The GSP and Local Governmental Agencies

SGMA requires coordination with Land Use Planning Agencies. CA Water Code 10727.4 states that "…a groundwater sustainability plan shall include, where appropriate and in collaboration with the appropriate local agencies, all the following:… (k) Processes to review land use plans and efforts to coordinate with land use planning agencies to assess activities that potentially create risks to groundwater quality or quantity.."

Table 1-3 (page 1-21) shows which member agencies, and affiliated members, implement water resources programs, but it does not present a working relationship with planning departments and permitting agencies.

Management Action 2 is titled: "Continue coordination efforts with other management and monitoring entities.", but there are still no details as to the success of these efforts. The SGA Board has recently been negotiating the form of a group which would interface with the Board of Supervisors, but the role of the representatives is still being decided. There is a hesitancy to take any direct actions in the land planning and well permitting processes.

Projects

Projects and Management Actions (354.44 (a)) states:"Each Plan shall include a description of the projects and management actions the Agency has determined will achieve the sustainability goal for the basin, including projects and management actions to respond to changing conditions in the basin."

One set of projects, numbers 56 through 59, looks at the Capay watershed and the community as an integrated whole. Together they work to improve the hydrological state of the watershed; improve farming practices to increase water infiltration and water holding capacity; develop a restoration plan for the native vegetation communities of the Capay Valley; and establish an equipment and knowledge hub for the human community. Copay is a unique location, but the ideas could be scaled to other areas. Together these projects do plan for a changing climate.

Summary

In summary, I feel like the beginning (Basin Setting) and end sections (Appendices) of the Draft plan were very helpful for understanding the Plan, but the summation of this information in the middle sections, such as the Sustainable Management Criteria, were not as well thought through.

Thank you again for the opportunity to read this report,

Linda Bell

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October 20, 2021

Kristin Sicke
Executive Director
Yolo Subbasin Groundwater Agency
34274 CA-16
Woodland, CA 95695
info@yolosga.org

Subject: CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE COMMENTS ON THE YOLO SUBBASIN DRAFT GROUNDWATER SUSTAINABILITY PLAN

Dear Ms. Sicke:

The California Department of Fish and Wildlife (Department) appreciates the opportunity to provide comments on the Yolo Subbasin Draft Groundwater Sustainability Plan (GSP) prepared by the Yolo Subbasin Groundwater Agency (YSGA) pursuant to the Sustainable Groundwater Management Act (SGMA). The Basin is designated as high priority under SGMA and must be managed under a GSP by January 31, 2022.

The Department is writing to support ecosystem preservation and enhancement in compliance with SGMA and its implementing regulations based on Department expertise and best available information and science. As trustee agency for the State's fish and wildlife resources, the Department has jurisdiction over the conservation, protection, and management of fish, wildlife, native plants, and the habitat necessary for biologically sustainable populations of such species (Fish & Game Code §§ 711.7 and 1802).

Development and implementation of GSPs under SGMA represents a new era of California groundwater management. The Department has an interest in the sustainable management of groundwater, as many sensitive ecosystems, species, and public trust resources depend on groundwater and interconnected surface waters (ISWs), including ecosystems on Department-owned and managed lands within SGMA-regulated basins.

SGMA and its implementing regulations afford ecosystems and species specific statutory and regulatory consideration, including the following as pertinent to GSPs:

- GSPs must **consider impacts to groundwater dependent ecosystems** (GDEs) (Water Code § 10727.4(l); see also 23 CCR § 354.16(g));
- GSPs must consider the interests of all beneficial uses and users of groundwater, including environmental users of groundwater (Water Code § 10723.2) and GSPs must **identify and consider potential effects on all beneficial uses and users of groundwater** (23 CCR §§ 354.10(a), 354.26(b)(3), 354.28(b)(4), 354.34(b)(2), and 354.34(f)(3));
- GSPs must **establish sustainable management criteria that avoid undesirable results** within 20 years of the applicable statutory deadline, including **depletions of**

interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water (23 CCR § 354.22 *et seq*. and Water Code §§ 10721(x)(6) and 10727.2(b)) and describe monitoring networks that can identify adverse impacts to beneficial uses of interconnected surface waters (23 CCR § 354.34(c)(6)(D)); and

- GSPs must **account for groundwater extraction for all water use sectors,** including managed wetlands, managed recharge, and native vegetation (23 CCR §§ 351(al) and 354.18(b)(3)).

Furthermore, the Public Trust Doctrine imposes a related but distinct obligation to consider how groundwater management affects public trust resources, including navigable surface waters and fisheries. Groundwater hydrologically connected to surface waters is also subject to the Public Trust Doctrine to the extent that groundwater extractions or diversions affect or may affect public trust uses. (*Environmental Law Foundation v. State Water Resources Control Board* (2018), 26 Cal. App. 5th 844; *National Audubon Society v. Superior Court* (1983), 33 Cal. 3d 419.) The groundwater sustainability agency (GSA) has "an affirmative duty to take the public trust into account in the planning and allocation of water resources, and to protect public trust uses whenever feasible." (*National Audubon Society*, *supra*, 33 Cal. 3d at 446.) Accordingly, groundwater plans should consider potential impacts to and appropriate protections for ISWs and their tributaries, and ISWs that support fisheries, including the level of groundwater contribution to those waters.

In the context of SGMA statutes and regulations, and Public Trust Doctrine considerations, groundwater planning should carefully consider and protect environmental beneficial uses and users of groundwater, including fish and wildlife and their habitats, GDEs, and ISWs.

The Department recognizes and appreciates the effort of the YSGA to characterize environmental users of groundwater in the subbasin and present a thorough analysis of current and historical groundwater conditions. However, the Department believes the GSP could establish more protective management criteria and improve its assessment of what constitutes an undesirable result for environmental users. The Department is providing additional comments and recommendations in Attachment A.

If have any questions related to the Departments comments and/or recommendations on the Yolo Subbasin Draft GSP please contact Bridget Gibbons, Environmental Scientist, at bridget.gibbons@wildlife.ca.gov.

Sincerely,

DocuSigned by:
Kevin Thomas
A2A0A9C574C3445...

Kevin Thomas
Regional Manager, North Central Region

Enclosures (Attachments A, B)

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Attachment A

CALIFORNIA DEPARTMENT OF FISH AND WILDLIFE COMMENTS ON THE YOLO SUBBASIN DRAFT GROUNDWATER SUSTAINABILITY PLAN

COMMENTS AND RECOMMENDATIONS

The Department's comments are as follows:

1. **Comment #1** – **Interconnected Surface Water Systems** (2.2 Groundwater Conditions, 2.2.6 Interconnected Surface Water Systems; starting page 2-101): The GSP should add clarity to its description of interconnected surface waters (ISW) within the subbasin.
    a. Issues:
        i. Groundwater Elevations: The GSP states that to identify ISW within the subbasin, the "minimum groundwater elevation" from water years 2006-2015 was compared with stream surface elevations (page 2-103, line 27). Presumably this should say either maximum groundwater elevation, or minimum depth to groundwater, as indicated in Figure 2-47. Additionally, groundwater levels should be compared to the streambed elevation, rather than the stream surface elevation, for assessment of interconnectedness.
        ii. Quantity and Timing of Depletions: Though Table 2-17 (page 2-110) presents the modeled annual average seepage volumes from ISW within the subbasin, the GSP does not include sufficient detail on the timing of depletions as required by 23 CCR § 354.16(f). In order to adequately assess ISW that may be gaining or losing at different times of the year, it is preferential to present seepage values by month, rather than by year. Additionally, the Department recommends including seepage values for the Upper Sacramento River and Lower Sacramento River separately. Figure 2-47 appears to show the Upper Sacramento as a primarily losing reach while the Lower Sacramento is a gaining reach. Aggregating seepage values across the entire Sacramento River makes it difficult to assess current conditions within shorter river segments. As the ISW sustainable management criteria (SMC) sets thresholds separately for the Upper and Lower Sacramento River, presenting

current conditions in the same manner would allow for a more direct comparison of baseline conditions and those that would occur under the SMC.

b. Recommendations:
    i. Groundwater Elevations: The GSP should be revised to clarify whether the ISW methodology used the minimum or maximum groundwater elevations. The Department recommends using the maximum groundwater elevations to be inclusive when identifying ISW within the subbasin. The methodology should be narrowly updated to compare groundwater levels with the streambed elevation, rather than the stream surface.
    ii. Quantity and Timing of Depletions: The Department recommends updating Table 2-17 to include average depletions by month. Information for the Upper and Lower Sacramento River should be presented individually.

2. **Comment #2** – **Groundwater Dependent Ecosystems** (2.2 Groundwater Conditions, 2.2.7 Groundwater Dependent Ecosystems; starting page 2-109): The GSP does not include sufficient detail or metrics on how the assessment of GDEs within the subbasin will be used to evaluate undesirable results or guide management criteria and actions.
    a. Issues:
        i. GDE Unit Susceptibility: The Department recognizes and appreciates the conservative approach to identifying GDEs with the subbasin, as well as the subsequent analysis assessing trends in Normalized Difference Vegetation Index (NDVI), groundwater levels, species dependence, and biodiversity values for GDE units. However, other than assessing trends within the subbasin, the GSP does not identify specific targets or metrics associated with these GDE trends that would indicate an undesirable result or trigger management actions within the subbasin.
        ii. Special Status Species: Table 2-20 (page 2-124) lists the number of freshwater species present in each GDE unit, subcategorized by listed species, vulnerable species, and endemic species. The GSP does not specifically identify which special status species are present within the subbasin, and it is unclear whether this assessment included aquatic species supported by ISW within the subbasin.
    b. Recommendations:
        i. GDE Unit Susceptibility: To leverage the robust GDE analysis for meaningful groundwater management, the Department

recommends the GSP clarify what constitutes an undesirable result for GDEs and how potential undesirable results will be avoided under the proposed SMC. The GSP should identify monitoring metrics for GDEs that will enable the YSGA to characterize GDE vulnerability to groundwater depletion and associated undesirable results, and to undertake management intervention accordingly. If undesirable results are occurring before minimum thresholds (MTs) are reached, SMC should be adjusted (See Comment #3).

ii. Special Status Species: The Department recommends the GSP clarify whether the species identification included aquatic species supported by ISW within the subbasin. The GSP should include a discussion of listed aquatic species present in ISW within the subbasin, including the federally threatened California Central Valley steelhead (*O. mykiss)*, state and federally endangered winter-run Chinook salmon (*O. tshawytscha*), state and federally threatened spring-run Chinook salmon (*O. tshawytscha*), and the federally threatened Southern distinct population segment of the North American green sturgeon (*A. medirstris*). The Department recommends the YSGA consider including a supplemental list of the identified special status species within the subbasin as an appendix to the GSP.

3. **Comment #3** – **Sustainable Management Criteria** (3.3 Chronic Lowering of Groundwater Levels, 3.6 Depletion of Interconnected Surface Water; starting page 3-3): Groundwater level and interconnected surface water SMC may not protect against undesirable results for fish and wildlife beneficial uses and users.
   a. Issue:
      i. Minimum Thresholds: MTs for groundwater levels are set as the historic lows over the period of record, or in the case of the North Yolo management area, at levels below the historic low. Similarly, ISW MTs are set at the historic lows for Upper Cache Creek, Putah Creek, and the Lower Sacramento River, and at levels below the historic low for the Upper Sacramento River. The GSP asserts that establishing MTs at or below historic lows is acceptable because undesirable results have not previously occurred within the basin; however, the GSP does not include sufficient analysis or discussion to support this claim. In 2015, the second of back-to-back critically dry water years in the Sacramento Valley which resulted in low groundwater levels, vegetated and aquatic GDEs experienced adverse impacts including stressed or dying riparian vegetation, poor instream habitat availability, and increased water

temperatures (DFW 2019). The groundwater level MTs listed in Table 3-1 (page 3-12) show that for many representative wells across the subbasin management areas, water levels that have historically been shallow enough to support GDEs would be permitted to fall below root zones, removing groundwater as an available water source to some GDEs; undesirable results, therefore, will likely be experienced before MTs are reached. It is also unclear what levels of streamflow depletion are projected to occur at the established MTs. The GSP does not characterize the relationship between depletions and impacts to environmental users, such as listed aquatic species, monthly river flows, or water temperatures. The ISW MT for Lower Cache Creek is the "recurrence of the spring average measurement for 1975 to present in at least one spring in every seven years" (page 3-24). It is the Department's understanding that this MT does not establish a true lower threshold for water levels, because any degree of depletion would be theoretically permissible for a period of 6-years, provided that in the 7th year the spring 1975 to present average water level is reached. This MT creates a system in which there may be no action taken during periods of significant groundwater level decline due to the length of time allowed to assess whether the MT has been exceeded. Though the historic hydrologic expectation is one of reoccurring groundwater table recovery, depending on the severity of groundwater depletion during the intervening years, one year of higher water levels out of every seven may not be sufficient to avoid undesirable results for environmental users, particularly as the frequency and intensity of dry water year types is expected to increase in California (Mann & Gleick 2015).

ii. Undesirable Results: To trigger a basin-wide undesirable result, minimum thresholds must be exceeded in two subbasin management zones. Under this definition, a single management zone could experience localized exceedances of groundwater level or ISW MTs for multiple years without triggering a basin-wide undesirable result or management intervention. While environmental users of groundwater are adapted to short-term lowering of groundwater levels during dry periods, extended periods of low groundwater levels may cause environmental users to experience significant stress or potentially irreversible mortality.

b. Recommendation:

i. Minimum Thresholds: The Department recommends the GSP reselect groundwater level and ISW MTs that would better protect environmental uses and users of groundwater, rather than allowing groundwater levels to reach or fall below historic lows, and that could trigger meaningful action on timescales shorter than seven years. The GSP should include additional analysis to demonstrate that MTs will not lead to undesirable results for beneficial users of groundwater, including environmental uses and users. Groundwater level MTs at representative monitoring wells near identified GDE areas should be assessed to ensure that GDEs will not lose access to groundwater before MTs are reached. The additional information and trends analyzed for GDEs, including NDVI, should also be tied to specific management criteria and metrics for implementing projects and management actions (See Comment #2). The GSP should discuss projected streamflow depletions that would result from the established MTs and then demonstrate that the SMCs will not lead to adverse impacts for environmental users of ISW, including listed aquatic species, related to water temperature or flows necessary for passage.

ii. Undesirable Results: Additional discussion is needed to characterize how the GSP will address local undesirable results to protect groundwater beneficial users, even if the two-management zone threshold is not met to trigger a basin-wide undesirable result.

4. **Comment #4** – **Monitoring Networks** (4.11 Monitoring Network Improvement Plan, 4.11.2.3 Surface Water, Interconnected Surface Water, and Groundwater Dependent Ecosystem Monitoring Network; starting page 4-29): Improvements to the monitoring network are necessary to better characterize GDEs and ISW within the subbasin.
   a. Issue: The GSP identifies improvements to the subbasin monitoring network that would allow for better characterization of ISW and GDEs, including the installation of additional shallow, near-stream nested monitoring wells, piezometers, and streamflow gages. It is unclear whether the YSGA intends to move forward with these identified improvements to the monitoring network. Figure 2-46 identifies existing stage and flow gages within the subbasin, but the GSP does not include these streamflow gages in the monitoring network for interconnected surface waters. The GSP states that gages are influenced by multiple factors, leading to difficulty in characterizing the specific impacts of groundwater pumping on streamflow depletion (page 3-22, line 6). Though the GSP relies on groundwater levels as a proxy for assessing ISW, it is still necessary to tie the impacts of groundwater pumping to the volume of groundwater depletions. Paired flow gages and monitoring wells can help

to better characterize ISW and the volume and timing of depletions and refine subbasin modeling of surface-groundwater interactions, leading to a more robust assessment of potential impacts to ISW within the subbasin.

b. Recommendation: The Department recommends that the GSP include specific plans and timelines associated with improvements to the monitoring network that will better characterize ISW and GDEs within the subbasin. The ISW monitoring network should include paired streamflow gages and shallow monitoring wells to better characterize the volume and timing of depletions related to groundwater pumping.

5. **Comment #5** – **Projects and Management Actions** (5.2.1 Projects and Management Actions; starting page 5-4): The GSP does not include projects and management actions that relate to demand management within the subbasin.
   a. Issue: The GSP indicates that the subbasin is expected to operate within its sustainable yield with the listed projects and management actions (PMAs) to ensure that undesirable results are avoided. The identified PMAs focus primarily on supply augmentation, conjunctive use, or infrastructure improvements. Given the cost and timing challenges of implementing supply augmentation projects, if undesirable results occur within the subbasin, it may be necessary to implement additional demand management projects to produce groundwater benefits.
   b. Recommendation: The Department recommends that the GSP include provisions or plans for demand management PMAs that could be implemented on a shorter timeframe if necessary to maintain basin sustainability.

CONCLUSION

In conclusion, though the draft GSP thoughtfully identifies environmental beneficial users of groundwater and provides detailed characterization of subbasin groundwater conditions, the GSP can further refine its management criteria and analyses in relationship to GDEs and ISW to better avoid potential impacts to environmental beneficial users of groundwater. The Department recommends that the Yolo Subbasin Groundwater Agency address the above comments before GSP submission to DWR to best prepare for the following regulatory criteria for plan evaluation:

1. The assumptions, criteria, findings, and objectives, including the sustainability goal, undesirable results, minimum thresholds, measurable objectives, and interim milestones are not reasonable and/or not supported by the best available information and best available science (23 CCR § 355.4(b)(1)). (See Comment #1, 2, 3)

2. The GSP does not identify reasonable measures and schedules to eliminate data gaps. (23 CCR § 355.4(b)(2)) (See Comment #4)
3. The interests of the beneficial uses and users of groundwater in the basin, and the land uses and property interests potentially affected by the use of groundwater in the basin, have not been considered. (23 CCR § 355.4(b)(4)) (See Comment #2, 3)
4. The projects and management actions are not feasible and/or not likely to prevent undesirable results and ensure that the basin is operated within its sustainable yield. (23 CCR § 355.4(b)(5)) (See Comment #5)

Attachment B

LITERATURE CITED

Department of Fish and Wildlife. 2019. Statewide Drought Response: Stressor Monitoring.

Mann, Michael E. & Gleick, Peter H. Climate change and California drought in the 21^{st} century. *Proceedings of the National Academy of Sciences of the United States of America. 112*(13): 3858-3859.

Comments and inputs from Capay Valley Regeneration/Capay Valley Vision on the

Public Draft
Yolo Subbasin Groundwater Agency
2022 Groundwater Sustainability Plan

Thank you very much for the opportunity to comment on the final draft of the Yolo Subbasin's Groundwater Sustainability Plan (GSPs). We congratulate you on this effort. We have seen some reviews of GSPs submitted from throughout California and the Yolo Subbasin plan appears to be a comprehensive and forward-thinking document compared to many others. Given this, the Yolo Subbasin plan has the potential to be a truly transformational plan. Our **overarching comments** on the plan, which we hope lead in that direction are below, followed by **specific comments on Chapters 1 and 2**, **and questions around the criteria of Chapter 3**.

Overarching comments:

1. Increase attention given to community input.

A hallmark of the Sustainable Groundwater Management Act (SGMA) is that local governance and development of GSPs as well as extensive public involvement is the key to achieving the statewide overarching goals by local implementations that fully accounts for differences among locales. Furthermore, local public involvement nurtures trust and ownership of GSPs so communities are more likely to follow the plans' guidance.

The YSGA made a concerted effort to present the GSP at community meetings of any group requesting them. The YSGA held at least 5 meetings in the Capay Valley Management area of the subbasin, in addition to numerous other meetings in other communities. The YSGA also made available to the public chapters of the report for comment and now has posted the entire final draft for addition comment. The willingness to listen has been exemplary, however listening has not necessarily resulted in true effect on the GSP.

We submitted many comments to the drafts of individual chapters but did not see many of them reflected in the draft final report. Many comments were made with the intent of making the plan more accessible to non-technical readers, like the general public. One UC Davis Emeritus professor from a science discipline remarked to us that documents we created to *simplify* the plan information for our Capay Valley public were much too complicated, disinviting people from reading them. Much of chapter 2 is a collection of facts, with little summary text to orient the reader in evaluating them. Thus, it is very tempting to skip over them, but they form the foundation for the plan's conclusions about sustainability and minimum thresholds.

Beyond the text of the report itself, we believe it important to acknowledge concerned input about things missing from the plan. For example, some residents of the Dunnigan Hills have expressed profound concern about the likelihood of their wells being able to continue to meet their needs with current rates of land use change to irrigated agriculture with a great acceleration of well creation. However, this is not acknowledged in the report.

2. The plan needs for dispute resolution process.

Another hallmark of SGMA is its potential to reduce the amount of litigation over groundwater rights. A process to resolve disputes is imperative to this aim as individual actions affect the amount of water available to groundwater users as a whole. The plan needs to include a framework for resolving disputes. The plan says, "the intent of the members under the JPA [joint powers agreement to create the Yolo Subbasin Groundwater Sustainability Agency] is to provide each member with the responsibility to implement SGMA and the GSP adopted by the YSGA within their respective Management Area, as delineated by this GSP (page 1-11)." Would the YSGA members within each management area possibly develop a process for resolving disputes if groundwater users perceive that activities of other users decrease their access to groundwater? Would the entire agency work to review disputes the Management Areas cannot resolve?

Such a resolution process needs to be in place very soon for the Yolo Subbasin as some areas already show signs of unsustainability, particularly the Winters and Dunnigan Hills areas designated as areas of special concern due to falling groundwater levels. Farmers in the Dunnigan Hills have urgently asked the YSGA to address falling groundwater levels as more acreage has been pressed into irrigation and more, very deep wells have been dug. Stakeholders need a way for their concerns to be meaningfully heard and accounted for.

3. More clarity is needed around the responsibility for sustainably managing the Subbasin's groundwater.

As mentioned above, page 1-11 of the draft report says, "the intent of the members under the JPA is to provide each member with the responsibility to implement SGMA and the GSP adopted by the YSGA within their respective Management Area, as delineated by this GSP." Does this mean that the YSGA itself does not have responsibility for implementing SGMA? This relationship between members and agency regarding responsibility for implementing SGMA needs to be clarified. This clarification needs to explain the status of member agencies in respect to each other for implementing SGMA: do the members need to act in concert, or may they act unilaterally? Another question is which members are part of which management areas – the ones that have been shown as part of the advisory committees for the management areas? Finally, the authority of the Agency and of the members to implement SGMA needs clarification.

4. Changes between the first published drafts and the current final draft in wells included for measuring trends in groundwater level show that more robust analysis should be done for choice and number of monitor wells used to measure minimum thresholds.

As we noted in our comments on the initial review draft for Chapter 2, Figure 2-20 based on 113 wells seemed to show that "the average groundwater level is on a declining trajectory from 2006 until today if you focus on the peaks in groundwater level. Nothing since 2006 has topped the groundwater level of that year – not even 2019 which was a very wet year that followed a very wet year in 2017. Further, the lows in 2014-15 are lower than the lows in 1991-92, even though more dry and critical years preceded 1991-92 than preceded 2014-15." However, Figure 2-20 in the current final draft does not show such trends. This changed graph is based on data from only 64 wells.

As stated in our detailed line comments below, we'd like to know why the number of wells was changed from 113 to 64, where the data comes from, and what were the criteria that changed to reduce the number of wells. Of equal or greater importance is that this change in the graph from draft to draft demonstrates the sensitivity to the conclusion for the number of wells included in an analysis. This difference raises into high relief the question of which monitoring wells to use for determining if management areas and the Subbasin have exceeded minimum thresholds for groundwater levels and storage. The plan envisions using only 8 monitoring wells per management area to assess groundwater level sustainability (about equal to the number of wells used in the data for the current final draft graph). Analysis needs to occur to show that the number and wells chosen have the best likelihood of revealing the true mean for groundwater levels each year for the Subbasin and the management areas. Also, as we commented earlier on the draft of Chapter 3, some of the monitoring wells selected for the Capay Valley management area appear to have very low points of groundwater levels suggesting problems with the data. If data from such wells will be used in measuring sustainability criteria, data anomalies need to be investigated to see if they are correct or reflect some problem in the measurement. Please refer to our comments here on Chapter 3.

5. Potential future scenarios for groundwater sustainability need to account more robustly for climate change variability. All three scenarios that the plan projects for likely groundwater sustainability into 2040 and 2070 predict that the Yolo Subbasin will have more precipitation than historically. We understand that the DWR models used show this, however as the YSGA's **Synthesis of Responses to Climate Change Comments** Reports "in the Yolo Subbasin, … we are right at the cusp of jet stream impacts. If the jet stream moves north or south in future climates, precipitation patterns could change accordingly – modeling for that future is very challenging." To be fully proactive for the possibility that the precipitation patterns could change and result in less precipitation, we urge that the plan include at least one scenario with less precipitation than experienced historically. The fact that, as the **Synthesis of Responses** states "Another important thing to note is that although we are seeing higher precipitation values in the Yolo Subbasin in the model, less of that water is being modeled as reaching the aquifer." As we understand it, less precipitation will percolate to the aquifers because higher temperatures will lead to higher evapotranspiration. However, even less will percolate to the aquifers if there is less precipitation as the temperatures will still be high, but the precipitation will be even less.

6. Projects are very comprehensive and appreciated – the report could provide more direction for the primary directions for implementation. We are very gratified that projects we suggested for the Capay Valley are included in the draft final report. We think the ecological/biological projects we propose offer very cost effective – and groundwater effective – sustainability measures. We echo the points that Paul Muller has made in his letter on the plan. We think that the projects proposed for Capay Valley would achieve the aims Mr. Muller describes and some could be implemented Subbasin-wide to benefit groundwater sustainability.

Specific comments on Chapters 1 and 2:

1 Introduction

New comment, page number
Page 1-11.7-10
Text in final draft: The intent of the members under the JPA is to provide each member with the responsibility to implement SGMA and the GSP adopted by the YSGA within their respective Management Area, as delineated by this GSP. The members and affiliated parties worked collaboratively to develop this GSP for the Subbasin in compliance with SGMA.
for Capay Valley, who then is the "responsible" entity for implementing the plan? How does this entity exercise this responsibility?

New comment, page number
Page 1-15 Title Figure 1-3
Text in final draft: Groundwater Dependent Communities
seems that communities in the Capay Valley are all groundwater dependent, at least for domestic water. Other areas are also, although they may not have a situation similar to Davis, for example, where a centralized water agency supplies groundwater to all homes. The title should be along the lines of "Public Water Service Areas Dependent on Groundwater" so it does not seem out of sync with p 17

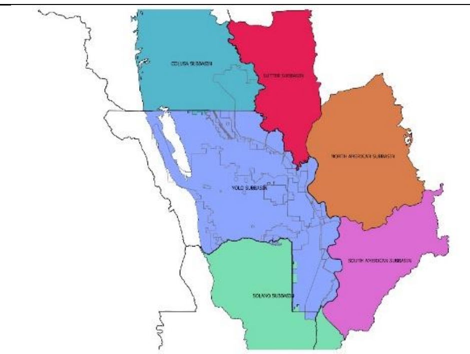
New comment, page number
Page 1-26.17-20
Text in final draft: California Resource Lab at University of California, Davis developed a Soil Agricultural Groundwater Banking Index (SAGBI) for groundwater recharge on agricultural land. As shown in Figure 1-9, approximately 20% of the subbasin has moderately good to excellent rating whereas approximately 63% of the area has poor to very poor rating.
SAGBI –It would be informative to add that the rating depends on current soil conditions, but these can be changed by human action. Suggest: Characteristics used to rate ground surface areas for SAGBI should be able to be improved for recharge by human action.

2 Basin Setting

(The comments here mostly refer to our earlier comments, Jack's 26May2021 response letter, and if we now see them resolved in the current (final) plan. Please keep in mind, we do not mean to be overly critical or nit-picking, but we've all put a lot of time into this and have provided comments that we think can clarify the plan for non-specialists; it would be valuable to respond not only to us, but to include the your valuable responses and explanations in the plan).

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
a. Page 2-1	a; page 1	
Text in final draft	Our earlier comment	
The Basin setting section is made up of the hydrogeologic conceptual model; the current and historical groundwater conditions; the water budget for the Yolo Subbasin; and the description of the six Subbasin management areas. This section provides the local and regional details as context for defining reasonable sustainable management criteria and projects and management actions for the Yolo Subbasin.	It would help readers to possibly start with some social and economic context, before introducing the Hydrogeologic Conceptual Model (HCM). Information that would help to frame the information in this chapter could include: the population distribution (incorporated cities, suburban, rural), major institutions, major economic sectors, importance to the State and how these are dependent on/relate to/determine/are determined by water use and resources.	
26May2021 RESPONSE:	We tried to put a lot of the background information into Chapter 1, and we are hoping that when the entire document is synthesized, that information will be present. This information is included in Section 1.5 'Description of Plan Area'	
Current comment:	We did not find information on population, economic sectors, dependence on water use and resources in section 1.5 'Description of Plan Area'	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
b. Page 2	b; page 2	
Text in final draft	Our earlier comment	
Same Figure 2.1 as before	Is there a map of the adjacent subbasins?	
26May2021 Response	This information can be found online at DWR's SGMA data viewer, which is a great user-friendly resource: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#boundaries 'Bulletin 118 Groundwater Basins – 2018' shows all of the Basin boundaries. Also, we'll include a map similar to the one below in the Basin Setting to provide context	

	
Current comment:	Physical Subbasin Boundaries – this section is very clear and very much appreciated. It would be good to include this map and information in the plan; the map sent in the response document is not in the current draft.

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New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
c. Page 2-5	**c; page 2**	
Text in final draft	**Our earlier comment**	
2.1.3 Principal Aquifers and Aquitards	Could the text provide definitions of "aquifer" and "aquitard," in addition to why we care about aquifer locations for the GSP? It would help us non-technical people interpret the rest of the section better.	
26May2021 Response	Yes, these should be defined - we are working with the consultants to incorporate a SGMA definition of aquifer and aquitard. In general, the aquifer is the medium in which groundwater can occupy. An aquitard is a geologic feature that restricts the flow of groundwater from one aquifer to another.	
Current comment:	We did not find these definitions in the current draft	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
d. Page 6	**d; page 2-7**	
Text in final draft	**Our earlier comment**	
2.1.3.1 Shallow Zone The shallow zone extends from the surface to a depth of about 220 feet below ground surface (bgs) and consists predominantly of alluvium as well as the upper portion of the	Given that most of the wells- including monitoring wells – in Capay Valley are far more shallow than the 220 depth of shallow wells, would it not make sense to elaborate more on this zone, and something of shallow wells and their production- typically quite low, not at all 1500 to 100 gpm as mentioned in the text. The	

<table>
<tr><td>Tehama Formation. The deposits consist of thick sand and gravel deposits within a mile or two of the major sediment sources of Cache and Putah Creeks. The coarse beds appear to thin laterally from the present stream channels with thinner distributary channel, and sheet flood sand deposits occurring under the more distal alluvial plains. Well yields can be relatively high where thick channel deposits are encountered with yields of several hundred to 1,500 gallons per minute (gpm). Specific capacities range up to 100 gpm per foot of drawdown or greater in this setting. More modest production (e.g., up to 500 gpm yields) likely results from wells constructed in thin sandsthat are more distant from stream channels and have lower specific capacities. Wells completed in even just a fewthin sand beds produce sufficient quantities for domestic use.</td>
<td>report states that “Wells completed in even just a few thin sand beds produce sufficient quantities for domestic use.”. Is there any further information on the sustainability of shallow, sand-bed based wells, and what is considered sufficient for domestic use?

We linked this with the data provided later in this earlier draft (but not repeated in the August draft), that

“The CASGEM network includes 145 wells, including 144 active wells and one well with data through October 2013. Total depth is known for 126 CASGEM wells (87%), including 56 wells in the Shallow Zone, 63 wells in the Intermediate Zone, and seven wells in the Deep Zone. The average depths of these three groups of wells is 118 feet, 359 feet, and 739 feet, respectively.”</td></tr>
<tr><td>26May2021 Response</td>
<td>We have information on well depths in the Capay Valley, although they are not currently included in this GSP – they can be viewed using the WRID. The table below shows the total well depths of the representative wells for Capay Valley. The distribution of these representative wells is similar to the total distribution of all wells in the Capay Valley MA.

<table>
<tr><th>State Well Number</th><th>Total Well Depth</th></tr>
<tr><td>10N02W16R001M</td><td>Unknown</td></tr>
<tr><td>10N02W18F001M</td><td>Unknown</td></tr>
<tr><td>10N03W02R002M</td><td>55</td></tr>
<tr><td>11N03W09Q001M</td><td>55</td></tr>
<tr><td>11N03W23L001M</td><td>66</td></tr>
<tr><td>11N03W23N001M</td><td>136</td></tr>
<tr><td>11N03W33F001M</td><td>75</td></tr>
<tr><td>12N03W20D001M</td><td>26</td></tr>
<tr><td>11N03W35D003M</td><td>152</td></tr>
<tr><td>10N03W24B002M</td><td>207</td></tr>
</table>

Wells in the shallow zone are between 0 and 220 feet in total depth. The average depth of the shallow wells is 118 feet.</td></tr>
</table>

Current comment:	Our conclusion, suggestion was that we think a very shallow well category is needed – this was not taken up.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
e. Page 2-7	**e; page7**	
Text in final draft	**Our earlier comment**	
Specific capacities for wells completed in the intermediate zone are comparatively lower than those for the shallow zone. Intermediate zone wells in the western alluvial plain likely have poor to low yields due to the lack of sand beds, in comparison to wells in the eastern alluvial plain. However, thick sand beds are less prevalent in the intermediate zone than the shallow zone	This seemed surprising, that "Specific capacities for wells completed in the intermediate zone are comparatively lower than those for the shallow zone". Can you provide insight as to why so many people drilling deeper wells?	
26May2021 Response	Specific Capacity is the volume of water discharged from a pump divided by the change in depth to water of the well. When comparing two wells in the same location with similar properties, but different depths, the deeper well will have higher discharge (more water) but will also have a larger change in depth to water. $$S_c = \frac{Q}{h_0 - h}$$ That means that the specific capacity will be lower for the well.	
Current comment:	Thank you for this explanation, though maybe not finished.- "That means that the specific capacity will be lower for the well"- do you mean deeper well? We actually have more questions, on this point: Why would the deeper well have higher discharge? And, does it really mean "deeper" or with the greatest change in depth to water (presumably h0-h denotes this. And the real question here for readers, is what is the implication of the intermediate wells having lower specific capacity. This response implies that it is nearly tautological that the intermediate zone wells will have lower specific capacity than the shallow zone wells because they are deeper, so what is the point of even mentioning it.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
f. 2-8, re Table 2.1	**f; page 8**	
Text in final draft	**Our earlier comment**	
See table.	This table seems to imply that the capacity of major aquifers in the subbasin have been identified. Is this correct? But then, there is only information on transmissivity for Capay Valley, not Storage Coefficient. Why is this? We see that on [Page 9] the Storage Coefficient (S): (defined as: Volume of water that is released from or takes into storage per unit surface area per unit change in water level (head); would this not be an l parameter/monitoring point for Capay Valley? Perhaps this is provided in Table 2-2…why not in Table 2.1?	
26May2021 Response	Capacity/storage of the major aquifers has been modeled. Transmissivity is the hydraulic conductivity*saturated thickness. So if you have transmissivity, and saturated thickness (depth to water) you can calculate hydraulic conductivity. Table 2-1 and Table 2-2 are from different sources. It looks like the Table titles may be incorrect. Table 2-2 should be (RMC, 2016). The hydcaulic conductivity, storage coefficients that are used in the YSGA model for Capay Valley come from the 2016 Capay Valley IGSM report from RMC Water and Environment (formerly WRIME).	
Current comment:	Not sure we totally understand the response, except that the values have been modeled.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
g. page 2-9,	**g; page 10**	
Text in final draft	**Our earlier comment**	
However, wells are not typically installed (screens) in the fine-grained layers so hydraulic properties have not been measured directly.		
Current comment:	Small typographic error in earlier text now corrected	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
h. p. 2-9	**h; pages 8-11**	
Text in final draft	**Our earlier comment**	
2.1.3.4 Aquifer Properties	**Aquifer Properties** is full of interesting information but what specifically does it portend for sustainable groundwater management? A summary at the end of such sections would be very helpful	
26May2021 Response	Yes, the importance of this information should be explained.	
Current comment:	We did not see this suggestion taken up	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
i. p. 2-10	**i; page 15**	
Text in final draft	**Our earlier comment**	

2.1.3.4 Topography	Equally for **2.1.4 Topography,** could there be an introductory paragraph that explains the relationship between aquifers and geology, assuming there is one. If there is not a relationship, then maybe the paragraph could explain why understanding the geology is important to groundwater planning. A concluding paragraph to the geology section could sum up what the geologic discussion tells us about Yolo Subbasin groundwater and groundwater planning.	
26May2021 Response	Storage, transmissivity, hydraulic conductivity are all aquifer properties that are determined by geology. The aquifer refers to the subsurface geology – it can contain water but doesn't necessarily have to.	
Current comment:	Interesting explanation, but we don't ask only for ourselves, our suggestion was that it would help the non-technical reader to have this in the report. We didn't see it there.	
New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
j. 2-21 to 2-29	**j; page 21-23**	
Text in final draft	**Our earlier comment**	
Figures 2-7, 2-8 and 2-9	The cross-sections are really cool!	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or

		Not answered
k. Page 2-29	**k; page 28-30**	
Text in final draft	**Our earlier comment**	
2.1.5.3 Soils Information on soils within the Yolo Subbasin were obtained from the Soil Survey Geographic Database (SSURGO) of the Natural Resources Conservation Service (NRCS). The SSURGO data included two categories of information relevant to the GSP: taxonomic soil orders and hydrologic soil groups. Taxonomic data include general characteristics of a soil and the processes of formation while hydrologic data relate to the soil's ability to transmit water under saturated conditions and is an important consideration for hydrology and groundwater recharge. In addition, the Soil Agricultural Groundwater Banking Index (SAGBI) was developed by the University of California at Davis and provides a rating of suitability of the soils for groundwater recharge. SAGBI is based on the hydrologic soil groups but includes considerations for topography, soil surface conditions, and chemical limitations. The following section describes the soils of Yolo Subbasin.	The paragraph under 2.1.5.3 is an example of explaining the kind of context/introduction to sections that help the reader understand the material that comes afterwards. The paragraph did a great job at explaining relationship between soils and groundwater planning. It really helped us in understanding the rest of the section.	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
l. Page 2-29	**l; pages 28-30**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Section on **Soil Agricultural Groundwater Banking Index**	Is there a map of the location of the different hydrologic soil groups and of the SAGBI distributions? (noting that portions of Capay Valley have not been mapped as explained on page 30: "SAGBI values are not available for over half of the areas within the Capay Valley MA and Dunnigan Hills MA." But are the values, and maps available for those that have data?	
26May2021 Response	Yes, this is included on page 30 of the Introduction Chapter. It can also be viewed here (SAGBI map): https://casoilresource.lawr.ucdavis.edu/sagbi/	
Current comment:	Indeed, Figure 1-9 appear to show pretty good coverage in the Valley proper-just not in the far upland hills, which is logical.	

	Could this not be noted, and reference to the map made here in Chapter 2? Also, It would be informative to add that the rating depends on current soil conditions, but these can be changed by human action.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
m. Page 2	**m; page 30**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Table 2-6	Yay that 46% of CV has excellent to moderately good SAGBI. Interesting that this is the highest percent of good and above SAGBI of any management area, even though run-off potential for the MA is fairly high according to table 2-6. Could any interpretation be provided to explain, hypothesize why this is so?	
26May2021 Response	The runoff data comes from the NRCS, which has soils data for the entire 'Capay Valley' area within the Yolo Subbasin – including the steep terrain and hilly rangelands. The SAGBI map has less spatial coverage in the Capay Valley.	
Current comment:	This makes sense, but we don't ask just for ourselves; this explanation would help others to understand. A further comment: There is a strange ordering to this table, From Excellent to good etc. to very poor, and then the last two rows are summaries of groupings of rows above, but this is not clear…they should be set off or placed appropriately to show this. It is important for Capay Valley, as it shows the highest potential for recharge in all the subbasin.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
n. Page 2-30 to 2-31	**n; page 31**	
Text in final draft	**Our earlier comment**	
Section 2.1.6- text remains the same and has not been elaborated upon in the current draft	Is it correct to conclude from the following quotes that slowing Cache Creek could likely have recharge benefits into the subbasin beyond the Capay Valley	

	Management Area? “Recharge to the intermediate zone occurs generally through precipitation recharge at outcrop areas and by interconnection” and “leakage from the overlying shallow zone, including possibly from the Sacramento River, Cache Creek, and Putah Creek via the shallow alluvium.” “Recharge to the deep zone beneath the eastern alluvial plain is believed to be from leakage from overlying aquifers, probably sourced from Sacramento River and Cache Creek to the north. The western alluvial plain deep zone is probably recharged from the overlying units and Tehama Formation outcrops to the west, especially those units associated with Cache and Putah Creeks. The deep zone is an increasingly confined system due to the presence of extensive overlying clay units and its overall depth.”
26May2021 Response	In general, the longer that water remains in the Cache Creek watershed, the more water will percolate into the shallow aquifer. There may be opportunities to increase retention time during storm runoff events, thus increasing deep percolation. We could look at some of the model outputs to see what the exchanges are between the Capay Valley MA and the Central Yolo MA. The boundary that is shared by the Capay Valley MA and the Central Yolo MA is relatively small, so there is likely not a lot of groundwater exchange between these two MAs.
Current comment:	It seems our question- “Is it correct to conclude from the following quotes that slowing Cache Creek could likely have recharge benefits into the subbasin beyond the Capay Valley Management Area?” would need more analysis, and is likely to be small…nonetheless, Still not certain about if Capay recharge would help the Yolo Subbasin generally. 9-10 recharge to the shallow zone occurs from infiltration along Cache and Putah Creeks. Aquifers and bodies are probably weakly connected to sand bodies surrounding major streams. Additional recharge likely occurs by deep percolation of precipitation and irrigation. The shallow zone is probably unconfined. Etc.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
o. Page 2-30 to 2-31	**o; page 31**	
Text in final draft	**Our earlier comment**	
Precipitation and runoff strongly influence local hydrology. According to Scott and Scalmanini (1975) precipitation occurs in cyclonic storm fronts where most of the rainfall occurs during 6 to 12-hour periods. Topographic characteristics result in high percentages of runoff from the mountains and foothills and the potential for flooding.	Is it correct to conclude from the following quotes that slowing down Cache Creek and tributaries could reduce flooding? "Precipitation and runoff strongly influence local hydrology. According to Scott and Scalmanini (1975) precipitation occurs in cyclonic storm fronts where most of the rainfall occurs during 6 to 12-hour periods. Topographic characteristics result in high percentages of runoff from the mountains and foothills and the potential for flooding."	
26May2021 Response	'Slowing'Cache Creek by changing the rainfall-runoff relationship seems to make sense: https://directives.sc.egov.usda.gov/OpenNonWebContent.aspx?content=17752.wba This would decrease 'peak' flows reaching Cache Creek, increase the width of the hydrographs, and may decrease the total amount of surface runoff reaching Cache Creek.	
Current comment:	Thank you for this explanation	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
p. Page 2-32	**p. page 32**	
Text in final draft	**Our earlier comment**	
Text has been corrected	small correction- "Diversions from Sacramento River water are not considered importation because the Sacramento River flow along" should be "Diversions from Sacramento River water are not considered importation because the Sacramento River flows along"	

New comment, page number
Page 2-32: 13
Text in final draft: 2.1.10 Water Rights A water right is a legal entitlement authorizing water to be diverted from a specified source and put to beneficial use. Based on the State Water Resources Control Board (SWRCB) water rights database, there are approximately 243 water right holders in the Yolo Subbasin. Figure 2-14 shows the active points of diversion in the Yolo Subbasin.
Our question: Water rights – does this apply only to rights for surface water?

New comment, page number

Page 2-32: 18
Text in final draft: 2.1.11 Data Gaps in the Hydrogeologic Conceptual Model
Our comment: Data gaps about aquifer connectivity – Excellent. More data on interdependence (and lack of it) of aquifers is very welcome!

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
q. Page 2-34	**q; page 37**	
Text in final draft	**Our earlier comment**	
The freshwater aquifer system in the Yolo Subbasin includes the shallow alluvium and upper Tehama Formation, which together have been divided into the shallow, intermediate and deep zones.	our question was: In the end are you identifying just two main 2 aquifers each with 3 zones? Is there then at least some rough numbers of their locations and capacities?	
26May2021 Response	The Yolo Subbasin, in general is broken up into three zones: - The shallow zone is from 0 – 220' below ground surface - The intermediate zone is from 220' to 600' - The intermediate zone is from 600' to 1500'. This is a broad characterization of the entire Yolo Subbasin aquifer that water is drawn from. This characterization may not perfectly describe areas within the basin, but this delineation was chosen to best characterize the subbasin as a whole.	
Current comment:	Okay, three zones in essentially one aquifer.	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
r. Page 2-34	**r; pages 38-39**	
Text in final draft	**Our earlier comment**	
Referring to previous tables, no longer in current draft	The numbers in tables 2-7 to 2-9 are not clear. I took the numbers to be the number of wells monitored in each period, but this did not make sense when these numbers were summed to show total wells. So I think the numbers must mean "new wells added in each time period" but I'm not 100% sure. A description of the meaning of the numbers would resolve the uncertainty.	

26May2021 Response	Max has re-written this section to describe the existing monitoring program more accurately and succinctly.
Current comment:	These tables, giving numbers and depths of groundwater monitoring wells over time in the CASGEM and WRID networks, have been removed from the draft- yet they were among the most interesting to us and the question above still remains- we'd like to see these numbers and understand better what they mean in terms of overall groundwater monitoring networks in place. Perhaps this is found in later chapters, but it would be most useful here.

New comment, page number
Page 2-42
Text in final draft: bullet points on page 2-42
Our comment: All bullet points say "depth to groundwater increased." These references need to include information on relative to what. The language in line 31 "Depths to groundwater recovered between 1978 and 1984" shows an effective way to describe what is happening. Possibly this section could say throughout, after depths to groundwater fell….

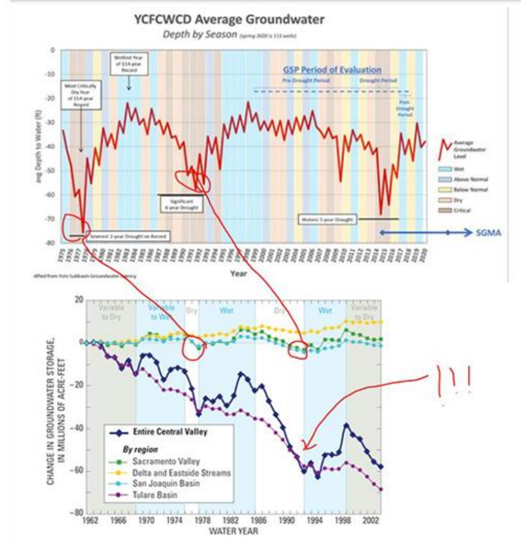
New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
s. Page 2-43 to 2-49	s; pages 40-47	
Text in final draft	Our earlier comment	
Referring to Figures 15-20	Figures 2-15 to 2-19 could be more transparent in labeling the data sources. 2-15, 2-16, and 2-19 say the SGMA data viewer. Page 38 says: "Groundwater levels have been measured at numerous wells in the Yolo Subbasin for the last 90 years, starting the early 1930s. These data are available from the California Statewide Groundwater Elevation Monitoring (CASGEM) program and the Yolo County Water Resources Information Database (WRID), as well as the DWR SGMA Data Viewer2, and various historical reports, including groundwater management plans." Does this mean that the Data Viewer has the data from all the preceding sources in the sentence (CASGEM and WRID)? Do CASGEM and WRID all have the same data? If the sentence could be clarified, it would help. Figures 2-17 and 2-18 show representative monitoring wells,	

	but do not say the data is from these wells. Maybe it seems that this would be obvious, but it might not hurt to say the data is from these wells if it is so. Figure 2-20 says the data is from 113 wells – are these wells all in WRID? Does WRID comprise these wells ONLY. Maybe a Venn type diagram of the various data sets would help make it clearer.
26May2021 Response	The underlying data in all of these figures is the same. The biggest difference is that some of the databases are updated more often. Wells that are not entered into the WRID by YCFCWCD/YSGA but have data collected by the state are entered into CASGEM & WDL & SGMA Data viewer. For example, when YCFCWCD collects data from their wells, it is immediately uploaded to the WRID. Then, YCFCWCD submits the data to CASGEM. CASGEM and the WDL will post the data shortly after that is done. Figure 2-15, Figure 2-16, Figure 2-17, Figure 2-18, and Figure 2-19 all come from the SGMA Data Viewer. Figure 2-17 will be updated to include the data source. We are working to coordinate databases. For CASGEM wells – a subset of the WRID – CASGEM and the WRID have the same data. There are wells in the WDL (Water Data Library) that have more recent data than the WRID. The wells that are displayed in these maps have long periods of record. This section is currently being revised.
Current comment:	Not sure this was resolved. Sources of data for tables were given as: Figure 2-15 SGMA data viewer Figure 2-16 SGMA data viewer Figure 2-17 no source given Figure 2-18 SGMA data viewer Figure 2-19 SGMA data viewer Your explanation above helps to understand data sources and what you mean by SGMA data, but we don't ask just for ourselves, this would be helpful for all readers.

	Figures 2-17 and 2-20 gives no source,- yet the data for Figure 2-20 is critical to the whole plan. More general comment (seeking greater understanding) is that we think The data are unlikely to be the same. Does this mean that the *wells* are all the same, but there are differences among the CASGEM, WRID, etc., in how recent the data for each well is? If this is so, then all the sets of wells should have the same number of wells, but I don't think they do. Once this is clear, there may be more questions.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
t. Page 2-49	**t; page 48**	
Text in final draft	**Our earlier comment**	
This sentence in the earlier draft: "The subset of 113 wells shown in **Figure 2-20** capture YCFCWCD's wells with a current water level measurement and a long data record. The YCFCWCD provides this bi-annual summary of this hydrograph to illustrate the state of the central-western portion of the Yolo Subbasin." Has been changed to: "The 64 wells shown in Figure 2-20 capture a subset of wells in the subbasin with a current water level measurement and a long data record."	We had previously asked: How do the WRID's 113 wells relate to the other wells discussed earlier? But now, the new Figure 2-20 does not give the source of data, and is somewhat similar to the earlier draft Figure 2-20 but with much higher low points, and other differences- can we understand why this has changed? The earlier graph showed, as we mentioned that "the average groundwater level is on a declining trajectory from 2006 until today if you focus on the peaks in groundwater level. The new graph does not show this…Also, as we had mentioned in the earlier graph the lows in 2014-15 are lower than the lows in 1991-92, even though more dry and critical years preceded 1991-92 than preceded 2014-15., yet the new graph also does not indicate such a trend.	
26May2021 Response	Max has substantially revised this section of Chapter 2 to make it easier to read and understand. The revisions that are made here may also help clarify comment q. There are 4,854 total wells in the WRID. They do not all have depth to water data. Certainly, these wells are important, and many of these wells will still be used to understand groundwater levels in the Yolo Subbasin. The 113 wells that you are referring to (Figure 2-20) in the WRID have long	

	periods of record and are monitored twice yearly by YCFCWCD. These wells do not have the same spatial extent as all of the wells in the Yolo Subbasin, as they are generally within the YCFCWCD service area. Your viewing permissions in the WRID may need to be changed, so you can see the 'All Wells' layer. Further response (and graphic): Thank you for the feedback. Figure 2-20 on page 48 is one of our most important figures in the entire GSP document. There are many details and caveats that probably deserve more explanation in the text. 1. The first detail is that this hydrograph is an average of more than 100 wells representing more than 200,000 acres and only in the YCFC&WCD service area, not the entire subbasin. The general patterns seen in this average hydrograph may not represent smaller sub areas within the YCFC&WCD service area. For smaller areas, the water balances by Management Area and YSGA Entity will give a better picture. 2. The second detail is probably a question of scale. This hydrograph actually shows amazing stability of groundwater levels and significant and complete recovery after 3 different drought cycles ('77, '91, and '14). The 2019 high is only 10 feet lower than the 1998 high, and only 5 feet lower than the 2006 high. A change of 5 or 10 feet off the maximum should be compared to other basins to the south, where groundwater level drops of hundreds of feet occur. For example, Page 77 in https://pubs.**usgs**.gov/pp/1401a/report.pdf. Check out the Tulare Basin.

	
Current comment:	Our original concern with the original Figure 2-20 graph was that we saw it as documenting that "the average groundwater level is on a declining trajectory from 2006 until today if you focus on the peaks in groundwater level. Nothing since 2006 has topped the groundwater level of that year – not even 2019 which was a very wet year that followed a very wet year in 2017. Further, the lows in 2014-15 are lower than the lows in 1991-92, even though more dry and critical years preceded 1991-92 than preceded 2014-15. The NEW figure 2-20 and text does not answer these questions, but instead, with less wells, attenuates these perceived trends. We'd like to know why the data was changed from 113 to 64, where the data comes from, and what were the criteria that changed to reduce the number of wells. It may be normal to throw out outliers, but in general, more data leads to more statistically reliable results…and the whole plan hinges on this data. Note that few if any non-technical people will consult the WRID database, the plan should not require that to understand what is proposed. The explanation provided in the 26 May 2021 response still refers to "more than 100 wells". We appreciate the note about scale, but remain convinced that we need to look at any

	downward heading trends in our subbasin; Tulare and San Joaquin did not do this.

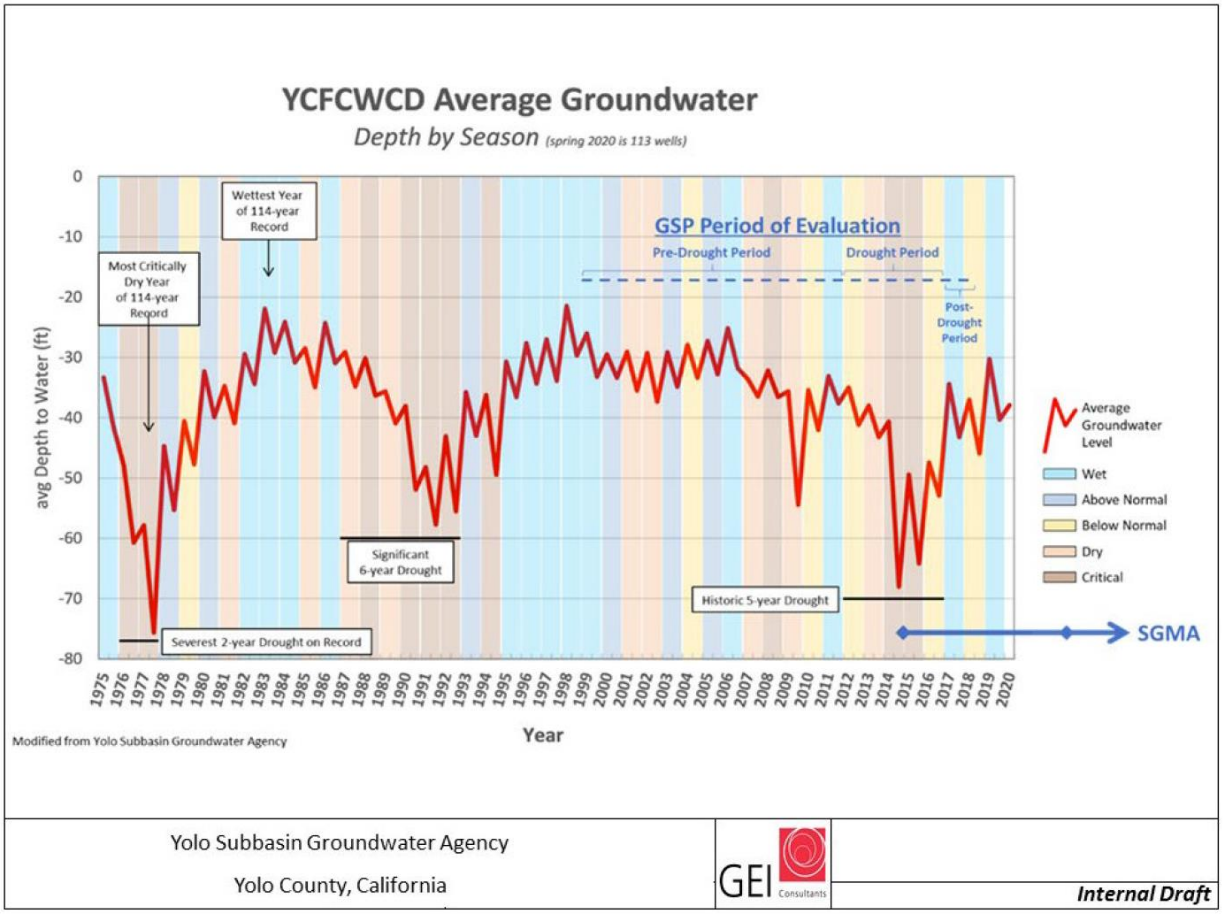


Figure 2-20. Historical Average Depth to Groundwater in YCFCWCD Service Area.

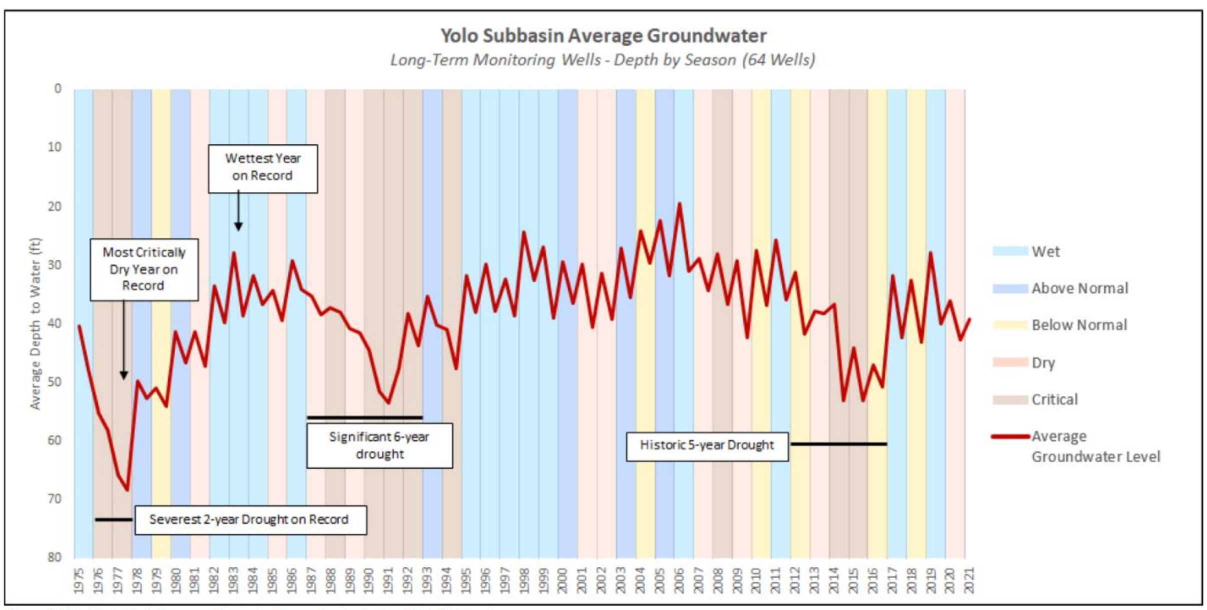


Figure 2-20. Historical Average Depth to Groundwater in the Yolo Subbasin

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
u. Page 50	**u; page 50**	
Text in final draft	**Our earlier comment**	
Future years are expected to be variable and possibly more extreme which will require vigilant attention to hydrologic conditions and a flexible management plan for surface water and groundwater.	We noted that this observation is relevant in light of our later comments on climate change, and how climate change is addressed in the plan, and scenarios	
Current comment:	Not sure this has been addressed	

New comment, page number
Page 2-50
Text in final draft: section 2.2.1.3 – Vertical Groundwater Gradients
Our comment: The value of this information is not clear. Intuitively, vertical gradients should be significant to a GSP, but the hydrographs and text do not give a good sense of what this actually tells us about groundwater sustainability.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
v. Page 50	**v; page 54**	
Text in final draft	**Our earlier comment**	
Sentence removed in new text	Is the following sentence "In addition, this model encompassed the old subbasin boundary, which included an area almost half of the current subbasin boundary" meant to express that the old model covered an area smaller than the current Subbasin? If so, do you think the sentence might be clearer stated as "In addition, this model encompassed only the original subbasin which included only about half the area of the current Yolo Subbasin"?	
Current comment:	resolved	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
w. Page 50	**w; page 55**	(not completely resolved)
Text in final draft	**Our earlier comment**	
While the change in groundwater storage in the Yolo Subbasin is generally positive and a substantial loss of storage cannot be seen over this period, the 2012 to 2016 drought showed a large decline in storage of nearly 400,000 acre-feet, similar to the drought of the late 1970's.	Figure 2-23 on groundwater storage change following the pattern of groundwater levels – shows a declining trajectory since 2006. The wet years of 2017 and 2019 did not return storage volumes even to 2011 level. In fact, the	

Change in storage increased to a positive value during 2017 due to a wet year, but then started decreasing again due to a below normal 2018. This illustration shows that the Subbasin responds quickly to variable recharge and pumping conditions.	decline trajectory is longer for storage than for groundwater level. Storage has declined since 1998, rising in 2006 compared to the years before it but not nearly as high as 1998, only to decline again until a small rise in the years 2011 and 12 before declining precipitously until the wet year of 2017. The dry year of 2018 immediately brought the storage area down to a level only seen in 1977. While 2019 was wet, 2020 and 21 have been noticeably dry, likely reducing groundwater storage to very low levels. Given this, the following edits to the conclusion for the groundwater storage section might be appropriate: While the change in groundwater storage in the Yolo Subbasin is generally positive and a substantial loss of storage cannot be seen over this period, the 2012 to 2016 drought showed a large decline in storage of nearly 400,000 acre-feet, similar to the drought of the late 1970's. Change in storage increased to a positive value during 2017 due to a wet year, but then started decreasing again due to a below normal 2018. This illustration shows that the while the Subbasin responds quickly to variable recharge and pumping conditions", the years since 2006 may suggest a declining trend in groundwater storage that demands careful attention to monitoring and management. [Note: we believe this comment is accurate even though I treated it as showing groundwater storage rather than cumulative change in groundwater storage. We are thinking the line graphs of both would have the same shape. If this is wrong, we will need some help understanding the graphs on cumulative change in storage. Finally, if graphs of both would have the same shape, what is the advantage to showing cumulative change over storage volumes?]

26May2021 Response	You are correct, cumulative change and storage volume will have the same shaped curves when plotted vs time. The advantage of cumulative change is that you can compare it to volume at time = 0 (1971) more easily. Figure 2-23 shows change in groundwater storage as calculated by a groundwater simulation model. The model is calibrated to actual measured groundwater, but it does have some assumptions that may make it more or less accurate. However, it is the best estimate we have for the overall changes in storage of the Yolo sub-basin. (Figure 2-20 only represents the YCFCWCD service area and shows actual groundwater level measurements.) The total storage (not change of storage) of the basin has been estimated at 13 million acre feet. So, on a percentage basis, the final year in Figure 2-23 shows a 'loss' since 1975 of less than 1.5%, while the maximum 'loss' in 1977 is around 3%. On a basin-wide scale, the Yolo sub-basin is doing great. Smaller, more localized areas may have concerns, such as the area around Winters, Yolo-Zamora, and near the Dunnigan Hills. At even smaller scale, some wells in the County are located in very specific perched or confined aquifers. These perched or confined aquifers may not recharge as quickly as other areas and will not sustainably produce water at certain pumping levels. In Yolo County, this tends to occur more often near hilly areas.
Current comment:	Thank you for the explanation; we feel this is a trend that merits a close watch, and the explanation would be helpful within the plan, not just to us.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
x. Page 50	**x; page 54**	
Text in final draft	**Our earlier comment**	
Groundwater quality monitoring and reporting is conducted through numerous public agencies. The following sections provide a summary of databases, programs and agencies that actively collect groundwater data, information on where the data is stored, and how it was used in the Basin Setting.	This section on monitoring existing water quality could be more easily understood by lay readers such as myself with a summary in the introductory paragraph about which data you use and for what. As an example of what I mean, one way to do this is to follow the last sentence in the intro	

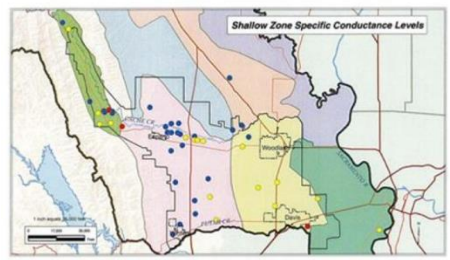
	paragraph with something like: "For constructing this plan, the YSGA used data from X, Y and Z. We used X because it gave us data about yada, yada, yada. Y provides data about yada, yada. The Y dataset complements the X data set because it has AAA that X data doesn't have…" …and so on. (a table might do this effectively with columns for Name of the data set, Agency, Data Description, Why necessary). But at the end of the day, we would want to know how water quality is being monitored, and in what form it will be made available and understandable to the general public.	
26May2021 Response	Yes, this section on water quality could be improved by adding some context, we will work with the consultants to make sure this is addressed.	
Current comment:	We did not see that this suggestion was taken up; we understand the YSGA is not going to undertake this monitoring itself, but will it not report on as done by different agencies, and make trends available to the public in one place?	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
y. Page 50	**y; page 57**	(not completely resolved)
Text in final draft	**Our earlier comment**	
While ILRP allows for compliance of their regulatory program through coalitions that cover a broad, non-contiguous area based on similar land use, SGMA and CV-SALTS will both require management areas/zones to be contiguous areas regardless of land use. In January 2022, domestic wells on lands enrolled in the ILRP will require testing.	Does this mean that all land within the Yolo Subbasin then falls in the management plan, for both groundwater management and nitrate/quality? Does this then include domestic wells?	
26May2021 Response	The grammatical errors in this sentence were dixed, hopefully it will make more sense with the new wording. Under the YSGA, the entire subbasin will need to be sustainable in terms of groundwater quality and nitrates – this includes domestic wells. The ILRP and CV-SALTS programs are mentioned here as other programs that monitor groundwater	

	quality. The implication is that the YSGA may need to expand/find additional sources of groundwater quality data in some of the areas that ILRP does not currently cover.
Current comment:	Typo corrected; not sure the questions have been answered (though sentence on domestic wells was added). The explanation in the response would be helpful in the draft plan itself.

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
z. Page 2-59	**z; page 60**	
Text in final draft	**Our earlier comment**	
In relation to the Department of Pesticide Regulation	Has the YSGA considered pesticide contamination of groundwater and used the Department of Pesticide Regulation data or any other data to evaluate if pesticides (including herbicides and fungicides) have contaminated Yolo Subbasin groundwater?	
26May2021 Response	Sustainable Management Criteria for water quality are currently in development. This information will be included in Chapter 3.	
Current comment:	Thanks for covering some of the organo chemical programs. Also for .27 Department of Pesticide Regulation coverage.	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
aa. Page 2-65	**aa; page 66**	
Text in final draft	**Our earlier comment**	
In the shallow groundwater zone, TDS is high (>1000 milligrams per liter [mg/l] or ppm) across a large portion of the eastern Subbasin, overlying West Sacramento, Davis, and Woodland. TDS values are also elevated in the Capay Valley. TDS is generally lower in the deeper groundwater zone, though patches of elevated TDS are present near Madison and north of Woodland, and concentrations in Capay Valley are uniformly above 500 mg/l.	This text and Figure 2.25 suggests (red dots) that this has been identified- some time ago- as a problem in lower portions of upper Cache Creek, within Capay Valley, and in Davis. Are they themselves flagging this as a problem?	

	
26May2021 Response	The minimum thresholds and measurable objectives for water quality are still under development for water quality in the Yolo Subbasin. Concerns about specific constituent water quality parameters should be addressed there.
Current comment:	Thank you for this explanation

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
bb. Page 2-65	bb; page 65	(not completely resolved)
Text in final draft	**Our earlier comment**	
2.2.4.4 Water Quality Evaluation	Should the fact that many rural residents use private wells since no water system is available be mentioned under Water Quality Evaluation as well as the steps were taken to address private wells – or the rationale for not addressing them? Water quality in such wells, used for domestic purposes, is an important issue.	
26May2021 Response	Domestic wells will be considered under sustainable management criteria for water quality in the Yolo Subbasin.	
Current comment:	It would useful to provide this clarity, in this section, not just to us.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
cc. Page 2-65	cc; page 65	
Text in final draft	**Our earlier comment**	
To better represent the groundwater quality of the principal aquifers, community water system water quality was evaluated.	An additional sentence would be helpful after "To better represent the groundwater quality of the principal aquifers, community water system water quality was evaluated" explaining why the community water system quality best represents the groundwater quality of principle aquifers. The rationale that the public water systems wells are deeper so give a more representative picture seems	

	confusing given information later that in general, the deeper aquifers show lower concentrations of contaminants.
26May2021 Response	We will discuss this with the consultants as well.
Current comment:	Suggestion was not taken up, question was not answered.

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
dd. Page 2-62 to 2-91	**dd; pages 65-94**	
Text in final draft	**Our earlier comment**	
See text in 2.2.4.4. Water Quality Evaluation, from pp. 2-62 to 2-91:	Data: Much of the data seemed quite old, including the 2004 data. Given that contamination would seemingly be in constant flux, conditions could be quite different today than even from 2014 or 2016, to the degree that 2004 data would be irrelevant except possibly to display trends. Then because of the statement on P87 that "At the time of this evaluation, data in the WRID after 2004 were not easily accessible" I thought maybe there was not much data after the 2004 study. However, P94 states "Water quality data used was collected between 2010 and 2020." Maybe these statements apply to different constituents, but then it would help to make this clearer in the text. Some of the maps (eg: 2-31) are labeled "2000-2016" leaving open the question of when the data really was collected. Finally, though, we had the impression from your discussion in a Working Group Meeting that an entity – maybe the Northern California Water Association – had provided fairly up to the minute data on contaminants. Did we misunderstand this?	
26May2021 Response	We will discuss this with the consultants as well.	
Current comment:	Not changed from before as far as we can tell…	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
ee. Page 2-85	**ee; page 87**	
Text in final draft	**Our earlier comment**	
See Section 2.2.4.5	Section 2.2.4.5 was very helpful at understanding what you concluded about water quality in the Subbasin. It would be	

	even better if placed at the beginning of the quality evaluation section as it would provide a context for what readers were reading and clues as to assessing the information in the rest of the section.
26May2021 Response	Yes, this context might be useful on page 65-66. We will consider changing its location.
Current comment:	Not changed from before as far as we can tell…

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
gg. Page 2-69 (does not follow page order of above)	**gg; page 70**	
Text in final draft	**Our earlier comment**	
Salinity – Public Water Systems	Salinity – Basinwide Conditions could be more easily understood with an introductory summary sentence along the lines of: Currently, the Basin has some areas with elevated salinity as indicated by either Electrical Conductivity (EC) or Total Dissolved Solids (TDS). Furthermore, salinity in shallow and intermediate groundwater zones appears to be increasing. Salinity in deeper groundwater zones appears lower and more stable.	
26May2021 Response	We will work to improve provide additional context on Salinity in the next version of Chapter 2.	
Current comment:	Not changed from before as far as we can tell… As mentioned in the comments when this was a draft chapter this section is titled "Salinity – Public Water Systems when it is primarily about agricultural water. Further comment here on final draft: p.2-69:11 "Extreme climatic conditions have the potential to introduce brackish waters into the subbasin again…, depending on future sea level rise and mitigation. However, further chemical analysis must be performed to robustly identify potential seawater intrusion." P2-54 should reference this information also. As it is, it gives the impression that sea intrusion is no risk at all. And, will this testing and analysis be done?	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
hh. Page 2-69 (does not follow page order of above)	**hh; page 95**	
Text in final draft	**Our earlier comment**	
2.2.5 Land Subsidence	Land Subsidence: this section is definitely the most technical of all the sections. My sense was that organizing it by data source put an unrealistic expectation on the non-technical reader to be able to evaluate the validity of each of the methods and keep the many various results in one's head to try to come to some conclusion about the severity of subsidence in the Subbasin. I think a summary paragraph after the intro paragraph would help if it said something along the lines of: This data suggests that subsidence is not generally a problem in the Subbasin. The different methodologies show a range of subsidence in the Valley between X and Y. The difference between the top and bottom of the range seems likely to have arisen because in the differences in methodologies, however even the top of the range does not indicate a subsidence rate likely to be unsustainable. Nonetheless, there are X areas where subsidence is of concern: A, B and C. [You could then possibly use a table to show the data of concern for each site]. We must continue to collect data on these areas. Etc… whatever you folks think. Such a paragraph would provide a guide for the reader to help sort through the rest of section and decide if the rest supports the conclusion.	
26May2021 Response	We will work to make the section of Chapter 2 easier for the reader to understand. Thank you for the written paragraph, that makes it easier to understand!	
Current comment:	Suggestion was not taken up.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
ii. Page 2-127	**ii; page 112**	
Text in final draft	**Our earlier commentS**	
Land surface water budgets quantify all the inflows and outflows to a specified area, from the bottom of the root zone, up to the land surface.	We thought we understood from the water budget meetings that the root zone was not included in the water budget, but this implies that it is…is it or not? Note that Figure 2-49 has no component of root zone water. How have they modeled the water in the root zone, and how would you account for management measures increase the water storage in the root zone, in project evaluation?	
26May2021 Response	Water in the root zone that percolates into the groundwater system is included as an inflow into the shallow aquifer. There is interaction of water between the root zone and the shallow aquifer. The land surface water budget includes water in the root zone. Water that is 'stored' in the root zone is not included in the groundwater storage or water budget for the groundwater. Root zone water would be broken up	
Current comment:	Thank you for this explanation; since our projects will focus on root zone water, it would be good to explain this within the plan. If we are to work to increase the soil sponge we will need to figure out how changes can be reflected in the model.	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
jj. Page 2-127	**jj; page 112**	
Text in final draft	**Our earlier comment**	
Grammatical error, now corrected.		

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
kk. Page 2-127 and 2-130	**kk; page 112**	
Text in final draft	**Our earlier comment**	
(page 2-127) Five future scenarios exist in the model. Urban demand in these five scenarios is based on Urban	Five future scenarios were incorporated where the demand is the same: urban demand is increased based on Urban	

Water Management Plan (UWMP) projections. The total urban demand is the same across the five modeled scenarios. Land use in the five future scenarios is held constant at 6 the 2016/2018 land use values. The differences between five future modeling scenarios are driven by the effect of the climate changes impacting irrigation demand, precipitation, and surface water supply availability.	Water Management Plan (UWMP) projections; the 2016/2018 irrigated crops are kept constant at 2016/2018 levels; and any change in irrigation demand is driven by the climate signal. Our comment on this was: The part in green says that for the five scenarios, demand is the same. The parts in yellow seem to say that changes in demand are considered. What am we not understanding? Among others, we question this assumption: in the model, the 2016/2018 irrigated crops are kept constant at 2016/2018 levels; and any change in irrigation demand is driven by the climate signal. Yet there have been, particularly over recent years, in the planting of irrigated tree crops in Yolo County: on what basis can we assume that this (totally economic, not climate signal related) demand will not continue to increase? It is even noted later [Page 114] that "An important feature of land use changes in the Yolo Subbasin is an increasing acreage of perennials, which have partly replaced field crops, and brought previously uncultivated area into production in some regions."- so we find it hard to reconcile these.
26May2021 Response	We have reworded this in the most recent draft of Chapter 2. It will need to be updated in the Water Budget Appendix as well. Essentially, what this sentence is trying to say is: The urban demand in all of the five future scenarios is the same amount, and that amount is an increase from the historical scenarios, based on UWMPs. The future agricultural demand is increased in these climate scenarios, based on changes in reference ET. The irrigated crops for the future scenarios are different from the historical scenarios. Within the future scenarios, all five cropping selections are the same. Future land use trends were not included in this version of the model. It is something

	that we are acutely aware of and will be incorporating this information into our 5-year updates. When the model was initially developed, land use trends were not included. See comments at the end of this document, **Synthesis of Responses to Climate Change Comments** .
Current comment:	Indeed, we think it is absolutely critical to include future land use trends in the model
…p. 130 The five scenarios are as follows and the cumulative and average precipitation for the Yolo Subbasin is higher in all climate projections, compared to that in the 'Historical' scenario.	The report needs to present justification for choosing to use higher cumulative and average precipitation for all the scenarios (except for the future baseline which is based on the same rainfall as the historical data. Readers need to know what climate change models are you used and why you selected those specific ones as well as which models you considered and rejected? Why is there not one scenario with lower cumulative or average precipitation, even for the so-called "dry extreme weather" scenario. For a genuine sensitivity analysis to assess risk of reaching unsustainable conditions, shouldn't the plan include least one scenario with drier weather than historical (and also increasing demands from tree crops?)
26May2021 Response	See comments at the end of document, **Synthesis of Responses to Climate Change Comments**

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
ll. Page 2-127	**ll; page 112, 115**	
Text in final draft	**Our earlier comment**	
Land surface water budgets quantify all the inflows and outflows to a specified area, from the bottom of the root zone, up to the land surface.	We thought we understood from the water budget meetings that the root zone was not included in the water budget, but this implies that it is…is it or not? Note that Figure 2-49 has no component of root zone water. How have they modeled the water in the root zone, and how would you account for management measures increase the water storage in the root zone, in project evaluation?	
Current comment:	Addressed in ii, above	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
mm. Page 2-131	**mm; page 112, 115**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Table 2-21. Land Use in the Yolo Subbasin.	On [previous] table 2-18, do “perennial crops” show up under “deciduous, subtropical and vine?” Also, native vegetation expanded significantly which most likely is perennial. However, it would not have the same effects on demand as agricultural production. Is it included as perennial acreage in the modeling?	
26May2021 Response	In the model, each crop has its own coefficient of water use. Almonds, walnuts, pistachios, vines are all have different water usage rates in the model. Page 34 of the model documentation shows the DWR Categories, and the crop input used in the model.	
Current comment:	Some explanation provided in section 2.2.9, that “An important feature of land use changes in the Subbasin is an increasing acreage of perennials crops (deciduous, subtropical, and vines), which have partly replaced field crops, and brought previously uncultivated area into production in some regions.” And the response above is helpful, it would be good to have this mentioned in the plan. (but second question not yet answered)	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
nn. Page 2-130	**nn; page 115**	(not completely resolved)
Text in final draft	**Our earlier comment**	
An important feature of land use changes in the Subbasin is an increasing acreage of perennials crops (deciduous, subtropical, and vines), which have partly replaced field crops, and brought	This sentence “Since ‘Future baseline’ and ‘Historical’ scenarios have the same climate, the impact of current, increased perennial crop acreage within the Yolo	

previously uncultivated area into production in some regions. The Future Baseline and Historical scenarios have the same climate, but different land use inputs; Future Baseline holds 2016 land use constant, while the Historical scenario relies on the historical land use datasets in Table 2-21. Comparing the Future Baseline scenario to Historical demonstrates the impact of the increased perennial acreage in 2016 relative to historical land use data. Perennial acreage is generally associated with more efficient irrigation practices. Because these crops are permanent, they also decrease the flexibility of water demand ("demand hardening"). Throughout the following sections, the comparison of the Future Baseline and Historical scenarios demonstrate the effects of this changing land use, largely in evapotranspiration and deep percolation. A model scenario incorporating future changes in land use is outside the scope of the current modeling effort but will be considered in future improvements of the YSGA model.	Subbasin is apparent (less inefficient, or more efficient, irrigation practices are altering evapotranspiration and deep percolation quantities)" is confusing in light of the sentence on P113 "The five scenarios are as follows and the cumulative and average precipitation for the Yolo Subbasin is higher in all climate projections, compared to that in the 'Historical' scenario." The green highlighting up above -says "future baseline" and "historical" have the same climate, while the yellow says precipitation is higher for all scenarios than the 'historical' scenario. What are we missing?	
26May2021 Response	Future baseline essentially looks at what would happen if we had the same climate as 1971 – 2016, and moved forward with 2016-2018 land uses. You are correct, that the Future_baseline and Historical should have the same precipitation amounts. The sentence could be worded better to clear up confusion – in this context 'Future_baseline' isn't really a climate projection, because it uses the historical climate and only changes land use/water infrastructure etc. That is why the precipitation amounts are the same on Table 2-20 (page 119). See comments at the end of this document, **Synthesis of Responses to Climate Change Comments**	
Current comment:	Not sure; is it not still true that higher precipitation is predicted for all future scenarios? The confusion could be reduced by the adding a sentence (in italics) as follows: …Subbasin is higher in all climate projections, compared to that in the 'Historical' scenario." *The Future Baseline is not a climate projection in that it keeps climate the same and varies only …..*	

New comment number, page number	(in relation to old comment letter, page number)	Resolved or

		Not answered
oo. Page 2-134	**oo; page 118**	
Text in final draft	**Our earlier comment**	
Table 2-22.	Could Table 2-19 explain how water year index is calculated?	
Current comment:	Information provided as "The Water Year Index and Water Year Type are provided from DWR, and "provide a classification to assess the amount of annual precipitation in a basin" 23 CCR §351(an). Additional information on the Water Year Index for the Sacramento Valley can be viewed in DWR's Sustainable Groundwater Management Act Water Year Type Dataset Development Report (DWR, 2021).	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
pp. Page 2-134 - 2-135	**pp; page 119**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Compared to the Historical scenario, the Future Baseline scenario results in more evapotranspiration and less deep percolation, demonstrating the effect of increased perennial acreage. In all 4 climate scenarios, the effect of climate change results in more evapotranspiration and more deep percolation than the Historical and Future Baseline scenarios.	Could the meaning of climate change (here used in the bullet: "The effect of climate change results in more evapotranspiration and more deep percolation") for this plan be defined? Does it only include temperature change or temperature and precipitation?	
26May2021 Response	Additional information on Climate Change and the assumptions about climate change can be found in the 'Model Documentation' and 'Water Budget' Appendices. Essentially, climate change is modeled as 'change factors' for precipitation and reference evapotranspiration (Page 39 of the model documentation). See comments at the end of this document, **Synthesis of Responses to Climate Change Comments**	
Current comment:	Thank you for this; it would be good to indicate this definition/reference in the chapter	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or

		Not answered
qq. Page 2-134 - 2-135	**qq; page 120**	
Text in final draft	**Our earlier comment**	
	Could the chapter explain why climate change is modelled as producing greater deep percolation? Some of the models I've seen for climate change predict that rain will occur over shorter time periods. In such cases, even if there is more precipitation (and I believe some climate change models predict lower precipitation) the likely result is more run-off, not necessarily more deep percolation unless measures are taken to improve water infiltration. Also, is the lower deep percolation from more perennial crops and irrigation changes expected to net out against the greater deep percolation due to climate change to produce the higher inflows than outflows for every scenario except DEW?	
26May2021 Response	The only scenario where deep percolation is greater than in the historical scenario is in the Future_2070_WMW scenario. Climate change scenarios have less deep percolation than the historical scenarios – when comparing the future scenarios, the deep percolation is less in the 'future baseline' (historical climate with 2016/2018 land use) than it is in the climate change scenarios. There is less deep percolation in all of the future scenarios, except 2070_WMW. We see less inflows into the groundwater system, in the future model, for every scenario except WMW (far right column of Table 2-21.). See comments at the end of this document, **Synthesis of Responses to Climate Change Comments**	
Current comment:	Thank you for this explanation; it would be helpful to include this in the current plan.	

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
rr. Page 2-138	**rr; page 122**	
Text in final draft	**Our earlier comment**	
Text is the same	This key claim in the discussion of groundwater storage "The groundwater	

	storage trace implies that the climate signal has dominated over this historical period at the Basin-wide level" really calls out that the plan needs much more discussion of and justification for the climate change assumed in the plan. The plan demonstrates at length that the recharge potential for the Subbasin is uncompromised – that declines in groundwater follow directly from droughts and that groundwater returns to high levels when rain is good. Thus, it is not recharge potential, but climate that determines groundwater levels. Since this is so, great care needs to go into selecting the climate change scenarios used, as well as realistically assessing the risks that climate change poses for the Subbasin.
26May2021 Response	Yes, the points made above are appropriate. What we see in the future scenarios is less water reaching the groundwater aquifer (decreases in deep percolation) in 4 of the 5 future scenarios. See comments at the end of this document, **Synthesis of Responses to Climate Change Comments**
Current comment:	And I would add, addressing increasing demands for groundwater, through increased acreage of crops

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
ss. Page 2-123	**ss; page 122**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Commenting on Table 2-26	According to [previous] Table 2-23, the two most recent decades of the last 5 decades show a groundwater storage decline of more than 590,000-acre-feet, wiping out the increases in 1990-2000 decade that single-handedly provided the only real increase in groundwater in the last 50 years (if we are reading the table correctly). 2/5ths of decades showed sharp declines in storage (2001-2010 and 2011-2018), 1/5th showed a significant increase (1990-2000) and 2/5ths of decades (1971-80 and 1981-90) showed little change. It	

	seems to us this short period in terms of definitive climate patterns – with its particular alternating pattern of wet and dry periods – has too much variability to draw any strong conclusions about the future. It seems especially risky to give any weight at all to the earlier decades. Rather, the later decades are more likely to be representative given the general scientific consensus that the climate is currently undergoing accelerating and unprecedented change.
26May2021 Response	That is essentially what the 2030 and 2070 centered future runs are doing. The distribution of wet and dry years is centered on the precipitation and ET scenarios in 2030 and 2070. Climate change models always use historical data to calibrate and downscale to, it is reasonable to assume that they will start showing more frequently occurring droughts as time moves forward. Additionally, the future scenarios take the most recent land use into account, as well as the most recent water rights and associated infrastructure into account.
Current comment:	This explanation would be helpful within the plan.

New comment number, page number	**(in relation to old comment letter, page number)**	Resolved or Not answered
tt. Page 2-138	**tt; page 123**	(not completely resolved)
Text in final draft	**Our earlier comment**	
Commenting on Table 2-26	For Figure 2-52, did the plan's methodology consist of starting with 1969 groundwater date and then using the data from Table 2-21 to run the model out until 2018? How was the data in table 2-21 arrived at?	
26May2021 Response	The x-axis 'dates' on 2-52 make it confusing. It would make more sense if it said 'Year 1' 'Year 2' 'Year 3'. The red line is what happened between 1970 and 2016. The other five lines are the future scenarios, and they are overlaid on the historical data to highlight the relative changes.	

Current comment:	Now Figures 2-59-60 The axis has not been changed, and this explanation would be very helpful in the plan.

New comment number, page number	(in relation to old comment letter, page number)	Resolved or Not answered
uu. Page 2-139	**uu; page 123**	(not completely resolved)
Text in final draft	**Our earlier comment**	
2.2.13 Sustainable Yield Based on the information presented above, a Sustainable Yield of 346 TAF per year is being proposed for the Yolo Subbasin. Figure 2-61 shows the modeled pumping time series for the historical period with the future scenarios included along with the proposed sustainable yield (the horizonal reference line).	For what purpose will the sustainable yield be used?	
26May2021 Response	The sustainable yield will be an additional tool to utilize in the decision-making process. Currently, the sustainable yield is not used in the establishment of minimum thresholds or measurable objectives; however, DWR will use the sustainable yield and annual reports to evaluate how the Subbasin is performing or working towards meeting objectives and overall sustainability. The sustainable yield value that is in Chapter 2 of the GSP may be used to develop a more in-depth water budget. Exactly how the sustainable yield will be used in the Yolo Subbasin is still in development.	
Current comment:	This is very helpful- but we did not ask for ourselves alone, this would be good to explain in the plan. Also what is TAF? It does not seem to be defined…we can guess total acre feet, but this should be clear.	

Synthesis of Responses to Climate Change Comments

The climate change models that the YSGA model uses comes from DWR. The DWR climate change model uses the best available data and science. This is a good resource with lots of additional information: DWR Climate Change Resource Guide. DWR's process for creating the climate change datasets was extensive and occurred over many years. DWR will release new climate change models as they deem appropriate when new data and methods necessitate new models. We are hoping to update the YSGA model in the future (5-year updates) with updated land use, additional projects, and climate change data – as available. When the next iteration of climate projections is available, the YSGA will be informed, and can convey that information to interested parties. This should be included in the 'Projects and Management Actions' Chapter of our GSP.

In climate change models, generally, temperature is higher in all projections – this means that ET demand will be higher. Precipitation projections of climate models have always been much more variable. Different models show different trends. According to SEI, this is especially true in the Yolo Subbasin, where we are right at the cusp of jet stream impacts. If the jet stream moves north or south in future climates, precipitation patterns could change accordingly – modeling for that future is very challenging.

SEI and YCFCWCD worked together, previously, to create some scenarios that were of interest to YCFCWCD – deeper, consecutive droughts, based on paleoclimate reconstructions, and not on climate change model output – Here is a link to that document: http://calag.ucanr.edu/Archive/?article=ca.2018a0005

Another important thing to note is that although we are seeing higher precipitation values in the Yolo Subbasin in the model, less of that water is being modeled as reaching the aquifer. The deep percolation values in the future scenarios are less than in the historical scenarios, except in the WMW case. From the aquifer's perspective, less water is coming in in the future scenarios. See the far right column of Table 2-21 (page121) below: [now Table 2-24]

Table 2-21. Average Annual Groundwater Budget

Average Annual Groundwater Budget (TAF)	Outflows				Varying Flows				Inflows			
	Pumping: Urban	Pumping: Irrigation	Drainage	Total Outflows	GW-SW Exchange	Lateral GW Flow: Outside Yolo	Lateral GW Flow	Total Varying Flows	Deep Percolation	YCFC Canal Recharge	Managed aquifer recharge:	Total Inflows
Entire Basin												
Historical	-33	-313	-28	-374	15	-28	0.0	-13	353	33	0.04	386
Future_Baseline	-16	-304	-16	-336	25	-40	0.0	-15	308	37	1.37	346
Future_2030	-15	-322	-15	-352	23	-37	0.0	-15	321	39	1.43	361
Future_2070	-15	-343	-15	-373	22	-35	0.0	-13	340	40	1.31	381
Future_2070_DEW	-15	-385	-13	-413	46	-6	0.0	39	323	37	1.30	360
Future_2070_WMW	-14	-311	-24	-348	-29	-79	0.0	-108	424	43	1.40	468

From the aquifer's perspective, there are less inflows in the future scenarios than in the historical.

Additionally, we will still be using empirical/observed data to continuously monitor all sustainable management criteria that apply to the Yolo Subbasin. We are not solely relying on the model outputs to make management decisions, or to establish minimum thresholds or measurable objectives. Continued monitoring of groundwater in the Yolo Subbasin will be an important part of a sustainable future. The model is one tool of many that will be used to ensure this sustainable future

3 Sustainable Management Criteria

New comment, page number
Page 1-11.7-10
Text in final draft: 3 Sustainable Management Criteria
Comment: We have copied below the relevant definitions and criteria, as the apply to the Capay Valley Management Area. We understand that the basin-wide "undesirable results" relate to the subbasin as a whole. But the measurable objective, and the minimum thresholds are specific to each management area. We have had questions previously about the monitoring wells chosen for Capay Valley and as we note in the **overarching comment 4**, there is a great sensitivity in the results for measurable objectives and minimum thresholds according to the number and selection of wells included in the plan. We need to be convinced that these are provide representative average picture in our management area; we ask that analysis is undertaken, and shared with the public show that the number and wells chosen have the best likelihood of revealing the true mean for groundwater levels each year for the Subbasin and the management areas.

*The basin-wide definition of **"undesirable results"** for the chronic lowering of groundwater levels is as follows: The point at which significant and unreasonable impacts over the planning and implementation horizon, as determined by depth or elevation of ground water, affect the reasonable beneficial use of, and access to, groundwater by overlying users. An undesirable result occurs when the minimum threshold criteria is exceeded in 51% or more of representative monitoring wells in two (2) management areas*

***Measurable objective** is equal to the average fall (Sep-Dec) groundwater elevation for the water year period of 2000 to 2011 at each Representative Well. Performance of the measurable objective will be measured as the five (5) year running average of the minimum fall (Sep-Dec) groundwater elevation.*

Minumum thresholds

To establish the minimum thresholds and measurable objectives for the Yolo Subbasin, the YSGA reviewed available well data and selected a subset of Representative Wells that would be used to establish minimum threshold values. These Representative Wells, shown in Figure 3-1, were selected because the well maintained a sufficient period of record to be representative of surrounding groundwater conditions and included sufficient spring and fall elevation data for the period of 2001 to 2011. Representative Wells were reviewed with stakeholders from the Management Area in which they are located to ensure the selected wells represented the best available data and were representative of local groundwater conditions. Based on historic, current, and projected groundwater conditions in the Subbasin, the YSGA developed several methodologies for establishing the minimum threshold value for each representative well, based on Management Area boundaries. The hydrographs for all Representative Wells used to establish minimum thresholds and measurable objectives are provided in Appendix E. The methodology for each Management Area is described below.

Capay Valley, Dunnigan Hills, Central Yolo, and South Yolo:
Exceedance of the historic minimum elevation in the period of record of each Representative Well in two consecutive years. The minimum threshold established with this methodology protect groundwater levels from chronically lowering to levels below the historical experience and recognize that groundwater conditions in these management areas is expected to behave similarly to historic conditions. No significant decreases in groundwater conditions are expected under future projected conditions.

Table 3-1. Yolo Subbasin Representative Wells and Minimum Threshold and Measurable Objective Values.

Management Area	YSGA Representative Well Number	State Well Number	Measurable Objective (ft)		Minimum Threshold (ft)	
			Depth to Water	*Groundwater elevation*	*Depth to Water*	*Groundwater elevation*
Capay Valley	276	10N02W16R001M	14.4	215.1	21.9	207.7
	277	10N02W18F001M	20.1	315.9	31.8	304.2
	280	10N03W02R002M	18.3	319.8	29.9	308.2
	285	11N03W09Q001M	21.2	382.9	48.3	355.8
	287	11N03W23L001M	15.1	296.1	24	287.2
	288	11N03W23N001M	34.6	285.5	49.1	271
	289	11N03W33F001M	19.6	351.2	29.6	341.2
	293	12N03W20D001M	21.5	381.1	26.2	376.4
	415	11N03W35D003M	28.5	280.7	36.3	273
	416	10N03W24B002M	68.1	322.1	109.1	281.1

My name is Christopher Foe. My wife and I have lived for 30 years at the intersection of County Road 29 and 95 and are located in the Central Yolo Groundwater Sub basin. Like all our neighbors, we are on a domestic well and so are very interested in the successful implementation of the groundwater management plan. Continuing to have access to groundwater of a high quality and of sufficient magnitude for our domestic use is an important component of the quality of our lives and of the continued value of our property.

The Yolo Sub basin Groundwater Agency (YSGA) is to be complimented for assembling a high quality document with many excellent analyses. The Yolo County Flood Control and Water Conservation District is also to be complimented for having the foresight to begin collecting groundwater elevation data half a century ago. This data has provided significant insight into seasonal and inter annual changes in groundwater elevation and made it possible to model future groundwater conditions. The comments provided below are intended to improve the document and make future management plans more successful.

Major comments

- I remain skeptical about the predictive ability of the YSGA model because of shortcomings discussed below. The ongoing drought may provide a unique opportunity to assess the model's accuracy and increase stakeholder confidence in its ability to predict future water elevation levels. The model could be used to predict groundwater levels at all compliance stations this fall. Model predictions can be compared with field measurements made this fall to assess model accuracy and precision in each sub basin. If the analysis is done, the results and a statistical analysis should be posted online for stakeholder evaluation.

  A robust model could be of great utility to landowners. If strong statistical correlations are obtained between predicted and observed values, then the model can be used with precipitation information collected this rainy season to predict groundwater levels at the end of the 2022 irrigation season. This will help landowners decide whether they need to be lowering their pumps this winter and spring and/or drilling new wells to reduce the chance of experiencing a dry well next year.

- The report is remiss in not including sustainability goals for water quality. Abundant groundwater of a degraded quality is of limited value to stakeholders. The YSGA is to be commended for coordinating the collection of groundwater monitoring data with other agencies. However, the YSGA needs to develop, *a priori,* sustainable management goals to evaluate this data and determine whether water quality management plans are needed. This is particularly true for nitrate contamination. Available data suggest that current nitrate levels in some regions exceed the primary MCL and constitute an ongoing human health drinking water hazard. The water quality problem is likely to become significantly worse if not promptly addressed. At a minimum, the YSGA should insure that all rural domestic drinking water wells in sub basins of concern are tested to determine nitrate levels. In addition, all new domestic drinking water wells should be tested as part of the construction process. This should occur whether the landowner is part of the Regional Board's Irrigated Lands Regulation Program or not. Nitrate may be removed from drinking water by ion exchange, distillation or reverse osmosis. However, landowners must be educated about the hazard and how to protect themselves. This should be an immediate YSGA management action.

- The Sustainability Plan is silent about what happens when minimum thresholds/measureable objectives are exceeded. There should be an explicit commitment by the JPA to undertake immediate corrective action when this occurs. The purpose of the corrective action is to slow/reverse the development of negative groundwater conditions and spur implementation of longer term actions. At a minimum, potential actions should include an immediate moratorium on new well construction in threaten sub basins.

<u>Minor comments</u>

- Page 1-24 line 33. The City of Davis and Woodland have percolation basins receiving storm runoff. These actions should be acknowledged, the amount of groundwater infiltration calculated, and in the management section, construction of additional percolation basins encouraged.

- Page 2-29 line 16. Please be consistent with units: TDS in figures 2-26 and 2-27 are in mg/l while on p 2-69 line 16 are in ppm. The different units result in the same numeric value but the general reader may not know that.

- Around Page 2-70. There is a similar problem with units for nitrate. The discussion appears to bounce around between concentrations reported as total nitrate and as N. For example Figure 2-29 are as total nitrate while figures 2-30 and 2-31 are as N. Sometimes in the text it is difficult to determine what the units being used are. Unlike with TDS, the different units result in different values. To eliminate confusion the text should use only one set of units. The most scientifically acceptable term is as N (example 10 mg-N/l).

- Page 2-70 Shallow groundwater nitrate contamination may be greater than pictured in the *Nitrate Basin wide Condition* section. The most recent figure is for the 2000-2016 time period (5 to 21 years ago) and shows wide spread concentrations greater than 5 mg-N/l in the Central, South and North basins. The 5 mg-N/l is often considered the leading edge of the nitrogen contamination plume. Monitoring data shows that nitrate concentrations in 50 percent of shallow Central Valley groundwater wells increased from 5 to 10 mg-N/l or greater in five years (in Levy et al 2021). About 75 percent of these wells had concentrations greater than 10 mg-N/l in ten years. The 10 mg-N/l concentration is the primary federal drinking water MCL for safe human consumption.

- Page 2-71 Table 2-13. What year was data in Table 2-13 collected?

- Page 2-71 A map of the location of current and historical dairies and horse boarding facilities would be useful to determine whether septic or animal facilities are the primary source of animal derived nitrogen.

- Page 2-71 or thereabouts. The nitrate section should be expanded to include more on the sources, transport and fate of nitrate. The section identifies that fertilizer application in agriculture is the major source of nitrate. The document should continue and identify nitrogen application rates (lbs/acre/yr) by the major crop types grown in the basin (Figure 1-4). Landon et al 2009 found that nitrate concentration in shallow groundwater (<200 ft) on the eastside of the San Joaquin Basin was positively correlated with percent orchard and vineyard land use. There was no relationship with other crop types suggesting that these two land uses were a major source of groundwater nitrogen. The discussion should also include a section on the fate of nitrate. Groundwater contamination is very expensive and difficult to remediate. Nitrate is slowly converted to gaseous nitrogen in anaerobic environments and lost from the soil profile to the atmosphere. But this is a slow process with the result that nitrate tends to accumulate in groundwater. Finally, Levy et al 2021 has shown a positive correlation between groundwater drawdown during droughts and an increase in nitrate concentration. Apparently, nitrate is sufficiently mobile and soluble that it remains in solution and is concentrated as water levels are drawn down. Understanding nitrate cycling is essential for understanding and managing contamination.

- Page 2-76. Figure 1-7 shows the distribution of domestic wells in the basin. Most of these wells likely draw water from the upper groundwater zone. Figure 1-7 should be overlaid on Figure 2-30 to identify the location of domestic drinking water wells at risk from elevated nitrate levels. An additional table should be included estimating how many domestic wells are likely contaminated with <2.5, 2.5-5.0, 5.0-7.5, 7.5-10.0 and >10.0 mg-N/l by sub basin. This information is essential for identifying the location and evaluating the magnitude of the human health nitrate contamination problem.

- Figure 2-56. Figure 2-56 is meaningless and should be discarded or significantly amended. The upper graph is a valid projection of future urban water use. The bottom graph for agriculture is misleading and should not be presented. It apparently is based on 2016 land use consumption values and used to make projections through 2061. Agricultural land use is rapidly changing in the basin. Table 2-21` shows that deciduous and vine crops have increased by 11.7 and 5.6 percent per year between 2008 and 2016. I believe the rate at which new orchards are being planted has continued or increased since then. In contrast, table 2-56 shows that grain, field crops and pasture acreage have all decreased. Orchards and vineyards almost exclusively rely on groundwater while row and field crops use surface water. Has an agricultural water use sensitivity analysis been done? Such an analysis is important because the pie charts in Figure 2-56 demonstrate that agriculture uses more than 95 percent of the water in the basin. Changes in agricultural use, not urban use, will drive changes in the water budget. Similar comments apply to the remainder of the groundwater elevation and storage discussion[1].

- Page 3-3 line 7 Please explain the rationale behind the determination that an undesirable result has occurred when the minimum threshold was exceeded in 51 percent of monitoring wells in two sub basins. A following section entitled "*Criteria for establishing minimum thresholds*" also does not explain the selection of the 51 percent value in two sub basins.

[1] At this land use conversion rate the entire 640,000 acre basin would be planted in orchards within the next 15 years, well within the proposed 20 year implementation period. My projection for the magnitude of new orchard acreage is obviously flawed but is included to emphasize the present rate of change of land use in the basin and the danger of extrapolating 6 year old agricultural land use date through 2070.

- Page 3-4 line 22. Several questions. First, is the period of exceedance a calendar or water year? Second, does this mean that both the fall and spring measurements need to be below the minimum threshold for two years or only one measurement in each of two consecutive years? Finally, is this calculated from static or sustained groundwater pumping level?

- Page 5-1 lines 11 to 15. The groundwater pumping values for all scenarios are very precise. There is clearly great uncertainty about future changes in both climate and urban and agricultural land use. Ninety-five percent confidence limits around these values would strengthen the discussion and emphasize the need for high quality monitoring data and a wide range of management options.

- Table 5-1. Three possible additional management actions are: first, inject treated UC Davis surface water into an intermediate aquifer and use the stored water to augment surface water supplies for irrigating research plots. Second, encourage the Cities of Davis, Woodland, and Winters to divert all storm runoff into percolation ponds for groundwater recharge. Finally, multiple off-channel gravel pits exist along Cache Creek. Winter storm runoff could be diverted into the pits and used for groundwater recharge and/or release into Cache Creek for downstream use during the irrigation season.

- Table 5-1. All rural domestic drinking water wells should be tested for nitrate concentration. New wells should be tested as part of their construction. Landowners should be educated about the threat of drinking nitrate contaminated well water and instructed on how to treat it.

References

Landon, M.K., K. Belitz, B. Jurgens, J. Kulongoski and T. Johnson. 2009. Status and understanding of groundwater quality in the central-eastside San Joaquin Basin, 2006: California GAMA Priority Basin Project. USGS Scientific Investigations Report 2009-5266.

Levy, Z., C Jurgens, K. Burow, S. Voss, K. Faulkner, J. Arroyo-Lopez, and M. Fram. 2021. Critical aquifer overdraft accelerates degradation of groundwater quality in California's Central Valley during Drought. Geophysical Research Letters 48 (17)

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OCTOBER 27, 2021

VIA E-MAIL and U.S. MAIL

Yolo Subbasin Groundwater Agency
34274 State Highway 16
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Email: info@yolosga.org

RE: Yolo Subbasin GSP Comments

Dear Board Members:

The purpose of this letter is to provide Yolo Subbasin Groundwater Agency (YSGA) with the comments of Deseret Farms of California to YSGA's draft groundwater sustainability plan (GSP).

First and foremost, we appreciate the time and effort YSGA's management staff, committees, and consultants have committed to preparing this draft GSP. Further, we appreciate the opportunity to provide comments to YSGA regarding its draft GSP. We hope YSGA will consider the following comments in finalizing the draft GSP for submission to the Department of Water Resources (DWR). In considering the following comments, we recognize that this draft GSP is a "living document," and will undergo updates and modifications as more information is gathered to help the Subbasin reach sustainability by 2042 and beyond.

Provided are our specific comments:

1. The draft GSP lacks specific sustainable management criteria for degraded water quality in the Subbasin.

The Sustainable Groundwater Management Act (SGMA) requires a GSP to include, among other things, descriptions of sustainable management criteria (SMC) for each applicable sustainability indicator, as identified by SMGA. (Cal. Code Regs., tit. 23, § 354.22 et seq.) Notably, the draft GSP expressly provides that "[t]he YSGA has not established specific sustainable management criteria for water quality in the Subbasin. . . ." (Pg. 3-15, Lines 2 – 3.) Instead, YSGA plans to rely on "current and future water quality standards established for drinking water and agricultural water uses by State and county regulatory agencies." (Pg. 3-15, Lines 2 – 4.) To avoid a finding of "incomplete" by DWR, YSGA must address this matter and develop a SMC for degraded water quality.

Further, while YSGA is developing this missing component of its GSP, we assume that it will rely on this existing language within its draft GSP. That means that, in the meantime, YSGA will rely on water quality standards established by State and county regulatory agencies. In doing so, we recommend that YSGA impose State regulatory water quality standards on agricultural water supplies and county regulatory water quality standards on public water supplies. Agricultural groundwater users within the Subbasin require regulatory certainty. Therefore, if YSGA were to upend the current structure of water quality regulations, it would risk placing these agricultural groundwater users in violation of standards that they would otherwise be in compliance with and create an inaccurate portrayal of noncompliance within the Subbasin.

2. The draft GSP should revise the Measurable Objectives and Minimum Thresholds for Chronic Lowering of Groundwater Levels SMC and the Reduction of Groundwater Storage SMC.

The Measurable Objectives (MO) and Minimum Thresholds (MT) for the Chronic Lowering of Groundwater SMC go beyond what is required to achieve YSGA's sustainability goal for the Subbasin. As expressly provided in the draft GSP, "the Yolo Subbasin is a relatively stable basin, with groundwater levels maintaining a relatively consistent long-term average elevation or depth to groundwater." (Pg. 3-4, Lines 4 – 6.) Nonetheless, YSGA relies on overly aggressive MOs and MTs that will ultimately inhibit landowners' ability to achieve these goals. Therefore, we recommend that the MOs and MTs for the Chronic Lowering of Groundwater SMC be lowered to allow for greater operational flexibility.

Further, the methodology used to establish the MOs for the Chronic Lowering of Groundwater SMC and the Reduction of Groundwater Storage SMC should be revised to provide clarity. Specifically, regarding both SMCs, the draft GSP provides:

> Measurable objective is equal to the average fall (Sep-Dec) groundwater elevation for the water period of 2000 to 2011 at each Representative well. Performance of the measurable objective will be measure as the five (5) year running average of the minimum fall (Sep-Dec) groundwater elevation.

It is unclear how YSGA will rely on and apply both "the water period of 2000 to 2011" and "the five (5) year running average." Therefore, additional clarity is needed to understand the interplay between these two seemingly contradictory sets of data. Further, the draft GSP does not provide any background or basis as to how these two time periods were established. To that end, we recommend either that the GSP: (A) expand the "water period of 2000 to 2011" to the "water period of 2000 to 2018;" or (B) expand the "five (5) year running average" to a "ten (10) year running average." Either option would incorporate a larger amount of data that would likely provide landowners the additional support necessary achieve the purpose of the MOs.

Thank you for the opportunity to provide these comments. We appreciate the significance of the considerations and decisions YSGA must undertake, and we look forward to working with you further regarding these matters.

Very truly yours,

James Strong
General Manager

October 27, 2021

Yolo Subbasin Groundwater Agency (YSGA)
34274 State Highway 16
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Submitted via email: info@yolosga.org

Re: Public Comment Letter for Yolo Subbasin Draft GSP

Dear Kristin Sicke,

On behalf of the above-listed organizations, we appreciate the opportunity to comment on the Draft Groundwater Sustainability Plan (GSP) for the Yolo Subbasin being prepared under the Sustainable Groundwater Management Act (SGMA). Our organizations are deeply engaged in and committed to the successful implementation of SGMA because we understand that groundwater is critical for the resilience of California's water portfolio, particularly in light of changing climate. Under the requirements of SGMA, Groundwater Sustainability Agencies (GSAs) must consider the interests of all beneficial uses and users of groundwater, such as domestic well owners, environmental users, surface water users, federal government, California Native American tribes and disadvantaged communities (Water Code 10723.2).

As stakeholder representatives for beneficial users of groundwater, our GSP review focuses on how well disadvantaged communities, drinking water users, tribes, climate change, and the environment were addressed in the GSP. While we appreciate that some basins have consulted us directly via focus groups, workshops, and working groups, we are providing public comment letters to all GSAs as a means to engage in the development of 2022 GSPs across the state. Recognizing that GSPs are complicated and resource-intensive to develop, the intention of this letter is to provide constructive stakeholder feedback that can improve the GSP prior to submission to the State.

Based on our review, we have significant concerns regarding the treatment of key beneficial users in the Draft GSP and consider the GSP to be **insufficient** under SGMA. We highlight the following findings:

1. Beneficial uses and users **are not sufficiently** considered in GSP development.
    a. Human Right to Water considerations **are not sufficiently** incorporated.
    b. Public trust resources **are not sufficiently** considered.
    c. Impacts of Minimum Thresholds, Measurable Objectives and Undesirable Results on beneficial uses and users **are not sufficiently** analyzed.
2. Climate change **is not sufficiently** considered.
3. Data gaps **are not sufficiently** identified and the GSP **does not have a plan** to eliminate them.

4. Projects and Management Actions **do not sufficiently consider** potential impacts or benefits to beneficial uses and users.

Our specific comments related to the deficiencies of the Yolo Subbasin Draft GSP along with recommendations on how to reconcile them, are provided in detail in **Attachment A.**

Please refer to the enclosed list of attachments for additional technical recommendations:

Attachment A	GSP Specific Comments
Attachment B	SGMA Tools to address DAC, drinking water, and environmental beneficial uses and users
Attachment C	Freshwater species located in the basin
Attachment D	The Nature Conservancy's "Identifying GDEs under SGMA: Best Practices for using the NC Dataset"
Attachment E	Maps of representative monitoring points in relation to key beneficial users

Thank you for fully considering our comments as you finalize your GSP.

Best Regards,

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Attachment A

Specific Comments on the Yolo Subbasin Draft Groundwater Sustainability Plan

1. Consideration of Beneficial Uses and Users in GSP development

Consideration of beneficial uses and users in GSP development is contingent upon adequate identification and engagement of the appropriate stakeholders. The (A) identification, (B) engagement, and (C) consideration of disadvantaged communities, drinking water users, tribes,[1] groundwater dependent ecosystems, streams, wetlands, and freshwater species are essential for ensuring the GSP integrates existing state policies on the Human Right to Water and the Public Trust Doctrine.

A. Identification of Key Beneficial Uses and Users

Disadvantaged Communities, Drinking Water Users, and Tribes

The identification of Disadvantaged Communities (DACs), drinking water users, and tribes is **insufficient**. We note the following deficiencies with the identification of these key beneficial users:

- The GSP fails to identify and map the locations of DACs, and describe the size of each DAC population within the subbasin.
- The GSP fails to identify and map tribal lands within the subbasin.
- The GSP provides a map of domestic well density in Figure 1.7, but fails to provide depth of these wells (such as minimum well depth, average well depth, or depth range) within the subbasin.
- The GSP fails to identify the population dependent on groundwater as their source of drinking water in the subbasin. Specifics are not provided on how much each DAC community relies on a particular water supply (e.g., what percentage is supplied by groundwater).

These missing elements are required for the GSA to fully understand the specific interests and water demands of these beneficial users, and to support the consideration of beneficial users in the development of sustainable management criteria and selection of projects and management actions.

RECOMMENDATIONS
• Describe and map the locations of DACs and provide the size of each DAC population. The DWR DAC mapping tool can be used for this purpose.[2]

[1] Our letter provides a review of the identification and consideration of federally recognized tribes (Data source: SGMA Data viewer) within the GSP from non-tribal members and NGOs. Based on the likely incomplete information available to our organizations for this review, we recommend that the GSA utilize the California Department of Water Resources' "Engagement with Tribal Governments" Guidance Document (https://water.ca.gov/Programs/Groundwater-Management/SGMA-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents) to comprehensively address these important beneficial users in their GSP.

[2] The DWR DAC mapping tool is available online at: https://gis.water.ca.gov/app/dacs/.

- Provide a map of tribal lands and describe the tribal population within the subbasin.
- Include a map showing domestic well locations and average well depth across the subbasin.
- Identify the sources of drinking water for DAC members, including an estimate of how many people rely on groundwater (e.g., domestic wells, state small water systems, and public water systems).

Interconnected Surface Waters

The identification of Interconnected Surface Waters (ISWs) is **incomplete**, based on incomplete identification of potential ISWs in the GSP.

We commend the YSGA for the thorough, comprehensive evaluation of ISWs in the subbasin. The methodology for the ISW analysis was adapted from The Nature Conservancy's ICONs map. The minimum groundwater elevation from water years 2006-2015 was intersected with the stream surface elevations. Gaining, losing, uncertain, and disconnected reaches are presented on Figure 2-47 (Interconnected Surface Water Bodies Under the Maximum Groundwater Elevation 2006-2015). The quantity and timing of depletions of interconnected surface waters is estimated by the Yolo Subbasin Groundwater Agency (YSGA) Model. The GSP presents the average annual stream seepage values and seasonal variability (spring and fall) of stream gains and losses as estimated by the model. Data gaps are identified and discussed in the text. The following recommendation would strengthen the clarity and completeness of the ISW evaluation.

RECOMMENDATION

- Clarify in the GSP text that reaches marked as 'uncertain' on Figure 2-47 are retained as *potential* ISWs in the GSP.

Groundwater Dependent Ecosystems

The identification of Groundwater Dependent Ecosystems (GDEs) is **insufficient**, due to the lack of a complete inventory, map, or description of fauna (e.g., birds, fish, amphibians) and flora (e.g., plants) species or habitat types in the subbasin's GDEs. Table 2-20 presents the number of species present in the subbasin's GDEs, but an inventory of those species is not provided.

Despite failing to identify fauna and flora, we commend the YSGA for their comprehensive evaluation of GDEs in the subbasin. The GSP mapped GDEs using the Natural Communities Commonly Associated with Groundwater dataset (NC dataset) (also referred to as the iGDE database in the GSP). The GSP presents a detailed discussion of the manner in which depth to groundwater, rooting depths, NDVI, and aerial imagery were used to establish GDE connection to groundwater. TNC's GDE Pulse tool was used to assess GDE vegetative health in the subbasin.

We commend the YSGA for their analysis of rooting depths of GDEs. The GSP states that where the depth to water was greater than 30 feet, GDEs were further evaluated based on an evaluation of the rooting depth of the dominant species within that polygon. The GSP states (2-114): "*Valley Oaks (Quercus lobata), for example, have a maximum rooting depth of nearly 25 feet. Studies suggest that the Valley Oak may be able to access groundwater much deeper, and up to nearly 80 feet in fractured rock ecosystems (Burgy, 1964).*" The GSP explains that the rooting depth is doubled as a conservative measure (in the case of valley oak, the 25 foot rooting depth is doubled to 50 feet for the screening threshold). We recommend instead that a 75-foot threshold be used for Valley Oak, supported by recent research which confirms Burgy (1964) and shows further that Valley Oak polygons from the NC dataset exhibit the ability to extend deep in alluvial systems to reach groundwater (up to approximately 75 feet).[3]

RECOMMENDATIONS
• Include an inventory of the fauna and flora present within the subbasin's GDEs (see Attachment C of this letter for a list of freshwater species located in the Yolo subbasin). Note any threatened or endangered species. • We recommend a depth-to-groundwater threshold of 75 feet be used instead of the 50 feet threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater.

Native Vegetation and Managed Wetlands

Native vegetation and managed wetlands are water use sectors that are required to be included into the water budget.[4,5] The integration of these ecosystems into the water budget is **insufficient**.

The water budget includes a separate item for evapotranspiration, but combines agriculture and native evapotranspiration into one term. The water budget did not explicitly include the current, historical, and projected demands of managed wetlands. The GSP states (4-29): "The YSGA water budget currently contains a data gap surrounding the consideration of managed wetlands. To ensure accurate consideration of managed wetlands moving forward, additional analysis and coordination will occur." We appreciate that managed wetlands are identified as a data gap in the budget, rather than left unrecognized. Please include a more detailed description of the process and timeline to address this data gap.

The omission of explicit water demands for native vegetation and managed wetlands is problematic because key environmental uses of groundwater are not being accounted for as water supply decisions are made using this budget, nor will they likely be considered in project and management actions.

RECOMMENDATIONS
• Quantify and present all water use sector demands in the historical, current, and projected water budgets with individual line items for each water use sector, including managed wetlands. If this is identified as a current data gap, then include a description of how it will be addressed, including a timeline for completion. • In the historical, current, and projected water budgets, include an individual line item for native vegetation, instead of lumping it together with agricultural evapotranspiration.

[3] Groundwater dependence of riparian woodlands and the disrupting effect of anthropogenically altered streamflow

[4] "'Water use sector' refers to categories of water demand based on the general land uses to which the water is applied, including urban, industrial, agricultural, managed wetlands, managed recharge, and native vegetation." [23 CCR §351(al)]

[5] "The water budget shall quantify the following, either through direct measurements or estimates based on data: (3) Outflows from the groundwater system by water use sector, including evapotranspiration, groundwater extraction, groundwater discharge to surface water sources, and subsurface groundwater outflow." [23 CCR §354.18]

B. Engaging Stakeholders

Stakeholder Engagement during GSP development

Stakeholder engagement during GSP development is **insufficient**. SGMA's requirement for public notice and engagement of stakeholders is not fully met by the description in the Notice and Communication Section (Section 1.5.5) of the Plan.[6]

We note the following deficiencies with the overall stakeholder engagement process:

- The GSP does not provide a stand-alone Stakeholder Communication and Engagement Plan for the subbasin.
- The opportunities for public involvement and engagement during the GSP development phase are not provided in the GSP. Groundwater users are mentioned in Section 1.5.5 as being stakeholders for public outreach activities in the subbasin, however no detailed information is provided on the type of outreach and engagement activities that have been conducted specifically for DACs, domestic well owners, tribes, and environmental stakeholders.
- The plan does not include a plan for continual opportunities for engagement through the implementation phase of the GSP for DACs, domestic well owners, tribes, and environmental stakeholders.

RECOMMENDATIONS

- Include a stand-alone, detailed and robust Stakeholder Communication and Engagement Plan that describes active and targeted outreach to engage DACs, domestic well owners, environmental stakeholders, and tribal stakeholders during the remainder of the GSP development process and throughout the GSP implementation phase. Refer to Attachment B for specific recommendations on how to actively engage stakeholders during all phases of the GSP process.
- Describe efforts to consult and engage with DACs and domestic well owners within the subbasin.
- Utilize DWR's tribal engagement guidance to comprehensively address all tribes and tribal interests in the subbasin within the GSP.[7]
- Describe efforts to consult and engage with environmental stakeholders within the subbasin.

[6] "A communication section of the Plan shall include a requirement that the GSP identify how it encourages the active involvement of diverse social, cultural, and economic elements of the population within the basin." [23 CCR §354.10(d)(3)]
[7] Engagement with Tribal Governments Guidance Document. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Sustainable-Groundwater-Management/Best-Management-Practices-and-Guidance-Documents/Files/Guidance-Doc-for-SGM-Engagement-with-Tribal-Govt_ay_19.pdf

C. Considering Beneficial Uses and Users When Establishing Sustainable Management Criteria and Analyzing Impacts on Beneficial Uses and Users

The consideration of beneficial uses and users when establishing sustainable management criteria (SMC) is **insufficient**. The consideration of potential impacts on all beneficial users of groundwater in the basin are required when defining undesirable results and establishing minimum thresholds.[8,9,10]

Disadvantaged Communities and Drinking Water Users

For chronic lowering of groundwater levels, the GSP mentions impacts on drinking water users when defining undesirable results. The GSP does not, however, analyze direct and indirect impacts on DACs, drinking water users, or tribes when defining undesirable results, or evaluate the cumulative or indirect impacts of proposed minimum thresholds on these stakeholders.

The GSP identifies constituents of concern (COCs) in the subbasin as arsenic, hexavalent chromium, nitrate, chloride, sodium, boron, selenium, conductivity, and total dissolved solids (TDS). The GSP states (3-15): "*The YSGA has not established specific sustainable management criteria for water quality in the Subbasin but will rely on current and future water quality standards established for drinking water and agricultural water uses by State and county regulatory agencies."* However, SMC should be established for constituents in the subbasin that may be impacted or exacerbated by groundwater use and/or management, in addition to coordinating with water quality regulatory programs.

The GSP only includes a very general discussion of impacts on drinking water users when defining undesirable results and evaluating the cumulative or indirect impacts of proposed minimum thresholds. The GSP does not, however, mention or discuss direct and indirect impacts on DACs, drinking water users, or tribes when defining undesirable results for degraded water quality, nor does it evaluate the cumulative or indirect impacts of proposed minimum thresholds on these stakeholders.

RECOMMENDATIONS

Chronic Lowering of Groundwater Levels

- Describe direct and indirect impacts on DACs, drinking water users, and tribes when describing undesirable results for chronic lowering of groundwater levels.
- Consider and evaluate the impacts of selected minimum thresholds and measurable objectives on DACs, drinking water users, and tribes within the subbasin. Further describe the impact of passing the minimum threshold for these users. For example, provide the number of domestic wells that would be de-watered at the minimum threshold.

[8] "The description of undesirable results shall include [...] potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results." [23 CCR §354.26(b)(3)]

[9] "The description of minimum thresholds shall include [...] how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests." [23 CCR §354.28(b)(4)]

[10] "The description of minimum thresholds shall include [...] how state, federal, or local standards relate to the relevant sustainability indicator. If the minimum threshold differs from other regulatory standards, the agency shall explain the nature of and the basis for the difference." [23 CCR §354.28(b)(5)]

Degraded Water Quality

- Establish SMC for the identified COCs in the subbasin that may be impacted or exacerbated by groundwater use and/or management. Ensure they align with drinking water standards.[11] Also, evaluate the cumulative or indirect impacts of proposed criteria for degraded water quality on DACs, drinking water users, and tribes.

- Describe direct and indirect impacts on DACs, drinking water users, and tribes when defining undesirable results for degraded water quality. For specific guidance on how to consider these users, refer to "Guide to Protecting Water Quality Under the Sustainable Groundwater Management Act."[12]

<u>Groundwater Dependent Ecosystems and Interconnected Surface Waters</u>

Sustainable management criteria for chronic lowering of groundwater levels provided in the GSP do not consider potential impacts to environmental beneficial users. The GSP neither describes nor analyzes direct or indirect impacts on environmental users of groundwater when defining undesirable results. This is problematic because without identifying potential impacts to GDEs, minimum thresholds may compromise, or even destroy, these environmental beneficial users. Since GDEs are present in the subbasin, they must be considered when developing SMC for chronic lowering of groundwater levels.

Sustainable management criteria for depletion of interconnected surface water are established by proxy using groundwater levels at shallow near-stream representative monitoring wells. However, no analysis or discussion is presented to describe how the SMC will affect GDEs, or the impact of these minimum thresholds on GDEs in the subbasin. Furthermore, the GSP makes no attempt to evaluate the impacts of the proposed minimum threshold on environmental beneficial users of surface water. The GSP does not explain how the chosen minimum thresholds and measurable objectives avoid significant and unreasonable effects on surface water beneficial users in the subbasin, such as increased mortality and inability to perform key life processes (e.g., reproduction, migration).

RECOMMENDATIONS

- When defining undesirable results for chronic lowering of groundwater levels, provide specifics on what biological responses (e.g., extent of habitat, growth, recruitment rates) would best characterize a significant and unreasonable impact to GDEs. Undesirable results to environmental users occur when 'significant and unreasonable' effects on beneficial users are caused by one of the sustainability indicators (i.e., chronic lowering of groundwater levels, degraded water quality, or depletion of interconnected surface water). Thus, potential impacts on environmental beneficial uses and users need to be considered when defining undesirable results in the

[11] "Degraded Water Quality [...] collect sufficient spatial and temporal data from each applicable principal aquifer to determine groundwater quality trends for water quality indicators, as determined by the Agency, to address known water quality issues." [23 CCR §354.34(c)(4)]
[12] Guide to Protecting Water Quality under the Sustainable Groundwater Management Act https://d3n8a8pro7vhmx.cloudfront.net/communitywatercenter/pages/293/attachments/original/1559328858/Guide_to_Protecting_Drinking_Water_Quality_Under_the_Sustainable_Groundwater_Management_Act.pdf?1559328858.

subbasin. Defining undesirable results is the crucial first step before the minimum thresholds can be determined.[13,14]

- When establishing SMC for the basin, consider that the SGMA statute [Water Code §10727.4(l)] specifically calls out that GSPs shall include "impacts on groundwater dependent ecosystems".

- When defining undesirable results for depletion of interconnected surface water, include a description of potential impacts on instream habitats within ISWs when minimum thresholds in the subbasin are reached.[15] The GSP should confirm that minimum thresholds for ISWs avoid adverse impacts to environmental beneficial users of interconnected surface waters as these environmental users could be left unprotected by the GSP. These recommendations apply especially to environmental beneficial users that are already protected under pre-existing state or federal law.[6,16]

2. Climate Change

The SGMA statute identifies climate change as a significant threat to groundwater resources and one that must be examined and incorporated in the GSPs. The GSP Regulations require integration of climate change into the projected water budget to ensure that projects and management actions sufficiently account for the range of potential climate futures.[17] The effects of climate change will intensify the impacts of water stress on GDEs, making available shallow groundwater resources more critical for their survival. Condon *et al.* (2020) shows that GDEs are more likely to succumb to water stress and rely more on groundwater during times of drought.[18] When shallow groundwater is unavailable, riparian forests can die off and key life processes (e.g., migration and spawning) for aquatic organisms, such as steelhead, can be impeded.

The integration of climate change into the projected water budget is **incomplete**. The GSP does incorporate climate change into the projected water budget using DWR change factors for 2030 and 2070 and considers multiple climate scenarios (e.g., the 2070 dry-extreme weather and 2070 wetter-moderate warming climate scenarios) in the projected water budget.

The GSP incorporates climate change into key inputs (e.g., precipitation and evapotranspiration) of the projected water budget. However, climate change was not incorporated into surface water flow inputs. Furthermore, the GSP does not calculate a sustainable yield based on the projected water budget with

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[13] "The description of undesirable results shall include [...] potential effects on the beneficial uses and users of groundwater, on land uses and property interests, and other potential effects that may occur or are occurring from undesirable results". [23 CCR §354.26(b)(3)]
[14] The description of minimum thresholds shall include [...] how minimum thresholds may affect the interests of beneficial uses and users of groundwater or land uses and property interests." [23 CCR §354.28(b)(4)]
[15] "The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results." [23 CCR §354.28(c)(6)]
[16] Rohde MM, Seapy B, Rogers R, Castañeda X, editors. 2019. Critical Species LookBook: A compendium of California's threatened and endangered species for sustainable groundwater management. The Nature Conservancy, San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/Critical_Species_LookBook_91819.pdf
[17] "Each Plan shall rely on the best available information and best available science to quantify the water budget for the basin in order to provide an understanding of historical and projected hydrology, water demand, water supply, land use, population, climate change, sea level rise, groundwater and surface water interaction, and subsurface groundwater flow." [23 CCR §354.18(e)]
[18] Condon et al. 2020. Evapotranspiration depletes groundwater under warming over the contiguous United States. Nature Communications. Available at: https://www.nature.com/articles/s41467-020-14688-0

climate change incorporated. If the water budgets are incomplete, including the omission of projected climate change effects on surface water flow inputs, and sustainable yield is not calculated based on climate change projections, then there is increased uncertainty in virtually every subsequent calculation used to plan for projects, derive measurable objectives, and set minimum thresholds. Plans that do not adequately include climate change projections may underestimate future impacts on vulnerable beneficial users of groundwater such as ecosystems, DACs, tribes, and domestic well owners.

RECOMMENDATIONS
• Incorporate climate change into surface water flow inputs for the projected water budget. • Calculate sustainable yield based on the projected water budget with climate change incorporated. • Incorporate climate change scenarios into projects and management actions.

3. Data Gaps

The consideration of beneficial users when establishing monitoring networks is **insufficient**, due to lack of specific plans to increase the Representative Monitoring Wells (RMWs) in the monitoring network that represent water quality conditions and shallow groundwater elevations around DACs, domestic wells, tribes, GDEs, and ISWs in the subbasin.

The GSP states (p. 4-11): "Rather than developing a new monitoring program, the YSGA will rely on existing programs to monitor water quality in the Subbasin." However, specific well names or locations are not provided for this monitoring network.

Figure 4-1 (Yolo Subbasin Groundwater Elevation Representative Monitoring Wells) shows that no groundwater elevation monitoring wells are located across portions of the subbasin near DACs, domestic wells, and tribes (see maps provided in Attachment E). Beneficial users of groundwater may remain unprotected by the GSP without adequate monitoring and identification of data gaps in the shallow aquifer. The Plan therefore fails to meet SGMA's requirements for the monitoring network.[19]

The GSP provides some discussion of data gaps for GDEs and ISWs in Sections 4.8.5 (Data Gaps) and Section 4.11.2.3 (Surface Water, Interconnected Surface Water, and Groundwater Dependent Ecosystem Monitoring Network), however does not provide specific plans, such as locations or a timeline, to fill the data gaps.

RECOMMENDATIONS
• Establish a monitoring network for the groundwater quality condition indicator. • Provide maps that overlay current and proposed monitoring well locations with the locations of DACs, domestic wells, tribes, GDEs, and ISWs to clearly identify potentially impacted areas. Increase the number of RMWs in the shallow aquifer across the subbasin as needed to adequately monitor all groundwater condition

[19] "The monitoring network objectives shall be implemented to accomplish the following: [...] (2) Monitor impacts to the beneficial uses or users of groundwater." [23 CCR §354.34(b)(2)]

- indicators. Prioritize proximity to DACs, domestic wells, tribes, and GDEs when identifying new RMWs.
- Further describe the biological monitoring that can be used to assess the potential for significant and unreasonable impacts to GDEs or ISWs due to groundwater conditions in the subbasin.

4. Addressing Beneficial Users in Projects and Management Actions

The consideration of beneficial users when developing projects and management actions is **insufficient**, due to the failure to completely identify benefits or impacts of identified projects and management actions to key beneficial users of groundwater such as GDEs, aquatic habitats, surface water users, DACs, drinking water users, and tribes. Therefore, potential project and management actions may not protect these beneficial users. Groundwater sustainability under SGMA is defined not just by sustainable yield, but by the avoidance of undesirable results for *all* beneficial users.

RECOMMENDATIONS

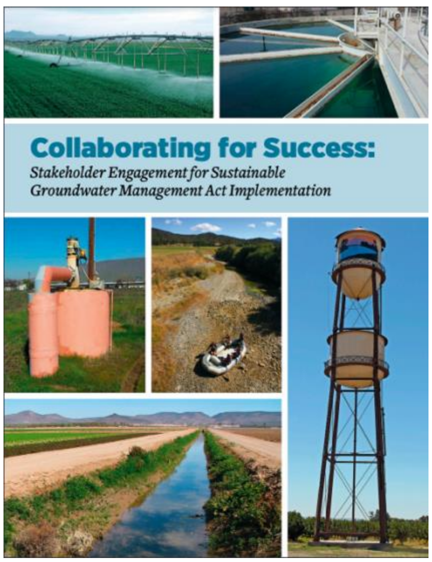
- For DACs and domestic well owners, include a drinking water well impact mitigation program to proactively monitor and protect drinking water wells through GSP implementation. Refer to Attachment B for specific recommendations on how to implement a drinking water well mitigation program. The GSP includes a brief discussion of a domestic well Impact mitigation program in Table 5-1, but very few details are provided.
- For DACs and domestic well owners, include a discussion of whether potential impacts to water quality from projects and management actions could occur and how the GSA plans to mitigate such impacts.
- Recharge ponds, reservoirs, and facilities for managed aquifer recharge can be designed as multiple-benefit projects to include elements that act functionally as wetlands and provide a benefit for wildlife and aquatic species. The GSP mentions creation of seasonal wetlands in Table 5-1 under the 'Groundwater Recharge and Managed Aquifer Recharge Projects'. For further guidance on how to integrate multi-benefit recharge projects into your GSP, refer to the "Multi-Benefit Recharge Project Methodology Guidance Document."[20]
- Develop management actions that incorporate climate and water delivery uncertainties to address future water demand and prevent future undesirable results.

[20] The Nature Conservancy. 2021. Multi-Benefit Recharge Project Methodology for Inclusion in Groundwater Sustainability Plans. Sacramento. Available at: https://groundwaterresourcehub.org/sgma-tools/multi-benefit-recharge-project-methodology-guidance/

Attachment B

SGMA Tools to address DAC, drinking water, and environmental beneficial uses and users

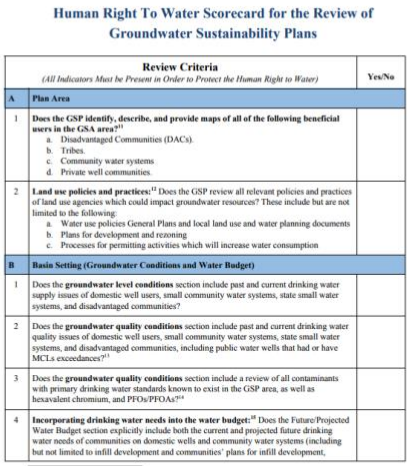
Stakeholder Engagement and Outreach



Clean Water Action, Community Water Center and Union of Concerned Scientists developed a guidance document called Collaborating for success: Stakeholder engagement for Sustainable Groundwater Management Act Implementation. It provides details on how to conduct targeted and broad outreach and engagement during Groundwater Sustainability Plan (GSP) development and implementation. Conducting a targeted outreach involves:

- Developing a robust Stakeholder Communication and Engagement plan that includes outreach at frequented locations (schools, farmers markets, religious settings, events) across the plan area to increase the involvement and participation of disadvantaged communities, drinking water users and the environmental stakeholders.
- Providing translation services during meetings and technical assistance to enable easy participation for non-English speaking stakeholders.
- GSP should adequately describe the process for requesting input from beneficial users and provide details on how input is incorporated into the GSP.

The Human Right to Water

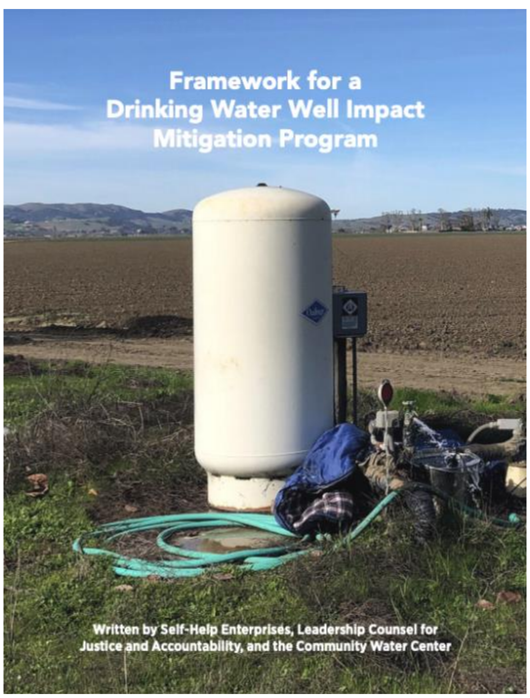


Human Right To Water Scorecard for the Review of Groundwater Sustainability Plans

	Review Criteria *(All Indicators Must be Present in Order to Protect the Human Right to Water)*	**Yes/No**
A	**Plan Area**	
1	**Does the GSP identify, describe, and provide maps of all of the following beneficial users in the GSA area?**[11] a. Disadvantaged Communities (DACs). b. Tribes. c. Community water systems d. Private well communities.	
2	**Land use policies and practices:**[12] Does the GSP review all relevant policies and practices of land use agencies which could impact groundwater resources? These include but are not limited to the following: a. Water use policies General Plans and local land use and water planning documents b. Plans for development and rezoning c. Processes for permitting activities which will increase water consumption	
B	**Basin Setting (Groundwater Conditions and Water Budget)**	
1	Does the **groundwater level conditions** section include past and current drinking water supply issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities?	
2	Does the **groundwater quality conditions** section include past and current drinking water quality issues of domestic well users, small community water systems, state small water systems, and disadvantaged communities, including public water wells that had or have MCLs exceedances?[13]	
3	Does the **groundwater quality conditions** section include a review of all contaminants with primary drinking water standards known to exist in the GSP area, as well as hexavalent chromium, and PFOs/PFOAs?[14]	
4	**Incorporating drinking water needs into the water budget:**[15] Does the Future/Projected Water Budget section explicitly include both the current and projected future drinking water needs of communities on domestic wells and community water systems (including but not limited to infill development and communities' plans for infill development,	

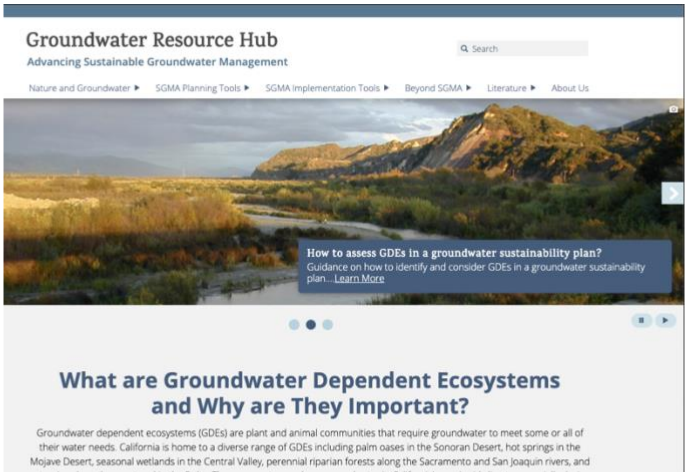
The Human Right to Water Scorecard was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid Groundwater Sustainability Agencies (GSAs) in prioritizing drinking water needs in SGMA. The scorecard identifies elements that must exist in GSPs to adequately protect the Human Right to Drinking water.

Drinking Water Well Impact Mitigation Framework



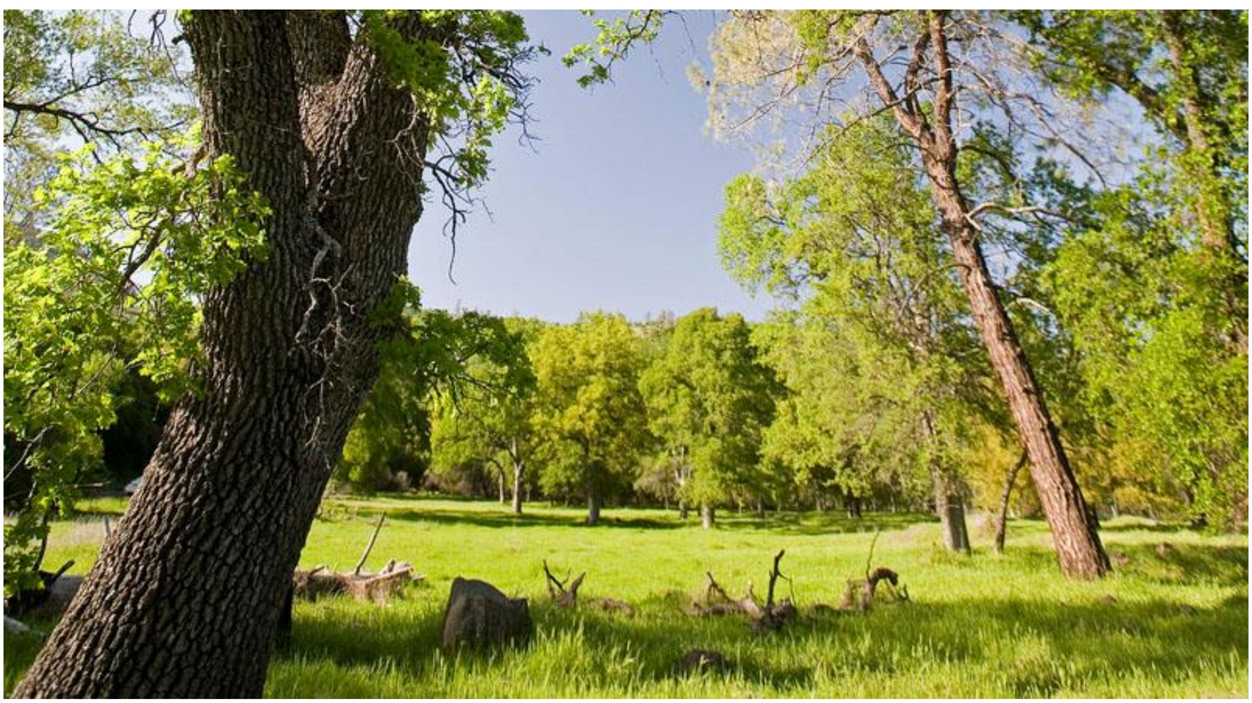
The Drinking Water Well Impact Mitigation Framework was developed by Community Water Center, Leadership Counsel for Justice and Accountability and Self Help Enterprises to aid GSAs in the development and implementation of their GSPs. The framework provides a clear roadmap for how a GSA can best structure its data gathering, monitoring network and management actions to proactively monitor and protect drinking water wells and mitigate impacts should they occur.

Groundwater Resource Hub



The Nature Conservancy has developed a suite of tools based on best available science to help GSAs, consultants, and stakeholders efficiently incorporate nature into GSPs. These tools and resources are available online at GroundwaterResourceHub.org. The Nature Conservancy's tools and resources are intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Rooting Depth Database



The Plant Rooting Depth Database provides information that can help assess whether groundwater-dependent vegetation are accessing groundwater. Actual rooting depths will depend on the plant species and site-specific conditions, such as soil type and availability of other water sources. Site-specific knowledge of depth to groundwater combined with rooting depths will help provide an understanding of the potential groundwater levels are needed to sustain GDEs.

How to use the database

The maximum rooting depth information in the Plant Rooting Depth Database is useful when verifying whether vegetation in the Natural Communities Commonly Associated with Groundwater (NC Dataset) are connected to groundwater. A 30 ft depth-to-groundwater threshold, which is based on averaged global rooting depth data for phreatophytes[1], is relevant for most plants identified in the NC Dataset since most plants have a max rooting depth of less than 30 feet. However, it is important to note that deeper thresholds are necessary for other plants that have reported maximum root depths that exceed the averaged 30 feet threshold, such as valley oak (*Quercus lobata*), Euphrates poplar (*Populus euphratica*), salt cedar (*Tamarix spp.*), and shadescale (*Atriplex confertifolia*). The Nature Conservancy advises that the reported max rooting depth for these deeper-rooted plants be used. For example, a depth-to groundwater threshold of 80 feet should be used instead of the 30 ft threshold, when verifying whether valley oak polygons from the NC Dataset are connected to groundwater. It is important to re-emphasize that actual rooting depth data are limited and will depend on the plant species and site-specific conditions such as soil and aquifer types, and availability to other water sources.

The Plant Rooting Depth Database is an Excel workbook composed of four worksheets:

1. California phreatophyte rooting depth data (included in the NC Dataset)
2. Global phreatophyte rooting depth data
3. Metadata
4. References

How the database was compiled

The Plant Rooting Depth Database is a compilation of rooting depth information for the groundwater-dependent plant species identified in the NC Dataset. Rooting depth data were compiled from published scientific literature and expert opinion through a crowdsourcing campaign. As more information becomes available, the database of rooting depths will be updated. Please Contact Us if you have additional rooting depth data for California phreatophytes.

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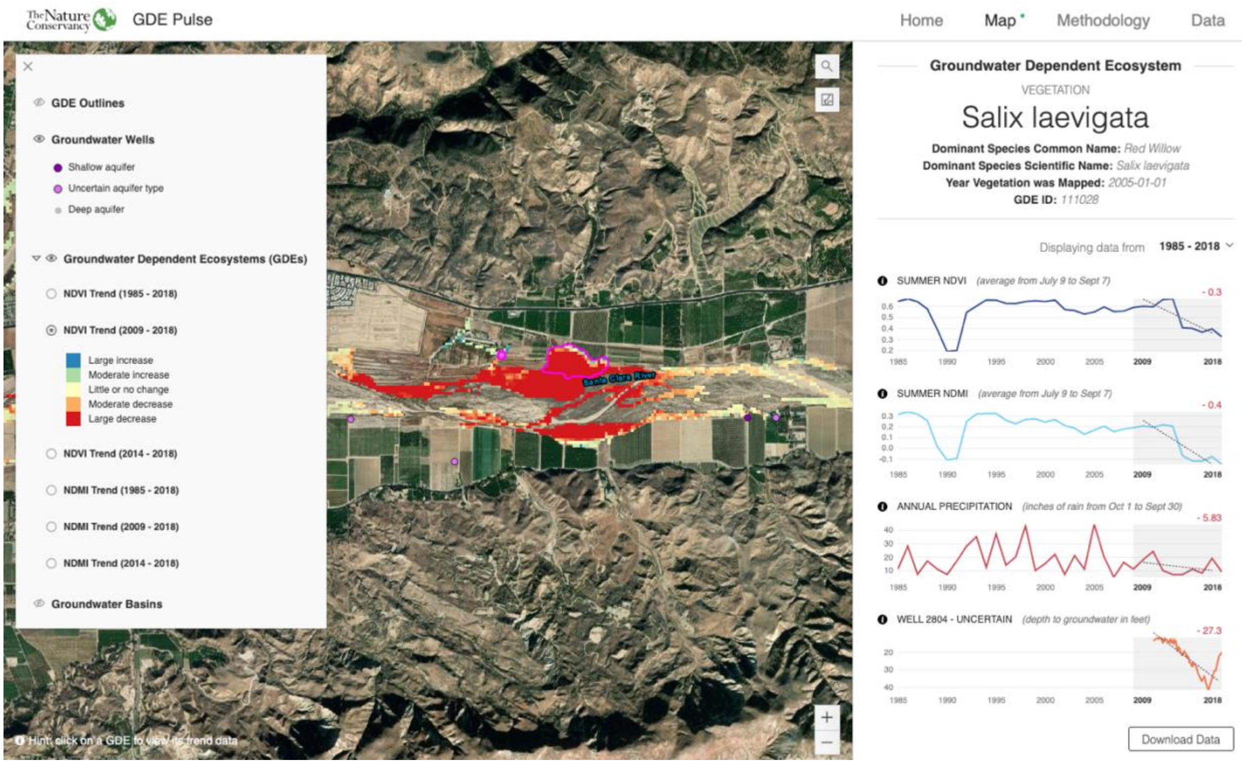
[1] Canadell, J., Jackson, R.B., Ehleringer, J.B. et al. 1996. Maximum rooting depth of vegetation types at the global scale. Oecologia 108, 583–595. https://doi.org/10.1007/BF00329030

GDE Pulse



[GDE Pulse](#) is a free online tool that allows Groundwater Sustainability Agencies to assess changes in groundwater dependent ecosystem (GDE) health using satellite, rainfall, and groundwater data. Remote sensing data from satellites has been used to monitor the health of vegetation all over the planet. GDE pulse has compiled 35 years of satellite imagery from NASA's Landsat mission for every polygon in the Natural Communities Commonly Associated with Groundwater Dataset. The following datasets are available for downloading:

Normalized Difference Vegetation Index (NDVI) is a satellite-derived index that represents the greenness of vegetation. Healthy green vegetation tends to have a higher NDVI, while dead leaves have a lower NDVI. We calculated the average NDVI during the driest part of the year (July - Sept) to estimate vegetation health when the plants are most likely dependent on groundwater.

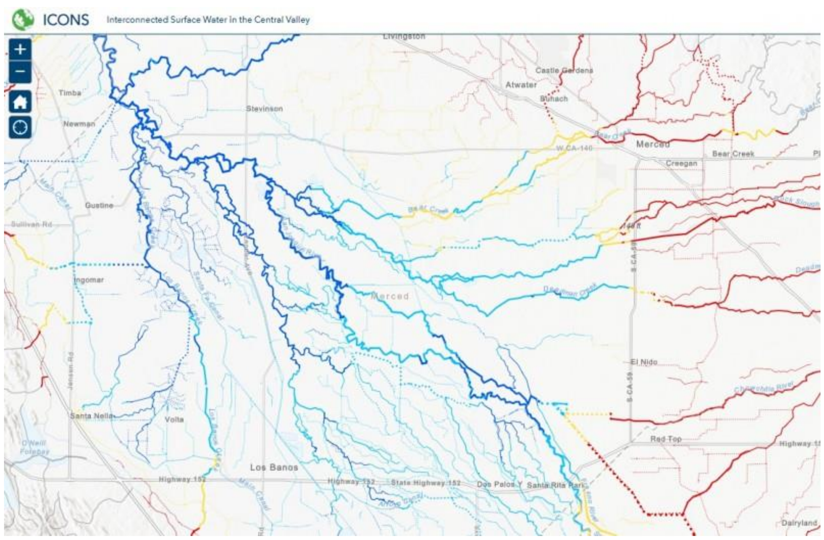
Normalized Difference Moisture Index (NDMI) is a satellite-derived index that represents water content in vegetation. NDMI is derived from the Near-Infrared (NIR) and Short-Wave Infrared (SWIR) channels. Vegetation with adequate access to water tends to have higher NDMI, while vegetation that is water stressed tends to have lower NDMI. We calculated the average NDVI during the driest part of the year (July–September) to estimate vegetation health when the plants are most likely dependent on groundwater.

Annual Precipitation is the total precipitation for the water year (October 1st – September 30th) from the PRISM dataset. The amount of local precipitation can affect vegetation with more precipitation generally leading to higher NDVI and NDMI.

Depth to Groundwater measurements provide an indication of the groundwater levels and changes over time for the surrounding area. We used groundwater well measurements from nearby (<1km) wells to estimate the depth to groundwater below the GDE based on the average elevation of the GDE (using a digital elevation model) minus the measured groundwater surface elevation.

ICONOS Mapper

Interconnected Surface Water in the Central Valley



[ICONS](#) maps the likely presence of interconnected surface water (ISW) in the Central Valley using depth to groundwater data. Using data from 2011-2018, the ISW dataset represents the likely connection between surface water and groundwater for rivers and streams in California's Central Valley. It includes information on the mean, maximum, and minimum depth to groundwater for each stream segment over the years with available data, as well as the likely presence of ISW based on the minimum depth to groundwater. The Nature Conservancy developed this database, with guidance and input from expert academics, consultants, and state agencies.

We developed this dataset using groundwater elevation data [available online](#) from the California Department of Water Resources (DWR). DWR only provides this data for the Central Valley. For GSAs outside of the valley, who have groundwater well measurements, we recommend following our methods to determine likely ISW in your region. The Nature Conservancy's ISW dataset should be used as a first step in reviewing ISW and should be supplemented with local or more recent groundwater depth data.

Attachment C

Freshwater Species Located in the Yolo Basin

To assist in identifying the beneficial users of surface water necessary to assess the undesirable result "depletion of interconnected surface waters", Attachment C provides a list of freshwater species located in the Yolo Basin. To produce the freshwater species list, we used ArcGIS to select features within the California Freshwater Species Database version 2.0.9 within the basin boundary. This database contains information on ~4,000 vertebrates, macroinvertebrates and vascular plants that depend on fresh water for at least one stage of their life cycle. The methods used to compile the California Freshwater Species Database can be found in Howard et al. 2015[1]. The spatial database contains locality observations and/or distribution information from ~400 data sources. The database is housed in the California Department of Fish and Wildlife's BIOS[2] as well as on The Nature Conservancy's science website[3].

Scientific Name	Common Name	Legal Protected Status		
		Federal	State	Other
BIRDS				
Actitis macularius	Spotted Sandpiper			
Aechmophorus clarkii	Clark's Grebe			
Aechmophorus occidentalis	Western Grebe			
Agelaius tricolor	Tricolored Blackbird	Bird of Conservation Concern	Special Concern	BSSC - First priority
Aix sponsa	Wood Duck			
Anas acuta	Northern Pintail			
Anas americana	American Wigeon			
Anas clypeata	Northern Shoveler			
Anas crecca	Green-winged Teal			
Anas cyanoptera	Cinnamon Teal			
Anas discors	Blue-winged Teal			
Anas platyrhynchos	Mallard			
Anas strepera	Gadwall			
Anser albifrons	Greater White-fronted Goose			
Ardea alba	Great Egret			
Ardea herodias	Great Blue Heron			
Aythya affinis	Lesser Scaup			
Aythya americana	Redhead		Special Concern	BSSC - Third priority

[1] Howard, J.K. et al. 2015. Patterns of Freshwater Species Richness, Endemism, and Vulnerability in California. PLoSONE, 11(7). Available at: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0130710

[2] California Department of Fish and Wildlife BIOS: https://www.wildlife.ca.gov/data/BIOS

[3] Science for Conservation: https://www.scienceforconservation.org/products/california-freshwater-species-database

Aythya collaris	Ring-necked Duck			
Aythya marila	Greater Scaup			
Aythya valisineria	Canvasback		Special	
Botaurus lentiginosus	American Bittern			
Bucephala albeola	Bufflehead			
Bucephala clangula	Common Goldeneye			
Butorides virescens	Green Heron			
Calidris alpina	Dunlin			
Calidris mauri	Western Sandpiper			
Calidris minutilla	Least Sandpiper			
Chen caerulescens	Snow Goose			
Chen rossii	Ross's Goose			
Chlidonias niger	Black Tern		Special Concern	BSSC - Second priority
Chroicocephalus philadelphia	Bonaparte's Gull			
Cinclus mexicanus	American Dipper			
Cistothorus palustris palustris	Marsh Wren			
Coccyzus americanus occidentalis	Western Yellow-billed Cuckoo	Candidate - Threatened	Endangered	
Cygnus columbianus	Tundra Swan			
Egretta thula	Snowy Egret			
Empidonax traillii	Willow Flycatcher	Bird of Conservation Concern	Endangered	
Fulica americana	American Coot			
Gallinago delicata	Wilson's Snipe			
Gallinula chloropus	Common Moorhen			
Grus canadensis	Sandhill Crane			
Haliaeetus leucocephalus	Bald Eagle	Bird of Conservation Concern	Endangered	
Himantopus mexicanus	Black-necked Stilt			
Icteria virens	Yellow-breasted Chat		Special Concern	BSSC - Third priority
Ixobrychus exilis hesperis	Western Least Bittern		Special Concern	BSSC - Second priority
Limnodromus scolopaceus	Long-billed Dowitcher			
Lophodytes cucullatus	Hooded Merganser			
Megaceryle alcyon	Belted Kingfisher			
Mergus merganser	Common Merganser			
Mergus serrator	Red-breasted Merganser			
Numenius americanus	Long-billed Curlew			
Numenius phaeopus	Whimbrel			

Nycticorax nycticorax	Black-crowned Night-Heron			
Oxyura jamaicensis	Ruddy Duck			
Pelecanus erythrorhynchos	American White Pelican		Special Concern	BSSC - First priority
Phalacrocorax auritus	Double-crested Cormorant			
Phalaropus tricolor	Wilson's Phalarope			
Piranga rubra	Summer Tanager		Special Concern	BSSC - First priority
Plegadis chihi	White-faced Ibis		Watch list	
Pluvialis squatarola	Black-bellied Plover			
Podiceps nigricollis	Eared Grebe			
Podilymbus podiceps	Pied-billed Grebe			
Porzana carolina	Sora			
Rallus limicola	Virginia Rail			
Recurvirostra americana	American Avocet			
Riparia riparia	Bank Swallow		Threatened	
Setophaga petechia	Yellow Warbler			BSSC - Second priority
Tachycineta bicolor	Tree Swallow			
Tringa melanoleuca	Greater Yellowlegs			
Tringa semipalmata	Willet			
Tringa solitaria	Solitary Sandpiper			
Vireo bellii	Bell's Vireo			
Vireo bellii pusillus	Least Bell's Vireo	Endangered	Endangered	
Xanthocephalus xanthocephalus	Yellow-headed Blackbird		Special Concern	BSSC - Third priority
CRUSTACEANS				
Branchinecta conservatio	Conservancy Fairy Shrimp	Endangered	Special	IUCN - Endangered
Branchinecta lynchi	Vernal Pool Fairy Shrimp	Threatened	Special	IUCN - Vulnerable
Branchinecta mesovallensis	Midvalley Fairy Shrimp		Special	
Hyalella spp.	Hyalella spp.			
Lepidurus packardi	Vernal Pool Tadpole Shrimp	Endangered	Special	IUCN - Endangered
Linderiella occidentalis	California Fairy Shrimp		Special	IUCN - Near Threatened
Stygobromus spp.	Stygobromus spp.			
FISH				
Acipenser medirostris ssp. 1	Southern green sturgeon	Threatened	Special Concern	Endangered - Moyle 2013
Oncorhynchus mykiss - CV	Central Valley steelhead	Threatened	Special	Vulnerable - Moyle 2013

Oncorhynchus mykiss irideus	Coastal rainbow trout			Least Concern - Moyle 2013
Oncorhynchus tshawytscha - CV spring	Central Valley spring Chinook salmon	Threatened	Threatened	Vulnerable - Moyle 2013
Oncorhynchus tshawytscha - CV winter	Central Valley winter Chinook salmon	Endangered	Endangered	Vulnerable - Moyle 2013
Pogonichthys macrolepidotus	Sacramento splittail		Special Concern	Vulnerable - Moyle 2013
Spirinchus thaleichthys	Longfin smelt	Candidate	Threatened	Vulnerable - Moyle 2013
HERPS				
Actinemys marmorata marmorata	Western Pond Turtle		Special Concern	ARSSC
Ambystoma californiense californiense	California Tiger Salamander	Threatened	Threatened	ARSSC
Anaxyrus boreas boreas	Boreal Toad			
Anaxyrus boreas halophilus	California Toad			ARSSC
Dicamptodon ensatus	California Giant Salamander			ARSSC
Pseudacris regilla	Northern Pacific Chorus Frog			
Rana boylii	Foothill Yellow-legged Frog	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Rana draytonii	California Red-legged Frog	Threatened	Special Concern	ARSSC
Spea hammondii	Western Spadefoot	Under Review in the Candidate or Petition Process	Special Concern	ARSSC
Taricha torosa	Coast Range Newt		Special Concern	ARSSC
Thamnophis gigas	Giant Gartersnake	Threatened	Threatened	
Thamnophis sirtalis fitchi	Valley Gartersnake			Not on any status lists
Thamnophis sirtalis sirtalis	Common Gartersnake			
INSECTS & OTHER INVERTS				
Ablabesmyia spp.	Ablabesmyia spp.			
Aeshna interrupta interna				
Aeshnidae fam.	Aeshnidae fam.			
Ambrysus spp.	Ambrysus spp.			
Ameletus imbellis	A Mayfly			
Anax junius	Common Green Darner			
Anax walsinghami	Giant Green Darner			

Archilestes californica	California Spreadwing			
Argia emma	Emma's Dancer			
Argia lugens	Sooty Dancer			
Argia vivida	Vivid Dancer			
Caenis spp.	Caenis spp.			
Callibaetis fluctuans	A Mayfly			
Callibaetis spp.	Callibaetis spp.			
Centroptilum spp.	Centroptilum spp.			
Chironomidae fam.	Chironomidae fam.			
Chironomus spp.	Chironomus spp.			
Cladotanytarsus spp.	Cladotanytarsus spp.			
Coenagrionidae fam.	Coenagrionidae fam.			
Corixidae fam.	Corixidae fam.			
Cricotopus spp.	Cricotopus spp.			
Cryptochironomus spp.	Cryptochironomus spp.			
Dicrotendipes spp.	Dicrotendipes spp.			
Dubiraphia spp.	Dubiraphia spp.			
Enallagma carunculatum	Tule Bluet			
Enallagma civile	Familiar Bluet			
Erpetogomphus compositus	White-belted Ringtail			
Erythemis collocata	Western Pondhawk			
Fallceon quilleri	A Mayfly			
Glyptotendipes spp.	Glyptotendipes spp.			
Gomphus kurilis	Pacific Clubtail			
Gyrinus affinis				Not on any status lists
Helicopsyche spp.	Helicopsyche spp.			
Hetaerina americana	American Rubyspot			
Hydropsyche spp.	Hydropsyche spp.			
Ischnura cervula	Pacific Forktail			
Ischnura denticollis	Black-fronted Forktail			
Ischnura perparva	Western Forktail			
Labrundinia spp.	Labrundinia spp.			
Libellula forensis	Eight-spotted Skimmer			
Libellula luctuosa	Widow Skimmer			
Libellula pulchella	Twelve-spotted Skimmer			
Libellula saturata	Flame Skimmer			
Microchironomus spp.	Microchironomus spp.			
Microvelia spp.	Microvelia spp.			
Mideopsis spp.	Mideopsis spp.			
Nectopsyche spp.	Nectopsyche spp.			
Neoclypeodytes spp.	Neoclypeodytes spp.			

Ochthebius spp.	Ochthebius spp.			
Octogomphus specularis	Grappletail			
Oecetis spp.	Oecetis spp.			
Pachydiplax longipennis	Blue Dasher			
Pantala flavescens	Wandering Glider			
Pantala hymenaea	Spot-winged Glider			
Paraleptophlebia cachea	A Mayfly			
Paratanytarsus spp.	Paratanytarsus spp.			
Pentaneura spp.	Pentaneura spp.			
Plathemis lydia	Common Whitetail			
Polypedilum spp.	Polypedilum spp.			
Procladius spp.	Procladius spp.			
Progomphus borealis	Gray Sanddragon			
Rhagovelia distincta				Not on any status lists
Rheotanytarsus spp.	Rheotanytarsus spp.			
Rhionaeschna multicolor	Blue-eyed Darner			
Sperchon spp.	Sperchon spp.			
Sympetrum corruptum	Variegated Meadowhawk			
Tanytarsus spp.	Tanytarsus spp.			
Tramea lacerata	Black Saddlebags			
Tricorythodes spp.	Tricorythodes spp.			
Zoniagrion exclamationis	Exclamation Damsel			
MAMMALS				
Castor canadensis	American Beaver			Not on any status lists
Lontra canadensis canadensis	North American River Otter			Not on any status lists
Neovison vison	American Mink			Not on any status lists
Ondatra zibethicus	Common Muskrat			Not on any status lists
MOLLUSKS				
Anodonta californiensis	California Floater		Special	
Ferrissia spp.	Ferrissia spp.			
Gonidea angulata	Western Ridged Mussel		Special	
Gyraulus spp.	Gyraulus spp.			
Margaritifera falcata	Western Pearlshell		Special	
Physa spp.	Physa spp.			
PLANTS				
Alnus rhombifolia	White Alder			
Alopecurus carolinianus	Tufted Foxtail			
Alopecurus saccatus	Pacific Foxtail			

Arundo donax	NA			
Baccharis salicina				Not on any status lists
Bolboschoenus fluviatilis				Not on any status lists
Bolboschoenus glaucus	NA			Not on any status lists
Bolboschoenus maritimus paludosus	NA			Not on any status lists
Callitriche longipedunculata	Longstock Water-starwort			
Callitriche marginata	Winged Water-starwort			
Carex nudata	Torrent Sedge			
Cephalanthus occidentalis	Common Buttonbush			
Chloropyron palmatum	NA	Endangered	Special	CRPR - 1B.1
Cotula coronopifolia	NA			
Crassula aquatica	Water Pygmyweed			
Crypsis vaginiflora	NA			
Cyperus erythrorhizos	Red-root Flatsedge			
Damasonium californicum				Not on any status lists
Downingia insignis	Parti-color Downingia			
Downingia ornatissima	NA			
Downingia pulchella	Flat-face Downingia			
Elatine californica	California Waterwort			
Elatine rubella	Southwestern Waterwort			
Eleocharis acicularis acicularis	Least Spikerush			
Eleocharis macrostachya	Creeping Spikerush			
Elodea canadensis	Broad Waterweed			
Epilobium campestre	NA			Not on any status lists
Epilobium cleistogamum	Cleistogamous Spike-primrose			
Eryngium aristulatum aristulatum	California Eryngo			
Eryngium castrense	Great Valley Eryngo			
Eryngium jepsonii	NA			Not on any status lists
Eryngium vaseyi vaseyi	Vasey's Coyote-thistle			Not on any status lists
Euthamia occidentalis	Western Fragrant Goldenrod			
Helenium puberulum	Rosilla			
Hibiscus lasiocarpos occidentalis			Special	CRPR - 1B.2
Juncus uncialis	Inch-high Rush			

Lasthenia fremontii	Fremont's Goldfields			
Leersia oryzoides	Rice Cutgrass			
Lemna minor	Lesser Duckweed			
Lemna minuta	Least Duckweed			
Lilaeopsis masonii	Mason's Lilaeopsis		Special	CRPR - 1B.1
Limnanthes douglasii rosea	Douglas' Meadowfoam			
Limosella acaulis	Southern Mudwort			
Ludwigia hexapetala	NA			Not on any status lists
Ludwigia peploides montevidensis	NA			Not on any status lists
Ludwigia peploides peploides	NA			Not on any status lists
Lythrum californicum	California Loosestrife			
Marsilea vestita vestita	NA			Not on any status lists
Mimulus latidens	Broad-tooth Monkeyflower			
Mimulus pilosus				Not on any status lists
Mimulus tricolor	Tricolor Monkeyflower			
Myosurus minimus	NA			
Myosurus sessilis	Sessile Mousetail			
Myriophyllum aquaticum	NA			
Navarretia cotulifolia	Cotula Navarretia			
Navarretia heterandra	Tehama Navarretia			
Navarretia leucocephala bakeri	Baker's Navarretia		Special	CRPR - 1B.1
Navarretia leucocephala leucocephala	White-flower Navarretia			
Neostapfia colusana	Colusa Grass	Threatened	Endangered	CRPR - 1B.1
Paspalum distichum	Joint Paspalum			
Perideridia kelloggii	Kellogg's Yampah			
Persicaria lapathifolia				Not on any status lists
Persicaria maculosa	NA			Not on any status lists
Persicaria punctata	NA			Not on any status lists
Phyla nodiflora	Common Frog-fruit			
Pilularia americana	NA			
Plagiobothrys humistratus	Dwarf Popcorn-flower			
Plagiobothrys leptocladus	Alkali Popcorn-flower			
Plantago elongata elongata	Slender Plantain			
Pleuropogon californicus californicus				Not on any status lists

Pogogyne douglasii	NA			
Pogogyne zizyphoroides				Not on any status lists
Psilocarphus brevissimus brevissimus	Dwarf Woolly-heads			
Psilocarphus oregonus	Oregon Woolly-heads			
Psilocarphus tenellus	NA			
Puccinellia simplex	Little Alkali Grass			
Rorippa curvisiliqua curvisiliqua	Curve-pod Yellowcress			
Rumex conglomeratus	NA			
Rumex stenophyllus	NA			
Rumex transitorius				Not on any status lists
Salix babylonica	NA			
Salix exigua exigua	Narrowleaf Willow			
Salix exigua hindsiana				Not on any status lists
Salix gooddingii	Goodding's Willow			
Salix laevigata	Polished Willow			
Salix lasiandra lasiandra				Not on any status lists
Salix lasiolepis lasiolepis	Arroyo Willow			
Salix melanopsis	Dusky Willow			
Schoenoplectus acutus occidentalis	Hardstem Bulrush			
Schoenoplectus americanus	Three-square Bulrush			
Schoenoplectus pungens longispicatus	Three-square Bulrush			
Schoenoplectus pungens pungens	NA			
Scirpus microcarpus	Small-fruit Bulrush			
Sinapis alba	NA			
Stachys ajugoides	Bugle Hedge-nettle			
Stachys stricta	Sonoma Hedge-nettle			
Symphyotrichum lentum	Suisun Marsh Aster		Special	CRPR - 1B.2
Tuctoria mucronata	Mucronate Orcutt Grass	Endangered	Endangered	CRPR - 1B.1
Veronica anagallis-aquatica	NA			

Attachment D

The Nature Conservancy

July 2019

IDENTIFYING GDEs UNDER SGMA

Best Practices for using the NC Dataset

The Sustainable Groundwater Management Act (SGMA) requires that groundwater dependent ecosystems (GDEs) be identified in Groundwater Sustainability Plans (GSPs). As a starting point, the Department of Water Resources (DWR) is providing the Natural Communities Commonly Associated with Groundwater Dataset (NC Dataset) online[1] to help Groundwater Sustainability Agencies (GSAs), consultants, and stakeholders identify GDEs within individual groundwater basins. To apply information from the NC Dataset to local areas, GSAs should combine it with the best available science on local hydrology, geology, and groundwater levels to verify whether polygons in the NC dataset are likely supported by groundwater in an aquifer (Figure 1)[2]. This document highlights six best practices for using local groundwater data to confirm whether mapped features in the NC dataset are supported by groundwater.

Figure 1. Considerations for GDE identification.
Source: DWR[2]

[1] NC Dataset Online Viewer: https://gis.water.ca.gov/app/NCDatasetViewer/

[2] California Department of Water Resources (DWR). 2018. Summary of the "Natural Communities Commonly Associated with Groundwater" Dataset and Online Web Viewer. Available at: https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Statewide-Reports/Natural-Communities-Dataset-Summary-Document.pdf

The NC Dataset identifies vegetation and wetland features that are good indicators of a GDE. The dataset is comprised of 48 publicly available state and federal datasets that map vegetation, wetlands, springs, and seeps commonly associated with groundwater in California[3]. It was developed through a collaboration between DWR, the Department of Fish and Wildlife, and The Nature Conservancy (TNC). TNC has also provided detailed guidance on identifying GDEs from the NC dataset[4] on the Groundwater Resource Hub[5], a website dedicated to GDEs.

BEST PRACTICE #1. Establishing a Connection to Groundwater

Groundwater basins can be comprised of one continuous aquifer (Figure 2a) or multiple aquifers stacked on top of each other (Figure 2b). In unconfined aquifers (Figure 2a), using the depth-to-groundwater and the rooting depth of the vegetation is a reasonable method to infer groundwater dependence for GDEs. If groundwater is well below the rooting (and capillary) zone of the plants and any wetland features, the ecosystem is considered disconnected and groundwater management is not likely to affect the ecosystem (Figure 2d). However, it is important to consider local conditions (e.g., soil type, groundwater flow gradients, and aquifer parameters) and to review groundwater depth data from multiple seasons and water year types (wet and dry) because intermittent periods of high groundwater levels can replenish perched clay lenses that serve as the water source for GDEs (Figure 2c). Maintaining these natural groundwater fluctuations are important to sustaining GDE health.

Basins with a stacked series of aquifers (Figure 2b) may have varying levels of pumping across aquifers in the basin, depending on the production capacity or water quality associated with each aquifer. If pumping is concentrated in deeper aquifers, SGMA still requires GSAs to sustainably manage groundwater resources in shallow aquifers, such as perched aquifers, that support springs, surface water, domestic wells, and GDEs (Figure 2). This is because vertical groundwater gradients across aquifers may result in pumping from deeper aquifers to cause adverse impacts onto beneficial users reliant on shallow aquifers or interconnected surface water. The goal of SGMA is to sustainably manage groundwater resources for current and future social, economic, and environmental benefits. While groundwater pumping may not be currently occurring in a shallower aquifer, use of this water may become more appealing and economically viable in future years as pumping restrictions are placed on the deeper production aquifers in the basin to meet the sustainable yield and criteria. Thus, identifying GDEs in the basin should done irrespective to the amount of current pumping occurring in a particular aquifer, so that future impacts on GDEs due to new production can be avoided. A good rule of thumb to follow is: *if groundwater can be pumped from a well - it's an aquifer*.

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[3] For more details on the mapping methods, refer to: Klausmeyer, K., J. Howard, T. Keeler-Wolf, K. Davis-Fadtke, R. Hull, A. Lyons. 2018. Mapping Indicators of Groundwater Dependent Ecosystems in California: Methods Report. San Francisco, California. Available at: https://groundwaterresourcehub.org/public/uploads/pdfs/iGDE_data_paper_20180423.pdf

[4] "Groundwater Dependent Ecosystems under the Sustainable Groundwater Management Act: Guidance for Preparing Groundwater Sustainability Plans" is available at: https://groundwaterresourcehub.org/gde-tools/gsp-guidance-document/

[5] The Groundwater Resource Hub: www.GroundwaterResourceHub.org

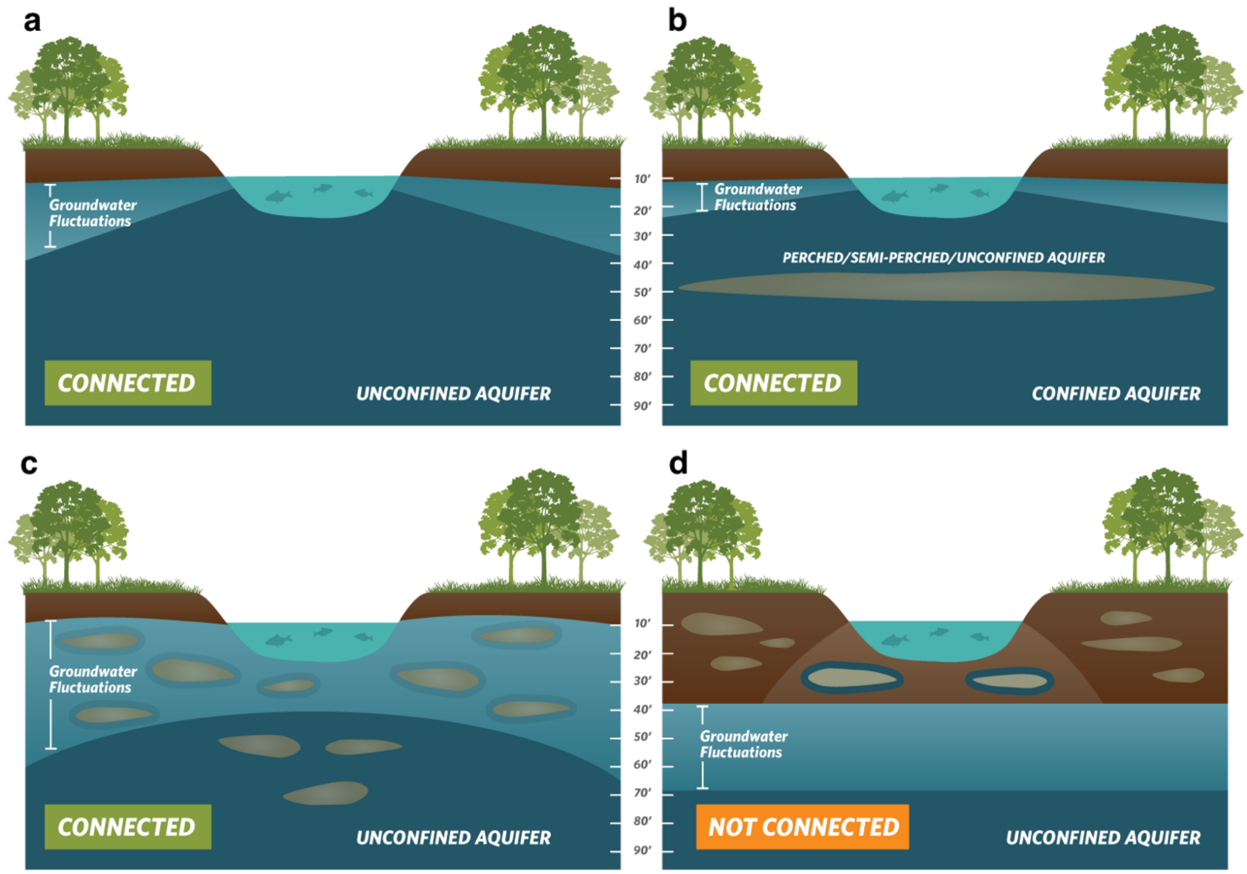

Figure 2. Confirming whether an ecosystem is connected to groundwater. Top: (a) Under the ecosystem is an unconfined aquifer with depth-to-groundwater fluctuating seasonally and interannually within 30 feet from land surface. **(b)** Depth-to-groundwater in the shallow aquifer is connected to overlying ecosystem. Pumping predominately occurs in the confined aquifer, but pumping is possible in the shallow aquifer. **Bottom: (c)** Depth-to-groundwater fluctuations are seasonally and interannually large, however, clay layers in the near surface prolong the ecosystem's connection to groundwater. **(d)** Groundwater is disconnected from surface water, and any water in the vadose (unsaturated) zone is due to direct recharge from precipitation and indirect recharge under the surface water feature. These areas are not connected to groundwater and typically support species that do not require access to groundwater to survive.

BEST PRACTICE #2. Characterize Seasonal and Interannual Groundwater Conditions

SGMA requires GSAs to describe current and historical groundwater conditions when identifying GDEs [23 CCR §354.16(g)]. Relying solely on the SGMA benchmark date (January 1, 2015) or any other single point in time to characterize groundwater conditions (e.g., depth-to-groundwater) is inadequate because managing groundwater conditions with data from one time point fails to capture the seasonal and interannual variability typical of California's climate. DWR's Best Management Practices document on water budgets[6] recommends using 10 years of water supply and water budget information to describe how historical conditions have impacted the operation of the basin within sustainable yield, implying that a baseline[7] could be determined based on data between 2005 and 2015. Using this or a similar time period, depending on data availability, is recommended for determining the depth-to-groundwater.

GDEs depend on groundwater levels being close enough to the land surface to interconnect with surface water systems or plant rooting networks. The most practical approach[8] for a GSA to assess whether polygons in the NC dataset are connected to groundwater is to rely on groundwater elevation data. As detailed in TNC's GDE guidance document[4], one of the key factors to consider when mapping GDEs is to contour depth-to-groundwater in the aquifer that is supporting the ecosystem (see Best Practice #5).

Groundwater levels fluctuate over time and space due to California's Mediterranean climate (dry summers and wet winters), climate change (flood and drought years), and subsurface heterogeneity in the subsurface (Figure 3). Many of California's GDEs have adapted to dealing with intermittent periods of water stress, however if these groundwater conditions are prolonged, adverse impacts to GDEs can result. While depth-to-groundwater levels within 30 feet[4] of the land surface are generally accepted as being a proxy for confirming that polygons in the NC dataset are supported by groundwater, it is highly advised that fluctuations in the groundwater regime be characterized to understand the seasonal and interannual groundwater variability in GDEs. Utilizing groundwater data from one point in time can misrepresent groundwater levels required by GDEs, and inadvertently result in adverse impacts to the GDEs. Time series data on groundwater elevations and depths are available on the SGMA Data Viewer[9]. However, if insufficient data are available to describe groundwater conditions within or near polygons from the NC dataset, include those polygons in the GSP <u>until</u> data gaps are reconciled in the monitoring network (see Best Practice #6).

Figure 3. Example seasonality and interannual variability in depth-to-groundwater over time. Selecting one point in time, such as Spring 2018, to characterize groundwater conditions in GDEs fails to capture what groundwater conditions are necessary to maintain the ecosystem status into the future so adverse impacts are avoided.

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[6] DWR. 2016. Water Budget Best Management Practice. Available at: https://water.ca.gov/LegacyFiles/groundwater/sgm/pdfs/BMP_Water_Budget_Final_2016-12-23.pdf

[7] Baseline is defined under the GSP regulations as "historic information used to project future conditions for hydrology, water demand, and availability of surface water and to evaluate potential sustainable management practices of a basin." [23 CCR §351(e)]

[8] Groundwater reliance can also be confirmed via stable isotope analysis and geophysical surveys. For more information see The GDE Assessment Toolbox (Appendix IV, GDE Guidance Document for GSPs[4]).

[9] SGMA Data Viewer: https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer

BEST PRACTICE #3. Ecosystems Often Rely on Both Groundwater and Surface Water

GDEs are plants and animals that rely on groundwater for all or some of its water needs, and thus can be supported by multiple water sources. The presence of non-groundwater sources (e.g., surface water, soil moisture in the vadose zone, applied water, treated wastewater effluent, urban stormwater, irrigated return flow) within and around a GDE does not preclude the possibility that it is supported by groundwater, too. SGMA defines GDEs as "ecological communities and species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface" [23 CCR §351(m)]. Hence, depth-to-groundwater data should be used to identify whether NC polygons are supported by groundwater and should be considered GDEs. In addition, SGMA requires that significant and undesirable adverse impacts to beneficial users of surface water be avoided. Beneficial users of surface water include environmental users such as plants or animals[10], which therefore must be considered when developing minimum thresholds for depletions of interconnected surface water.

GSAs are only responsible for impacts to GDEs resulting from groundwater conditions in the basin, so if adverse impacts to GDEs result from the diversion of applied water, treated wastewater, or irrigation return flow away from the GDE, then those impacts will be evaluated by other permitting requirements (e.g., CEQA) and may not be the responsibility of the GSA. However, if adverse impacts occur to the GDE due to changing groundwater conditions resulting from pumping or groundwater management activities, then the GSA would be responsible (Figure 4).

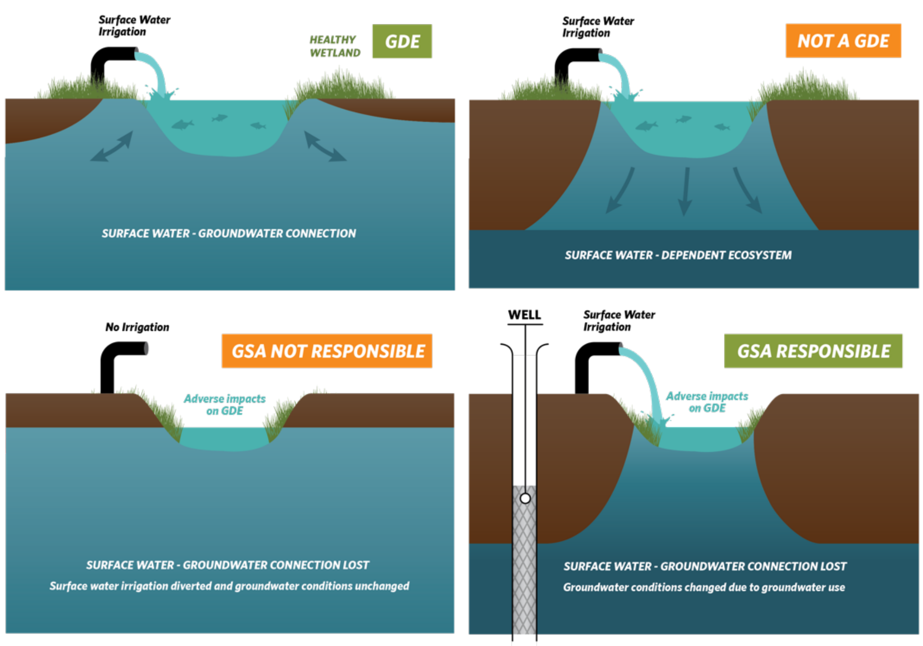

Figure 4. Ecosystems often depend on multiple sources of water. Top: (Left) Surface water and groundwater are interconnected, meaning that the GDE is supported by both groundwater and surface water. **(Right)** Ecosystems that are only reliant on non-groundwater sources are not groundwater-dependent. **Bottom: (Left)** An ecosystem that was once dependent on an interconnected surface water, but loses access to groundwater solely due to surface water diversions may not be the GSA's responsibility. **(Right)** Groundwater dependent ecosystems once dependent on an interconnected surface water system, but loses that access due to groundwater pumping is the GSA's responsibility.

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[10] For a list of environmental beneficial users of surface water by basin, visit: https://groundwaterresourcehub.org/gde-tools/environmental-surface-water-beneficiaries/

BEST PRACTICE #4. Select Representative Groundwater Wells

Identifying GDEs in a basin requires that groundwater conditions are characterized to confirm whether polygons in the NC dataset are supported by the underlying aquifer. To do this, proximate groundwater wells should be identified to characterize groundwater conditions (Figure 5). When selecting representative wells, it is particularly important to consider the subsurface heterogeneity around NC polygons, especially near surface water features where groundwater and surface water interactions occur around heterogeneous stratigraphic units or aquitards formed by fluvial deposits. The following selection criteria can help ensure groundwater levels are representative of conditions within the GDE area:

- Choose wells that are within 5 kilometers (3.1 miles) of each NC Dataset polygons because they are more likely to reflect the local conditions relevant to the ecosystem. If there are no wells within 5km of the center of a NC dataset polygon, then there is insufficient information to remove the polygon based on groundwater depth. Instead, it should be retained as a potential GDE until there are sufficient data to determine whether or not the NC Dataset polygon is supported by groundwater.

- Choose wells that are screened within the surficial unconfined aquifer and capable of measuring the true water table.

- Avoid relying on wells that have insufficient information on the screened well depth interval for excluding GDEs because they could be providing data on the wrong aquifer. This type of well data should not be used to remove any NC polygons.

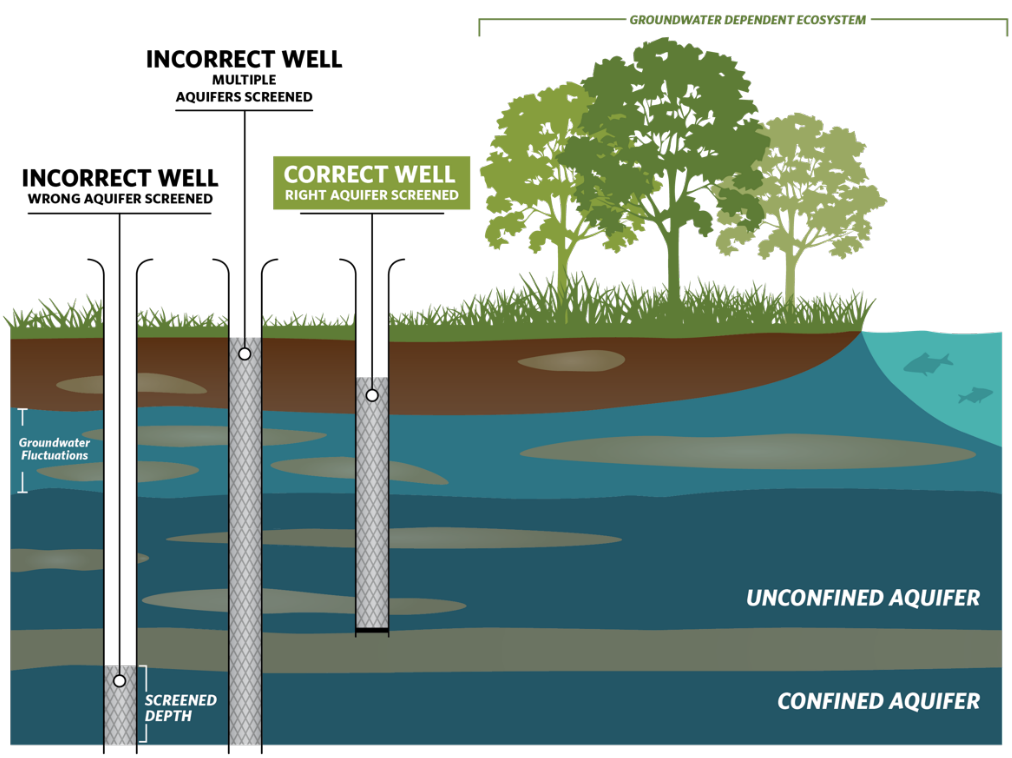

Figure 5. Selecting representative wells to characterize groundwater conditions near GDEs.

BEST PRACTICE #5. Contouring Groundwater Elevations

The common practice to contour depth-to-groundwater over a large area by interpolating measurements at monitoring wells is unsuitable for assessing whether an ecosystem is supported by groundwater. This practice causes errors when the land surface contains features like stream and wetland depressions because it assumes the land surface is constant across the landscape and depth-to-groundwater is constant below these low-lying areas (Figure 6a). A more accurate approach is to interpolate **groundwater elevations** at monitoring wells to get groundwater elevation contours across the landscape. This layer can then be subtracted from land surface elevations from a Digital Elevation Model (DEM)[11] to estimate depth-to-groundwater contours across the landscape (Figure b; Figure 7). This will provide a much more accurate contours of depth-to-groundwater along streams and other land surface depressions where GDEs are commonly found.

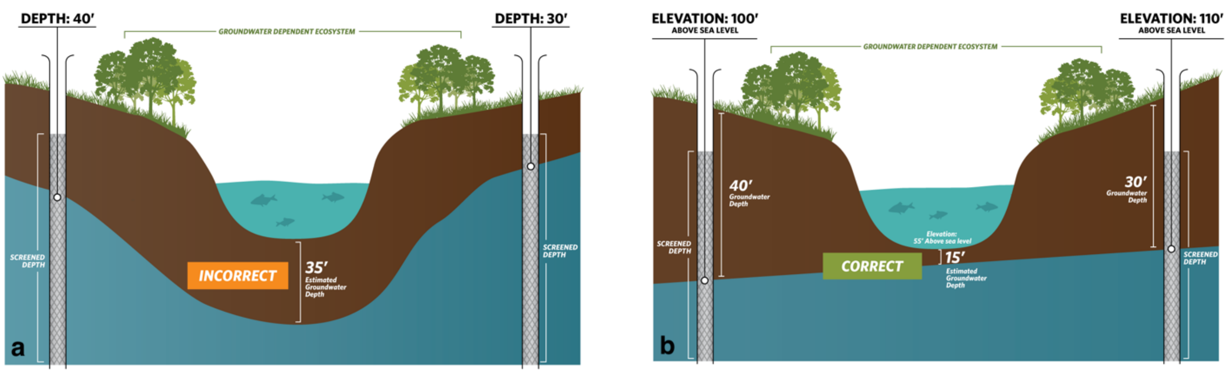

Figure 6. Contouring depth-to-groundwater around surface water features and GDEs. (a) Groundwater level interpolation using depth-to-groundwater data from monitoring wells. **(b)** Groundwater level interpolation using groundwater elevation data from monitoring wells and DEM data.

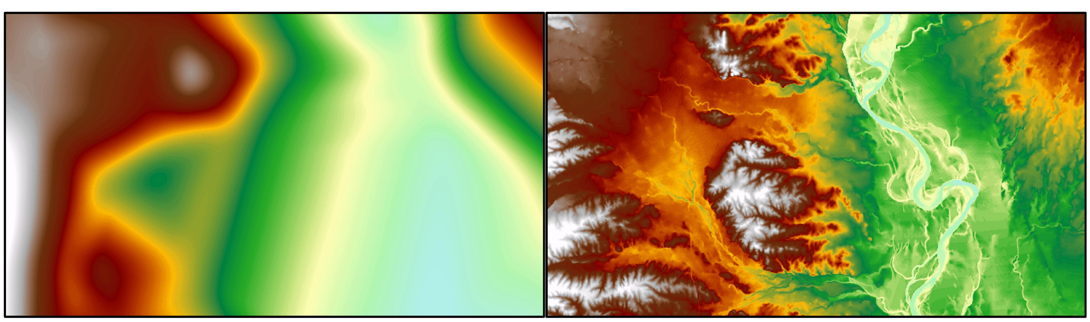

Figure 7. Depth-to-groundwater contours in Northern California. (Left) Contours were interpolated using depth-to-groundwater measurements determined at each well. **(Right)** Contours were determined by interpolating groundwater elevation measurements at each well and superimposing ground surface elevation from DEM spatial data to generate depth-to-groundwater contours. The image on the right shows a more accurate depth-to-groundwater estimate because it takes the local topography and elevation changes into account.

[11] USGS Digital Elevation Model data products are described at: https://www.usgs.gov/core-science-systems/ngp/3dep/about-3dep-products-services and can be downloaded at: https://iewer.nationalmap.gov/basic/

BEST PRACTICE #6. Best Available Science

Adaptive management is embedded within SGMA and provides a process to work toward sustainability over time by beginning with the best available information to make initial decisions, monitoring the results of those decisions, and using the data collected through monitoring programs to revise decisions in the future. In many situations, the hydrologic connection of NC dataset polygons will not initially be clearly understood if site-specific groundwater monitoring data are not available. If sufficient data are not available in time for the 2020/2022 plan, **The Nature Conservancy strongly advises that questionable polygons from the NC dataset be included in the GSP until data gaps are reconciled in the monitoring network.** Erring on the side of caution will help minimize inadvertent impacts to GDEs as a result of groundwater use and management actions during SGMA implementation.

KEY DEFINITIONS

Groundwater basin is an aquifer or stacked series of aquifers with reasonably well-defined boundaries in a lateral direction, based on features that significantly impede groundwater flow, and a definable bottom. *23 CCR §341(g)(1)*

Groundwater dependent ecosystem (GDE) are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface. *23 CCR §351(m)*

Interconnected surface water (ISW) 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. *23 CCR §351(o)*

Principal aquifers are aquifers or aquifer systems that store, transmit, and yield significant or economic quantities of groundwater to wells, springs, or surface water systems. *23 CCR §351(aa)*

ABOUT US

The Nature Conservancy is a science-based nonprofit organization whose mission is *to conserve the lands and waters on which all life depends*. To support successful SGMA implementation that meets the future needs of people, the economy, and the environment, TNC has developed tools and resources (www.groundwaterresourcehub.org) intended to reduce costs, shorten timelines, and increase benefits for both people and nature.

Attachment E

Maps of representative monitoring sites in relation to key beneficial users

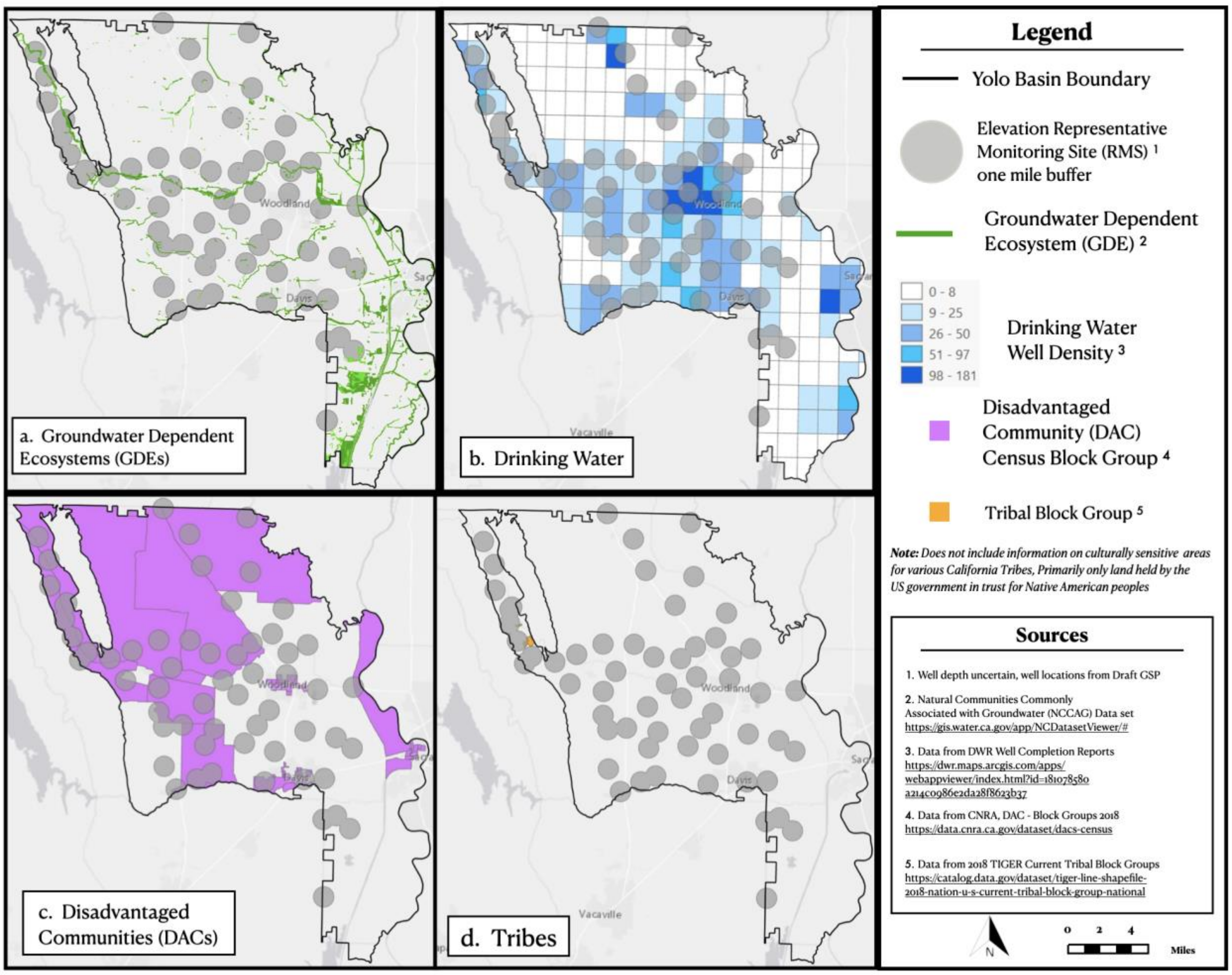

Figure 1. Groundwater elevation representative monitoring sites in relation to key beneficial users: a) Groundwater Dependent Ecosystems (GDEs), b) Drinking Water users, c) Disadvantaged Communities (DACs), and d) Tribes.

Special Concerns Areas need more data collection.

The Hungry Hollow where we live and have been farming for the last 37 years has been historically a dry farmed region. This means that there have been no wells for YSGA to collect data on. Our area is now labeled a special concern region and SGMA is lacking historical groundwater data to compare with past use and future needs. The fringe areas, including our land, are among areas seeing accelerated water decline which is an indicator of unsustainable usage. Therefore more time is needed to collect data, to find wells to monitor so that more complete information can be collected to understand the usage and recharge levels. How can we find sustainability with new wells bring drilled that are changing the water usage with every new hole in the ground?

- **There needs to be a 10 year moratorium on any new wells drilled on historically non-irrigated land. This will give time to collect data and to more fully understand the groundwater levels.**

Moving Surface Water via Pipelines.

Access to water, groundwater and surface water is a community resource. How can this resource be shared equally, and not monopolized by any one person or corporation that has the enough money for a pipeline to take care of their personal needs? This water is community water; therefore it should be used for the entire community not serving a few that can afford to pay for a pipeline to their landholdings. Landowners that are dependent on a pipeline allow them the ability to develop more land, and during the summer months when water from this pipeline is not available, those land owners are going to use groundwater. Our Hungry Hollow our water is very good water, lacking salts and boron that is prevalent in Cache Creek water, therefore piping Cache Creek water into the Hungry Hollow will degrade the quality of water.

- **Pipelines are not for the good of the entire community, they will advance land development, increase groundwater usage, and degrade water quality.**

How will we achieve sustainability?

Generally the SGMA plan does not seem to include the inhabitants of the landscape, but more importantly it does not include the potential of our community to make a difference in water usage. I feel that if we are looking into the future of water as a diminishing resource, then our communities need to be involved and participating in the management of water usage in their daily lives. Agriculture is the main user of the groundwater and surface water, and can have the biggest effect of groundwater recharge, surface water usage and what sustainability will look like for the future. To understand sustainability is one part of the puzzle, but more importantly how will we achieve sustainability in our communities is another question. Our communities need to be involved in the process. In my mind this means that we need to be innovative, willing to learn, and to incorporate new farming practices that will enhance water storage in our orchards and fields. Our community needs to learn from other farmers, participate in research in collaboration with organizations working towards these goals. We need to work together, share information, actively doing trials, tests, and experimentation on different management practices to achieve reduction in water usage. The future of Agriculture in California can be protected by working today to adjust our management practices. Our communities need to work together; sacrifice equally making changes as how we live on the land, how to use our shared natural resources and learn how to store more of our water in the soils, and reduce our annual water extraction needs.

- **We need to establish working groups that include our agricultural leaders in our communities to come together to initiate a proactive drought conservation management practices that have the goal of minimizing water usage and maximizing water retention in our soils, starting from the top of the watershed down into the valley floor.**
- **These working groups offer hands on opportunities, sharing results of these experimental practices among our agricultural community so that we can learn together what is working and what is not. These management practices need to be monitored as to the effects that they make, the differences of water usage and water recharge with these practices.**

Thank you for all of your efforts to include the community of Yolo County to make comments and to learn what is happening with the California mandate and SGMA plan. I do hope that my comments are helpful.

Sincerely,

Annie Main -Good Humus Produce

There needs to be a 10 year moratorium on any new wells drilled on historically non-irrigated land. This will give time to collect data and to more fully understand the groundwater levels.

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Access to water, groundwater and surface water is a community resource. How can this resource be shared equally, and not monopolized by any one person or corporation that has the enough money for a pipeline to take care of their personal needs? This water is community water; therefore it should be used for the entire community not serving a few that can afford to pay for a pipeline to their landholdings. Landowners that are dependent on a pipeline allow them the ability to develop more land, and during the summer months when water from this pipeline is not available, those land owners are going to use groundwater. In Hungry Hollow our water is very good water, lacking salts and boron that is prevalent in Cache Creek water, therefore piping Cache Creek water into the Hungry Hollow will degrade the quality of water.

- **Pipelines are not for the good of the entire community, they will advance land development, increase groundwater usage, and degrade water quality. They are also not a long-term solution to our issues.**

- **We need to establish working groups that include our agricultural leaders in our communities to come together to initiate a proactive drought conservation management practices that have the goal of minimizing water usage and maximizing water retention in our soils, starting from the top of the watershed down into the valley floor.**

- **These working groups offer hands on opportunities, sharing results of these experimental practices among our agricultural community so that we can learn together what is working and what is not.**
  These management practices need to be monitored as to the effects that they make, the differences of water usage and water recharge with these practices.

Thank you for all of your efforts to include the community of Yolo County to make comments and to learn what is happening with the California mandate and SGMA plan. I do hope that my comments are helpful.

Sincerely,
Claire Main

Comment on the Draft Yolo Subbasin Groundwater Agency Sustainability Plan

My wife and I have been farming in Hungry Hollow on the corner of Rd 15B and 84A since 1983. Our water supply for our 20 acre farm has consisted of a domestic well that has gone dry and a 500' agricultural well drilled in 1971. In 1987 PGE measured our ag well static water level at 99 ft. By January of 2017 that static level was measured at 172 ft. By January of 2020 the static level was down another 20 ft to 192 ft and this year during the early spring our submersible pump was dropped 60' deeper into the well to stop the pumping of air. Our static water level currently stands at 212 ft, after a summer that saw us pumping from below 220'. We are concerned for the future of our Hungry Hollow home because our children are currently involved in the family business that is wholly encompassed by the farm in Hungry Hollow, and plan to continue to provide food for the Sacramento region for the foreseeable future .

In the meantime, several of our neighbors domestic wells have been either re-drilled or their submersible pumps dropped lower. It is increasingly evident to those of us living and farming here that present use, exacerbated by groundwater demands of newly developed wells watering thousands of acres of perennial crops, and coupled with the effects of the current drought, have brought us not only to an overdraft , but to a severe overdraft of the aquifers we rely on for our domestic and agricultural water for our personal and business uses .

While a lack of monitoring wells in our area, and indeed all along the eastern bench of the Capay Hills and the Blue Ridge between Winters and Esparto, has hindered the establishment of a credible base to determine the extent of the problem, the fact that wellwaters in our area are dropping rapidly, indicating serious overdraft, requires us to take measures to:

1. Acquaint YSGA and SGMA with the need for immediate action
2. Provide data that substantiates the need through well drilling and repair data from the benchlands between Winters and Dunnigan
3. Ask for the immediate support of YSGA and the Board of Supervisors in providing the needed protections for the diminishing groundwater resource in our area, including severe restrictions on the additional development of groundwater resources until a stabilized return to pre 2020 groundwater levels can be assured.

A few final thoughts.

First, it is clear that the speed and power of the financial investment and development groups to alter existing landscape and community resource norms in our area has far outstripped the speed with which we are reacting to the changes that are introduced. The continuous purchase and reconfiguring of hill ground in Western Yolo County combined with the indiscriminate extraction of a diminishing community water resource without regard for the needs of the local community has avalanched in the midst of a historic drought that demands rather, greater care and preservation efforts from all of us. It is essential that we use all the powers of our elected public officials and governmental bodies to re-establish the rights of all to a reasonable share of a sustained essential resource.

Second, it should be noted that there is a likely geologic delineation between the aquifers to the north of Rd 16A in Hungry Hollow and the aquifers to the south. This delineation should show clearly in the difference between the water qualities of these two regions. If there is indeed a delineation it should be acknowledged as a goal of the YSGA to protect the higher quality waters to the north from the introduction of lower quality water from sources to the south.

Finally, I would hope that in addition to concerns about the mingling of waters of differing quality, that the idea of allowing additional development of land through the pumping of water from the Cache Creek Canals will be carefully studied for its potential for increasing groundwater pumping and resulting overdraft during periods of greatest concern.

Jeff Main
Good Humus Produce
October 27, 2021

To Yolo County Flood Control and Water Conservation District

October 27.2021

Re: Comments on the Draft SGMA document,

Dear Yolo Sub Basin Groundwater Agency,

I am writing to express concerns about the whole of a more sustainable water future for the areas included in Yolo Counties Draft YSGA -GSA document. My comments are written without reading the whole draft that has been put forward for public comment, yet in spite of that deficiency, I am hoping the these comments might be considered.

In many presentations by Yolo County Flood Control, as well as in this draft document, the point is made how historical well monitoring going back to the 1950's demonstrates how the county water basins have periods of stress and then generally rebound over time. During this period, even with the addition of Indian Valley Reservoir to bolster recharge, there has been a significant change in the number of acres irrigated in permanent crops with those crops being grown in areas that have previously been dry farmed. The past 10 or so years are critical and most relevant to this analysis and much of the historical data may be less relevant to the discussion of Sustainability. The factors of Climate change and the impact on winter rains, the dependability of recharge of Indian Valley and Clear Lake, along with the changing cropping patterns in the basin may change the modeling. This analysis and projection should be a considered part of this plan. The year-round demand for water, the change in infiltration patterns from dry farmed, row crop agriculture and orchard systems will have a distinct impact on the future patterns of water use and should be factored into the analysis of sustainability.

The concept of water infiltration and soil permeability and SAGBI soil classifications should be considered with varying land use practices that could increase permeability and retention of the rain that does fall. It is clear that residual organic matter and living plants on the soil surface slow down water velocity, reduce the impact of heavy rains by breaking up water particles, reducing direct impact on soil surface and allowing more water to infiltrate. The critical factor of water infiltration from predicted weather events that may be more violent and intense require that a good look be taken of the factor of recharge from infiltration and amending the SAGBI analysis. A change in infiltration or 10% over the permeable land surface of the county would result in more than 650,000 acres absorbing – given an average of 30 inches of rainfall – 3 inches over those acres. Infiltration is increased with well managed residual dry matter, ground cover, cover crops, greater organic matter and slowing the velocity of water over the landscape. These are things that could be seriously considered and would have a tangible path to implementation, and already are incentivized through various NRCS partnerships. This is not the same as flooding fields in high water events as a strategy in the county- a strategy with limited potential in loan and clay loam soils.

There should be areas set aside for study and integrated thinking – like Hungry Hollow where even moderate rainfall events create heavy runoff and flooding from hill areas and bare orchards. New partnerships with range land users to move cattle off when residual dry matter achieves a certain % of ground cover, new grazing practices encourage re-introduction of deep rooted perennials, and land use practices that increase water retention and storage should be measured and paid for by all who benefit from these practices. The upland areas of the Sub basin are critical in the long-term stability of our entire basin.

Although these are implementation steps, the principles of conservation, infiltration and retention should be stressed as a central strategy throughout the plan. Keeping the water here that falls on the Sub-basin lands requires slowing it down, spreading it out and allowing it to infiltrate. When an estimated 500,000 acre feet left the Cache Creek Watershed in 2018 thorough high water flows in Cache Creek, it represented a lost opportunity and a considerable part of the counties annual water budget. If even 10 % of this infiltrated, it would have been 50,000 acre feet that would have been released slowly into the larger environment. The report should stress more than conservation – It should look at new patterns of capture on all of the lands of the sub-basin.

It should also be stated strongly that the impacts to the basin under the purview of YSGA and GSP needs to guarantee that those on the edges of the foothills from Winters to Dunnigan are assured that they wont be the vicitms of overdraft- when evidence is showing that there seems to be the greatest impact of unsustainable groundwater management -within the basin as a whole-on those areas. I am sure that the data from monitoring wells is showing this impact- so that pumping in the basin as a whole may need to be reduced in order to assure equity in the application of the protections that should be afforded to all by SIGMA. This should start with your first point of a moritorium on new wells and the drilling of backup wells that are being drilled to be ahead of potential restrictions on drilling that may be coming. All new wells should be test pumped to determine the impact on neighboring wells and to determine the size of pump motor that could be installed. That is a round about way to potentially limit the size of new permanent crop plantings.

The GSA plan should be proactive here even though it is a politically sensitive issue. The lower San Joaquin Valley historically contained wetlands with valley lakes that have been drained, and water extraction beyond recharge has created the untenable situation that exists there. This report needs to be cognizant of the fact that overdraft is entirely possible here given the surge in year round demand and the potential for extreme events in terms of drying and warming weather.

There is discussion about pipeing water from Cache Creek north to Hungry Hollow. A thorough analysis is needed here. If that water is used to irrigate permanent crops- trees and vines, the issues of groundwater over draft would be accelerated in years when there is no cache creek water available and those permanent crops still need water. That would accelerate over draft in those years when water tables would likewise be challenged due to drought. It might be suggested that the water piped into the area should only be used on annual crops so that those fields could not be dependent upon year round irrigation and groundwater, and that those fields could lie fallow in periods of severe drought.

This will require leadership and collaborative discussion among many stakeholders on an ongoing basis. The YSGA and GSP process can facilitate this conversation- bringing many parties to the table to respond to changing conditions. 2040 may be far too late for intelligent response to factors that begin to show trends not anticipated in this draft.

It should be clear that groundwater is a shared resource available to property owners who use it efficiently for productive purposes. Over draft and unreasonable taking should not be a right but needs to be considered as a collective problem where solutions need be equitable, considering rights beyond individual rights. The process of entering into this discussion with property owners and water users needs to be part of YSGA and GSP- baked in- workshops on water conservation and infiltration, new collaborations with rangeland users. Innovative practices for slowing, pooling and retaining water in collaboration with filling unlined ditches when appropriate.

In many San Joaquin County communities the reality of having no water or water contaminated with nitrates or other forms of Ag pollution are real and may be beyond remediation. These realities fall most heavily upon those who can least afford their costs. There should be an economic component to the analysis- the burden of overdraft should not be borne by those least able to afford the costs of mitigating well loss. Trigger points for the edges of the basin should be considered to equitably deal with dwindling groundwater levels on the foothill areas of Dunnigan through Hungry Hollow to Winters.

I realize these comments are not specific to the Draft and specific language or ideas there in, however a much larger scale of thinking about sustainability of our water resources challenges us and the general ideas in this letter need consideration and investment. A change in awareness as part of long term implementation in water policy is needed with a comprehensive discussion about this shared resource that transcends purely individual interests of individual property owners.
Thanks for your consideration, Paul Muller

Thanks, Paul Muller

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
West Coast Region
650 Capitol Mall, Suite 5-100
Sacramento, California 95814-4700

September 29, 2021

Kristin Sicke, Assistant General Manager
Yolo Subbasin GSA
34274 State Highway 16
Woodland, California 95695

Electronic transmittal only

Re: NOAA's National Marine Fisheries Service Comments on the Developing Groundwater Sustainability Plan for the Yolo Subbasin

Dear Ms. Sicke:
NOAA's National Marine Fisheries Service (NMFS) is the federal agency responsible for managing, conserving, and protecting living marine resources in inland, coastal, and offshore waters of the United States. We derive our mandates from numerous statutes, including the Federal Endangered Species Act (ESA) and the Magnuson-Stevens Fishery Conservation and Management Act (MSA). The purpose of the ESA is to conserve threatened and endangered species and their ecosystems.

The California Department of Water Resources (DWR) has designated the Yolo subbasin a "high" priority for groundwater management, necessitating the development of a Groundwater Sustainability Plan (GSP) by January 2022, as required under California's Sustainable Groundwater Management Act of 2014 (SGMA). Several waterways that overlie portions of the Yolo subbasin support federally threatened California Central Valley (CCV) steelhead (*Oncorhynchus mykiss*), endangered Sacramento River winter-run Chinook salmon (*O. tshawytscha*), threatened Central Valley (CV) spring-run Chinook salmon (*O. tshawytscha*), and the Southern distinct population segment of North American green sturgeon (*Acipenser medirstris*), henceforth referred to as ESA-listed species. In addition, the Yolo subbasin is designated as Essential Fish Habitat for Pacific Coast Chinook salmon [including CV fall-run Chinook salmon (*O. tshawytscha*) and CV late fall-run Chinook salmon (*O. tshawytscha*)], which are managed under the MSA. This letter transmits NMFS' comments concerning the draft Final GSP for the Yolo subbasin, released for public comment on August 28, 2021.

Surface water and groundwater are hydrologically linked in the Yolo subbasin, and this linkage is critically important in creating seasonal habitat for ESA-listed species. Where the groundwater aquifer supplements streamflow, the influx of cold, clean water is critically important for maintaining temperature and flow volume. Pumping water from these aquifer-stream complexes has the potential to affect salmon and steelhead habitat by lowering groundwater levels and interrupting the hyporheic flow between the aquifer and stream. NMFS is concerned that groundwater extraction in the Yolo subbasin is currently impacting ESA-listed species instream habitat, and submits the following comments to assist the Groundwater Sustainability Agency (GSA) in adequately addressing those impacts.

Comments

Avoiding Undesirable Results: We recommend the GSA adequately address the following requirement for minimum thresholds as spelled out in the SGMA regulations:

> "The relationship between the minimum thresholds for each sustainability indicator, including an explanation of how the Agency has determined that basin conditions at each minimum threshold will avoid undesirable results for each of the sustainability indicators." (CCR 23 §354.28(b)(2))

According to DWR (2021), "it is up to GSAs to define in their GSPs the specific significant and unreasonable effects that would constitute undesirable results and to define the groundwater conditions that would produce those results in their basins." The GSA should describe what conditions within the subbasin would constitute an undesirable result with regard to streamflow depletion, ensuring that the description accounts for impacts to instream habitat that support all life-stages of ESA-listed species. The currently proposed sustainable management criteria for streamflow depletion do not include any explanation of how they will meet this requirement. For instance, the Lower Cache Creek streamflow depletion minimum threshold of "the recurrence of the spring (March-May) average measurement for 1975 to present in at least one spring in every seven (7) years" (page 3-24) has no apparent basis in ecology or any linkage to the aquatic habitat degradation caused by streamflow depletion that ultimately influences whether migrating and spawning salmon, steelhead, and sturgeon survive. If a lack of available data prevents such an effort, NMFS recommends the GSA follow guidance from California Department of Fish and Wildlife (2019) and develop conservative streamflow depletion thresholds as a precautionary principle until the surface flow/groundwater dynamic in the Yolo subbasin is better studied and understood.

Using Groundwater Elevations as a Proxy for Streamflow Depletion: If the GSA intends to propose groundwater elevations as a minimum threshold for streamflow depletion, the GSA should provide an explanation, with supporting best available science, for why groundwater levels are a reasonable proxy for interconnected surface water depletion. In addition, please explain why those levels are sufficient to avoid streamflow depletion that significantly impacts surface water beneficial uses.

Basing Sustainable Management Criteria on Historical Drought Conditions: Proposing groundwater elevations from the 2011-2016 period as streamflow depletion minimum thresholds and measurable objectives is likely inappropriate for avoiding significant impacts to ESA-listed species and their critical habitats, and EFH for Pacific Coast salmon. A basic hydraulic principle is that groundwater flow is proportional to the difference between groundwater elevations at different locations along a flow path. Using this basic principle, groundwater flow to a stream or, conversely, seepage from a stream to the underlying aquifer is proportional to the difference between water elevation in the stream and groundwater elevations at locations away from the stream. Minimum thresholds and measurable objectives consistent with groundwater elevations seen during California's recent historic drought, such as that crafted for the Upper Sacramento River (page 3-25), would likely create historically high streamflow depletion rates and result in instream conditions that negatively affect ESA-listed species and their critical habitats, and EFH for Pacific Coast salmon. If a lack of data prevents the development of appropriate sustainable management criteria, the GSA should commit to designing and implementing studies that better inform appropriate "ecologically-based" minimum thresholds and measurable objectives for streamflow depletion.

NMFS recommendation for future Projects and Management Actions: We suspect that groundwater recharge projects are likely to be an important action implemented as part of the effort to achieve groundwater sustainability in the Yolo subbasin. NMFS encourages the GSA to consider implementing recharge projects that facilitate floodplain inundation and offer multiple benefits, including downstream flood attenuation, groundwater recharge, and ecosystem service. Managed floodplain inundation can recharge floodplain aquifers, which in turn slowly release stored water back to the stream during summer months. These projects also reconnect the stream channel with floodplain habitat, benefitting juvenile salmon, steelhead, and sturgeon by creating off-channel habitat characterized by slow water velocities, ample cover in the form of submerged vegetation, and high food availability. As an added bonus, these types of multi-benefit projects likely have more diverse grant funding streams that can lower their cost as compared to traditional off-channel recharge projects. NMFS is available to work with any GSA interested in designing and implementing floodplain recharge projects.

Please direct questions regarding this letter to Amanda Cranford, of my staff, at Amanda.Cranford@noaa.gov or (916) 930-3706.

Sincerely,

A. Catherine Marcinkevage

Cathy Marcinkevage
Assistant Regional Administrator
California Central Valley Office

References:

California Department of Fish and Wildlife. 2019. Fish & Wildlife Groundwater Planning Considerations. California Department of Fish and Wildlife, Groundwater Program. June 2019. 28 pp. Available at: https://cawaterlibrary.net/document/fish-wildlife-groundwater-planning-considerations/

California Department of Water Resources. 2021. Letter from Craig Altare (DWR) to Taylor Blakslee (Cuyama Basin GSA), re. Cuyama Valley - 2020 Groundwater Sustainability Plan. Available at https://sgma.water.ca.gov/portal/gsp/assessments/32

Cc: To the File ARN 151422-WCR2021-SA00121

Electronic copy only:

Angela Murvine, California Department of Fish and Wildlife Statewide SGMA Coordinator, Angela.Murvine@wildlife.ca.gov

Bridget Gibbons, California Department of Fish and Wildlife Central Valley SGMA Biologist, Bridget.Gibbons@wildlife.ca.gov

Craig Altare, California Department of Water Resources, Supervising Engineering Geologist, Craig.Altare@water.ca.gov

Barrett Kaasa, Yolo Subbasin SGMA Point of Contact, California Department of Water Resources, Barrett.Kasaa@water.ca.gov

Dave Pratt comments on Public Draft chapters 1, 3, 4, 5 of the Yolo GSP

General comment: The big issue for the GSP is groundwater levels. The GSP is good on how to assess the situation: It establishes reasonable minimum thresholds for groundwater levels and then proposes a reasonable way to use these to decide what makes an "undesirable result" for the Basin. But then it says nothing at all about who does what in an attempt to correct any undesirable results. If control of ground water is to be kept local as much as possible, the GSP will have to include this. Maybe it's not the job of GEI to discuss this, but somebody has to.

Specific comments:

Page 1-25, lines 5-7: Has a farmer really ever had to wait 6 weeks to get water on a crop?

Page 1-25, well permitting process: Does the county, at present, have any authority to refuse a permit on the grounds that there isn't enough water or that the proposed use of the water is not in the public interest? Control of issuing permits ought to be worth a major discussion in the GSP.

Table 1-4, Public Meetings and workshops: Many of these are listed as YSGA Executive Committee meetings. Weren't these actually solo efforts by Tim O'Halloran?

Page 3-1, line 22: The word should be sustainably rather than sustainabilty.

Figure 3-2, page 3-9: If this figure is to be used for anything important, there should be a discussion about the accuracy of drawing lines in places where there are few data points. For example, how can it be that the 10, 20, 30, 40, 50, 60, and 70 contours of minimum threshold elevations in the southeast part of the county extend right to the Sacramento River, which is essentially at sea level?

Table 3-1, pages 3-12 to 3-13: Were some wrong numbers entered for well 249? From the numbers as entered, you would conclude that the ground elevation at the well was sea level, which doesn't figure for central Yolo County. (The maps of well locations don't seem to show this well at all.)

Comment on Groundwater Plan

Our family has been a subscriber to Good Humus Produce (one of the early Community Supported Agriculture farms which are icons of California's family farming community) for close to 30 years. Our family was one of the early families in California to appreciate the amazing resource provided by Good Humus Produce (and other similar farms) and its value for California and the environment. We are thankful to be able to take advantage of this opportunity to (1) know the source of our weekly fruits and vegetables, (2) know that the food was coming from land where the farmers were caretakers of the soil and the related environment and (3) support small family farms that are critical to the mosaic of farming, urban and wildlife habitat that makes California unique.

Good Humus Produce is located in the Dunnigan Hills Management Area of the Yolo Subbasin of the Sacramento Valley Groundwater Basin. Farmers in Yolo County, and especially those from the Yolo Subbasin, have been leaders in encouraging the development of these kinds of farms. With this in mind, we are commenting on the Draft Yolo Subbasin Groundwater Agency 2022 Groundwater Sustainability Plan (Draft Plan) and we are also asking Yolo County supervisors to consider the following comments and requests as Yolo County considers its future development.

Water Code Section 113 (enacted by SGMA) states that "[I]t is the policy of the state that groundwater resources be managed sustainably for long-term reliability and multiple economic, social, and environmental benefits for current and future beneficial uses." In enacting SGMA, the Legislature recognized the importance for communities, farms, and the environment of properly managing groundwater resources and recognized that failure to manage groundwater to prevent long-term overdraft infringes on groundwater rights. SGMA states the Legislature's intent to "enhance local management of groundwater consistent with rights to use or store groundwater and Section 2 of Article X of the California Constitution" (Water Code Section 10720.1).

Section 1.3 of the Draft Plan identifies a subgoal to “Achieve sustainable groundwater management in the Yolo Subbasin by maintaining or enhancing groundwater quantity and quality through the implementation of projects and management actions to support beneficial uses and users”. The Draft Plan states (Section 2.3.1 at page 2-145) that in the Dunnigan Hills Management Area, in the past 15 years, many thousands of acres of olives, grapes, and almonds have been planted and that many new wells have been drilled to service these new plantings. With regard to the Capay Valley, Dunnigan Hills, Central Yolo, and South Yolo Management Areas, the Draft Plan states (page 3-4) that the minimum threshold established with the methodology of the Draft Plan would “protect groundwater levels from chronically lowering to levels below the historical experience recognizing that groundwater conditions in these management areas are expected to behave similarly to historic conditions”. The Draft Plan (also at page 3-4) concludes that “No significant decreases in groundwater conditions are expected under future projected conditions”.

I believe that you have heard from Good Humus Produce and others that they have observed a growing amount of investment agriculture developing land and water resources on unirrigated lands in the Dunnigan Hills and other areas of ‘special concern. It appears that there have been significant increases in “investment” perennial crops in the area on land not previously irrigated and dramatic drops in water levels of its wells, as a result of increases in groundwater extracted from an apparently declining aquifer. These observations are not consistent with a conclusion that no significant decreases in groundwater conditions are expected under future project conditions.

The lowering of the groundwater in Hungry Hollow, the area where Good Humus Produce is located, has spread additional costs for well drilling, pumps lowering and operating costs and may threaten the ability of some farms to access water needed to supply their needs. These types of impacts affect both homeowners and farmers who have chosen to live and work in Yolo Subbasin, and who have provided many economic, social and environmental benefits for the area. While certainly the current drought may have contributed to some of apparent decline, it seems pretty clear that some of the decline is a result of recent increases in irrigated agriculture.

Although the Draft Plan identifies several projects and management actions, it is not at all clear that such actions would provide adequate groundwater for "historic" water users, much less for recent (within the last 10-15 years) or for planned future withdrawals. The focus of SGMA is "sustainable groundwater management". However, neither SGMA nor the Draft Plan deal with the actual determination of how to achieve sustainability. It does not appear that Yolo County and/or relevant water agencies have really addressed that question. Continuing agricultural development (and quite likely recent past agricultural development) cannot continue without adversely affecting current and future economic, social, and environmental beneficial uses. Apparently, some plans have been proposed that would include bringing surface water of questionable water quality via pipelines to some farms in the area. The Draft Plan does not address the question of reduced pumping and/or taking land out of production. Difficult choices may have to be made. The process going forward at both the Draft Plan level and Yolo County planning should take into consideration: the impact of climate change on groundwater management; the nature of different agricultural operations and their impacts on society, local economies and the environment; and, if they become necessary, how pumping restrictions should be allocated, including limits based on historic pumping.

Given the level of current knowledge of ground water levels and effects of current and future planned agricultural development, we strongly support the following recommendations of Good Humus Produce which we think make a lot of sense.

- **A 10-year moratorium on any new wells drilled for groundwater extraction on what have been historically non-**

irrigated land. This will give time to collect data and to more fully understand the groundwater levels and what is groundwater sustainability in the Dunnigan Hills and other "special concern" areas.

- **Additional input from the community.** Establish working groups that include local community agricultural leaders to come together to initiate proactive drought conservation management practices that have the goal of minimizing water usage and maximizing water retention in our soils, starting from the top of the watershed down into the valley floor. These working groups can offer hands-on opportunities, sharing results of these experimental practices among our agricultural community so that we can learn together what is working and what is not, including monitoring the effects of different practices with regard to water usage and water recharge.

Katherine and George Spanos
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Tully & Young
Comprehensive Water Planning

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October 27, 2021

Kristin Sicke
Executive Director
Yolo Subbasin Groundwater Agency
ksicke@yologsa.org

Dear Ms. Sicke,

The City of West Sacramento would like to express its gratitude for the time and effort that the Yolo Subbasin Groundwater Agency's Board and Staff (Agency) continually provide to address the groundwater management issues throughout the Yolo Subbasin. We recently reviewed the Public Draft Groundwater Sustainability Plan (GSP) and would like to provide some input for the Agency's consideration. As we discussed on the telephone, the City is a participating member of the Agency's Board and offers these observations in the context of further enhancing the GSP. As such, please note the following for your consideration:

1. Figure 1-3 on page 1-13 indicates that the City is not a "groundwater dependent community." The City has diversified its water supply portfolio and part of that portfolio remains groundwater. Thus, although we are not "wholly dependent" I think the City considers groundwater a part of its usable water asset portfolio in much the same way as the City of Davis and City of Woodland (both integrated with surface supplies delivered from WDCWA) that are depicted as groundwater dependent communities.
2. Figure 1-4 shows a distribution of grain and hay crops throughout the City of West Sacramento's service area. Although this may have been true in the past, much of the area depicted in this graphic is fully developed and devoid of agricultural production.
3. Figures 1-6 through 1-8 show a wide distribution of various agricultural, domestic, and municipal wells within the City of West Sacramento. We would appreciate a citation to this data source (or sources) to ensure that it stays up to date with the City's well management activities.
4. Page 1-31 – the City would like its 2020 update to its General Plan Housing Element noted in the statement about the City's General Plan.
5. Page 2-20 – there appear to be a couple typographical errors on this page and on page 2-32 the word "southwestern" is misspelled.
6. Figure 2-14 on Page 2-37 does not appear to show the City's point of diversion for Permit 18150.

7. Figure 2-24 on page 2-63 should list the City as a Public Water System in the legend and the figure should include a spatial recognition of the City's service area.
8. Tables 2-12 through 2-15 do not show the City as a Public Water System or show the water quality information that would apply to the City in those tables.
9. Page 1-203 cites The Nature Conservancy's water model. The City notes the following disclaimer that TNC shows at the identified link that should be incorporated into the text as it indicates that there is some uncertainty with what could be concluded from the information. The link states: "This map categorizes the rivers and streams in the Central Valley on the likelihood that they are ISW, using groundwater depth as a proxy to determine if the surface water is hydraulically connected to groundwater." (highlight added). Perhaps this would be well-suited for a footnote since The Nature Conservancy notes that the output is a "likelihood" rather than something more definitive.
10. Page 2-104 lines 6 through 12. There seems to be some speculation related to groundwater substitution transfers in this section. These transfers are highly controversial for a number of reasons and we think that adding language about the interconnectivity of surface water and groundwater in this instance is misplaced. The DWR Water Transfer Whitepaper is not law but is instead policy generated by DWR staff that has not yet been formerly ratified or challenged. We would encourage the Agency to simply delete this text and provide more generalized language about hydraulic connectivity between surface water and groundwater.
11. Page 2-109 - There appears to be a typo in lines 13 and 14.
12. General comment – one source of groundwater recharge certainly applies to sources of water that are applied to land through irrigation (and other overland-spreading activities). Additional methods of groundwater recharge may need to be added to the characterization of recharge for groundwater basins even if the discussion is merely qualitative. Examples may include diversion of flood flows through the Yolo bypass, water regularly moving through the drain in the Yolo Bypass, water moving in the deep water ship channel, application of irrigation water above the ET amounts to crops, and application of irrigation water in urban landscapes.
13. Section 2.2.9 on page 2-130 should include a brief discussion about the conversion of agricultural acreage to urban acreage. This is a particularly important component in the City's service area because significant water conservation has been achieved in the City's service area on a per acre basis when land is converted from agricultural production to urban landscapes. Much of that conserved water benefits the Yolo Subbasin groundwater conditions in the South Yolo Management Area.
14. Figure 2-56 on page 2-132 shows future use over 65,000 but the number in the side table in the figure says 50,270. We are unclear on the data correlation in this table and suggest it could be explained in words if the data shown is correct.

15. Table 2-22 on page 2-134 needs a units characterization.
16. Page 2-139 identifies 346 TAF as the sustainable yield of the entire Yolo Subbasin. We recognize that components of this figure are aggregated among the various management areas.
17. Section 2.3.5 on page 2-146 should recognize that the City's water use history in a little more detail. We recommend the following language be added after the first sentence on line 16: "The City historically delivered groundwater to its customers as the exclusive source of water for many years before building its surface water diversion and treatment facilities. The City continues to preserve and use groundwater in its service area for various purposes and is looking to improve its groundwater system to provide necessary system redundancy to ensure safe and reliable water supplies for all of the City's residents and businesses." We would also ask that the last sentence with the word "dependency" in it be deleted that starts on line 16. Also, the word "city" should be capitalized in the first sentence on line 16.
18. Page 4-7 there is a typographical error in the Table legend.
19. Page 5-20, P 68 and P 69 in the table are projects for the City of West Sacramento. We would prefer that P 68 be titled "West Sacramento Well Improvements that may include Aquifer Storage and Recovery."
20. Appendix page 47 PDF has the same figure as shown in Figure 2-56 on page 2-132 that may require more explanation.
21. Section 2.1.5.2.2 of the Appendix (page 209 of Appendix PDF) should probably be modified in a few ways.
    a. The characterization of the NDWA contract should be modified and redact the word "unlimited" and add "highly reliable" instead. The rest of that sentence after the comment should be deleted.
    b. The sentence that states "This is not implemented into the model at this time" is somewhat concerning. The City's ability to use groundwater should be in the model and we are not sure what this sentence is conveying. In addition, the notations in Figures 1-6 through 1-8 indicate that well water is being used within the City which should be incorporated into the model.
    c. The City sends its wastewater to SRCSD not the City of Sacramento as noted in the sentence starting with "Although."
    d. The table depicting "Sources of Information" for the City of West Sacramento. A few things here: the City's CVP Contract is number 0-07-20-W0187-P rather than what is depicted in that table. Also, the City is in the final stages of updating its 2020 UWMP and has updated its Housing Element in 2020 for its General Plan (the GP is cited elsewhere (page 1-31) in the GSP so should be cited in this table).

If a reference could be made that these data will be modified based upon future updates to planning documents, that would be helpful.

We greatly appreciate the opportunity to provide additional input to the Agency's GSP. And we look forward to reviewing the next draft as it becomes available. If you have any questions or need further discussion about any of the items noted in this letter, please do not hesitate to contact me.

Sincerely,

Gwyn-Mohr Tully

Gwyn-Mohr Tully
Tully & Young, Inc.

Yolo Subbasin Groundwater Agency
2022 Groundwater Sustainability Plan

Yolo County, CA

Appendix D
Interbasin Coordination Letters

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Sacramento Groundwater Authority
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November 22, 2021

Ms. Kristin Sicke
Groundwater Sustainability Plan Manager
Yolo Subbasin Groundwater Agency
34274 State Highway 16
Woodland, CA 95695

Dear Ms. Sicke,

The purpose of this letter is to document the coordination activities and to summarize our understanding related to the adjacent Groundwater Sustainability Plans (GSPs) covering the North American Subbasin (NASb) and the Yolo Subbasin. Coordination meetings between representatives of the NASb and the Yolo Subbasin occurred on the following:

- August 31, 2020
- July 13, 2021
- August 10, 2021

At the July 13, 2021 meeting, we discussed the following topics:

- Groundwater flow across our common boundary
- Projected land use changes along our common boundary
- Monitoring network along our common boundary
- Minimum Thresholds (MTs) along the boundary
- How to document our coordination (e.g., letter to include in GSP? something more formal?)

At the August 10, 2021 meeting, our modeling consultants met to discuss technical aspects of our modeling effort. In particular, we felt this was necessary because we are using different modeling platforms. Our modeling teams agreed that small differences in boundary flows calculated by the models are not material.
Based on our coordination, the NASb concludes the following with respect to the Yolo Subbasin:

1. Current and projected groundwater flow, projected land use changes, and MTs near our common boundary do not appear to impede our respective abilities to achieve our sustainability goals.
2. The monitoring network along our common boundary is sufficient to detect significant changes that could impact our respective GSPs and we will actively share monitoring information along our common boundary.
3. It is currently preferrable to document our coordination through this correspondence rather than through a more formal interbasin agreement.

As a result of the above coordination, we have been able to share information to the mutual benefit of each subbasin's GSP development effort and have been able to confirm that the implementation of our respective GSPs will not adversely impact the attainment of our sustainability goals. We have examined findings in each GSP along our boundaries and either confirmed consistency or have agreed to work together during GSP implementation to resolve differences, to the extent they merit such effort.

We recommend a minimum of an annual coordination meeting after the completion of each GSP annual report to share information on monitoring results and other implementation activities and to identify and address any emerging trends that may be of concern along our common boundary. We will also coordinate through quarterly meetings of the Northern California Water Association Groundwater Management Task Force Meetings.

Sincerely,

Rob Swartz
Groundwater Sustainability Plan Manager
North American Subbasin

SOLANO SUBBASIN
GROUNDWATER SUSTAINABILITY AGENCY

November 11, 2021

Ms. Kristin Sicke
Groundwater Sustainability Plan Manager
Yolo Subbasin Groundwater Agency
34274 State Highway 16
Woodland, CA 95695

Subject; Interbasin Coordination between the Solano and Yolo Groundwater Sustainability Plans

Dear Ms. Sicke:

The purpose of this letter is to document the coordination activities and to summarize our understanding related to the adjacent Groundwater Sustainability Plans (GSPs) covering the Solano Subbasin and the Yolo Subbasin.

Coordination meetings between representatives of the Solano Subbasin and the Yolo Subbasin occurred on the following dates:

- May 6, 2020 – introductory/kickoff meeting
- July 1, 2020
- December 9, 2020
- April 6, 2021 – PMA coordination call convened by Ag Innovations on behalf of the Solano GSP team – included participation by Yolo, East San Joaquin, East Contra Costa, and Tracy Subbasins
- July 9, 2021
- August 30, 2021

At the July 1, 2020, meeting, we discussed the following topics:

- Groundwater flow across our common boundary
- Hydraulic and hydrogeologic conditions in each subbasin
- Potential management actions being explored by each subbasin
- Monitoring network along our common boundary

At the December 9, 2020, meeting, we discussed the following topics:

- Monitoring network along our common boundary - under the UC Davis Putah Creek well monitoring effort and USBR reference survey
- Current status of model development in each subbasin
- Groundwater level trends in the vicinity of the City of Winters

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At our July 9, 2021, meeting, we discussed the following topics:

- Interconnected surface waters along the Yolo and Solano Subbasin boundaries
- Current status of the TSS monitoring wells along Putah Creek with Yolo Subbasin
- Integrated Hydrologic Model results for each subbasin
- Northwestern "focus area" along common boundary for potential recharge opportunities
- Yolo Subbasin Water Information Database
- Continued data sharing between both subbasins

At our August 30, 2021, meeting, we discussed the following topics:

- Expansion of the TSS monitoring well network across the common subbasin boundary
- Representative Monitoring Site locations within each subbasin and the approach taken to develop each subbasin's monitoring network
- Current status of the TSS monitoring wells along Putah Creek with Yolo Subbasin
- How to document our coordination efforts (e.g., letter versus more formal agreement)

Based on our coordination efforts, the Solano GSP team understands the following with respect to the Yolo GSP:

1. Current and projected groundwater flows, projected land use changes, and minimum thresholds (MTs) near our common boundary along Putah Creek do not appear to impede our respective abilities to achieve each of our sustainability goals.
2. The monitoring network along our common boundary should be expanded to advance the understanding of interconnected surface water and detect significant changes that could affect our respective GSPs.
3. We will actively share monitoring information along our common boundary.
4. It is currently preferable to document our coordination through this correspondence rather than through a more formal interbasin agreement.

As a result of the above coordination, we have shared information to the mutual benefit of each subbasin's GSP development effort and confirmed that the implementation of our respective GSPs will not adversely affect our respective sustainability goals. We have examined findings in each GSP along our boundaries, confirmed consistency, and agreed to work together during GSP implementation to ensure ongoing sustainability efforts continue to be consistent.

We recommend a minimum of an annual coordination meeting with your subbasin representatives after the completion of our first GSP annual reports to facilitate the exchange of technical information, coordinate on implementation activities, and identify and address any emerging trends that may be of concern along our common boundary.

Sincerely,

Chris Lee
GSP Manager, Solano Subbasin

827 7th St, Rm 301
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Sacramento Central Groundwater Authority
Managing Groundwater Resources in Central Sacramento County

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December 6, 2021

Ms. Kristin Sicke
Executive Officer
Solano Subbasin
Yolo Subbasin Groundwater Agency
34274 State Highway 16
Woodland, CA 95695

Subject: Inter-basin Coordination Between Yolo and South American Subbasins

Dear Ms. Sicke:

This letter documents the coordination activities and summarizes our understanding of the adjacent Groundwater Sustainability Plans (GSPs) covering the South American Subbasin (SASb) and the Yolo Subbasin (Yolo).

Inter-basin coordination occurred through a series of meetings/calls and email exchanges.

In the initial introductory meetings/calls, the topics that were covered included:

1. Introductions of GSP team members
2. Inter-basin coordination agreement – discussion of potential points of agreement, benefits of formal versus informal approach – discussed example agreements, potential content
3. Information exchange – discussed potential areas of coordination and associated topics (primarily related to boundary exchange characteristics - groundwater flows, designation of interconnected surface waters (ISW), Sustainable Management Criteria (SMC) and monitoring network, hydrogeology, Groundwater Dependent Ecosystem (GDE) identification, etc.) and process for coordinating
4. Potential/need for coordinated outreach along boundaries
5. Next steps and the benefit of additional future meetings – identification of information that could be shared

The primary outcomes from each of the initial meetings was to achieve consensus on (1) desiring collaboration, (2) sharing information related to GSP development (e.g. Projects and Management Actions (PMAs), modeling, ISW, GDE, shallow well analysis), and (3) achieving these objectives through an informal process versus a formal agreement.

In the subsequent calls that were convened, numerous topics were discussed, including:

1. Status of GSP development – availability of information/websites/schedules
2. PMAs – significant projects occurring along boundaries
3. Models being used and Modeling assumptions
4. Groundwater flows across the surface water boundaries
5. Interconnected Surface Water Designations – stream depletion estimates
6. Monitoring Network along boundaries
7. SMC – Minimum levels and Measurable objectives along the boundaries
8. Projected land use changes along the boundaries
9. GDE methodology
10. Shallow Well impact analysis
11. Agreement to review draft GSPs
12. Process to document coordination between adjacent basin GSP efforts – agreement to use mutually developed letter to summarize coordination actions

Coordination meetings between representatives of SASb and Yolo occurred on the following days:

- September 29, 2020 (introductory call)
- March 23, 2021 (introductory meeting)
- April 28, 2021 (introductory meeting)
- September 1, 2021

At the September 1, 2021 meeting, we discussed the following topics:

- Groundwater flow across our common boundary
- Projected land use changes along our common boundary
- Monitoring network along our common boundary
- Minimum Thresholds (MTs) along the boundary
- Documentation of coordination

Based on our coordination, the SASb GSP team concludes the following with respect to the Yolo GSP:

1. Current and projected groundwater flow, projected land use changes, and MTs near our common boundary do not appear to impede our respective abilities to achieve our sustainability goals.
2. The monitoring network along our common boundary is sufficient to detect significant changes that could impact our respective GSPs and we will actively share monitoring information along our common boundary.
3. It is currently preferable to document our coordination through this correspondence rather than through a more formal inter-basin agreement.

We have shared information to the mutual benefit of each subbasin's GSP development effort and confirmed that the implementation of our respective GSPs will not adversely impact the attainment of our sustainability goals. We have examined findings in each GSP along our boundaries and either confirmed consistency or have agreed to work together during GSP implementation to resolve differences, to the extent they merit such effort.

We recommend a minimum of an annual meeting between our respective GSAs after the completion of each GSP annual report to facilitate the exchange of technical information, coordinate on implementation activities, and to identify and address any emerging trends that may be of concern along our common boundary. Additionally, we will coordinate through meetings of the Northern California Water Association Groundwater Management Task Force and the Association of California Water Agencies Groundwater Management Committee.

Sincerely,

John Woodling
GSP Manager, South American Subbasin

Colusa Groundwater Authority
Groundwater Sustainability Agency

1213 Market Street | Colusa, CA 95932 | 530.458.0480 | colusagroundwater.org

January 19, 2022

Ms. Kristin Sicke
Yolo Subbasin Groundwater Agency
Executive Officer
Emailed: ksicke@yolosga.org

Ms. Sicke,

This letter documents the coordination activities and summarizes our understanding of the adjacent Groundwater Sustainability Plans (GSPs) covering the Yolo Subbasin and Colusa Subbasin.

Coordination meetings between representatives of the Yolo Subbasin and Colusa Subbasin occurred on the following dates:

- December 16, 2020
- February 3, 2021
- June 2, 2021
- June 16, 2021
- July 16, 2021
- August 5, 2021

On December 16, 2020, the Colusa Subbasin and Yolo Subbasin's respective modeling consultants met to discuss technical aspects of our modeling effort, which was necessary because we are using different modeling platforms. Our modeling teams agreed that small differences in boundary flows calculated by the models are immaterial.

At the February 3, 2021 meeting, Mary Fahey and you had a brief call to coordinate on general components of interbasin coordination and we reviewed the next steps and opportunities for working together.

At the June 2, 2021 meeting, there was a larger discussion with members of the North Yolo Management Area and South Colusa Subbasin to discuss the following with respect to our unique subbasins:

1. Sustainable Management Criteria approaches
    a. Representative Monitoring Network Coverage
    b. Proposed Minimum Thresholds and Measurable Objectives
2. Common Data Gaps
3. Multi-Benefit Projects in Both Subbasins (ground-based surveys, RD 108 conjunctive use projects, etc.)

And at the June 16 and August 5, 2021 meetings, the teams followed up on the June 2, 2021 discussion and reported on the status of certain action items.

On July 16, 2021, we participated in the South Colusa County Groundwater Discussion hosted by RD 108, which provided stakeholders with information on monitoring efforts in the area and projects planned to be included in the Colusa Subbasin GSP.

Based on our coordination, the Colusa Subbasin concludes the following related to Yolo Subbasin:

1. Current and projected groundwater flow, projected land use changes, and MTs near our common boundary do not appear to impede our respective abilities to achieve our sustainability goals.
2. The monitoring network along our common boundary is sufficient to detect significant changes that could impact our respective GSPs and we will actively share monitoring information along our common boundary.
3. It is currently preferrable to document our coordination through this correspondence rather than through a more formal interbasin agreement.

As a result of the above coordination, we have shared information to the mutual benefit of each subbasin's GSP development effort and have confirmed that the implementation of our respective GSPs will not adversely impact the attainment of our sustainability goals. We have examined findings in each GSP along our boundaries and either confirmed consistency or have agreed to work together during GSP implementation to resolve differences, to the extent they merit such effort.

We recommend a minimum of an annual coordination meeting after the completion of each GSP annual report to share information on monitoring results and other implementation activities and to identify and address any emerging trends that may be of concern along our common boundary. Additionally, we will coordinate through quarterly meetings of the Northern California Water Association Groundwater Management Task Force, and Association of California Water Agencies Groundwater Management Committee.

Sincerely,

Denise Carter
Chairperson on the Colusa Groundwater Authority

Yolo Subbasin Groundwater Agency
2022 Groundwater Sustainability Plan

Yolo County, CA

Appendix E
Yolo SGA Model Documentation

Contents

Figures

Tables

1 Overview of the Yolo SGA Model

The Yolo Sustainable Groundwater Agency model (YSGA model) is a linked surface water-ground water model developed using Water Evaluation and Planning (WEAP)[1] and MODFLOW[2]. WEAP (Yates et al., 2005a, 2005b) is an integrated surface water – groundwater modeling tool, which integrates rainfall-runoff hydrology, reservoir operation, water demands from cities and crops, and allocations of water to those demands from surface and groundwater supplies. The WEAP model used in the YSGA model builds on several years of development of the Cache Creek system at the Yolo County scale (Mehta et al., 2018, 2011; Winter et al., 2017).

MODFLOW is a finite-difference groundwater modeling tool developed by the USGS (Harbaugh, 2005). In the YSGA model, MODFLOW simulates the groundwater budget of the Yolo basin's 3-layer aquifer. The MODFLOW model was built using the inputs, aquifer parameters, boundary conditions and aquifer representation from a Yolo County IWFM model (Flores Arenas, 2016) which in turn was informed by a IGSM model of Yolo County (WRIME, 2006).

1.1 Temporal Scope

SGMA regulations require that annual water budgets are based on three different periods: a ten-year historic period, the 'current' year, and a 50-year projected period. The current water year is defined in the GSP Emergency Regulations (§354.18(c)(1)) as the year with "the most recent population, land use, and hydrologic conditions".

1.1.1 Historical and Current Period

The YSGA model runs at a monthly time step. The historical to current period covers 48 years, from Water Year (WY) 1971 to WY 2018. Although GSP regulations require a minimum 10 year period for historical water budgets, we leveraged earlier work that modeled a substantially longer period (WY 1971-WY 2005 (Mehta et al., 2013), and WY 1971-2008 (Mehta et al., 2018). These 48 years cover a large spread of water year types, significant and contiguous drought periods (WY 1976-WY 1977, WY 1987-WY 1992, WY 2007-2009 and WY 2012-WY2016), and significant and contiguous wet periods of note (WY 1971-WY 1975, WY 1982-1984, WY 1995-WY 2000 and WY 2005-WY 2006). The Water Year Index (Sacramento Valley) and the Water Year Types for the historical to current water year type are listed in Table 1-1. Water Year 2018 – the last year of the model run in the historical period – is treated as the current period. This is the most recent year for which almost all datasets are available. Climate and water rights data are updated to WY 2018 in the YSGA model. Land use data, however, is only available to 2016 (the LandIQ dataset provided by the SGMA data portal[3]). Hence 2016 Land use data is used and kept constant through 2018.

[1] See https://www.weap21.org/ for more information.
[2] See https://water.usgs.gov/ogw/modflow/ for more information.
[3] See https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#waterbudget; Accessed 8.31.2018

Table 1-1. Sacramento River Water Year Index and Water Year Types, C = Critical, D = Dry, BN = Below Normal, AN = Above Normal, W = Wet.

Water Year	Water Year Index	Water Year Type	Water Year	Water Year Index	Water Year Type
1971	10.37	W	1995	12.89	W
1972	7.29	BN	1996	10.26	W
1973	8.58	AN	1997	10.82	W
1974	12.99	W	1998	13.31	W
1975	9.35	W	1999	9.8	W
1976	5.29	C	2000	8.94	AN
1977	3.11	C	2001	5.76	D
1978	8.65	AN	2002	6.35	D
1979	6.67	BN	2003	8.21	AN
1980	9.04	AN	2004	7.51	BN
1981	6.21	D	2005	8.49	AN
1982	12.76	W	2006	13.2	W
1983	15.29	W	2007	6.19	D
1984	10	W	2008	5.16	C
1985	6.47	D	2009	5.78	D
1986	9.96	W	2010	7.08	BN
1987	5.86	D	2011	10.54	W
1988	4.65	C	2012	6.89	BN
1989	6.13	D	2013	5.83	D
1990	4.81	C	2014	4.07	C
1991	4.21	C	2015	4	C
1992	4.06	C	2016	6.71	BN
1993	8.54	AN	2017	14.14	W
1994	5.02	C	2018	7.14	BN

1.1.2 Future period

Future projections use climate change projections provided by DWR on the SGMA data viewer[4] which is summarized here. Additional information is provided in later sections (Section 2.1.4). Climate projections in the YSGA model are based on climate change model runs centered around the mid-2030's period, and the mid- 2070's period. In the YSGA model, each future projection uses the final state of the historical model run as the initial state of the future run. In other words, each climate projection in the model is investigating the outcome of that corresponding projection's climate occurring from WY 2019 onwards, for the next 48 years. For example, the future projection that uses the central tendency of the climate change models around the 2030's, investigates the outcome of that climate occurring from WY 2019 – WY 2056.

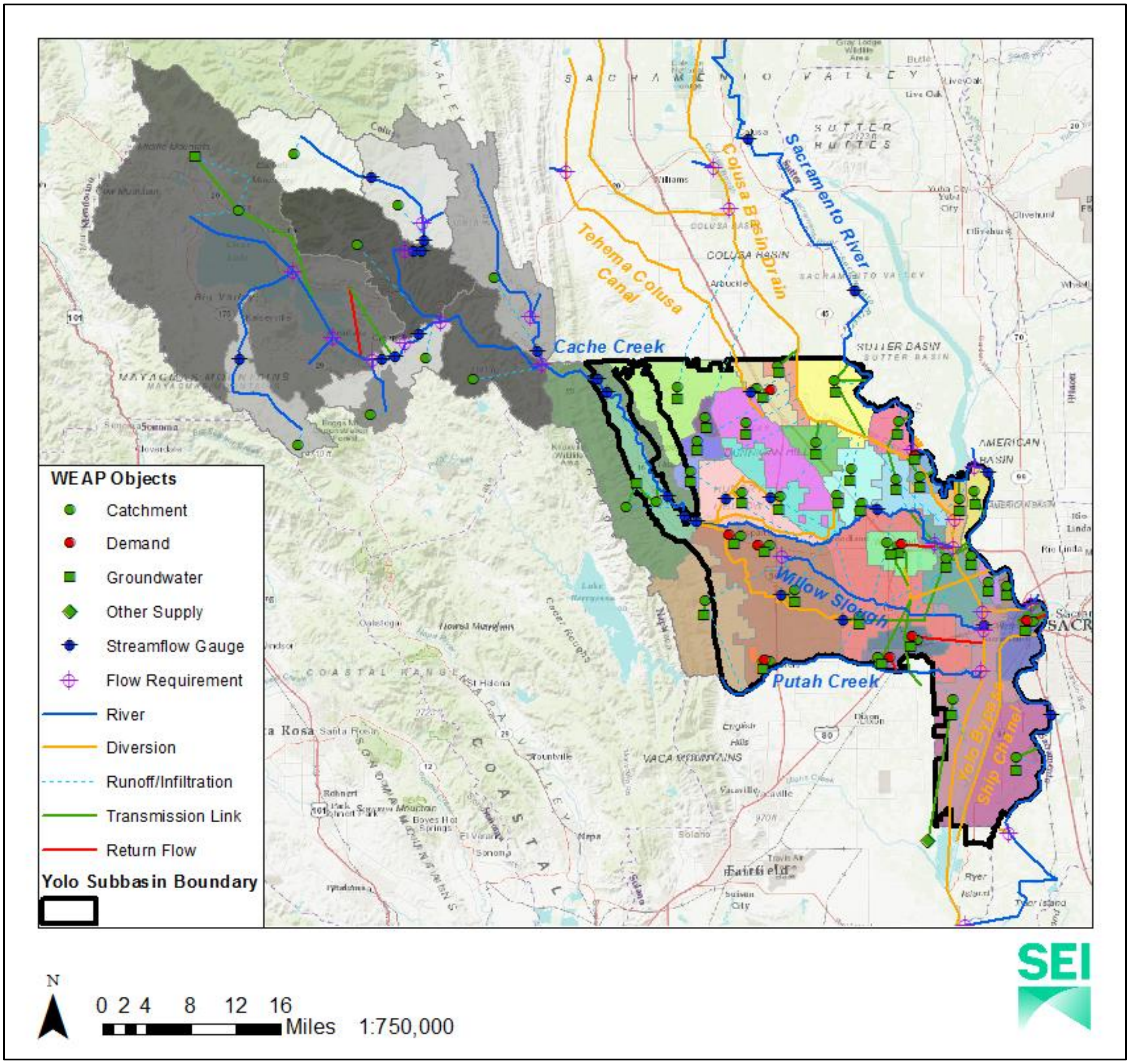
[4] SEE https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#waterbudget Accessed 8.31.2020

1.2 Spatial Scope

The spatial scope of the YSGA model is shown in Figure 1-1 and Figure 1-2. Figure 1-1 shows that the YSGA model's land surface water budget explicitly includes not just the YSGA basin boundary, but also the upstream Cache Creek watershed (including Clear Lake and Indian Valley reservoir). That is, the hydrology and operations of the Cache Creek watershed are simulated. Other important surface water inflows and boundaries are represented as input data, such as the Tehama Colusa Canal and Colusa Basin Drain, and stream flows (Sacramento River and Putah Creek).

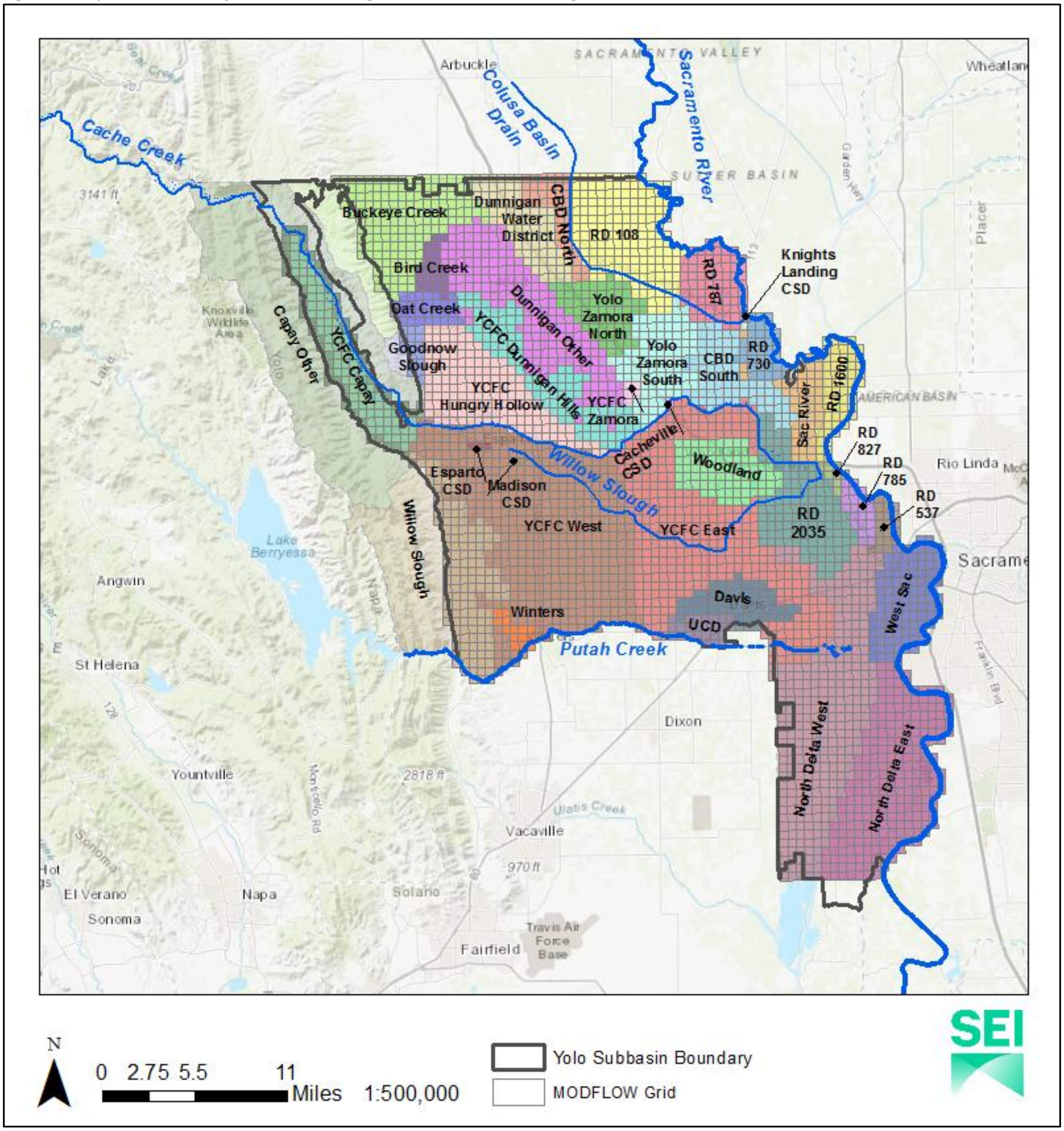
Figure 1-2 shows a closer view of the Yolo basin disaggregation into catchments in the YSGA model, with the MODFLOW computational grid overlaid. Surface water diversions, recharge, and groundwater pumping were simulated at the scale of the catchments shown in Figure 1-2. These boundaries mostly represent water district, urban, or hydrogeologic boundaries. Regions outside of water districts and urban areas are considered “white areas” that fall under County jurisdiction for purposes of SGMA. The MODFLOW grid covers only those parts of the Yolo basin boundary in which the groundwater aquifer exists, as represented in the IWFM model that it is derived from. For purposes of calculating water budgets, the individual catchments have been grouped into Management Areas, as shown in Figure 1-3. The black boundary represents the official Basin boundary. The MODFLOW grid, which represents the modeled alluvial aquifer, is shown in grey. Colored polygons are the model catchments. Model catchments, for which the land surface water budgets are computed, extend beyond the alluvial aquifer, as is most obvious in western Yolo County (hills on Capay, west of Winters, and west of Buckeye Creek. Data sources used to characterize the hydrology, agriculture, and urban water use are summarized in Section 1.4.

Figure 1-1. Spatial domain of the Land Surface Budget



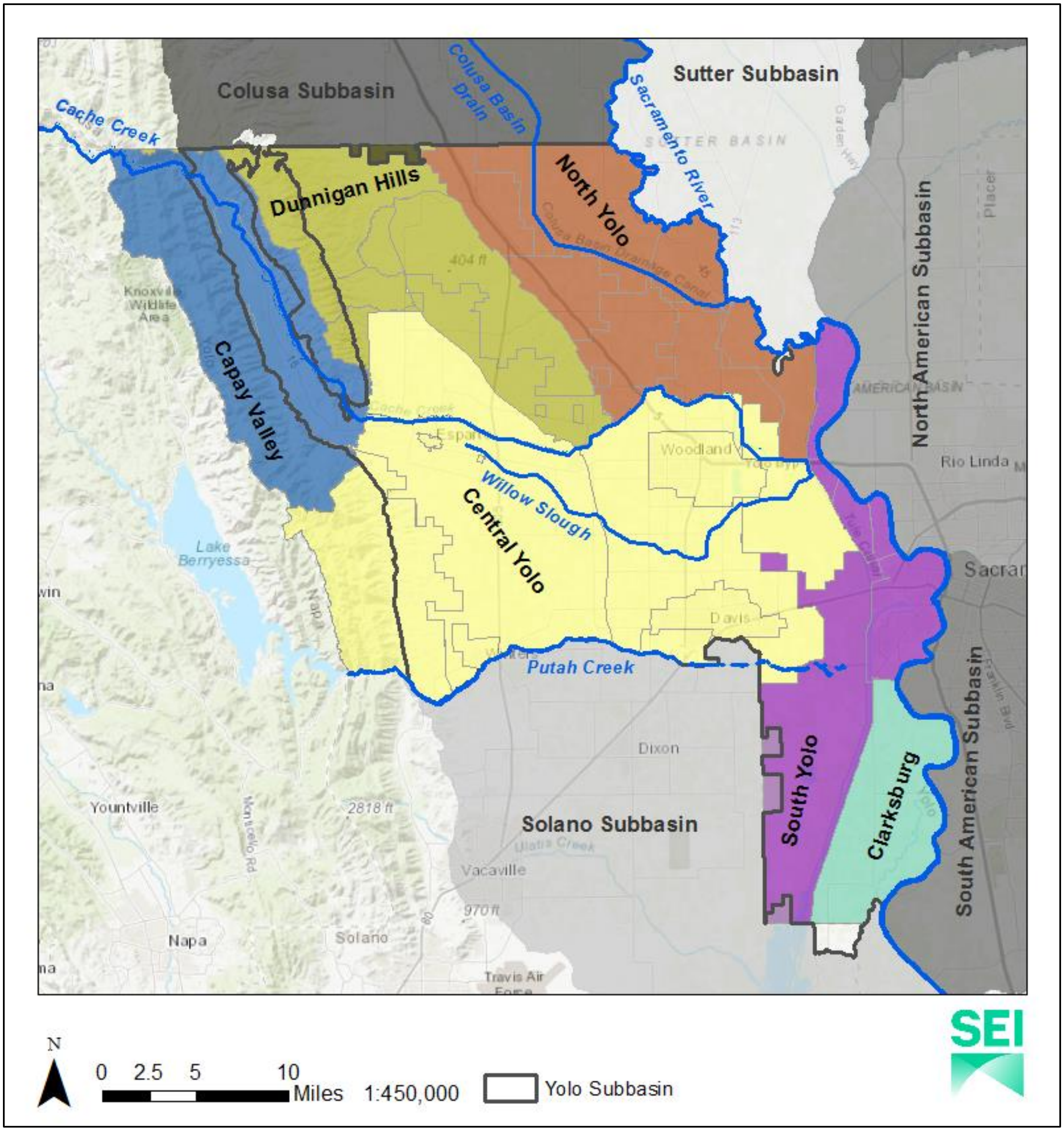
Catchments within Yolo County are shown as colored polygons, and catchments upstream of Capay Valley in the Cache Creek Watershed are shown in shades of grey. See the following figure for each catchment labeled by name. WEAP objects used to develop the WEAP schematic are also shown.

Figure 1-2 Spatial domain of the MODFLOW groundwater model along with catchment boundaries.



Black boundary represents the official Basin boundary. The MODFLOW grid, which represents the modeled alluvial aquifer, is shown in grey. Colored polygons are the model catchments. Model catchments, for which the land surface water budgets are computed, extend beyond the alluvial aquifer, as is most obvious in western Yolo County (hills in Capay, west of Winters, and west of Buckeye Creek).

Figure 1-3 Management Areas in the Yolo Basin and Neighboring Subbasins



The colored polygons show the model boundaries used to aggregate the land surface water budget for corresponding Management Areas. Entity boundaries are shown in light gray within the management areas. The Yolo Subbasin is outlined in thick gray lines. Neighboring basins are shaded in grays. Major surface water bodies are labeled for reference. Official Management Area boundaries in this figure correspond to the intersection of the Yolo Basin boundary with the colored polygons.

Table 1-2 Subdivisions of the YSGA model

Modeled Area name	Entity name/White Area name	Area (ac)
Entire Modeled Area	Yolo County and Cache Creek watershed in Lake County	1,197,657
Yolo County		639,089
Capay Valley Management Area		85,515
Capay Other	White Area, small towns	67,097
YCFC Capay	YCFC, Yocha Dehe Wintun Nation, Small towns	18,418
Central Yolo Management Area		242,680
Davis catch	Davis	8,688
Esparto CSD catch	Esparto CSD	446
Madison CSD catch	Madison CSD	68
RD 2035	RD 2035	20,375
UCD catch	UCD	3,701
Willow Slough	White Area	44,339
Winters catch	Winters	2,053
Woodland catch	Woodland	12,701
YCFC East	YCFC	55,340
YCFC Hungry Hollow	YCFC	23,872
YCFC West	YCFC	71,097
Clarksburg Management Area		36,500
North Delta East	RD 150, RD 307, RD 765, Most of RD 999	36,500
Dunnigan Hills Management Area		92,345
Bird Creek	White Area	3,467
Buckeye Creek	White Area	34,409
Dunnigan Other	Cal Am Water Dunnigan, White Area	28,916
Goodnow Slough	White Area	4,083
Oat Creek	White Area	4,742
YCFC Dunnigan Hills	YCFC	16,728
North Yolo Management Area		103,770
Cacheville CSD catch	Cacheville CSD	98
CBD North	White Area	5,119
CBD South	White Area	12,177
Dunnigan Water District	Dunnigan Water District	11,597
Knights Landing CSD catch	Knights Landing CSD	162
RD 108	RD 108	25,075
RD 730	RD 730	4,829
RD 787	RD 787	10,286
Sac River	White Area	7,833
YCFC Zamora	YCFC	669
Yolo Zamora North	White Area	10,581

Modeled Area name	Entity name/White Area name	Area (ac)
Yolo Zamora South	White Area	15,344
South Yolo Management Area		78,279
North Delta West	Parts of 2068, White Area	49,635
RD 1600	RD 1600	7,056
RD 537	RD 537	2,455
RD 785	RD 785	3,226
RD 827	RD 827	1,189
West Sac catch	West Sac, RD 900	14,718
Cache Creek Watershed		558,568
Bear Creek		66,247
Copsey Creek		20,384
Clear Lake		244,881
Kelsey Creek		26,165
Lower Indian Valley		66,445
Middle Indian Valley		36,751
Seigler Canyon		13,791
Upper Indian Valley		38,538
Upper Cache Creek		45,368
Yolo Subbasin		559,840
Yolo Subbasin (Official)		540,400

The WEAP portion of the YSGA model, which represents the land surface system and hydrology, covers 1,197,657 acres (Table 1-2). This includes all of Yolo County (639,089 acres in the WEAP portion of the model) and the Cache Creek system in Lake County (558,568 acres).

The MODFLOW portion of the YSGA model covers 559,840 acres (Table 1-2). Due to the resolution and spatial extent of the MODFLOW model (as mentioned earlier, derived from the IWFM model), and the pre-existing WEAP model which covers the entire county, there are small differences between the official Basin boundary (540,400 acres) and the YSGA's MODFLOW groundwater model boundary (Table 1-3). Figure 1-4 below shows these differences, and Table 1-3 explains them. The total area of these differences is very small (19,440 acres, less than 3% of the Yolo subbasin), and will not affect the model estimates significantly.

Figure 1-4 Differences between model domain and GSA/management area boundaries

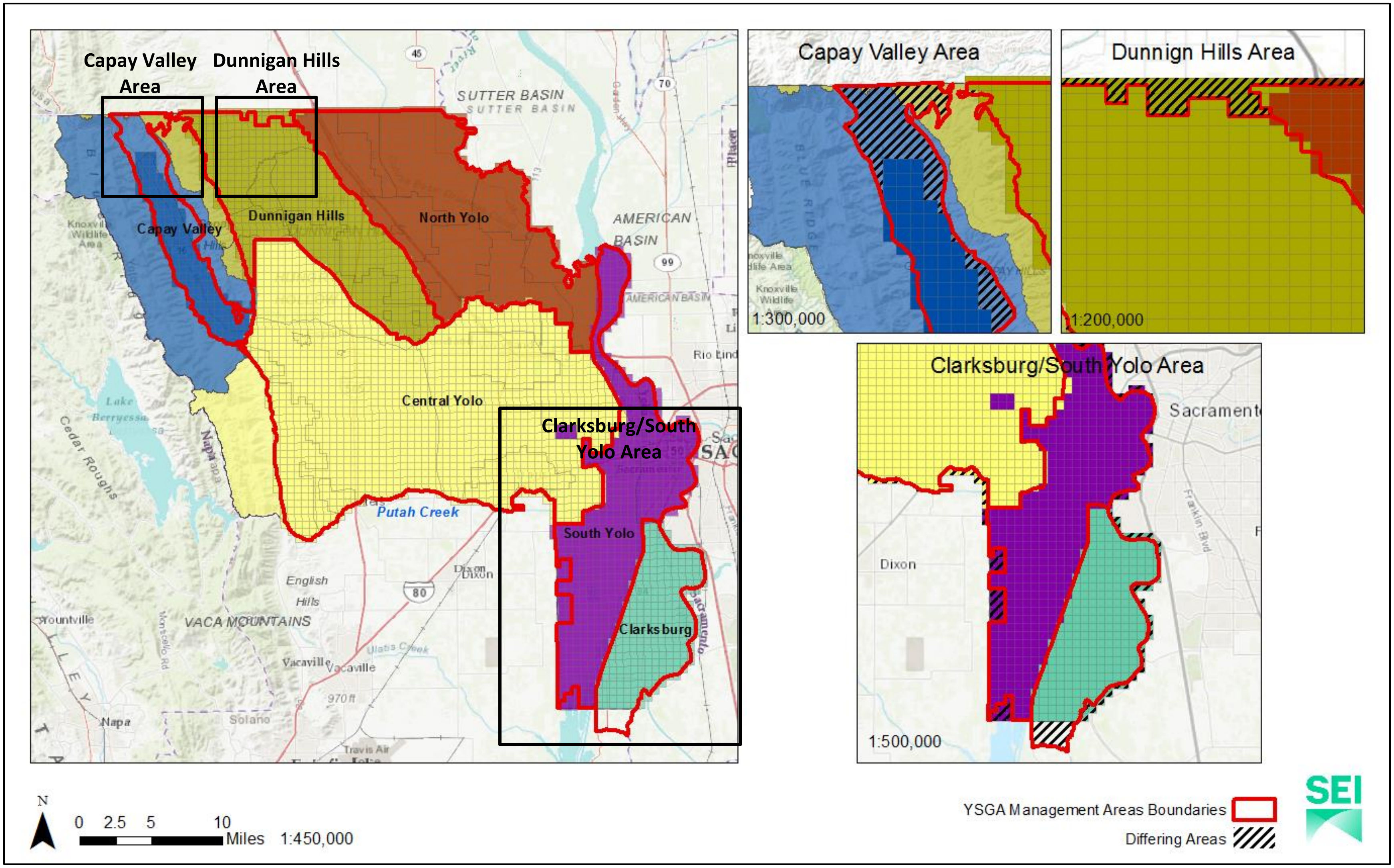


Table 1-3. Model domain difference from Yolo basin boundary

Region	Description	Status
Dunnigan Hills Area	Northern boundary of basin and county	This region is within the model domain because it is within Yolo County; but not included in the Yolo subbasin boundary.
Clarksburg/ South Yolo Area	Southern tip of Clarksburg Management Area	This region is included in the Yolo subbasin boundary, but is not included within the model because of data challenges related with the area being outside of the county.
Clarksburg/ South Yolo Area	Small cut outs in South Yolo Management Area	This region is included in the model because it is in Yolo County but not included in the Yolo subbasin.
Capay Valley Area	Uppermost, hilly portion of Capay bordering Buckeye creek headwaters	This portion is included in the model's land surface budget, but the MODFLOW grid and associated information shows that the alluvial aquifer does not extend into the hills; hence it is not included in the MODFLOW model however recharge from this region does enter the groundwater model (Also see Figure 1-2)

1.2.1 Upper Cache Creek Watershed Representation

The surface hydrology and reservoir operations of the entire Cache Creek watershed above the Yolo sub-basin is represented in the YSGA model because Indian Valley Reservoir and Clear Lake provide substantial surface water for irrigation in the Yolo sub-basin. Groundwater in this area upstream of the Yolo sub-basin in Lake County is not modeled with MODFLOW. Instead it is represented using a lumped parameter model described below. The upper watershed is divided into 9 catchments (Figure 1-5). Catchment boundaries are an aggregated version of the HUC-12 watersheds layer. This aggregation was based on climate considerations, the locations of major infrastructure (reservoirs), in-stream flow requirements, and flow gauges. This portion of the model remains largely unchanged from the previously developed WEAP model, except for extending the input climate datasets (Mehta et al., 2013). Just as in the catchments that are within the Yolo sub-basin downstream, upstream climate and land-cover information is used to simulate rainfall-runoff, evapotranspiration and water demands. These catchments' water balance is calculated at a monthly time step using WEAP's soil moisture method (SMM). Runoff, interflow and baseflow from these catchments combine to simulate streamflow in Cache Creek, the North Fork of Cache Creek, Copsey Creek, Bear Creek and Kelsey Creek. The reason for the difference in algorithms between upstream and valley water balances is that the SMM model is better suited for simulating regions dominated by natural hydrology, while the MABIA module is better suited for simulation of irrigated agriculture. Details of these calculations are given in Section 1.3. Soil water parameters in these catchments were adjusted during calibration of streamflow using observations at three-gauge locations from 1971 to 2000. Streamflow calibration is described in more detail in Section 3.2.3.

Clear Lake and Indian Valley reservoirs and their operations are simulated based on the Gopcevic Decree (for flood releases) and Solano Decree (for irrigation releases), providing water for irrigation to the Yolo

County Flood Control and Water Conservation District (YCFC) catchments within the county. A detailed explanation of the representation of these reservoir operations is provided in Section 3.1.2, where the representation of YCFC is explained in detail.

Demands in the upper Cache Creek watershed are as represented in the Central Valley Planning Area model used in the Department of Water Resources Water Plan Updates.

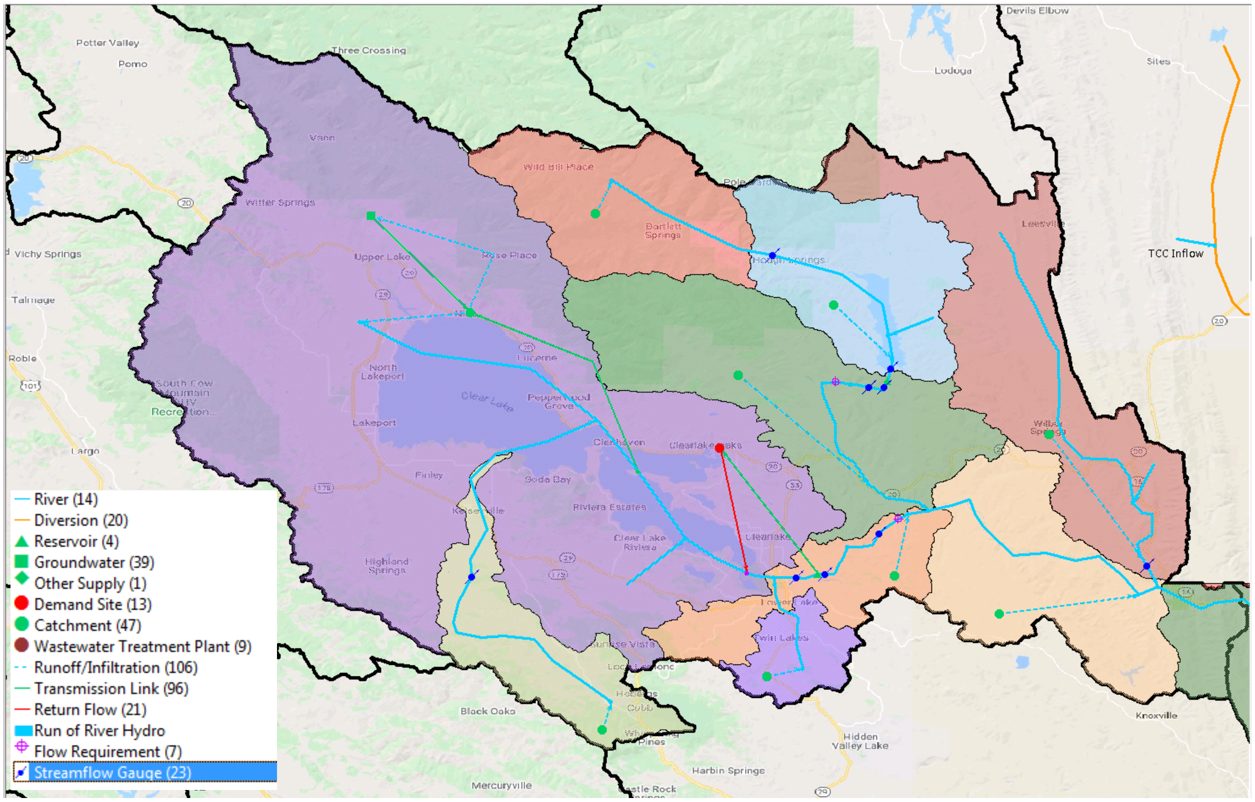


Figure 1-5. Representation of the Cache Creek watershed in the WEAP schematic view

1.2.2 Yolo County Representation

In Yolo County, the modeled area is divided into 38 catchments. These catchments represent the entities as well as parts of the landscape that are not covered by an entity's service area. Figure 1-2 shows the area that is represented by each catchment within WEAP, and its corresponding name. Catchment boundaries were developed using the water agency and urban boundaries, previously developed groundwater models' area boundaries and USGS Hydrologic Unit Code (HUC) 8[5] area boundaries. Some entity areas are divided into multiple catchments (e.g., YCFC), and some are fully contained in only one catchment.

The surface water balance of the 38 catchments within the County is calculated on a daily time step. This includes irrigation demand, evapotranspiration, and runoff, using climate and land use data inputs to WEAP's MABIA method, as described in Section 1.3.2. If irrigation occurs within the entity's boundary, the catchment is connected to at least one water source by a transmission link (green line) which delivers water from the source to the catchment. If irrigation water is available, the irrigation demand is

[5] See https://water.usgs.gov/GIS/huc.html for more information on the USGS hydrologic unit divisions of the U.S.

met up to the limit of available water, either from surface water or groundwater. Surface water is limited by water rights, canal constraints, and water availability. In most catchments, groundwater is not limited.

All catchments are connected to a groundwater node and surface water body by a runoff/infiltration link (blue dotted line) to allow for runoff and infiltration to flow from the catchment area to the receiving water bodies. Some catchments provide runoff to more than one surface water body because the catchment area overlies two watersheds (Table 1-4).

The County area of the model contains 37 groundwater objects (green squares) which represent the area of the underlying aquifer within the associated catchment. The boundaries of the groundwater objects in the model are the same as the boundaries of the catchments for all catchments except Capay Other and YCFC Capay, and catchments that do not entirely fall within the groundwater basin. Given the idiosyncrasies of how WEAP reports MODFLOW results, having the groundwater object boundaries follow the catchment boundaries simplifies groundwater budget reporting. In the Capay Valley, there is only one groundwater object which represents the aquifer underlying both catchments. The entirety of the Yolo Subbasin is modeled within MODFLOW.

If an entity has water demands other than irrigation (for example, cities), the entity is also represented by a demand object (red dot, Figure 1-1), and often this is connected to a wastewater treatment plant. The demand object is connected to at least one water supply to meet the corresponding demands. Entities that have access to both surface water and groundwater are set up such that they use surface water primarily, if it is available, and only use groundwater when there is not sufficient surface water to meet the demand.

Table 1-4. WEAP catchments and percentage of their area that runs off into the watersheds within Yolo County.

WEAP catchment Name	Water body	Percent of area's runoff contributing to water body	WEAP catchment Name	Water body	Percent of area's runoff contributing to water body
Bird Creek	Colusa Basin	100	RD 785	Bypass	100
Buckeye Creek	Colusa Basin	100	RD 787	Sac River	55
Cacheville CSD catch	Cache Creek	100	RD 787	Colusa Basin	45
Capay Other	Cache Creek	100	RD 827	Bypass	78
YCFC Capay	Cache Creek	100	RD 827	Willow Slough	22
CBD North	Colusa Basin	100	Sac River	Sac River	73
CBD South	Bypass	40	Sac River	Cache Creek	25
CBD South	Cache Creek	45	UCD catch	Putah Creek	100
CBD South	Colusa Basin	15	West Sac catch	Sac River	100
Davis catch	Bypass	100	Willow Slough	Putah Creek	48
Dunnigan Other	Colusa Basin	100	Willow Slough	Willow Slough	52
Dunnigan Water District	Colusa Basin	100	Winters catch	Putah Creek	100
Esparto CSD catch	Cache Creek	32	Woodland catch	Cache Creek	56
Esparto CSD catch	Willow Slough	68	Woodland catch	Willow Slough	44
Goodnow Slough	Cache Creek	85	YCFC Dunnigan Hills	Cache Creek	56
Goodnow Slough	Colusa Basin	15	YCFC Dunnigan Hills	Colusa Basin	44
Knights Landing catch	Sac River	100	YCFC East	Bypass	14
Madison CSD catch	Willow Slough	100	YCFC East	Cache Creek	21
North Delta East	Bypass	100	YCFC East	Putah Creek	16
North Delta West	Bypass	80	YCFC East	Willow Slough	49
North Delta West	Putah Creek	20	YCFC Hungry Hollow	Cache Creek	100
Oat Creek	Colusa Basin	100	YCFC West	Putah Creek	31
RD 108	Colusa Basin	74	YCFC West	Willow Slough	69
RD 108	Sac River	26	YCFC Zamora	Colusa Basin	100
RD 1600	Bypass	100	Yolo Zamora North	Colusa Basin	100
RD 2035	Bypass	37	Yolo Zamora South	Cache Creek	20
RD 2035	Cache Creek	22	Yolo Zamora South	Colusa Basin	80
RD 2035	Willow Slough	40			
RD 537	Bypass	100			
RD 730	Bypass	100			

1.3 Model Computation

This section summarizes the algorithms used for various modeling aspects in the YSGA model, with references to published literature for the detailed equations.

As mentioned in Section 1.1, the surface water budget (climate-driven hydrology and water allocation) is computed by WEAP's built-in routines, while the groundwater flow is computed by MODFLOW (Table 1-5).

Table 1-5 Computational aspects of model

YSGA Model regions	Algorithm within WEAP	Reference to algorithm details	Computation time step	Reporting time step
Watersheds in Lake county	Soil Moisture Model	(Yates, 1996; Yates et al., 2005a, 2005b)	Monthly	Monthly
Catchments within Yolo basin	MABIA	(Jabloun and Sahli, 2012)	Daily	Monthly
Valley floor	MODFLOW	(Harbaugh, 2005)	Sub-daily	Monthly

WEAP has several built-in soil moisture budget algorithms to choose from. WEAP uses a Linear Program solver to allocate water from one or more sources to one or more demands, at every time step, based on a user-defined assignment of supply preferences and demand priorities. The allocation is constrained by operations rules such as reservoir release rules, canal capacities, and diversion restrictions based on water rights. This allocation routine is the same irrespective of which soil moisture budget is chosen.

1.3.1 Soil Moisture Method (SMM)

In the YSGA model, the upstream Clear Lake catchment's surface water budget, which is outside the MODFLOW model domain, is computed by WEAP's Soil Moisture Method (SMM) algorithm, at a monthly time step. The SMM equations are extensively described in Yates et al. (2005b) and online[6]. The root zone soil moisture balance is expressed as a one-dimensional differential equation which is solved at each time step (See Figure 1-6).

$$Rd_j \frac{dz_{1,j}}{dt} = P_e(t) - PET(t)k_{c,j}(t)\left(\frac{5z_{1,j} - 2z_{1,j}^2}{3}\right) - P_e(t)z_{1,j}^{RRF_j} - f_j k_{s,j} z_{1,j}^2 - (1-f_j)k_{s,j} z_{1,j}^2 \qquad \text{Eq.1}$$

where $z_{1,j}$ ranges from 0.0 to 1.0 and is the relative storage given as a fraction of the total effective storage of bucket 1 (the root zone), Rd_j (mm) for land cover fraction, j. The effective precipitation, P_e, gets partitioned into the various outflows, ET (second term on right); Runoff (third term), interflow (fourth term) and deep percolation (5th term). In Eq 1., the calculation for the potential evapotranspiration, PET, is done using the Penman-Monteith equation modified for a standardized crop of grass, 0.12 m in height and with a surface resistance of 69 s/m. The $k_{c,j}$ is the crop/plant coefficient for each fractional land cover. The third term represents surface runoff, where RRF_j is the Runoff Resistance Factor of the land cover. Higher values of RRF_j lead to less surface runoff. The fourth and fifth terms are the interflow and deep percolation terms, respectively, where the parameter $k_{s,j}$ is an estimate of the root zone saturated conductivity (mm/time) and f_j is a partitioning coefficient related to soil, land cover type, and topography that fractionally partitions water both horizontally and vertically. In Figure 1-6, deep percolation feeds a second bucket which represents the aquifer. This bucket produces baseflow which is a function of a conductivity term and the relative storage in bucket 2.

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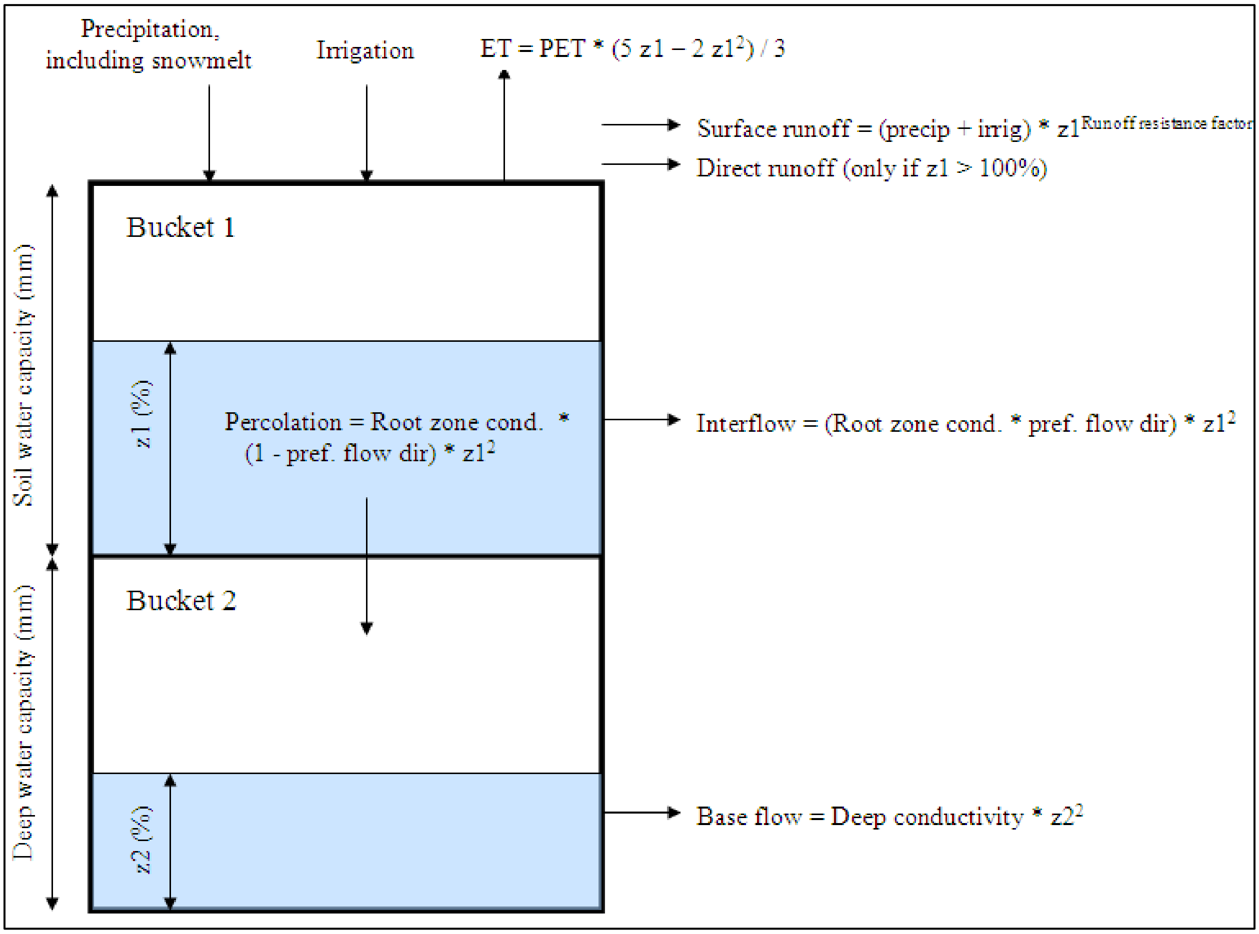
[6] See https://www.weap21.org/WebHelp/Two-bucket_Method.htm#:~:text=The%20Soil%20Moisture%20Method%20calculates,water%20above%20ground%20to%20decrease. Accessed 8.31.2020.

Figure 1-6 Conceptual diagram of the Soil Moisture Method



1.3.2 MABIA Method

The MABIA Method is used in the YSGA model to simulate surface hydrology in the catchments overlying the MODFLOW groundwater model. MABIA is a daily simulation of transpiration, evaporation, irrigation requirements and scheduling, crop growth and yields. It was derived from the MABIA suite of software tools, developed at the Institut National Agronomique de Tunisie by Dr. Ali Sahli and Mohamed Jabloun. The algorithms and descriptions contained here are for the combined MABIA-WEAP calculation procedure. All the equations are described in (Jabloun and Sahli, 2012).

The MABIA Method uses the standard and well-known 'dual crop coefficient ' K_c method, as described in the classic FAO-56 article (Allen et al. 2005) whereby the K_c value is divided into a 'basal' crop coefficient, K_{cb}, and a separate component, K_e, representing evaporation from the bare soil surface. The basal crop coefficient represents actual ET conditions when the soil surface is dry but sufficient root zone moisture is present to support full transpiration.

In all catchments within the subbasin, irrigation demand and evapotranspiration from the land surface are calculated on a daily time step using the dual crop coefficient approach described in Food and

Agricultural Organization (FAO) Irrigation and Drainage Paper No. 56 (FAO 56)[7]. The method requires climate data inputs (described in Section 2.1.2) to calculate a reference evapotranspiration using the Penman-Monteith Equation. Individual crops are assigned crop coefficients (described in Section 2.1.3) that are used to scale the reference evapotranspiration to reflect crop planting dates, canopy development rates, and harvest dates. This approach is also used to simulate bare soil evaporation and water use by native vegetation.

MABIA estimates the soil moisture budget by estimating ET, surface runoff, infiltration, and deep percolation. It requires specification of soil parameters such as soil water capacity and soil depth. The Soil Conservation Service (SCS) curve number method is used in a modification to the MABIA method to calculate effective rainfall (NRCS, 1986; SCS, 1972). MABIA uses the reference evapotranspiration, crop specific parameters, and soil moisture status to calculate an irrigation demand for each crop type. In WEAP, these demands are met either by available surface and/or groundwater. Water availability is specific to the water rights and wells used by each entity, as described in Section 2.1.5.

1.3.3 MODFLOW and WEAP-MODFLOW linkage

MODFLOW is a three-dimensional finite-difference groundwater modeling platform created by the U.S. Geological Survey (USGS). When linked, data and results flow back and forth between WEAP and MODFLOW for each WEAP calculation timestep. With this coupling between the models, it is possible to study how changes in management on the surface (recharge and pumping) affect the overall system (e.g., groundwater-stream interactions, drawdown, and lateral groundwater flows).

The versions of MODFLOW that can be linked to WEAP are MODFLOW 2000, MODFLOW 2005 and MODFLOW-NWT[8]. MODFLOW simulates steady and nonsteady flow in an irregularly shaped flow system in which aquifer layers can be confined, unconfined, or a combination of confined and unconfined. Flow from external stresses, such as flow to wells, areal recharge, evapotranspiration, flow to drains, and flow through riverbeds, can be simulated. Hydraulic conductivities or transmissivities for any layer may differ spatially and be anisotropic (restricted to having the principal directions aligned with the grid axes), and the storage coefficient may be heterogeneous. Specified head and specified flux boundaries can be simulated as can a head dependent flux across the model's outer boundary that allows water to be supplied to the boundary in the modeled area at a rate proportional to the head difference between a location outside the modeled area and the boundary cell.

The ground-water flow equation is solved using the finite-difference approximation. The flow region is subdivided into cells in which the medium properties are assumed to be uniform. In plan view, the cells are made from a grid of mutually perpendicular lines that may be variably spaced. Model layers can have varying thickness. A flow equation is written for each cell. Several solvers are provided for solving the resulting matrix problem; the user can choose the best solver for the particular problem. Flow-rate and cumulative-volume balances from each type of inflow and outflow are computed for each time step.

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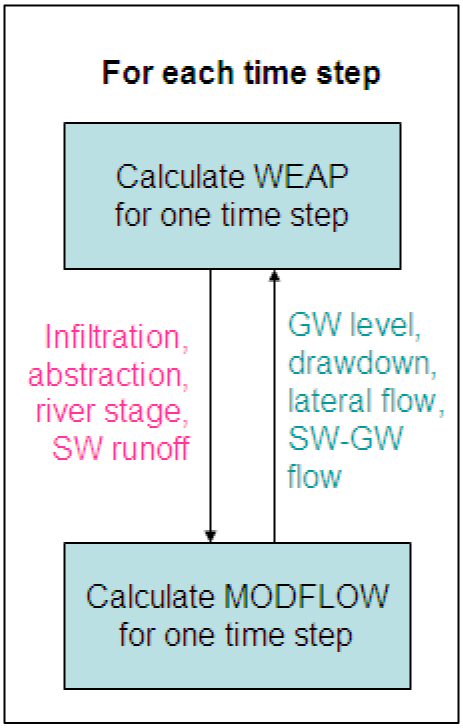
[7] http://www.fao.org/3/X0490E/X0490E00.htm

[8] See https://water.usgs.gov/ogw/modflow/modflow or http://water.usgs.gov/nrp/gwsoftware/modflow2000/modflow2000.html or http://en.wikipedia.org/wiki/MODFLOW

For more information about MODFLOW, see the USGS MODFLOW home page, Online Guide to MODFLOW, or the MODFLOW User Guide.

Figure 1-7 shows the linkage between MODFLOW and WEAP. At each WEAP time step, WEAP passes key fluxes it has computed (deep percolation, pumping demand, river stage) to MODFLOW, which then runs using a stress period the same length as the WEAP time step, and passes back to WEAP its calculation of the groundwater flux, stream seepage, drainage flows, and groundwater elevations.

Figure 1-7 WEAP-MODFLOW linkage



The MODFLOW model grid for the YSGA model is shown in Figure 1-2. Active cells correspond to those areas that have an underlying aquifer layer below the land surface. All model parameters were imported, as a starting point, from the IWFM model (Flores Arenas, 2016). Some parameters were adjusted during the calibration process, which is detailed in Section 3.

On the surface, the MABIA module of WEAP calculates evapotranspiration, irrigation demands, infiltration, and runoff at a daily timestep. The daily information is summed and passed as a monthly value for pumping and recharge to MODFLOW at the spatial scale of the catchment. Water availability from rivers, streamflows, flows in canals, and all other surface water related information is simulated at a monthly timestep using the water allocation routines in WEAP. Stream stage is passed to MODFLOW. MODFLOW calculates the groundwater balance, boundary flows, and resulting groundwater elevation and reports it back to WEAP on a monthly timestep.

1.4 Data Sources

This section summarizes the data sources used in the YSGA model for the historical period, and the main assumptions for both historical and future scenarios.

Table 1-6 Summary of data sources used in the YSGA model

Category	Variable	Historical		Future Projections	
		Sources	**Model use**	**Sources**	**Model use**
Climate	Precipitation	PRISM[1]	Input data	Historical, modified by Climate Change factors provided by DWR	Input data
	ETo	CIMIS[2]	Calibration	Historical, modified by Climate Change factors provided by DWR	Input data
	Minimum Temperature	PRISM[1]	Input data	NA	
	Maximum Temperature	PRISM[1]	Input data	NA	
	Wind speed	(Livneh et al., 2013); CIMIS[2]	Input data	NA	
	Humidity	PRISM[1]	Input data	NA	
Land Use	Agricultural land use	DWR Land Use Surveys3; Yolo County Annual Agriculture Commissioner Reports; DWR SGMA Portal (LandIQ dataset)	Input data	Agricultural land use kept constant to Current Year	Input data
	Non-agricultural land uses	DWR Land Use Surveys[3];	Input data	Growth projections from urban head plans[6]	Input data
Irrigation	Schedule	Sacramento-San Joaquin basin Study[4] (Reclamation, 2015)	Input data	Same as historical	Input data

Category	Variable	Historical		Future Projections	
		Sources	**Model use**	**Sources**	**Model use**
	Crop coefficients	Sacramento-San Joaquin basin Study[4] (Reclamation, 2015)	Input data; Calibration	Same as historical	Input data
	Irrigation efficiency	NA	Calibration	Same as historical	Input data
	Applied Water	DWR Applied Water Estimates[5], Groundwater management plans and personal communication[6]	Calibration	NA	Model output
	Water sources and supply	SWRCB eWRIMS water rights database[7], personal communication[6]	Input Data	Same as historical	Input Data
Urban	Water demand, including population	Urban water plans and personal communication[6]; CA Department of Finance Population data[8]	Input data	Growth projections from urban master plans[6]	Input data
Urban	Water sources and supply	Urban water plans and personal communication[6]; SWRCB eWRIMS water rights database[7]	Input data (water rights)	Urban water plans[6]	Input data (water rights)
Hydrology	Stream flows	USGS[9]; CDEC[10]	Calibration	NA	Model output
Hydrology	Stream flows	USGS9; CDEC[10]	Input Data	Same as historical	Input data
Hydrology	Initial groundwater conditions	WRID[11]; SGMA[12]; IWFM model (Flores Arenas, 2016)	Input data	Historical model end-of simulation set as future model run initial conditions	Input data
Hydrology			Input data,	NA	Input data

Category	Variable	Historical		Future Projections	
		Sources	**Model use**	**Sources**	**Model use**
	Groundwater boundary conditions	IWFM model (Flores Arenas, 2016)	Calibration		
	Groundwater elevations (time series)	WRID[11]; SGMA[12]; WDL [13];	Calibration, Model output	NA	Model output
	Reservoir operations (storage levels, outflows)	CDEC[10]; Conversations with and data supplied by YCFC[6]	Calibration, Model output	NA	Model output
	In-stream flow requirements	CDEC[10]; Conversations with and data supplied by YCFC[6]	Input data	Same as historical	Input data

1 http://www.prism.oregonstate.edu/explorer/ Accessed 5.19.2019

2 https://cimis.water.ca.gov/Default.aspx . Accessed 5.19.2019

3 https://gis.water.ca.gov/app/CADWRLandUseViewer/ Accessed 9.1.2020

4 https://www.usbr.gov/watersmart/bsp/docs/finalreport/sacramento-sj/Sacramento_SanJoaquin_TechnicalReport.pdf Accessed 9.1.2020

5 https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates Accessed 2.1.2019.

6 A complete list of entity-specific data sources and personal communication is provided in the Model Documentation Appendix, and in spreadsheet format to the YSGA

7 https://www.waterboards.ca.gov/waterrights/water_issues/programs/ewrims/

8 http://www.dof.ca.gov/Forecasting/Demographics/Estimates/

9 https://waterdata.usgs.gov/nwis/sw

10 https://cdec.water.ca.gov/

11 Yolo County Water Resources Information Database (https://wrid.facilitiesmap.com/Login.aspx)

12 SGMA Data Viewer https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#gwlevels

13 California Water Data Library https://wdl.water.ca.gov/GroundWaterLevel.aspx

2 Model Input Data

2.1 Surface Water Model Inputs

2.1.1 Land Use Data

Land use information for areas within Yolo County were gathered from several sources to create an annual time series of land use over the historical simulation period (WY 1971-WY 2018). In the Upper Cache Creek watersheds in Lake County, it was assumed that recent land cover surveys represent conditions for the entire study period since much of the area is native vegetation.

2.1.1.1 Cache Creek Upper Watershed

In these catchments, land cover information is static and sourced from the National Landcover Data Set (NLCD)[9] for year 2001. The spatial data set was intersected with the catchment boundaries (Figure 1-5) to extract the area of each landcover type in each catchment. Table 2-1 shows the land use categories for these catchments and the corresponding descriptions from NLCD.

Table 2-1. Land Use categories for the Cache Creek Watershed catchments.

NLCD Code	*NLCD Name*	*WEAP Landuse Category*
11	Open Water	Water
21	Developed, Open Space	Developed, Open Space
22	Developed, Low Intensity	Developed, Low Intensity
23	Developed, Medium Intensity	Developed, Medium Intensity
24	Developed, High Intensity	Developed, High Intensity
31	Barren Land (Rock/Sand/Clay)	Barren
41	Deciduous Forest	Forest
42	Evergreen Forest	Forest
43	Mixed Forest	Forest
52	Shrub/Scrub	Forest
71	Grassland/Herbaceous	Grassland
81	Pasture/Hay	Pasture
82	Cultivated Crops	Cultivated
90	Woody Wetlands	Water
95	Emergent Herbaceous Wetlands	Water

[9] https://www.mrlc.gov/data

2.1.1.2 Yolo County Catchments

Within Yolo County, several data sources were used to assemble a time series of agricultural and non-agricultural land use for each catchment. Table 2-2 summarizes the different datasets used for different time periods. Figure 2-1 provides a visual narrative of data used for each catchment.

For the period 1975 – 2008, for most of the catchments, the area of each crop category in each catchment was calculated using a combination of (non-spatial) annual Agricultural Commissioner's reports[10] and (spatial) DWR Land Use surveys that were available from 1989, 1996, 2008, 2014 and 2016 (Table 2-2). The spatial distribution of each crop's total acreage (from the Crop Reports) was determined by the DWR Landuse Surveys - available for the years 1989, 1997, 2008, 2014, 2016. Between these years (and before 1981), the spatial distribution is assumed to be constant. Since the total annual irrigated acreage varies every year, the acreage of each crop in each catchment also varies every year. Some exceptions were:

- Some entities collect their own crop coverage data and these were used (Figure 2-1)
- In some cases, the interpolations led to fractional areas less than one acre which were not considered realistic. In those cases, professional judgement was used to make a decision based on a combination of satellite imagery investigations and meetings with Max Stevenson of YCFC.
- Of particular concern was determining irrigated pastures vs not irrigated (especially in Bear Creek, Oat Creek, and Buckeye Creek), and ensuring orchards were being introduced in the correct areas at the correct times, between the gaps in the spatial datasets. Mr. Stevenson, as Assistant General Manager with YCFC is well informed on the land use around the county.

For the 1971-1975 period, total acreage of crops from a 1976 study (Clendenen & Associates, 1976) was used, after finding unexplainable differences between the Agricultural Commissioner's Report and the acreages reported in this study.

After 2008, the Agricultural Commissioner's Crop Reports were not used for total acreage because of several discrepancies that were discussed in a meeting between the model development team and the Deputy Agricultural Commissioner in Woodland. Instead, the spatial datasets of DWR Land Use Surveys from 2014 and 2016 were used (Table 2-2).

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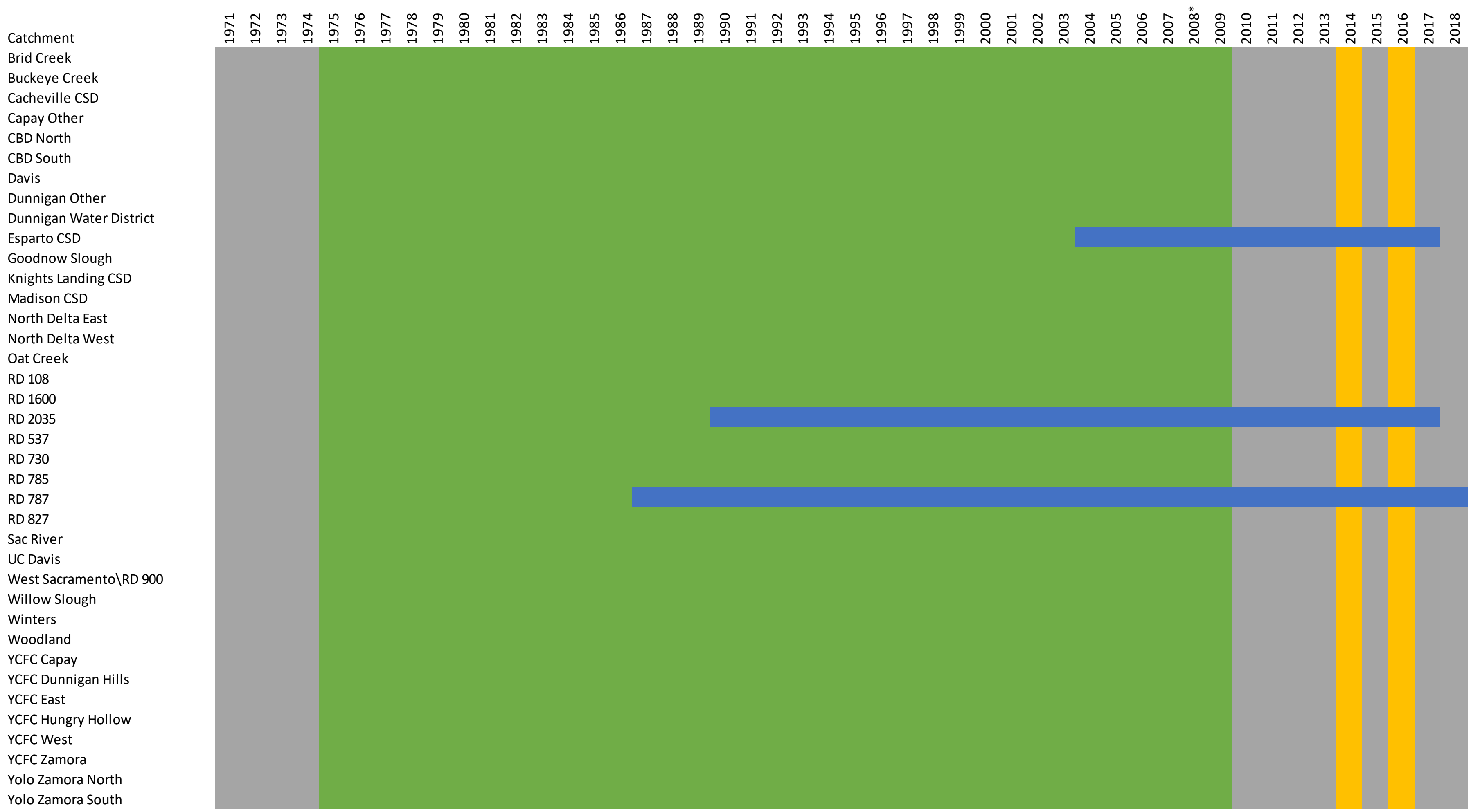
[10] http://www.yolocounty.org/general-government/general-government-departments/agriculture-cooperative-extension/agriculture-and-weights-measures/crop-statistic



[1] Land use data were provided by the district but not sufficient to use

Land use data generated using DWR spatial data and Ag Comissioner Reports

Land use data generated using Land IQ dataset available on SGMA data portal

Land use data provided by the entity

Land use data held constant from the closest year with data

This does not take into account areas that were changed due to input from Max Stevenson, which should be added later.

*In years 2008 onward, modifications were made for new almond orchards: if almond area drastically increased, the new area was considered "young almonds" for the three years before being classified as "almond"

Figure 2-1. Graph showing the data sources used to develop timeseries of annual land use for each entity.

Table 2-2. Explanation of land use data sources for all catchments that did not supply their own data (all except Dunnigan Water District, RD 2035 and RD 787).

Year	Land use data source
1971-1974	Assumed same as 1975 data reported in (Clendenen & Associates, 1976)
1975-1989	Annual Yolo County Agricultural Commissioner's Crop Reports +1989 DWR Land Use Survey: spatial dataset
1990-1997	Annual Yolo County Agricultural Commissioner's Crop Reports + 1997 DWR Land Use Survey: spatial dataset
1998-2009	Annual Yolo County Agricultural Commissioner's Crop Reports + 2008 DWR Land Use Survey: spatial dataset
2010-2013	Held constant from 2009, except where young almonds switches to almonds after 3 years
2014	DWR Land Use Survey based on Land IQ dataset from DWR SGMA Data Viewer: spatial dataset
2015	Held constant from 2014 except where young almonds switches to almonds after 3 years
2016	DWR Land Use Survey based on Land IQ dataset from DWR SGMA Data Viewer: spatial dataset
2017	Same as 2016 except where young almonds switches to almonds after 3 years
2018	Same as 2017 except where young almonds switches to almonds after 3 years

2.1.1.3 Non-agricultural land use

Non-agricultural land use areas in the model within Yolo County are categorized into urban, water and native vegetation These were calculated from DWR Land Use Surveys[11] for years 1989, 1997 and 2008 (Table 2-3). This is a spatial dataset, which was intersected with each catchment to calculate the area of each land use category in each catchment. Prior to 1989 and after 2008 these values were held constant. In RD 2035, an additional non-agricultural land use category called managed wetlands was created. In these areas, the evapotranspiration is modeled the same as native vegetation, however, the area is flooded 12 inches deep between December and August each year (personal communication, Darren Cordova, MBK Engineering, 2018).

Evapotranspiration, rainfall, runoff, and soil moisture are calculated in these non-agricultural areas with the MABIA method the same way they are calculated in the agricultural land. These areas are not irrigated in the model.

[11] https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use

Table 2-3. Non agricultural land use classes included in the Yolo County catchments

WEAP Category	Description	DWR Definition	DWR Landuse Codes
Native Vegetation	The area remaining as the difference between the sum of all other agricultural and non-agricultural classes, and the total catchment area.	N\A	N\A
Urban	All Urban Classes in the DWR spatial datasets	Urban, Urban residential, Commercial, Industrial, Urban landscape, Vacant	U, UR, UC, UI, UL, UV
Water	Water surface	Water surface	NW

2.1.2 Climate Data

The main source of historical climate data was the PRISM dataset (PRISM Climate Group, 2004) (http://www.prism.oregonstate.edu/explorer/ , downloaded on 5/19/2019). Temperature, precipitation and dew point temperature data are available as gridded monthly and daily datasets from 1982 onwards, at 4km resolution. Relative humidity was calculated from dewpoint temperature using Equation 3.1 and from vapor pressure deficit using Equation 3.2.

$$RH = \frac{e_a}{e_s} * 100 \tag{3.1}$$

where:

e_a (P_a) = vapor pressure at dew point temperature T(C) = $0.6108^{17.27T_{dew}/(T_{dew}+237.3)}$

e_s = saturation vapor pressure at ambient temperature T(C) = $0.6108^{17.27T/(T+237.3)}$

$$Rh = 100 - \left(100 * \frac{VPD}{SVP}\right) \tag{3.2}$$

where:

VPD = average vapor pressure deficit

SVP = saturation vapor pressure at ambient temperature T(C) = $0.6108^{17.27T/(T+237.3)}$

Data were averaged over the area of each catchment to develop a single time series of climate data per catchment. For the timeframe when PRISM data are not available (before 1982), or when a variable is not available in PRISM (wind speed), other datasets were use. These are summarized in Table 2-4.

Table 2-4. Climate Data Sources

Variable	Sources
Precipitation	PRISM (1982-2018) (Livneh et al., 2013) (Pre-1982)
ETo	CIMIS[12]
Minimum Temperature	PRISM(1982-2018) (Livneh et al., 2013) (Pre-1982)
Maximum Temperature	PRISM (1982-2018) (Livneh et al., 2013) (Pre-1982)
Wind speed	(Livneh et al., 2013); Upto 2011 CIMIS (2012-2018)
Dew point/vapor pressure	PRISM (1982-2018) (Livneh et al., 2013) (Pre-1982)

2.1.3 Crops

Eighteen irrigated crop categories are represented in the Yolo County catchments (Table 2-5). These categories are nearly identical to those in the DWR Agricultural Land and Water use estimates[13], facilitating calibration of modeled applied water and evapotranspiration to estimates provided by DWR. Table 2-5 shows the crop categories from the DWR Agricultural Land and Water use estimates (column 1), the definition of the categories (column 2), and the land use codes for each category from the DWR Land Use Surveys (column 3). Column 3 refers to the Class 1 and Subclass 1 codes from the DWR Land Use Surveys, which are two separate fields in the DWR Land Use Surveys.

[12] https://cimis.water.ca.gov/Default.aspx . Accessed 5.19.2019
[13] https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates

Table 2-5. DWR crop names, and corresponding model assignations

DWR Category	DWR Crop Definition	DWR Landuse Codes[7]	WEAP category	MABIA crop
Grain	Wheat, barley, oats, miscellaneous grain and hay, and mixed grain and hay	G	Grain	Winter Wheat
Rice	Rice and wild rice	R	Rice	Rice[5]
Cotton	Cotton	F1	Cotton	Cotton
SgrBeet	Sugar beets	F5	Sugar beet	Sugar Beets
Corn	Corn (field and sweet)	F6	Corn	Corn
DryBean	Beans (dry)	F10	Dry Beans	Dry Beans
Safflwr	Safflower	F2	Safflower	Safflower
Oth Fld	Flax, hops, grain sorghum, sudan, castor beans, miscellaneous fields, sunflowers, hybrid sorghum/sudan, millet and sugar cane	F (all other)	Other field	Sunflower[3]
Alfalfa	Alfalfa and alfalfa mixtures	P1	Alfalfa	Alfalfa
Pasture	Clover, mixed pasture, native pastures, induced high water table native pasture, miscellaneous grasses, turf farms, bermuda grass, rye grass and klein grass	P (all other)	Pasture	Irrigated Pasture
Pro Tom	Tomatoes for processing	T15	Tomatoes	Tomatoes
Fr Tom	Tomatoes for market	T26		
Cucurb	Melons, squash and cucumbers	T9	Cucurbits	Squash[1]
On Gar	Onions and garlic	T10	Other truck	Asparagus[4]
Potato	Potatoes	T12		
Oth Trk	Artichokes, asparagus, beans (green), carrots, celery, lettuce, peas, spinach, flowers nursery and tree farms, bush berries, strawberries, peppers, broccoli, cabbage, cauliflower and brussel sprouts	T (all other)		
Al Pist	Almonds and pistachios	D12	Young Almonds [8]	Young Almonds
			Almonds	Almonds
Oth Dec	Apples, apricots, cherries, peaches, nectarines, pears, plums, prunes, figs, walnuts and miscellaneous deciduous	D (all other)	Other Deciduous	Walnuts[2]
Subtrop	Grapefruit, lemons, oranges, dates, avocados, olives, kiwis, jojoba, eucalyptus and miscellaneous subtropical fruit	C	Subtropical	Olives[6]
Vine	Table grapes, wine grapes and raisin grapes	V	Vine	Vines

[1] Based on Yolo County crop reports, melons, squash, and watermelons are grown in the area. Watermelons likely cover the largest area, but good cost and return data do not exist, which was required for economic modeling that will be conducted with this hydrologic model.

[2] Most common deciduous tree grown in Yolo County after almonds

[3] Most common field crop grown in Yolo County, after crops with their own categories

[4] Based on Yolo County crop reports, asparagus, broccoli, lettuce, cucumber, strawberries, are all grown in Yolo, but for purposes of economic modeling, cost studies on asparagus are most relevant for Yolo County.

[5] Rice flooding for decomposition is modeled in all rice areas in Yolo County in addition to typical flooding patterns

[6] Olives (for oil) are an important crop in the region and are becoming increasingly common

[7] Landuse codes are from the DWR Land Use Survey spatial datasets

[8]Starting in 2008, and new areas of almonds were categorized as “Young Almond” for the first three years they exist. After three years, these areas are reclassified as “Almond”

2.1.3.1 Crop Parameters

Within each catchment, each of the irrigated crops has several parameters that define the hydrological characteristics of the crop such as evapotranspiration rate, irrigation management, surface runoff, and deep percolation. These variables are listed in Table 2-6.

Each representative crop is included in the WEAP MABIA crop library which contains crop specific information needed to calculate evapotranspiration and irrigation requirements for that crop. These parameters were adjusted during calibration as described in Section 3.1.3. Other parameters, such as the depletion factor, maximum crop height, minimum and maximum rooting depth, and fraction wetted were based on FAO 56 and were not adjusted during calibration (Table 2 7). The percentage of the irrigation that does not recharge soil moisture and results in deep percolation was based on values found in the SacWAM model (Table 2 8).

Table 2-6. Variables, their description, their set value within the model, and the source used to set their value, as included within all catchments using the MABIA method. Unless otherwise noted, values indicated are for all land use categories, agricultural and non agricultural.

Variable Type	**Variable Name**	**Variable Description**	**Value setting**	**Notes**
Land use	Area	Area of each land use/crop category, within each catchment	See Section 2.1 for land use categories	See Section 2.1.3
	Crops	Representative crop	See Section 2.1 for representative crops and associated parameters	See Section 2.1.3
	Surface Layer Thickness	Depth of surface layer subject to drying by evaporation	0.05 m	
	Total Soil Thickness	Depth of soil moisture simulation.	2 m for irrigated crops 0.5 m for native vegetation	
	Soil Water Capacity	Available water capacity – difference between field capacity and permanent wilting point.	Clay Loam (14.44%)	Common soil type in Yolo County
	Maximum Infiltration Rate	Amount of water than can infiltrate into soil over 24 hours	Unlimited	Default
	Maximum Percolation Rate	Amount of water that can percolate from soil to groundwater over 24 hours	Unlimited for all land use categories except rice, which is set to 0.635 mm/day	Rice is based on UC Cooperative Ext.
	Max Soil Retention	Used in calculating rainfall runoff with Curve Number	See Section 1.3.2	
	Effective Precipitation	Percent of precipitation available for evapotranspiration	See Section 1.3.2	
	Fraction Covered	Effective fraction of soil surface shaded by vegetation	Calculated as per FAO 56	Calculated
	Direct Recharge to Groundwater	Of the precipitation not available for evapotranspiration, the percent that goes directly to groundwater recharge	Zero everywhere except 100% for native vegetation in Buckeye, Oat, Bird, Willow Slough, Dunnigan Other	
Climate	Precipitation	Daily precipitation	See Section 2.1.2	
	ETref	Daily evapotranspiration for a reference land class	Calculated by WEAP using the Penman-Monteith equation	
	Min Temperature	Minimum Daily Temperature	See Section 2.1.2	
	Max Temperature	Maximum Daily Temperature	See Section 2.1.2	
	Latitude	Latitude of catchment's center		
	Min Humidity	Minimum daily relative humidity	See Section 2.1.2	
	Max Humidity	Maximum Daily Relative humidity	See Section 2.1.2	
	Wind	Average daily windspeed	See Section 2.1.2	
	Wind Speed measurement height	Height above ground of measurement of wind speed	2.0 m	
	Altitude	Altitude of catchment	50 m	
	Solar Radiation	Daily solar radiation	Calculated by WEAP using Hargreaves Formula	Calculated
	Krs	Adjustment coefficient for Hargreaves Formula	0.16	Default

Variable Type	Variable Name	Variable Description	Value setting	Notes
Irrigation[1]	Irrigation schedule	Irrigation method and schedule	For all crops except safflower and rice, each crop is fully irrigated from the plant date to harvest date. Safflower irrigation stops 16 days prior to harvest. See section 3.1.3 for details.	
	Fraction Wetted	Fraction of soil surface wetted by irrigation system	Crop specific, based on typical irrigation technology. See Table 2-7.	
	Irrigation Efficiency	Percent of supplied water available for evapotranspiration	See section 3.1.3	Calibrated
	Pump Layer	MODFLOW layer from where irrigation water is pumped	Layer 2 for agricultural water uses	IWFM Model
	Loss to groundwater	Of the supplied water not available for transpiration, the percent that infiltrates to groundwater	Crop-specific. Also modified in calibration – see Table 2-7.	SacWAM Model
	Loss to runoff	Of the supplied water not available for transpiration, the percent that runs off to surface water	100-Loss to groundwater	Calculated
	Irrigation use of runoff	Percent of catchment's runoff which can be used for irrigation internally within the catchment	Catchment specific, see Table 2-8.	
Flooding	Minimum Depth	Minimum required depth of flooding	0 for all land use categories except rice (see section 2.1.3) and managed wetlands (see section 2.1.1.3)	See section 2.1.3 and 2.1.1.3
	Maximum Depth	Maximum allowable depth of flooding	0 for all land use categories except rice (see section 2.1.3) and managed wetlands (see section 2.1.1.3))	See section 2.1.3 and 2.1.1.3
	Target Depth	If flooded depth is at or above minimum, will irrigate until this depth is reached	0 for all land use categories except rice (see section 2.1.3) and managed wetlands (see section 2.1.1.3))	See section 2.1.3 and 2.1.1.3
	Release Requirement	This amount of water will be released from flooded areas to be replaced with new supply	0 for all land use categories except rice (see section 2.1.3)	See section 2.1.3 and 2.1.1.3
	Initial Surface Depth	Initial value for surface depth at beginning of simulation	0 mm	Default
Priority	Irrigation Priority	Priority for irrigation demand. When there are shortages in water supply, demands with highest priority (lowest number value) receive water first	Catchment specific, see Table 2-8.	

Table 2-7. Crop specific parameters used in the MABIA module. Depletion Factor, Maximum Height, Root Depth, Fraction Wetted, and Loss to Groundwater. All values except Loss to Groundwater were based on FAO 56. Loss to Groundwater was based on the SacWAM model.

Crop	Depletion Factor	Maximum Height (m)	Min Root Depth (m)	Max Root Depth (m)	Fraction Wetted	Loss to Groundwater (%)
Alfalfa	0.55	0.7	1.5	1.5	1	94
Almonds	0.4	5	1.5	1.5	0.2	92
Young Almonds	0.4	2	0.75	0.75	0.2	92
Corn	0.55	1	0.15	1.35	0.5	94
Cotton	0.65	1.5	0.15	1.35	0.5	93
Cucurbits	0.5	0.3	0.5	0.5	0.5	93
Dry Beans	0.45	0.4	0.15	0.75	0.5	94
Grain	0.55	1	0.15	1.65	1	94
Other Deciduous	0.5	4	1.7	2.4	0.25	94
Other Field	0.45	2	0.8	1.5	0.5	93
Other Truck	0.45	0.8	1.2	1.8	0.75	94
Pasture	0.55	0.2	1.5	1.5	1	91
Rice	NA	NA	NA	NA	NA	94
Safflower	0.6	0.8	0.15	1.5	0.5	93
Subtropical	0.65	5	1.2	1.7	0.5	94
Sugar Beets	0.55	0.5	0.15	0.95	0.5	92
Tomatoes	0.4	0.6	0.15	1.1	0.5	91
Vines	0.45	2	1	1.5	0.2	92

Table 2-8. Loss to Groundwater Adjustment by Catchment.

Catchment	Loss to groundwater Adjustment	Irrigation use of Runoff (%)	Irrigation Priority[1]
Bird Creek	1	0	7
Buckeye Creek	1	0	7
Cacheville CSD	1	0	7
Capay Other	0.5	0	7
CBD North	0.2	0	7
CBD South	0.1	0	7
Davis catch	0.9	0	7
Dunnigan Other	1	0	7
Dunnigan Water District	0.1	0	7
Esparto CSD	1	0	7
Goodnow Slough	1	0	7
Knights Landing CSD	1	0	7
Madison CSD	1	0	7
North Delta East	0.2	0	7
North Delta West	1	0	7
Oat Creek	1	0	7
RD 108	0.1	90	7
RD 1600	0.7	90	7
RD 2035	0.4	90	7
RD 537	0.1	90	7
RD 730	1	90	7
RD 785	1	90	7
RD 787	0.5	90	7
RD 827	0.2	90	7
Sac River	0.1	90	7
UCD	0.9	0	7
West Sac	0.5	0	7
Willow Slough	1	0	7
Winters	1	0	7
Woodland	0.1	0	7
YCFC Capay	1	0	1
YCFC Dunnigan Hills	1	0	5
YCFC East	0.1	0	3
YCFC Hungry Hollow	0.5	0	4
YCFC West	0.8	0	2
YCFC Zamora	1	0	6
Yolo Zamora North	0.3	0	7
Yolo Zamora South	0.1	0	7

[1]This is only for agricultural irrigation, not domestic water demands or landscaping irrigation in these areas

2.1.3.2 Rice Parameters

Due to its unique cultivation method, rice has a different set of parameters than other crops. In the YSGA, the timing and magnitude of rice flooding was based on a rice management description written by Todd Hillaire of DWR. The flooding pattern begins with a pre-planting irrigation used to saturate the soil and pond water to a depth of 3 inches. This irrigation starts five days prior to planting day. Following planting, the water can drain. After plant emergence, water is ponded to a depth of 5 inches (125 mm) by May 26. This depth is maintained until July 1 at which point the depth is increased to a depth of 8 inches (200 mm) by July 31. This depth is maintained until the end of August at which point the field can drain until September 15.

During the winter months, the fields are flooded to promote rice-straw decomposition and to attract waterfowl. In the YSGA model, this flooding is assumed to start on October 15 and reach a *Target Depth* of 3 inches by January 1. Rainfall can collect in the fields up to a depth of 8 inches. Starting January 15, no more water is added to the fields. During the first two weeks of March, the fields are actively drained to a depth of zero inches.

The Target Depth and Minimum Depth parameters in the MABIA module was set using the time series described above. The maximum depth was specified using the time series described above with the exception at the end of the rice season this value was kept at 8 inches (200 mm) to allow the ponded water to dissipate due to evaporation and deep percolation.

In order to maintain favorable temperature and salinity levels, rice paddies have a continuous flow of water entering and leaving the paddy. In the MABIA module this is expressed as a depth of water per day. Based on the Hillaire description, this parameter was given a value of 2 mm/d to represent the continuous flow of water through the rice paddies.

2.1.4 Climate Change Projections

The California Department of Water Resources (DWR) provides datasets, tools and guidance regarding climate change datasets that can be used by GSA's to develop their GSP's. These datasets are related to climatology, hydrology and water operations. Climatological datasets are provided in the form of change factors for precipitation and reference evapotranspiration, as gridded data for the state. Projected stream flows are available as inflows for major Central Valley streams, and streamflow change factors for other watersheds. Most inflows and all operations data were simulated using the Calsim II model.

Data represent projections for two future climate periods: 2030, and 2070:

- There are 4 scenarios; one for 2030 representing the central tendency from several downscaled climate models; and three for 2070 (central tendency, dry-extreme warming, and wetter with moderate warming)
- The process involved a "climate period analysis". Historical inter-annual variability (1915-2011) is preserved while the magnitude of events is perturbed based on projected temperature and precipitation changes from general circulation models.

2.1.4.1 Processing Steps

The provided climate change datasets (eight in all, covering four scenarios and two change factors, for ETo and precipitation, in each scenario) had to be applied to the historical climate datasets in the YSGA model, for each catchment. The steps involved were:

- Downloading the grid and associated climate change datasets for the extent of the model using the SGMA Data Viewer Tool (accessed online Sept 15 2019) (https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#). There are 157 grid cells covering the rectangular region of the model boundary (See Figure 2-2).
- Using GIS geoprocessing tools, the spatially weighted average of each grid cell intersection with each model catchment boundary was computed, with intersection area composing the weights.
- This weighted average was applied to the historical climate series for that catchment, in every time step from 1971 to 2018 (the historical modeling period). For example,

Consider Pv and Ev are the precipitation and ET factors to be applied to the historical climate data for a catchment C at a particular time step.

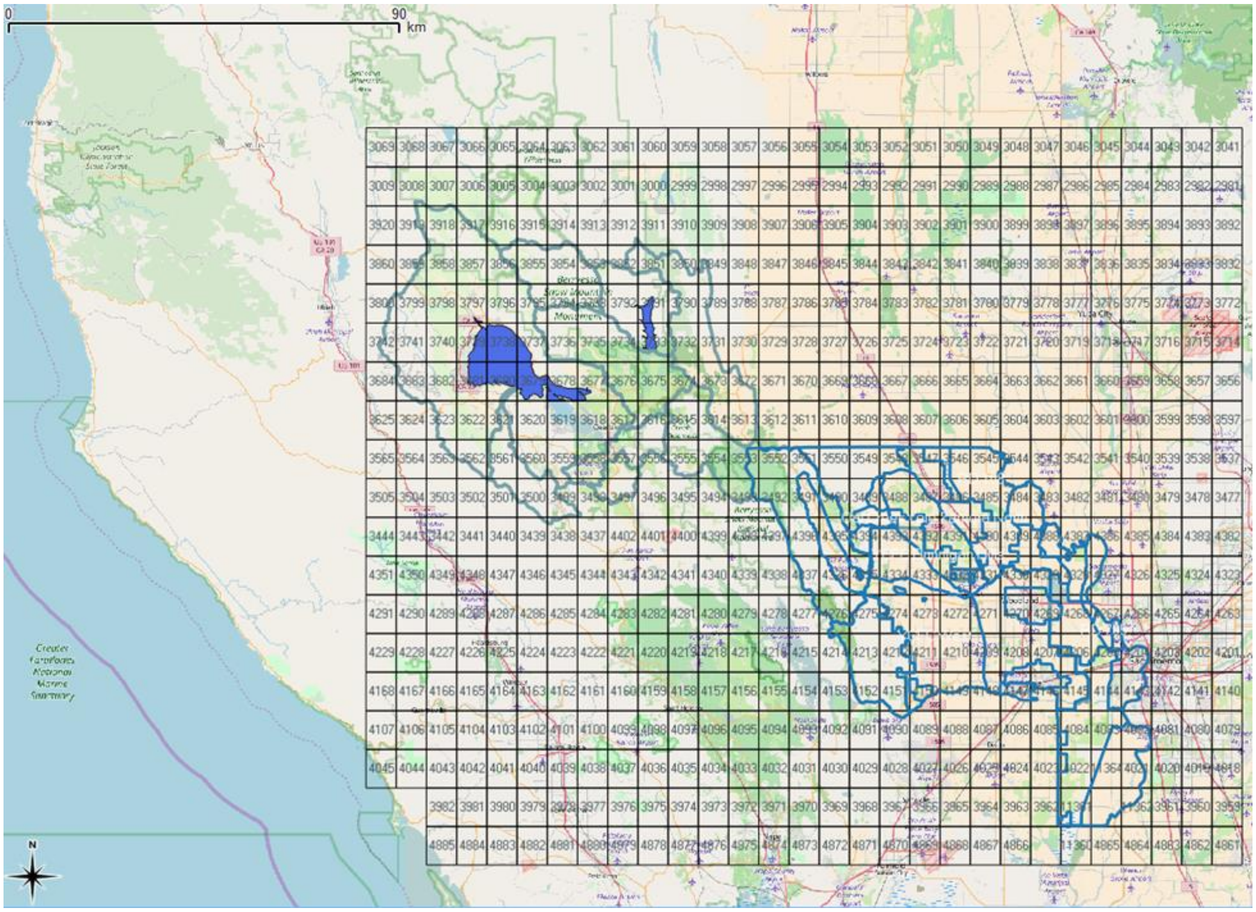
P(c) is a vector of precipitation change factors (available from 1915 to 2011) to be applied to relevant grids intersecting a catchment.

P(c) = avg(Av*Pv); where Av is the fractional area intersection between a climate grid v and the catchment c; and Pv is the Precipitation change factor vector for that grid.

Similarly, E(c), is a vector of ETo change factors (available from 1915 to 2011) to be applied to relevant grids intersecting a catchment.

E(c) = avg(Av*Ev); where Av is the fractional area intersection between a climate grid v and the catchment c; and Ev is the Precipitation change factor vector for that grid.

Figure 2-2. Climate change grids overlaid over YSGA model boundary



However, the climate change factors are available only up to 2011. The following steps were taken to select change factors from water years that came closest to observations from 2011 to 2018:

- Water year types and flows were downloaded from CDEC (accessed 9/30/2019) http://cdec.water.ca.gov/reportapp/javareports?name=WSIHIST
- A historical water year type was assigned to the years 2012 – 2018, based on minimum absolute difference in Sacramento River Index WY flow sums from a given WY (between 1915-2011) and the missing years (2012-2018). Water Years were assigned to missing WY as shown in Table 2-9.

Table 2-9 Water Years assigned to fill missing years

Actual WY	Change factor assigned from closest WY
2012	1979
2013	1979
2014	1994
2015	1988
2016	2005
2017	1983
2018	2009

Note: 2013 was closest, but cannot be used since the climate change factors only go up to 2011. Next closest WY was 1979.

2.1.4.2 Water Operations and Climate Change

Central Valley Project operations that impact Yolo County were simulated in the CalSim model runs. Results for CVP allocations and Term 91 were extracted from the CalSim model and used to constrain surface water availability for Settlement Contractors, CVP Contractors, and water rights subject to Term 91.

2.1.5 Water Management Inputs

In this section, the rules and regulations that are used to manage surface water use within the basin are discussed.

2.1.5.1 Surface Water Rights

Many surface water rights registered with the State of California have restrictions. These can include any one or combination of the following:

1. **Instantaneous maximum diversion** (cfs), typically appropriative rights or riparian/Pre-1914 rights
2. **Monthly maximum diversions** (AF/month), typically USBR contracts
3. **Annual maximum diversions** (AF/water right year), typically USBR contracts or appropriative rights. These are limited to a certain amount available over a designated set of months, e.g., April-October or January-December. This time period will be referred to as the water right year.

For surface water rights that have one type of restriction, the restriction is implemented as a “maximum flow volume” in the YSGA model. For surface water rights that have more than one type of restriction (either instantaneous and annual, or monthly and annual), cumulative annual diversions are tracked and the water available at each time step is this amount subtracted from the total water right volume.

2.1.5.1.1 Woodland-Davis Clean Water Agency

The City of Woodland, City of Davis, and UC Davis established the Woodland-Davis CWA which recently acquired surface water rights for the Sacramento River. Given that the historical simulation runs through Water Year 2018, surface water is only available in the last two years of that simulation. Table 2-10 summarizes the water rights and their limitations.

Water licenses 5487a and 904a, which were transferred from the Conaway Preservation Group to the CWA, provide the cities with 10,000 AF of surface water from June to September each year, and monthly restrictions on diversions for these rights are designated by Settlement Contract 14-06-200-7422X-R-1. This right is subject to 25% reductions in Shasta Critical years.

The Woodland-Davis CWA also has permit 20281 which allocates 45,000 AF to the CWA each year (Jan 1-Dec 31), limited by a maximum diversion rate of 80.1 cfs on average each month. This right is subject to reductions due to Term 91, which ensures sufficient flows in the Delta, and therefore often restricts water rights during summer months.

Effectively, due to the capacity of the water treatment plant, the cities have 30 million gallons per day (MGD) available. This is allocated into 18 MGD, 10.2 MGD and 1.8 MGD for Woodland, Davis, and UCD, respectively when neither reduction due to a Shasta Critical year nor Term 91 are in effect. The diversion from the river is limited to the maximum instantaneous diversion rate of the two water rights, 80 cfs. Diversions to the three cities are limited by the MGD rate listed above. If Term 91 is in effect in a given month, no water can be diverted in the model. If it is a Shasta Critical Year, the total MGD mentioned above is reduced by 25%.

Table 2-10. Available water to the Woodland Davis CWA, divided between water rights.

Water licenses 5487a and 904a			**Permit 20281**	
Annual limitation	**Instantaneous limitation**	**Monthly limitation (per settlement contract 14-06-200-7422X-R-1)**	**Annual limitation (Jan 1-Dec 31)**	**Instantaneous limitation**
10,000 AF	80 cfs	Jun 2,500 AF Jul 3,500 AF Aug 500 AF Sep 3,500 AF	45,000 AF	80 cfs
10,000 AF/yr	57,917 AF/yr	10,000 AF/yr	45,000 AF/yr	4,760 AF/mo 57,917 AF/yr
Additional Restrictions: In a Shasta Critical year, base supply agreed to be diverted April-October is reduced by 25% each month			Additional Restrictions: Subject to reductions based on Term 91	

Sources of information

Settlement Contract 14-06-200-7422X-R-1 Draft, 4/4/2013
Water Permit 20281
Water License 904A
Water License 5487A
Davis Woodland CWA Water Rights Briefing Paper
Draft Environmental Assessment: Amendatory Contract between the United States and Conaway Preservation Group, LLC and Sacramento River Settlement Contract betweel the United Stated and the Woodland-Davis Clean Water Agency (July 2013)
Conversation with the City of Woodland, 6/8/17
Woodland Davis CWA Website, Accessed: Aug, 2017
Meeting with all participating entities: 5/31/18

ASR Well injection and recovery data and WDCWA deliveries data provided by City of Woodland and CivicSpark Fellows	
Personal communication with Matt Cohen, City of Woodland, 10/10/2019	

2.1.5.1.2 Water right restrictions

2.1.5.1.2.1 Central Valley Project Contracts

During the historical simulation period (WY 1971 - WY 2018) all settlement contracts were reduced during Shasta Critical Years by 25%.

During this same period, project allocations for agricultural and urban contractors north of the Delta were available from the Bureau of Reclamation for 1977-2018[14]. We adjusted allocations accordingly for the historical period of the model. If the allocation changed over time within the season, we took the latest allocation for that water year. For example, if the allocation started as 50% in March, but was 100% by April, we assumed April for the entire water year. Prior to 1977, we assumed 100% allocation for all contracts.

2.1.5.1.2.2 Term 91

For all water rights affected by Term 91, we developed assumptions based on data available for 2012-2018, based on water year type.[15] Per Table 2-11, when Term 91 is enacted, no surface water from the affected right is available in the model, until the month indicated under "Term 91 Lifted". Because this affects all rights granted since 1965, this is implemented during the entire historical period (1971-2018).

Table 2-11. Assumptions for Term 91, implemented in the WEAP model

Water Year Type	Term 91 Enacted	Term 91 Lifted
Critical	April	Nov
Dry	May	Sep
Below Normal	Jun	Oct
Above Normal	Jul	Sep
Wet	Not Enacted	Not Enacted

2.1.5.1.2.3 Water Rights not restricted by Term 91

Some water rights included in the YSGA model are not affected by Central Valley Project operations nor Term 91. Water available via these rights are limited according to their face value or diversion limitation, but not further limited, even in dry years, in the model. These are listed in Table 2-12, below.

[14] Available from: https://www.usbr.gov/mp/cvo/vungvari/water_allocations_historical.pdf
[15] Based on information from https://www.waterboards.ca.gov/water_issues/programs/delta_watermaster/term91.html

Table 2-12. Areas within the model with unrestricted water rights

Catchment Name	Water Source
RD 108	Colusa Basin Drain
RD 787	Colusa Basin Drain
RD 2035	Willow Slough
UC Davis	Putah Creek

2.1.5.1.2.4 Unrestricted Water Rights

It is likely that water right holders along the Sacramento River, Delta and Colusa Basin Drain are affected by some annual restrictions. However, due to lack of information about the type and face value of their rights and contracts, there are no restrictions – in the YSGA model - on the surface water available to the areas listed in Table 2-132-12 below.

Table 2-13. Areas within the model with unrestricted water rights

Catchment Name	Water Source
RD 537	Sacramento River
RD 730	Sacramento River
RD 827	Sacramento River
RD 1600	Sacramento River
CBD North	Colusa Basin Drain
CBD South	Colusa Basin Drain
North Delta East	Delta
North Delta West	Delta

Each individual water right represented in the model is described in the following section, where each entity's representation is explained in detail.

2.1.5.2 Cities/Towns/Urban Areas

2.1.5.2.1 City of Davis

Runoff simulated from the physical area representing the City of Davis ends up in the Yolo Bypass (See Table 1-4 for a summary of each catchment's assigned runoff destination). Agricultural areas within this area are irrigated with groundwater, pumped from layer 2 in the MODFLOW model. At this time, the water demand of golf courses is not explicitly incorporated in the model, nor are detention ponds.

Domestic demand is split into two categories of water use rates (residential and other) based on Drinc Portal data supplied by the City of Davis. This rate is multiplied by the population, sourced from the Department of Finance, to estimate total annual water demand for the city[16]. This annual demand gets distributed each month with a monthly variation that was developed based on the City of Davis Residential Use data supplied by Marie Graham.

[16] The information sourced from the Department of Finance differed slightly from population included in City of Davis Residential Use data provided by Marie Graham (2014-2017 data), however, in order to have a long contiguous record, the Department of Finance data was used.

Until June 2016, the city's domestic demand was met entirely by groundwater, also pumped from layer 2 in the MODFLOW groundwater model. In June 2016, Davis began supplying water from the Sacramento River via the Woodland-Davis CWA (see Section 2.1.5.1 for more details). The eWRIMS Water rights database shows that Davis has a riparian right for Putah Creek. This is currently included in the model but never used, because this supply is not mentioned in the UWMPs, and City staff indicate that this right is not used.

The city's wastewater treatment plant is included in the YSGA model. Correspondence with the City of Davis indicated that the average inflow to the plant is 4.5 MGD, with an average effluent rate of 4 MGD. This was used to calculate monthly consumption before reaching the treatment plant (e.g. water used for irrigating lawns, which never reaches the sewer system). It is assumed all this consumption is largely evapotranspiration and therefore, it is higher in the summer than in the winter. Prior to 2016, the City of Davis Wastewater Treatment Facility was made up entirely of facultative ponds. After this, the city upgraded their system to an activated sludge plant that discharges into the Willow Slough bypass and then the Yolo bypass. In the historical model simulation prior to 2016, all water that reaches the treatment plant is consumed within treatment, with 80% evaporating from ponds and 20% infiltrating to groundwater. After 2016, 11% of inflows to the plant are lost during treatment, and the remaining flows out to the Yolo Bypass.

Sources of information

2015 Urban Water Management Plan
2006 City of Davis-UC Davis Groundwater Management Plan
2006 City of Davis Storm water Management Plan
Municipal Service Review and Sphere of Influence Study (2016): City of Davis, El Macro County Service Area, North Davis Meadows County Service Area, Willowbank County Service Area
Phase I Hydrogeologic Investigation Deep Aquifer Study (1999)
Various in person, phone and email conversations with Marie Graham and Stan Gryczko, City of Davis
City of Davis Residential Use data (Drinc Portal data) provided by Marie Graham 6/29/18
Monthly production data provided by Stan Gryczko 5/23/18
California Department of Finance (population data)
Meeting with cities 5/31/2018

2.1.5.2.2 City of West Sacramento/RD 900

The geographic area of RD 900 and West Sacramento are represented together by the West Sac catchment in the YSGA model. Prior to 2003, agricultural water demands are first met with water made available by RD 900's Settlement Contract 14-06-200-1779A-R-1, and then supplemented with groundwater pumped from layer 2 in the MODFLOW model if the surface water is not sufficient. After 2003, these demands are only met with groundwater. All groundwater for irrigation is assumed to be sourced from private wells. This is based on information provided by the City of West Sacramento, indicating that RD 900 no longer uses their surface water right. Surface runoff generated within the area of West Sacramento and RD 900 all flows into the Sacramento River (See Table 1-4 for each catchment's runoff destinations).

Domestic demand is split into two categories of water use rates (residential and other) based on Drinc Portal data supplied by Paulina Benner at the City of West Sacramento. This rate is multiplied by the population, sourced from the Department of Finance, to estimate the total annual water demand for the city. Annual demand is distributed for each month with a monthly variation based on supplied data.

Prior to 1986, all domestic demands are met with groundwater which is pumped from layer 2 in the MODFLOW model. It is possible that prior to 1986, before the city was incorporated, residents purchased surface water from the East Yolo Community Services District, however this is not confirmed due to lack of records and therefore is not incorporated in the model. From 1986 onward, the water treatment plant was built and therefore surface water is available for domestic demands. These are met with water from the Sacramento River via three agreements: Water Permit 18150, USBR Contract 0-07-20-W0187 and water made available by the North Delta Water Agency (NDWA). In the model, the order of priorities for these sources are first, Permit water, then, CVP contract water, then water from the NDWA. The amount of water than can be delivered from the NDWA is highly reliable. In reality, the northern part of the city only receives permit and CVP water and the southern part receives NDWA water. Therefore, the northern part of the city could be at risk if there are shortages in surface water. In the model, groundwater can be used to meet any unmet demand if the surface water supplies are exhausted. During the baseline simulation this did not occur following 1986.

Although West Sacramento previously had its own WWTP, and now sends its water to the Sacramento Regional Wastewater Treatment Plant, only one plant is represented in the YSGA model which only receives water from West Sacramento.

Below are the sources of information used to characterize water management in the City of West Sacramento. Future updates to the model will reflect updated planning documents.

Sources of information

Water Permit 18150
Contract 14-06-200-1779A-R-1
Contract 0-07-20-W0187
2010 Urban Water Management Plan
2015 Urban Water Management Plan
City of West Sacramento 2035 General Plan
Municipal Service Review/Sphere of Influence study, 2009
Various phone, email and in person conversations with Paulina Benner, City of West Sacramento
West Sac diversions spreadsheet provided by Paulina Benner 6/14/18
Residential consumption spreadsheet (Drinc Portal data) provided by Paulina Benner 7/3/18
Department of Finance (population data)
Meeting with cities 5/31/2018

2.1.5.2.3 City of Winters

Agricultural areas within the geographic boundary of the City of Winters is irrigated by groundwater pumped from layer 2 in the MODFLOW model. Any runoff generated within this catchment flows into Putah Creek (See Table 1-4 for each catchment's runoff destination).

The city's urban demand is also met entirely by groundwater pumped from layer 2. The per capita water use rate within this demand is divided into four categories based on Water Use Reports from the Drinc Portal (supplied by Carol Scianna): residential, commercial, industrial and landscape irrigation. This rate gets multiplied by the population, sourced from the Department of Finance, to estimate the total annual water demand[17]. Annual demand is distributed for each month with a monthly variation based on supplied data.

Wastewater from the urban demand is sent to the city's WWTP which has a capacity of 0.91 MGD according to the City of Winters Municipal Service Review and Sphere of Influence Study (2008). Because the ponds do not have an outflow, all water that reaches the plant either evaporates or contributes to groundwater. Although some treated wastewater has been sold to the nearby prune orchard for irrigation, and there is some spraying of effluent that occurs, these are likely small volumes that do not highly influence the overall water budget, so they are not represented in the model.

Sources of Information

Multiple Data Sets provided by Carol Scianna, City of Winters (historical monthly pumping 2006-2017, monthly water use in Drinc Portal Annual Reports 2013-2017, average WWTF influent flows 2008-2017, 2018-2006 Well Soundings data
City of Winters Municipal Service Review and Sphere of Influence Study (2008)
Winters Water Master Plan 2006
Winters Sewer Collection System Master Plan (2006)
Conversations with Carol Scianna, 4/26/2017, 5/24/2018, various email correspondences
Water License 6154
California Department of Finance (population data)
Meeting with cities 5/31/2018

2.1.5.2.4 City of Woodland

Agricultural areas withing the geographic boundary of the City of Woodland are irrigated with groundwater pumped from layer 2 in the MODFLOW model. Any runoff generated within the catchment flows into Willow Slough and Cache Creek, per fractions in Table 1-4.

Domestic demand is split into two categories of water use rates (residential and other). Due to lack of information, almost all the details of the domestic demand in Woodland are a replication of those from Davis. Water use rates from the City of Davis, were multiplied by the population of Woodland (sourced

[17] Population data supplied by the City of Winters did not differ much from Department of Finance data, so Department of Finance data were used to maintain consistency of data source with other cities.

from the Department of Finance), to calculate the total annual water demand for the city. Annual demand is distributed for each month using City of Davis' monthly variation.

Before 2016, this demand is entirely met with groundwater, pumped from layer 2 of the MODFLOW model. Beginning in 2016, water from the Sacramento River via the Woodland-Davis CWA becomes available to meet Woodland's domestic supply (See Section 2.1.5.1.1). Woodland's confined Aquifer Storage and Recovery (ASR) project also became operational in 2016. Based on conversations and data provided by Matt Cohen, City of Woodland, from the middle of 2016, some of Woodland's allocation of CWA water is injected into the ASR wells, while the rest (the majority) is used for City delivery directly. This data is used directly from 2016 to 2018 in the YSGA model. Recycled water from the wastewater treatment plant (0.5 MGD), is also used as a water source in the YSGA model. Although Woodland purchases water from the spot market, no quantitative details were able to incorporate this in the YSGA model.

For future scenarios, supply preferences are set up in the following order: recycled water from the waste water treatment plant (0.5 MGD) is first, then Aquifer Storage and Recovery (ASR) water, then the CWA and only after that is the unconfined aquifer (layer 2) used. Effectively, this represents Woodland's marked reduction in historical dependence on the unconfined aquifer. Woodland's stated goal of ASR injection is 10,000 AF per year. However, for the future runs, the YSGA model currently uses the 2018 amount of water reported to be injected (500 million gallons per year, or 1,534 AF), with a monthly distribution also determined from 2018 data. Of this injected water, 1368 AF is pumped from the ASR for City use (again based on 2018 data).

Woodland's confined aquifer where ASR is implemented is not currently represented in MODFLOW, as it is beyond the scope of the YSGA model effort. It is represented as a simple groundwater object (a bucket model) instead. The ground water budget includes inflow and outflow volumes for this ASR, but its effects on regional or overlying unconfined layers, if any, cannot be modeled by the YSGA model. Extensive hydrogeologic and numerical modeling of Woodland's ASR, conducted as part of the feasibility and permitting process, are available from the City of Woodland.

Wastewater from the city is routed to the wastewater treatment plant which has a capacity of 14.7 MGD. A maximum of 0.5 MGD of treated water is available to the city as supply beginning in 2016 (per conversation with the City of Woodland, 6/8/17). The rest of the wastewater effluent is discharged into the Yolo Bypass. Due to lack of information, there are no treatment losses are included in the model.

Sources of information

City of Woodland Urban Water Management Plan 2015
City of Woodland Urban Water Management Plan 2010
Public Review Draft General Plan (2016)
City of Woodland Municipal Service Review/Sphere of Influence Update 2011
Conversations with the City of Woodland, 6/8/17, 10/10/18
ASR Well injection and recovery data provided by City of Woodland and CivicSpark Fellows
City of Davis Residential Use data (Drinc Portal data) provided by Marie Graham 6/29/18

City of Davis Monthly production data provided by Stan Gryczko 5/23/18
California Department of Finance (population data)
Meeting with cities 5/31/2018

2.1.5.2.5 University of California, Davis (UCD)

Agricultural water demand within the geographic boundary of UCD is irrigated preferentially with water from the Solano Project (4,000 AF per year from Putah Creek). If more water is needed, it is pumped from layer 2 in the MODFLOW model. Currently, the Russel Tract is not included in the UC Davis catchment but rather, it is included in the YCFC West catchment. This is due to limited information on the exact location and size of the farmed area. Similarly, the area of UC Davis outside of Yolo County is not currently included in the model due to lack of information on land use, water use and groundwater conditions there.

All runoff generated in the UCD catchment is routed to Putah Creek. Detention ponds and the Arboretum are not currently represented in the model.

Urban demand is split into three categories, “Domestic”, “Aquaculture” and “Landscape irrigation”, with associated information taken directly from the UC Davis Water Supplies, Systems and Usage memorandum, dated 02/06/18 (hereafter, UC Davis Water Supply Memo). The domestic category has an annual activity level in units of weighted campus user, while the Landscape irrigation demand is in units of acres. Values are given in the UC Davis Water Supply Memo for years 2005-2008 and 2016-2017. Due to lack of information, it is assumed that the weighted campus user population was 60% of latest levels, in 1971 at the start of the simulation and grew linearly to 2005 and between 2008 and 2017. Landscape irrigation area is assumed to be constant from 1971 to 2005 at 2005 levels. Each are multiplied by water use rates to estimate total demand. Aquaculture demand is incorporated as a total demand, without an annual activity level or water use rate, and remains constant throughout the entire historical period at 2017 levels. Landscape irrigation demand fluctuates monthly based on the monthly variation calculated for the City of Davis. Consumption is calculated as 39% on average, based on 1.17 MGD average daily wastewater generation reported in the Long Range Development Plan EIR (2018).

Prior to 2016, all water is pumped from layer 2 in the MODFLOW model. Starting in water year 2016, 1.8 MGD of surface water from the Sacramento River is available to meet UCD urban demand. This source is preferentially used over groundwater. Additionally, starting in June 2016, 33 million gallons per year of recycled water from the waste water treatment plant is available to meet the urban demand (per conversation with Camille Kirk, UCD). This is also preferentially used before groundwater, in the YSGA model.

All water not consumed is routed to the wastewater treatment plant. The plant has a capacity of 3.6 MGD (source: Long Range Development Plan EIR (2018), Section 3.17). Outflows from the plant discharge into Putah Creek. No information was available on water lost in treatment.

Sources of Information

UC Davis Drought Response Action Plan (2014)

University of California, Davis Sewer System Management Plan (2009)
2018 Long Range Development Plan Environmental Impact Report, Sections 3.10, 3.13 and 3.17
2006 City of Davis-UC Davis Groundwater Management Plan
Phase I Hydrogeologic Investigation Deep Aquifer Study (1999)
Overview of The UC Davis Wastewater Collection And Treatment System Website: https://facilities.ucdavis.edu/utilities Accessed: 8/14/17
Memorandum: Infrastructure Information for LRDP Environmental Review Water Supplies, Systems and Usage, 2/6/2018
Conversations with Camille Kirk, UCD
Meeting with cities 5/31/2018

2.1.5.2.6 Rural Water Use

Rural water use includes demands for small towns or other non-agricultural demands in the County that do not receive water from a district or city supply. Their physical area is incorporated into the catchment where they are located (e.g. YCFC); their water demand estimations are documented below.

2.1.5.2.6.1 Capay Valley

Non-agricultural water demands in Capay Valley include those of the Cache Creek Casino, Yocha Dehe Golf Club (starting in 1985), Tribal housing, and rural water use from private pumping. These categories and total demands were developed based on a Capay Groundwater study (RMC Water and Environment, 2016) which provides demands for each category up to 2007 (in Table 3.4 of the Capay Groundwater Study), after which point demands are held constant. Due to limited information, the total demand is included in the model, rather than a population and water use rate. The golf course portion of the demand only occurs from April to October and is met with 287 AF/year from Cache Creek. Additionally, 17% of water use is available for reuse, estimated from the Capay Groundwater Study. The rest of the demand is met with groundwater from layer 2. Due to lack of information, there is no monthly variation for the other demand categories. The consumption rate in both demand nodes is assumed as 40% (based on Madison CSD rates), due to lack of Capay-specific information. All water that is not consumed is routed to groundwater.

2.1.5.2.6.2 Small Towns

Non-agricultural demand for small towns is represented in aggregated manner within their respective catchments and Management Areas. Capay and Monument Hills, for example, are represented in aggregate in the YCFC West catchment of Central Yolo Management Area, in the YSGA model. Similarly, water demand for the town of Zamora is included in the North Yolo Management Area, and Clarksburg demand is included in the Clarksburg Management Area.

These demands are calculated as the area of the towns (estimated from the Yolo County GIS database, Yolo County Cities and Towns Open Data shapefile) multiplied by 2.0 af/ac, the water use rate used in the Capay Groundwater Study for estimating rural water use. The demands are met by groundwater pumped from layer 2. Consumption rate in all demand nodes is 40%, based on Madison CSD, due to lack of town-specific information. It is assumed septic systems are used; therefore, all unconsumed water is returned to groundwater.

Domestic water use within the boundaries of Dunnigan Water District is represented in the Dunnigan urban demand and the wastewater treatment plant is represented. Currently, the demand node conceptually aggregates all 166 private wells that exist within this area, per the 2005 Hydrogeologic Characterization Report of Dunnigan Water District. Due to lack of information, the population of Dunnigan serviced by California American Water is not separate from the rest of the population of Dunnigan at this time. Similarly, the wastewater treatment plant is included in the model but is not active due to lack of information. The demand node has a consumption rate of 40%, based on Madison Community Service District, and all remaining water is returned to groundwater.

Sources of Information

Technical Memorandum CCCR Event Center Projct TEIR Hydrological Model of Capay Valley April, 2010
Capay IGSM Update and Scenario Analysis: Final Report (RMC, 2016)
Madison Community Service District Final Facility Master Plan Report (2011)
Yolo County GIS database, "Yolo County Cities and Towns Open Data" shapefile
Email communication with Evan Jacobs, California American Water-Dunnigan
2005 Hydrogeologic Characterization Report, Dunnigan Water District (West Yost and Davids Engineering Inc, 2005)
2005 Groundwater Management Investigation, Dunnigan Water District (Dunnigan Water District and Davids Engineering Inc, 2005)

2.1.5.3 Community Service Districts (CSD)

2.1.5.3.1 Cacheville CSD

Cacheville CSD supplies the town of Yolo with water. There is no land within the District's boundaries that is categorized as agricultural. All runoff generated within the district's area flows into Cache Creek (See Table 1-4 for each catchments runoff destination).

The town of Yolo has a daily average water use rate of 118 gpm and a population of 452 (2030 Countywide General Plan, General Plan Amendment 2013-01). These values are included in the model to make up the domestic demand, and stay constant for the entire baseline scenario. Due to lack of additional information, there is no monthly variation in the model so demand does not vary with seasons. All water to meet this demand is pumped from layer 2 in the MODFLOW model. Groundwater supply to the demand is limited by the sum of the capacity of the district's two wells (Cacheville CSD Municipal Service Review and Sphere of Influence Study, 2014). Because all water is treated by individual septic systems, there is no WWTP included for this entity. Consumption within the demand site is 40%, based on the Madison CSD consumption rate (see section on Madison CSD for details), and the remaining water is returned back to groundwater through septic systems.

Sources of information

Cacheville CSD Municipal Service Review and Sphere of Influence Study (2014)
2030 Countywide General Plan, General Plan Amendment 2013-01 Disadvantaged Unincorporated Communities Assessment
Madison Community Service District Final Facility Master Plan Report (2011)

2.1.5.3.2 Esparto CSD

Runoff generated within the district's area contributes to Cache Creek and Willow Slough (See Table 1-4 for each catchment's runoff destination). Any area classified as agricultural within the district's area is irrigated with groundwater pumped from layer 2 in the MODFLOW model.

The average daily demand generated by the population of Esparto is 650 gpm and the population is 3108, per the Western Yolo Special Districts Municipal Service Review and Sphere of Influence Study (2014). These values stay constant in the model and make up the domestic demand for the district's service area. The demand is met with groundwater, also pumped from layer 2. This supply is limited by the summed capacity of Esparto CSD's wells (Well 1A, 5, 6, 5B and emergency well, combined capacity: 1432 gpm). Due to lack of information, there is no monthly variation in the model so demand does not vary with seasons. Consumption within the demand site is 40%, based on the Madison CSD consumption rate (see section on Madison CSD for details). The remaining water flows to the Esparto WWTP which is made up of 10 facultative ponds. Consumption (evaporation) within the pond system is 45.5%, based on the calculated evaporation in the Madison system, and the remaining water recharges groundwater.

Sources of Information

Municipal Service Review and Sphere of Influence Study for the Western Yolo Special Districts (2015)
Town of Madison Flood Hazard Mitigation Study (1991)

2.1.5.3.3 Knights Landing CSD

Runoff generated within the district's area contributes to the Sacramento River (See Table 1-4 for each catchment's runoff destination). Any area classified as agricultural within the district's area is irrigated with groundwater pumped from layer 2 in the MODFLOW model.

The domestic demand stays constant throughout the baseline run, based on a population of 902 people and 204 GPM daily average water demand (Knights Landing Municipal Service Review and Sphere of Influence Study, 2014). Domestic demands are met with groundwater from layer 2, with supply limited by the total capacity of Knights Landing CSD's three wells (Knights Landing Municipal Service Review and Sphere of Influence Study, 2014). Due to lack of information, there is no monthly variation in the model so demand does not vary with seasons. Consumption within the demand site is 40%, based on the Madison CSD consumption rate (see section on Madison CSD for details).

Wastewater from the urban demand is sent to the WWTP, which is made up of 10 facultative ponds with a capacity of 112,000 gpd (2030 Countywide General Plan, General Plan Amendment 2013-01). Due to lack of information, 45.5% of water that flows into the WWTP is "consumed" (evaporated), based on the Madison CSD WWTP. The remainder recharges groundwater.

Sources of information

Knights Landing CSD Municipal Service Review and Sphere of Influence Study (2014)

2030 Countywide General Plan, General Plan Amendment 2013-01 Disadvantaged Unincorporated Communities Assessment
Madison Community Service District Final Facility Master Plan Report (2011)

2.1.5.3.4 Madison CSD

Agricultural land within Madison CSD boundaries is irrigated with groundwater from layer 2 in the MODFLOW model. Domestic demand is also met with groundwater from layer 2.

The domestic demand is split into eight categories based on the Madison CSD Final Facility Master Plan Report (Master Plan), Appendix F, Table 1: low, medium and high density residential, general and local commercial, industrial, public/quasi-public and parks and recreation. Each of these categories has an annual activity level, in acres, which stays constant for the entire historical period, except "Residential Low" whose activity level is defined as number of households. These are then multiplied by annual water use rates, also derived from the Master Plan, which also stay constant. The parks and recreation demand only exists between April and October, based on the Golf Course demand in Capay Valley (Technical Memorandum CCCR Event Center Project TEIR Hydrological Model of Capay Valley (April, 2010). Some pumping data were provided by Madison CSD, but because they are only for a few months, it was not enough information to use in the model at this time.

The urban demand has a pumping limit of 1050 gpd, which is the sum of the production rate of Park Wells 1, 2 and 3 (Master Plan, Appendix F, Table 1). The consumption rate within the demand node is 40%, which results in average daily flow to the WWTP of 0.15 MGD. Wastewater is sent to Madison's WWTP, which has a capacity of 70,000 GPD. Almost half (45.5%) of the water is "consumed" during the treatment process in the model and is lost from the system. This represents evaporation from the ponds and is calculated based on values in the Madison Master Plan, Appendix G, Table 5. The remaining volume is recharged to groundwater.

Sources of information

Madison Community Service District Final Facility Master Plan Report (2011)
Municipal Service Review and Sphere of Influence Study for the Western Yolo Special Districts (2015)
Town of Madison Flood Hazard Mitigation Study (1991)

2.1.5.4 Reclamation Districts 108, 787, 2035

2.1.5.4.1 RD 108

RD 108 agricultural lands are irrigated with water from the Sacramento River, Colusa Basin Drain, and groundwater. In the YSGA model, water availability from the Sacramento River is represented via 2 diversion links. One combines Water license 3065, 3066, 3067 and the riparian right, which are all limited to monthly allotments by Settlement Contract 14-06-200-876A-R-1. Within the model, water is available based on these monthly restrictions, but is not further restricted by the total 725 cfs max diversion rate for the combined rights. The second diversion link from the Sacramento River represents Permit 21274 by which RD 108 has access to 36,000 AF of Sacramento River water per year at a maximum of 240 cfs. In the YSGA model, water is also available from the Colusa Basin drain at 75 cfs from April 1 to October 1, representing Water License 7060.

Supply preferences in the YSGA model, are set such that irrigation demand is met first by surface water sources evenly across the different surface water rights, and then from groundwater, which is pumped from layer 2 in the MODFLOW model. However, there is likely too much water available to the catchment in the model because the entirety of the above-mentioned rights are available, however, only the area of the district within Yolo County is included in the model. For this reason, groundwater is rarely pumped in this district.

A portion of runoff generated within the catchment runs off to the Sacramento River and the Colusa Basin Drain (See Table 1-4 for each catchment's runoff destination).

Before contributing to these streams, 90% of runoff is available for reuse for irrigation, if there is a simulated demand for it. All groundwater recharge contributes to the groundwater node for RD 108. Drains are represented in RD 108 in the model. This effectively keeps the water table deeper than the root zone. Water that enters the drains from groundwater is routed to the Sacramento River. More details on drains is provided in Section 2.2.2.2.

Some land use data were provided by RD 108 but are not currently incorporated into the model because they were only provided for a few years and were not enough to incorporate at this time. Land use is based on DWR spatial data and Yolo County Ag Commissioner Reports (see Section 2.1.1 for more information).

Sources of Information

Water License 3065
Water License 3066
Water License 3067
Water License 7060
Water Permit 21274
Settlement Contract 14-06-200-876A-R-1
RD 108 Groundwater Management Plan (2008) (RD 108, 2008)
Conversation with Bill Vanderwaal, 3/8/17
Landuse data, maps and water balance data provided by Bill Vanderwaal, 3/8/17

2.1.5.4.2 RD 787

Runoff generated by RD 787 (River Garden Farms) flows into the Sacramento River and the Colusa Basin Drain (See Table 1-4 for each catchment's runoff destination). Drains are represented in RD 787 in the model. This effectively keeps the water table deeper than the root zone. Water that enters the drains from groundwater is routed to the Sacramento River. More detail on drains is provided in Section 2.2.2.2. Most of the land is owned by River Garden Farms, with a small portion owned by Faye Properties. Unlike most other catchments, the annual land use data for this catchment is based on information provided by the district for both River Garden Farms and Faye Properties, for years 1987-2015. Prior to 1987, land use from the methods described in Section 2.1.1 were used. The difference of the total area of the district (approximately 10,000 acres) and the area classified as a crop-covered by the information provided by the district (approximately 6,000-7,000 acres) is considered native vegetation and is not irrigated (approximately 3,000-4,000 acres).

River Garden Farms has water rights from the Sacramento River and the Colusa Basin Drain. All rights from the Sacramento River (License 1718, 3123) are represented by a single diversion link which is limited by monthly diversions per Settlement Contract 14-06-200-878A-R-1 plus 10.5 TAF per year. This additional water represents the water available to the Faye Property, which, according to Roger Cornwell of River Garden Farms, uses 9-12 TAF of surface water per year. All water diverted from the Sacramento River in the model is subject to reductions of 25% in Shasta Critical Years in the YSGA model. Water License 4636 for the Knights Landing Ridge Cut is represented by a diversion from the Colusa Basin Drain to the catchment, limited by the max diversion rate of 19 cfs From April 1 to Sept 15. The state's water rights database indicates that River Garden Farms has applied for a permit for water from Lateral 14A. This is not included in the model. Before runoff generated within this catchment contributes to the streams mentioned above, 90% of runoff is available for reuse for irrigation, if there is a demand for it.

In the model, the land is first irrigated with water from the Sacramento River, then from the Colusa Basin Drain, and if more water is still needed to meet the irrigation demand, water is pumped from layer 2 of the MODFLOW groundwater model.

Sources of information

Water License 1718
Water License 3123
Water License 4636
Settlement Contract 14-06-200-878A-R-1
RD 787 Groundwater Management Plan (Luhdorff and Scalmanini, Consulting Engineers, 2012)
Land use and diversion data supplied by Darren Cordova, MBK Engineering
Email exchanges with Darren Cordova, MBK Engineering

2.1.5.4.3 RD 2035

This area is mainly made up of land owned by Conaway Ranch (approximately 15,500 acres) and the remaining area (6,000 acres) is owned by other landowners. Runoff from this area flows into Yolo Bypass, Cache Creek and Willow Slough (See Table 1-4 for each catchment's runoff destination).

Unlike most other catchments, the annual land use data for this catchment is based on information provided by the district for the area of Conaway Ranch, for years 1990 to 2015[18]. Prior to 1990, land use is based on the method described in Section 2.1.1.

[18] Using this land use in the later years, while it makes the crop data for the fields in Conaway Ranch more accurate, may reduce the total cropped area because the area of land not owned by Conaway Ranch is categorized as native vegetation.

Conaway Ranch has water rights for the Sacramento River, Willow Slough, Cache Creek and the Yolo Bypass. In the YSGA model, a diversion from the Sacramento River represents Licenses 5487b, 904b, and 905 which are restricted under Settlement Contract 14-06-200-7422A-R-1 and another diversion represents the riparian right. Water under all rights except the riparian right is available up to the monthly allocation as outlined in the Contract. The diversion from Willow Slough represents Water License 6320, which makes 9.4 cfs available between April and October. The diversion from the Yolo Bypass represents Permit 19372, which makes 10,000 AF per year available between April and September. Water from the Sacramento River under the CVP permit is the first priority, so water is first taken from the Sacramento River under this right to meet demands. If additional water is needed, it is taken under the Yolo Bypass permit, then Willow Slough, and finally pumped from layer 2 in the MODFLOW groundwater model.

Conaway Ranch's riparian rights, for the Sacramento River and Cache Creek are represented in the model, but due to limited information on how much water is actually used under these rights, no water is available under them in the model. RD 2035 has reported no diversions from Cache Creek since 2008, which supports this assumption. Before runoff from this catchment contributes to the streams mentioned above, 90% of runoff is available for reuse for irrigation, if there is a demand for it.

Sources of Information

Water License 904B
Water License 905
Watr License 5487B
Water License 6320
Water Permit 19372
Settlement Contract 14-06-200-7422a-r-1
RD 2035 Groundwater Management Plan (1995)
Municipal Service Review and Sphere of Influence Study Yolo County Public Water and Reclamation Districts (2005)
Diversion and crop data supplied by Darren Cordova, MBK Engineering 9/7/18
Various personal and email correspondences with Darren Cordova, MBK Engineering and Mike Hall, Conaway Preservation Group

2.1.5.5 Reclamation Districts east of the ship channel

RD's 150, 307, 765 and 999 are currently represented in the model as one combined catchment representing the entire area between the Ship Channel and the Sacramento River. Land use data was assembled using the method described in Section 2.1.1. Because these districts do not supply irrigation water, it is unknown exactly how much water is available to them. However, it is likely that individuals who own land within these areas have their own water rights and have no shortage of surface water, and therefore, this catchment is connected to the Sacramento River with a diversion. This makes unrestricted surface water available from the Sacramento River, mimicking riparian rights. While this area can pump groundwater in the model, due to the unrestricted surface water supply, this never occurs in the historical simulation.

Reclamation District 765 is currently included within the catchment “North Delta West”, which receives unlimited surface water for irrigation from a source in the model called “Delta”. Based on interactions with this district, it is assumed there is no shortage of surface water supply to this area as they pump water out of the area year-round.

Runoff generated within each of these catchments is routed to various drainages listed in Table 1-4. Drains are represented in these catchments in the model. This effectively keeps the water table deeper than the root zone. Water that enters the drains from groundwater is routed to the Sacramento River. More detail on drains is provided in Section 2.2.2.2. Before any runoff contributes to the streams however, 90% of runoff is available for reuse for irrigation, if there is enough demand for it.

Sources of Information

Previously developed IWFM model of Yolo County
Meeting with Reclamation Districts 8/13/2018
Municipal Service Review and Sphere of Influence Study Yolo County Public Water and Reclamation Districts (2005)

Other Reclamation Districts

RDs 537, 730, 785, 827, 1600 and the “white area” west of RD 1600, called “Sac River” catchment in the YSGA model, are each represented by one catchment. Land use data was assembled as described in Section 2.1.1. Because these districts do not supply irrigation water, it is unknown exactly how much water is available to them. However, it is likely that individuals who own land within these areas have their own water rights and therefore, each catchment is connected to the Sacramento River with a diversion with unrestricted surface water available from the Sacramento River, mimicking riparian rights. While these areas can pump groundwater in the model, due to the unrestricted surface water supply, this never occurs in the historical scenario. RD 730 also has an unlimited supply of water available from the Colusa Basin Drain, based on information from the previous IWFM model developed in Yolo County. This source is preferred only if sufficient water is not available from the Sacramento River, which does not occur in the historical simulation.

Runoff generated from these catchments is routed to various water bodies, listed in Table 1-4.

Drains are implemented in RDs 1600 and 730 in the model. This effectively keeps the water table deeper than the root zone. Water that enters the drains from groundwater is routed to the Sacramento River. More details on drains is provided in Section 2.2.2.2. Before any runoff contributes to the streams however, 90% of runoff is available for reuse for irrigation, if there is a demand for it.

Sources of Information

Previously developed IWFM model of Yolo County
Meeting with Reclamation Districts 8/13/2018
Municipal Service Review and Sphere of Influence Study Yolo County Public Water and Reclamation Districts (2005)
Correspondence with Michele Clark, RD 1600

2.1.5.6 Other Districts

2.1.5.6.1 Yolo County Flood Control and Water Conservation District (YCFC)

YCFC's service area covers a large portion of Yolo County and the Yolo Groundwater Basin. YCFC's service area boundary is represented by six catchments in the YSGA model. YCFC Capay, YCFC East, YCFC West, YCFC Hungry Hollow, YCFC Dunnigan Hills and YCFC Zamora (Figure 1-2). Land use data were assembled as described in Section 2.1.1. Runoff from these catchments flows into various surface water bodies, as shown in Table 1-4.

YCFC delivers water to its customers through two main canals, the Winters Canal and the West Adams Canal. All catchments can draw water from the canals except the catchment which represents YCFC's customers in the Capay Valley ("YCFC Capay"), which draw water directly from Cache Creek. All areas can also draw water from their respective groundwater sources, which they do only if there is not sufficient surface water to meet their demands.

The annual allocation of available surface water to the district is calculated based on the Solano Decree and allocation logic described below. The total allocation is then distributed over 12 months based on percentages developed from 2007 diversions at Capay Dam, and then each month is divided among the five catchments (all excluding YCFC Capay) based on percentages developed from 2016 delivery data provided by Max Stevenson, YCFC. Because the Clover Canal which currently delivers water to YCFC Dunnigan Hills was not built until 1985, no water is delivered to that catchment until after 1985 (per conversation with Max Stevenson, YCFC).

2.1.5.6.1.1 Solano Decree

Clear Lake, located in Lake County northwest of Yolo County, is a source of surface water for YCFC who then sells it to growers within their service area. In 1914 the Cache Creek Dam was constructed to add additional storage and to control lake releases to Cache Creek. The YCFC has a prior appropriation right to water released from Clear Lake, which is controlled by the Solano Decree, a legally binding agreement between Lake and Yolo Counties (Superior Court of the State of California, 1995, 1978).

The Decree is used to determine the total amount of water available from Clear Lake for the entire irrigation season as a function of the lake level on April 1. If the level is greater than or equal to 7.56 feet Rumsey (a local datum) then the YCFC can divert 150 TAF of water from the Lake. If the lake level is less than 3.22 feet at Rumsey, then no water is available for release. For lake levels between those thresholds the volume available is prescribed through tables and charts. The YSGA model explicitly integrates the working logic of the Solano decree, based on earlier published work by the modeling team (Mehta et al., 2013, 2018).

2.1.5.6.1.2 Indian Valley Reservoir

YCFC also has a prior appropriation right to water released from Indian Valley reservoir, which was built later, in 1975. Water released from Indian Valley Reservoir flows down the North Fork of Cache Creek into Cache Creek where it is available to YCFC. All water in this reservoir is available to YCFC except 20 TAF, which is reserved for municipal water supply to a nearby town.

2.1.5.6.1.3 YCFCWCD Irrigation Allocation

The total water available to YCFC from both reservoirs in each water year is calculated in the YCFC model in April. Each year, the “allocation”, a number between 0 and 1 which represents the fraction of a full allocation that is available each year is calculated based on the equation below.

$$Allocation = \frac{CL_{allowable\ withdrawal} + IV_{Apr\ 1\ storage} - IV_{carryover} - IV_{Evap}}{Full\ Allocation}$$

Where:

$CL_{allowable\ withdrawal}$ *= the allowable withdrawal from Clear Lake calculated based on the Solano Decree (explained above)*

$IV_{Apr\ 1\ storage}$ *= the volume of water in Indian Valley on April 1st in the model*

$IV_{carryover}$*= 20 TAF, the volume of water in Indian Valley reserved for municipal use*

IV_{Evap} *= Volume of water that will evaporate in Indian Valley in the following year, therefore not available to withdrawal, calculated as 11.22% of Indian Valley’s April 1 storage, based on 2000-2009 simulations of SacWAM[19].*

Full allocation = 235 TAF, the maximum volume YCFC has diverted from Cache Creek in one water year between 1976 and 2009. This occurred in 2007.

The allocation is then multiplied by the *target diversion*, which is the largest diversion in a water year that YCFC has recorded since water year 1976: 235 TAF, and the *monthly distribution* which distributes the annual water availability across the irrigation months, based on 2007 distributions at Capay. This then gives the total volume of water available to YCFC for the water year, set as the maximum diversion on the diversion from Cache Creek at Capay Dam, which then gets distributed among the five catchments within YCFC.

2.1.5.6.1.4 YCFC Canal Losses

It is understood that the unlined canal system loses water to groundwater. Canal losses were set in the model based on earlier IGSM modeling (WRIME, 2006), and a canal recharge feasibility field study (YCFCWCD, 2012). The total water available from Capay Dam, minus losses in canals, is distributed among each YCFC catchment based on delivery data from 2016 provided by Max Stevenson. Because the Clover Canal which currently delivers water to YCFC Dunnigan Hills was not built until 1985, no water is delivered to that catchment until after 1985. The fraction of total available flows from Capay Dam available to each catchment is shown in Table 2-14.

[19] https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/sacwam/

Table 2-14. Fraction of total available water that is allocated to each catchment serviced by YCFC, based on 2016 subsystem flows.

	Percent of Serviced area prior to 1985	Percent of Serviced area 1985 and later
YCFC West	0.693	0.639
YCFC East	0.161	0.148
YCFC Hungry Hollow	0.145	0.133
YCFC Zamora	0.001	0.001
YCFC Dunnigan Hills	0	0.078

Sources of Information

Previous WEAP model development, conducted in coordination with the District. See:
Mehta V, Young C, Bresney S, Spivak D, Winter J. 2018. How can we support the development of robust groundwater sustainability plans? Calif Agr 72(1):54-64. https://doi.org/10.3733/ca.2018a0005.
Various conversations and meetings with Tim O'Halloran, Kristin Sicke and Max Stevenson
Canal diversion and delivery data sets provided by Max Stevenson
Canal Recharge Feasibility Study 2012 (YCFCWCD, 2012)
IGSM Report (WRIME, 2006)

2.1.5.6.2 Dunnigan Water District (DWD)

Land use data for DWD up to 2004 was assembled as described in Section 2.1.1. From 2004 to 2017, land use is based on crop information provided by DWD's Donita Hendrix. Runoff generated contributes to the Colusa Basin Drain (See Table 1-4). Before this runoff contributes to the stream, however, 90% of runoff is available for reuse for irrigation, if there is enough simulated demand for it.

The District has rights to surface water from the Tehama Colusa Canal. In the YSGA model, the diversion from the Tehama Colusa Canal to the catchment represents DWD's CVP Contract 14-06-200-399A-IR5, which states 19,000 AF of water is available each year. Deliveries in the model begin in April 1983, as stated in the Groundwater Management Plan (Davids Engineering Inc, 2007). However, it seems Dunnigan Water District often uses less water than their total water right. Hence in the YSGA model for the historical simulation, recorded monthly diversions are made available to Dunnigan Water District, which is a different approach from the representation of all other surface water rights in the model. When the allocation is lower than the District's demand for water, the District purchases water from settlement contracts to meet its customers' needs. However, it is also stated in the District's Groundwater Management Plan (Davids Engineering Inc, 2007) that growers irrigate on average, 2 AF per acre, which is quite low compared to other regions in the county. This is confirmed by conversations with Donita Hendrix from the District who stated that growers under-irrigate and that not all land is cultivated each year. The Groundwater Management Plan also states that average irrigation efficiency is likely 85% in this area. During calibration (Section 3) this parameter was set to 85% and groundwater pumping was restricted to 90% of the demand. This resulted in an average applied water rate of 2.1 AF per acre. Because of the difficulty in understanding how much additional water the District actually needs, additional purchases are not implemented in the model at this time. If additional water is needed for irrigation in the model, water is pumped from groundwater. In future simulations, groundwater pumping is not restricted.

Sources of Information

2007 Groundwater Management Plan (Dunnigan Water District and Davids Engineering Inc, 2005; Davids Engineering Inc, 2007)
2005 Hydrogeologic Characterization Report of Dunnigan Water District (Davids Engineering Inc, 2007)
CVP Project Contract 14-06-200-399A-IR5
Email, telephone and in person communication with Donita Hendrix, Dunnigan Water District
Land use and water delivery data provided by Donita Hendrix, Dunnigan Water District

2.1.5.7 Areas outside of any district: "White Areas"

White areas in the model are areas that do not fall within the jurisdiction of a Reclamation district, city or other water and land use management agency. These areas have their own catchments, and land use data were assembled as described in Section 2.1.1. In the northwest part of Yolo County, white areas are in Buckeye Creek, Bird Creek, Oat Creek and Goodnow Slough (Figure 1-2), whose boundaries are based on USGS HUC8 boundaries. The area within the Capay Valley that is not part of the YCFC service area is predominantly the steep hills, represented in the YSGA model as "Capay Other" catchment (Figure 1-2). The area from the western border of YCFC to the western border of the county past City of Winters is represented by a catchment called Willow Slough (Figure 1-2). In the model, only groundwater is made available for any irrigation in these areas. Buckeye Creek, Bird Creek, Oat Creek and Goodnow Slough have little irrigated land in the historical period. Additionally, the groundwater system in this area is very poorly understood (WRIME, 2006). This poses many challenges for modeling groundwater flows in this area.

White areas in the northeast part of the county occur in five catchments: Dunnigan Other (the area in Dunnigan Hills that is not serviced by YCFC), CBD North, Yolo Zamora North, Yolo Zamora South, and CBD South (Figure 1-2). These boundaries are mainly based on previously develop models' boundaries.

Except for CBD North and CBD South, it is assumed that only groundwater is available for irrigation. In CBD North and South, an unlimited supply of surface water is assumed available from the Colusa Basin Drain. Sufficient information on the actual surface water diverted by growers in these regions is currently unknown.

The white area occurring west of the ship channel, is included in one catchment called "North Delta West" (Figure 1-2), whose boundaries are based on previous modeling efforts. The small area that borders the Sacramento River, North Delta East and West Sacramento is not technically a White Area but RD 765. However, at this time its area is included within the catchment with the rest of the area west of the ship channel.

The catchment called “Sac River”, the only area along the river that is not serviced by a Reclamation district, is assumed to have unlimited surface water supply from the Sacramento River.

Sources of Information

Technical Memorandum CCCR Event Center Project TEIR Hydrological Model of Capay Valley (April 2010)

2.2 Groundwater Model Inputs

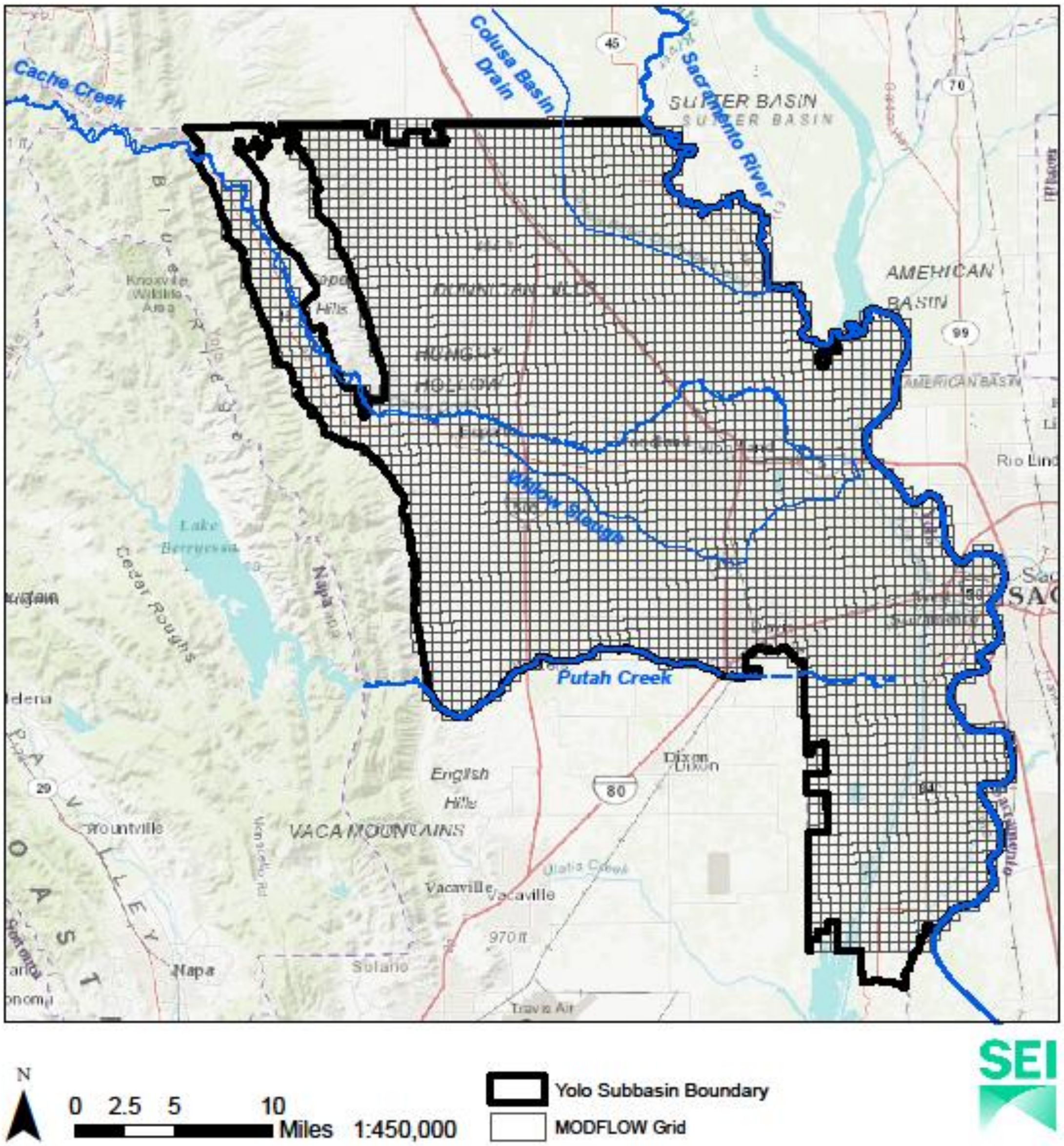
The MODFLOW model used in this effort was based on a model first developed by WRIME, Inc. using the IGSM software (WRIME, 2006) and further refined in the IWFM software by Carlos Arenas, Ph.D. student at U.C. Davis (Flores Arenas, 2016). For readers interested in a description of the hydrogeology of the Yolo County groundwater system and its representation in the original numerical model which served as the basis for this model, please see the WRIME (2006) report. Below, we provide a description of the MODFLOW model and the inputs that were extracted from the IWFM input files.

2.2.1 Model Domain

The MODFLOW model grid is made of uniform square cells that are ½ mile on a side. There are 85 rows from north to south and 80 columns from east to west. The size of the cells was chosen to provide resolution adequate to capture the shape of the important boundaries and features in the model domain. In the vertical dimension, the model consists of three layers representing the Quaternary Alluvium, the Upper Tehama Formation, and the Lower Tehama Formation. The ground surface elevation and geological unit contacts were extracted from the IWFM model input files. Elevations were interpolated for a point at the center of each MODFLOW grid cell using the nearby points on the IWFM mesh.

The boundary of the MODFLOW model domain follows the same boundaries as the IWFM model in most cases (Figure 2-3. MODLFOW model domain and subbasin boundary.Figure 2-). The western edge corresponds with the contact between the Coast Range and the valley floor sediments and includes the Capay Valley floor. The northern border of the model coincides with the Yolo – Colusa County line. The eastern border of the model coincides with the Sacramento River. From the Sacramento River, moving west, the southern boundary coincides with boundary of Solano County. Near the city of Davis, the model boundary follows Putah Creek upstream to where the creek emerges from the Coast Range close to the town of Winters. The southern boundary in this model differs from the IWFM model in that the boundary follows the county boundary (and Putah Creek) while the IWFM model has the boundary located south of the Creek. This change was made to simplify the specification of recharge and groundwater pumping boundaries using the existing WEAP model that has a boundary at the county border.

Figure 2-3. MODLFOW model domain and subbasin boundary.



2.2.2 Model Boundary Conditions

2.2.2.1 Pumping and Recharge Boundaries

The groundwater pumping and recharge boundaries are calculated on a monthly time step by the surface water hydrology and management routines in the WEAP software. The groundwater pumping boundary is applied to the same layers as specified in the IWFM model, mostly to layer 2. The WEAP software writes the input file for the MODFLOW WEL package for each month of the simulation. The recharge boundary is applied to layer 1 unless it does not exist in which case it is applied to layer 2. The WEAP software writes the input file for the MODFLOW RCH package for each month of the simulation.

2.2.2.2 Drain Boundary

In regions close to the Sacramento River where the water table can be close to the ground surface, surface channels provide a route for the discharge of groundwater into the surface water system. To mimic that process the MODFLOW DRN package was used to place a drainage boundary in reclamation Districts 108, 1600, 730, 787, and North Delta East and North Delta West. The drains were placed at an elevation 4 feet below the ground and given an estimated conductance of 4,500 ft^2/d.

2.2.2.3 Lateral boundaries

In general, the lateral boundaries in the MODFLOW model are either no-flow or general head boundaries, similar to the IWFM model. On the west side of the model the contact between the valley floor sediments and Coast Range (including the Capay Valley) is a no flow boundary. Along the northern edge of the model domain general head boundaries were imposed for all three layers. Along the eastern edge of the model, which follows the Sacramento River, general head boundaries were imposed in all three layers for the southern portion of the boundary starting due east of the city of Woodland and extending to the southernmost point on the model domain. The boundary north of the City of Woodland is no flow, remaining consistent with the IWFM model. General head boundaries were also applied in all three layers to the boundaries with Solano County. All general head boundary conditions were imposed using the MODFLOW GHB package.

2.2.2.4 Stream boundaries

Stream-aquifer interactions are simulated in the model using the MODFLOW RIV package. Remaining consistent with the IWFM model, these boundaries were applied for Cache Creek, Putah Creek, Willow Slough, Sacramento River, Knights Landing Ridge Cut, Colusa Basin Drain, Yolo Bypass, and the Ship Channel. Channel geometry information and streambed conductivity information were obtained from the IWFM input files.

2.2.3 Aquifer Hydraulic Parameters

In the MODFLOW model, the Block Centered Flow package version 6 (BCF6) was used to simulate groundwater flow. The aquifer hydraulic parameters required for this package were extracted from the IWFM input files. To obtain parameter values, a grid of points located at the MODFLOW cell centers was overlaid with the IWFM nodes and nearest neighbor assignments were made to each MODFLOW cell center. The values for horizontal hydraulic conductivity, specific yield, storage coefficient, and vertical hydraulic conductivity for each MODLFOW cell center were then extracted from the nearest neighboring IWFM node. VCONT values (vertical hydraulic conductivity divided by the thickness from a layer to the layer below) were calculated using the vertical hydraulic conductivities and layer thickness values using Equation 5-39 in the MODFLOW 2005 documentation (Harbaugh, 2005).

2.2.4 Initial heads

The MODFLOW model initial heads for October 1, 1970 were taken from the IWFM input files based on the nearest neighbor approach described above.

3 Model Calibration

The combined WEAP-MODFLOW model was calibrated in a series of steps. The initial steps were focused on the surface water processes including rainfall runoff, reservoir operations, crop ET, and irrigation management. With those portions of the model calibrated the groundwater pumping and recharge boundary conditions for the groundwater model were set and calibration of the ground water model was then completed. The observation data used in calibration are listed in Table 3-1.

Table 3-1 Calibration field and datasets

Type	**Subtype**	**Location**	**Period of Data Downloaded**	**Data source**
Catchment water balance	Streamflow	Kelsey Creek	Oct 1976-Sept 2008, monthly	USGS: https://waterdata.usgs.gov/ca/nwis/uv?11449500
Catchment water balance	Streamflow	Hough Springs	Oct 1976-Sept 2008, monthly	USGS: https://waterdata.usgs.gov/ca/nwis/uv?11451100
Catchment water balance	Streamflow	Cache Creek at Yolo	Oct 1974- Sept 2009, monthly	USGS: https://waterdata.usgs.gov/nwis/uv?site_no=11452500
Catchment water balance	Reference ET (ETo)	Davis CIMIS station	Aug 1982 to July 2017, monthly timestep	CIMIS: http://www.cimis.water.ca.gov/WSNReportCriteria.aspx Downloaded on 8/28/2017
Catchment water balance	Solar Radiation			
Catchment water balance	Actual ET	Actual ET for 19 crop categories	2005, monthly timestep	DWR's CUP model version 6.9: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Water-Use-Models Sacramento San Joaquin Basin Study: https://www.usbr.gov/watersmart/bsp/docs/finalreport/sacramento-sj/Sacramento_SanJoaquin_TechnicalReport.pdf
Catchment water balance	Applied Water	DWR water portfolio, at Detailed Analysis Unit (DAU) resolution	1998-2010, annual timestep	DWR Land and Water Use: http://www.water.ca.gov/landwateruse/anlwuest.cfm
Operations	YCFC deliveries sales and canal losses	Releases from Capay dam, and sales from Winters and West Adams canal	1975-2013, Monthly timestep	YCFC, personal communication, 2015
Operations	Reservoir Volume	Volume in Clear Lake and Indian Valley Reservoir	1974-2009, monthly timestep	YCFC, personal communication, 2015
Groundwater	Groundwater Levels	All wells in the database (in and near Yolo County)	Time series available for each well (varies by well)	WRID database (https://wrid.facilitiesmap.com/login.aspx) YCFC, personal communication, 1/30/2017
Groundwater	Groundwater Levels	All data for all wells within 5km of Yolo County's border	Time series available for each well (varies by well)	DWR Water Data Library http://www.water.ca.gov/waterdatalibrary/index.cfm downloaded 12/8/16

3.1 Surface Water Calibration

3.1.1 Rainfall Runoff

The initial step was to calibrate the catchments in the upper Cache Creek portion of the model that are upstream of the subbasin boundary but supply irrigation water to the subbasin. Streamflows in North Fork of Cache Creek at Hough Springs and Kelsey Springs, the tributaries to Indian Valley Reservoir and Clear Lake, respectively, which have USGS stream gauges, were calibrated in the model by adjusting soil parameters in the catchments which runoff into these creeks. Cache Creek downstream, at Yolo, was also calibrated by adjusting reservoir outflows, diversions (see the following sections on operations) and soil parameters in the corresponding catchments. Goodness of fit statistics are shown in Table 3-2 and the observed and modeled streamflows for each creek are shown in Figure 3-1, Figure 3-2, and Figure 3-3.

Table 3-2. Calibration statistics for streamflows, compared to USGS gauges.

	Kelsey Creek	**North Fork Cache Creek at Hough Springs**	**Cache Creek at Yolo**
NSE	0.89	0.82	0.81
RMSE (AF)	2,592	5,609	40,247
PBias (%)	-5	-13	-13
Calibration period	Oct 1976-Sept 2008, monthly	Oct 1976-Sept 2008, monthly	Oct 1974- Sept 2009, monthly

Figure 3-1. Observed and modeled streamflow in Kelsey Creek.

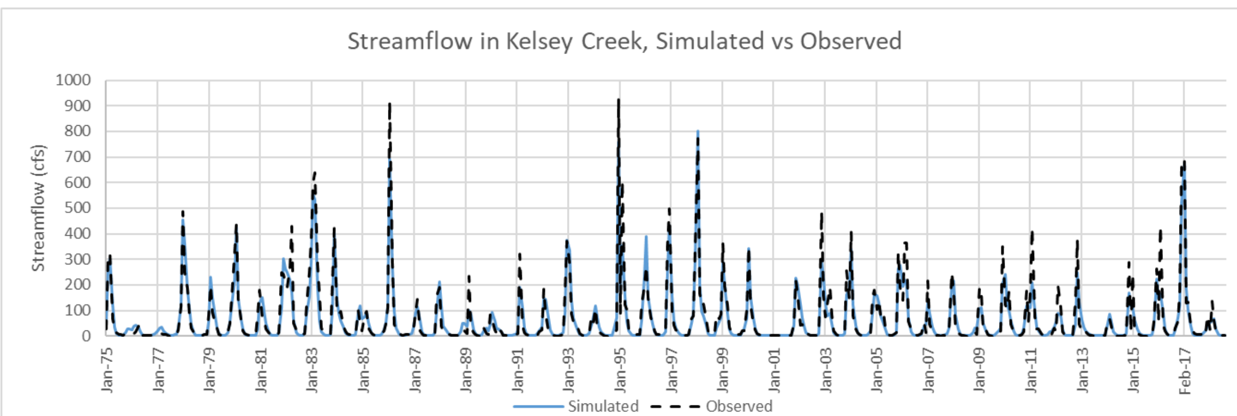


Figure 3-2 Observed and modeled streamflow in North Fork Cache Creek at Hough Springs.

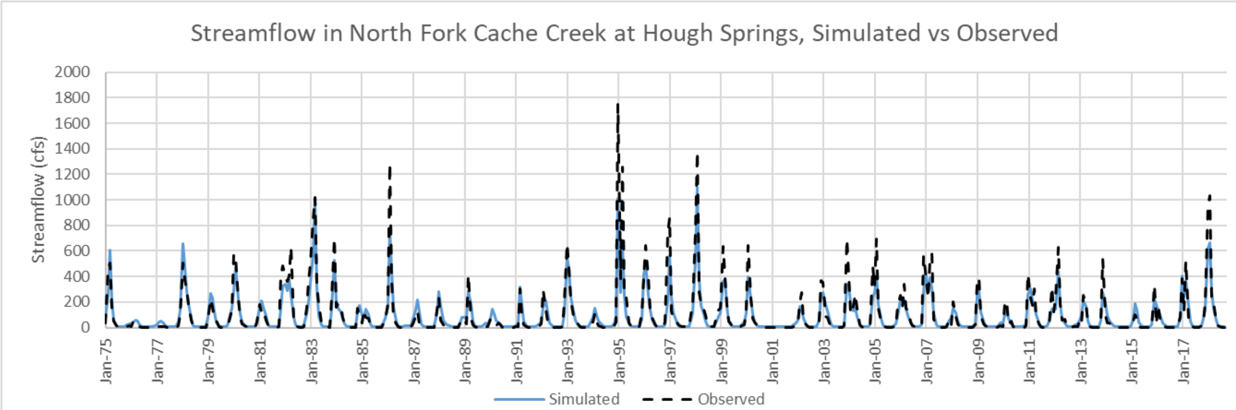
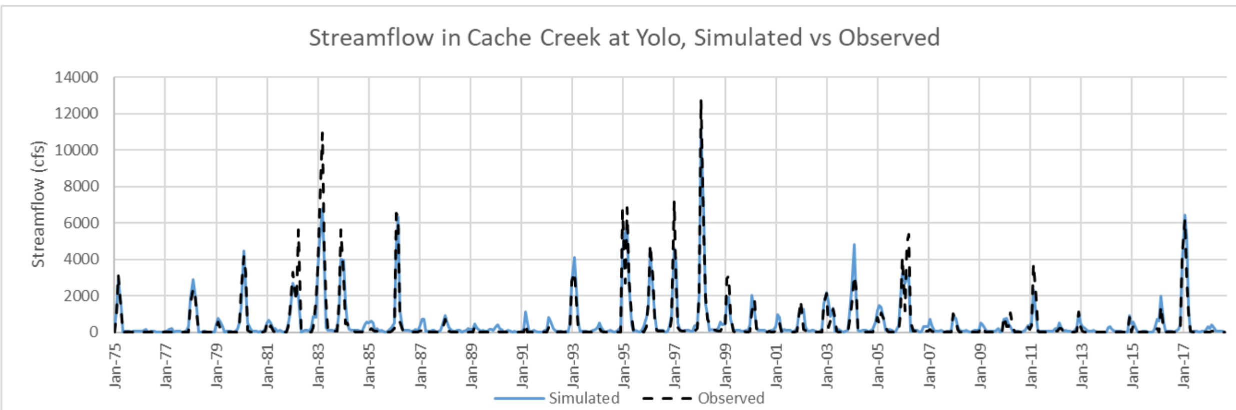


Figure 3-3. Observed and modeled streamflow in Cache Creek at Yolo.



3.1.2 Reservoir operations

The second stage of calibration was focused on Clear Lake and Indian Valley reservoirs. Reservoir volumes are determined by a combination of upstream hydrology, operating rules, and irrigation demands further downstream. Operating rules for Clear Lake are largely determined by the Solano Decree (Superior Court of the State of California, 1995, 1978) in the irrigation season and the Gopcevic decree in the winter. Indian Valley operating rules were obtained from YCFCWD. These rules have been integrated into the YSGA model, as described earlier in (Mehta et al., 2013). Later sections of this chapter describe the calibration of applied water and canal deliveries, which have a bearing on the calibration of these reservoir volumes.

Model performance for the two reservoirs are shown in Table 3-3. Modeled and observed volumes are shown in Figure 3-4 and Figure 3-5.

Table 3-3 Calibration statistics for the two reservoirs in the model

	Clear Lake	Indian Valley
NSE	0.91	0.89
RMSE (AF)	32,937	31,001
PBias (%)	-1.4	-2.4
Calibration period	Water Year 1974-2010 (monthly)	Oct 1975- May 2010 (monthly)

Figure 3-4. Clear Lake observed and modeled volumes.

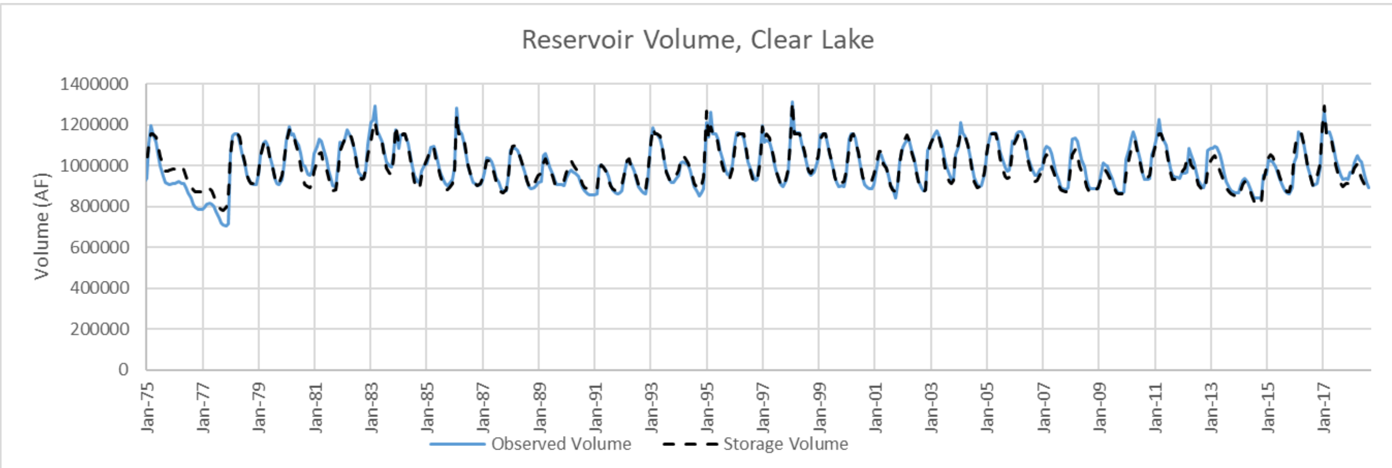
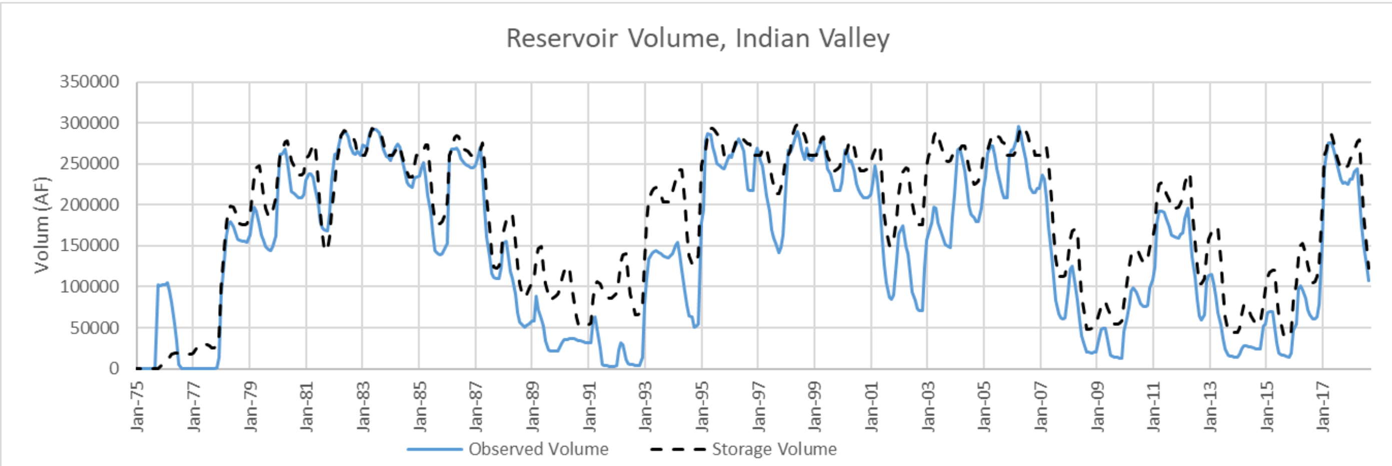


Figure 3-5. Indian Valley Reservoir observed and modeled volumes.



3.1.3 Crop evapotranspiration

Crop ET was simulated using the routines in the MABIA module of WEAP. These routines calculate crop ET using the dual crop coefficient approach described in FAO 56 (Allen et al., 2005). As a first step, the calculations of solar radiation and reference ET were validated by comparison with observations. Following that, basal crop coefficients were calibrated so that crop ET from the dual crop coefficient method in MABIA agreed with ET rates used in the Sacramento – San Joaquin Basin Study (Reclamation, 2015). The Basin Study ET rates were computed by Andy Draper of MWH in a technical memorandum using crop coefficients provided by DWR. The details of these calculations are provided as an appendix to the Basin Study report.

3.1.3.1 Solar Radiation and Reference ET

Solar radiation and reference ET in the MABIA module are calculated using the Hargreaves method and the Penman Monteith equation. To verify the simulated values the calculated solar radiation and reference ET were compared against CIMIS data downloaded from the Davis CIMIS station. Average monthly modeled and CIMIS solar radiation values are shown in the following tables and figures (Solar radiation: Table 3-4 and Figure 3-6, Reference ET: Table 3-5, Figure 3-7) for water year 1983-2015. The calculations show a reasonable match for solar radiation and reference ET.

Table 3-4. Monthly average solar radiation in watts per square meter (Averaged over WY 1983-2015).

Month	Modeled S (W/m2)	CIMIS S (W/m2)	Diff (Model-CIMIS), W/m2
Jan	91	80	11
Feb	128	124	4
Mar	181	183	-2
Apr	245	250	-5
May	295	294	1
Jun	325	328	-3
Jul	333	330	3
Aug	301	298	3
Sep	242	238	3
Oct	169	168	1
Nov	109	103	6
Dec	82	72	10

Figure 3-6. Monthly average solar radiation in watts per square meter. Averaged over WY 1983-2015.

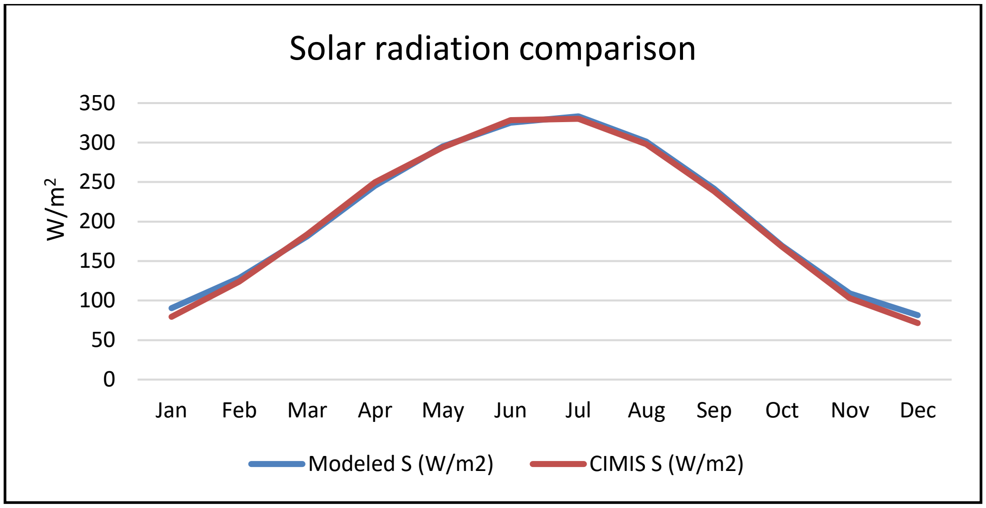
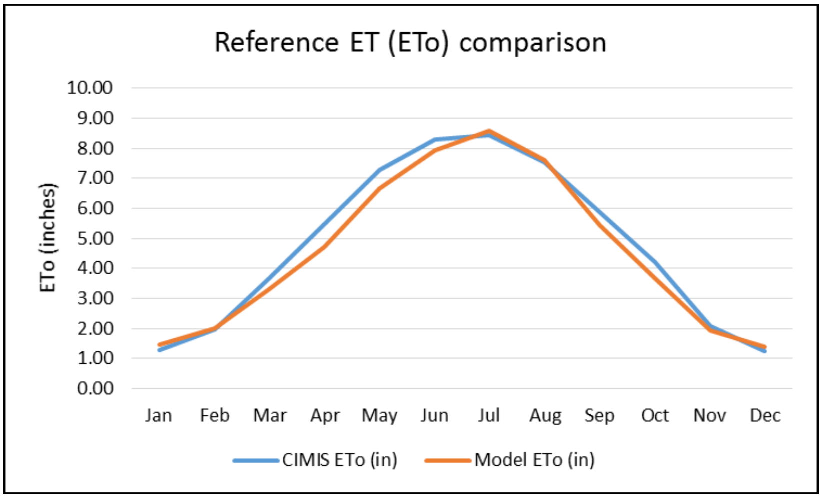


Table 3-5. Observed reference ET (ETo), modeled ETo and the difference between them. Averaged over WY 1983-2015.

Month	CIMIS ET_o (in)	Model ET_o (in)	Diff(Model ET_o-Obs ET_o)
Jan	1.27	1.48	0.20
Feb	1.96	2.01	0.05
Mar	3.69	3.30	-0.39
Apr	5.46	4.71	-0.75
May	7.27	6.68	-0.59
Jun	8.30	7.95	-0.35
Jul	8.45	8.60	0.15
Aug	7.53	7.60	0.06
Sep	5.86	5.46	-0.40
Oct	4.21	3.66	-0.55
Nov	2.08	1.95	-0.12
Dec	1.26	1.38	0.13
Total	57.34	54.77	-2.57

Figure 3-7. Average monthly ET_o, in inches (Averaged over WY 1983-2015).



3.1.3.2 Crop Coefficients

Basal crop coefficients were developed by adjusting the coefficients so that the crop ET from the YSGA model matched the monthly crop ET rates for the WY 2005 irrigation season as simulated using DWR's CUP model. ET rates for most crops came from the results of CUP model runs done for the Basin Study (Reclamation, 2015). Additional CUP model runs were done for crops not simulated in that study. Planting dates, harvest dates, and growth period lengths from the Basin Study were used for all crops (Table 3-6). The exceptions were the following cases:

1. Squash, the representative crop for Cucurbits. In this case, the planting date of April 1 from FAO 56 was used instead of Jan 15. Crop ET was simulated with CUP version 6.9.
2. Asparagus, the representative crop for Other Truck. Crop ET was simulated with CUP version 6.9.
3. Walnuts, representative crop for Other Deciduous. Crop ET was simulated with CUP version 6.9.
4. Sunflower, representative crop for Other Field. Crop ET was simulated with CUP version 6.9.
5. Olives, representative crop for Subtropical. Crop ET was simulated with CUP version 6.9.
6. The values for the Young Almonds category (almond trees up to three years old) were set based on a UCANR study on young almonds (Jarvis-Shean et al., 2018) as there was no representation of this category in the Basin Study.

In the YSGA model, the k_{cb} values in the MABIA module were adjusted so that crop ET from during the irrigation season was within a 3% difference of the CUP model value. For tomato and grain, it was necessary to adjust the length of the growth periods while maintaining overall season length. Even with the additional adjustments, grain ET could only be calibrated within a 4% difference from the Basin Study. This was likely due to differences in the input precipitation data sets. The YSGA model used gridded PRISM data that contain springtime rain that does not appear in the CIMIS record. For safflower the irrigation schedule was adjusted to stop irrigation on July 15, even though harvest occurs on July 31, based on the literature which states that safflower is minimally irrigated, sometimes only once a season, and irrigation could be stopped as early as May.[20] The comparison between the YSGA model and CUP model ET rates is shown in Figure 3-8 and Table 3-7.

Following the effort described above, the basal crop coefficients were reduced by 5% to account for decreased crop vigor and bare spots (ITRC, 2003).

[20] Based on: https://coststudyfiles.ucdavis.edu/uploads/cs_public/63/a9/63a948b0-8cef-4843-b66c-ac27006f726f/safflowersv2011.pdf

CUP Model								YSGA model								Both models	
Crop name	Stage length (days)				Crop Coefficients			Crop Name	Stage length (days)				Crop Coefficients			Plant Date	Total Growing Season Days
	Init	Dev	Mid	Late	K_c ini	K_c mid	K_c end		Init	Dev	Mid	Late	K_{cb} ini	K_{cb} mid	K_{cb} end		
Alfalfa	91	91	91	91	1	1	1	Alfalfa	91	92	91	91	0.9	0.9	0.9	1-Jan	365
Almonds[1]	0	115	92	23	0.55	1.2	0.65	Almonds	0	115	91	23	0.4	0.95	0.65	1-Mar	229
Corn (grain)	31	38	46	38	0.2	1.05	0.6	Corn	31	38	46	38	0.12	0.85	0.52	1-May	153
Squash	18	28	27	18	0.5	0.95	0.75	Cucurbits	25	35	25	15	0.15	0.9	0.7	1-Apr[1]	100[2]
Dry Bean	26	17	55	10	0.15	0.9	0.15	Dry Bean	26	17	55	10	0.15	0.9	0.15	15-Jun	108
Wheat	53	74	64	21	0.3	1.05	0.15	Grain	53	79	39	41	0.05	0.7	0.05	1-Nov	212
Walnuts	0	115	57	57	0.55	1.2	0.6	Other Deciduous	0	115	57	57	0.5	1.1	0.55	1-Apr	229
Sunflower	27	33	47	27	0.2	1.05	0.4	Other Field	27	33	46	27	0.1	0.95	0.35	1-May	133
Asparagus	44	47	256	18	0.25	0.95	0.25	Other Truck	44	47	256	18	0.25	0.95	0.25	1-Jan	365
Pasture	91	91	91	91	0.95	0.95	0.95	Pasture	91	92	91	91	0.9	0.9	0.9	1-Jan	365
Rice	33	18	68	19	1.2	1.05	0.8	Rice	33	18	69	19	1.16	0.9	0.9	15-May	139
Safflower	21	34	43	24	0.2	1.05	0.25	Safflower	21	34	43	24	0.1	0.7	0.1	1-Apr	122
Sugar beet	30	60	70	40	0.2	1.15	0.95	Sugar beet	30	60	70	40	0.15	0.95	0.85	15-Mar	200
Olives	0	120	124	120	0.9	0.9	0.9	Subtropical	0	120	125	120	0.9	0.9	0.9	1-Jan	365
Tomato	38	38	46	31	0.2	1.2	0.6	Tomato	48	39	45	21	0.05	0.85	0.35	1-Apr	153
Wine grapes	0	54	108	54	0.45	0.8	0.35	Vine	0	54	107	54	0.05	0.5	0.25	1-Apr	215
NA								Young Almonds	0	115	57	57	0.2	0.5	0.3	1-Mar	229

[1] Mid-season crop coefficients for almonds and other tree crops may vary between 0.90 – 1.15 depending on whether a cover crop is present.

[2] Plant date is Jan 15 in the Basin Study

[3] Total number of days to maturity is 91 in the Basin Study

Table 3-6. Growth stage length and kc values from the Basin Study and the WEAP model, after calibration and modifications to reduce ET.

Figure 3-8. Comparison of monthly simulated crop ET rates from Basin Study (red) and YSGA models (blue).

Crop	Irrigation Season	Basin Study Actual ET (in)	WEAP Actual ET (in)	% Diff
Alfalfa	Ap-Sep	36.9	36.3	-1.5
Almond	March-Oct	47.2	46.1	-2.4
Corn	May-Sep	28.2	27.5	-2.6
Cucurbits	Jan-Apr	8.1	8.2	1.8
Grain	Nov-May	16.0	16.6	3.8
Other Deciduous	March-Oct	45.7	45.8	0.3
Other Field	May-Sep	26.0	25.7	-1.2
Other Truck	Ap-Sep	40.5	40.8	0.8
Pasture	Ap-Sep	35.3	35.9	1.7
Rice	May-Sep	33.9	33.6	-0.8
Safflower	Apr-Jul	20.2	17.5	-13.2
Tomato	April-Aug	27.9	28.4	1.8
Vine	April-Nov	32.2	26.8	-16.8

Table 3-7. WEAP and CUP ET comparison.

3.1.4 Irrigation water management

After setting the crop ET parameters, the applied water rates in the model were calibrated to DWR's applied water data[21] for the Detailed Analysis Unit titled "Lower Cache Creek." Average annual applied water was calculated for 1998-2010 for all crops that existed in those years. The irrigation efficiency parameter in the MABIA module was adjusted until the simulated applied water agreed with the DWR values within 3% (Table 3-8). The exceptions to this approach were for rice, cucurbits (squash) and other truck (asparagus). In MABIA the irrigation efficiency parameter is not used for flooded crops. Instead, to adjust applied water, the flow through parameter was adjusted to 2 mm/d. For cucurbits (squash), a value of 18 inches of applied water was indicated by the UC Davis Cooperative Extension[22], and 30 inches for other truck (asparagus).[23] For other truck, adjusting the irrigation efficiency was not enough to achieve the desired level of calibration, likely due to discrepancies in selected representative crops

[21] Data can be accessed here: https://water.ca.gov/Programs/Water-Use-And-Efficiency/Land-And-Water-Use/Agricultural-Land-And-Water-Use-Estimates

[22] 18 inches if based on information from the UC Davis Small Farm Program http://sfp.ucdavis.edu/crops/squash1/

[23] 30 inches is based on information from the UC Davis Vegetable Research and Information Center: https://anrcatalog.ucanr.edu/pdf/7234.pdf

between the DWR categories and the WEAP categories. Since this crop type is a relatively small area in Yolo County no further calibration was attempted.

Table 3-8. Comparison of average applied water from DWR DAU's and WEAP for each crop.

Crop	Irrigation Efficiency	WEAP	Lower Cache Creek DAU	Difference (%)
Alfalfa	54	5.15	5.29	-2.81
Almond	74	4.01	4.10	-2.25
Corn	58	2.91	2.99	-2.62
Cucurb	80	1.46	1.50[2]	-2.56
DryBean	69	1.88	1.91[3]	-1.60
Grain	28	1.16	1.16	-0.51
Oth Dec	72	4.22	4.12	2.43
Oth Fld	63	2.53	2.58	-1.79
Oth Trk	100	2.79	2.50[2]	10.47
Pasture	49	5.64	5.77	-2.35
Rice	83, 2[1]	5.38	5.52	-2.72
Safflwr	95	0.88	0.90	-1.66
SgrBeet	62	3.93	4.02[4]	-2.20
Subtrop	90	3.40	3.30[5]	2.94
Tomato	54	2.91	2.98	-2.47
Vine	96	1.55	1.59	-2.68
Young Almonds	95[6]			

[1] This value is the release requirement in flooding, in millimeters. This is the value that was adjusted in calibration for rice rather than irrigation efficiency, which is also indicated above.

[2] This value is from a UC Davis Cooperative Extension resource.

[3] This value is the average of 1998 only.

[4] This value is the average of 1998-2000 only.

[5] This value is the average of 2000 only.

[6] No observed information is available for Young Almonds, so efficiency was set and not later adjusted.

3.2 Groundwater Calibration

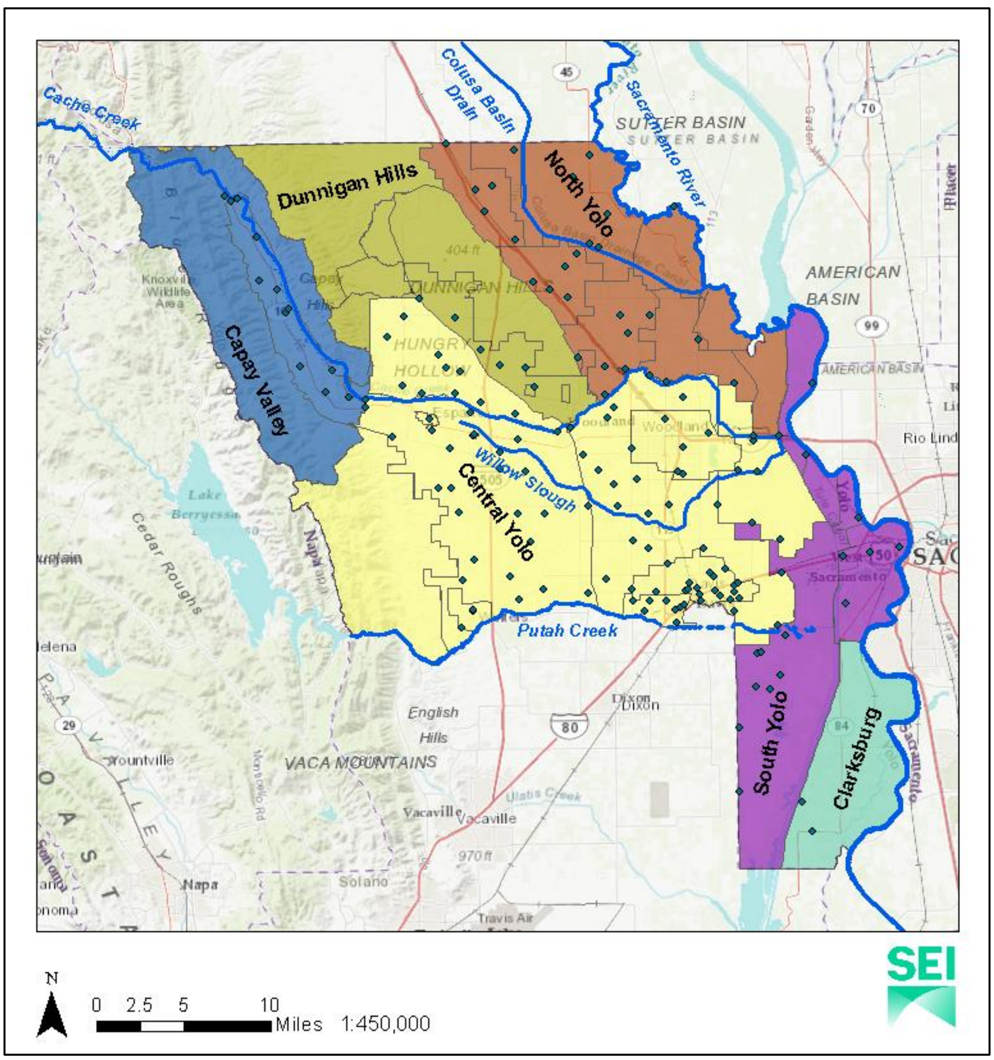
Calibration of the MODFLOW groundwater model was focused on comparisons of simulated values with observations of water levels in wells and reported stream seepage rates. In the discussion below, details about the calibration targets, calibration methods, and calibration results are provided.

3.2.1 Calibration Targets

3.2.1.1 Observation Wells

The modeling team worked with Yolo County Flood Control and Water Conservation District staff to identify 174 monitoring wells throughout the study area that have: a multi-decade record of observations during the study period of Water Years 1971 – 2018, a known well depth, and a known location and ground surface elevation. The wells are distributed throughout the County but do not provide uniform coverage of all regions (Figure 3-9). The Central Yolo, Capay Valley, and North Yolo management areas have the densest coverage of wells, largely due to the long running data collection efforts by the Yolo County Flood Control and Water Conservation District. The Clarksburg and South Yolo management areas have relatively few observation wells. The Dunnigan Hills management area has the largest area without any observation wells. This includes the Dunnigan Hills, Buckeye Creek, Bird Creek, and Oat Creek sub-regions. Due to the lack of available observation data in some regions, the requirement that a well have multiple decades of observations was relaxed in some cases. The focus was on wells with multiple observations during the final two decades of the simulation period.

Figure 3-9. Location of observation wells used in groundwater model calibration.



3.2.1.2 Stream Seepage Estimations

Published estimations of stream seepage for water bodies in the Yolo County area were used to provide guidance in the calibration of stream bed conductivity.

A review of previous studies for Putah Creek reports a groundwater ridge in connection with the creek for most of the stream in the study area (Luhdorff and Scalmanini, Consulting Engineers, 2010). A study from 1961-1975 found an average annual stream seepage loss of 18,133 af/yr (Mullen and Nady, 1985). This is similar to the annual average value (1971-2000) from the IGSM groundwater model of 21,800 af/yr (WRIME, 2006).

In the same study for years 1961 – 1975 (Mullen and Nady, 1985) the portion of Cache Creek between Capay and Rumsey had an average gain of groundwater of 440 af/yr. The lower portion of the Creek from Capay to Yolo had an average loss of 25,400 af/yr. These values compare with 2,600 af/yr of gain and 37,900 af/yr of average loss for 1971-2000 from the IGSM model for the upper and lower reaches, respectively (WRIME, 2006).

Detailed analyses of other streams in the study area were not found. In general, an analysis of the C2VSim groundwater model suggests that all streams on the valley floor in the study area are losing streams during the period of 2000 - 2009 (The Nature Conservancy, 2014). This is in comparison to the IGSM study that indicates the Sacramento River and Yolo Bypass are gaining streams during 1971-2000.

3.2.2 Calibration of Groundwater Heads

The initial specification of aquifer hydraulic parameters, including horizontal and vertical hydraulic conductivity, specific yield, and storage coefficient, was done using the values in the IWFM model used in the dissertation by Carlos Arenas (Flores Arenas, 2016). Initial comparisons between simulated and observed heads at the wells discussed above showed relatively poor performance in comparison to that achieved by the IWFM model. To a degree, this was expected as the specification of pumping and recharge in the WEAP-MODFLOW model were calculated using a different algorithm than that in IWFM and they are not as highly resolved spatially. For that reason, the modeling team partnered with Carlos Arenas to work at improving model performance through a calibration process. The initial calibration was based on the assumption that the horizontal conductivities developed for the original IGSM model were the least uncertain. The other aquifer parameters, vertical conductivity and storage terms, were considered less certain and were adjusted to improve model performance.

During this stage of the calibration process the focus was on adjusting vertical conductivities to better match observed groundwater head elevations and adjusting storage terms to better match the seasonal fluctuations in groundwater heads. During this process it was found that a reduction in the fraction of irrigation inefficiency that results in deep percolation improved model performance for some regions. This was achieved by introducing a factor that scaled the parameters described in Section 2.1.3.1. This factor had a value of 1.0 in the Capay Valley sub-region, a value of 0.7 in the western portion of the Central Yolo management area and the entire Dunnigan Hills management area. A value of 0.3 was used in the North Yolo management area and the northern portion of the South Yolo management area. A value of 0.7 was used in the southern portion of the South Yolo management area and the Clarksburg management area.

During calibration it became apparent that in the region of Buckeye Creek, Bird Creek, Oat Creek, and Goodnow Slough simulated groundwater heads were falling and affecting the heads in Hungry Hollow area. A review of the original IGSM model showed a similar pattern of falling simulated heads in the Hungry Hollow wells which conflicts with the observations. This resulted in losses in groundwater storage that did not seem realistic, given that the well observations show a dynamic equilibrium similar to other wells. To remedy this, the native vegetation land cover parameters in Buckeye Creek, Bird Creek, Oat Creek, Dunnigan Other, and Goodnow Slough was adjusted to maximize deep percolation and produce little surface runoff. Horizontal hydraulic conductivity values were also adjusted by a factor of 0.5 in the Buckeye Creek, Bird Creek, Oat Creek, and Goodnow Slough sub-regions and by a factor of 0.1 for the Dunnigan Other sub-region. With this adjustment, the groundwater storage in this region fluctuated during the simulation but ended close to the initial storage at the end of 2018. Future efforts with this model should address the lack of information available in this region so that it can be better characterized.

Finally, comparisons of simulated and observed heads in the Dunnigan Water District and Yolo Zamora area showed simulated heads were too low. Additional research of this area, which has limited surface water availability suggests that irrigation efficiencies are relatively high in this region (Davids Engineering Inc, 2007). Irrigation efficiencies for this region were set to 85%, resulting in less groundwater pumping and higher simulated head values.

3.2.3 Calibration of Stream Seepage

Stream seepage was calibrated by adjusting the initial values of stream bed conductivity obtained from the IWFM model. Using the calibration targets discussed in Section 3.2.1.2, the stream bed conductivities of Cache Creek, Putah Creek and the Yolo Bypass were adjusted to provide a closer match between simulated and estimated values. Conflicting or limited information was available for other streams, such as the Sacramento River, therefore no additional calibration was conducted.

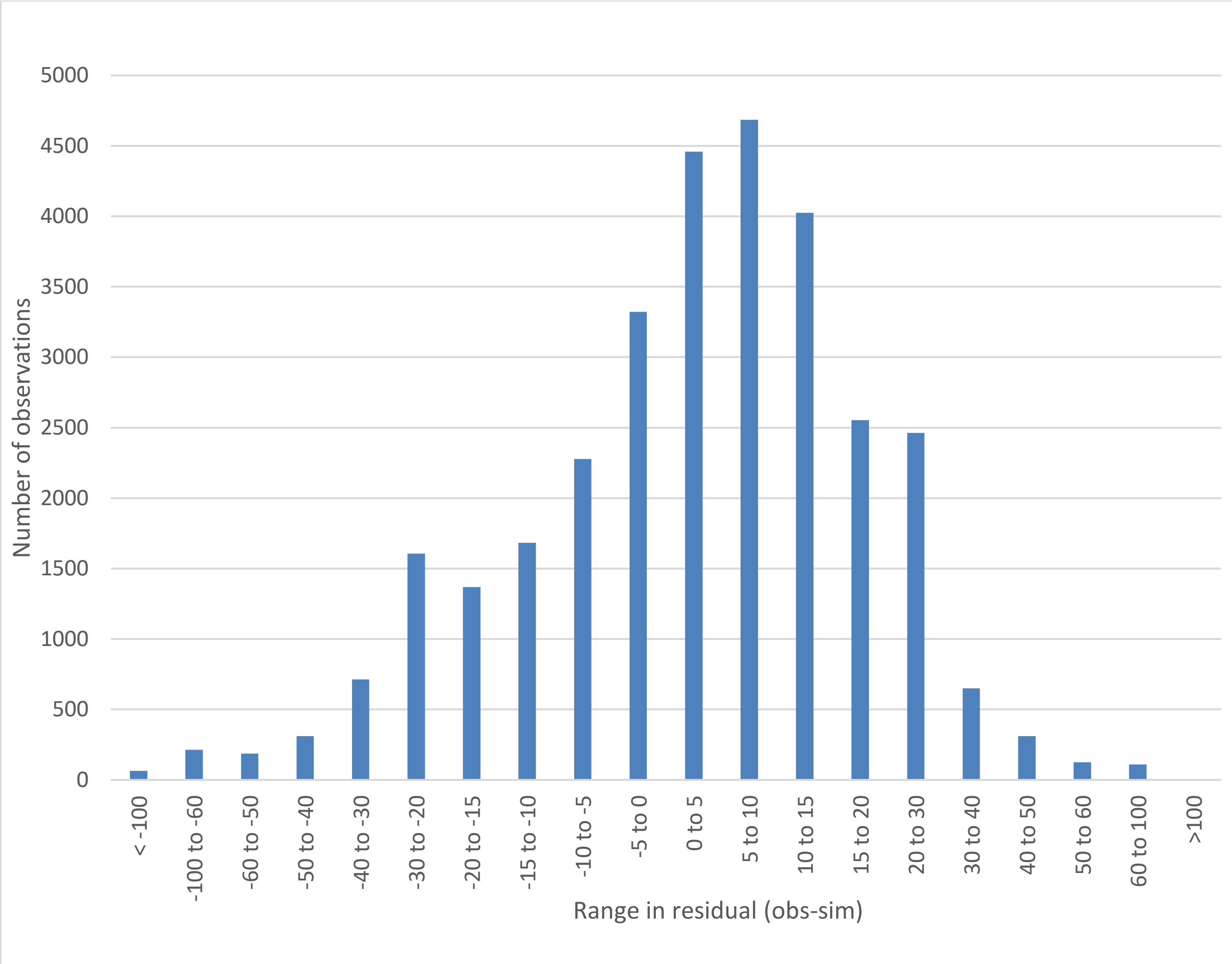
3.2.4 Calibration Results

Below is a discussion of the calibration results for the groundwater model. Both the groundwater heads and the stream seepage results are discussed

3.2.4.1 Groundwater Heads

Comparisons between observed and simulated groundwater heads at individual wells are provided for the 174 observation wells used in the calibration in Appendix A of this document. A histogram of the residuals, calculated as observed minus simulated, is shown in Figure 3-10. The histogram shows that on average the model under predicts groundwater heads by 2.2 ft. 78% of the simulated values are within 20 feet of observed, 47% are within 10 ft, and 25% are within 5 ft of observed. As mentioned earlier, this fit is not as close as it was in the IGSM model (61% within 10 ft) nor the IWFM model (53% within 10 ft), however, this is not surprising as the recharge and pumping boundary conditions were applied uniformly at the catchment scale, compared with the finite element scale in the other models.

Figure 3-10. Histogram of residuals calculated as observed - simulated.

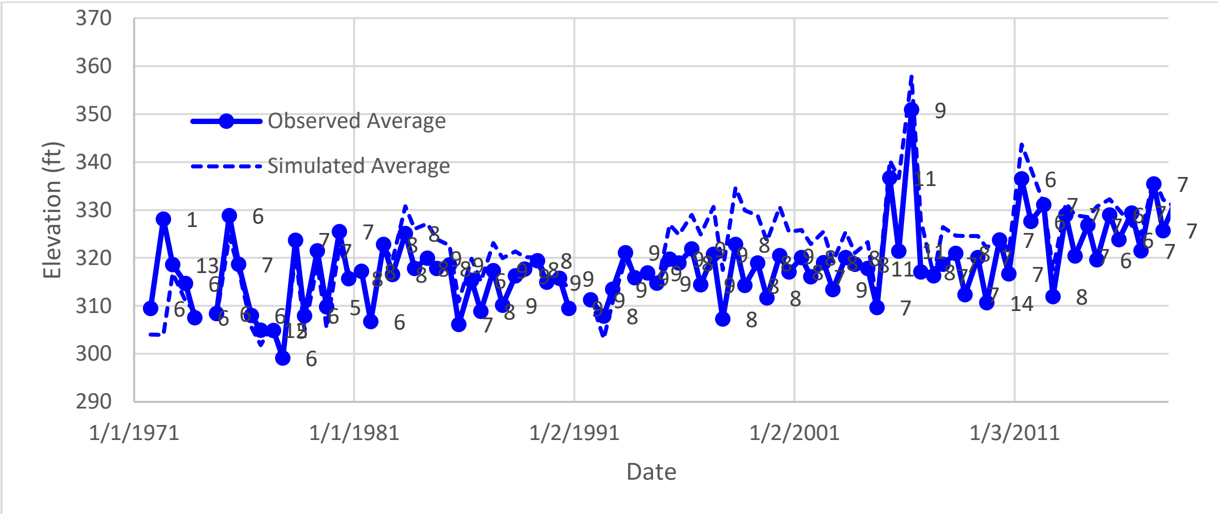


Due to the large number of wells, there will not be a discussion of each well. Instead, regions with similar behavior will be discussed and plots of observed and simulated heads averaged over multiple wells will be presented to demonstrate model behavior. It should not be expected that the plots, which average observations and simulated values from many wells, will provide a visually consistent reflection of water table behavior during the historical period. This is because observations wells, located at different elevations, go on- and off-line during the simulation period.

3.2.4.1.1 Capay Valley

Simulated heads in layer 1 of the Capay Valley provide a reasonable approximation of the observed heads with a general over prediction of water table elevation (Figure 3-11). The average bias for all observation wells is 8.5 ft. This means that the simulated values overpredicted head, on average.

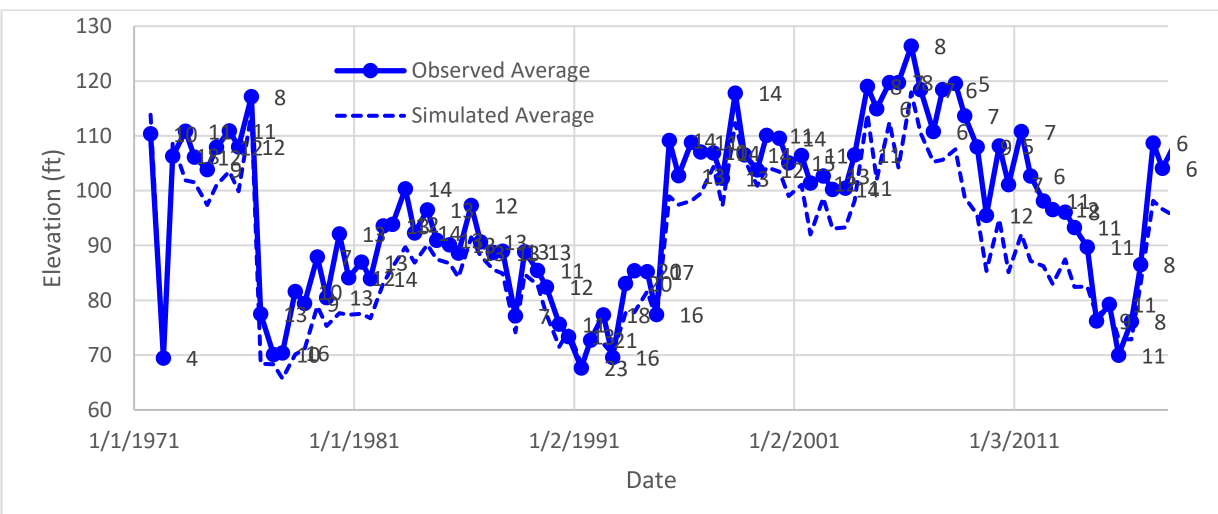
Figure 3-11. Average observed and simulated heads in layer 1 of Capay Valley. Numbers of observations are provided for each point.



3.2.4.1.2 Central Yolo

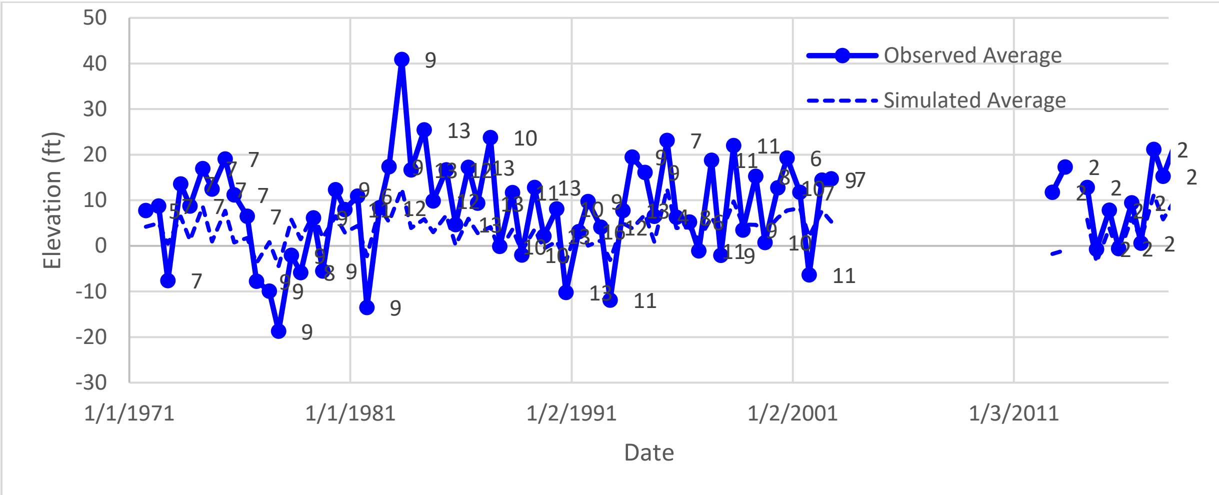
On the western side of the Central Yolo management area, the simulated heads in the YCFC West sub-region show a reasonable approximation by the model with a general underprediction of water table elevation (Figure 3-12). Average simulated values are within 10 ft of observed for most of the simulation and the average bias for all observation wells is -3.5 ft.

Figure 3-12. Average observed and simulated heads in layer 1 of the YCFC West sub-region. Number of observations are provided for each point.



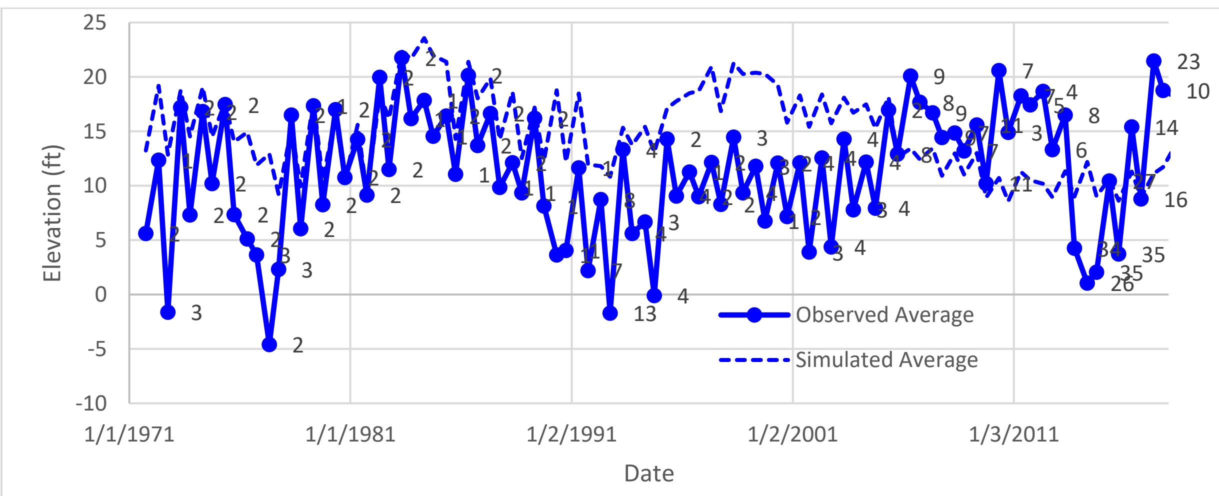
Further to the east the heads on the UC Davis campus show general agreement with the observations from layer 2 (Figure 3-13). The simulated values in this region do not track the variation in heads as well but do remain in the range of the observations. The average bias for these wells is 5.5 ft.

Figure 3-13. Average observed and simulated heads in layer 2 of the UC Davis sub-region. Number of observations are provided for each point.



At the far eastern edge of the management area the simulated heads for wells in layer 1 of RD 2035 are within range of the observations (Figure 3-14). The average bias for these wells is 3.7 ft.

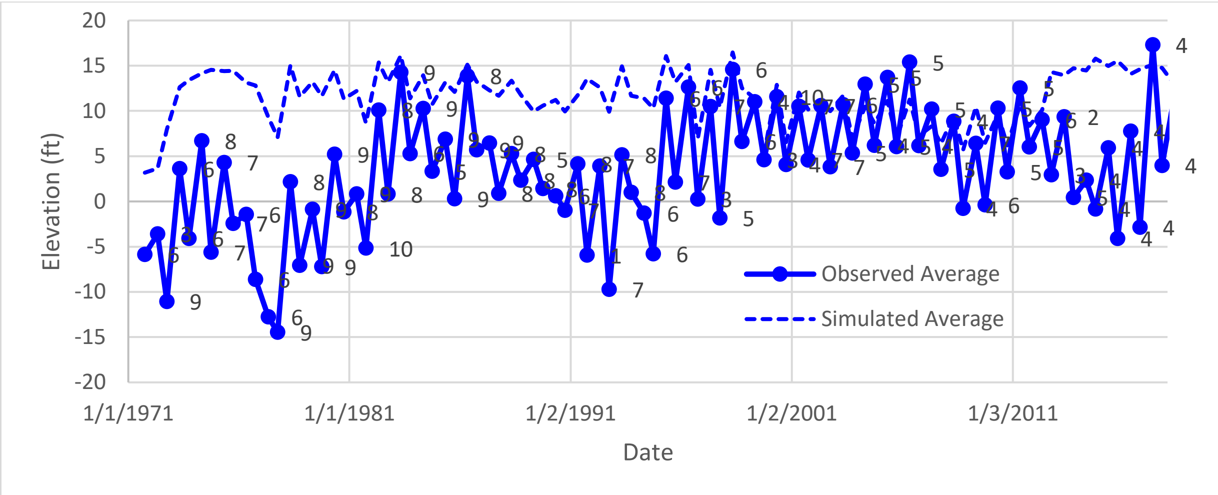
Figure 3-14. Average observed and simulated heads in layer 1 of the RD 2035 sub-region.



3.2.4.1.3 South Yolo

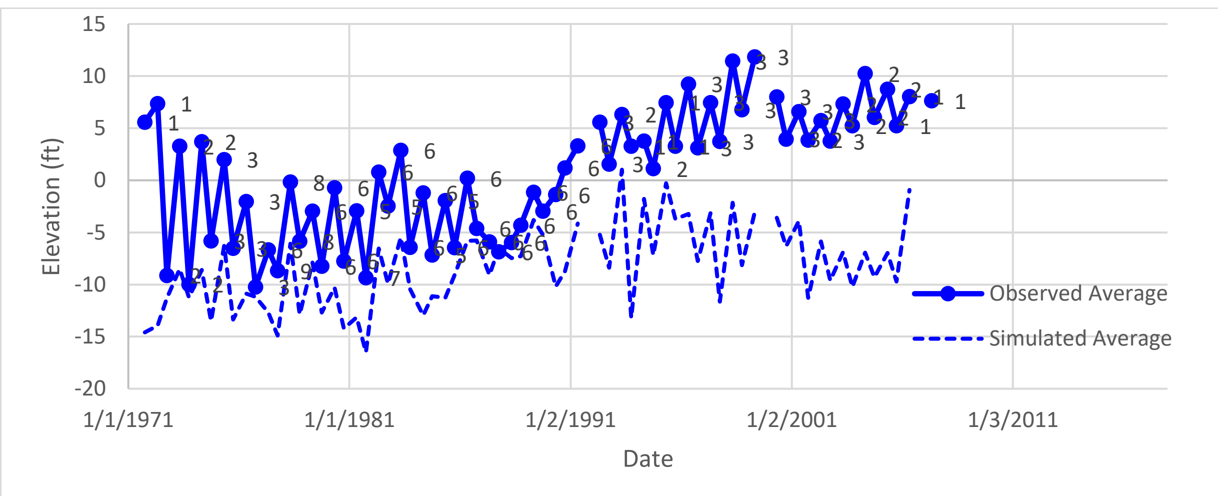
The largest sub-region in the South Yolo management area is North Delta West. This sub-region shows that on average the simulated heads in layer 1 are on average higher than the observations during the first half of the simulation and in the last decade (Figure 3-15). The average bias for these wells is 10.2 ft.

Figure 3-15. Average observed and simulated heads in layer 1 of North Delta East sub-region.



Most other sub-regions in the South Yolo management area do not have many observation wells. The West Sacramento sub-region has 3 wells that are in layer 2 (Figure 3-9). They show that the model generally underpredicts groundwater head but is within 5 to 10 ft much of the simulation (Figure 3-16). The average bias for these wells is -10.5 ft.

Figure 3-16. Average observed and simulated heads in layer 2 of the West Sacramento sub-region.



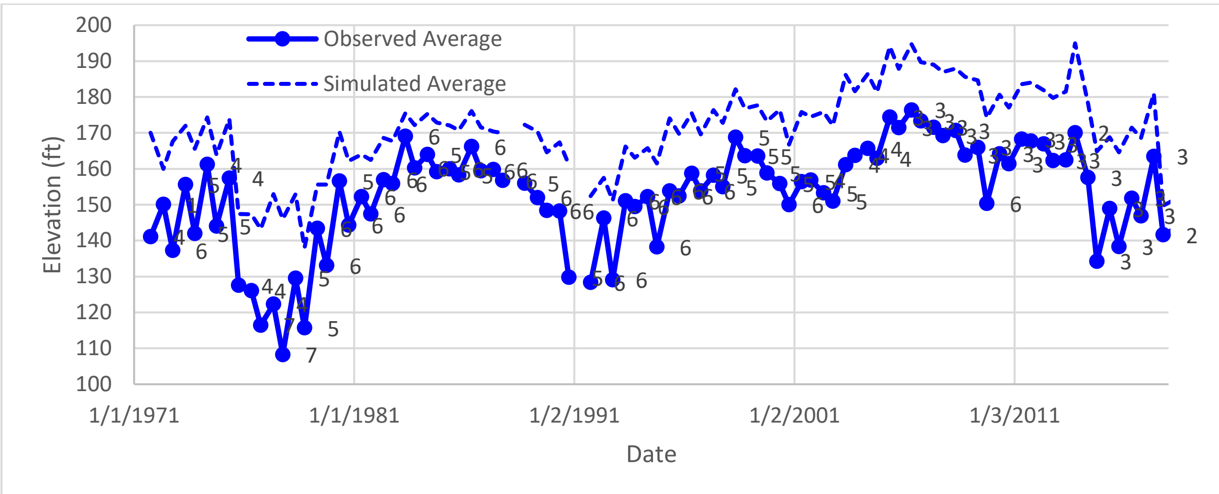
3.2.4.1.4 Clarksburg

The Clarksburg management area only has 2 observation wells in layer 1 with limited information. In much of the simulation period there is only one observation well available with observations that range over 3 to 4 feet seasonally. In general, the simulated values are within 1 or 2 feet of the observations.

3.2.4.1.5 Dunnigan Hills

The Dunnigan Hills management area is the most poorly defined region in the model. In addition to the uncertainty in hydrogeology of the region, there are few observation wells. This is probably due to the region having relatively little irrigated acreage historically. The observation wells that do exist are all located in the YCFC Hungry Hollow sub-region, an actively irrigated region. For these wells, the model consistently overestimates water table elevation in layer 1 but does follow the inter-seasonal patterns (Figure 3-17). The average bias for these wells is 17.1 ft.

Figure 3-17. Average observed and simulated heads in layer 2 of the YCFC Hungry Hollow sub-region



3.2.4.1.6 North Yolo

The North Yolo management area is made up of 9 sub-regions. Many of the observation wells are located west and south of the Colusa Basin Drain. Simulated heads at wells located west and south of the Colusa Basin Drain show reasonable agreement with observations. In the Dunnigan Water District the simulated heads in layer 2 mimic the observed slow recovery of heads in the final years of the simulation (Figure 3-18). In the Yolo Zamora North sub-region the simulated heads of layer 2 are also in reasonable agreement with the observations (Figure 3-19). Average bias for the wells is 0.1 ft and 3.0 ft, respectively.

Figure 3-18. Average observed and simulated heads in layer 2 of Dunnigan Water District.

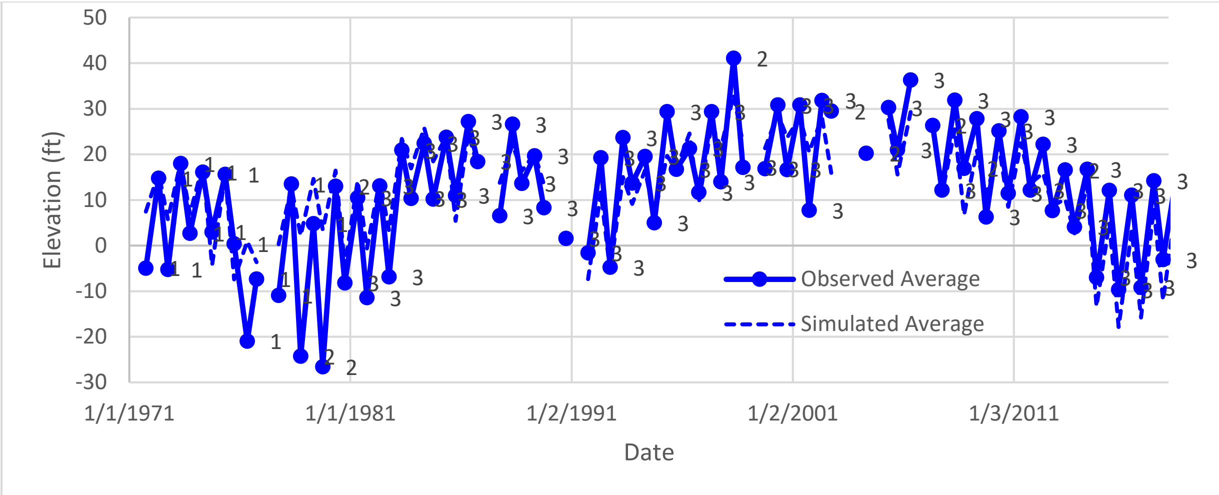
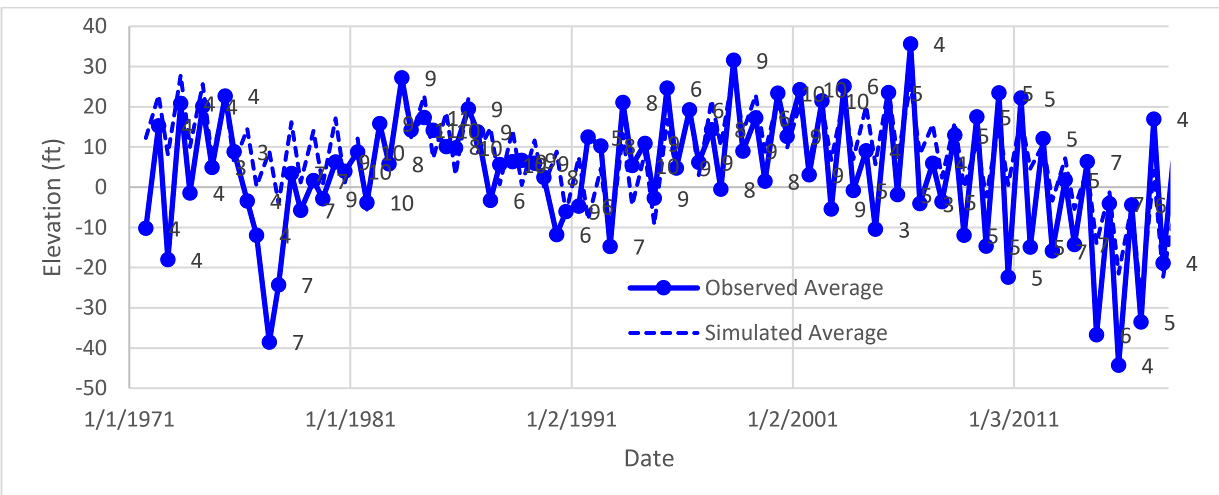
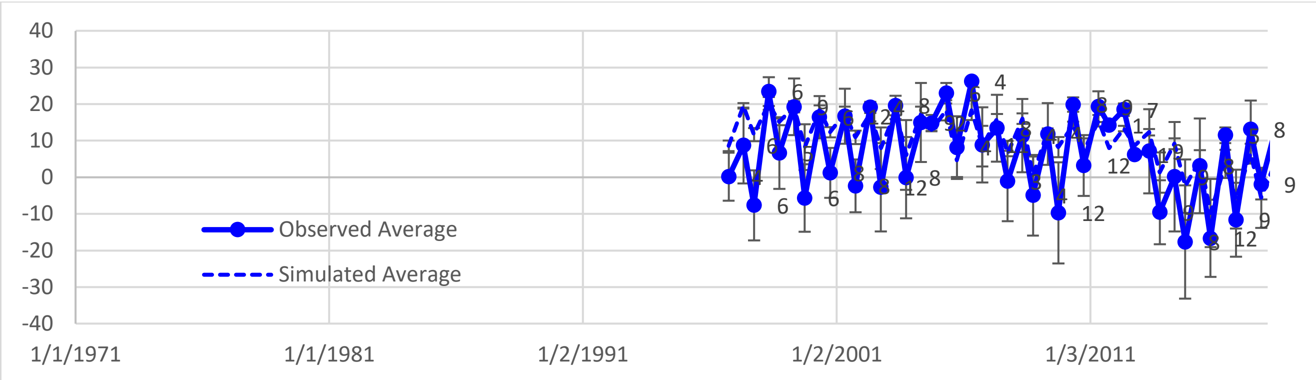


Figure 3-19. Average observed and simulated heads inlayer 2 of the Yolo Zamora North sub-region.



East of the Colusa Basin Drain the simulated values of head in RD 108 match reasonably well starting in the 2000s (Figure 3-20).

Figure 3-20. Average observed and simulated heads in layer 2 of RD 108.



3.2.4.2 Stream Seepage

The stream seepage calibration was conducted using the estimates of stream seepage found in the literature and the results published with the original IGSM model. Table 3-9 provides a comparison of simulated and estimated values.

Table 3-9. Simulated and estimated average annual stream seepage values (TAF). Positive values signify flow from aquifer to stream.

Stream Reach	Simulated Value (1971-2000)	IGSM (1971-2000)	Mullen and Nady (1961-1975)	TNC (2001-2009)
Upper Cache Creek	7.9	2.6	0.4	<0
Lower Cache Creek	-34.9	-37.9	-25.4	<0
Putah Creek	-13.9	-21.8	-18.1	<0
Willow Slough	0.0	-14.1	--	--
Colusa Basin Drain	0.0	1.3	--	--
Knights Landing Ridge Cut	1.6	4.9	--	--
Sacramento River	-1.0	15.3	--	<0
Yolo Bypass	33.0	41.7	--	<0

In agreement with the Mullen and Nady and IGSM estimates, the model has the upper Cache Creek between Capay and Rumsey gaining water from the aquifer. This is in disagreement with the TNC study, however, the resolution of that analysis may have averaged over the entire Cache Creek. The model simulates a losing stream for lower Cache Creek (from Capay to Yolo) in agreement with all three of the other estimations. Simulated stream seepage for Willow Sough and the Colusa Basin Drain were very small. This is in contrast to the 14.1 TAF average annual loss simulated in the IGSM model for Willow Slough. Since no corroborating information could be found for Willow Slough, the initial parameters were not adjusted. The Knights Landing Ridge Cut was simulated to be a gaining reach as it was in the IGSM model. The Sacramento River was simulated to have a stream loss of about 1 TAF per year, which agrees in direction with the TNC report. However, this is in contrast to the IGSM model which reports that the Sacramento River is gaining. Due to the conflicting estimates, the original parameters were not adjusted. In the Yolo Bypass the model agrees with the IGSM model and has the reach gaining flow from the aquifer.

3.3 Uncertainty

All models are simplified abstractions of reality, and therefore water budgets will always exhibit uncertainty (Loucks and van Beek, 2017). Uncertainty in model outputs arise from uncertain or missing input data, model parameter uncertainty, natural variability (in climate, hydrology, geology, land use), and measurement errors (California DWR, 2020). For example, large uncertainties are likely to exist in model estimates of SW-GW interaction and GDE's simply because of inadequate – or complete lack - of data.

For the Yolo Basin historical water budget:

Land use and related irrigation management (variations in planting and harvest dates across space and time, for example) exhibit relatively large uncertainty. Section 2.1.1.2 describes some of the issues in generating a time series of cropping patterns for the Yolo Basin: different datasets with differing categorization; acreages not being the same; methods being different and so on. The land use uncertainty affects all components of a water budget[24].

Surface water supply in several areas of the Yolo Basin is not well known, as in some of the Reclamation Districts; and in the Willow Slough drainage, and in the Clarksburg and Yolo bypass. Assumptions were made, which largely allowed surface water use to take precedence over groundwater pumping. See Section 2.1.5.

Groundwater levels and trends are uncertain in some areas like in north-west Yolo. Although groundwater observations are scarce in areas close to Sacramento River as well, there is widespread knowledge that water levels are shallow there. Additionally, surface elevations and screening depths are uncertain, and in many cases, missing. The latter point made it challenging to ascertain which aquifer layer was being pumped.

Geology and stratigraphy is uncertain in the Dunnigan Hills area (WRIME, 2006).

Climate uncertainty, while it exists, is relatively less than the above uncertainties, because climate in the Yolo basin is not very spatially variable. Climate input from different sources of data (e.g. station data versus gridded PRISM data) can be used as a used as a measure of this uncertainty.

For the future scenarios' water budget, climate change and land use change represent the main drivers in water budget uncertainty: these impacts are documented in the main text of the Water Budget Chapter.

3.3.1 Model sensitivity

Model sensitivity analysis explores the influence of selected uncertainties on model outputs of interest. Model sensitivity analysis can help test the robustness and stability of the model; impact of data

[24] This is true of all Basins

inaccuracies and uncertainties; and can help prioritize future monitoring by identifying those variables that most influence critical model outputs.

Model sensitivity is an extensive field of its own; comprehensive sensitivity analysis - through formal approaches like Generalized Likelihood Uncertainty Estimation (GLUE), for example - are beyond the scope of this GSP. This section reports on a few sensitivity tests on data and parameters that were known to be influential: namely, aquifer hydraulic parameters, crop acreage and surface water availability.

Table 3-10 provides a summary of the sensitivity tests. In separate model runs, a parameter from Table 3-10 was changed relative to its value in the baseline, calibrated model, by the ratios listed. Correspondingly, its effect on the model result was logged, using the ratio of groundwater storage of the sensitivity run to the that in the baseline, calibrated run.

The higher the slope of the resulting curve, the greater the sensitivity. A positive slope indicates that the model result rises with increasing parameter values; a negative slope indicates that it decreases with increasing parameter values.

3.3.1.1 Aquifer and crop parameters

For specific yield, only changes in layer 1 were analyzed as that is the layer that is most likely to have unconfined conditions and utilizes the specific yield parameter. Specific storage was varied in layer 2 only as this is the layer in which most areas are treated as confined by the model and where most pumping occurs. Hydraulic conductivity was varied in all three layers. The crop coefficients were varied as an approximation of a change in irrigated crop area reflecting uncertainty in land use input data.

Results are presented in Table 3-11 and Figure 3-21 below.

Of all the parameters investigated, **the model is most sensitive to crop coefficient**. This supports the earlier assertion that land use uncertainty is an important source of uncertainty in water balances, and supports the substantial effort put into calibrating the crop ET values. The next most sensitive parameter is hydraulic conductivity (K); as hydraulic conductivity increases, groundwater storage decreases. The model is more sensitive to this change than to specific yield, specific storage and streambed conductivity (K streambed). The model is moderately sensitivity to specific yield, and least sensitive to streambed conductivity and specific storage.

These findings qualitatively echo those of earlier modeling efforts in the county (e.g. WRIME 2006).

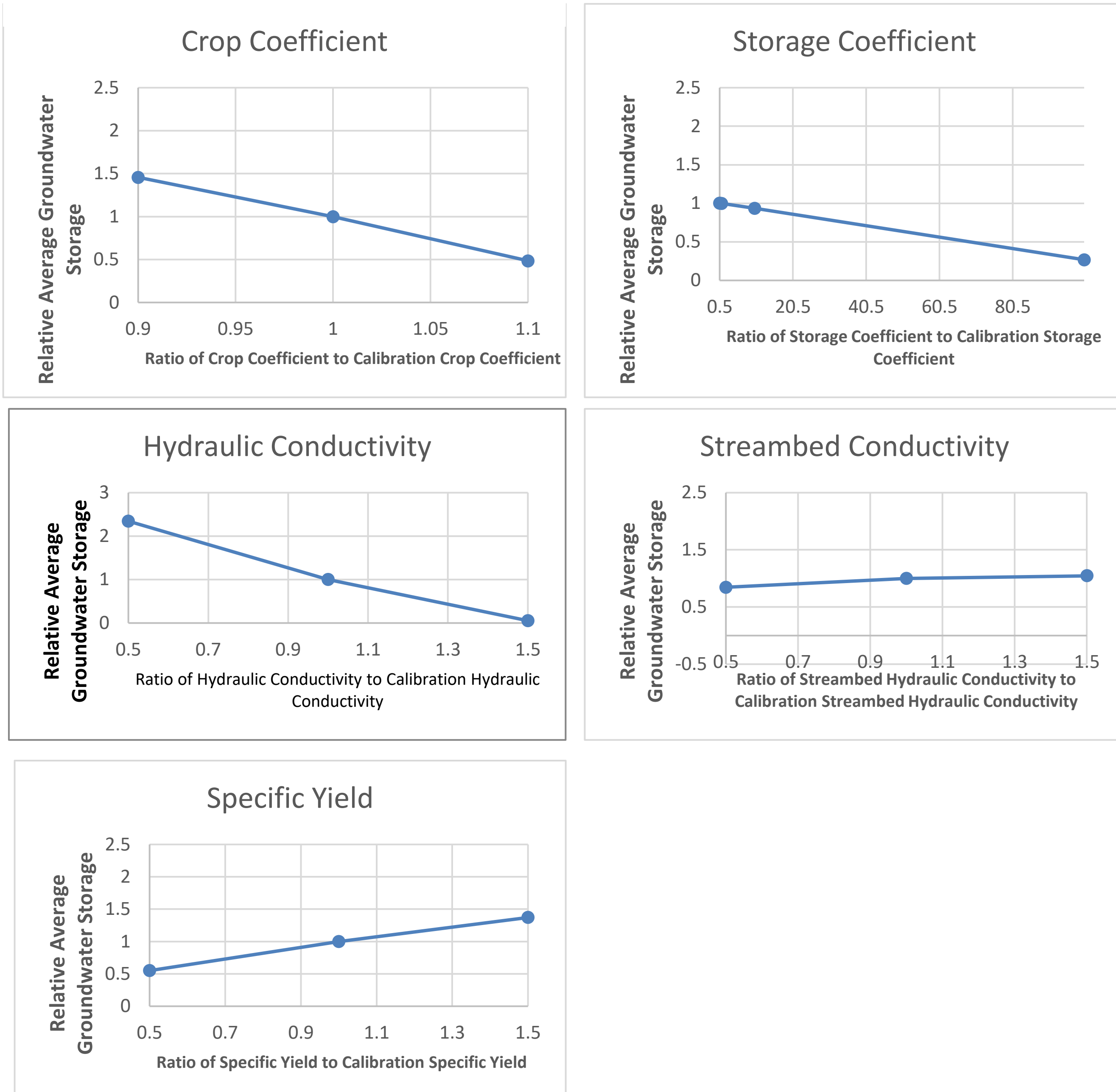
Table 3-10 Summary of Sensitivity tests to parameters

Parameter	Range of ratios over calibrated values	Notes	Metrics used
Sy (specific yield)	0.5, 1, 1.5	Layer 1	Change in basin storage
Ss (specific storage)	0.5, 1, 10	Layer 2	
K streambed	0.5, 1, 1.5		
K	0.5, 1, 1.5	All layers	
Crop Acreage	Change crop coefficients by factor of 0.9, 1.0, 1.1	All crops	
Surface water supply	Reduce SW supply in CBD South to 10% of demand Reduce SW supply to YCFC East from Willow Slough to 20% of demand SW supply to RD 108 to 50% of contract amount		Simulation of groundwater elevations in selected wells

Table 3-11 Parameter sensitivity

Parameter	Average Slope
Sy (specific yield)	0.820
Ss (specific storage)	-0.007
K streambed	0.199
K	-2.29
Crop Coefficients	-4.85

Figure 3-21 Sensitivity tests with respect to parameters



3.3.1.2 Surface water availability

This section documents the sensitivity of the model to uncertainties in surface water availability to some areas of the Yolo Subbasin.

During review of the model calibration by the YSGA members, the issue of surface water availability arose. Specifically, there is uncertainty in the amount of surface water that is used in the Colusa Basin Drain South, YCFC East and RD 108 areas of the model. In the Colusa Basin Drain South region it is uncertain how much surface water is available from the Colusa Basin Drain. In the baseline model surface water from the Drain is unlimited. In YCFC East it is uncertain what portion of the area utilizes water from Willow Slough. In the baseline model the water used is only limited by the amount available in the Slough. For RD 108 the baseline model has the water right for the entirety of RD 108 (both Yolo and Colusa Counties) available to only the Yolo County portion of the District.

In order to assess the sensitivity of model results to these surface water availability assumptions, a scenario was created in which:

1. CBD South can only meet 10% of demand using surface water diverted from the Colusa Basin Drain.
2. YCFC East can only meet 20% of demand using surface water diverted from Willow Slough.
3. RD 108 can only divert 50% of the entire District's water right.

To assess the performance of the model under the new assumptions about surface water availability a root-mean-square statistic was created based on observed and simulated heads at observation well locations. See Table 3-12 below.

A lower RMSE implies a better fit of modeled groundwater elevations to observations.

Table 3-12 Root mean squared error (Rmse) in groundwater elevations

Location	Baseline	Reduced Surface Water
CBD South Layer 2	19.65	10.01
YCFC East Layer 1	9.55	8.43
YCFC East Layer 2	7.27	11.91
RD 108 Layer 2	10.93	20.65

Conclusions on sensitivity to surface water availability

YCFC East and RD 108 results provide no conclusive evidence that the model should be changed. In RD 108, assuming reduced surface water availability worsens the simulation of elevations. In YCFC East, slightly better performance in level 1 of the aquifer and a worse performance in level 2. In CBD South, results suggest better performance against observations. On further investigation, making this change also increases overall annual average Basin pumping by 24 TAF, and reduces average annual groundwater storage over the historical period by 6 TAF/yr. Future updates to the GSP will include an updated YSGA model which incorporates this change in surface water availability to CBD South.

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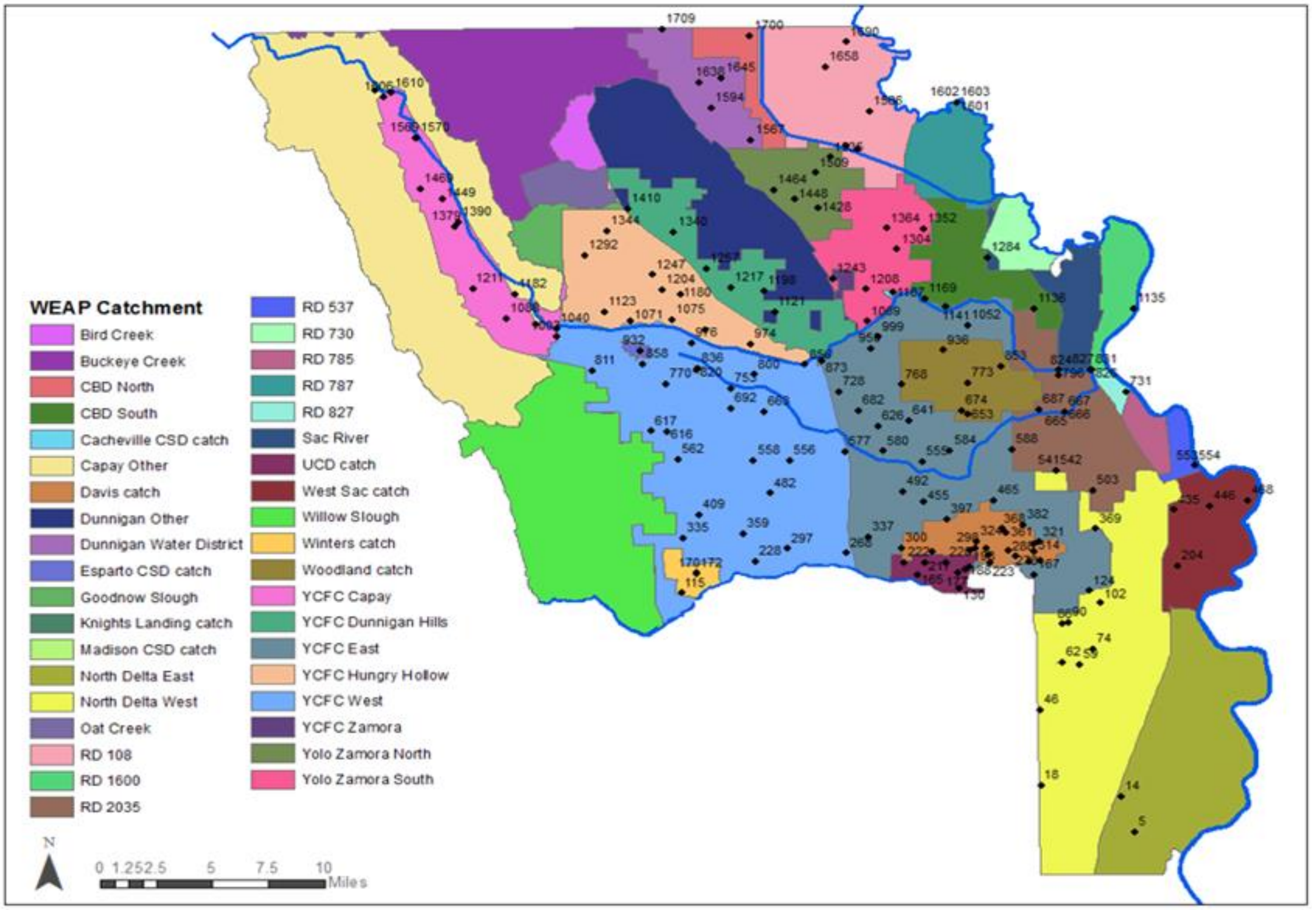
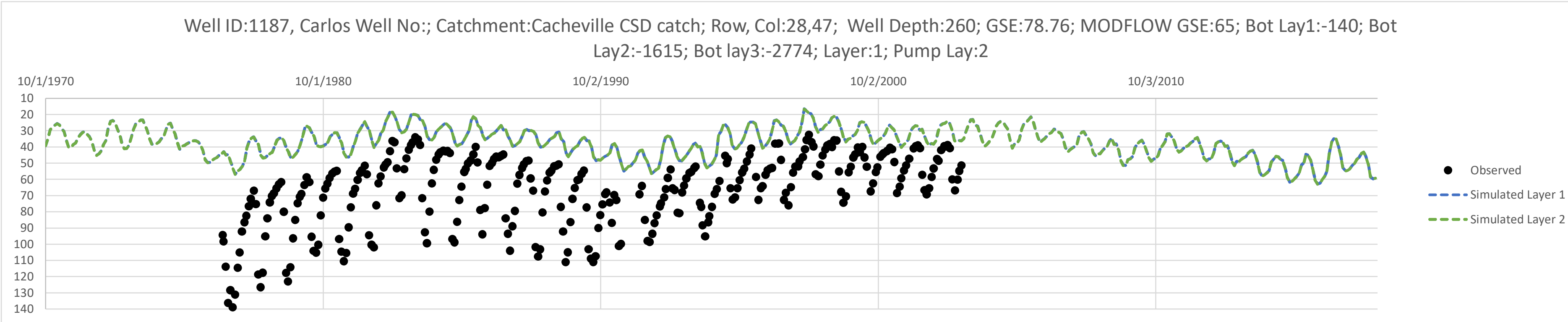
Appendix A Comparisons of simulated and observed groundwater heads.

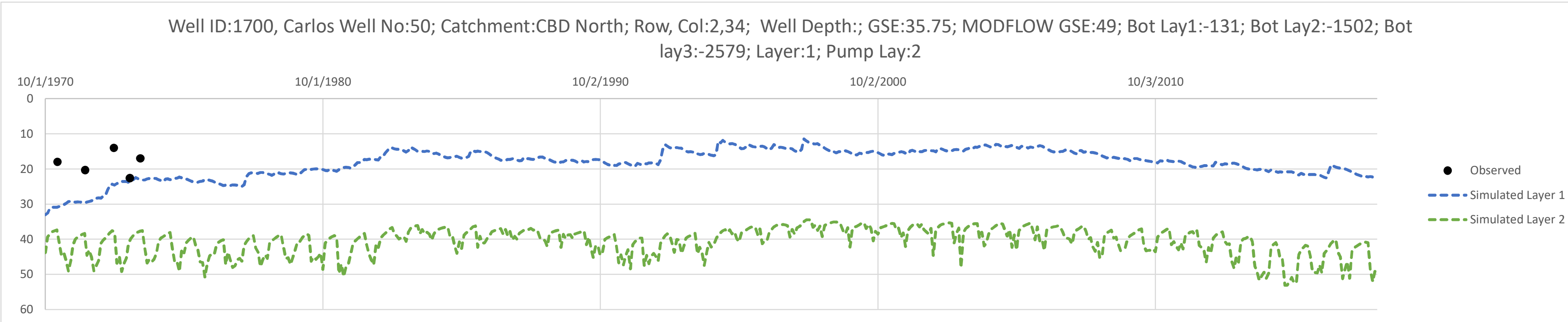
Figure 1. All wells included in this tool, and their location relative to WEAP catchments representing the various entities in Yolo County.



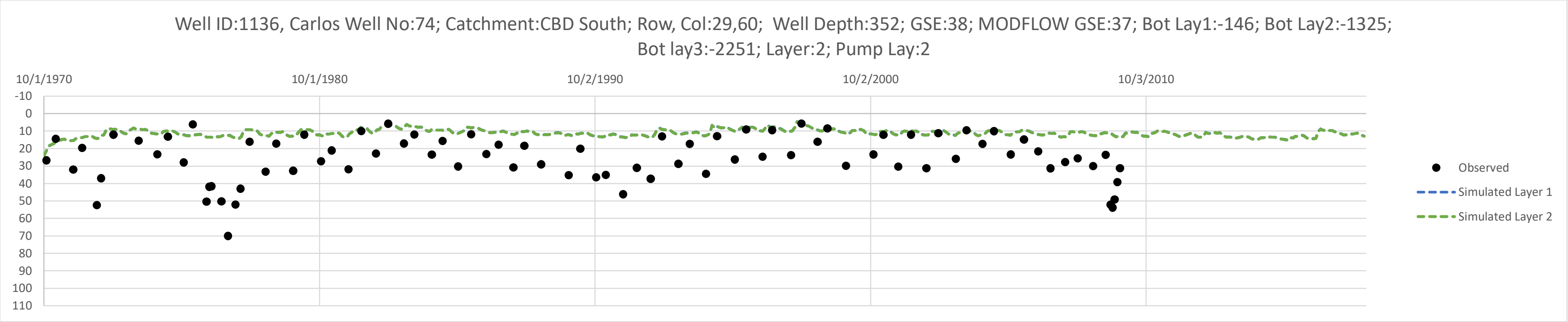
Cacheville CSD Catchment

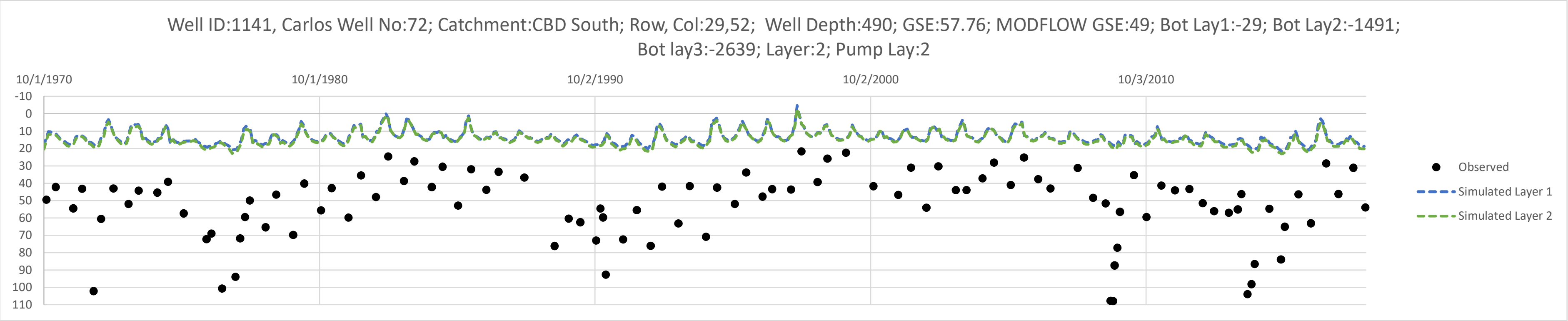


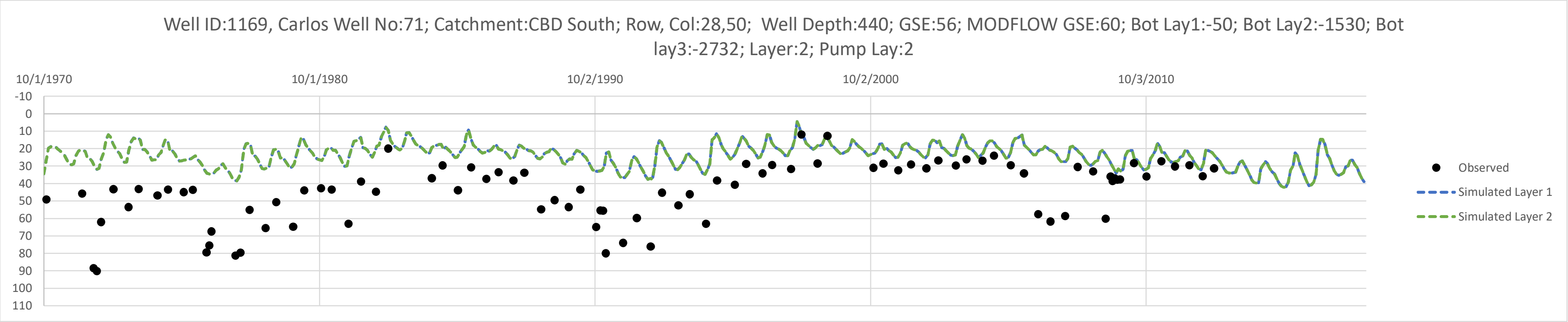
CBD North Catchment



CBD South Catchment

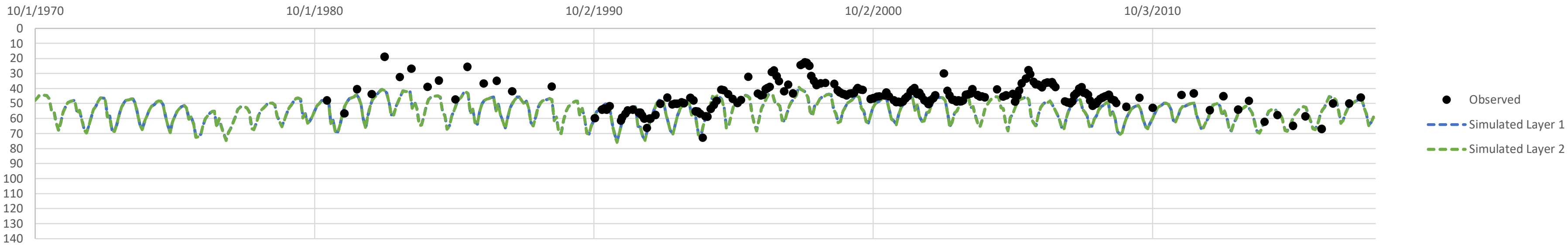




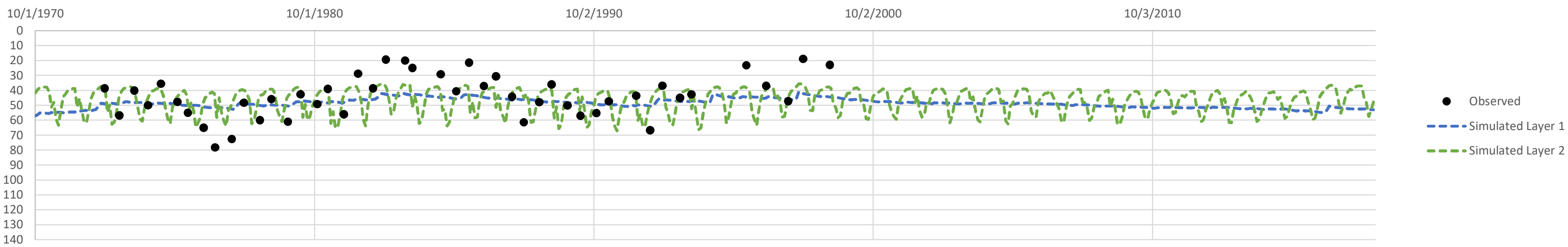


Davis Catchment

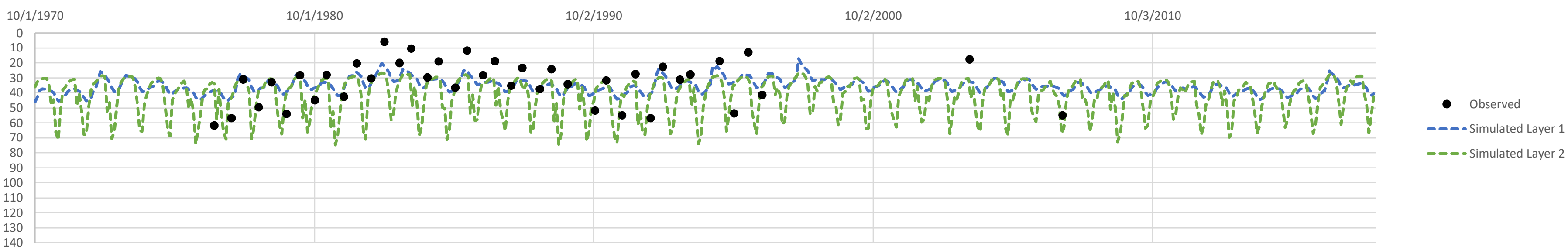
Well ID:222, Carlos Well No:; Catchment:Davis catch; Row, Col:54,48; Well Depth:156; GSE:66.78; MODFLOW GSE:67; Bot Lay1:-33; Bot Lay2:-1545; Bot lay3:-2812; Layer:2; Pump Lay:2



Well ID:223, Carlos Well No:125; Catchment:Davis catch; Row, Col:54,55; Well Depth:204; GSE:47.55; MODFLOW GSE:47; Bot Lay1:-59; Bot Lay2:-1649; Bot lay3:-2857; Layer:2; Pump Lay:2

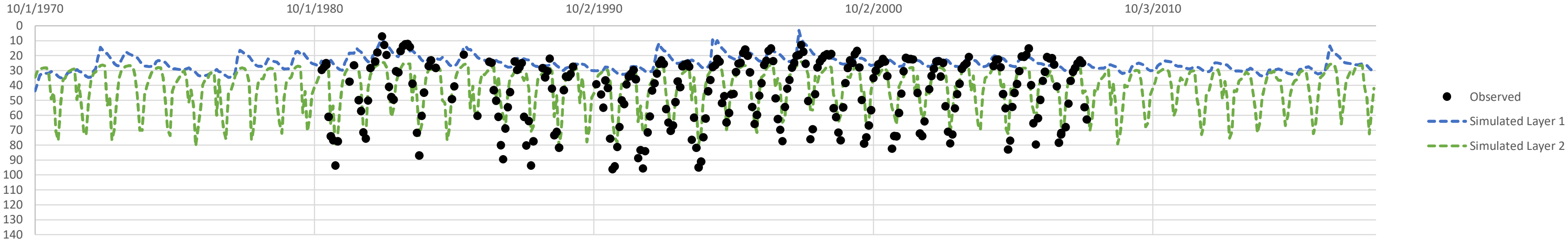


Well ID:225, Carlos Well No:; Catchment:Davis catch; Row, Col:54,59; Well Depth:148; GSE:37.04; MODFLOW GSE:35; Bot Lay1:-95; Bot Lay2:-1613; Bot lay3:-2844; Layer:2; Pump Lay:2



Davis Catchment

Well ID:232, Carlos Well No:; Catchment:Davis catch; Row, Col:54,60; Well Depth:427; GSE:27.77; MODFLOW GSE:32; Bot Lay1:-97; Bot Lay2:-1613; Bot lay3:-2834; Layer:2; Pump Lay:2



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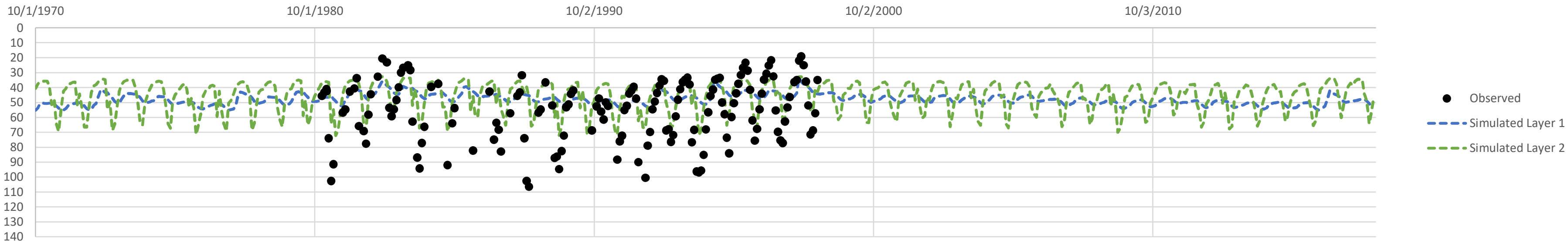
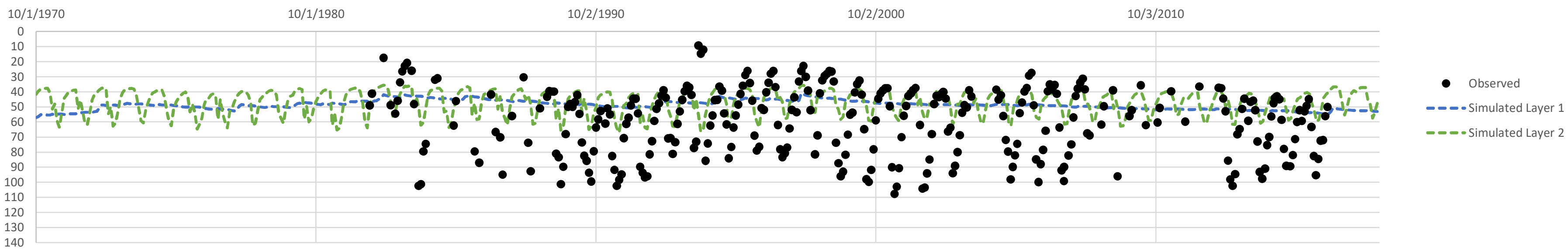
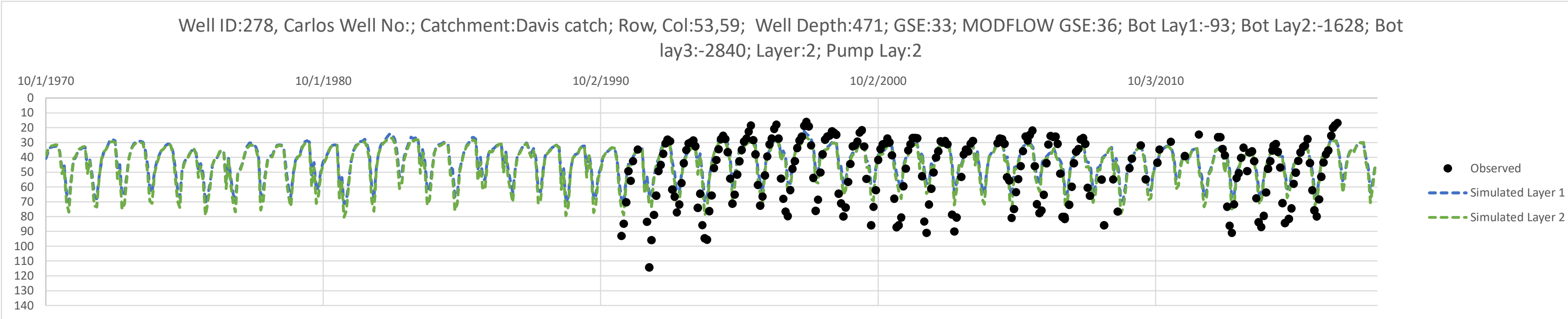
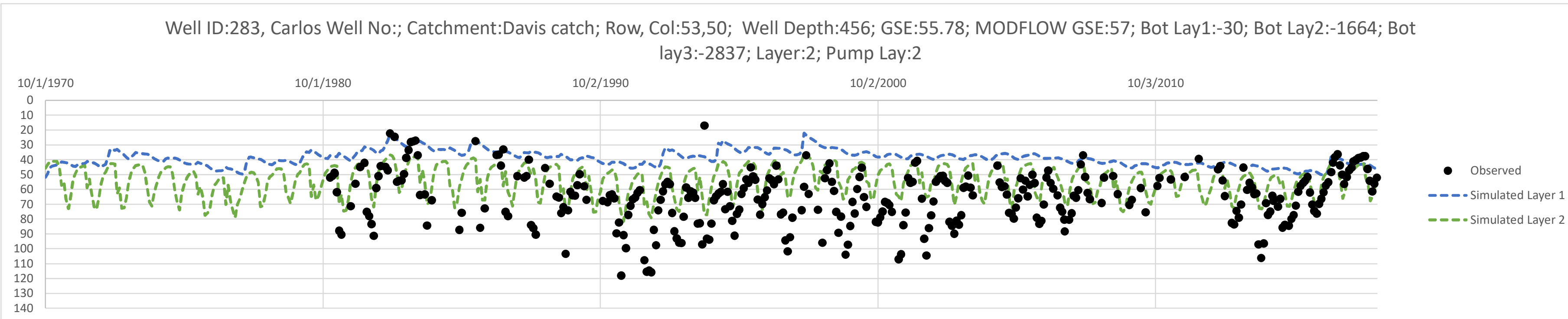


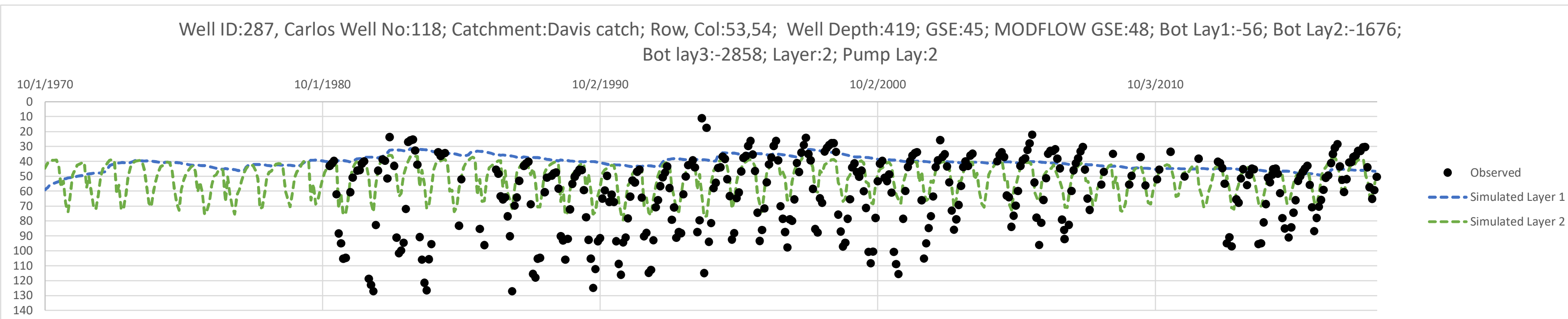
Well ID:260, Carlos Well No:; Catchment:Davis catch; Row, Col:54,55; Well Depth:460; GSE:44; MODFLOW GSE:47; Bot Lay1:-59; Bot Lay2:-1649; Bot lay3:-2857; Layer:2; Pump Lay:2



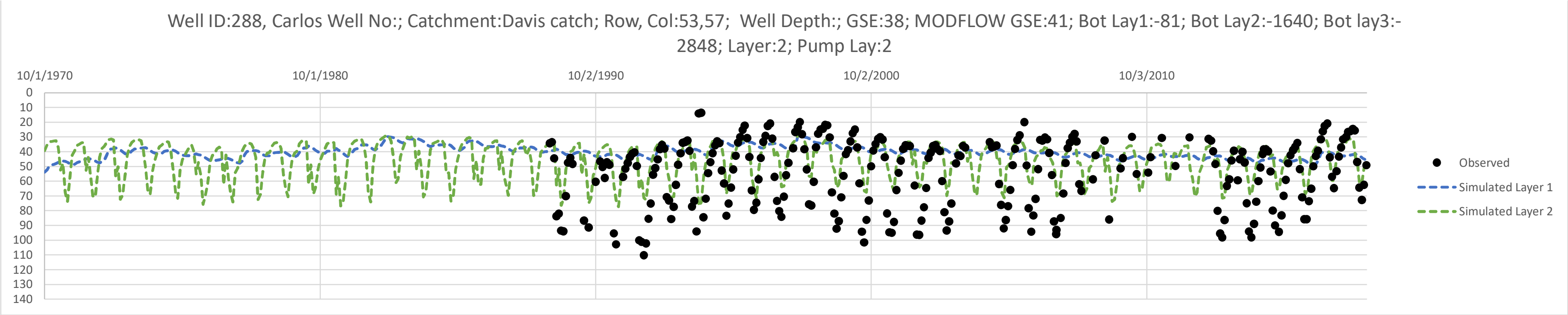
Davis Catchment

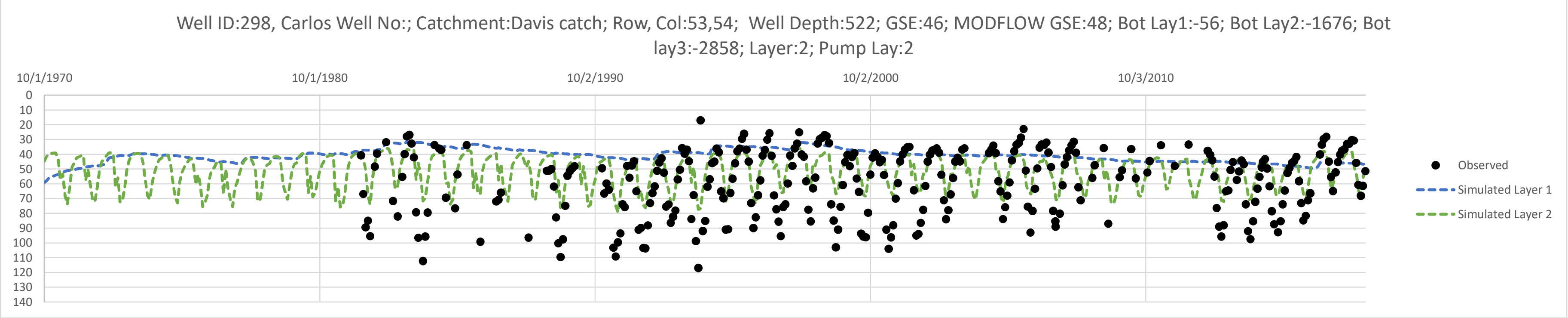


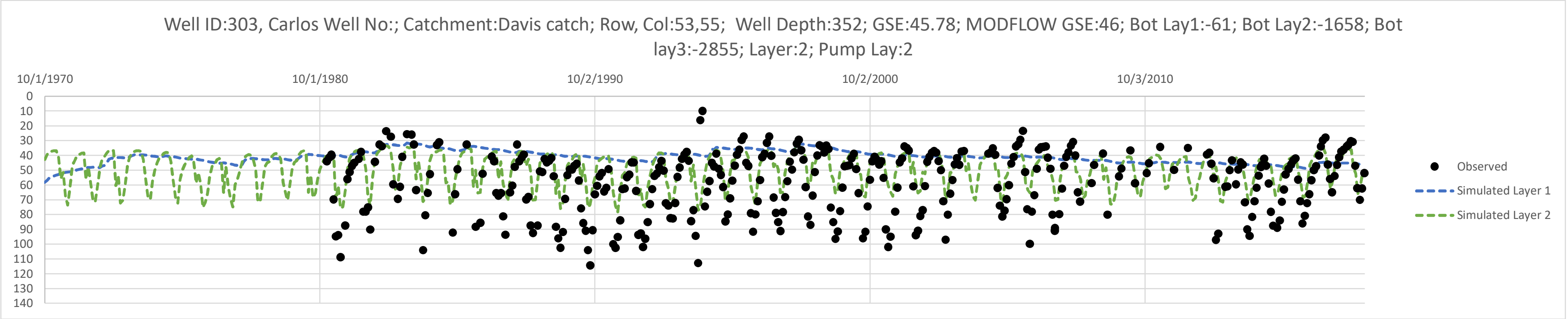




Davis Catchment

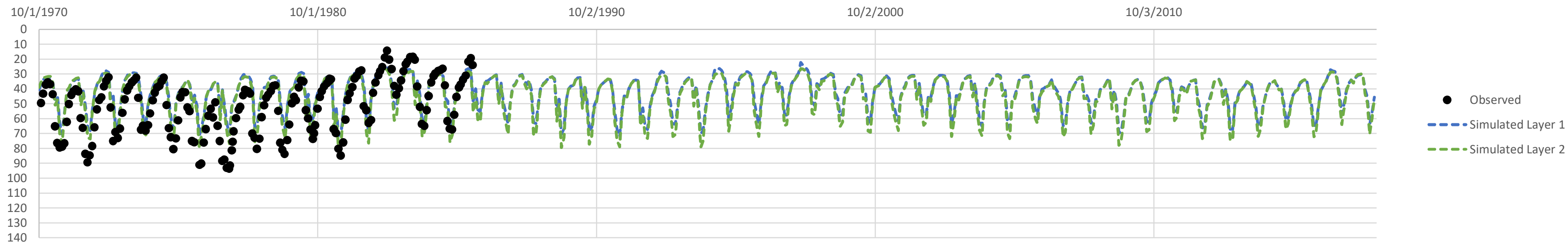




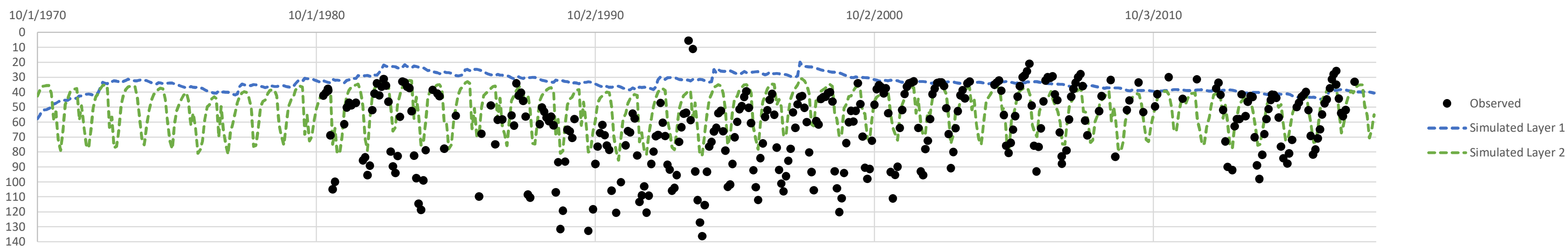


Davis Catchment

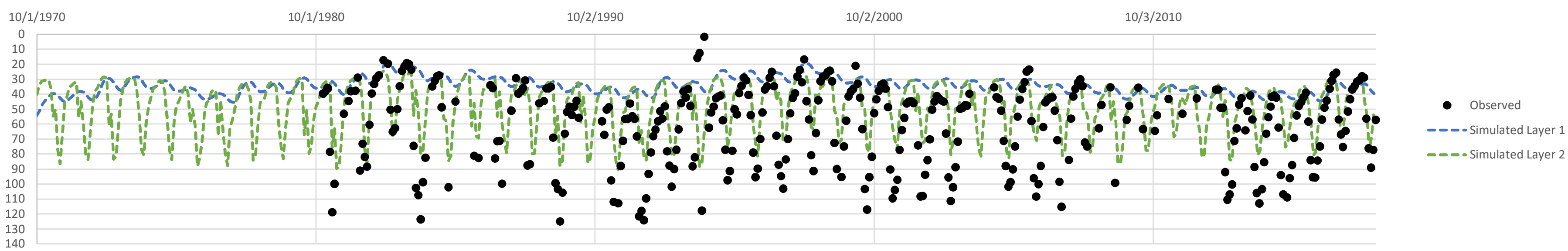
Well ID:314, Carlos Well No:128; Catchment:Davis catch; Row, Col:53,59; Well Depth:303; GSE:33.18; MODFLOW GSE:36; Bot Lay1:-93; Bot Lay2:-1628; Bot lay3:-2840; Layer:2; Pump Lay:2



Well ID:324, Carlos Well No:; Catchment:Davis catch; Row, Col:52,54; Well Depth:337; GSE:44.78; MODFLOW GSE:46; Bot Lay1:-49; Bot Lay2:-1694; Bot lay3:-2851; Layer:2; Pump Lay:2

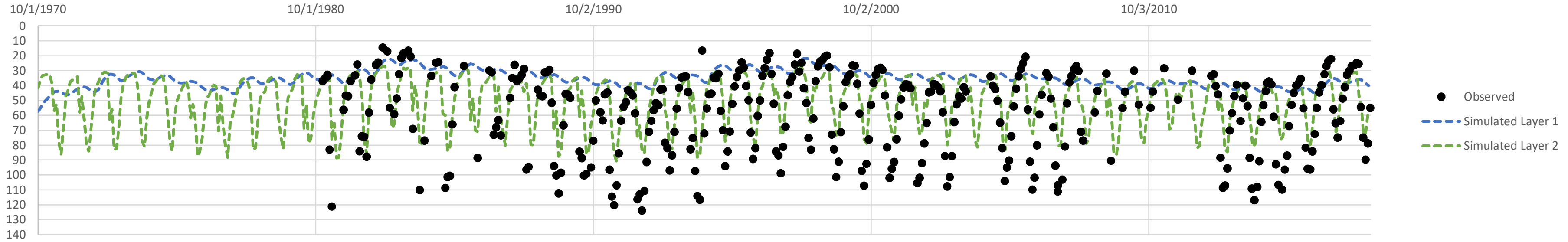


Well ID:361, Carlos Well No:; Catchment:Davis catch; Row, Col:51,57; Well Depth:510; GSE:42.78; MODFLOW GSE:39; Bot Lay1:-75; Bot Lay2:-1648; Bot lay3:-2827; Layer:2; Pump Lay:2

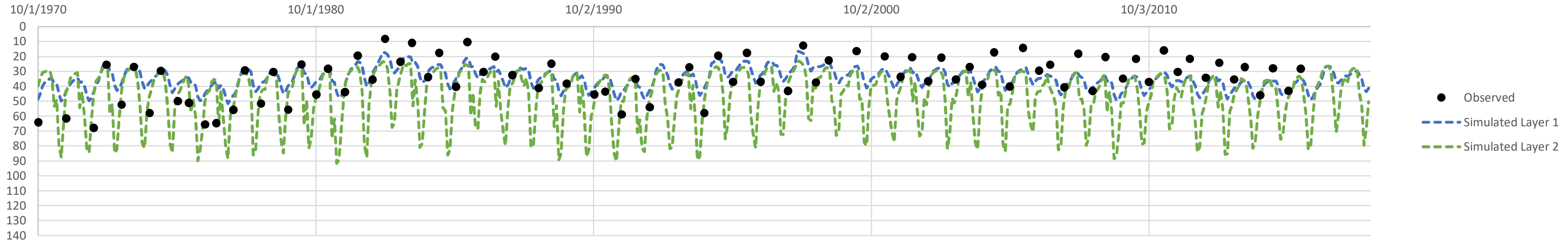


Davis Catchment

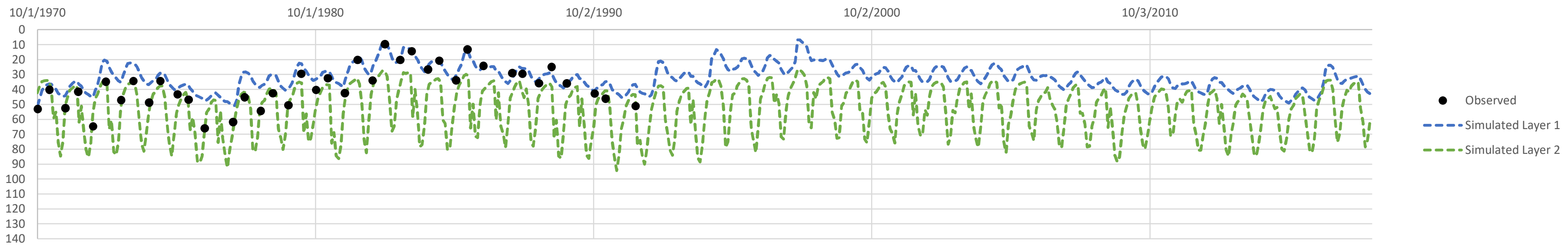
Well ID:368, Carlos Well No:; Catchment:Davis catch; Row, Col:51,56; Well Depth:520; GSE:38.78; MODFLOW GSE:42; Bot Lay1:-71; Bot Lay2:-1657; Bot lay3:-2835; Layer:2; Pump Lay:2



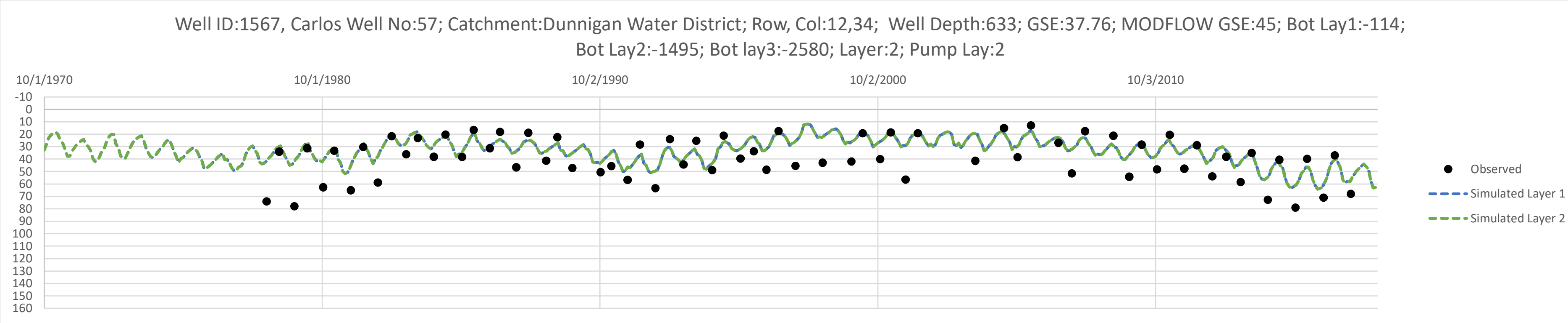
Well ID:382, Carlos Well No:129; Catchment:Davis catch; Row, Col:51,58; Well Depth:328; GSE:34.78; MODFLOW GSE:37; Bot Lay1:-79; Bot Lay2:-1647; Bot lay3:-2817; Layer:1; Pump Lay:2

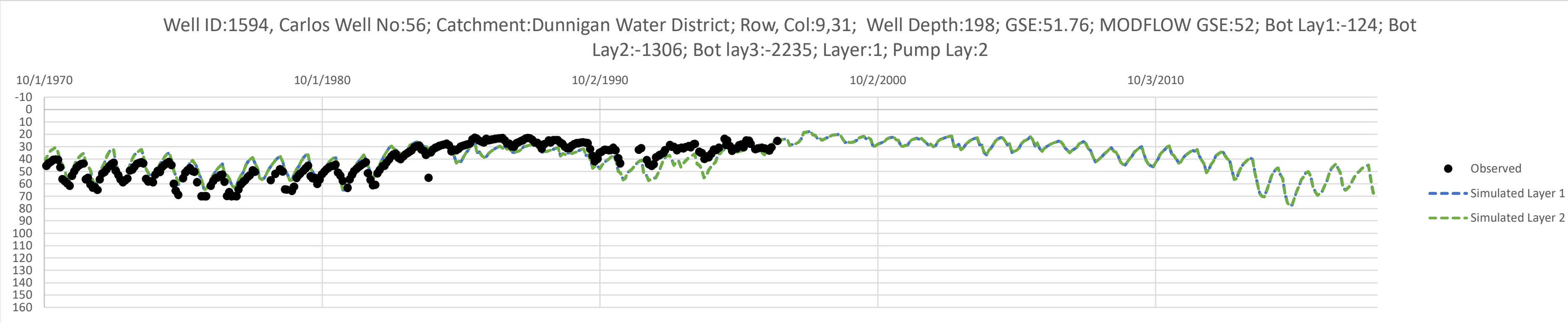


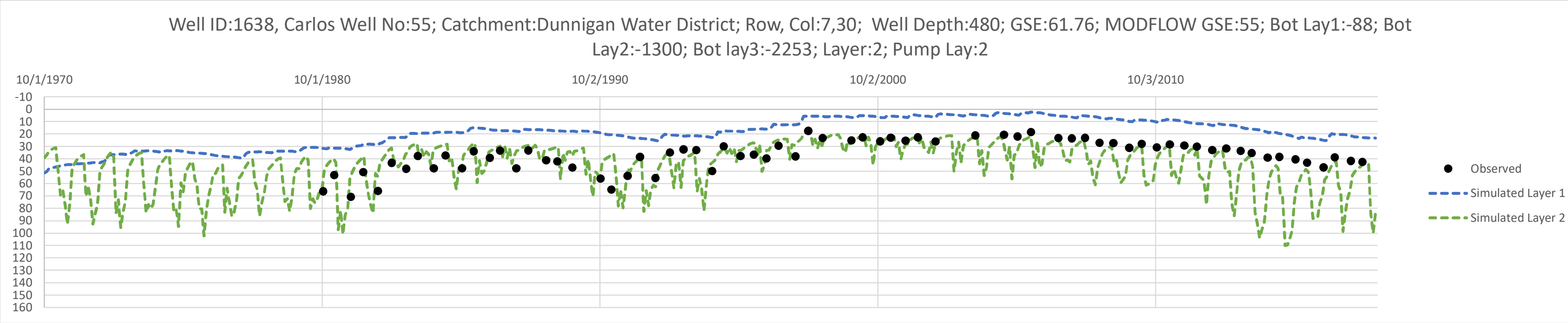
Well ID:397, Carlos Well No:123; Catchment:Davis catch; Row, Col:50,52; Well Depth:228; GSE:49.78; MODFLOW GSE:52; Bot Lay1:-16; Bot Lay2:-1740; Bot lay3:-2837; Layer:2; Pump Lay:2



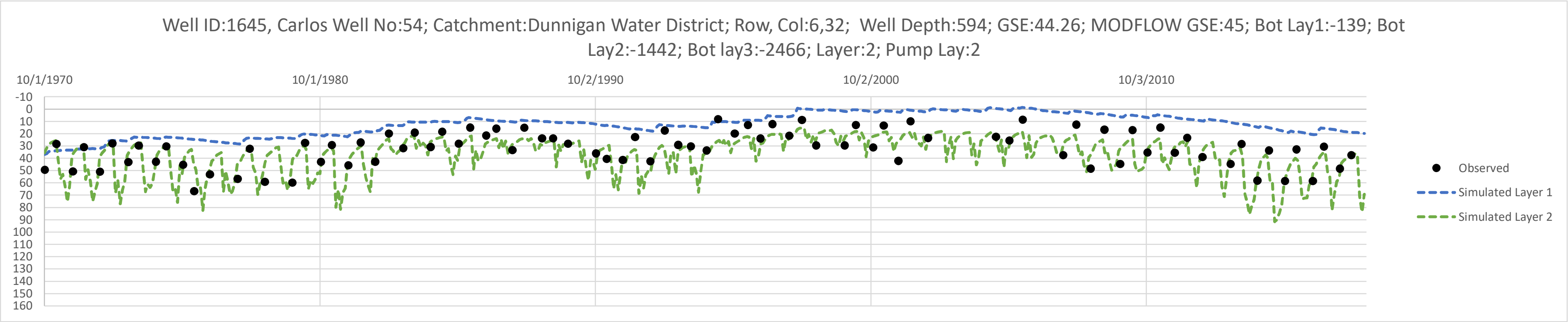
Dunnigan Water District Catchment

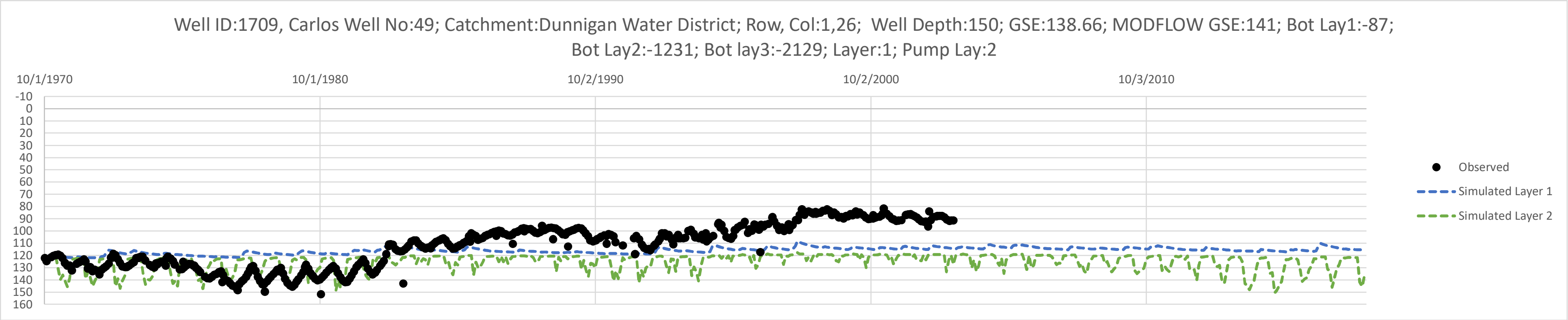




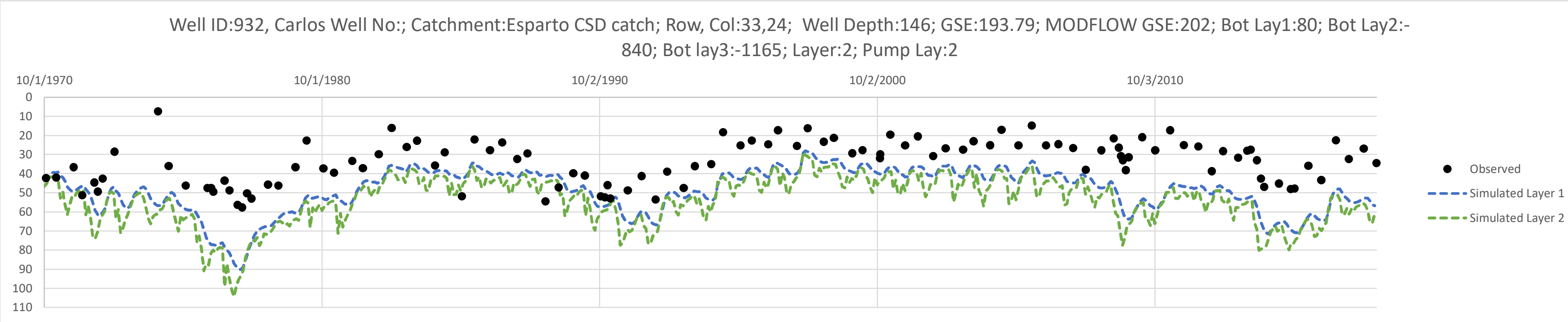


Dunnigan Water District Catchment

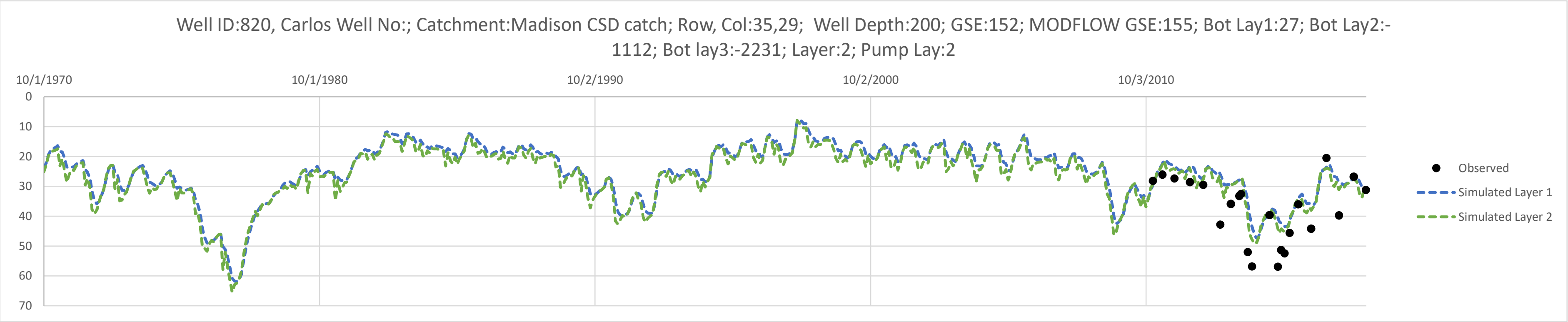


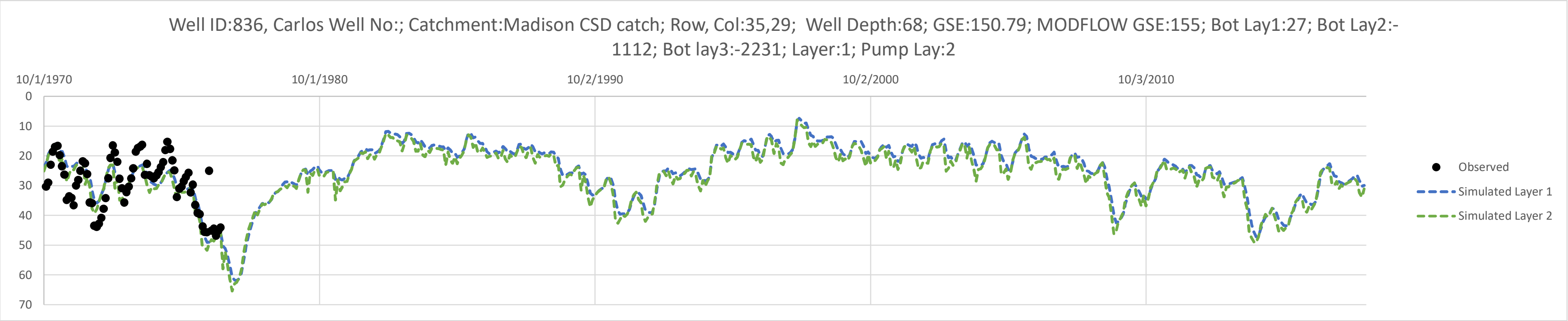


Esparto CSD Catchment

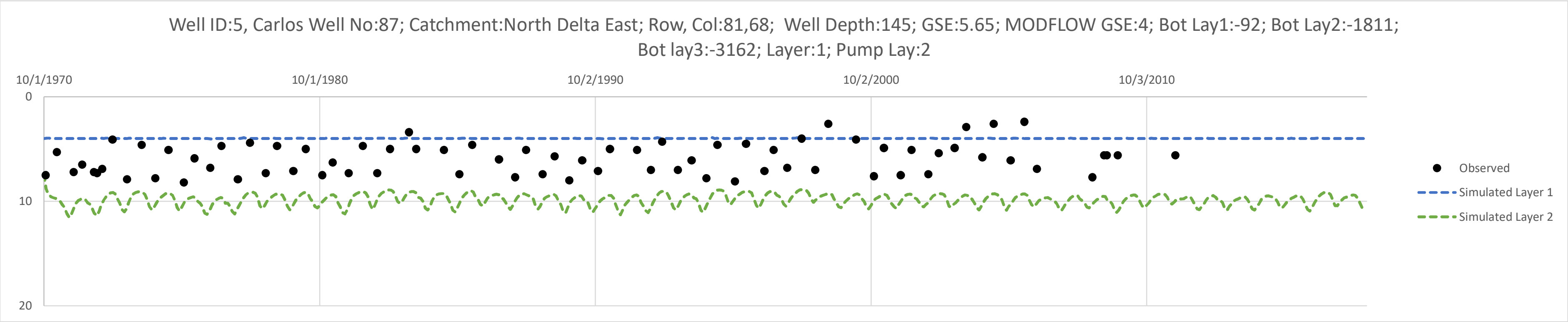


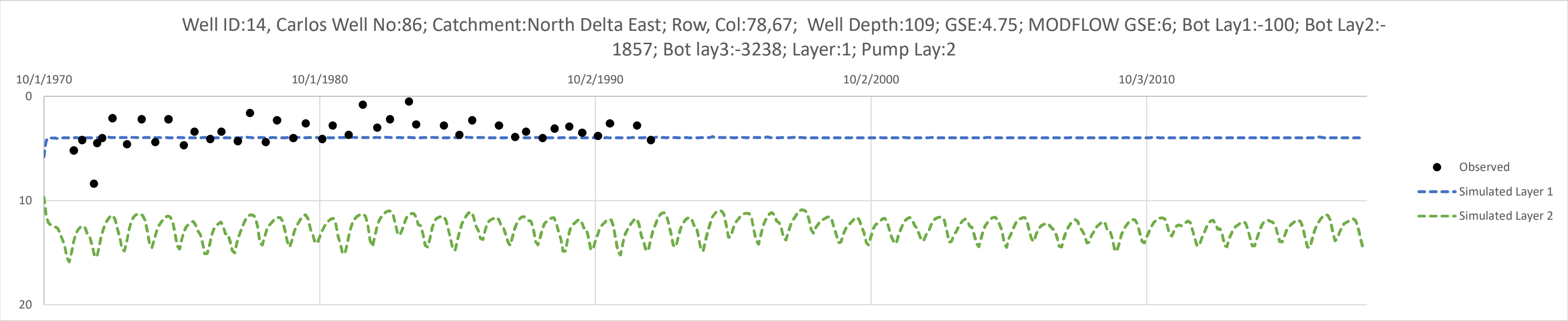
Madison CSD Catchment



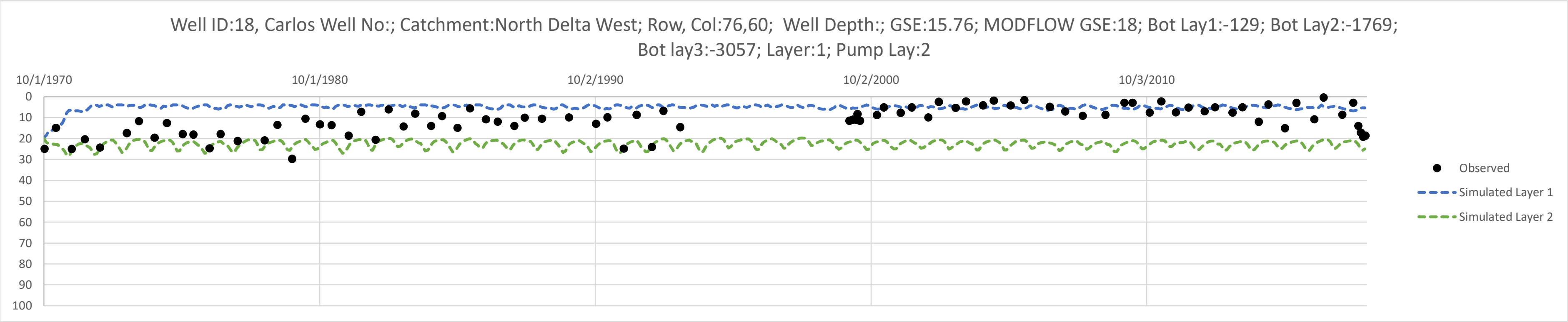


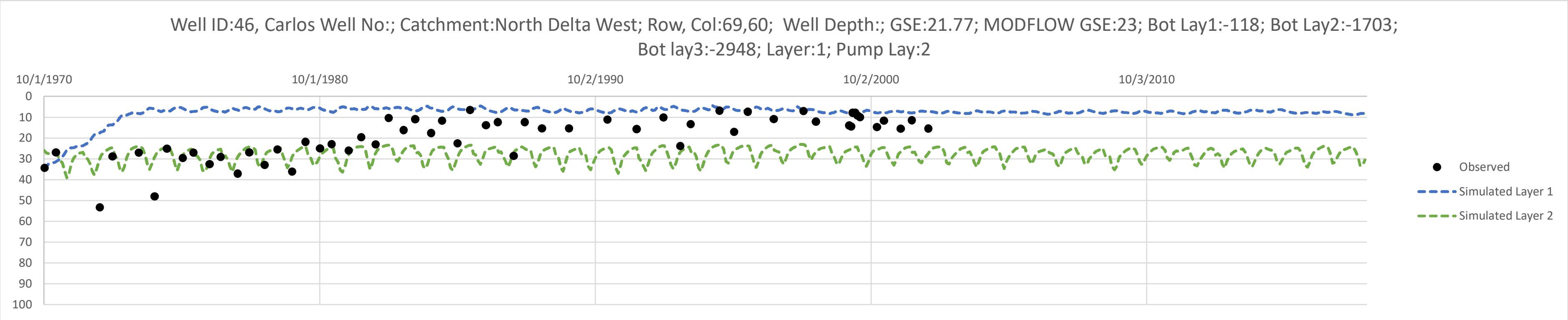
North Delta East Catchment

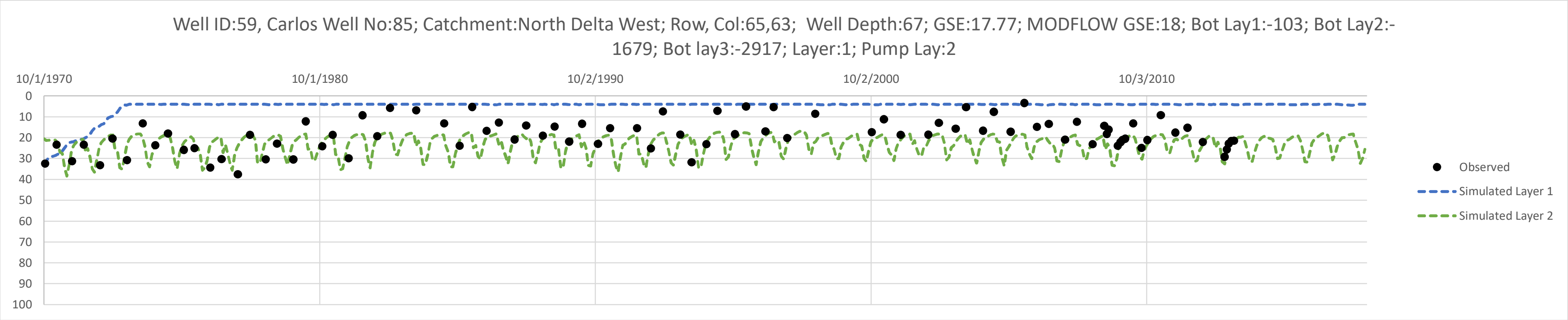




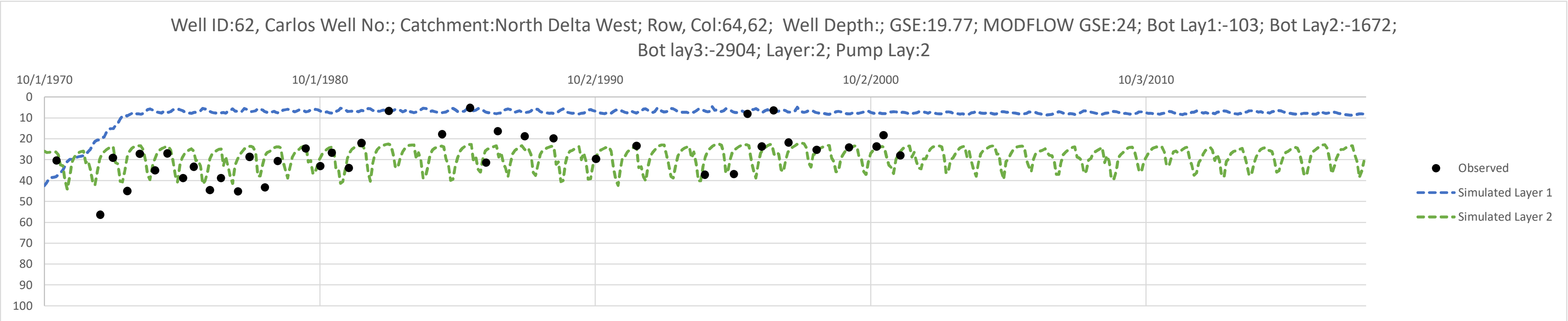
North Delta West Catchment

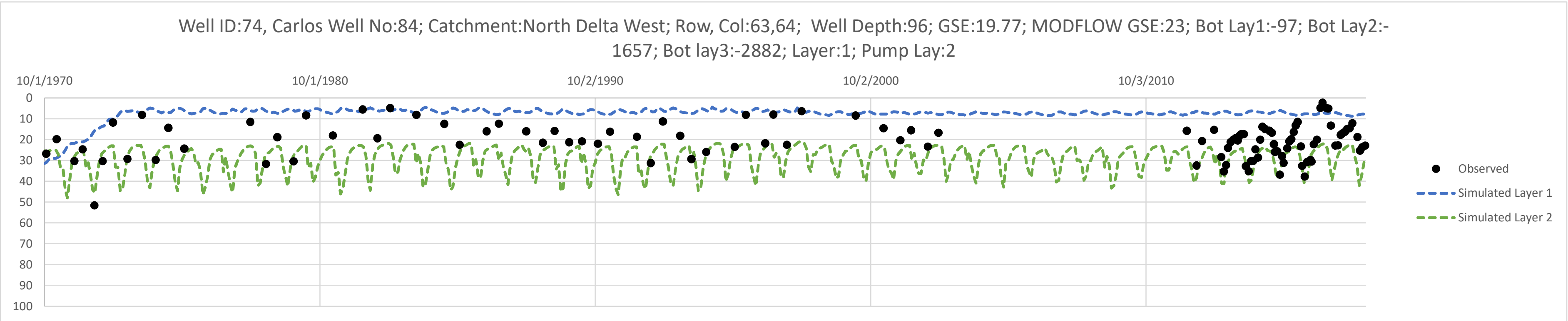


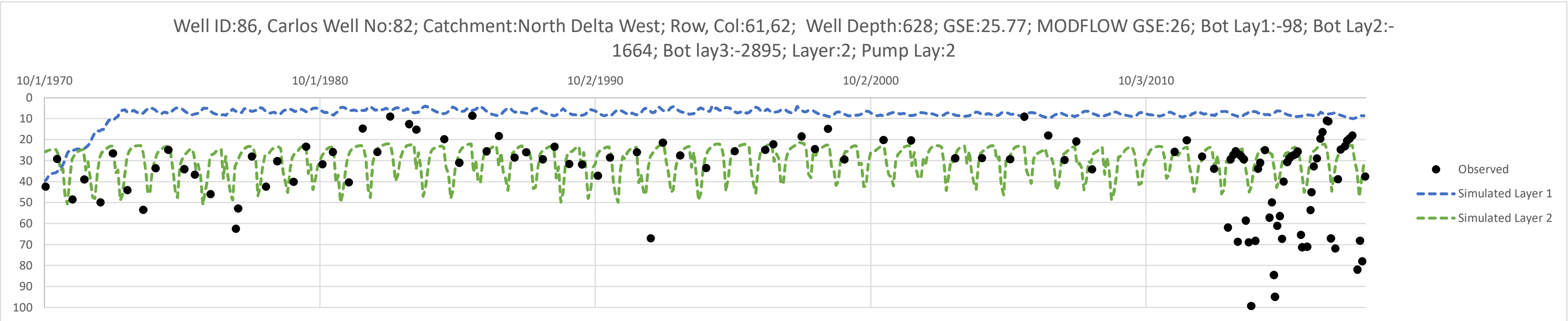




North Delta West Catchment







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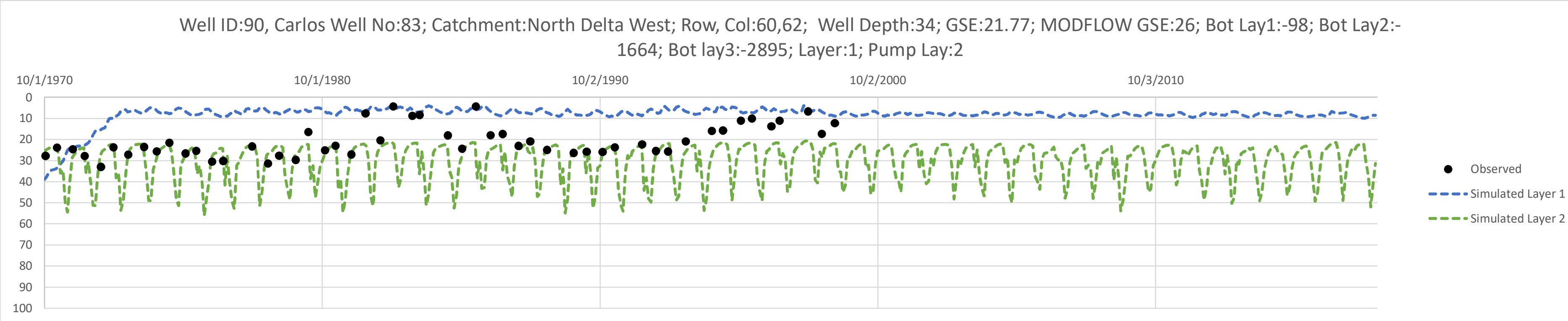
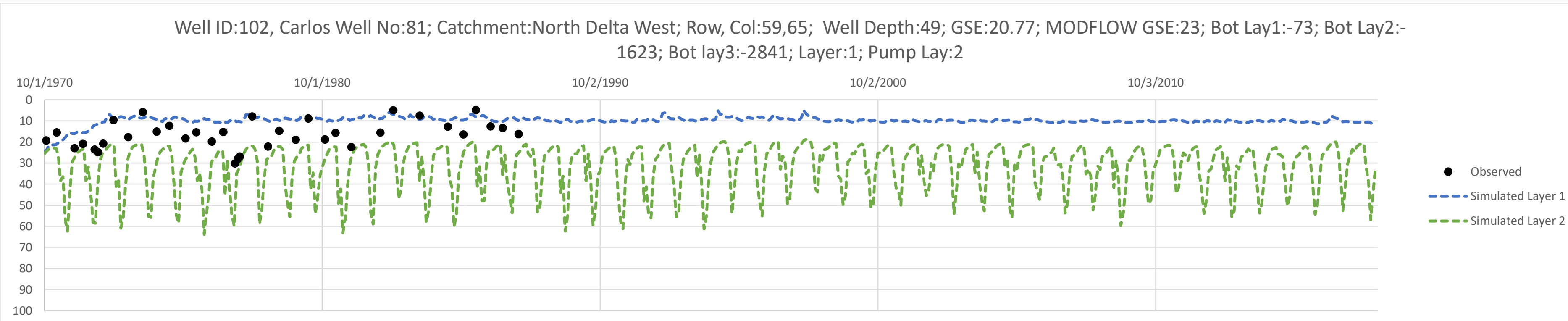
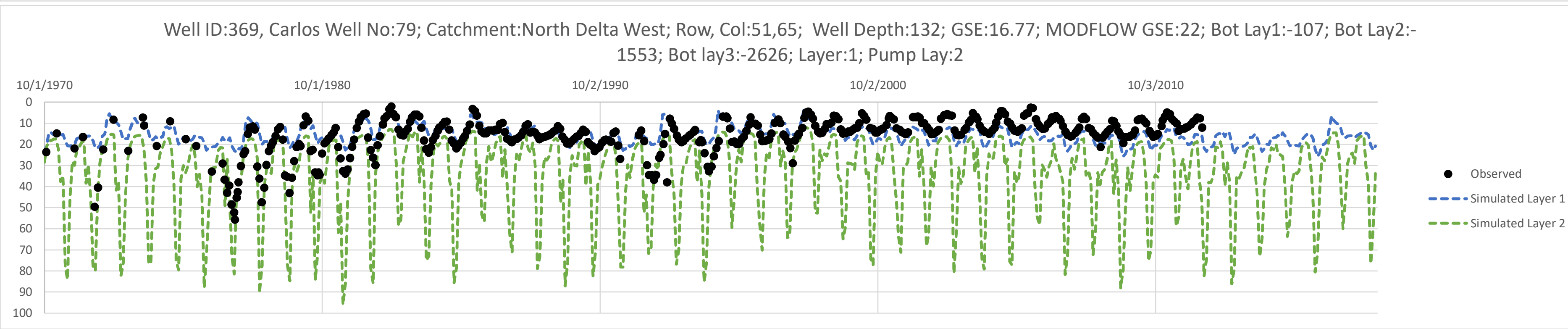
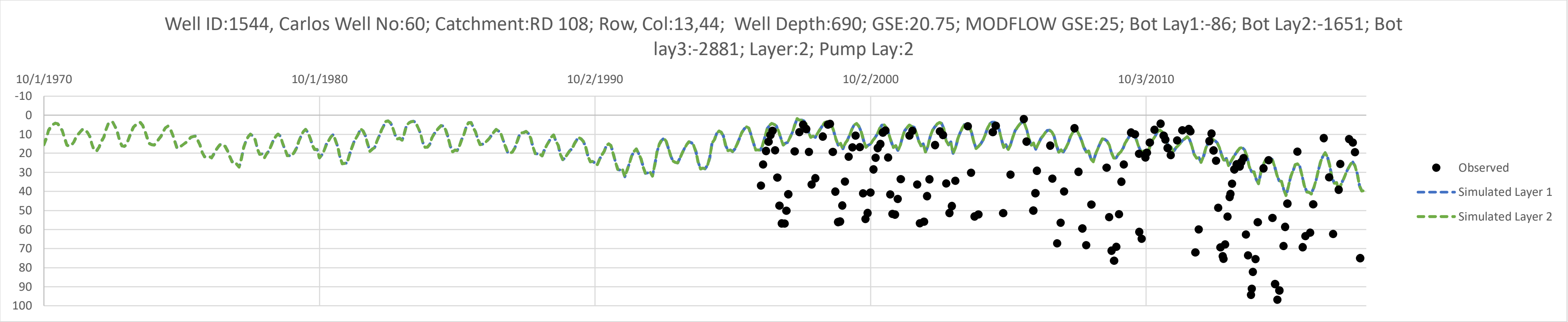
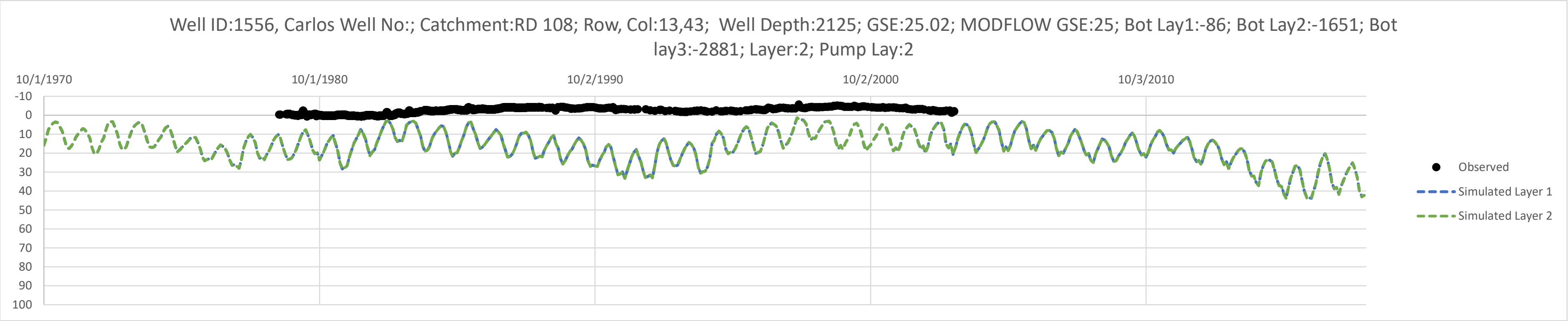


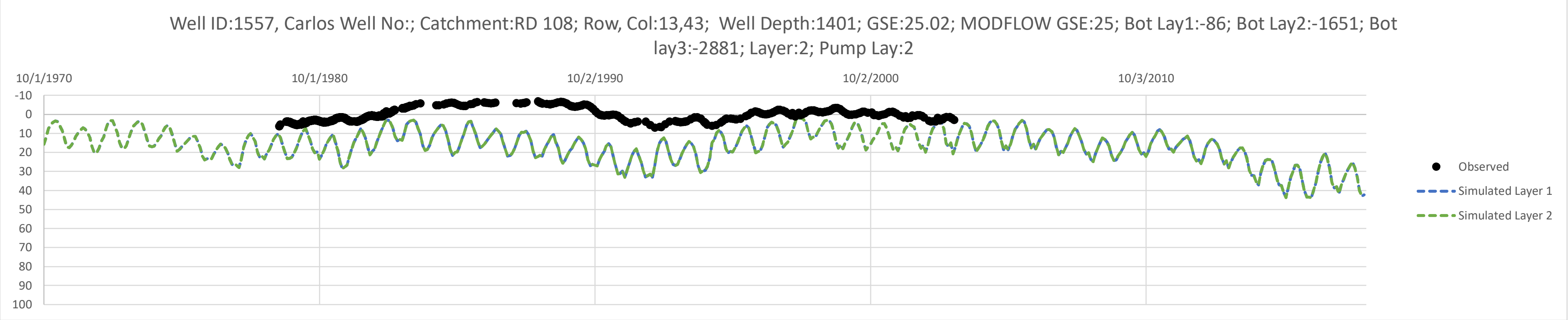




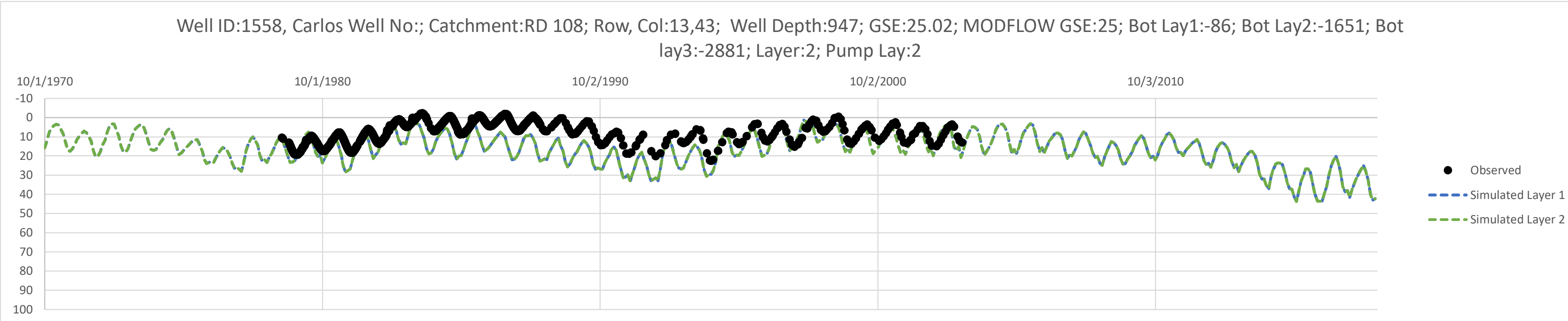
RD 108 Catchment

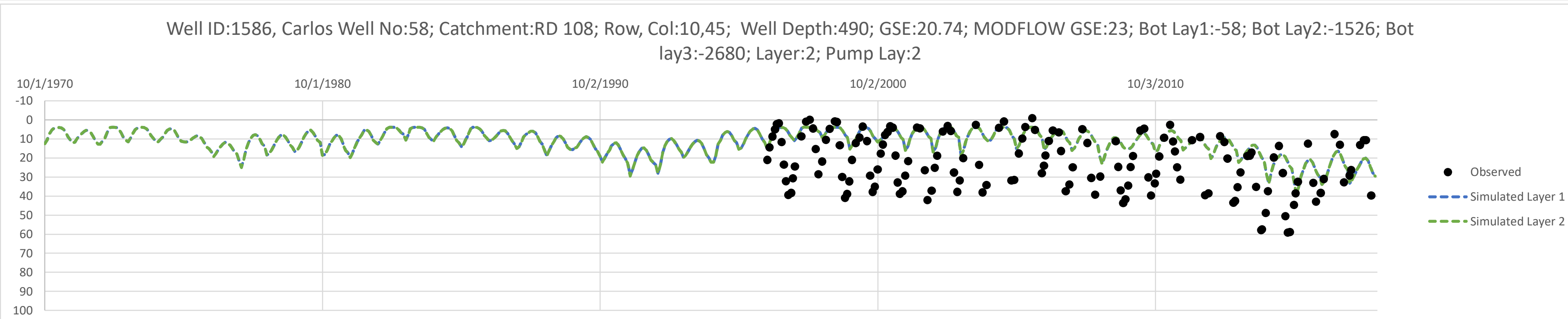


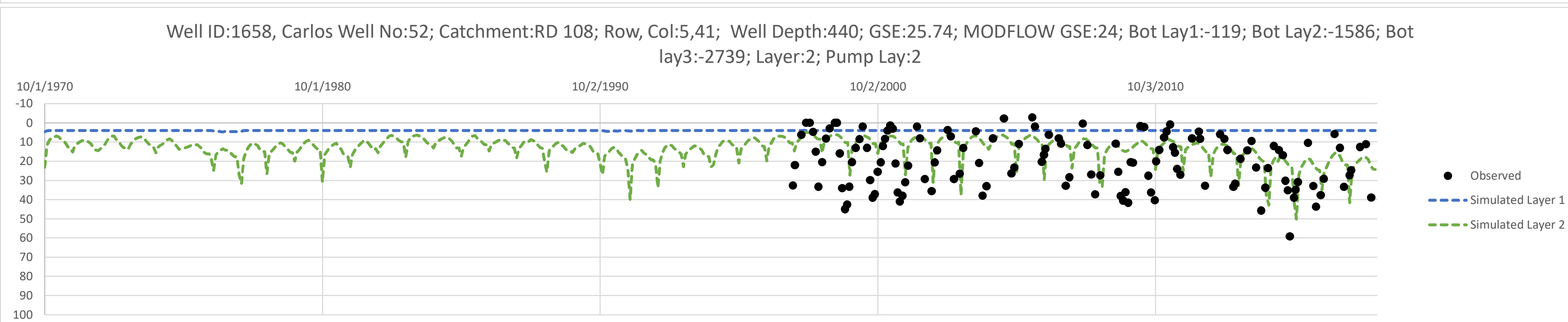




RD 108 Catchment







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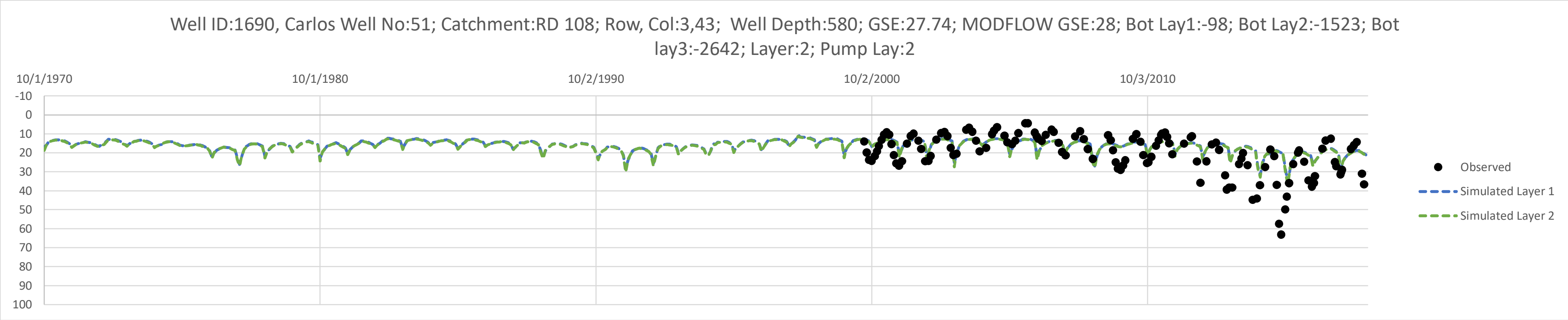
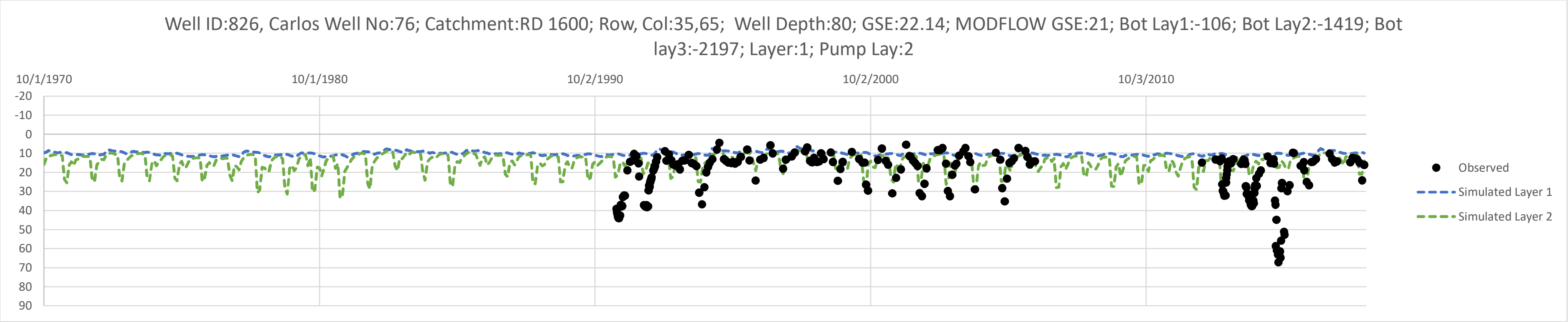
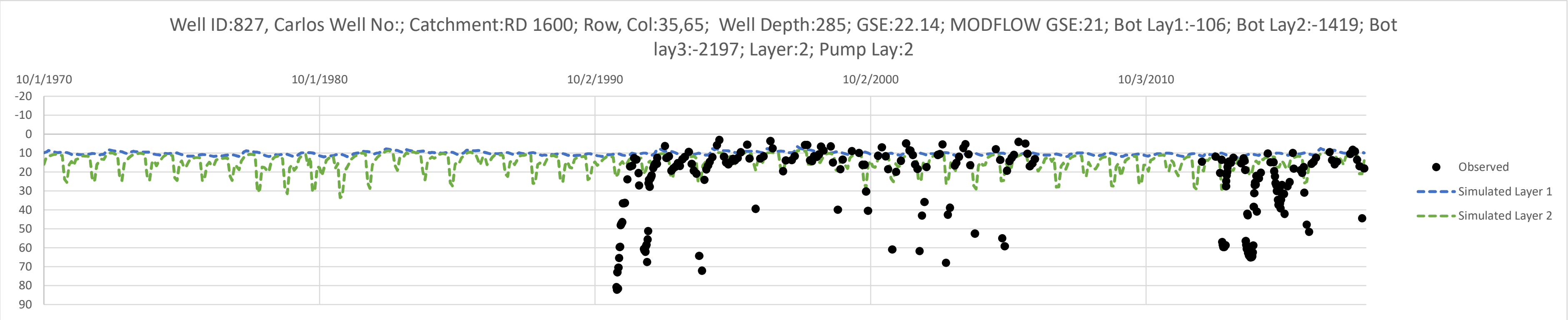
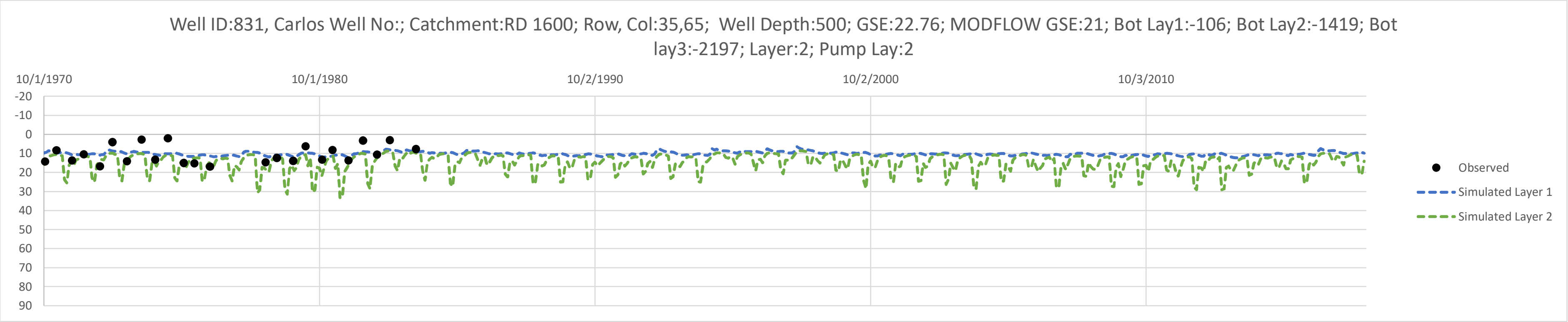


RD 1600 Catchment







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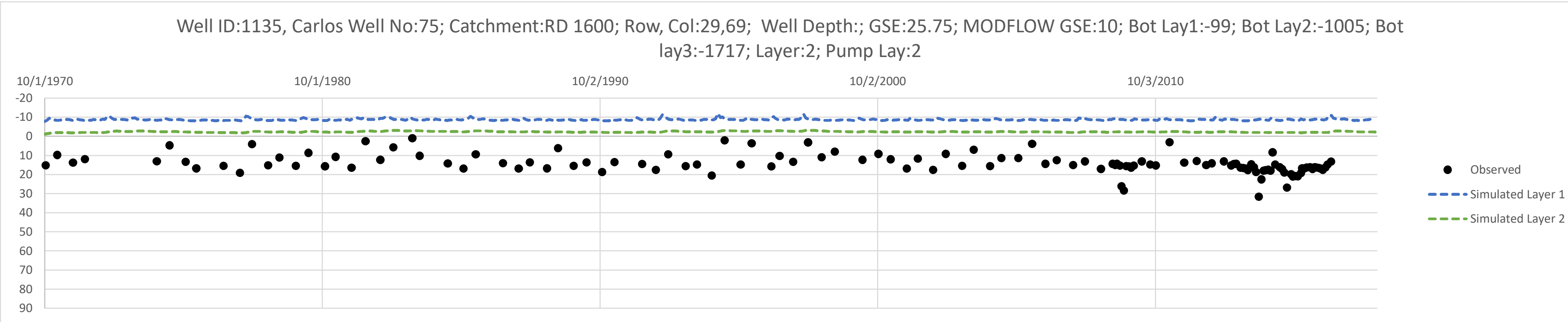
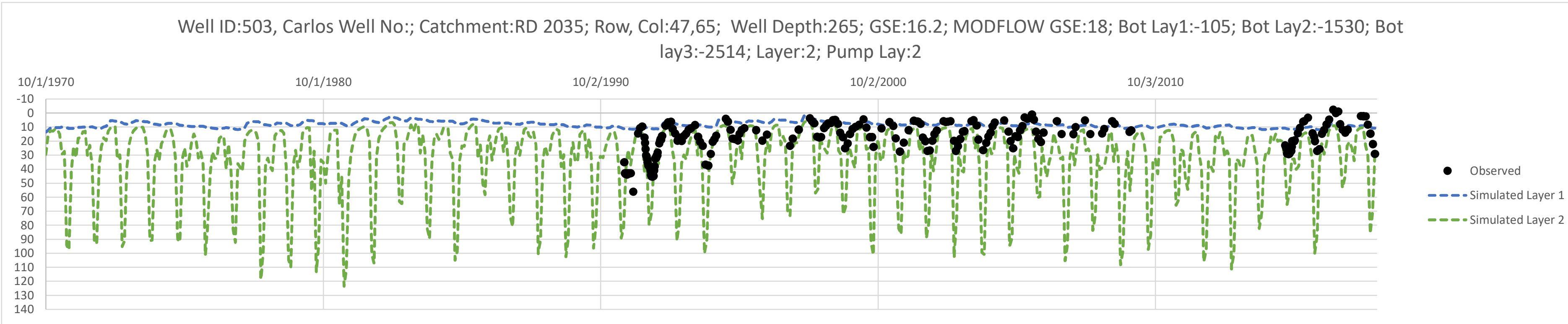
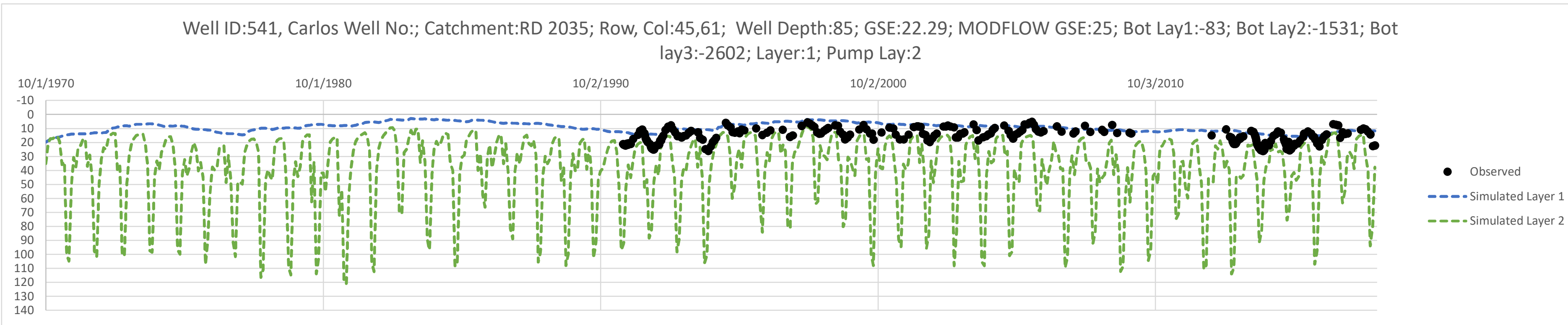
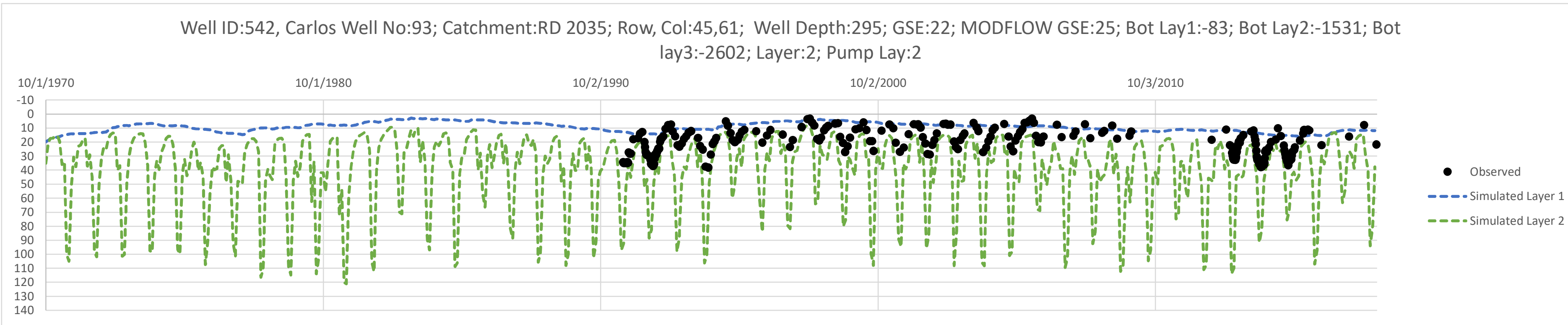


RD 2035 Catchment







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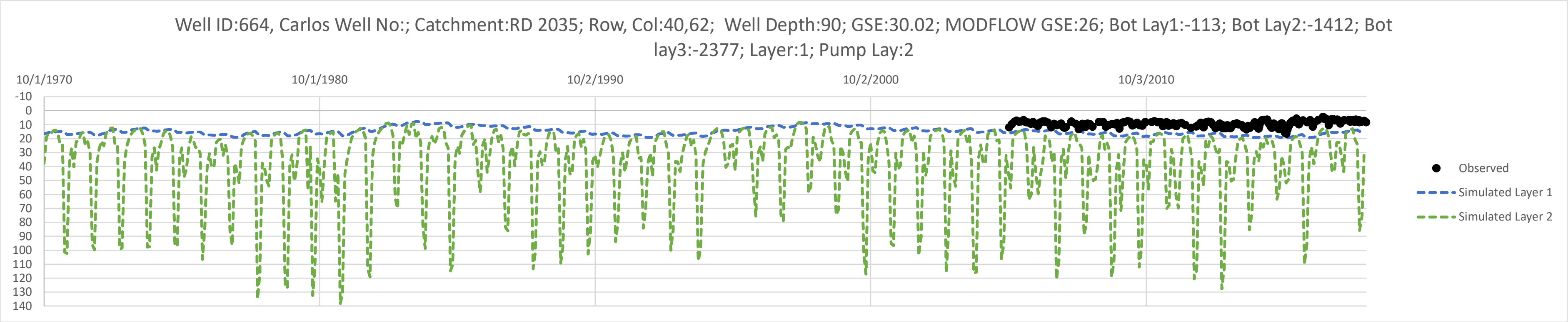

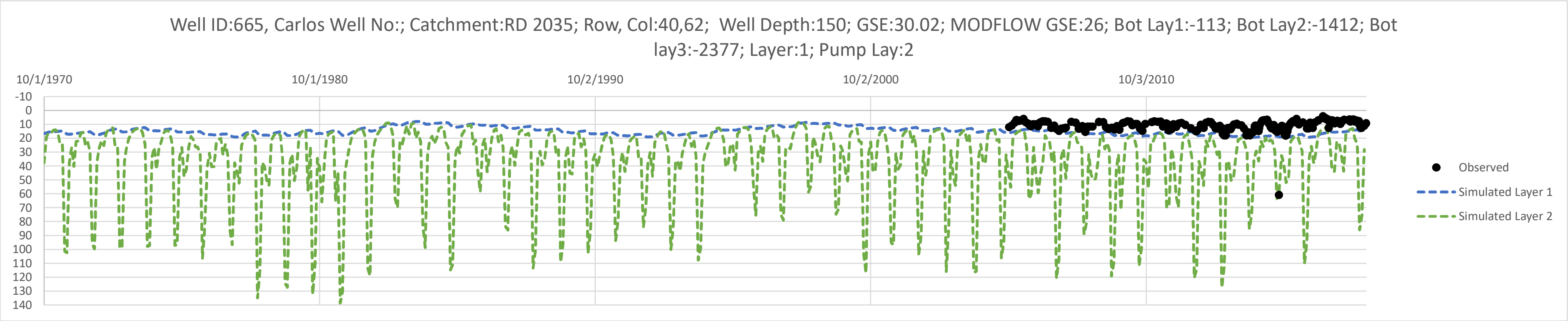

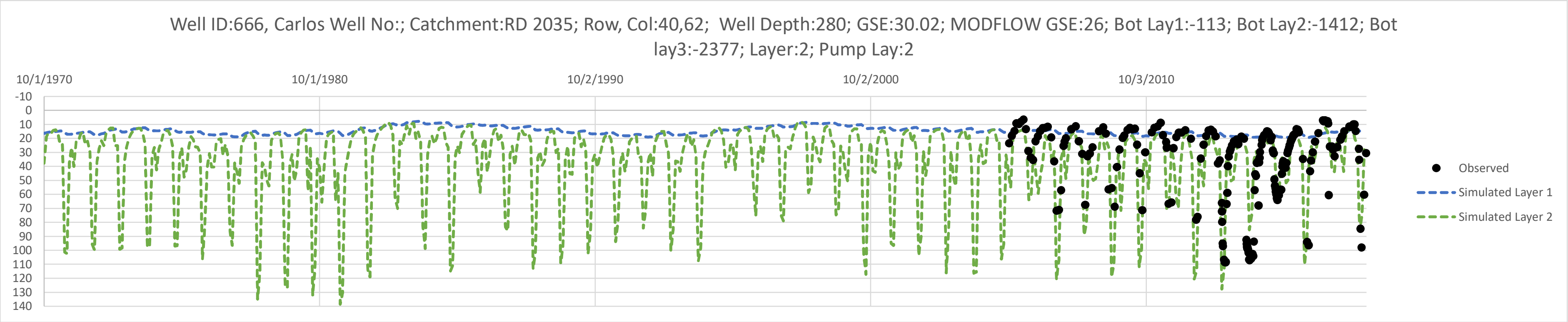

RD 2035 Catchment