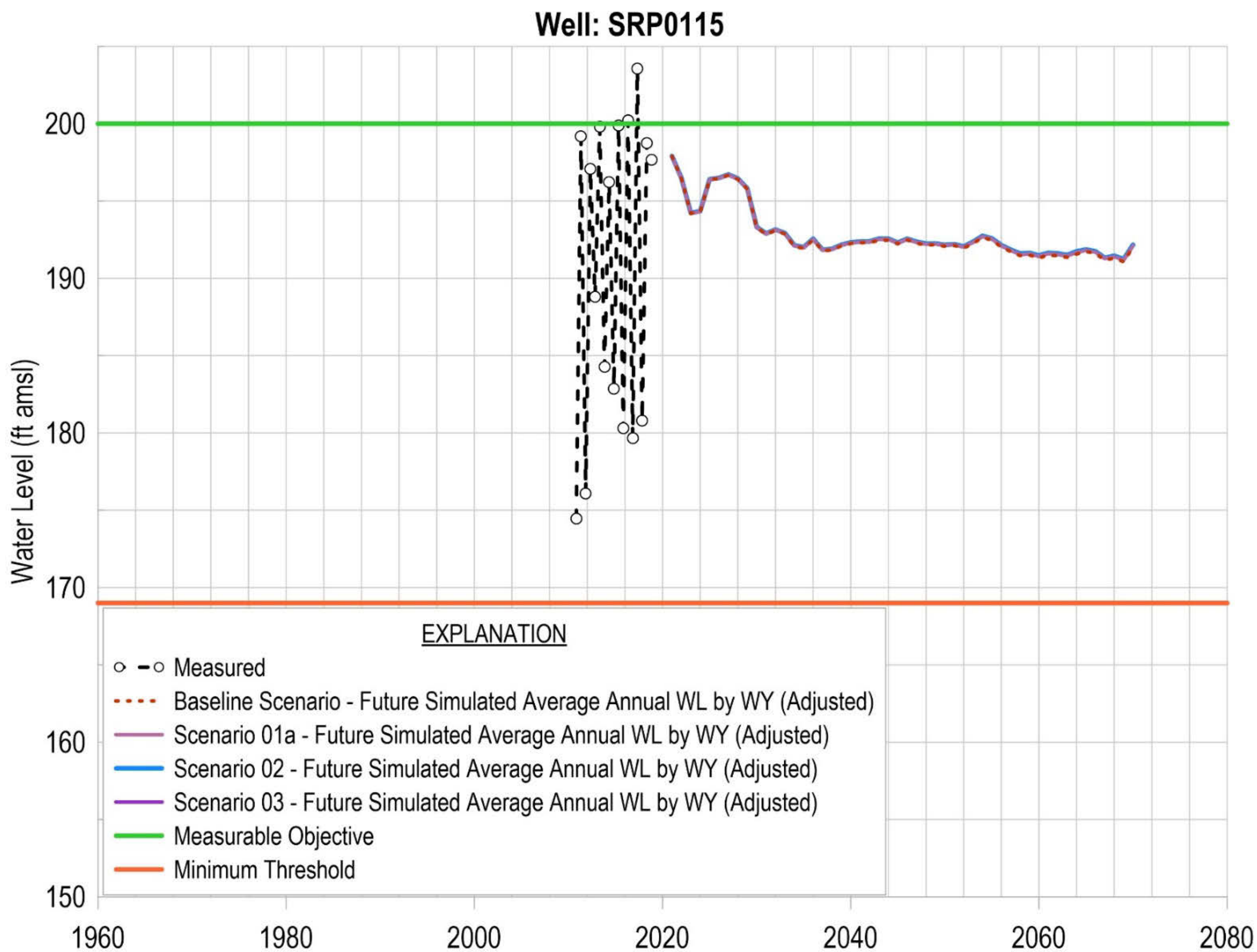


Figure 21 Waterlevel Hydrograph for SRP0115

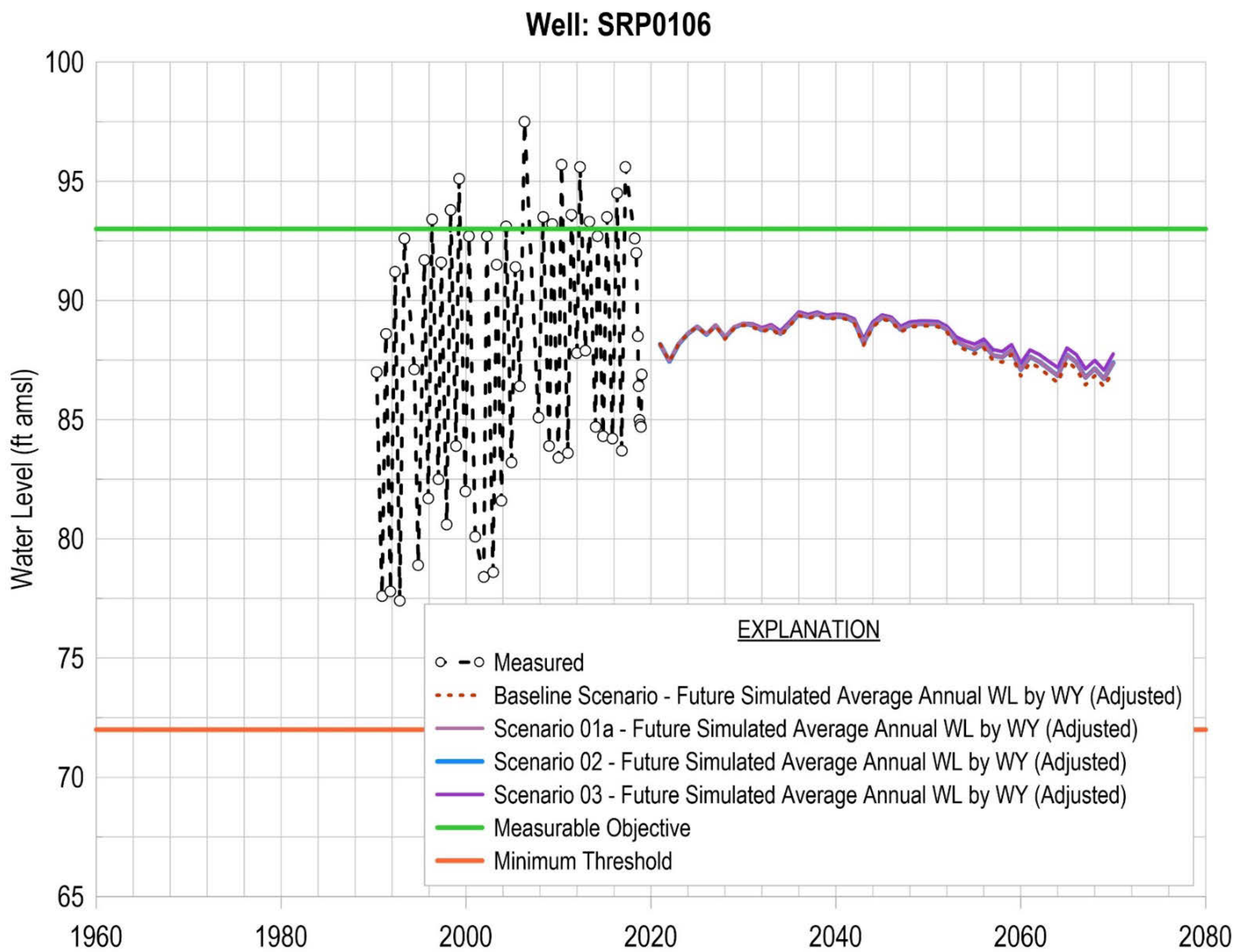


Figure 22 Waterlevel Hydrograph for SRP0106

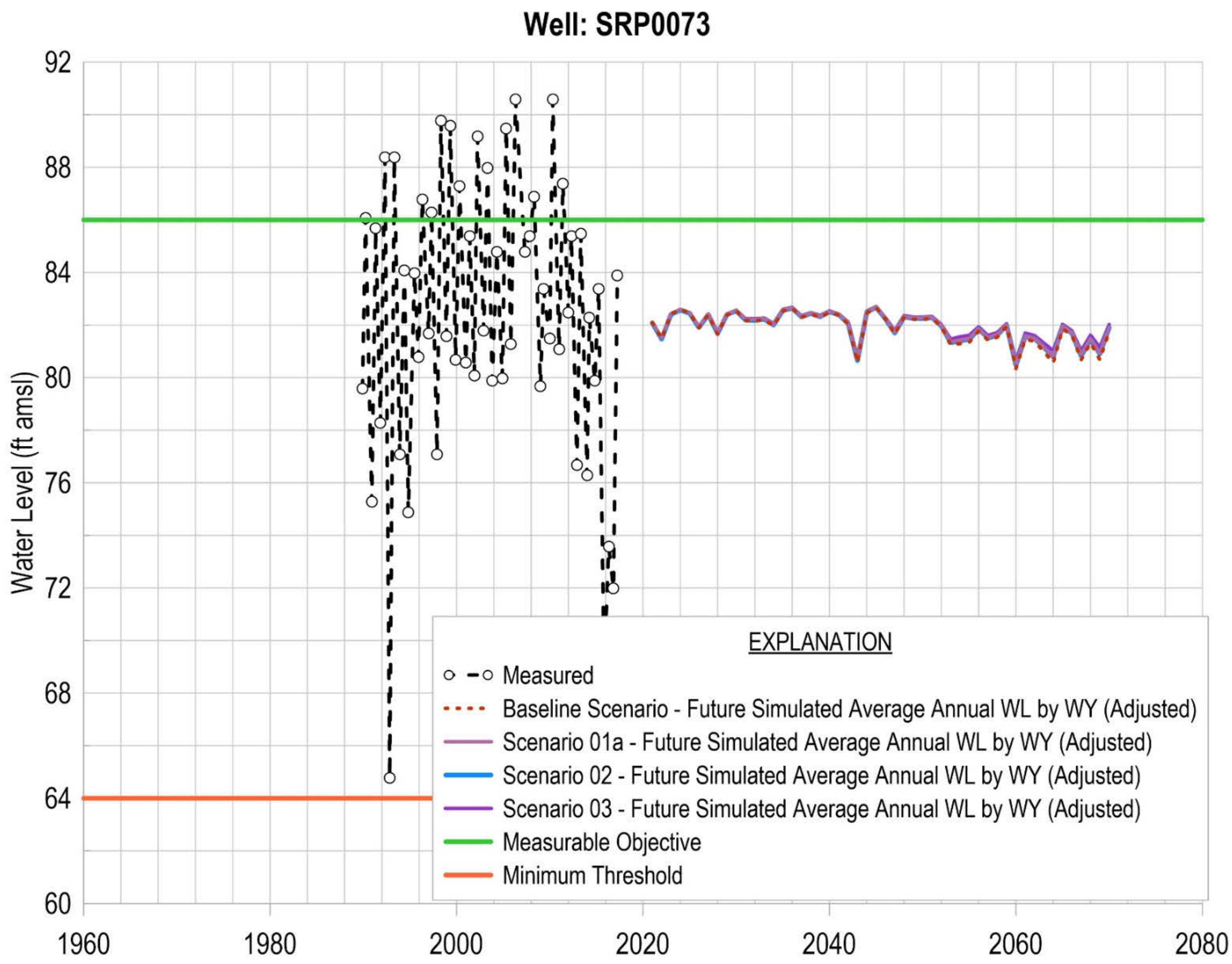


Figure 23 Waterlevel Hydrograph for SRP0073

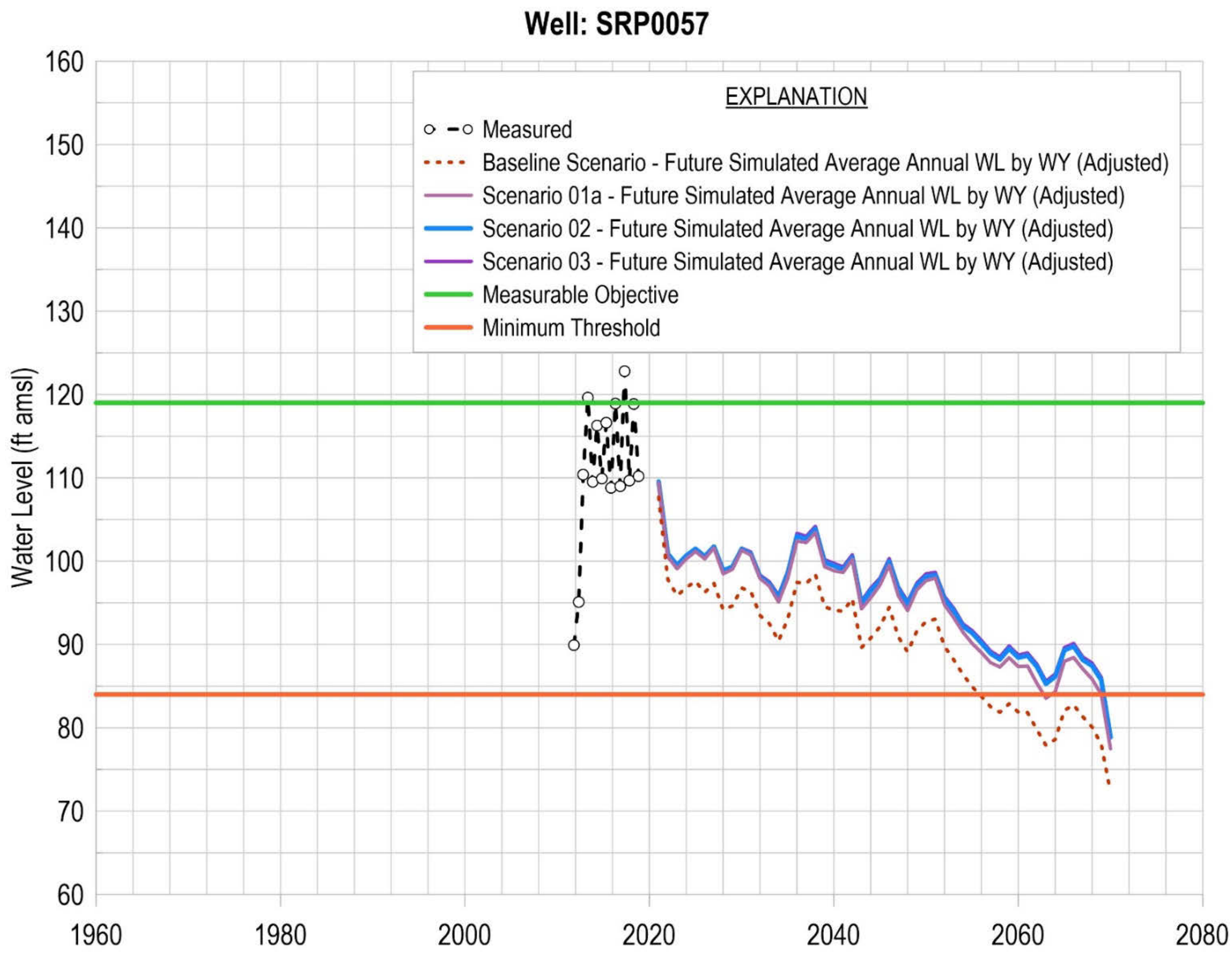


Figure 24 Waterlevel Hydrograph for SRP0057

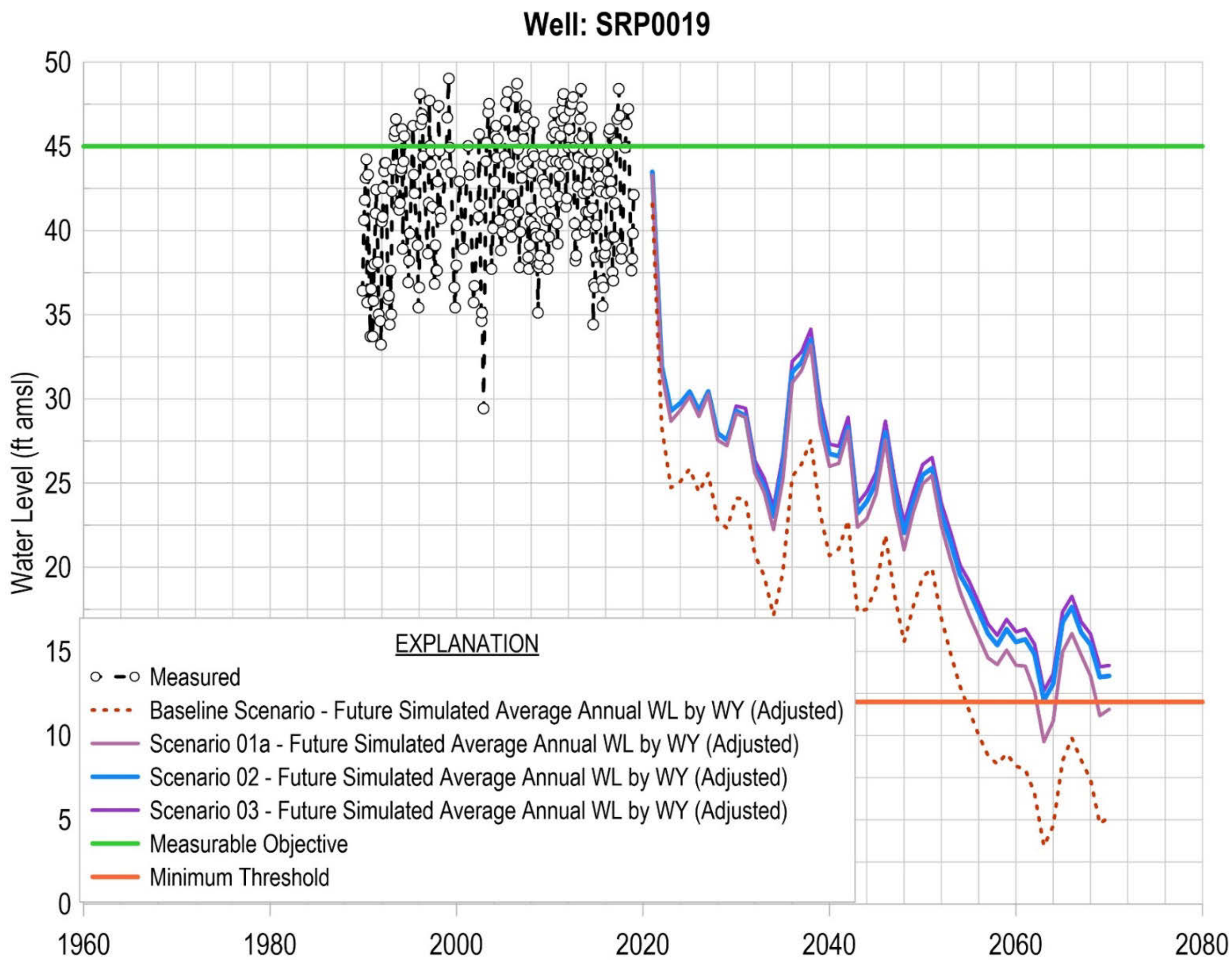


Figure 25 Waterlevel Hydrograph for SRP0019

.

Appendix 7-A
Model Maintenance and Improvements for the Santa Rosa Plain Groundwater Sustainability Plan

.

DRAFT

Appendix 7-A:
Model Maintenance and Improvements

Groundwater Sustainability Plan

Santa Rosa Plain Groundwater Subbasin

Table of Contents

1 Projects and Management Actions

The Groundwater Sustainability Plain (GSP) for the Santa Rosa Plain (Subbasin) relied on groundwater modeling to support development of historical, current, and projected water budgets, and to evaluate projected benefits from implementing Projects and Management Actions (PMA) scenarios.

The Santa Rosa Plain Hydrologic Model (SRPHM) is a thoroughly developed, documented, and tested tool that has been used in the development of the GSP. The SRPHM was originally developed by the USGS (Wolfenden and Nishikawa, 2014), and revised by Sonoma Water for purposes of developing more accurate water budgets in the Subbasin. The accuracy of the model is dependent on the data available used to inform its development. As new data becomes available assessments will be made to determine if changes to the model may be necessary. Changes to the model could be small, such as adjusting a parameter that controls runoff, or it may be systemic, such as changing location of a boundary or fault or hydraulic properties of a local area. Recommended model improvements that are relevant to GSP implementation will be addressed during the first five years of GSP implementation. In addition to recommended model improvements, routine model maintenance activities will also be conducted during GSP implementation. Routine model update tasks include updating the model with recent land use, pumping, and climate data, and recalibrating the model, if necessary. Finally, model predictive simulations will be updated to reflect new information on alternative future climate scenarios and PMA planning and implementation.

All model improvements incorporated during GSP implementation will build on additional data collection and interpretation activities described in GSP Section 7. These additional data will be used to verify model inputs (Section 2.2), compare against model outputs (Section 2.3), and guide improvements to model structure (Section 3).

This appendix summarizes model improvements that are planned during the first five years of GSP implementation, including updating input data, improving the model structure, and refining the representation of projected PMAs for the 5-year GSP assessment.

2 Update Data Inputs to Model

2.1 Update Simulation Period

The SRPHM simulation period covers the period from 1976 through 2018. During GSP implementation, the simulation period will be extended through Water Year (WY) 2025 for the 5-year GSP update due in 2027. As part of extending the simulation period, the following data inputs will be updated and incorporated in the model:

- Update land use with available spatial dataset(s), both inside and outside of the Subbasin, if available
- Update agricultural irrigation pumping based on new information and land use changes
- Update rural domestic pumping based on updated parcel database and/or updated rural domestic pumpage estimates, if available
- Update municipal and industrial pumping rates, add new wells if necessary
- Streamflow diversion locations and rates
- Update recycled water deliveries and distribute to receiving model cells
- Precipitation and reference evapotranspiration

2.2 Verify Model Inputs Against Available Data

During assessment of SRPHM, several model inputs were identified as sources of uncertainty due to uncertain or limited data. During GSP implementation, these model inputs will be validated against the following additional datasets collected as part of GSP implementation, depending on necessity and impact:

- Irrigation well locations and depths
- Metered irrigation pumping
- Locations and rates of surface water diversions and surface-water storage
- Assignment of distribution of model hydraulic properties, which will be compared against updated hydrogeologic conceptual model from future aquifer test results and airborne electromagnetic survey data
- Estimates of riparian consumptive use to include as model structure improvements

2.3 Verify Model Outputs Against Available Data

Existing groundwater level and interconnected surface water networks will be expanded during GSP implementation (GSP Section 7.2.4). Data collected from these monitoring networks will be used to check model simulation results, and provide guidance to model re-calibration planned toward the end of the first 5 years of GSP implementation.

- Compare simulated streamflow against discharge measurements where available
- Compare simulated shallow groundwater levels against recent data from interconnected surface water wells
- Comparison of mapped seeps and springs against simulated exfiltration
- Compare observed actual evapotranspiration rates to simulated rates for agricultural areas in order calibrate agricultural pumpage

3 Improvements to Model Structure

The following model structural improvements will be addressed during GSP implementation:

- Incorporate updates to model code of AG Package as they become available and if applicable. Such improvements would include surface-water diversions and water-storage for agriculture uses
- Examine how agricultural irrigation practices are implemented in model, and compare with newly available data, existing studies, and other information
- Consider developing explicit representation of riparian consumptive use
- Review and consider any appropriate and necessary modifications to boundary conditions along the Petaluma Valley basin, Healdsburg Area, and Wilson Grove Formation Highlands Groundwater Basin (Wilson Grove Basin). Given the nature and importance of the Wilson Grove boundary, specific tasks are recommended to assess how this boundary is currently simulated by the model and whether the model domain should be expanded further into the Wilson Grove Basin:
    - Evaluate in detail the groundwater conditions at this boundary, focusing on determining the hydraulic gradient, estimated fluxes and its sensitivity to nearby groundwater pumping
    - Perform sensitivity analyses of existing model to determine sensitivity of boundary flux
    - Analyze groundwater levels, groundwater geochemistry, and other information
    - Analyze hydraulic properties of the faults along the Wilson Grove boundary that are likely to be at least 'minor barriers to flow' (p. 140; Nishikawa, 2013)

4 Five-Year Model Update and Maintenance

The SRPHM, incorporating model updates and improvements described in GSP Sections 2 and 3, will be used to support the five-year update to the GSP. The updated model will be re-calibrated to both existing and new data collected during GSP implementation, and will be used to update historical and current water budgets (Section 4.1, below), and to provide future projected water budgets and water levels for comparison against Sustainable Management Criteria (Section 4.2, below) and to support planning and implementation of PMAs.

As part of the five year update to the GSP, the latest available projected climate science and data will be reviewed and considered for incorporation into the scenarios for the Water Year 2026 through 2072 projected period.

4.1 Update Historical and Current Water Budgets for Reporting

As part of the five-year update to the GSP, the model will be assessed to determine if recalibration is necessary. If necessary, recalibration will occur after completing the model update and improvement tasks described in the above Sections 2 and 3. Model recalibration would entail adjusting model hydraulic properties and other model parameters to improve the goodness-of-fit between hydrologic and hydrogeologic datasets, and their model-simulated equivalents. At a minimum, datasets to be used during model calibration would include:

- Groundwater level hydrographs at groundwater-level and interconnected surface water Representative Monitoring Point (RMP) wells, including all new wells
- Streamflow hydrographs from existing and any new stream gages
- Individual low-flow discharge measurements and groundwater-surface water exchange rates collected during future seepage runs

After completing model recalibration, revised simulated historical and current water budgets will be prepared through the extended simulation period (Section 2.1, above).

4.2 Update Future Projected Conditions

A number of PMAs were evaluated using the SRPHM (GSP Appendix 6A). These included implementation of water-use efficiency and other demand reduction projects, construction and operation of ASR wells and construction and operation of stormwater recharge facilities. Specific project details, such as assumptions for water-use efficiency programs, ASR and stormwater recharge volumes and schedules, and infrastructure locations, were defined based on limited best available information at the time.

As stated in Section 7.2.6 of the GSP, the GSA plans to immediately begin implementation of select PMAs. This will include permitting and conceptual design. As specific project details are refined, the representation of PMAs in the model will be updated so that groundwater model projections are based on updated designs of PMAs. Specific areas of update for each project grouping are summarized below:

Simulation of Group 1 Projects

- Update simulation to include refined estimates of conservation and groundwater-use efficiency

Simulate Group 2 Projects:

- Improve simulations of On-Farm and other dispersed recharge by incorporating information as it becomes available

Simulation of Group 3 Projects:

- Simulate proposed ASR projects, optimize project implementation, and additional recycled water opportunities
    - Update source water availability and transmission system capacity assumptions
    - Optimize and update locations and operations, with cost benefit analysis for future alignment options

Management Actions:

- Simulate potential policy options for future GSA consideration or recommendation, including the below initial list of potential policy options:
    - Water conservation plan requirements for new development
    - Low impact development or water efficient landscape plan requirements

Predictive simulation results based on the updated and recalibrated model, with refined representation of PMAs, will then be processed to provide:

- Projected water budgets
- Projected groundwater levels relative to Sustainable Management Criteria for RMP wells
- Projected changes in exchange with interconnected surface water

Updated future projected conditions will likely vary from projections in the GSP due to the following:

- Starting head distributions will reflect groundwater responses to climate and pumping stresses through WY2025
- The model structure and calibration will be revised relative to the SRPHM
- Details of PMAs will have been further developed since GSP preparation

Citations

Nishikawa, Tracy, ed., 2013, Hydrologic and geochemical characterization of the Santa Rosa Plain watershed, Sonoma County, California: U.S. Geological Survey Scientific Investigations Report 2013–5118, 178 p.