APPENDIX A

Notice of Decision to Become a Groundwater Sustainability Agency

Kern River Groundwater Sustainability Agency

April 12, 2016

Mark Nordberg, GSA Project Manager
Sustainable Groundwater Management Section
California Department of Water Resources
P.O. Box 942836
Sacramento, California 94236-0001

Re: Notice of Decision to Become a Groundwater Sustainability Agency

Dear Mr. Nordberg,

Per Section 10723.8(a) of the California Water Code, the City of Bakersfield, the Kern Delta Water District, and the Kern County Water Agency Improvement District No.4 hereby give notice of their decision to form the Kern River Groundwater Sustainability Agency (GSA) for a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin.

The Sustainable Groundwater Management Act (SGMA), passed in 2014, requires that all basins designated as high- or medium-priority basins that are subject to critical overdraft conditions are to be managed under a groundwater sustainability plan (GSP) or coordinated GSPs (Section 10720.7). The Kern County Subbasin is a high-priority basin and is identified as having critical overdraft conditions. Information regarding the status of groundwater basins is provided by the California Department of Water Resources (DWR) at:
http://www.water.ca.gov/groundwater/sgm/cod.cfm.

This GSA notification and supporting materials are submitted to DWR within 30 days of the decision to form the GSA by its member agencies per Water Code §10723.8(a).

Water Code §10723.8(a)(1) requires that this GSA notification include information regarding the service area boundaries of the GSA and the boundaries of the basin the GSA intends to manage. Exhibit 1 includes three maps to satisfy the requirements of Water Code §10723.8(a)(1). Map (A) shows the Kern River GSA boundary. Map (B) shows the Kern River GSA boundary within the Kern County Subbasin. Map (C) shows the boundaries of the service areas of the agencies that comprise the Kern River GSA. The digital GIS data corresponding to the GSA boundary maps shown in Exhibit 1 are included with this submittal and provided on compact disc.

Water Code §10723.8(a)(1) also requires information regarding other agencies managing or proposing to manage groundwater within the basin. At the time of this Kern River GSA Notification submittal to DWR, it is our understanding that the Buena Vista Water Storage District has submitted a Notification to Form a GSA with DWR for a portion of the Kern County Subbasin. Within the Kern County subbasin, we understand that other agencies may be considering or proposing to form GSAs to manage groundwater resources in their own services areas. To our knowledge at this time, the following entities have held either a public hearing or expressed interest in forming a GSA: the Kern Groundwater Authority (KGA) and the Olcese Water District. We understand that the Greenfield County Water District has held a public hearing, passed a resolution to form a GSA, and will be submitting their Notification to Form a GSA with DWR.

On March 1, 2016 the governing Board of the Kern Delta Water District held a public hearing (Water Code §10723.b) regarding formation of the Kern River GSA. On March 15, 2016 the Board passed Resolution 2016-03 wherein the District resolved to become a GSA in cooperation with the City of Bakersfield and Improvement District No.4 of the Kern County Water Agency for the portion of the Kern County Subbasin as shown in Exhibit 1. Exhibit 2 contains a copy of the approved resolution to form the Kern River GSA by the governing Board of the Kern Delta Water District. Exhibit 3 includes details regarding the public noticing of the March 1, 2016 hearing by the Kern Delta Water District. The noticing process was consistent with the requirements of Section 6066 of the California Government Code.

On March 2, 2016 the City Council of Bakersfield held a public hearing (Water Code §10723.b) regarding formation of the Kern River GSA. On March 30, 2016 the City Council passed Resolution 039-16 wherein the City resolved to become a GSA in cooperation with the Kern Delta Water District and Improvement District No.4 of the Kern County Water Agency for the portion of the Kern County Subbasin as shown in Exhibit 1. A copy of Resolution 039-16 is included in Exhibit 2. Details regarding the public noticing of the March 2, 2016 hearing by the City Council are provided in Exhibit 3 and are consistent with the requirements of Section 6066 of the California Government Code.

On March 31, 2016 the Board of Directors of the Kern County Water Agency on behalf of Improvement District No.4 held a public hearing (Water Code §10723.b) regarding formation of the Kern River GSA. On March 31, 2016 the Board of Directors passed Resolution 11-16 wherein the Kern County Water Agency, Improvement District No.4 resolved to become a GSA in cooperation with the Kern Delta Water District and the City of Bakersfield for the portion of the Kern County Subbasin as shown in Exhibit 1.   A copy of Resolution 11-16 is included in Exhibit 2. Details regarding the public noticing of the March 31, 2016 hearing by the Board of Directors are provided in Exhibit 3 and are consistent with the requirements of Section 6066 of the California Government Code.

Exhibit 4 provides a memorandum of understanding (MOU) between the Kern Delta Water District, City of Bakersfield, and Kern County Water Agency Improvement District No.4 to form the Kern River GSA and manage groundwater resources sustainably within the GSA boundary. Please note that Exhibit C-1 to the MOU in Exhibit 4 contains a list of additional agencies that have joined the Kern River GSA.   Exhibit 5 includes additional supporting documents related to these additional agencies that have joined the Kern River GSA.

Per California Water Code §10723.2, GSAs shall consider the interests of all beneficial uses and users of groundwater within their service area, as well as those responsible for implementing Groundwater Sustainability Plans (GSPs). Exhibit 6 lists interested parties developed pursuant to Water Code §10723.2 and describes how these users and uses will be considered during the development and operation of the Kern River GSA and implementation of the GSP for the Kern River GSA. If additional interested parties are discovered, they too will be included in the development and operation of the GSA and the development and implementation of the agency's sustainability plan (Water Code 10723.8(a)(4)).

Water Code §10723.4 states that a GSA shall also establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents. Any person may request, in writing, to be placed on the list of interested persons. The Kern River GSA will establish and maintain such a list of persons interested in receiving notices.

Except for the authorities granted to a GSA pursuant to Part 2.74 of Division 6 of the California Water Code (SGMA), no new bylaws, ordinances, or authorities have been adopted by the District or City at this time of forming the Kern River GSA (Water Code §10723.8(a)(3)).

The undersigned hereby represents that the information required by California Water Code §10728.3 is included within this notice and that the notification process is complete.

If you have any further questions or require any clarification regarding the information provided in this GSA Notification submittal, please do not hesitate to contact one of our GSA program coordinators as identified on the following page.

Thank you,

Rodney Palla
President, Board of Directors, Kern Delta Water District

Harold Hanson
Vice Mayor, City of Bakersfield

Ted Page
President, Board of Directors, Kern County Water Agency

GSA Program Coordinators

Art Chianello
Water Resources Manager
Water Resources Department
(661) 326-3715
achianel@bakersfieldcity.us

Mark Mulkay
General Manager
Kern Delta Water District
(661) 834-4656
mulkay@kerndelta.org

David Beard
Manager
Kern County Water Agency
Improvement District No. 4
(661) 634-1400
dbeard@kcwa.com

Exhibits:

Exhibit 1: GSA Maps – including (A) map of Kern River GSA boundary, (B) map of Kern River GSA boundary within Kern County Subbasin, and (C) map of Kern River GSA showing member agencies service area boundaries

Exhibit 2: GSA Forming Resolutions by Kern Delta Water District, City of Bakersfield, and Improvement District No. 4 of the Kern County Water Agency

Exhibit 3: Public Hearing Noticing Information for GSA Member Agencies

Exhibit 4: Memorandum of Understanding (MOU) Between the City of Bakersfield, Kern Delta Water District, and Improvement District No.4 of the Kern County Water Agency

Exhibit 5: Supporting Documents for Entities Also Joining the Kern River GSA

Exhibit 6: List of Interested Parties

Exhibit 7: List and Map of Disadvantaged Communities (DAC) in GSA

EXHIBIT 1

GSA MAPS

INCLUDING:

(A) MAP OF KERN RIVER GSA BOUNDARY

(B) MAP OF KERN RIVER GSA BOUNDARY WITHIN KERN COUNTY SUBBASIN

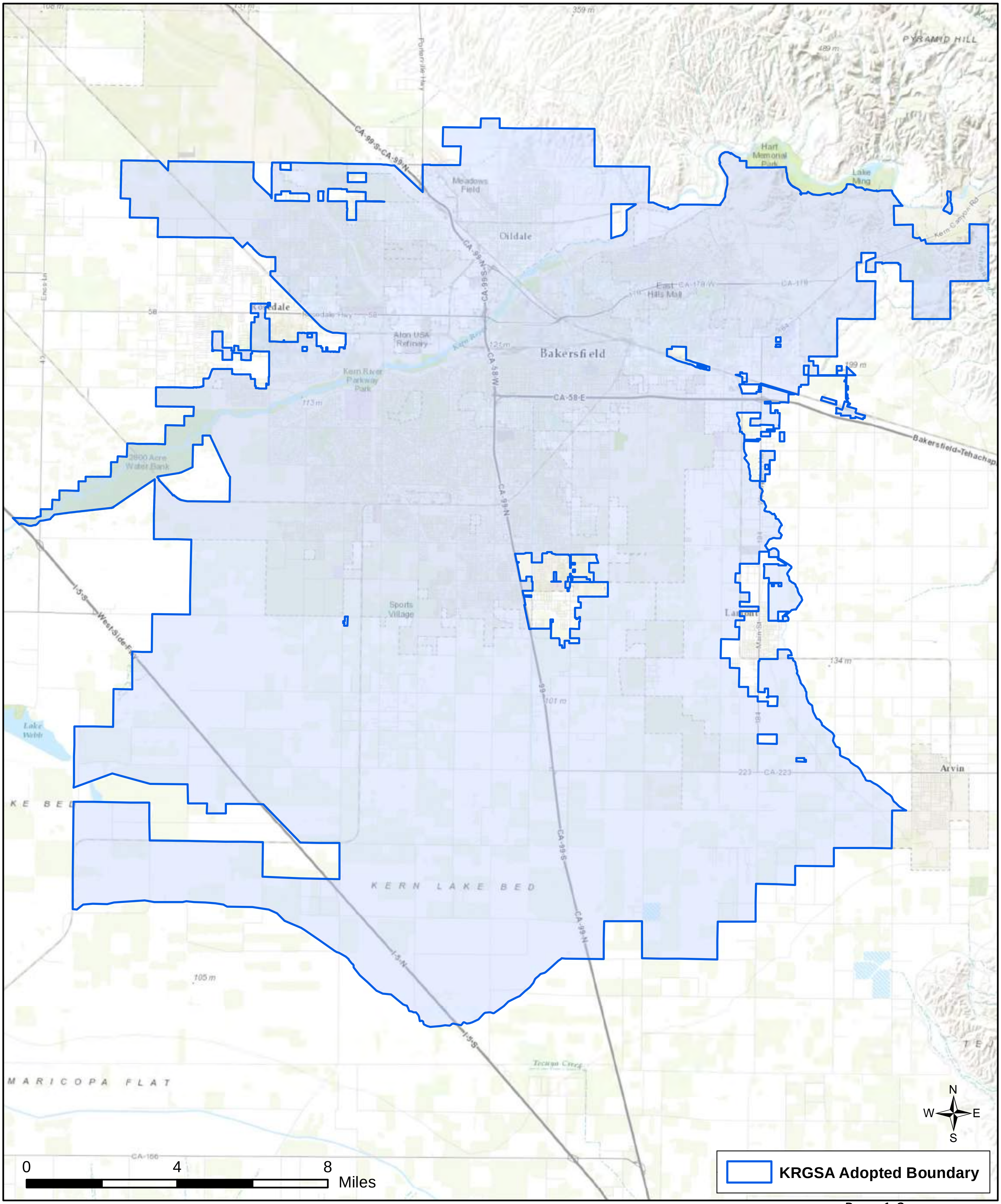
(C) MAP OF KERN RIVER GSA SHOWING MEMBER AGENCIES SERVICE AREA BOUNDARIES

--- FOR OFFICIAL USE ONLY ---

Exhibit 1-A

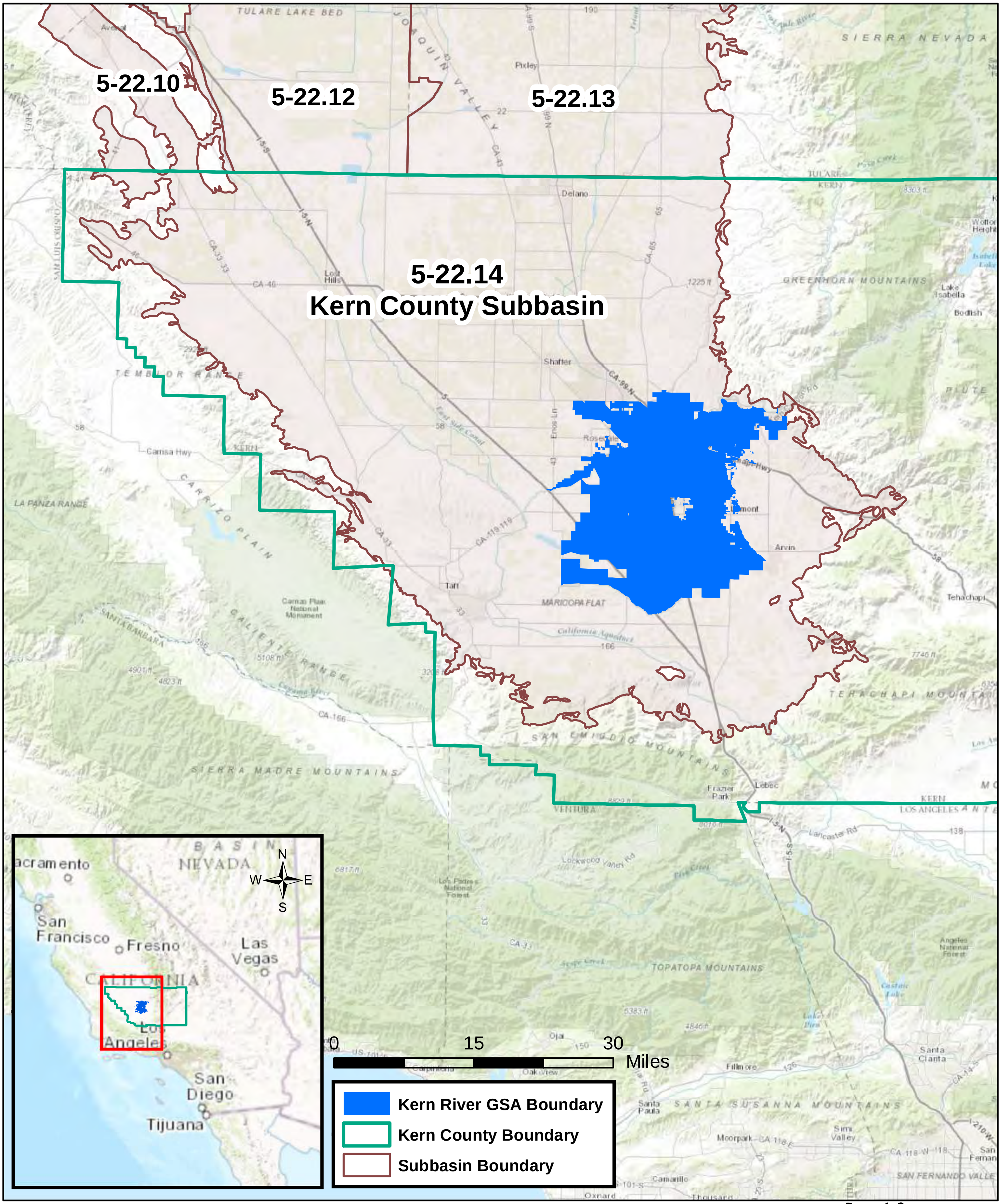
Kern River Groundwater Sustainability Agency (GSA)

Adopted Boundary as of March 31, 2016



Kern River Groundwater Sustainability Agency (GSA)

Adopted GSA Boundary Within Subbasin 5-22.14 of the Tulare Lake Hydrologic Region



--- FOR OFFICIAL USE ONLY ---

Kern River Groundwater Sustainability Agency (GSA)

Adopted Boundary with Service Areas

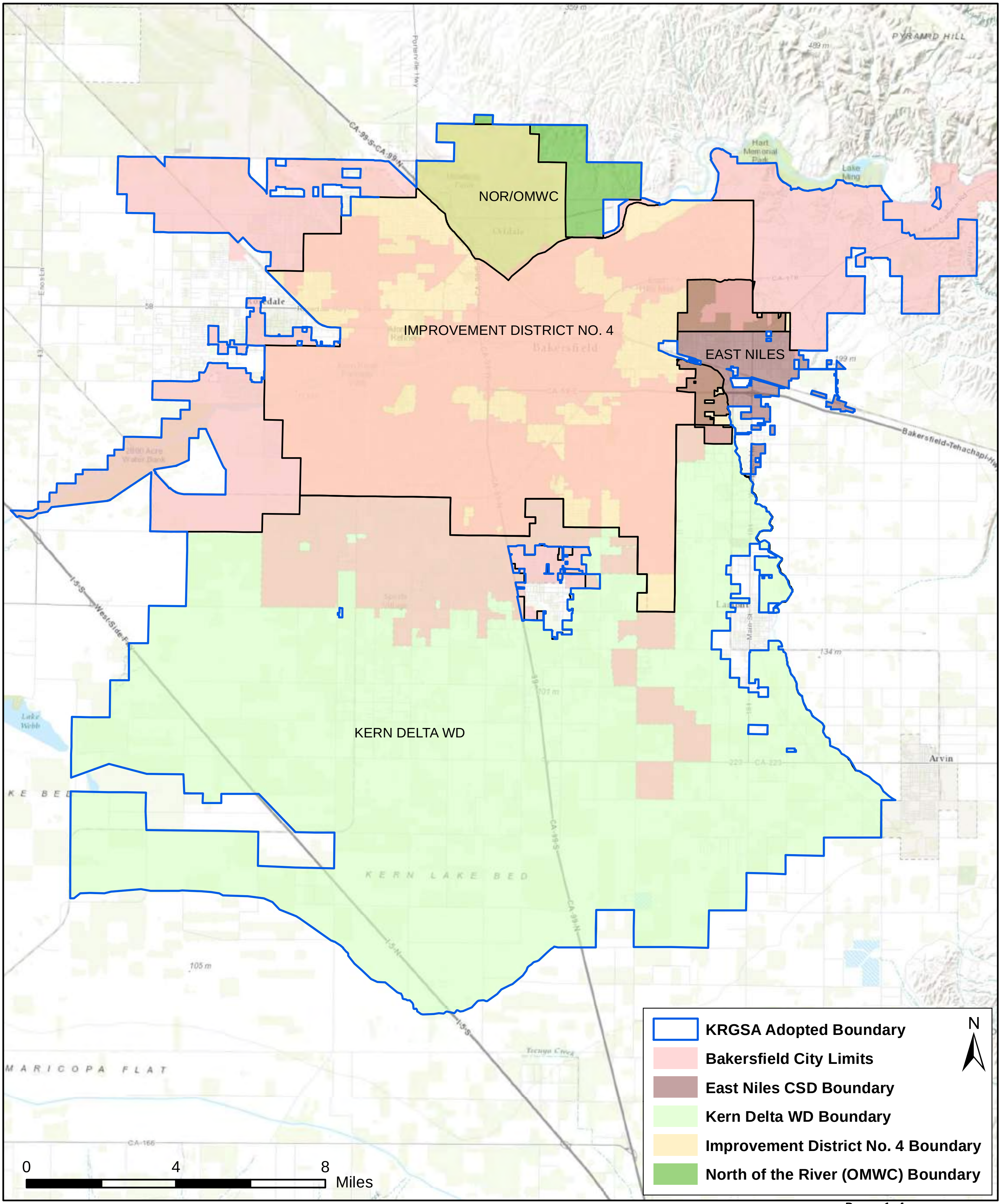


EXHIBIT 2

<u>RESOLUTIONS</u>

INCLUDING:

(A) RESOLUTION FORMING GSA, APPROVED BY BOARD OF DIRECTORS OF THE KERN DELTA WATER DISTRICT, MARCH 15, 2016

(B) RESOLUTION FORMING GSA, APPROVED BY CITY COUNCIL OF THE CITY OF BAKERSFIELD, MARCH 30, 2016

(C) RESOLUTION FORMING GSA, APPROVED BY BOARD OF DIRECTORS IMPROVEMENT DISTRICT NO.4 OF THE KERN COUNTY WATER AGENCY, MARCH 31, 2016

BEFORE THE BOARD OF DIRECTORS OF
THE KERN DELTA WATER DISTRICT

RESOLUTION NO. 2016-03

IN THE MATTER OF:

KERN DELTA WATER DISTRICT DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, Kern Delta Water District ("District") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code §34000) and overlies a portion of the Kern County Subbasin of the San Joaquin Valley Groundwater Basin portion of the Tulare Lake Hydrologic Region, as defined in Bulletin 118 of the California Department of Water Resources and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the City of Bakersfield (City) is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the District desires to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code 10723.6 (b); and

WHEREAS, the District held a public hearing on Tuesday March 1, 2016 pursuant to California Water Code section §10723(b), after publication of notice of such hearing pursuant to California Government Code section §6066; and

WHEREAS, at the public hearing, the Kern Delta Water District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to form a Groundwater Sustainability Agency, which may include the City of Bakersfield and other Local Agencies and which may include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That Kern Delta Water District herein decides to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other local agencies, and which may include the participation of legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as depicted in the notification provided to the Department of Water Resources pursuant to California Water Code 10723.8, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section §10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section §10723.4.

6. That the General Manager of Kern Delta Water District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code §10723.6(a), as deemed appropriate by the General Manager, and cause notice to be given to the California Department of Water Resources of the decision of Kern Delta Water District to create the above referenced Groundwater Sustainability Agency.

ALL THE FOREGOING being on the motion of Director Frick, seconded by Director Tillema and authorized by the following vote, namely:

AYES: Antongiovanni, Bidart, Collins, Frick, Garone, Kaiser, Palla, Tillema

NOES: None

ABSENT: None

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of March, 2016.

Rodney Palla
Board President of Directors
KERN DELTA WATER DISTRICT

ATTESTED:

L. Mark Mulkay
Assistant Secretary of the Board of Directors
KERN DETLA WATER DISTRICT

RESOLUTION NO. 039 - 16

A RESOLUTION OF THE COUNCIL OF THE CITY OF BAKERSFIELD TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT.

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of Groundwater Sustainability Plans; and

WHEREAS, Water Code Section 10723(a) authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because City manages water, has water supply, and has land use responsibilities over a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, Kern Delta Water District ("Kern Delta") is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of City; and

WHEREAS, Improvement District No. 4 ("ID4") is also a local agency qualified to become a GSA and overlies a portion of the Kern County Subbasin; and

WHEREAS, City held a public hearing on March 2, 2016, after publication of notice pursuant to Government Code Section 6066 to consider adoption of this Resolution; and

WHEREAS, City, Kern Delta, and ID4 will work collaboratively with other interested entities to form a GSA known as the Kern River Ground Water Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in **Exhibit "A"** attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment.

NOW THEREFORE, BE IT RESOLVED by the Council of the City of Bakersfield as follows:

1. The above recitals and findings are true and correct.

2. That City of Bakersfield does hereby elect in concert with Kern Delta Water District and Improvement District No. 4 to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on **Exhibit "A"** attached to this Resolution.

3. That City of Bakersfield, Kern Delta Water District and Improvement District No. 4 will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to the City of Bakersfield and Kern Delta Water District.

4. That the Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code Section 10723.2

5. That the Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code Section 10723.4.

6. That City of Bakersfield, Kern Delta Water District, and Improvement District No. 4 will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin to DWR.

----------o0o----------

I HEREBY CERTIFY that the foregoing Resolution was passed and adopted by the Council of the City of Bakersfield at a regular meeting thereof held on MAR 3 0 2016, by the following vote:

YES:	COUNCIL MEMBER RIVERA, MAXWELL, WEIR, SMITH, HANSON, SULLIVAN, PARLIER
NOES:	COUNCIL MEMBER None
ABSTAIN:	COUNCIL MEMBER None
ABSENT:	COUNCIL MEMBER None

Roberta Gafford

ROBERTA GAFFORD, CMC
CITY CLERK and Ex Officio Clerk of
the Council of the City of Bakersfield

APPROVED MAR 3 0 2016

By

HARVEY L. HALL
Mayor

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

By Virginia Gennaro
VIRGINIA GENNARO
City Attorney

RI:dll
S:\WATER\GSA\Reso.Fnl.Docx

Exhibit 2-B

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

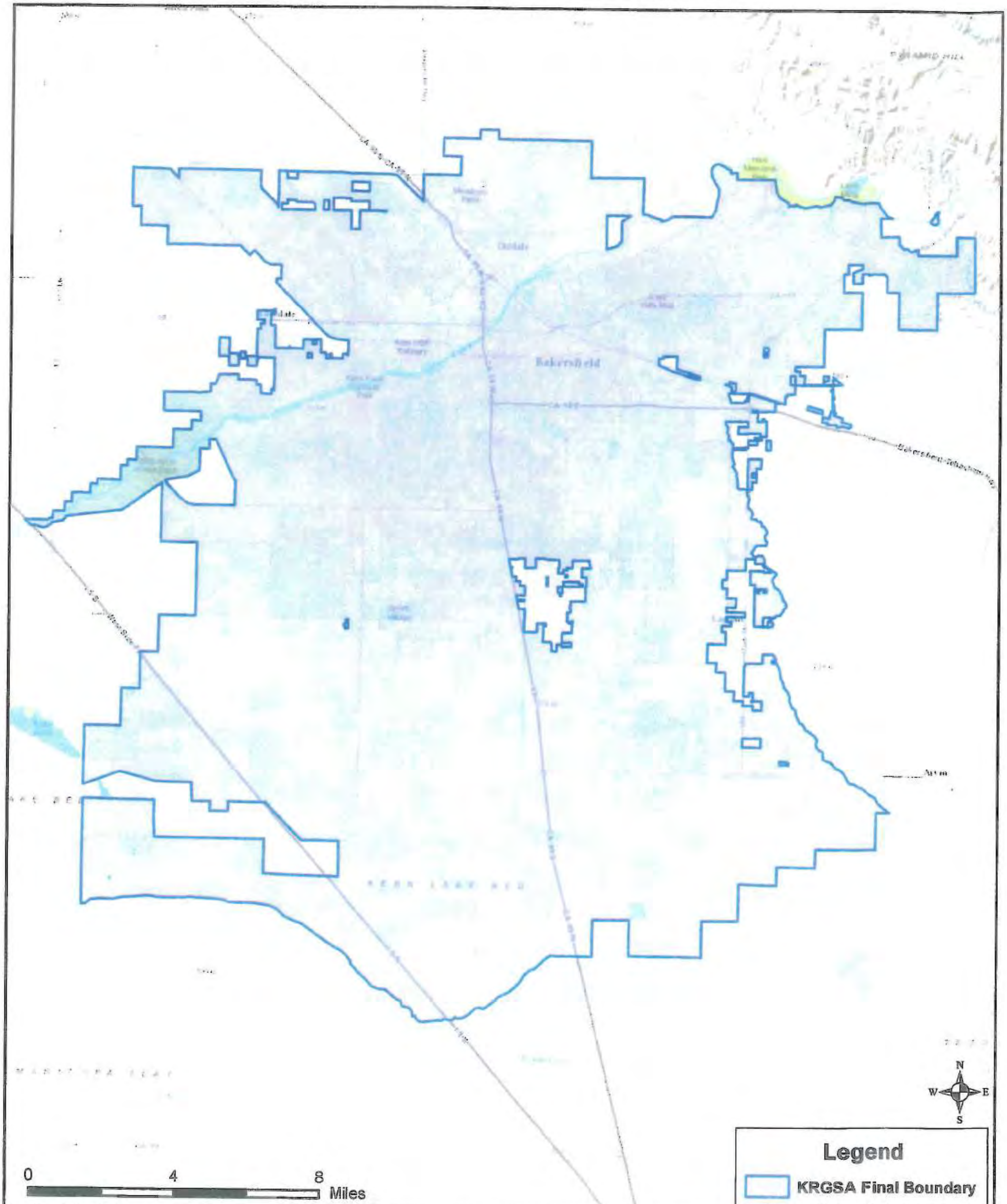


EXHIBIT " A "

BEFORE THE BOARD OF DIRECTORS

OF THE

KERN COUNTY WATER AGENCY

In the matter of:

AUTHORIZING IMPROVEMENT *
DISTRICT NO. 4 TO BECOME A *
GROUNDWATER SUSTAINABILITY *
AGENCY *

I, Lucinda J. Infante, Secretary of the Board of Directors of the Kern County Water Agency, of the County of Kern, State of California, do hereby certify that the following resolution proposed by Director Lundquist, and seconded by Director Fast, was duly passed and adopted by said Board of Directors at an official meeting hereof this 31st day of March, 2016, by the following vote, to wit:

Ayes: Lundquist, Fast, Wulff, Milobar, Cerro and Page

Noes: None

Absent: Hafenfeld

Lucinda J. Infante

Secretary of the Board of Directors
of the Kern County Water Agency

Resolution No. 11-16

WHEREAS, the Board of Directors (Board) of the Kern County Water Agency (Agency) is also empowered as the Board of the Agency Improvement District No. 4 (ID4); and

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of

Groundwater Sustainability Plans; and

WHEREAS, Water Code section 10723 authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, ID4 is a local agency qualified to become a GSA because ID4 is an Improvement District of the Kern County Water Agency formed to provide a supplemental water supply for the metropolitan Bakersfield area and overlies a portion of the Kern County Subbasin (Basin Number 5- 22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because the City manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Subbasin; and

WHEREAS, Kern Delta Water District (Kern Delta) is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of the City; and

WHEREAS, the Agency, the City and Kern Delta will work collaboratively with other interested agencies to form a GSA known as the Kern River Groundwater Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in Exhibit A attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment; and

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Kern County Water Agency, acting as the Board of Directors of Improvement District No. 4, that:

1. The foregoing recitals are true and correct.

2. ID4 does hereby elect in concert with the City and Kern Delta to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on Exhibit A.

3. ID4, the City and Kern Delta will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to ID4, the City and Kern Delta.

4. The Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section 10723.2.

5. The Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements and availability of draft plans, maps and other relevant documents, as required by California Water Code section 10723.4.

6. ID4, the City and Kern Delta will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the Kern County Subbasin.

7. The Agency Board President is authorized to execute the Memorandum of Understanding Forming the Kern River Groundwater Sustainability Agency as shown on Exhibit B.

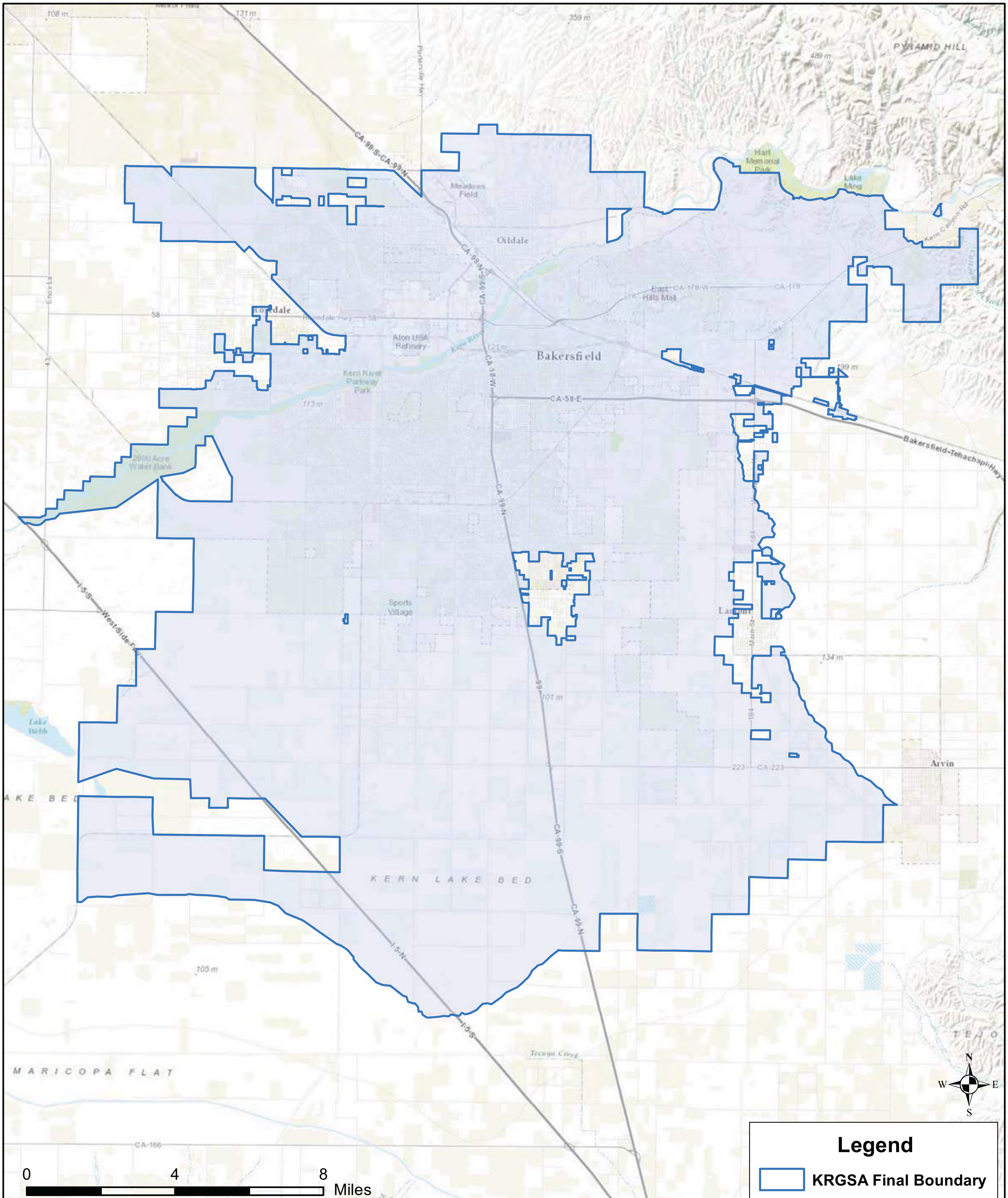
--- FOR OFFICIAL USE ONLY ---

Exhibit 2-C

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

Exhibit A



MEMORANDUM OF UNDERSTANDING FORMING THE KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

THIS MEMORANDUM OF UNDERSTANDING ("MOU") is made and entered into on _______________________, by and between the **CITY OF BAKERSFIELD,** a municipal corporation, ("CITY" herein), **KERN DELTA WATER DISTRICT** ("KERN DELTA" herein), and **KERN COUNTY WATER AGENCY on behalf of its IMPROVEMENT DISTRICT NO. 4,** ("ID4" herein), each a "Party" and collectively the "Parties."

WHEREAS, on September 16, 2014, Governor Jerry Brown signed into law Senate Bills 1168 and 1319 and Assembly Bill 1739, known collectively as the Sustainable Groundwater Management Act ("SGMA"); and

WHEREAS, the purpose of SGMA is to create a comprehensive management system in the State of California by creating structure to manage groundwater at the local level, while providing authority to the State to oversee and regulate, if necessary, the local groundwater management system; and

WHEREAS, SGMA empowers local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities to provide a buffer against drought and contribute to reliable water supply for the future; and

WHEREAS, Water Code Section 10723.6 authorizes a combination of local agencies overlying a groundwater basin to elect to become a Groundwater Sustainability Agency ("GSA") by using a memorandum of agreement or other legal agreement; and

WHEREAS, CITY is a local agency qualified to become a GSA because CITY manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Sub-basin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin ("Basin"), a DWR-designated high-priority basin; and

WHEREAS, Kern Delta is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code, manages water, has a water supply and overlies a portion of the Basin just south of CITY; and

WHEREAS, ID4 is also a local agency qualified to become a GSA because ID4 is an improvement district of the Kern County Water Agency formed to provide a supplemental water supply for the metropolitan Bakersfield area and overlies a portion of the Basin; and

WHEREAS, on February 10, 2016, CITY and KERN DELTA entered into Agreement No. 10-009 to establish a working relationship with the goal of jointly forming a GSA; and

WHEREAS, CITY and KERN DELTA mutually agree to add ID4 as a Party to this MOU; and

WHEREAS, on March 1, 2016, KERN DELTA held a public hearing to determine whether to become a GSA, and on March 15, 2016, KERN DELTA adopted Resolution No. 2016-03 electing to jointly become a GSA with CITY and ID4, a copy of which is attached hereto as **Exhibit "A-1"**; and

WHEREAS, on March 2, 2016, CITY held a public hearing to determine whether to become a GSA and on March 30, 2016, CITY adopted Resolution No. 039-16, electing to jointly become a GSA with KERN DELTA and ID4, a copy of which is attached hereto as **Exhibit "A-2"**; and

WHEREAS, on March 31, 2016, ID4 held a public hearing to determine whether to become a GSA, and on March 31, 2016, ID4 adopted Resolution No. __________-16, electing to jointly become a GSA with CITY and KERN DELTA, a copy of which is attached hereto as **Exhibit "A-3"**; and

WHEREAS, CITY, KERN DELTA and ID4 will jointly submit a Notice of Decision to form and be the founding Parties of a GSA, which will cover the portion of the Basin as shown on the map in **Exhibit "B-1"** attached hereto and incorporated herein; and

WHEREAS, the Parties will work collaboratively with other interested agencies to develop and implement a Ground Water Sustainability Plan ("GSP") to sustainably manage the Basin pursuant to SGMA.

NOW, THEREFORE, incorporating the above recitals herein and exhibits attached, it is mutually understood and agreed as follows:

1. <u>PURPOSE</u>. This MOU is entered into by and between the Parties to facilitate a cooperative and ongoing working relationship that will allow compliance with SGMA and State law, both as amended from time to time.

2. <u>KERN RIVER GROUND WATER SUSTAINABILITY AGENCY</u>. The Parties hereby establish the Kern River Groundwater Sustainability Agency ("KRGSA") to manage the portion of the Basin as set forth in **Exhibit "B-1."**

3. ADDITIONAL AGENCIES. Additional agencies with service area boundaries outside the jurisdiction of the Parties may join and incorporate their service area boundaries or portions thereof into KRGSA upon the mutual consent of all Parties. The additional agencies will be added to **Exhibit "C-1,"** as amended from time to time in compliance with SGMA, and the boundaries of the KRGSA may be expanded accordingly.

4. POWERS

4.1 In addition to any other action available to develop and implement SGMA, including a GSP, the KRGSA may perform the following functions:

4.1.1 Adopt standards for measuring and reporting water use.

4.1.2 Develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA.

4.1.3 Develop and implement conservation best management practices.

4.1.4 Develop and implement metering, monitoring and reporting related to groundwater pumping.

5. DECISION MAKING PROCESS

5.1 With the exceptions noted herein, it is the intent of the Parties that all actions undertaken by the KRGSA are done by unanimous consent of the Parties; however, if unanimous consent is not possible, a majority vote of the Parties is required.

5.2 In the event of an impasse or disagreement, the Parties shall use their best efforts to find a mutually agreeable result. To this effect, the Parties shall consult and negotiate with each other in good faith in an attempt to reach a solution that is mutually satisfactory. If the Parties do not reach a solution, then the matter shall be submitted to non-binding arbitration or mediation within a reasonable period of time.

6. ROLES AND RESPONSIBILITIES OF THE PARTIES

6.1 The Parties will work jointly to fulfill the Purpose of this MOU, SGMA, and the development and implementation of a GSP within the boundaries of the KRGSA.

6.2 The Parties will meet regularly to discuss SGMA, GSP development and implementation activities, assignments, and ongoing work progress.

6.3 The Parties may form committees as necessary from time to time discuss issues that impact the KRGSA.

6.4 The CITY and ID4 are jointly responsible for implementing the GSP in areas of the KRGSA that are within both City limits and ID4 boundaries.

6.5 KERN DELTA is responsible for implementing the GSP in agricultural areas of the KRGSA within KERN DELTA's boundary.

7. **FUNDING.** Unless agreed to otherwise, each Party's participation in this MOU is at its sole cost and expense.

8. **TERM**. This MOU shall remain in effect unless terminated by the mutual written consent of the Parties and as allowed by State law.

9. **AMENDING THE MOU**. This MOU and Exhibits hereto may only be amended by a subsequent writing, approved and signed by all Parties.

10. **HOLD HARMLESS**. No Party, nor any officer or employee of a Party, shall be responsible for any damage or liability occurring by reason of anything done or omitted to be done by another Party under or in connection with this MOU.

APPROVED AS TO CONTENT:
CITY OF BAKERSFIELD

By:______________________________
HARVEY L. HALL
Mayor

DATE:__________________

WATER BOARD

By: ______________________________
HAROLD HANSON
Water Board Chair

Draft - See final signed version on Page 4-5.

APPROVED AS TO CONTENT:
KERN DELTA WATER DISTRICT

By:______________________________
RODNEY PALLA
Board President

DATE:_______________________

KERN DELTA WATER DISTRICT

By: ______________________________
L. MARK MULKAY
General Manager

Additional Signatures on Following Page

WATER RESOURCES DEPARTMENT

By: ______________________________
ART CHIANELLO
Water Resources Manager

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

Draft - See final signed version on Page 4-6.

By:______________________________
VIRGINIA GENNARO
City Attorney

COUNTERSIGNED:

By:______________________________
NELSON SMITH
Finance Director

APPROVED AS TO FORM:

By:______________________________
GENE R. McMURTREY
Attorneys for Kern Delta Water District

APPROVED AS TO CONTENT:
IMPROVEMENT DISTRICT 4

By: ______________________________
TED R. PAGE
Board President

APPROVED AS TO FORM:

By: ______________________________
AMELIA T. MINABERRIGARAI
General Counsel

VG:dll/vlg
S:\WATER\GSA\MOU Kern Delta&ID4.City-Final.Docx

BEFORE THE BOARD OF DIRECTORS OF THE KERN DELTA WATER DISTRICT

RESOLUTION NO. 2016-03

IN THE MATTER OF:

KERN DELTA WATER DISTRICT DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, Kern Delta Water District ("District") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code §34000) and overlies a portion of the Kern County Subbasin of the San Joaquin Valley Groundwater Basin portion of the Tulare Lake Hydrologic Region, as defined in Bulletin 118 of the California Department of Water Resources and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the City of Bakersfield (City) is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the District desires to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code 10723.6 (b); and

WHEREAS, the District held a public hearing on Tuesday March 1, 2016 pursuant to California Water Code section §10723(b), after publication of notice of such hearing pursuant to California Government Code section §6066; and

WHEREAS, at the public hearing, the Kern Delta Water District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to form a Groundwater Sustainability Agency, which may include the City of Bakersfield and other Local Agencies and which may include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That Kern Delta Water District herein decides to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other local agencies, and which may include the participation of legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as depicted in the notification provided to the Department of Water Resources pursuant to California Water Code 10723.8, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section §10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section §10723.4.

6. That the General Manager of Kern Delta Water District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code §10723.6(a), as deemed appropriate by the General Manager, and cause notice to be given to the California Department of Water Resources of the decision of Kern Delta Water District to create the above referenced Groundwater Sustainability Agency.

ALL THE FOREGOING being on the motion of Director Frick, seconded by Director Tillema and authorized by the following vote, namely:

AYES: Antongiovanni, Bidart, Collins, Frick, Garone, Kaiser, Palla, Tillema

NOES: None

ABSENT: None

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of March, 2016.

Rodney Palla
Board President of Directors
KERN DELTA WATER DISTRICT

ATTESTED:

L. Mark Mulkay
Assistant Secretary of the Board of Directors
KERN DETLA WATER DISTRICT

RESOLUTION NO. ______________

A RESOLUTION OF THE COUNCIL OF THE CITY OF BAKERSFIELD TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT.

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of Groundwater Sustainability Plans; and

WHEREAS, Water Code Section 10723(a) authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because City manages water, has water supply, and has land use responsibilities over a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, Kern Delta Water District ("Kern Delta") is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of City; and

WHEREAS, Improvement District No. 4 ("ID4") is also a local agency qualified to become a GSA and overlies a portion of the Kern County Subbasin; and

WHEREAS, City held a public hearing on March 2, 2016, after publication of notice pursuant to Government Code Section 6066 to consider adoption of this Resolution; and

WHEREAS, City, Kern Delta, and ID4 will work collaboratively with other interested entities to form a GSA known as the Kern River Ground Water Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in **Exhibit "A"** attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment.

NOW THEREFORE, BE IT RESOLVED by the Council of the City of Bakersfield as follows:

1. The above recitals and findings are true and correct.

2. That City of Bakersfield does hereby elect in concert with Kern Delta Water District and Improvement District No. 4 to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on **Exhibit "A"** attached to this Resolution.

3. That City of Bakersfield, Kern Delta Water District and Improvement District No. 4 will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to the City of Bakersfield and Kern Delta Water District.

4. That the Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code Section 10723.2

5. That the Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code Section 10723.4.

6. That City of Bakersfield, Kern Delta Water District, and Improvement District No. 4 will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the

Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin to DWR.

----------o0o----------

I HEREBY CERTIFY that the foregoing Resolution was passed and adopted by the Council of the City of Bakersfield at a regular meeting thereof held on ____________________________, by the following vote:

YES: COUNCIL MEMBER RIVERA, MAXWELL, WEIR, SMITH, HANSON, SULLIVAN, PARLIER
NOES: COUNCIL MEMBER ____
ABSTAIN: COUNCIL MEMBER ____
ABSENT: COUNCIL MEMBER ____

Draft - See final signed version on Page 2-23.

____
ROBERTA GAFFORD, CMC
CITY CLERK and Ex Officio Clerk of the Council of the City of Bakersfield

APPROVED __________

By ____________________________
HARVEY L. HALL
Mayor

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

By ____________________________
VIRGINIA GENNARO
City Attorney

RI:dll
S:\WATER\GSA\Reso.Fnl.Docx

--- FOR OFFICIAL USE ONLY ---

Exhibit 2-C

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

Exhibit B-1

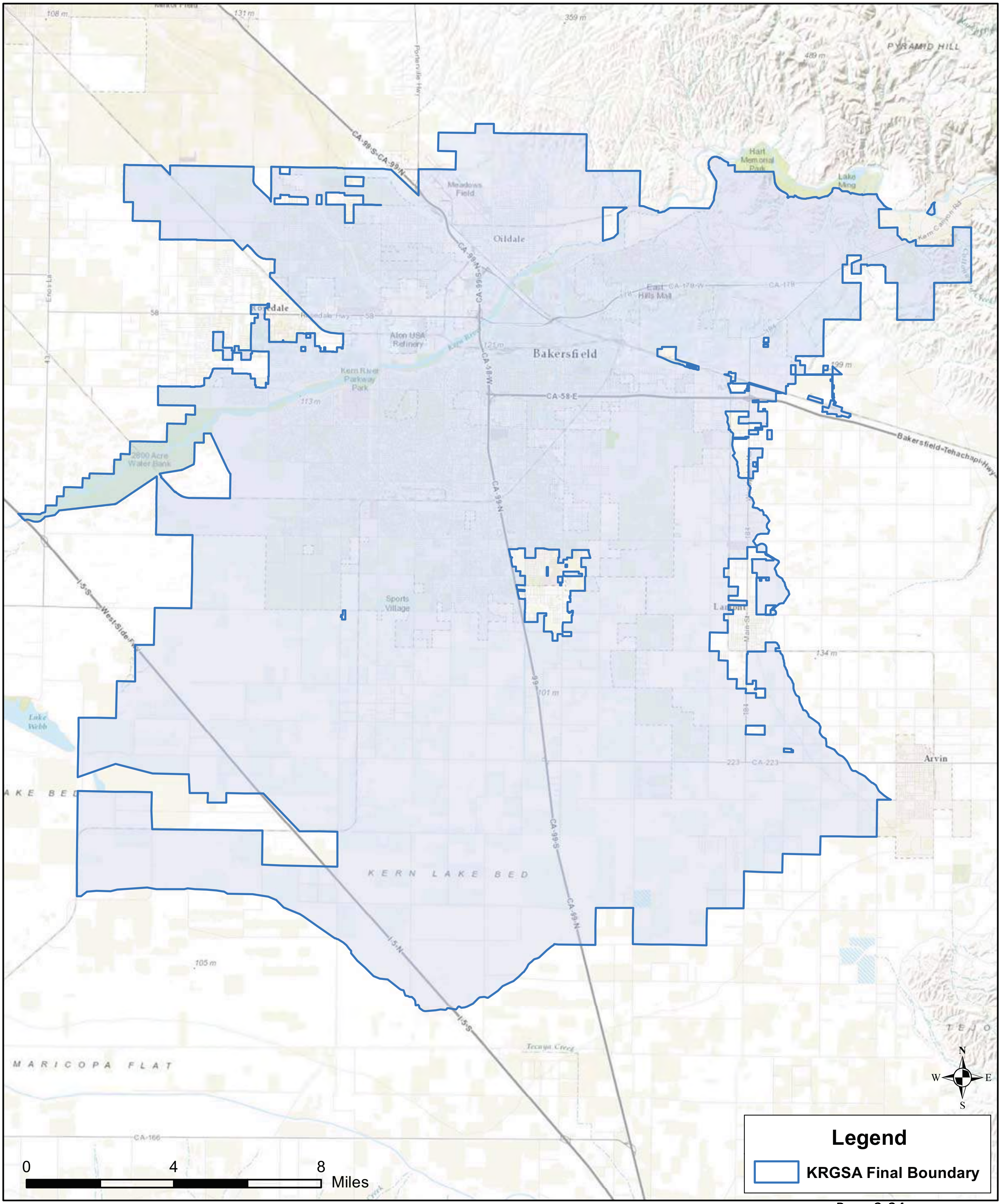


EXHIBIT C-1

ADDITIONAL AGENCIES

The agencies identified below hereby agree to join and incorporate their service area boundaries, or portion thereof, into the Kern River Ground Water Sustainability Agency ("KRGSA") as shown on the maps attached as Exhibit "B".

EAST NILES COMMUNITY SERVICE DISTRICT

By:______________________________

TIMOTHY P. RUIZ
GENERAL MANAGER

Draft - See final signed version on Page 4-34.

OILDALE MUTUAL WATER COMPANY /NORTH OF THE RIVER MUNICIPAL WATER DISTRICT

By:______________________________

DOUG NUNNELEY
General Manager

S:\WATER\GSA\ADDITIONAL AGENCIES.Docx

EXHIBIT 3

NOTICING

INCLUDING:

(A) NOTICING FOR MARCH 1, 2016 PUBLIC HEARING - KERN DELTA WATER DISTRICT

(B) NOTICING FOR MARCH 2, 2016 PUBLIC HEARING - CITY OF BAKERSFIELD

(C) NOTICING FOR MARCH 31, 2016 PUBLIC HEARING – IMPROVEMENT DISTRICT NO.4 KERN COUNTY WATER AGENCY

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

KERN DELTA WATER DIST
501 TAFT HWY
BAKERSFIELD, CA 93307

Ad Number:	14078033	**PO #:**	
Edition:	1TBC	**Run Times**	2
Class Code	Public Notices		
Start Date	2/16/2016	**Stop Date**	2/23/2016
Billing Lines	15	**Inches**	90.92
Total Cost	$ 231.18	**Account**	1KDE05
Billing Address	KERN DELTA WATER DIST 501 TAFT HWY BAKERSFIELD,CA 93307		

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 2/16/16
2/23/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

BMcy

DATED AT BAKERSFIELD CALIFORNIA
2/23/16

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARINGNOTICE IS HEREBY

Ad Number 14078033

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723 (b), Kern Delta Water District (District) will hold a public hearing on Tuesday March 1, 2016 at the hour of 1:00 p.m., at the District offices located at 501 Taft Highway, Bakersfield, California to consider and determine whether the District shall decide to become a Groundwater Sustainability Agency and/or to consider and determine whether the District will form a Groundwater Sustainability Agency with one or more other local agencies and water purveyors, for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the District, to the attention of L. Mark Mulkay, District Manager no later than 1:00 p.m. on Tuesday March 1, 2016. During the hearing, the District will receive oral and written comments before making a decision.

FEBRUARY 16,23, 2016
14078033

RECEIVED
MAR 11 2016
KDWD

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

CITY OF BAKERSFIELD/LEGALS ONL
1600 TRUXTUN AVE 2ND FLOOR
BAKERSFIELD, CA 93301

Ad Number:	14078413	**PO #:**	
Edition:	1TBC	**Run Times**	**2**
Class Code	Public Notices		
Start Date	2/16/2016	**Stop Date**	2/21/2016
Billing Lines	23	**Inches**	138.92
Total Cost	$ 346.70	**Account**	1BCI11
Billing Address	CITY OF BAKERSFIELD/LEGALS OI 1600 TRUXTUN AVE 2ND FLOOR BAKERSFIELD,CA 93301		

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER
AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 2/21/16
2/16/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Myrna Lorrence

DATED AT BAKERSFIELD CALIFORNIA

FEB 21 2016

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARING NOTICE IS HERE

Ad Number 14078413

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that the City Council of the City of Bakersfield will hold a public
hearing pursuant to California Water Code § 10723 on March 2, 2016, at 3:30 p.m., or as
soon thereafter as the matter maybe heard, in the City Council Chambers at City Hall South,
1501 Truxtun Avenue, Bakersfield, California to determine whether the City should elect to
become a Groundwater Sustainability Agency (GSA) under the Sustainable Groundwater Man
agement Act (SGMA) for a portion of the Kern County Subbasin of the Tulare Lake Ground
Water Basin.

PUBLIC COMMENT will be accepted in writing on or before the hearing date indicated above at
the City Clerk's Office, 1600 Truxtun Avenue, Bakersfield, CA 93301. Any interested person
may appear and be heard as to whether the City should become a GSA.

ROBERTA GAFFORD, CMC
Clerk of the City of Bakersfield and
Ex-Officio Clerk of the Council

FEBRUARY 16,21, 2016
14078413

 2011 Agency Org Proof of Publication

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

Ad Number:	14102957	**PO #:**	
Edition:	1TBC	**Run Times**	2
Class Code	Public Notices		
Start Date	3/17/2016	**Stop Date**	3/24/2016
Billing Lines	78	**Inches**	462.92
Total Cost	$ 513.82	**Account**	1KCO85
Billing Address	KERN COUNTY WATER AGENCY P.O. Box 58 BAKERSFIELD,CA 93302		

KERN COUNTY WATER AGENCY
P.O. Box 58
BAKERSFIELD, CA 93302

RECEIVED - Kern County Water Agency
MAR 28 2016
ATM DMB SMR NLP CMV DRB
CLC BEW HLM LAB MMV MLA LJI
All Orig to file Scan

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION. PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 3/17/16
3/24/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

B Mertz

DATED AT BAKERSFIELD CALIFORNIA

3/24/16

Solicitor I.D.: 0

First Text

NOTICE OF PUBLIC HEARING ON DECISION TO

NOTICE OF PUBLIC HEARING ON DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723 (b), the Kern County Water Agency (Agency) will hold a public hearing on Thursday, March 31, 2016 at the hour of 2:00 p.m., at the Agency offices located at 3200 Rio Mirada Drive, Bakersfield, California to consider and determine whether the Agency shall decide to become a Groundwater Sustainability Agency and/or to consider and determine whether the Agency will form a Groundwater Sustainability Agency with one or more other local agencies and water purveyors, for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the Agency, to the attention of David R. Beard, Improvement District No. 4 Manager, no later than 1:30 p.m. on Thursday, March 31, 2016. During the hearing, the Agency will receive oral and written comments before making a decision.

Lucinda J. Infante
Secretary of the Board of Directors
of the Kern County

BEFORE THE BOARD OF DIRECTORS

OF THE

KERN COUNTY WATER AGENCY

In the matter of:

AUTHORIZING THE PUBLISHING OF A NOTICE OF PUBLIC HEARING FOR THE DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY

I, Lucinda J. Infante, Secretary of the Board of Directors of the Kern County Water Agency, of the County of Kern, State of California, do hereby certify that the following resolution proposed by Director Lundquist, and seconded by Director Milobar, was duly passed and adopted by said Board of Directors at an official meeting hereof this 16th day of March, 2016, by the following vote, to wit:

Ayes: Lundquist, Fast, Milobar, Hafenfeld, Cerro and Page
Noes: None
Absent: Wulff

Lucinda J. Infante
Secretary of the Board of Directors
of the Kern County Water Agency

Resolution No. 07-16

WHEREAS, the Board of Directors (Board) of the Kern County Water Agency (Agency) is also empowered as the Board of the Agency Improvement District No. 4 (ID4); and

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of Groundwater Sustainability Plans; and

WHEREAS, Water Code section 10723 authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, the Agency is a local agency qualified to become a GSA because the Agency manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high priority basin; and

WHEREAS, the Agency is required to notice a public hearing pursuant to Government Code section 6066 to consider the formation of a Groundwater Sustainability Agency; and

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Kern County Water Agency, acting as the Board of Directors of Improvement District No. 4, that:

1. The foregoing recitals are true and correct.
2. A public hearing will be held on Thursday, March 31, 2016 at 2:00 p.m. on ID4's decision to become of a Groundwater Sustainability Agency for a portion of the Kern County Subbasin.
3. Agency staff is authorized and directed to publish the Notice of Public Hearing in the manner prescribed by law.

MARCH 17,24, 2016
14102957

EXHIBIT 4

MEMORANDUM OF UNDERSTANDING (MOU)

BETWEEN CITY OF BAKERSFIELD,

KERN DELTA WATER DISTRICT, and

IMPROVEMENT DISTRICT NO.4 OF THE KERN COUNTY WATER AGENCY

16-048

MEMORANDUM OF UNDERSTANDING FORMING THE KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

THIS MEMORANDUM OF UNDERSTANDING ("MOU") is made and entered into on MAR 30 2016, by and between the **CITY OF BAKERSFIELD,** a municipal corporation, ("CITY" herein), **KERN DELTA WATER DISTRICT** ("KERN DELTA" herein), and **KERN COUNTY WATER AGENCY on behalf of its IMPROVEMENT DISTRICT NO. 4,** ("ID4" herein), each a "Party" and collectively the "Parties."

WHEREAS, on September 16, 2014, Governor Jerry Brown signed into law Senate Bills 1168 and 1319 and Assembly Bill 1739, known collectively as the Sustainable Groundwater Management Act ("SGMA"); and

WHEREAS, the purpose of SGMA is to create a comprehensive management system in the State of California by creating structure to manage groundwater at the local level, while providing authority to the State to oversee and regulate, if necessary, the local groundwater management system; and

WHEREAS, SGMA empowers local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities to provide a buffer against drought and contribute to reliable water supply for the future; and

WHEREAS, Water Code Section 10723.6 authorizes a combination of local agencies overlying a groundwater basin to elect to become a Groundwater Sustainability Agency ("GSA") by using a memorandum of agreement or other legal agreement; and

WHEREAS, CITY is a local agency qualified to become a GSA because CITY manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Sub-basin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin ("Basin"), a DWR-designated high-priority basin; and

WHEREAS, Kern Delta is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code, manages water, has a water supply and overlies a portion of the Basin just south of CITY; and

WHEREAS, ID4 is also a local agency qualified to become a GSA because ID4 is an improvement district of the Kern County Water Agency formed to provide a supplemental water supply for the metropolitan Bakersfield area and overlies a portion of the Basin; and

WHEREAS, on February 10, 2016, CITY and KERN DELTA entered into Agreement No. 10-009 to establish a working relationship with the goal of jointly forming a GSA; and

WHEREAS, CITY and KERN DELTA mutually agree to add ID4 as a Party to this MOU; and

WHEREAS, on March 1, 2016, KERN DELTA held a public hearing to determine whether to become a GSA, and on March 15, 2016, KERN DELTA adopted Resolution No. 2016-03 electing to jointly become a GSA with CITY and ID4, a copy of which is attached hereto as **Exhibit "A-1"**; and

WHEREAS, on March 2, 2016, CITY held a public hearing to determine whether to become a GSA and on March 30, 2016, CITY adopted Resolution No. 039-16, electing to jointly become a GSA with KERN DELTA and ID4, a copy of which is attached hereto as **Exhibit "A-2"**; and

WHEREAS, on March 31, 2016, ID4 held a public hearing to determine whether to become a GSA, and on March 31, 2016, ID4 adopted Resolution No. 11-16, electing to jointly become a GSA with CITY and KERN DELTA, a copy of which is attached hereto as **Exhibit "A-3"**; and

WHEREAS, CITY, KERN DELTA and ID4 will jointly submit a Notice of Decision to form and be the founding Parties of a GSA, which will cover the portion of the Basin as shown on the map in **Exhibit "B-1"** attached hereto and incorporated herein; and

WHEREAS, additional detail identifying boundaries of the Parties and agencies covering the portion of the Basin as shown in Exhibit "B-1" is shown on the maps attached as **Exhibit "B-2"** and **"B-3"**; and

WHEREAS, the Parties will work collaboratively with other interested agencies to develop and implement a Ground Water Sustainability Plan ("GSP") to sustainably manage the Basin pursuant to SGMA.

NOW, THEREFORE, incorporating the above recitals herein and exhibits attached, it is mutually understood and agreed as follows:

1. **<u>PURPOSE</u>.** This MOU is entered into by and between the Parties to facilitate a cooperative and ongoing working relationship that will allow compliance with SGMA and State law, both as amended from time to time.

2. KERN RIVER GROUND WATER SUSTAINABILITY AGENCY. The Parties hereby establish the Kern River Groundwater Sustainability Agency ("KRGSA") to manage the portion of the Basin as set forth in **Exhibit "B-1."**

3. ADDITIONAL AGENCIES. Additional agencies with service area boundaries outside the jurisdiction of the Parties may join and incorporate their service area boundaries or portions thereof into KRGSA upon the mutual consent of all Parties. The additional agencies will be added to **Exhibit "C-1,"** as amended from time to time in compliance with SGMA, and the boundaries of the KRGSA may be expanded accordingly.

4. POWERS

4.1 In addition to any other action available to develop and implement SGMA, including a GSP, the KRGSA may perform the following functions:

4.1.1 Adopt standards for measuring and reporting water use.

4.1.2 Develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA.

4.1.3 Develop and implement conservation best management practices.

4.1.4 Develop and implement metering, monitoring and reporting related to groundwater pumping.

5. DECISION MAKING PROCESS

5.1 With the exceptions noted herein, it is the intent of the Parties that all actions undertaken by the KRGSA are done by unanimous consent of the Parties; however, if unanimous consent is not possible, a majority vote of the Parties is required.

5.2 In the event of an impasse or disagreement, the Parties shall use their best efforts to find a mutually agreeable result. To this effect, the Parties shall consult and negotiate with each other in good faith in an attempt to reach a solution that is mutually satisfactory. If the Parties do not reach a solution, then the matter shall be submitted to non-binding arbitration or mediation within a reasonable period of time.

6. **ROLES AND RESPONSIBILITIES OF THE PARTIES**

6.1 The Parties will work jointly to fulfill the Purpose of this MOU, SGMA, and the development and implementation of a GSP within the boundaries of the KRGSA.

6.2 The Parties will meet regularly to discuss SGMA, GSP development and implementation activities, assignments, and ongoing work progress.

6.3 The Parties may form committees as necessary from time to time discuss issues that impact the KRGSA.

6.4 The CITY and ID4 are jointly responsible for implementing the GSP in areas of the KRGSA that are within both City limits and ID4 boundaries.

6.5 KERN DELTA is responsible for implementing the GSP in agricultural areas of the KRGSA within KERN DELTA's boundary.

7. **FUNDING.** Unless agreed to otherwise, each Party's participation in this MOU is at its sole cost and expense.

8. **TERM.** This MOU shall remain in effect unless terminated by the mutual written consent of the Parties and as allowed by State law.

9. **AMENDING THE MOU.** This MOU and Exhibits hereto may only be amended by a subsequent writing, approved and signed by all Parties.

10. **HOLD HARMLESS.** No Party, nor any officer or employee of a Party, shall be responsible for any damage or liability occurring by reason of anything done or omitted to be done by another Party under or in connection with this MOU.

APPROVED AS TO CONTENT: **CITY OF BAKERSFIELD**	APPROVED AS TO CONTENT: **KERN DELTA WATER DISTRICT**
By:______________________	By:______________________
HARVEY L. HALL Mayor	**RODNEY PALLA** Board President
DATE: MAR 3 0 2016	DATE: April 1, 2016

CITY OF BAKERSFIELD ORIGINAL

Additional Signatures on Following Page

WATER BOARD

By: ______________________
HAROLD HANSON
Water Board Chair

KERN DELTA WATER DISTRICT

By: ______________________
L. MARK MULKAY
General Manager

WATER RESOURCES DEPARTMENT

By: ______________________
ART CHIANELLO
Water Resources Manager

APPROVED AS TO FORM:

By: ______________________
GENE R. McMURTREY
Attorneys for Kern Delta Water District

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

By: Virginia Gennaro
VIRGINIA GENNARO
City Attorney

APPROVED AS TO CONTENT:
IMPROVEMENT DISTRICT 4

By: ______________________
TED R. PAGE
Board President

COUNTERSIGNED:

By: ______________________
NELSON SMITH
Finance Director

APPROVED AS TO FORM:

By: ______________________
AMELIA T. MINABERRIGARAI
General Counsel

STATE OF CALIFORNIA
County of Kern

I, Roberta Gafford, City Clerk of the City of Bakersfield, State of California, hereby certify the foregoing and annexed to be a full, true and correct copy of the original Agreement 16-048 on file in this office and that I have compared the same with the original.
WITNESS my hand and seal this 8 day of April 2016
Roberta Gafford, City Clerk
By:
By: ______________________ Deputy City Clerk

VG:dll/vlg
S:\WATER\GSA\MOU Kern Delta&ID4.City-Final.Docx

BEFORE THE BOARD OF DIRECTORS OF
THE KERN DELTA WATER DISTRICT

RESOLUTION NO. 2016-03

IN THE MATTER OF:

KERN DELTA WATER DISTRICT DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, Kern Delta Water District ("District") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code §34000) and overlies a portion of the Kern County Subbasin of the San Joaquin Valley Groundwater Basin portion of the Tulare Lake Hydrologic Region, as defined in Bulletin 118 of the California Department of Water Resources and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the City of Bakersfield (City) is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the District desires to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code 10723.6 (b); and

WHEREAS, the District held a public hearing on Tuesday March 1, 2016 pursuant to California Water Code section §10723(b), after publication of notice of such hearing pursuant to California Government Code section §6066; and

WHEREAS, at the public hearing, the Kern Delta Water District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to form a Groundwater Sustainability Agency, which may include the City of Bakersfield and other Local Agencies and which may include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That Kern Delta Water District herein decides to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other local agencies, and which may include the participation of legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as depicted in the notification provided to the Department of Water Resources pursuant to California Water Code 10723.8, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section §10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section §10723.4.

6. That the General Manager of Kern Delta Water District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code §10723.6(a), as deemed appropriate by the General Manager, and cause notice to be given to the California Department of Water Resources of the decision of Kern Delta Water District to create the above referenced Groundwater Sustainability Agency.

ALL THE FOREGOING being on the motion of Director Frick, seconded by Director Tillema and authorized by the following vote, namely:

AYES: Antongiovanni, Bidart, Collins, Frick, Garone, Kaiser, Palla, Tillema

NOES: None

ABSENT: None

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of March, 2016.

Rodney Palla
Board President of Directors
KERN DELTA WATER DISTRICT

ATTESTED:

L. Mark Mulkay
Assistant Secretary of the Board of Directors
KERN DETLA WATER DISTRICT

RESOLUTION NO. 039-16

A RESOLUTION OF THE COUNCIL OF THE CITY OF BAKERSFIELD TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT.

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of Groundwater Sustainability Plans; and

WHEREAS, Water Code Section 10723(a) authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because City manages water, has water supply, and has land use responsibilities over a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, Kern Delta Water District ("Kern Delta") is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of City; and

WHEREAS, Improvement District No. 4 ("ID4") is also a local agency qualified to become a GSA and overlies a portion of the Kern County Subbasin; and

WHEREAS, City held a public hearing on March 2, 2016, after publication of notice pursuant to Government Code Section 6066 to consider adoption of this Resolution; and

WHEREAS, City, Kern Delta, and ID4 will work collaboratively with other interested entities to form a GSA known as the Kern River Ground Water Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in **Exhibit "A"** attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment.

NOW THEREFORE, BE IT RESOLVED by the Council of the City of Bakersfield as follows:

1. The above recitals and findings are true and correct.

2. That City of Bakersfield does hereby elect in concert with Kern Delta Water District and Improvement District No. 4 to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on **Exhibit "A"** attached to this Resolution.

3. That City of Bakersfield, Kern Delta Water District and Improvement District No. 4 will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to the City of Bakersfield and Kern Delta Water District.

4. That the Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code Section 10723.2

5. That the Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code Section 10723.4.

6. That City of Bakersfield, Kern Delta Water District, and Improvement District No. 4 will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin to DWR.

----------o0o----------

I HEREBY CERTIFY that the foregoing Resolution was passed and adopted by the Council of the City of Bakersfield at a regular meeting thereof held on MAR 3 0 2016, by the following vote:

YES:	COUNCIL MEMBER RIVERA, MAXWELL, WEIR, SMITH, HANSON, SULLIVAN, PARLIER
NOES:	COUNCIL MEMBER None
ABSTAIN:	COUNCIL MEMBER None
ABSENT:	COUNCIL MEMBER None

Roberta Gafford

ROBERTA GAFFORD, CMC
CITY CLERK and Ex Officio Clerk of
the Council of the City of Bakersfield

APPROVED MAR 3 0 2016

By

HARVEY L. HALL
Mayor

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

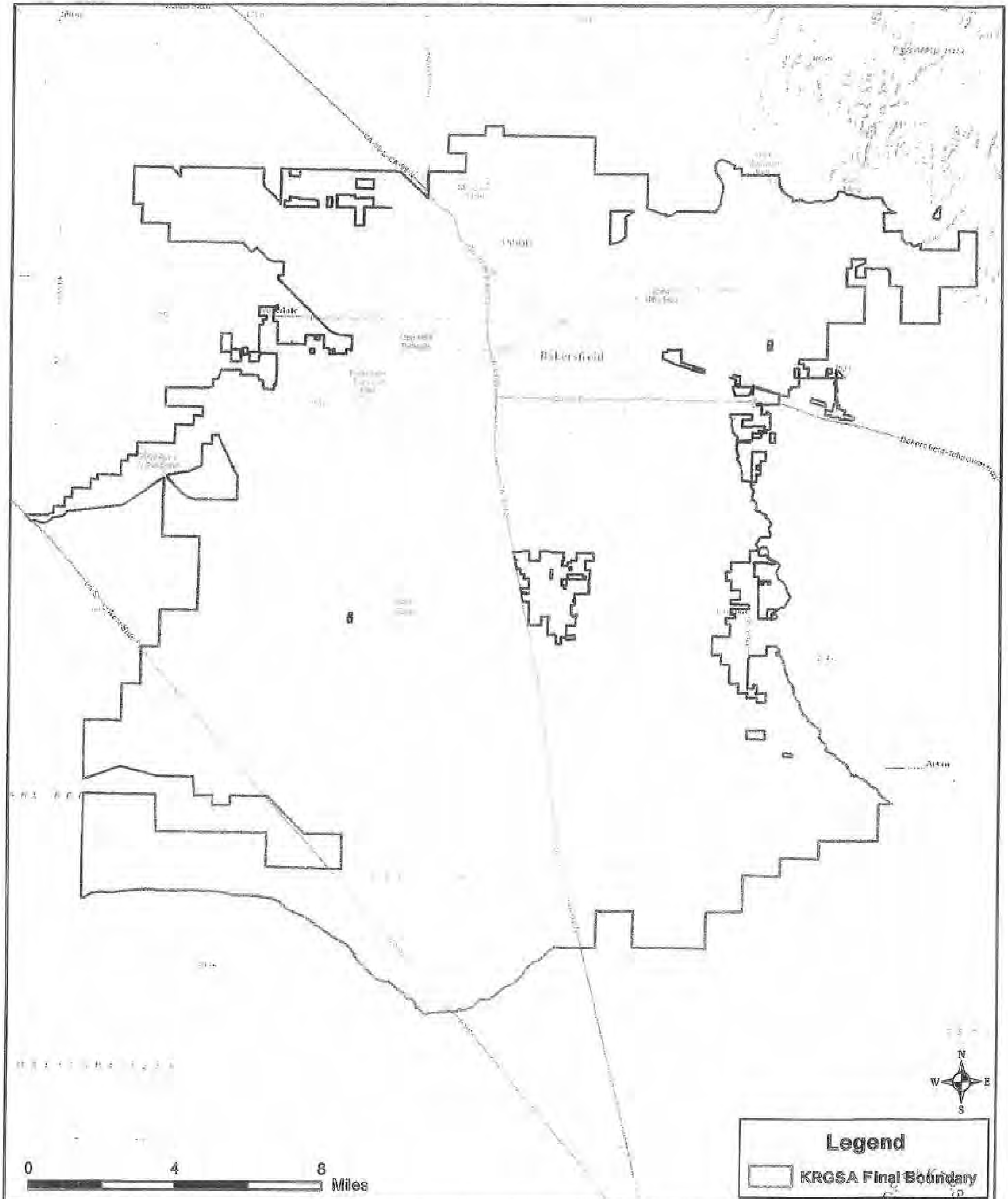
By Virginia Gennaro

VIRGINIA GENNARO
City Attorney

RI:dll
S:\WATER\GSA\Reso.Fnl.Docx

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016



BEFORE THE BOARD OF DIRECTORS

OF THE

KERN COUNTY WATER AGENCY

In the matter of:

AUTHORIZING IMPROVEMENT *
DISTRICT NO. 4 TO BECOME A *
GROUNDWATER SUSTAINABILITY *
AGENCY *

I, Lucinda J. Infante, Secretary of the Board of Directors of the Kern County Water Agency, of the County of Kern, State of California, do hereby certify that the following resolution proposed by Director Lundquist, and seconded by Director Fast, was duly passed and adopted by said Board of Directors at an official meeting hereof this 31st day of March, 2016, by the following vote, to wit:

Ayes: Lundquist, Fast, Wulff, Milobar, Cerro and Page

Noes: None

Absent: Hafenfeld

Lucinda J. Infante

Secretary of the Board of Directors
of the Kern County Water Agency

Resolution No. 11-16

WHEREAS, the Board of Directors (Board) of the Kern County Water Agency (Agency) is also empowered as the Board of the Agency Improvement District No. 4 (ID4); and

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of

EXHIBIT "A-3"

Groundwater Sustainability Plans; and

WHEREAS, Water Code section 10723 authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, ID4 is a local agency qualified to become a GSA because ID4 is an Improvement District of the Kern County Water Agency formed to provide a supplemental water supply for the metropolitan Bakersfield area and overlies a portion of the Kern County Subbasin (Basin Number 5- 22.14 DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because the City manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Subbasin; and

WHEREAS, Kern Delta Water District (Kern Delta) is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of the City; and

WHEREAS, the Agency, the City and Kern Delta will work collaboratively with other interested agencies to form a GSA known as the Kern River Groundwater Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in Exhibit A attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment; and

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Kern County Water Agency, acting as the Board of Directors of Improvement District No. 4, that:

1. The foregoing recitals are true and correct.

2. ID4 does hereby elect in concert with the City and Kern Delta to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on Exhibit A.

3. ID4, the City and Kern Delta will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to ID4, the City and Kern Delta.

4. The Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section 10723.2.

5. The Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements and availability of draft plans, maps and other relevant documents, as required by California Water Code section 10723.4.

6. ID4, the City and Kern Delta will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the Kern County Subbasin.

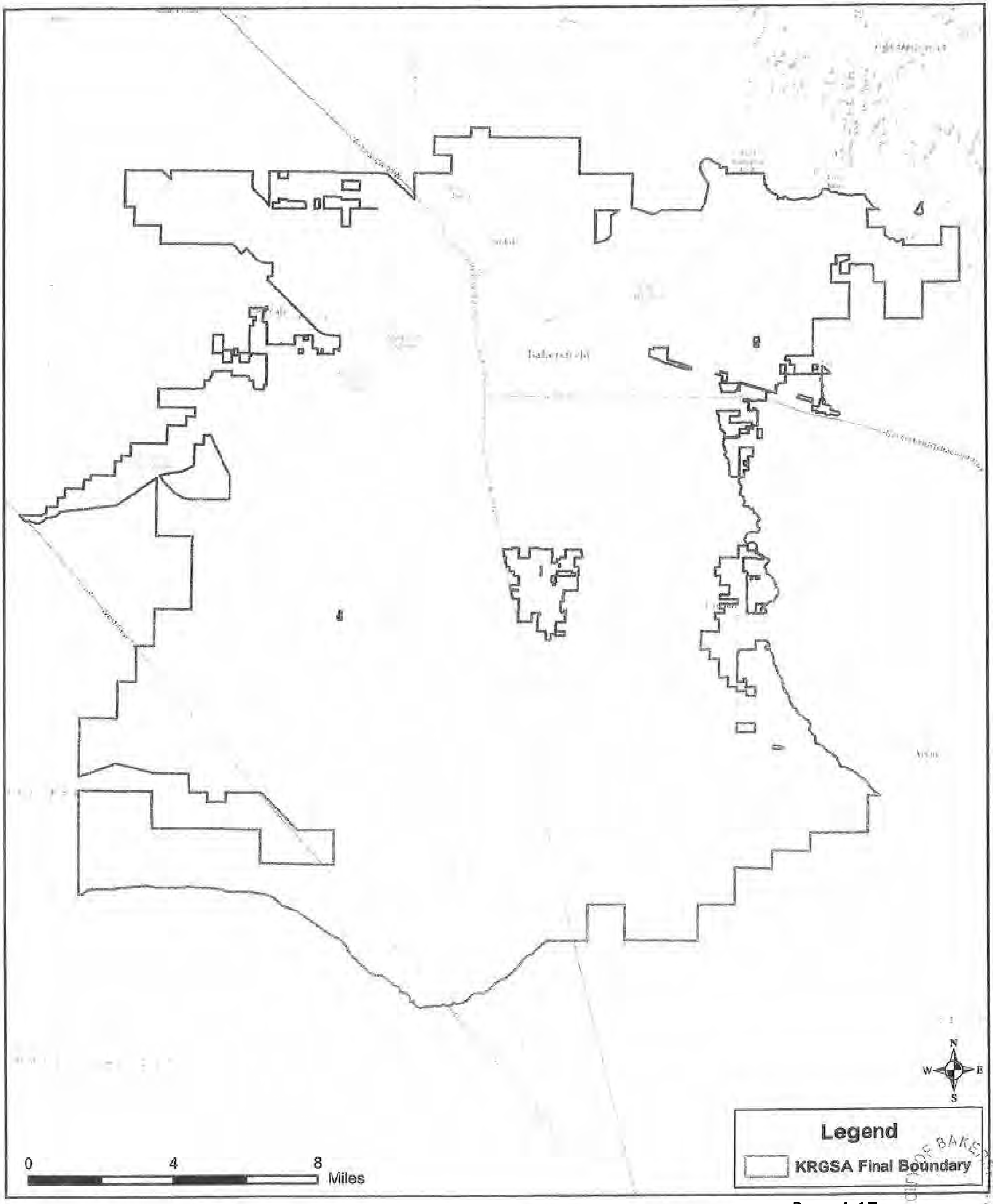
7. The Agency Board President is authorized to execute the Memorandum of Understanding Forming the Kern River Groundwater Sustainability Agency as shown on Exhibit B.

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

Exhibit A



____

MEMORANDUM OF UNDERSTANDING FORMING THE KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

THIS MEMORANDUM OF UNDERSTANDING ("MOU") is made and entered into on ____________________, by and between the **CITY OF BAKERSFIELD,** a municipal corporation, ("CITY" herein), **KERN DELTA WATER DISTRICT** ("KERN DELTA" herein), and **KERN COUNTY WATER AGENCY on behalf of its IMPROVEMENT DISTRICT NO. 4,** ("ID4" herein), each a "Party" and collectively the "Parties."

WHEREAS, on September 16, 2014, Governor Jerry Brown signed into law Senate Bills 1168 and 1319 and Assembly Bill 1739, known collectively as the Sustainable Groundwater Management Act ("SGMA"); and

WHEREAS, the purpose of SGMA is to create a comprehensive management system in the State of California by creating structure to manage groundwater at the local level, while providing authority to the State to oversee and regulate, if necessary, the local groundwater management system; and

WHEREAS, SGMA empowers local agencies to adopt groundwater management plans that are tailored to the resources and needs of their communities to provide a buffer against drought and contribute to reliable water supply for the future; and

WHEREAS, Water Code Section 10723.6 authorizes a combination of local agencies overlying a groundwater basin to elect to become a Groundwater Sustainability Agency ("GSA") by using a memorandum of agreement or other legal agreement; and

WHEREAS, CITY is a local agency qualified to become a GSA because CITY manages water, has a water supply, and has land use responsibilities over a portion of the Kern County Sub-basin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin ("Basin"), a DWR-designated high-priority basin; and

WHEREAS, Kern Delta is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code, manages water, has a water supply and overlies a portion of the Basin just south of CITY; and

WHEREAS, ID4 is also a local agency qualified to become a GSA because ID4 is an improvement district of the Kern County Water Agency formed to provide a supplemental water supply for the metropolitan Bakersfield area and overlies a portion of the Basin; and

WHEREAS, on February 10, 2016, CITY and KERN DELTA entered into Agreement No. 10-009 to establish a working relationship with the goal of jointly forming a GSA; and

WHEREAS, CITY and KERN DELTA mutually agree to add ID4 as a Party to this MOU; and

WHEREAS, on March 1, 2016, KERN DELTA held a public hearing to determine whether to become a GSA, and on March 15, 2016, KERN DELTA adopted Resolution No. 2016-03 electing to jointly become a GSA with CITY and ID4, a copy of which is attached hereto as **Exhibit "A-1"**; and

WHEREAS, on March 2, 2016, CITY held a public hearing to determine whether to become a GSA and on March 30, 2016, CITY adopted Resolution No. 039-16, electing to jointly become a GSA with KERN DELTA and ID4, a copy of which is attached hereto as **Exhibit "A-2"**; and

WHEREAS, on March 31, 2016, ID4 held a public hearing to determine whether to become a GSA, and on March 31, 2016, ID4 adopted Resolution No. __________-16, electing to jointly become a GSA with CITY and KERN DELTA, a copy of which is attached hereto as **Exhibit "A-3"**; and

WHEREAS, CITY, KERN DELTA and ID4 will jointly submit a Notice of Decision to form and be the founding Parties of a GSA, which will cover the portion of the Basin as shown on the map in **Exhibit "B-1"** attached hereto and incorporated herein; and

WHEREAS, the Parties will work collaboratively with other interested agencies to develop and implement a Ground Water Sustainability Plan ("GSP") to sustainably manage the Basin pursuant to SGMA.

NOW, THEREFORE, incorporating the above recitals herein and exhibits attached, it is mutually understood and agreed as follows:

1. **PURPOSE.** This MOU is entered into by and between the Parties to facilitate a cooperative and ongoing working relationship that will allow compliance with SGMA and State law, both as amended from time to time.

2. **KERN RIVER GROUND WATER SUSTAINABILITY AGENCY.** The Parties hereby establish the Kern River Groundwater Sustainability Agency ("KRGSA") to manage the portion of the Basin as set forth in **Exhibit "B-1."**

3. **ADDITIONAL AGENCIES**. Additional agencies with service area boundaries outside the jurisdiction of the Parties may join and incorporate their service area boundaries or portions thereof into KRGSA upon the mutual consent of all Parties. The additional agencies will be added to **Exhibit "C-1,"** as amended from time to time in compliance with SGMA, and the boundaries of the KRGSA may be expanded accordingly.

4. **POWERS**

4.1 In addition to any other action available to develop and implement SGMA, including a GSP, the KRGSA may perform the following functions:

4.1.1 Adopt standards for measuring and reporting water use.

4.1.2 Develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA.

4.1.3 Develop and implement conservation best management practices.

4.1.4 Develop and implement metering, monitoring and reporting related to groundwater pumping.

5. **DECISION MAKING PROCESS**

5.1 With the exceptions noted herein, it is the intent of the Parties that all actions undertaken by the KRGSA are done by unanimous consent of the Parties; however, if unanimous consent is not possible, a majority vote of the Parties is required.

5.2 In the event of an impasse or disagreement, the Parties shall use their best efforts to find a mutually agreeable result. To this effect, the Parties shall consult and negotiate with each other in good faith in an attempt to reach a solution that is mutually satisfactory. If the Parties do not reach a solution, then the matter shall be submitted to non-binding arbitration or mediation within a reasonable period of time.

6. **ROLES AND RESPONSIBILITIES OF THE PARTIES**

6.1 The Parties will work jointly to fulfill the Purpose of this MOU, SGMA, and the development and implementation of a GSP within the boundaries of the KRGSA.

6.2 The Parties will meet regularly to discuss SGMA, GSP development and implementation activities, assignments, and ongoing work progress.

6.3 The Parties may form committees as necessary from time to time discuss issues that impact the KRGSA.

6.4 The CITY and ID4 are jointly responsible for implementing the GSP in areas of the KRGSA that are within both City limits and ID4 boundaries.

6.5 KERN DELTA is responsible for implementing the GSP in agricultural areas of the KRGSA within KERN DELTA's boundary.

7. **FUNDING.** Unless agreed to otherwise, each Party's participation in this MOU is at its sole cost and expense.

8. **TERM.** This MOU shall remain in effect unless terminated by the mutual written consent of the Parties and as allowed by State law.

9. **AMENDING THE MOU.** This MOU and Exhibits hereto may only be amended by a subsequent writing, approved and signed by all Parties.

10. **HOLD HARMLESS.** No Party, nor any officer or employee of a Party, shall be responsible for any damage or liability occurring by reason of anything done or omitted to be done by another Party under or in connection with this MOU.

APPROVED AS TO CONTENT: **CITY OF BAKERSFIELD**	APPROVED AS TO CONTENT: **KERN DELTA WATER DISTRICT**
By:____________________ **HARVEY L. HALL** Mayor	By:____________________ **RODNEY PALLA** Board President
DATE:____________	DATE:____________
WATER BOARD	**KERN DELTA WATER DISTRICT**
By: ____________________ **HAROLD HANSON** Water Board Chair	By: ____________________ **L. MARK MULKAY** General Manager

Draft - See final signed version on Page 4-5.

Additional Signatures on Following Page

WATER RESOURCES DEPARTMENT

By: ______________________________
ART CHIANELLO
Water Resources Manager

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

By: ______________________________
VIRGINIA GENNARO
City Attorney

COUNTERSIGNED:

By: ______________________________
NELSON SMITH
Finance Director

APPROVED AS TO FORM:

By: ______________________________
GENE R. McMURTREY
Attorneys for Kern Delta Water District

APPROVED AS TO CONTENT:
IMPROVEMENT DISTRICT 4

By: ______________________________
TED R. PAGE
Board President

APPROVED AS TO FORM:

By: ______________________________
AMELIA T. MINABERRIGARAI
General Counsel

Draft - See final signed version on Page 4-6.

VG:dll/vlg
S:\WATER\GSA\MOU Kern Delta&ID4.City-Final.Docx

**BEFORE THE BOARD OF DIRECTORS OF
THE KERN DELTA WATER DISTRICT**

RESOLUTION NO. 2016-03

IN THE MATTER OF:

KERN DELTA WATER DISTRICT DECISION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, Kern Delta Water District ("District") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code §34000) and overlies a portion of the Kern County Subbasin of the San Joaquin Valley Groundwater Basin portion of the Tulare Lake Hydrologic Region, as defined in Bulletin 118 of the California Department of Water Resources and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the City of Bakersfield (City) is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the District desires to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code 10723.6 (b); and

WHEREAS, the District held a public hearing on Tuesday March 1, 2016 pursuant to California Water Code section §10723(b), after publication of notice of such hearing pursuant to California Government Code section §6066; and

WHEREAS, at the public hearing, the Kern Delta Water District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to form a Groundwater Sustainability Agency, which may include the City of Bakersfield and other Local Agencies and which may include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That Kern Delta Water District herein decides to form a Groundwater Sustainability Agency which may include the City of Bakersfield and other local agencies, and which may include the participation of legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as depicted in the notification provided to the Department of Water Resources pursuant to California Water Code 10723.8, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section §10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section §10723.4.

6. That the General Manager of Kern Delta Water District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code §10723.6(a), as deemed appropriate by the General Manager, and cause notice to be given to the California Department of Water Resources of the decision of Kern Delta Water District to create the above referenced Groundwater Sustainability Agency.

BAKERSFIELD ORIGINAL

ALL THE FOREGOING being on the motion of Director Frick, seconded by Director Tillema and authorized by the following vote, namely:

AYES: Antongiovanni, Bidart, Collins, Frick, Garone, Kaiser, Palla, Tillema

NOES: None

ABSENT: None

ABSTAIN: None

I HEREBY CERTIFY that the foregoing resolution is the resolution of the Kern Delta Water District as duly passed and adopted by its Board of Directors at a legally convened meeting held on the 15th day of March, 2016.

Rodney Palla
Board President of Directors
KERN DELTA WATER DISTRICT

ATTESTED:

L. Mark Mulkay
Assistant Secretary of the Board of Directors
KERN DETLA WATER DISTRICT

RESOLUTION NO. ____________

A RESOLUTION OF THE COUNCIL OF THE CITY OF BAKERSFIELD TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT.

WHEREAS, on September 16, 2014, the Sustainable Groundwater Management Act (SGMA) was signed into law by the Governor to provide for sustainable management of groundwater by providing local groundwater agencies with the authority to sustainably manage groundwater through the adoption of Groundwater Sustainability Plans; and

WHEREAS, Water Code Section 10723(a) authorizes local land use authorities, water suppliers, and certain other local agencies, or a combination of local agencies, overlying a groundwater basin to elect to become a Groundwater Sustainability Agency (GSA) for the basin; and

WHEREAS, the City of Bakersfield (City) is a local agency qualified to become a GSA because City manages water, has water supply, and has land use responsibilities over a portion of the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin; and

WHEREAS, Kern Delta Water District ("Kern Delta") is also a local agency qualified to become a GSA because Kern Delta is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code and overlies a portion of the Kern County Subbasin just south of City; and

WHEREAS, Improvement District No. 4 ("ID4") is also a local agency qualified to become a GSA and overlies a portion of the Kern County Subbasin; and

WHEREAS, City held a public hearing on March 2, 2016, after publication of notice pursuant to Government Code Section 6066 to consider adoption of this Resolution; and

WHEREAS, City, Kern Delta, and ID4 will work collaboratively with other interested entities to form a GSA known as the Kern River Ground Water Sustainability Agency, which will cover the portion of the Kern County Subbasin as shown on the map included in **Exhibit "A"** attached hereto and incorporated herein; and

WHEREAS, adoption of this Resolution does not constitute a "Project" under the California Environmental Quality Act (CEQA) pursuant to 15060(c)(3) and 15378(b)(5) of the State CEQA Guidelines because it is an administrative action that does not result in any direct or indirect physical change in the environment.

NOW THEREFORE, BE IT RESOLVED by the Council of the City of Bakersfield as follows:

1. The above recitals and findings are true and correct.

2. That City of Bakersfield does hereby elect in concert with Kern Delta Water District and Improvement District No. 4 to become a Groundwater Sustainability Agency known as the Kern River Groundwater Sustainability Agency to cover the portion of DWR Basin No. 5-22.14 as shown on **Exhibit "A"** attached to this Resolution.

3. That City of Bakersfield, Kern Delta Water District and Improvement District No. 4 will work to develop the governing structure of the Kern River Groundwater Sustainability Agency, which may involve other entities in addition to the City of Bakersfield and Kern Delta Water District.

4. That the Kern River Groundwater Sustainability Agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code Section 10723.2

5. That the Kern River Groundwater Sustainability Agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code Section 10723.4.

6. That City of Bakersfield, Kern Delta Water District, and Improvement District No. 4 will jointly submit a notice of their decision to form the Kern River Groundwater Sustainability Agency for a portion of the

Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin to DWR.

---------o0o---------

I HEREBY CERTIFY that the foregoing Resolution was passed and adopted by the Council of the City of Bakersfield at a regular meeting thereof held on ______________________, by the following vote:

YES:	COUNCIL MEMBER RIVERA, MAXWELL, WEIR, SMITH, HANSON, SULLIVAN, PARLIER
NOES:	COUNCIL MEMBER ______________________
ABSTAIN:	COUNCIL MEMBER ______________________
ABSENT:	COUNCIL MEMBER ______________________

____

ROBERTA GAFFORD, CMC
CITY CLERK and Ex Officio Clerk of the Council of the City of Bakersfield

APPROVED ______________

Draft - See final signed version on Page 4-12.

By ______________________
HARVEY L. HALL
Mayor

APPROVED AS TO FORM:
VIRGINIA GENNARO
City Attorney

By ______________________
VIRGINIA GENNARO
City Attorney

RI:dll
S:\WATER\GSA\Reso.Fnl.Docx

Exhibit 4

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

Exhibit B-1

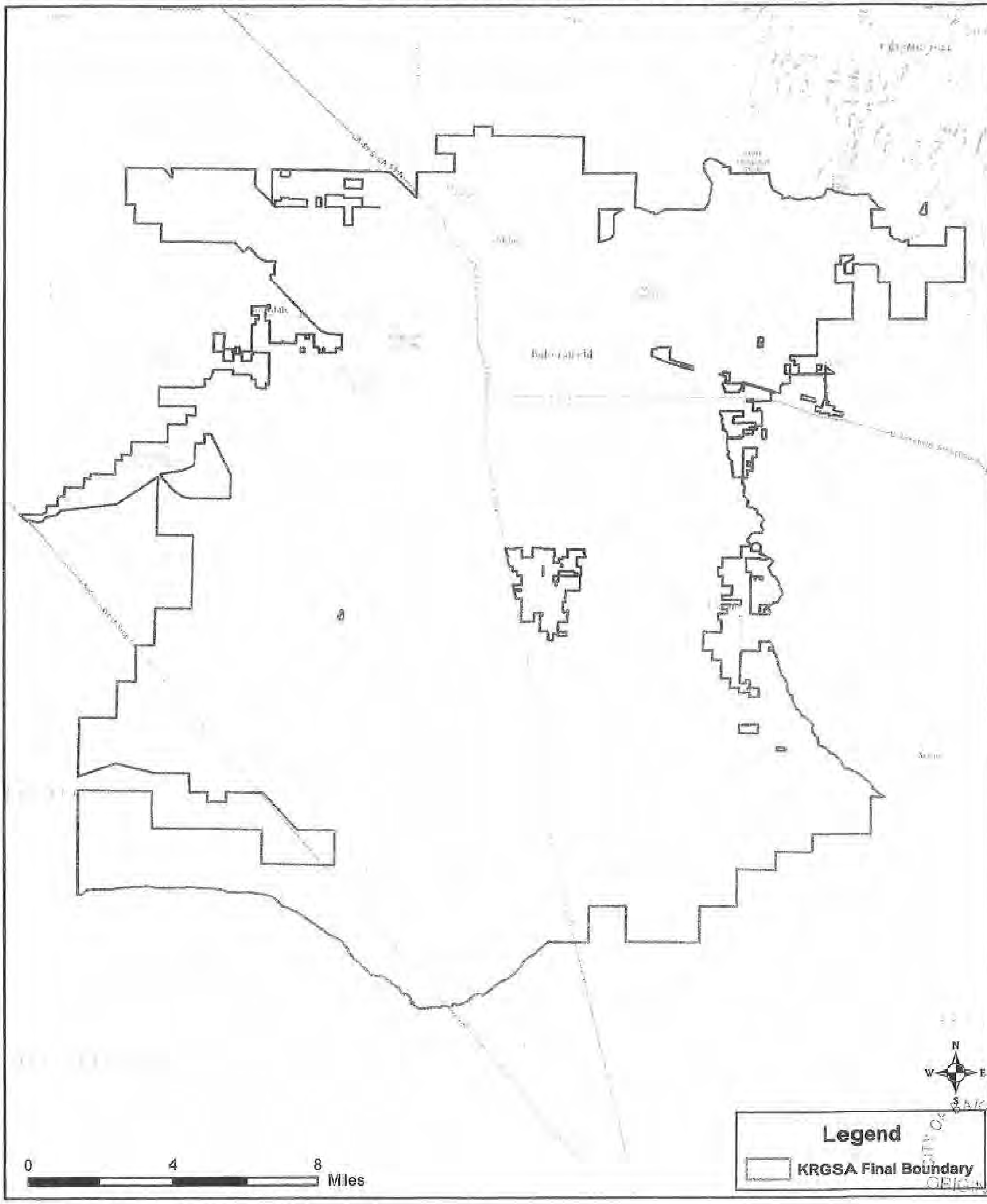


EXHIBIT C-1

ADDITIONAL AGENCIES

The agencies identified below hereby agree to join and incorporate their service area boundaries, or portion thereof, into the Kern River Ground Water Sustainability Agency ("KRGSA") as shown on the maps attached as Exhibit "B".

EAST NILES COMMUNITY SERVICE DISTRICT

By:______________________________

TIMOTHY P. RUIZ
GENERAL MANAGER

Draft - See final signed version on Page 4-34.

OILDALE MUTUAL WATER COMPANY
/NORTH OF THE RIVER MUNICIPAL WATER DISTRICT

By: ______________________________

DOUG NUNNELEY
General Manager

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

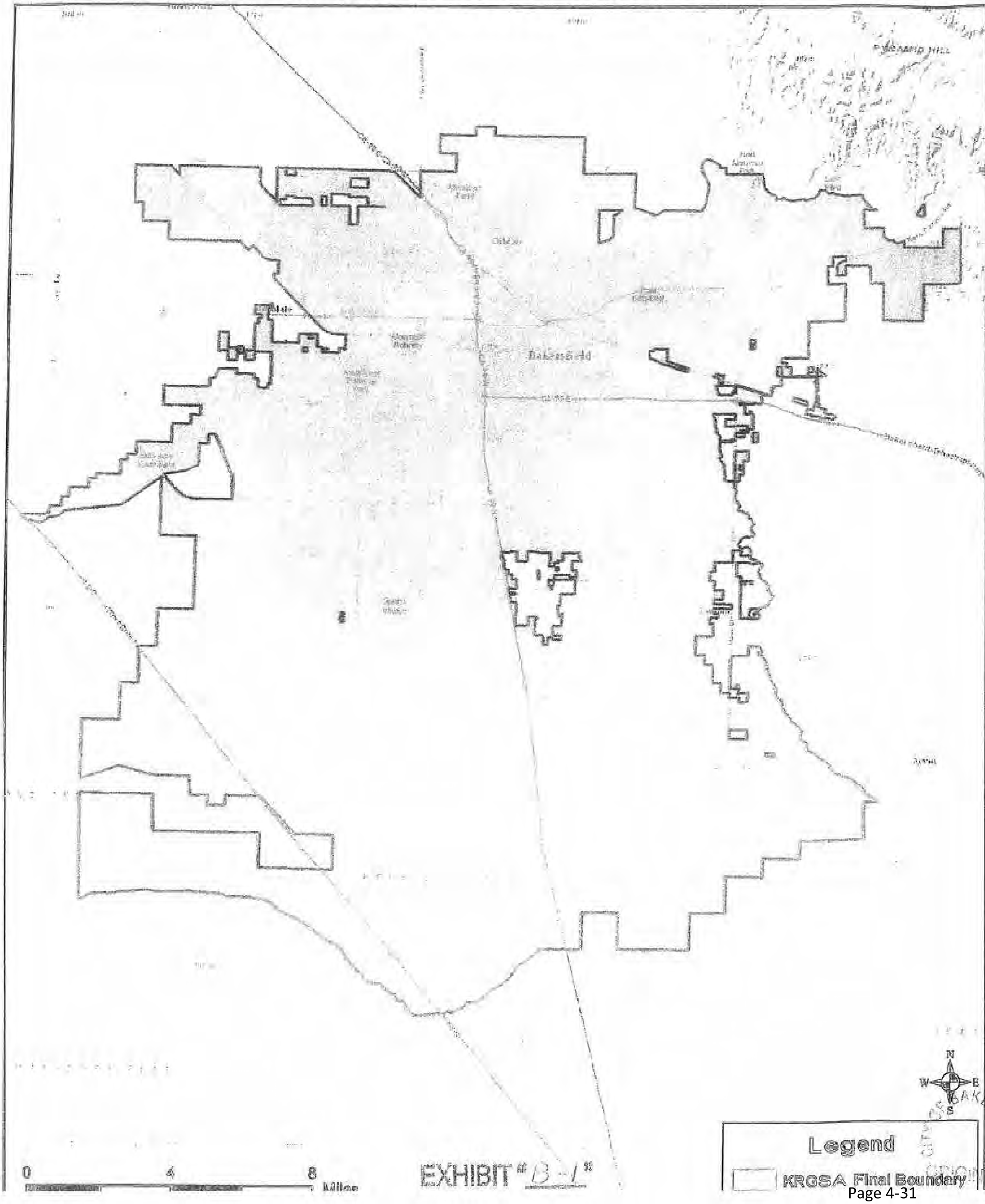


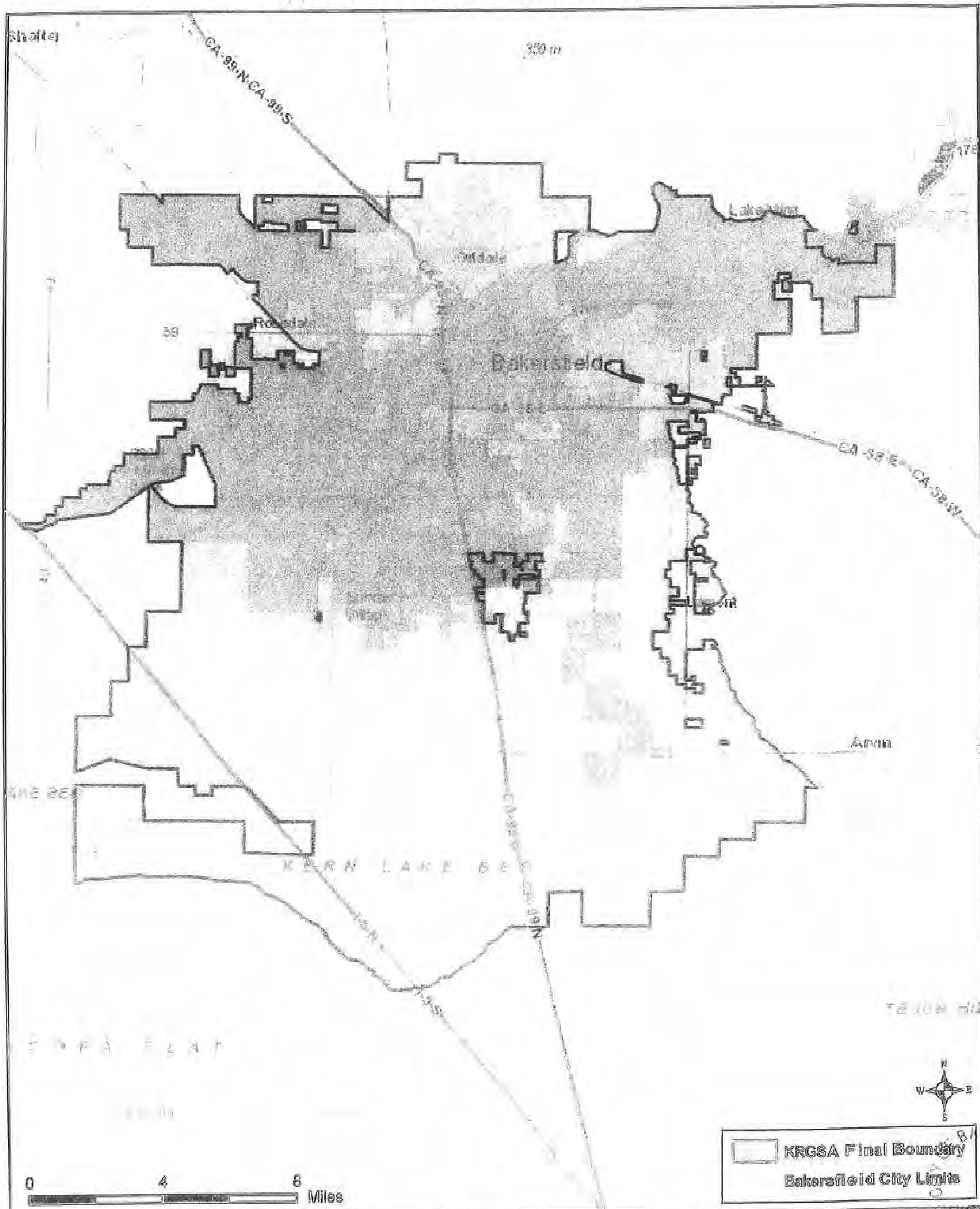
EXHIBIT "B-1"

Exhibit 4

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016



EXHIBIT

Exhibit 4

— FOR OFFICIAL USE ONLY —

Kern River Groundwater Sustainability Agency (GSA)

Approved Boundary as of March 30, 2016

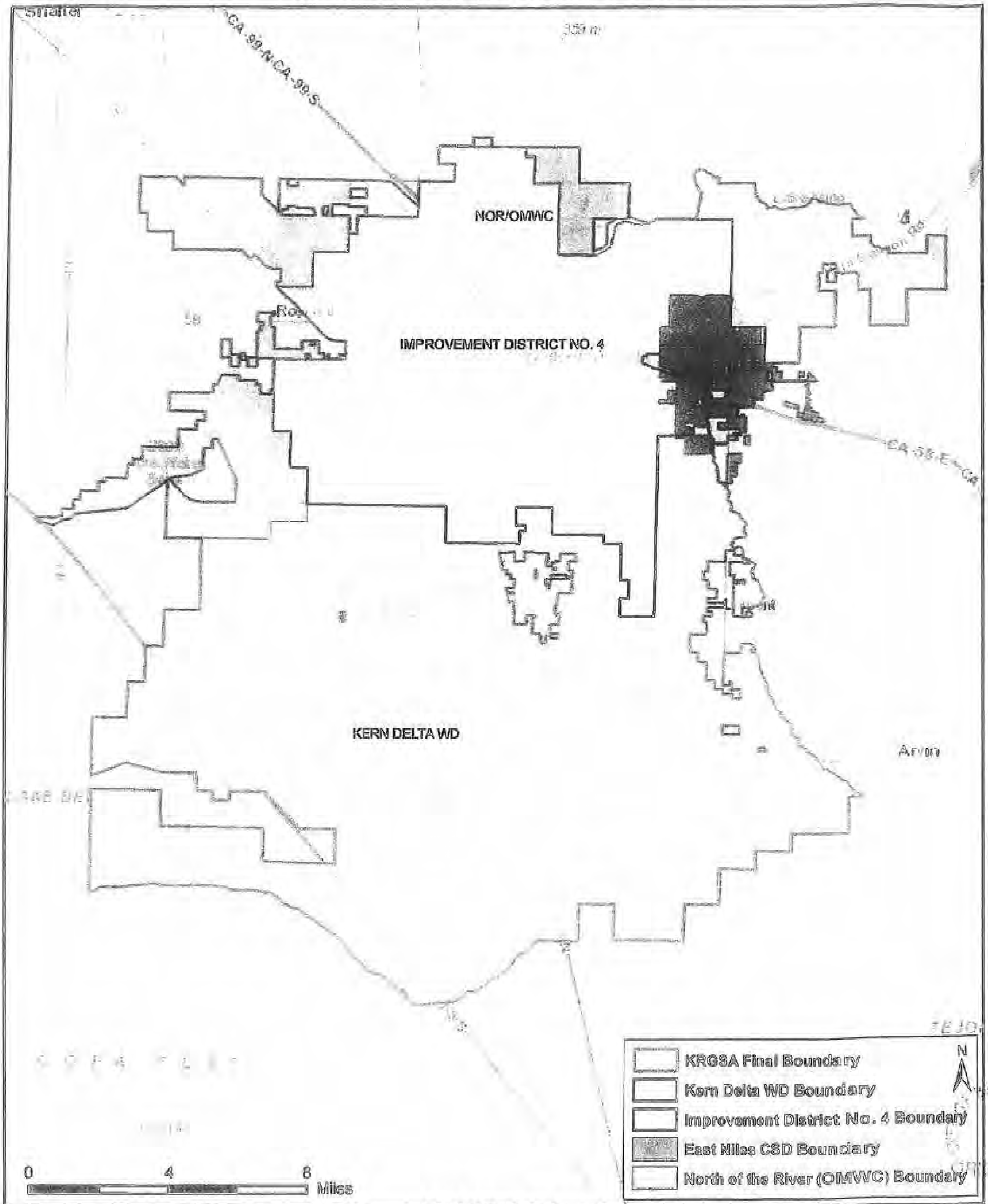


EXHIBIT C-1

ADDITIONAL AGENCIES

The agencies identified below hereby agree to join and incorporate their service area boundaries, or portion thereof, into the Kern River Ground Water Sustainability Agency ("KRGSA") as shown on the maps attached as Exhibit "B".

EAST NILES COMMUNITY SERVICE DISTRICT

By:________________________________
TIMOTHY P. RUIZ
GENERAL MANAGER

OILDALE MUTUAL WATER COMPANY
/NORTH OF THE RIVER MUNICIPAL WATER DISTRICT

By: ________________________________
DOUG NUNNELEY
General Manager

S:\WATER\GSA\ADDITIONAL AGENCIES.Docx

EXHIBIT "C"

EXHIBIT 5

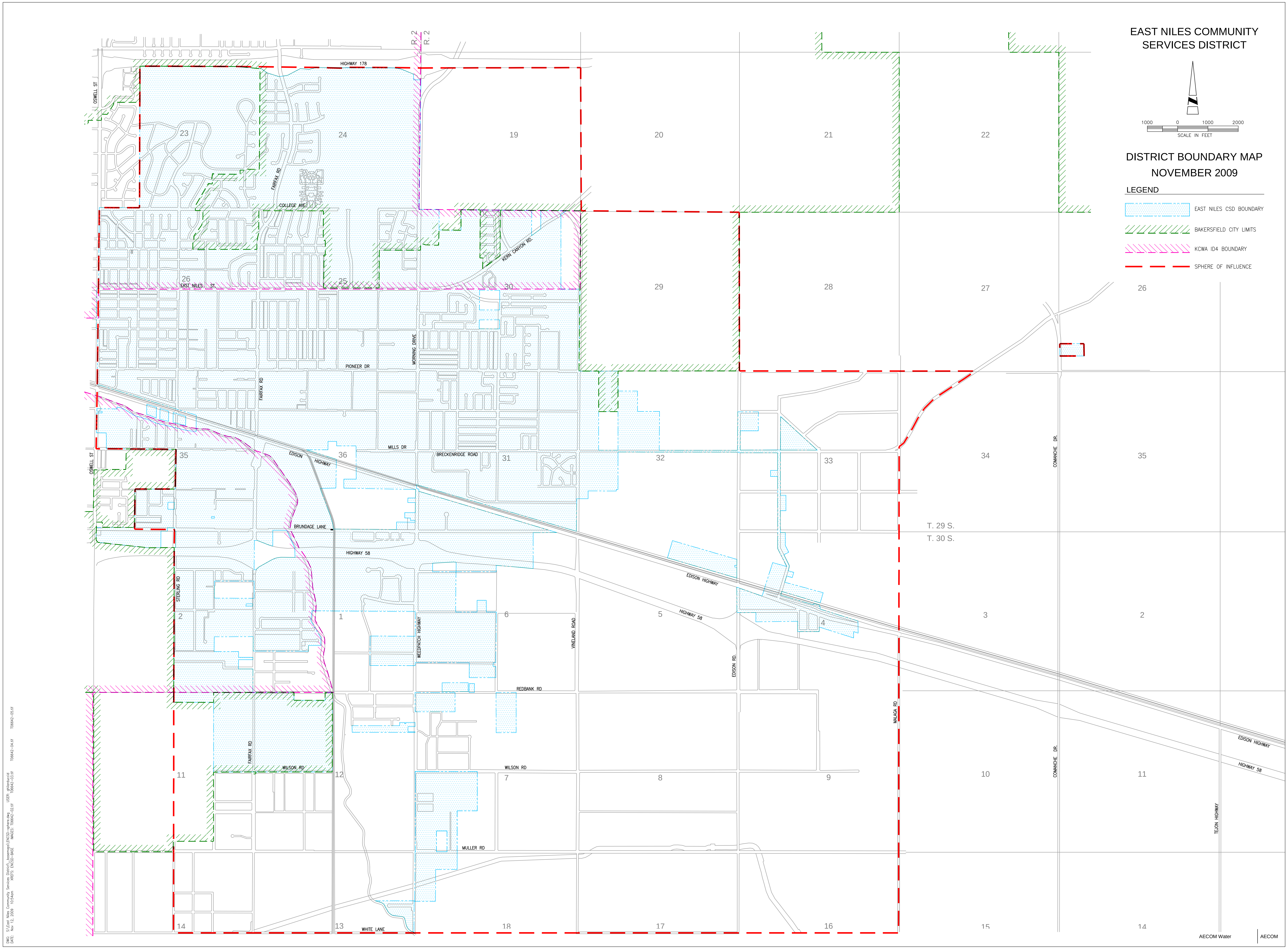
SUPPORTING DOCUMENTS FOR ENTITIES ALSO JOINING THE KERN RIVER GSA

INCLUDING:

DOCUMENTS FROM

(A) EAST NILES COMMUNITY SERVICES DISTRICT

(B) NORTH OF THE RIVER MUNICIPAL WATER DISTRICT


EAST NILES COMMUNITY SERVICES DISTRICT
N
1000 0 1000 2000
SCALE IN FEET
DISTRICT BOUNDARY MAP
NOVEMBER 2009
LEGEND
EAST NILES CSD BOUNDARY
BAKERSFIELD CITY LIMITS
KCWA ID4 BOUNDARY
SPHERE OF INFLUENCE
HIGHWAY 178
COLLEGE AVE
EAST NILES ST
PIONEER DR
MILLS DR
BRECKENRIDGE ROAD
KERN CANYON RD.
EDISON HIGHWAY
BRUNDAGE LANE
HIGHWAY 58
REDBANK RD
WILSON RD
MULLER RD
WHITE LANE
OSWELL ST
FAIRFAX RD
MORNING DRIVE
STERLING RD
WEEDPATCH HIGHWAY
VINELAND ROAD
EDISON RD
MALAGA RD
COMANCHE DR.
TEJON HIGHWAY
T. 29 S.
T. 30 S.
R. 28
R. 29
AECOM Water
AECOM

**BEFORE THE BOARD OF DIRECTORS OF
THE EAST NILES COMMUNITY SERVICES DISTRICT**

RESOLUTION NO. 2016-04

EAST NILES COMMUNITY SERVICES DISTRICT DECISION TO FORM AND PARTICIPATE IN A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code § 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code §10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code §10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, East Niles Community Services District ("District") is a Community Services District formed and operating pursuant to and in accordance with the Community Services District Law, (commencing with Government Code §61000) and overlies a portion of the Kern County Subbasin of the San Joaquin Valley Groundwater Basin portion of the Tulare Lake Hydrologic Region, as defined in Bulletin 118 of the California Department of Water Resources and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, Kern Delta Water District ("Kern Delta") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code §34000) and is a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the City of Bakersfield (City) is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code 10721 (n); and

WHEREAS, the District desires to form and participate in a Groundwater Sustainability Agency which may include Kern Delta, the City of Bakersfield, other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code 10723.6 (b); and

WHEREAS, the District held a public hearing on Monday, March 21, 2016 pursuant to California Water Code section §10723(b), after publication of notice of such hearing pursuant to California Government Code section §6066; and

WHEREAS, at the public hearing, the East Niles Community Services District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to form a Groundwater Sustainability Agency, which is ultimately intended to include Kern Delta Water District, the City of Bakersfield, and perhaps other Local Agencies, and which may also include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That the East Niles Community Services District herein decides to form a Groundwater Sustainability Agency which will include all or part of Kern Delta Water District, the City of Bakersfield, and other local agencies, and which may also include the participation of other legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as depicted in the notification provided to the Department of Water Resources pursuant to California Water Code 10723.8, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section §10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section §10723.4.

6. That the General Manager of East Niles Community Services District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code §10723.6(a), as deemed appropriate by the General Manager, and cause notice to be given to the California Department of Water Resources of the decision of East Niles Community Services District to create and participate in the above referenced Groundwater Sustainability Agency.

PASSED AND ADOPTED at a regular meeting of the Board of Directors of the East Niles Community Services District held on the 21st day of March 2016, by the following vote, to wit:

AYES: Directors Harger, McCalla, Powell and Ruiz
NOES: None
ABSENT: Director Mayberry
ABSTAIN: None

Sally A. Ruiz
Board President

ATTESTED:

Board Secretary

EAST NILES COMMUNITY SERVICES DISTRICT
NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723 (b), East Niles Community Services District (District) will hold a public hearing on Monday March 21, 2016 at the hour of 5:30 p.m., at the District offices located at 1417 Vale Street, Bakersfield, California to consider and determine whether the District shall decide to become a Groundwater Sustainability Agency and/or to consider and determine whether the District will form a Groundwater Sustainability Agency with one or more other local agencies and water purveyors, for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the District, to the attention of Timothy P. Ruiz, District Manager no later than 5:00 p.m. on Monday, March 21, 2016. During the hearing, the District will receive oral and written comments before making a decision.

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

EAST NILES COMMUNITY SVC
1417 VALE ST
BAKERSFIELD, CA 93306

Ad Number:	14091226	**PO #:**	
Edition:	1TBC	**Run Times**	2
Class Code	Legal Notices		
Start Date	3/1/2016	**Stop Date**	3/8/2016
Billing Lines	17	**Inches**	102.92
Total Cost	$ 265.06	**Account**	1ENC02
Billing Address	EAST NILES COMMUNITY SVC 1417 VALE ST BAKERSFIELD,CA 93306		

--

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER
AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 3/1/16
3/8/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Myrana Lorence

DATED AT BAKERSFIELD CALIFORNIA

MAR 0 8 2016

Solicitor I.D.: 0

First Text
EAST NILES COMMUNITY SERVICES DISTRICTN(

Ad Number 14091226

EAST NILES COMMUNITY SERVICES DISTRICT
NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723 (b), East Niles Community Services District (District) will hold a public hearing on Monday March 21, 2016 at the hour of 5:30 p.m., at the District offices located at 1417 Vale Street, Bakersfield, California to consider and determine whether the District shall decide to become a Groundwater Sustainability Agency and/or to consider and determine whether the District will form a Groundwater Sustainability Agency with one or more other local agencies and water purveyors, for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the District, to the attention of Timothy P. Ruiz, District Manager no later than 5:00 p.m. on Monday, March 21, 2016. During the hearing, the District will receive oral and written comments before making a decision.

March 1, 8, 2016
14091226

RECEIVED MAR 1 5 2016

North of the River Municipal Water District

PO Box 5836 – Bakersfield, CA - 93388
(661) 399-5516 office / (661) 399-5598 fax

RESOLUTION No. 2016-2

NORTH OF THE RIVER MUNICIPAL WATER DISTRICT DECISION TO FORM AND PARTICIPATE IN A GROUNDWATER SUSTAINABILITY AGENCY PURSUANT TO THE SUSTAINABLE GROUNDWATER MANAGEMENT ACT

WHEREAS, the California legislature passed a statewide framework for sustainable groundwater management, known as the Sustainable Groundwater Management Act (California Water Code sections 10720 et seq.) pursuant to Senate Bill 1168, Senate Bill 1319, and Assembly Bill 1739, which was approved by the Governor and Chaptered by the Secretary of State on September 16, 2014; and

WHEREAS, pursuant to the Sustainable Groundwater Management Act, sustainable groundwater management is intended to occur pursuant to Groundwater Sustainability Plans that are created and adopted by Groundwater Sustainability Agencies; and

WHEREAS, pursuant to California Water Code section 10723(a), a Local Agency or combination of Local Agencies, as defined in California Water Code section 10721(n), may decide to become or form a Groundwater Sustainably Agency; and

WHEREAS, North of the River Municipal Water District ("District") is a local agency qualified to become a GSA because the District manages water and has a water supply in a portion of the Kern County Sub-basin (Basin Number 5-22.14, DWR Bulletin 118) within the San Joaquin Valley Groundwater Basin, a DWR-designated high-priority basin and is therefore a "Local Agency" as defined within California Water Code section 10721(n); and

WHEREAS, Kern Delta Water District ("Kern Delta") is a California Water District formed and operating pursuant to and in accordance with Division 13 of the California Water Code (commencing with Water Code section 34000) and is a "Local Agency" as defined within California Water Code section 10721(n); and

WHEREAS, the City of Bakersfield ("City") is a local public agency that manages water, has a water supply, and has land use responsibilities, and is therefore a "Local Agency" as defined within California Water Code section 10721(n); and

WHEREAS, Improvement District No. 4 of the Kern County Water Agency ("ID4") is also a local agency qualified to become a GSA and overlies a portion of the Kern County Sub-basin and is therefore a "Local Agency" as defined within California Water Code section 10721(n); and

WHEREAS, the District desires to form and participate in a Groundwater Sustainability Agency which may include Kern Delta, the City of Bakersfield, ID4, other Local Agencies, and which may also include the participation of certain water corporations regulated by the Public Utilities Commission and mutual water companies, as authorized pursuant to Water Code section 10723.6(b); and

WHEREAS, the District held a public hearing on Wednesday, April 6, 2016 pursuant to California Water Code section 10723(b), after publication of notice of such hearing pursuant to California Government Code section 6066; and

WHEREAS, at the public hearing, the North of the River Municipal Water District Board of Directors considered oral and written comments to the extent provided by the public; and

WHEREAS, it would be in the best interests of the District to participate in a Groundwater Sustainability Agency, which is ultimately intended to include Kern Delta Water District, the City of Bakersfield, and ID4, and perhaps other Local Agencies, and which may also include the participation of various legally authorized entities.

NOW, THEREFORE, BE IT RESOLVED AS FOLLOWS:

1. That the foregoing is true and correct.

2. That the North of the River Municipal Water District herein decides to participate in a Groundwater Sustainability Agency which will include all or part of Kern Delta Water District, the City of Bakersfield, ID4, and other local agencies, and which may also include the participation of other legally authorized entities, and which shall have all the powers granted to a groundwater sustainability agency pursuant to the Sustainable Groundwater Management Act.

3. That the portion of the groundwater basin that the herein formed Groundwater Sustainability Agency shall manage shall be that portion of the basin as stated in the notification provided to the Department of Water Resources pursuant to California Water Code section 10723.8, the map provided at the public hearing, and which boundary may be modified from time to time.

4. That the groundwater sustainability agency hereby created shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans, as required by California Water Code section 10723.2.

5. That the groundwater sustainability agency hereby created shall establish and maintain a list of persons interested in receiving notices regarding plan preparation, meeting announcements, and availability of draft plans, maps, and other relevant documents, as required by California Water Code section 10723.4.

6. That the General Manager of North of the River Municipal Water District shall be authorized to execute a memorandum of agreement or other legal agreement(s) with other local agencies and legally authorized entities pursuant to Water Code section 10723.6(a), as deemed appropriate by the General Manager, and may consent to the City of Bakersfield or Kern Delta to provide notice to the California Department of Water Resources of the decision of the North of the River Municipal Water District to participate in the above referenced Groundwater Sustainability Agency.

7. Consistent with the Sustainable Groundwater Management Act and in particular Water Code section 10720.5(b), the District's participation in the above-referenced Groundwater Sustainability Agency shall not determine or alter in any manner the District's or its constituents' surface water or groundwater rights or otherwise modify the District's powers and authorities under applicable law.

PASSED AND ADOPTED at a regular meeting of the Board of Directors of the North of the River Municipal Water District held on the 6th day of April 2016, by the following vote, to wit:

AYES: Directors: Etcheverry, Tyack, Hupp, Barnes and Enos

NOES: None

ABSENT: None

ABSTAIN: None

Board President

ATTESTED:

Board Secretary

North of the River Municipal Water District
Notice of Public Hearing

Notice is hereby given pursuant to California Water Code Section 10723 (b) and California Gov. Code Section 6066 that a Public Hearing with the North of the River Municipal Water District ("NOR") Board of Directors will be held on April 6, 2016 at 4:30 p.m. at 2836 McCray Street, Bakersfield, CA 93308. The purpose of the hearing is to hear public comments regarding a proposed NOR Groundwater Sustainability Agency ("GSA") or become a GSA under the Sustainable Groundwater Management Act of 2014 for certain portions of the Kern County Sub-basin lying within the service area.

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

YOUNG WOOLRIDGE/LEGAL
1800 30TH AVE 4TH FLR
BAKERSFIELD, CA 93301

Ad Number:	14105292	**PO #: 11856-33**	
Edition:	1TBC	**Run Times**	**2**
Class Code	Legal Notices		
Start Date	3/23/2016	**Stop Date**	3/30/2016
Billing Lines	22	**Inches**	132.92
Total Cost	$ 178.42	**Account**	1YOU09
Billing Address	YOUNG WOOLRIDGE/LEGAL 1800 30TH AVE 4TH FLR BAKERSFIELD,CA 93301		

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 3/23/16
3/30/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

B Montoya

DATED AT BAKERSFIELD CALIFORNIA
3/30/16

Solicitor I.D.: 0

First Text
NOTICE OF PUBLIC HEARING NORTH OF THE RI

Ad Number 14105292

NOTICE OF PUBLIC HEARING NORTH OF THE RIVER MUNICIPAL WATER DISTRICT

Notice is hereby given pursuant to California Water Code Section 10723(b) and California Gov. Code Section 6066 that a Public Hearing with the North of the River Municipal Water District (NOR) Board of Directors will be held on April 6, 2016 at 4:30 p.m. at 2836 McCray Street, Bakersfield, CA 93308. The purpose of the hearing is to hear public comments regarding a proposed NOR Groundwater Sustainability Agency ("GSA") or NOR combining with other public agencies to become a GSA under the Sustainable Groundwater Management Act of 2014 for certain portions of the Kern County Sub-basin lying within its service area.

March 23, 30, 2016
(14105292)

EXHIBIT 6

LIST OF INTERESTED PARTIES

Pursuant to Water Code Section 10723.2: a groundwater sustainability agency (GSA) shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing groundwater sustainability plans (GSPs). The list of interested parties presented below was developed during the current GSA formation process. Many of the agencies identified below have already been contacted by the City of Bakersfield, Kern Delta Water District, or the Kern County Water Agency Improvement District No. 4 or to coordinate the GSA planning process. The interests of the agencies, organizations, and individuals identified below shall be considered during the development of the GSP for the GSA.

(a) Holders of overlying groundwater rights, including:

(1) Agricultural users.

- Rosedale Ranch Improvement District
- Various landowners

A significant portion of the land located within the Kern River GSA boundary is used for agricultural purposes. Kern District Water District maintains a landowner list and contact information for such users within its service area boundaries. The GSA will maintain a landowner list of all other such users, with contact information.

(2) Domestic well owners.

- Bear Mountain Truck Stop
- Cal Mat (Panama Lane Facility)
- Cemex Construction Materials Pacific LLC
- Countryside Market & Restaurants
- Delta Trading Water System
- Donnovan Bros. Golf
- Derrel's Mini Storage #66
- Farmer John Egg Ranch #2
- Golden Empire Concrete Company
- Grace Community Church Water System
- Harvest Steakhouse
- J.G. Boswell Company Water System
- Kern County Cemetery Association
- Kern Oil and Refining Company
- Kidz Kountry Preschool

- Lakeside School
- Pinewood Lake Homeowners Association
- Seven Oaks Country Club
- Stockdale Country Club
- Various private entities

There may be additional domestic well owners located within the GSA boundary. The GSA will maintain a list of such owners, with contact information.

(b) Municipal well operators.

- Ashe Water Company
- City of Bakersfield
- California Water Service Company
- East Niles Community Services District
- Greenfield County Water District
- Kern County Water Agency, Improvement District No.4
- North of the River Mutual Water District

It is believed that this is the extent of the municipal well operators located partially or fully within the GSA boundary. However, there may be other municipal well owners located partially or fully within the GSA boundary. The GSA will maintain a list of municipal well operators with contact information.

(c) Public water systems.

- Ashe Water Company
- Athal Mutual Water System
- Bear Mountain RV Park Water System
- California Water Service Company
- Casa Loma Water Company
- East Niles Community Services District
- East Wilson Road Water Company
- El Adobe POA, Inc.
- Fuller Acres Mutual Water Company
- Gosford Road Water Company
- Greenfield County Water District
- North of the River Mutual Water District
- Oasis Property Owners Association
- Oildale Mutual Water Company
- Old River Mutual Water Company
- Panama Road Property Owners Association
- Ski West Village Water System

- South Kern Mutual Water Company
- Stockdale Annex Mutual Water Company
- Stockdale Mutual Water Company
- Vaughn Water Company
- Wini Mutual Water Company

It is believed that this is the extent of the public water systems located partially or fully within the GSA boundary.   However, there may be other public water systems located partially or fully within the GSA boundary. The GSA will maintain a list of public water systems with contact information.

(d) Local land use planning agencies.

- County of Kern
- Kern County Planning and Community Development Department

The City of Bakersfield is also a local land use planning agency within the GSA boundary. The City Manager's office, City Attorney, Community Development Department, and Water Resources Department have been, and will continue to be, engaged in a coordinated effort in the formation of this GSA, development of the subsequent GSP, and ongoing coordination with other GSAs in the Kern River Subbasin with the goal of ensuring sustainability within the Subbasin.

(e) Environmental users of groundwater.

- Panorama Vista Preserve
- Kern River Parkway Foundation
- City of Bakersfield

The City has developed the Kern River Flow and Municipal Water Program to restore streamflow and increase groundwater recharge along the Kern River. The Program will implement City-adopted plans and policies to enhance and protect the natural resources of the Kern River through increasing river flows. Increased river flows provide benefits of increased groundwater recharge, recreation, and habitat enhancement. The Program would allow surplus water to flow down the Kern River channel seasonally and percolate to the groundwater basin below. The City draws off of the recharged basin to support its municipal water supply needs. The Kern River Flow and Municipal Water Program will be considered in development of the GSP.

(f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies.

- Buena Vista Water Storage District
- Rosedale-Rio Bravo Water Storage District

The City and Kern-Delta Water District own long-standing historic surface water rights and supplies, and typically use such water supplies for deliveries to constituents (surface deliveries and conjunctive use deliveries) within the their boundaries.

(g) The federal government, including, but not limited to, the military and managers of federal lands.

- There are no known lands owned or operated by the federal government within the GSA. If in the future such interests are discovered, they will be included as an interested party.

(h) California Native American Tribes.

- *There are no known lands owned or operated by California Native American Tribes within the GSA. If in the future such interests are discovered, they will be included as an interested party.*

(i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems.

- Calder's Corner
- Edison
- Greenfield
- Kern City
- Magunden

Exhibit 7 provides a list and map of the census tracts within the GSA boundary that meet the definition of "disadvantaged community."[1] The GIS data of the disadvantaged community census tracts shown in the attached map were obtained from the CalEPA website.[2]

(j) Entities listed in Section 10927 that are monitoring and reporting groundwater elevations in all or a part of a groundwater basin managed by the groundwater sustainability agency.[3]

[1] As defined in *Designation of Disadvantaged Communities Pursuant to Senate Bill 535 (De Leon).* Available:<http://www.calepa.ca.gov/EnvJustice/GHGInvest/Documents/SB535DesCom.pdf>. Accessed: January 26, 2016.

[2] Available:<http://www.calepa.ca.gov/EnvJustice/GHGInvest/>. Accessed: January 26, 2016.

[3] Water Code Section 10927. Any of the following entities may assume responsibility for monitoring and reporting groundwater elevations in all or a part of a basin or subbasin in accordance with this part:
(a) A watermaster or water management engineer appointed by a court or pursuant to statute to administer a final judgment determining rights to groundwater.
(b) (1) A groundwater management agency with statutory authority to manage groundwater pursuant to its principal act that is monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.
(2) A water replenishment district established pursuant to Division 18 (commencing with Section 60000). This part does not expand or otherwise affect the authority of a water replenishment district relating to monitoring groundwater elevations.
(3) A groundwater sustainability agency with statutory authority to manage groundwater pursuant to Part 2.74 (commencing with Section 10720).
(c) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to Part 2.75 (commencing with Section 10750) and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010, or a local agency or county that is managing all or part of a groundwater basin or subbasin pursuant to any other legally enforceable groundwater management plan with provisions that are substantively similar to those described in that part and that was monitoring groundwater elevations in all or a part of a groundwater basin or subbasin on or before January 1, 2010.

- Kern Groundwater Authority
- Kern Water Bank Authority
- Arvin-Edison Water Storage District
- Deer Creek & Tule River Authority
- Kern County Water Agency Improvement District 4
- Kern-Tulare Water District
- North Kern Water Storage District
- Semitropic Water Storage District
- Shafter-Wasco Irrigation District
- Kern Fan Authority (which is a coalition consisting of the Kern-Delta Water District, Buena Vista Water Storage District, Henry Miller Water District, and Rosedale-Rio Bravo Water Storage District, and which was previously known as the Kern River Fan Group)

The City and Kern-Delta Water District also monitor and report groundwater elevations. Cal Water, the City's operations and maintenance contractor, takes monthly groundwater elevation readings for the City's domestic water wells. City staff also measures groundwater levels in the City's Olcese Wells and in monitoring wells in the City's 2800 Acre Recharge Facility. Kern Delta staff takes certain weekly, monthly, and bi-annual groundwater elevation measurements throughout the District. Some of the bi-annual data is reported to the Kern County Water Agency and some to the State of California through the California Statewide Groundwater Elevation Monitoring (CASGEM) program.

The following are other interested parties that do not fit the various categories outlined in Water Code §10723.2:

- Kern River Watershed Coalition Authority

All of the above interested parties will be considered in the operation of the GSA and the development of the GSP.

(d) A local agency that is managing all or part of a groundwater basin or subbasin pursuant to an integrated regional water management plan prepared pursuant to Part 2.2 (commencing with Section 10530) that includes a groundwater management component that complies with the requirements of Section 10753.7.
(e) A local agency that has been collecting and reporting groundwater elevations and that does not have an adopted groundwater management plan, if the local agency adopts a groundwater management plan in accordance with Part 2.75 (commencing with Section 10750) by January 1, 2014. The department may authorize the local agency to conduct the monitoring and reporting of groundwater elevations pursuant to this part on an interim basis, until the local agency adopts a groundwater management plan in accordance with Part 2.75 (commencing with Section 10750) or until January 1, 2014, whichever occurs first.
(f) A county that is not managing all or a part of a groundwater basin or subbasin pursuant to a legally enforceable groundwater management plan with provisions that are substantively similar to those described in Part 2.75 (commencing with Section 10750).
(g) A voluntary cooperative groundwater monitoring association formed pursuant to Section 10935.

Regional Coordination

Regional coordination is an important component of forming this GSA and the subsequent GSP. Currently, the Kern Groundwater Authority (KGA) has been engaging in public outreach, and both the City of Bakersfield (City), Kern-Delta Water District (KDWD), and the Kern County Water Agency Improvement District No. 4 (ID4) and have participated in this current outreach effort with the KGA. To date, the KGA, has organized a number of regular meetings since April 2014 at which the City, KDWD, and ID4 have participated. Prior to the KGA, the City also participated in regional coordination meetings with the Kern Groundwater Management Committee (KGMC) since January 2012. These meetings with the KGA and the KGMC included discussion of the SGMA and Kern County local compliance and coordination efforts.

Continued Public Outreach

This GSA will conduct public outreach efforts to engage the public and interested parties listed above in the ongoing effort to comply with SGMA and develop the GSP. It is the GSA's intent to hold additional educational workshops in the future to keep the public and interested parties informed of the ongoing GSP development efforts. We will plan workshops in the future before adoption of the GSP. Additional future public outreach efforts may include forming a committee to oversee public outreach and potentially developing a website to provide the public with current information regarding the GSA. The purpose of these efforts would be to ensure a clear communication path with the public and interested parties to keep them informed regarding the progress of the GSA and GSP.

The Kern River GSA will consider the interests of all of the foregoing beneficial uses and users of groundwater, as well as those responsible for implementing GSPs. In this effort, the District will (1) continue to meet with the KGA and its members, (2) meet with other local GSAs that may be formed and endeavor to coordinate with such agencies pursuant to §§ 10727 and 10727.6, (3) have open and public meetings of the Kern River GSA members' Board of Directors, and (4) solicit feedback in the adoption of its GSP and any subsequent amendments. In addition to the foregoing, and pursuant to Water Code §10727.8, prior to initiating the development of a GSP, the Kern River GSA will make available to the public and DWR a written statement describing the manner in which interested parties may participate in the development and implementation of the GSP. The Kern River GSA will encourage the active involvement of diverse social, cultural, and economic elements of the population within that portion of the groundwater basin to be managed by the Kern River GSA. For these purposes, interested parties will include entities listed in Water Code §10927 that are monitoring and reporting groundwater elevations in all or a part of the groundwater basin that is managed by the Kern River GSA.

Furthermore, and pursuant to Water Code §10728.4, the Kern River GSA will adopt or amend its GSP only after a public hearing, held at least 90 days after providing notice to any city or county within the area of the proposed plan or amendment. The Kern River GSA will also review and consider comments from any city or county that receives notice pursuant to the above-referenced Water Code section and will consult with a city or county that requests consultation within 30 days of receipt of the notice.

EXHIBIT 7

DISADVANTAGED COMMUNITIES (DAC) IN KERN RIVER GSA

INCLUDING:

(A) LIST OF DACs
(B) MAP OF DACs

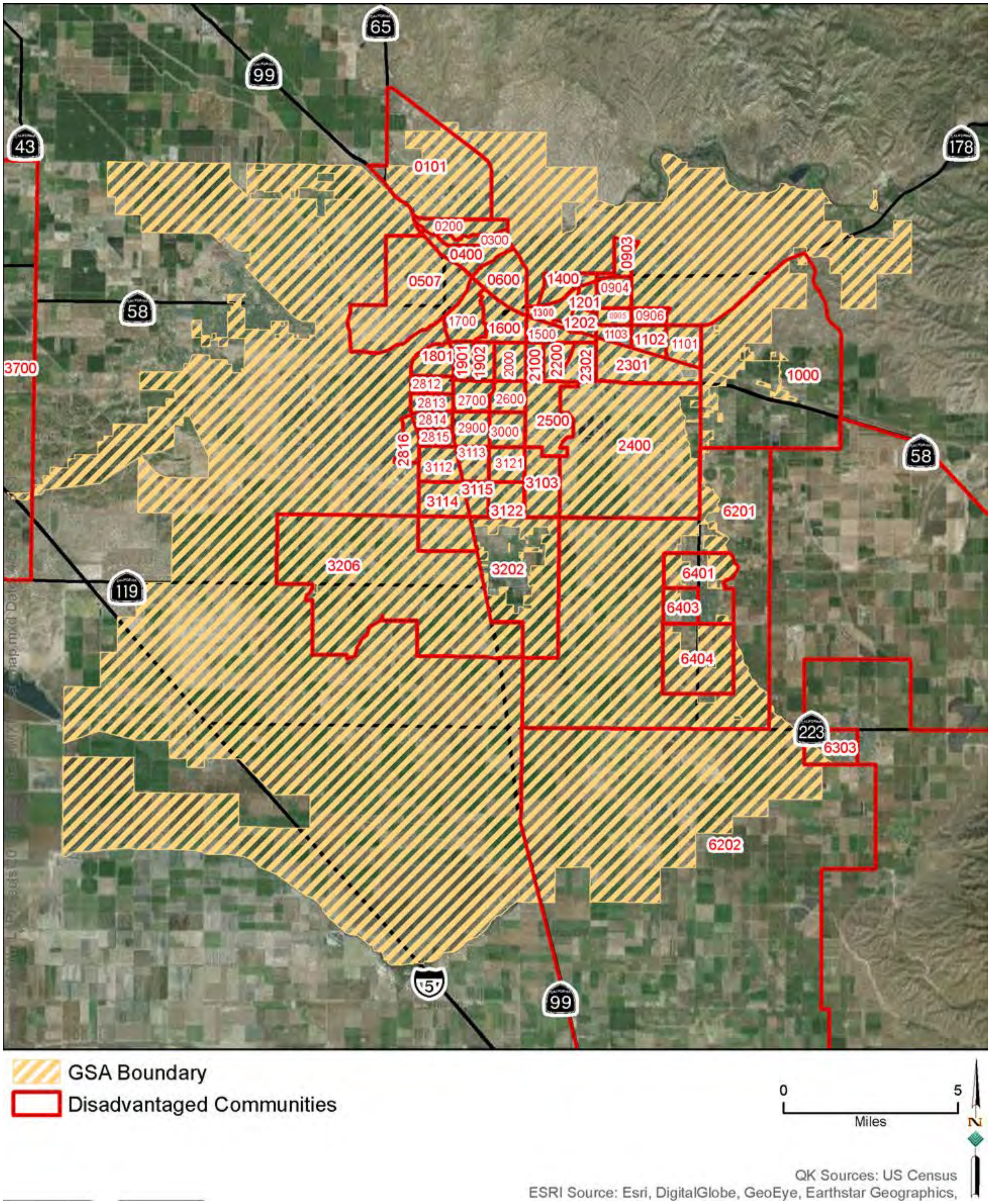
(A) DACs Listed by Census Tract within the Kern River GSA Boundary

GEOID[1]	Tract Name[2]	Population[3]	Nearest Zip Code
3113	Census Tract 31.13	5298	93307
3112	Census Tract 31.12	5658	93313
2900	Census Tract 29	6787	93309
0300	Census Tract 3	4381	93308
0200	Census Tract 2	7957	93308
3206	Census Tract 32.06	13845	93307
2812	Census Tract 28.12	5581	93309
6201	Census Tract 62.01	3244	93203
0400	Census Tract 4	4495	93301
0507	Census Tract 5.07	3703	93309
0600	Census Tract 6	6453	93301
0904	Census Tract 9.04	4402	93306
0903	Census Tract 9.03	4150	93306
0905	Census Tract 9.05	2553	93306
0906	Census Tract 9.06	3881	93306
3115	Census Tract 31.15	5954	93307
3114	Census Tract 31.14	7430	93313
3122	Census Tract 31.22	8612	93307
3121	Census Tract 31.21	8136	93307
1103	Census Tract 11.03	5588	93307
1201	Census Tract 12.01	3269	93305
1202	Census Tract 12.02	5864	93305
1500	Census Tract 15	2682	93307
1400	Census Tract 14	8745	93305
1300	Census Tract 13	7205	93305
1600	Census Tract 16	1580	93307
2200	Census Tract 22	5804	93307
1700	Census Tract 17	4088	93309
2100	Census Tract 21	3372	93307
1902	Census Tract 19.02	4958	93301
1901	Census Tract 19.01	3786	93309
1801	Census Tract 18.01	6251	93309
2302	Census Tract 23.02	3444	93307
2301	Census Tract 23.01	10255	93307
3700	Census Tract 37	3806	93206
6202	Census Tract 62.02	6887	93243
3103	Census Tract 31.03	3810	93307
2000	Census Tract 20	7529	93307
2600	Census Tract 26	3500	93307
2700	Census Tract 27	6152	93309
2500	Census Tract 25	8592	93307

GEOID[1]	Tract Name[2]	Population[3]	Nearest Zip Code
2400	Census Tract 24	8470	93307
3000	Census Tract 30	8119	93307
3202	Census Tract 32.02	17216	93307
2813	Census Tract 28.13	4327	93309
2815	Census Tract 28.15	4918	93309
2814	Census Tract 28.14	4306	93309
2816	Census Tract 28.16	6119	93309
0101	Census Tract 1.01	12616	93308
6303	Census Tract 63.03	6768	93203
6404	Census Tract 64.04	3318	93241
6403	Census Tract 64.03	6513	93241
1000	Census Tract 10	10276	93307
6401	Census Tract 64.01	8698	93241
1102	Census Tract 11.02	6496	93307
1101	Census Tract 11.01	4413	93307

Notes:
[1]Partial U.S. Census GEOID. Each full GEOID begins with 0602900 followed by the partial GEOID shown in the table. For example, partial GEOID 3112 has a full U.S. Census GEOID of 06029003112.
[2]GSA boundary includes all or part of the aerial extent of each census tract.
[3]GSA boundary includes all or part of the population for each census tract.

(B) Map of DACs Identified by Census Tract within the Kern River GSA Boundary



APPENDIX B

Notification of Intent to Develop Groundwater Sustainability Plan

Kern River Groundwater Sustainability Agency

May 19, 2017

Mr. Trevor Joseph
Sustainable Groundwater Management Section Chief
California Department of Water Resources
P.O. Box 942836
Sacramento, California 94236-0001

SUBJECT: NOTIFICATION OF INTENT TO DEVELOP GROUNDWATER SUSTAINABILITY PLAN

Dear Mr. Joseph,

The purpose of this letter is to notify you that the Kern River Groundwater Sustainability Agency (KRGSA) intends to develop a Groundwater Sustainability Plan (GSP) pursuant to Water Code Section 10727.8 for its service area within the Kern County Subbasin (Basin Number 5-22.14, DWR Bulletin 118). The KRGSA is an exclusive GSA whose formation was posted by DWR on April 21, 2016.

The KRGSA is engaged in several coordination and outreach efforts across the Kern County Subbasin, as well as, within the more specific service area of the KRGSA. The KRGSA actively participates in technical and planning meetings and forums with other GSAs in the Kern County Subbasin, recognizing that the findings of the KRGSA's GSP will need to be coordinated with other GSP development efforts occurring in parallel within the Kern County Subbasin. The KRGSA has taken the lead in developing modelling tools that will facilitate integration and plan alignment among multiple GSAs/GSPs in the subbasin. The KRGSA holds monthly public meetings to review and discuss on-going planning activities in support of the GSA and GSP development process. These meetings welcome public input and feedback to the GSA and the GSP development process.

Once the GSP process is more fully underway, the KRGSA will also be holding quarterly meetings with the specific objective of reviewing progress in developing the technical elements of the GSP. These quarterly GSP update meetings will be open to the public and welcome participation by other GSAs in the Kern County subbasin, interested parties within the basin or KRGSA service area, or other members of the public. In addition to these coordination and technical efforts described above, the KRGSA will also be holding educational workshops specifically intended for the interested parties and general public (residents) living in the KRGSA service area. These additional workshops will have an educational focus to inform attendees on the overall role and purpose of the GSA, describe the method and process to develop the GSP, and share our understanding on how the GSP will eventually be implemented. One of the key goals of these public workshops will be to hear comments and feedback from the public that can be used to further inform the GSP development process.

The KRGSA has established a website at: http://kernrivergsa.org/ . This website is already actively in use and will continue to provide the public with key information regarding the GSA and GSP development process including the dates of public meetings and workshops. The KRGSA website also makes our resource planning and GSP documents available to the public.

Attached for your reference is the draft KRGSA GSP development schedule. More specific dates for public workshops and other educational and outreach events will be added to the working schedule in time.

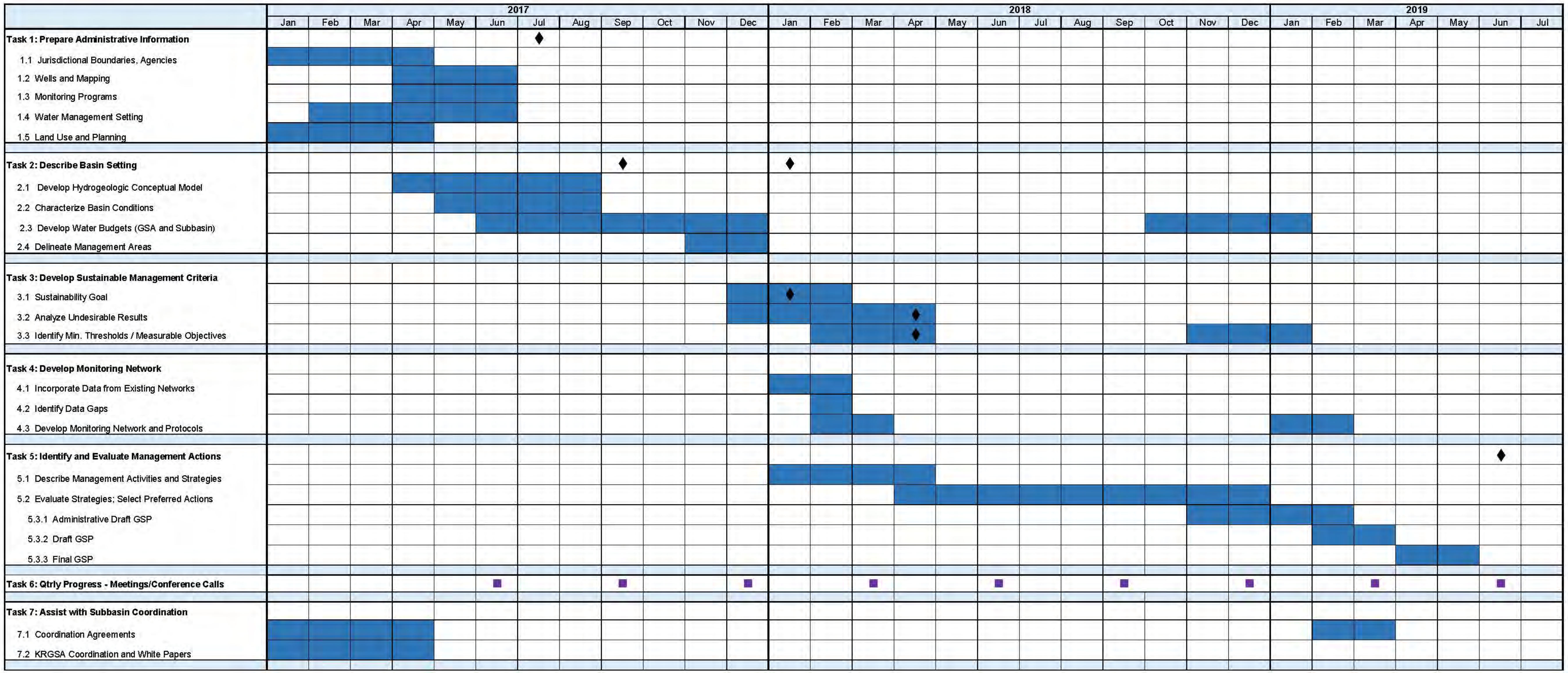
If you have any questions regarding our GSP development process, please don't hesitate to contact me at the phone number or email below.

Thank you,

Art Chianello

Art Chianello, P.E.
City of Bakersfield, Water Resources Manager
achianel@bakersfieldcity.us
(661) 326-3715

Table 1. KRGSA Groundwater Sustainability Plan, Project Schedule **Todd Groundwater**



Note: Schedule revised to coordinate with Subbasin Modeling tasks (see Table 2).

KRGSA Meeting or Workshop ♦

Progress Report (In-person Meeting or Conference Call) ■

APPENDIX C

Notice of Greenfield County Water District's Intent to Serve as Groundwater Sustainability Agency For A Portion of the Kern County Subbasin 5-22.14

Memorandum of Understanding for Development and Implementation of a Groundwater Sustainability Plan

Memorandum of Understanding RE Participation in Kern River Groundwater Sustainability Agency

Greenfield County Water District

551 TAFT HIGHWAY PHONE (661) 831-0989
BAKERSFIELD, CALIFORNIA 93307

April 12, 2016

Via Email & FedEx

Mark Nordberg, GSA Project Manager
Senior Engineering Geologist
California Department of Water Resources
901 P Street, Room 213A
P. O. Box 942836
Sacramento, CA 94236
Mark.Nordberg@water.ca.gov

Dane Mathis
Sup. Engineering Geologist
3374 East Shields Avenue
Fresno, CA 93726
Dane.Mathis@water.ca.gov

Re: **Notice of Greenfield County Water District's Intent to Serve as Groundwater Sustainability Agency For A Portion of the Kern County Subbasin- 5-22.14**

This letter constitutes notice to the Department of Water Resources (**DWR**), pursuant to Water Code sections 10723(d) and 10723.8, of Greenfield County Water District's (**District**) intent to undertake sustainable groundwater management of a portion of the Kern County Subbasin (**Basin**) No. 5-22.14 as a Groundwater Sustainability Agency (**GSA**) pursuant to the Sustainable Groundwater Management Act (**SGMA**). This notice of intent is timely filed within 30 days of the date the District's Board of Directors (**Board**) approved a resolution electing to serve as a GSA. The resolution is attached hereto as Exhibit 1, and maps showing the District's service area boundaries and proposed GSA management area are attached as an exhibit to the resolution. No new bylaws, ordinances, or other new authorities were adopted in connection with this resolution to serve as GSA.

As of the date of this notice, DWR has posted a notice pursuant to Water Code section 10733.3 of Buena Vista Water Storage District's intent to serve as a GSA for a portion of the Basin.

A list of potential GSAs within the Basin is attached as Exhibit 2. Potential GSA's within the District's proposed management area include the City of Bakersfield and Kern Delta Water District. The District anticipates coordinating with both the City of Bakersfield and Kern Delta Water District in the development of a Groundwater Sustainability Plan (**GSP**).

Interested parties within the District's proposed GSA management area, determined pursuant to Water Code section 10723.2, and to the best of the District's knowledge, include:

(a) Holders of Overlying Groundwater Rights, including:

(1) Agricultural Users,

The District's proposed management area is composed predominantly of residential, commercial and industrial water users, most of whom have a pre-existing relationship with the District. There is a small amount of agricultural land within the District, most of which is fallow pending development. Active agricultural water users within the District's boundary will fall under the GSA of Kern Delta Water District.

(2) Domestic Well Owners.

There are domestic wells within the proposed GSA management area. However, because SGMA excludes "de minimis extractors" (those that extract no more than two acre-feet per year) from certain regulatory requirements, it is anticipated that the GSP will exclude some domestic wells from such requirements.

(b) Municipal Well Operators.

The District is the only known municipal well operator within the proposed management area.

(c) Public Water Systems.

The District is the only known public water system within the proposed management area.

(d) Local Land Use Planning Agencies.

The County of Kern and the City of Bakersfield and the local land use planning agencies.

(e) Environmental Users of Groundwater.

N/A.

(f) Surface Water Users, if there is a Hydrologic Connection between Surface and Groundwater bodies.

The District, Kern Delta Water District and the City of Bakersfield are surface water users within the District's boundaries.

(g) The Federal Government, including, but not limited to, the Military and Managers of Federal Lands.

N/A

(h) California Native American Tribes.
N/A

(i) Disadvantaged Communities, including, but not limited to, those Served by Private Domestic Wells or Small Community Water Systems.
The District is not aware of any Disadvantaged Communities within the proposed management area.

(j) Entities listed in Water Code Section 10927 that are Monitoring and Reporting Groundwater Elevations in all or part of a Groundwater Basin Managed by the Groundwater Sustainability Agency.
Possibly Kern Delta Water District and the City of Bakersfield.

The District intends to engage in a collaborative, open and inclusive process in implementing SGMA. The District will listen to and consider the interests of the Basin's other GSAs, stakeholders, and other interested parties in the development and operation of the GSA, and in the development and implementation of the GSP. Interested parties will have opportunities, both formal and informal, to provide input to the District through the process of developing, operating, and implementing the GSA and GSP. Such opportunities may include, but are not limited to, public comment as required by SGMA (e.g., Water Code section 10728.4); opportunities for public comment during the initial District's regular and special board meetings, and at other times to be determined and noticed pursuant to Water Code section 10727.8(a).

Mel Johnson, General Manager and Secretary
Greenfield County Water District

GREENFIELD COUNTY WATER DISTRICT

RESOLUTION NO. 2016-01

A RESOLUTION OF THE BOARD OF DIRECTORS OF
GREENFIELD COUNTY WATER DISTRICT
FOR AN ELECTION TO SERVE AS
GROUNDWATER SUSTAINABILITY AGENCY

WHEREAS, the Sustainable Groundwater Management Act of 2014 ("SGMA") was signed into law on September 16, 2014 and became effective January 1, 2015; and

WHEREAS, SGMA requires that each California groundwater basin or subbasin be managed by a Groundwater Sustainability Agency (GSA), or multiple GSAs, and that such management be implemented pursuant to an approved Groundwater Sustainability Plan (GSP) or multiple GSPs; and

WHEREAS, Greenfield County Water District (District) overlies a subbasin of the San Joaquin Valley Groundwater Basin known as the Kern County Subbasin (Basin No. 5-22.14 in the Department of Water Resources' CASGEM system), an unadjudicated groundwater basin overlying portions of Kern County (the "Basin"); and

WHEREAS, the District, as a local public agency overlying the Basin, is authorized to be a GSA for the Basin; and

WHEREAS, notice of a public hearing to consider whether the District should elect to be a GSA for a portion of the Basin, a copy of which is attached as **Exhibit A**, was published in the *Bakersfield Californian* on February 25, 2016 and again on March 3, 2016, pursuant to section 6066 of the Government Code, as required by section 10723(b) of the Water Code; and

WHEREAS, courtesy copies of the hearing notice were also provided to the Basin's other potential GSAs within the Basin, including the Kern Groundwater Authority, County of Kern City of Bakersfield and Kern Delta Water District;

NOW, THEREFORE, BE IT RESOLVED BY THE BOARD OF DIRECTORS OF GREENFIELD COUNTY WATER DISTRICT as follows:

1. The District hereby elects to be the exclusive Groundwater Sustainability Agency for at least that portion of the Kern County Subbasin that is shown on the map attached hereto as **Exhibit B** and incorporated herein by this reference.

2. Within 30 days of the date of this Resolution, the General Manager is directed to submit a notice of the District's intent to the Department of Water Resources, pursuant to Water Code section 10723.8(a).

3. The General Manager shall, after complying with Water Code section 10727.8, begin the process of developing the District's Groundwater Sustainability Plan for the Basin in accordance with all applicable statutes and regulations.

Exhibit 1

4. The General Manager shall create and maintain a list of persons interested in receiving notices concerning the District's SGMA process pursuant to section 10723.4 of the Water Code.

5. The General Manager shall provide regular progress reports on SMGA implementation to the Board.

PASSED AND ADOPTED this 14th day of March, 2016.

David Rasmussen
President of the Board of Directors

ATTEST:

Mel Johnson, Secretary

SECRETARY'S CERTIFICATE

I HEREBY CERTIFY that the foregoing Resolution No. 16-01 was duly passed and adopted by the Board of Directors of Greenfield County Water District at a regular meeting thereof held on March 14, 2016, on the following roll call vote:

AYES:	David Rasmussen
	Roberto Figueroa
	Robert Actis
	Alex Alvarado
	Dennis Costa
NOES:	None
ABSTAIN:	None
ABSENT:	None

Mel Johnson, Secretary
Greenfield County Water District

Exhibit A

GREENFIELD COUNTY WATER DISTRICT

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723(b), the Board of Directors of Greenfield County Water District (District) will hold a public hearing on March 14, 2016, at 7:00 p.m., at the District's office located at 551 Taft Highway, Bakersfield, California to consider and decide whether the District shall become a Groundwater Sustainability Agency for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the District, to the attention of Mel Johnson, District Manager, no later than 7:00 p.m. on Monday, March 14, 2016. During the hearing, the District will receive oral and written comments before making a decision.

Dated: February 23, 2016

GREENFIELD COUNTY WATER DISTRICT

By ______________________
Mel Johnson
General Manager and Secretary

PROOF OF PUBLICATION

The BAKERSFIELD CALIFORNIAN
P.O. BOX 440
BAKERSFIELD, CA 93302

GREENFIELD COUNTY WATER DISTRICT
551 TAFT HIGHWAY
BAKERSFIELD, CA 93307

Ad Number:	14087881	**PO #:**	
Edition:	1TBC	**Run Times**	2
Class Code	Public Notices		
Start Date	2/25/2016	**Stop Date**	3/3/2016
Billing Lines	23	**Inches**	138.92
Total Cost	$ 349.20	**Account**	1GRE35
Billing Address	GREENFIELD COUNTY WATER DIS 551 TAFT HIGHWAY BAKERSFIELD,CA 93307		

STATE OF CALIFORNIA
COUNTY OF KERN

I AM A CITIZEN OF THE UNITED STATES AND A RESIDENT OF THE COUNTY AFORESAID: I AM OVER THE AGE OF EIGHTEEN YEARS, AND NOT A PARTY TO OR INTERESTED IN THE ABOVE ENTITLED MATTER. I AM THE ASSISTANT PRINCIPAL CLERK OF THE PRINTER OF THE BAKERSFIELD CALIFORNIAN, A NEWSPAPER OF GENERAL CIRCULATION, PRINTED AND PUBLISHED DAILY IN THE CITY OF BAKERSFIELD COUNTY OF KERN,

AND WHICH NEWSPAPER HAS BEEN ADJUDGED A NEWSPAPER OF GENERAL CIRCULATION BY THE SUPERIOR COURT OF THE COUNTY OF KERN, STATE OF CALIFORNIA, UNDER DATE OF FEBRUARY 5, 1952, CASE NUMBER 57610; THAT THE NOTICE, OF WHICH THE ANNEXED IS A PRINTED COPY, HAS BEEN PUBLISHED IN EACH REGULAR AND ENTIRE ISSUE OF SAID NEWSPAPER AND NOT IN ANY SUPPLEMENT THEREOF ON THE FOLLOWING DATES, TO WIT: 2/25/16
3/3/16

ALL IN YEAR 2016

I CERTIFY (OR DECLARE) UNDER PENALTY OF PERJURY THAT THE FOREGOING IS TRUE AND CORRECT.

Nyana Lorence

DATED AT BAKERSFIELD CALIFORNIA

MAR 0 8 2016

Solicitor I.D.: 0

First Text
GREENFIELD COUNTY WATER DISTRICTNOTICE

Ad Number 14087881

GREENFIELD COUNTY WATER DISTRICT

NOTICE OF PUBLIC HEARING

NOTICE IS HEREBY GIVEN that, pursuant to California Water Code section 10723(b), the Board of Directors of Greenfield County Water District (District) will hold a public hearing on March 14, 2016, at 7:00 p.m., at the District's office located at 551 Taft Highway, Bakersfield, California to consider and decide whether the District shall become a Groundwater Sustainability Agency for a portion of the Kern County Subbasin of the Tulare Lake Groundwater Basin. Written comments should be submitted to the District, to the attention of Mel Johnson, District Manager, no later than 7:00 p.m. on Monday, March 14, 2016. During the hearing, the District will receive oral and written comments before making a decision.

Dated: February 23, 2016

GREENFIELD COUNTY WATER DISTRICT

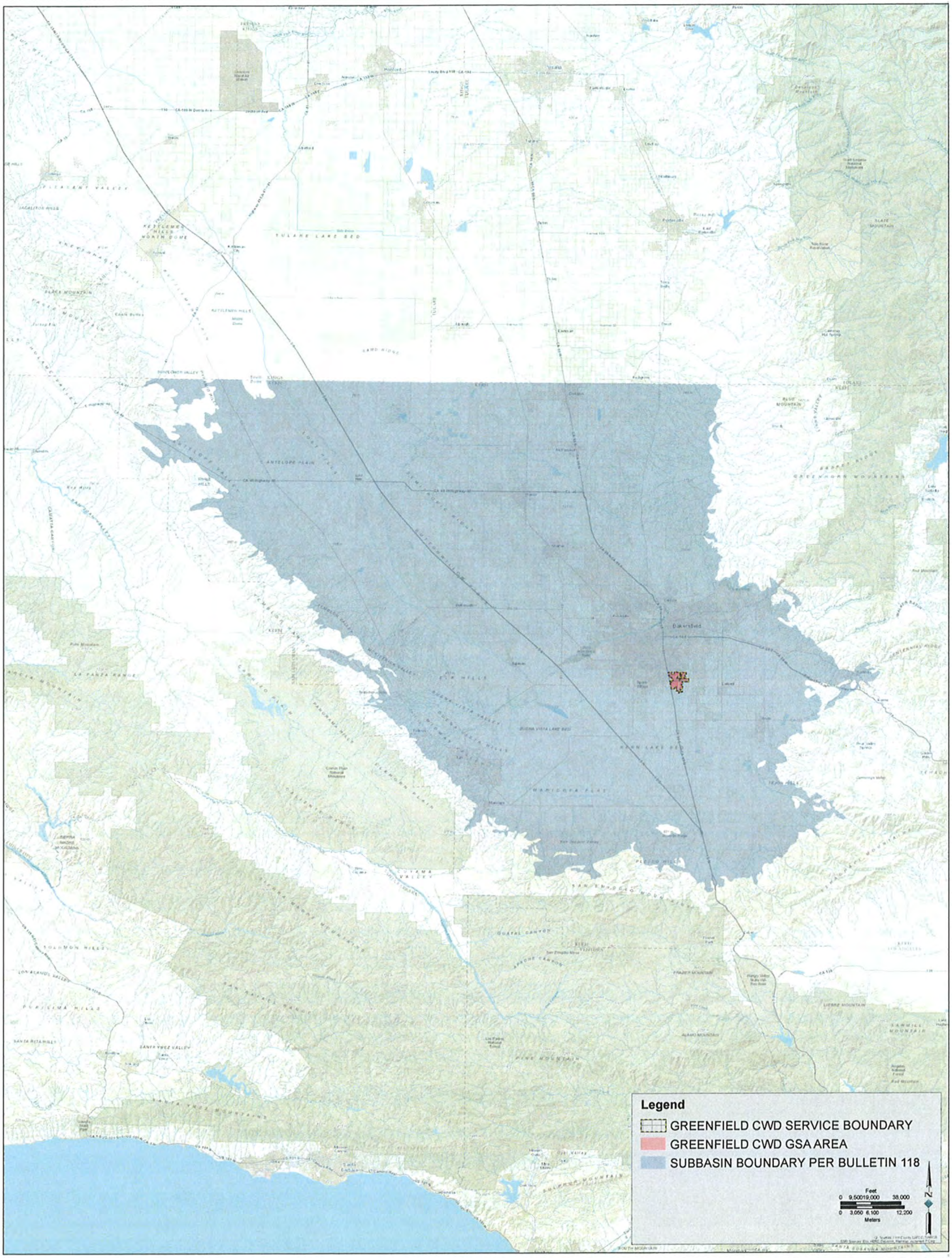
By /s/
Mel Johnson
General Manager and Secretary

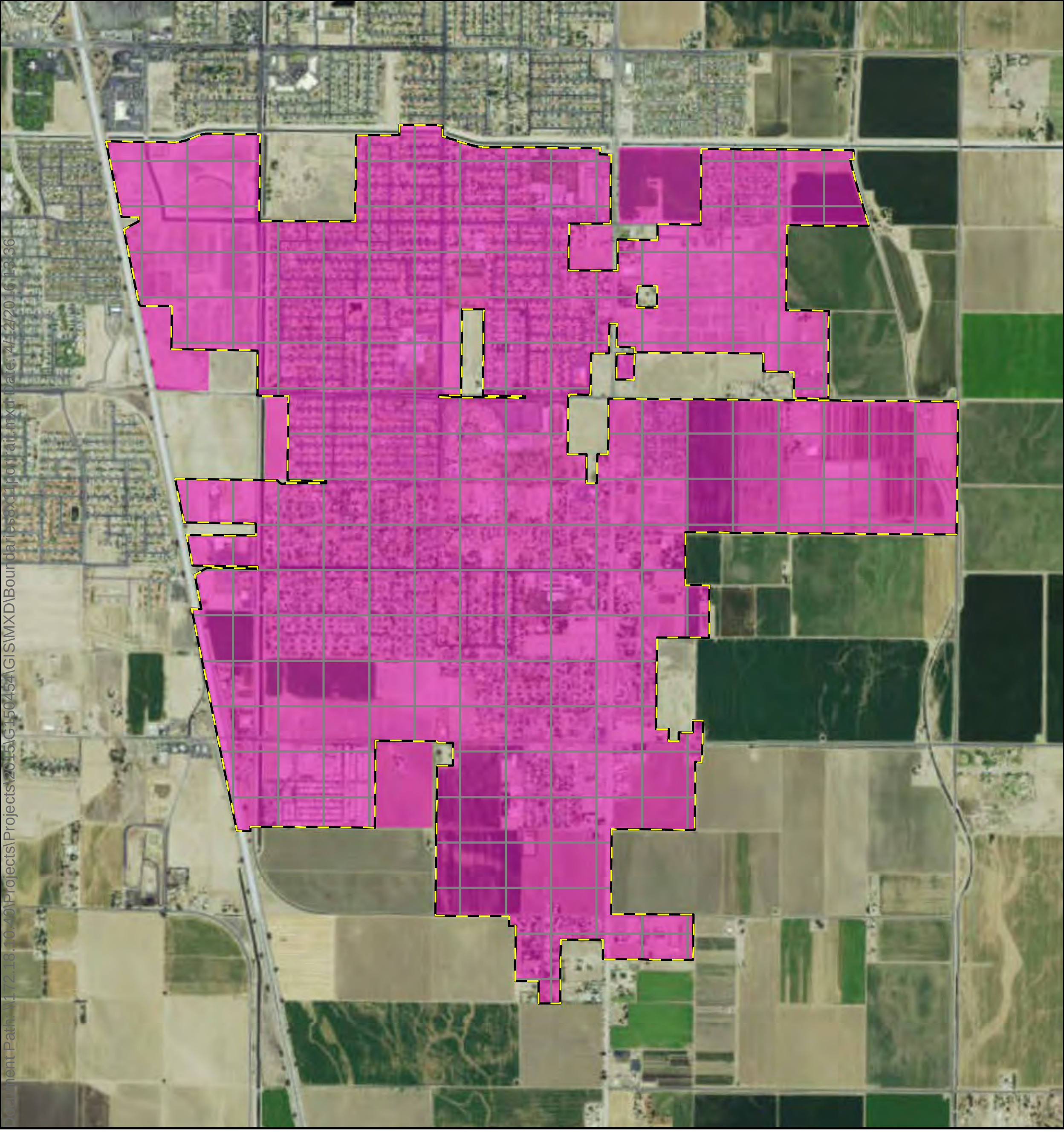
FEBRUARY 25, MARCH 3, 2016
14087881

Exhibit B

Greenfield County Water District GSA Boundary

GSA Boundary within subbasin 5-22.14 of the Tulare Lake Hydrologic Region





Greenfield County Water District GSA Boundary

GREENFIELD CWD SERVICE BOUNDARY

GREENFIELD CWD GSA AREA

0 2,100

Feet

N

QK Sources:

ESRI Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics,

Arvin Edison Community Services District
Arvin-Edison Water Storage District
Belridge Water Storage District
Berrenda Mesa Water District
Buena Vista Water Storage District
Buttonwillow County Water District
Cawelo Water District
City of Arvin
City of Bakersfield
City of Delano
City of Maricopa
City of McFarland
City of Shafter
City of Taft
City of Wasco
County of Kern
Delano-Earlimart Irrigation District
Devil's Den Water District
East Niles Community Services District
Henry Miller Water District
Kern County Water Agency (Including Improvement District No. 4)
Kern Delta Water District
Kern-Tulare Water District
Lamont Public Utilities District
Lost Hills Utility District
Lost Hills Water District
McAllister Ranch Irrigation District
North of the River Municipal Water District
North Kern Water Storage District
Olcese Water District
Rag Gulch Water District
Rosedale Ranch Improvement District
Rosedale-Rio Bravo Water Storage District
Semitropic Water Storage District
Shafter-Wasco Irrigation District
Southern San Joaquin Municipal Utility District
West Kern Water District
Wheeler Ridge-Maricopa Water Storage District

Exhibit 2

MEMORANDUM OF UNDERSTANDING FOR DEVELOPMENT AND IMPLEMENTATION OF A GROUNDWATER SUSTAINABILITY PLAN

This MEMORANDUM OF UNDERSTANDING ("MOU") is made and entered into on 1-14-2019 by and between the **Kern River Groundwater Sustainability Agency** ("KRGSA") and **Greenfield County Water District** a Groundwater Sustainability Agency ("Greenfield"), each a "Party" and collectively the "Parties."

WHEREAS, the KRGSA was formed pursuant to a Memorandum of Understanding ("KRGSA MOU") by and between the City of Bakersfield, Kern Delta Water District, and Kern County Water Agency on behalf of its Improvement District No. 4 ("KRGSA MOU Parties") and is the exclusive groundwater sustainability agency for a portion of the Kern Subbasin (Department of Water Resources basin # 5-022.14); and

WHEREAS, the KRGSA has retained one or more consultants to prepare a groundwater sustainability plan ("GSP") for the area within the KRGSA boundaries ("KRGSA GSP") pursuant to the Sustainable Groundwater Management Act ("SGMA"); and

WHEREAS, Greenfield is also an exclusive groundwater sustainability agency for a portion of the Kern Subbasin (Department of Water Resources basin # 5-022.14); and

WHEREAS, the entirety of the geographic area encompassed by Greenfield's boundaries is encircled by the KRGSA's boundaries; and

WHEREAS, Greenfield has requested to participate in and coordinate with the KRGSA in the preparation and implementation of the KRGSA GSP with the intent that the KRGSA GSP will include both KRGSA and Greenfield lands; and

WHEREAS, KRGSA is willing to allow Greenfield to participate in the preparation and implementation of the KRGSA GSP upon the terms and conditions hereinafter stated.

NOW, THEREFORE, incorporating the above recitals herein, it is mutually understood and agreed as follows:

1. <u>EXPANDED KRGSA GROUNDWATER SUSTAINABILITY PLAN</u>:

   1.1 The KRGSA will continue with the preparation of the KRGSA GSP, and will expand such GSP to include the area located within the existing Greenfield GSA boundaries ("Greenfield GSA Area"), as depicted on Exhibit A, and as such area may be amended from time to time. Greenfield will timely provide all necessary information and data to the KRGSA and its consultants, and cooperate in the preparation of such GSP.

1.2 Outreach activities undertaken in the preparation and adoption of the KRGSA GSP shall include those persons or entities designated by Greenfield as "interested parties" under SGMA.

1.3 All KRGSA GSP preparation, maintenance, and updating costs attributable to inclusion of the Greenfield GSA Area (including but not limited to plan preparation, modeling, and outreach costs) shall be paid by Greenfield, such costs to be allocated between Greenfield and KRGSA on a per-acre basis (Greenfield GSA gross acreage area in relation to the entire KRGSA gross acreage area). Payment shall be due upon invoicing and payable within thirty (30) days thereof.

1.4 Greenfield shall have timely access to all non-privileged drafts, reports, technical information, and other materials and communications, and an ability to be actively engaged in all open meetings related to the preparation, review, adoption, and implementation of the KRGSA GSP.

1.5 Adoption of the KRGSA GSP shall be determined by the KRGSA MOU Parties, pursuant to the KRGSA MOU. Greenfield shall separately consider whether to adopt the KRGSA GSP.

1.6 Greenfield is responsible for implementing the KRGSA GSP within the Greenfield GSA Area. The KRGSA is responsible for implementing the KRGSA GSP within its Area.

2. <u>DECISION-MAKING PROCESS</u>: All actions and decisions regarding KRGSA GSP preparation and adoption shall be made by KRGSA MOU Parties, pursuant to the KRGSA MOU. This MOU shall at no time be construed to modify, alter, or amend the KRGSA MOU.

3. <u>GROUNDWATER SUSTAINABILTY PLAN COORDINATION</u>: The KRGSA GSP shall be coordinated with other Kern County Basin groundwater sustainability plans through the KRGSA.

4. <u>GENERAL PROVISIONS</u>:

4.1 This MOU shall remain in effect unless terminated by either Party in writing or as allowed by State law.

4.2 This MOU may only be amended by a subsequent writing, approved and signed by all Parties.

4.3 No Party, nor any officer or employee of a Party, shall be responsible for any damage or liability occurring by reason of anything done or omitted to be done by another Party under or in connection with this MOU.

APPROVED AS TO CONTENT
KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

By: ______________________
RODNEY PALLA, Board Chair

Date: 1/10/2019

APPROVED AS TO FORM
KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

By: Virginia Gennaro

Date: 1/10/2019

APPROVED AS TO CONTENT
GREENFIELD COUNTY WATER DISTRICT

By: ______________________
ALEX ALVARADO, Board President

Date: 1/14/19

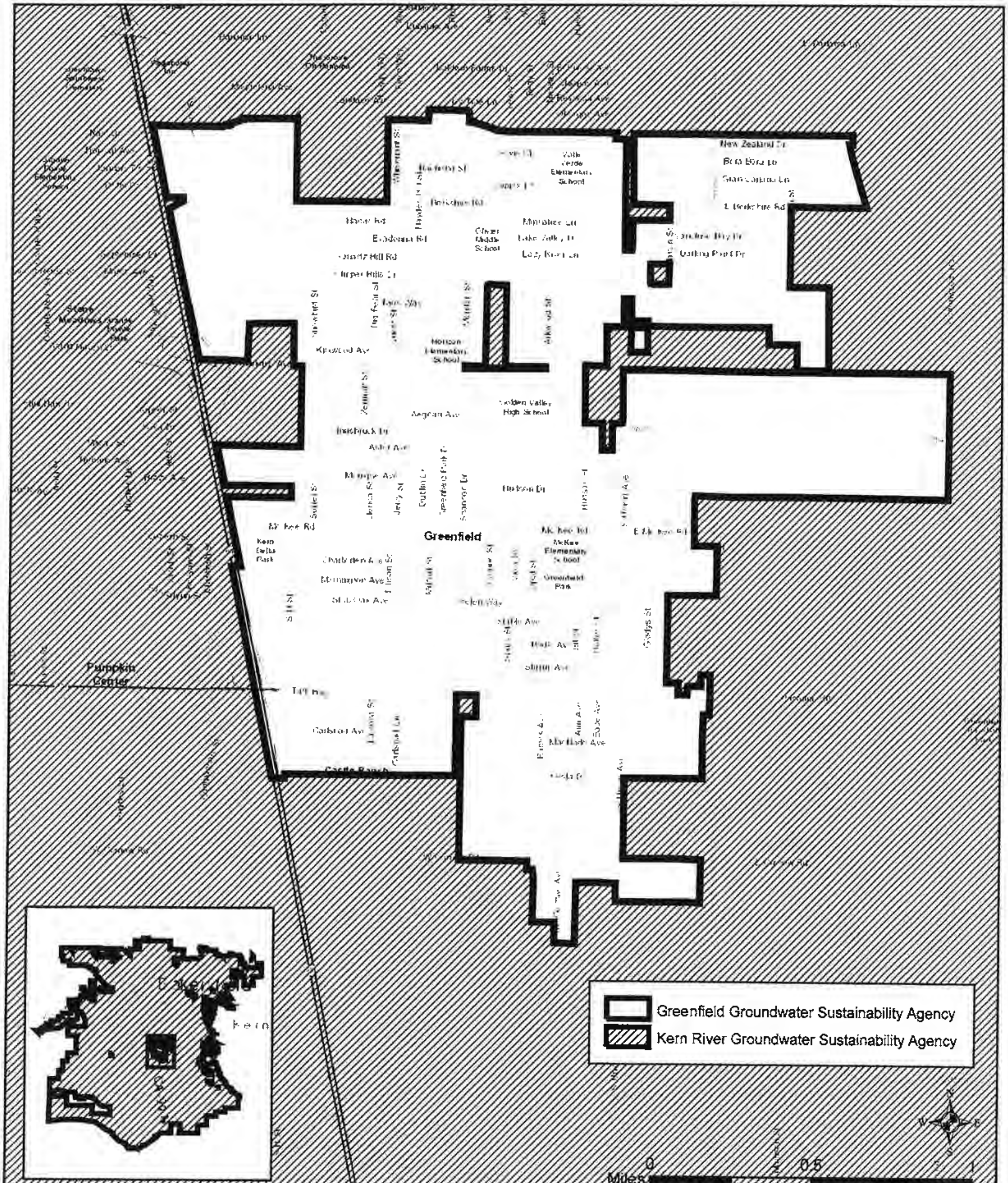
APPROVED AS TO FORM
GREENFIELD COUNTY WATER DISTRICT

By: ______________________
ROBERT G. KUHS, District Counsel

Date: 1-14-2019

Greenfield Groundwater Sustainability Agency

Kern River Groundwater Sustainability Agency
Memorandum of Understanding Exhibit A



Kern County
Agt.# 1138-2016

MEMORANDUM OF UNDERSTANDING
RE PARTICIPATION IN
KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Agreement No. KRGSA16-003
Approved Dec 1, 2016

THIS MEMORANDUM OF UNDERSTANDING is made as of DEC 06 2016 (Effective Date) by and among the **County of Kern** (County) and the **Kern River Groundwater Sustainability Agency** (KRGSA), collectively the "Parties", each of whom agree as follows:

RECITALS

A. On or about March 30, 2016, certain entities entered into Agreement 16-048 entitled "Memorandum of Understanding Forming the Kern River Groundwater Sustainability Agency" (MOU).

B. On or about April 12, 2016, the KRGSA filed a notice of determination to become a GSA with the Department of Water Resources (DWR), which notice was posted by DWR on April 21, 2016.

C. On or about July 20, 2016, the County filed a notice of determination to become a GSA which created an overlap with the KRGSA causing both notices to be suspended pending resolution of the overlap.

D. The Parties now desire to resolve the overlap by (i) having the County withdraw its notice of determination to become a GSA with respect to lands within the boundaries of the proposed KRGSA and (ii) having the County join the KRGSA as a non-voting "additional entity", all upon the terms and conditions hereinafter stated.

MEMORANDUM

1. County agrees to withdraw its notice of determination to become a GSA with respect to lands within the boundaries of the proposed KRGSA.

2. County has jurisdiction over certain lands within the Kern County Sub-basin which the County may wish to designate for inclusion within the boundaries of the KRGSA. The KRGSA will consider inclusion within the boundaries of the KRGSA of the lands designated by the County and, if included, such lands shall be subject to the MOU, the KRGSA Bylaws, and any rules or regulations of the KRGSA heretofore or hereafter adopted or amended.

3. County hereby commits to participate in the KRGSA as a non-voting "additional entity". County participation as a non-voting "additional entity" is conditioned on the following assurances provided by the KRGSA:

   a. <u>Indemnification</u>: If the County is asked by the KRGSA to use the County's police powers for a specific purpose for the KRGSA, then the KRGSA shall indemnify the County against liability for the exercise of its police powers.

   b. <u>Land Use Powers</u>: The KRGSA and its participants agree, and the GSP will provide, that nothing in the GSP or any actions taken by the KRGSA, shall modify, limit or preempt the County's police powers, including its land use authority. On the other hand, the County does

AGENCY
ORIGINAL

not intend to designate or zone a specific project with an expectation that the KRGSA will provide more water allotment than that which is determined by the GSP allotment and policies.

c. <u>White Lands</u>: The KRGSA will manage "white lands" included within its boundaries if requested to do so by the County.

d. <u>Well Permits</u>: Well permitting is under the County's jurisdiction and should remain so. The KRGSA will not transform the well-permitting process from a ministerial function (which does not trigger CEOA) to a discretionary function (which triggers CEOA) without prior consultation with the County. If the GSP or the KRGSA shall cause CEQA to be triggered with respect to well permitting. KRGSA shall indemnify County against liability, costs and attorney's fees awarded to petitioner(s) in any CEQA challenge to well permitting.

e. <u>Water Transfers</u>: Water transfers within the basin are essential to economic stability and future development opportunities. The KRGSA will consider this position when assessing its water transfer policy in the GSP. Further, the KRGSA does not intend to restrict use of water within its boundaries to a specific use.

f. <u>Unincorporated Communities</u>: The needs and water resources of unincorporated communities will be considered and addressed in the GSP.

g. <u>JPA v. MOU</u>: It is understood that the development and implementation of the GSP does not require the joint exercise of powers among the Parties and, therefore, formation of a JPA is unnecessary. The Parties will form a JPA if and to the extent legally mandated.

h. <u>Participation</u>: The KRGSA will ensure that all additional agencies (including the County) will have a continuous opportunity to participate in the preparation, review, and adoption of the GSP. The term "participate" in this context means access to all non-privileged drafts, reports, technical information, and other materials and communications, and an ability to be actively engaged in all open meetings related to the preparation, review, and adoption of the GSP. "Actively engaged" means as a signatory to the MOU (i.e., an "additional agency") and more than as a member of the general public.

i. <u>Oil & Gas</u>: The KRGSA will cooperate with the County, the oil and gas industry, and the State Department of Water Resources to preserve and protect available water supplies. Additionally, the GSP may incorporate current adopted mitigation measures found in the Oil and Gas Environmental Impact Report approved by the Board of Supervisors as a means to address best management practices and related GSA oil and gas concerns.

APPROVED AS TO CONTENT:	APPROVED AS TO CONTENT:
COUNTY OF KERN	**KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY**
By: ______________________	By: ______________________
MICK GLEASON, Board Chair	**RODNEY PALLA**, Board Chair
DATE: DEC 06 2016	DATE: Dec. 1 2016

APPROVED AS TO FORM
Office of County Counsel
Kern County
By: ______________________

AGENCY ORIGINAL

KRGSA
Agreement No. 16-003(A)
Approved June 6, 2019

KERN RIVER GSA

Rodney J. Palla, Chair
Bob Smith
Gene Lundquist

June 14, 2019

Mr. Alan Christensen
Chief Deputy CAO
County Administrative Office
1115 Truxtun Avenue, Fifth Floor
Bakersfield CA, 93301-4639

Dear Mr. Christensen:

This letter is in response to your June 4, 2019 letter (enclosed) to the Kern River Groundwater sustainability Agency (KRGSA), in which you requested the KRGSA manage certain non-districted areas (white lands) within the current boundaries of the KRGSA.

As you referenced in your letter, the December 6, 2016 Memorandum of Understanding (MOU) between the County of Kern and the KRGSA (enclosed) includes the following language:

> 2. *County has jurisdiction over certain lands within the Kern County Sub-basin which the County may wish to designate for inclusion within the boundaries of the KRGSA. The KRGSA will consider inclusion within the boundaries of the KRGSA of the lands designated by the County and, if included, such lands shall be subject to the MOU, the KRGSA Bylaws, and any rules or regulations of the KRGSA heretofore or hereafter adopted or amended.*
>
> *3c. White Lands: The KRGSA will manage "white lands" included within its boundaries if requested to do so by the County.*

The KRGSA Board of Directors recently approved the County's request and this letter serves as confirmation that the KRGSA will manage and monitor the "white land" areas within the boundaries of the KRGSA (see areas outlined in red on the enclosed map), pursuant to the MOU. It is the view of the KRGSA that the existing MOU with the County provides for this inclusion and management activity and no further agreement is necessary. Please provide the County's concurrence by returning a signed copy of this letter to the KRGSA so we may proceed accordingly.

Sincerely,

Rodney Palla -Chair
Kern River Groundwater Sustainability Agency

Enclosures

On Behalf of the County of Kern

APPENDIX D

Kern County Groundwater Subbasin Coordination Agreement

APPENDIX E

Kern County Groundwater Subbasin Coordination Agreement

APPENDIX F

KRGSA Communication and Engagement Plan for the Sustainability Plan

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

COMMUNICATION AND ENGAGEMENT PLAN FOR THE GROUNDWATER SUSTAINABILITY PLAN

AUGUST 2019

DRAFT

COMMUNICATION AND ENGAGEMENT PLAN FOR THE GROUNDWATER SUSTAINABILITY PLAN

Prepared for:

Kern River Groundwater Sustainability Agency
City Hall North
1600 Truxtun Avenue
Bakersfield, CA 93301
KernRiverGSA.org

Contact Persons:
Art Chianello, City of Bakersfield
David Beard, Kern County Water Agency Improvement District No. 4
Mark Mulkay, Kern-Delta Water District

Consultants:

Horizon Water and Environment
Contact: Ken Schwarz
Phone: (510) 986-1851

Quad Knopf, Inc.
Contact: Ken Bonesteel
Phone: (661) 616-2600

August 2019

Table of Contents

Appendices

List of Figures

List of Tables

ACRONYMS AND ABBREVIATIONS

CGC	California Government Code
City	City of Bakersfield
Communication Plan	*Communication and Engagement Plan for the Groundwater Sustainability Plan*
CWC	California Water Code
DAC	Disadvantaged Community
Draft Strategic Plan	*Sustainable Groundwater Management Plan DRAFT Strategic Plan*
DWR	Department of Water Resources
GSA	Kern River Groundwater Sustainability Agency
GSP	Groundwater Sustainability Plan
ID4	Improvement District No. 4
KCWA	Kern County Water Agency
KDWD	Kern-Delta Water District
KRGSA	Kern River Groundwater Sustainability Agency
MOU	Memorandum of Understanding
NOD	*Notice of Decision to Become a Groundwater Sustainability Agency*
NOI	Notice of Intent
Plan	*Communication and Engagement Plan for the Groundwater Sustainability Plan*
Regulations Guide	*Sustainable Groundwater Management Program Groundwater Sustainability Plan (GSP) Emergency Regulations Guide*
SGMA	Sustainable Groundwater Management Plan
Subbasin	Kern County Subbasin (No. 5-22.14)

SECTION 1. INTRODUCTION

The Sustainable Groundwater Management Act (SGMA) became state law in 2015 and requires that important groundwater basins in California be managed sustainably. Local groundwater sustainability agencies (GSAs) are empowered to develop groundwater sustainability plans (GSPs) that establish a basic understanding of groundwater resources in the basin and describe the planning and management actions that are being implemented so that undesirable results are avoided through the active management of the basin. SGMA requires that all basins designated as high- or medium-priority basins subject to critical overdraft conditions are to be managed under a GSP or coordinated GSPs (California Water Code [CWC] Section 10720.7). The Kern County Subbasin is a high-priority basin and is identified as having critical overdraft conditions.

This introductory section of the Communication and Engagement Plan (Communication Plan or Plan) introduces the Kern River Groundwater Sustainability Agency (KRGSA), the development of its GSP, and summarizes the purpose of this Communication Plan within the GSP framework. This section also describes the regulations and requirements of the SGMA that pertain to public outreach and receiving stakeholder input and introduces the geographic scales (tiers) used to organize this Plan. This section also summarizes the categories of interested parties from which the KRGSA is soliciting input during GSP development, and outlines the outreach efforts for various interested parties.

1.1. Kern River Groundwater Sustainability Agency Overview

Per California Water Code (CWC) Section 10723.8(a), the City of Bakersfield (City), Kern-Delta Water District (KDWD), and Improvement District No. 4 (ID4) of the Kern County Water Agency (KCWA) formed the KRGSA for a portion of the Kern County Subbasin (No. 5-22.14) (Subbasin) as defined in Department of Water Resources (DWR) Bulletin 118 (California Department of Water Resources, 2003) within the San Joaquin Valley Groundwater Basin.

On March 1, 2, and 31 of 2016, the KDWD Board of Directors (Board), City of Bakersfield City Council, and KCWA Board, respectively, held public hearings per CWC Section 10723(b) regarding formation of the KRGSA. On March 15, 2016, the KDWD Board passed Resolution 2016-03 wherein the District resolved to become a GSA in cooperation with the City and ID4. On March 30, 2016, the City Council passed Resolution 039-16 wherein the City resolved to become a GSA in cooperation with KDWD and ID4. On March 31, 2016, the KCWA Board passed Resolution 11-16 wherein ID4 resolved to become a GSA in cooperation with the KDWD and the City. The noticing processes for KDWD, the City, and ID4 were consistent with the requirements of California Government Code (CGC) Section 6066.

A Memorandum of Understanding (MOU) was developed between the City, KDWD, and ID4 to form the KRGSA and manage groundwater resources sustainably within the GSA boundary. This MOU includes the following additional participating agencies that have joined the KRGSA:

- East Niles Community Services District
- Oildale Mutual Water Company / North of the River Municipal Water District

The following private entities are also participating in the KRGSA:

- California Water Service Company
- Vaughn Water Company

In April 2016, the newly formed KRGSA submitted a notification and supporting materials to the California Department of Water Resources (DWR) describing the forming of the KRGSA. DWR posted the KRGSA Notice on its website on April 21, 2016. The KRGSA Notice underwent the 90-day noticing period, which was interrupted for a few months while the KRGSA clarified and removed some small boundary overlaps with the County of Kern's GSA. The KRGSA became an exclusive GSA in February 2017.

1.2. Communication and Engagement Plan Goals and Purpose

The purpose of this Communication and Engagement Plan is to:

- Describe the process by which the KRGSA engages with the community and stakeholders to inform them of the GSP development process and provide a basis to receive input from the community regarding the GSP;
- Provide a basis to document and demonstrate how the KRGSA communicated with and engaged stakeholders throughout the development of the GSP;
- Comply with SGMA communication and engagement guidance and requirements;
- Provide a basis to share with the public the KRGSA's governance and decision-making process, and methods for disseminating information;
- Serve as the "communications section" of the GSP;
- Demonstrate compliance with SGMA requirements for communication and public engagement; and
- Be a living document throughout the GSP development process to serve the KRGSA's needs for communication and engagement.

1.3. SGMA Requirements and Guidance for Outreach

Per CWC Section 10723.2, GSAs shall consider the interests of all beneficial uses and users of groundwater within their service area as well as those responsible for implementing GSPs.

A core component to developing a GSP is communication and engagement. As stated in the *Sustainable Groundwater Management Plan Draft Strategic Plan* (Draft Strategic Plan) (California Department of Water Resources, 2015):

> *Successful implementation [of the GSP] is directly tied to effective communication and outreach, in addition to coordination at all levels of government…In addition to communication, proactive outreach to and engagement of partners and stakeholders is essential to achieving sustainable groundwater management at the local and regional level. Local and regional agencies in turn must reach out to keep local citizens, groundwater users, and stakeholders informed. Adaptive, practical, and two-way communication is essential to establishing and maintaining the partnerships needed. This section of the Strategic Plan provides an overview of DWR's initial plan for communication, outreach, and coordination with partners. The key audiences for this effort include:*
>
> - *<u>State, Federal and Tribal Governments</u> – Governor's Administration, Legislature and key state and federal agencies, tribes*
> - *<u>Regional and local governments and agencies</u> – Water and groundwater management agencies and districts; land use entities such as counties and cities*
> - *<u>Other stakeholders</u> – Non-governmental organizations including water and groundwater, environmental, environmental justice, agriculture; universities*
> - *<u>General public</u> – Residents, employers, and employees who live and/or work within the KRGSA boundaries*

The Draft Strategic Plan (California Department of Water Resources, 2015) describes how "communication" provides for continuous sharing of information on all aspects of SGMA implementation. DWR envisions that proactive, regular, and timely communication enable the following benefits to be developed between GSAs and their communities. The Draft Strategic Plan highlights that GSAs should:

- <u>Engage</u> – Seek and maintain collaboration and cooperation with other agencies and stakeholders, and solicit and encourage public participation in SGMA implementation
- <u>Educate</u> – Educate stakeholders, water users, and citizens on the requirements of the SGMA and water management sustainability objectives, and DWR's role in its implementation, relative to other State agencies

- Provide Accessibility – Provide easy access to informative materials, data, reports and DWR's technical experts

- Demonstrate Accountability – Measure and report on progress and accomplishments in implementing the SGMA and provide transparency about DWR's implementation activities

The Draft Strategic Plan (California Department of Water Resources, 2015) also provides that "outreach" is critical to successful implementation of the SGMA. Outreach, stakeholder and public engagement, and interaction through the GSP development process fosters proactive interaction of information, ideas, and the opportunity for a two-way exchange. The GSP Emergency Regulations Guide (Regulations Guide) (California Department of Water Resources, 2016), describe that a GSP must include a "communications section" for identifying and engaging the public stakeholders. This section should be developed as one of the first priorities of the plan (California Department of Water Resources, 2016).

GSP Regulations (Section 354.10) require a communications section to include the following:

1. An explanation of the GSA's decision-making process.

2. Identification of opportunities for public engagement and a discussion of how public input and response will be used.

3. A description of how the GSA encourages active involvement of diverse social, cultural, and economic elements of the population within the basin.

4. The method the GSA shall follow to inform the public about progress implementing the Plan, including the status of projects and actions.

DWR released additional draft guidance documents for engagement and communication, including a Guidance Document for Groundwater Sustainability Plan – Stakeholder Communication and Engagement (C&E Guidance Document) (California Department of Water Resources, January 2018). The C&E Guidance Document describes how a GSP could meet public notification and engagement requirements in order to comply with the SGMA and GSP regulations. However, the C&E Guidance Document provides that GSAs have discretion on how they communicate and engage with beneficial uses and users of water within the basin.

During the adequacy review of the GSP, DWR will assess:

1. Whether 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 been considered; and

2. Whether the GSA or local agency has adequately responded to comments that raise credible technical or policy issues with the GSP or alternative.

This Communication Plan has been developed to follow and comply with the communication guidance of the Draft Strategic Plan, criteria and requirements of the SGMA Regulations Guide, and more recent guidance provided in the C&E Guidance Document as described above.

1.4. Geographic Scales of the Communication and Engagement Plan

The implementation of this Communication and Engagement Plan requires coordination and/or outreach at multiple geographical scales, ranging from topics of statewide attention to issues focused within the KRGSA service area. More specifically, these geographic zones are considered as follows:

- Engagement Within the KRGSA Service Area –The boundary of the KRGSA service area is nested within the greater Kern County Subbasin boundary. The KRGSA conducts more specific outreach directly to interested parties within the KRGSA service area to explain the GSA formation and GSP development process, receive feedback on these processes, and understand better the needs and concerns of the interested parties, stakeholders, and community members within the KRGSA service area.

- Engagement Across Kern County Subbasin – The KRGSA actively participates in outreach and planning activities, information exchanges, and coordination within the boundary of the Kern County Subbasin. This includes leadership and coordination for technical studies including groundwater model development for the benefit of the entire Kern County Subbasin. The KRGSA also participates in GSP coordination activities with multiple GSAs and other parties throughout the Kern County Subbasin. These activities provide the basis for the future coordination and alignment of multiple GSPs within the Kern County Subbasin.

- Engagement Outside Kern County Subbasin Boundary – The KRGSA participates in outreach and planning activities, information exchanges, and coordination with parties outside of the Kern County Subbasin including participating in statewide forums and providing technical documents for the benefit of other California GSAs.

The Kern County Subbasin and KRGSA boundaries are shown in Figures 1-1 and 1-2, respectively.

--- FOR OFFICIAL USE ONLY ---

Kern River Groundwater Sustainability Agency (GSA)

Adopted GSA Boundary Within Subbasin 5-22.14 of the Tulare Lake Hydrologic Region

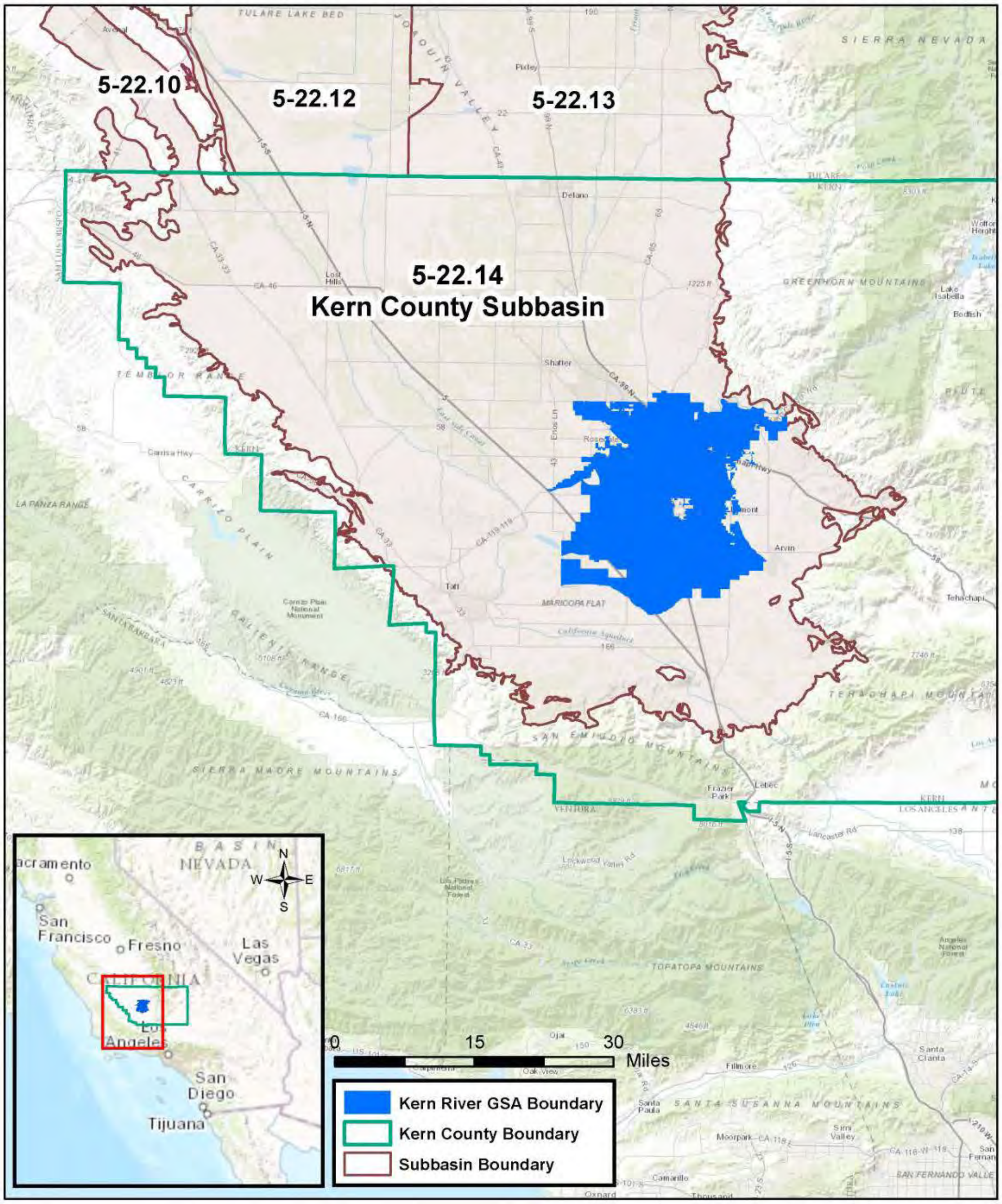


Figure 1-1
Kern County Subbasin Boundary

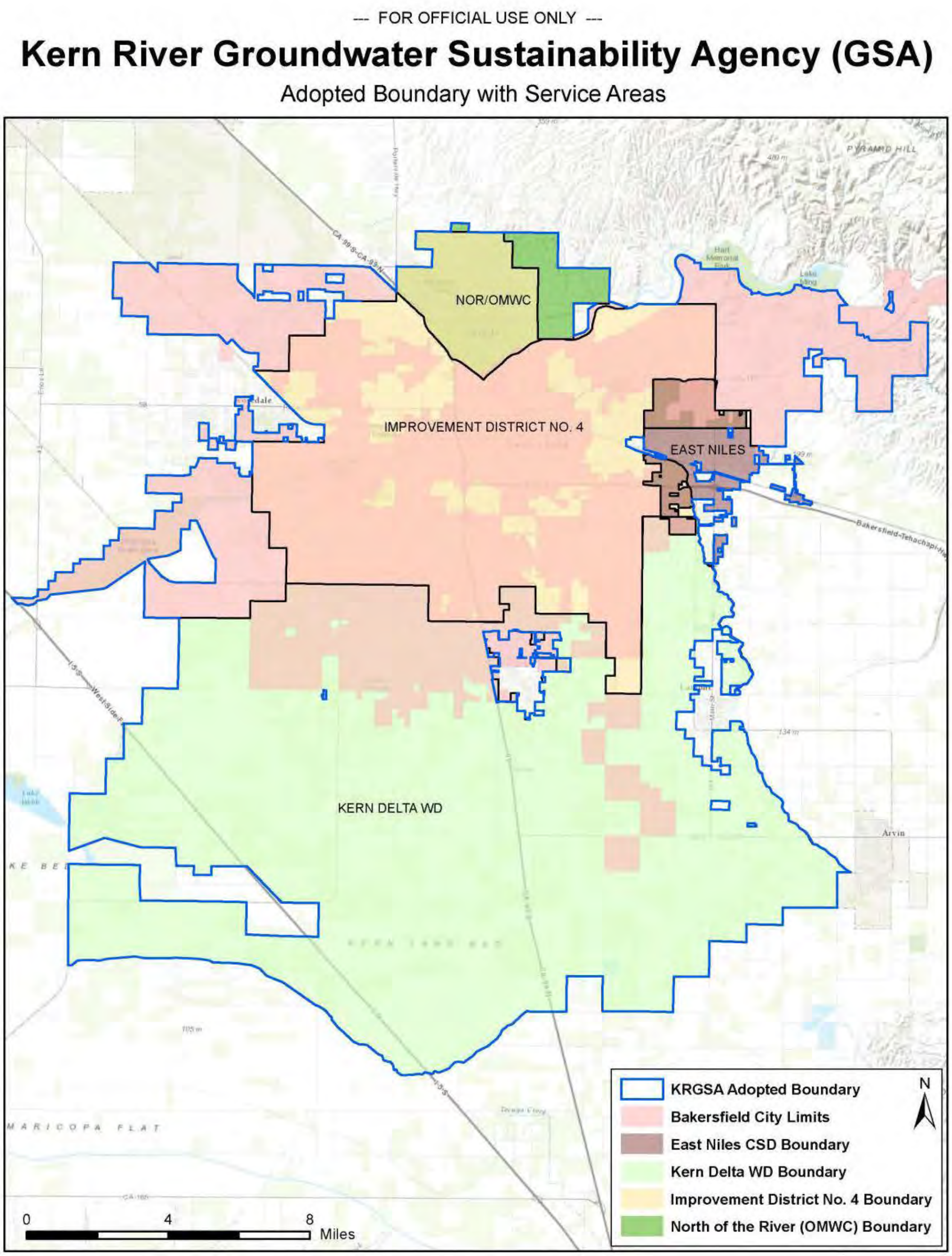


Figure 1-2
KRGSA Boundary

1.5. Overview of Interested Parties

Pursuant to CWC Section 10723.2, a GSA shall consider the interests of all beneficial uses and users of groundwater, as well as those responsible for implementing GSPs. The following list includes the categories of interested parties that have been identified for potential outreach by the KRGSA pursuant to CWC Section 10723.2:

- Holders of overlying groundwater rights, including:
  - Agricultural users and
  - Domestic well owners;
- Municipal well operators;
- Public water systems;
- Local land use planning agencies;
- Environmental users of groundwater;
- Surface water users;
- Federal government;
- California Native American tribes;
- Disadvantaged communities;
- Groundwater monitoring and reporting entities; and
- Specific interested parties requesting information and communication from KRGSA.

A complete list of interested parties is provided in Appendix A. More specific information regarding the KRGSA's approach to engaging with interested parties is described in Sections 3, 4, and 5 below.

1.6. Notification of Intent to DWR

On May 19, 2017, the KRGSA sent DWR a notification of intent (NOI) to a develop a GSP pursuant to CWC Section 10727.8. In general, the NOI outlines the KRGSA communication and engagement efforts to date and briefly discusses efforts that are planned in the future. The NOI sent to DWR is provided in the GSP.

SECTION 2. KRGSA ORGANIZATION AND GOVERNANCE

The governance and management of the KRGSA occurs through 4 primary units:

1. Board of Directors – One representative each from the City of Bakersfield, the Kern Delta Water District (KDWD), and Kern County Water Agency's Improvement District 4 (ID4). The Board of Directors serves as the executive decision-making body of the KRGSA.

2. Participating Agencies – East Niles Community Services District, Oildale Mutual Water Company/North of the River Municipal Water District, California Water Service Company, and Vaughn Water Company are participating agencies in the KRGSA.

3. Management Group – A representative from each of the MOU signatory agencies of the KRGSA (City of Bakersfield, Kern Delta Water District, and Improvement District #4 – Kern County Water Agency) manages the day-to-day ongoing tasks that the KRGSA conducts, including: developing the GSP, coordinating with partner agencies across the Kern County Subbasin, managing consultants, and conducting outreach efforts within the KRGSA service area.

4. Legal Counsel – An attorney from each of the each of the MOU signatory agencies of the KRGSA (City of Bakersfield, Kern Delta Water District, and Improvement District #4 – Kern County Water Agency) guides the KRGSA on legal topics.

In terms of governing actions and decision-making, under the *Notice of Decision to Become a Groundwater Sustainability Agency,* the KRGSA may:

1. Adopt Standards for measuring and reporting water use,

2. Develop and implement policies designed to reduce or eliminate overdraft within the boundaries of the GSA,

3. Develop and implement conservation best management practices; and

4. Develop and implement metering, monitoring, and reporting related to groundwater pumping.

In addition, the MOU signatory agencies of the KRGSA have the decision-making power necessary to meet SGMA requirements, including the development and implementation of a GSP within the KRGSA boundaries. According to the MOU creating the KRGSA, it is the intent that all implementation actions occur following unanimous agreement by the signatory agencies. In order to properly conduct these responsibilities and decision-making processes, the parties meet regularly to discuss SGMA and GSP development and implementation activities, including this Communication & Engagement Plan. Decision-making occurs at routine KRGSA board and management team meetings. A list of these meetings can be found in Appendix B.

The KRGSA routinely decides how it will coordinate with partner agencies across the Kern County Subbasin and consultants to conduct the coordination and technical studies needed to develop the GSP. Activities to support the GSP objective include conducting coordination meetings, technical workshops, model development, data analysis, and other communication and engagement services within the KRGSA.

SECTION 3. COMMUNICATION AND ENGAGEMENT WITHIN KRGSA SERVICE AREA

The following section discusses KRGSA's outreach within the KRGSA service area.

3.1. KRGSA Website

The KRGSA has developed a website (kernrivergsa.org) that provides information about the Agency, including its history, current Board members, and contact information. The website is also a repository of resources and documents such as the KRGSA bylaws, the agency's notification package to the DWR for its formation, applicable geographical information system (GIS) shapefiles, and Board agendas and meeting minutes. The website also has a tab where a party can request inclusion in, and information regarding, KRGSA matters.

3.2. Public Meetings and Workshops

The KRGSA has held public meetings and workshops throughout the development of the GSP. A list of regularly scheduled board meetings can be found in Appendix B. In addition, KRGSA agendas and minutes for regular Board meetings can be found on the "Board Members" tab of the KRGSA website at www.kernrivergsa.org/?page_id=79. KRGSA also holds special meetings and workshops approximately every quarter during the GSP development process. Appendix C lists the public meetings and workshops held by the KRGSA.

The public meetings and workshops have varied in their location, timing, and content, but each served to meet the SGMA's requirements of ensuring that (1) 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 been considered, and (2) the GSA has adequately responded to comments that raise credible technical or policy issues with the GSP.

The interested parties listed in Appendix A are invited to KRGSA meetings and workshops and are also notified of all public meetings and workshops once they formally request such notifications.

3.2.1. KRGSA TECHNICAL GROUNDWATER WORKSHOPS

During the development of the KRGSA's GSP, the Agency has held several technical workshops to guide the GSP development process. The schedule for these workshops is identified in the General Schedule provided in Appendix C. Appendix D provides presentation materials for KRGSA meetings and workshops. KRGSA-sponsored technical workshops are listed below:

- Groundwater Supply Workshop – July 13, 2017
- C&E Workshop – General Public and DAC Workshop – September 2017
- C2VSim Modeling Workshop – November 2017

- Basin Setting Workshop – January 2018
- Hydrogeology Modeling/Groundwater Conditions Workshop – April 2018
- Kern County Subbasin Water Budget Workshop – June 2018
- General Public and DAC Workshop – August 2018
- General Public and DAC Workshop – November 2018
- Interested Parties Workshop – March 2019
- Groundwater Technical Workshop – April 2019
- Draft GSP Presentation – August 2019
- General Public and DAC Workshop – October 2019
- General Public and DAC Workshop – November 2019

3.2.2. GENERAL COMMUNITY ENGAGEMENT WORKSHOPS

During the development of the KRGSA's GSP, the Agency held several community workshops to solicit input and feedback on the GSP development process. The schedule for these workshops is identified in the General Schedule provided in Appendix C. Appendix D provides presentation materials for KRGSA meetings and workshops.

3.3. General Outreach and Audience Mapping

Pursuant to SGMA requirements, the KRGSA conducted extensive audience outreach and audience mapping to better understand the KRGSA's constituency as part of developing this Communication & Engagement plan. This process included directly contacting and surveying potentially interested parties within the KRGSA's boundaries. DWR's Draft Communication and Engagement Plan (2017), provides guidance that GSA's should include the following audiences for outreach, as interested parties to the GSA/GSP, as applicable:

- State, Federal, and Tribal Governments
- Regional and local governments and agencies
- Other stakeholders
- Disadvantaged Communities (DACs)
- General public

Section 3.3.1 describes the steps taken to conduct thorough, targeted outreach to the aforementioned interested parties.

3.3.1. OUTREACH FOR INTERESTED PARTIES

Under the SGMA, the KRGSA should conduct outreach to the interested parties in its service area. The KRGSA conducted initial outreach by utilizing water service records to contact parties identified as interested stakeholders, including service providers and registered groundwater users. This process included, where possible, direct phone calls and emails notifying parties about KRGSA activities including workshops, public meetings, and other events. The targeted outreach effort also collected primary contact information from interested parties. Data collected includes names, phone numbers, email addresses, and organizational information. This data enables efficient and targeted sharing of pertinent information in the future.

Interested parties are also engaged through additional communication and engagement efforts happening at the Kern County Subbasin scale. Table 3-1 describes what type of outreach effort has been conducted for the different interested party categories.

Table 3-1
Outreach Effort Approach for Interested Party Categories

Interested Party Category	Outreach Approach		
	KRGSA Service Area	Kern County Subbasin	
		GSP and Management Coordination with Other GSAs	Technical Studies and Coordination
Agricultural users[1]	X	X	
Domestic well owners[1]	X	X	
Municipal well operators[2]	X		X
Public water systems[2]	X		X
Local land use planning agencies[1]	X	X	
Environmental users of groundwater[3]	X		
Surface water users	X		X
Disadvantaged communities[3]	X		
Groundwater monitoring and reporting entities[2]	X		X

[1]For large agricultural users and well owners outside of the KRGSA - some outreach and coordination may be needed if the other GSA is developing goals, policies, and implementation measures applicable to a large area that may potentially also affect the KRGSA.
[2]Some operators and systems are tasked with monitoring and maintaining water use records and may have valuable input on technical studies or cross-subbasin coordination.
[3]Outreach with these parties is specific to the KRGSA service area.

In the *Notice of Decision to Become a Groundwater Sustainability Agency* (NOD) (Kern River Groundwater Sustainability Agency, 2016), the KRGSA determined that there are no known lands owned or operated by the federal government within the GSA. Therefore, this interested party category is excluded from further consideration in this Communication Plan. Additionally, the NOD determined that there are no known lands owned or operated by California Native American tribes within the GSA and therefore, this interested party category is also excluded.

GSP communication and engagement must include outreach to Disadvantaged Communities (DACs) in the GSA service area. Serving the needs of low-income communities is a high priority for DWR to ensure that such communities receive due consideration in the development of GSPs. There are several DACs within KRGSA boundaries and this C&E Plan specifically included efforts to reach these communities. More information about measures used to engage the DACs in the KRGSA service area included in Section 3.5. Appendix A lists the DACs in the KRGSA service area and provides a map of their locations by census block.

3.3.2. INTERESTED PARTIES AND INDIVIDUALS REQUESTING INFORMATION

In addition to the interested parties discussed above, the KRGSA received correspondence from specific interested parties and individuals requesting that they receive information (e.g., notices, meeting announcements, documents) related to the development of the GSP. Appendix A provides information about these additional interested parties and individuals.

3.4. Targeted Meetings with Interested Parties

In addition to roughly quarterly public meetings and workshops, the KRGSA also held a series of targeted meetings with various interested parties to provide updates on the GSP development process and to receive specific input on their interests for the GSP. These targeted meetings were designed to inform targeted parties of KRGSA activities while providing a more personal forum to gather information and communicate with interested parties. Appendix E lists the targeted meetings held by the KRGSA.

All interested parties and individuals listed in Appendix A that requested to be notified of GSA activities were also notified of future targeted meetings once they formally requested such notifications.

3.5. Outreach to Disadvantaged Communities

The California Department of Water Resources places a high priority on the inclusion of disadvantaged communities in Groundwater Sustainability Plan development. There are two main classifications: Disadvantaged Communities (DAC) and Severely Disadvantaged Communities (SDAC). California defines a DAC as "a community with an annual median household income that is less than 80 percent of the Statewide annual median household income" (Water Code §79505.5). California defines an SDAC as "a community with an annual median household income that is less than 60 percent of the Statewide annual median household income" (Water Code § 79702(v)). These communities, widely dispersed throughout California and the Kern County Subbasin, are especially sensitive to groundwater overdraft and decreases in local water quality such as that in the KRGSA Service Area.

As part of the targeted engagement approach, the KRGSA has engaged Self Help Enterprises to assist in reaching out to and facilitating meetings with specifically targeted DACs or SDACs within the KRGSA service area that are mapped as such according to the state guidelines. A list of Disadvantaged and Severely Disadvantaged Communities that were identified for outreach can be found in Appendix A, and Figure A-1 identifies locations of these DACs by Census Tract within the KRGSA service area.

Meetings targeted toward informing and gathering the input of DACs and SDACs have been held at the following locations:

- August 20, 2018 – Fruitvale-Norris Park Recreation Room, 6221 Norris Road, Bakersfield, CA 93308
- November 13, 2018 – Bear Mountain Recreation David Head Center, 10300 San Diego St., Lamont, CA 93241
- Additional meetings will occur in October and November 2019 to review and solicit comments on the draft GSP.

Each presentation included a general overview of the SGMA, an introduction to the establishment of the KRGSA, and technical information about development of the GSP. All informational and promotional materials, including flyers, comment cards, stakeholder surveys, and copies of the presentation, are made available in English and Spanish. A Spanish-language translator is available at all DAC meetings to assist as needed.

SECTION 4. COMMUNICATION AND ENGAGEMENT ACROSS KERN COUNTY SUBBASIN

The following section discusses KRGSA's coordination and outreach within the Kern County Subbasin.

4.1. General Kern County Subbasin Coordination and Outreach

4.1.1. Regular and Special KRGSA Board Meetings

The KRGSA Board holds regular meetings that are open and available to the public every first Thursday at 10:00 a.m. These meetings are usually located at City Hall North, 1600 Truxtun Avenue, Conference Room A, Bakersfield, CA, but occasionally have also been held at the Kern County Water Agency. The KRGSA Board also conducts special meetings to inform or discuss particular topics relevant to GSA coordination efforts or the development of the GSP. Both regular and special meetings of the KRGSA are noticed, follow an agenda, and occur under the purview of the Brown Act (Cal. Gov. Code Section 54950 *et seq.*), which governs open meetings for local government bodies. A list of KRGSA's scheduled and special meetings is found in Appendix B. The agendas, presentation materials, and meeting minutes for regular and special meetings of the KRGSA can be found on the "Board Members" tab of the KRGSA website at www.kernrivergsa.org/?page_id=79. The agenda of the most current upcoming meeting is also posted under this tab prior to the meeting and in compliance with applicable law.

4.1.2. Coordination with Kern Groundwater Authority

The Kern Groundwater Authority (KGA) provides local policy makers, stakeholders, and the public a forum to monitor, report, and discuss groundwater activities and issues in Kern County. The KGA is the largest GSA in the Kern County Subbasin and is composed of nineteen member agencies. The KGA has formed a GSA with its service area across Kern County, though its GSA boundary does not include areas that have already been designated as exclusive GSAs, such as within the KRGSA. The KGA has organized several workshops and meetings in Kern County to discuss groundwater (www.kerngwa.com/workshops) and representatives of the KRGSA have attended and participated in most of those meetings. In addition, KRGSA worked directly with KGA to prepare the SGWP Grant Application on behalf of the entire Kern County Subbasin.

The KRGSA management team sees the KGA as a valuable partner in Kern County to coordinate with on GSP development. Per SGMA requirements, the KRGSA and KGA have developed a coordination agreement to ensure that their respective GSPs are aligned and not contradictory. The KRGSA also sees the KGA as a valuable partner to coordinate with during the GSP implementation phases over the longer-term.

4.1.3. Other Subbasin Coordination

In addition to the KGA, the KRGSA has also coordinated with other GSAs in the Kern County Subbasin, including the GSAs formed by the Buena Vista Water Storage District, Greenfield County Water District, West Kern Water District, Pioneer Groundwater Recharge and Recovery Project, Olcese Water District, Henry Miller Water District, Semitropic Water Storage District, McFarland, and Cawelo Water District. The KRGSA has invited representatives of these other GSAs to its regular meetings and scheduled workshops to keep these other regional groundwater management agencies apprised of the KRGSA's planning activities. Similarly, managers from the KRGSA have participated in several meetings and workshops sponsored by these other GSAs. For example, KRGSA participated in a SGMA Roundtable meeting on October 20, 2017, with almost every GSA within the subbasin to ensure GSP compliance. Similarly, KRGSA joined many of the GSAs in the region to participate in a SGMA Open House sponsored by KGA and the Kern County Farm Bureau on May 14, 2019. Another such open house is being planned for September 26, 2019. The KRGSA is working closely with these other GSAs to develop appropriate coordination agreements to guide the implementation of the various GSPs.

4.2. Technical and Modeling Coordination and Outreach in Kern County Subbasin

The KRGSA has taken an active role in leading the Subbasin-wide groundwater modeling efforts and has provided technical expertise to the benefit of the entire Subbasin. In partnership with the KGA and other entities, the KRGSA with its groundwater consultant Todd Groundwater, is developing a Subbasin-wide groundwater–surface water numerical model based on the DWR C2VSim model, which provides a common platform for sustainability analyses by GSAs in the Kern County Subbasin. More specifically, the modeling approach that KRGSA has sponsored enables GSAs to develop Subbasin-wide water budgets in compliance with GSP regulations. The modeling framework enables the GSAs to coordinate their GSP development across the Subbasin. KRGSA's leadership in developing these shared modeling tools has assisted the Subbasin in achieving its sustainability goals. Appendix C lists the technical workshops led by the KRGSA. The interested parties identified in Appendix A are invited to attend these technical workshops. All specific interested parties and individuals found in Appendix A are also notified of future technical workshops once they formally request such notifications. Appendix D provides presentation materials for technical workshops.

SECTION 5. KRGSA COMMUNICATION AND ENGAGEMENT OUTSIDE OF SUBBASIN

The following section discusses KRGSA's leadership actions and coordination efforts outside of the Kern County Subbasin that support SGMA and provide coordination benefits across the state.

5.1. Participation in DWR Forums and Workshops Participation

The KRGSA has participated in DWR forums and workshops throughout the development of the GSP. These forums and workshops covered a variety of topics including, but not limited to, GSP preparation, coordination and outreach, and sustainable groundwater management. These forums and workshops occurred in various locations across the state, as well as in webinars. Appendix C identifies the DWR forums and workshops that the KRGSA has participated in throughout the GSP development process.

In 2017, DWR announced Proposition 1 grant funding to assist GSAs with development of their GSPs. DWR hosted a Groundwater Sustainability Plan and Projects Grant Proposal Solicitation Workshop on September 27, 2017. KRGSA and KGA participated in this workshop as the primary GSAs in the Kern County Subbasin. KRGSA and KGA submitted a grant proposal in November 2017 and were awarded $1.5 million in grant funding in April 2018.

5.2. White Paper Development

A draft coordination agreement has been developed for Kern County Subbasin GSAs and is undergoing legal review as of November 2018. As part of this process, the member agencies have developed and disseminated a series of white papers that describe common baseline conditions in the subbasin. The topics of these white papers are as follows:

A – Groundwater Elevation Data
B – Groundwater Extraction Data
C – Surface Water Supply Data
D – Total Water Use
E – Change in Groundwater Storage

5.3. Other Board Meetings and Workshops

All KRGSA member agencies hold regular and special board meetings on a monthly schedule. The schedule for these meetings is provided in Appendix C.

SECTION 6. GENERAL SCHEDULE

The General Schedule shown in Appendix C describes the communication and engagement activities that have been conducted and/or planned on behalf of the KRGSA for SGMA purposes. These communication and engagement activities are designed to comply with SGMA guidance and requirements, engage interested parties, and inform the public of new developments. This schedule is subject to change throughout the GSP development process and is only meant as a general guide for planned activities.

The General Schedule includes outreach and coordination across all three scales described above, with special focus on those parties located within KRGSA boundaries. This outreach began with calls and emails to groundwater users and suppliers as identified in county and municipal documents. Every effort has been made to contact each groundwater user or supplier; in circumstances where the contact information provided was inaccurate or out of date, additional efforts have been made to contact the parties directly.

Other methods of contacting interested parties include email blasts, advertising on the KRGSA webpage, placement of information in local newspapers, notifying local municipalities and agencies, and contacting relevant internet blogs and websites. Self Help Enterprises has assisted with additional avenues of notification to DACs. The schedule is subject to change and will continue to be updated as additional workshops and meetings occur, dates change, and the GSP progresses toward completion.

REFERENCES

Community Water Center. (2015). *Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act.*

California Department of Water Resources. (2015). *Sustainable Groundwater Management Program DRAFT Strategic Plan.*

California Department of Water Resources. (2016). *Sustainable Groundwater Management Program Groundwater Sustainability Plan (GSP) Emergency Regulations Guide.*

California Department of Water Resources. (January 2018). *Guidance Document for Groundwater Sustainability Plan - Stakeholder Communication and Engagement.*

Department of Water Resources. (2003). *California's Groundwater, Bulletin 118, Update 2003.*

Kern River Groundwater Sustainability Agency. (2016). *Notice of Decision to Become a Groundwater Sustainability Agency.*

APPENDICES

APPENDIX A
INTERESTED PARTIES

Groundwater Rights Holders

The groundwater rights holders include 1) agricultural users and 2) domestic well owners.

AGRICULTURAL USERS

The agricultural users identified for outreach include, but are not limited to:

- Rosedale Ranch Improvement District
- Various landowners

DOMESTIC WELL OWNERS

The domestic well owners identified for outreach include, but are not limited to:

- Bear Mountain Truck Stop;
- Cal Mat (Panama Lane Facility);
- Cemex Construction Materials Pacific LLC;
- Countryside Market & Restaurants;
- Delta Trading Water System;
- Donnovan Bros. Golf;
- Derrel's Mini Storage #66;
- Farmer John Egg Ranch #2;
- Golden Empire Concrete Company;
- Grace Community Church Water System;
- Harvest Steakhouse;
- J.G. Boswell Company Water System;
- Kern County Cemetery Association;
- Kern Oil and Refining Company;
- Kidz Kountry Preschool;
- Lakeside School;
- Pinewood Lake Homeowners Association;

- Seven Oaks Country Club;
- Stockdale Country Club; and
- Various private entities.

Municipal Well Operators

The municipal well owners identified for outreach include, but are not limited to:

- Ashe Water Company;
- City of Bakersfield;
- California Water Service Company;
- East Niles Community Services District;
- Greenfield County Water District (now WAKC);
- Kern County Water Agency, Improvement District No.4; and
- North of the River Mutual Water District.

Public Water Systems

The public water system identified for outreach include, but are not limited to:

- Ashe Water Company;
- Athal Mutual Water System;
- Bear Mountain RV Park Water System;
- California Water Service Company;
- Casa Loma Water Company;
- East Niles Community Services District;
- East Wilson Road Water Company;
- El Adobe POA, Inc.;
- Fuller Acres Mutual Water Company;
- Gosford Road Water Company;
- Greenfield County Water District (now WAKC);
- North of the River Mutual Water District;
- Oasis Property Owners Association;
- Oildale Mutual Water Company;
- Old River Mutual Water Company;
- Panama Road Property Owners Association;
- Ski West Village Water System;

- South Kern Mutual Water Company;
- Stockdale Annex Mutual Water Company;
- Stockdale Mutual Water Company;
- Vaughn Water Company; and
- Wini Mutual Water Company.

Local Land Use Planning Agencies

The local land use planning agencies identified for outreach include, but are not limited to:

- City of Bakersfield;
- County of Kern; and
- Kern County Planning and Natural Resources Department.

Environmental Users of Groundwater

The environmental users of water identified for outreach include, but are not limited to:

- Panorama Vista Preserve;
- Kern River Parkway Foundation; and
- City of Bakersfield.

Surface Water Users

The surface water users identified for outreach include, but are not limited to:

- Buena Vista Water Storage District and
- Rosedale-Rio Bravo Water Storage District

Federal Government

There are no federal government surface water users in the KRGSA service area, and therefore no outreach has been identified to this category of interested party.

California Native American Tribes

There are no California Native American tribes that have land ownership or land management responsibilities in the KRGSA, and therefore no outreach has been identified to this category of interested party.

Disadvantaged and Severely Disadvantaged Communities

The disadvantaged or severely disadvantaged communities identified for outreach with the assistance of Self Help Enterprises include, but are not limited to:

- Buttonwillow
- Calder's Corner
- Cherokee Strip
- Crome-Heights Corner
- Edison
- Fruitvale
- Fuller Acres
- Kern City
- Lamont
- Lonsmith
- Lost Hills
- Magunden
- Mayfair
- Meridian
- Mexican Colony
- Oil Junction
- Oildale
- Pond
- Saco
- Smith Corner
- Thomas Lane
- Weed Patch
- Weed Patch Highway

Figure A-1 shows the locations of these communities by Census Tract.

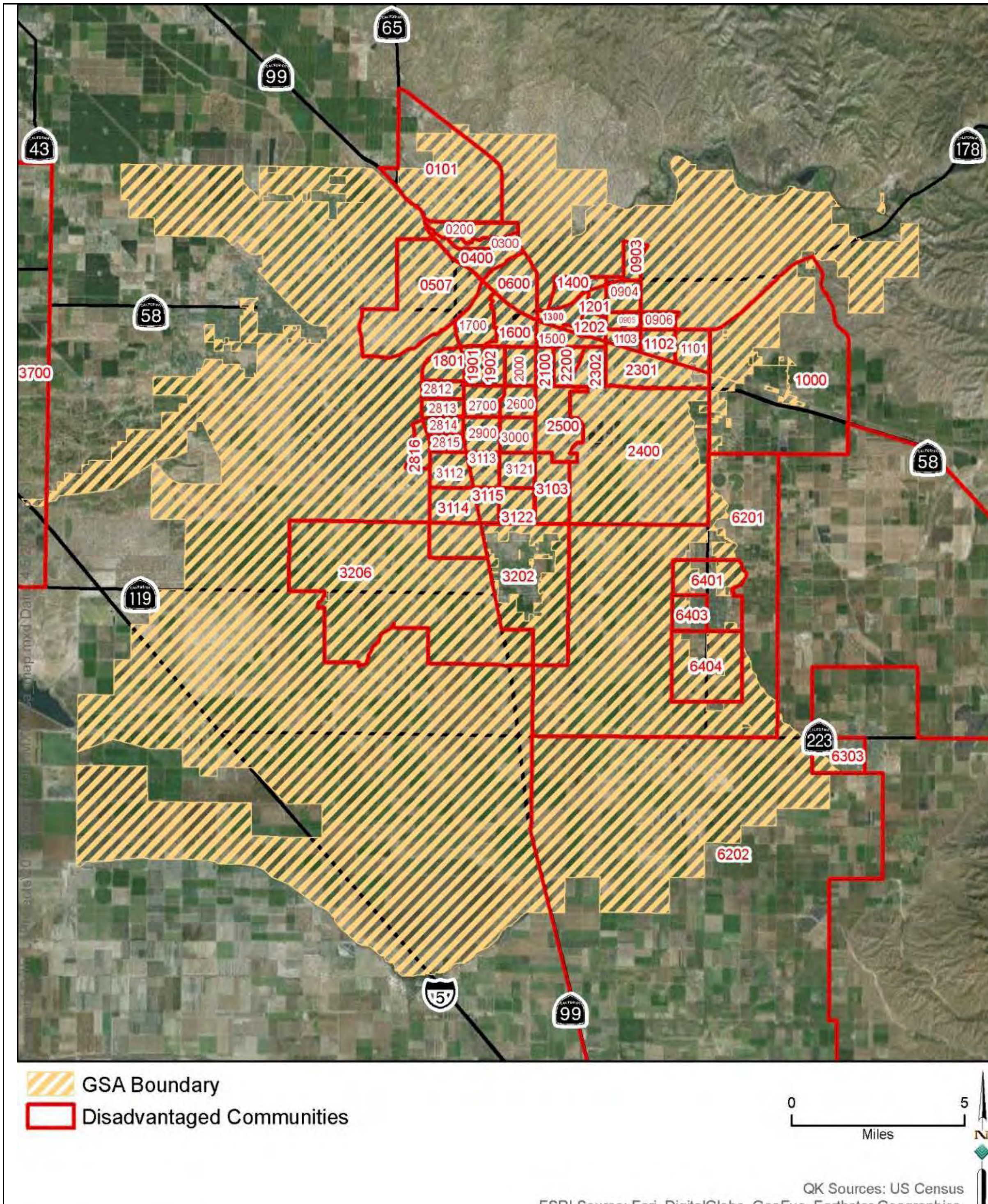


Figure A-1

Disadvantaged Communities within KRGSA Service Area

Groundwater Monitoring and Reporting Entities

The groundwater monitoring and reporting entities identified for outreach include, but not limited to:

- Kern Groundwater Authority;
- Kern Water Bank Authority;
- Arvin-Edison Water Storage District;
- Deer Creek & Tule River Authority;
- Kern County Water Agency Improvement District 4;
- Kern-Tulare Water District;
- North Kern Water Storage District;
- Semitropic Water Storage District;
- Shafter-Wasco Irrigation District; and
- Kern Fan Authority (a coalition consisting of the Kern-Delta Water District, Buena Vista Water Storage District, Henry Miller Water District, and Rosedale-Rio Bravo Water Storage District, and which was previously known as the Kern River Fan Group).

Specific Interested Parties Requesting Information and Communication from KRGSA

Name	Contact Information	Date Requested
Kristal Davis Fadtke, Senior Environmental Scientist	California Department of Fish & Game 830 S Street Sacramento, CA 95811 (916) 445-3453 kristal.davis-fadtke@wildlife.ca.gov	6/2/16
Evelyn Young Spath, EdD; Executive Assistant to the President	California State University, Bakersfield Mail Stop 33 BDC 9001 Stockdale Highway Bakersfield, CA 93311 (661)654-2241	7/14/16
Patty Poire	Grimmway Farms (661) 845-5790 ppoire@grimmway.com	11/11/16
Joe Cisneros	(661) 817-3600 joepcisneros@gmail.com	1/6/17
Shelley Huskey; Environmental Manager, QISP	(217) 454-3542 shelleyk.huskey@cemex.com	1/17/17
Kristin Dobbin, Regional Water Management Coordinator	Community Water Center 311 West Murray Avenue Visalia, CA 93291 (559) 733-0219 kristin.dobbin@communitywater center.org	1/18/17
Pamela McNemar, Certified Legal Secretary	Young Wooldridge 1800 30th Street, 4th Floor Bakersfield, CA 93301 (661) 327-9661 pmcnemar@youngwooldridge.com	1/27/17
Scott Lipton, Government Affairs Specialist	Aera Energy LLC (661) 665-5927 sdlipton@aeraenergy.com	2/27/17
Tim Gobler	Wonderful Orchards (661) 776-1321 timothy.gobler@wonderful.com	2/27/17
Preston Brittian	Pacific Resources (661) 301-1708 pres@prh2o.com	3/2/17

Name	Contact Information	Date Requested
J. Paul Hendrix	Tulare Irrigation District 6826 Avenue 240 Tulare, CA 93274 (559) 686-3425 jph@tulareid.org	3/22/17
Matthew Fisher	Rancho del Rio Mutual Water Company (661) 858-3938 mfisher@cmcfarming.com	5/12/17
Anthony J. Amarante	1307 Princeton Avenue Bakersfield, CA 93305 (661) 873-0407	N/A
Kristal Davis-Fadtke, Senior Environmental Scientist	California Department of Fish and Wildlife 830 S Street Sacramento, CA 95811 Kristal.davis-fadtke@wildlife.ca.gov (916) 445-3453	N/A
Evelyn Young Spath Executive Assistant to CSU Bakersfield President	9001 Stockdale Highway Bakersfield, CA 93311 Eyoung3@csub.edu	N/A
Greg Hammett	ghammett@bmwd.org ghammett@beldridgewsd.com	N/A
Don A. Wright	Freelance Journalist/Consultant daw@sti.net (559) 355-2389	N/A
Lisa Rubin	Dellavalle Laboratory, Inc. L.Rubin@dellavallelab.com (408) 667-7661	N/A
Steve Tolin	Kern High Stolin@kernhigh.org 827-3181	10/24/2017
Todd Noble	Edison School District tnoble@edison.k12.ca.us 340-1150	10/24/2017
David Carlsen	Greenfield Unified School District carlsend@gfusd.net 837-6030	10/24/2017
Armando Murrieta	Self Help Enterprises	10/24/2017
Helena Gutierrez	Self Help Enterprises helenag@selfhelpenterprises.org (562) 659-0095	10/24/2017

Name	Contact Information	Date Requested
Veronica Penen	Self Help Enterprises veronicap@selfhelpenterprises.org (559) 802-1635	10/24/2017
Briana 'Bri' Seapy, Statewide SGMA Coordinator	CDFW Groundwater Program groundwater@wildlife.ca.gov (916) 445-1724	4/17/18
Fuller Acres Mutual Water Company	P.O. Box 125, Lamont, CA 93241 fulleracresw@yahoo.com (661) 319-5008	5/21/18
Darin Ritchie	4904 Islands Drive Bakersfield, CA 93312 (661) 213-3875	6/12/18
Matthew Owens	California Department of Water Resources Groundwater Management Section 3374 East Shields Avenue, Room 3 Fresno, CA 93726 (559) 230-3335 Matthew.Owens@water.ca.gov	6/12/18
Raminder Kahlon, Director	CPUC Water Division 505 Van Ness Avenue, Room 3102 San Francisco, CA 7031837 Raminder.Kahlon@cpuc.ca.gov	1/15/19
Andrew G. Gordus, Ph.D., Staff Toxicologist	CDFW Central Region GSA contact person 1234 East Shaw Avenue Fresno, CA 93710 (559) 243-4014, ext. 239 Andy.Gordus@wildlife.ca.gov	1/15/19

APPENDIX B
SCHEDULE OF KRGSA AND AGENCY BOARD MEETINGS

Table B-1. Schedule of KRGSA and Agency Board Meetings

Meeting Type	Date	Location	Summary
KRGSA Meetings			
KRGSA Coordination	7/11/2017	Rosedale-Rio Bravo Water Storage District	KGA Groundwater Authority General Meeting
KRGSA Technical Workshop	7/13/2017	Kern County Water Agency Board Room	Technical Groundwater Supply Workshop
KRGSA Coordination	7/17/2017	Phone	Discuss Coordination agreement for DWR grant funding.
KRGSA C&E Workshop	9/14/2017	Bakersfield City Chambers	Communication & Engagement Workshop
KRGSA Coordination Meeting	9/14/2017	Bakersfield City Chambers	Discuss GSP Coordination
Kern County Subbasin Grant Application Meeting	9/14/2017		SGMA Planning Grant Program
KRGSA GSP Coordination	9/15-11/3 (every Friday)	Phone	Coordinate Kern County Subbasin GSP Application
SGMA Roundtable (SHE)	10/20/2017	South Valley SGMA Practitioners	Coordinate SGMA Compliance
SGMA Roundtable for Schools (SHE)	10/24/2017	Bakersfield City School District Professional Development Center	Overview of SGMA/GSP Coordination with school districts
C2VSim Modeling Workshop	11/1/2017		
Basin Setting Workshop	1/1/2018		
Kern County Subbasin Water Budget Workshop	6/1/2018		
KRGSA Groundwater Workshop (SHE)	8/20/2018	Fruitvale-Norris Park Recreation Room, Bakersfield	Overview of SGMA with DACs and stakeholders
General Public/DAC Workshop	11/13/2018	Bear Mountain Recreation David Head Center, Lamont	Overview of SGMA with DACs and stakeholders
Groundwater Technical Workshop	4/1/2019		
Draft GSP Presentation	8/21/2019		

Table B-1. Schedule of KRGSA and Agency Board Meetings

Basinwide/Other GSA Meetings			
Kern County Groundwater Subbasin - Workshop 2	11/1/2016	KCWA, Bakersfield	Overview of SGMA and GSP requirements
Kern County Groundwater Subbasin - Workshop 3	11/15/2016	Kern Ag Pavilion	
Other workshops	11/28, 12/5, 12/20/2016		
Getting Involved in Groundwater (SHE, UCS, CWC)	10/26/2017	University Square Hotel, Fresno	Toolkit release and panel discussion
KGA GSA Community Workshop (SHE)	4/26/2018	Shafter	Overview of SGMA and GSP requirements
Local Agency Meeting	5/9/2018		Discuss C2VSim data needs for modeling by Todd Groundwater
KGA GSA Community Workshop (SHE)	5/21/2018	Arvin Veterans Hall, Arvin	Overview of SGMA and GSP requirements
Local Agency Meeting	8/6/2018		Discuss water budget - Todd Groundwater
Arvin-Edison WSD and Arvin CSD SGMA Workshop (SHE)	10/2/2018	Arvin Veterans Hall, Arvin	Three informational workshops
Groundwater Quality and SGMA Roundtable (SHE, CWC, UCS, LCJA	10/10/2018	Visalia	Focused on groundwater contamination
Local Agency Meeting	10/16/2018		Preliminary C2VSim model results - Todd Groundwater
GSP Workshop 2.0 (SHE)	10/27/2018		Followup to previous workshops in Aprl, June 2017
Local Agency Meeting	1/11/2019		Draft historical water budgets - Todd Groundwater
Local Agency Meeting	3/22/2019		Revised draft historical and current water budgets - Todd Groundwater
SGMA Open House (KGA, KCFB)	5/14/2019		
GSP Open House (KGA, KCFB)	9/26/2019		

Table B-1. Schedule of KRGSA and Agency Board Meetings

Technical Peer Review Team Meetings			
Peer Review Meeting #1	5/17/2018		
Peer Review Meeting #2	9/26/2018		
Peer Review Meeting #3	10/16/2018		
Peer Review Meeting #4	11/13/2018		
Peer Review Meeting #5	12/4/2018		
Additional Coordination Information			
The Nature Conservancy	9/24/2018	Email + file attachments	Potential beneficial users of surface water in your GSA
Leadership Counsel of		letter to KRGSA	
Agency Board Meetings			
KRGSA Board Meetings - KRGSA Board Meetings occur at 10:00 AM on the 1st Thursday of every month at Bakersfield City Hall, North Conference Room A, 1600 Truxtun Avenue, Bakersfield, CA 93301.			
KRGSA Board Meeting	3/2/2017	KRGSA	Water Budget presentation by Todd Groundwater
KRGSA Board Meeting	7/13/2017	KRGSA	
KRGSA Board Meeting	8/3/2017	KRGSA	
KRGSA Board Meeting	9/7/2017	KRGSA	
KRGSA Board Meeting	9/14/2017	KRGSA	Special meeting: SGMA and development of a local GSP
KRGSA Board Meeting	10/5/2017	KRGSA	
KRGSA Board Meeting	11/2/2017	KRGSA	
KRGSA Board Meeting	12/7/2017	KRGSA	
KRGSA Board Meeting	1/4/2018	KRGSA	
KRGSA Board Meeting	2/1/2018	KRGSA	
KRGSA Board Meeting	3/1/2018	KRGSA	
KRGSA Board Meeting	4/5/2018	KRGSA	Hydrogeologic Modeling/ Groundwater Conditions presentation by Todd Groundwater
KRGSA Board Meeting	5/3/2018	KRGSA	
KRGSA Board Meetings, cont'd			
KRGSA Board Meeting	6/7/2018	KRGSA	
KRGSA Board Meeting	8/2/2018	KRGSA	

Table B-1. Schedule of KRGSA and Agency Board Meetings

KRGSA Board Meeting	9/6/2018	KRGSA	
KRGSA Board Meeting	10/4/2018	KRGSA	
KRGSA Board Meeting	11/8/2018	KRGSA	Special meeting: C2VSim model update
KRGSA Board Meeting	10/6/2018	KRGSA	
KRGSA Board Meeting	1/10/2019	KRGSA	
KRGSA Board Meeting	2/7/2019	KRGSA	
KRGSA Board Meeting	3/12/2019	KRGSA	
KRGSA Board Meeting	4/4/2019	KRGSA	
KRGSA Board Meeting	5/2/2019	KRGSA	
KRGSA Board Meeting	6/6/2019	KRGSA	
KRGSA Board Meeting	7/11/2019	KRGSA	
KRGSA Board Meeting	8/1/2019	KRGSA	
KRGSA Board Meeting	8/21/2019	KRGSA	Special meeting: Presentation of GSP

Kern Delta Water District - KDWD Board Meetings occur at 12:00 Noon at KDWD on the 1st and 3rd Tuesday of every month, at 501 Taft Hwy Bakersfield, CA 93307.

City of Bakersfield City Council Meetings - City of Bakersfield City Council meetings begin at 3:30 PM and 5:15 PM. The exact dates are variable, but routinely run the second and 4th Wednesday of the month. Meeting are at Bakersfield City Hall, South Council Chambers, 1501 Truxtun Avenue, Bakersfield, CA 93301.

Improvement District No. 4 - KCWA/ID4 Meetings occur at 12:00 Noon on the 4th Thursday of every month. (Except the 3rd Thursday in November and December), at 3200 Rio Mirada

Bakersfield Water Board - The Bakersfield Water Board meetings are held monthly on the first Wednesday at 2:00 p.m., in the Water Resources Department Conference Room, 1000 Buena Vista Road, Bakersfield, CA 93311.

Urban Bakersfield Advisory Committee - UBAC Board meetings occur at 2:30 PM on the day before any KCWA board meeting, at 3200 Rio Mirada Drive, Bakersfield, CA 93308.

APPENDIX C
PUBLIC WORKSHOP SCHEDULE

Schedule Overview
Kern River Groundwater Sustainability Agency
KRGSA Communication & Engagement Tracking Sheet
August 2019

Tasks and Target Areas		2017							2018											
		June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1. KRGSA Service Area																				
1.1	KRGSA Website																			
1.2	Public Meetings & Workshops	*	GW Supply Workshop	*	General Public and DAC Workshop	*	C2VSim Modeling Workshop	*	Basin Setting Workshop	*	*	Hydrogeo. Modeling/ GW Conditions Workshop	*	Kern County Subbasin Water Budget Workshop	*	General Public and DAC Workshop	*	*	General Public and DAC Workshop	*
1.3	General Outreach & Audience Mapping																			
1.4	Targeted Meetings with Interested Parties																			
1.5	Outreach to Disadvantaged Communities																			
2. Kern Subbasin Coordination & Outreach																				
2.1	General Outreach																			
2.2	Regular and Special KRGSA Board Meetings	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
2.3	Coordination with Kern Groundwater Authority												♦				♦	♦	♦	♦
2.4	Workshops and Other Subbasin Coordination		GW Supply Workshop		General Public and DAC Workshop		C2VSim Modeling Workshop		Basin Setting Workshop			Hydrogeo. Modeling/ GW Conditions Workshop	C2VSim Data Needs Local Agency Mtg	Kern County Subbasin Water Budget Workshop		General Public/DAC | Water Budget Workshops		Prelim. C2VSim Model Results Local Agency Mtg	General Public and DAC Workshop	
3. Communication and Engagement Outside Kern Subbasin																				
3.1	DWR Forums and Workshop Participation																			
3.2	White Papers (2016)																			
3.3	Other Board Meetings and Workshops	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*

*	Denotes a board meeting. The different boards and meeting dates are listed below.
♦	Denotes a Technical Peer Review Team meeting.
(grey cell)	Denotes ongoing activity throughout the period.

Schedule Overview
Kern River Groundwater Sustainability Agency
KRGSA Communication & Engagement Tracking Sheet
August 2019

Tasks and Target Areas		2019												2020+
		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	TBD
1. KRGSA Service Area														
1.1	KRGSA Website													
1.2	Public Meetings & Workshops	*	*	Interested Parties Workshop	GW Technical Workshop		*	*	Draft GSP Presentation	*	General Public and DAC Workshop	General Public and DAC Workshop	*	*
1.3	General Outreach & Audience Mapping													
1.4	Targeted Meetings with Interested Parties													
1.5	Outreach to Disadvantaged Communities													
2. Kern Subbasin Coordination & Outreach														
2.1	General Outreach													
2.2	Regular and Special KRGSA Board Meetings	*	*	*	*	*	*	*	*	*	*	*	*	*
2.3	Coordination with Kern Groundwater Authority													
2.4	Workshops and Other Subbasin Coordination	Historical Water Budget Local Agency Mtg		Water Budget Local Agency Mtg	GW Technical Workshop				Draft GSP Presentation		General Public and DAC Workshop	General Public and DAC Workshop		
3. Communication and Engagement Outside Kern Subbasin														
3.1	DWR Forums and Workshop Participation					DWR Open House								
3.2	White Papers													
3.3	Other Board Meetings and Workshops	*	*	*	*	*	*	*	*	*	*	*	*	*

*	Denotes a board meeting. The different boards and meeting dates are listed below.
♦	Denotes a Technical Peer Review Team meeting.
(grey shading)	Denotes ongoing activity throughout the period.

APPENDIX D
PUBLIC WORKSHOP MATERIALS

Kern River Groundwater Sustainability Agency

Groundwater Sustainability Plan – Consultant Workplan

Special Meeting: July 12, 2016

Outline

1. SGMA Overview and Background
2. GSA Formation Process
3. GSP Requirements
4. Consultant Workplan for GSP
5. Consultant Qualifications and Experience

SGMA Overview

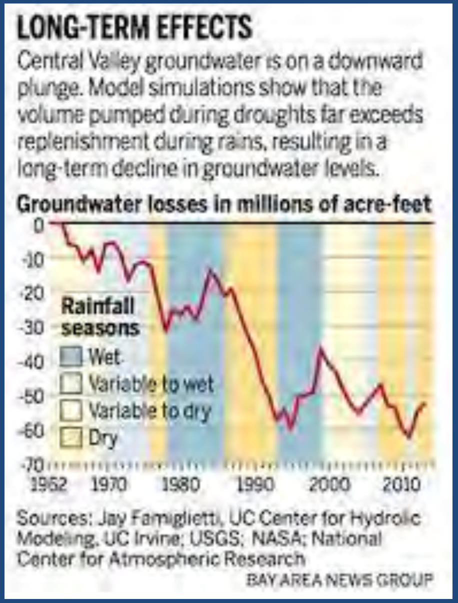
- The Sustainable Groundwater Management Act (SGMA) of 2014 established a new structure for managing California's groundwater resources at a local level by local agencies.

- SGMA requires the formation of locally-controlled groundwater sustainability agencies (GSAs) in the State's high- and medium-priority groundwater basins and subbasins (basins).

- A GSA is responsible for developing and implementing a groundwater sustainability plan (GSP) to meet the sustainability goal of the basin, to ensure that the basin is operated within its sustainable yield, without causing undesirable results.

SGMA: Focus on Sustainability

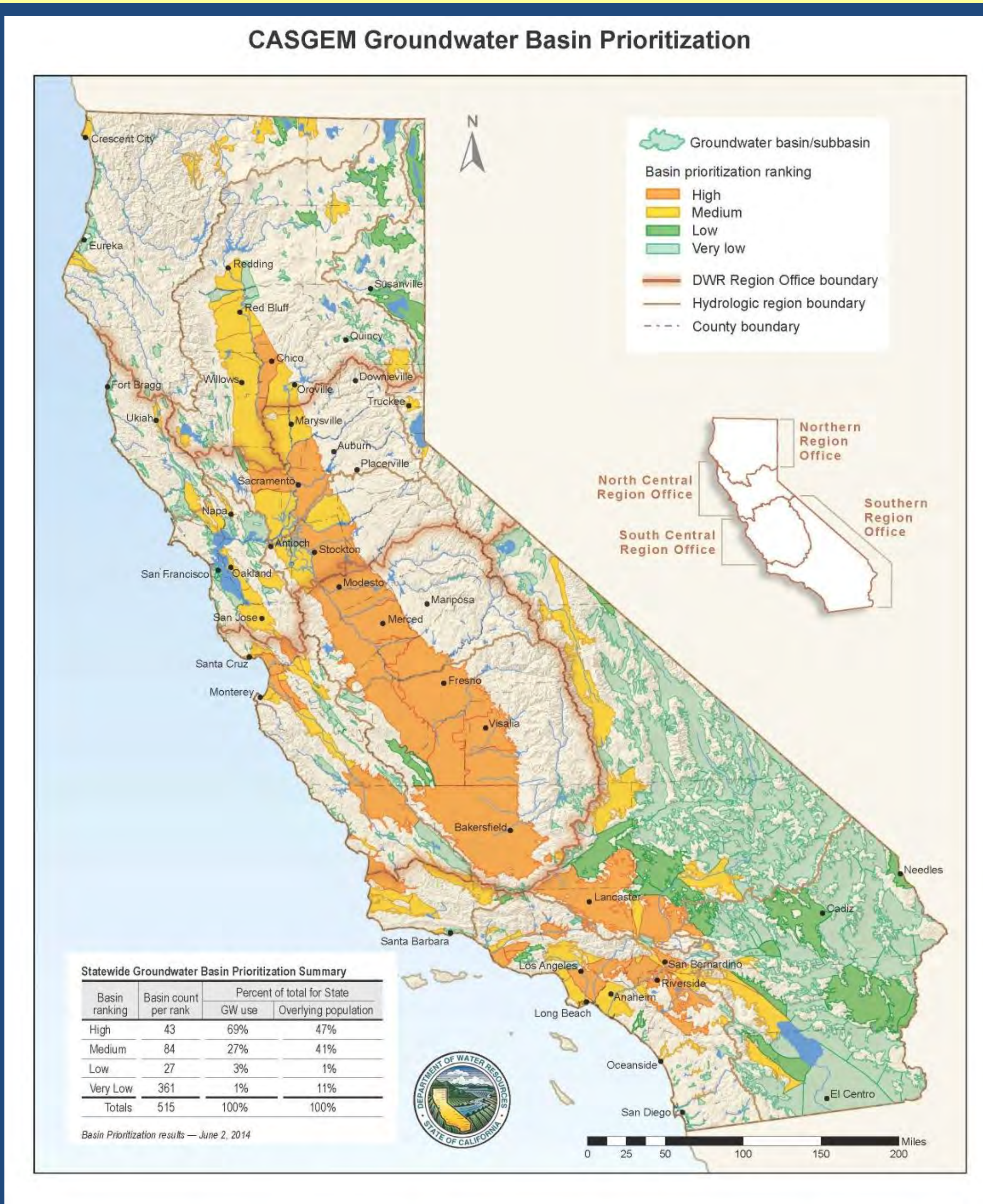
- According to SGMA – Sustainable yield is the maximum quantity of water that can be withdrawn annually from a groundwater supply without causing an undesirable result. Sustainable yield is calculated over a base period that is representative of long-term conditions in the basin.



SGMA: Protect Against Undesirable Results

1. Chronic lowering of groundwater levels and depletion of supply.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

Kern County Subbasin – High Priority



Kern County Subbasin – Critically Overdrafted Basin

SGMA Timeline

- SGMA requires that GSAs are formed by June 30, 2017.
- SGMA requires that GSPs for critically overdrafted basins are developed by January 31, 2020.
- State intervention, through the SWRCB, may (will) occur at the local level if local agencies don’t achieve timeline or comply with SGMA requirements.

Kern River GSA Formation Process

- ❑ Member agencies held hearings and approved formation of the KRGSA in March 2016.

- ❑ April 12 – GSA formation notification was submitted to DWR
  - ✓ GSA boundary maps
  - ✓ GSA forming resolutions
  - ✓ Public hearing notifications
  - ✓ MOU
  - ✓ Supporting documentation from other entities joining the KRGSA
  - ✓ List of interested parties
  - ✓ List and map of disadvantaged communities

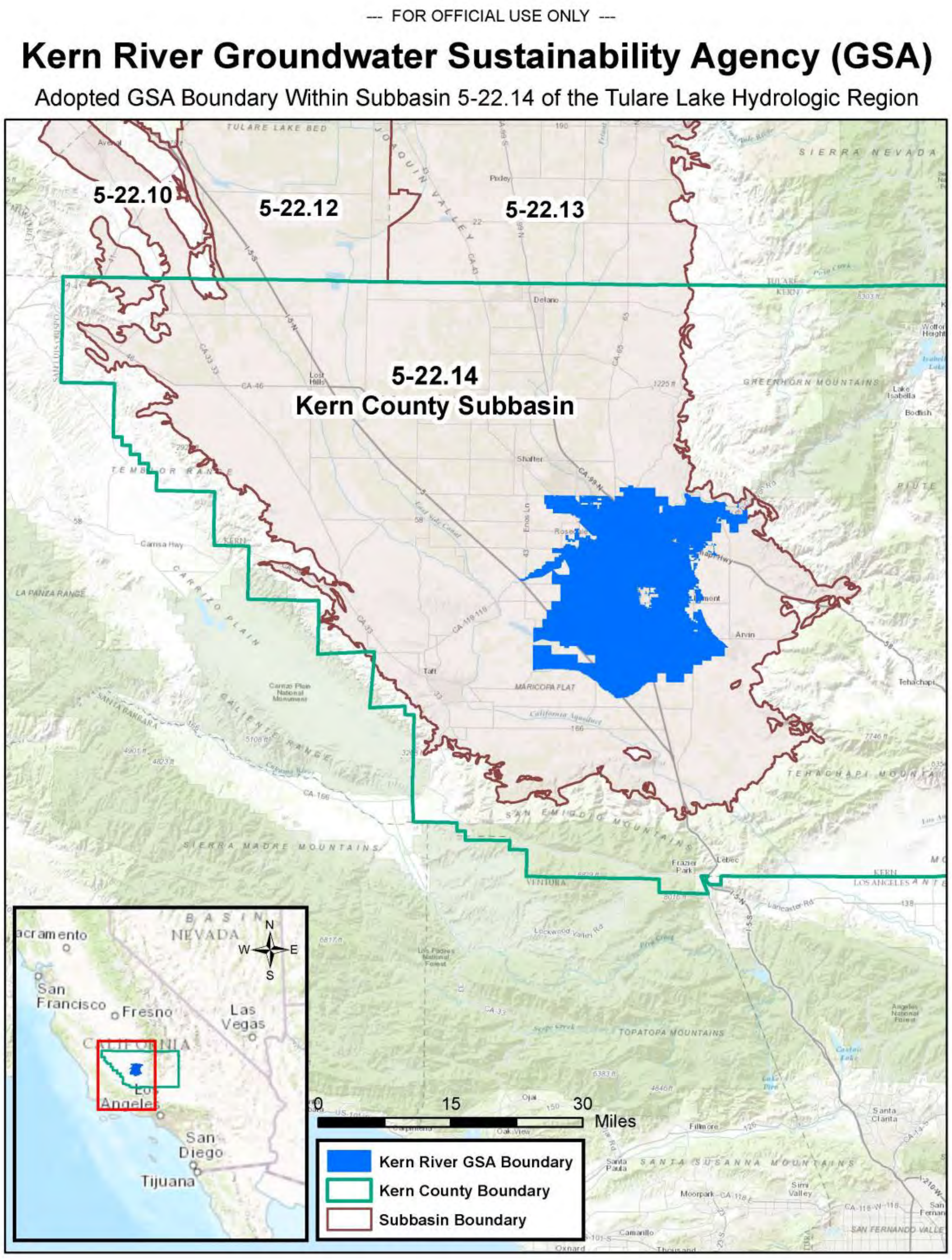
- ❑ April 21 – DWR posted KRGSA notification

- ❑ 90-day notification period ends July 20, 2016

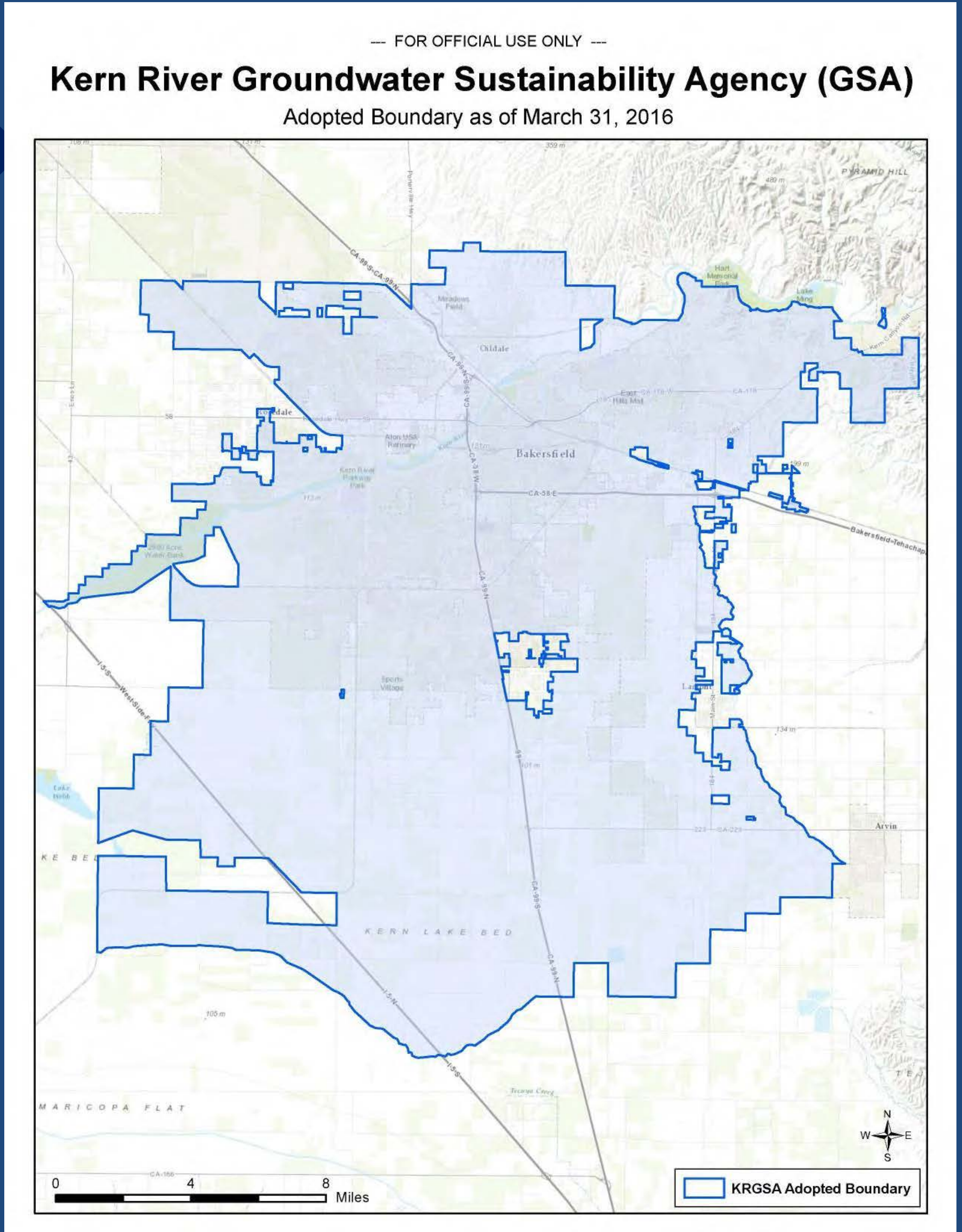
SGMA – No Overlapping GSAs

- A key issue for SGMA and DWR is that there are not overlapping areas between and among various GSAs.
- GSA areas need to be discreet and unique – without overlap. This is an ongoing issue, there are several basins with overlapping GSAs
- http://www.water.ca.gov/groundwater/sgm/gsa_table.cfm

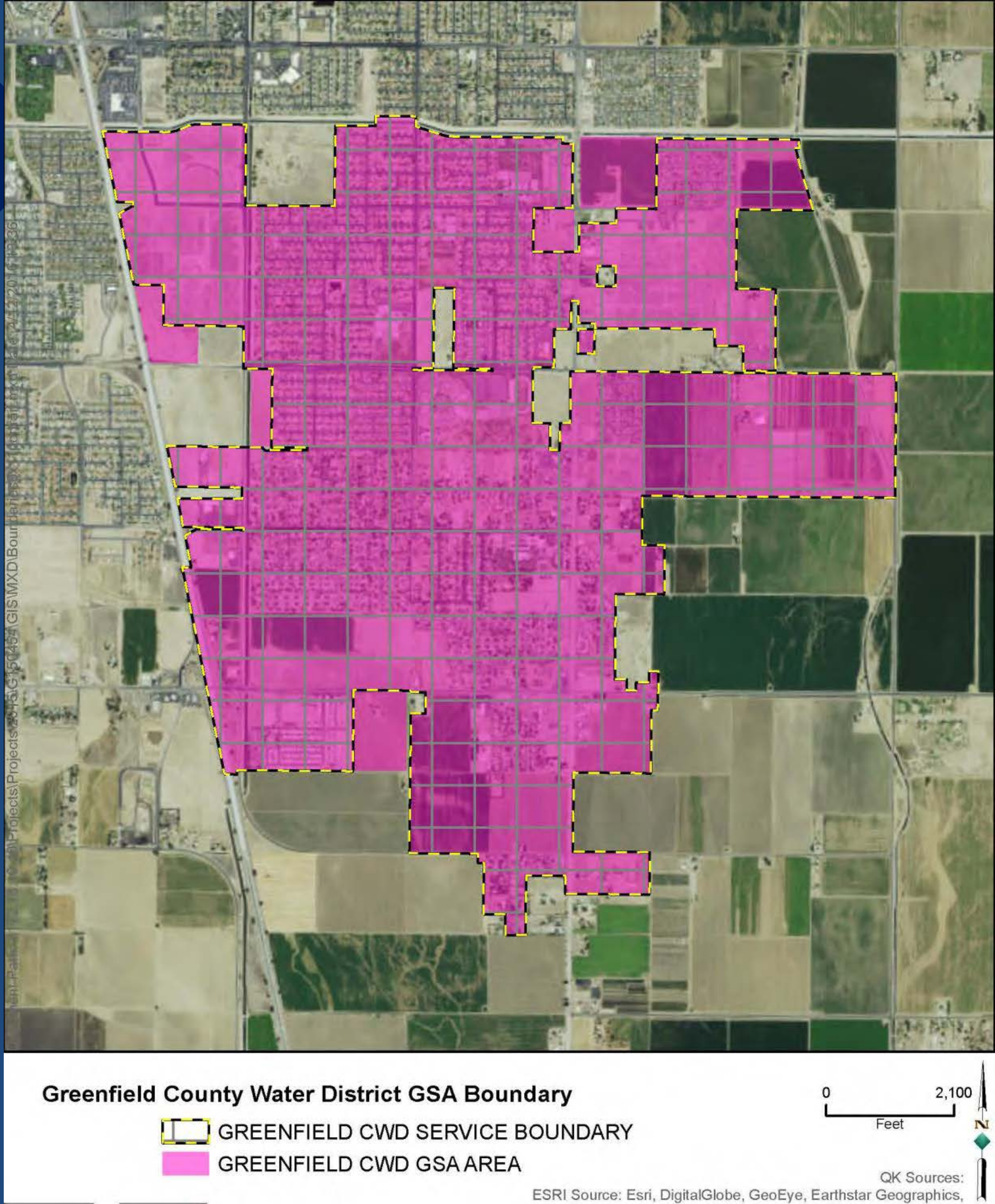
Kern River GSA



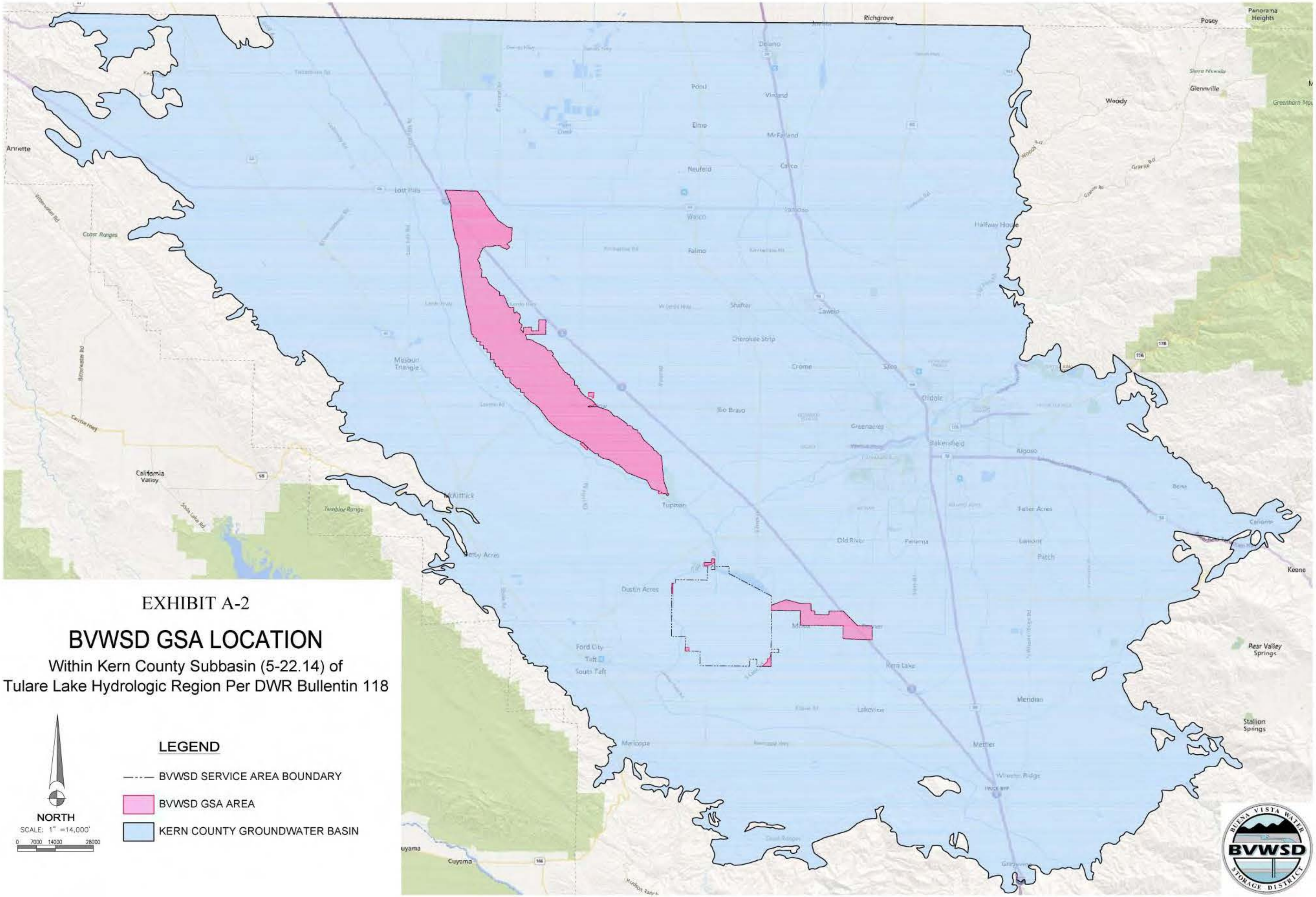
Kern River GSA



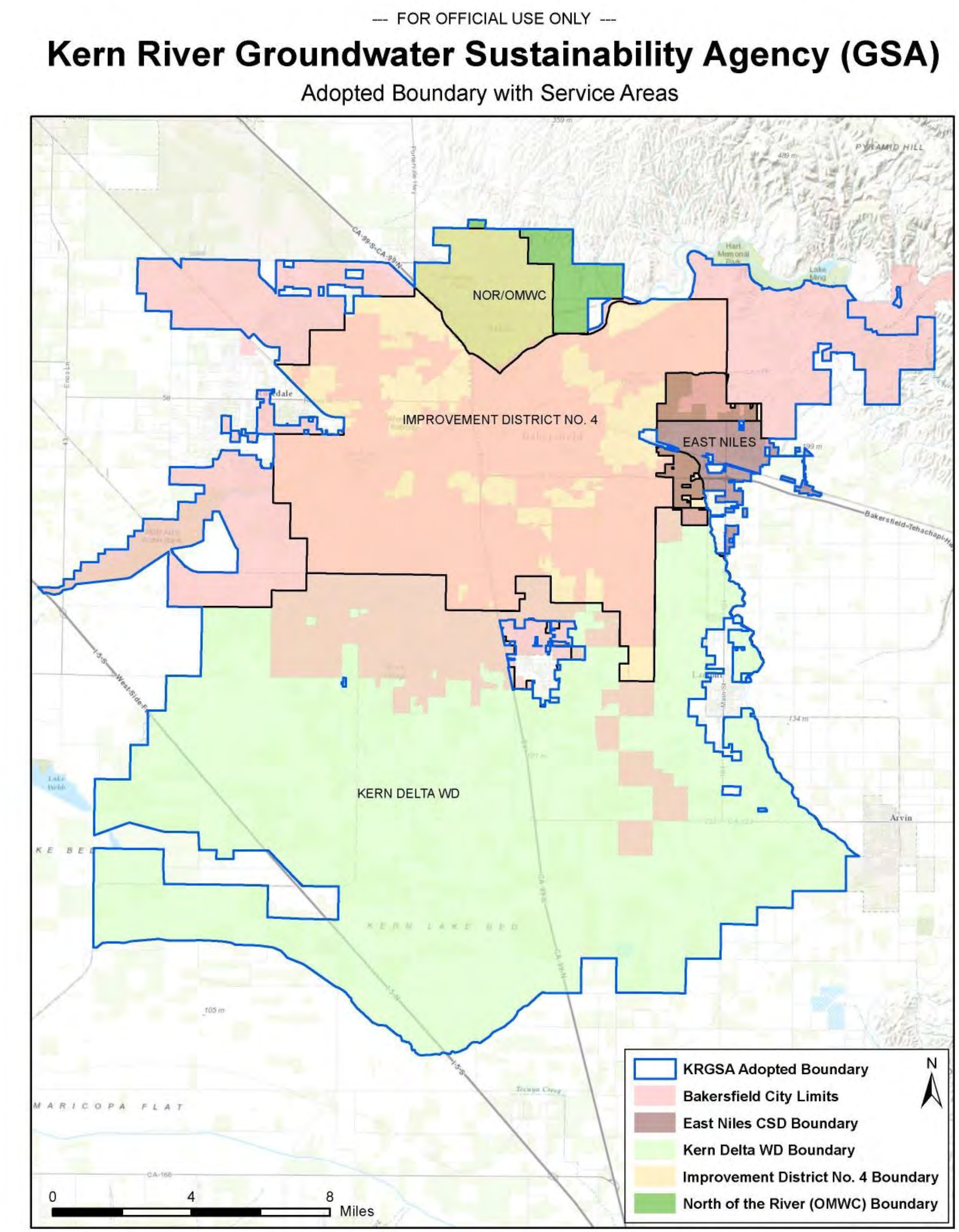
Greenfield CWD GSA



Buena Vista WSD GSA



Kern River GSA



KRGSA Status is Pending

GSA Name	Basin Name	Basin Number	County(s) the GSA is Located	Date Notice Posted	Status or 90-day Period
County of Kern	Kern County	5-22.14	Kern	06/17/2016	Overlap
Greenfield County Water District	Kern County	5-22.14	Kern	04/21/2016	07/20/2016
Kern River Groundwater Sustainability Agency	Kern County	5-22.14	Kern	04/21/2016	07/20/2016
Buena Vista Water Storage District	Kern County	5-22.14	Kern	03/10/2016	Overlap

Groundwater Sustainability Plan

- Kern River GSA now poised to prepare a GSP for its GSA area
- SGMA requires that GSPs for critically overdrafted basins are developed by January 31, 2020.
- DWR recently published emergency regulations regarding the objectives and content of an acceptable GSP.

Importance of Coordinated Plan

- The GSP regulations focus on coordination and agreement across GSAs within a basin or subbasins.

- Kern River GSA will continue to meet with neighboring GSAs and interested parties to develop a coordinated plan within the overall basin.

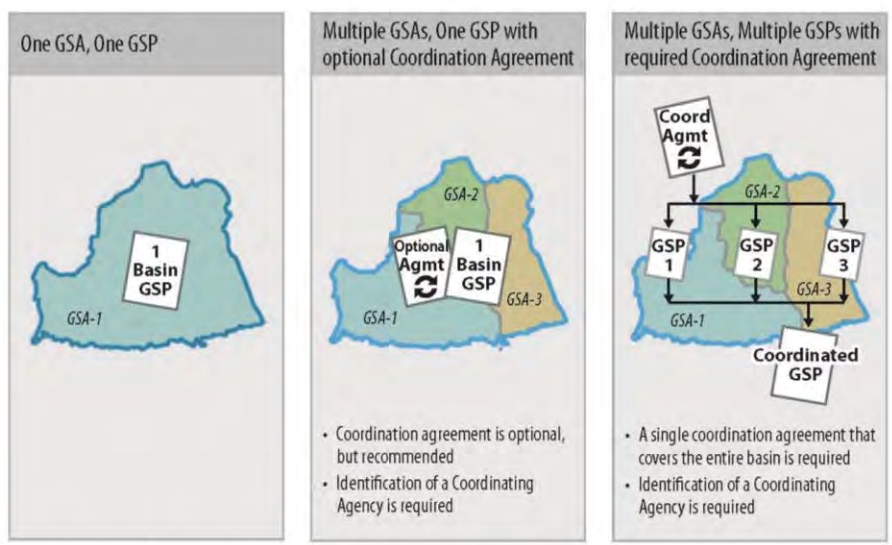


Figure 2. Three Options for GSP Submittals

GSP – Plan Contents

1. Administrative Information
2. Basin Setting
3. Sustainable Management Criteria
4. Monitoring Networks
5. Projects and Management Actions

GSP – Plan Contents

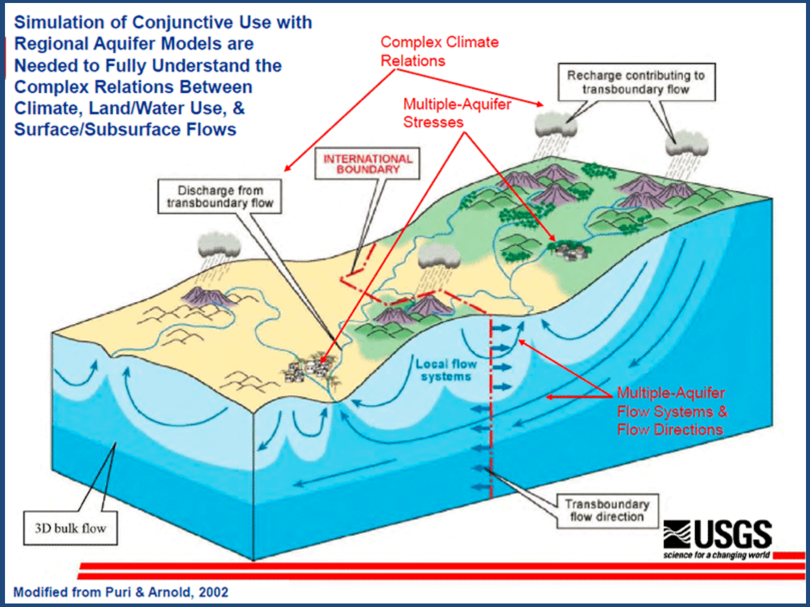
1. Administrative Information

- ❑ Introduction to Administrative Information
- ❑ Executive Summary + References
- ❑ Agency Information
- ❑ Description of Plan Area
- ❑ Notice and Communication

GSP – Plan Contents

2. Basin Setting

- ❑ Introduction
- ❑ Hydrologic Conceptual Model
- ❑ Groundwater Conditions
- ❑ Water Budget
- ❑ Management Areas

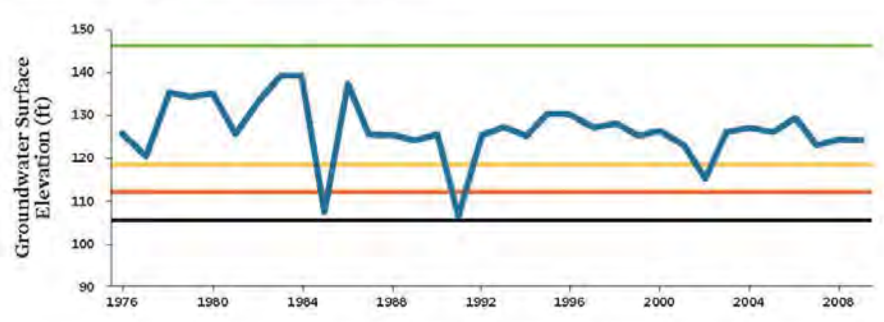


GSP – Plan Contents

3. Sustainable Management Criteria

- ❑ Introduction
- ❑ Sustainability Goal
- ❑ Undesirable Results
- ❑ Minimum Thresholds
- ❑ Measurable Objectives

FIGURE 2 Fixed Triggers for Groundwater Management



In this example, the threshold for chronic lowering of groundwater levels is the lowest groundwater elevation recorded (black line). Fixed triggers have been set at the land surface elevation (green-light trigger), one standard deviation (yellow-light trigger), and two standard deviations (red-light trigger) below the average groundwater elevation. The blue line represents the data, which are recorded depth-to-groundwater measurements over time.

Union of Concerned Scientists 2015

GSP – Plan Contents

4. Monitoring Networks

- ❑ Introduction
- ❑ Monitoring Network
- ❑ Representative Monitoring
- ❑ Assessment and Improvement
- ❑ Reporting to DWR

GSP – Plan Contents

5. Projects and Management Actions

- Introduction
- Projects and Management Actions

Groundwater Sustainability Plan

Consultant Workplan

Two consultant teams

- Horizon / QK – program management, schedule tracking, plan development and review, community outreach and communication, DWR coordination
- Todd GW – technical groundwater analysis for plan development, lead author on technical plan components

Groundwater Sustainability Plan

Horizon Workplan

1. Confirm Workplan – develop GSP outline/approach based on final DWR GSP guidelines
2. Support Basin Coordination
3. Peer Review Draft GSP Sections
4. Communication and Outreach
5. GSP Projects and Management Actions
6. GSP Plan Refinement
7. GSP Plan Approval and DWR Submittal

Groundwater Sustainability Plan

Tentative Schedule

	Task	Start	End
1	Final GSP Regulations and Confirm Consultant Workplan	June 2016	August 2016
2	Basin Coordination	June 2016	December 2019
3	GSP: Peer Review Draft Chapters	July 2016	October 2017
4	GSP: Communication Plan	July 2016	November 2016
5	GSP: Projects and Management Actions	April 2018	March 2019
6	GSP: Plan Refinement and Finalization	April 2019	July 2019
7	GSP Approval and Submittal to DWR	September 2019	December 2019
8	General Program Communications and Meetings	June 2016	January 2020

Horizon Water and Environment

Firm Description and Qualifications

- Interdisciplinary environmental consulting firm specializing in California water resources
- Public agency focus – water supply districts, flood control agencies, cities, counties, State agencies (DGS, DWR, CDFW, CDFA, CPUC)
- Planning documents - EIRs, river and watershed mgmt plans, gw mgmt plans, ws evaluations, O&M manuals, permit applications, GPUs, grant applications, CIP manuals, storwmwater mgmt plans, restoration and mitigation, monitoring plans, etc.

Horizon Water and Environment

Ken Schwarz - Qualifications

- BA - UC Berkeley; MA/Ph.D. - UCLA
- 23 yrs. consulting experience
- Director at Philip Williams & Associates
- Principal at Jones & Stokes Associates
- Founded Horizon in 2008

Horizon Water and Environment

Ken Schwarz – Relevant Experience

- State Board Testimony on Kern River Flows
- Kern River Flow and Municipal Water Program EIR
- Kern River USACE Levee Inspection Compliance
- Expert Witness and Legal Proceedings Support
- Program Manager for SCWA, SJWC, SM County, CC County, SCVWD on past/current projects

Horizon WATER and ENVIRONMENT

Quad Knopf

Firm Description and Qualifications

- 40-year presence in Central Valley
- Local Bakersfield Office
  - Planning
  - GIS
  - Engineering, survey, urban design, and biology
- Steve Esselman – local project manager with many years of Bakersfield experience

Quad Knopf

Firm Description and Qualifications

- Public outreach and coordination
- Strong knowledge of program area, communities, and local priorities
- Supported KRGSA application and notification
- Local research and spatial analysis
- QK staff live and work in Kern County, share a desire for a successful community outcome

Questions

Horizon
WATER and ENVIRONMENT

Modeling Approach for GSP-Required Water Budgets

KERN COUNTY GROUNDWATER SUBBASIN

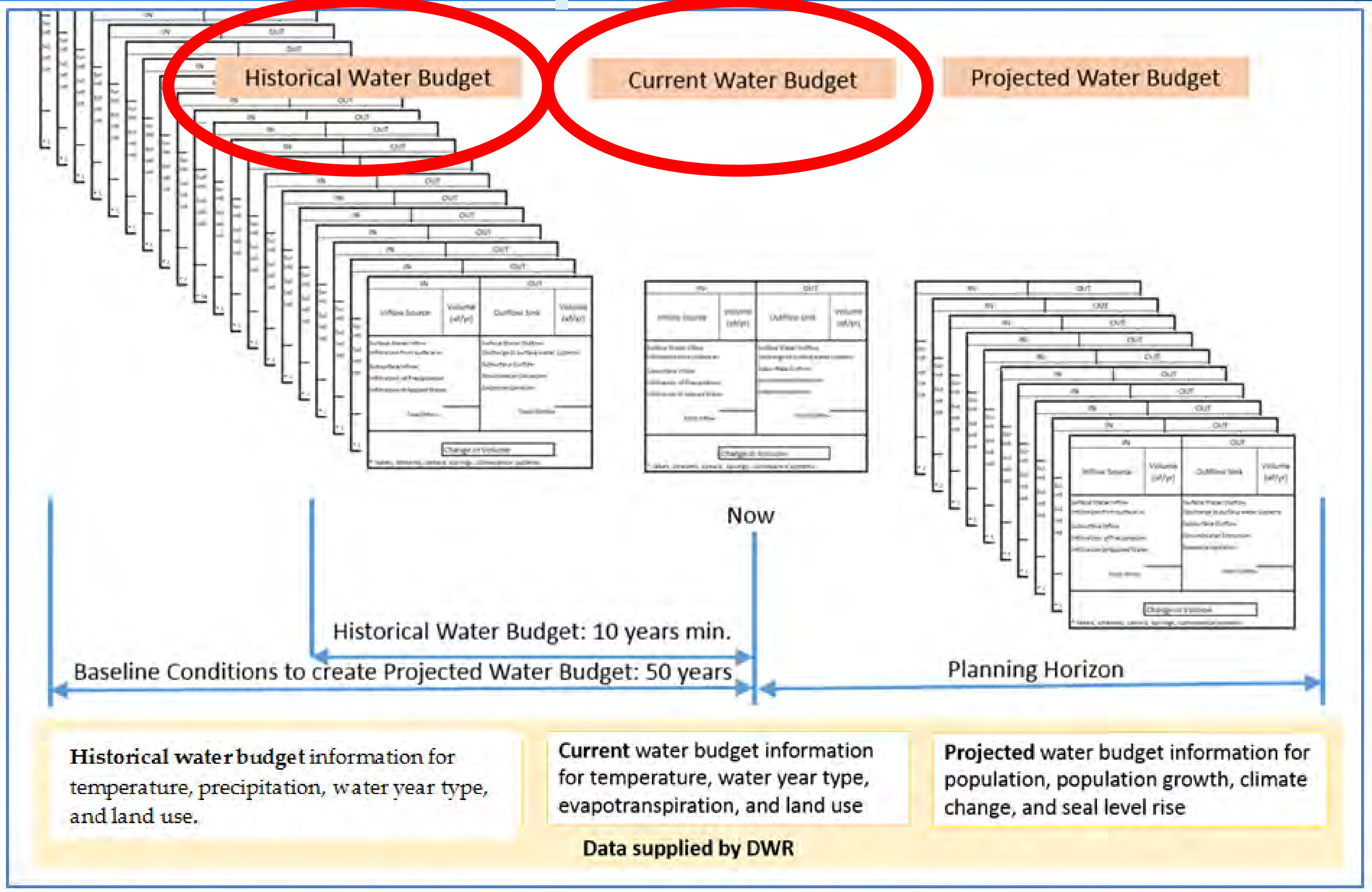
TODD GROUNDWATER

KRGSA requested modeling approach to comply with GSP regulations

- Historical and Current Water Budgets
- Cover entire subbasin
- Quantify annual overdraft over average conditions
- Meet GSP deadlines
  - Model is not the end zone; water budgets are the **basis** for the plan and sustainability indicators
  - Lot to do AFTER model water budgets are available
  - Need a tool that is close to being DONE!

TODD GROUNDWATER

GSP Requirements

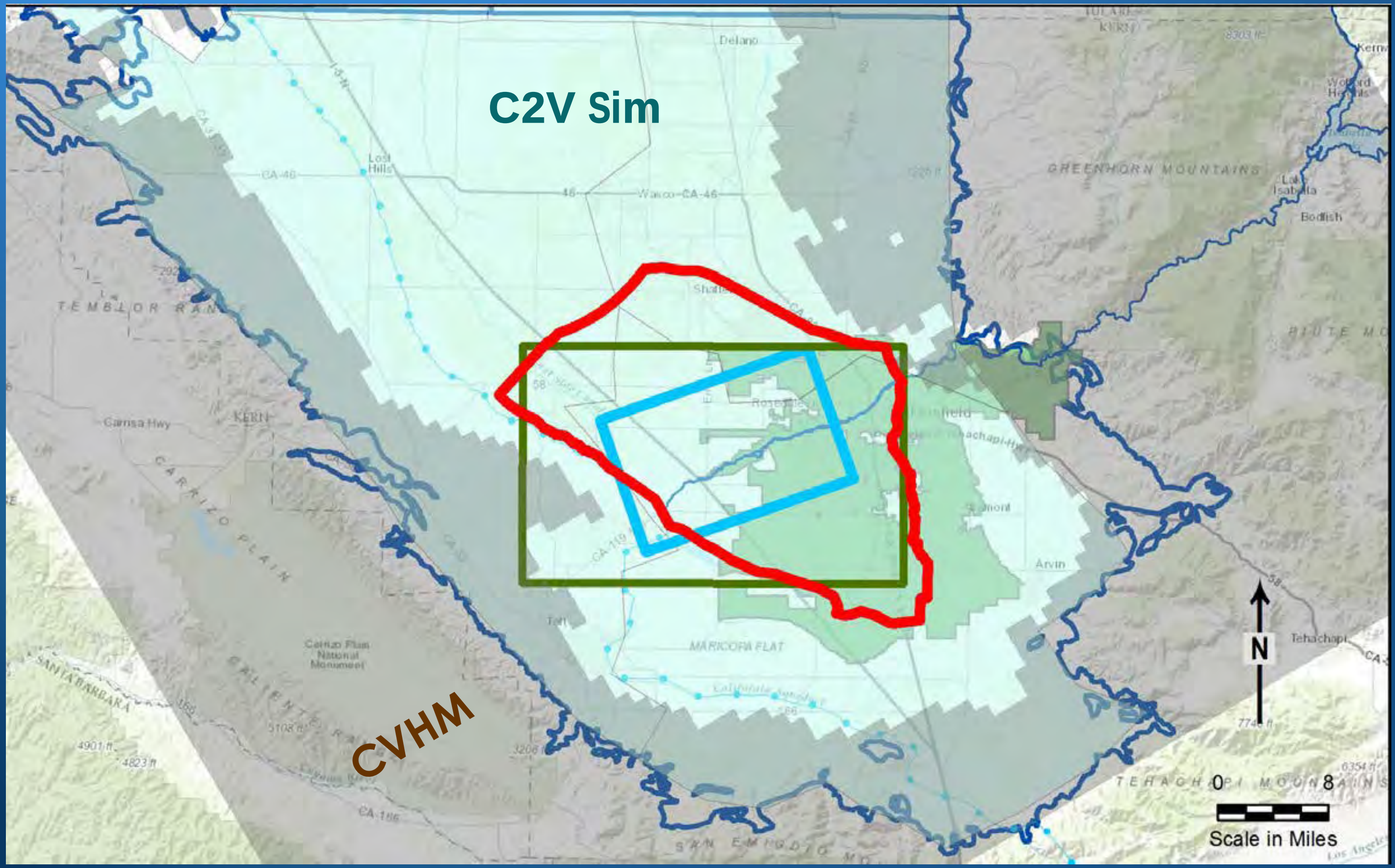


Focus on Current and historical budgets first

Must cover entire subbasin!

TODD GROUNDWATER

Potential GSP Modeling Tools

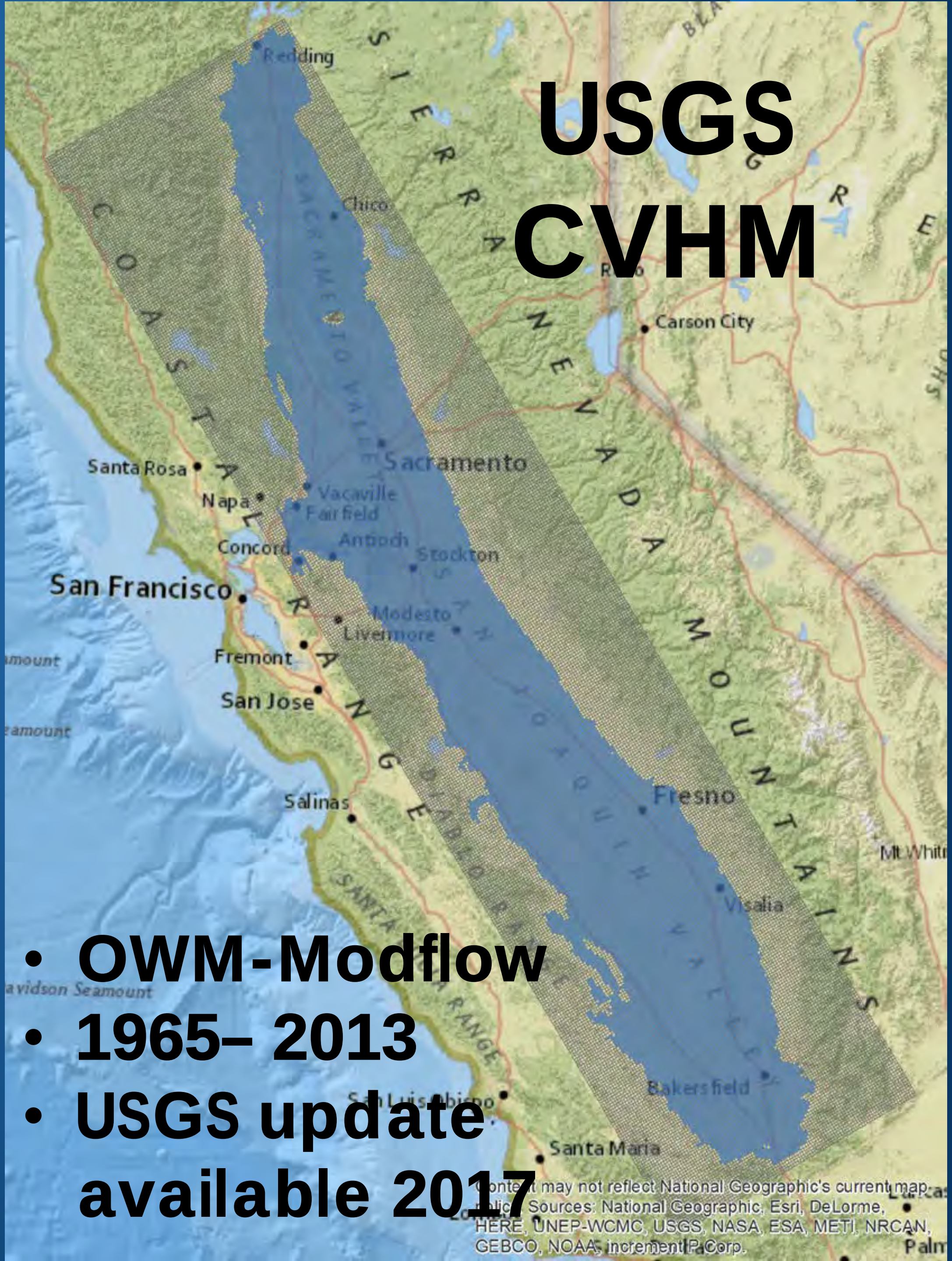


- 2 Regional Models
- 3 Local Models
- Additional Agency local models
- More than one model may be beneficial for various GSP tasks
- Use the right tool for the job

TODD GROUNDWATER

DWR C2VSim

- IWFM code
- 1922 – 2015
- DWR update available 2017



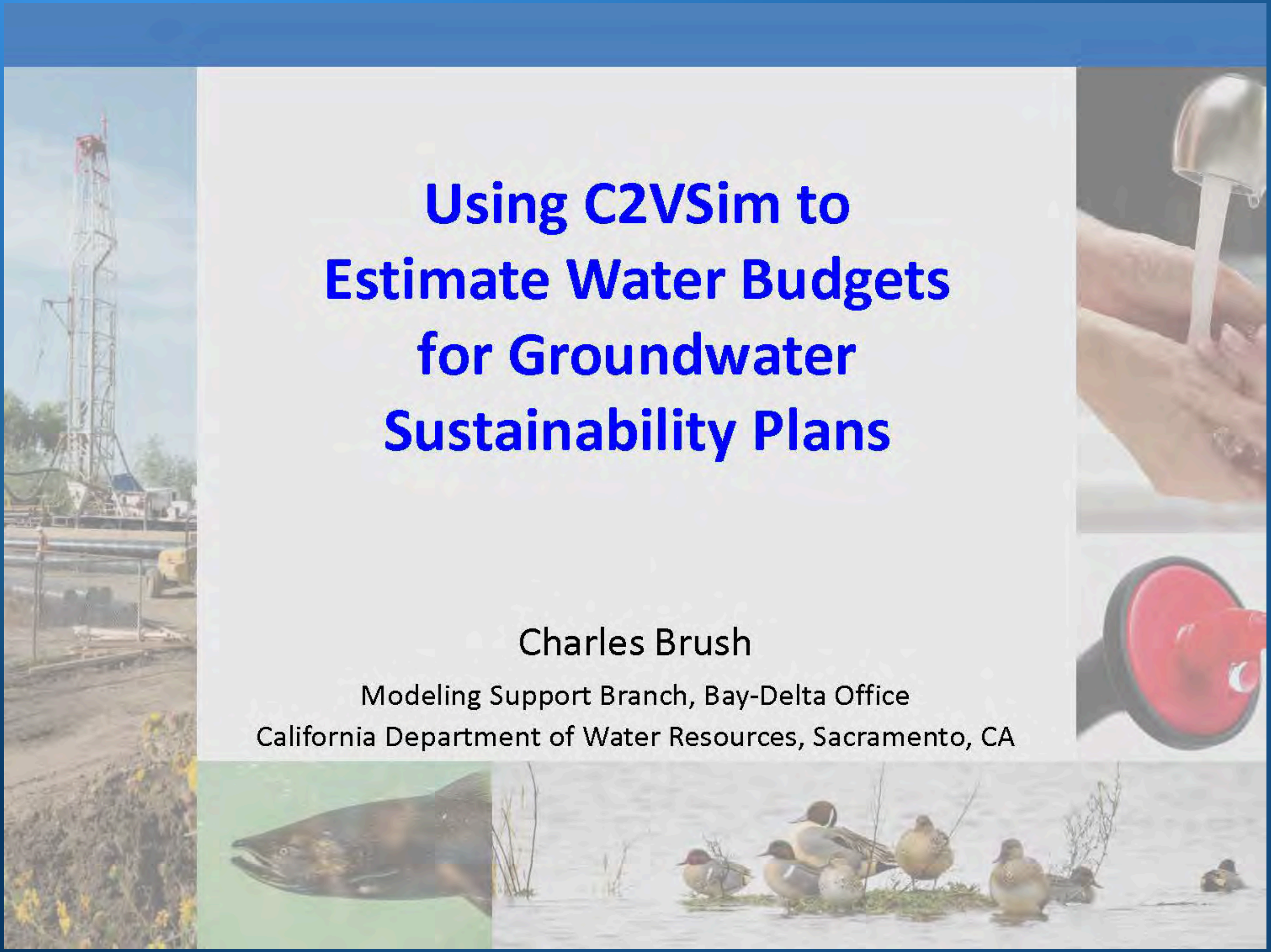
USGS CVHM

- OWM-Modflow
- 1965– 2013
- USGS update available 2017

Application to Water Budgets

Model	Advantages	Disadvantages
Local Models	• Hydrogeology • Water Budgets • Calibrations	• Don't cover entire subbasin • Don't "talk" to each other • Most not updated
CVHM	• Regional Model • Hydrogeology	• Not yet updated • No banking/recharge • Calibration • Lack of modeling tools
C2VSIM	• Regional Model • Focus on Water Budgets • Update in progress • DWR-approved for SGMA	• Hydrogeology? • Calibration? • Improvements in progress

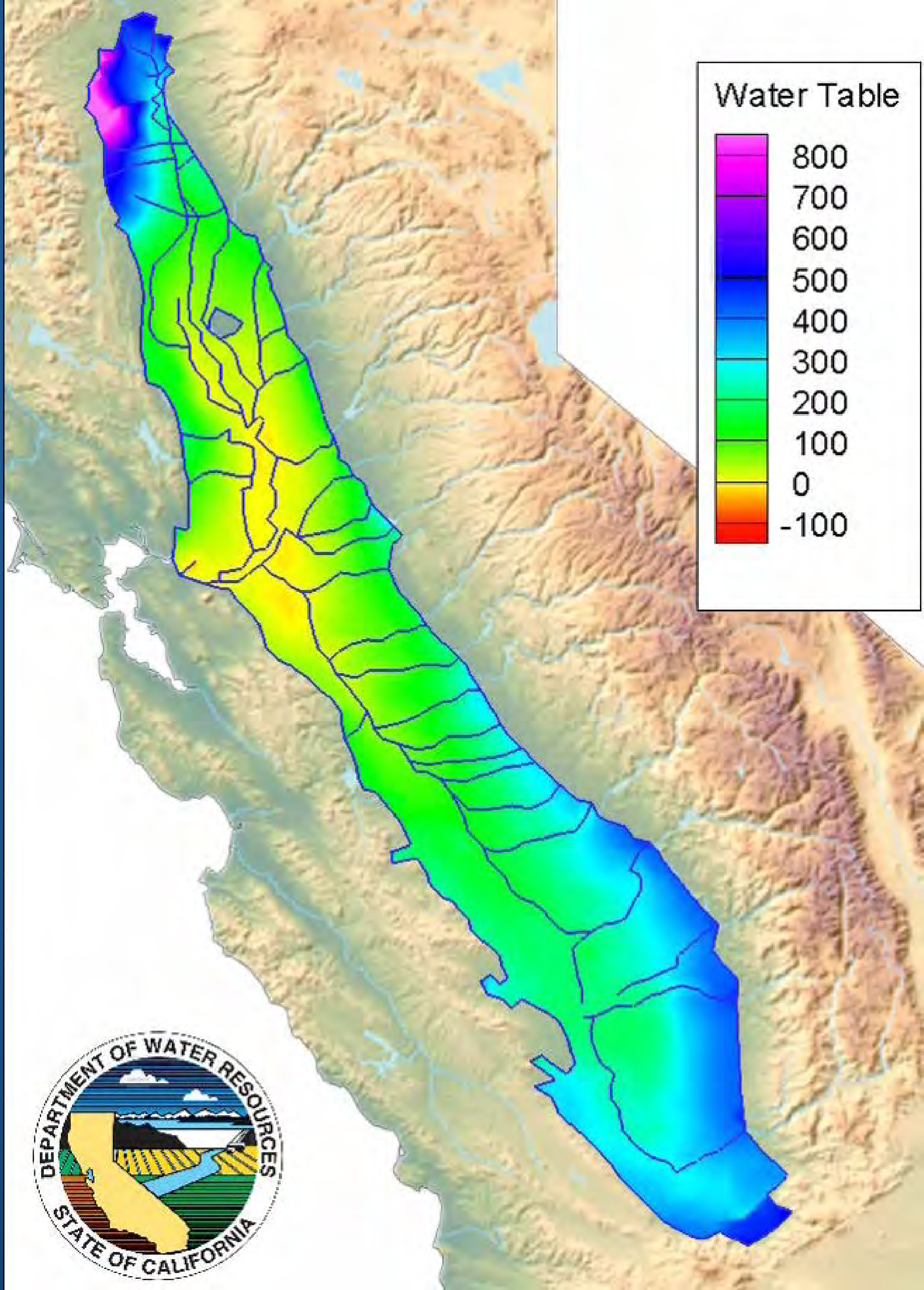
DWR 2016 Presentation



- DWR Technical Assistance with C2VSim for GSPs
- §354.18(f) "The Department shall provide…C2VSIM… for use…in developing the water budget."

C2VSim Model focus on Water Budgets

- DWR use for surface water and groundwater budgets
- Supports statewide applications for Bay-Delta office, CalSim 3, CWP
- Facilitate local zone budgets



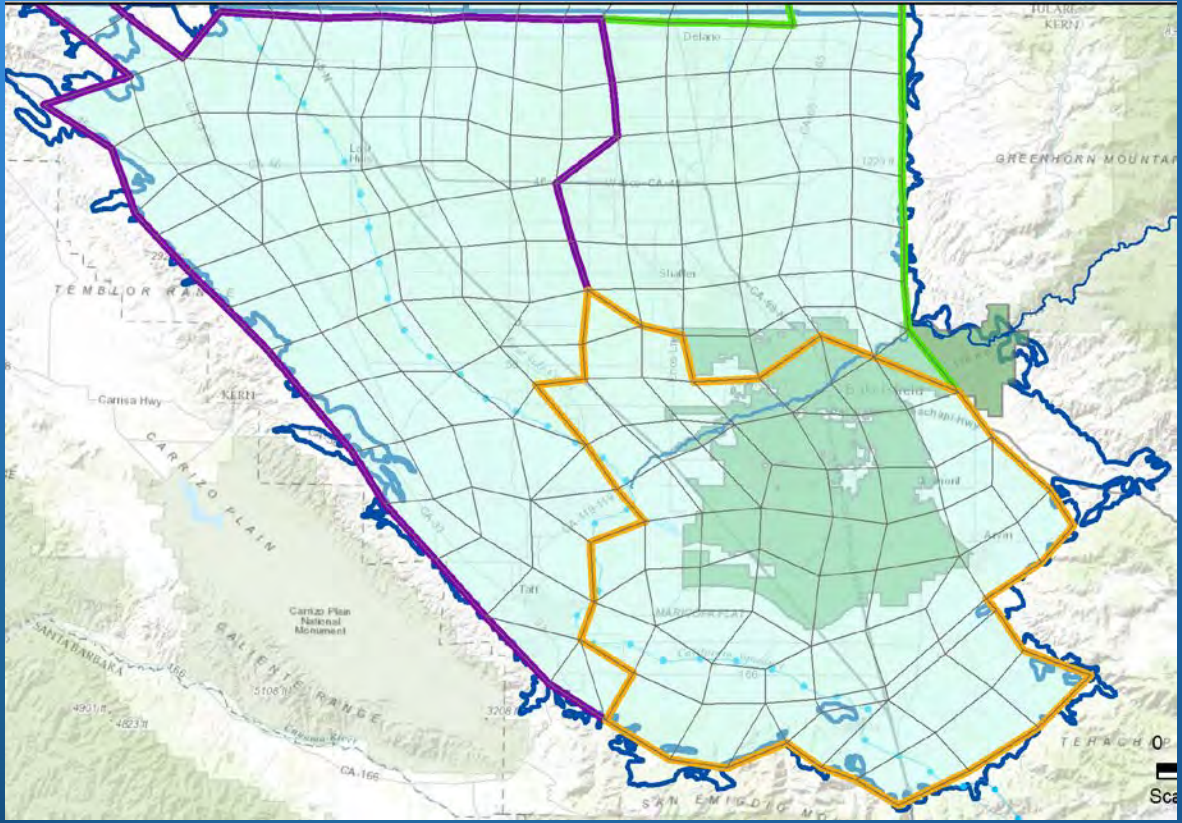
TODD GROUNDWATER

C2VSim Regional Model

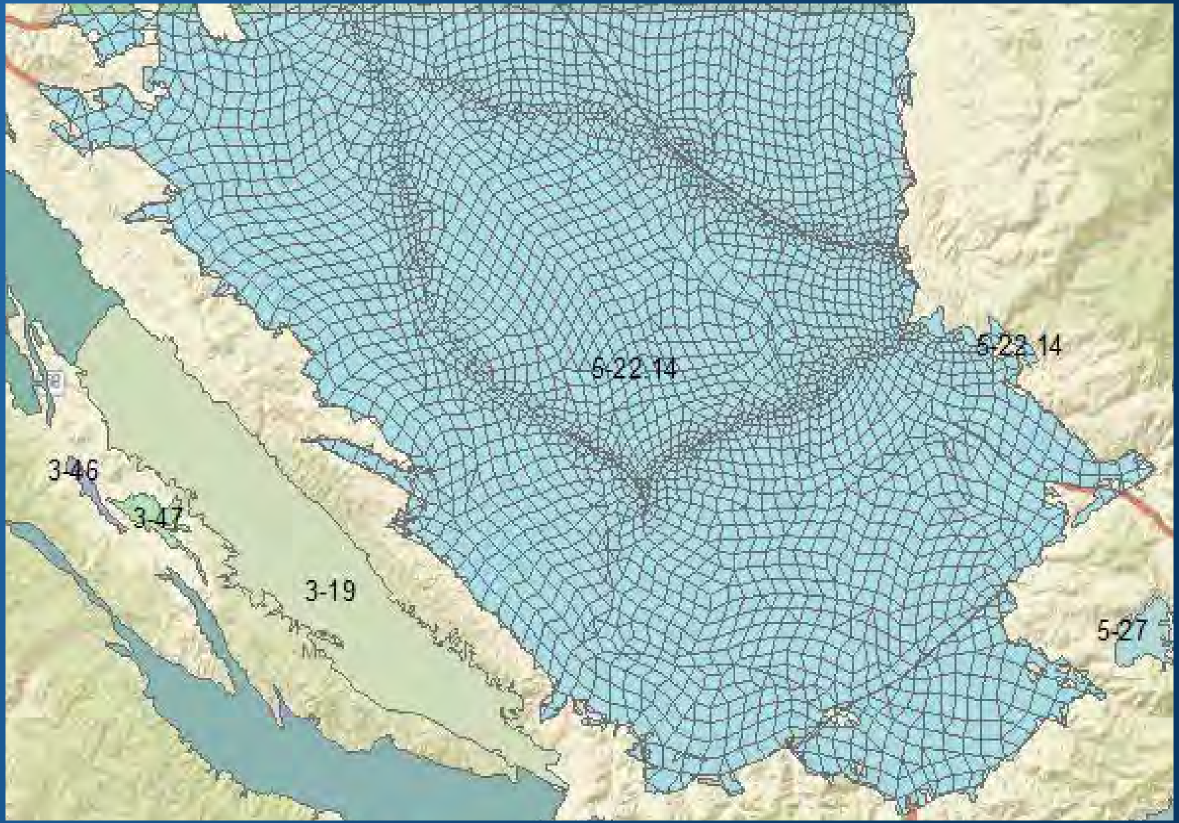
- Monthly streamflow, surface water diversions, precipitation, land use (crop acreages)
- Dynamically calculates crop water demands, allocates precipitation, soil moisture, and surface water
- Calculates groundwater demand
- 1922 – 2009 WY
- Calibrated 1976-2003 WY
- Update through 2015 in progress

TODD GROUNDWATER

Coarse-grid v. Fine-grid Model



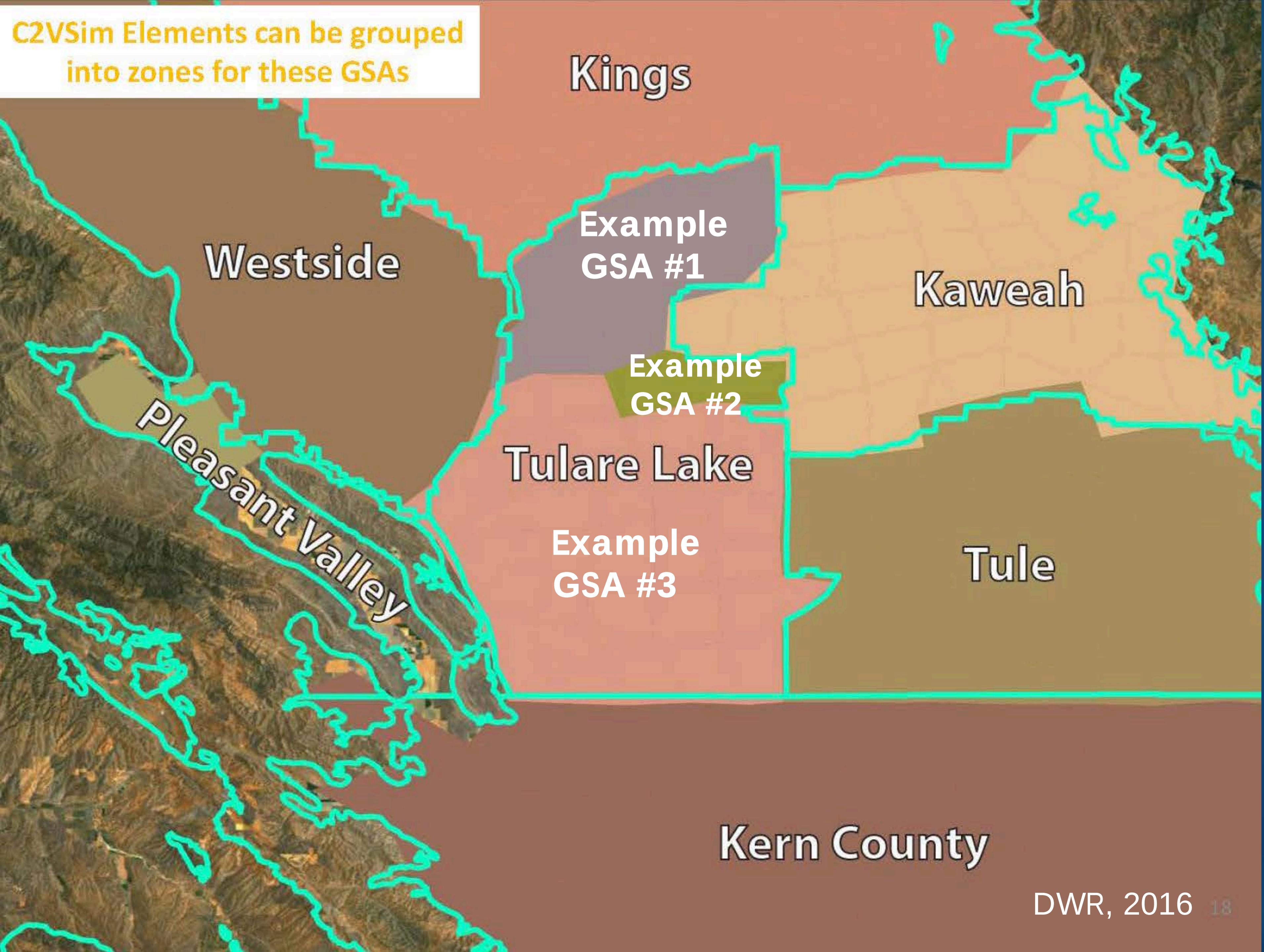
Average Element Area:
14.4 square miles



Average Element Area:
0.64 square miles

TODD GROUNDWATER

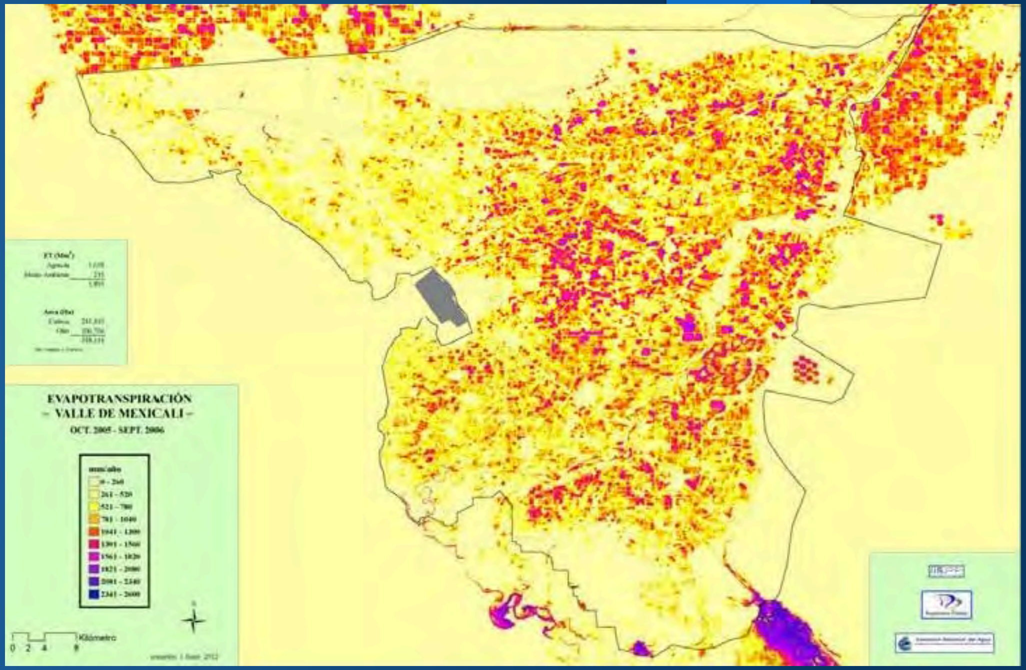
Creating C2VSim Zones around Districts or GSAs



DWR, 2016

TODD GROUNDWATER

Proposed C2VSim Revisions



- METRIC data from ITRC
  - Processing in progress
  - Final format? Monthly ET Zones? 20 years?
  - Acceptance of ET data?
  - ET zones v. crop coefficients
- Kern Fan Banking Operations
- Local GSA/District areas with accurate data

TODD GROUNDWATER

Steps for Model Revision

- Get C2VSIM update inputs from DWR NOW
- Work with DWR on updated features in new model
- Review METRIC data and develop method for model input
- Parse model into zone budgets matching GSA/District boundaries
- GSAs provide input for water budget modifications in local area
- Update banking operations
- Revise C2VSim – use fine-grid if available; coarse-grid if not; update to fine-grid when available.
- Develop current and historical water budgets for the entire subbasin
- GSAs can use local models or regional model for analyzing projects
- Hydrogeologic Conceptual Models from the GSPs can be used for recommendations of future model improvements

TODD GROUNDWATER

Criteria for Historical Water Budget Time Period

- Sufficiently long to approximate average hydrologic conditions (Kern River, precipitation)
- Recent time periods - current operations, widely-available and higher-quality data
- Initial conditions of stable (low) water levels
- Proposed:
  - Current water budget – WY 2015
  - Historical water budget – WY 1995 – WY 2014
  - Kern Fan Banking – back through WY 1978
- Also compile data through WY 2016

TODD GROUNDWATER

GSP Modeling Approach Advantages

- C2VSIM developed by DWR for water budgets
- Sanctioned by DWR and incorporated into GSP regulations
- Existing tool
- Covers entire subbasin
- Update and improvements available
- Relatively straightforward to check and revise local Agency data

TODD GROUNDWATER

Discussion

Kern River Groundwater Sustainability Agency (KRGSA)

Groundwater Supply Workshop
Groundwater Sustainability Plan (GSP)

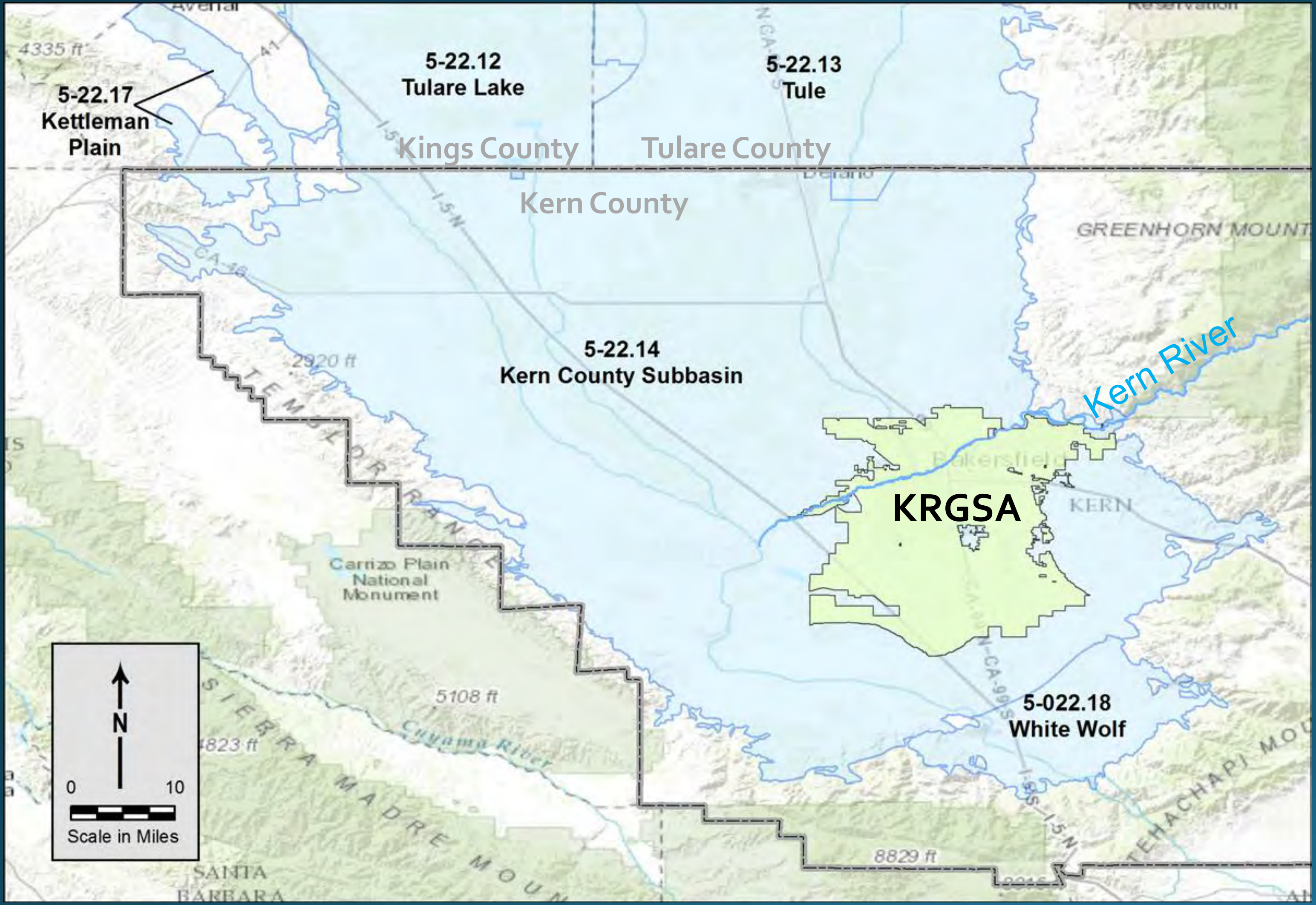
July 13, 2017

Workshop Presentation

- KRGSA Formation
- Contents of a Groundwater Sustainability Plan (GSP)
- Sustainability Criteria
- KRGSA Planning Area
- Request for information on groundwater supply and demand
- Schedule

TODD GROUNDWATER

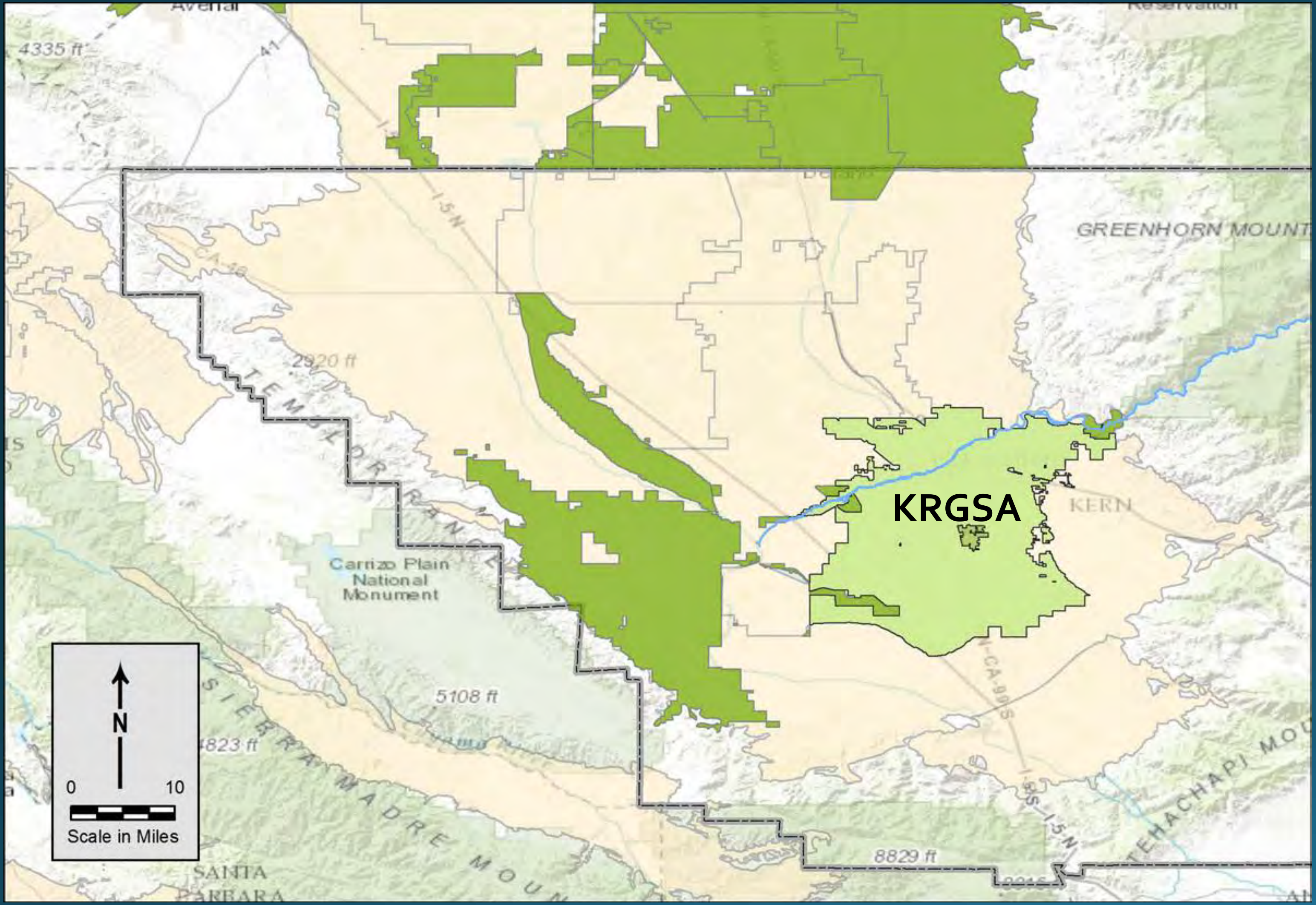
KRGSA and Groundwater Basins



- Located in Kern County Subbasin
- DWR critically-overdrafted basin
- KRGSA
  - 357 square miles
  - Kern River

TODD GROUNDWATER

GSAs in Kern County Subbasin



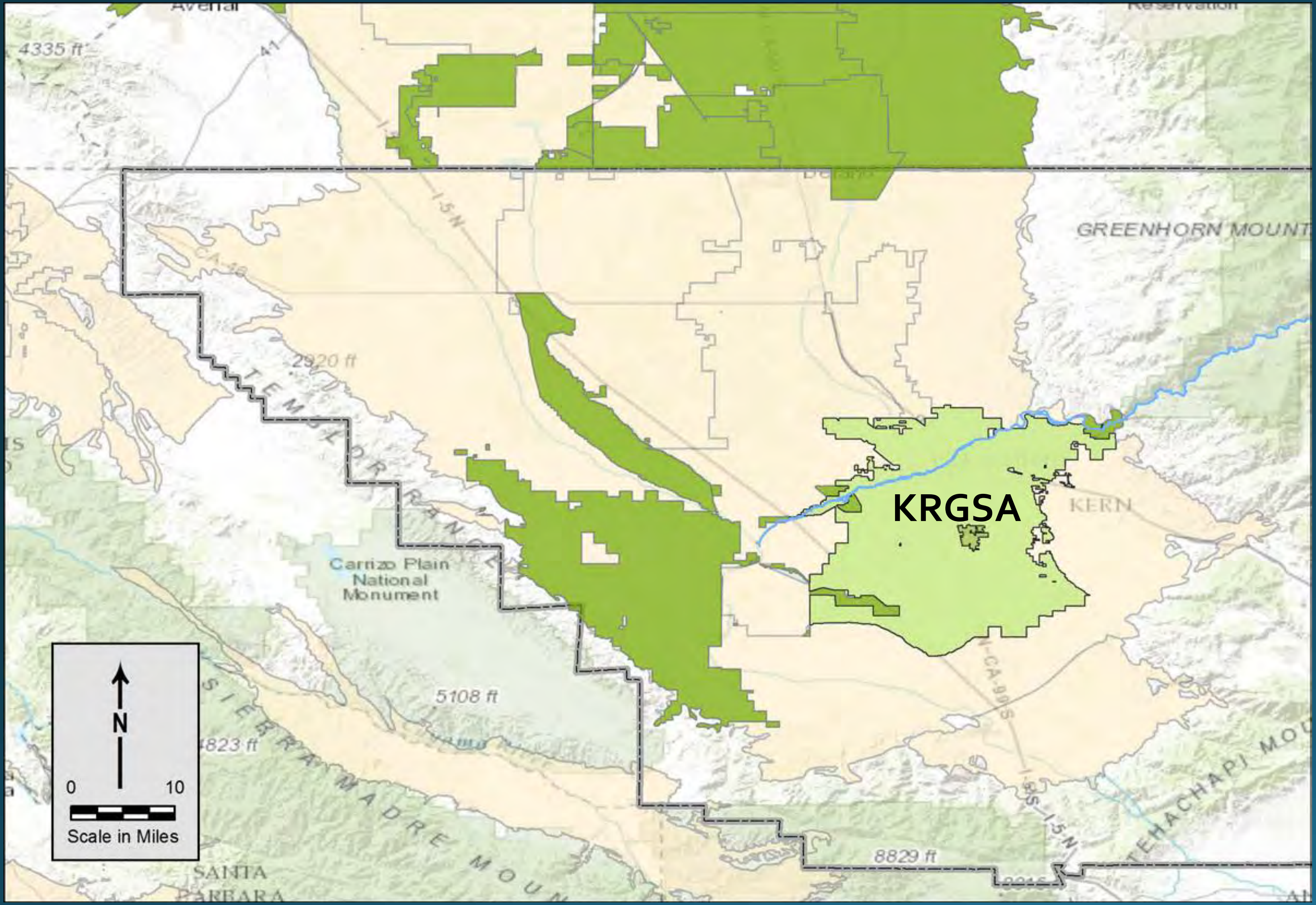
- GSAs cover entire subbasin
- KRGSA Exclusive GSA December 2016
- Others recently formed

Exclusive GSA

GSA Notice Submitted

TODD GROUNDWATER

GSAs in Kern County Subbasin



- GSAs must form ***Groundwater Sustainability Plans (GSP)*** by 2020
- Achieve sustainability by 2040

Exclusive GSA

GSA Notice Submitted

TODD GROUNDWATER

What is in a Groundwater GSP?

Data Compilation / Data Management System

Institutional Setting – Water Supply / Plan Area

Workshop

Hydrogeologic Conceptual Model / Groundwater

Water Budget (Current and Historical)

Sustainability Goals and Criteria

Management Scenarios Projected Water Budget

Monitoring Networks

Plan Development

TODD GROUNDWATER

Sustainability Indicators

 Chronic lowering of water levels

 Depletion of groundwater in storage

 Degradation of groundwater quality

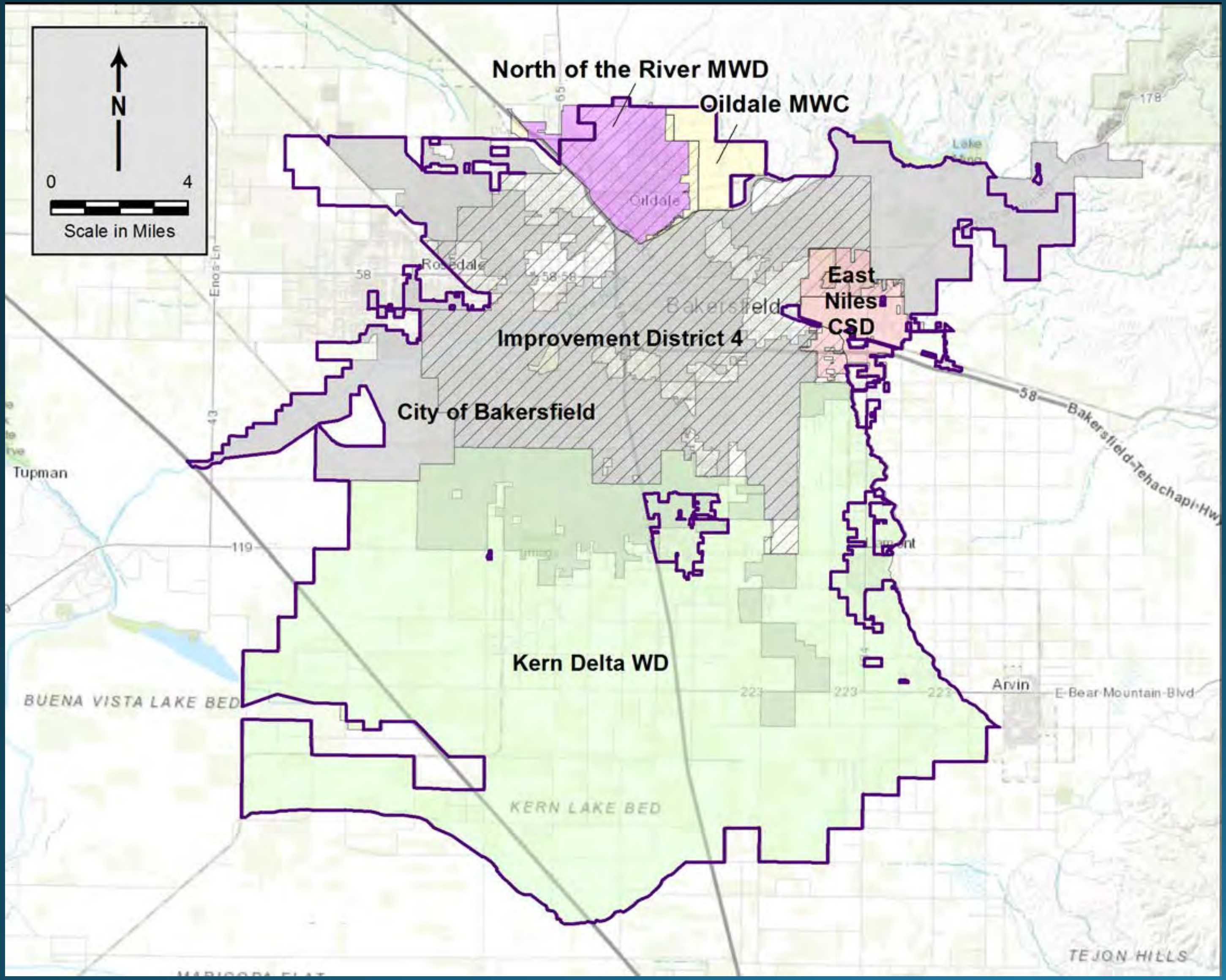
 Land subsidence from groundwater pumping

 Depletion of interconnected surface water affecting beneficial uses

An indicator is an <u>undesirable result</u> if determined to be "significant and unreasonable"

TODD GROUNDWATER

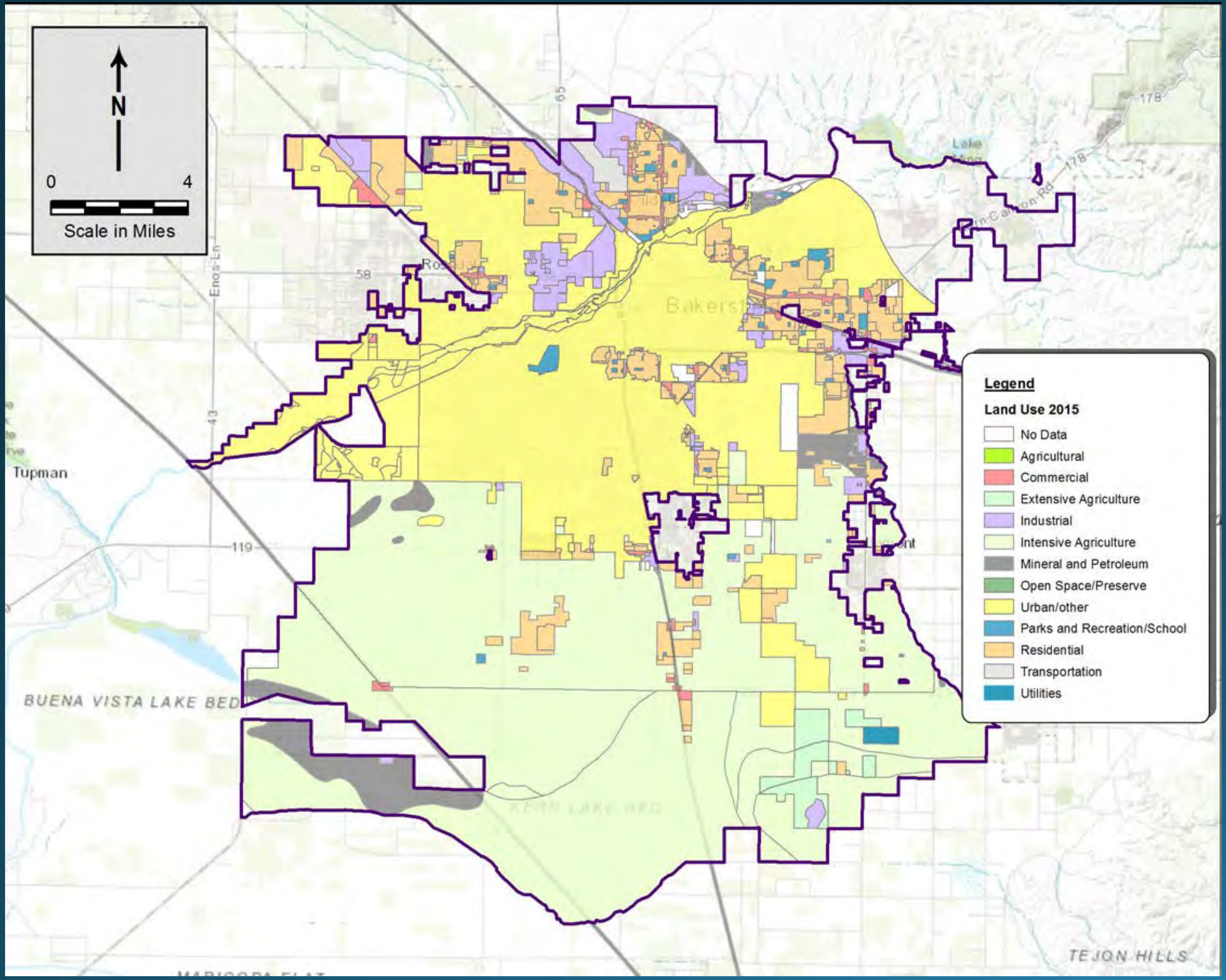
KRGSA and Member Agencies



- BOARD/MANAGEMENT:
  - City of Bakersfield
  - Kern County Water Agency, Improvement District 4 (ID4)
  - Kern Delta Water District
- PARTICIPATING AGENCIES:
  - East Niles Community Services District (CSD)
  - North of the River Municipal Water District (MWD) / Oildale Mutual Water Company (MWC)
  - CA Water Service Company
  - Vaughn Water Company

TODD GROUNDWATER

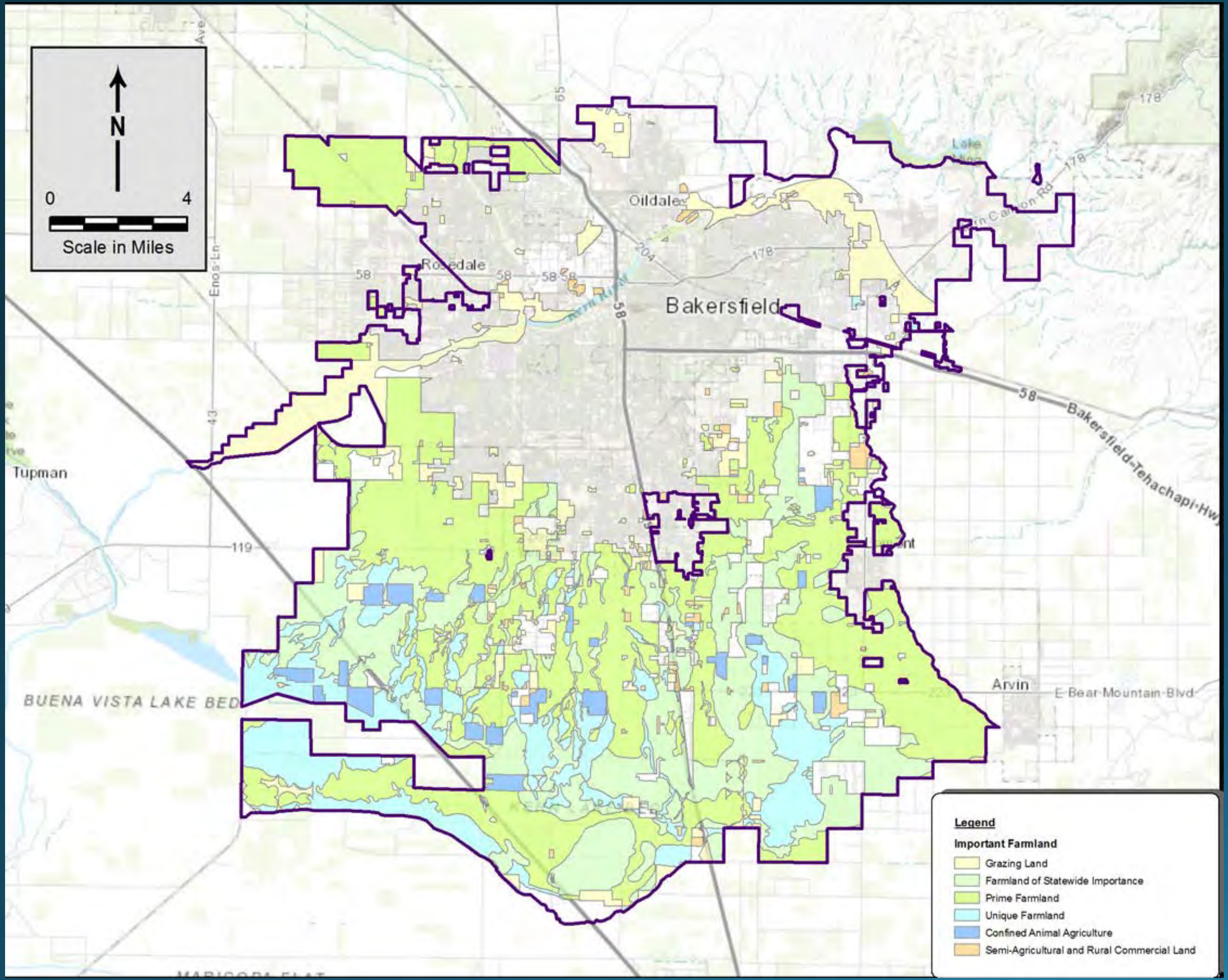
Land Use



- Mix of Land Uses
- Large urban center
- Residential and industrial
- Large agricultural area
- Some petroleum resources

TODD GROUNDWATER

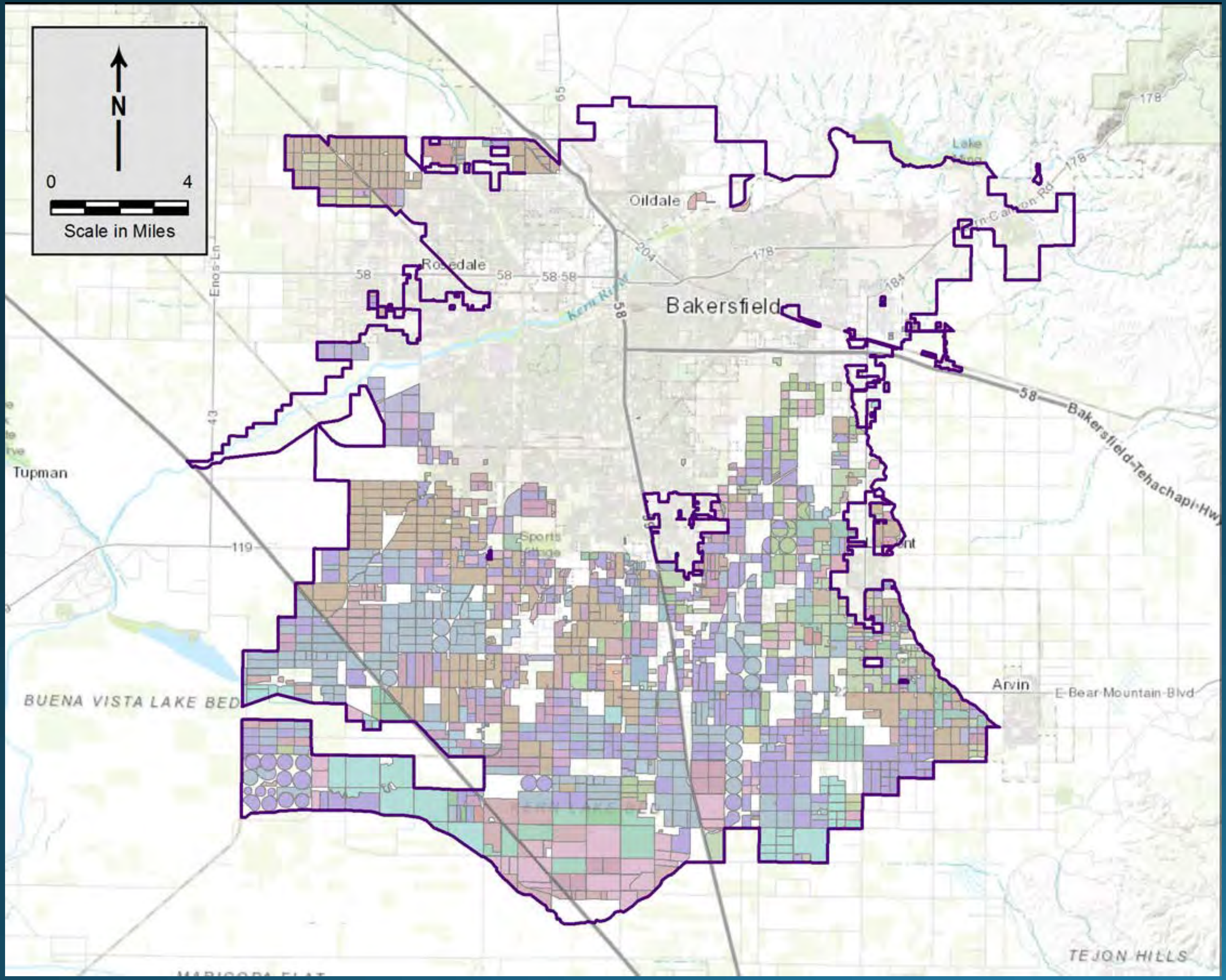
Farmland of State Importance



- Prime and unique Farmland
- Some Grazing Lands
- Dairies

TODD GROUNDWATER

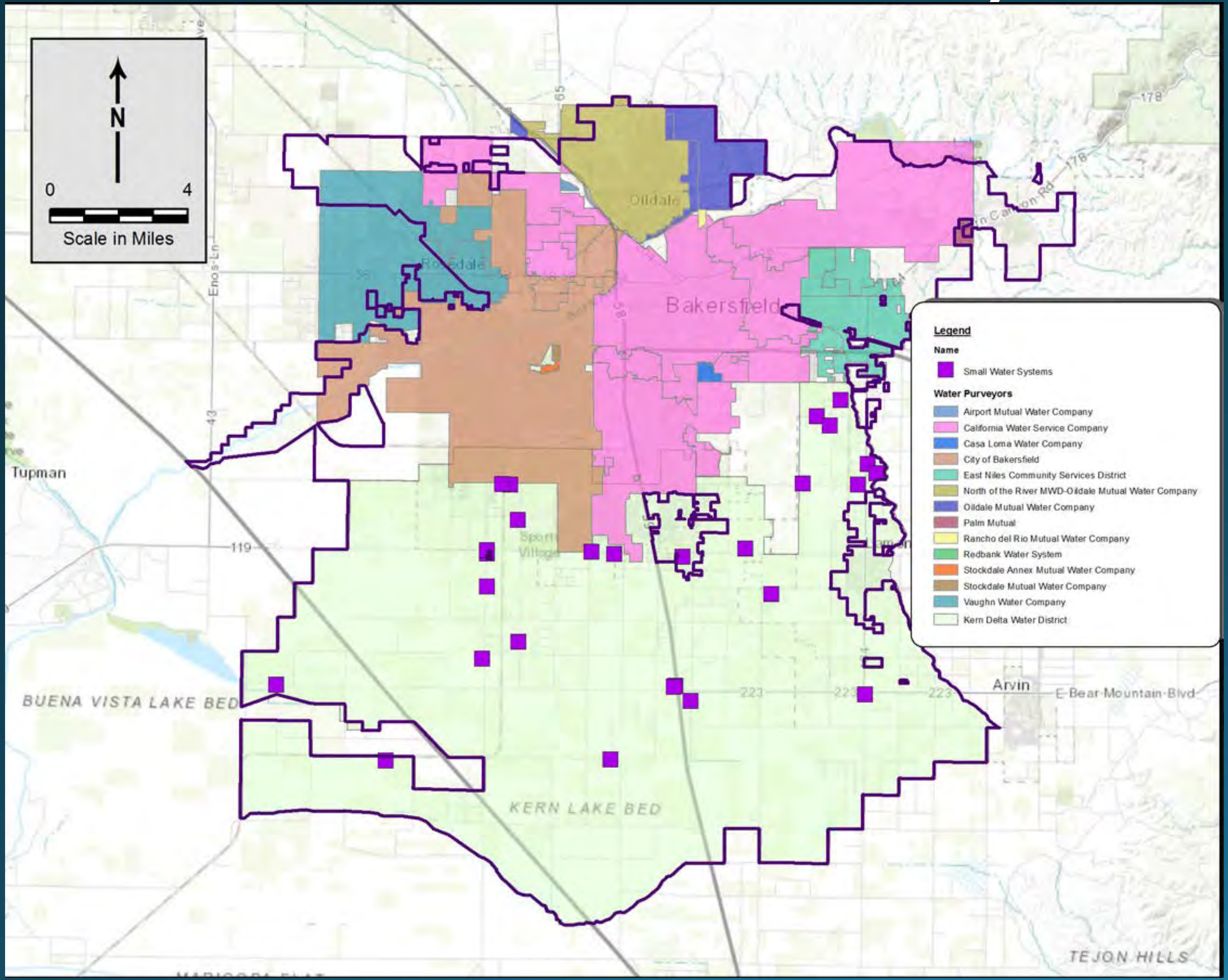
Agricultural Crops



- Mix of agricultural crops
- Increasing permanent crops

TODD GROUNDWATER

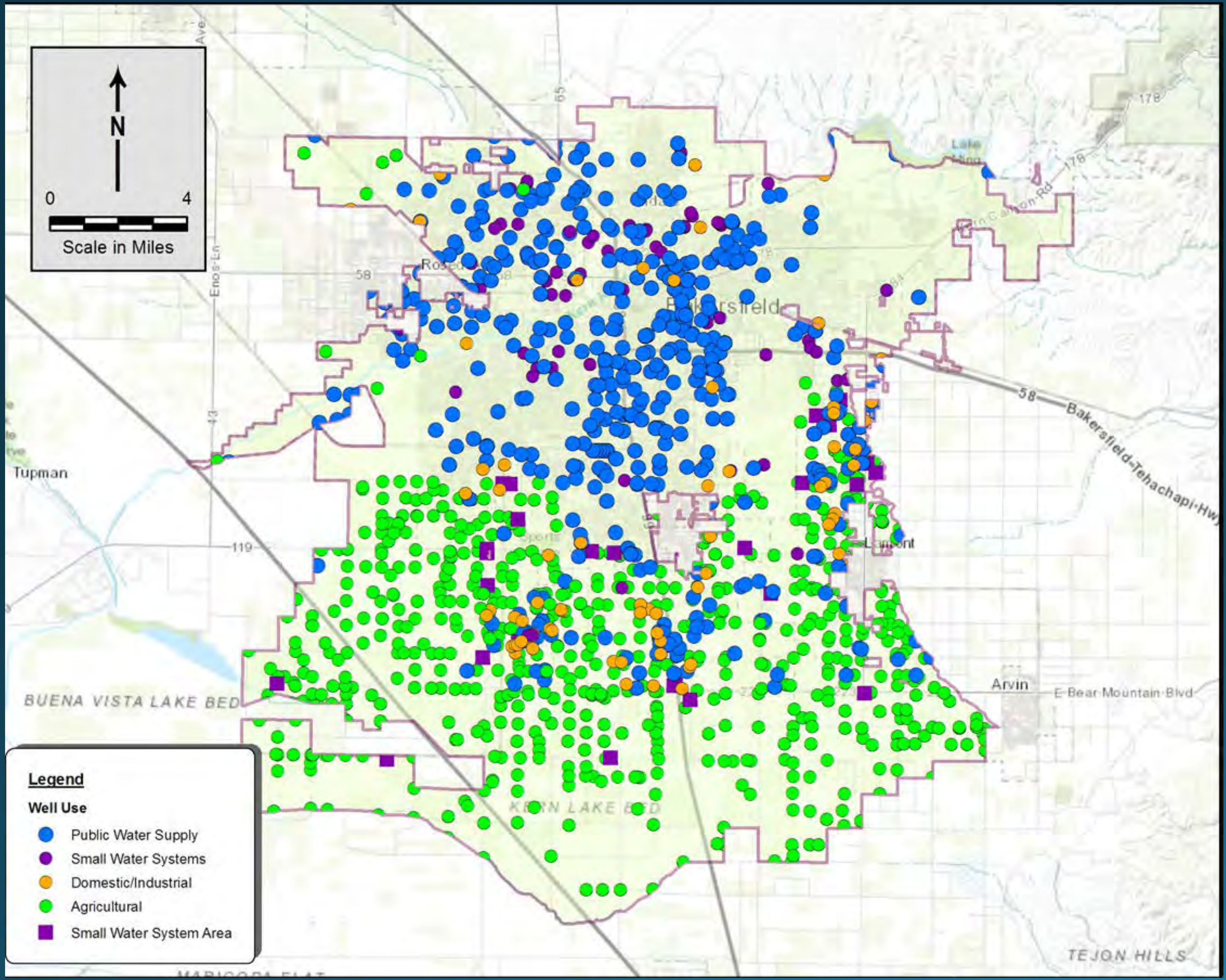
Local Water Purveyors



- 46 water suppliers in the KRGSA
- Includes 32+ small water systems
- Most of these systems rely on groundwater for part of supply

TODD GROUNDWATER

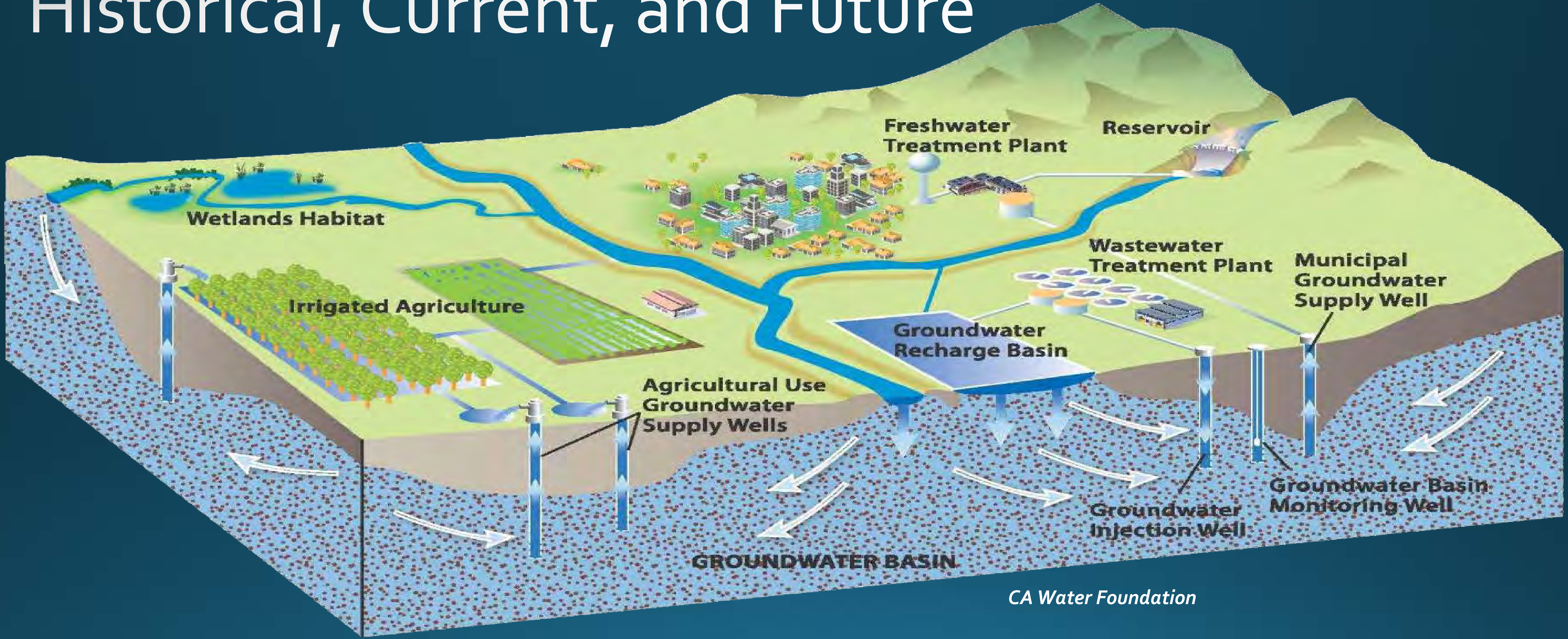
Active Wells in the KRGSA >1,100



- 300+ municipal water supply wells
- 93+ small water system wells
- 106 domestic / industrial wells
- 642 agricultural wells
- GSP regulations require well identification and mapping

TODD GROUNDWATER

GSP Requires Detailed Water Budgets: Historical, Current, and Future



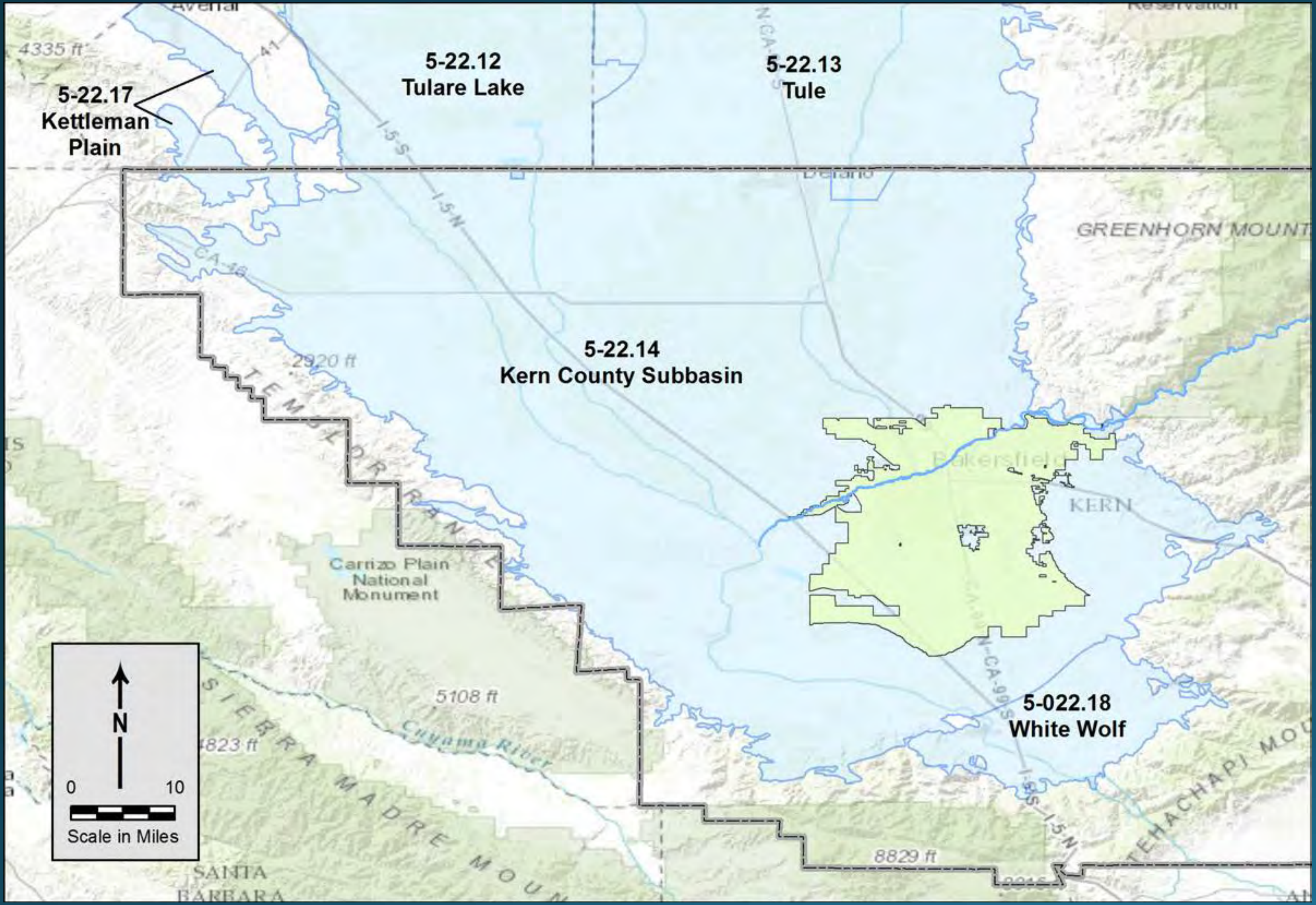
CA Water Foundation

Tabulate inflows and outflows for the KRGSA groundwater system

Document surface water entering and leaving the GSA

TODD GROUNDWATER

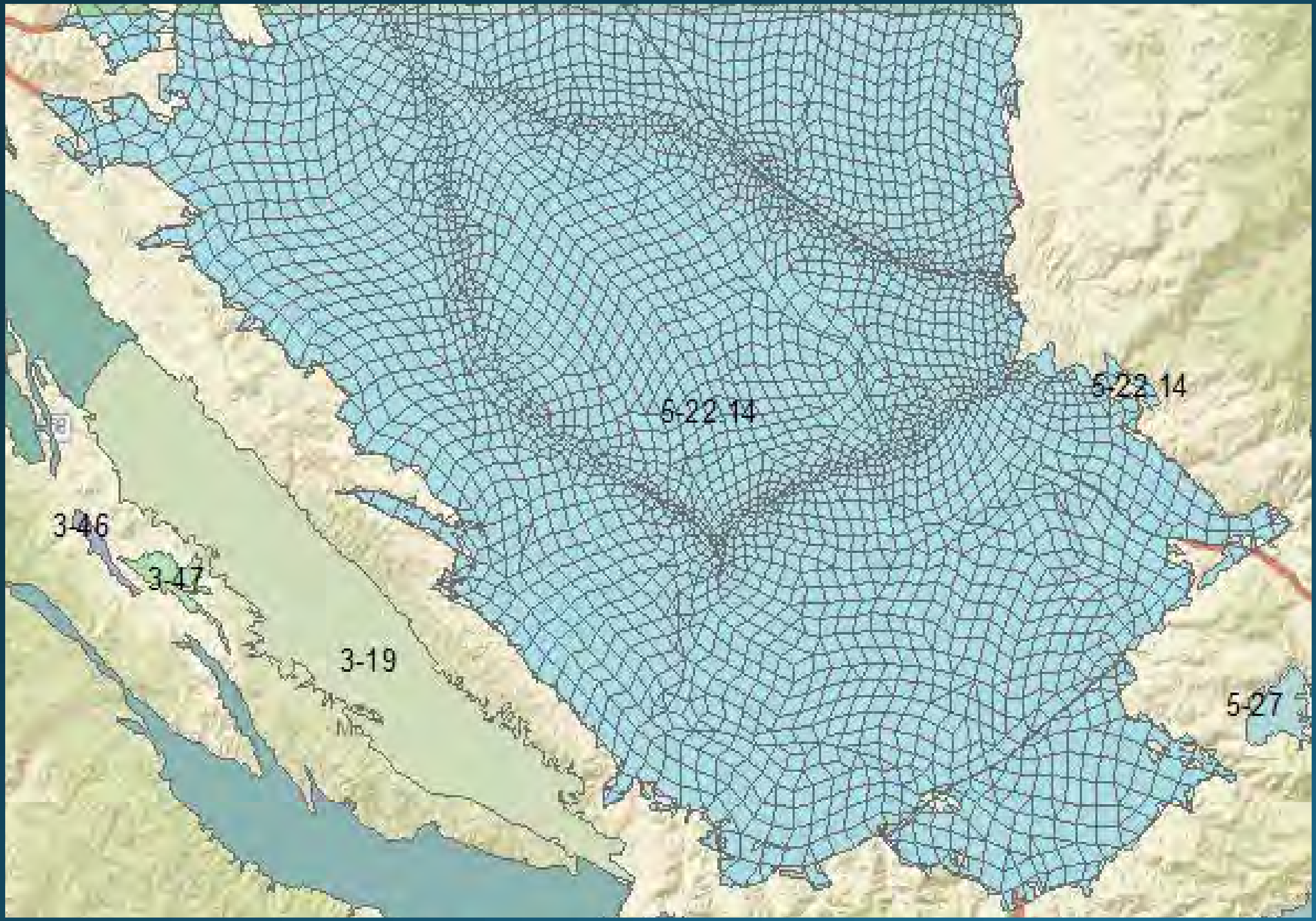
GSP Basin-wide Water Budgets



- Account for all inflows, outflows, and change in storage (groundwater and surface water)
- Current, Historical, and Projected water budgets
- Must cover the entire subbasin (>3,000 mi²)

TODD GROUNDWATER

DWR Basin-wide Groundwater Model



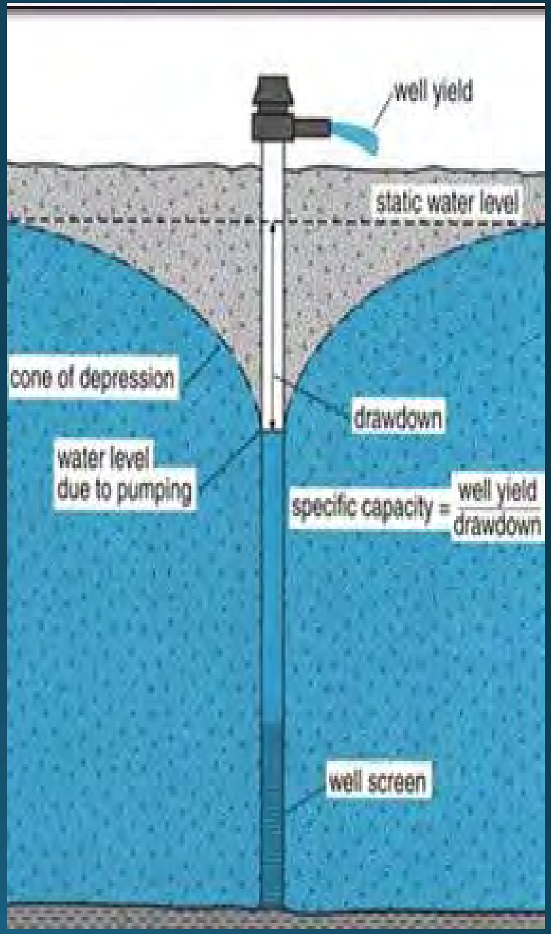
- C2VSim numerical computer model
- Regional model with incomplete local data
- Modify local water budgets for KRGSA in model
- Model Study Period:

  WY 1994 – WY 2015

TODD GROUNDWATER

Well and Production Data Needed

- Wells
  - Number of wells and location (lat/long, coordinates)
  - Depth, screen interval, casing diameter and materials
  - Surface elevation / reference elevation
  - Capacity and use (active, standby, etc.)
  - Water use
- Monthly pumping (by well): <u>October 1994 – Present</u>
- If monthly data unavailable, will estimate from annual production
- Other water sources and use



TODD GROUNDWATER

Wastewater and Recycled Water Needed

- City of Bakersfield
  - WWTP #2 and #3
  - Recharge ponds
  - Irrigation with recycled water
- Kern Sanitation Authority
- NOR Sanitary District No. 1
- Kern County Service Area 71
- Septic systems – where?

TODD GROUNDWATER

Schedule

- GSP must be completed by 2020
- 2017
  - Describe Plan Area
  - Evaluate hydrogeology and groundwater conditions
  - Develop and analyze water budgets
  - Evaluate sustainability indicators for undesirable results
- 2018
  - Determine Sustainability Criteria
  - Identify and analyze management actions
  - Develop Plan
- 2019
  - Coordinate with other GSPs in the subbasin
  - Develop Monitoring networks
  - Prepare data for plan submittal to DWR

TODD GROUNDWATER

Get Involved

- GSP will contain information on the shared groundwater supply in the KRGSA
- GSP regulations require management and reporting of groundwater extractions
- Monthly Board meetings
- Quarterly information meetings

http://kernrivergsa.org

TODD GROUNDWATER

Discussion and Questions

TODD GROUNDWATER

Kern River Groundwater Sustainability Agency

Public Meeting:

Introduction to the KRGSA and Developing a Groundwater Sustainability Plan

September 14, 2017

Meeting Agenda

- SGMA Overview
- KRGSA Background
- KRGSA Groundwater Sustainability Plan Overview
- GSP Components and Activities
- GSP Timeline
- How to Get Involved
- Feedback, Questions, and Comments

SGMA Overview

- Requires Groundwater Sustainability Agencies to be formed in high or medium priority basins by June 2017
- GSAs are to develop a Groundwater Sustainability Plan (GSP).
- Basins can have a single GSP or multiple coordinated GSPs.
- Kern County GSP(s) due January 31, 2020.

Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014

Source: Department of Water Resources

SGMA Key Steps and Timeline

Step One

Local agencies must form Groundwater Sustainability Agencies by June 30, 2017

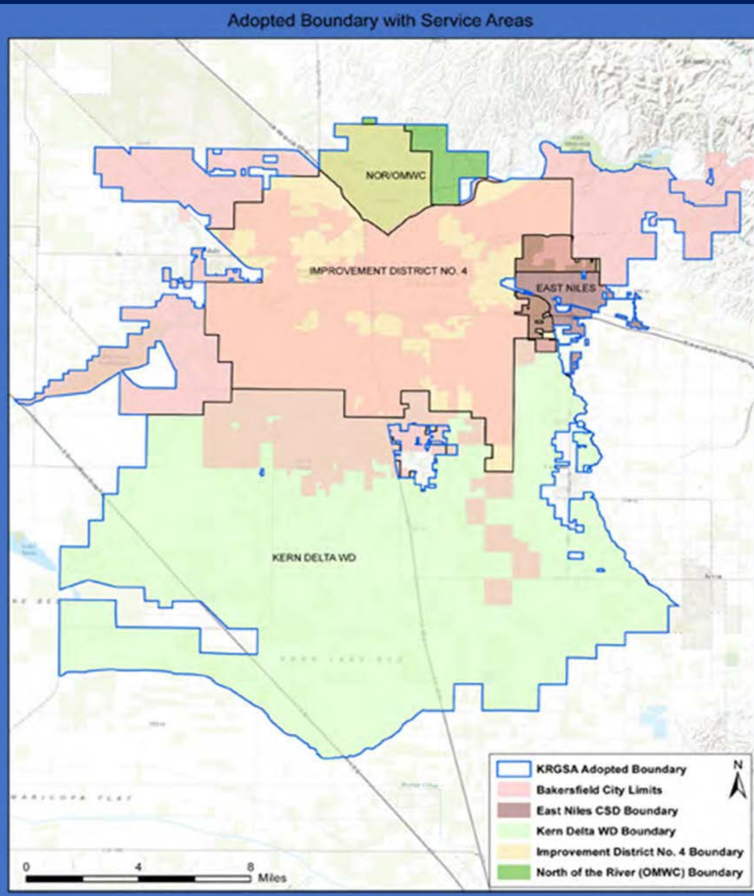
Step Two

Local GSAs must adopt a Groundwater Sustainability Plan (GSP) by Jan. 31, 2020.

Step Three

Once GSP is in place, local agencies must achieve sustainability by 2040.

Kern River Groundwater Sustainability Agency



Source: Kern River Groundwater Sustainability Agency

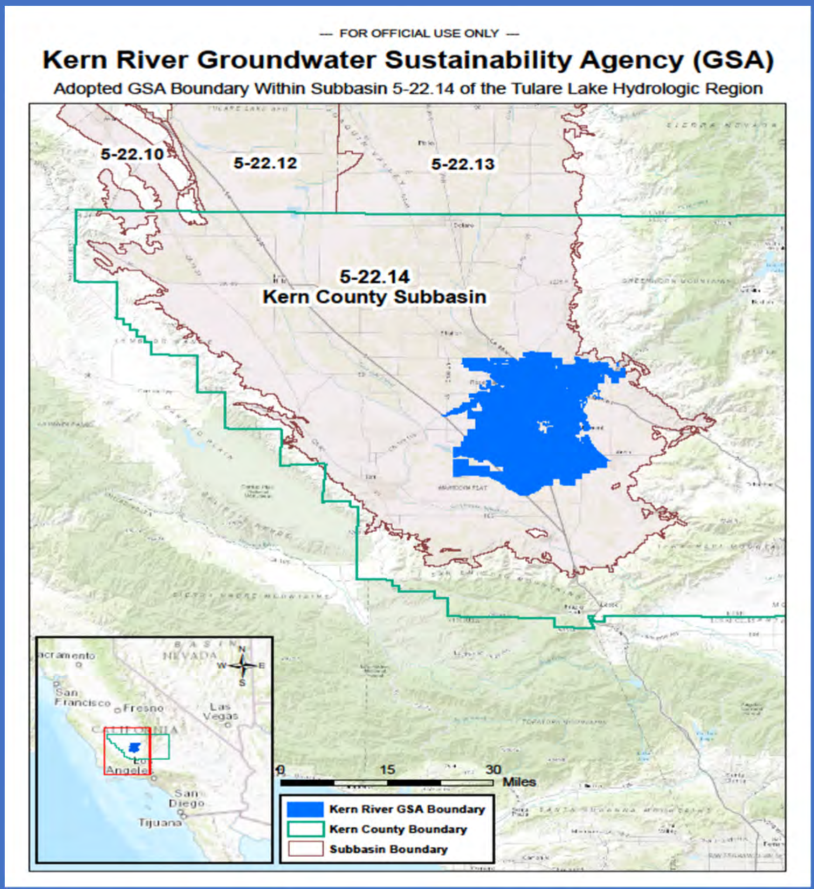
Core Agencies

- City of Bakersfield
- Kern County Water Agency Improvement District 4 (ID4)
- Kern Delta Water District (KDWD)

Participating Agencies

- East Niles Community Services District (CSD)
- North of the River Municipal Water District (MWD)/Oildale Mutual Water Company (MWC)
- California Water Service Co.
- Vaughn Water Company

KRGSA and Kern County Subbasin

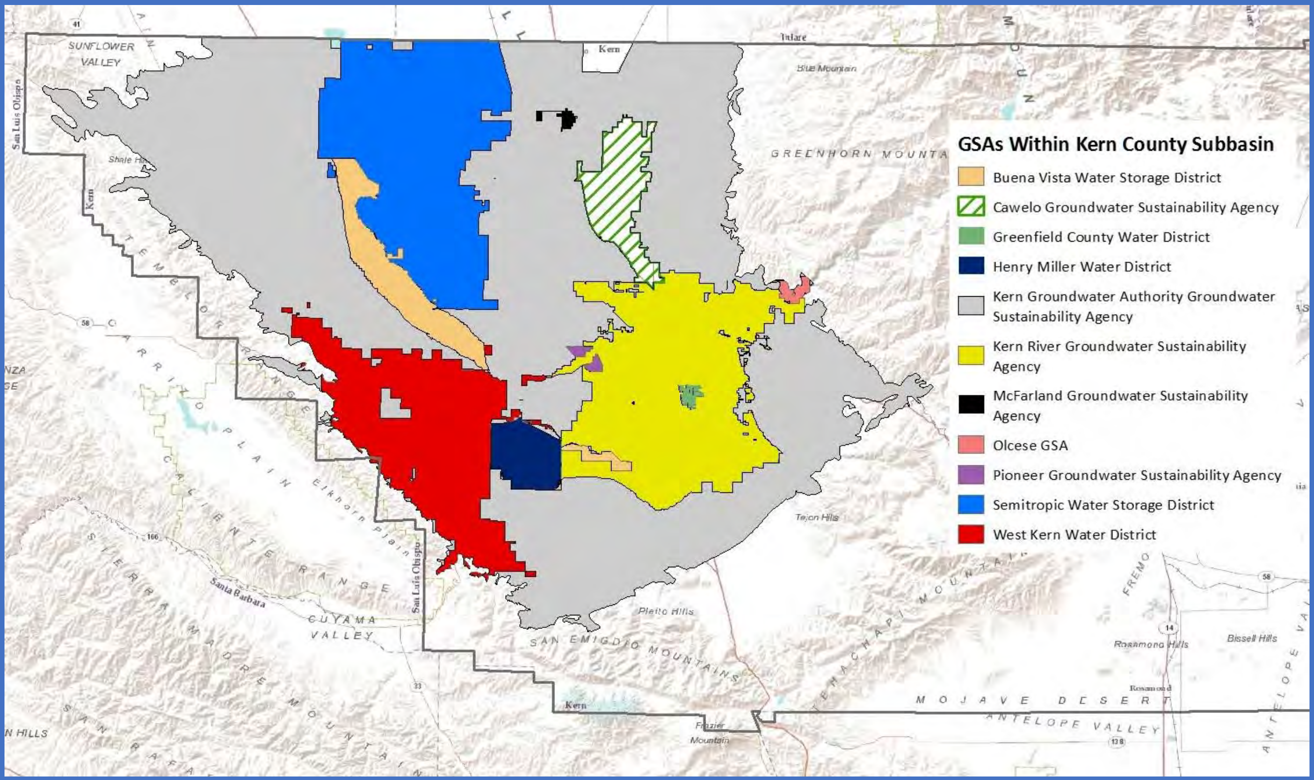


Source: Kern River Groundwater Sustainability Agency

- KRGSA located in the Kern County Subbasin
- Critically-overdrafted Basin
- KRGSA - 357 sq. mi.

Coordination with other GSAs in Kern County Subbasin

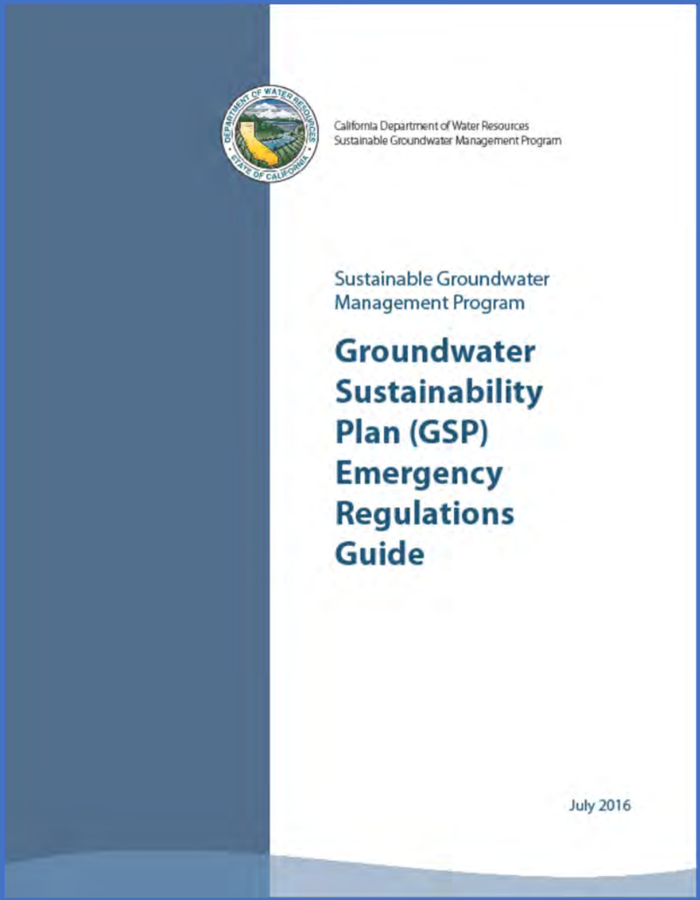
Eleven GSAs Within Kern County Subbasin



Source: DWR SGMA Portal

GSP Requirements and Goals

- Manage groundwater without causing undesirable results.
- Don’t adversely affect an adjacent basin.
- Describe basin-wide governance and coordination to reach sustainability.
- Establish timeline to fill data gaps.
- Use adaptive management.
- Achieve sustainability goal for basin by 2040.



Prevent Undesirable Results

Chronic lowering of water levels.

Depletion of groundwater.

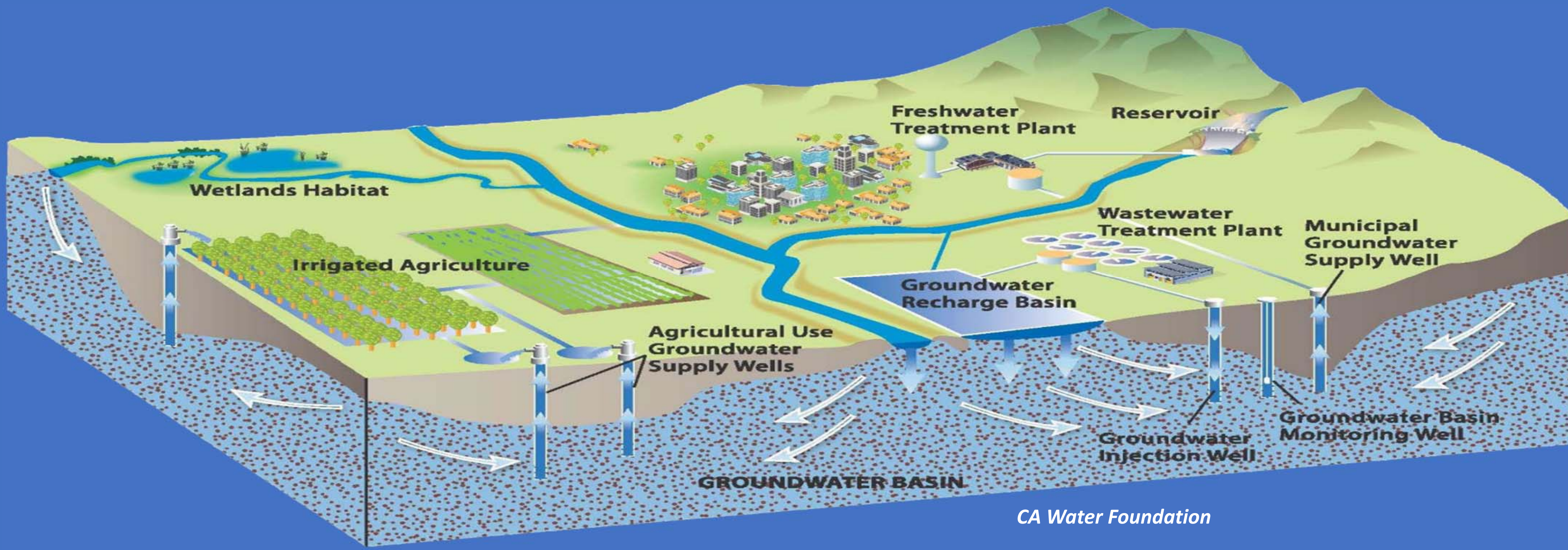
Degradation of groundwater quality.

Land subsidence from groundwater pumping.

Depletion of interconnected surface water affecting beneficial uses.

Understanding the Basin

- GSP requires conceptual model/understanding of basin.
- GSP must describe basin water budget.
- GSP includes management actions to achieve sustainability.



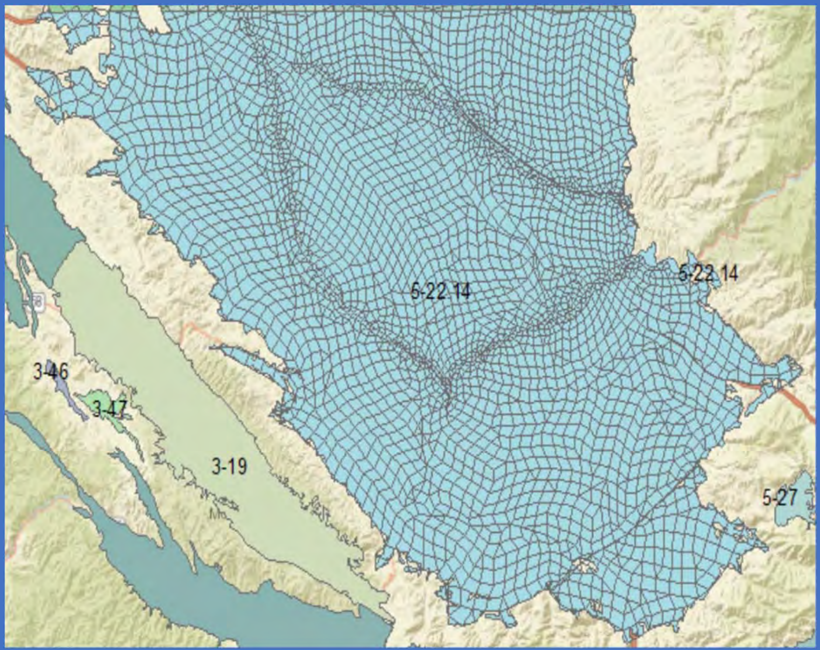
CA Water Foundation

Developing the GSP

Todd Groundwater is the technical consultant for the KRGSA, developing the groundwater analysis and modeling

1. Conduct Data Compilation/Management.
2. Establish Water Supply/Plan Area.
3. Develop a Hydrogeologic Conceptual Model and Conceptual Groundwater Budget.
4. Develop Water Budget for Current and Historic Conditions.
5. Establish Sustainability Goals and Criteria.
6. Establish Management Scenarios and Projected Water Budget for Future Conditions.
7. Actively Monitor Networks and GSP Development.

Kern County Groundwater Model



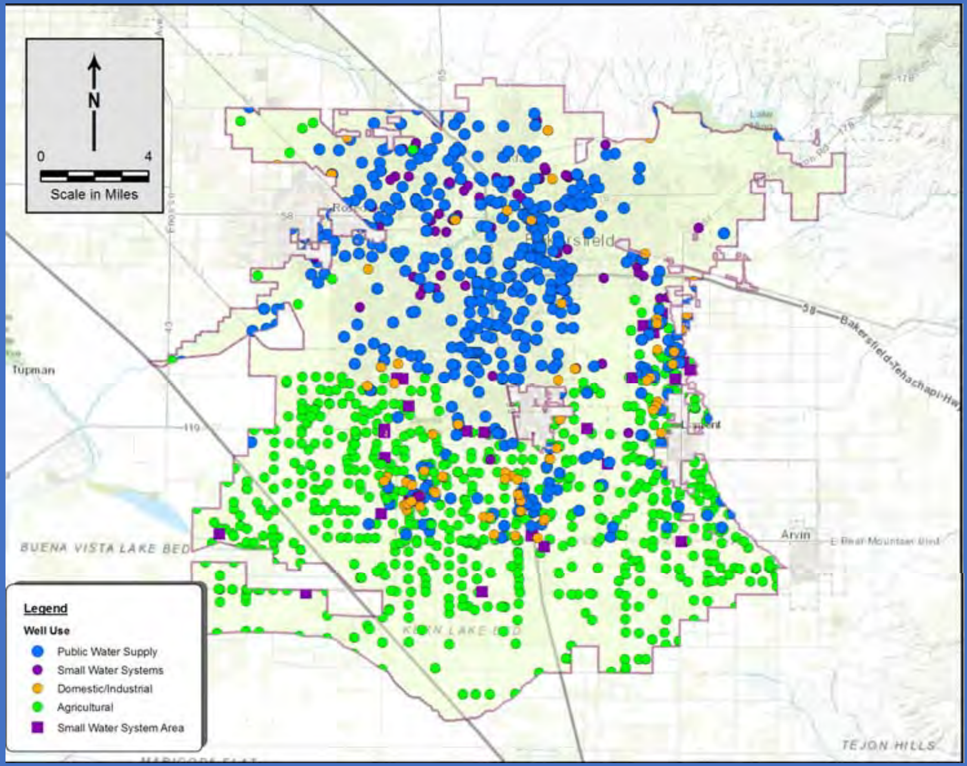
Source: Todd Groundwater

Importance of Community Participation

Public Input is Essential:

- Data
- Feedback on GSP
- Feedback on potential management actions
- Implementation and monitoring
- Reflects community ideas and concerns

Active Wells in KRGSA Territory



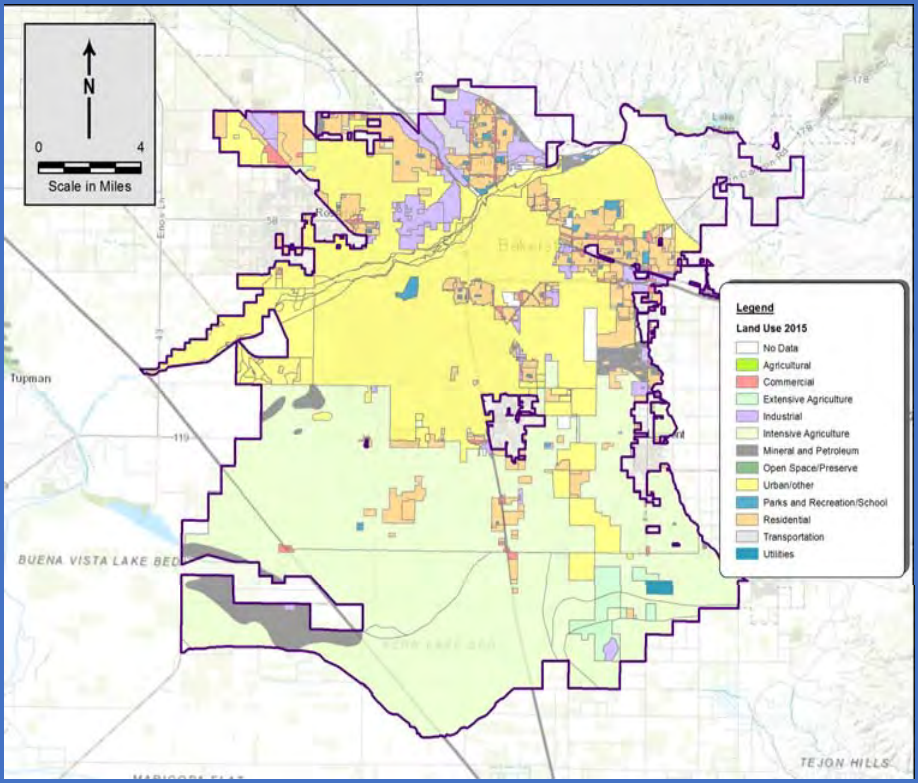
Source: Todd Groundwater

Stakeholders and Community Participation

- KRGSA to engage a broad range of stakeholders within the KRGSA and the Kern County Subbasin, prior to making any local decisions.

- Stakeholders (Interested Parties) include:
  - Water Providers
  - Public Agencies
  - Disadvantaged Communities
  - Environmental Groups
  - Agricultural Entities
  - Industrial Users
  - Other GSAs
  - Parties Requesting Contact
  - Any Other Beneficial Uses and Users

Land Uses Within KRGSA Territory

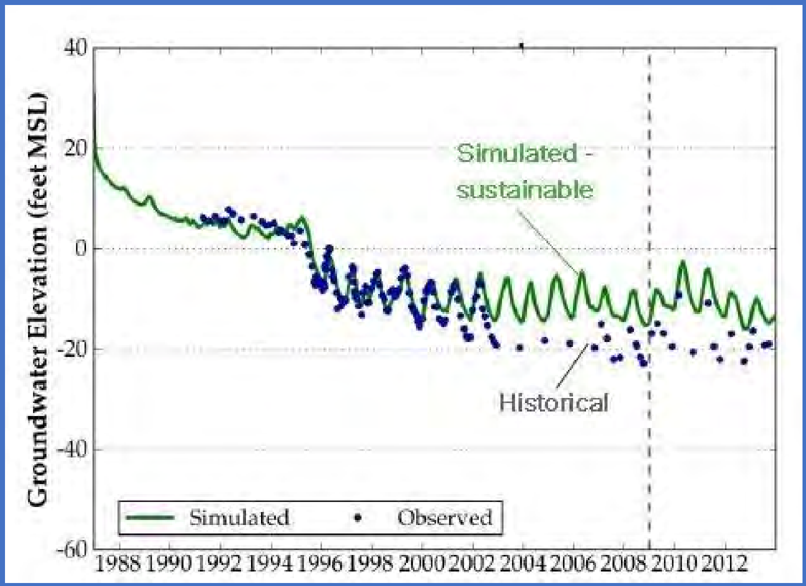


Source: Kern River Groundwater Sustainability Agency

KRGSA Activities Moving Forward

- Continue GSP Development.
- Develop water budget to evaluate scenarios.
- Coordinate with other agencies in Kern County Subbasin.
- Conduct outreach to interested parties.
- Provide GSP status updates & meetings.
- Conduct targeted meetings and public workshops.

Simulated Sustainable Groundwater Model



Source: Todd Groundwater

KRGSA Timeline 2017-2020

Introductory Public Meeting

September 14, 2017

KRGSA Basin Setting and Sustainability Workshop

January, 2018

Minimum Thresholds and Undesirable Results Workshop April, 2018

On-Going GSP Preparation and Outreach

On-Going Meetings With Stakeholders

Draft GSP Workshop 2019

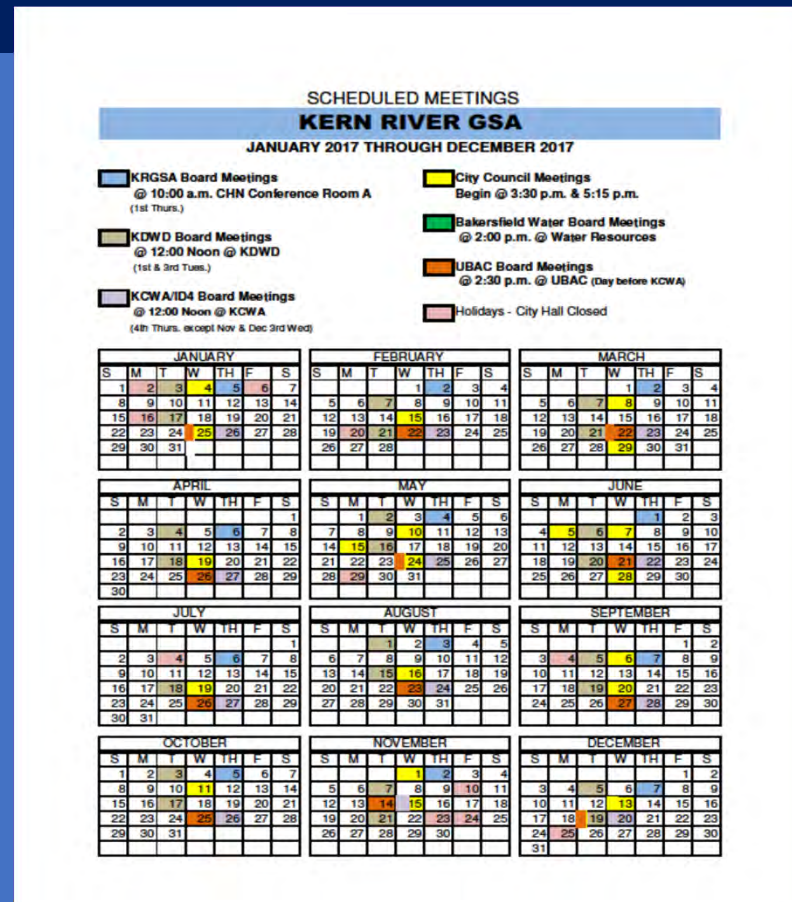
Coordinate Multiple GSPs Within Kern County Subbasin

Submit KRGSA GSP by January 31, 2020

How to Get Involved

- Tracking on Website
- Quarterly Public Meetings and Workshops
- Monthly Board Meetings
- Upcoming Targeted Meetings
- Request a Meeting with KRGSA Staff
- Sign Up Sheet (to be added to contact list)

http://kernrivergsa.org



Source: Kern River Groundwater Sustainability Agency

Feedback and Questions

Source: Kern River Groundwater Sustainability Agency

Thank you!

Please contact us with any questions or concerns.

For more information, please visit our website at:

http://kernrivergsa.org

Phone: (661) 326-3767

Email: krgsa@kernrivergsa.org

Kern River Groundwater Sustainability Agency (KRGSA)

Hydrogeologic Conceptual Model and Groundwater Conditions

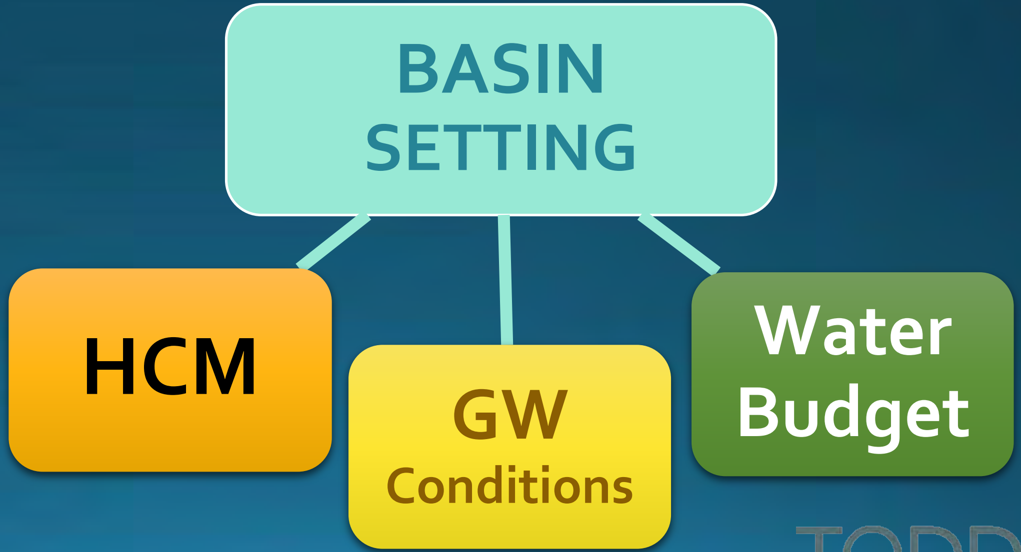
Groundwater Sustainability Plan (GSP)

April 5, 2018

TODD GROUNDWATER

Workshop Presentation

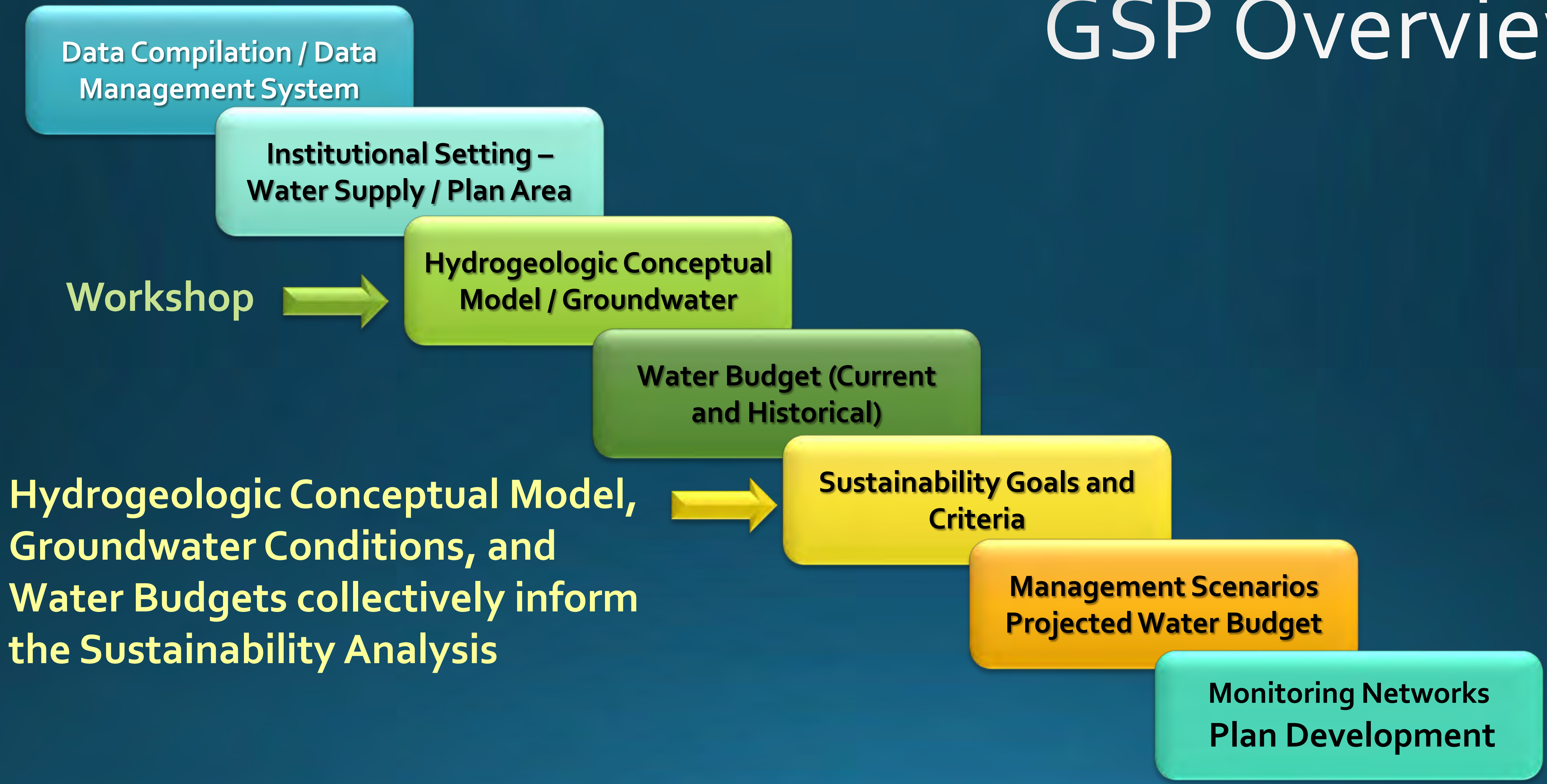
- Groundwater Sustainability Plan (GSP) Requirements
- Hydrogeologic Conceptual Model (HCM)
- Groundwater Conditions
- Next Steps



DRAFT

TODD GROUNDWATER

GSP Overview



DRAFT

TODD GROUNDWATER

Hydrogeologic Conceptual Model Regulatory Requirements

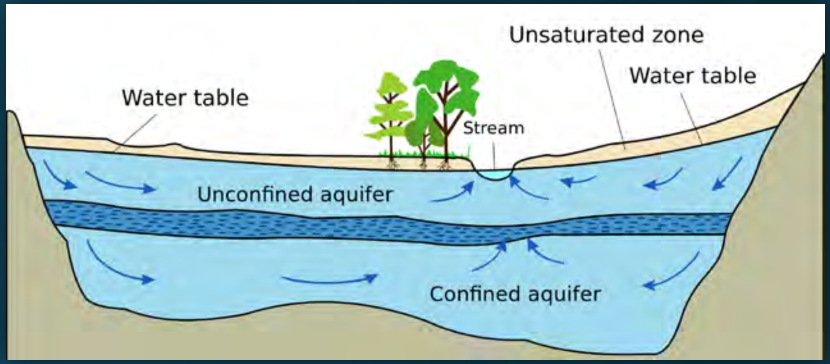
What does the groundwater basin look like?

- Physical Setting
  - Topography
  - Geologic and structural setting
  - Surface geology, soils
  - Hydrology
- Groundwater Basin and Aquifers
  - Basin geometry, lateral boundaries and bottom
  - Principal aquifers and aquitards and properties
  - Stratigraphic and structural changes

DRAFT

TODD GROUNDWATER

Groundwater Conditions Regulatory Requirements

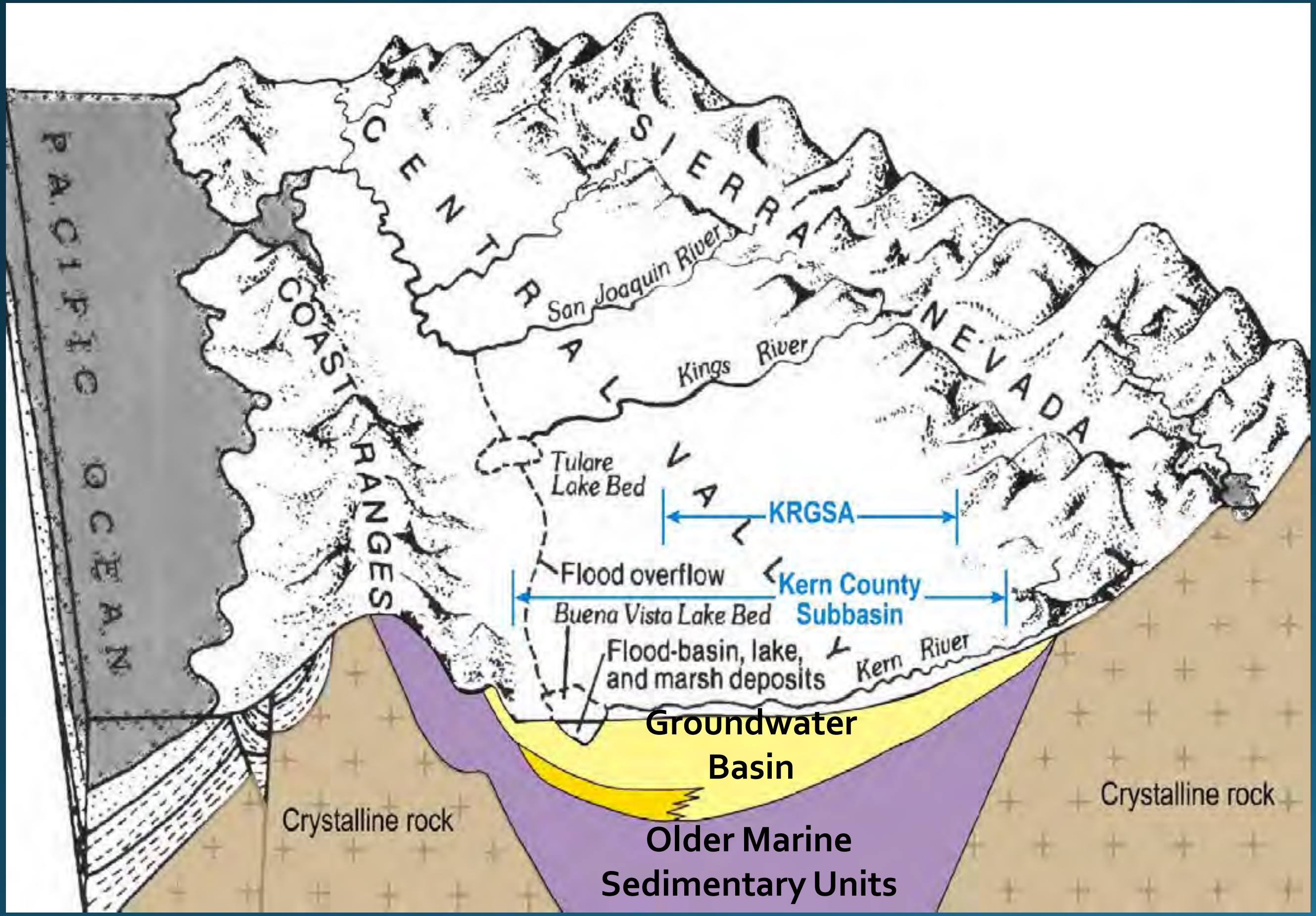


What are the current and historical groundwater conditions?

- Hydrographs (changes in groundwater levels over time)
- Groundwater elevation contour maps
- Changes in groundwater in storage (between seasonal highs)
- Groundwater quality
- Land subsidence
- Groundwater Dependent Ecosystems (if applicable)

DRAFT

Conceptual Hydrogeologic Setting Kern County Subbasin

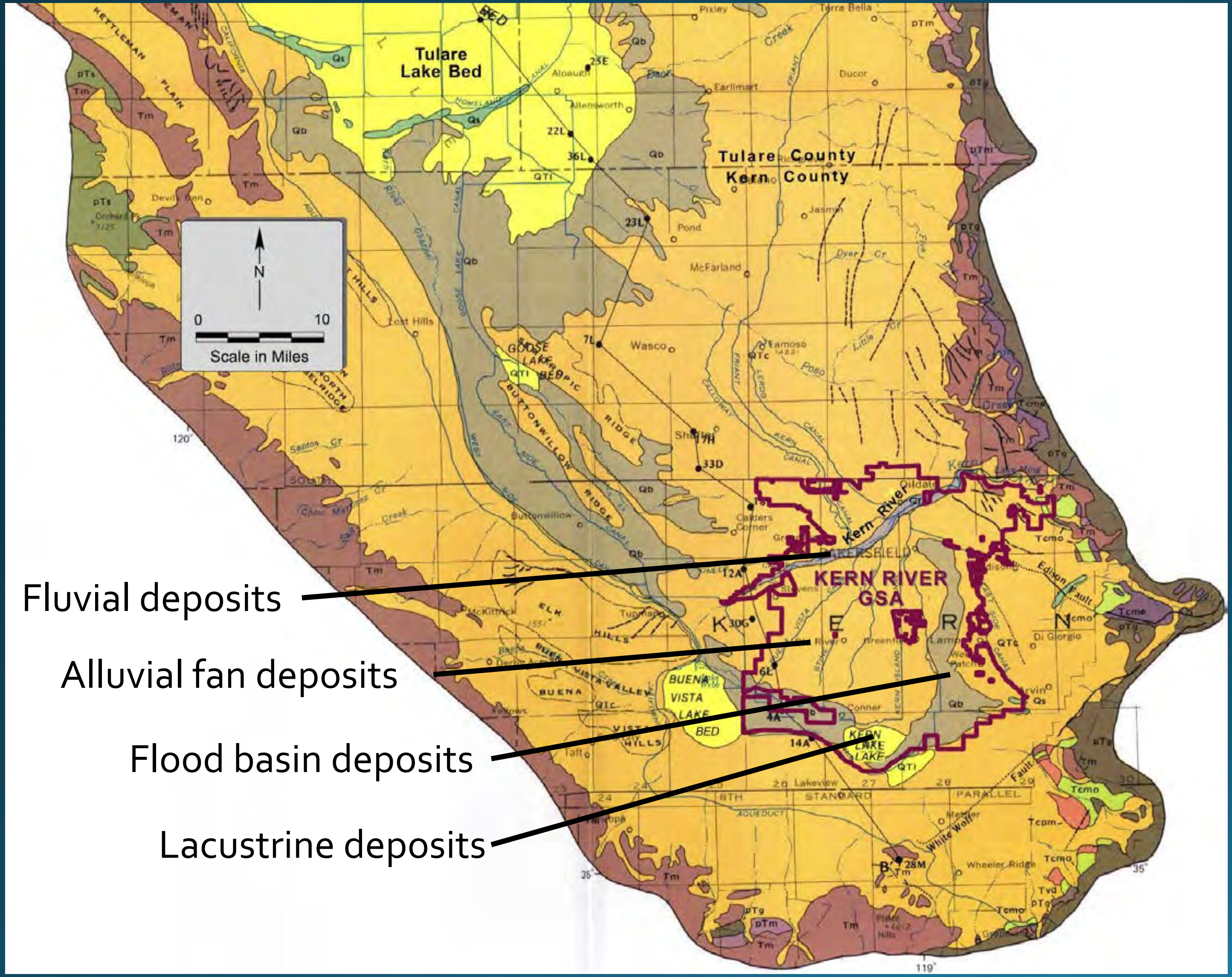


- Alluvial-filled trough between the Sierra Nevada and Coast Ranges
- Underlain by older marine sedimentary units
- Flanked by crystalline bedrock

DRAFT

TODD GROUNDWATER

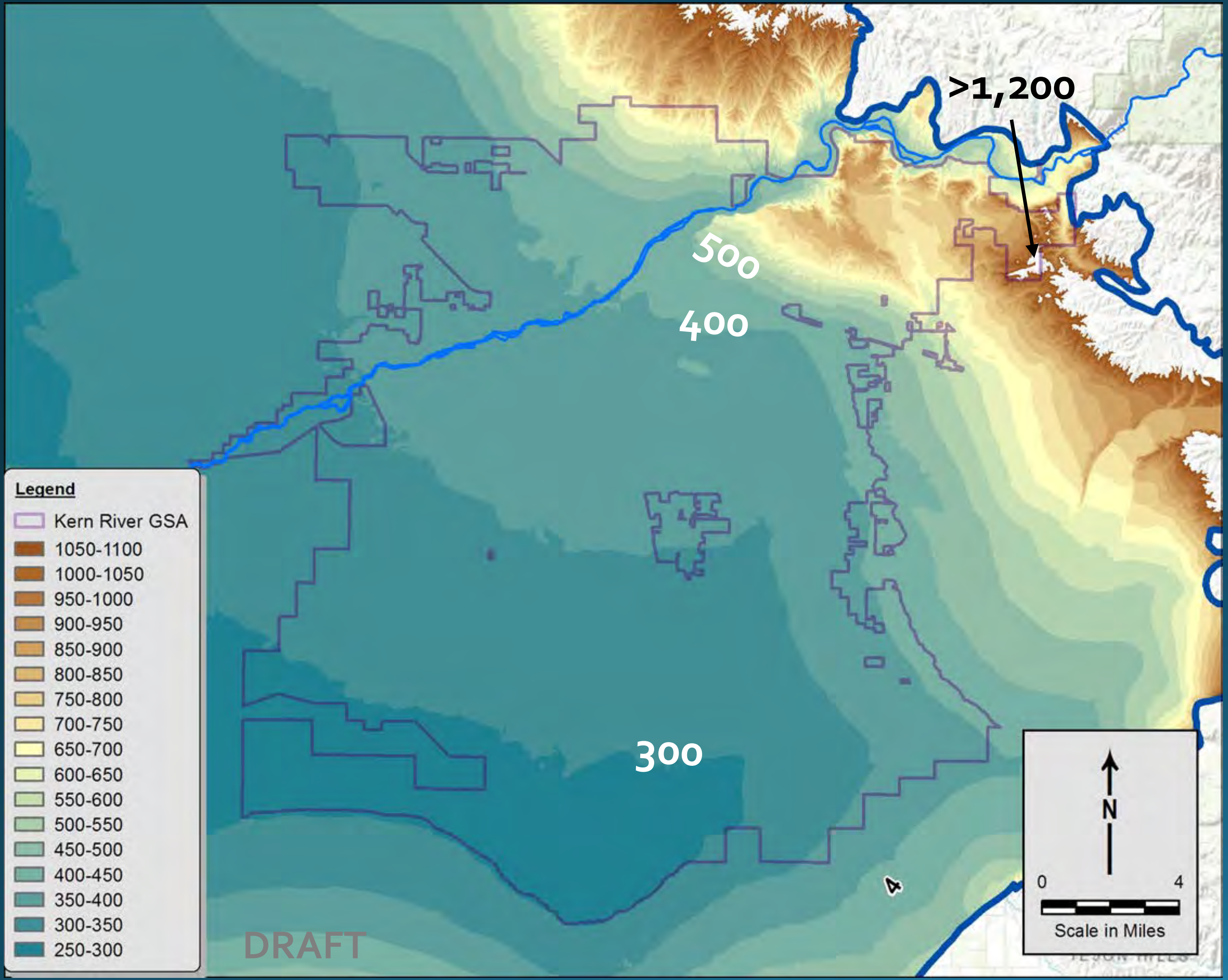
Regional Geology and Depositional Environments



- Coarse-grain fluvial deposits along the Kern River in the KRGSA
- Coarse-grain alluvial fan
- Fine-grain flood basin deposits along fan edges
- Fine-grain lacustrine deposits in the old lake beds

TODD GROUNDWATER

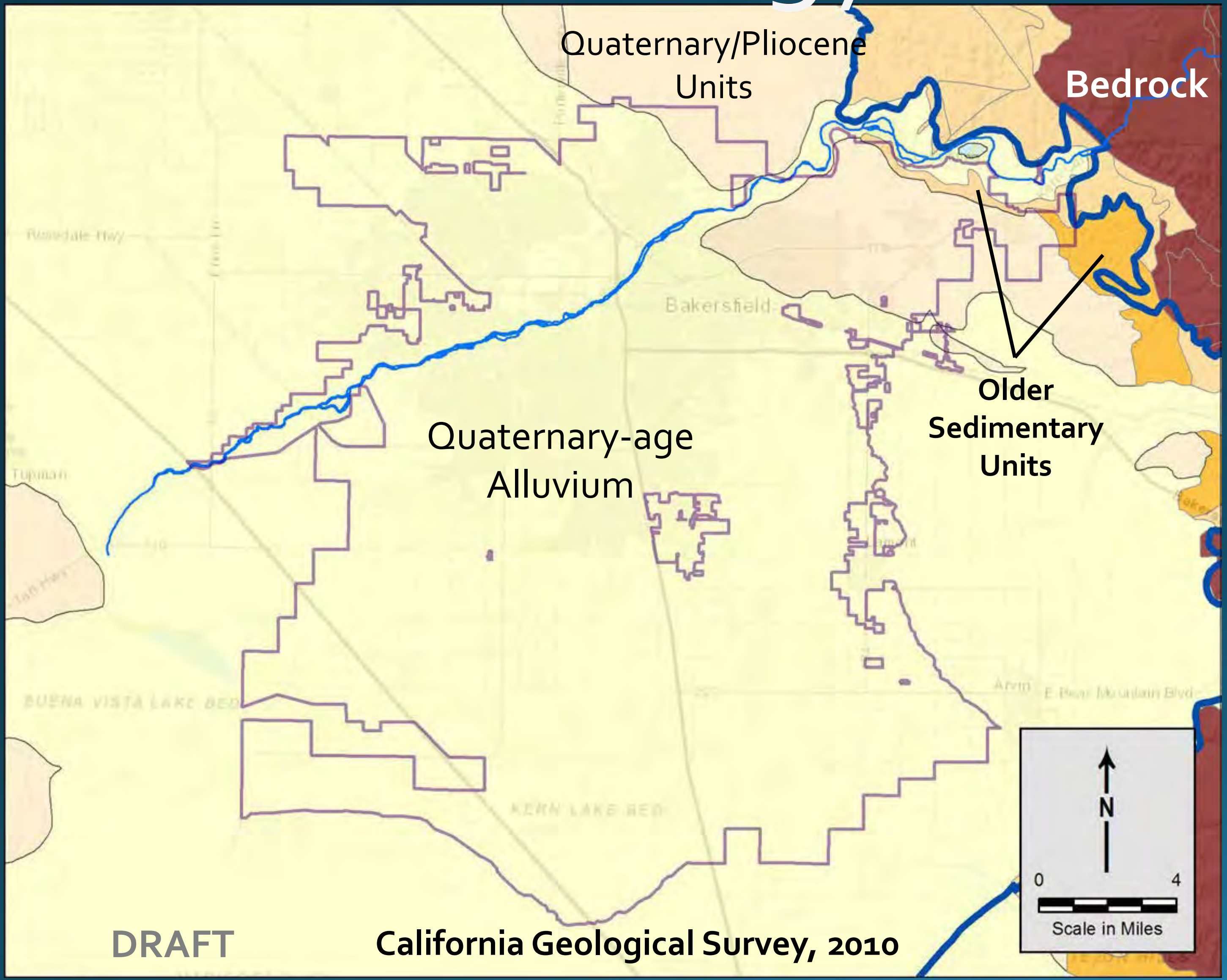
Ground Surface Elevations - KRGSA



- Ground surface elevations vary >900 feet over the KRGSA
- Highest elevation in the northeast > 1,200 ft msl
- Lowest elevation in the south of about 280 ft msl
- Most of the KRGSA between 300 ft msl and 400 ft msl

TODD GROUNDWATER

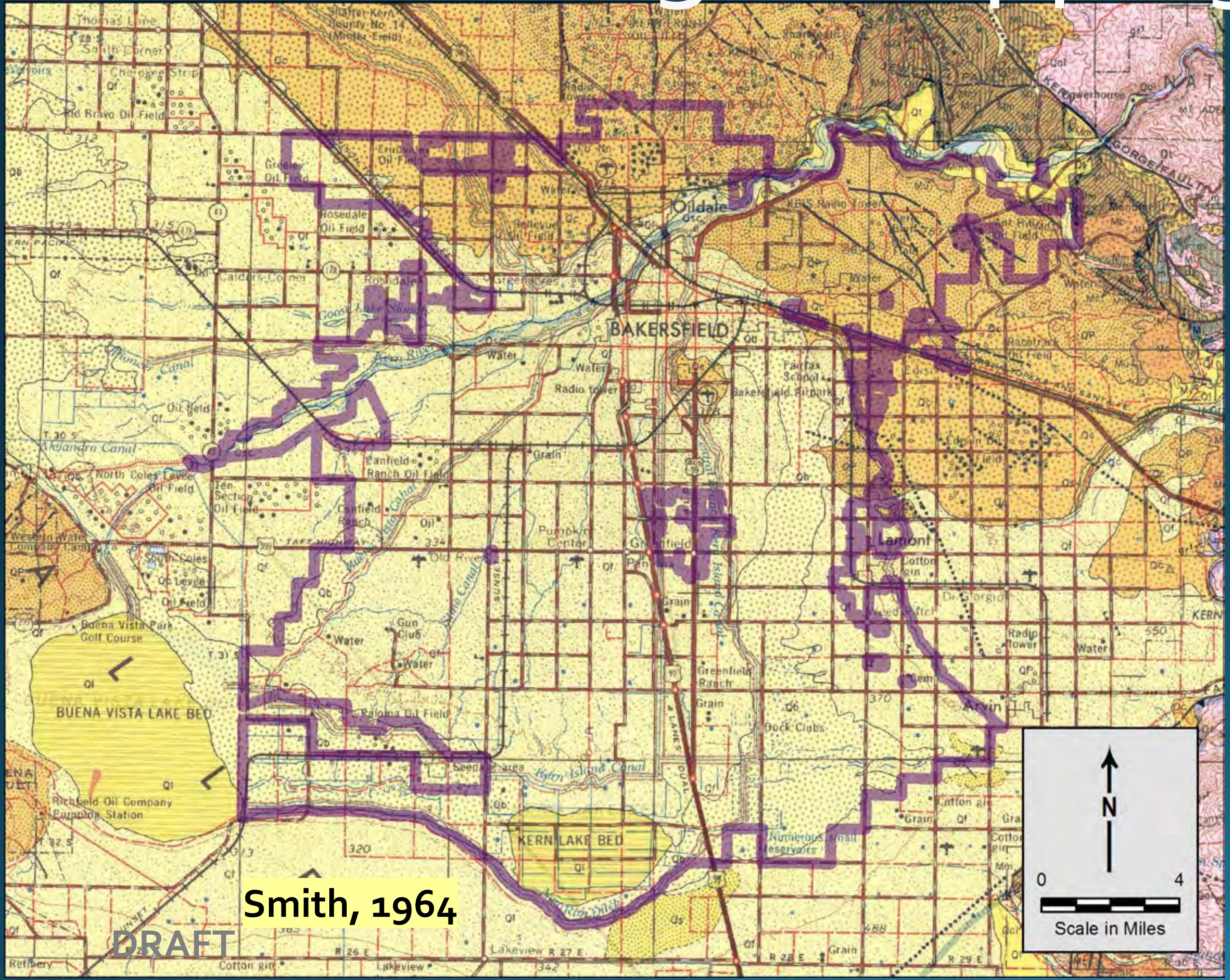
Surface Geology – Statewide Maps



- KRGSA mostly overlain by Quaternary age alluvial deposits
- Rimmed by older units on the northwest in upper surface elevations
- Quaternary- and Pliocene-age units begin around 500 feet msl
- Miocene units at higher elevations (above about 800 ft msl)

TODD GROUNDWATER

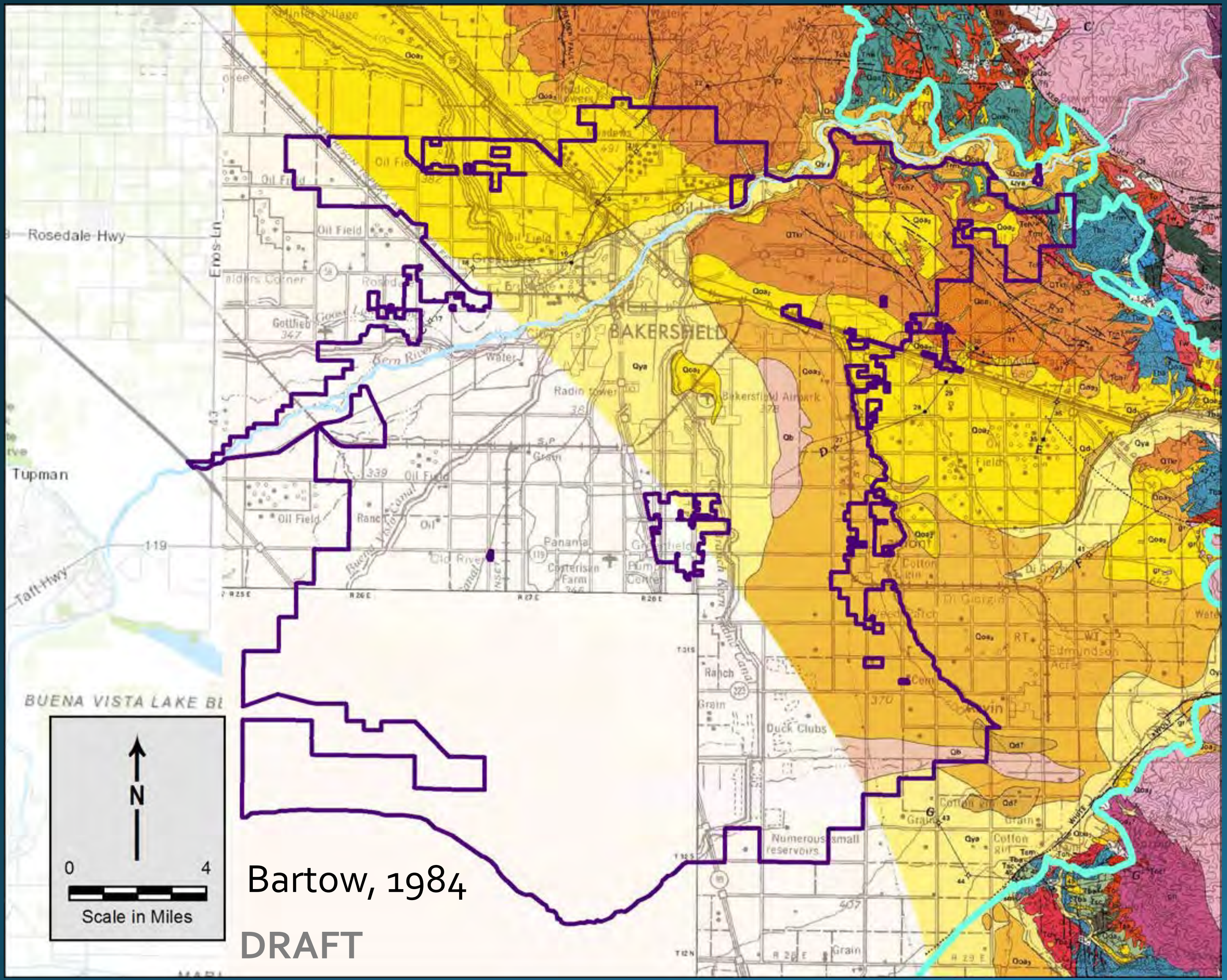
Local Geologic Mapping



- Older local geologic maps provide more detail in the northeast
- Local maps for the Bakersfield Quadrangle compiled by Division of Mines and Geology 1964
- Contain structural information required by GSP regulations such as geologic faults and folds

TODD GROUNDWATER

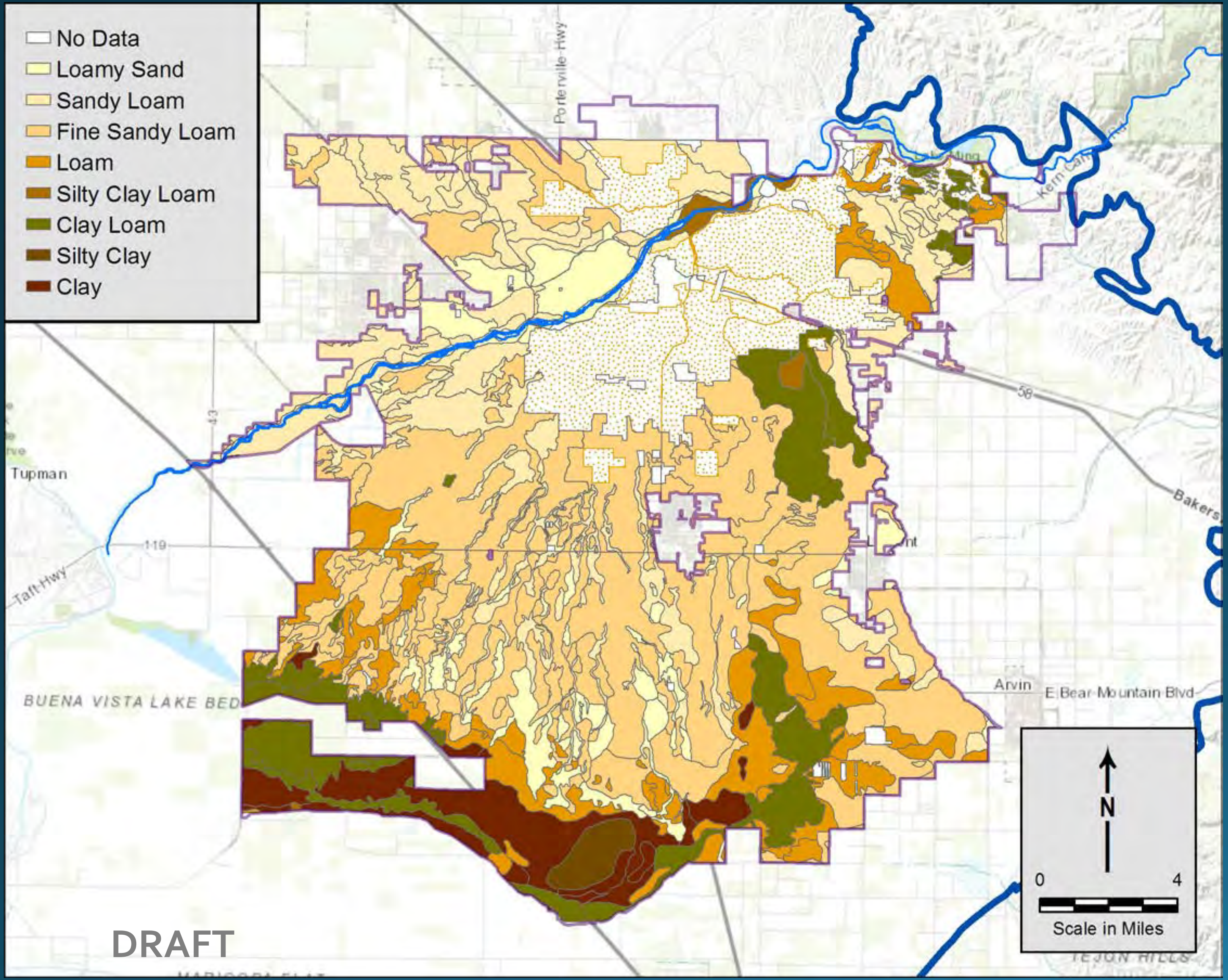
Additional USGS Geology Map



- Additional compilation and modifications provided by USGS, 1984
- Focus on the Tertiary geology
- General agreement with other maps with additional modifications

TODD GROUNDWATER

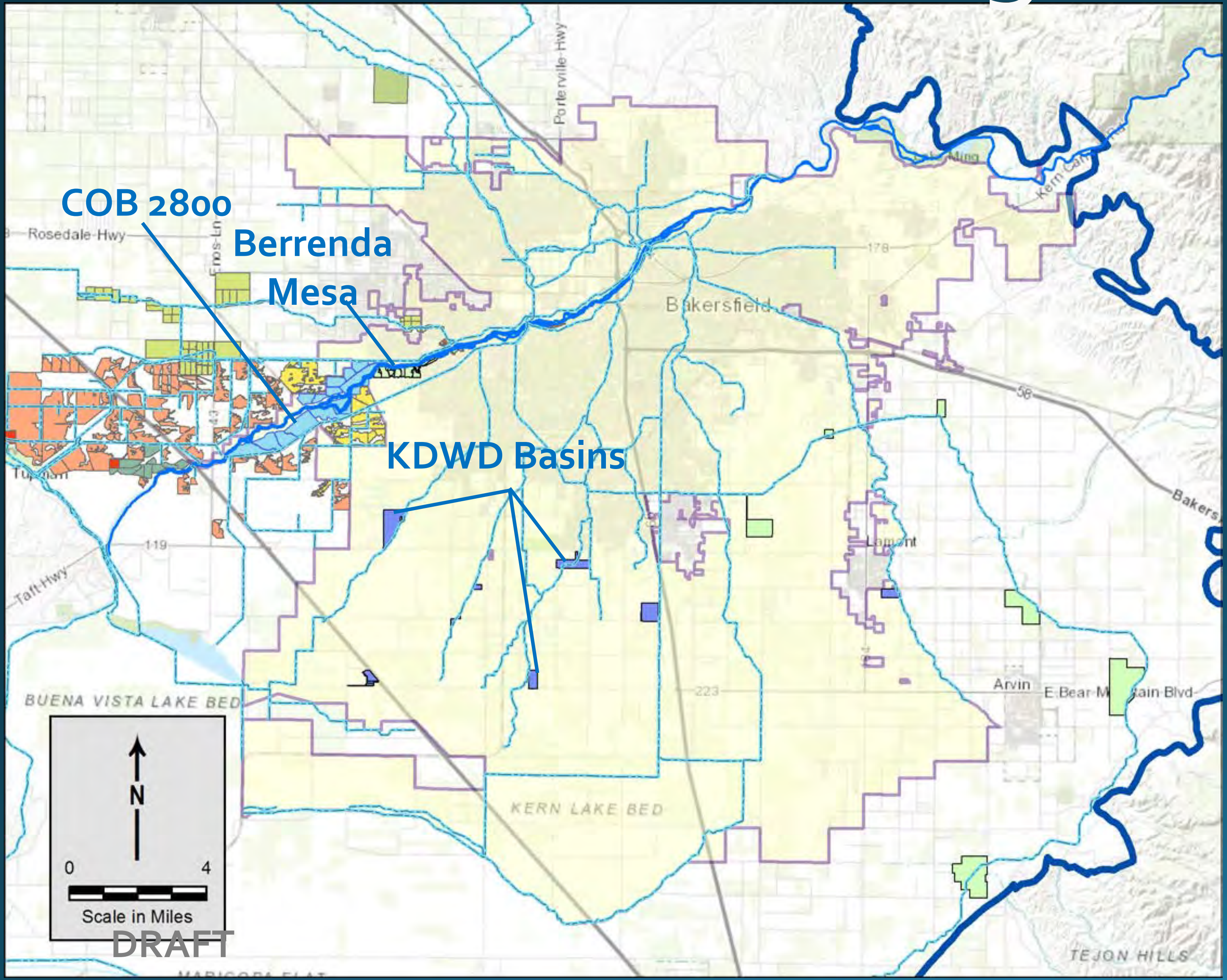
Soil Textures



- More permeable textures indicated by lighter colors (white, yellow, light orange)
- Lower permeability textures indicated by dark orange, green and brown
- Soil textures agree well with geologic framework

TODD GROUNDWATER

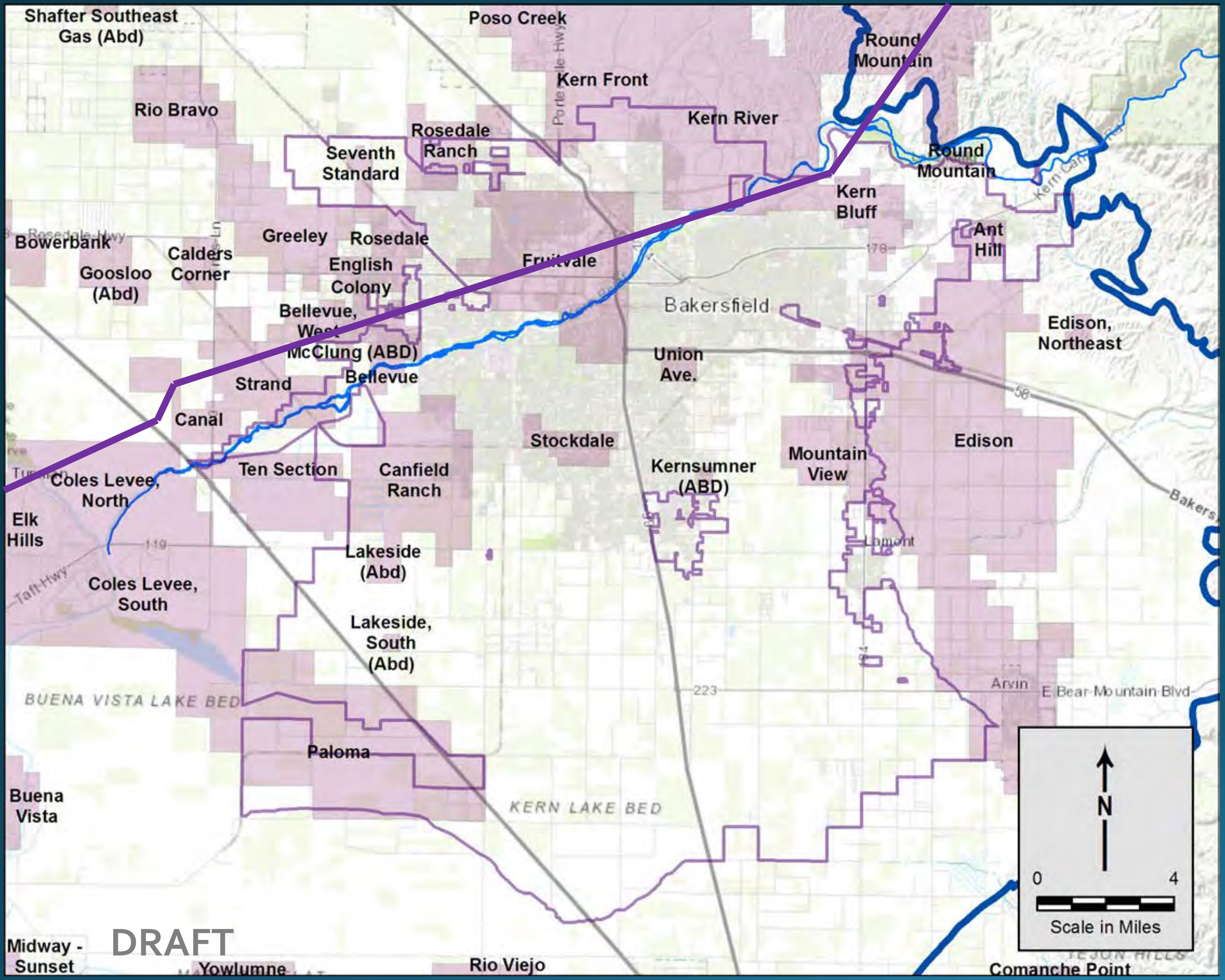
Canals and Recharge Basins



- Managed recharge in river channel, unlined canals, and basins
- KRGSA groundwater banking projects:
  - COB 2800 Acres
  - KCWA Berrenda Mesa
  - KDWD Metropolitan Project
- Numerous additional banking projects nearby

TODD GROUNDWATER

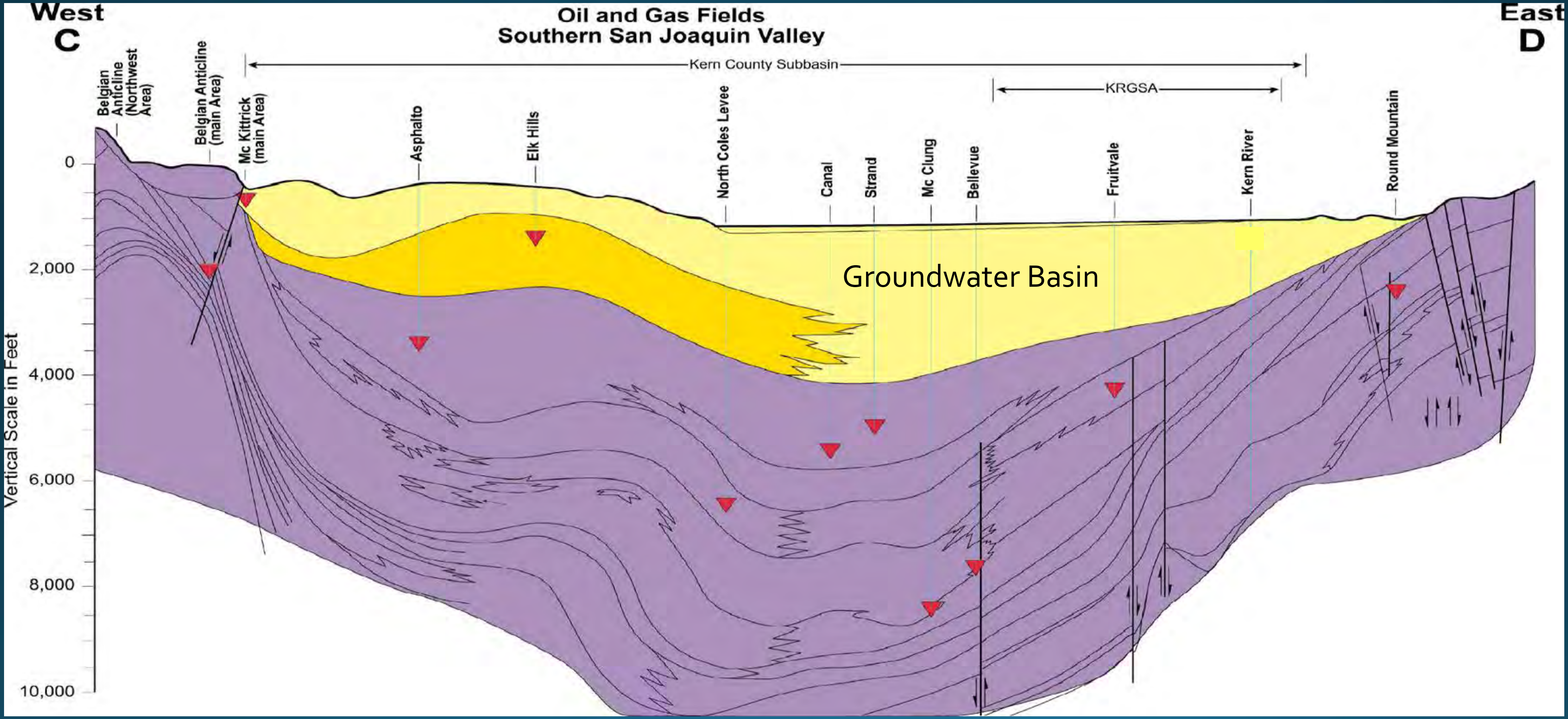
Oilfields in Vicinity of KRGSA



- KRGSA underlain by numerous oilfields at depth
- Cross section through northern GSA illustrates relationship to the groundwater basin

TODD GROUNDWATER

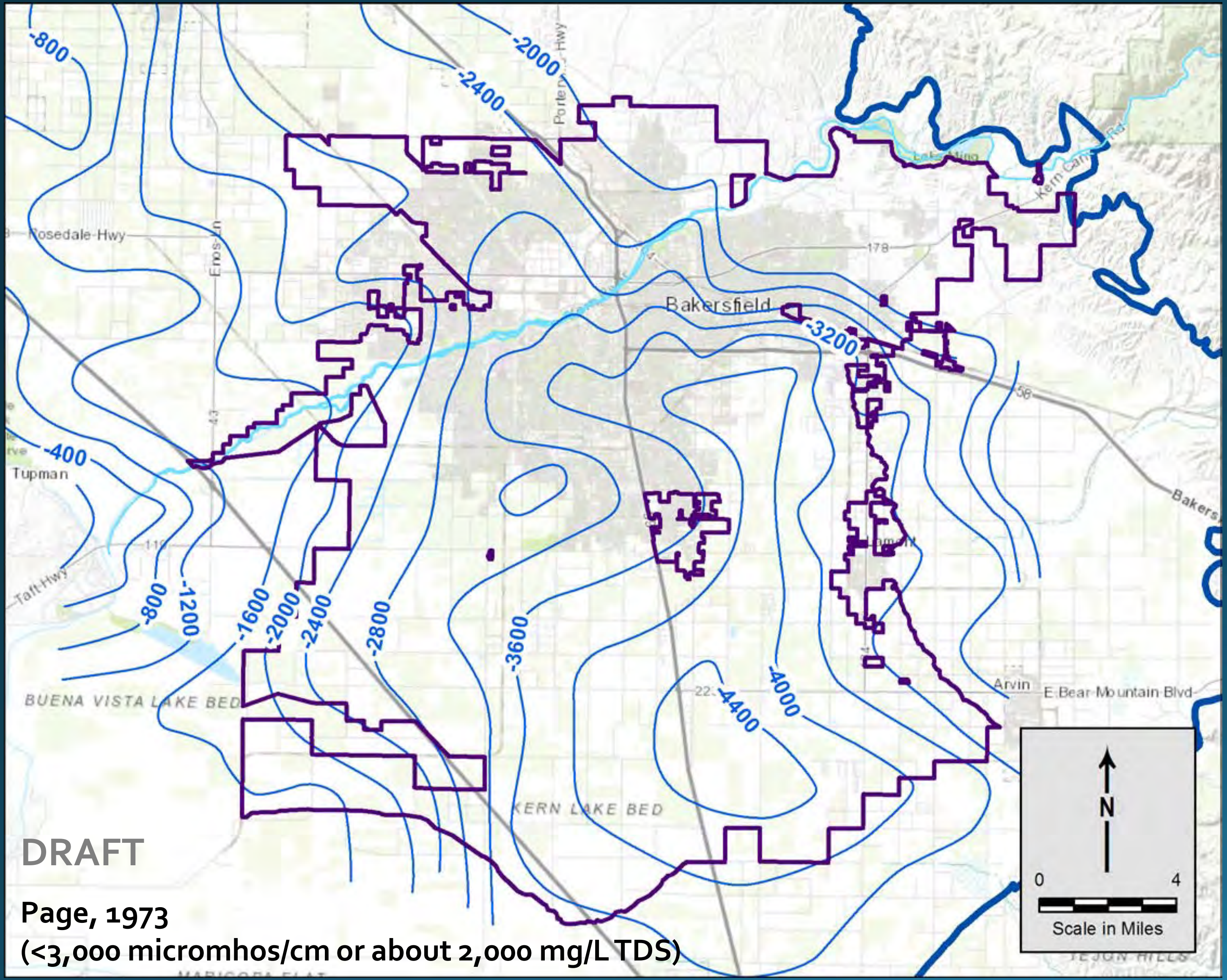
Regional Cross Section and Oil Fields



DRAFT

TODD GROUNDWATER

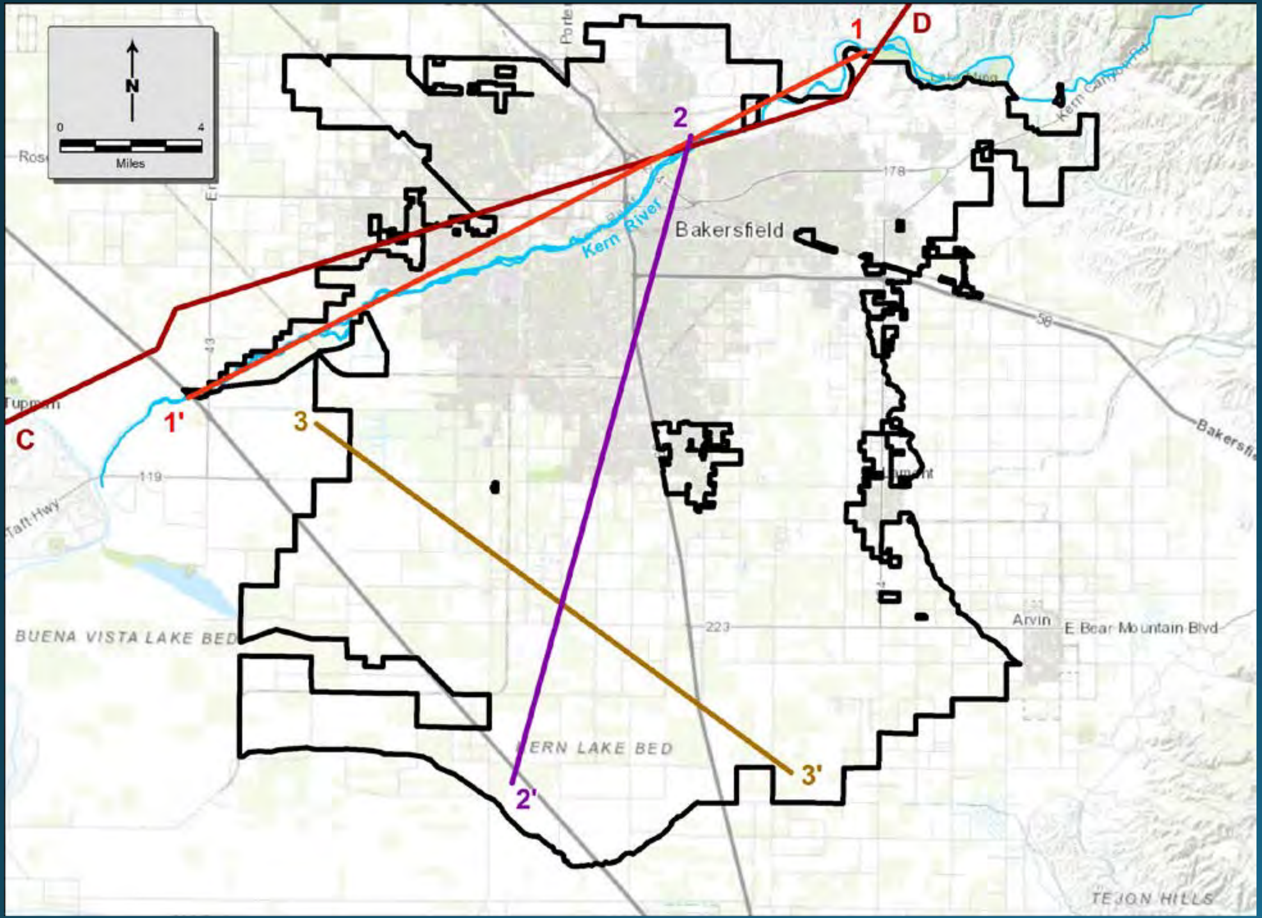
Basin Bottom – Base of Fresh Water



- USGS mapped the base of fresh water in 1973
- Provide depths to define the groundwater basin bottom
- Operationally, the basin is limited by elevated metals and other constituents at depth (almost all wells <1,100 feet deep)

TODD GROUNDWATER

Cross Section Location Map

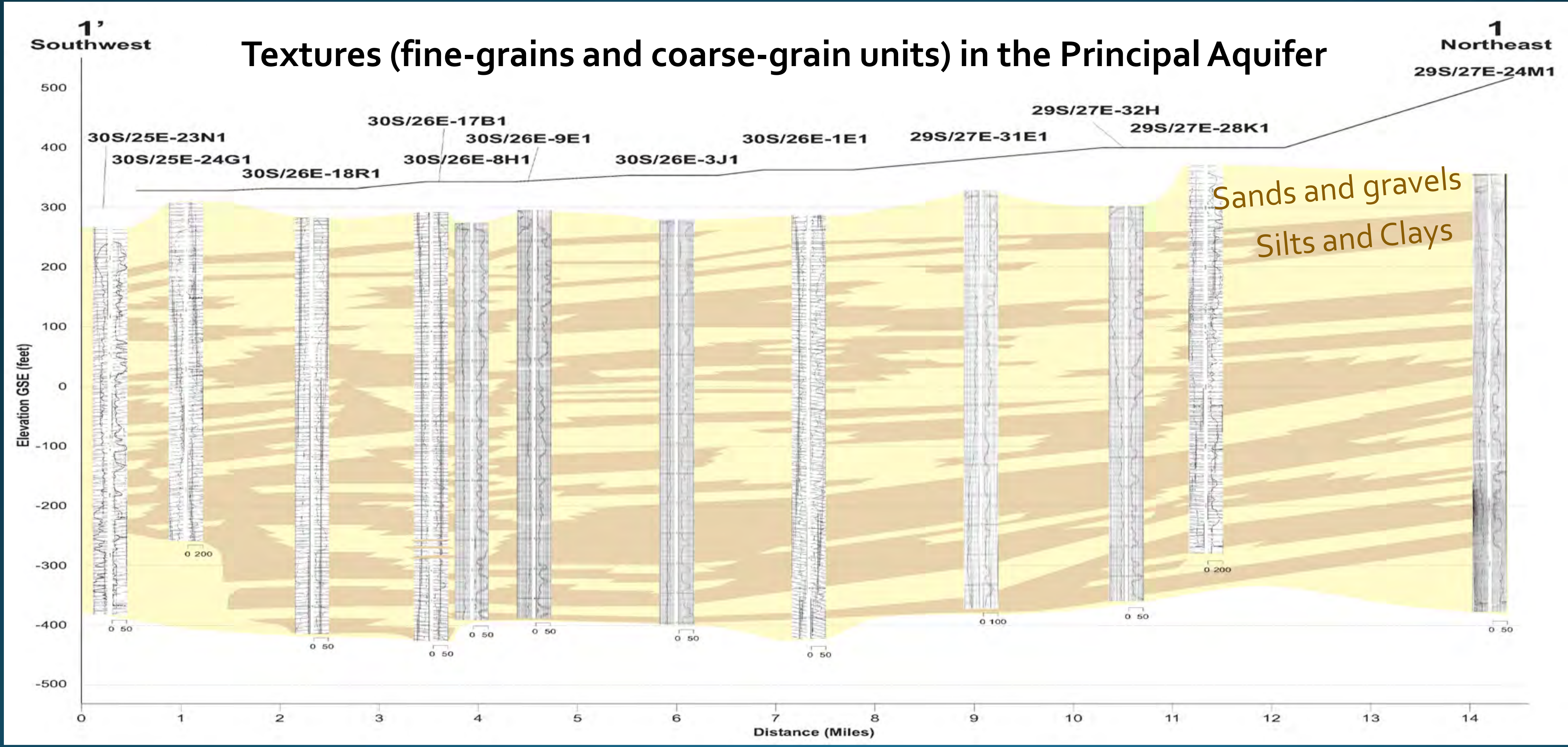


- Numerous working cross sections developed across KRGSA
- Illustrate principal aquifer and subsurface textures
- Developed using geophysical logs at large scale; reduced for convenience in report

DRAFT

TODD GROUNDWATER

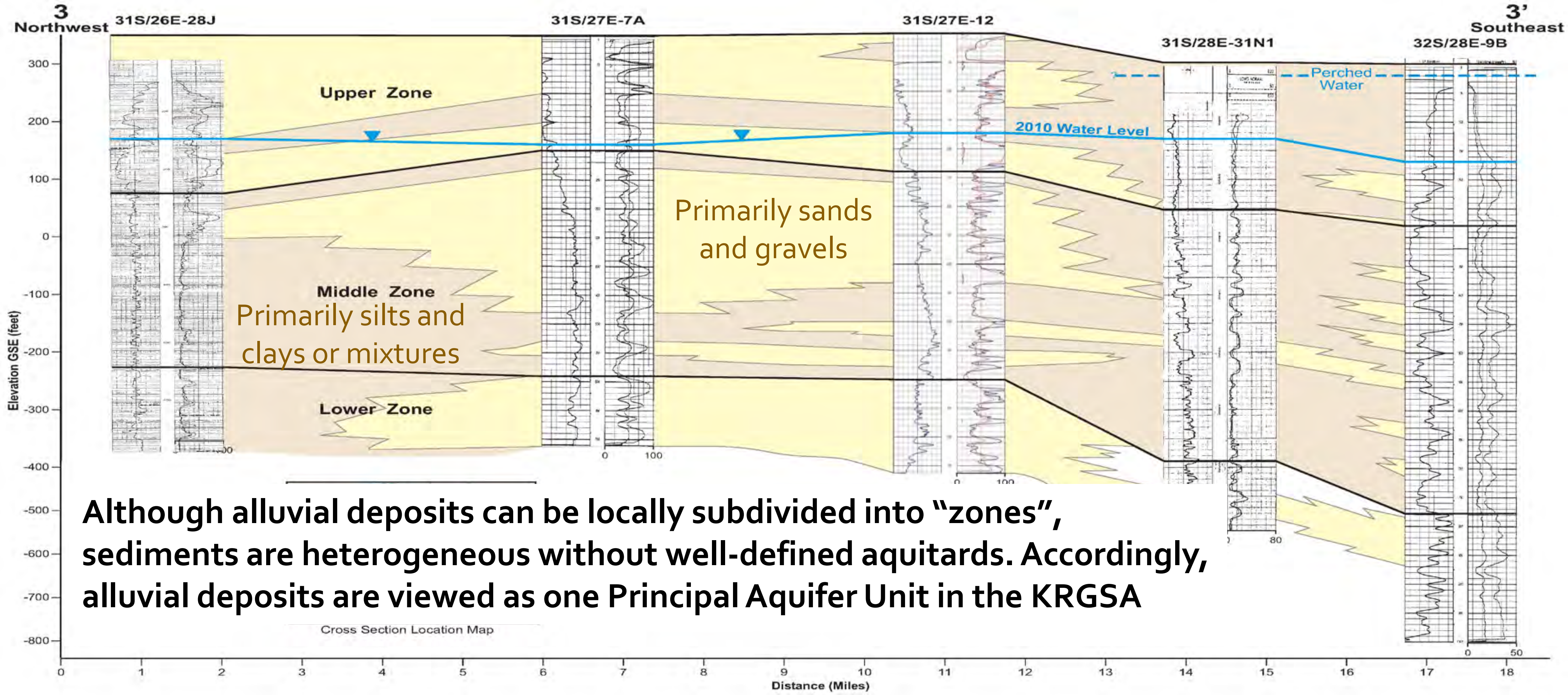
15-mile Cross Section along the Kern River



DRAFT

TODD GROUNDWATER

19-mile Cross Section in southern KRGSA

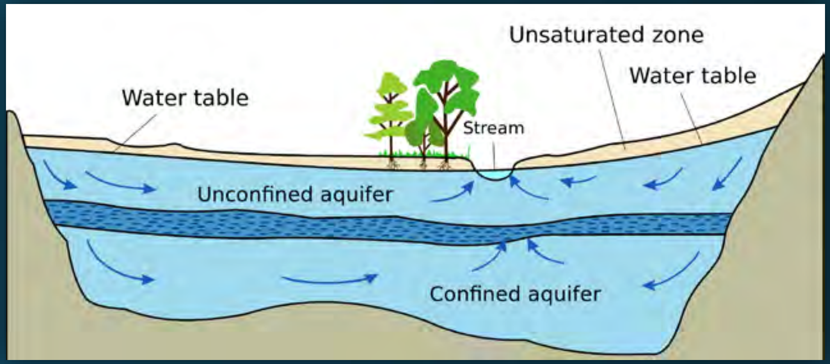


Although alluvial deposits can be locally subdivided into "zones", sediments are heterogeneous without well-defined aquitards. Accordingly, alluvial deposits are viewed as one Principal Aquifer Unit in the KRGSA

DRAFT

TODD GROUNDWATER

Groundwater Conditions Regulatory Requirements

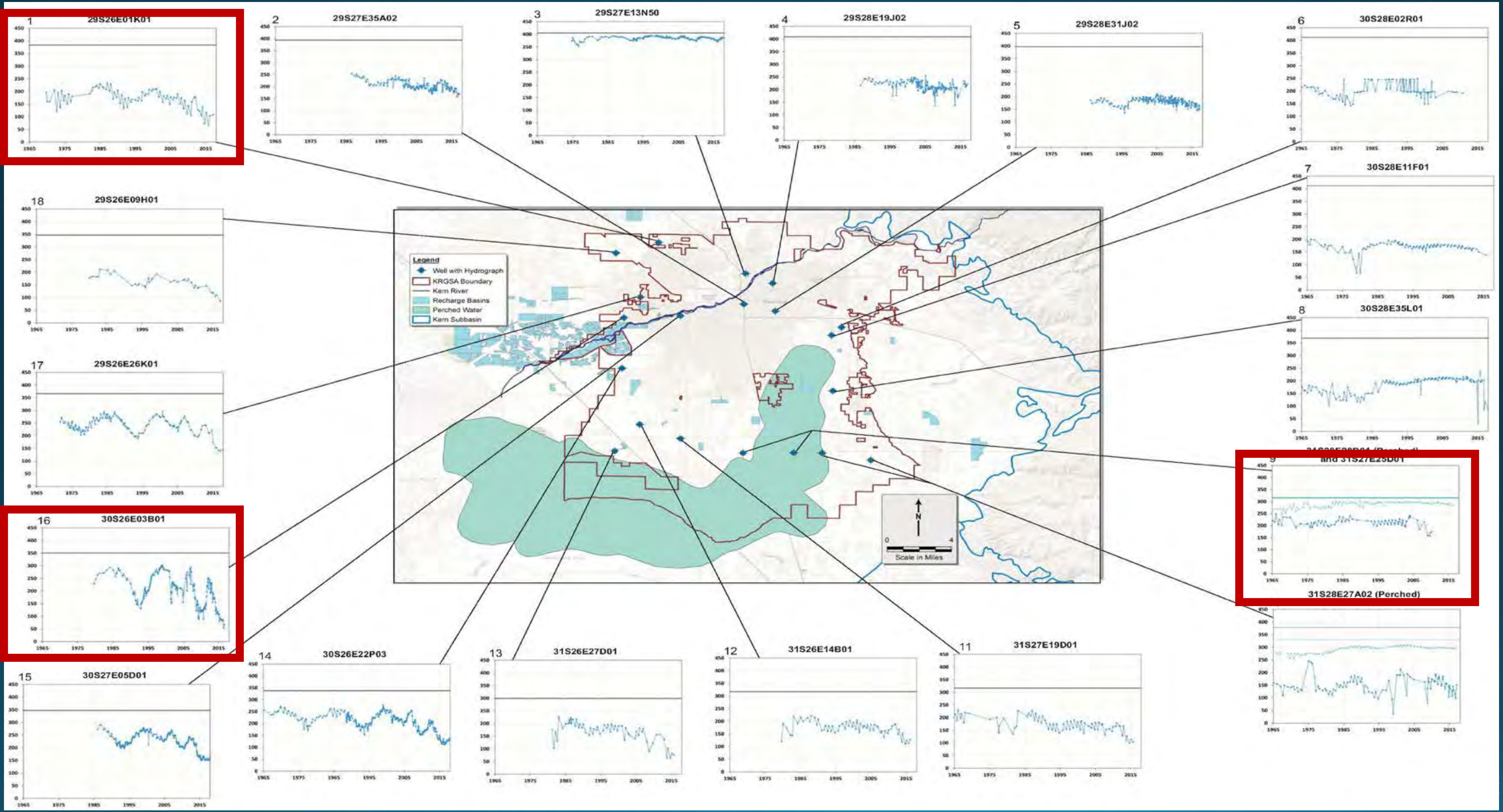


What are the current and historical groundwater conditions?

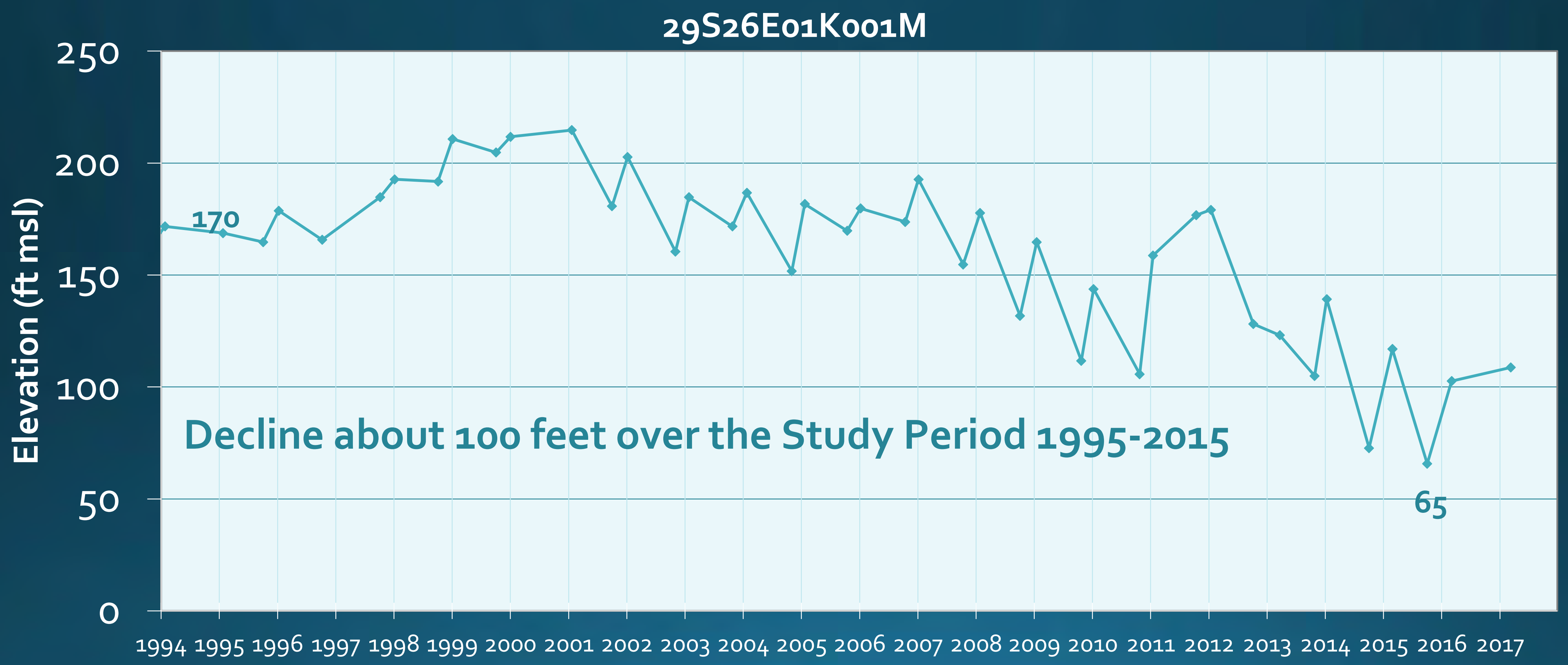
- Hydrographs (changes in groundwater levels over time)
- Groundwater Elevation Contour Maps
- Changes in groundwater in storage (between seasonal highs)
- Groundwater quality
- Land subsidence
- Groundwater Dependent Ecosystems

DRAFT

KRGSA Water Level Hydrographs 1965-2017



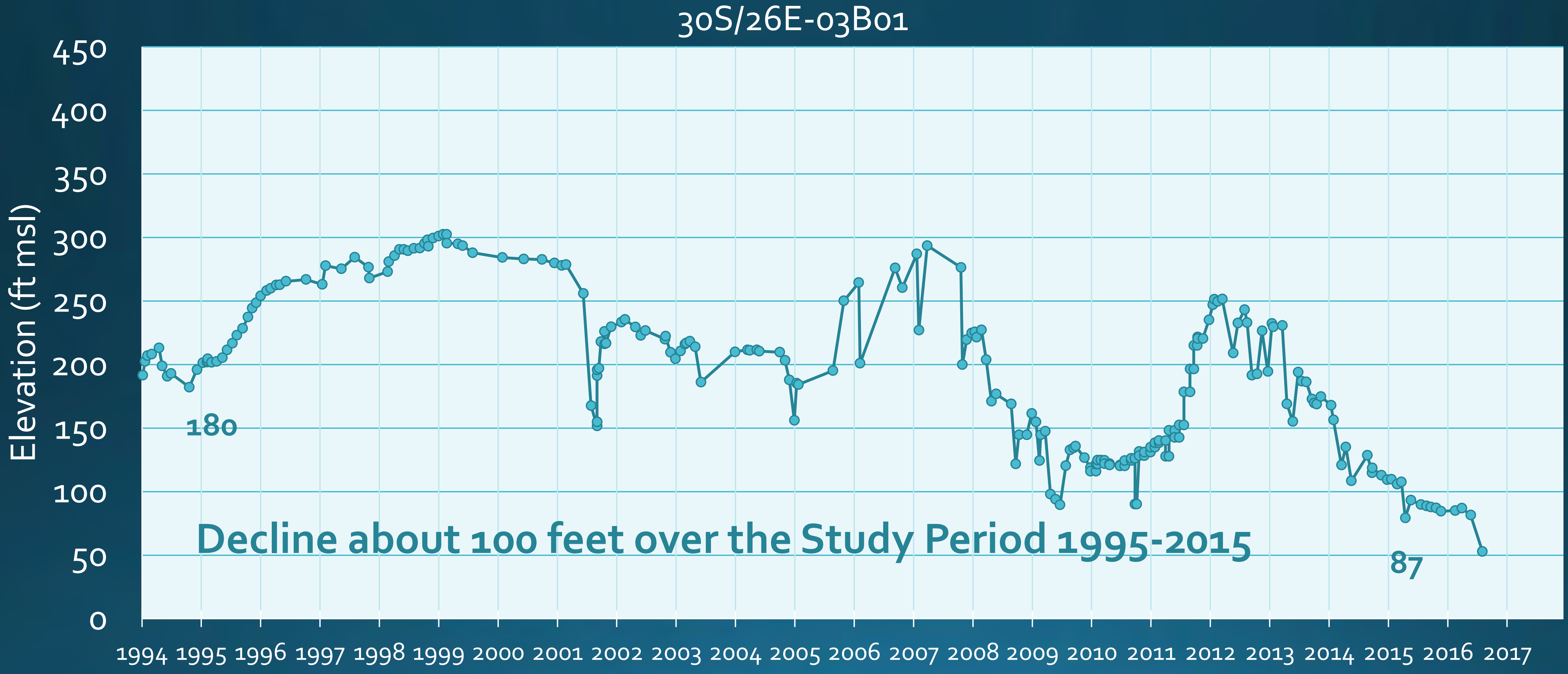
Northern Border KRGSA



DRAFT

TODD GROUNDWATER

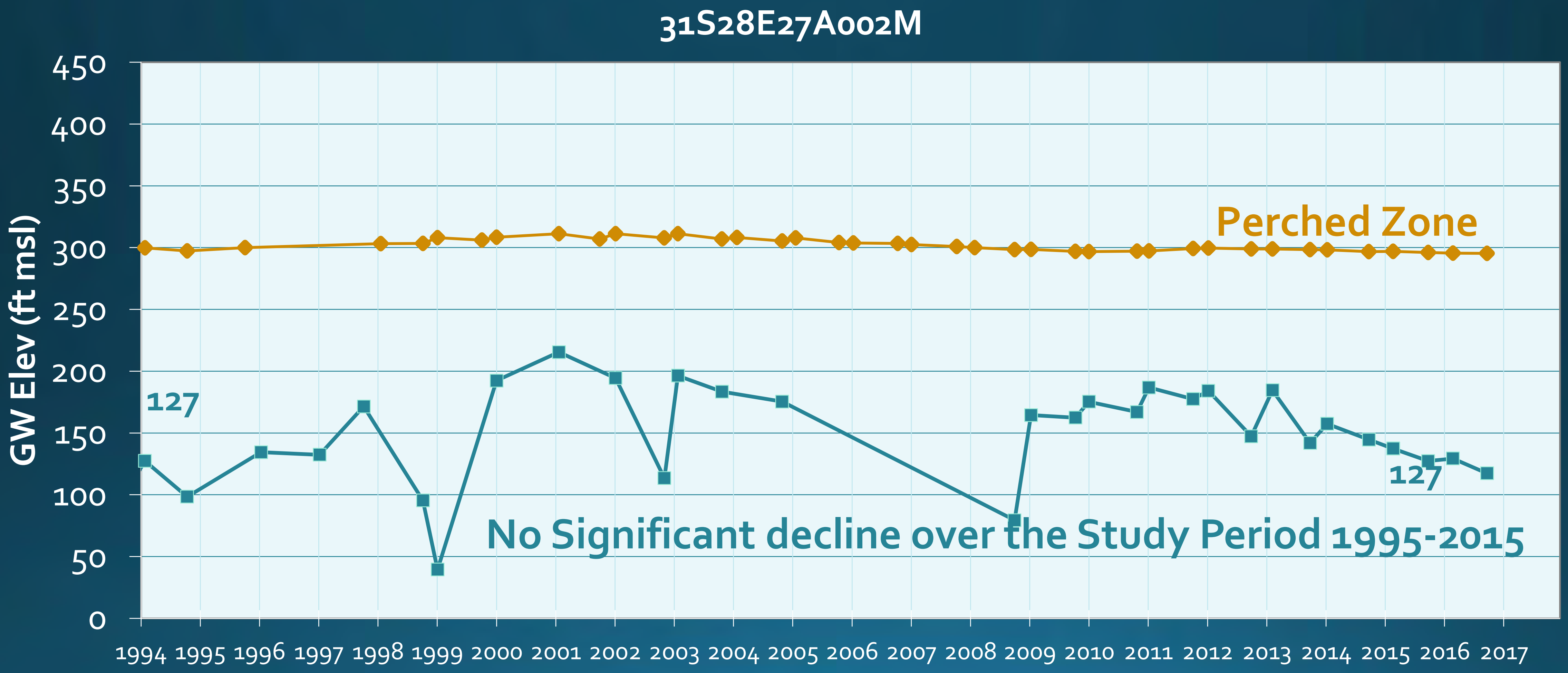
Western KRGSA (Banking Area)



DRAFT

TODD GROUNDWATER

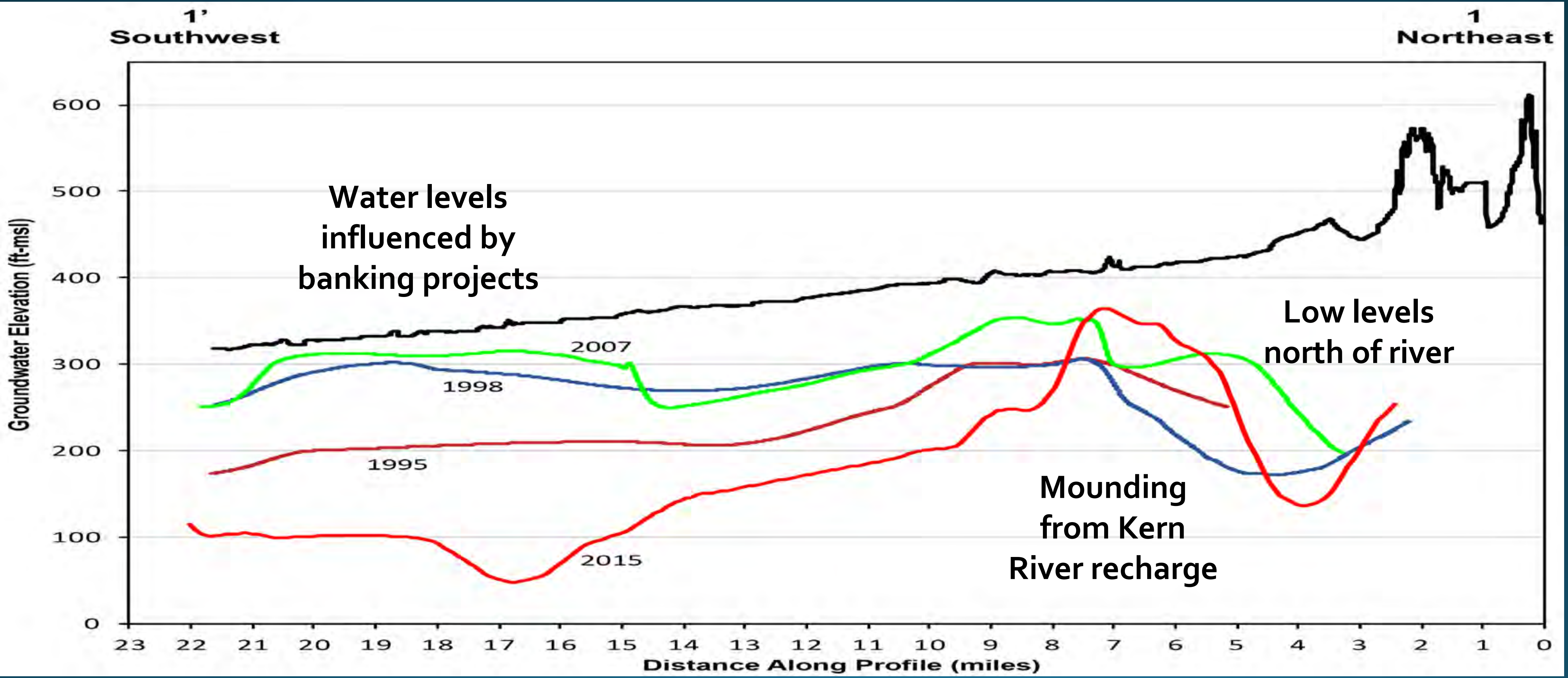
Southeastern KRGSA



DRAFT

TODD GROUNDWATER

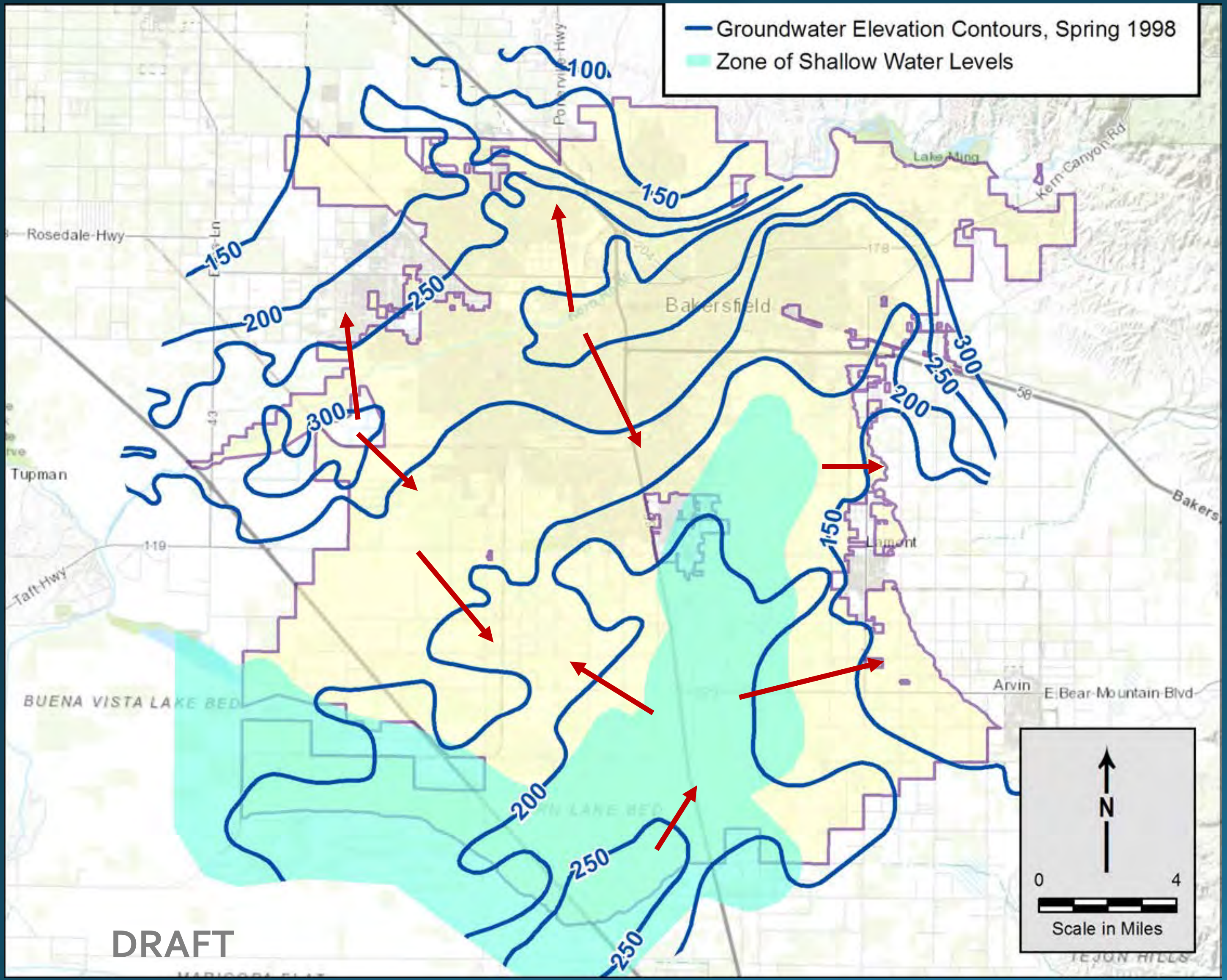
Hydrologic Profiles beneath the Kern River



DRAFT

TODD GROUNDWATER

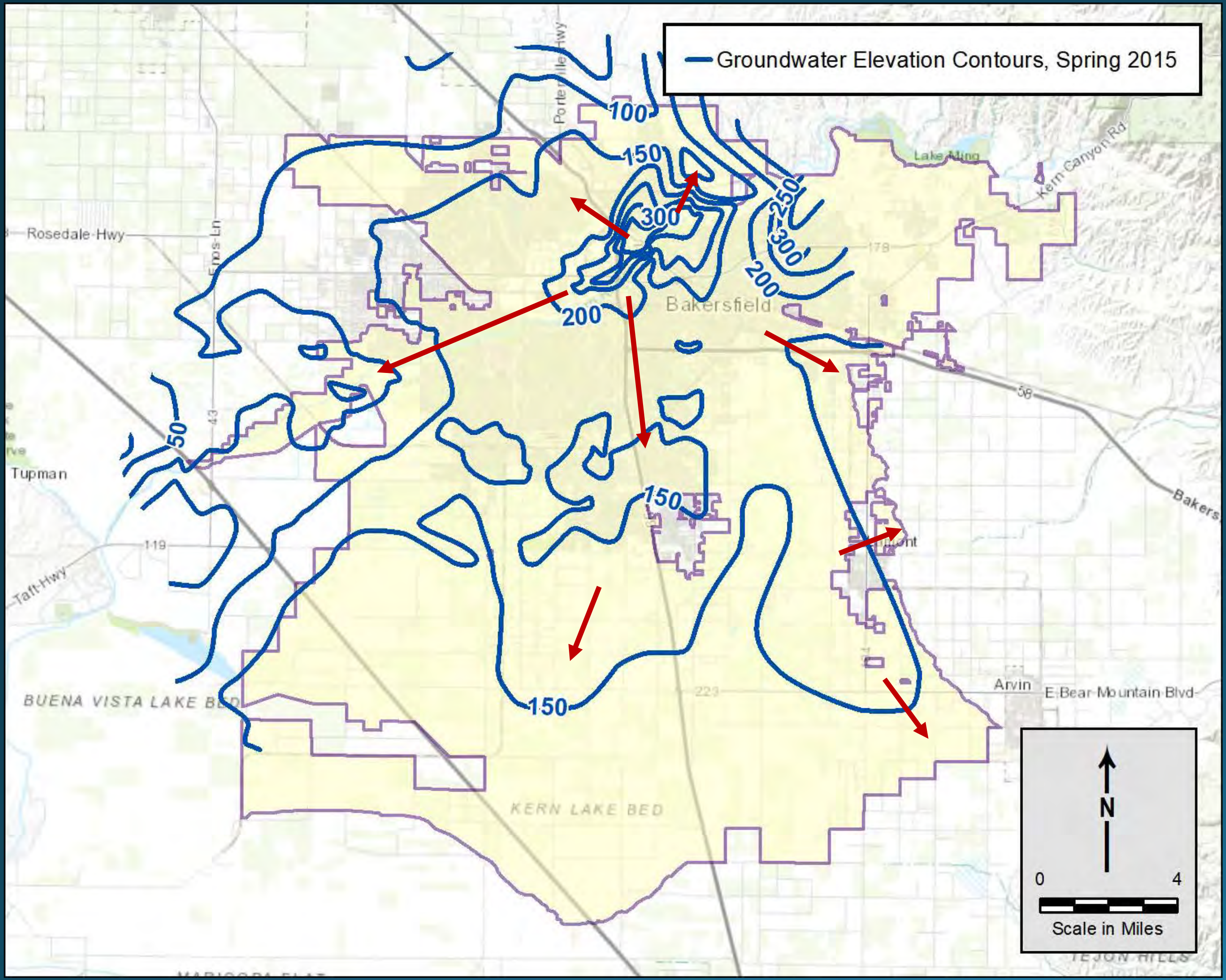
Groundwater Elevation Contours 1998



- 20 groundwater elevation contour maps (Spring data)
- Examined maps and data for perched layers (zone of shallow water levels)
- Example for wet year - Spring 1998

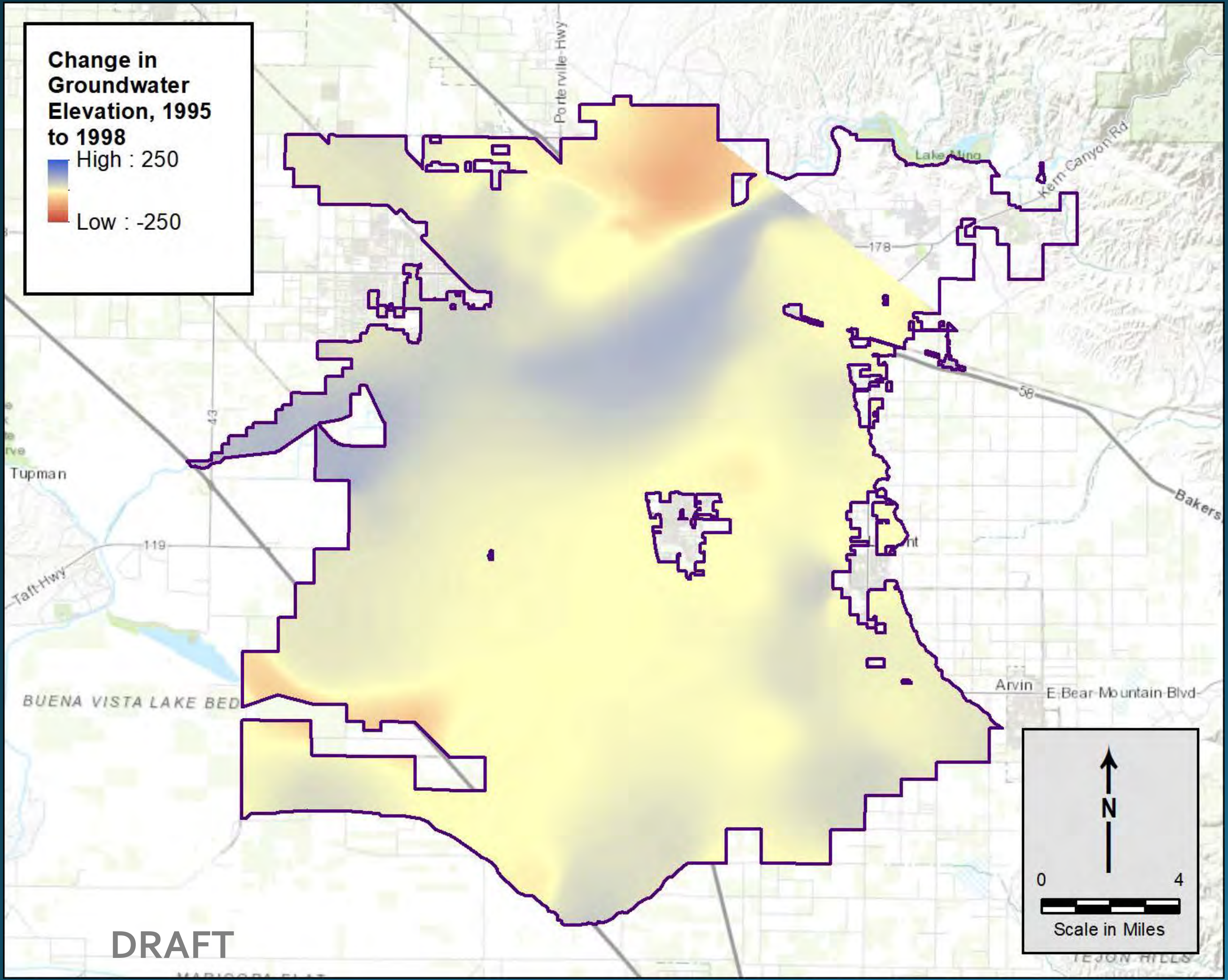
TODD GROUNDWATER

Groundwater Elevation Contours 2015



- Severe Drought year
- In general, higher water levels than surrounding areas
- Except for the river, groundwater is flowing out of the KRGSA

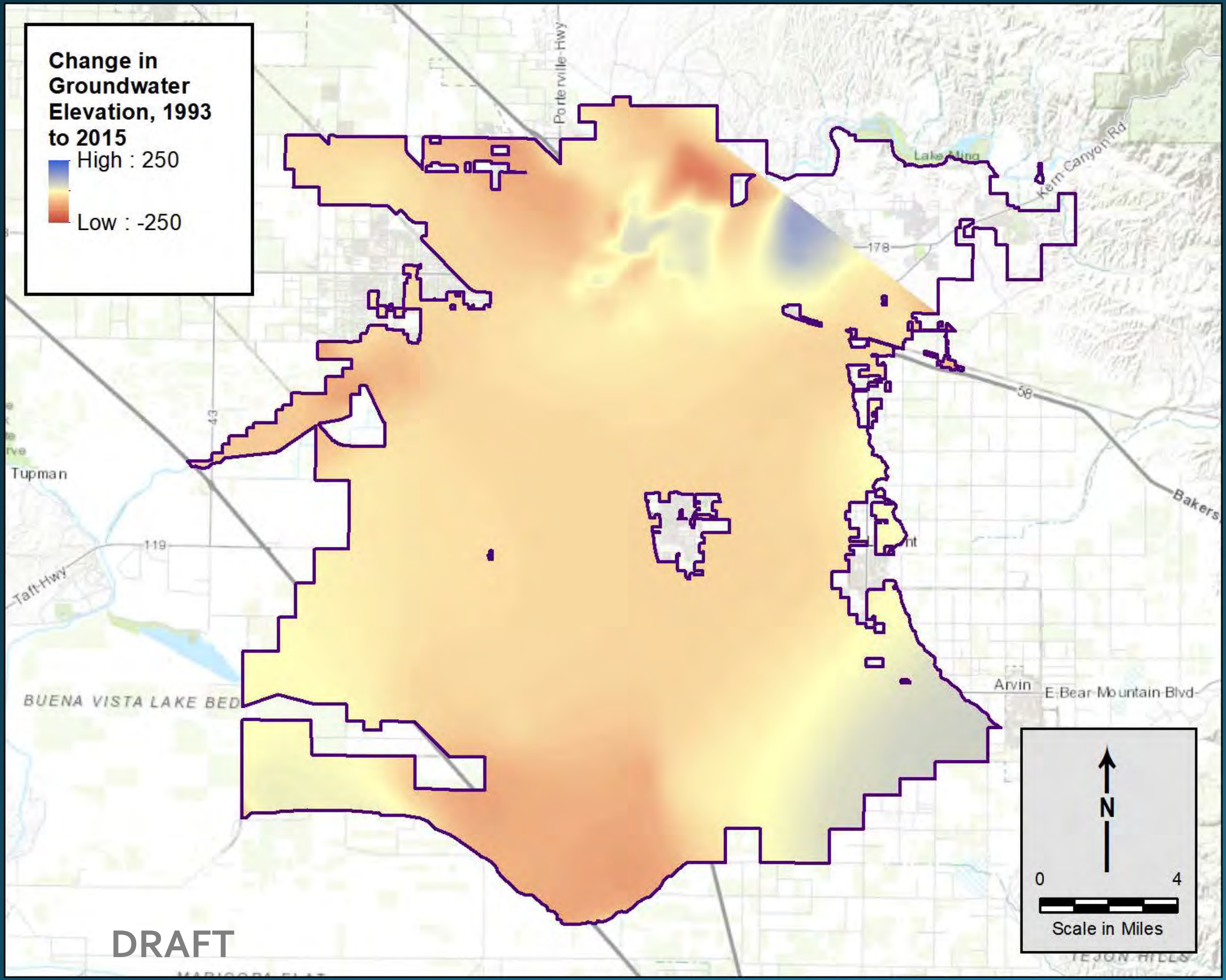
Change in Groundwater in Storage, 1995 to 1998



- Created 20 annual water levels change maps using KCWA Spring water level contour maps
- Blues areas indicate water level rise; red areas indicate water level declines
- Limited data create uncertainty for some areas and time periods

TODD GROUNDWATER

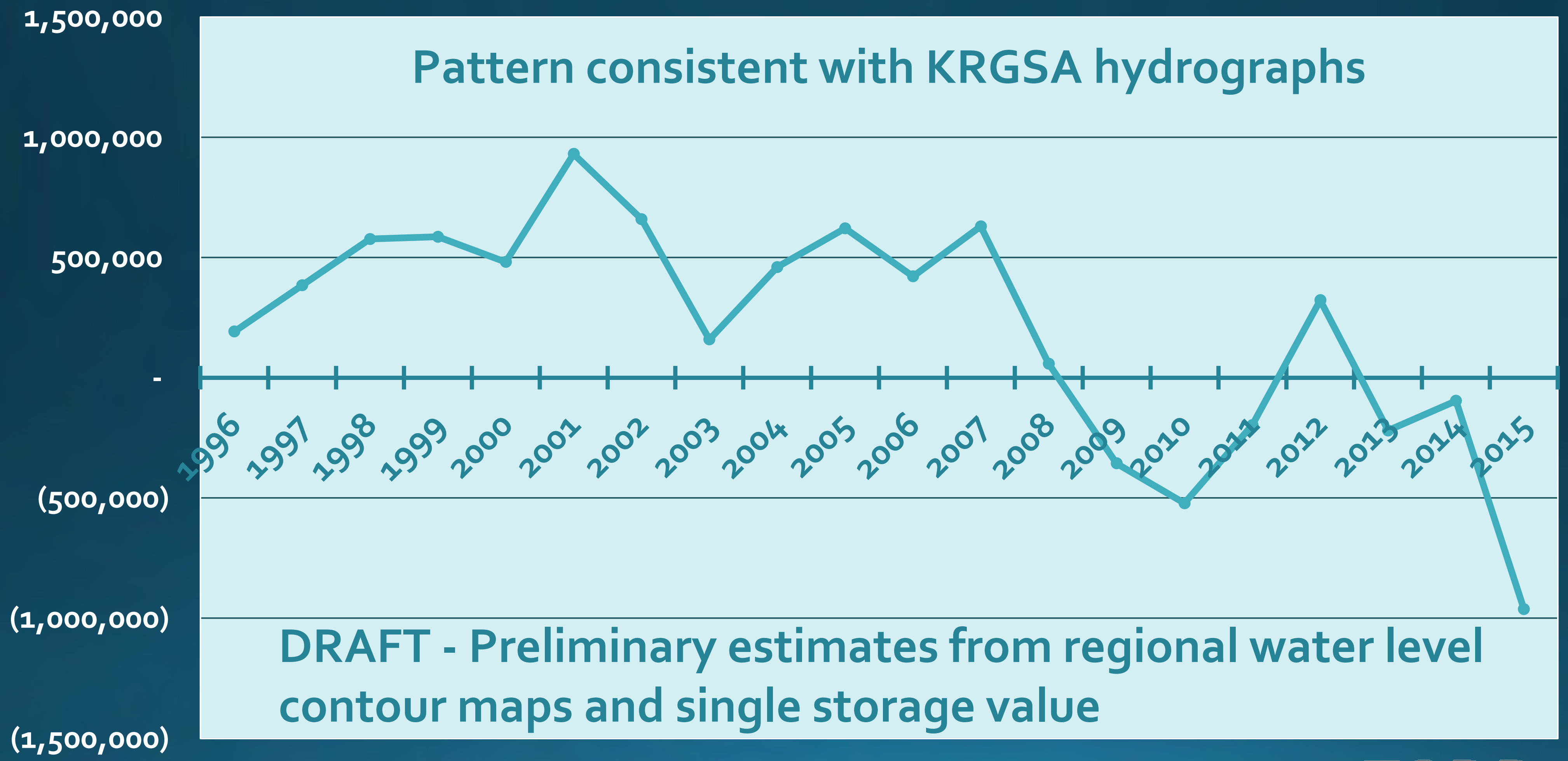
Change in Groundwater in Storage, 1993 to 2015



- Change in water levels over the entire study period
- Impacts of the recent drought result in water level declines over most of the KRGSA
- Some areas of uncertainty due to limited data

TODD GROUNDWATER

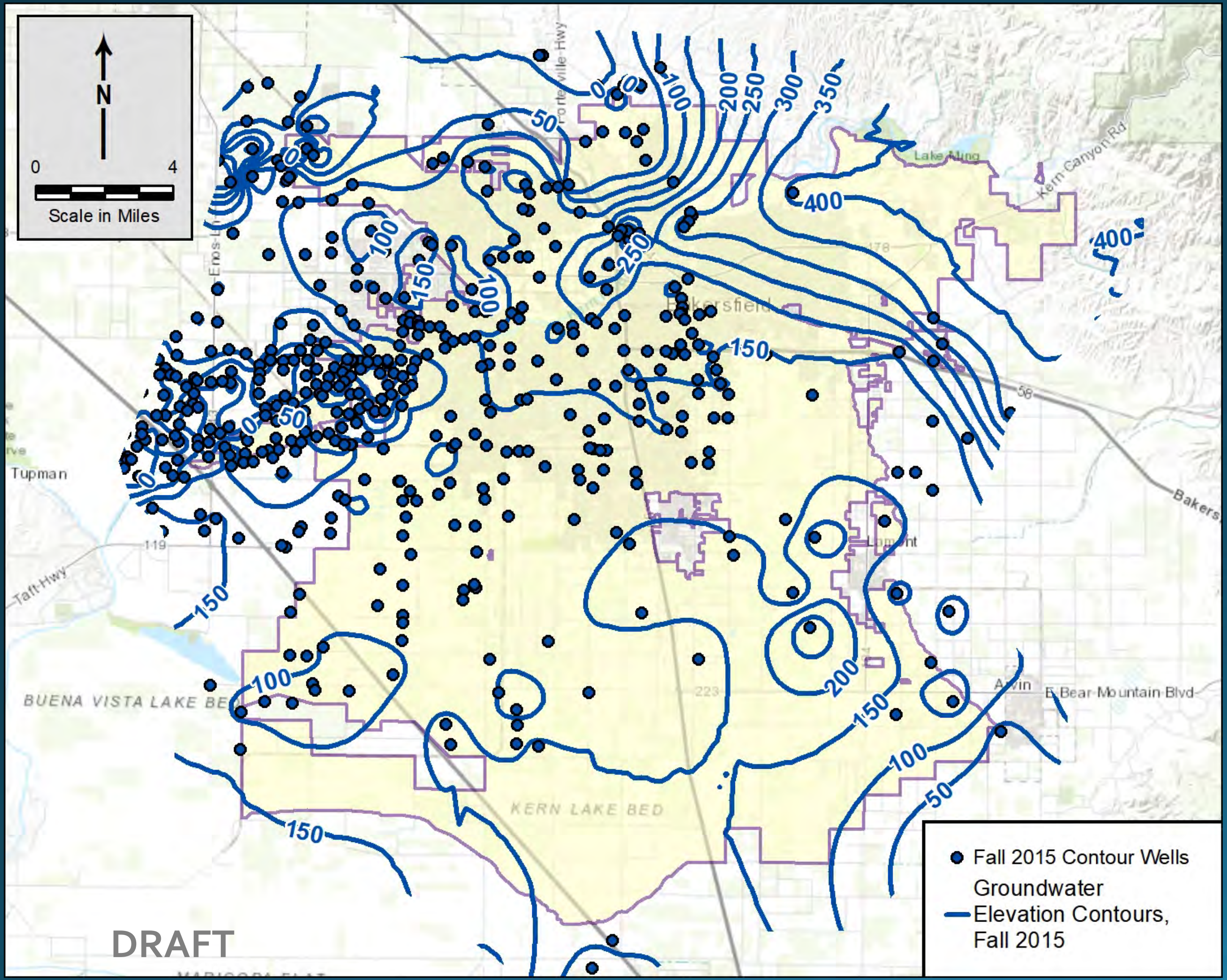
Cumulative Change in Storage from Annual Spring Water Level Contour Maps



DRAFT

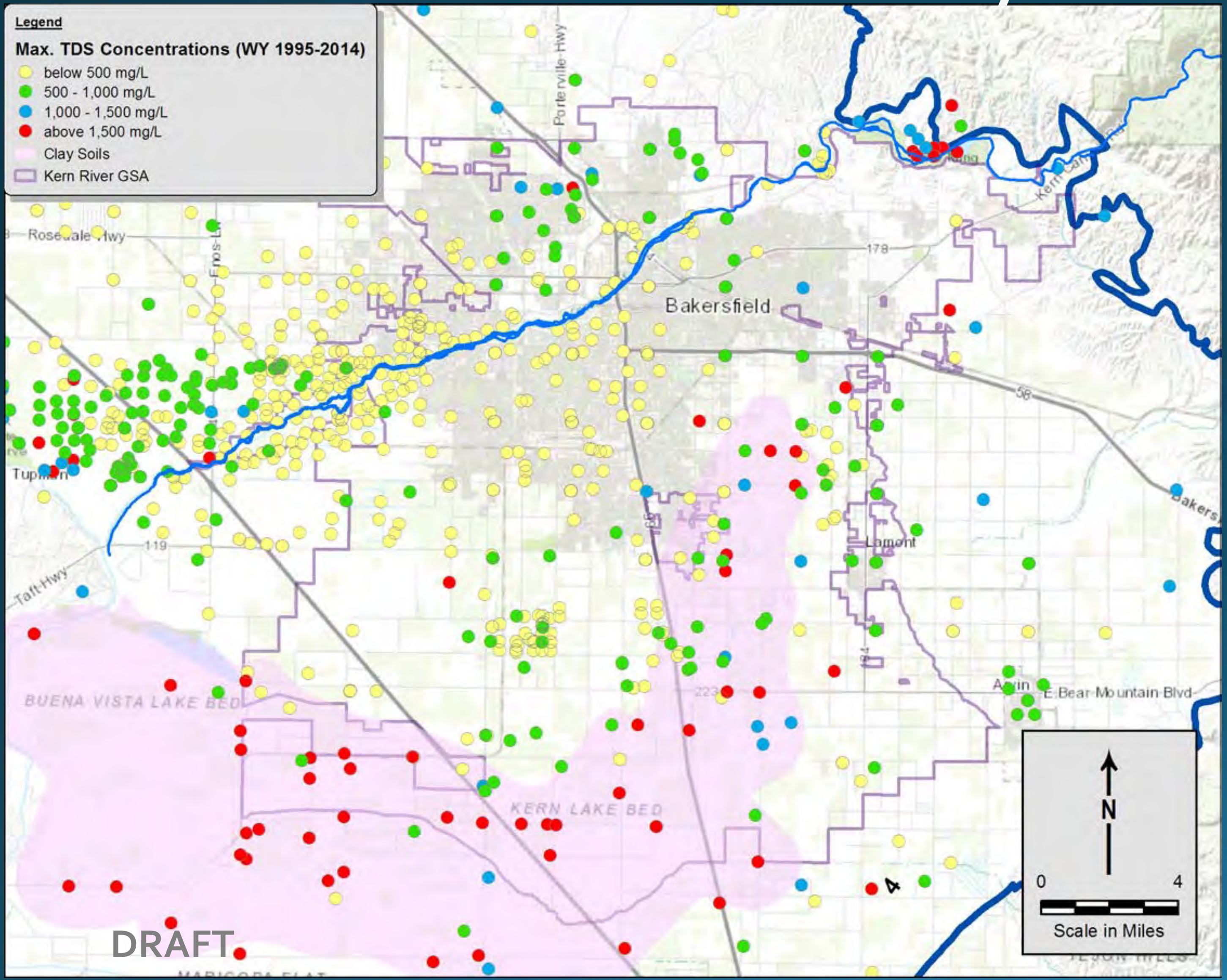
TODD GROUNDWATER

Minimum Groundwater Elevation Contours, Fall 2015



- Generated a groundwater elevation contour map for Fall 2015
- Represents minimum water levels in KRGSA
- Potential application to sustainability analysis and criteria
- Subsidence and other(?) undesirable results

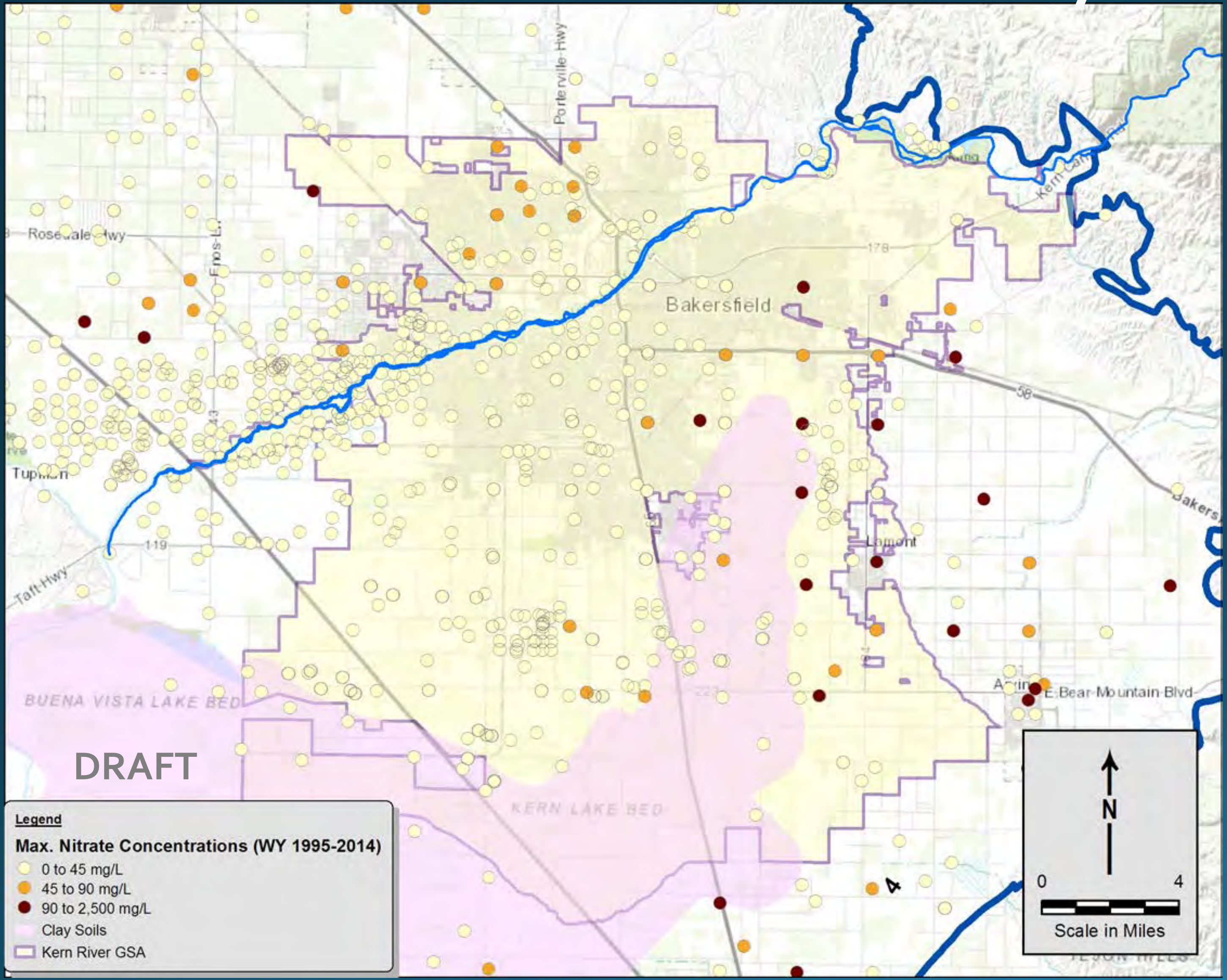
Groundwater Quality - Distribution of TDS



- Water quality database 1995 – 2014
- Total Dissolved Solids (TDS) below 1,000 mg/L over most of the KRGSA
- Elevated TDS values associated with clay-rich sediments and areas of perched groundwater

TODD GROUNDWATER

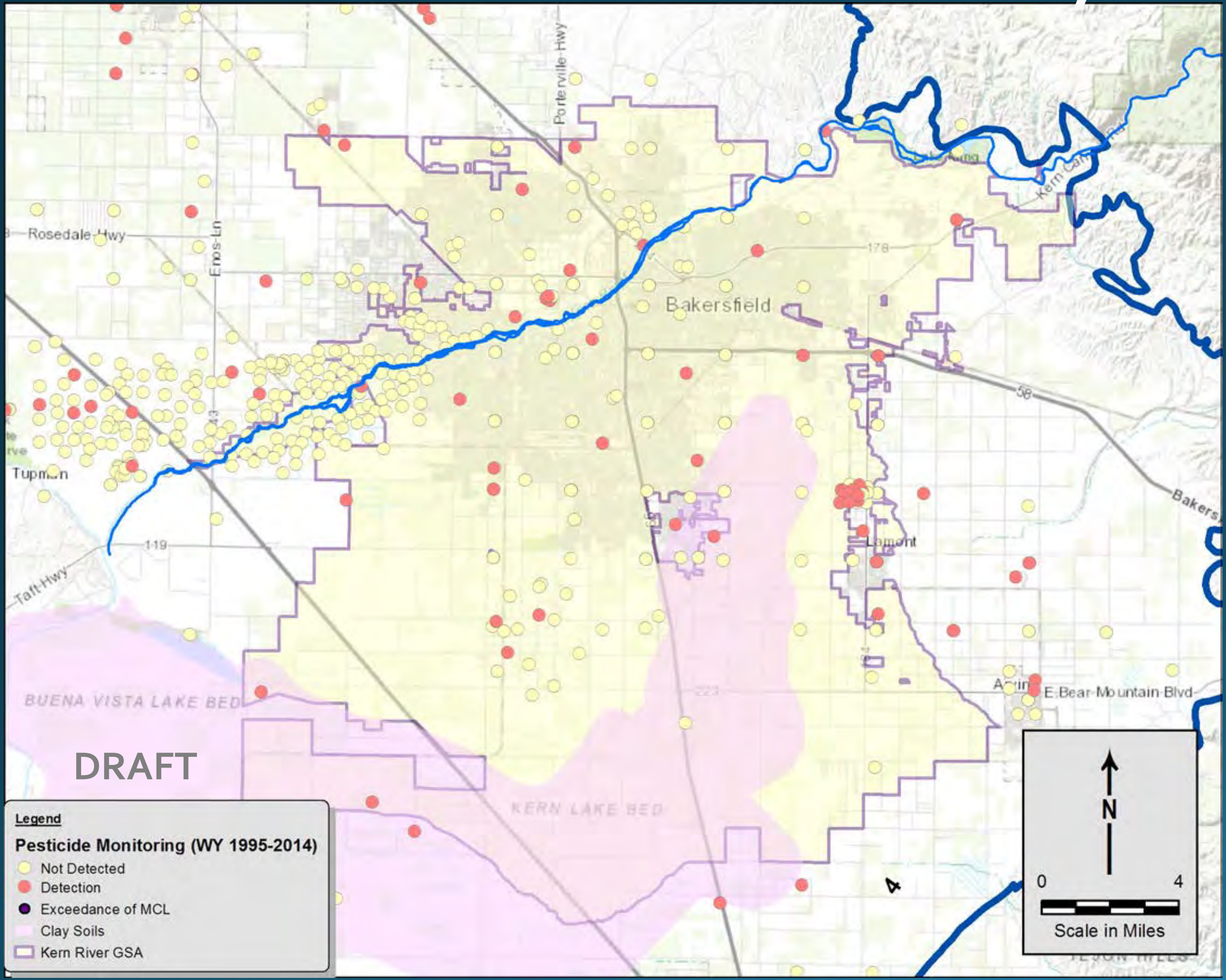
Groundwater Quality – Nitrate (NO_3)



- Most of the area has concentrations below MCL
- Localized areas of elevated nitrate exceeding the MCL
- Areas of limited data
- Additional water quality data from Cal Water

TODD GROUNDWATER

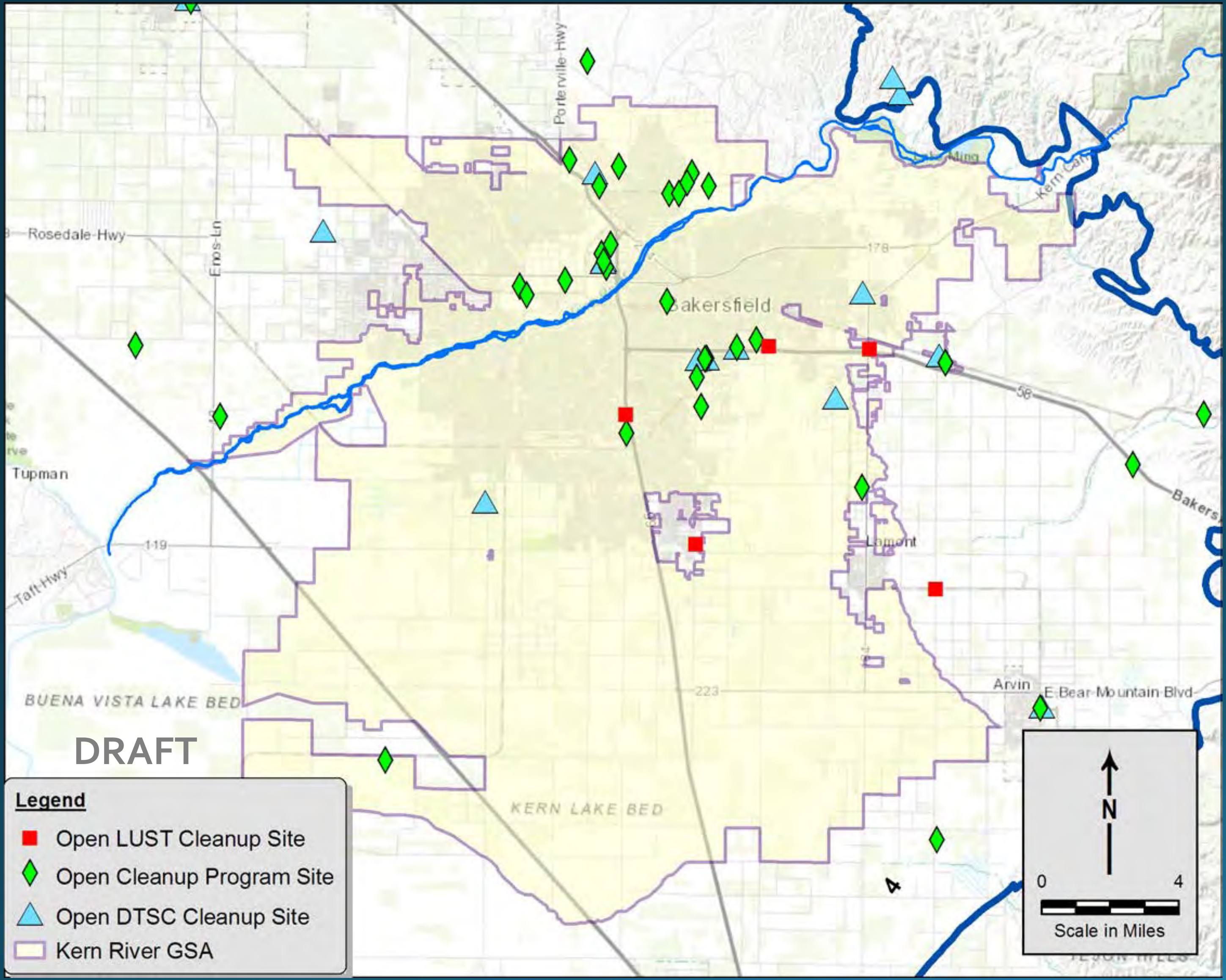
Groundwater Quality - Pesticides



- Localized areas of pesticides detected in groundwater
- No concentrations exceeding MCLs
- Additional water quality data available from Cal Water

TODD GROUNDWATER

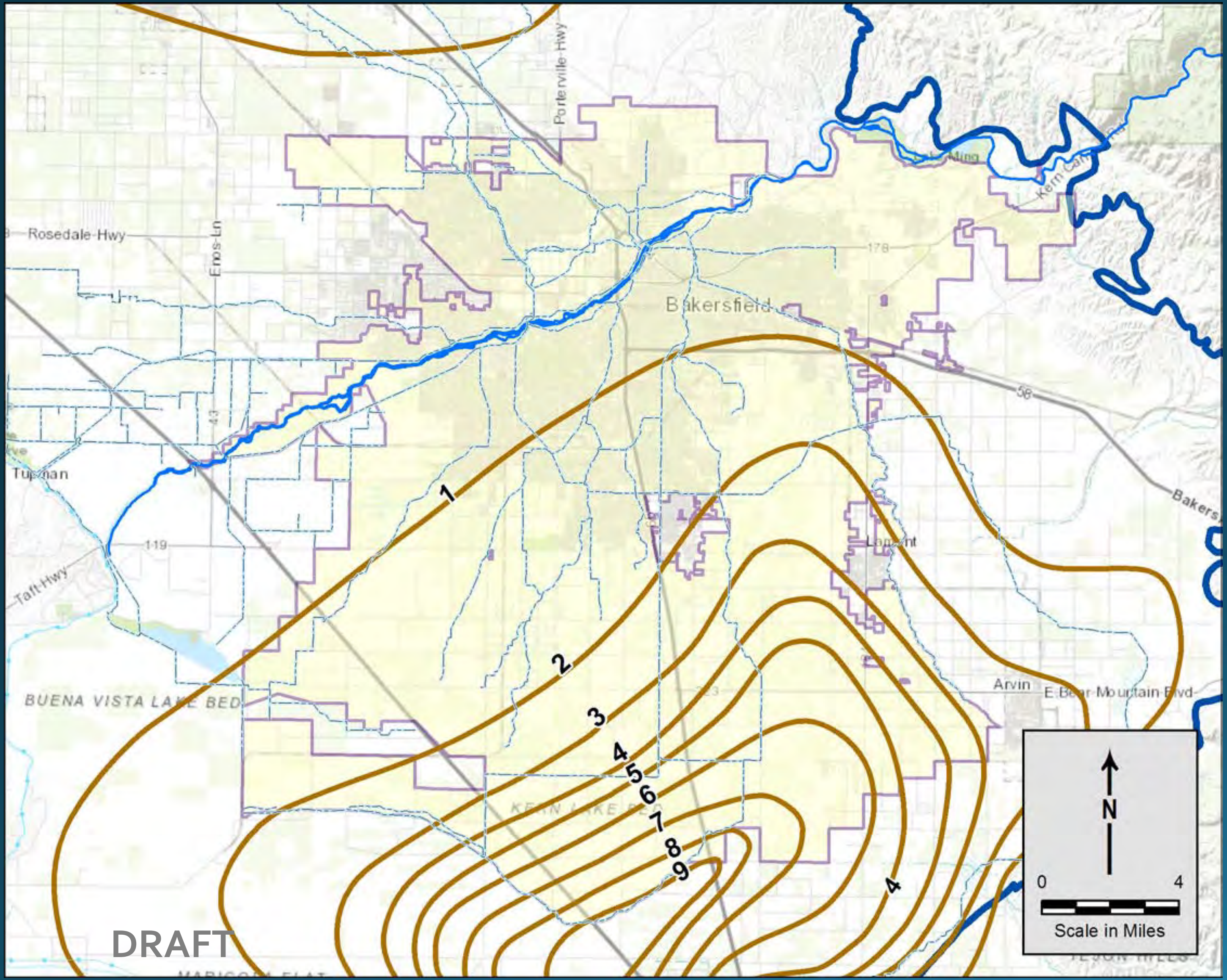
Groundwater Quality – Environmental Cleanup Sites



- Environmental Cleanup sites under the regulation of the Central Valley Water Board
- Data available from GeoTracker (state website)
- Only active (open) sites are included

TODD GROUNDWATER

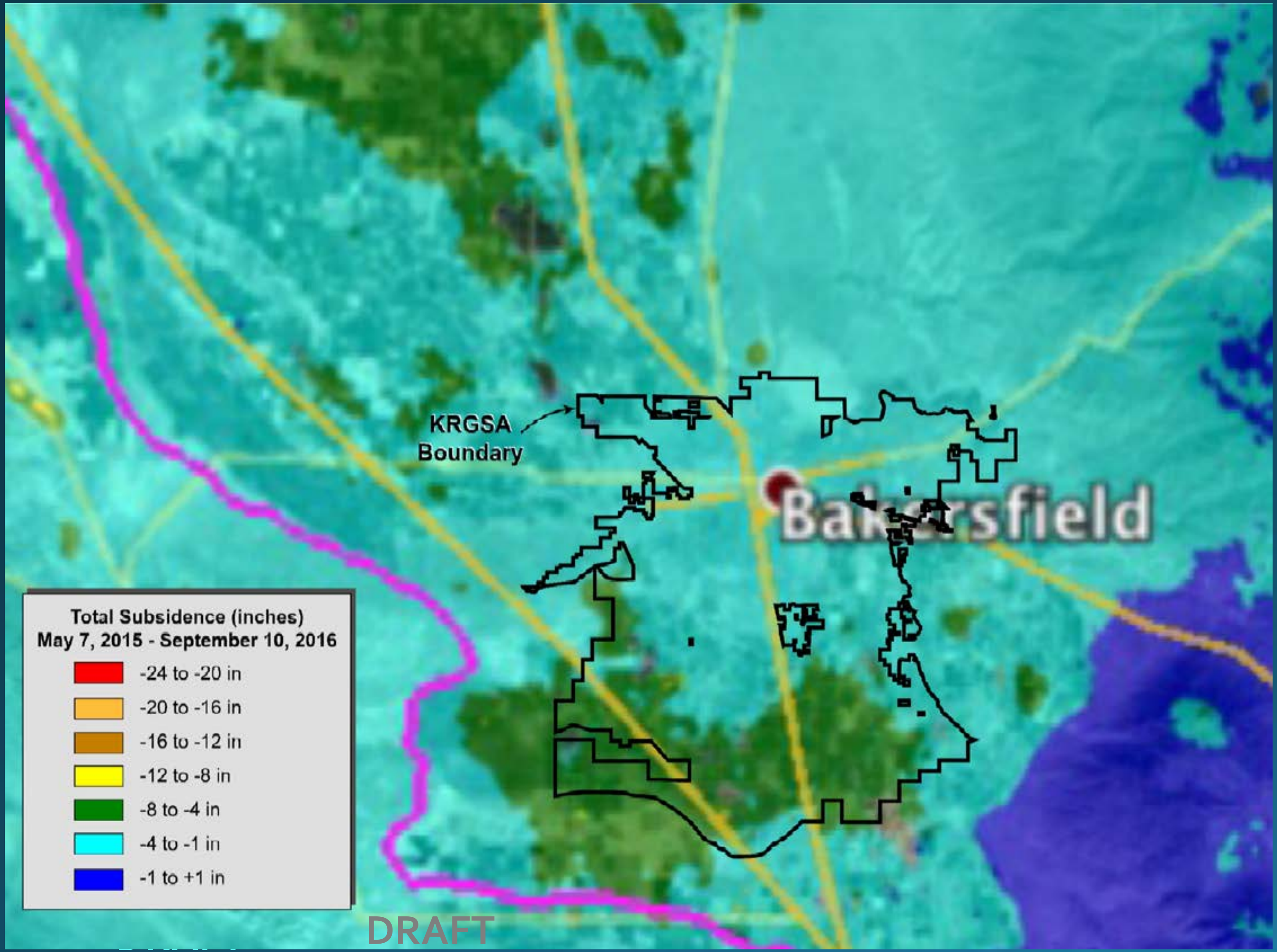
KRGSA Historical Subsidence 1926-1970



- Historical subsidence mapped by USGS (in feet)
- Associated with clay sediments in the southern portion of the KRGSA

TODD GROUNDWATER

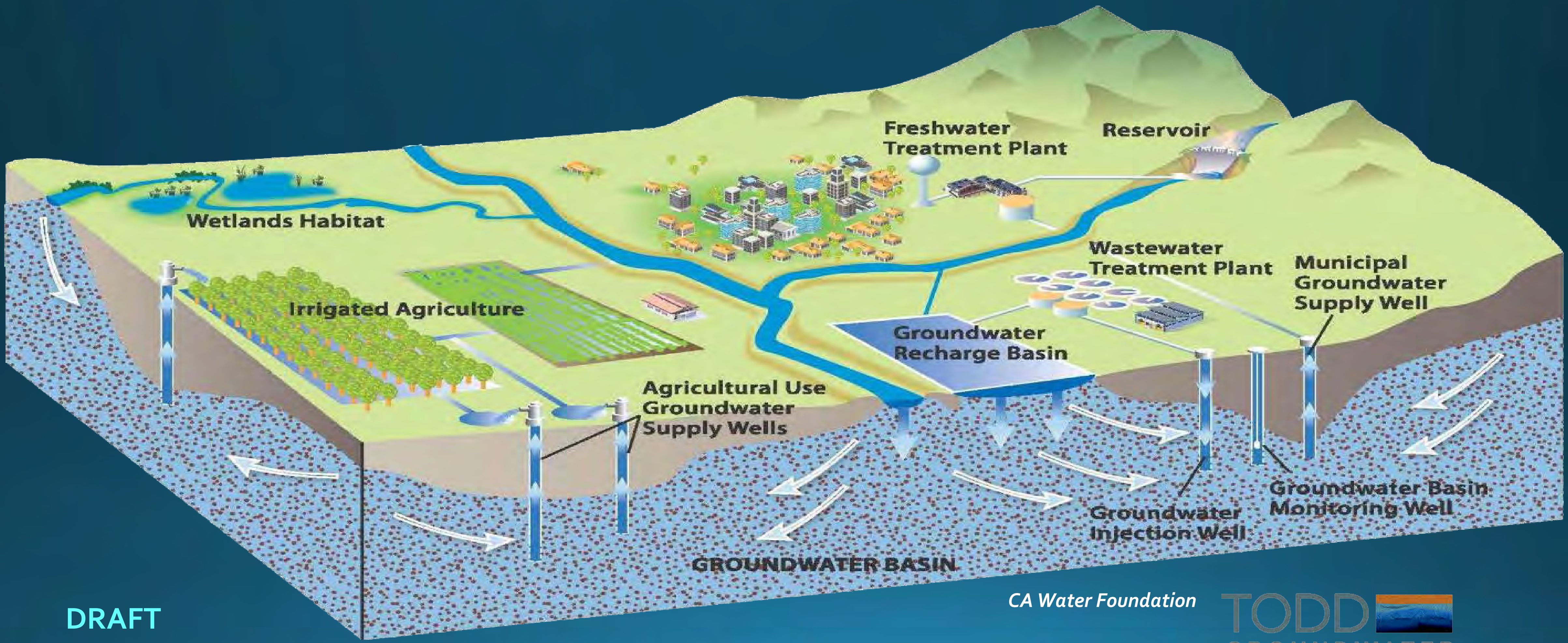
Recent Subsidence 2015 - 2016



- Analyzed by Jet Propulsion Laboratory
- 4 to 8 inches of recent subsidence indicated in the southern KRGSA.

TODD GROUNDWATER

Next Step – Finalize KRGSA Water Budget

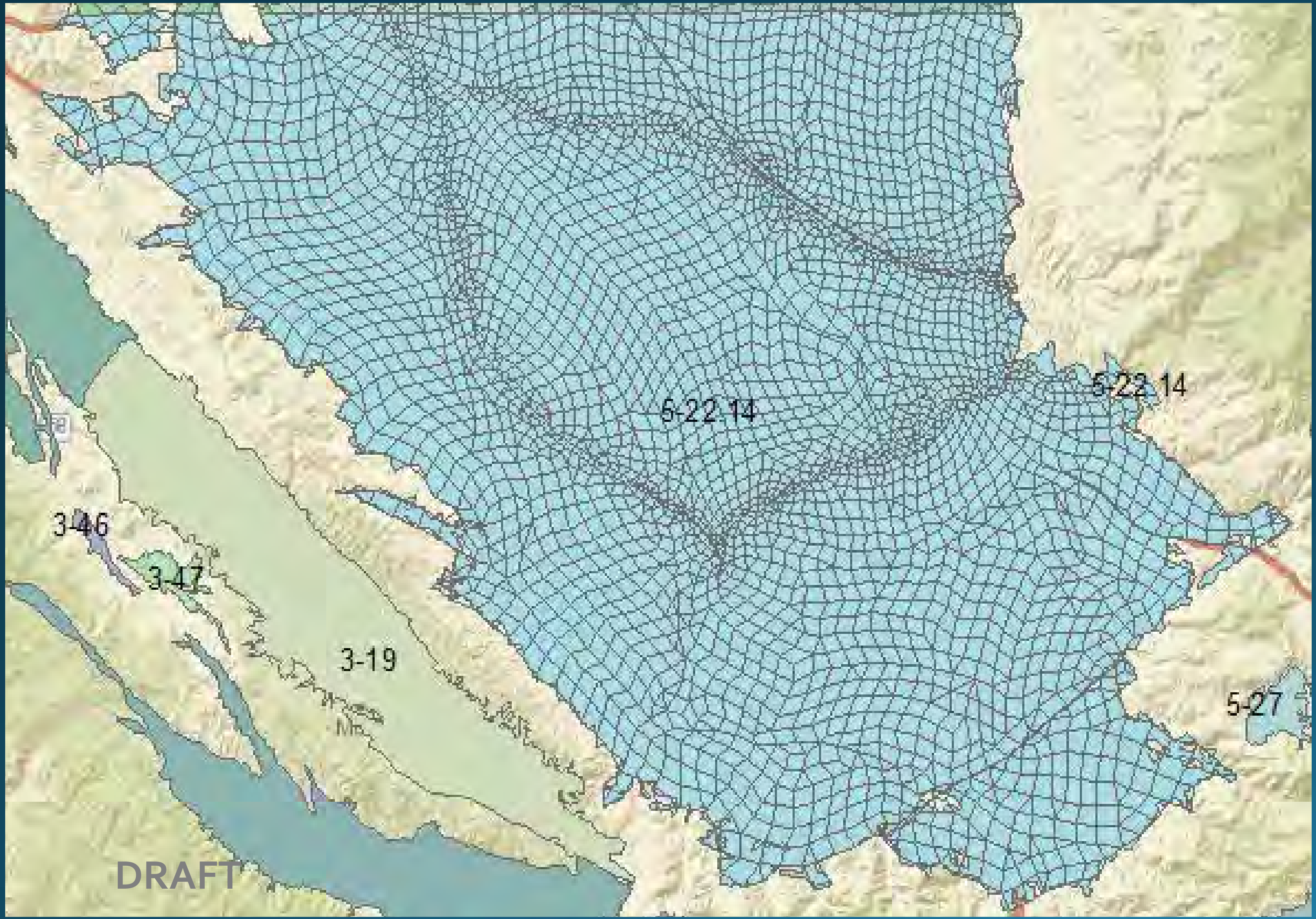


CA Water Foundation

DRAFT

TODD GROUNDWATER

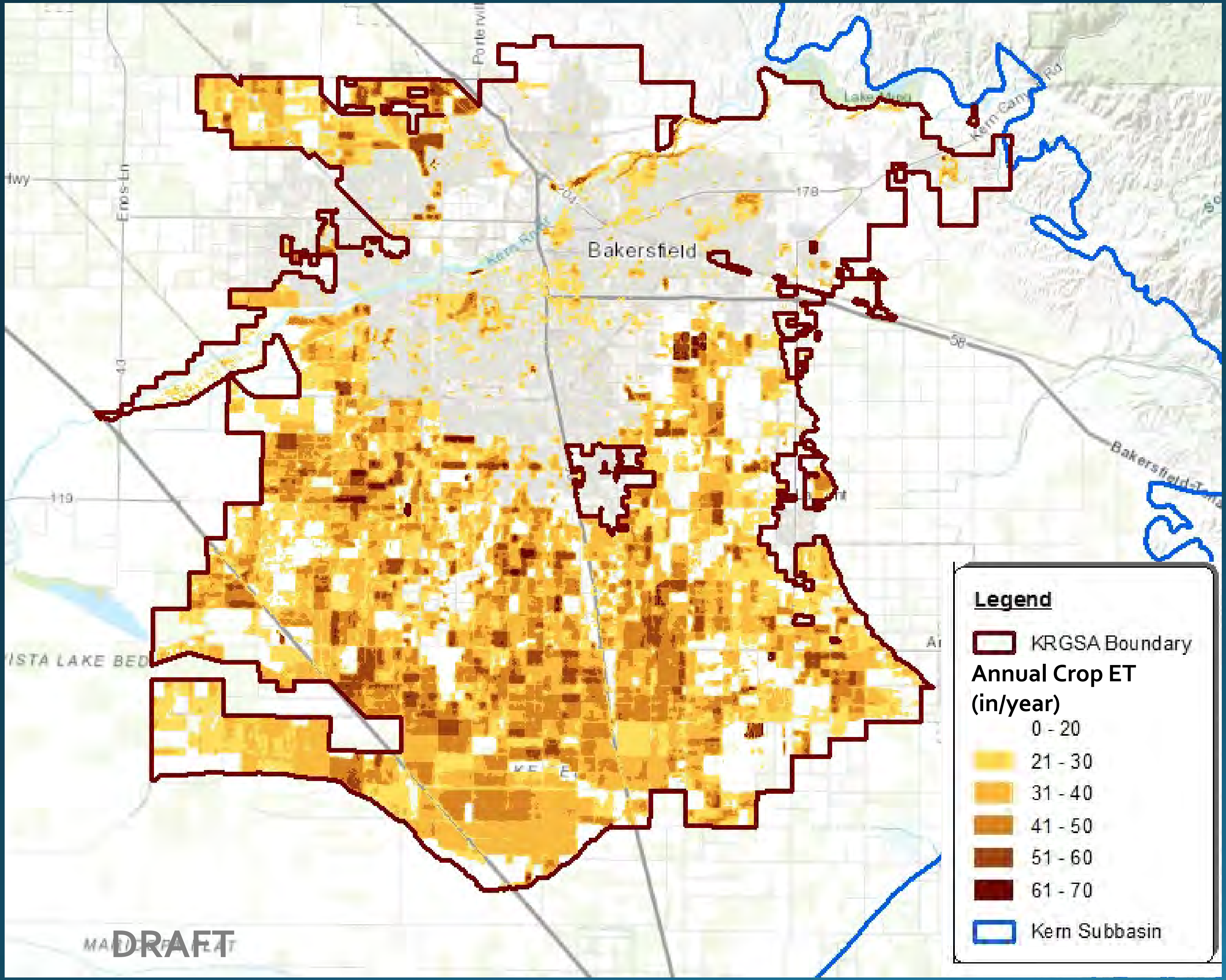
Incorporate KRGSA data into the Basin-wide Groundwater Model



- Received early release of C2VSim model
- Model runs successfully; working on pre-processing
- Involving former DWR modeler who built the current version as a subconsultant
- On-call advisor to expedite schedule

TODD GROUNDWATER

METRIC Data Processing



- 240 METRIC maps covering the entire Kern Subbasin
- ET data for each 30m x 30m pixel (1/4 acre)
- More than 800,000 pixels in KRGSA
- Processing to limit data to agricultural areas
- Reconcile with water budgets

TODD GROUNDWATER

Discussion and Questions

TODD GROUNDWATER

SGMA Discussion Meeting

July 17, 2018

Name	Company	Email
Wyatt Shipley	Vaquero Energy	wshipley@vaqueroenergy.com
Mark Yarlot	Hathaway LLC	myarlot@hathawayllc.com
David Chapin	Aera Energy LLC	dcchapin@aeraenergy.com
Randy Horne	Naftex	RHORNE@NAFTEX.COM
B Joe Ashley	CRC	joe.ashley@crc.com
Abby Auffant	Chevron	AmAuffant@chevron.com
Diana Martin	Chevron	martindo@huntnAK.com
Jeff Johnson	Chevron	jojw@chevron.com
Steve Lewis	E+B	slewis@ebresources.com
Trent Rosenlieb	Berry	trosenlieb@bry.com
Christina Halley	Sentinel Peak Resources	challey@sentinelpeakresources.com
Tim Cowley	Macpherson	tcowley@MacphersonEnergy.com
Christine Zimmerman	WSPA	christine@wspa.org
Willie Rivera	CIPA	willie@cipa.org

Kern River Groundwater Sustainability Agency (KRGSA)

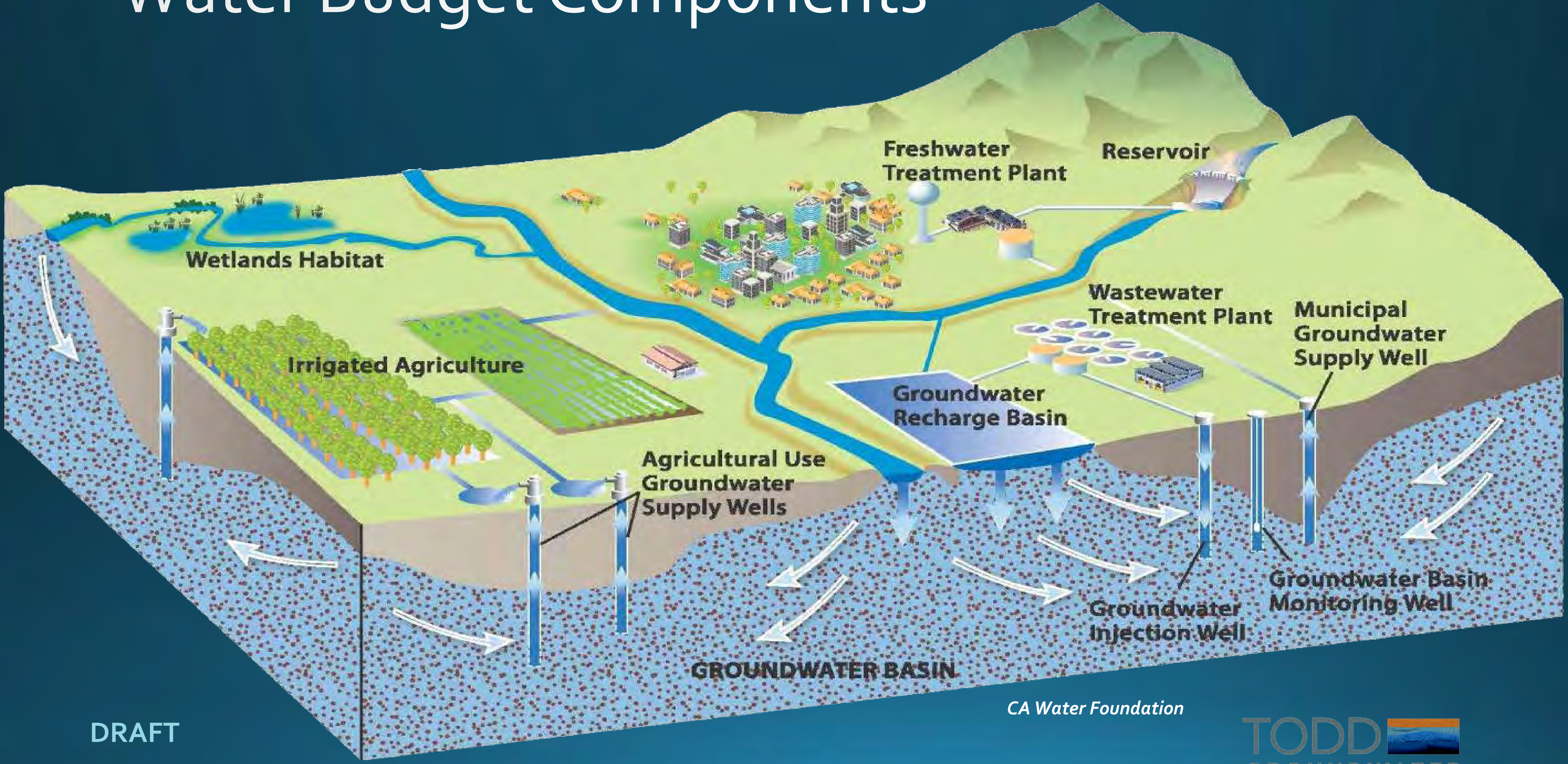
DRAFT

Water Budget Workshop
KGA Coordination Committee Meeting

August 6, 2018

TODD GROUNDWATER

Water Budget Components



CA Water Foundation

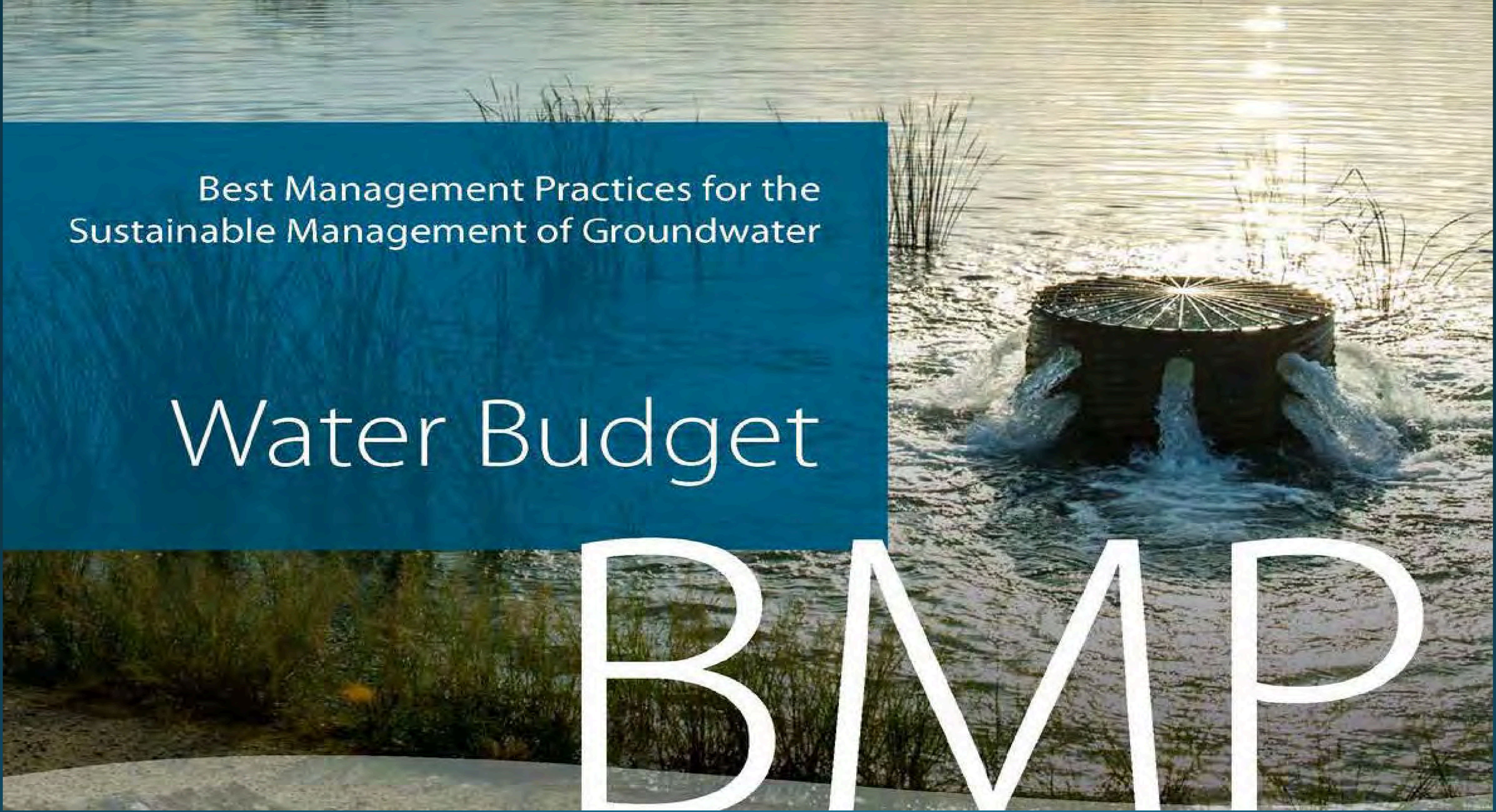
DRAFT

TODD GROUNDWATER

Best Management Practices for the Sustainable Management of Groundwater

Water Budget

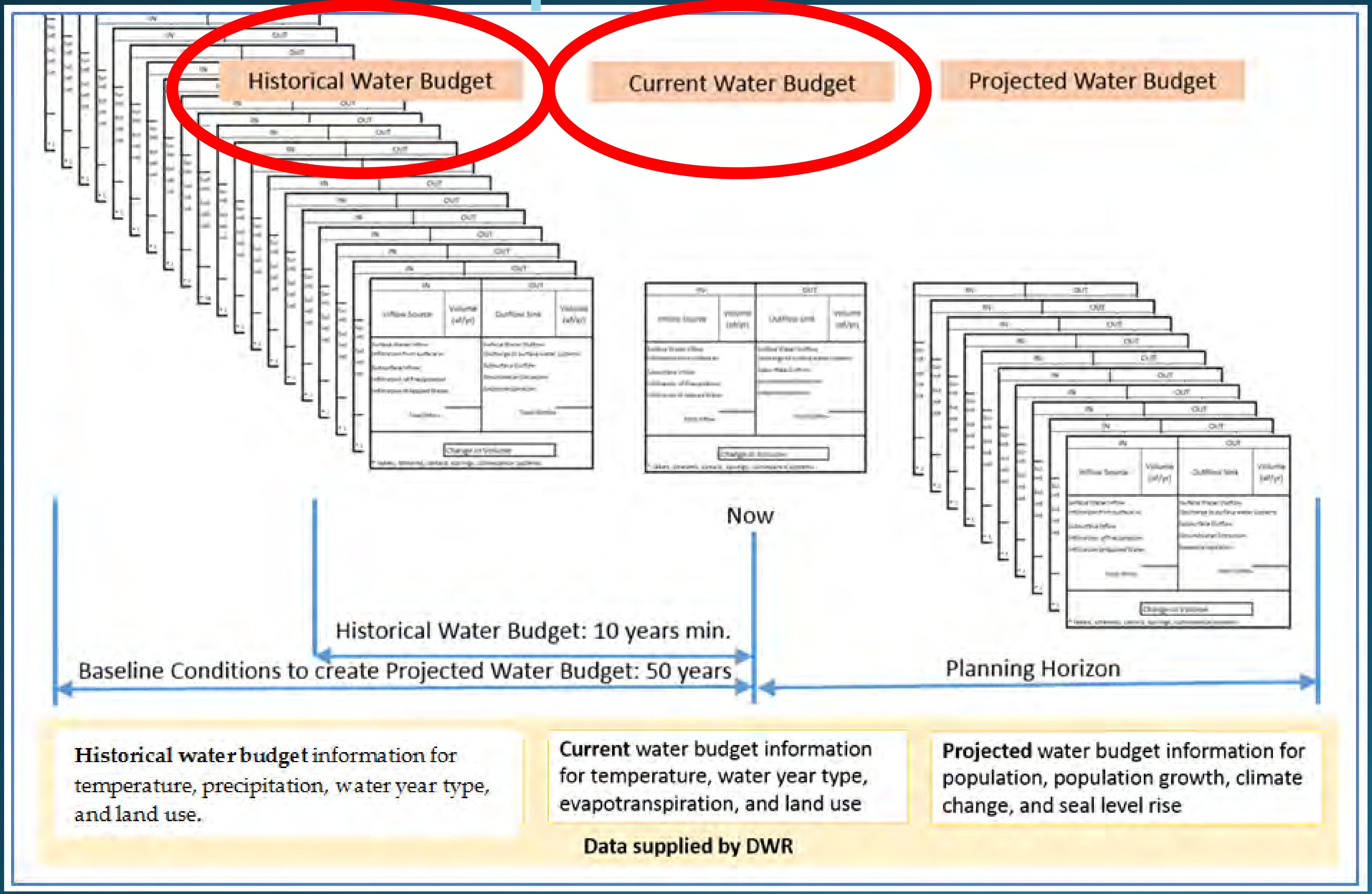
BMP



DRAFT

TODD GROUNDWATER

GSP Requirements

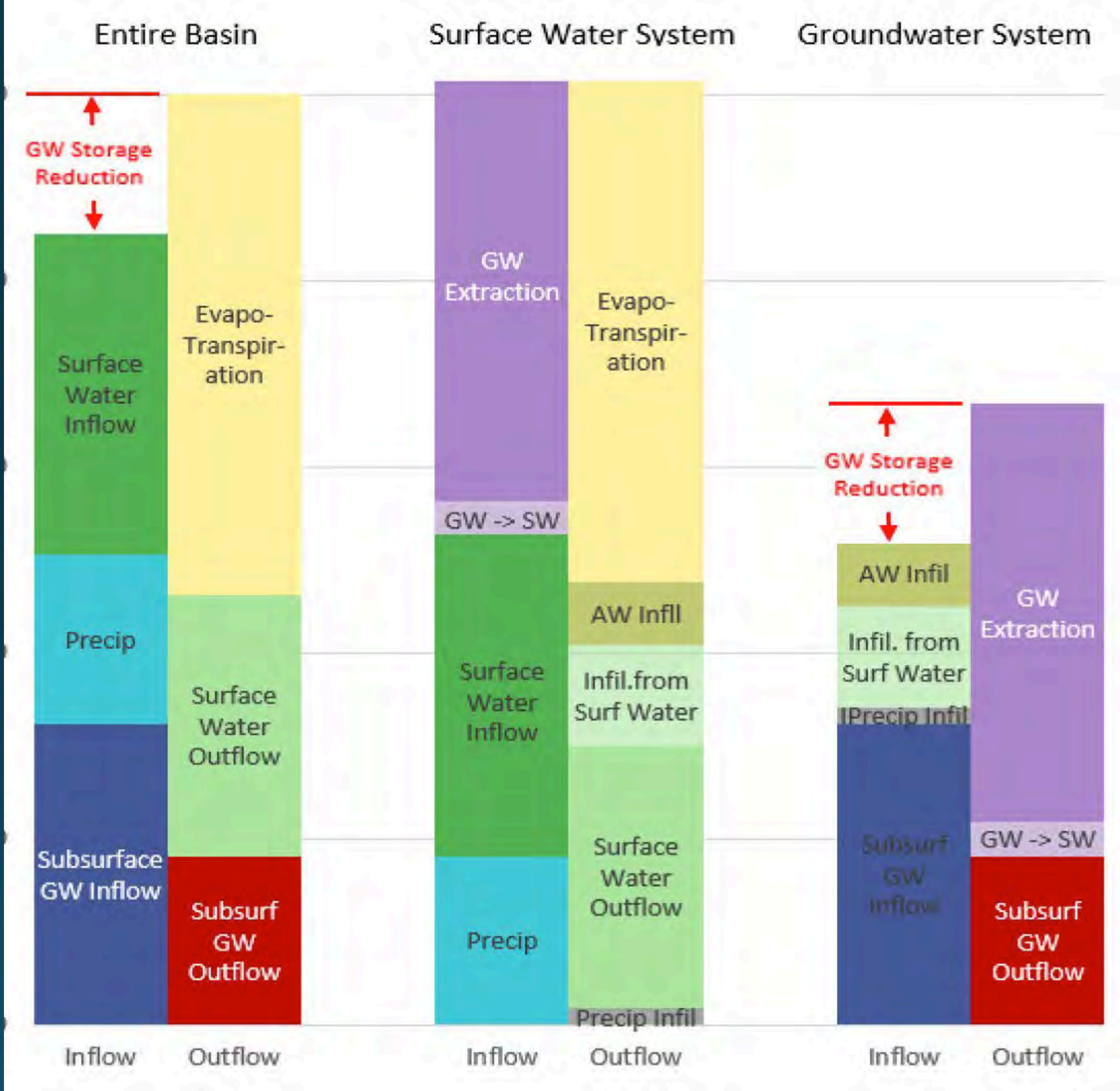


Focus on current and historical budgets first

Must cover entire subbasin

DRAFT

TODD GROUNDWATER



Water Budgets BMP Example

- Separate water budgets for groundwater and surface water
- Combine for GSA and Subbasin budgets
- Graphical representation required by regulations

DRAFT

TODD GROUNDWATER

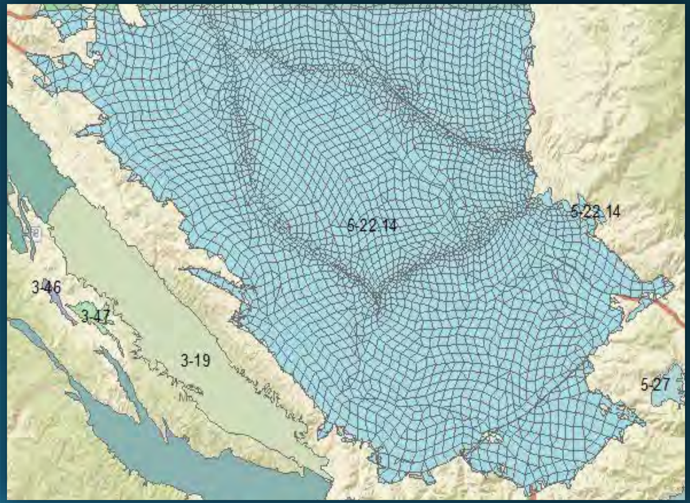
KRGSA Water Budgets

KRGSA Water Budgets – KRGSA GSP

- Develop Water Budgets for KRGSA agencies (without subsurface inflows and outflows)
- Scale up to a KRGSA Water Budget for the GSP

Subbasin Water Budgets – Groundwater Model

- Incorporate water budgets into the Subbasin groundwater model
- Combine with other subbasin water budget data
- Use model for Subbasin Water Budget and subsurface inflows and outflows

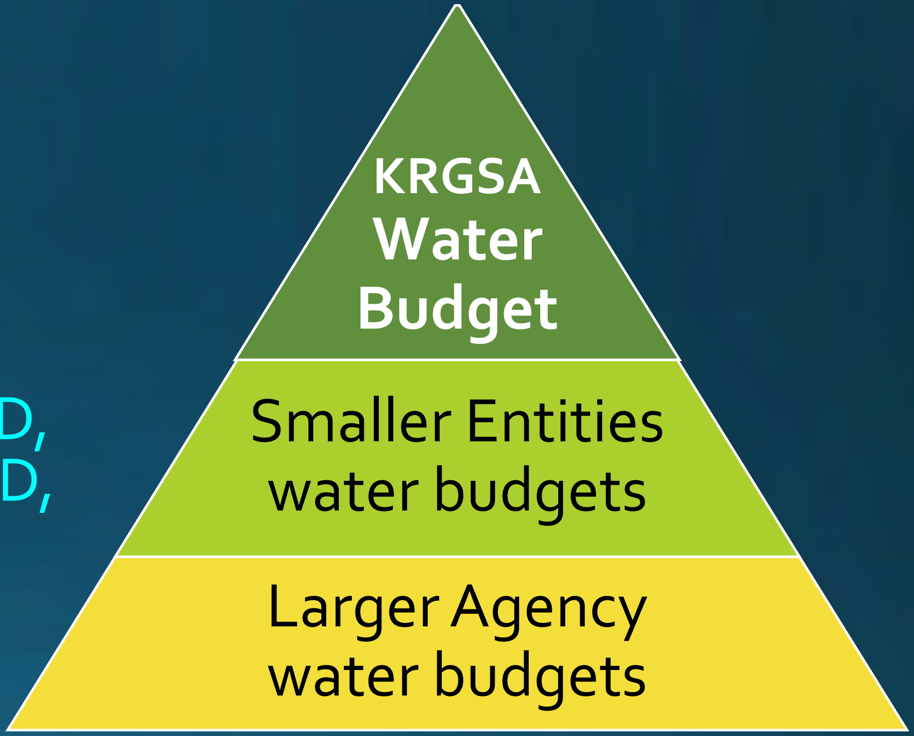


DRAFT

TODD GROUNDWATER

KRGSA Water Budgets - Approach

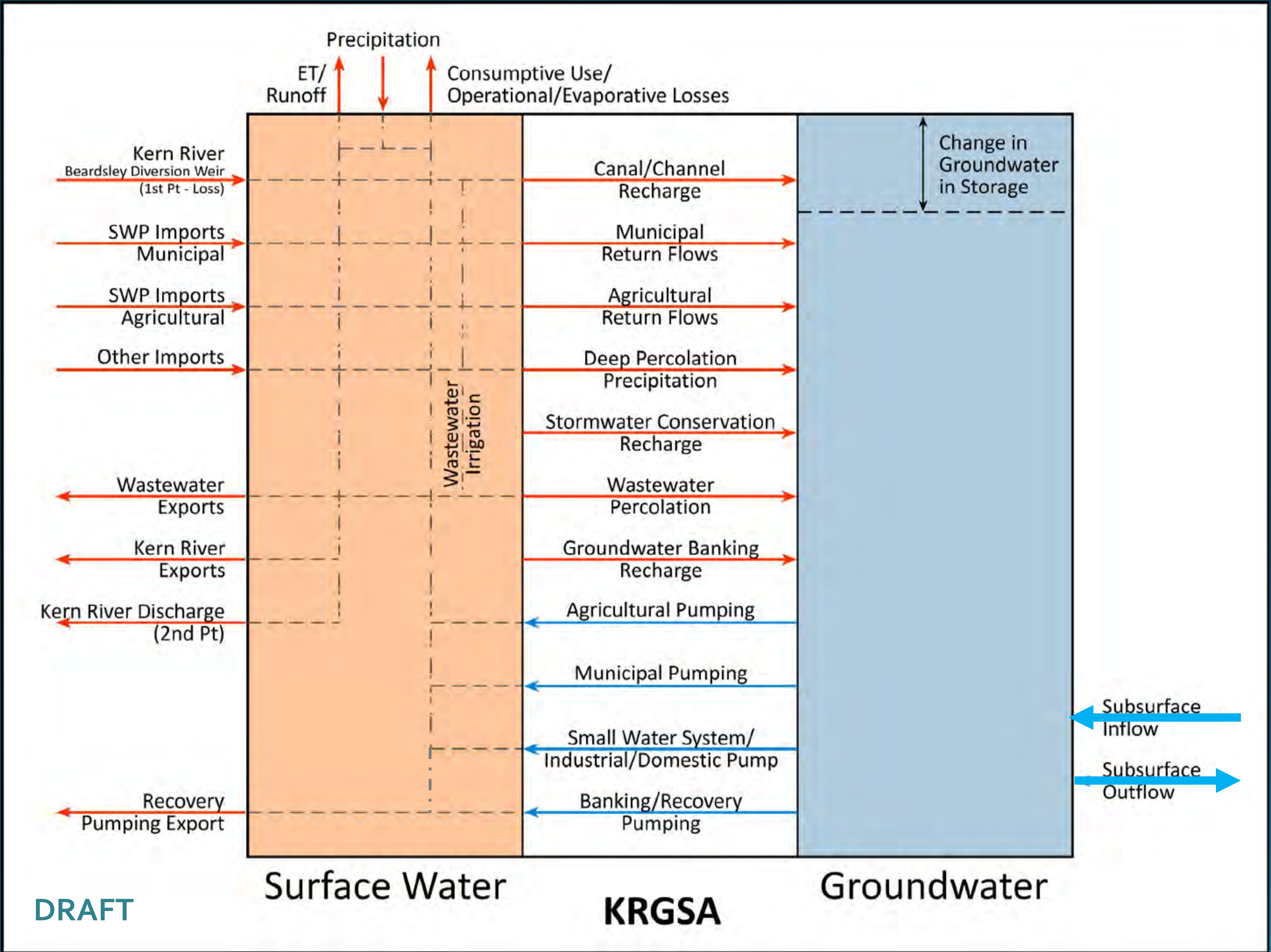
- Conduct analysis at the agency level
  - KCWA Improvement District No. 4 (ID4)
  - City of Bakersfield Water Resources
  - Kern Delta Water District
- Incorporate additional agencies/areas:
  - Cal Water, Greenfield County WD, East Niles CSD, NOR/OMWC, Berrenda Mesa, Rosedale Ranch ID, Vaughn MWC, Lamont CSD
- Combine for a KRGSA Water Budget
  - Groundwater and Surface Water
  - Document space and time
- How to handle "white areas" within KRGSA?



DRAFT

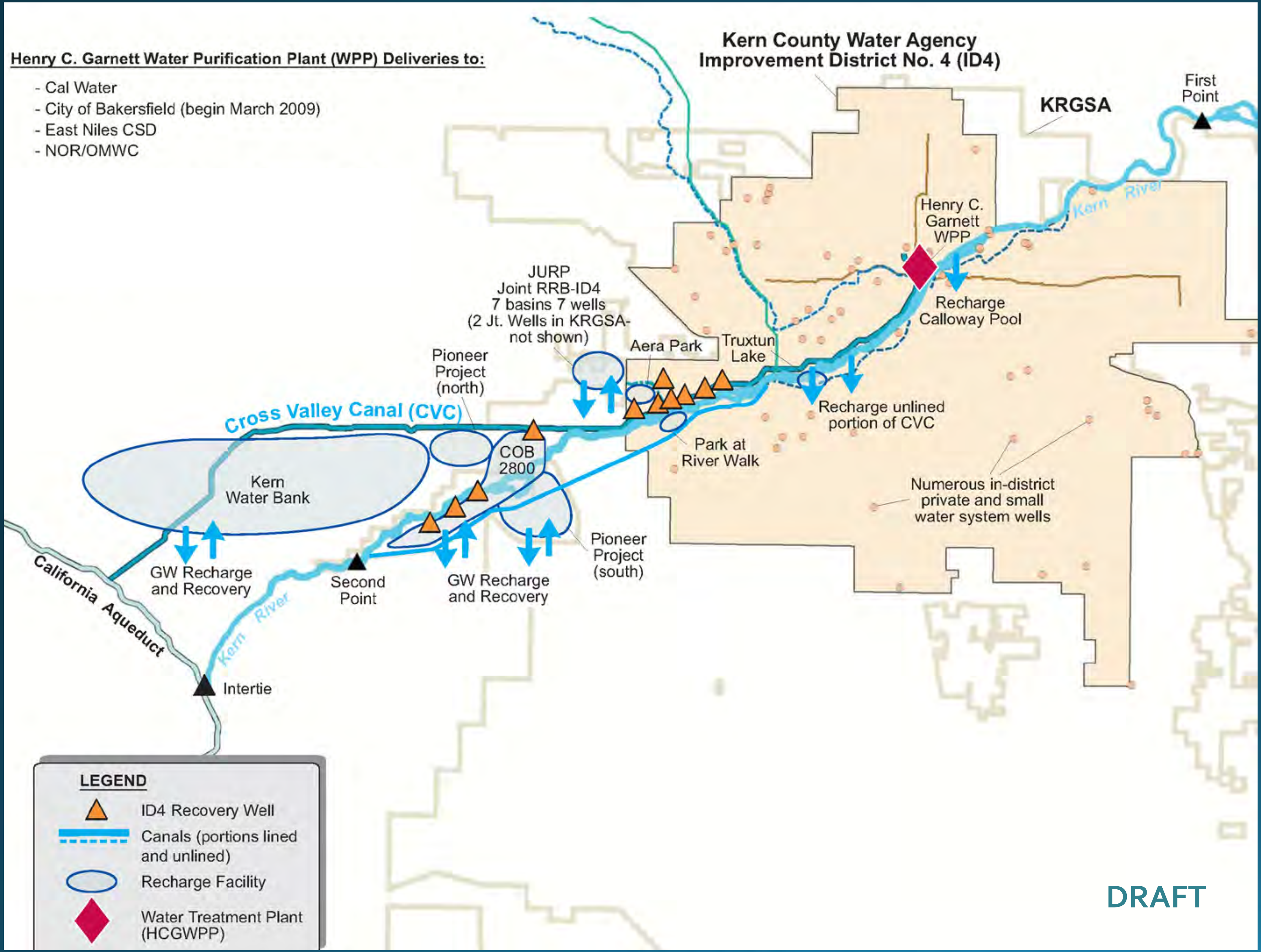
TODD GROUNDWATER

KRGSA Combined Water Budget Components



TODD GROUNDWATER

Schematic Diagram ID4



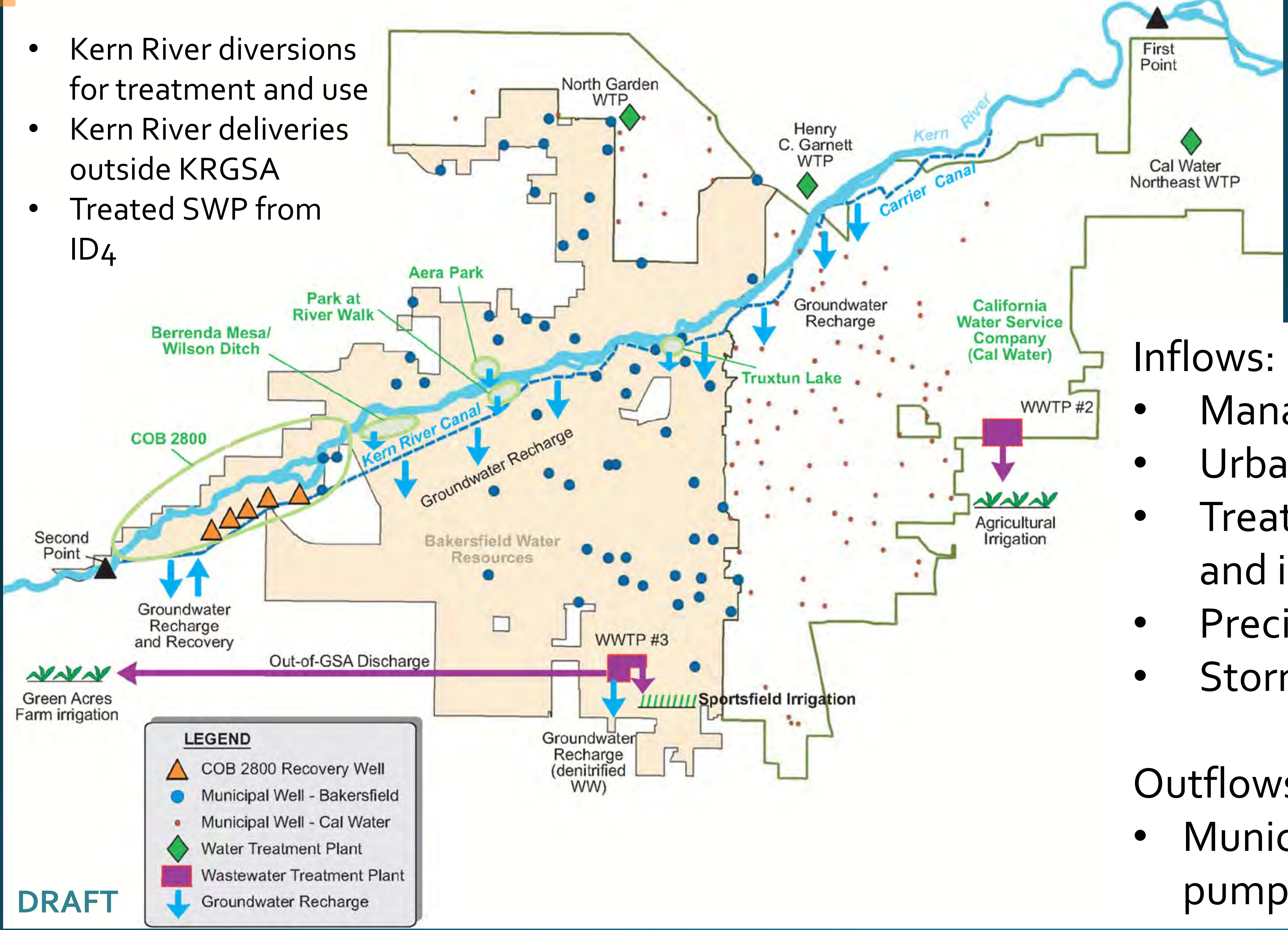
- Monthly inflows to the WPP including SWP, groundwater, and other water sources by exchange
- Recharge in Calloway pool, unlined CVC, and banking projects (supplemental data from KR Annual Reports)
- ID4 recovery pumping
- Private in-district pumping (except City, Cal Water, other agencies)
- Treated surface water deliveries other KRGSA agencies

TODD GROUNDWATER

Schematic Diagram Bakersfield

Water Resources

- Kern River diversions for treatment and use
- Kern River deliveries outside KRGSA
- Treated SWP from ID4



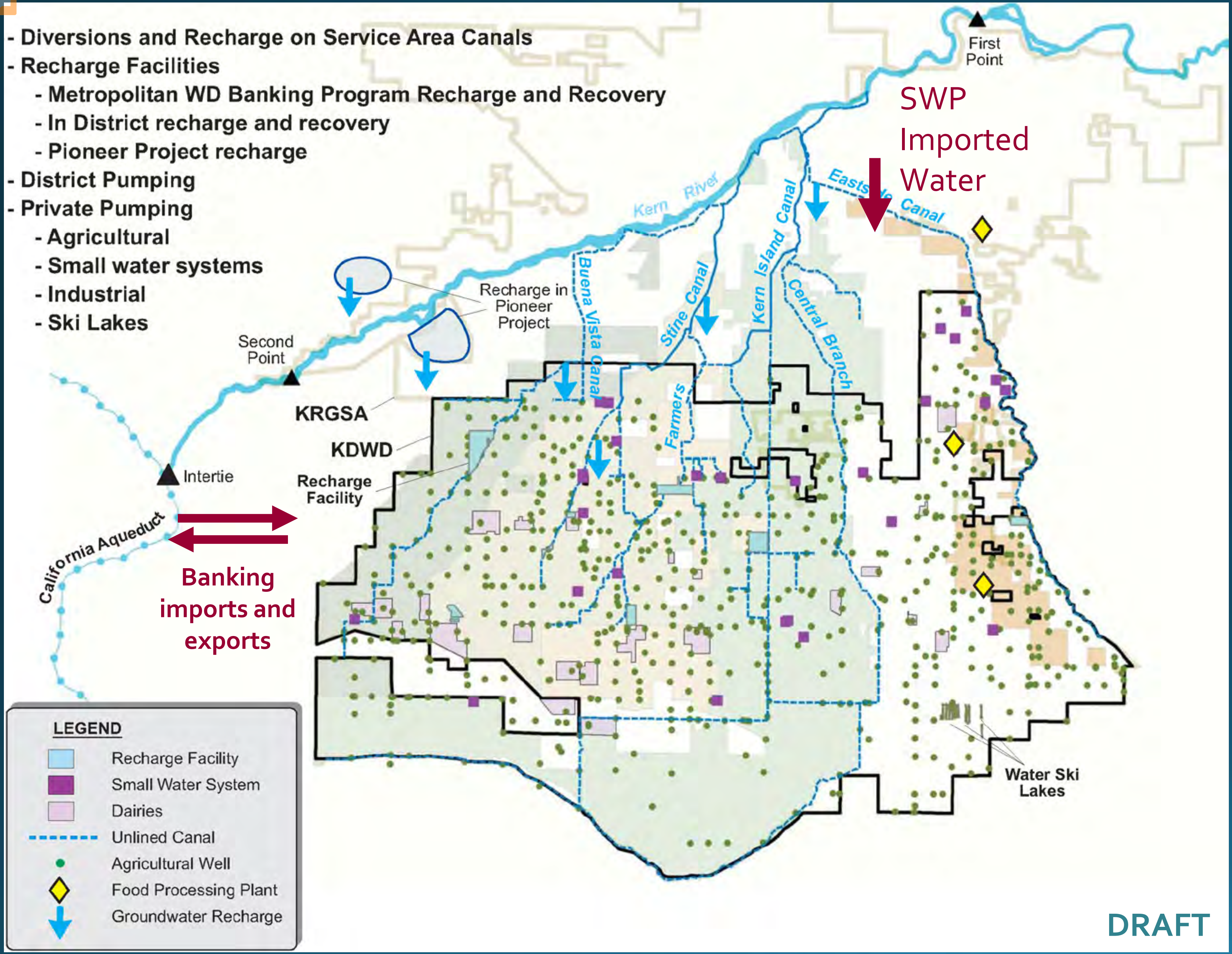
DRAFT

Inflows:

- Managed Recharge
- Urban Return Flows
- Treated wastewater recharge and irrigation return flows
- Precipitation infiltration
- Stormwater conservation

Outflows

- Municipal and Recovery pumping

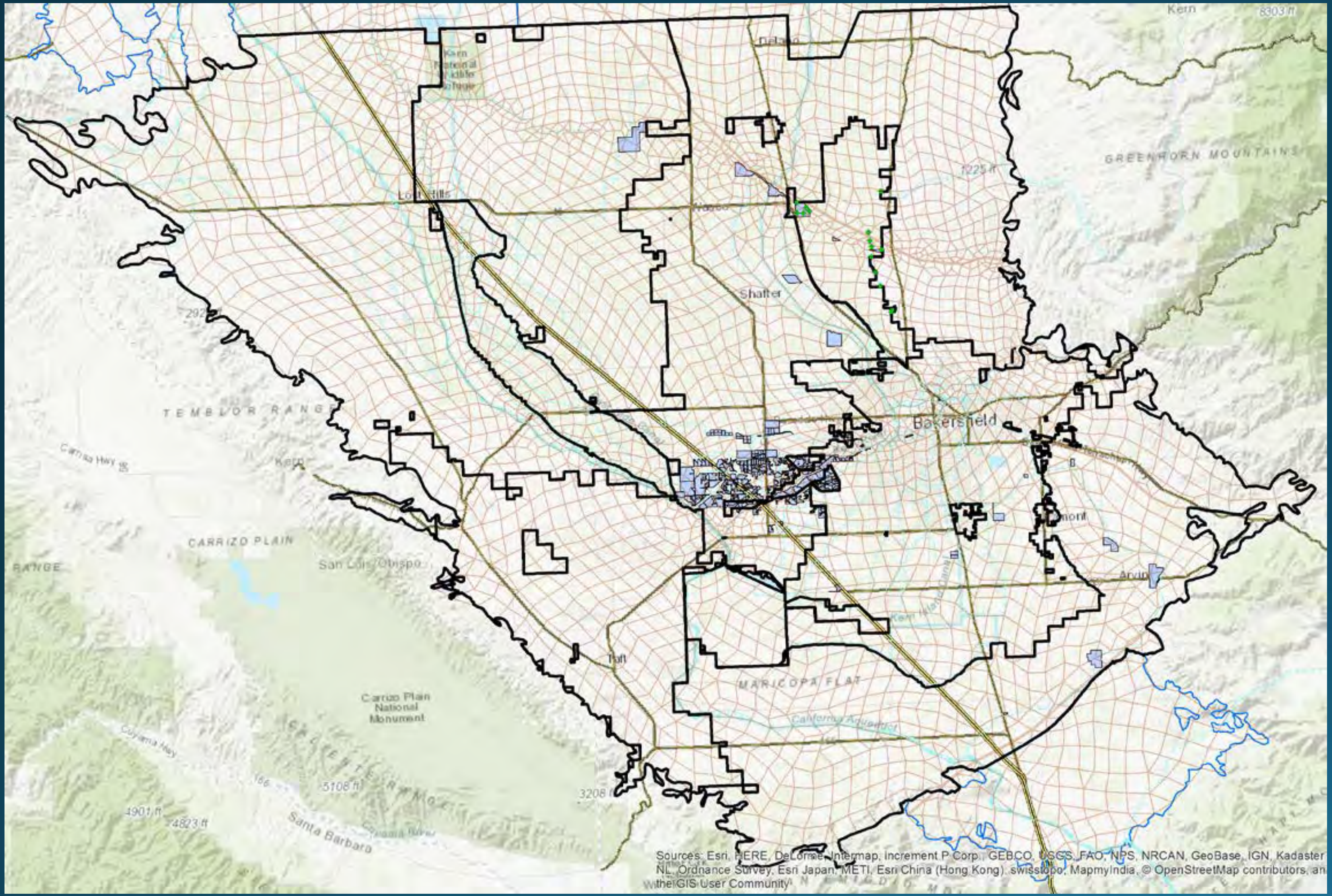


Schematic Diagram KDWD

- Agricultural ET demand from METRIC ET data
- Diversions and managed recharge from District and KR Annual Reports
- ET demand not met by surface water assumed pumped from groundwater
- Dairies and food processing pump groundwater, consume small amounts, then recirculate for irrigation and recharge

TODD GROUNDWATER

Subbasin Water Budget - C2VSim Update



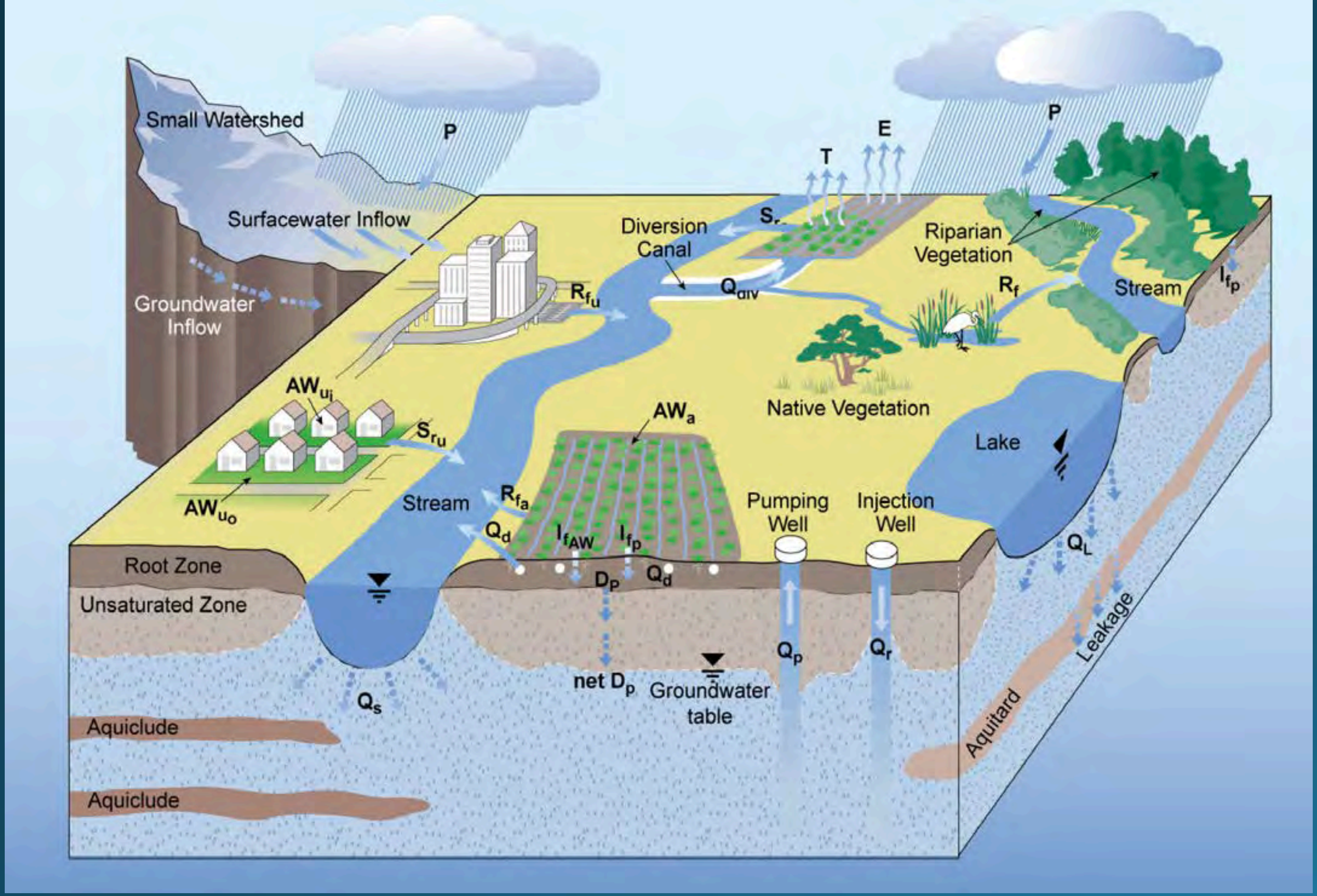
- C2VSim – DWR regional planning model released May 2018
- Use C2VSim model for subbasin water budget analysis
- Revise managed water supply and demand data with local subbasin data
- Maintain current model structure (layers and properties)
- Incorporate other existing data already in the C2VSim (e.g., soils)

DRAFT

TODD GROUNDWATER

Subbasin Water Budget - Approach

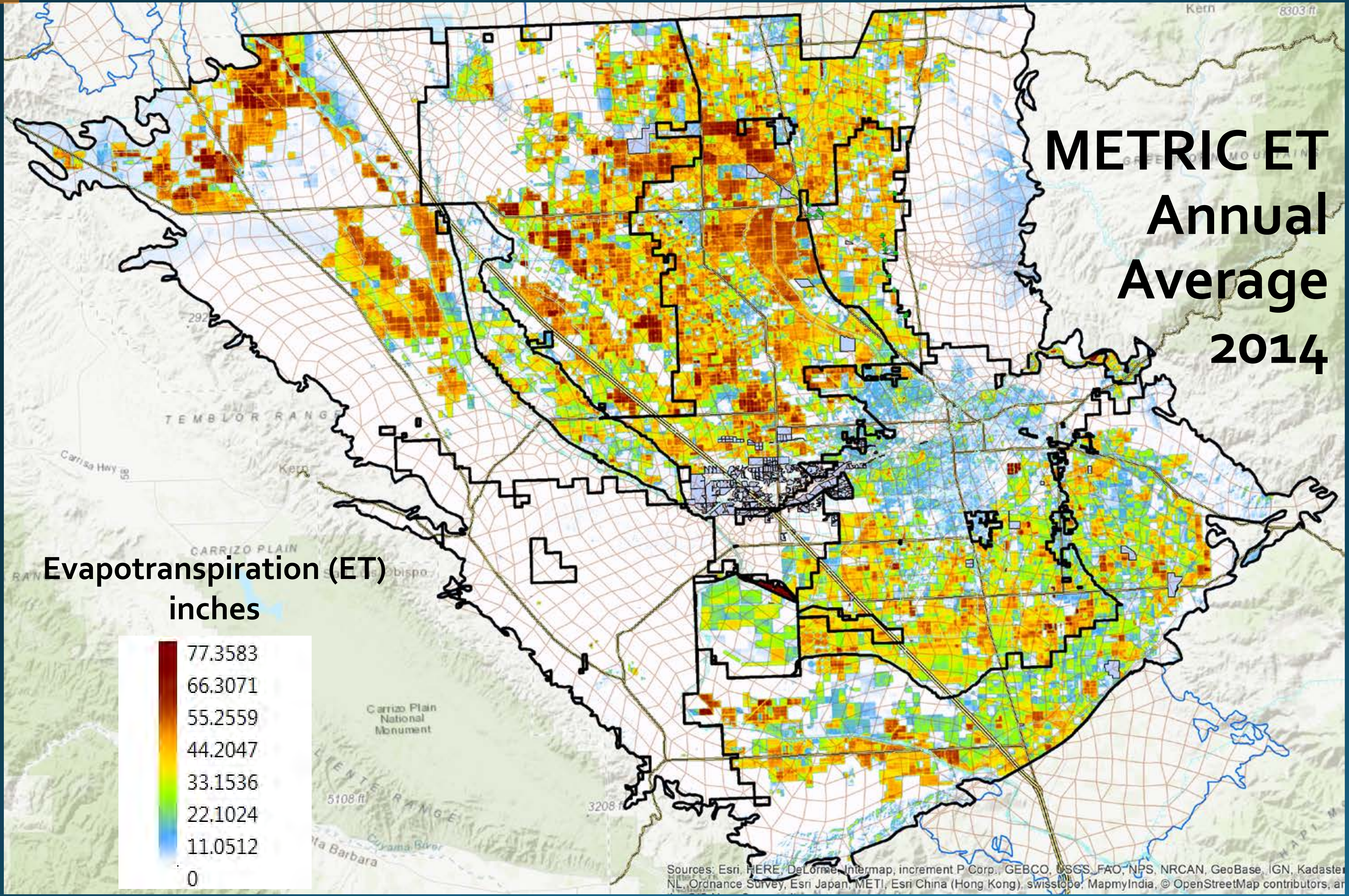
Update Managed Water Supply and Demand Data



- Surface water diversions by water district
- Groundwater banking and recharge programs
- Groundwater banking recovery for in-basin use and export
- M&I water use
- Locally important water budget components
- Crop demand based on METRIC ET data

DRAFT

TODD GROUNDWATER

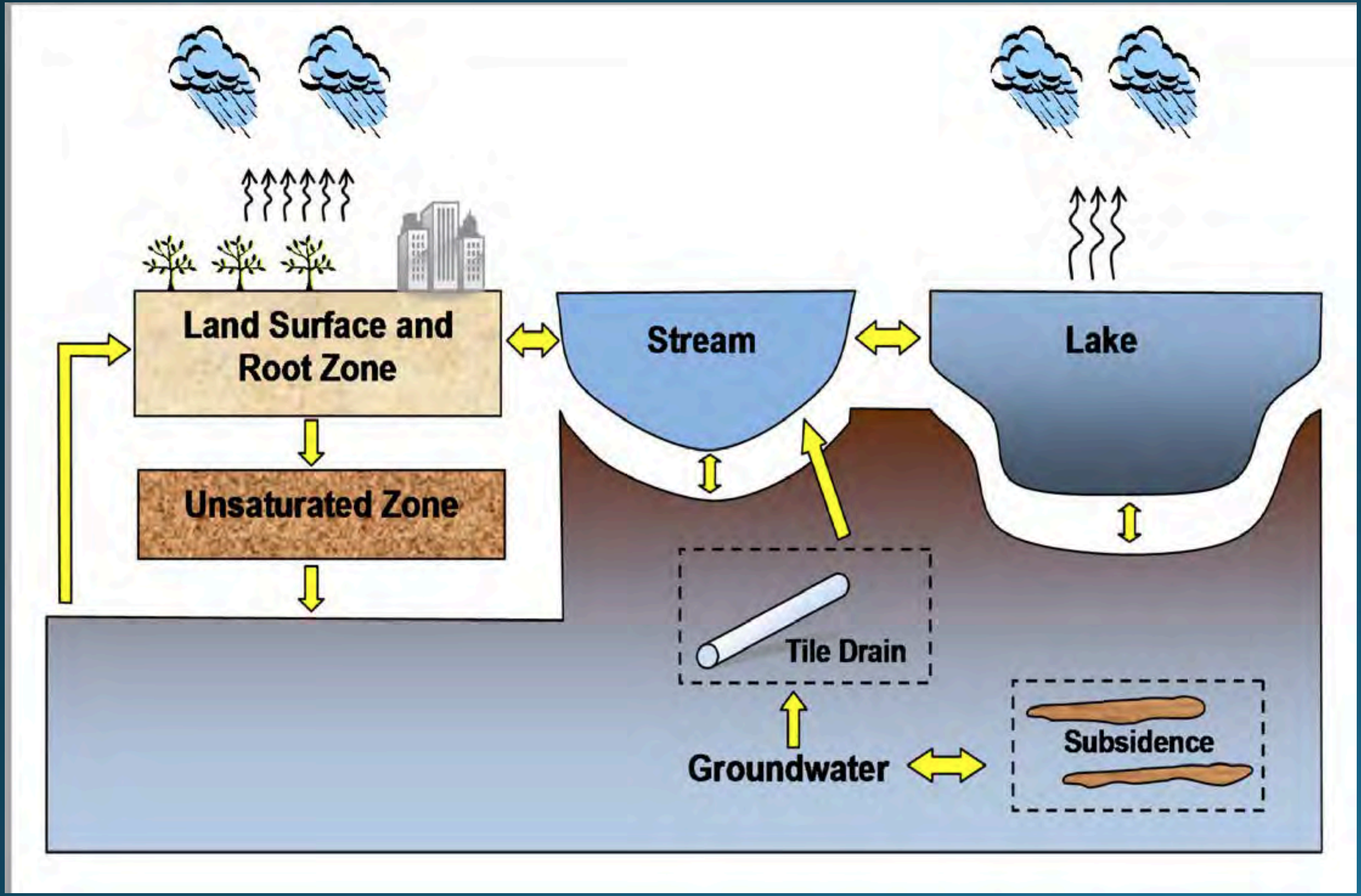


- Monthly data 1994-2015 (except 2012)
- Use for Irrigated Agriculture
- Approximate cutoff of 20 inches per year to exclude urban areas

DRAFT

TODD GROUNDWATER

IWFM – Integrated Process-Based Model

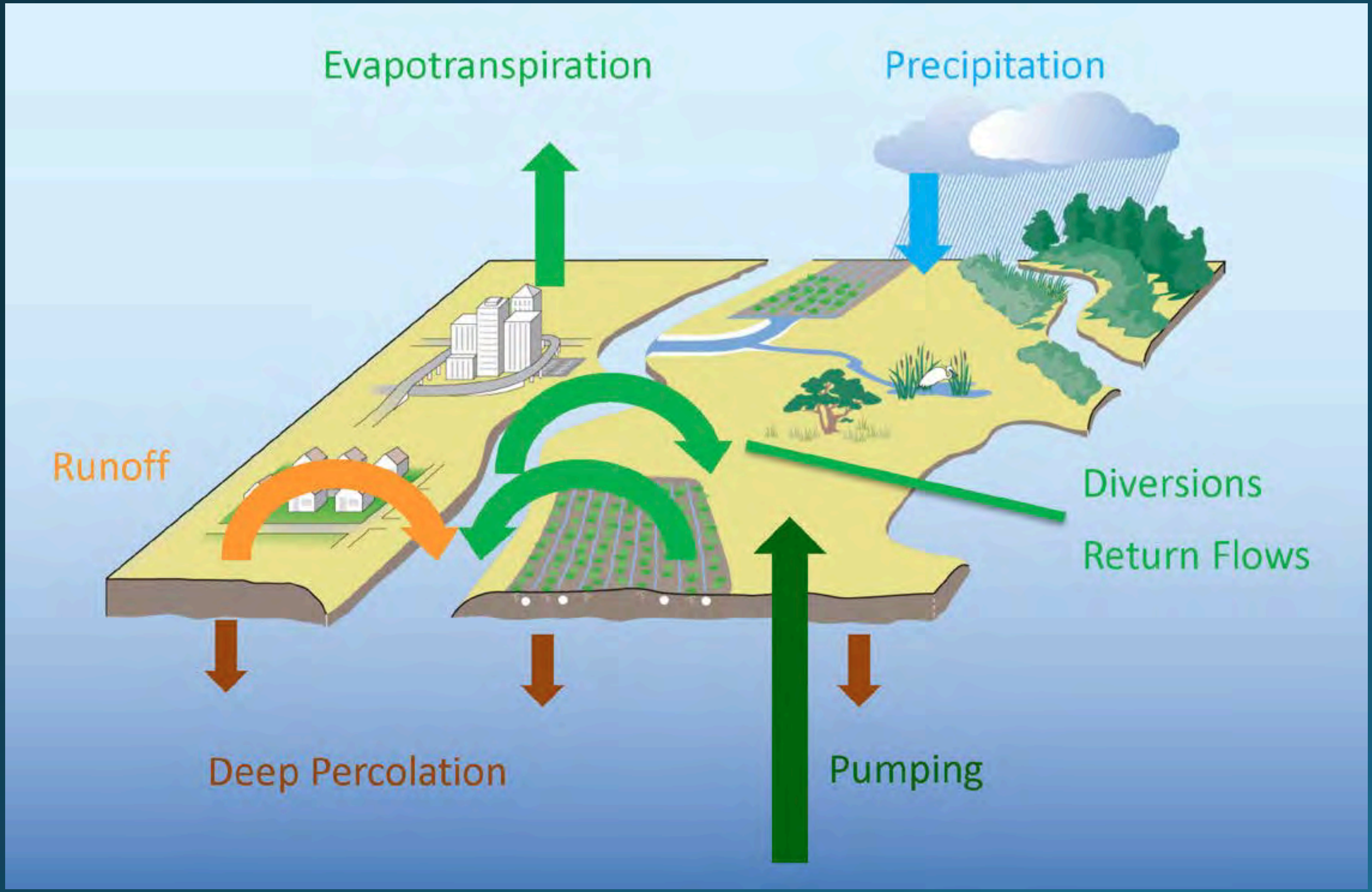


- Model simulates key hydrological processes
  - Surface Land Use, Root Zone, and Unsaturated Zone
  - Surface water deliveries from rivers and canals
  - Groundwater flow
- Focus on physical water
  - Where does the "wet water" go? (not paper exchanges)
  - Prevent "double-counting"

TODD GROUNDWATER

DRAFT

Land Surface and Root Zone Processes

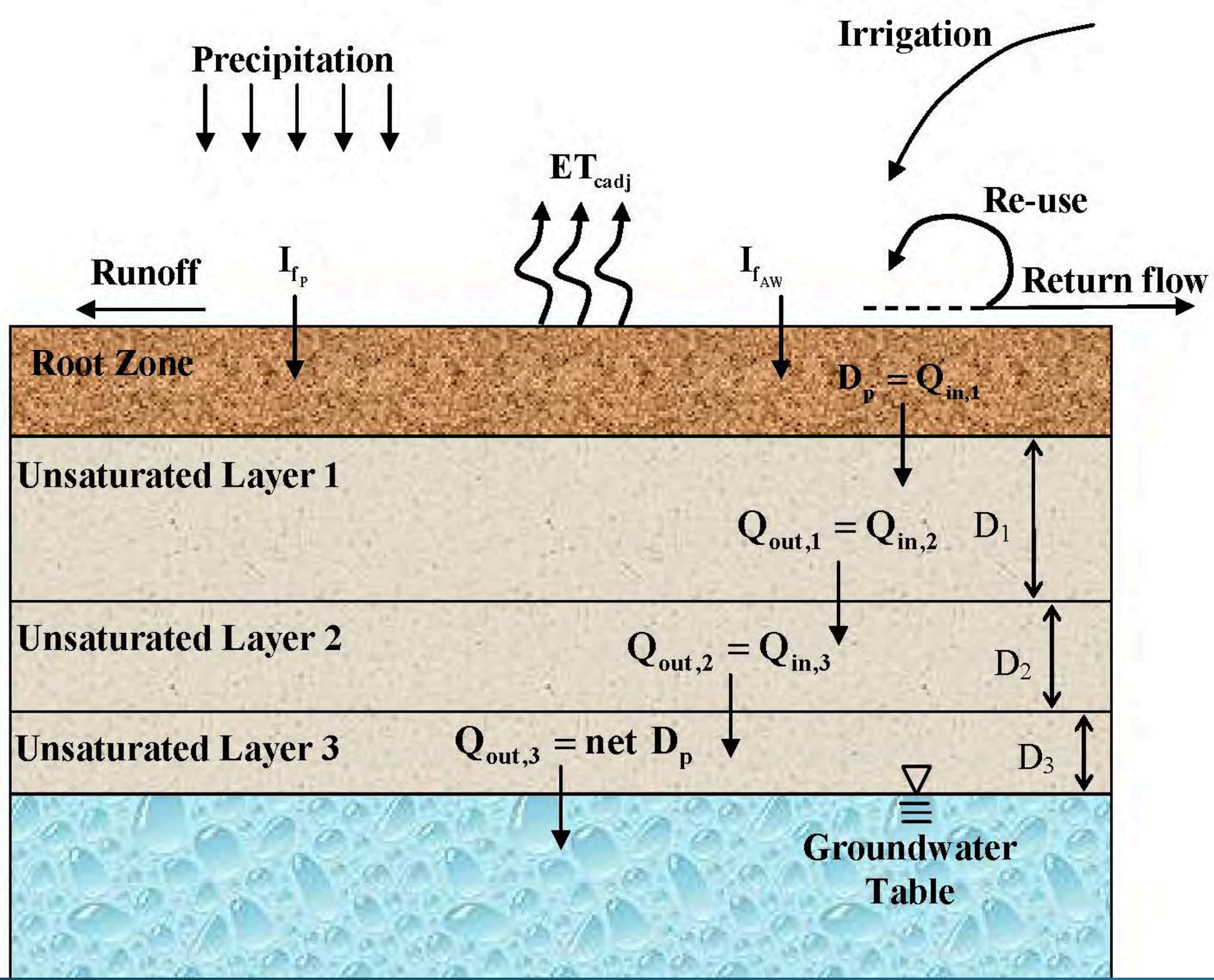


- Automatically adjusts diversions and pumping to meet demands following user-defined rules
  - Uses surface water, groundwater, and precipitation to meet water demand for different land uses
- Root Zone water budget tracks:
  - Surface runoff
  - Consumptive use
  - Deep percolation to groundwater

DRAFT

TODD GROUNDWATER

IWFM Independent Demand Calculator (IDC)



- Calculates agricultural demand based on soil moisture budget
  - Monthly METRIC data used to generate crop ET time series to determine crop demand
  - Tracks change in soil moisture content throughout simulation
  - If soil moisture falls below minimum level (wilting point), irrigation water added to reach target level (field capacity) to cover ET, deep percolation and runoff

DRAFT

TODD GROUNDWATER

Example Water Budget Output for Each Process Module

Land and Water Use Budget

	Column	Flow	08/31/2004	Source
Agricultural	Area (AC)		6,604,404	
	Potential CUAW		2,586,635	
	Supply Requirement	OUT	3,294,699	
	Pumping	IN	1,601,200	GW
	Diversion	IN	1,693,677	SW
	Shortage	(IN)	-177	
	Re-use		67,228	
Urban	Area (AC)		1,147,412	
	Supply Requirement	OUT	249,902	
	Pumping	IN	162,716	GW
	Diversion	IN	91,371	SW
	Shortage	(IN)	-4,185	
	Re-use		0	

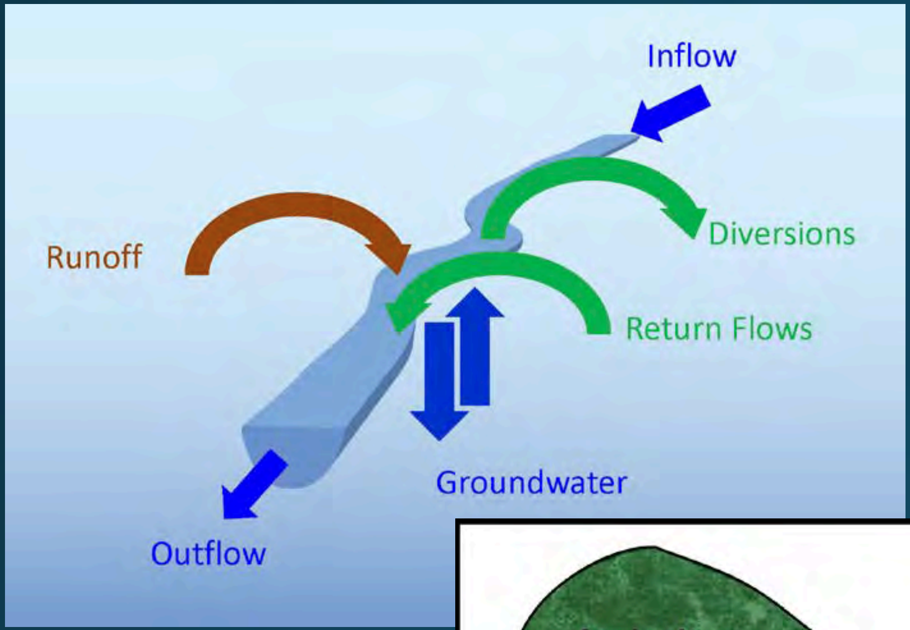
Root Zone Moisture Budget

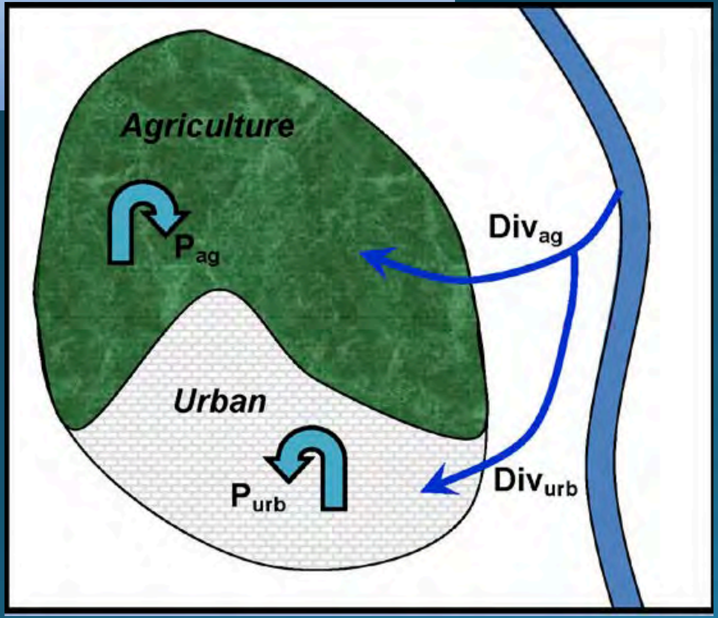
	Column	Flow	08/31/2004	Process
Agricultural	Area (AC)		6,604,404	
	Precipitation	IN	92	
	Runoff	OUT	0	SW
	Prime Applied Water		3,294,876	
	Reused Water		67,228	
	Total Applied Water	IN	3,362,104	GW/SW
	Return Flow	OUT	99,094	SW
	Beginning Storage		4,100,673	
	Net Gain from Land Expansion (+)	+/-	0	
	Infiltration (+)	IN	3,195,874	
	Actual ET (-)	OUT	3,051,486	
	Deep Percolation (-)	OUT	166,381	GW
	Ending Storage (=)		4,078,680	

DRAFT

TODD GROUNDWATER

Surface Water Process



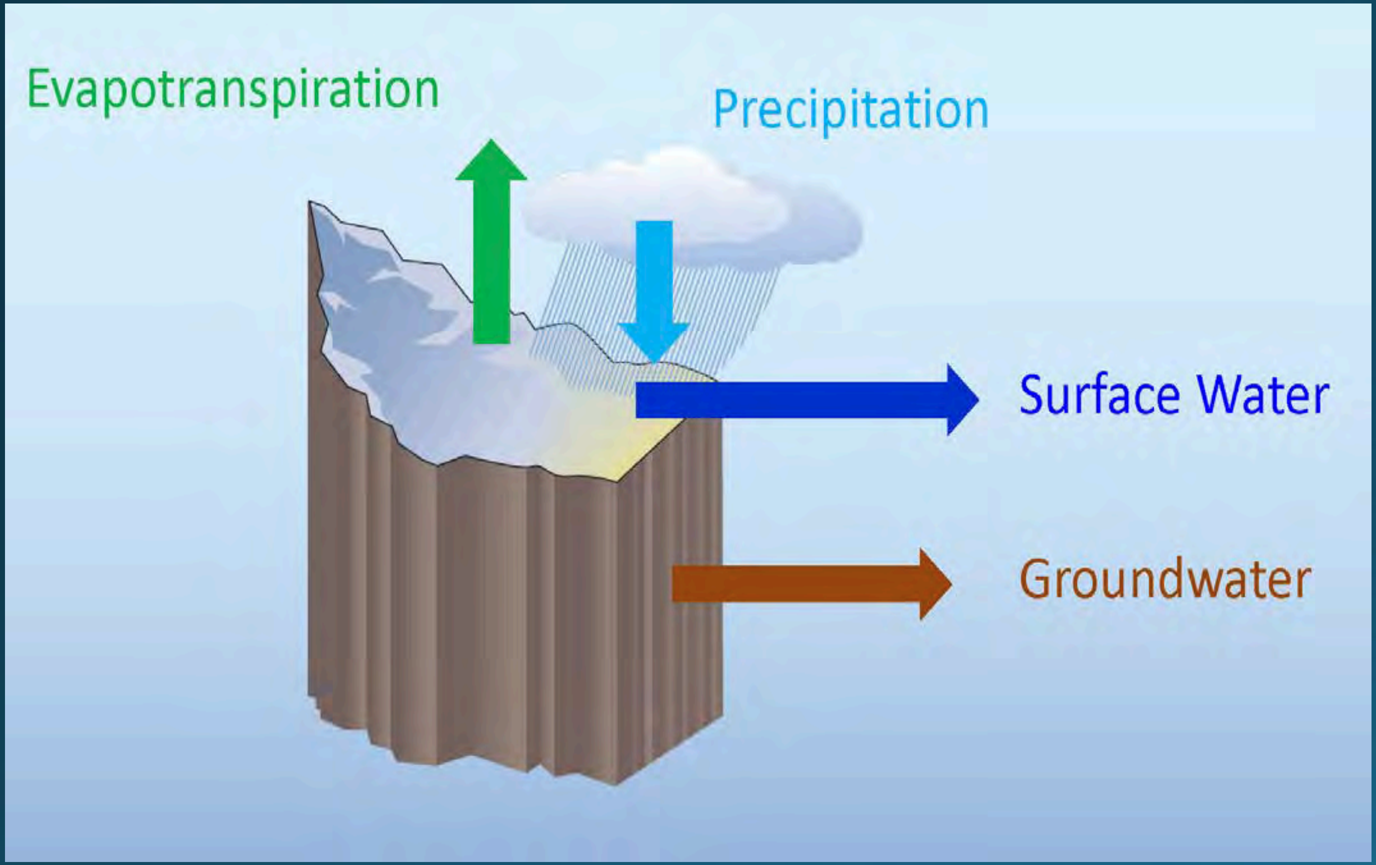


- Tracks surface water delivered for agricultural and urban use
  - Directs diversions to designated subareas
  - Each subarea provides for spatial distribution of agricultural and urban use
- Surface Water budget tracks:
  - Diversions
  - River and canal seepage
  - Groundwater-surface water interactions
  - Natural inflows and outflows

DRAFT

TODD GROUNDWATER

Small Watershed Process

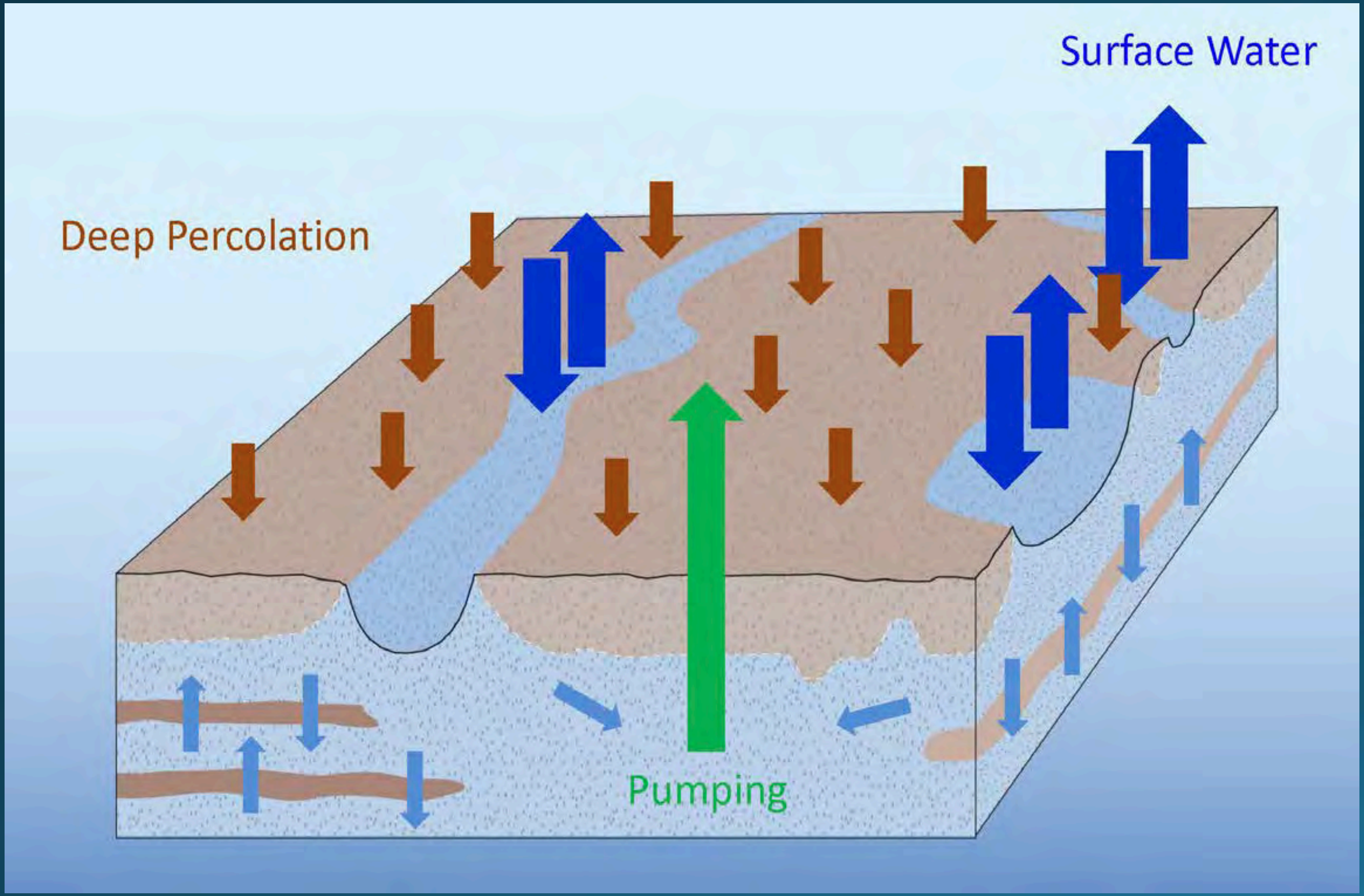


- Calculates runoff and inflow from adjacent small watersheds
  - Uses Soil Conservation Service methods for estimating runoff
  - Systematic method to track inflow from unmeasured watersheds
- Small Watershed budget tracks
  - Surface water runoff into basin
  - Infiltration of runoff to groundwater
  - Subsurface inflow into basin

DRAFT

TODD GROUNDWATER

Groundwater Process



- Groundwater process integrates the inflows and outflows from other processes and simulates
  - Flow through aquifers
  - Groundwater pumping (unless designated)
  - Subsidence
- Groundwater budget tracks:
  - Volume for each inflow and outflow component
  - Storage change over time
  - Change in groundwater levels

Groundwater Budgets List Inflow and Outflow of All Components for Each Time Step

Groundwater Budget

Subregion 12

Column	Flow	08/31/2004	Process
Deep Percolation	IN	2,880	RZ
Beginning Storage (+)		42,057,306	
Ending Storage (-)		42,064,339	
Net Deep Percolation (+)	IN	8,203	UZ
Gain from Stream (+)	+/-	-11,243	SW
Recharge (+)	IN	21,179	LS
Gain from Lake (+)	+/-	0	SW
Boundary Inflow (+)	IN	0	SWS
Subsidence (+)		-62	
Subsurface Irrigation (+)	IN	0	LS
Tile Drain Outflow (-)	OUT	0	SW
Pumping (-)	OUT	7,200	LS
Net Subsurface Inflow (+)	+/-	-3,844	GW
Discrepancy (=)		0.00	
Cumulative Subsidence		977	

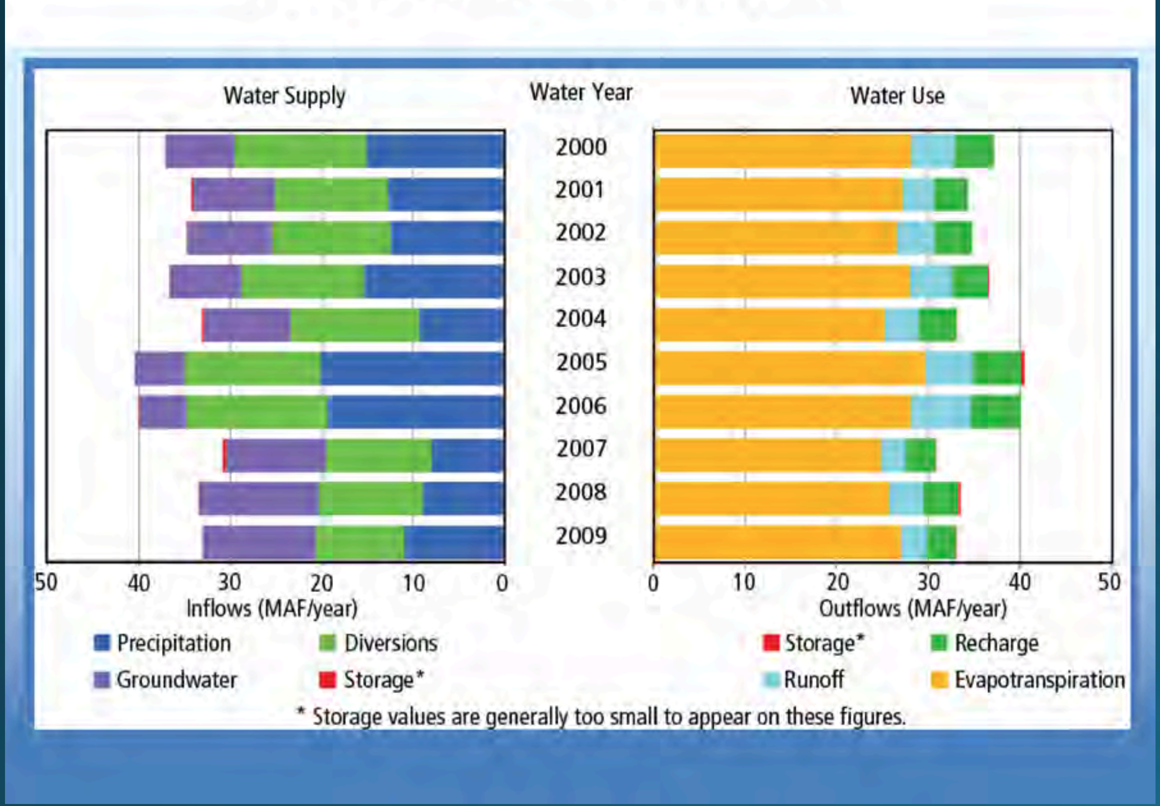
Z-Budget

Subregion 12, 8/31/2008

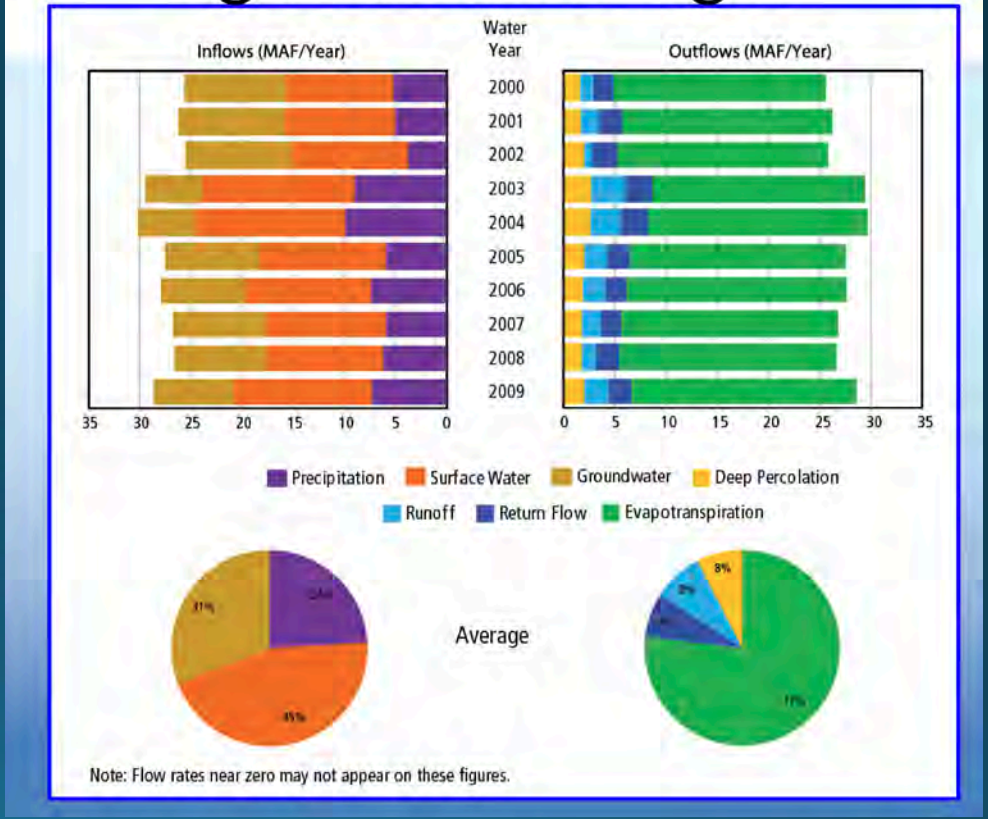
Column	Flow	IN	OUT	Process
GW Storage		8,766	15,838	
Streams	+/-	6,253	17,491	SW
Tile Drains	OUT	0	0	SW
Subsidence		18	80	
Net Deep Percolation	IN	8,203	0	LS
Small Watershed Baseflow	IN	0	0	SWS
Small Watershed Percolation	IN	0	0	SWS
Diversion Recoverable Loss	IN	21,179	0	SW
Bypass Recoverable Loss	IN	0	0	SW
Lakes	+/-	0	0	SW
Pumping by Element	OUT	0	0	LS
Pumping by Well	OUT	0	7,200	LS
Zones 12 and 10	+/-	397	2,248	
Zones 12 and 11	+/-	2,952	2,619	
Zones 12 and 13	+/-	713	3,005	
Overall Zone Error		0.00		

Water Budget Data can be Presented Graphically

Sources and Sinks



Agricultural Budget



DRAFT

TODD GROUNDWATER

Model Results will only be as good as the input data provided

- C2VSim Kern County Subbasin revisions focus on managed water supply and demand data of regional or local significance during the hydraulic period
- Data need to be consistent with data and databases that will be included in each GSP
- If data are unavailable, the DWR data set in C2VSim is used as the default

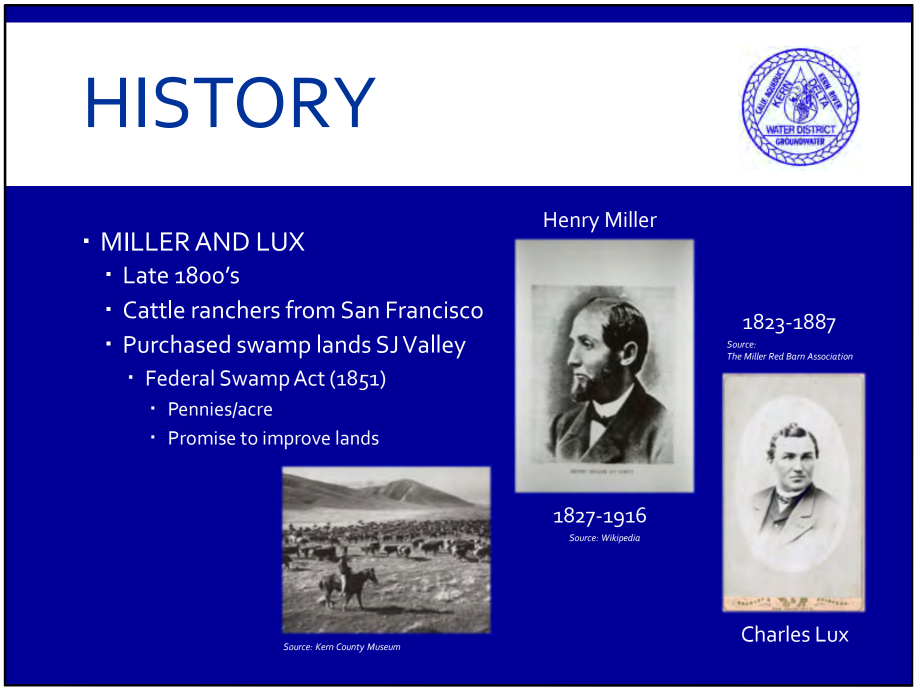
Modeling Schedule

- NOW: completing initial model runs with priority components
- Late August: provide model to peer reviewer
- August – Sept: Internal QA/QC
- Sept – Oct: Identify, compile, and incorporate the lower-priority budget items and make corrections to existing data, as needed
- Early November – share results

TODD GROUNDWATER

DRAFT

Good afternoon – thank you for choosing to spend some time with us here at Kern Delta, we welcome the opportunity to tell you a little about ourselves.
So I'm going to give you a cursory history of how we came to be – and then we'll jump into who and where we are now, and what we do on a daily basis. I'm absolutely not a historian, so, please, if you are better-versed in these historical details, shout them out



So, land, San Joaquin Valley, 1800s – Henry Miller and Charles Lux (both of whom had immigrated from German) were a couple of prosperous butchers from San Francisco, they decided to jump into cattle ranching in the SJ Valley…they were savvy,

HISTORY

- HAGGIN, TEVIS, CARR
  - Wealthy capitalists
    - Invested in county lands
    - Purchased water rights and systems created by early farmers
- DROUGHT 1877
  - Haggin et al began draining the Kern River channeling water to their lands
    - Tens of thousands of Miller & Lux cattle perished

Dreadful Effects of Drought in California.

It is estimated that from one half to two-thirds of the sheep in the State have perished from starvation. The loss of cattle is not so large, as they were taken to the mountains in time. Dr. Swain, of Watsonville, recently started for the mountains from Fresno, with over three thousand sheep, and the lifeless carcases of over twenty-five hundred of them now mark the route taken. The doctor says that unclaimed dead and dying sheep cover the plains, and hundreds of sheep and lambs fall into line behind the waggon of the traveller, and follow, in the hope of getting a morsel of hay. One man from the San Joaquin Valley lost every sheep he had—eleven thousand—during a storm, and went home a penniless man. Another, an Italian, thought he could save the cost of ferrying his sheep across the Tuolumne River by swimming them, and eight hundred were drowned in the attempt. Another man east of Visalia, despairing of ever getting his sheep to where there was feed, turned twelve thousand out to starve. If he undertook to drive them to the mountains many of them must die of starvation before reaching there, because there is no feed on the way; and then, when the mountains are reached, all the good feed is already taken up by men who hold possession, shot gun in hand, and who are desperate enough to fight to the death. There will probably be a good many cases of bloodshed and death in the mountains this summer, and many stockmen will mysteriously disapper to return no more.—WATSONVILLE (CALIFORNIA) TRANSCRIPT.

Not too long after Miller and Lux purchased their lands

HISTORY

- LAWSUIT
  - Miller & Lux v. Haggin et al, M&L win
- WRIGHT IRRIGATION ACT 1887
  - Farmers can work together
  - Tax themselves
  - Appropriate water rights
    - Bring water to their own farms via irrigation districts

Source:
Photo by Carleton Watkin circa 1880-1890, courtesy: Kern County Museum

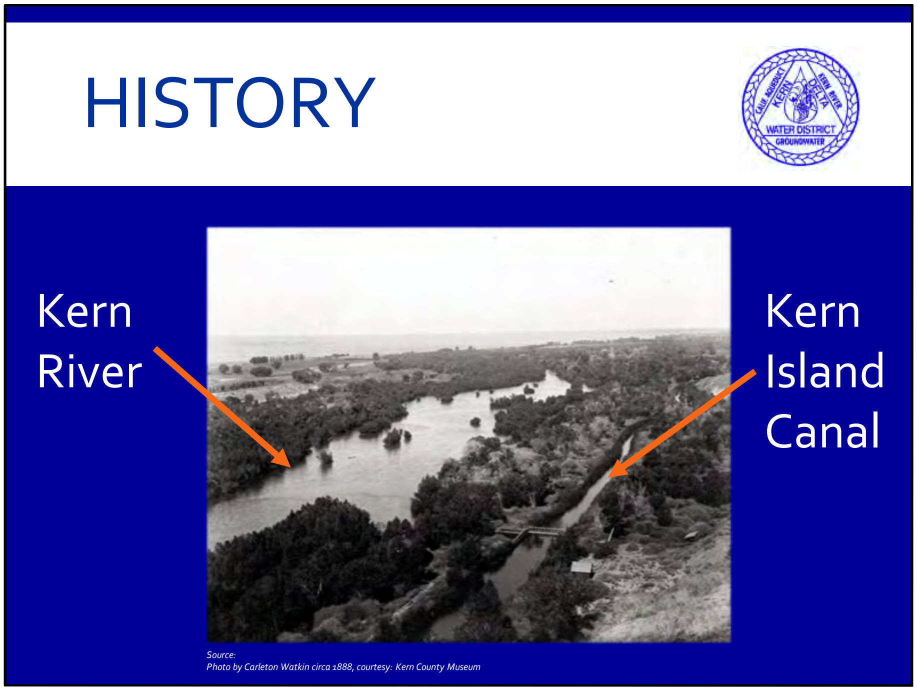
Miller & Lux won, critical importance because out of that came the Wright Irrigation Act

HISTORY

- KERN LAND COMPANY FORMS
  - Deliver Kern River water to lands south of the river
  - Five Canal Companies
    - Buena Vista
    - Stine
    - Farmers
    - Kern Island
    - Eastside

Source: Kern County Land Company, 1897 - Library of Congress Geography and Map Division Washington, D.C. 20540-4650 USA dcu

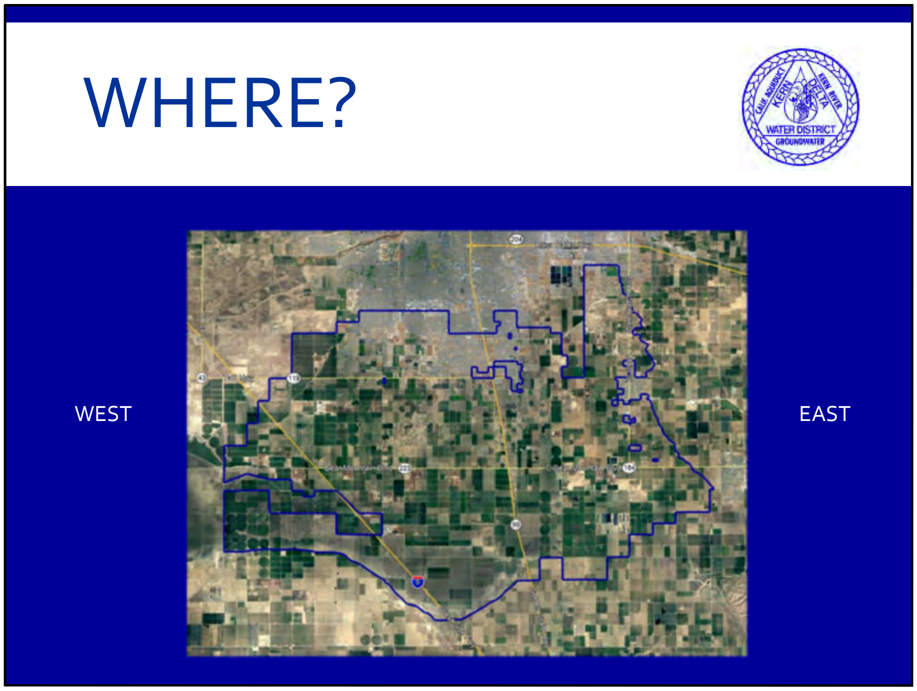
These canals, from the late 1800s, are the canals & the systems we use today in 2018



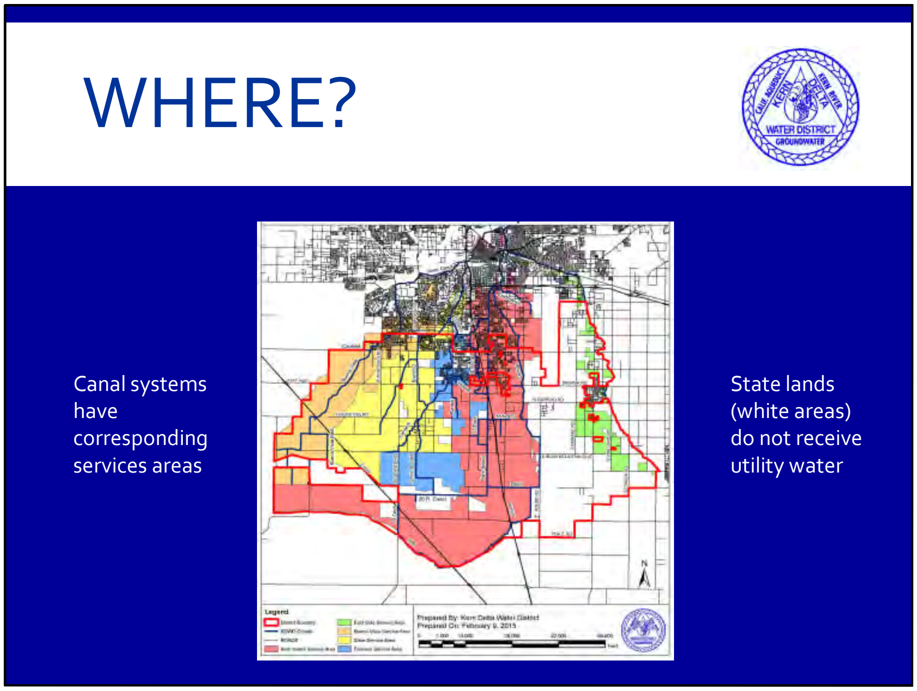
So this is a look at the construction of the Kern Island Canal, one of, and the biggest, of our 5 canal system - but let's move ahead to find out how Kern Delta Water District got here

Fast forward to the color pictures
1965 KDWD forms for exactly 2 reasons: 1) to contract for state water and 2) to protect existing landowner water rights

And here again, the Kern Island Canal, approximately 130 years later and still at peak performance.
Tidbit of information: when the Kern Island canal is running at full capacity it is capable of running at 475 cfs – 213,195 gallons per minute (448.83 conversion unit)



So now that we know how and why Kern Delta came to be, let's look at where we are: We stretch from west of the I-5 to the Buena Vista Lake bed, then all the way east past Weedpatch Highway, into Arvin. We have over 128,000 acres within our boundaries, with approximately 80,000 acres being irrigated agriculture – the irrigated acreage number change with the growing seasons as well as with the continued residential and commercial development that takes farmland out of production.



So here’s another look at out District – the shaded colors indicate our different service areas – each canal system has a designated service area – the areas correspond to the canal locations, it’s pretty much just logistics. So why aren’t there any canals in the white area? Those are what we call state lands, and from what I know (???) Back when the canals were being constructed, the landowners in these areas chose not to pitch in any $, thus, no canals were constructed for them (in these area)

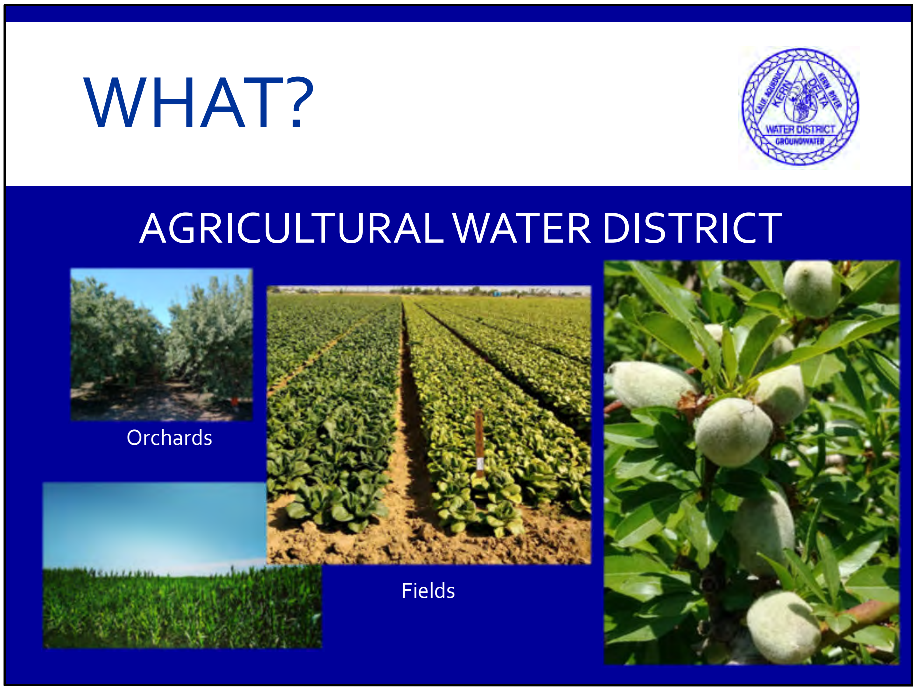
We are kind of everywhere. We are in developed beautiful locations like Mill Creek Park,

We are also in places you might not even know about – we were here long before the major thoroughfares

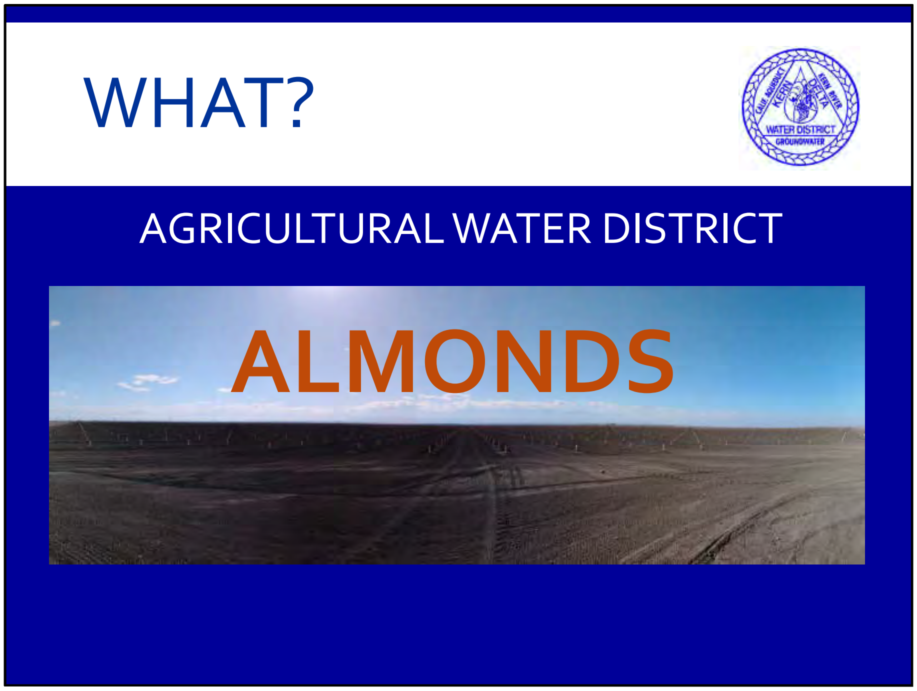
WHAT?

AGRICULTURAL WATER DISTRICT

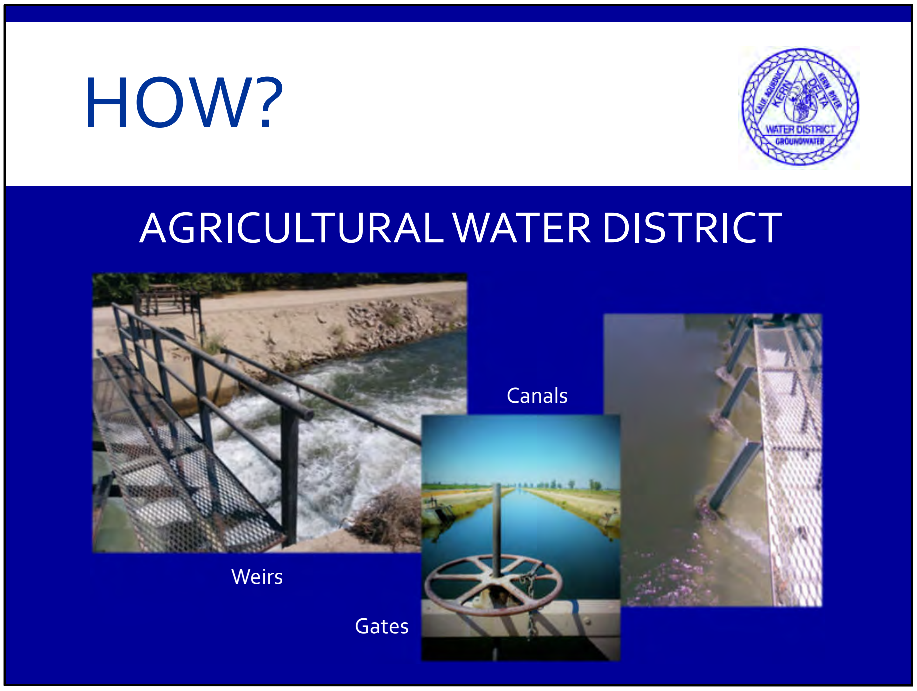
I guess I should slow down after showing you where we are and all those nice pictures of the canals and tell you exactly WHAT we are – so, we're an agricultural water (you probably already knew that), and we sell and deliver Kern River water and to a lesser extent, California State Aqueduct water, to growers… so that



this can happen!



And this!



How is this done? Old school. Canals, weirs, gates – all tended to by hand, gates opened and closed by a team of canal tenders – up and down the canals all day long every day. It's the grower's responsibility, their choice, to decide what to do with the water once it leaves our canal – some may channel it into a reservoir where it's piped out into sprinklers in their fields, some may have field that directly abuts the canal and choose to let the water flow right onto the field – but they place the order, they pay, and we deliver.

FACT

WATER RIGHTS

KERN DELTA WATER DISTRICT
HAS
THE
1ST
WATER
RIGHTS
ON
THE
KERN RIVER

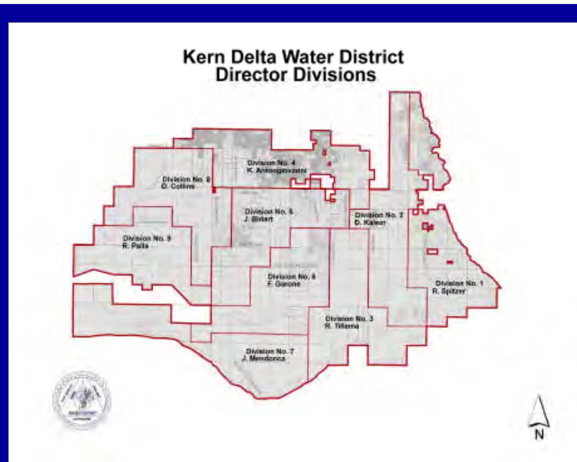
FIRST 300 CFS OF FLOW → KERN DELTA

134,649 GALLONS/MINUTE

ACCESSIBILITY

Directors are accessible to their constituents (growers)

Constituents not happy?
↓
elect alternate

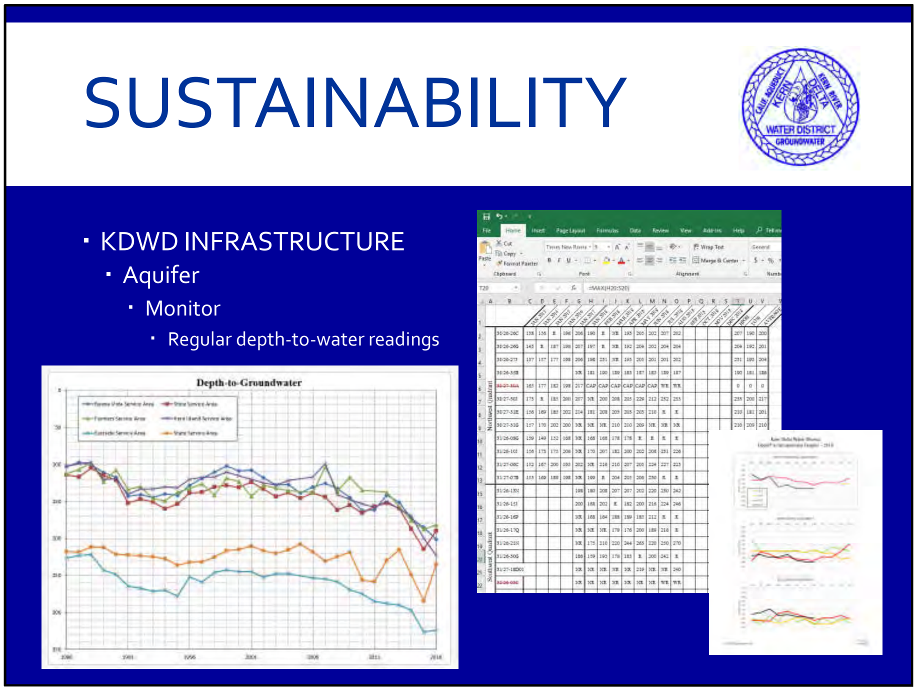


Public meetings every month per Brown Act

Public records

Kern Delta is governed by a Board of Directors – these Directors/members have a division – the growers know who the Director for their division is – don't like him vote him out

As an independent Special District because we get our funding in 2 ways: direct water sales, and property assessments.

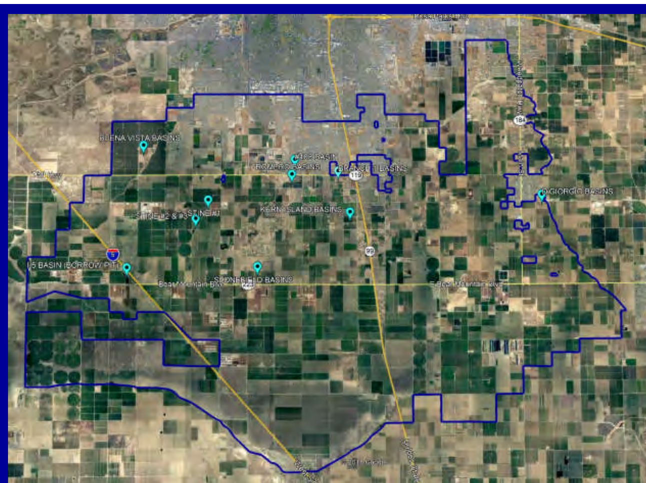


How do we sustain our infrastructure? Our infrastructure sustains agriculture, the service we provide out here is the only water-delivery service the growers have (aside from a grower utilizing his own well)– our canals, weirs, gates, are part of our infrastructure, but also our aquifer, the aquifer below, is critical (DISCUSS SGMA: sustainability requirements, avoiding deadly sins, what we do and plan to do, etc.)– and that is one of the very important things we do – monitor it. We monitor depth to groundwater levels throughout our entire district on a continual basis: we measure monthly for our Board/in-house purposes to keep track of trends, groundwater declines as well as hopefully rebounds. We also measure depth to water levels and share the data with various state agencies to comply with various regulations (CASGEM, SGMA).

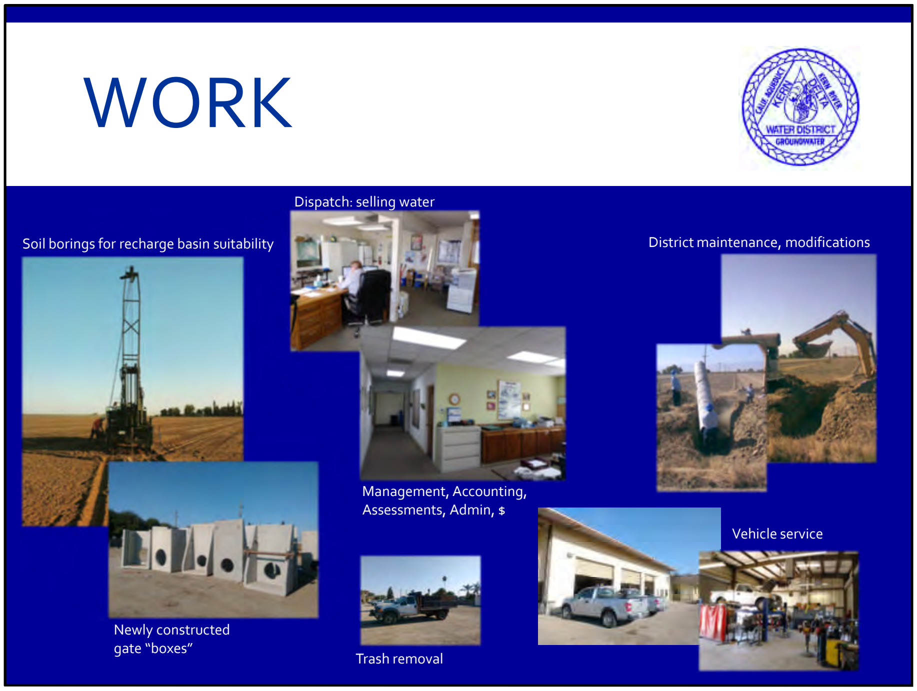
We currently have over 800 acres of active recharge ponds, and we are in the process of purchasing additional lands to construct more. Actively recharging the aquifer, which is critically overdraft in the San Joaquin Valley is not only good stewardship, it helps us with our SGMA goal attainment (not critically overdrafting it anymore, avoiding subsidence), etc (mention benefits)

SUSTAINABILITY

Over 800 acres of active recharge basins



Over 800 acres spread throughout the District…..perched water table area where there are none



One of the great things here at Kern Delta is that we do all of our own maintenance, we do a lot of our own construction work, (describe soil borings for basin, tie into sustainability)

Caliente creek perpendicular to Eastside canal, excess waters dump into our canal, runs high, soils become super saturated and give way - we work together as a team and we inevitably find solutions – and by and large as I mentioned, we do all of the work ourselves.

Protection for public safety

‘cause sometimes…………critters

Other challenges? Well…..we do the best we can

THE END

ARVIN-EDISON WATER STORAGE DISTRICT & ARVIN COMMUNITY SERVICES DISTRICT

INVITES YOU TO AN…

INFORMATIONAL WORKSHOP ON

SUSTAINABLE GROUNDWATER PLAN & COMPLIANCE

TUESDAY, OCTOBER 2, 2018

THREE SEPARATE WORKSHOPS

TIMES: 8:00 A.M. 1:00 P.M. & 5:00 P.M.

LOCATION: ARVIN VETERAN'S HALL

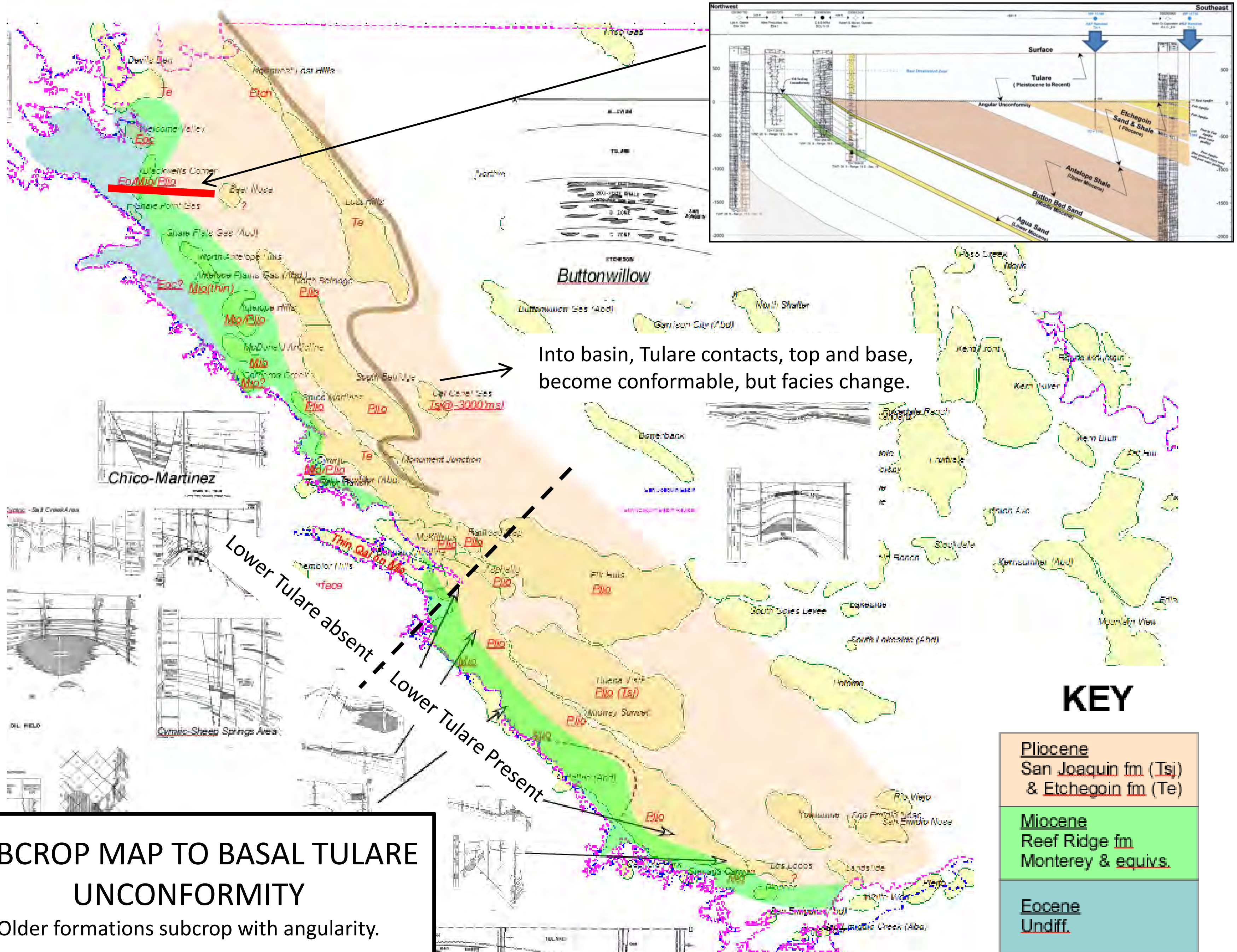
414 4th STREET

ARVIN, CALIFORNIA

Self-Help Enterprises

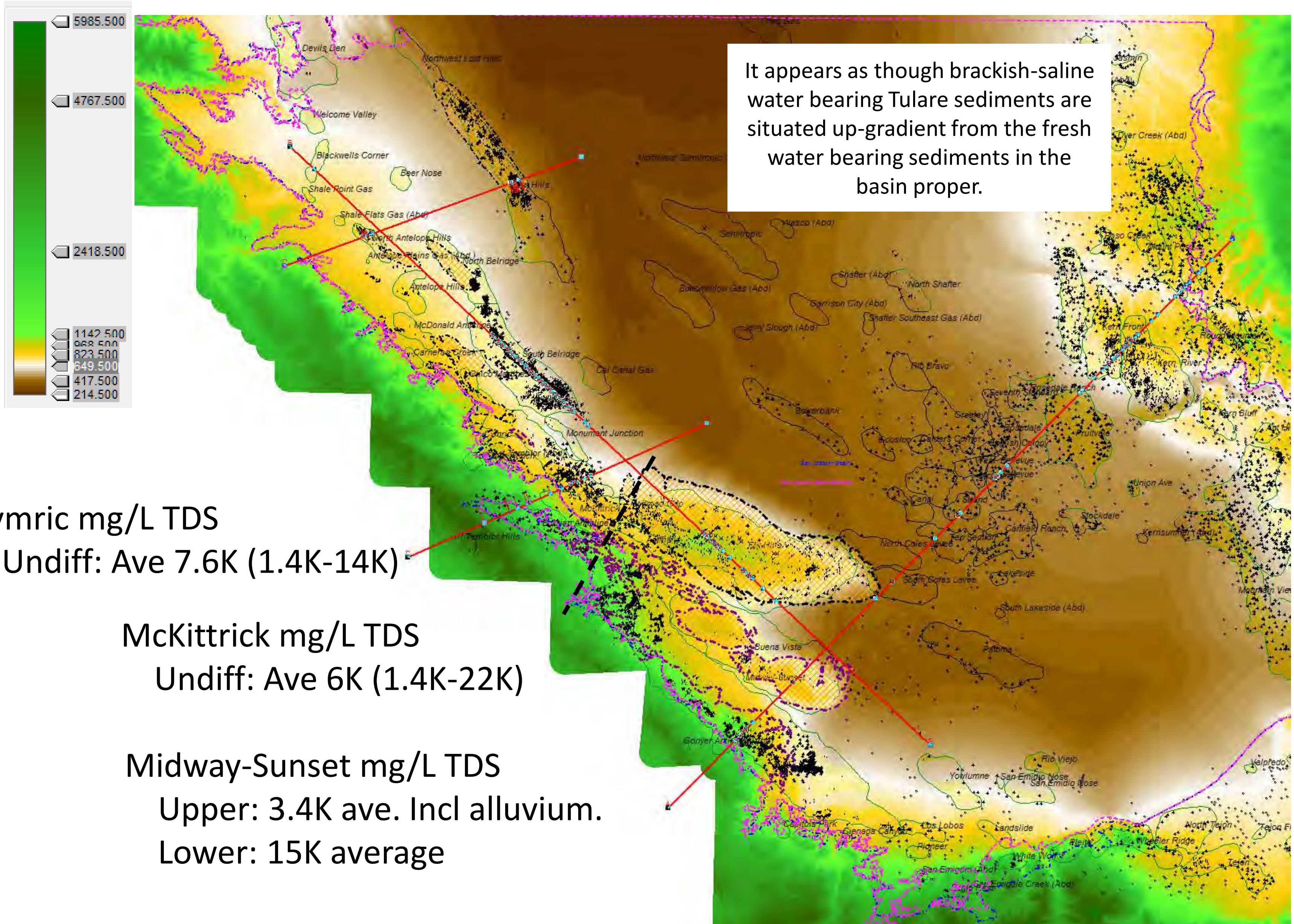
ARVIN-EDISON est. 1942 75 YEARS WATER STORAGE DISTRICT

ARVIN COMMUNITY SERVICES DISTRICT



SUBCROP MAP TO BASAL TULARE UNCONFORMITY

Older formations subcrop with angularity.



It appears as though brackish-saline water bearing Tulare sediments are situated up-gradient from the fresh water bearing sediments in the basin proper.

Cymric mg/L TDS

Undiff: Ave 7.6K (1.4K-14K)

McKittrick mg/L TDS

Undiff: Ave 6K (1.4K-22K)

Midway-Sunset mg/L TDS

Upper: 3.4K ave. Incl alluvium.

Lower: 15K average

GROUND ELEVATION WITH TULARE FM OUTCROPS & WATER QUALITY

Kern River Watershed Coalition Authority

Groundwater Quality Assessment Report

Kern County, California • February 2015

Prepared for:

Kern River Watershed Coalition Authority

Prepared by:

EST. 1968 PROVOST & PRITCHARD CONSULTING GROUP
An Employee Owned Company

LAND IQ

TODD GROUNDWATER

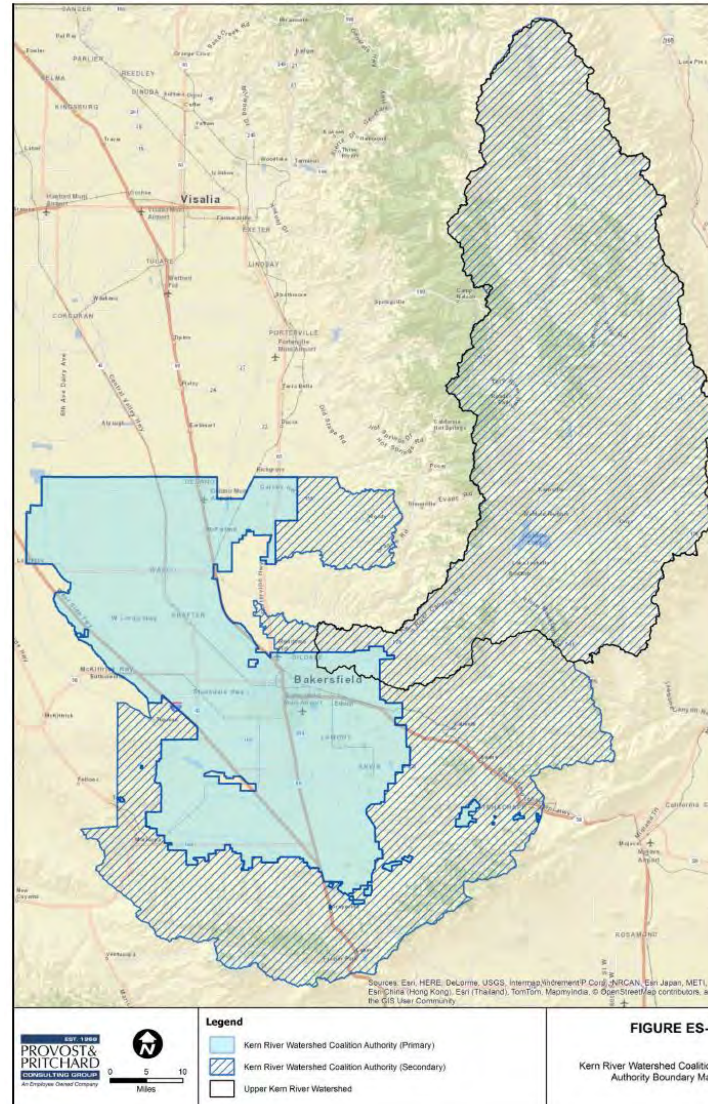


Figure ES-1. Kern River Watershed Coalition Authority Boundary

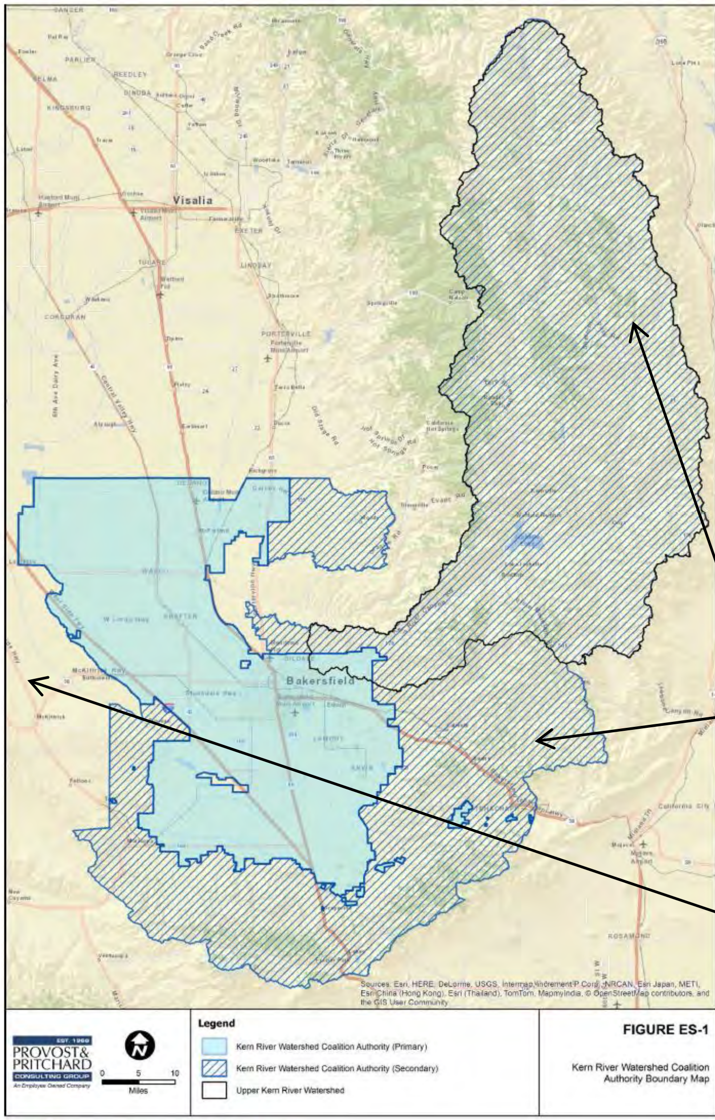


Figure ES-1. Kern River Watershed Coalition Authority Boundary

8.2 Significant Recharge Areas and Rates

8.2.1 Natural Recharge

Natural recharge is a function of precipitation, ET, and soil moisture holding capacity, as noted above. Precipitation and ET records for the primary KRWCA area are available from the California Irrigation Management Information System (CIMIS) Station. Average annual precipitation from the Shafter Station (No. 5) is 6.3 inches, which is relatively low compared to an annual potential evapotranspiration (ET) of 57 inches. As a consequence, deep percolation of precipitation past the root zone occurs infrequently or not at all. A daily soil moisture balance was completed for the Kern Fan (Todd, 2012) using the Thornthwaite and Mather method (1955 and 1957). This soil moisture balance showed that precipitation is generally consumed by evapotranspiration within a few days of a rainfall event, and there is no excess available water for recharge to groundwater.

In the secondary area where precipitation volumes are higher and evapotranspiration is generally lower, natural recharge is likely the primary source of recharge to groundwater. However, precipitation and runoff varies greatly, estimates of ET from vegetation are more difficult (due to the wide variety of vegetation and little research to support estimates), and there is little unconsolidated material in this area, as indicated in Section 5. The variations in precipitation and runoff, difficulty of estimating ET, limited extent of unconsolidated material, and predominance of fractured bedrock groundwater makes estimation of natural recharge in these areas infeasible.

Basin groundwater supply comes from here:
1)immense watersheds
2)sandy media for infiltration and recharge

Not here:
1)limited watershed area
2)Eto>>precip conditions dominate
3)Fractured Miocene shales capture rainwater

EXPLAINING AIR SANDS

THE PROBLEM OF PRECIPITATION AND EVAPORATION – CALCULATING THE DEFICIT AND EXPLAINING THE PERMANENT PRESENCE OF AIR SANDS

<u>CIMIS STATIONS</u>

#205 Coalinga

#54 Blackwells Corner

#146 Belridge

infrequently or not at all. A daily soil moisture balance was completed for the Kern Fan (Todd, 2012) using the Thornthwaite and Mather method (1955 and 1957). This soil moisture balance showed that precipitation is generally consumed by evapotranspiration within a few days of a rainfall event, and

Thornwaite & Mather method to be applied to data from these three CIMIS stations

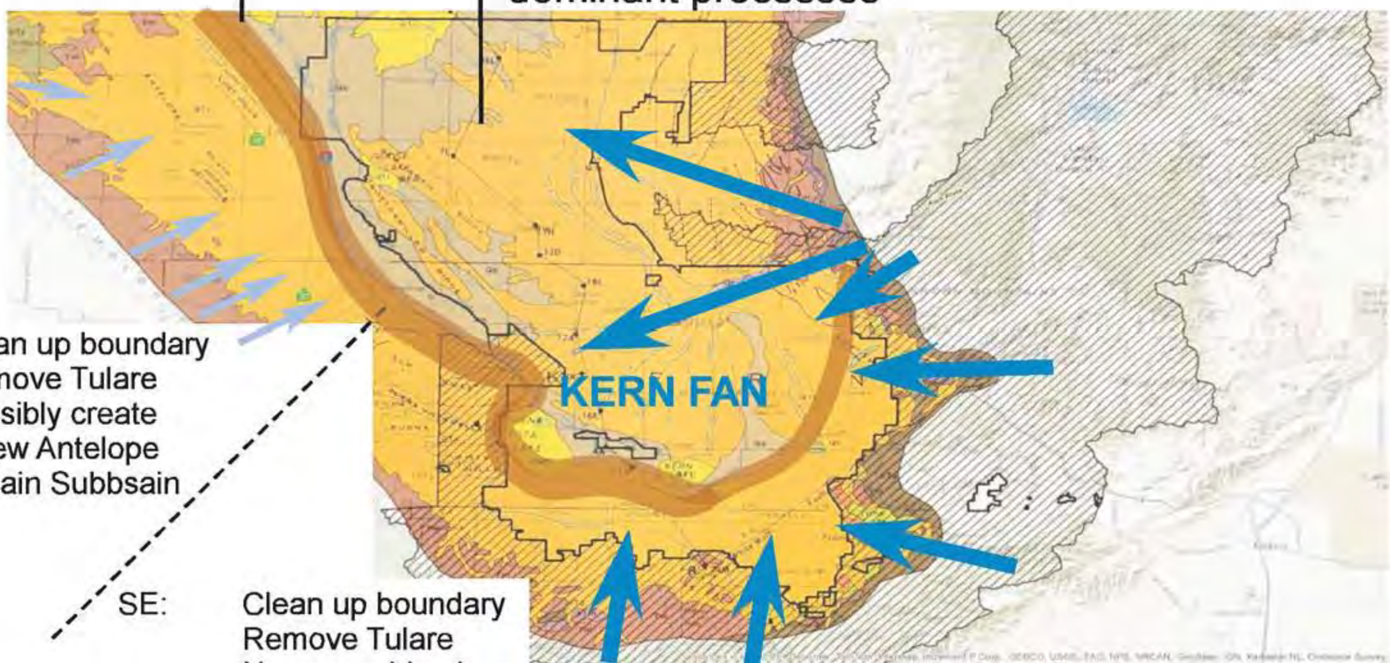
Debris-flow dominant facies

Reworked Coast Range sources

Lacustrine-marsh silts and clays dominant

Fluvial-deltaic: streamflow dominant processes

Sierran & Transverse Range sources



NW: Clean up boundary
Remove Tulare
Possibly create new Antelope Plain Subbsain

SE: Clean up boundary
Remove Tulare
No new subbasin

CIPA/WSPA Meeting with KGA
1/9/19

Name	Company/Agency	Email
CHAD HATHAWAY	HATHAWAY LLC	CHATHAWAY@HATHAWAYLLC.COM
Matt Mayry	GEI	MMayry@geiconsultants.com
LARRY RODRIGUEZ	GEI	lrodriguez@geiconsultants.com
Jim Voyles	Chevron	jamesvoyles@chevron.com
Janie Moehnke	Chevron	JMoehnke@chevron.com
Diana Martin	HAK	martindp@HuntenAk.com
Jeff Johnson	Chevron	johnsjw@chevron.com
KEVIN MALAMMA	STANTEC/CHEVRON	Kevin.malamma@stantec.com
Megan Schwartz	Catalyst	mschwartz@ce.solutions
AMY ROTH	E+B NATURAL RES.	aROTH@ebresources.com
David Chapin	Aera	dcchapin@aeraenergy.com
Julie GLAVIN	AERA	jaglavin@aeraenergy.com
Christine Zimmerman	WSPA	christine@wspa.org
HARRY STARKEY	WKWD	harry@wkwd
MARK SMITH	EOC	eoc1911@gmail.com
STEVE LEWIS	E&B	slewis@ebresources.com
Rebecca Smith	WSPA/DowneyBrand	rsmith@downeybrand.com
Chris Reedy	VWM	creedy@valleywatermanagement.org
TIM Lorley	Macpherson	tlorley@macphersonenergy.com
RANDY HORNE	NAFTEX OP. CO.	RHORNE@NAFTEX.COM
Christin Faber	Aera Energy	clfaber@aeraenergy.com

CIPA/WSPA Meeting with KGA
1/9/19

Name	Company/Agency	Email
Christina Dixon	Sentinel Peak Resources	cdixon@sentinelpeakresources.com
Megan Silva	Aera	mesilva@aeraenergy.com

Response to WSPA Comments

Comments	Response	Edits Made	Notes
General Comments	Additional edits have been made; however, additional sources and references to back up all changes are pending before the document can be considered a final draft. All exempted aquifers and primacy productive limits that were reasonably accessible in the public domain have been excluded from discussion as aquifer for beneficial use. **It is requested that WSPA members review the list of Exemptions, Primacy Productive Limits with depths to Hydrocarbons, and provide additional comments to maintain appropriate accuracy.** A Conceptual Profile was added in response to Exhibit A recommendation. The Definable bottom of the Basin has been updated. Additional data will likely be considered to further refine the Base of Fresh Water and the Base of USDW.	A Conceptual Profile was added in response to Exhibit A recommendation. The Definable bottom of the Basin has been updated. Additional data will likely be considered to further refine the Base of Fresh Water and the Base of USDW.	General Comments
2.1.2.1	Corcoran Clay extents and updates are pending for the west side and southwest side including Lost Hills and Midway Sunset area. Additional feedback coordination with WSPA members may be helpful for GEI regarding this comment.		Corcoran Clay
2.1.3	Lateral and vertical boundaries of formations may not be possible to fully address for the 2020 GSP due to time constraints in completing the GSP in time for public review, unless WSPA members have very specific input to expedite this process; rather, the 2020 GSP is focusing on extent of known groundwater use, groundwater quality, depth to freshwater, depth to non-USDW, and exempted aquifers.	Revisions have been made in the text to better clarify the lateral boundaries as it relates to groundwater quality, depth to freshwater, depth to non-USDW, and exempted aquifers	Lateral and Vertical boundaries of formations.
2.1.5	Bottom of Basin has been updated with discussion of depth to freshwater, depth to non-USDW, and exempted aquifers.	Bottom of Basin has been updated with discussion of depth to freshwater, depth to non-USDW, and exempted aquifers. Due to time constraints, the Umbrella GSP may not present all structure and differing depths of hydrocarbons within Productive Limits and Exemptions. **At this time, the shallowest hydrocarbon depth was used for presentation within the Productive limits and exempted aquifers.** A Data Gap will be acknowledged regarding the mapping of non-USDW and exempted aquifers associated with Oil and Gas activities. based on generalization as described above.	Bottom of Basin
2.1.6	Updates to aquifer descriptions have been made; however, this section is very much in draft form.		Principal Aquifers.
2.1.6.3	Beneficial use or affects of activities are pending for the Umbrella Chapter. Once chapter GSPs, are available, additional data on water quality and use of aquifers across the subbasin can be documented in the Umbrella Setting.		Water Quality of Principal Aquifers.
2.1.8	GEI respectfully requests that WSPA members provide USGS researchers with approval to allow the use of USGS pp1713 3-D Geologic model layers 11 to 15 (Temblor to TOPO), in order to better develop acceptable cross sections with respect to Oil and Gas fields, at a subbasin-wide scale.	In the interim, the conceptual profile provides details of the current understanding of the subbasin from west to east. Final Cross sections will delineate Base of Freshwater data, non-USDW data by Gillespie et. al., and any data from depth to Hydrocarbons in Primacy Productive limits, as well as depth to and lateral extents of exempted aquifers that intersect the cross section lines.	Cross Sections
2.1.9.3	No comment at this time		
2.1.9.6	Revision made as recommended		Produced water as an imported source of water.
2.2.5	UICs have been removed. **WSPA member input is requested to clarify which Produced Water Ponds should remain in this section to satisfy SGMA requirements.** It is not the intent of this section to evaluate or confirm whether any or all of these sites as listed by regulatory agencies are significantly impacting groundwater with beneficial use. This section presents cases as were listed from the regulatory databases, and labels them as <u>potential</u> groundwater contamination sites and plumes.		GW Quality
2.2.5.1	GW quality section has been modified substantially, but it may not better address comments provided. This section will likely be a work in progress for the next few months.	Added brief paragraph on naturally occurring hydrocarbon deposits.	GW Quality
2.2.6	Added recommended comment	Added recommended comment	Land Subsidence
2.2.8	Potential GDEs A new map of the KCS with neighboring subbasins will be added; similar to Exhibit B that was provided	New NCCAG figures are provided in Appendix, and revised discussion has been added accordingly.	Potential GDEs
2.4	*pending*		MA, Mgmt zones

Kern Groundwater Authority & Kern County Farm Bureau

invites you to the...

SGMA Open House

Sustainable Groundwater Management Act

A "One-Stop-Shop" for groundwater users with interests throughout the Kern Subbasin to meet with representatives from subbasin GSAs and water/irrigation districts, and from the State Water Resources Control Board & California Department of Water Resources to discuss the Kern Subbasin Groundwater Sustainability Plans and future SGMA implementation.

Tuesday, May 14, 2019 from 5:30 to 7:30 p.m.

Location: Kern Ag Pavilion (3300 E. Belle Terrace, Bakersfield, CA 93307)

Participating groundwater sustainability agencies (GSAs) and water/irrigation districts that will have tables at the event:

Kern Groundwater Authority

- Arvin Community Services District (ACSD)
- Arvin-Edison Water Storage District (AEWSD)
- Cawelo Water District (CWD)
- City of Shafter
- County of Kern
- Kern County Water Agency (KCWA)
- Kern-Tulare Water District (KTWD)
- Kern Water Bank Authority (KWBA)
- North Kern Water Storage District (NKWSD)
- Rosedale-Rio Bravo Water Storage District (RRBWSD)
- Semitropic Water Storage District (SWSD)
- Shafter-Wasco Irrigation District (SWID)
- Southern San Joaquin Municipal Utility District (SSJMUD)
- Tejon-Castaic Water District (TCWD)
- West Kern Water District (WKWD)
- Westside District Water Authority (WDWA)
- Wheeler Ridge-Maricopa Water Storage District (WRMWSD)

Henry Miller Water District GSA

Buena Vista Water Storage District GSA

Olcese Water District GSA

Kern River GSA

- Kern Delta Water District
- City of Bakersfield
- Improvement District No. 4

Co-hosted by:

KERN GROUNDWATER AUTHORITY

KERN COUNTY FARM BUREAU

For questions about the event, email ppoire@kerngwa.com or call the Kern County Farm Bureau at (661) 397-9635.

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Jasmene del Aguila	Suite 212 1527 19th St. Bakersfield, CA 93301	661-843-7677	jdelaguila@leadershipcounsel.org
David Ansolabehere	17207 Enovatrin Farm	661 393-6072	
Lawrence O'Leary	on file	619 840 3622	lawrence@mottech.com
Max Palmer	1717 W Park Ave, Redlands, CA 92373	909-292-6296	max.palmer@gsinc.com
Marko Zaninovich	1998 Road 152 Delano 93215	661 792 3151	
David Nixon			DANAEWSD@AOL.COM
Michelle Anderson			manderson@kcwa.com

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Karen Andrew		661 747-7835	KAndrew@farmmanagementservices.com
Marcos Perez	5080 California Ave	661 336 0967	marcos.perez@usda.gov
Rick Iger		661 303 6607	riger@ppeng.com
Dominic Farinelli	10400 F	559-930-5767	dominic@powwowenergy.com
Pres Brittain	4831 Calloway #102/Bksfd 93312	661-301-1708	pres@prh2o.com
Dennis Mullins		328-5358	
Dan Hoekstra	7122 Heatherwood Dr 93313	805 839 8292	dan@hoekstraassociates.com
Tim Holtermann	P.O. Box 507	(661) 340-3201	tims@holtermann-ag.com
Jeff Giumarra	P.O. Bin 1969 Bakersfield 93303	661-395-7000	jeffg@grapeking.com

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Paul Nugent	Bakersfield CA 93312 4831 Calloway Dr. Ste. 102	829-5109	nugentag@gmail.com ~~rod@rtsag.com~~
Rod Stiefvater	"	"	rod@rtsag.com
DAN RAYTIS		444 5770	dan@bbr.law
Jason Selvidge			jselvidge@aol.com
Gabriela Gonzalez	2600 F St 93301	661 421 3515	gabriela@provconsult.com
SATYA GALA	GEI	916 388 4166	SGALA@GEICONSULTANTS.COM
KENT H. STEPHENS	1998 Rd 152 DELANO, CA 93215	661 792-3151	
Ken Bonesteel		661 616 4600	KBonesteel@PPENG.COM
Aaron Wilson Wilson Ag	P.O. Box 1300 Shafter 93263	661 746 2673	wilsonag@atginternet.com
Alan Christensen	Kern County	661 817 0443	achristensen@kerncounty.com
DEE JASPAR	DJA	661 393 4796	djaspar@djacivil.com

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Don A Wright	11465 Tollhouse Rd Clovis CA 93619	559/355-2389	don@water wrights.net
Ron Bock	283 N. Caesar Ave CLOVIS CA 93612	559/435-4333	morethankful@aol.com
Geoff VandenHeuvel	1407 Monsecco St Tulare, CA	909-730-1240	geoff@milkproducers.org
Mark Valpredo	5279 FALLGATTER ST BKFLD CA 93308	661-747-2056	MBVALPREDO@GMAIL.COM
Reilly Hossner	2023 Regis Dr, Davis, CA 95618	925 464 0399	reilly@bachandassociates.com
Walt Fisher	PO Box 68 Edison CA 93220	661.805-5797	IBCATTLE@AOL.COM
Rob Goff	13654 Hwy 33, Lost Hills, CA 93249	661-203-9660	rob.goff@wonderful.com
Javi Higuera Jr	2231 Orpheus Ct 93308	661-300-0229	Javi@trilogyplm.com
Marty Barnes	133 Easy St 93308	661 809-5612	gmc2001cb gmail.com
[illegible]	PO Box 455	6612136754	KCR@ATGINTERNET.COM
Desiree Lawrence	11200 River Run Blvd. #101	410-6026	lawrenced@missionbank.com
Mike Martens	" "	410-6021	martensm@missionbank.com

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Warren Plaskett	11638 S. Granite Rd Bak 93308	661 979 5445	papaplaskett@yahoo.com
Bill Dewey	985 W. Millbrook Hanford CA 93230	559-904-6959	bill.dewey@olcmnet.com
Juan Ramos	930 18th Bakersfield CA 93301	661 229-8542	juanr@2bfarminginc.com
MEL JOHNSON	551 TAFT HWY BAK. CAL 93307	661-333-3914	greenfieldwater@hotmail.com
Tim Ruiz	P.O. Box 6038 BAK, CA 93306	661-871-2011	truiz@eastnilescsd.org
ALAN TRAN	12000 Vista Del Mar Playa Del Rey, CA 90293	310-648-5995	ALAN.TRAN@Lacity.org
LEE WADDLE	31162 APPALOOSA VISALIA 93292	559-368-3519	LWADDLE@TechAg.com
BEN KING	P.O. Box 29 COLUSA CA 95932	530-723-3119	bking@paegldag.com
Mark Tomlinson	PO Box 2205	661-322-4004	mtomlinson@kuhsparkerlaw.com
Shulamit Shroder	1031 S. Mt. Vernon	661-868-6218	sashroder@ucanr.edu
Jose A Gomez R	930 18th Bakerfield	661 201-9052	pepe@2bfarminginc.com
Julio Ramos	930 18th st Bakersfield 93301	661 344-6599	Julio@2bfarminginc.com

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Tom Watson	tomwatson@aqualogic.com	323 823 2324	
Don Uhrig	2910 Club Dr Los Angeles, CA 90064	310 497-3117	DBURF@AOL.COM
Anona Dutton	—	650-292-9100	adutton@ekiconsult.com
Ella Kelsey	PO Box 455, McFarland 93250	661-792-3604	[illegible] @ atg internet, com
Matt Thomson	19407 Wildwood Rd Buttonwillow, CA 93206	661 549-3088	mjthomson1@gmail.com
Christina Lutter Zimmerman	901 Tower Way, Ste 300 Bakersfield, CA	661-343-5753	christine@wspa.org
Dan Bartel	849 Allen Rd Bakersfield CA 93312	661 589 6045	dbartel@rrbwsd.com
Eric Averett	"	"	eaverett@rrbwsd.com
Tom Brackeen	441 Vineland Rd Bks 93307	661 549 8123	tom@sridge.net
Doug Gosling			dgosling@browngosling.com
John Karnes		661 808 0766	TECTA.1976@GMAIL.COM
Vincent Sorena		661-340-0848	vincent.sorena@ac-foods.com

Kern County SGMA Open House
May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Stacie Ann Silva	—	—	SSILVA@NEWCURRENTWATER.COM
Mohammad Gorayya	1508 Fiddlespring Dr BKF 93311	661-398-5500	MGorayya@gmail.com
Jake Cauzza	1600 Corn Camp Rd Buttonwillow 93206	661-331-0760	Jakecauzza@gmail.com
Rebecca Smith	621 Capitol Mall, 18th Floor Sacramento CA	916-520-5281	rsmith@downeybrand.com
JOE ELLER	4300 MIDWAY RD, TAFT, CA 93268	661-763-1537	jeller@holmeswestern.com
Micah Eggleton	—	—	ceggleton@woodardcurran.com
JEFF LOOKER	1998 RD 152, DELANO, CA 93215	(661) 792-3151	jlooker@sunviewvineyards.com
Randy Womble	8660 Indian Clover Ct. Bakersfield 93311	213 216 4114	randywomble57@gmail.com
Scott Hamilton	7718 Dovin Park Dr 93308	661 3031540	scott@resource econ. solutions
JOHN ALLEN	9301 SHAFTER RD 93311	661.332.2038	allenalmonds@gmail.com
Jeff Johnson	7812 Calle Espada 93309	661-412-7059	jojw@chevron.com
Sam Blue			SBLUE@BAKERSFIELDCITY.US

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Andy Gordus	1234 East Shaw Ave Fresno, CA DFish+Wildlife	559 243-4014 x239	Andy.gordus@wildlife.ca.gov
Chris Bellue	Kern Delta Water Dist.	661 834-4656	chris@kerndelta.org
Kate Melberg	1149 South Broadway St. Los Angeles, CA 90015	213-847-5188	sarah.melberg@lacity.org
Christina Jones	"	213 847 5179	Christina.jones@lacity.org
GARY MORRIS	24886 HWY 33 FELLOWS CA 93224	661-332-5280	GJMORRIS45@HOTMAIL.COM
STEVE LEWIS	1600 NORRIS RD BAK CA 93306	661-912-2604	slewis@cbresources.com
John Battistoni	1234 E Shaw Ave Fresno CA 93710 CaDept. of Fish & Wildlife	559-243-4014	John.Battistoni@wildlife.ca.gov
Don Nelson	5330 Office Center Ct #34 Bakersfield, CA 93309	661-378-8652	don.bakersfield@yahoo.com
Matthew Hodden	2106 Lone Tree Ct 93312	661-717-3967	matthew@supremealmonds.com
Tom Regan	300 N. Lake Ave, Ste 400 Pasadena, CA 91101	(626)568-6044	thomas.regan@stantec.com
Eric Vogler	300 N LAKE PASADENA	626 298 5009	eric.vogler@stantec.com
KRIS LAWRENCE	1405 Commercial way, suite 125 Bakersfield, CA, 93309	661-666-1095	klawrence@lhwd.org

Kern County SGMA Open House

May 14, 2019, Kern Ag Pavilion

Name	Mailing Address	Telephone	Email
Martin Milobar	154 E White Ln 93307	661-302-7457	mmilobar@kcwa.com
Mark Sherfy	4200 Truxtun Ave Suite 101 93309	661-858-3016	msherfy@farmmanagementservices.com
Steve Johnson	5405 peppertree Ln 93309	909-476-2247	steve.johnson@geinc.com
Frank Guzman	711 Pine Cone st 93226	661 742 5725	Frank.Guzman@olamnet.com
Robert Kuhs	P. O. Box 2205 Bak 93303		
Kelly Cecil	3647 Puccini St.	661-330-7071	Kelly_384@outlook.com
Kevin Pascoe	9400 Etchart Rd. Bak. 93314	661-805-6331	KPascoe@grimmway.com
Everett McGhee	8520 Fuller Dr. 93307	661-319-5008	fulleracresw@yahoo.com
Frances Alcorn	8520 Fuller Dr. 93307	661-319-5008	
Ben Taft	PO Box 445 Edison, CA 93220	661 978-9044	ben@calfruitdepot.com
Mohammad Yaghmour	1031 S. Mt Vernon Ave Bakersfield 93307	661-868-6211	mayaghmour@ucanr.edu
Leroy Ellinghouse	1416 9th st Sac Ca 95814	916 653-7168	leroy.e@water.ca.gov

ARVIN-EDISON WATER STORAGE DISTRICT
& ARVIN COMMUNITY SERVICES DISTRICT

INVITES YOU TO AN

INFORMATIONAL WORKSHOP ON

SUSTAINABLE GROUNDWATER PLAN & COMPLIANCE

THURSDAY, MAY 30, 2019

THREE SEPARATE WORKSHOPS

TIMES: 8:00 A.M. 1:00 P.M. & 5:00 P.M.

LOCATION: ARVIN VETERAN'S HALL

414 4th STREET

ARVIN, CALIFORNIA

ARVIN-EDISON WATER STORAGE DISTRICT
& ARVIN COMMUNITY SERVICES DISTRICT

Te invita a un taller informativo sobre el

plan de agua subterranea

sustentable y cumplimeniento

Jueves 30 Mayo del 2019

tres talleres a las

Horarios: <u>8:00 A.M.</u> <u>1:00 P.M.</u> y <u>5:00 P.M.</u>

Ubicación: Salon de veteranos de Arvin

414 4th Street

ARVIN, CALIFORNIA

Self-Help Enterprises

ARVIN-EDISON WATER STORAGE DISTRICT

ARVIN COMMUNITY SERVICES DISTRICT

Kern Groundwater Authority & Kern County Farm Bureau

invites you to the...

GSP Public Review Open House

Sustainable Groundwater Management Act & Groundwater Sustainability Plan (GSP)

A “One-Stop-Shop” for groundwater users with interests throughout the Kern Subbasin to meet with representatives from subbasin GSAs and water/irrigation districts to discuss the Kern Subbasin Groundwater Sustainability Plans during the 90-day public review period.

Thursday, September 26, 2019 from 5:30 to 7 p.m.

Location: Kern Ag Pavilion (3300 E. Belle Terrace, Bakersfield, CA 93307)

Participating groundwater sustainability agencies (GSAs) and water/irrigation districts that will have tables at the event:

Kern Groundwater Authority

- Arvin Community Services District (ACSD)
- Arvin-Edison Water Storage District (AEWSD)
- Cawelo Water District (CWD)
- City of Shafter
- County of Kern
- Kern County Water Agency (KCWA)
- Kern-Tulare Water District (KTWD)
- Kern Water Bank Authority (KWBA)
- North Kern Water Storage District (NKWSD)
- Rosedale-Rio Bravo Water Storage District (RRBWSD)
- Semitropic Water Storage District (SWSD)
- Shafter-Wasco Irrigation District (SWID)
- Southern San Joaquin Municipal Utility District (SSJMUD)
- Tejon-Castaic Water District (TCWD)
- West Kern Water District (WKWD)
- Westside District Water Authority (WDWA)
- Wheeler Ridge-Maricopa Water Storage District (WRMWSD)

Henry Miller Water District GSA

Buena Vista Water Storage District GSA

Olcese Water District GSA

Kern River GSA

- Kern Delta Water District
- City of Bakersfield
- Improvement District No. 4

Co-hosted by:

KERN GROUNDWATER AUTHORITY

KERN COUNTY FARM BUREAU

For questions about the event, email ppoire@kerngwa.com or call the Kern County Farm Bureau at (661) 397-9635.

APPENDIX E
TARGETED WORKSHOP MATERIALS

You're Invited!
GROUNDWATER WORKSHOP

THIS WORKSHOP WILL COVER:

- California's New Groundwater Law — the Sustainable Groundwater Management Act (SGMA) of 2014
- Your Groundwater Sustainability Agency (GSA)
- Your Groundwater Sustainability Plan (GSP)
- How to participate!

Workshop

DATE: Monday, August 20, 2018

TIME: 5:30 - 7 p.m.

WHERE: Fruitvale-Norris Park Recreation Room,

6221 Norris Road, Bakersfield, CA, 93308

For more information

Call or email Eva Dominguez (559) 802-1634, EvaD@SelfHelpEnterprises.org or Maria Herrera (559) 802-1676, MariaH@SelfHelpEnterprises.org

Translation services will be available

Self-Help Enterprises

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Estas Invitado: TALLER SOBRE EL AGUA SUBTERRÁNEA

TEMAS DEL TALLER:

- Nueva ley estatal del agua subterráne: la Ley del Manejo Sostenible del Agua Subterránea (SGMA, por sus siglas en ingles) de 2014
- Su Agencia de Manejo Sostenible de Agua Subterránea (GSA, por sus siglas en ingles) y Plan de Manejo Sostenible del Agua Subterránea
- Como participar!

Taller

FECHA: Lunes, 20 de Agosto de 2018

HORA: 5:30 - 7 de la tarde

DÓNDE: Sala de recreación Fruitvale-Norris Park

6221 Norris Road, Bakersfield, CA 93308

Llame o envié un correo electrónico a
Eva Dominguez (559) 802-1634, EvaD@SelfHelpEnterprises.org o
Maria Herrera (559) 802-1676, MariaH@SelfHelpEnterprises.org

Servicios de traducción estarán disponibles

Self-Help Enterprises

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

KRGSA KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Stakeholder Survey

Date: ________________________________

Stakeholder Type (check all that apply):

	Agricultural User		Domestic Well Owner/User		Municipal Well Operator
	Public Water Systems		Local Land Use Planning Agency		Environmental User
	Surface Water User		Native American Tribe		Disadvantaged/Rural Community Resident
	City Resident		Food Processor		Industrial User/Oil Producer
	Entity monitoring and reporting groundwater elevations in all or part of the groundwater basin				

Note: Please complete your name and contact information if you'd like to be added to the GSA's email and mailing list for future updates and information regarding Sustainable Groundwater Management Act (SGMA) and the Kern River Groundwater Sustainability Agency.

Name: ________________________________

Address: ________________________________

City: ____________________ State: __________ Zip: __________

Email: ____________________ Telephone: ____________________

1. Are you familiar with Sustainable Groundwater Management Act (SGMA) regulations? ☐ Yes ☐ No
2. Are you currently working on or discussing groundwater management in this region? ☐ Yes ☐ No
3. Do you own or manage/operate land in this region? ☐ Yes ☐ No
4. Where are you getting your water supply?
   ☐ City or Community Water System ☐ Surface ☐ Groundwater
   ☐ Both Groundwater & Surface Water ☐ Unknown
5. Agricultural & Domestic Well Users: What is your well(s) depth? ____________________
6. Agricultural & Domestic Well Users: Has your well(s) ever gone dry? ☐ Yes ☐ No
   If yes, when (month/year)? ____________________
7. If you are an Agricultural User, do you: ☐ Irrigate ☐ Dry Farm ☐ Graze Livestock
   ☐ Other: ____________________
8. Municipal Users: Please identify type of water use: ☐ Water Supply for Homes/Businesses ☐ Golf Course
   ☐ Park/Recreation ☐ Cemetery ☐ Water Feature ☐ Other ____________________
9. Industrial Users: Please identify type of water use: ☐ Food Processing ☐ Energy Production/Refining
   ☐ Production of Durable/Nondurable Goods ☐ Other ____________________

10. Domestic Users: Please identify type of water use: ☐ One Home Indoor/Outdoor Use
☐ Multiple Homes Indoor/Outdoor Use ☐ Water Feature ☐ Livestock ☐ Other ______________________

11. What is your primary interest in land or water resources management? ______________________

12. Do you have concerns about groundwater management? ☐ Yes ☐ No

If so, what are they? ______________________

13. Do you have requests or recommendations regarding groundwater management? ☐ Yes ☐ No

If so, what are they? ______________________

14. Is there any other information that KRGSA should be aware of or take into consideration while developing the Groundwater Sustainability Plan (GSP)?

Please return completed surveys to KRGSA by scanning and emailing to AChianel@bakersfieldcity.us, or mailing to Art Chianello, KRGSA, 1600 Truxtun Avenue, Bakersfield, CA 93301.

Stakeholder Surveys may also be completed online by visiting www.kernrivergsa.org.

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Encuesta de Partes Interesadas

Fecha: ______________________________

Tipo de Interesado (marque todas que apliquen):

☐	Usuario agrícola	☐	Propietario / usuario de pozo doméstico	☐	Operador municipal de pozos
☐	Sistema de agua público	☐	Agencia local de planificación del uso de la tierra	☐	Usuario ambiental
☐	Usuario de agua superficial	☐	Tribu nativo americana	☐	Residente de comunidad desventajada/ rural
☐	Residente de la ciudad	☐	Procesador de alimentos	☐	Usuario industrial/Productor de petróleo
☐	Entidad que monitorea y reporta elevaciones de aguas subterráneas en toda o parte de la cuenca de agua subterránea				

Nota: Por favor complete su nombre y la información de contacto si desea ser agregado a la lista de correo electrónico de la GSA y lista de correo para futuras actualizaciones Y información sobre la Ley del Manejo Sostenible del Agua Subterránea (SGMA) y la Agencia del Manejo del Agua Subterránea de Kern River (KR GSA).

Nombre:____

Dirección Postal: ____

Ciudad:______________________________Estado:__________Código postal: __________

Correo Electrónico:___________________________Teléfono: ______________________

1. ¿Está usted familiarizado con las regulaciones de la ley de Manejo Sostenible del Agua Subterránea (SGMA)? ☐ Sí ☐ No

2. ¿Está usted actualmente involucrado en actividades o discusiones sobre el manejo de aguas subterráneas en esta región? ☐ Sí ☐ No

3. ¿Usted es propietario o administra/opera tierra en esta región? ☐ Sí ☐ No

4. ¿De dónde recibe su suministro de agua?

   ☐ Sistema de agua de la ciudad o la comunidad ☐ Superficie ☐ Agua subterránea

   ☐ Agua subterránea y superficial ☐ No sé

5. Usuarios de pozos Agrícolas Y Domésticos: ¿Cuál es la profundidad de su pozo(s)? ____________________

6. Usuarios de poza Agrícolas Y Doméesticos: ¿Alguna vez se ha secado su pozo(s)? ☐ Sí ☐ No

   ¿Si la respuesta es sí, cuándo (mes/año)? ______________________________________

7. Si eres un usuario agrícola, cual haces: ☐ Irrigar ☐ Granja seca ☐ Pastoreo

   ☐ Otro: ____

8. Usuarios Municipales: Identifique el tipo de uso del agua: ☐ Suministro de Agua para Hogares/Negocios ☐ Campo de Golf

   ☐ Parque y Recreación ☐ Cementerio ☐ Fuente de Agua ☐ Otro ______________________

9. Usuarios Insustriales: Identifique su uso del agua: ☐ Procesamiento de Alimentos ☐ Produccion/Refinacion de Energia

   ☐ Produccion de Bienes Duraderos/No Duraderos ☐ Other__________________________________

10. Usuarios Domesticos: Identifique su uso de agua: ☐ Uso Fuera/Dentro de Un Hogar

☐ Uso Fuera/Dentro de Multiples Hogares ☐ Fuente de Agua ☐ Ganado ☐ Otro ______________________________

11. ¿Cuál es su interés principal en el manejo de recursos de agua o tierra?

____

____

____

____

12. ¿Tiene preocupaciones acerca el manejo de las aguas subterráneas? ☐ Sí ☐ No
Si la respuesta es sí, ¿cuáles son?

____

____

____

____

____

____

____

13. ¿Tiene usted alguna recomendación sobre el manejo de agua subterráneas? ☐ Sí ☐ No
Si la respuesta es sí, ¿cuáles son?

____

____

____

____

14. ¿Tiene usted alguna otra información pertinente que debería tener en cuenta el Kern River GSA para desarrollar el Plan de Manejo Sostenible de Agua Subterránea (GSP)?

____

____

____

____

____

____

Por favor regrese la encuesta terminada al Kern River GSA enviando un correo electrónico a AChianel@bakersfieldcity.us o por correo a Art Chianello, KRGSA, 1600 Truxtun Avenue, Bakersfield, CA 93301.

Esta Encuesta de Partes Interesadas también se puede completar visitando la página www.kernrivergsa.org.

Kern River Groundwater Sustainability Agency
Groundwater Workshop

Monday, August 20, 2018 5:30 p.m.
Fruitvale-Norris Park Recreation Room
6221 Norris Road, Bakersfield, CA 93308

AGENDA

5:30 p.m. – 5:40 p.m.	Welcome & Introductions
5:40 p.m. – 6:10 p.m.	California's New Groundwater Law and Groundwater Sustainability Plans
6:10 p.m. – 6:30p.m.	Local Efforts to Comply with SGMA - Kern River Groundwater Sustainability Agency GSP Development Efforts
6:30 p.m. – 6:50 p.m.	Share your Thoughts – Stakeholder Survey
6:50 p.m. – 7:00 p.m.	Next Steps and Closing Remarks

Agencia de Sostenibilidad de Aguas Subterráneas de Kern River
Taller de Agua Subterránea

Lunes, 20 de agosto 2018 5:30 p.m.
Fruitvale-Norris Park Recreation Room
6221 Norris Road, Bakersfield, CA 93308

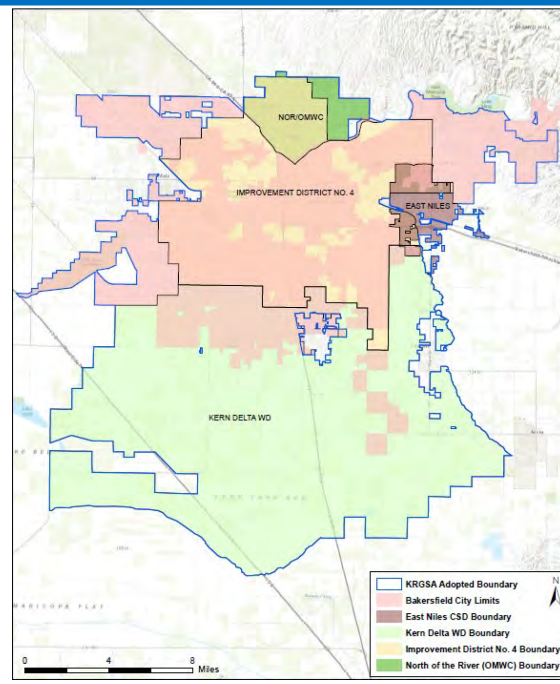
AGENDA

5:30 p.m. – 5:40 p.m.	Bienvenida y Introducciones
5:40 p.m. – 6:10 p.m.	Nueva Ley de Aguas Subterráneas de California y Planes de Sostenibilidad de Aguas Subterráneas
6:10 p.m. – 6:30p.m.	Esfuerzos Locales para Cumplir con SGMA - Esfuerzos para Desarrollar el GSP de Kern River GSA
6:30 p.m. – 6:50 p.m.	Comparta sus Pensamientos - Encuesta de Partes Interesadas
6:50 p.m. – 7:00 p.m.	Próximos Pasos y Comentarios de Cierre

Get to Know Your
Groundwater Sustainability Agency:
Kern River Groundwater Sustainability Agency

OVERVIEW

The Sustainable Groundwater Management Act (SGMA) is a new law that, once fully implemented, will fundamentally change the way we use and manage groundwater in California. The Act applies to areas that rely heavily on groundwater. The Act requires local agencies to form Groundwater Sustainability Agencies (GSAs) to manage and regulate groundwater. Once formed, these GSAs have new powers, including the ability to limit or suspend groundwater pumping and charge fees for groundwater extraction and will be responsible for ensuring that groundwater conditions improve by 2040.



To do so, GSAs will need to develop and implement Groundwater Sustainability Plans (GSPs). GSPs will need to document the groundwater conditions in the area; establish goals to prevent negative impacts; and identify projects and management actions that improve groundwater conditions.

YOUR GSA AT A GLANCE

GSA NAME	Kern River Groundwater Sustainability Agency
FORMED	March 30, 2016
AGENCY TYPE	Joint Powers Authority (A joint powers authority is an entity which consists of two or more public agencies jointly exercising powers, limited by the combined territorial jurisdictions of the individual agencies.)
GSA MEMBER AGENCIES	City of Bakersfield, Kern County Water Agency, Kern Delta Water District—Improvement District No. 4 (ID4)
GSA BOUNDARIES	Edison, Fuller Acres, Lamont (small northern portion only), Oildale, Oil Junction, Rexland Acres, Weedpatch
BOARD OF DIRECTORS	Chair—Rodney Palla, President, Kern Delta Water District Board Member—Gene Lundquist, Kern Delta Water District—ID4 Board Member—Bob Smith, City of Bakersfield
GSA MEETINGS	Meetings are held on the first Thursday of each month at 10:00 a.m. at 1600 Truxtun Ave, Bakersfield, CA 93301, first floor conference room A

GET INVOLVED!

Most unincorporated communities in the San Joaquin Valley are solely reliant on groundwater for drinking water. Many more residents rely on private wells. SGMA intends to bring different water users together to decide how to use and manage groundwater. As a result, decisions made by the GSAs will affect residents in rural communities.

Get involved and HELP your GSA:

- **Understand the groundwater challenges affecting rural unincorporated communities and/or private wells.**
- **Identify and develop projects that improve groundwater conditions in your community.**
- **Identify ways to keep rates affordable.**

Ways to Get Involved:

- Register as an interested party for the GSA to receive notices of meetings and important information about Groundwater Sustainability Plan (GSP) development.
- Attend the GSA board meetings. Give public comment or ask questions about their work.

Together, we can make sure that drinking-water needs are well represented in this important process!

CONTACT INFORMATION

Kern River Groundwater Sustainability Agency:
Rodney Palla, (661) 326-3767, Krgsa@kernrivergsa.org

Self-Help Enterprises:
Maria Herrera, (559) 802-1676, MariaH@selfhelpenterprises.org

Department of Water Resources (DWR) Regional SGMA Coordinator:
Matt Owens, (559) 230-3335, Matthew.Owens@water.ca.gov

Factsheet developed by:

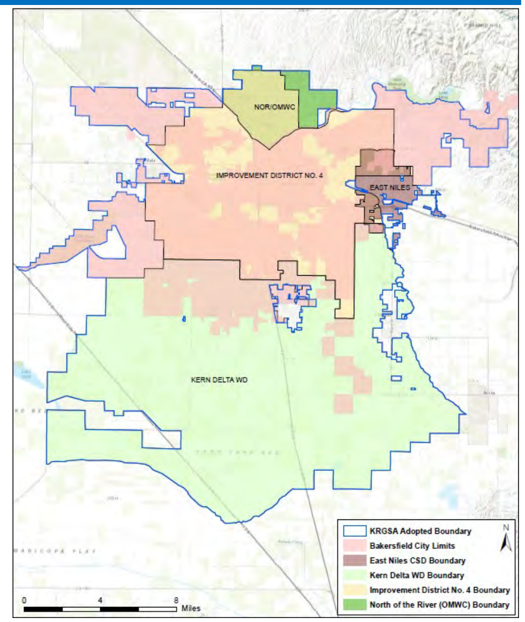
Self-Help Enterprises | COMMUNITY WATER CENTER / EL CENTRO COMUNITARIO POR EL AGUA | LEADERSHIP COUNSEL FOR JUSTICE & ACCOUNTABILITY | CLEAN WATER FUND

Updated July 2018

Conozcan su Agencia del Manejo Sostenible de Agua Subterránea:

Agencia de Manejo Sostenible de Agua Subterránea de Kern River

RESUMEN



La Ley del Manejo Sostenible del Agua Subterránea (SGMA por sus siglas en inglés) es una nueva ley que, una vez plenamente implementada, cambiará la manera en que usamos y regulamos el uso del agua subterránea en California. Áreas que dependen mucho más del agua subterránea para consumo humano, agricultura, y otros usos deben cumplir con esta Ley. La Ley requiere que agencias locales dentro de esas áreas formen Agencias de Manejo Sostenible de Agua Subterránea (GSAs por las siglas en inglés) para manejar y regular el uso del agua subterránea. Una vez formadas, estas agencias tendrán nuevos poderes y funciones, incluso el poder de limitar o suspender el bombeo de agua subterránea y cobrar tarifas por la extracción de agua subterránea. Para el año 2040, cada agencia debe asegurar que la condición del agua subterránea en su área se mejore.

Para tal fin, las agencias tendrán que desarrollar e implementar Planes de Manejo Sostenible de Agua Subterránea (GSPs por sus siglas en ingles). Estos Planes deben documentar las condiciones del agua subterránea en el área; establecer metas para prevenir los impactos negativos; e identificar proyectos y acciones de manejo que mejoraran las condiciones de agua subterránea.

SU GSA A SIMPLE VISTA

NOMBRE DE GSA	Agencia del Manejo Sostenible del Agua Subterránea de Kern River
FECHA FORMADA	30 de marzo 2017
TIPO DE AGENCIA	Autoridad de Poderes Conjunta (Una autoridad de poderes conjunta es una entidad que consiste en dos o más agencias públicas que ejercen conjuntamente poderes, limitadas por las jurisdicciones territoriales combinadas de las agencias individuales).
AGENCIAS MIEMBROS DE LA GSA	Cuidad de Bakersfield, Agencia de Agua del Condado de Kern, Distrito de Agua de Kern Delta—Distrito de Mejora No. 4 (ID4)
ÁREA DE LA GSA	Edison, Fuller Acres, Lamont (pequeña porción del norte solamente), Oildale, Oil Junction, Rexland Acres, Weedpatch
MESA DIRECTIVA	Presidente—Rodney Palla, Distrito de Agua de Kern Delta Miembro de la Mesa—Gene Lundquist, Distrito de Agua de Kern Delta —ID4 Miembro de la Mesa—Bob Smith, Cuidad de Bakersfield
JUNTAS DE LA GSA	Las juntas se llevan acabo cada primer jueves del mes a las 10:00 a.m. en 1600 Truxton Ave, Bakersfield, CA 93301, salon de conferencia A en el primer piso

¡INVOLUCRARSE!

La mayoría de las comunidades no incorporadas en el Valle de San Joaquín dependen únicamente en el agua subterránea para el agua potable. Muchos residentes más utilizan pozos privados. SGMA tiene la intención de reunir a diferentes usuarios de agua para que juntos decidan cómo usar y manejar el agua subterránea. Como resultado, las decisiones tomadas por los GSA afectarán a los residentes en las comunidades rurales.

Involúcrate y AYUDA a tu GSA a:

- **Entender los desafíos del agua subterránea que afectan las comunidades no incorporadas y / o los pozos privados.**
- **Identificar y desarrollar proyectos que mejoren las condiciones del agua subterránea en su comunidad.**
- **Identificar maneras de mantener tarifas de SGMA económicas.**

Como Participar:

- Para recibir notificaciones sobre las juntas de la GSA e información importante sobre el desarrollo del GSP, registrarse como persona interesada de la GSA.
- Asista a las juntas de la Mesa Directiva y/o del comité de la GSA. Proporcione comentarios públicos o haga preguntas sobre el trabajo de la GSA.
- **Solicite servir en un comité.**

Juntos, podemos asegurarnos de que las necesidades de agua potable estén bien representadas en este importante proceso!

INFORMACION DE CONTACTO

Agencia del Manejo Sostenible del Agua Subterránea de Kern River
Rodney Palla, (661) 326-3767, Krgsa@kernrivergsa.org

Self-Help Enterprises:
Maria Herrera, (559) 802-1676, MariaH@selfhelpenterprises.org

Departamento de Recursos Hidricos, Coordinador Regional de SGMA:
Matt Owens, (559) 230-3335, Matthew.Owens@water.ca.gov

Hoja informativa desarrollada por:

Self-Help Enterprises · COMMUNITY WATER CENTER EL CENTRO COMUNITARIO POR EL AGUA · LEADERSHIP COUNSEL FOR JUSTICE & ACCOUNTABILITY · CLEAN WATER FUND

Updated July 2017

Kern River GSA Groundwater Workshop
Monday, August 20, 2018, 5:30 - 7 p.m.
Fruitvale Norris Park Recreation Room, 6221 Norris Road, Bakersfield, CA 93308

	Name/Nombre	Agency/Agencia	Phone/Telefono	Email/Correo Electrónico	Would you like to be notified of future meetings? ¿Desea que le avisemos sobre futuras reuniones?
1	Dennis Fox	Cal Fishermans Alliance	661 366 4093	NA	918 Blossom 9330
2	Steven Teglia	City of Bakersfield	661 326-3747		
3	Bill White	Victory Mutual Water	661 301-2363		
4	Jana Marquez	Kern Delta WD	661 834 4656	Jana@Kerndelta.org	
5	Mark Mulkay	KernDelta WD	661 834-4656	Mark@kerndelta.org	
6	ROSS SPITZER	KERN DELTA WD	661-201-5968	SPITZER.ROSS@gmail.com	
7	[illegible]	Athal mutual Water	661-477-8625	[illegible]121810@Yahoo.com	
8	Frances Alcorn	Fuller Acres M. W. Co.	661-319-5008	fulleracresw@yahoo.com	P.O. 125 Lamont 93
9	Chris Bellue	Kern Delta	834-4656	Chris@kerndelta.org	
10	TONY MATTOS	EL ADOBE POA	661-428-9050	TMATTOS@TEJONRANCH.COM	
11					
12	Patty Poire	KGA GSA	661-479-7171		
13					
14					
15					
16					

[illegible]

	Name/Nombre	Agency/Agencia	Phone/Telefono	Email/Correo Electrónico	Would you like to be notified of future meetings? ¿Desea que le avisemos sobre futuras reuniones?
17	Robby Lester	Victory Mutual Water Co	661 303 7459		
18	Terry Erlewine	~~[illegible]~~ Kern GW Authority		terlewine@ppeng.com	
19	MICHAEL SALAZAR	SOUTH KERN MUTUAL WATER	661. 243-6179		
20	Doug Nunneley	Oildale Mut/North of the River MWD	661-399-5516	dnunneley@oildalewater.com	
21	Angie Garcia	Athal Mutual Water	3466156	angelacgarcia@Yahoo.com	
22	Xavier + Gloria Reyes	East Niles C.S.D.	871-2011	greyes@eastnilescsd.org	
23	Everett McGhee	Fuller Acres Mutual Water	661-319-5028	felleracres@yahoo.com	
24	KEVIN F. COYLE	BAKERSFIELD PLANNING	661-326-3681	KCoyle@bakersfieldcity.us	
25	Adeyinka Glover	Leadership Counsel	661 8~~4~~3-7677	aglover@leadershipcounsel.org	Yes
26	Gene A. Lundquist	KRGSA	661 343.7192	golundquist@icloud.com	no
27	Terry Savino	QK Engineering	661-331-8577		
28	ART Chianello	City of Bakersfield KRGSA	661-326-3115	achianello@bakersfieldcity.us	Yes
29					
30					
31					
32					
33					
34					

Kern River Groundwater Sustainability Agency

Groundwater Workshop

August 20, 2018

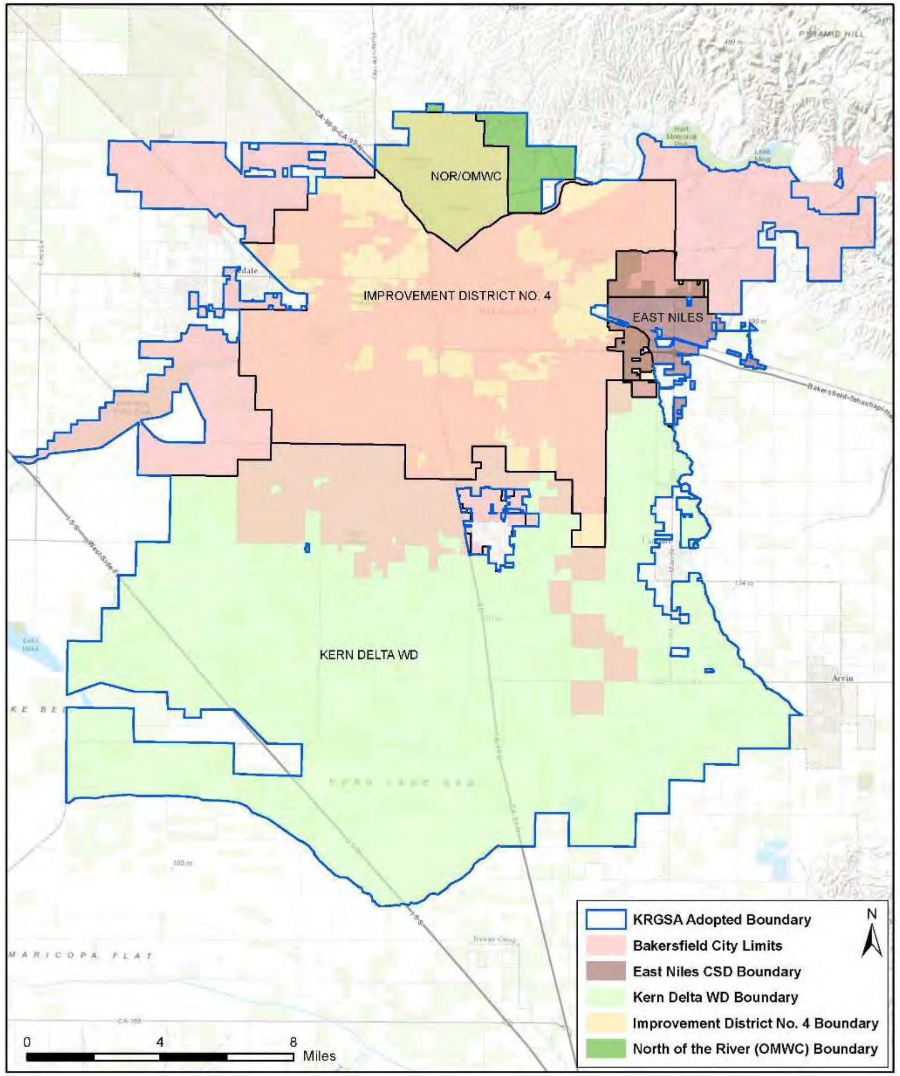
Horizon WATER and ENVIRONMENT

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Self-Help Enterprises

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY



Members of the Kern River GSA

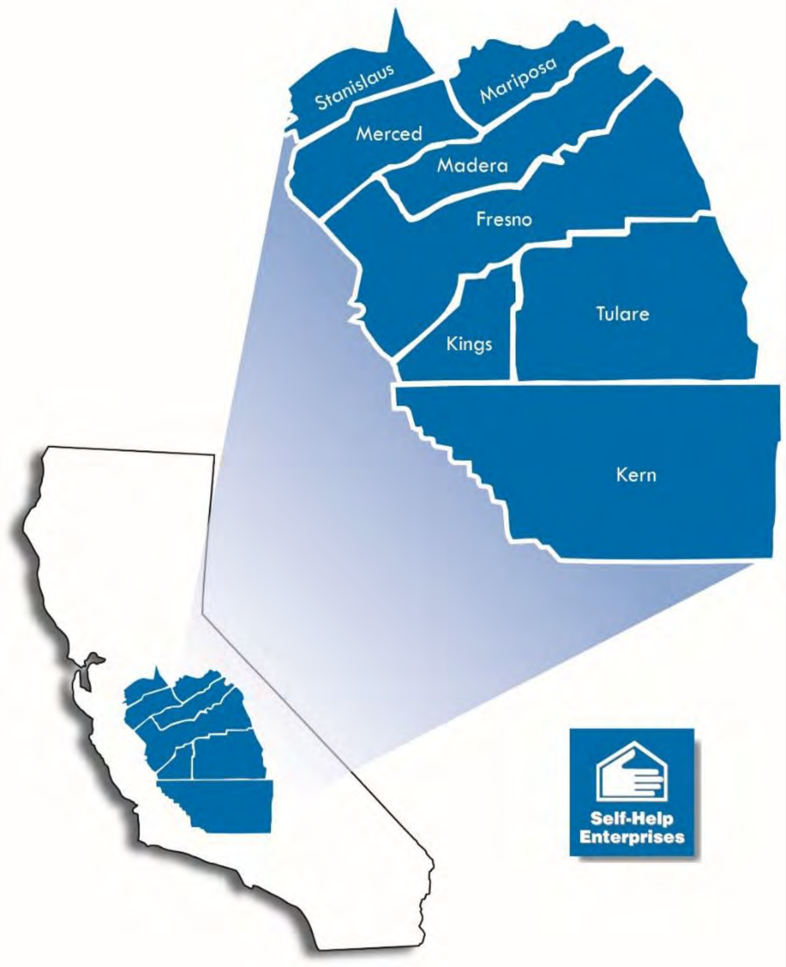
- City of Bakersfield
- Kern County Water Agency – Improvement District #4 (ID4)
- Kern Delta Water District

Communities within the GSA

- Edison
- Fuller Acres
- Oildale
- Oil Junction
- Rexland Acres
- Weedpatch
- Lamont (small northern portion only)

SELF-HELP ENTERPRISES (SHE)

- SHE is a nationally-recognized non-profit housing and community development organization whose mission is to work together with low-income families to build and sustain healthy homes and communities.
- Community Development Program provides technical assistance and leadership development in rural communities who face clean water, sanitary sewer and other infrastructure challenges.
- Community Engagement and Planning Team supports community participation in regional water management and groundwater sustainability planning as well as building water management capacity and expertise in rural communities.

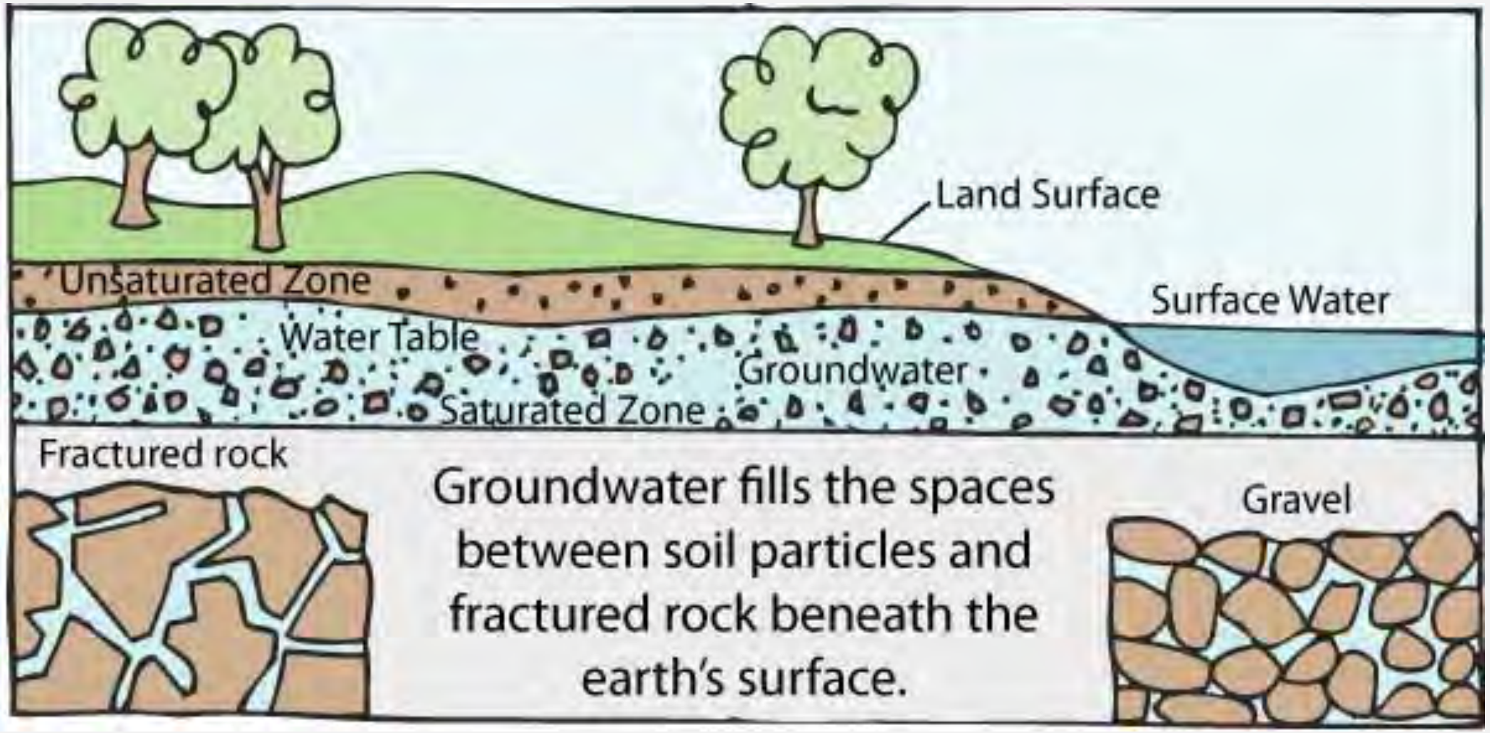


WORKSHOP OVERVIEW

- California’s New Groundwater Law – The Sustainable Groundwater Management Act (SGMA)
- Groundwater Sustainability Plans (GSPs)
- KRGSA’s GSP Development Efforts
- Share Your Thoughts – Stakeholder Survey
- Wrap Up and Closing Remarks

GROUNDWATER MATTERS

On average Californians get 40% of their water from groundwater. During droughts, that number can go up to 60%.



- In the Central Valley, we are even more dependent on groundwater than the state as a whole
- 90% of Central Valley residents rely on groundwater for at least part of their drinking water supply
- Most unincorporated communities are 100% reliant on groundwater – includes many of our small school districts

HOW COMMUNITIES AND SCHOOLS USE GROUNDWATER

HISTORICAL GROUNDWATER MANAGEMENT

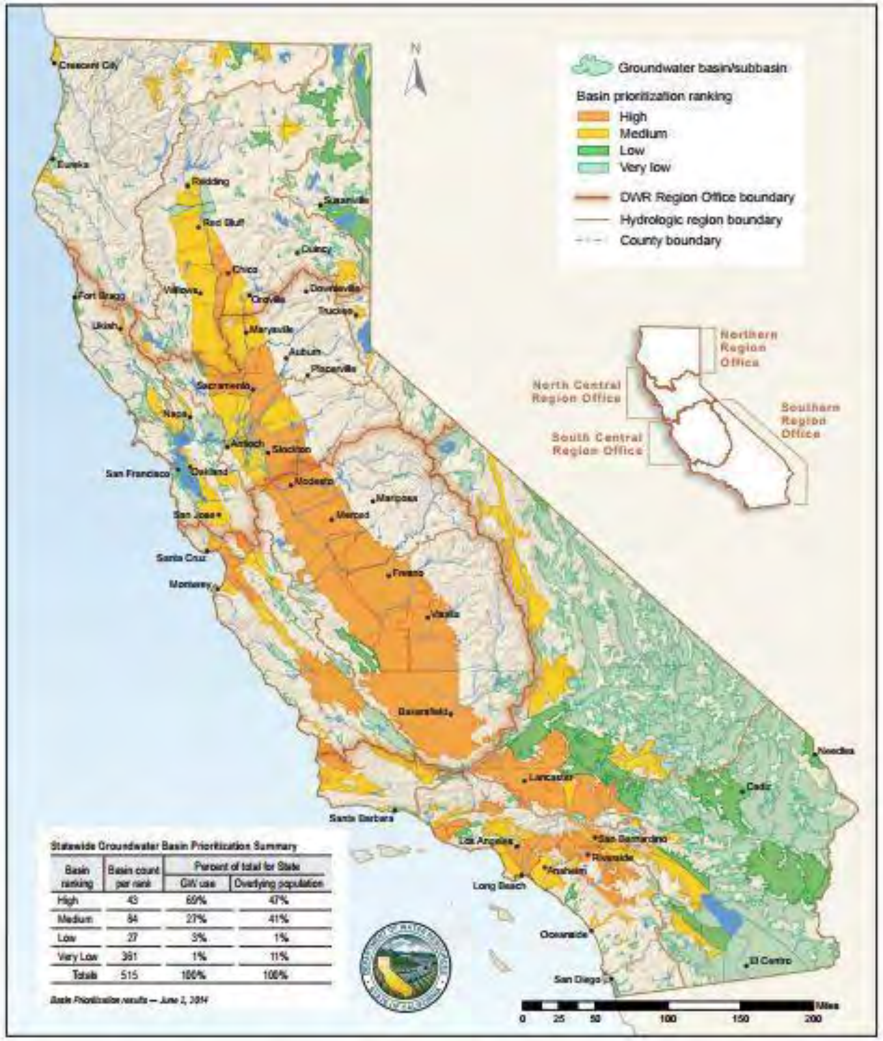
- Previously, groundwater management was voluntary in certain areas of the state
- Groundwater levels have been declining due to over-pumping, less surface water, and not enough recharge
- The drought (2012-2016) had an unprecedented impact on our state
- Dry wells (i.e., Arvin, Lamont area, and many others)
- Subsidence

CALIFORNIA'S SUSTAINABLE GROUNDWATER MANAGEMENT ACT (SGMA)

- Three-bill package: SB 1168 (Pavley), AB 1739 (Dickinson), SB 1319 (Pavley)
- Signed by Governor Brown on September 16, 2014
- Objective: Ensure the long-term reliability of our groundwater resources and connected surface water resources requiring "sustainable" management
- Core Principle: Local control

PREVENT UNDESIRABLE RESULTS

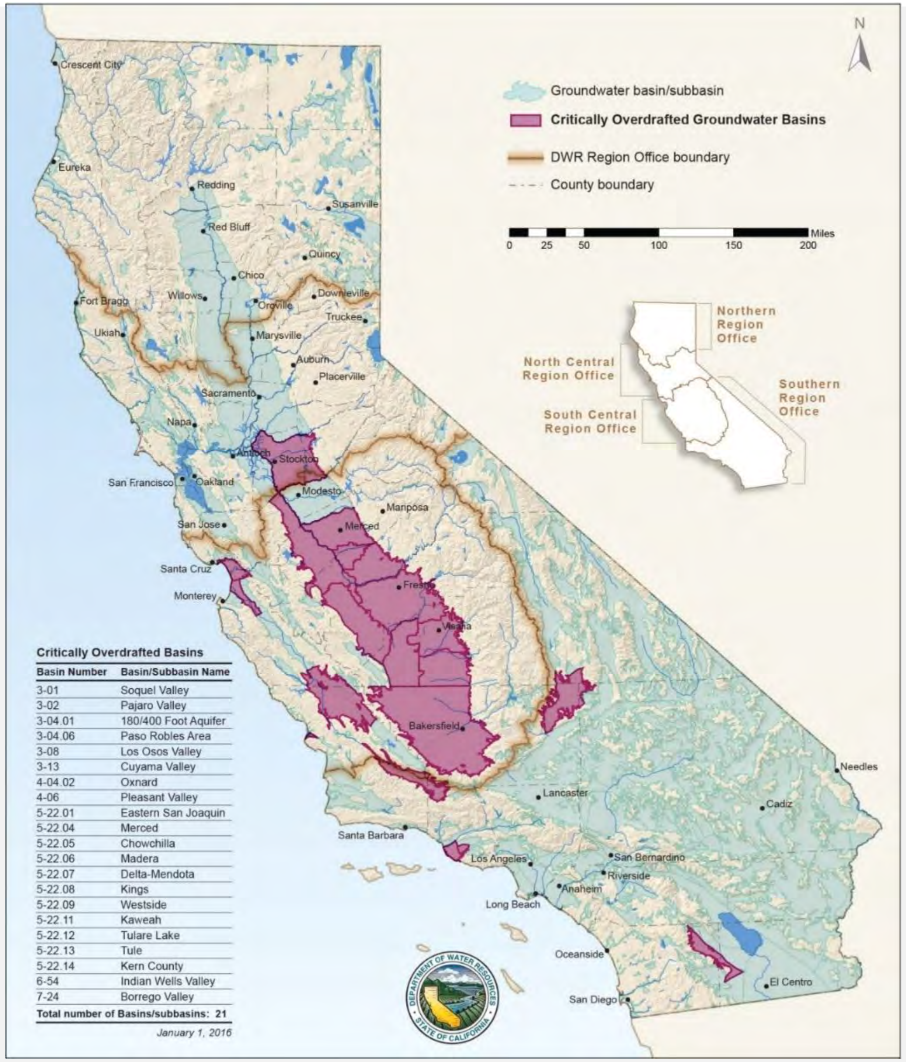
WHO MUST COMPLY WITH SGMA?



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014



Critically Overdrafted Basins

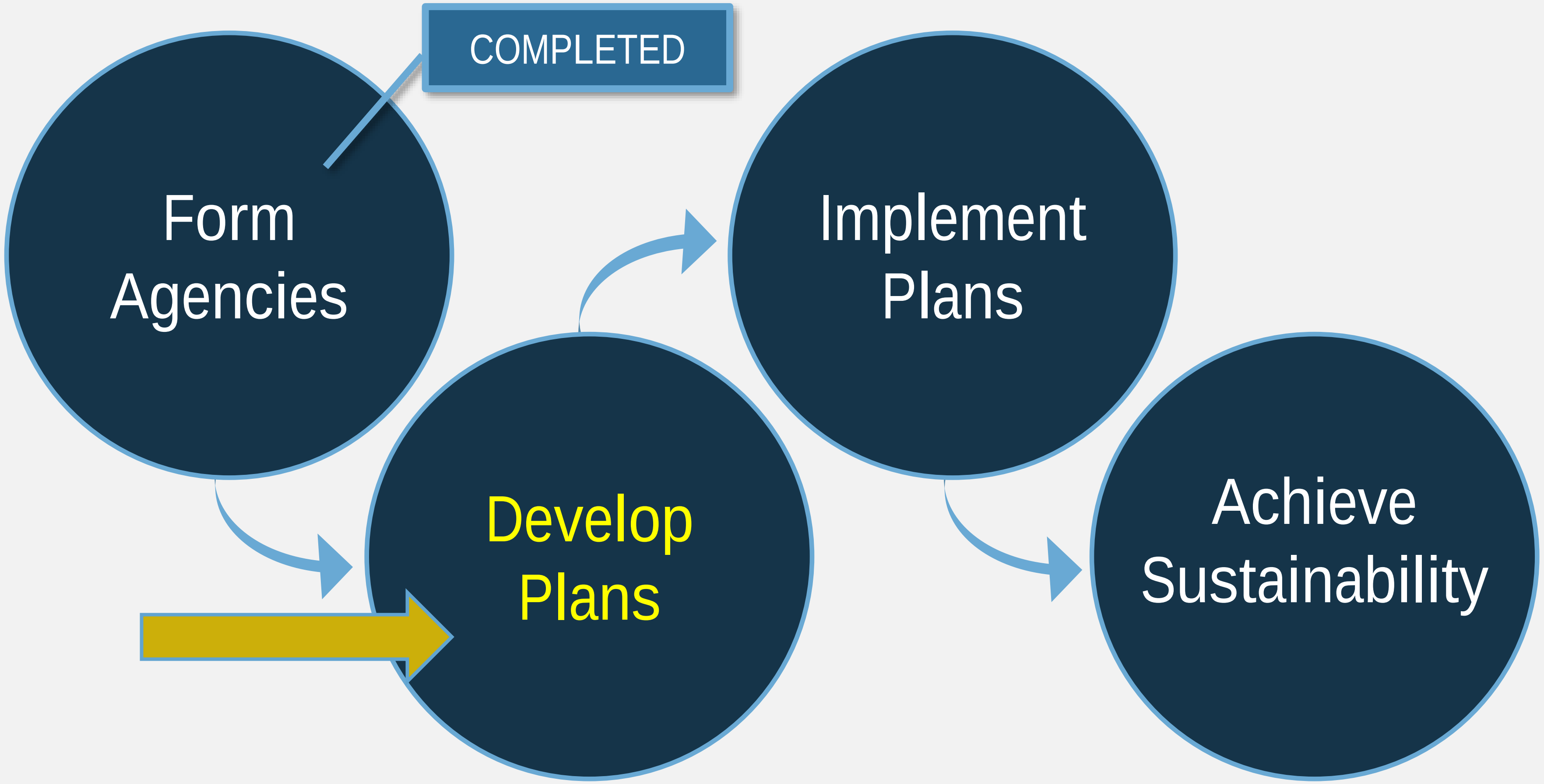
Basin Number	Basin/Subbasin Name
3-01	Soquel Valley
3-02	Pajaro Valley
3-04.01	180/400 Foot Aquifer
3-04.06	Paso Robles Area
3-08	Los Osos Valley
3-13	Cuyama Valley
4-04.02	Oxnard
4-06	Pleasant Valley
5-22.01	Eastern San Joaquin
5-22.04	Merced
5-22.05	Chowchilla
5-22.06	Madera
5-22.07	Delta-Mendota
5-22.08	Kings
5-22.09	Westside
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
6-54	Indian Wells Valley
7-24	Borrego Valley
Total number of Basins/subbasins: 21	

January 1, 2016

WHOSE INTERESTS ARE AT STAKE?

- Holders of overlying groundwater rights (agricultural and domestic)
- Public water systems
- Local land use planning agencies
- Environmental users of groundwater
- Surface water users
- California Native American tribes
- Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems

SGMA DESIGN


COMPLETED
Form Agencies
Develop Plans
Implement Plans
Achieve Sustainability

MULTIPLE GSAs IN A SUBBASIN

- More than one GSA can be formed in a sub-basin
- If there are multiple GSAs in a sub-basin, the GSAs can collaborate to write one single plan, or each GSA can write its own plan so long as the GSAs establish a coordination agreement for implementing multiple plans.
- However, GSAs must cover the entire area of the sub-basin, leaving no areas unmanaged
- All GSAs were approved in July 2017

POWERS AND RESPONSIBILITIES OF A GSA

DEVELOPMENT OF GROUNDWATER SUSTAINABILITY PLANS

- GSPs must contain important information:
  - Description of plan area & basin setting
  - Sustainability criteria
  - Monitoring program and projects

- GSPs will serve as the roadmap to achieve sustainability

- GSAs will need to develop GSPs with stakeholder input

GSP SUBMITTAL AND APPROVAL BY DWR

- GSPs must be written by January 31, 2020 (or January 31, 2022 if the basin is not critically overdrafted)

- DWR determinations
  - Adequate
  - Inadequate
  - Incomplete

- If the Department of Water Resources decides that a GSP will not sustainably manage groundwater by 2040 (or 2042 if not in critically overdrafted basins)…

  → <u>The State may step in and manage the sub-basin itself!</u>

  Much more expensive
  Less local control

GSP IMPLEMENTATION AND ACHIEVING SUSTAINABILITY

- After submitting its GSP, a GSA has 20 years to reach sustainability
  - Sustainability must be reached by 2040 (2042 for areas not in critical overdraft)
- DWR will review all plans every five years to assess progress and recommend corrective actions as needed
- Annual Reporting

QUESTIONS & ANSWERS

GROUNDWATER SUSTAINABILITY PLANS

1. Description of the plan area and basin setting: Groundwater conditions, water budget, hydrogeological conceptual model, management areas

2. Sustainability criteria: set sustainability goal, set minimum thresholds for undesirable results, set measurable objectives

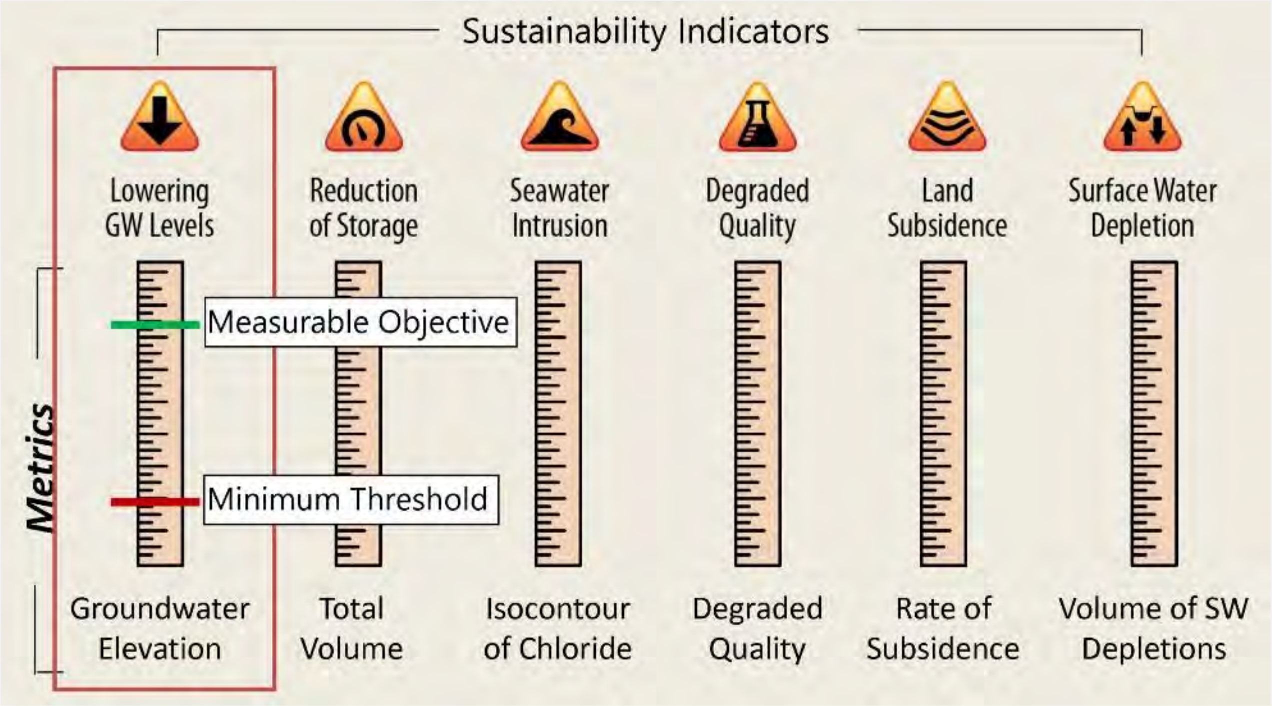
3. Projects and management actions: projects, management actions, mitigation measures, monitoring plan

WATER BUDGETS

SUSTAINABILITY CRITERIA
MEASUREABLE OBJECTIVES AND MINIMUM THRESHOLDS

Prevent “Undesirable results that are significant and unreasonable”

At this time, the only undesirable result that we can be certain doesn’t apply to the Kern River GSA area is Seawater intrusion



SUSTAINABILITY IS DEFINED LOCALLY

- SGMA requires GSAs to define sustainability using two concepts:
  - Measurable objectives are aspirational <u>goals</u>. Technically, you should achieve them by 2040 (or 2042 if not critically overdrafted).
  - Minimum thresholds are to be <u>avoided</u>. If they are crossed, you may be out of compliance with your plan and violating the obligation to reach sustainability.

GENERAL PRINCIPLES – MEASURABLE OBJECTIVES AND MINIMUM THRESHOLDS

- Cannot harm sustainability in a neighboring basin
- Cannot continue to be in long-term overdraft
- Cannot deplete surface water

MANAGEMENT ACTIONS AND PROJECTS

KRGSA's GSP DEVELOPMENT EFFORTS

GSAs AND GSPs IN KERN SUBBASIN
(AS OF APRIL 2018)

- GSAs Preparing Their Own GSPs:
  - Kern River GSA
  - Kern Groundwater Authority
  - Buena Vista Water Service District GSA
  - Henry Miller Water District GSA
  - Olcese Water District GSA

- GSAs That Have Not Formalized GSP Preparation Plans:
  - City of McFarland GSA
  - Greenfield County Water District GSA

GSP OVERVIEW

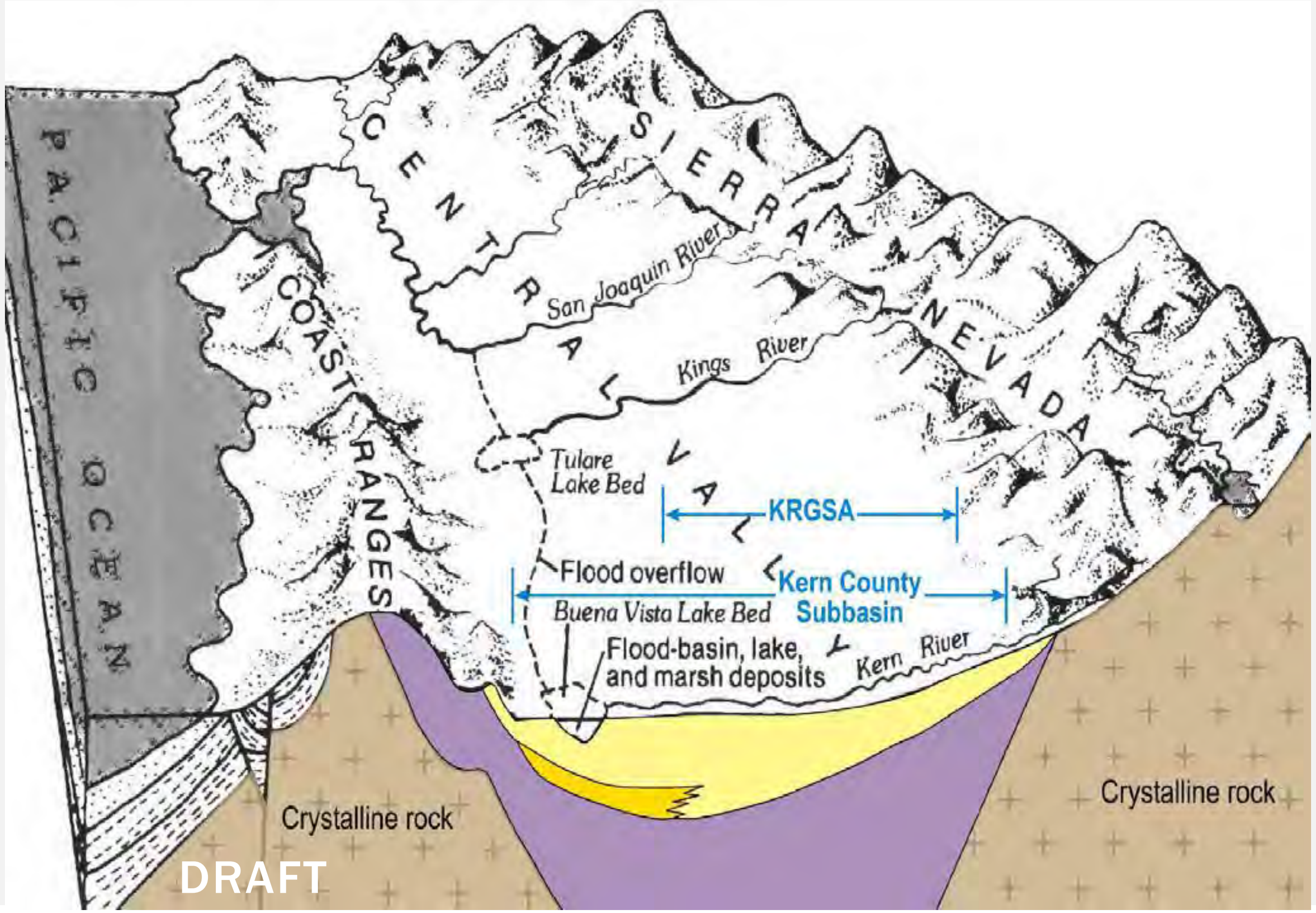
- Data Compilation / Data Management System
- Institutional Setting – Water Supply / Plan Area
- Hydrogeologic Conceptual Model / Groundwater
- Water Budget (Current and Historical)
- Sustainability Goals and Criteria
- Management Scenarios Projected Water Budget
- Monitoring Networks Plan Development

Hydrogeologic Conceptual Model, Groundwater Conditions, and Water Budgets collectively inform the Sustainability Analysis

DRAFT

TODD GROUNDWATER

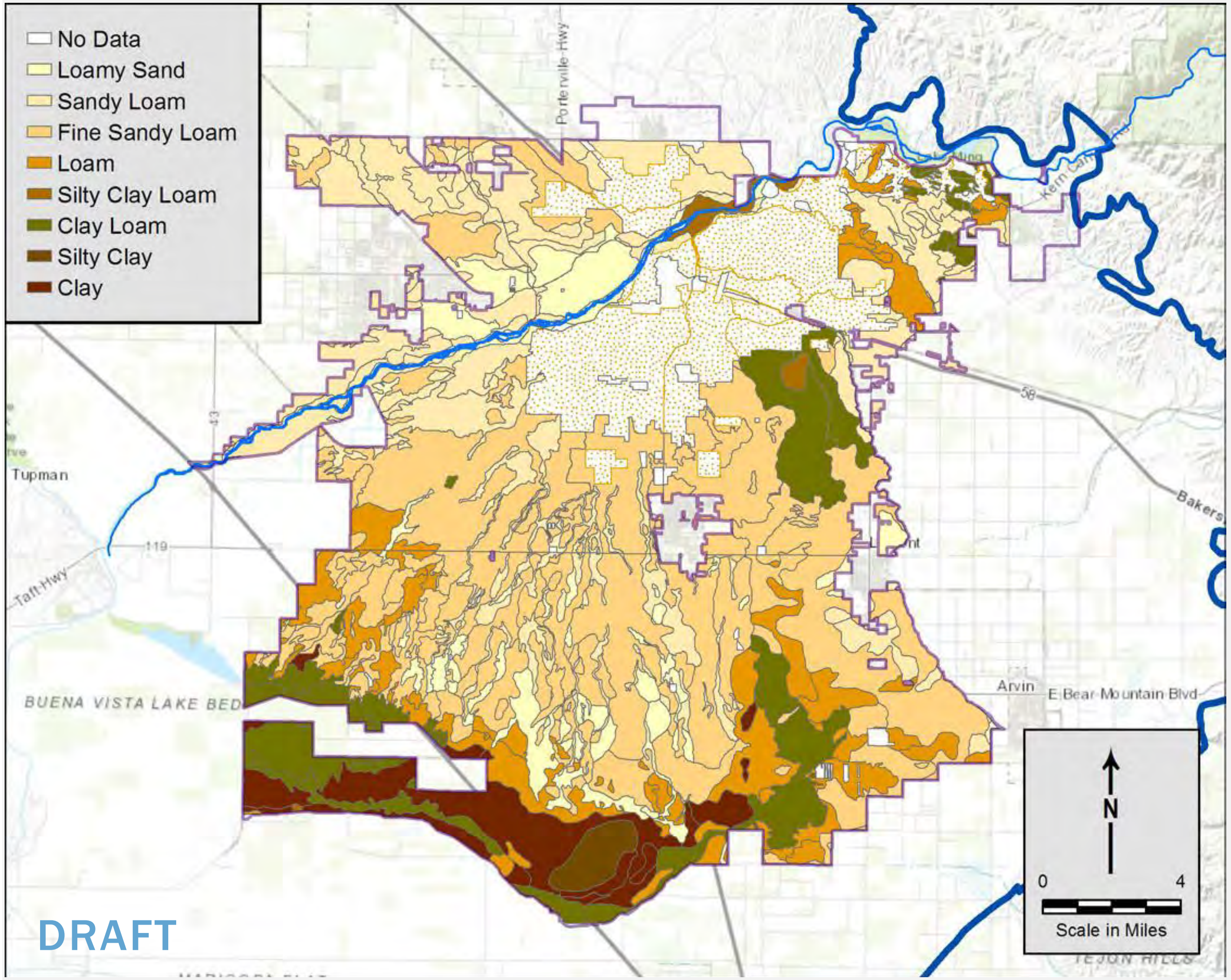
CONCEPTUAL HYDROGEOLOGIC SETTING KERN COUNTY SUBBASIN



- Alluvial-filled trough between the Sierra Nevada and Coast Ranges
- Underlain by older marine sedimentary units
- Flanked by crystalline bedrock

TODD GROUNDWATER

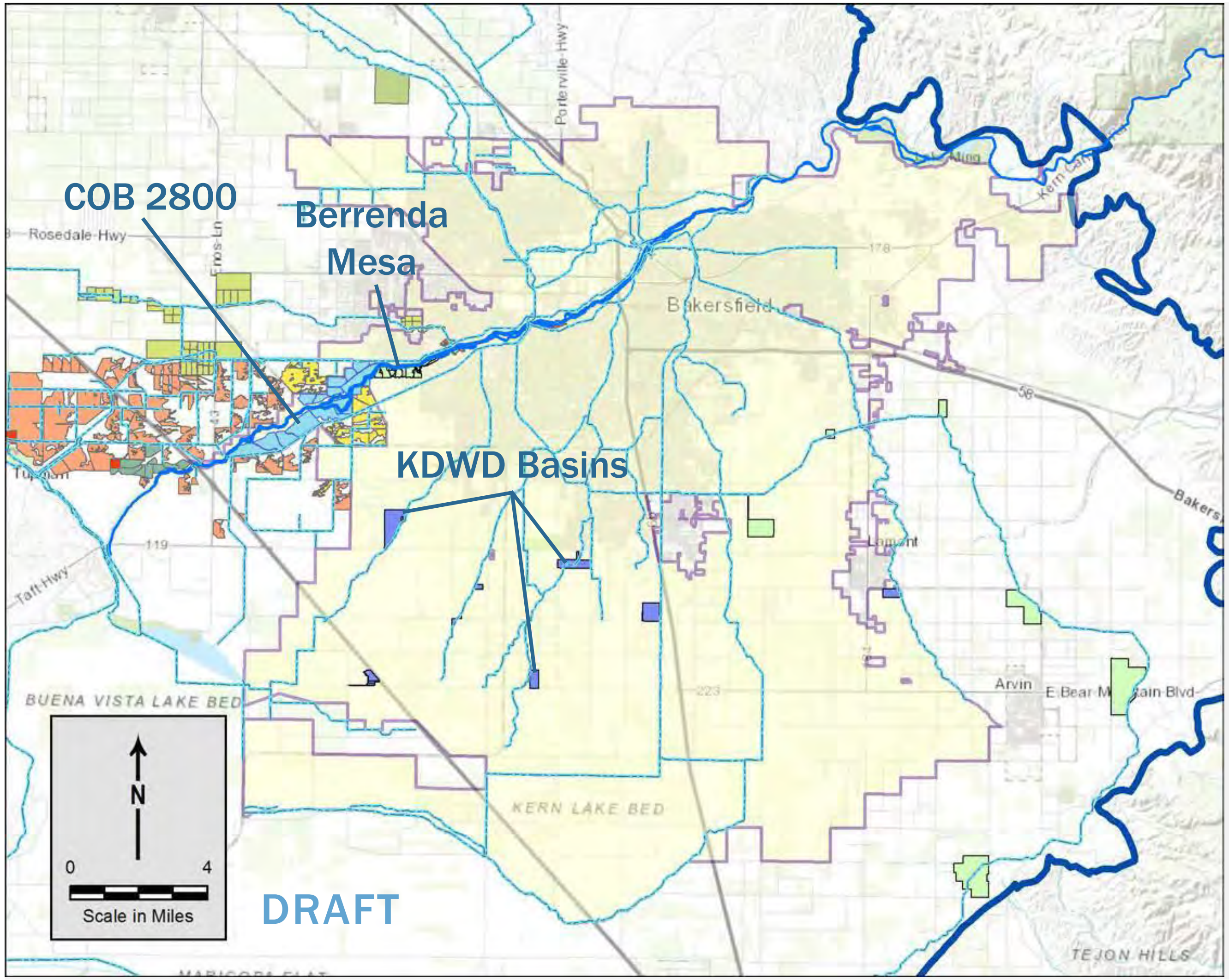
SOIL TEXTURES



- More permeable textures indicated by lighter colors (white, yellow, light orange)
- Lower permeability textures indicated by dark orange, green and brown
- Soil textures agree well with geologic framework

TODD GROUNDWATER

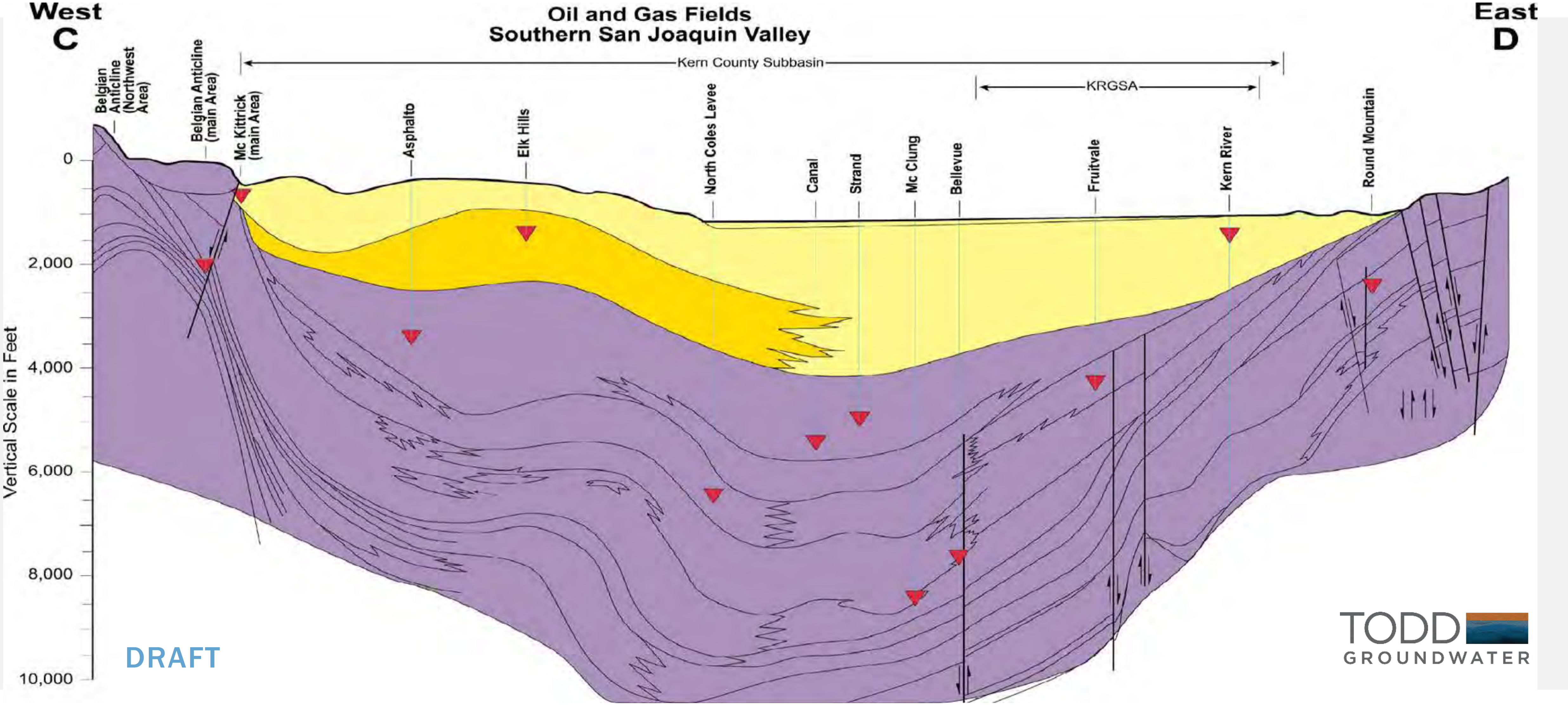
CANALS AND RECHARGE BASINS



- Managed recharge in river channel, unlined canals, and basins
- KRGSA groundwater banking projects:
  - COB 2800 Acres
  - KCWA Berrenda Mesa
  - KDWD Metropolitan Project
- Numerous additional banking projects nearby

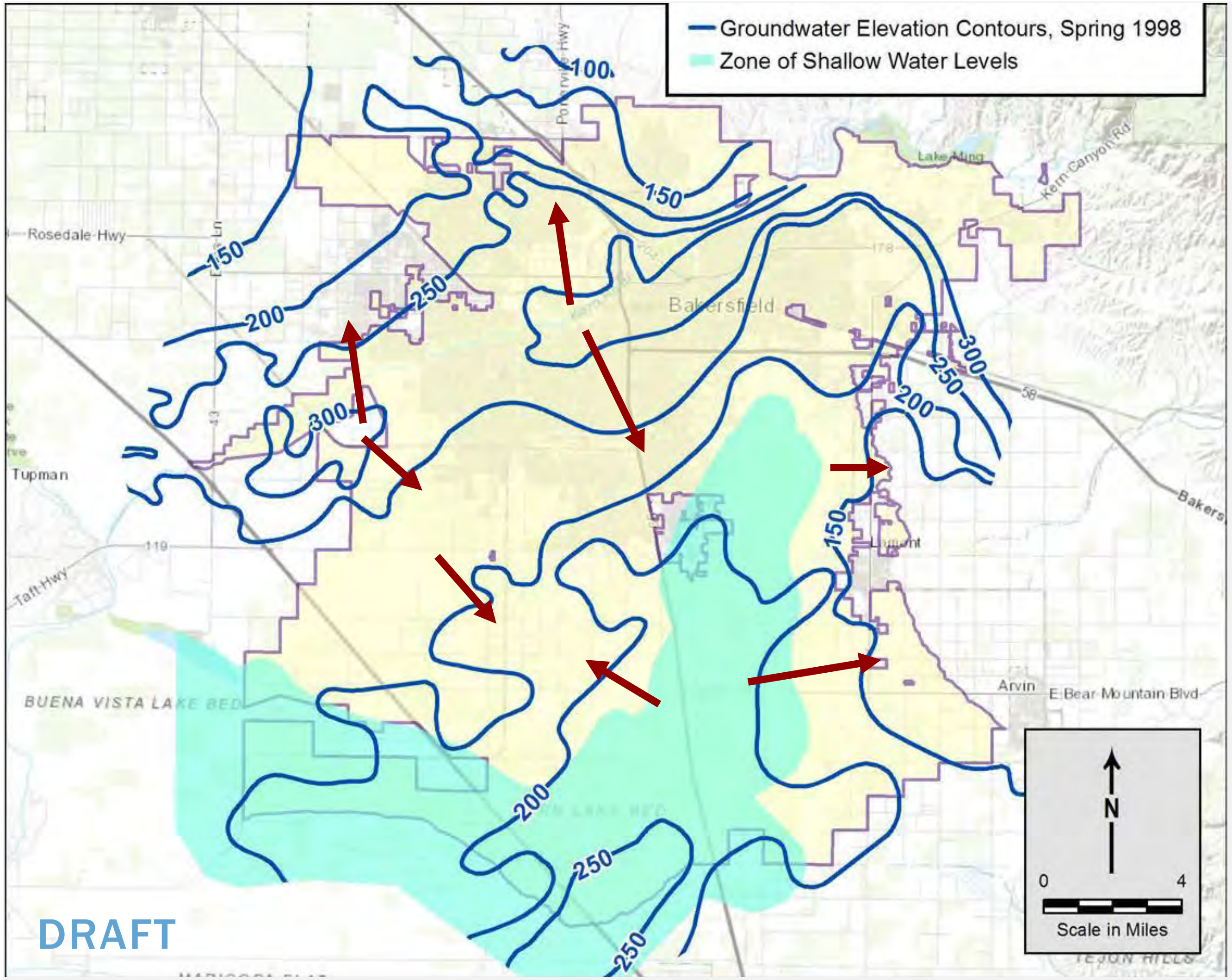
TODD GROUNDWATER

REGIONAL CROSS SECTION AND OIL FIELDS



TODD GROUNDWATER

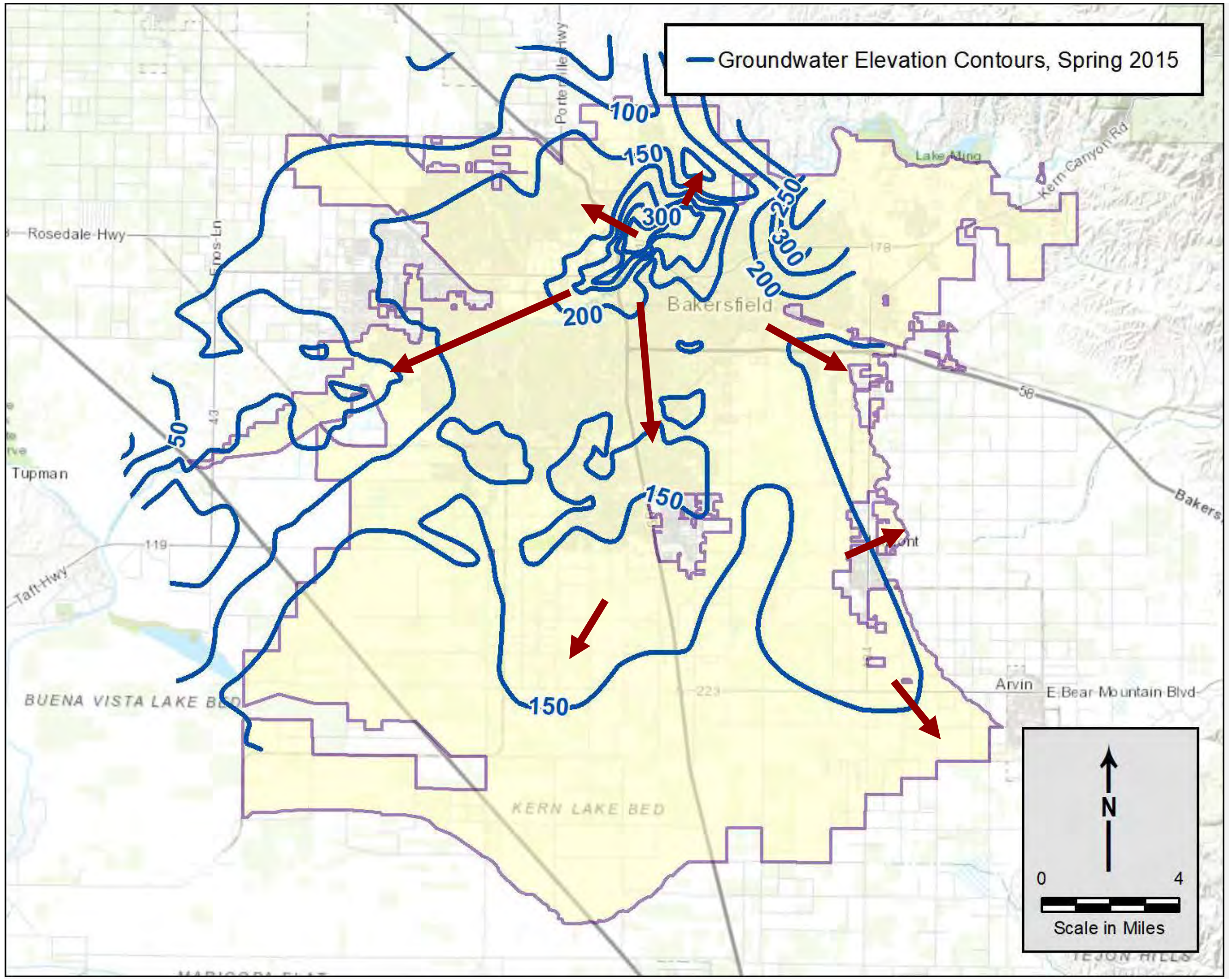
GROUNDWATER ELEVATION CONTOURS 1998



- 20 groundwater elevation contour maps (Spring data)
- Examined maps and data for perched layers (zone of shallow water levels)
- Example for wet year - Spring 1998

TODD GROUNDWATER

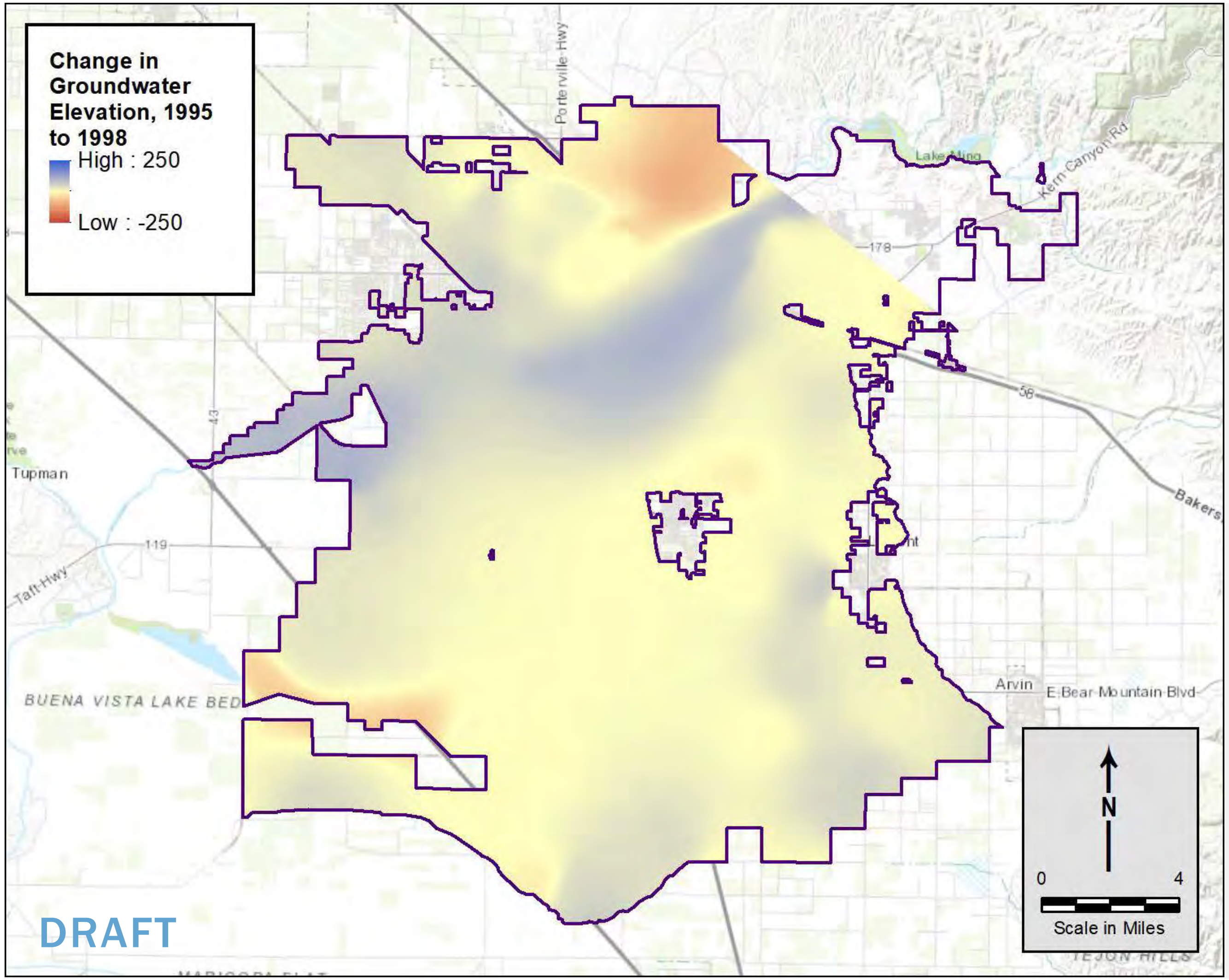
GROUNDWATER ELEVATION CONTOURS 2015



- Severe Drought year
- In general, higher water levels than surrounding areas
- Except for the river, groundwater is flowing out of the KRGSA area

TODD GROUNDWATER

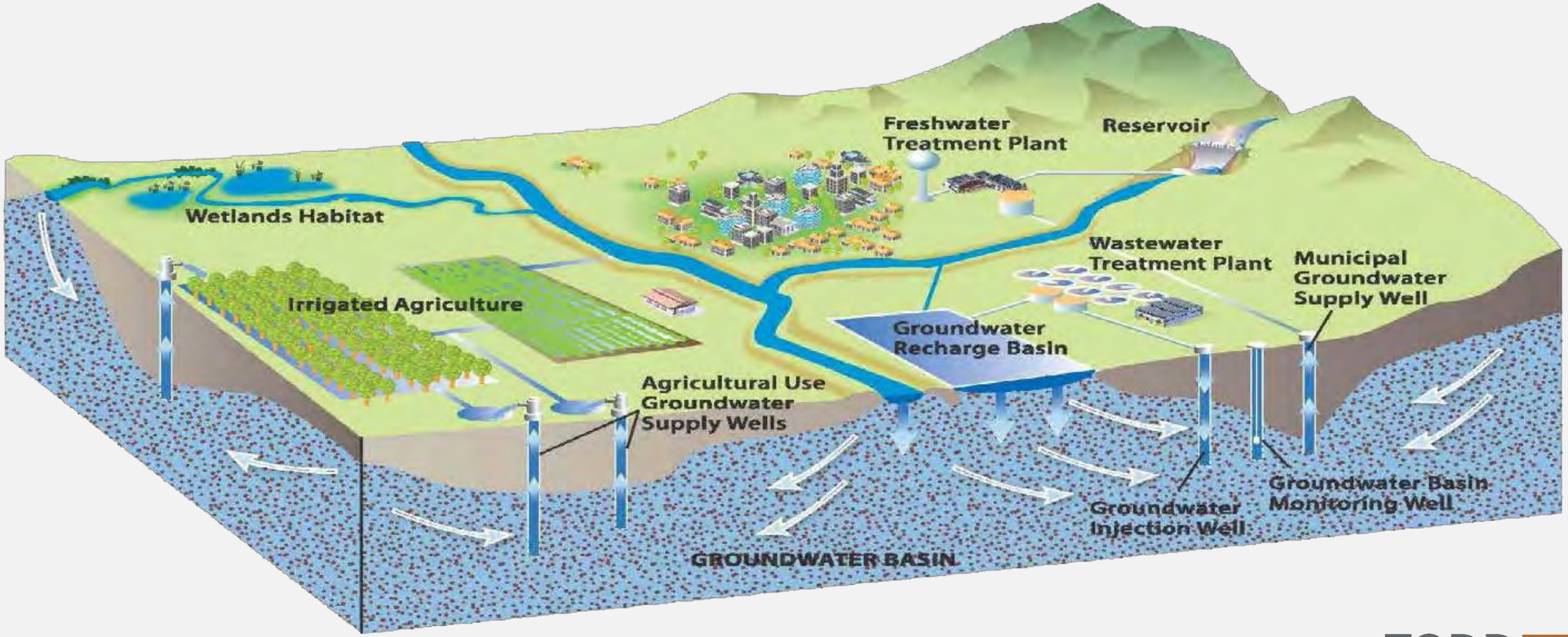
CHANGE IN GROUNDWATER IN STORAGE, 1995-1998



- Created 20 annual water level change maps using KCWA Spring water level contour maps
- Blue areas indicate water level rise; red areas indicate water level declines
- Limited data create uncertainty for some areas and time periods

TODD GROUNDWATER

FINALIZING THE KRGSA WATER BUDGET



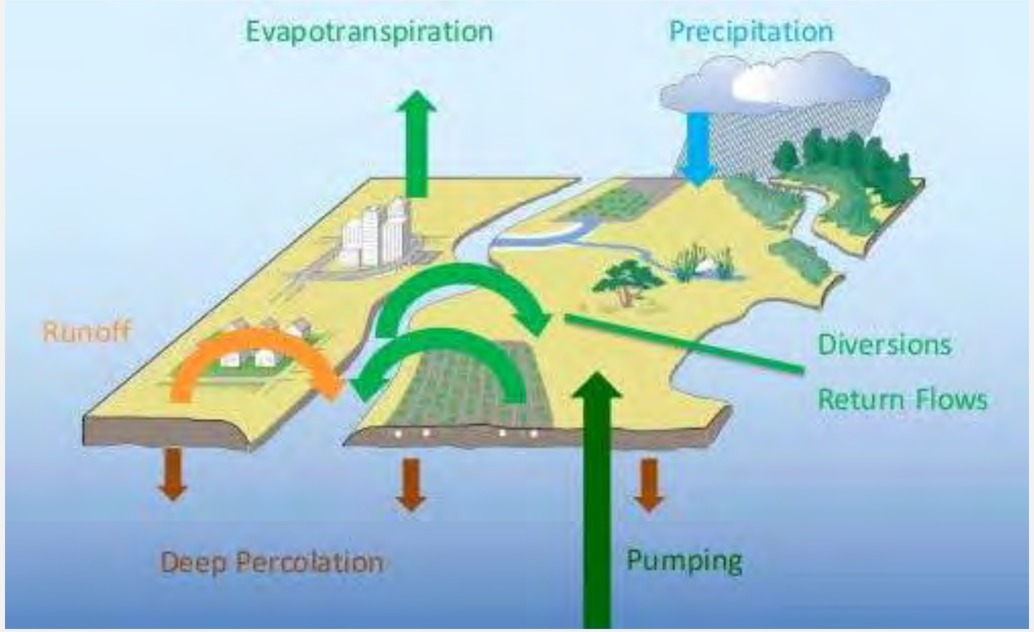
CA Water Foundation

DRAFT

TODD GROUNDWATER

KRGSA WATER BUDGETS – APPROACH

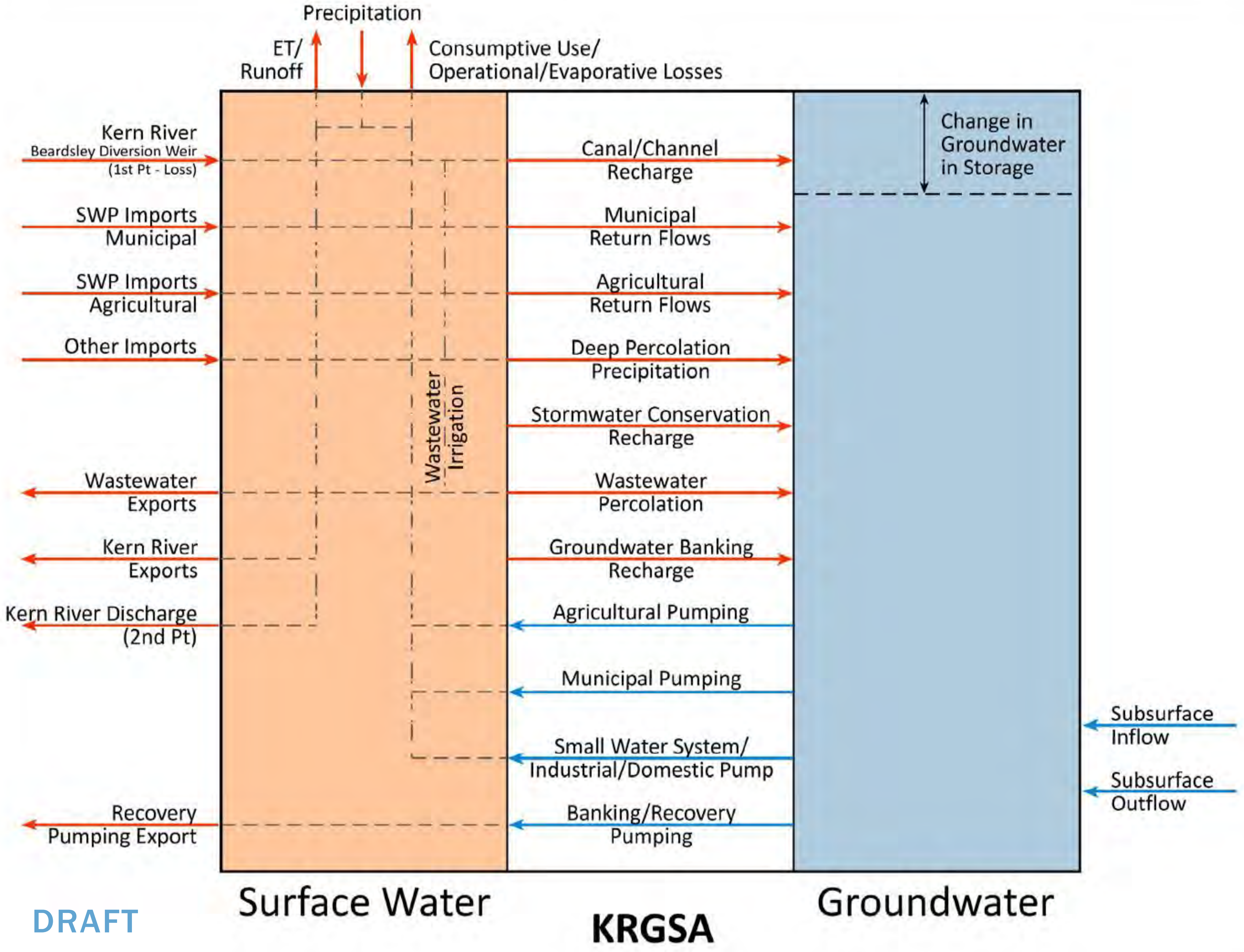
- Kern County water managed in real time for optimal use
- Provides flexibility and optimization of water but results in complex accounting of physical molecules
  - Focus on the **physical system**
    - Where does the "wet water" go? (not paper exchanges)
    - Water budget process follows the molecules – does not assign "ownership" of the water
    - Prevent "double-counting"



DRAFT

TODD GROUNDWATER

KRGSA COMBINED WATER BUDGET COMPONENTS



DRAFT

TODD GROUNDWATER

NEXT STEPS

- Work with agencies to reconcile data and local water budgets
- Compile for KRGSA
- Format data sets for model

Horizon WATER and ENVIRONMENT

TODD GROUNDWATER

QUESTIONS & ANSWERS

PARTICIPATE IN GSP DEVELOPMENT

You can help shape what is included in the plan by:

- Providing information about your past or present groundwater challenges
- Sharing information about your water usage and/or water well
- Sharing your vision for sustainability
- Identifying projects that can help address the groundwater conditions
- Completing the Stakeholder Survey

STAKEHOLDER SURVEY

We want to hear from you!

- What do you know about SGMA?
- How do you use water?
- What else should we know?

STAY INVOLVED

- Attend GSA Meetings
  - KRGSA Board Meetings are held the last Wednesday of each month at 8 a.m. at 1600 Truxtun Avenue, Bakersfield, CA 93301
- Get on the “interested parties” list to receive correspondence and information from the KRGSA
- Visit the website to learn more: http://www.kernrivergsa.org/
- Attend future workshops

ADDITIONAL INFORMATION AND RESOURCES

- Technical Assistance for Severely Disadvantaged Communities
  - Self-Help Enterprises: https://www.selfhelpenterprises.org
    - Eva Dominguez, 559-802-1634, EvaD@selfhelpenterprises.org
    - Maria Herrera, 559-802-1676, MariaH@selfhelpenterprises.org
- Local Information – Kern River GSA: https://kernrivergsa.org
    - Art Chianello, 661-326-3715, AChianel@bakersfieldcity.us
- Statewide Information
  - Department of Water Resources: https://sgma.water.ca.gov/portal/
  - State Water Resources Control Board: https://www.waterboards.ca.gov/water_issues/programs/gmp/sgma.html

UPCOMING REGIONAL WORKSHOPS

- Groundwater Quality Roundtable – October 3, 2018
- Groundwater Workshop 2.0 – October 27, 2018

Sponsored by Self Help Enterprises, Leadership Counsel for Justice and Accountability, Community Water Center, and Union of Concerned Scientists

More information is available at the back table

THANK YOU!

Agencia de Manejo Sostenible de Agua Subterránea de Kern River

Taller de Agua Subterránea

20 de Agosto 2018

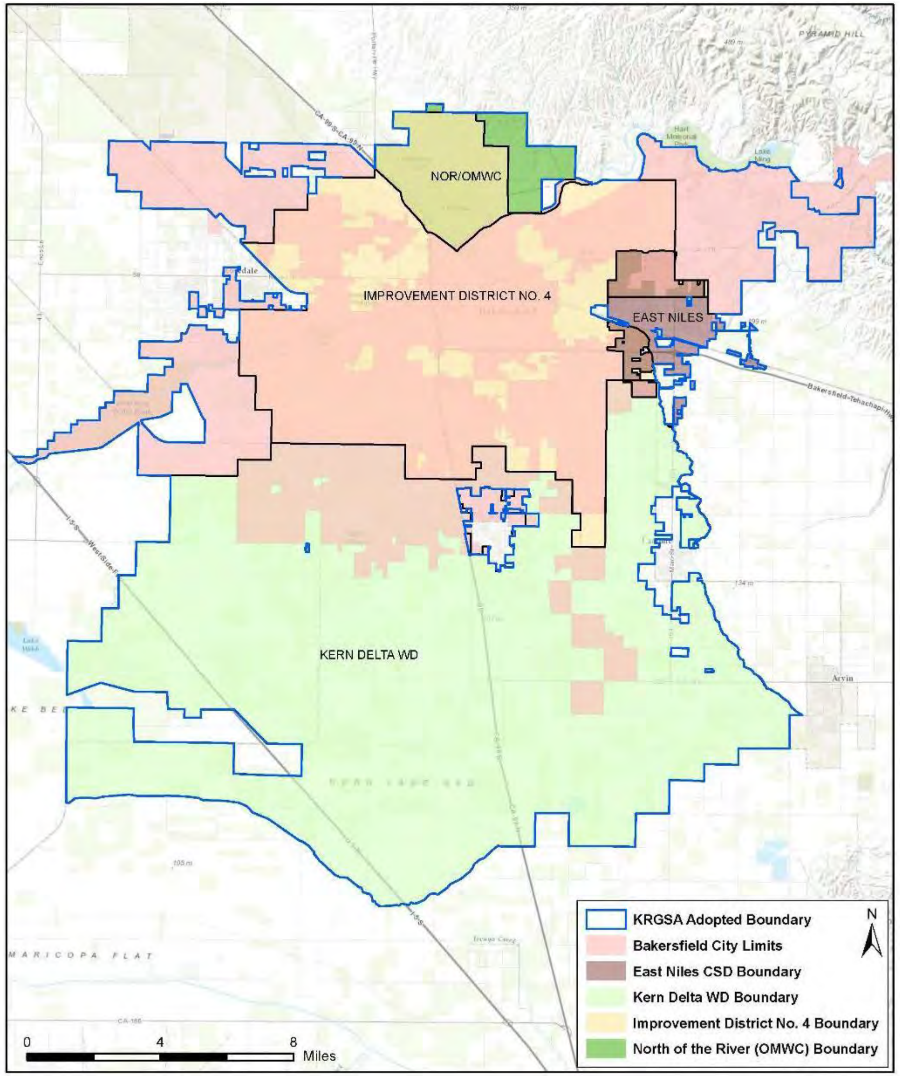
Horizon WATER and ENVIRONMENT

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Self-Help Enterprises

AGENCIA DE MANEJO SOSTENIBLE DE AGUA SUBTERRÁNEA DE KERN RIVER (KRGSA)



Miembros de la Kern River GSA

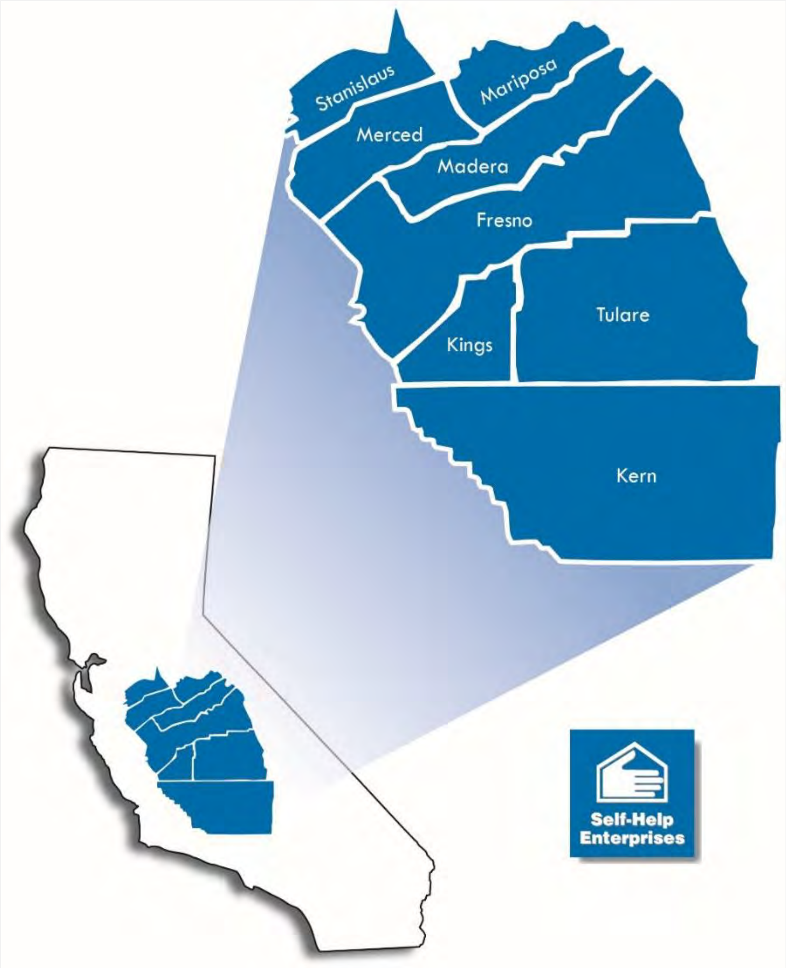
- Cuidad de Bakersfield
- Agencia de Agua del Condado de Kern – Distrito de Mejora No. 4
- Distrito de Agua de Kern Delta

Comunidades dentro de la GSA

- Edison
- Fuller Acres
- Oildale
- Oil Junction
- Rexland Acres
- Weedpatch
- Lamont (pequeña porción del norte solamente)

SELF-HELP ENTERPRISES (SHE)

- SHE es una organización de vivienda y desarrollo comunitario reconocida a nivel nacional (organización sin fines de lucro) cuya misión es trabajar junto con familias de bajos ingresos para construir y mantener hogares y comunidades saludables.
- El Programa de Desarrollo Comunitario brinda asistencia técnica y desarrollo de liderazgo en comunidades rurales que enfrentan desafíos para proporcionar agua limpia, alcantarillado sanitario y otra infraestructura.
- El Equipo de Planeación y Participación de la Comunidad apoya la participación de la comunidad en la gestión regional del agua y la planificación de la sostenibilidad del agua subterránea, así como la capacidad y experiencia en la gestión del agua en las comunidades rurales.

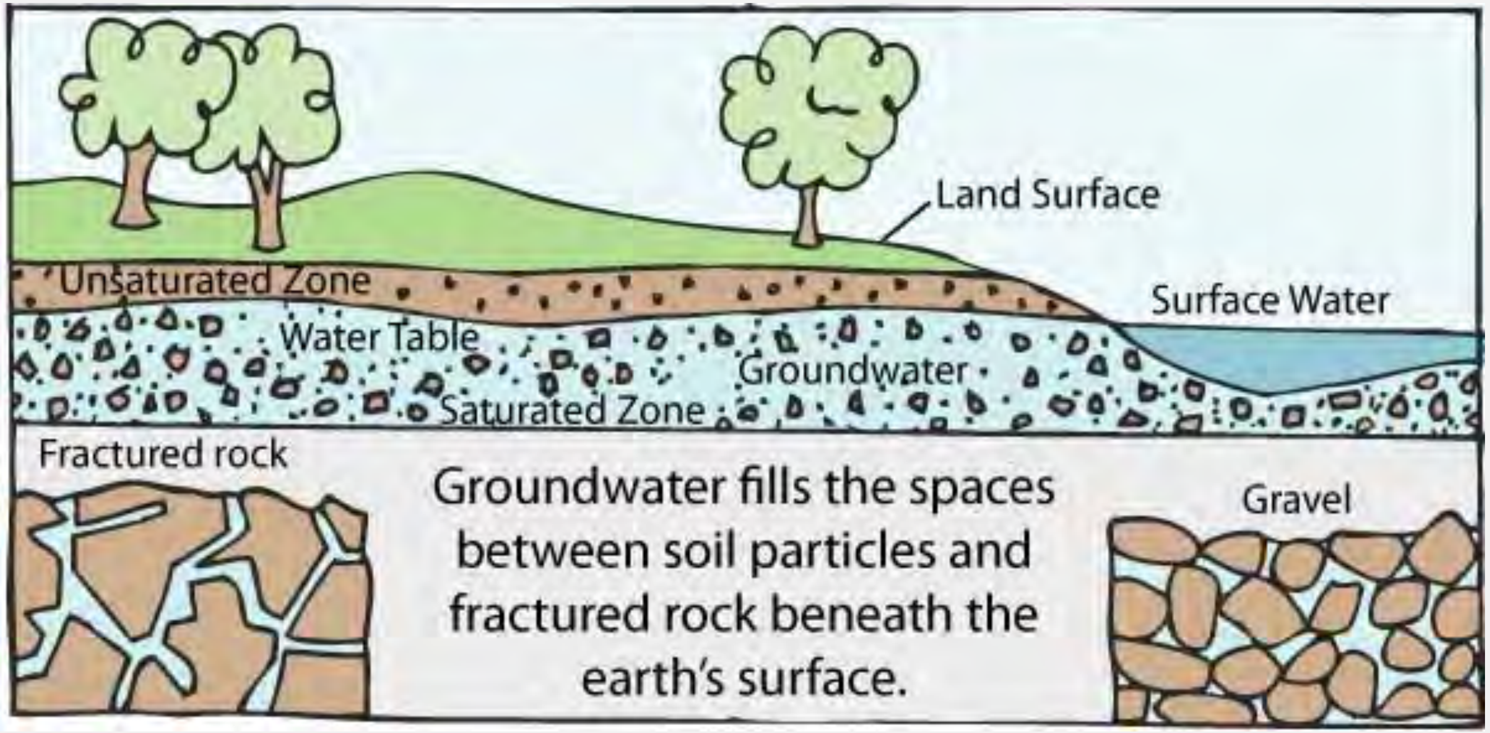


DESCRIPCIÓN GENERAL DEL TALLER

- Nueva Ley Estatal del Agua Subterránea: Ley del Manejo Sostenible del Agua Subterránea (SGMA)
- Planes de Sostenibilidad de Aguas Subterráneas (GSPs)
- Esfuerzos para Desarrollar el GSP de la KRGSA
- Comparta sus Pensamientos – Encuesta para las Partes Interesadas
- Palabras de Finalización y Cierre

IMPORTANCIA DE AGUA SUBTERRÁNEA

En promedio, California obtienen el 40% de su agua del agua subterránea. Durante las sequías, ese número puede llegar hasta el 60%.



- En el Valle Central, somos aún más dependientes del agua subterránea que el estado en general
- El 90% de los residentes de Central Valley dependen del agua subterránea para al menos parte de su suministro de agua potable
- La mayoría de las comunidades no incorporadas dependen en un 100% de las aguas subterráneas, e incluyen muchos de nuestros distritos escolares pequeños.

CÓMO LAS COMUNIDADES & LAS ESCUELAS UTILIZAN EL AGUA SUBTERRÁNEA

DESAFÍOS DEL AGUA SUBTERRÁNEA: ¿POR QUÉ LA LEY DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA?

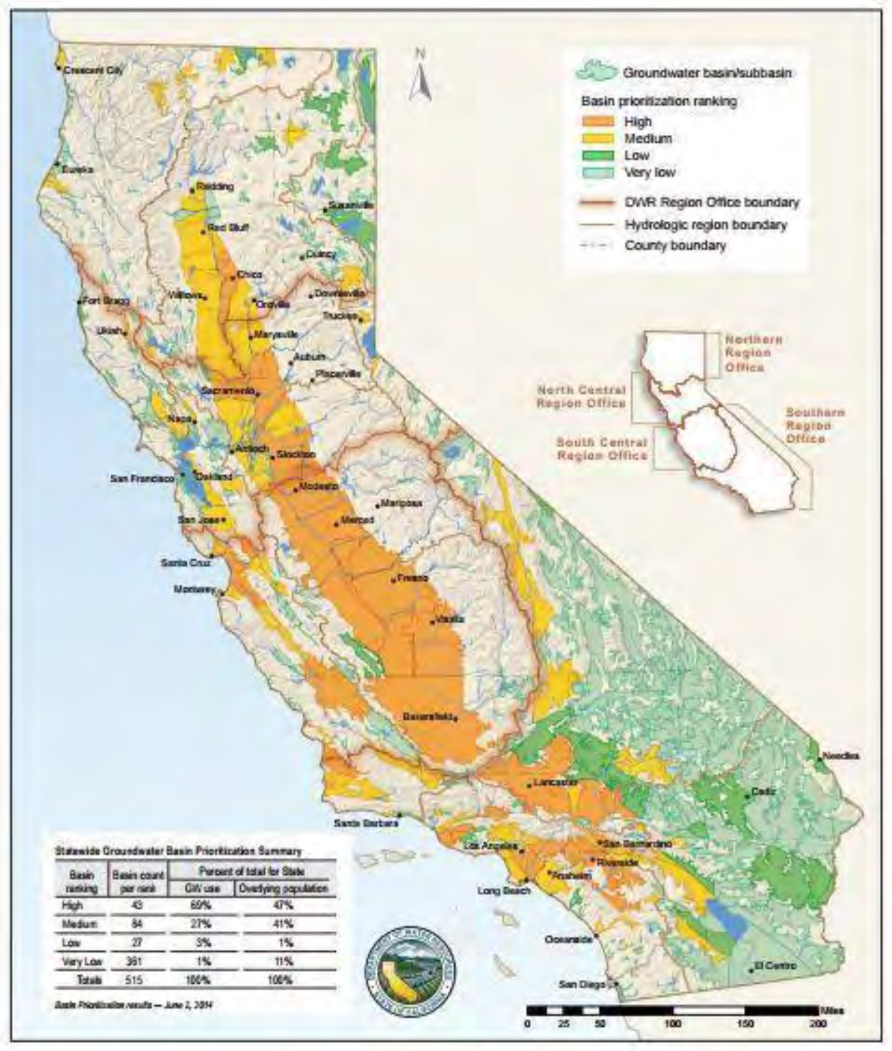
- Anteriormente, el manejo del agua subterránea era voluntaria en ciertas áreas del estado
- Los niveles de agua subterránea han disminuido debido al exceso de bombeo, las restricciones excesivas en las importaciones de agua de superficie y la falta de recarga
- La sequía (2012-2016) tuvo un impacto sin precedentes en nuestro estado.
- Pozos secos (por ejemplo: Arvin, área de Lamont y muchos otros)
- Hundimiento

LEY DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA DE CALIFORNIA (SGMA)

- Paquete de tres leyes: SB 1168 (Pavley), AB 1739 (Dickinson), SB 1319 (Pavley)
- Firmado por el Gobernador Brown el 16 de Septiembre de 2014
- Objetivo: Asegurar la confiabilidad a largo plazo de nuestros recursos de agua subterránea y los recursos hídricos superficiales conectados que requieren manejo "sostenible”
- Principio central: control local

PREVENIR LOS RESULTADOS INDESEABLES

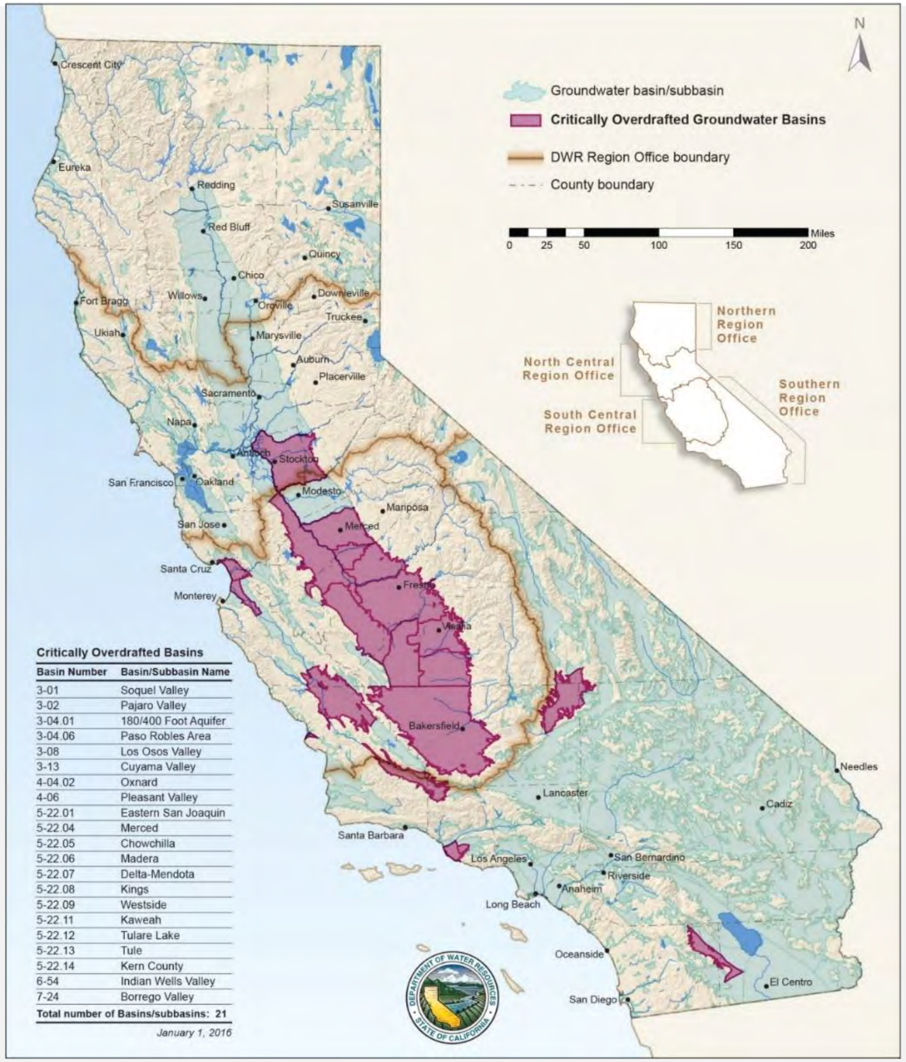
¿QUIÉN DEBE CUMPLIR CON SGMA?



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014



Critically Overdrafted Basins

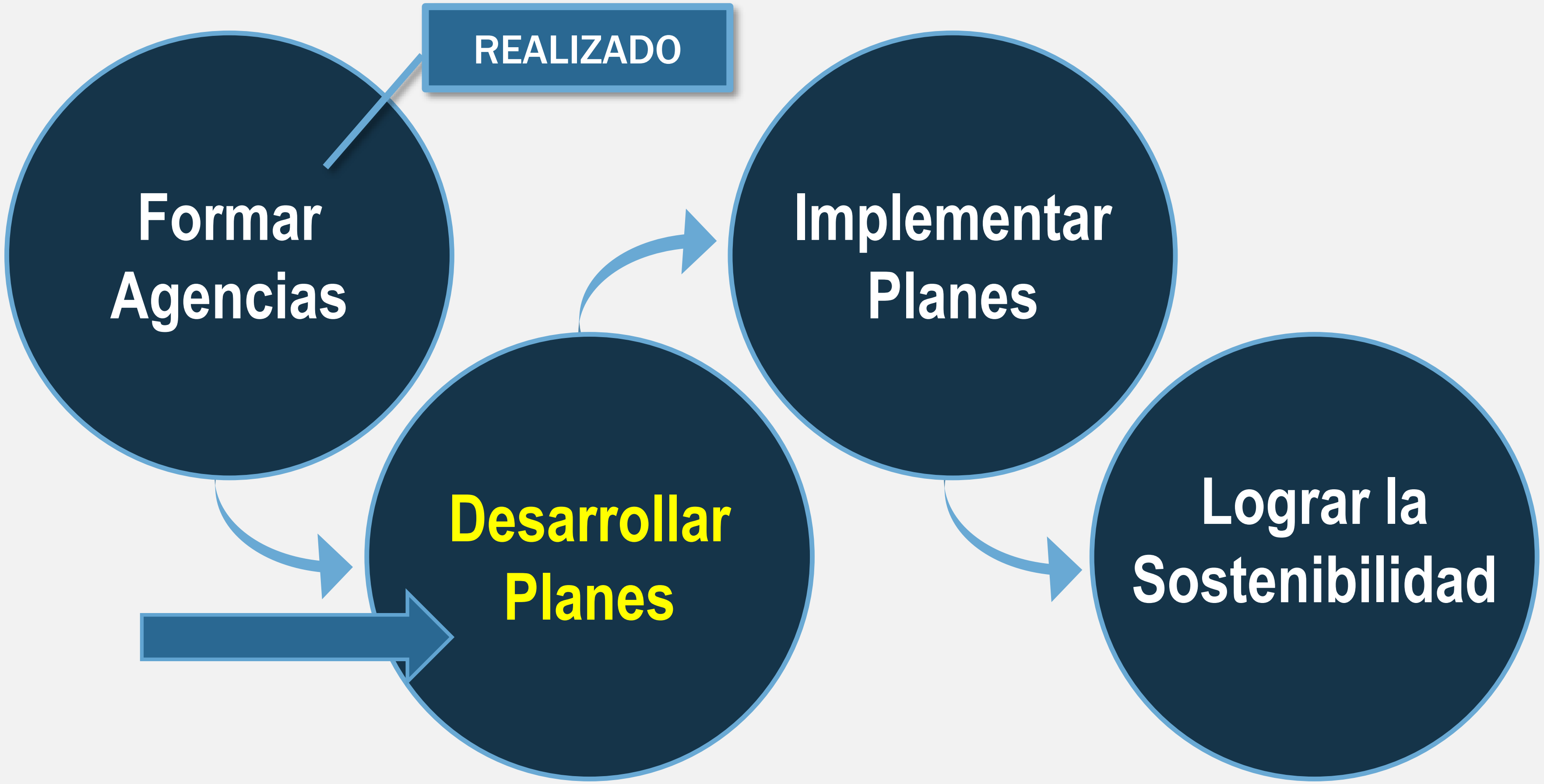
Basin Number	Basin/Subbasin Name
3-01	Soquel Valley
3-02	Pajaro Valley
3-04.01	180/400 Foot Aquifer
3-04.06	Paso Robles Area
3-08	Los Osos Valley
3-13	Cuyama Valley
4-04.02	Oxnard
4-06	Pleasant Valley
5-22.01	Eastern San Joaquin
5-22.04	Merced
5-22.05	Chowchilla
5-22.06	Madera
5-22.07	Delta-Mendota
5-22.08	Kings
5-22.09	Westside
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
6-54	Indian Wells Valley
7-24	Borrego Valley
Total number of Basins/subbasins: 21	

January 1, 2016

¿CUÁLES SON LOS INTERESES EN JUEGO?

- Titulares de derechos de aprovechamiento de agua subterránea (agricultura y doméstico)
- Sistemas de agua públicos
- Agencias locales de planificación del uso de la tierra
- Usuarios del agua subterránea para uso ambientales
- Usuarios de agua superficial
- Tribus de Nativos Americanos de California
- Comunidades de bajo ingresos, incluso las que reciben agua de pozos domésticos privados o pequeños sistemas de agua comunitarios

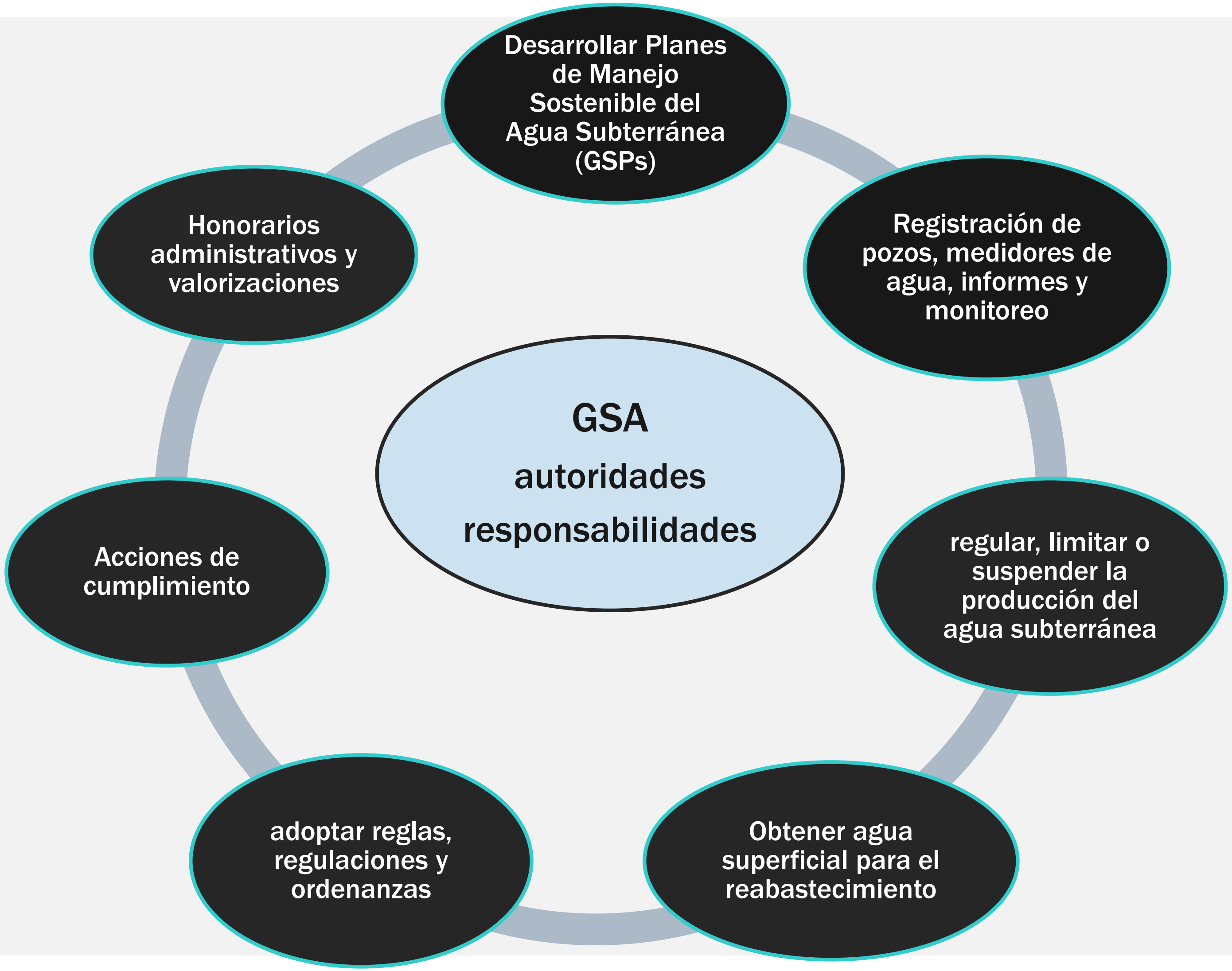
DISEÑO DE SGMA



MÚLTIPLES GSAS EN UNA SUBCUENCA

- Mas de una GSA se puede formar en una subcuenca
- Si existen múltiples GSAs en una subcuenca, las GSAs pueden colaborar para crear un plan único, o cada GSA puede crear su propio plan solo que las GSAs establecen un acuerdo de coordinación para implementar múltiples planes.
- Sin embargo, las GSAs deben cubrir toda el área de la subcuenca, sin dejar áreas sin gestionar
- Todas las GSAs fueron aprobadas en Julio 2018

¿QUÉ PUEDE HACER UNA GSA?



DESARROLLO DEL PLAN DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA

- Los GSPs deben incluir información importante:
  - Descripción del área del plan y la colocación del cuenca
  - Criterios de sostenibilidad de la cuenca
  - Programa de monitoreo y proyectos

- Los GSP servirán como una hoja de ruta para lograr la sostenibilidad dentro de 20 años

- Las GSAs deben desarrollar los GSPs con la participación de las partes interesadas

ENVÍO DE GSP Y APROBACIÓN POR DWR

- Los GSPs deben ser escritos antes del **31 de enero 2020 (o 31 de enero 2022 si la cuenca no esta críticamente en exceso)**

- Determinaciones de DWR (Departamento de Recursos Hídricos)
  - Adecuado
  - No Adecuado
  - No Completo

- Si el Departamento de Recursos Hídricos decide que el GSP **no gestionara de forma sostenible las aguas subterráneas antes del 2040 (o 2042 si la cuenca no esta críticamente en exceso)**…

→ **<u>El Estado puede intervenir y administrar la subcuenca en sí!</u>**

Mucho mas costoso
Menos control local

IMPLEMENTACIÓN DE GSP Y LOGRO DE SOSTENIBILIDAD

- Después de presentar su GSP, una GSA tiene 20 años para alcanzar la sostenibilidad
  - **La sostenibilidad debe alcanzarse para 2040 (2042 para áreas que no están críticamente en exceso)**
- DWR revisará todos los planes cada cinco años para evaluar el progreso y recomendar acciones correctivas según sea necesario
- Reportes Anuales

PREGUNTAS Y RESPUESTAS

PLANES DE SOSTENIBILIDAD DE AGUAS SUBTERRÁNEAS

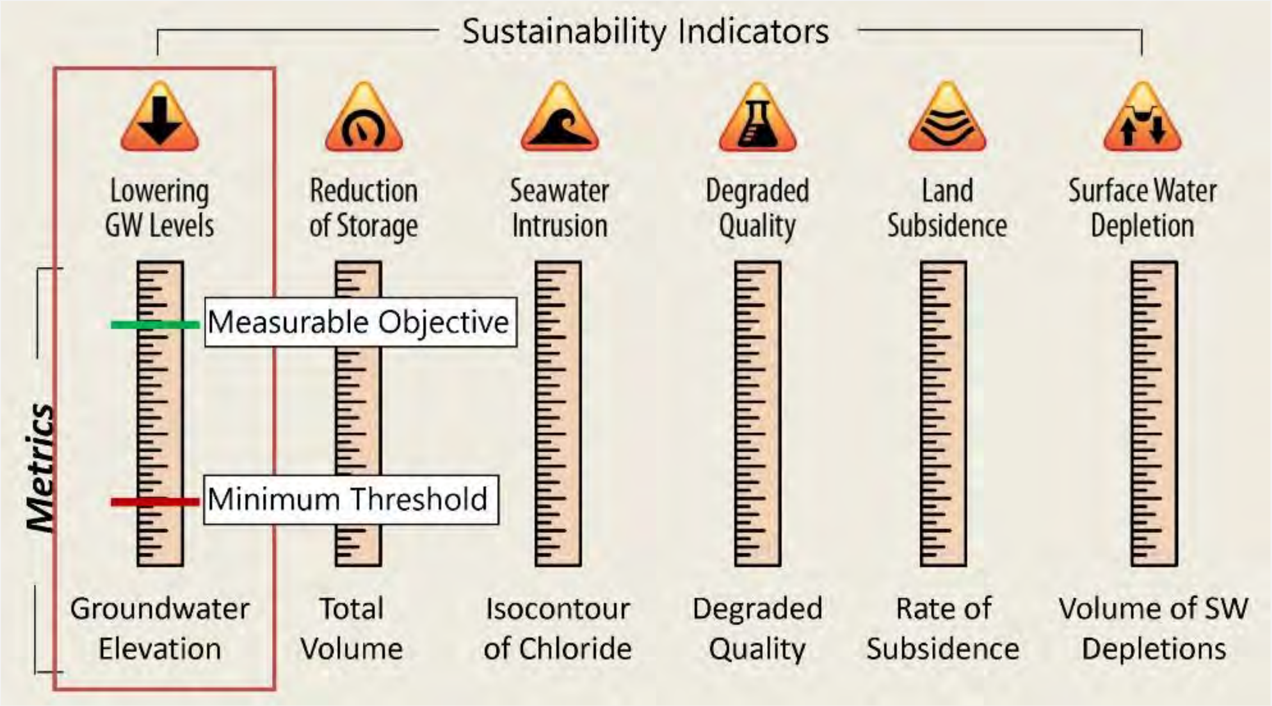
1. **Descripción del área del plan y la configuración de la cuenca:** Aguas subterráneas, presupuesto hídrico, modelo conceptual hidrogeológico, áreas de manejo
2. **Criterios de sostenibilidad:** establecer un objetivo de sostenibilidad, establecer umbrales mínimos para resultados indeseables, establecer objetivos medibles
3. **Proyectos y acciones de gestión:** proyectos, acciones de manejo, medidas de mitigación, plan de monitoreo

PRESUPUESTOS DE AGUA

CRITERIOS DE SOSTENIBILIDAD
OBJETIVOS MEDIBLES Y UMBRALES MÍNIMOS

Prevenir "resultados indeseables que son significativos e irrazonables“

En este momento, el único resultado indeseable del que podemos estar seguros no se aplica al área de Kern River GSA es la intrusión de agua de mar



LA SOSTENIBILIDAD SE DEFINE LOCALMENTE

- SGMA requiere que la GSA define la sostenibilidad utilizando dos conceptos:
  - **Objetivos Medibles** son metas aspiracionales. Técnicamente, deberías alcanzarlos para 2040 (o 2042 si no es cuenca críticamente en exceso).
  - **Umbrales Minimos** deben ser evitados Si se cruzan, puede estar fuera del cumplimiento de su plan y violar la obligación de alcanzar la sostenibilidad.

PRINCIPIOS GENERALES - OBJETIVOS MEDIBLES Y UMBRALES MÍNIMOS

- No se puede dañar la sostenibilidad en una cuenca vecina
- No puede seguir estando en exceso a largo plazo
- No se puede agotar el agua superficial

ACCIONES Y PROYECTOS DE GESTIÓN

ESFUERZOS DE DESARROLLO PARA EL GSP DE KRGSA

GSAs Y GSPs EN LA SUBCUENCA KERN
(DESDE ABRIL 2018)

- **GSAs Que Prepararan su Propio GSP:**
  - Kern River GSA
  - Kern Groundwater Authority
  - Buena Vista Water Service District GSA
  - Henry Miller Water District GSA
  - Olcese Water District GSA
- **GSAs Que No Han Formalizado Sus Planes Para Preparar Su GSP:**
  - City of McFarland GSA
  - Greenfield County Water District GSA

GSP VISION EN CONJUNTO

Recopilación de datos / Datos
Sistema de gestión

Entorno institucional -Área de abastecimiento de agua / plan

Modelo hidrogeológico conceptual/agua subterránea

Presupuesto de agua
(actual e histórico)

Objetivos de sostenibilidad y Criterios

¿Escenarios de gestión?
Presupuesto de agua proyectado

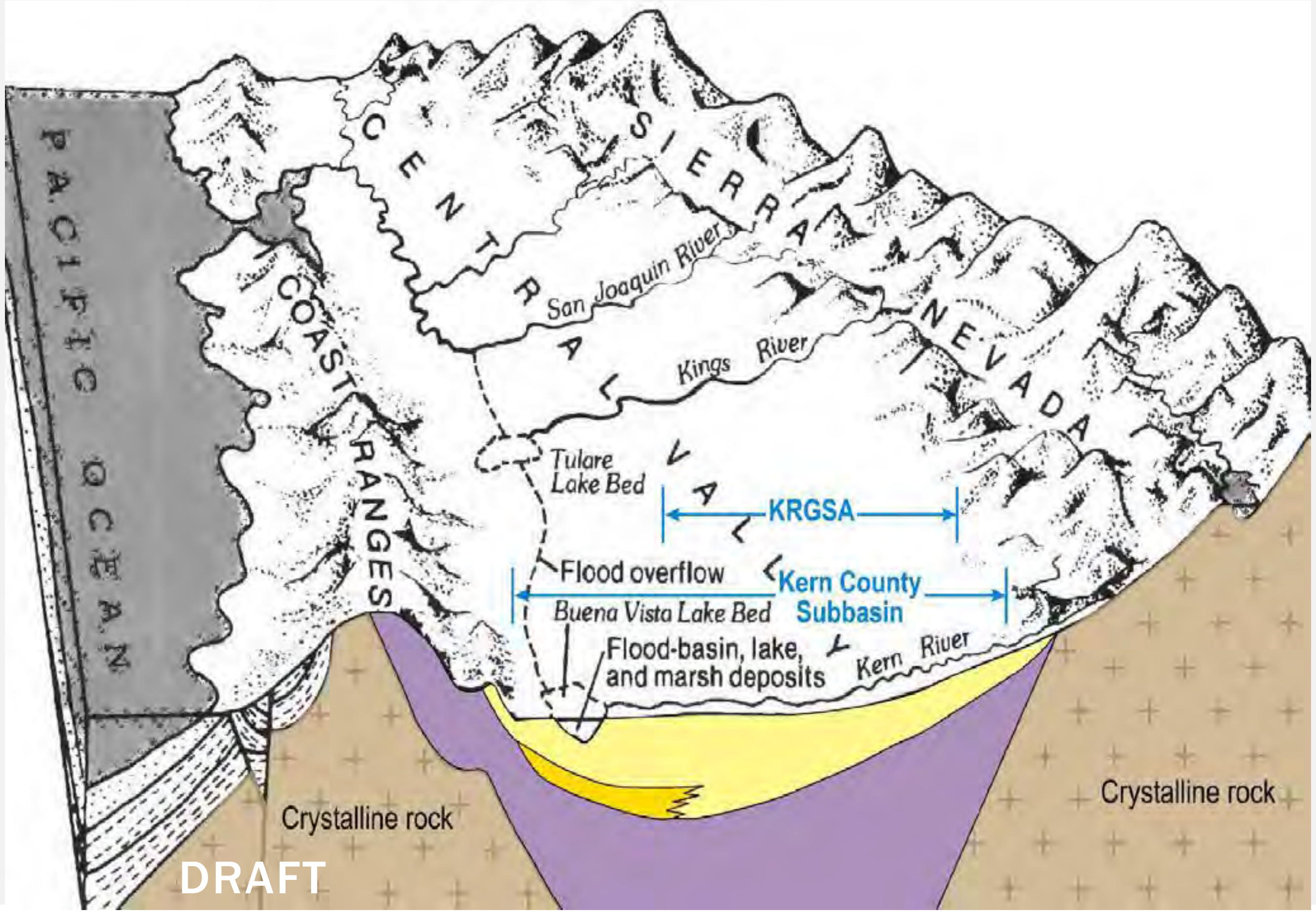
Redes de monitoreo
Plan de desarrollo

Modelo conceptual hidrogeológico, condiciones de aguas subterráneas y presupuestos hídricos informan colectivamente el análisis de sostenibilidad

DRAFT

TODD
GROUNDWATER

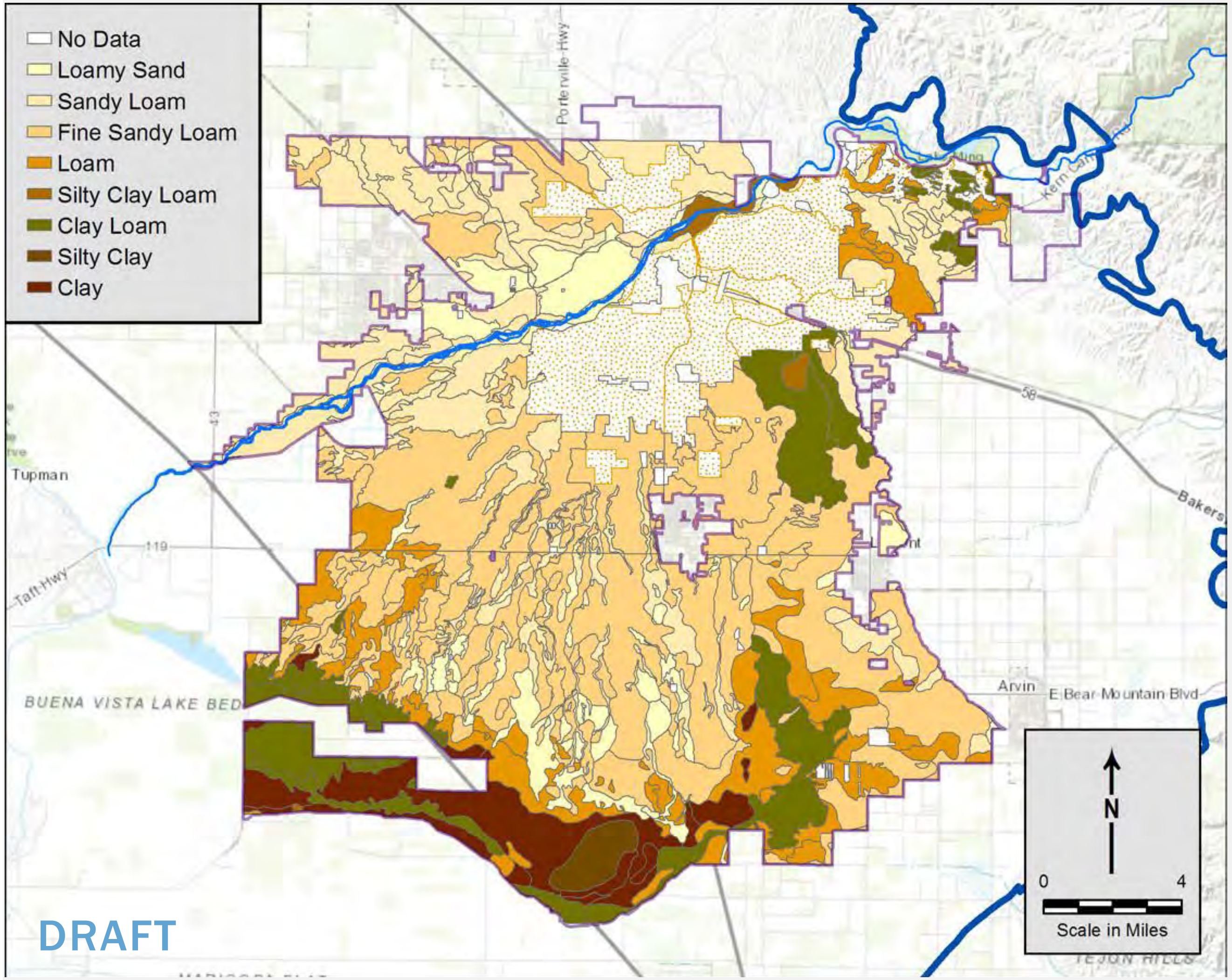
CONFIGURACIÓN HIDROGEOLÓGICA CONCEPTUAL SUBCUENCA DEL CONDADO DE KERN



- Canal lleno de aluviones entre Sierra Nevada y Coast Ranges
- Subyacente por unidades sedimentarias marinas más antiguas
- Flanqueado por un lecho de roca cristalino

TODD GROUNDWATER

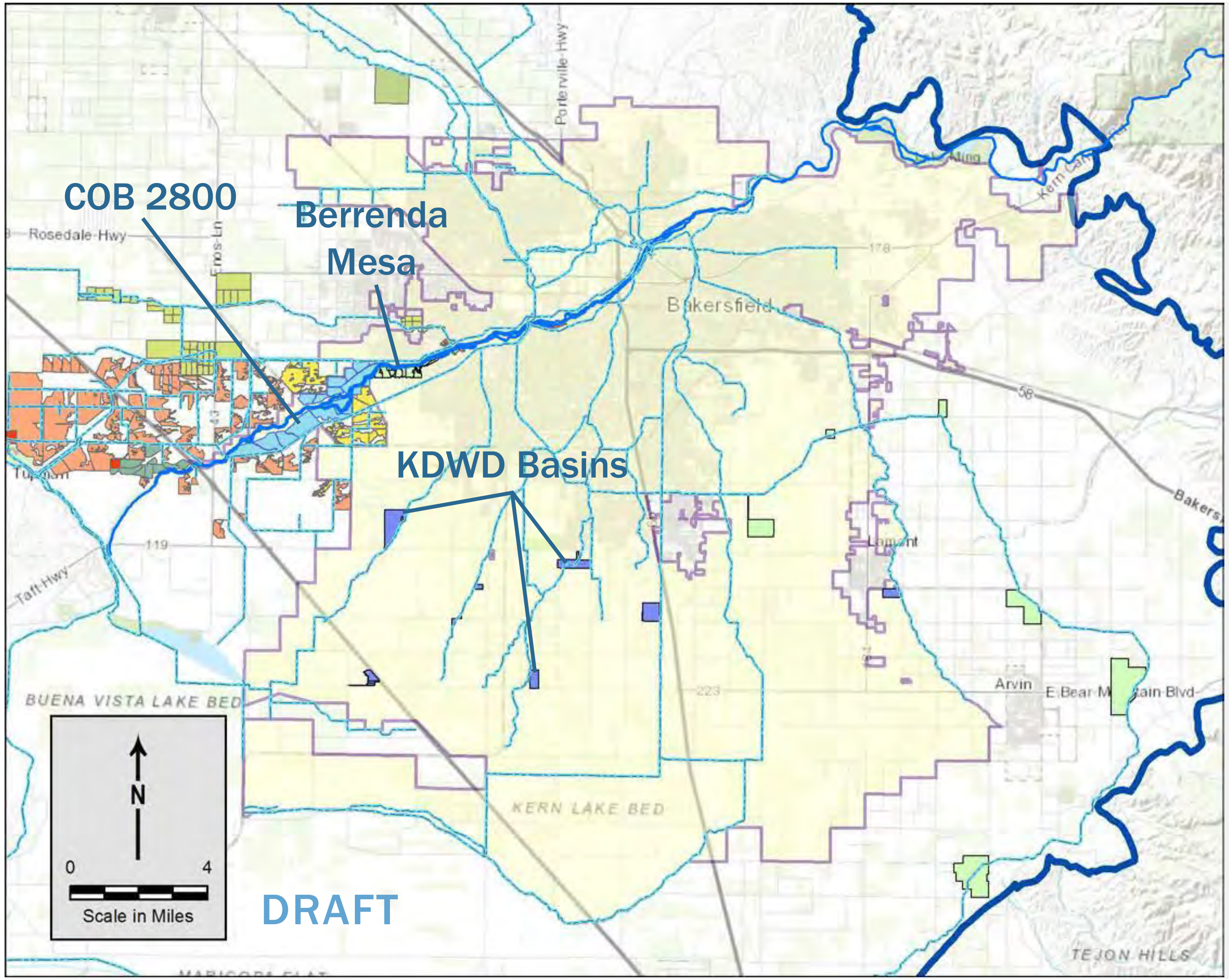
TEXTURAS DEL TIERRA



- Texturas más permeables indicadas por colores más claros (blanco, amarillo, naranja claro)
- Las texturas de baja permeabilidad indicadas por naranja oscuro, verde y marrón
- Las texturas del suelo concuerdan bien con el marco geológico

TODD GROUNDWATER

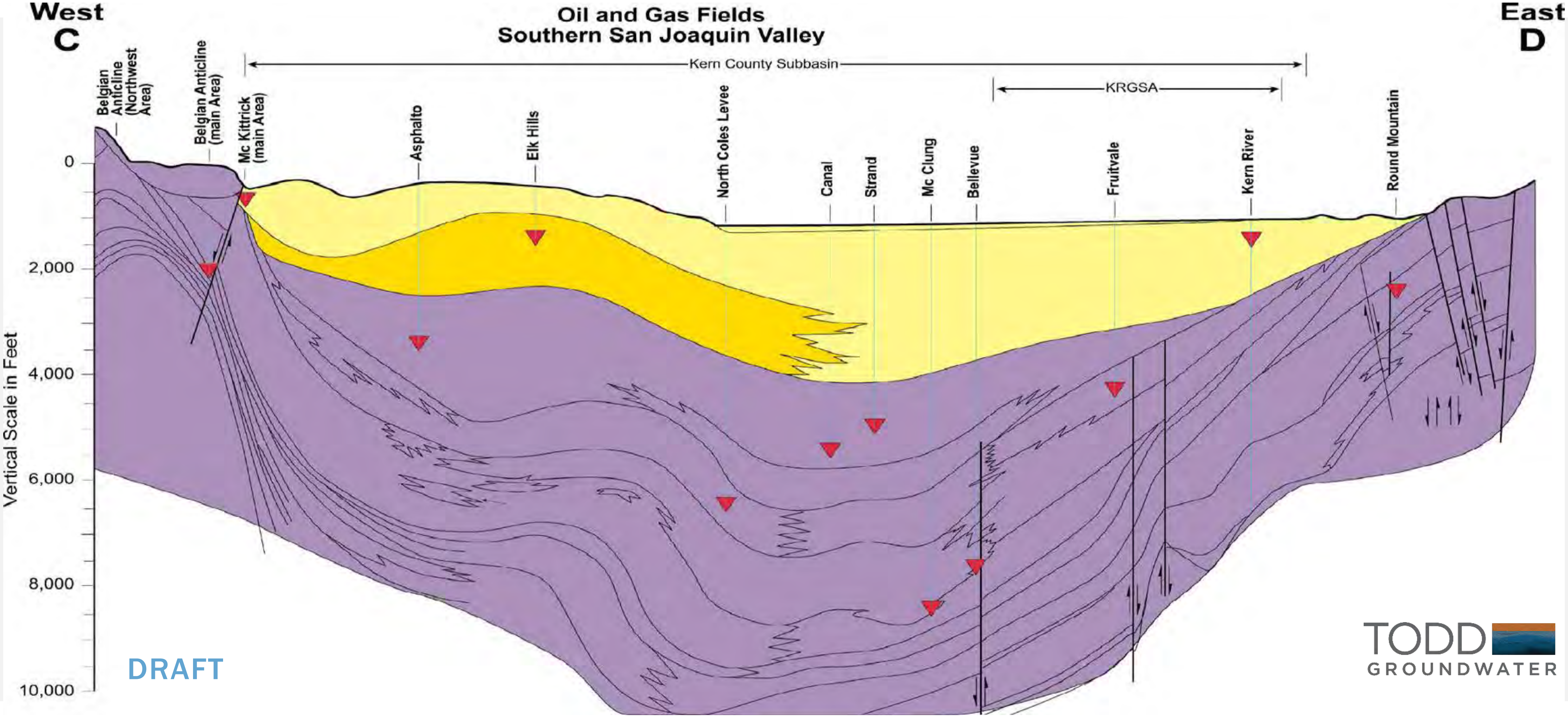
CANALES Y CUENCAS DE RECARGA



- Recarga administrada en el canal del río, canales sin revestimiento y cuencas
- Proyectos de banca de aguas subterráneas KRGSA:
  - COB 2800 Acres
  - KCWA Berrenda Mesa
  - KDWD Proyecto Metropolitano
- Numerosos proyectos bancarios adicionales cerca

TODD GROUNDWATER

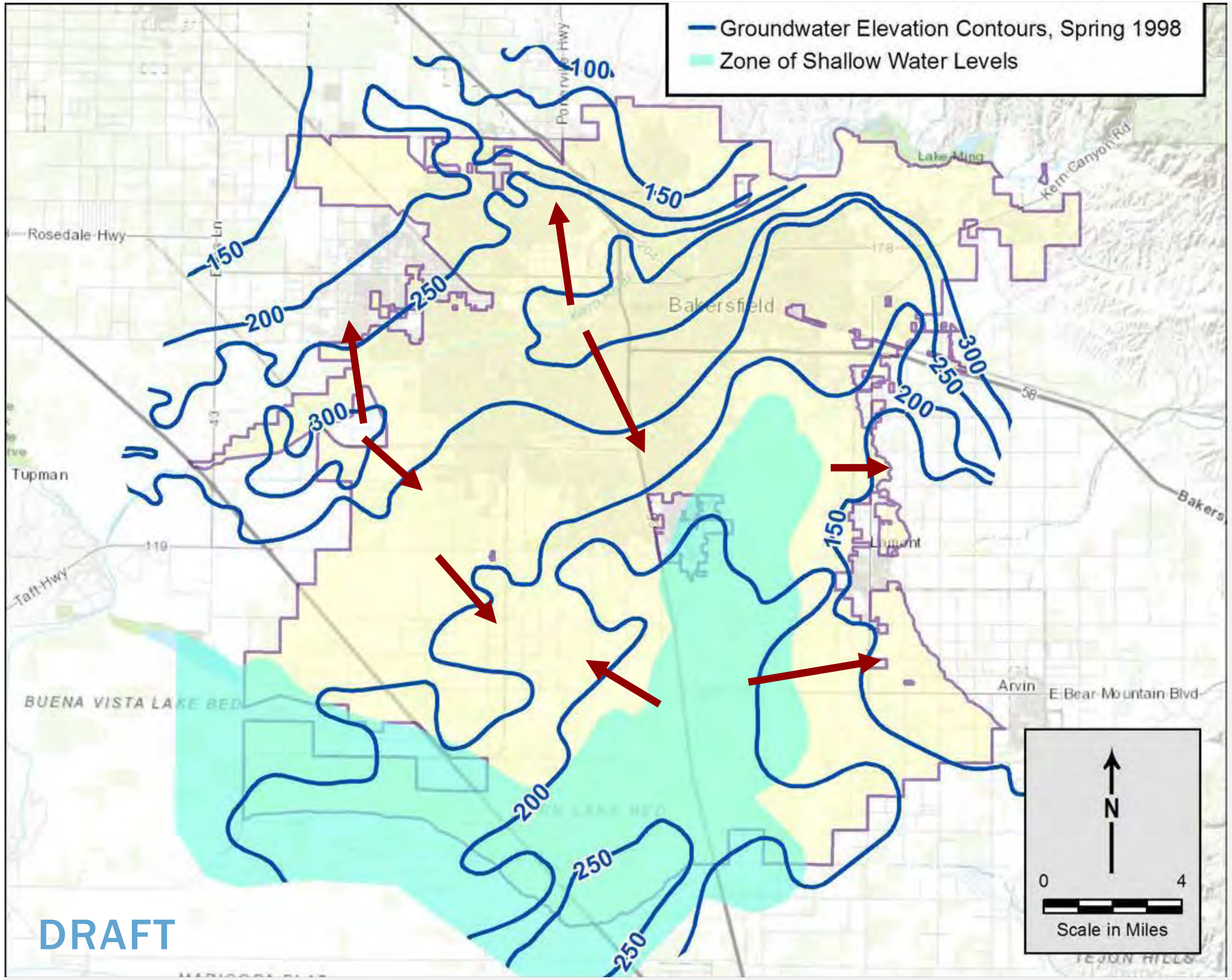
SECCIÓN REGIONAL Y YACIMIENTOS PETROLÍFEROS



DRAFT

TODD GROUNDWATER

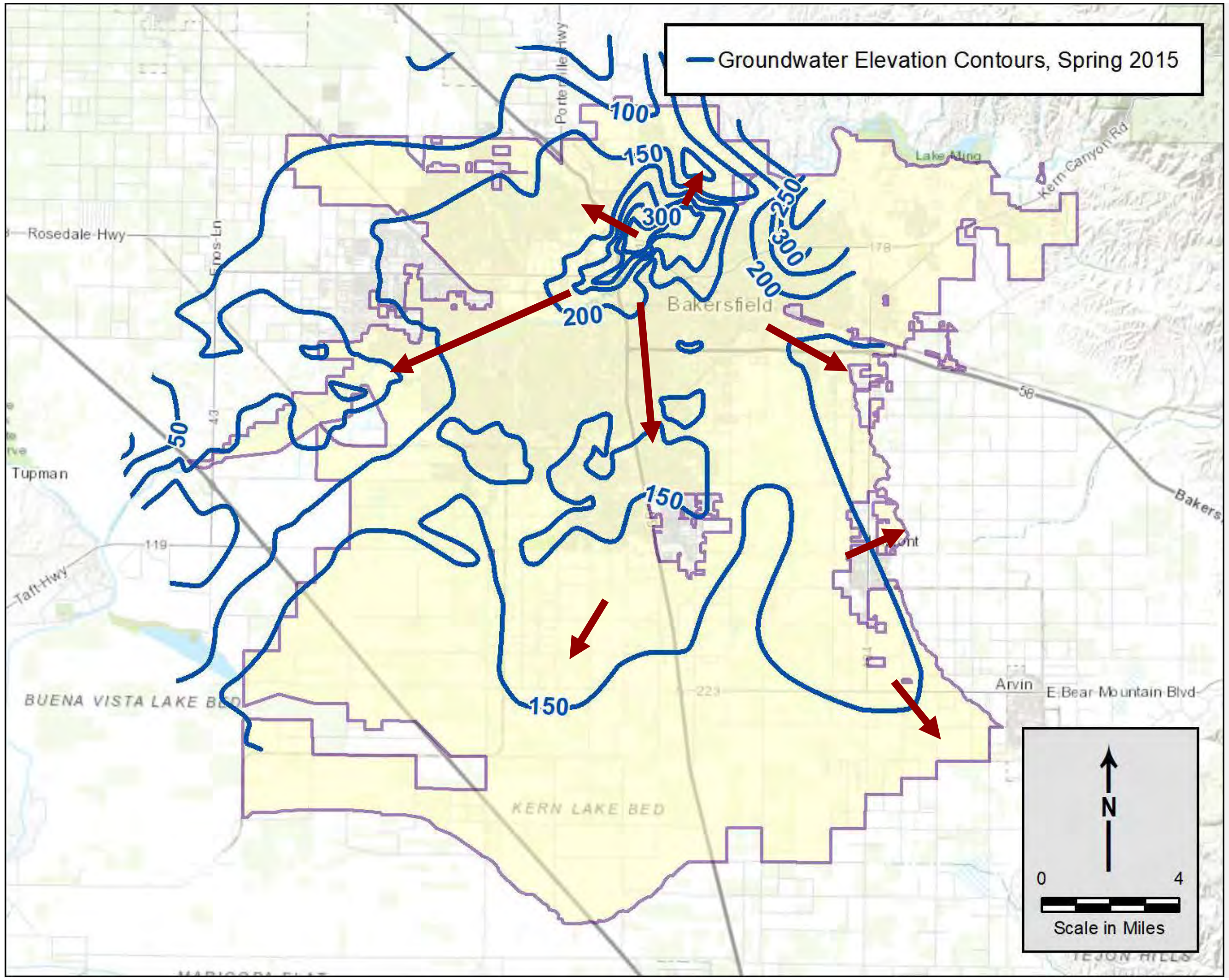
CONTORNOS DE ELEVACIÓN DEL AGUA SUBTERRÁNEA 1998



- 20 mapas de contorno de elevación del agua subterránea (datos de primavera)
- Mapas y datos examinados para capas encaramadas (zona de niveles de aguas poco profundas)
- Ejemplo para el año lluvioso - Primavera de 1998

TODD GROUNDWATER

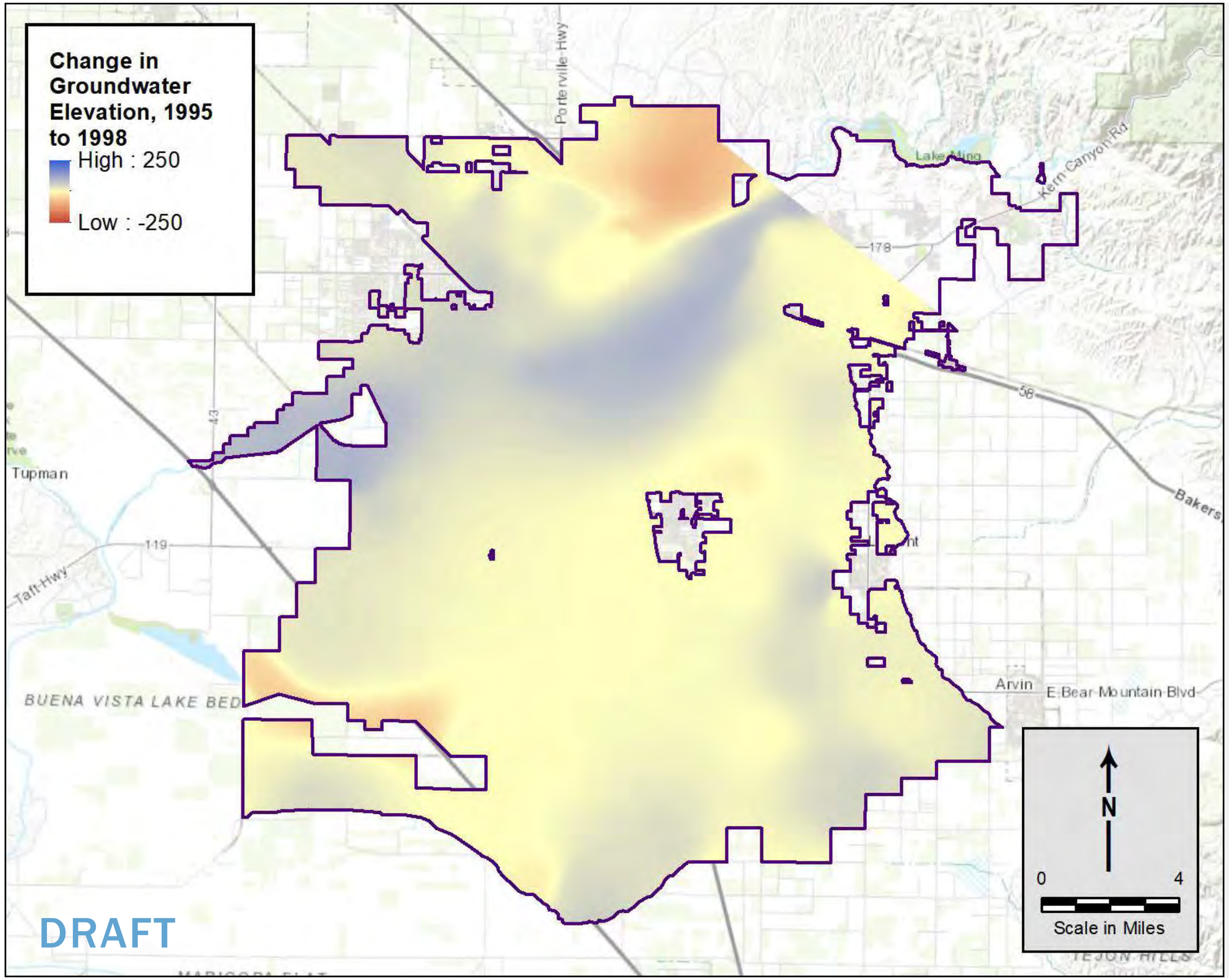
CONTORNOS DE ELEVACIÓN DE AGUA SUBTERRÁNEA 2015



- Año de sequía severa
- En general, niveles de agua más altos que las áreas circundantes
- Excepto por el río, el agua subterránea fluye fuera del área de KRGSA

TODD GROUNDWATER

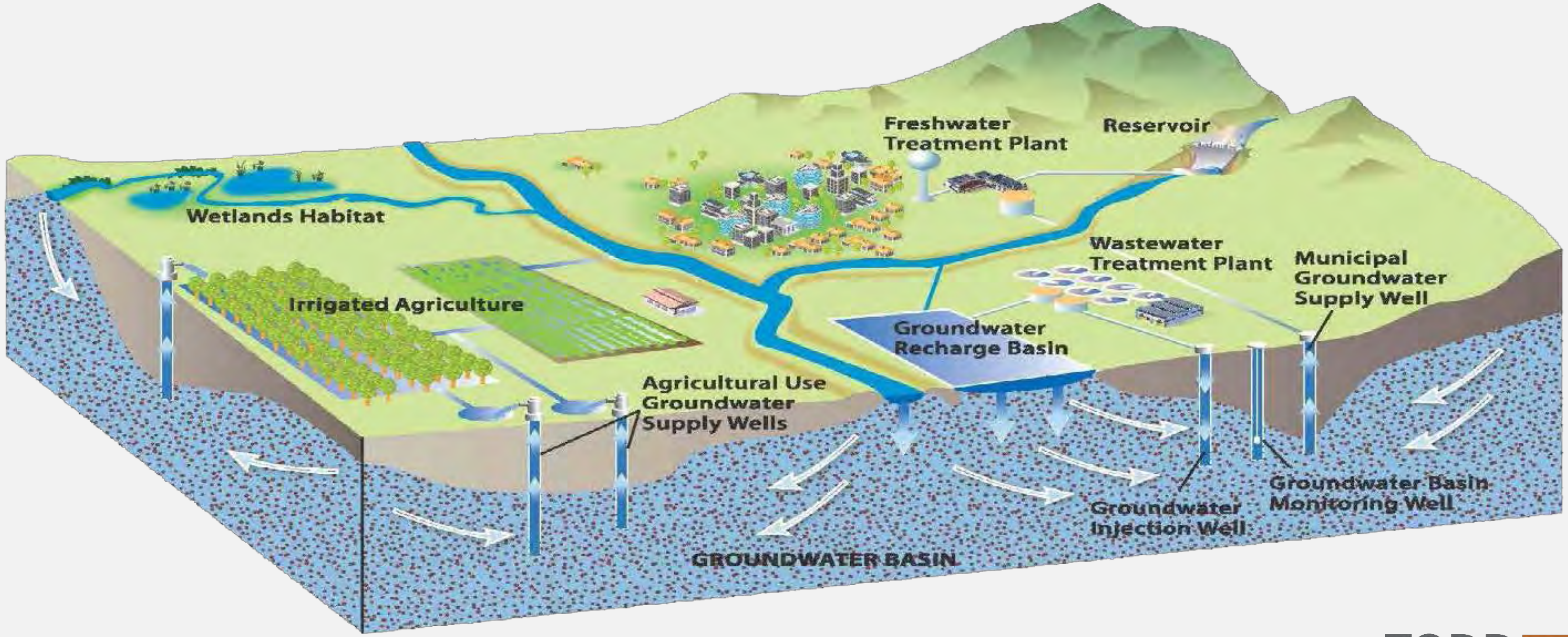
CAMBIO EN LAS AGUAS SUBTERRÁNEAS EN EL ALMACENAMIENTO, 1995-1998



- Se crearon 20 mapas anuales de cambio de nivel de agua utilizando los mapas de contorno de nivel de agua de KCWA Spring
- Las áreas azules indican un aumento en el nivel del agua; las áreas rojas indican una disminución del nivel de agua
- Los datos limitados crean incertidumbre para algunas áreas y períodos de tiempo

TODD GROUNDWATER

FINALIZANDO EL PRESUPUESTO DE AGUA DE KRGSA



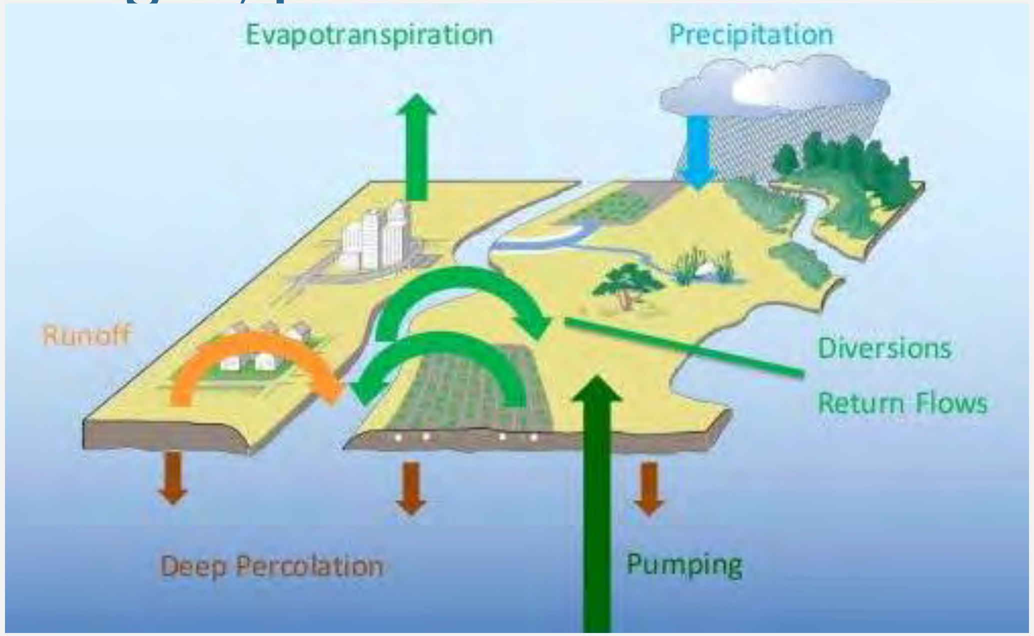
CA Water Foundation

DRAFT

TODD GROUNDWATER

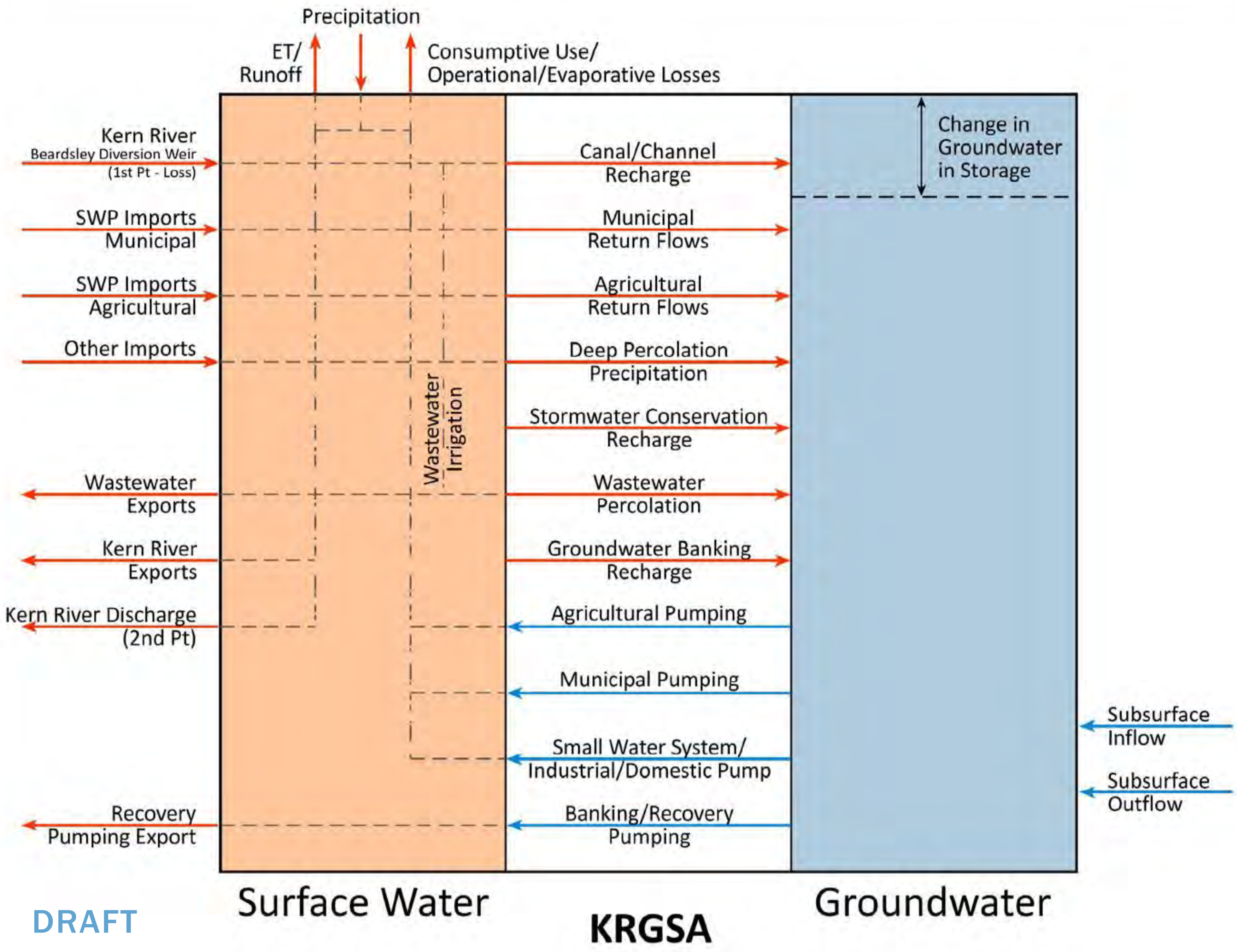
PRESUPUESTOS DE AGUA KRGSA - ENFOQUE

- El agua del Condado de Kern se administra en tiempo real para un uso óptimo
- Proporciona flexibilidad y optimización de agua, pero da como resultado una contabilidad compleja de moléculas físicas
  - Enfoque en el sistema físico
    - ¿A dónde va el "agua mojada"? (no intercambios de papel)
    - El proceso presupuestario del agua sigue las "moléculas": ¿no se le asigna "propiedad" al agua?
    - Evitar el "doble conteo"



DRAFT

TODD GROUNDWATER



DRAFT

COMPONENTES DE PRESUPUESTO COMBINADO DE AGUA DE KRGSA

TODD GROUNDWATER

PROXIMOS PASOS

- Trabajar con agencias para conciliar datos y presupuestos locales de agua
- Compilar para KRGSA
- Formato de conjuntos de datos para el modelo

Horizon WATER and ENVIRONMENT

TODD GROUNDWATER

PREGUNTAS Y RESPUESTAS

PARTICIPE EN EL DESARROLLO DEL GSP

Puede ayudar a dar forma a lo que está incluido en el planificar por :

- Proporcionar información sobre sus desafíos de agua subterránea pasados o presentes
- Compartir información sobre su consumo de agua y / o pozo
- Compartiendo su visión para la sostenibilidad
- Identificar proyectos que pueden ayudar a abordar las condiciones del agua subterránea
- Completando la Encuesta de Parte Interesada

ENCUESTA DE PARTES INTERESADAS

Queremos escuchar de ti!

- ¿Qué sabes sobre SGMA?
- ¿Cómo se usa el agua?
- ¿Qué más deberíamos saber?

MANTENTE INVOLUCRADO

- Asista a las reuniones de GSA
  - Las reuniones de la Mesa Directiva de KRGSA se llevan a cabo el último miércoles de cada mes a las 8 a.m. en 1600 Truxtun Avenue, Bakersfield, CA 93301.
- Ingrese en la lista de "partes interesadas" para recibir correspondencia e información de KRGSA
- Visita el sitio web para saber más: http://www.kernrivergsa.org/
- Asiste a talleres futuros

INFORMACIÓN ADICIONAL Y RECURSOS

- Asistencia técnica para comunidades severamente desfavorecidas
  - Self-Help Enterprises: https://www.selfhelpenterprises.org
    - Eva Dominguez, 559-802-1634, EvaD@selfhelpenterprises.org
    - Maria Herrera, 559-802-1676, MariaH@selfhelpenterprises.org
- Información Local– Kern River GSA: https://kernrivergsa.org
    - Art Chianello, 661-326-3715, AChianel@bakersfieldcity.us
- Información Estatal
  - Department of Water Resources: https://sgma.water.ca.gov/portal/
  - State Water Resources Control Board: https://www.waterboards.ca.gov/water_issues/programs/gmp/sgma.html

PRÓXIMOS TALLERES REGIONALES

- Discusión Sobre la Calidad de Agua Subterránea y la Ley de Manejo Sostenible del Agua Subterránea– October 10, 2018

- Taller Sobre el Plan del Manejo Sostenible del Agua Subterránea– October 27, 2018

Patrocinado por Self Help Enterprises, Leadership Counsel for Justice and Accountability, Community Water Center, y Union of Concerned Scientists

Más información está disponible en la mesa de atrás

GRACIAS!

Kern River Groundwater Sustainability Agency

KERN GROUNDWATER AUTHORITY

DRAFT

Kern County Subbasin C2VSim Modeling Update

October 26, 2018

TODD GROUNDWATER

Presentation Outline

- Objectives and Background
- Moving Data into the Model
- Current Model Performance
- Next Steps for Historical/Current Water budgets
- Proposed Projected Future Water Budgets

DRAFT

TODD GROUNDWATER

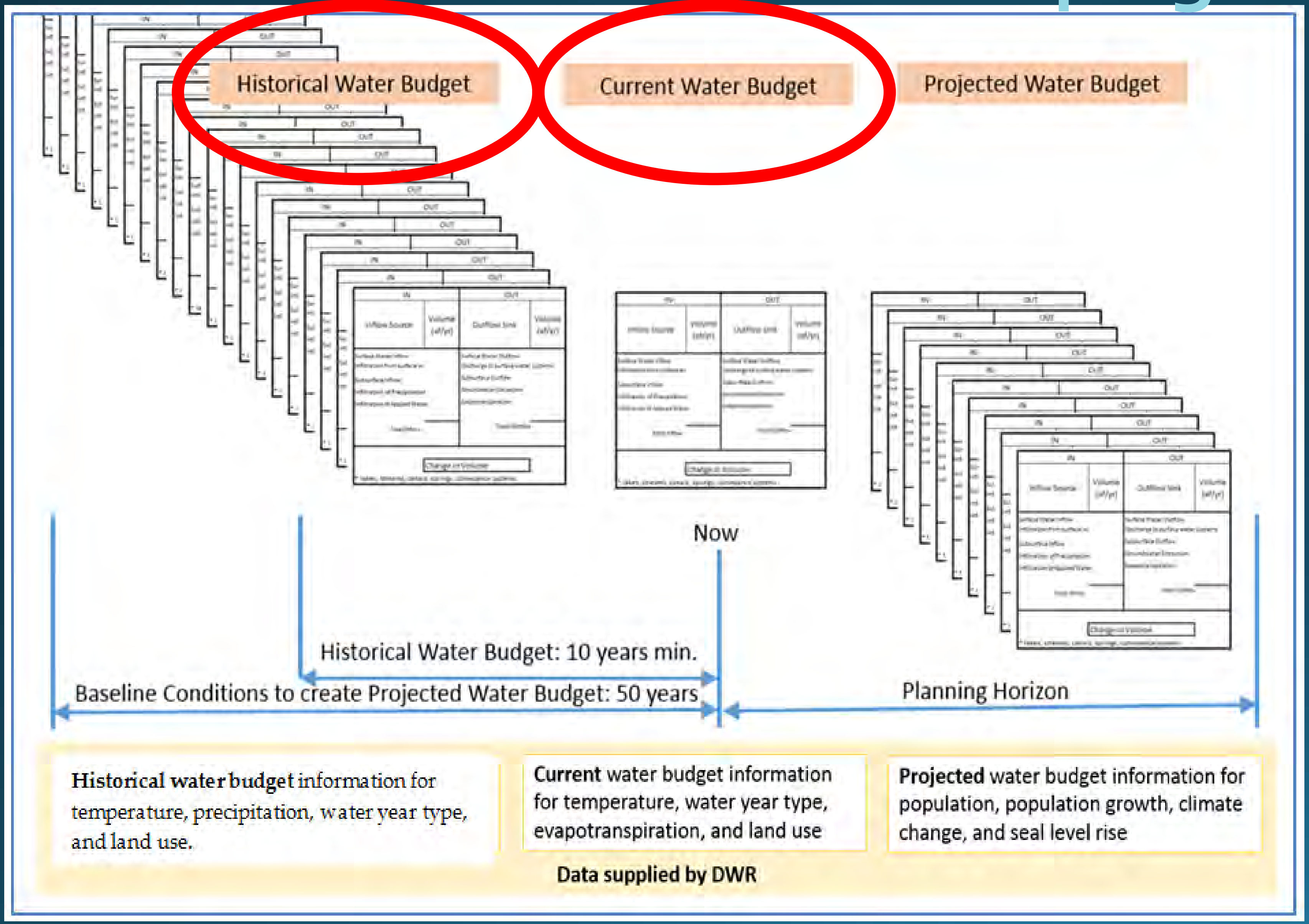
Acknowledgements

- C2VSim Model Team
  - Mike Maley – Todd Groundwater
  - Charlie Brush – Hydrolytics LLC (formerly with DWR)
- Peer Review Team
  - Saquib Najmus and Frank Qian, Woodard & Curran
- Data Gatherers
  - GEI compiled surface water data for KGA and others
  - Todd GW compiled data for KRGSA, Kern River and past modeling efforts
- KRGSA and KGA
  - Water Districts and Consultants
  - Terry Erlewine and Patty Poire

DRAFT

TODD GROUNDWATER

DWR Guidance for Developing Water Budgets



- Separate groundwater and surface water budget
- Consistent approach for all GSAs in the Subbasin
- For entire Subbasin with interactions with adjoining subbasins
- Tabular and graphical representation required by regulations

DRAFT

TODD GROUNDWATER

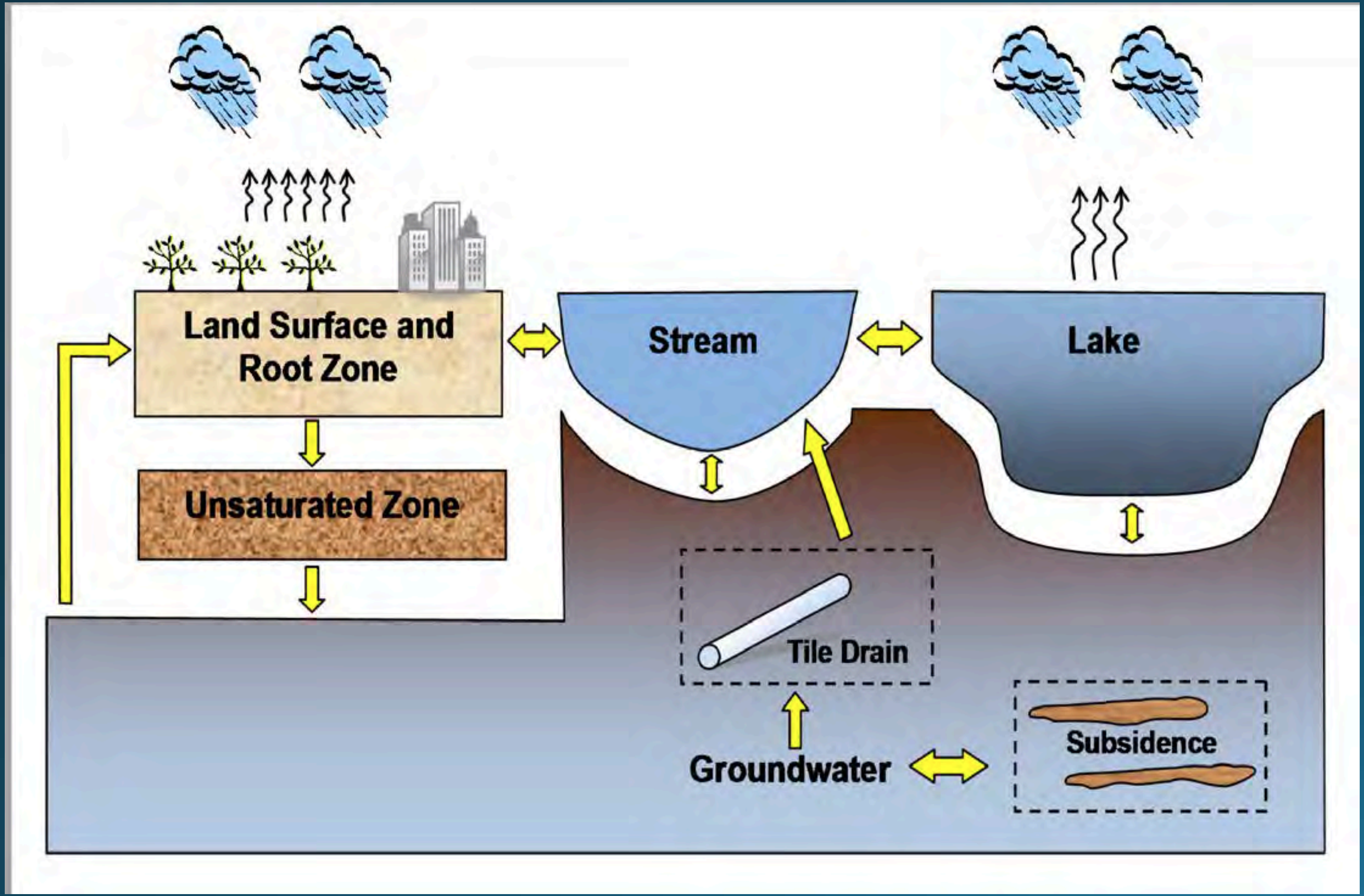
Keeping up with Summer Schedule

- NOW: completing initial model runs with priority components
- Late August: provide model to peer reviewer
- August – Sept: Internal QA/QC
- Sept – Oct: Identify, compile, and incorporate the lower-priority budget items; make corrections to existing data, as needed
- Early November – share results

C2VSim is a Regional Planning Model

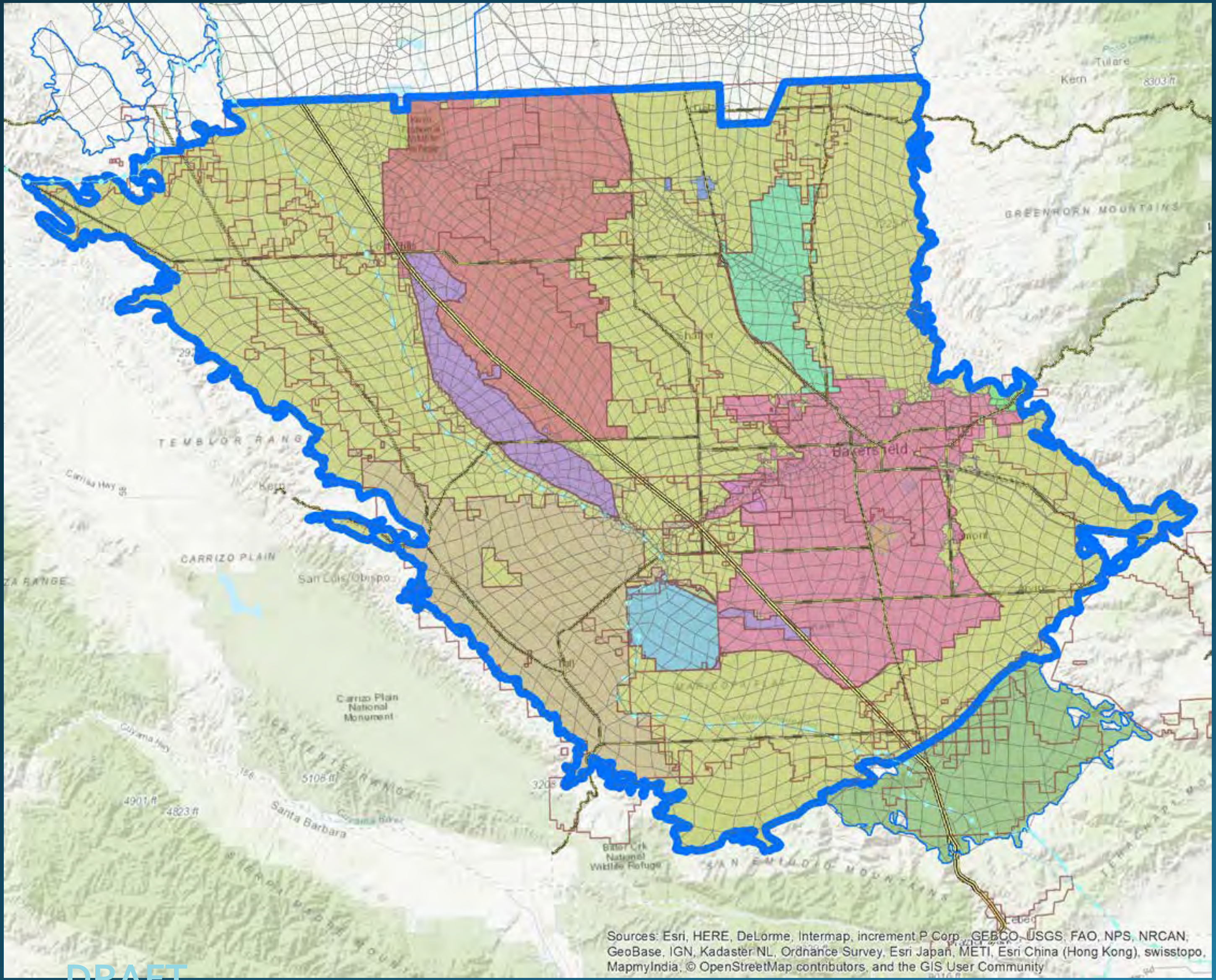
- C2VSim
  - Covers Entire Central Valley
  - Focus to support CVP/SWP Planning
  - Beta-Version released May to support SGMA
- Regional Planning Model for DWR
  - Regionalized data application and assumptions
- Kern County was not original focus
  - Lacks key data for groundwater banking and local water use

IWFM – Integrated Process-Based Model



- Model simulates key hydrological processes
  - Land Surface, Root Zone, and Unsaturated Zone
  - Surface water deliveries from rivers and canals
  - Groundwater flow
- Demand-driven model
  - Many control points
- Tracks water throughout the system
  - Need to understand water consumption and losses

Subbasin Water Budget - C2VSim Update



- Use C2VSim model for subbasin water budget analysis
- Update Managed Water Supply and Demand Data
  - Use local subbasin data
  - Focus on physical water
- Maintain current model structure (layers and properties)
- Retain general C2VSim data structure with Kern County Updates

TODD GROUNDWATER

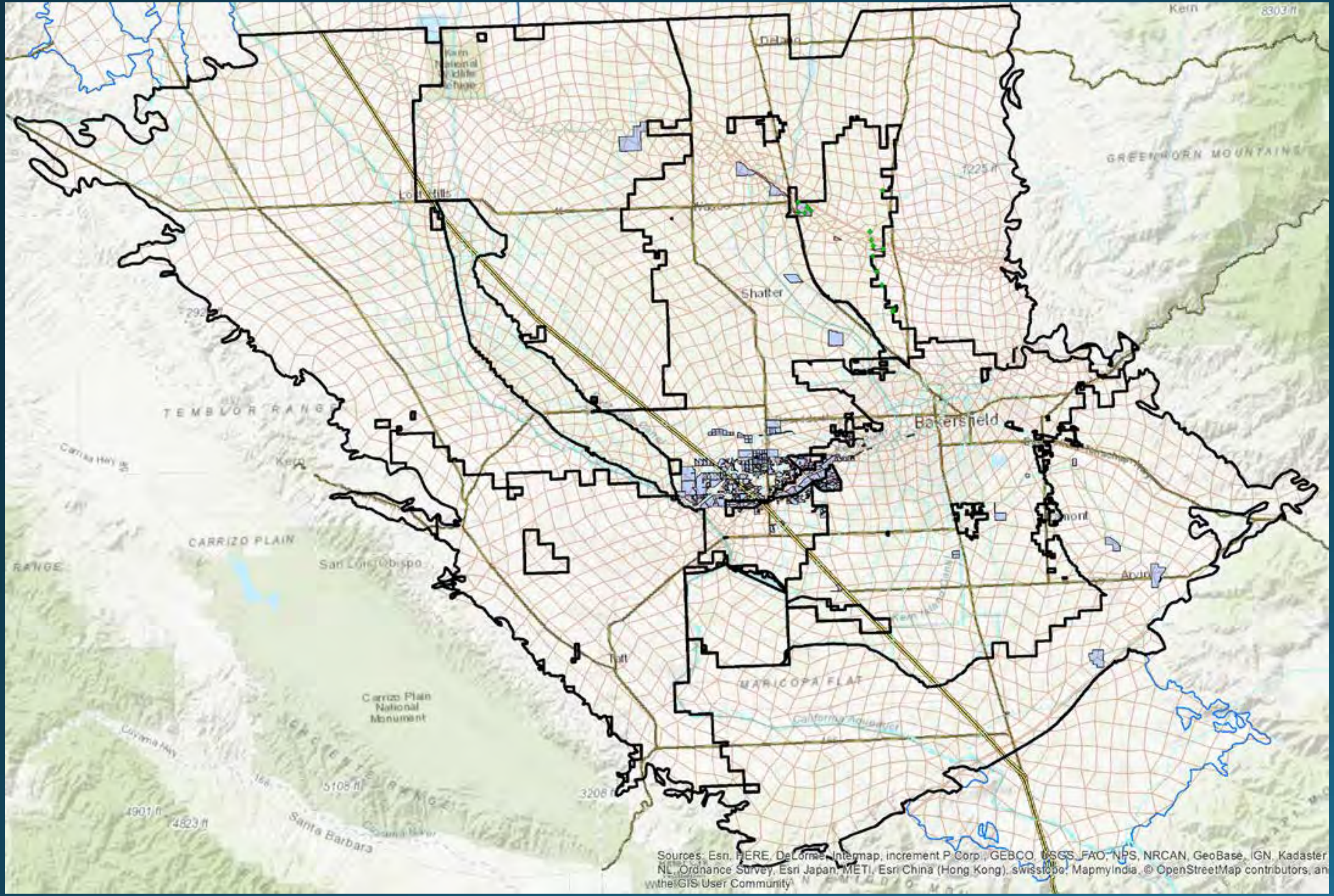
Phased Approach to Model Revisions

- Phase 1 – Data Input
  - Restructure model to incorporate new data
- Phase 2 – Updates and Beta-Version Revisions
  - Review and update new data - QA/QC
  - Revise Beta-version parameters affecting model performance
- Phase 3 – Local Revisions
  - Incorporate locally-significant data
  - Continue to improve model performance
- Draft Historical and Current Water Budgets for District Review
- Phase 4 – Revisions and Refinements
  - Provide water budget updates
  - Final water budgets for GSP

DRAFT

TODD GROUNDWATER

Working Collaboratively with Peer Reviewers

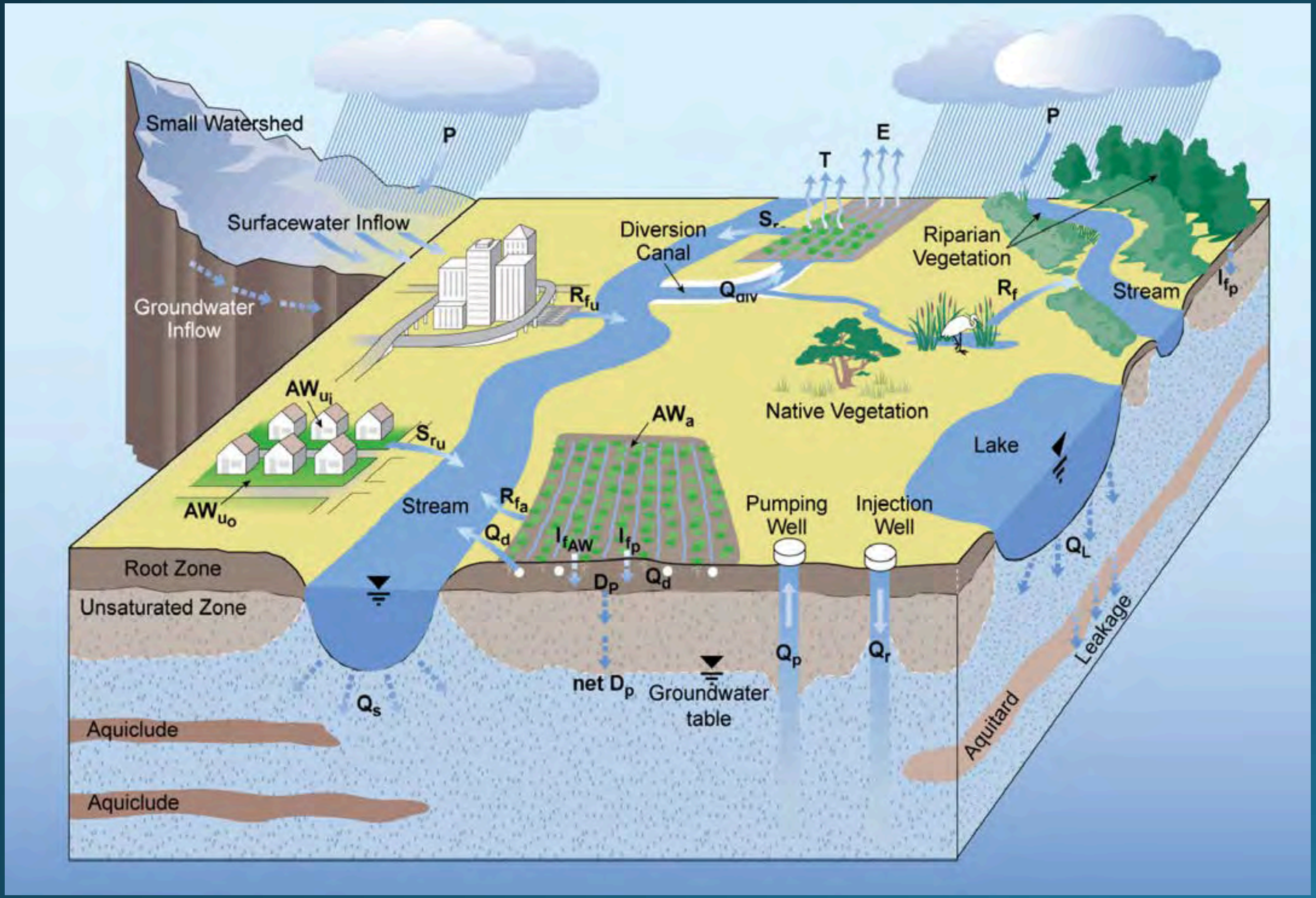


- Regular Meetings to Discuss Model Progress
  - Vet approach with experienced modelers
  - Working to resolve issues
- W&C reviewing data consistency and application in the model

DRAFT

TODD GROUNDWATER

Managed Water Supply and Demand Data

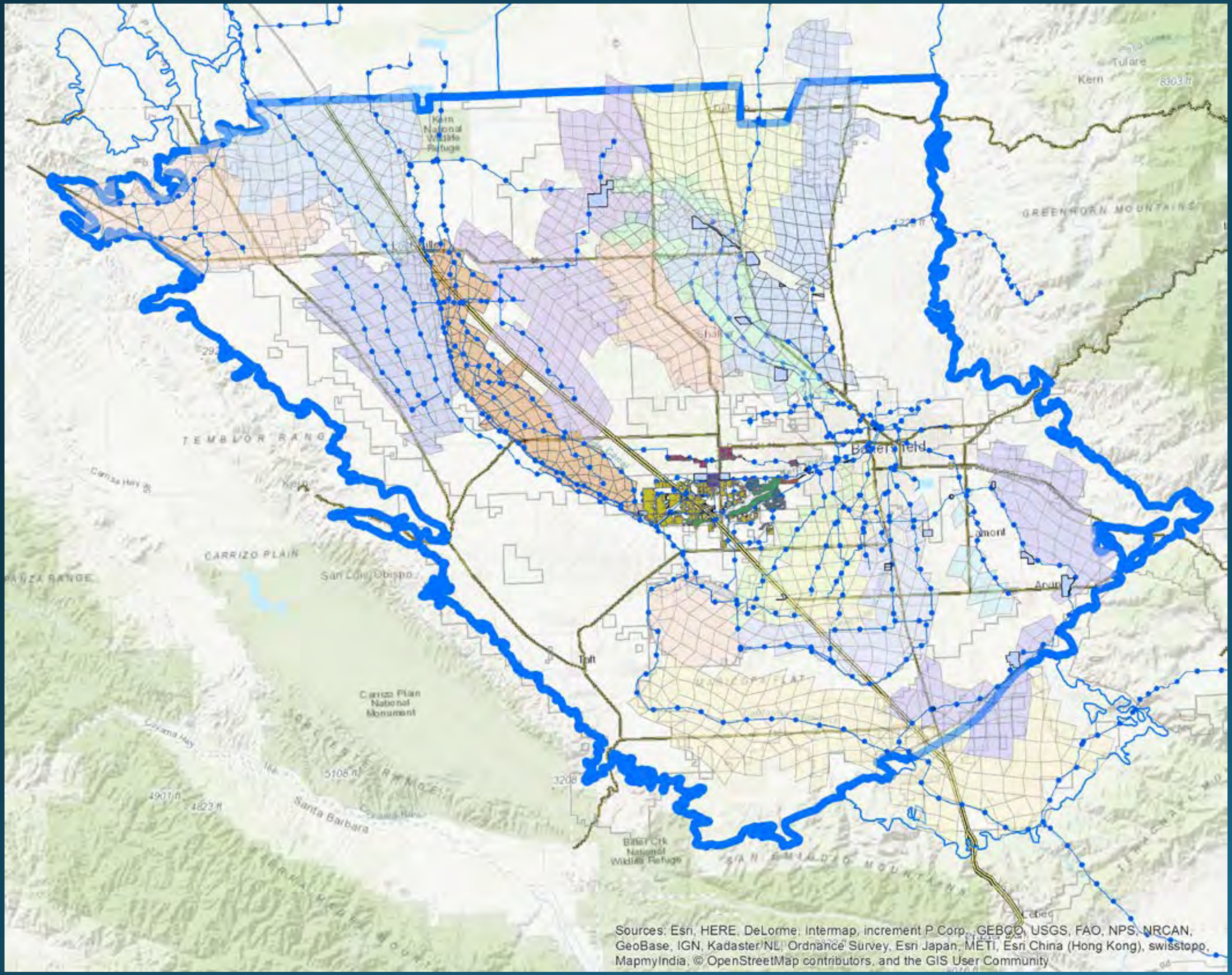


- Surface water diversions by water district
- Groundwater banking and recharge programs
- Groundwater banking recovery for in-basin use and export
- Crop demand based on METRIC ET data
- Urban M&I water use
- Locally important water budget components

DRAFT

TODD GROUNDWATER

Surface Water Conveyance and Service Areas



- Separate diversion for:
  - Each surface water source
  - Each district service area
  - Groundwater banking projects
  - Urban use
- Surface Water Data Sources
  - GEI compiled surface water data for KGA and others
  - Todd GW compiled surface water data for KRGSA and Kern River

DRAFT

TODD GROUNDWATER

Surface Water Conveyance and Service Areas

Arvin Edison WSD	Cawelo WD	Lost Hills WD	Shafter-Wasco ID
Belridge WSD	Henry Miller WD	North Kern WSD	Semitropic WSD
Berrenda Mesa WD	Kern Delta WD (5 SAs)	Rosedale Ranch ID	SSJMUD
Buena Vista WSD (2 SAs)	Kern-Tulare WD	Rosedale-Rio Bravo WSD	Wheeler Ridge-Maricopa WSD

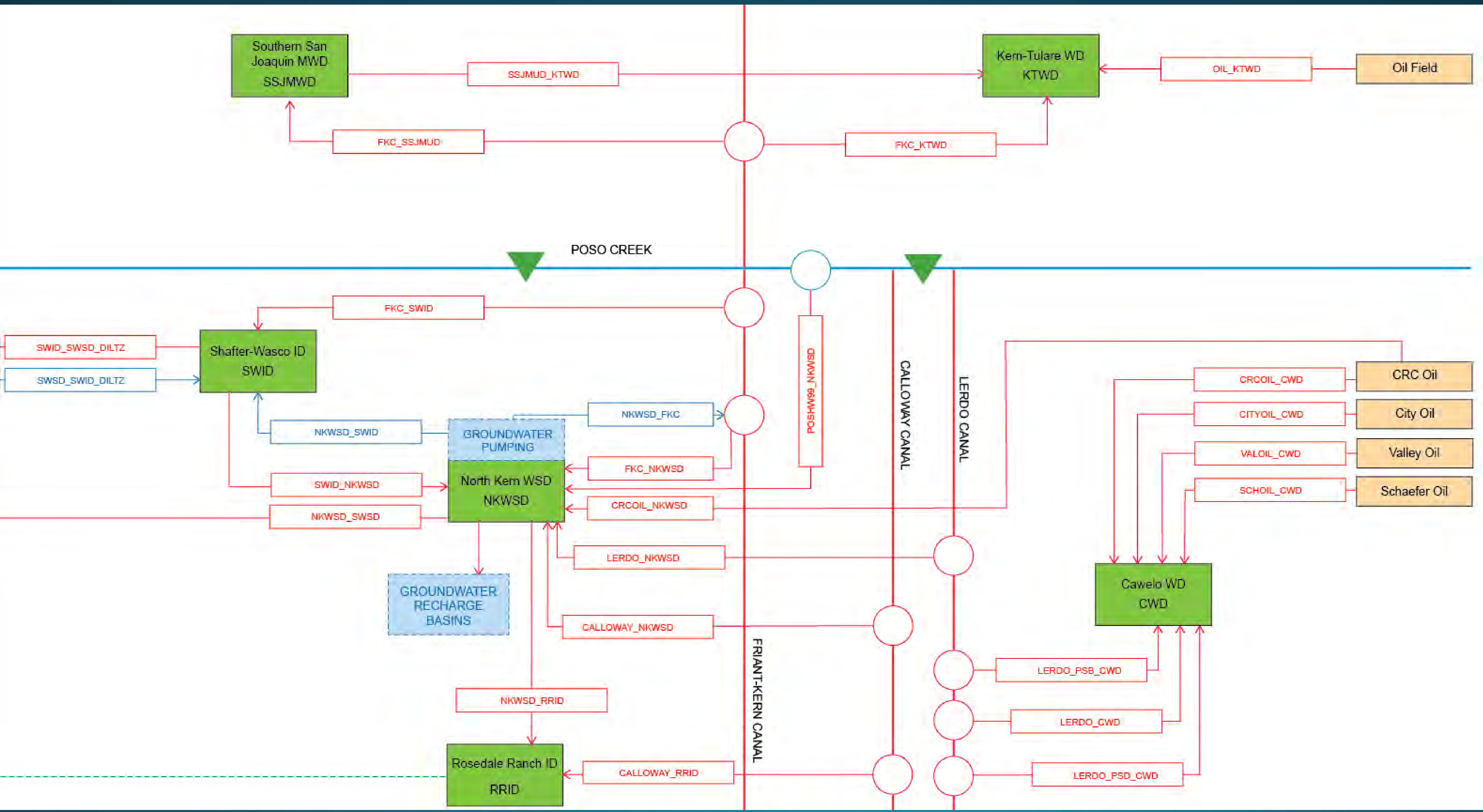
2800 Acres	Buena Vista WSD	Kern Water Bank	Semitropic WSD
Arvin-Edison WSD	Cawelo WD	North Kern WSD	West Kern WD
Berrenda Mesa WSD	Kern Delta WD	Pioneer Project	

City of Bakersfield
KCWA ID 4
Lost Hills UD

Kern NWR

DRAFT

TODD GROUNDWATER


Southern San Joaquin MWD SSJMWD
SSJMUD_KTWD
Kern-Tulare WD KTWD
OIL_KTWD
Oil Field
FKC_SSJMUD
FKC_KTWD
POSO CREEK
FKC_SWID
SWID_SWSD_DILTZ
SWSD_SWID_DILTZ
Shafter-Wasco ID SWID
POSO69MWKN_OSD
CALLOWAY CANAL
LERDO CANAL
CRC Oil
CRCOIL_CWD
CITYOIL_CWD
City Oil
VALOIL_CWD
Valley Oil
SCHOIL_CWD
Schaefer Oil
NKWSD_FKC
NKWSD_SWID
GROUNDWATER PUMPING
FKC_NKWSD
SWID_NKWSD
North Kern WSD NKWSD
CRCOIL_NKWSD
NKWSD_SWSD
LERDO_NKWSD
GROUNDWATER RECHARGE BASINS
Cawelo WD CWD
CALLOWAY_NKWSD
FRIANT-KERN CANAL
LERDO_PSB_CWD
NKWSD_RRID
LERDO_CWD
Rosedale Ranch ID RRID
CALLOWAY_RRID
LERDO_PSD_CWD

KERN-TULARE WATER DISTRICT

SUMMARY OF INFLOWS AND OUTFLOWS FOR **ENTIRE DISTRICT** (AF)

		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Inflows																
(+)	Friant-Kern Canal Deliveries	38,767	42,364	40,806	43,409	46,477	36,575	42,660	44,686	48,407	42,059	36,842	40,227	35,278	35,027	39,488
(+)	From Other Districts															
(+)	SSJMUD	0	0	0	0	0	0	2,081	2,168	40	0	2,344	0	1,969	1,541	188
(+)	Oilfield Produced Water	386	374	380	376	346	277	248	257	241	238	208	265	216	204	356
(=)	**Total Inflow to District**	**39,153**	**42,738**	**41,187**	**43,785**	**46,823**	**36,852**	**44,989**	**47,111**	**48,688**	**42,297**	**39,394**	**40,492**	**37,463**	**36,772**	**40,032**
Outflows																
(+)	To Other Districts	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
(=)	**Total Outflow from District**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Difference																
(=)	**Inflow - Outflow**	**39,153**	**42,738**	**41,187**	**43,785**	**46,823**	**36,852**	**44,989**	**47,111**	**48,688**	**42,297**	**39,394**	**40,492**	**37,463**	**36,772**	**40,032**

SUMMARY OF INFLOWS AND OUTFLOWS WITHIN **KERN SUBBASIN** (AF)

		1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Inflows																
(=)	**Total Inflow to Kern Subbasin**	**25,902**	**28,273**	**27,218**	**28,935**	**30,126**	**23,711**	**28,946**	**29,591**	**29,850**	**25,637**	**23,825**	**24,490**	**22,658**	**21,908**	**23,837**
Outflows																
(=)	**Total Outflow from Kern Subbasin**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Difference																
(=)	**Inflow - Outflow**	**25,902**	**28,273**	**27,218**	**28,935**	**30,126**	**23,711**	**28,946**	**29,591**	**29,850**	**25,637**	**23,825**	**24,490**	**22,658**	**21,908**	**23,837**

Summary | (+) FKC | (+) SSJMUD | (+) Produced | INFLOWS | (-) Other Districts | OUTFLOW

Friant-Kern Canal Diverisons

Kern-Tulare Inflow (AF)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	TOTAL
1993	203	347	1,359	2,427	4,724	6,484	7,390	6,749	4,868	2,815	1,008	394	38,767
1994	222	379	1,485	2,652	5,162	7,086	8,076	7,375	5,319	3,077	1,102	430	42,364
1995	214	365	1,430	2,554	4,972	6,825	7,779	7,104	5,124	2,963	1,061	415	40,806
1996	228	388	1,522	2,717	5,289	7,261	8,275	7,557	5,450	3,152	1,129	441	43,409
1997	244	415	1,629	2,909	5,663	7,774	8,860	8,091	5,836	3,375	1,209	472	46,477
1998	192	327	1,282	2,289	4,457	6,118	6,972	6,367	4,592	2,656	951	372	36,575
1999	191	337	1,204	2,225	5,189	7,122	8,065	7,558	5,776	3,595	1,398	0	42,660
2000	34	85	965	2,816	6,067	8,224	8,545	7,695	5,561	2,317	1,253	1,124	44,686
2001	69	102	1,224	2,607	7,043	8,590	8,957	8,787	6,456	3,704	618	250	48,407
2002	171	551	1,761	3,547	5,342	7,118	7,378	6,489	4,744	3,347	1,108	503	42,059
2003	0	755	2,399	2,723	3,668	6,097	6,967	5,562	4,213	3,285	715	458	36,842
2004	273	304	1,552	3,721	6,078	7,105	7,085	6,543	4,846	2,110	424	186	40,227
2005	0	79	554	2,123	3,291	6,015	7,195	6,770	4,732	2,531	1,496	492	35,278
2006	244	749	800	686	4,520	6,485	6,709	6,226	4,883	2,176	977	572	35,027
2007	863	217	1,927	2,861	5,063	6,413	6,946	6,402	4,263	2,943	1,567	23	39,488
2008	0	210	1,901	3,517	5,169	6,328	7,478	6,526	4,870	3,107	957	289	40,352
2009	85	322	1,936	2,967	4,693	5,297	6,717	5,482	3,873	1,934	1,456	303	35,065
2010	75	5	742	1,088	3,899	5,817	6,731	6,486	4,645	2,464	852	0	32,804
2011	383	337	719	1,719	3,954	5,383	6,761	6,397	4,758	2,359	1,173	381	34,324
2012	468	1,135	1,301	1,285	4,114	6,223	6,657	6,647	4,357	2,968	1,133	0	36,288
2013	0	203	1,440	3,134	5,068	6,364	7,016	6,051	3,860	3,152	1,166	880	38,334
2014	286	219	773	1,229	2,315	3,080	4,150	3,777	2,762	1,549	406	136	20,682
2015	40	55	601	854	1,095	2,212	2,946	2,773	2,251	1,448	386	407	15,068
2016	37	5	814	1,932	3,613	4,879	5,928	5,237	3,455	2,108	228	0	28,236

Source: Data provided by KTWD (via email from Costas Cero dated 5/8/2018)

Kern-Tulare Water District

<u>Kern-Tulare WD from Friant-Kern Canal</u>

1922-1960	Zero
1961-1992	Estimated: Monthly average of 1993-97
1993-2015	District data

<u>Kern-Tulare WD from SSJMUD</u>

1922-1992	Zero
1993-2015	District data

<u>Kern-Tulare WD from Oilfield produced water</u>

1922-1992	Zero
1993-2015	District data

TODD GROUNDWATER

	A	B	C	D	E
1				Estimated	Non-operation
2		Description	Friant-Kern Canal Diverisons to Kern-Tulare WD	SSJMUD Deliveries to Kern-Tulare WD	Oilfield Produced Water to Kern-Tulare WD
3					
4		Source	Kern-Tulare WD	Kern-Tulare WD	Kern-Tulare WD
5			SW IMPORT	SW IMPORT	SW IMPORT
6			AG	AG	AG
7		Ann. Avg.	24.07	0.13	0.15
8		Count	1143	1143	1143
9			(TAF)	(TAF)	(TAF)
859	1992.10	07/31/1992	8.076	0.000	0.000
860	1992.11	08/31/1992	7.375	0.000	0.000
861	1992.12	09/30/1992	5.319	0.000	0.000
862	1993.01	10/31/1992	3.077	0.000	0.000
863	1993.02	11/30/1992	1.102	0.000	0.000
864	1993.03	12/31/1992	0.430	0.000	0.000
865	1993.04	01/31/1993	0.203	0.000	0.031
866	1993.05	02/28/1993	0.347	0.000	0.028
867	1993.06	03/31/1993	1.359	0.000	0.031
868	1993.07	04/30/1993	2.427	0.000	0.030
869	1993.08	05/31/1993	4.724	0.000	0.033
870	1993.09	06/30/1993	6.484	0.000	0.033
871	1993.10	07/31/1993	7.390	0.000	0.033
872	1993.11	08/31/1993	6.749	0.000	0.034
873	1993.12	09/30/1993	4.868	0.000	0.033
874	1994.01	10/31/1993	2.815	0.000	0.034
875	1994.02	11/30/1993	1.008	0.000	0.033
876	1994.03	12/31/1993	0.394	0.000	0.032
877	1994.04	01/31/1994	0.222	0.000	0.031
878	1994.05	02/28/1994	0.379	0.000	0.029
879	1994.06	03/31/1994	1.485	0.000	0.032

Data | Summary | (+) FKC | (+) SSJMUD | (+) Produced

	A	B	BB	BC	BD	BE	BF	BG	BH	BI	BJ	BK	BL
1													
2		Description	Imports to Kern Delta WD Buena Vista SA for Ag	Kern River to Kern Delta Water District (KDWD) for Ag via BVWSD Maples SA Outflow	Friant-Kern Canal Diversions to Kern-Tulare WD	SSJMUD Deliveries to Kern-Tulare WD	Oilfield Produced Water to Kern-Tulare WD	CA Aqueduct Diversions to Lost Hills WD for Ag	North Kern WSD Poso Creek to Poso Recharge	North Kern WSD Poso Creek to Poso Section 27 Recharge	North Kern WSD Poso Creek to Ag	North Kern WSD Imports to Poso Recharge	North Kern WSD Imports to Poso Section 27 Recharge
3		Tag											
4		Reference		(1993-2013) - BVWSD spreadsheet (sheet labeled "Maples	Kern-Tulare WD	(1922-1959) zero; (1960-1992) Avg of monthly del 1993-1997; (1993-	Kern-Tulare WD	DWR SWP Operations Data for San Joaquin Field					
5		Source	SW IMPORT	KERN RIVER	SW IMPORT	SW IMPORT	SW IMPORT	SW IMPORT	POSO CREEK	POSO CREEK	POSO CREEK	IMPORTS	IMPORTS
6		Usage	AG	AG	AG	AG	AG	AG	RECHARGE	RECHARGE	AG	RECHARGE	RECHARGE
7		-8,942.65			0.00	0.00	0.00	0.00					
8		Divs set up			x	x	x	x					
9			(TAF)		(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)
10	1922.01	10/31/1921	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
11	1922.02	11/30/1921	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
12	1922.03	12/31/1921	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
13	1922.04	01/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
14	1922.05	02/28/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
15	1922.06	03/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
16	1922.07	04/30/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
17	1922.08	05/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
18	1922.09	06/30/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
19	1922.10	07/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
20	1922.11	08/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
21	1922.12	09/30/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	1923.01	10/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	1923.02	11/30/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	1923.03	12/31/1922	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
25	1923.04	01/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
26	1923.05	02/28/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
27	1923.06	03/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
28	1923.07	04/30/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
29	1923.08	05/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
30	1923.09	06/30/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
31	1923.10	07/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
32	1923.11	08/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
33	1923.12	09/30/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
34	1924.01	10/31/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
35	1924.02	11/30/1923	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

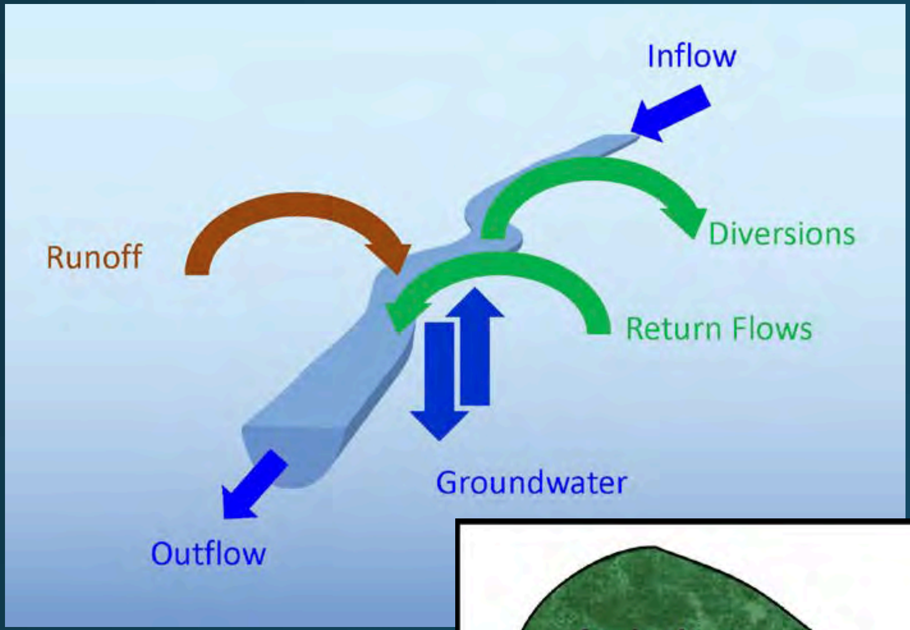
Diversion Data | Pumping Data | Recharge Data | KERN RIVER WATER BALANCE

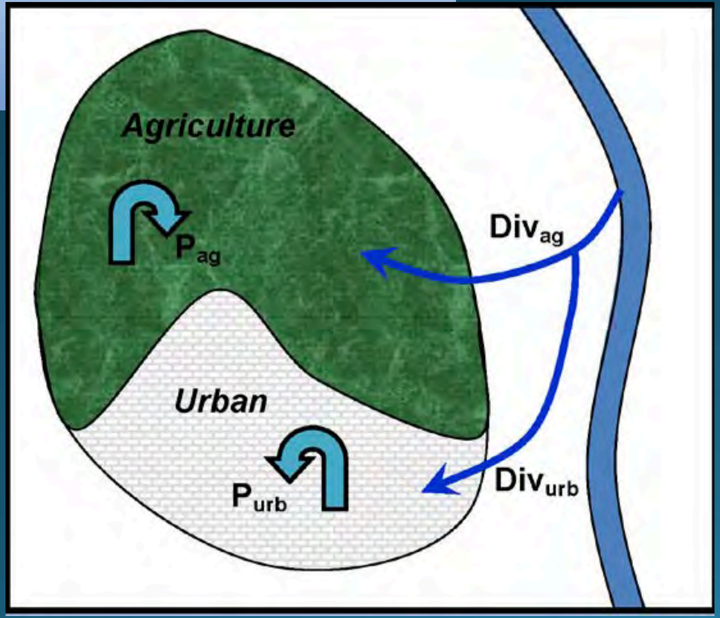
TODD GROUNDWATER

	A	B	PI	PJ	PK	PL	PM	PN	PO	PP	PQ	PR	PS	PT	PU	PV	PW
1	Old Div#	C DIV ID#	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437
2	District ID	C	8	8	9	9	9	10	11	11	11	11	11	11	11	11	11
3	Description	C Desc	Kern Delta WD from Imports to Buena Vista SA for Ag	Kern River to Kern Delta Water District (KDWD) for Ag via	Kern-Tulare WD from Friant-Kern Canal for Ag	Kern-Tulare WD SSJMUD Imports for Ag	Kern-Tulare WD Oilfield Produced Water for Ag	Lost Hills WD CA Aqueduct Diversions for Ag	North Kern WSD Poso Creek to Poso Recharge	North Kern WSD Poso Creek to Poso Section 27 Recharge	North Kern WSD Poso Creek to Ag	North Kern WSD Imports to Poso Recharge	North Kern WSD Imports to Poso Section 27 Recharge	North Kern WSD Imports to Rosedale Basin Recharge	North Kern WSD Imports to Minter Basin Recharge	North Kern WSD Imports to Wright Basin Recharge	North Kern WSD Import to Switch Basin Recharge
4	Notes	C	52	53	54	55	56	57	58	59	60	61	62	63	64	65	66
5	New Div#	C COLUMN:	423	424	425	426	427	428	429	430	431	432	433	434	435	436	437
6		C	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
7	0.00	C	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
8		C															
9		C	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)
1074	6/30/2010	06/30/2010_24:00	0.817	0.000	5.817	0.000	0.060	16.041	0.000	0.000	0.000	0.000	0.000	0.000	0.551	0.079	0.00
1075	7/31/2010	07/31/2010_24:00	0.639	0.000	6.731	0.000	0.060	19.012	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1076	8/31/2010	08/31/2010_24:00	0.600	0.000	6.486	0.000	0.062	16.546	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1077	9/30/2010	09/30/2010_24:00	1.276	0.000	4.645	0.000	0.061	10.091	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1078	10/31/2010	10/31/2010_24:00	1.402	0.000	2.464	0.000	0.062	5.191	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1079	11/30/2010	11/30/2010_24:00	0.313	0.000	0.852	0.000	0.057	0.904	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1080	12/31/2010	12/31/2010_24:00	0.482	0.000	0.000	0.000	0.058	0.069	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1081	1/31/2011	01/31/2011_24:00	0.000	0.000	0.383	0.000	0.059	1.077	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1082	2/28/2011	02/28/2011_24:00	0.000	0.000	0.337	0.000	0.059	1.089	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1083	3/31/2011	03/31/2011_24:00	0.312	0.000	0.719	0.000	0.062	1.765	0.000	0.000	0.000	0.000	2.707	0.000	0.000	0.000	0.00
1084	4/30/2011	04/30/2011_24:00	0.881	0.000	1.719	0.000	0.064	6.394	0.000	0.016	0.000	0.000	0.000	0.506	0.000	0.000	0.00
1085	5/31/2011	05/31/2011_24:00	0.966	0.000	3.954	0.000	0.066	9.863	0.000	1.609	0.000	0.000	0.842	1.107	0.000	0.000	0.00
1086	6/30/2011	06/30/2011_24:00	0.694	0.000	5.383	0.000	0.069	16.094	0.000	2.402	0.000	0.000	0.000	1.204	0.000	0.000	0.00
1087	7/31/2011	07/31/2011_24:00	0.287	0.000	6.761	0.000	0.074	20.806	0.000	0.000	0.000	0.000	0.132	1.375	0.000	0.000	0.00
1088	8/31/2011	08/31/2011_24:00	0.385	0.000	6.397	0.000	0.075	17.875	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1089	9/30/2011	09/30/2011_24:00	1.724	0.000	4.758	0.000	0.085	11.022	0.000	0.000	0.000	0.000	0.146	0.454	0.000	0.000	0.00
1090	10/31/2011	10/31/2011_24:00	0.085	0.000	2.359	0.000	0.088	6.333	0.000	0.000	0.000	0.000	0.000	0.375	0.000	0.000	0.00
1091	11/30/2011	11/30/2011_24:00	0.205	0.000	1.173	0.000	0.086	0.540	0.000	0.000	0.000	0.000	2.333	7.924	1.250	0.000	0.00
1092	12/31/2011	12/31/2011_24:00	1.183	0.000	0.381	0.000	0.092	1.396	0.000	0.000	0.000	0.000	0.478	5.895	0.000	0.000	0.00
1093	1/31/2012	01/31/2012_24:00	0.151	0.000	0.468	0.000	0.095	1.350	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.00
1094	2/29/2012	02/29/2012_24:00	0.596	0.000	1.135	0.000	0.093	1.985	0.000	0.000	0.000	0.000	0.079	0.056	0.079	0.056	0.00

C2VSim Diversions - Phase 3 | Diversion Data | Pumping Data | Recharge Data

Surface Water Process





- Tracks surface water delivered for agricultural and urban use
  - Directs diversions to designated subareas
  - Each subarea provides for spatial distribution of agricultural and urban use
- Surface Water budget tracks:
  - Diversions
  - River and canal seepage
  - Groundwater-surface water interactions
  - Natural inflows and outflows

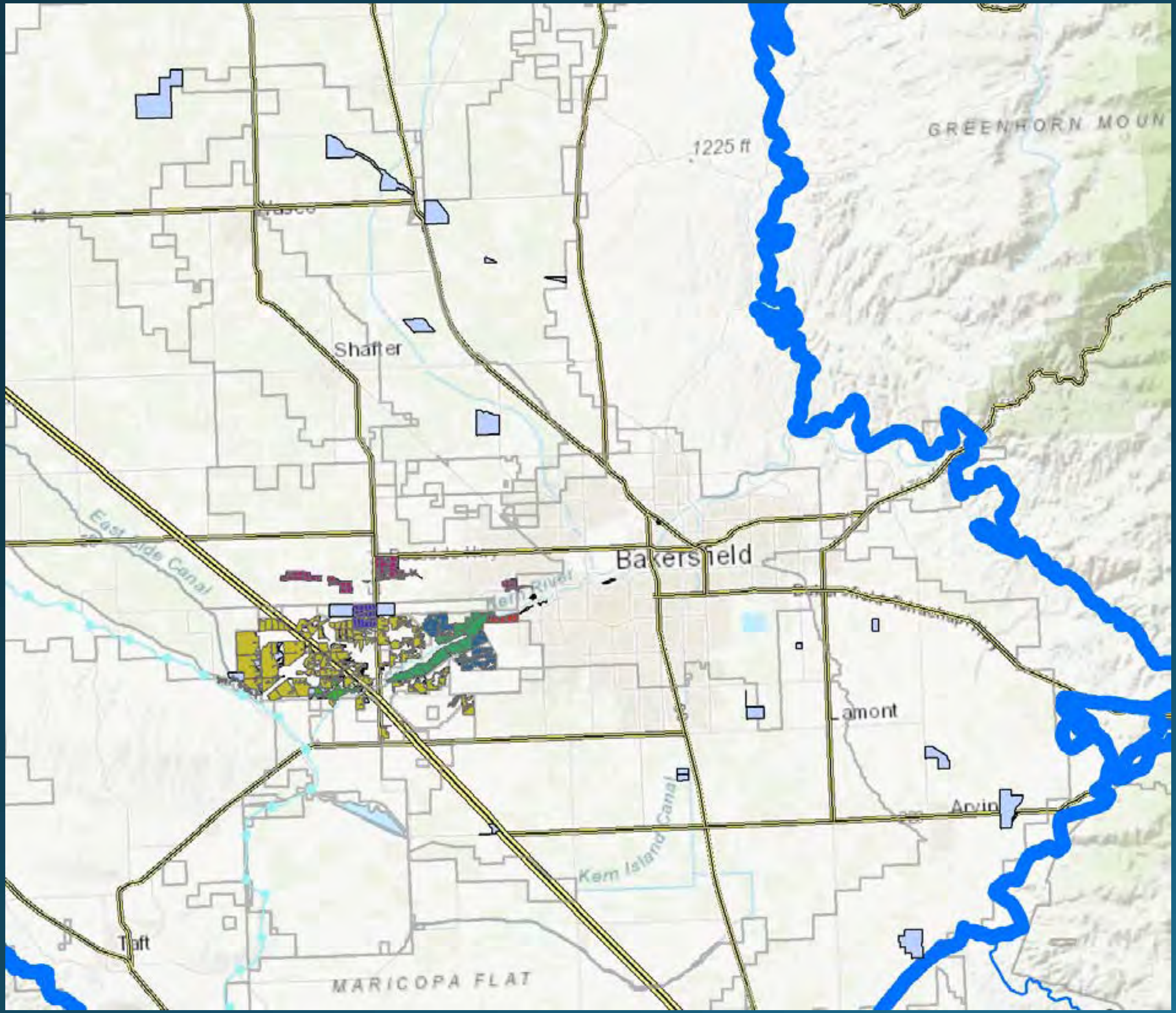
DRAFT

Kern-Tulare Water District

Diversion	Leakage	Evap.	Delivery
Kern-Tulare WD from Friant-Kern Canal	1%	1%	98%
Kern-Tulare WD from SSJMUD	1%	1%	98%
Kern-Tulare WD from Oilfield produced water	1%	1%	98%

TODD GROUNDWATER

Groundwater Banking and Recharge Locations

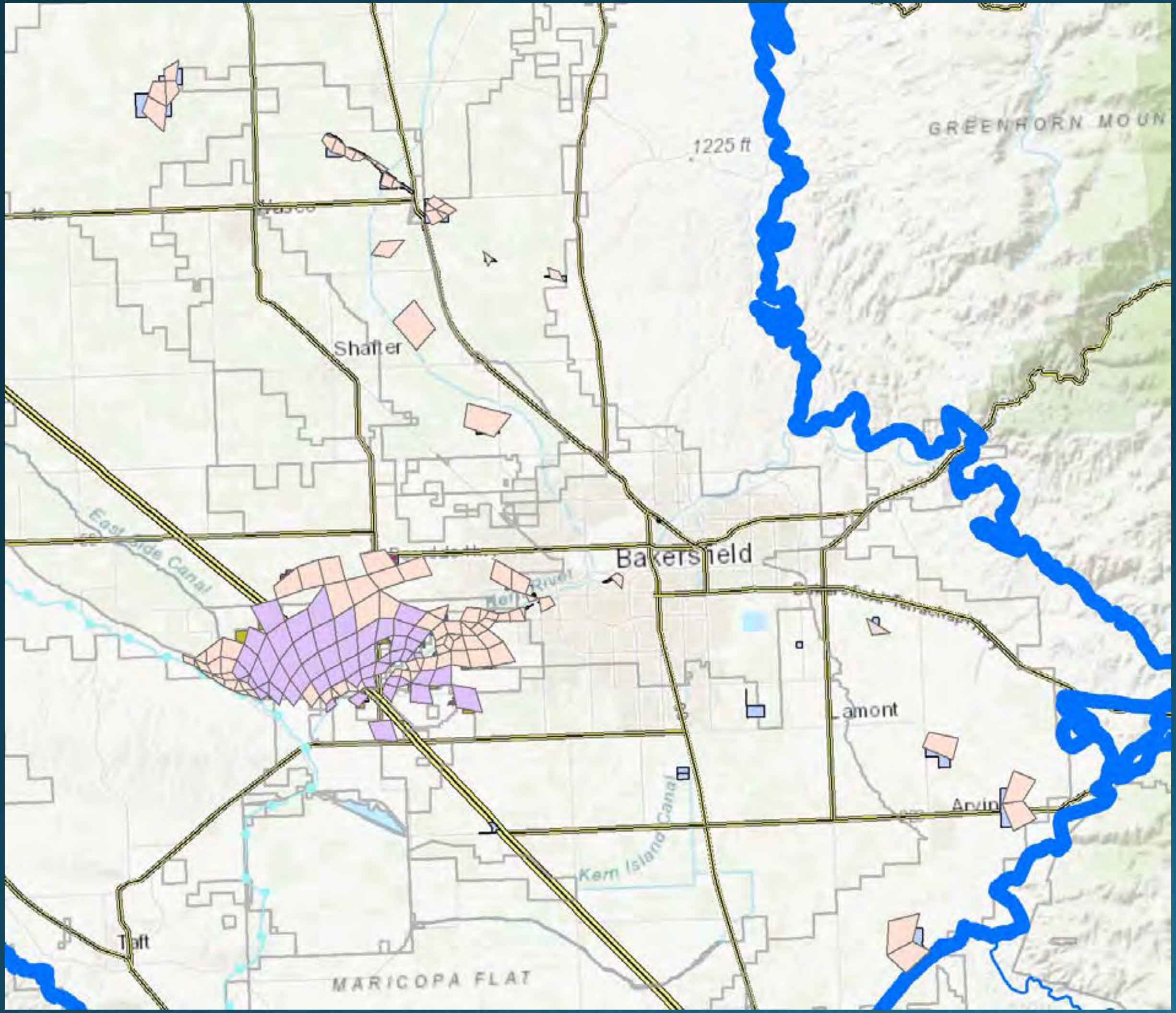


- Data Sources
  - Directly from local districts
  - Published reports or other sources
  - Historic data back to 1960's
- Facilities Include:
  - Groundwater Banks
  - Managed Aquifer Recharge
  - Recovery Wells

DRAFT

TODD GROUNDWATER

Assigned C2VSim Elements to GW Banks

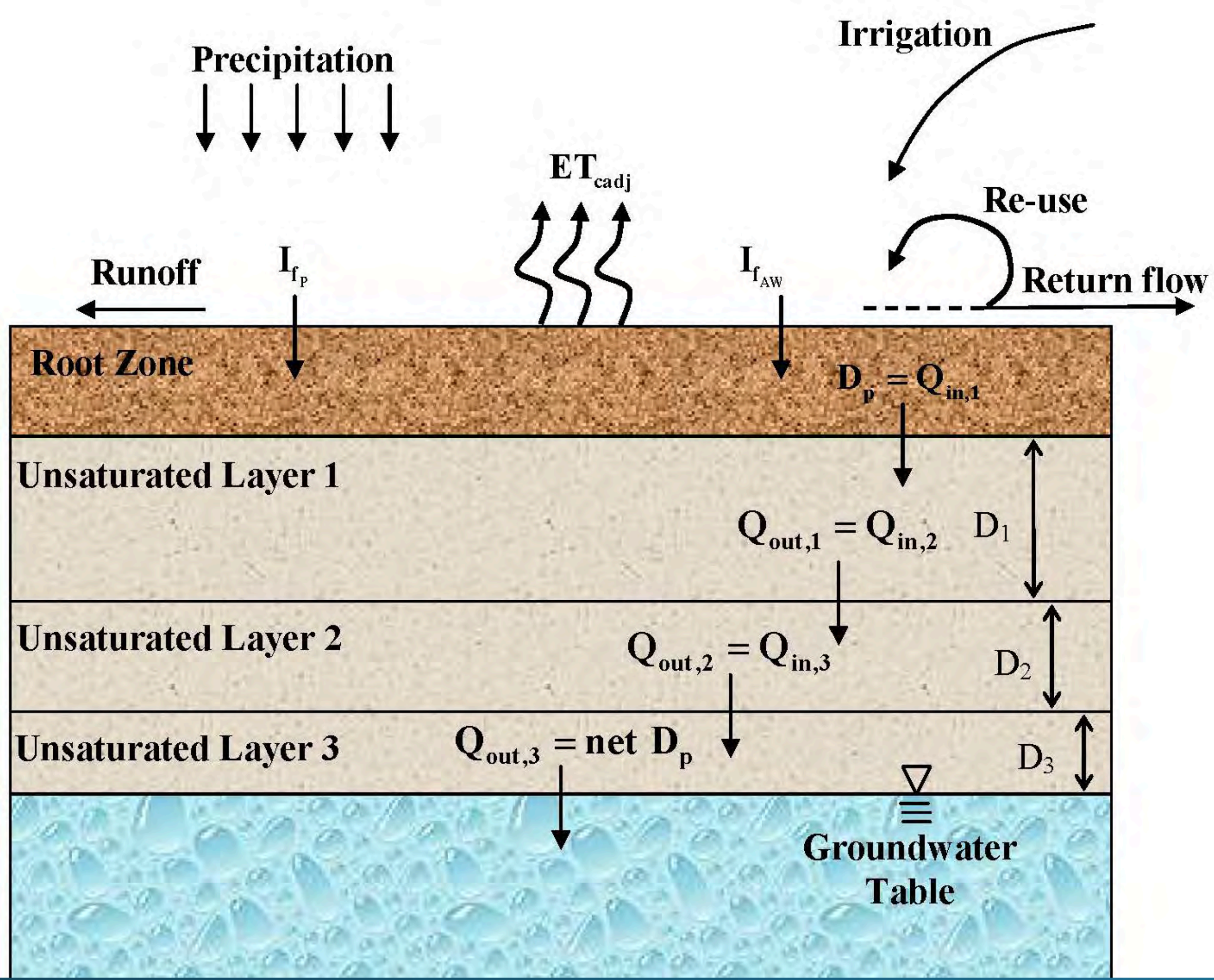


- Data Sources
  - Directly from local districts
  - Published reports or other sources
  - Historic data back to 1960's
- Facilities Include:
  - Groundwater Banks
  - Managed Aquifer Recharge
  - Recovery Wells

DRAFT

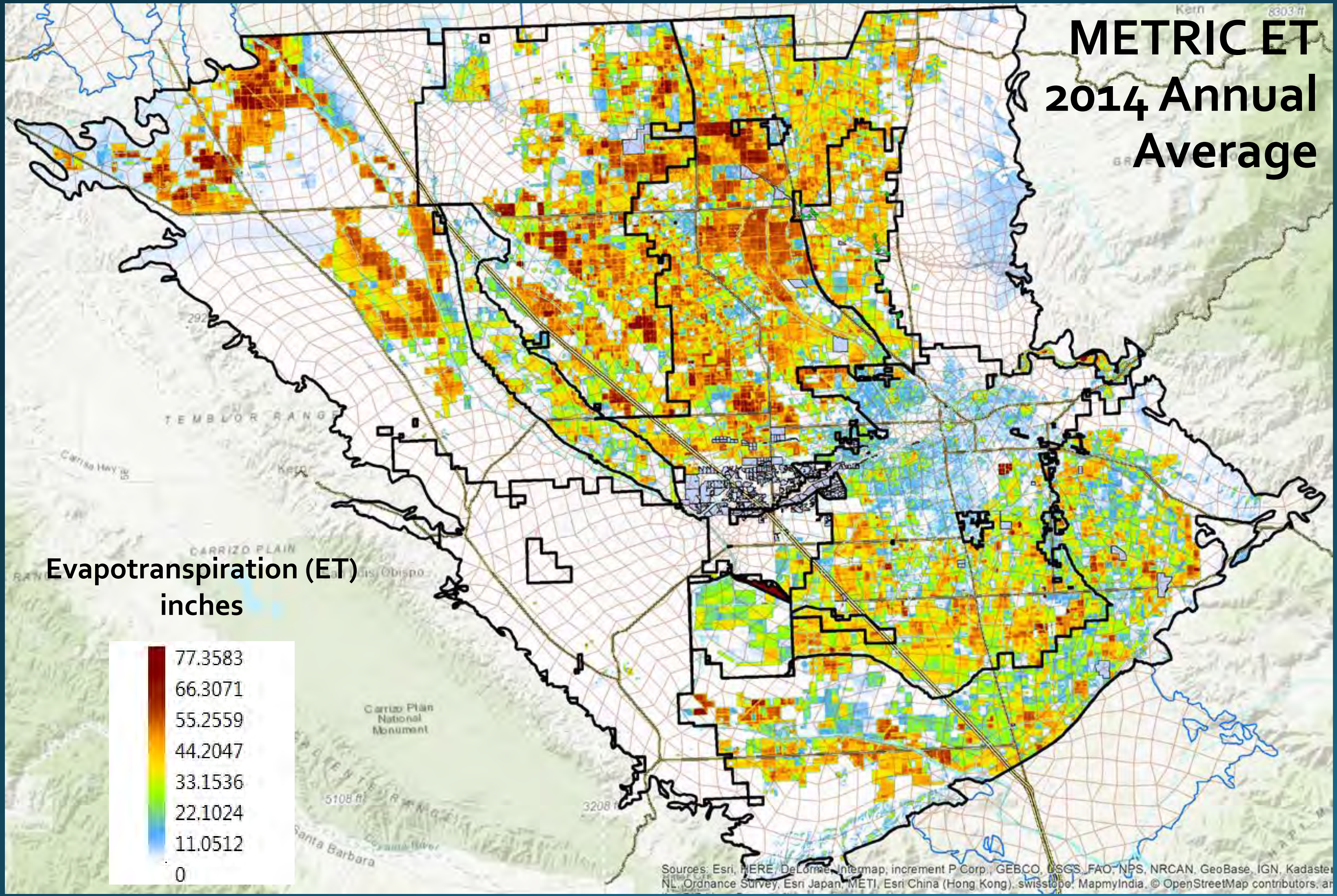
TODD GROUNDWATER

IWFM Demand Calculator (IDC)



- Calculates agricultural demand based on soil moisture budget
  - Monthly crop ET time series
  - Tracks soil moisture content throughout simulation
  - If soil moisture falls below minimum level (wilting point), irrigation water added to reach target level (field capacity) to cover ET, deep percolation and runoff

ITRC METRIC ET Data

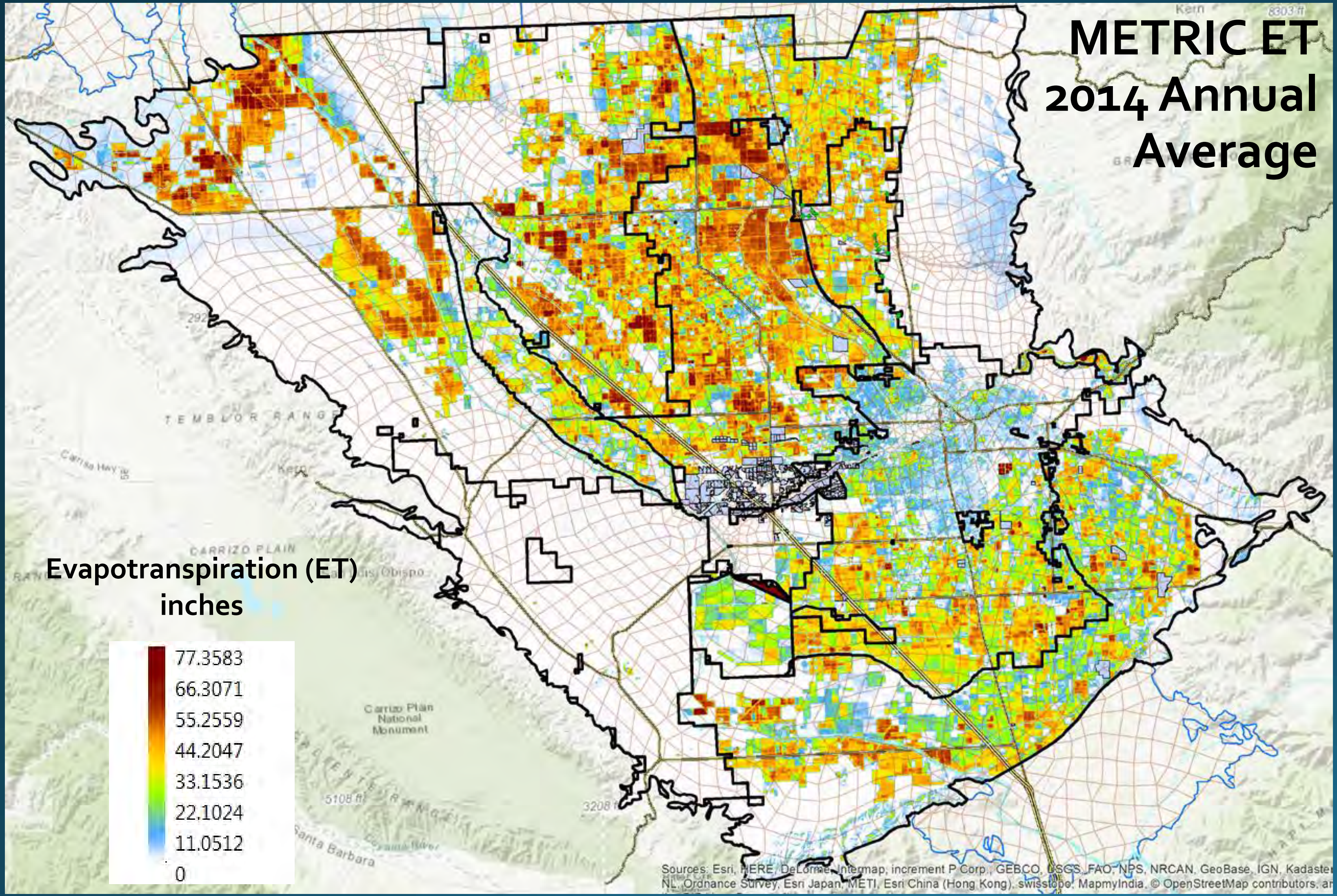


- Monthly data from ITRC
  - 1994-2015 (no 2012)
  - 30 m pixel
- Calculated METRIC ET rates for:
  - Irrigated Agriculture
  - Other land use

TODD GROUNDWATER

DRAFT

Mapping METRIC ET Data to C2VSim

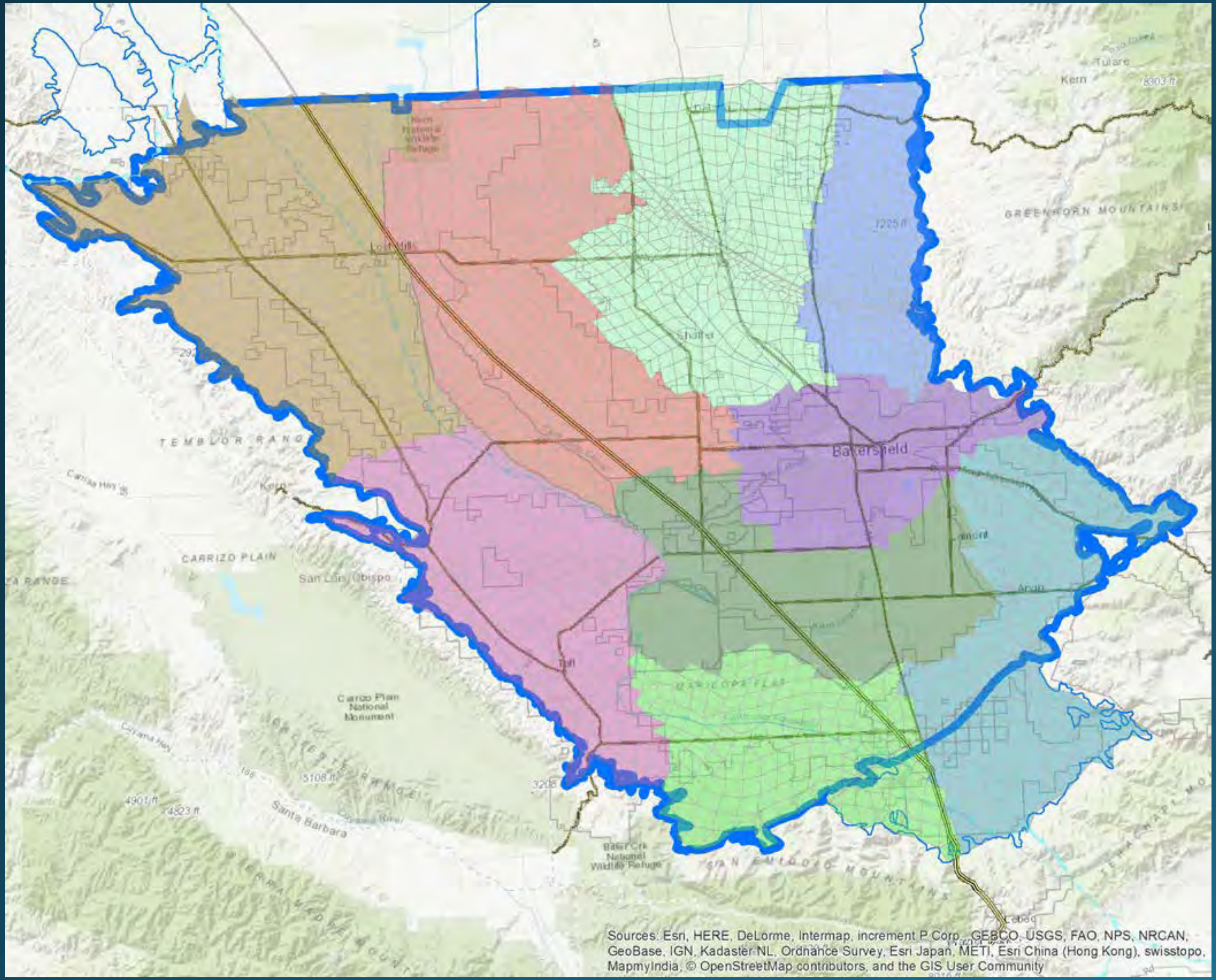


- METRIC ET Processing
  - Correlate METRIC ET and land use at 30 m pixel level
  - Average up pixel ET rate to C2VSim crop type or land use
  - Monthly Average ET for each C2VSim crop type
  - Maintain Volumetric Consistency

DRAFT

TODD GROUNDWATER

C2VSim Applies Urban Demand over Zone

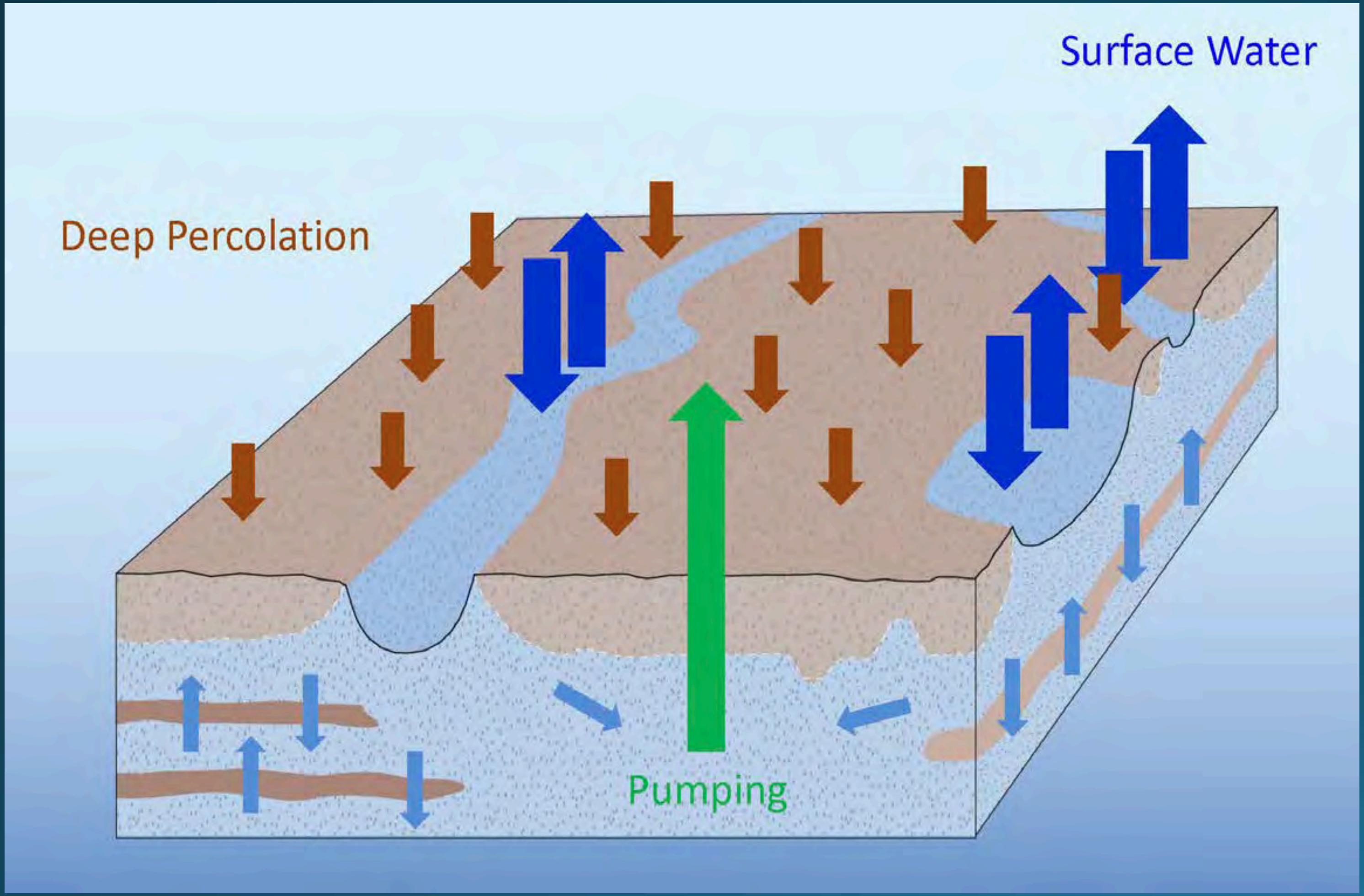


- Urban Demand Data
  - Surface water deliveries
  - Groundwater pumping volumes from major water purveyors
- C2VSim uses Urban Zones
  - Applied to urban land use areas
  - Population and Per Capita Use for M&I
- Kern County Updates
  - Defined new Metro Bakersfield Zone
  - Updated population data
  - Revised Per Capita Rates to reflect actual water use

DRAFT

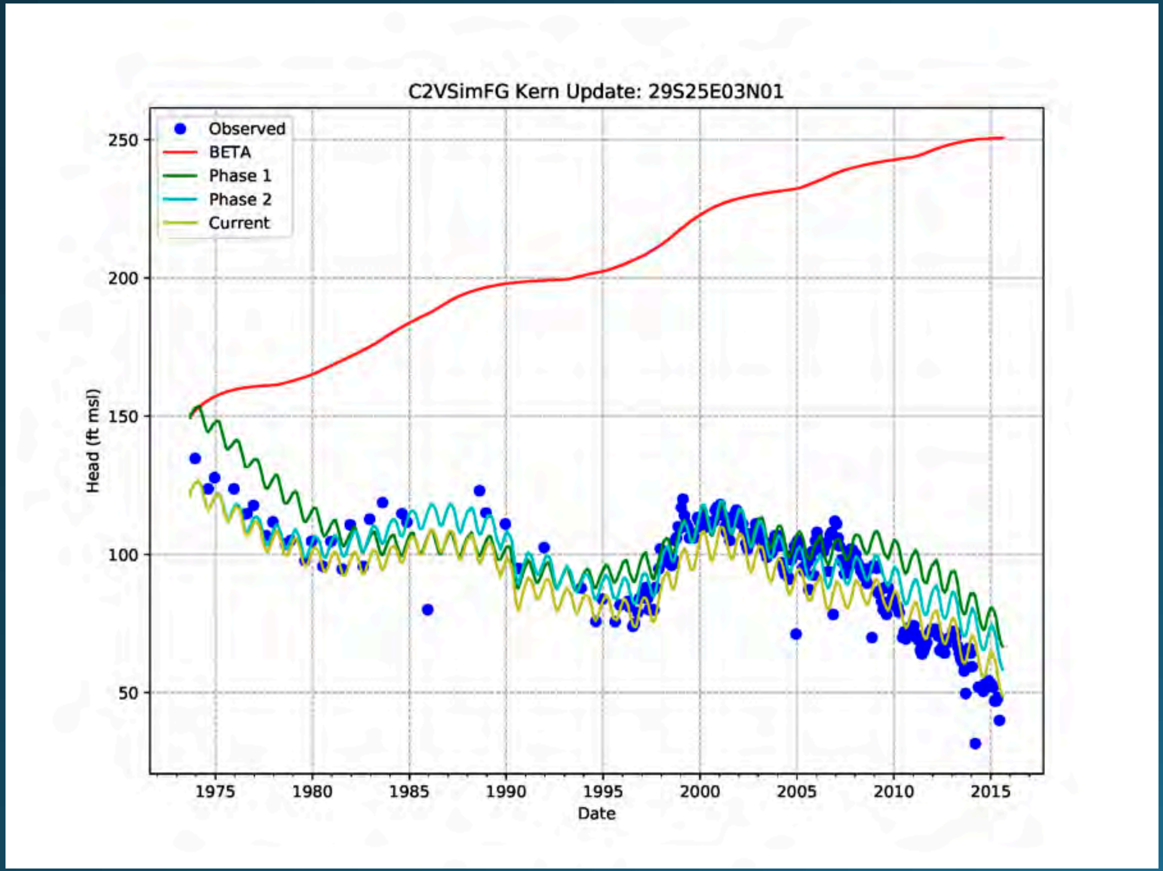
TODD GROUNDWATER

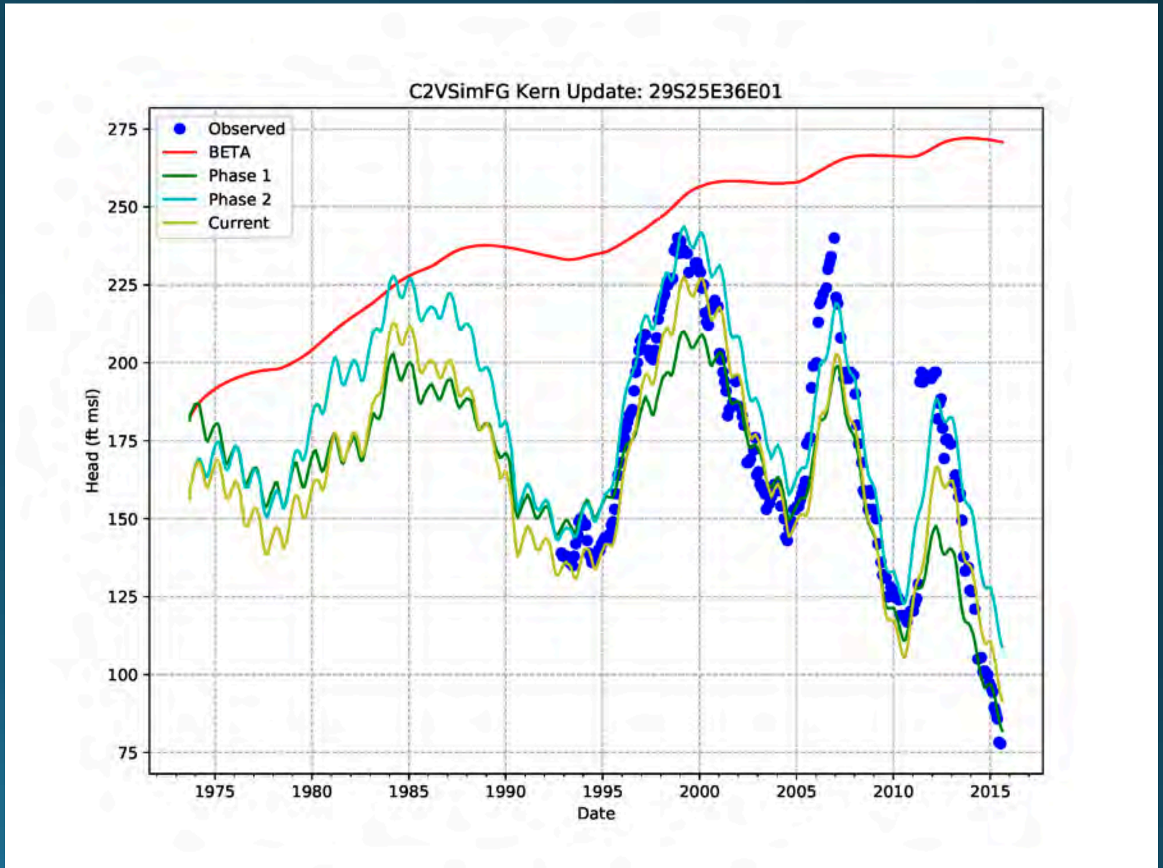
Groundwater Process



- Groundwater process integrates the inflows and outflows from other processes
- Groundwater budget tracks:
  - Volume for each inflow and outflow component
  - Storage change over time
- Change in groundwater levels
  - Hydrographs

Examples of Model Performance Rosedale-Rio Bravo Area

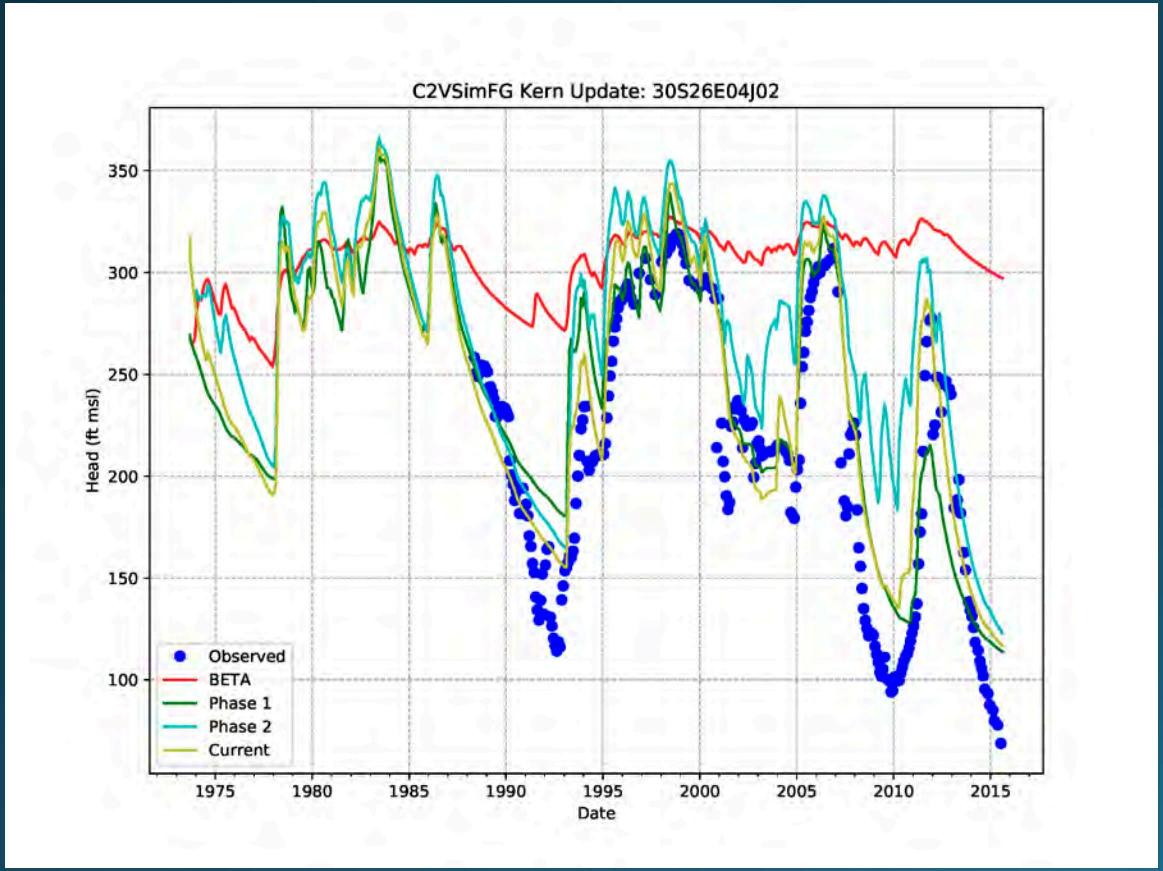


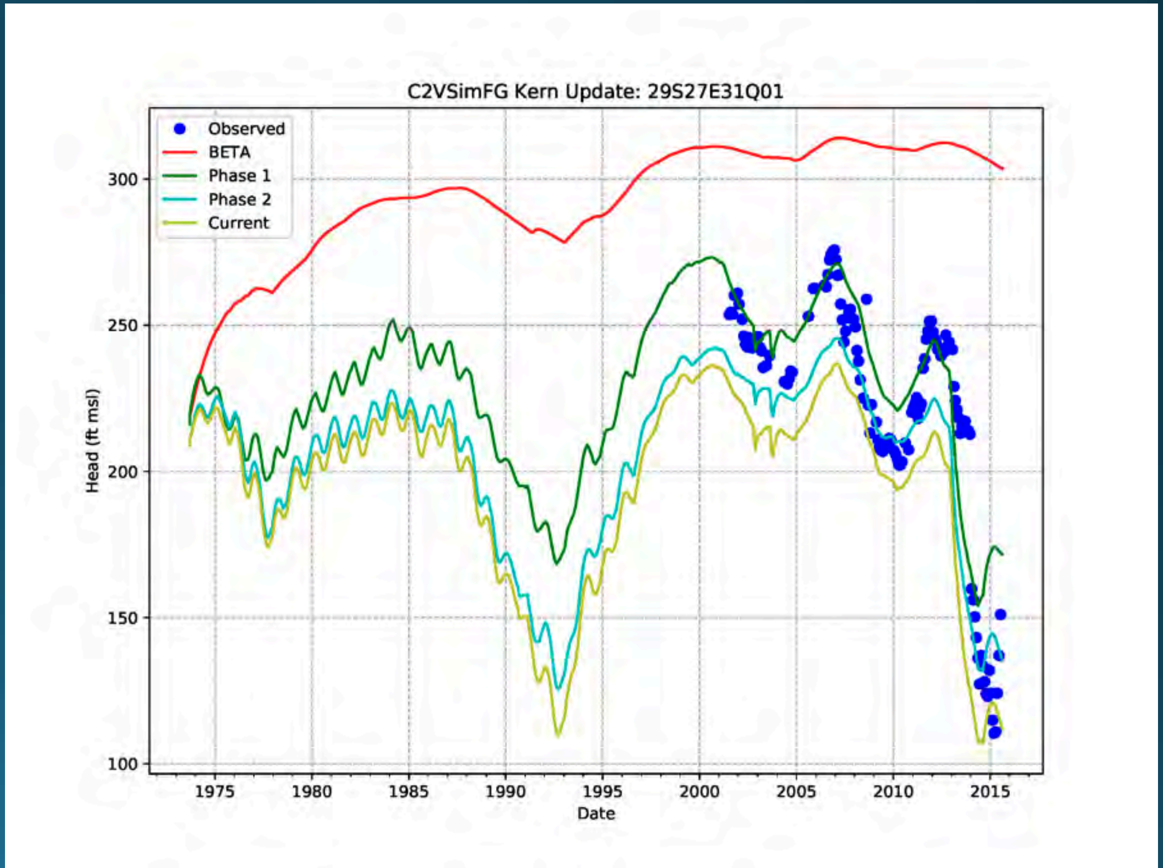


DRAFT

TODD GROUNDWATER

Examples of Model Performance City of Bakersfield

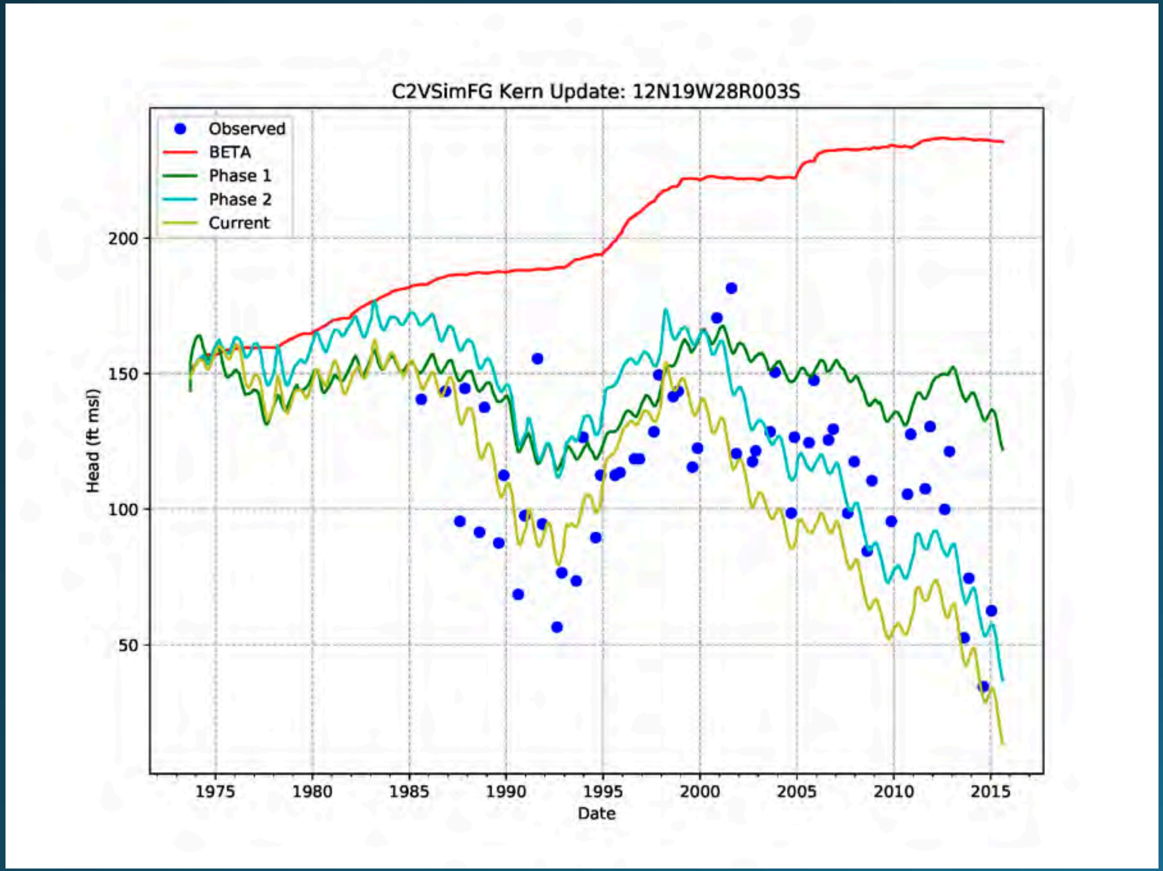


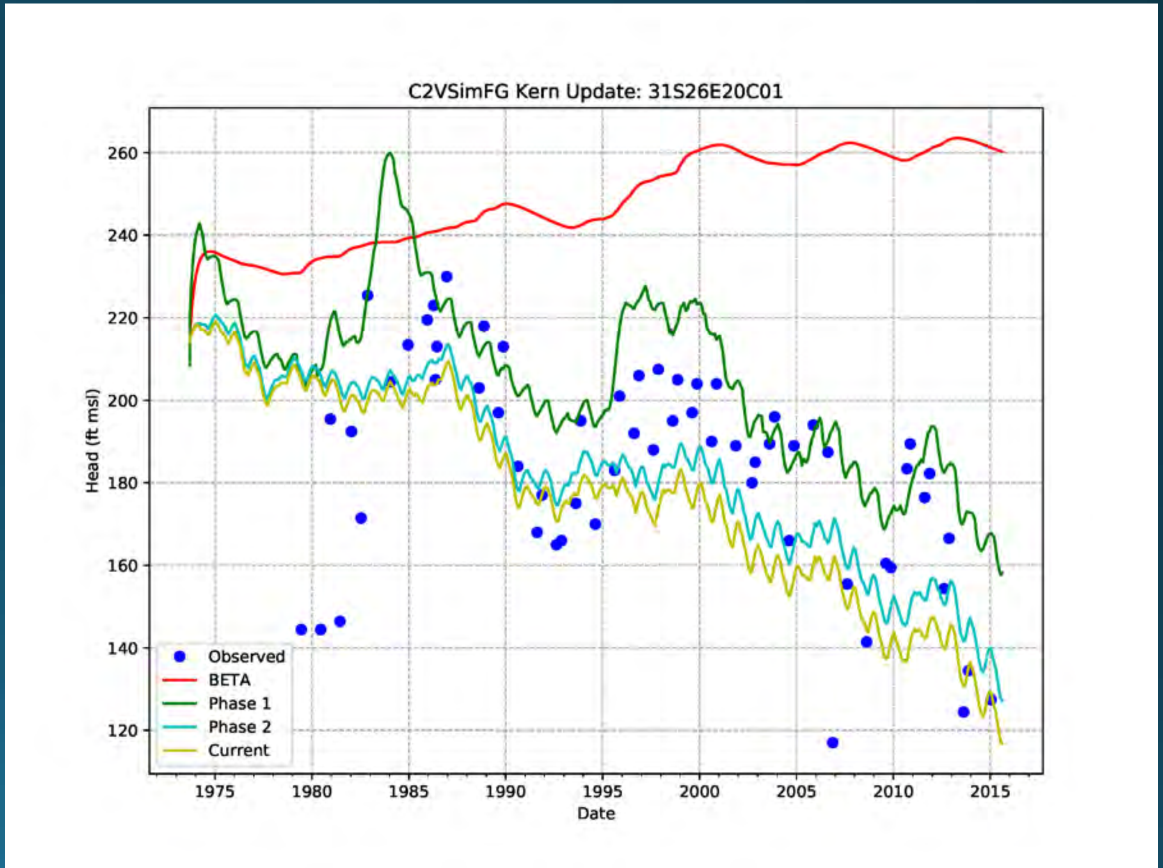


DRAFT

TODD GROUNDWATER

Examples of Model Performance Arvin-Edison WSD and Kern Delta WD

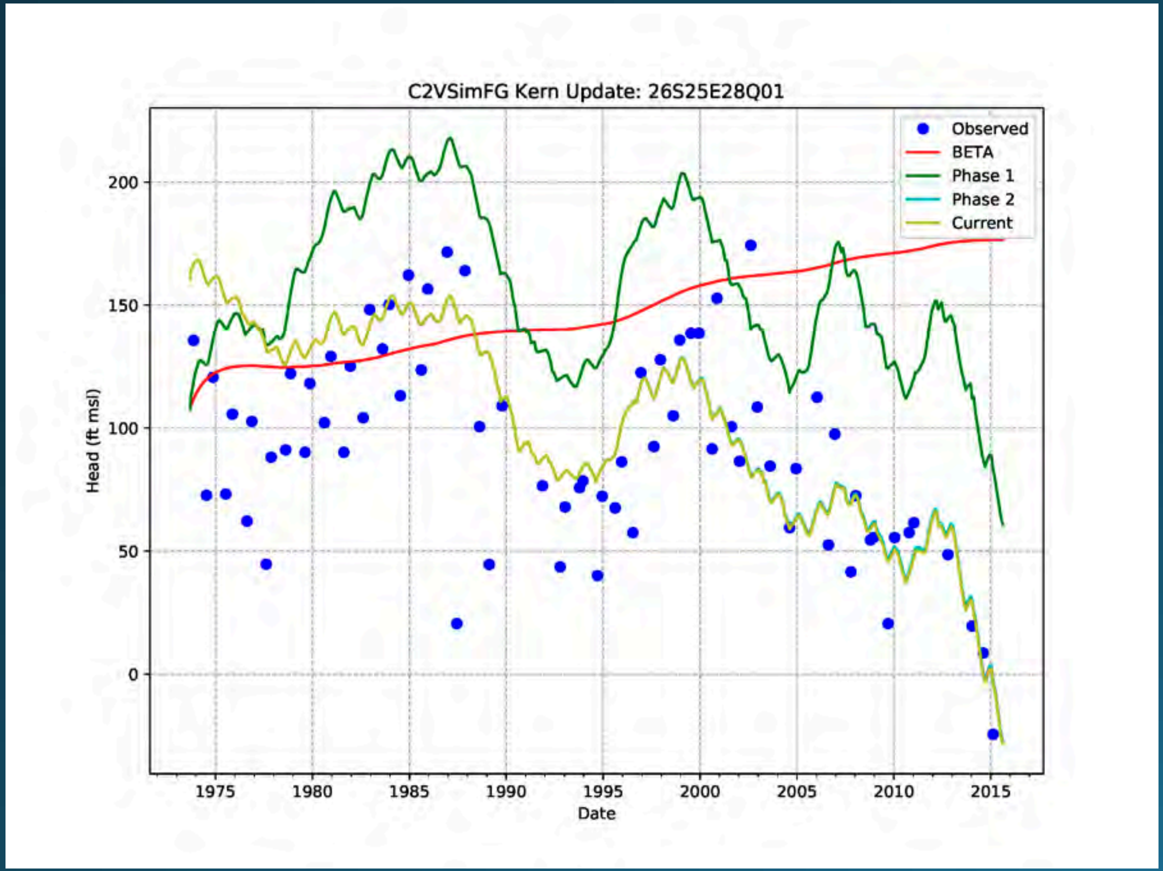


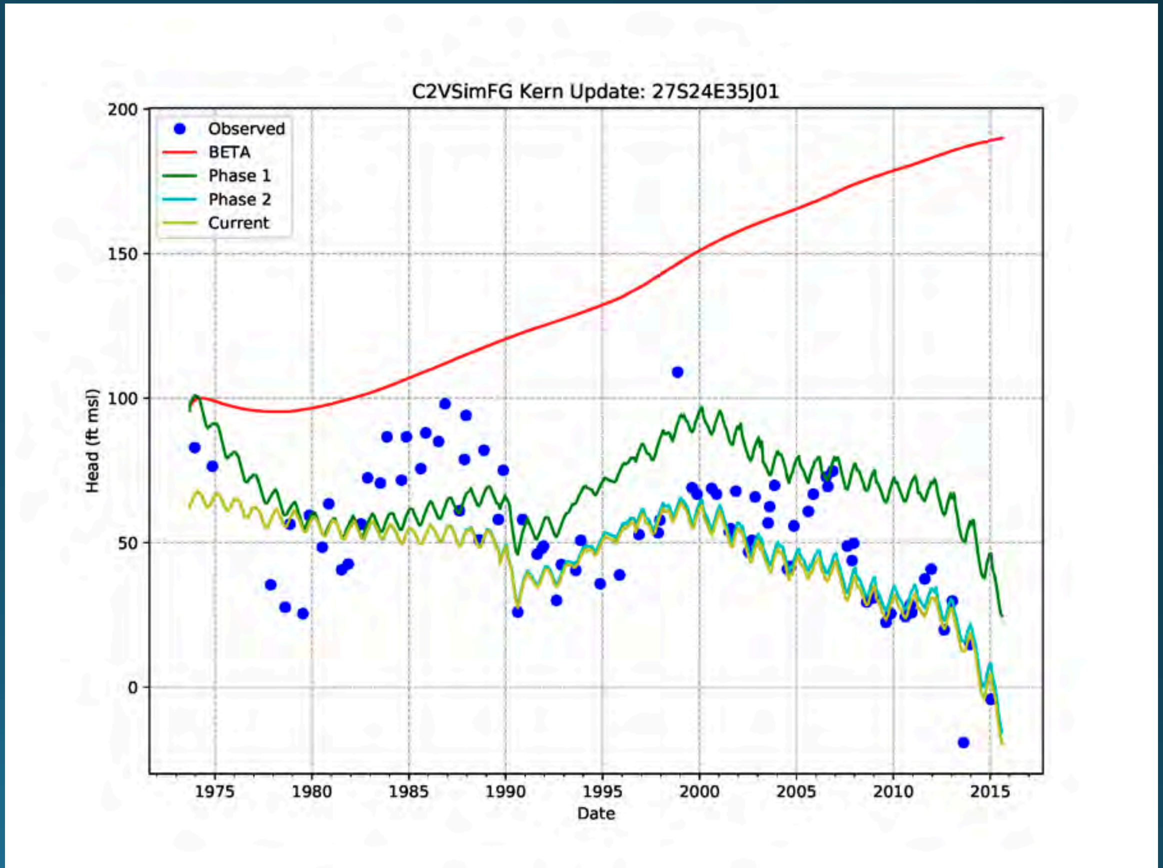


DRAFT

TODD GROUNDWATER

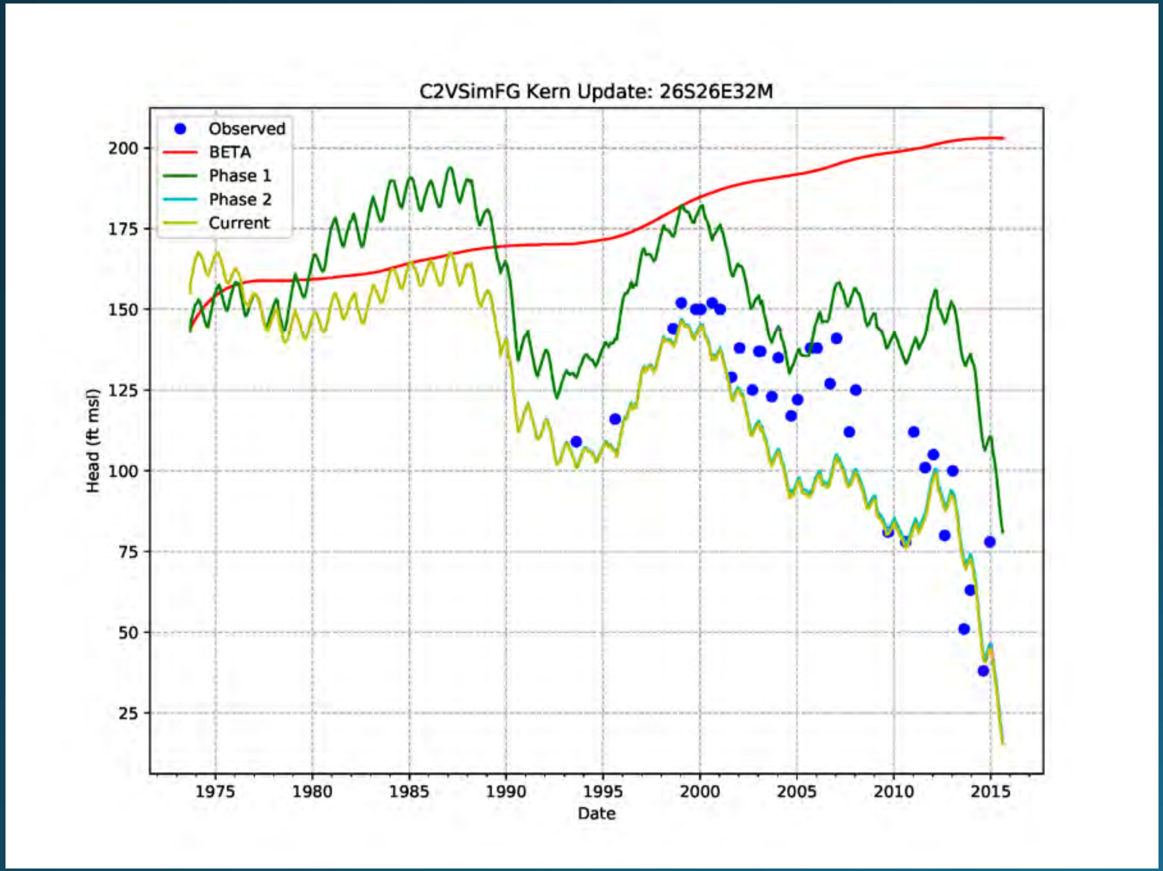
Examples of Model Performance
North Kern WSD and Shafter-Wasco ID

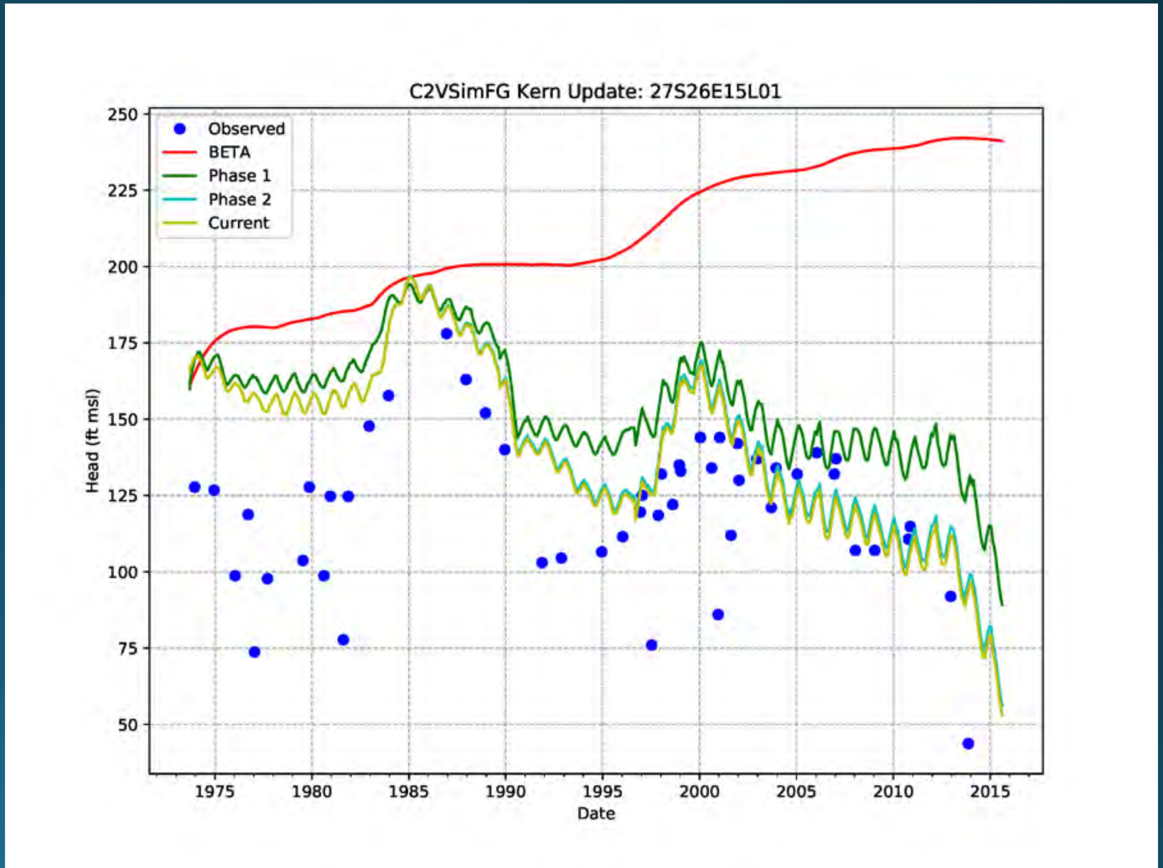




DRAFT

Examples of Model Performance Cawelo WD and Kern-Tulare WD

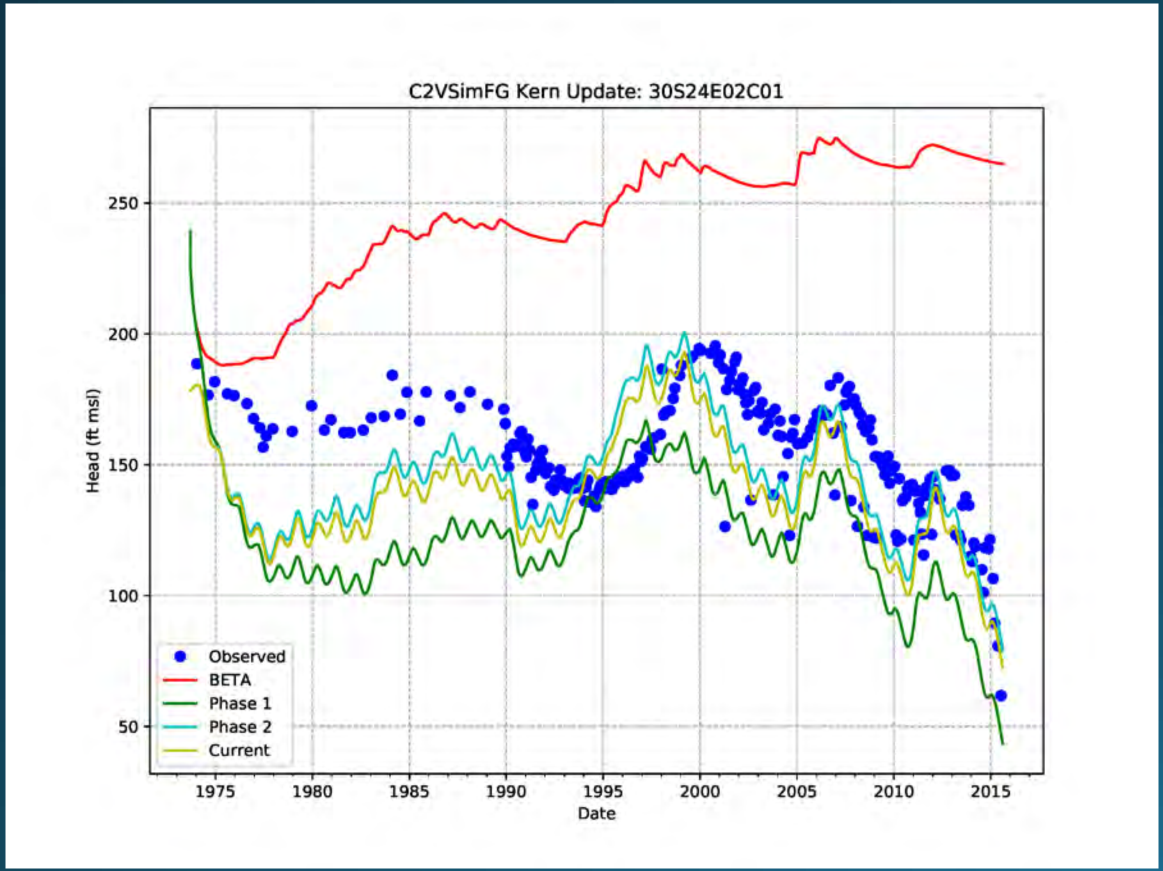


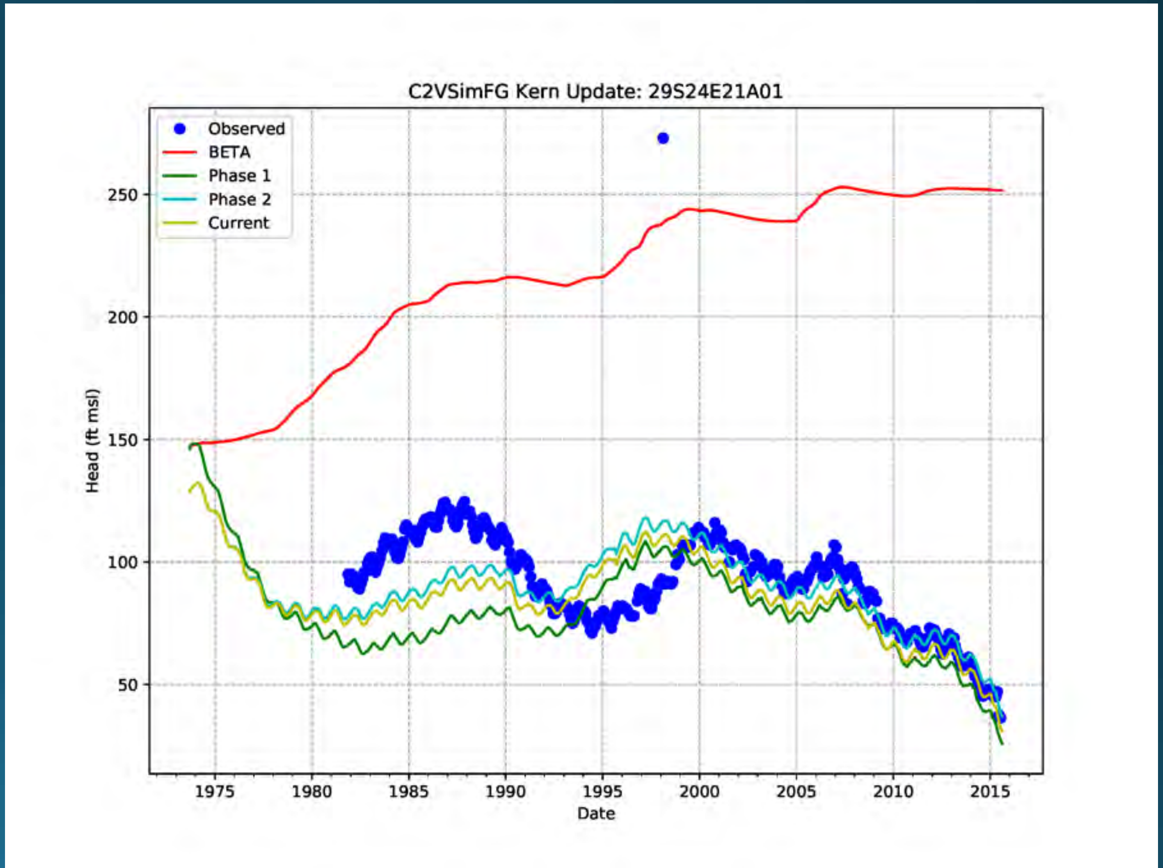


DRAFT

TODD GROUNDWATER

Examples of Model Performance Buena Vista WSD and Semitropic WSD

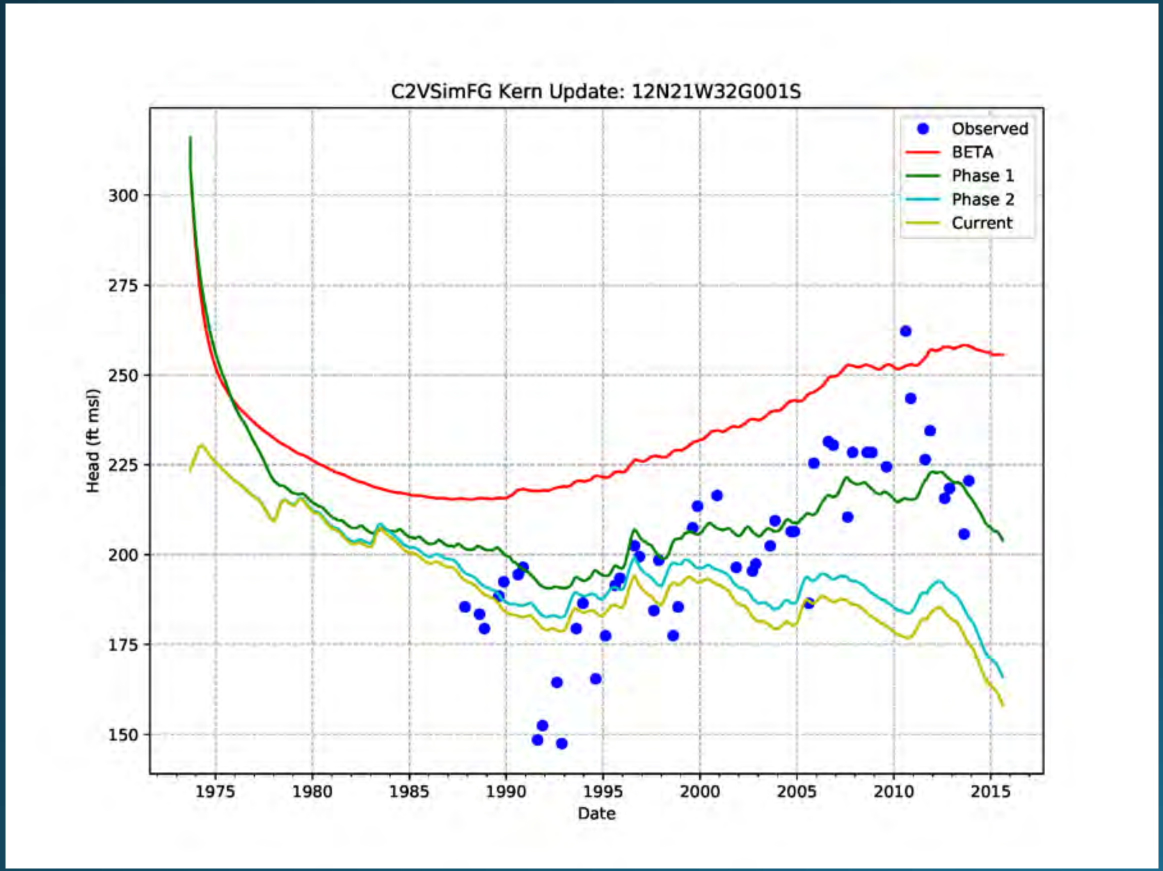


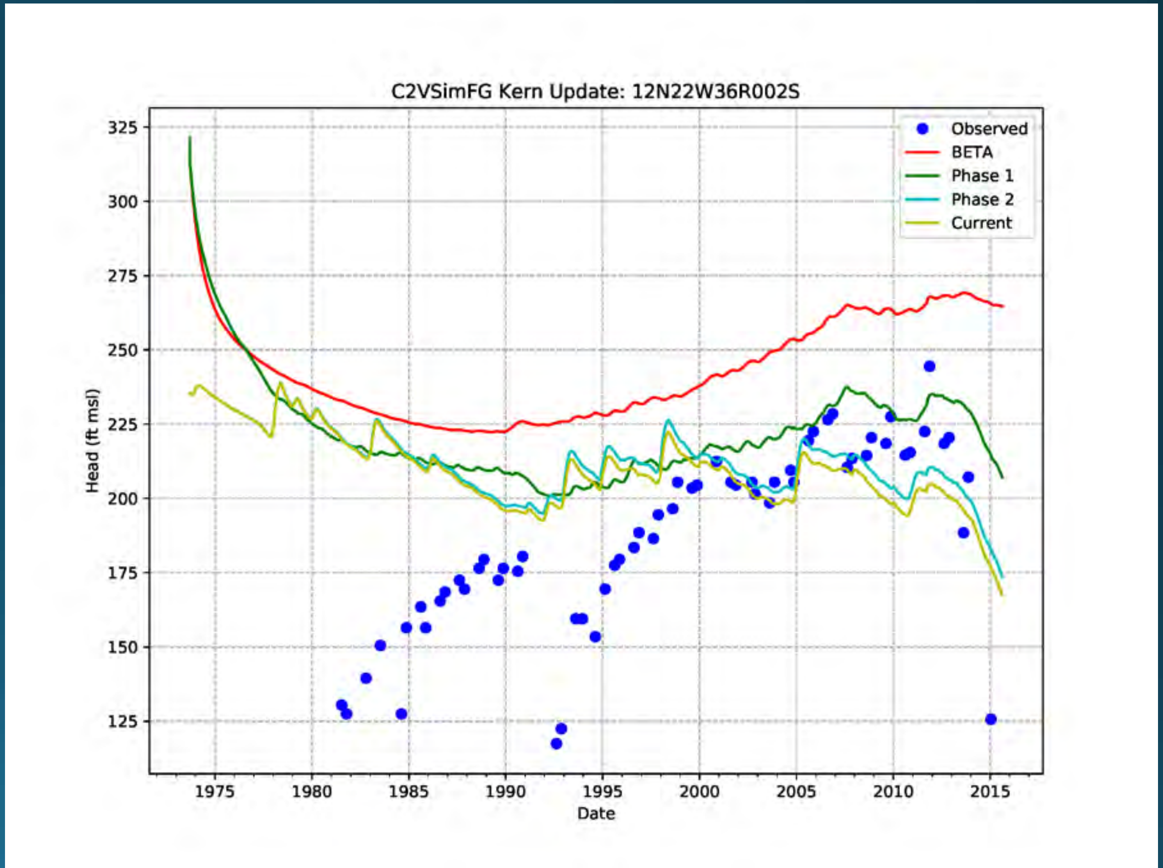


DRAFT

TODD GROUNDWATER

Examples of Remaining Model Issues – Initial Condition Affecting Results

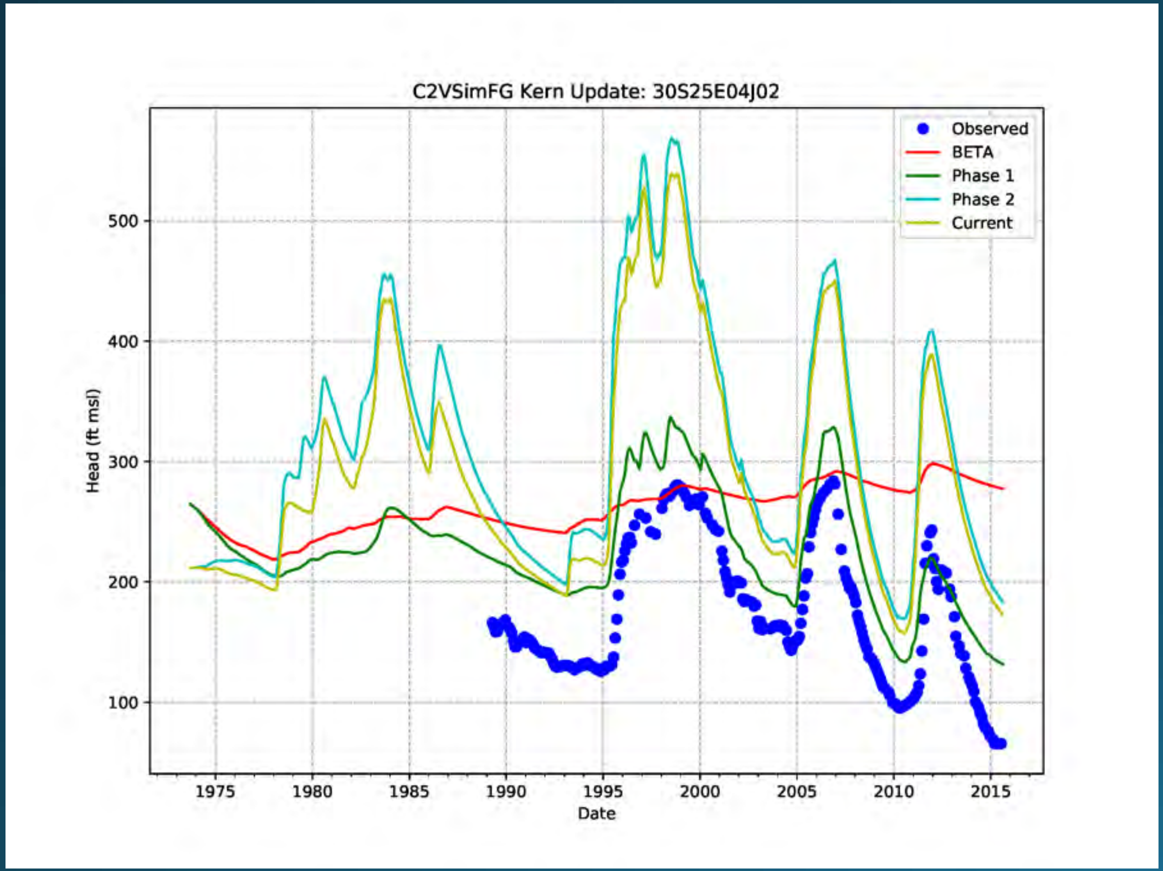


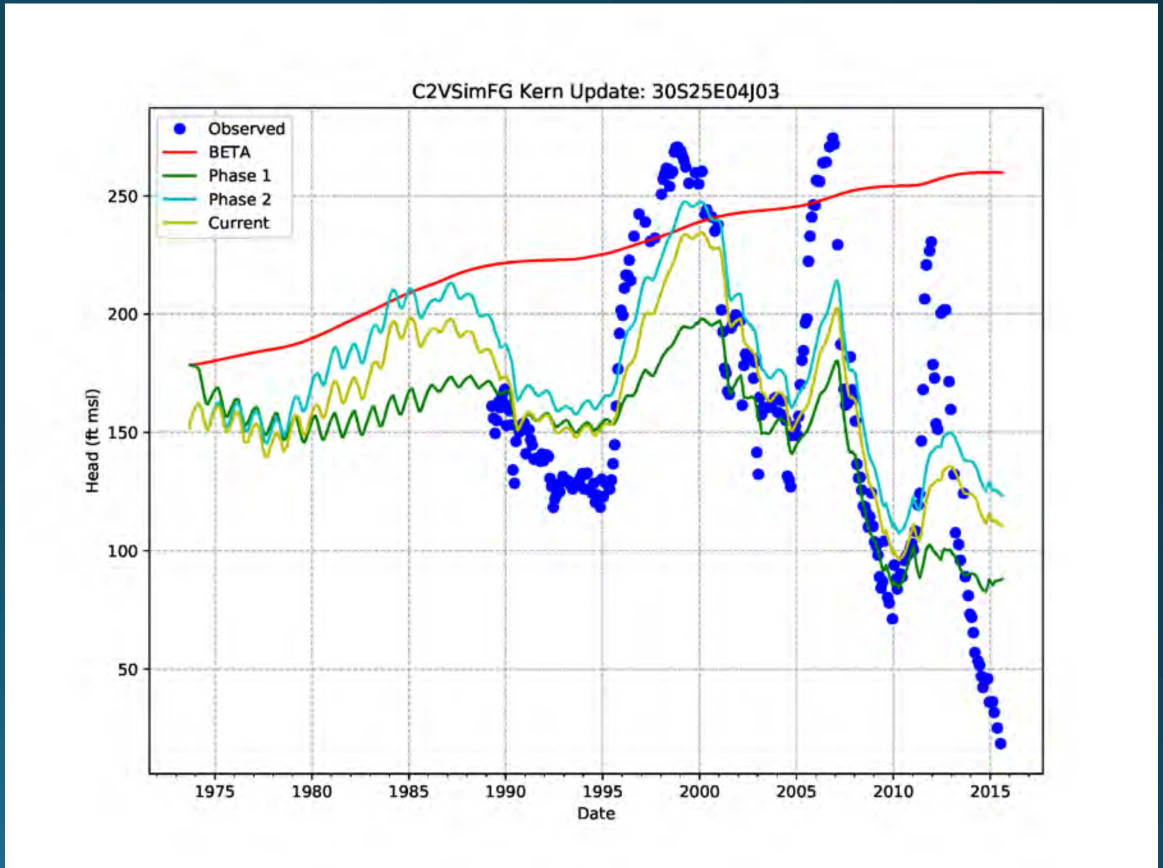


DRAFT

TODD GROUNDWATER

Examples of Remaining Model Issues – Excess Recharge Retention in Layer 1

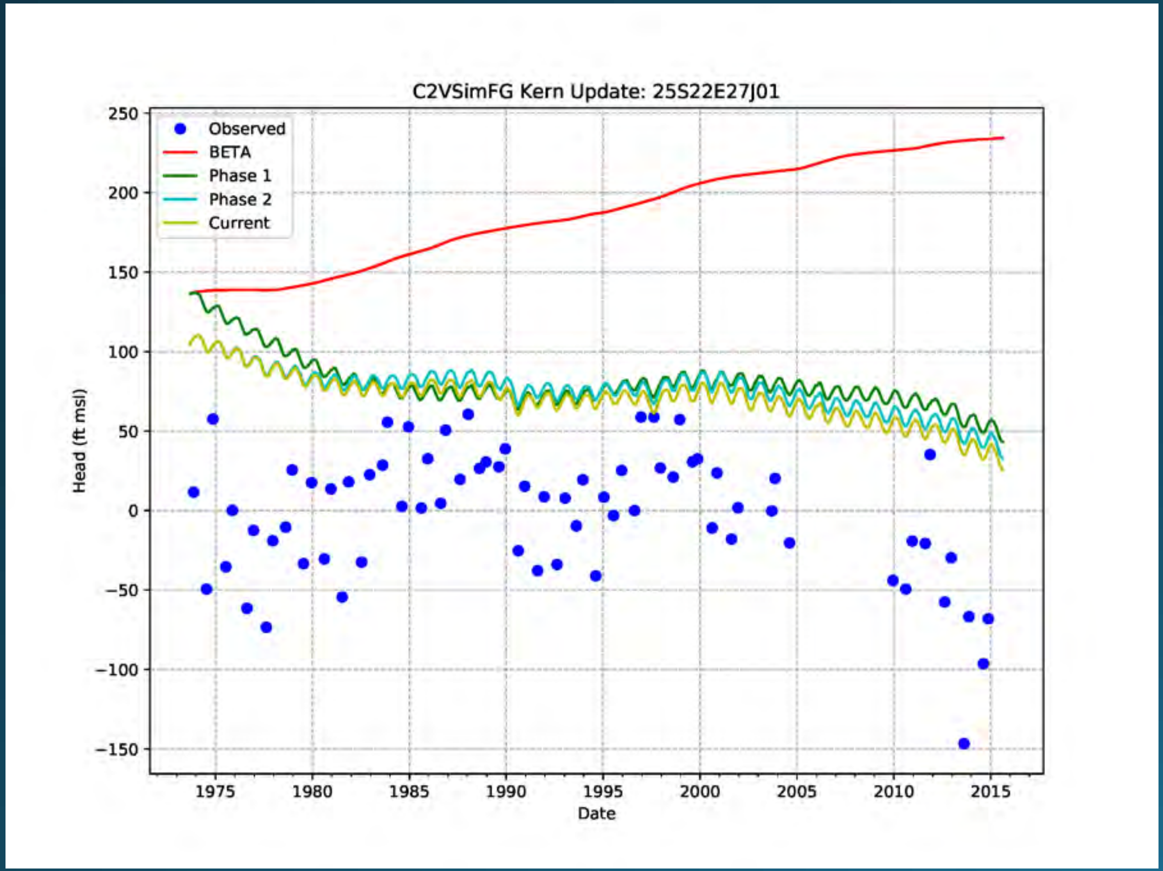


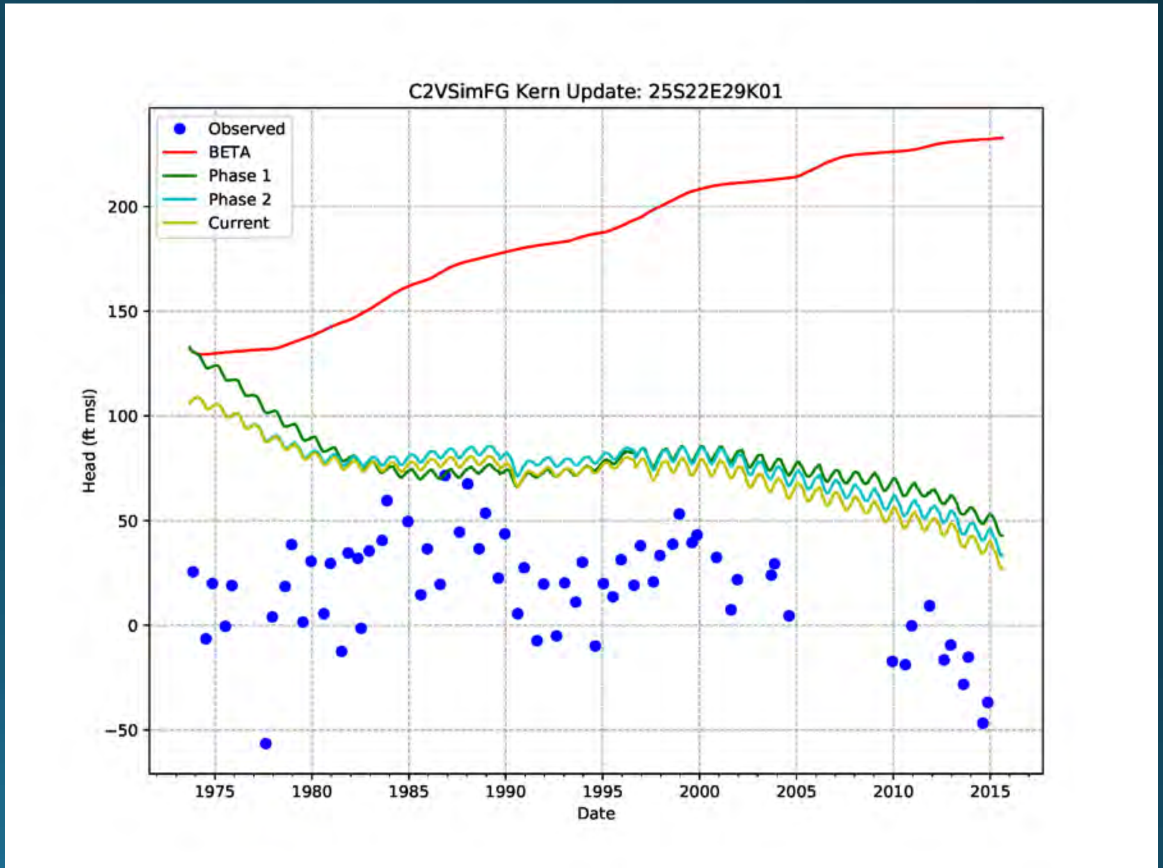


DRAFT

TODD GROUNDWATER

Examples of Remaining Model Issues – Unwarranted Stream Recharge in Northwest

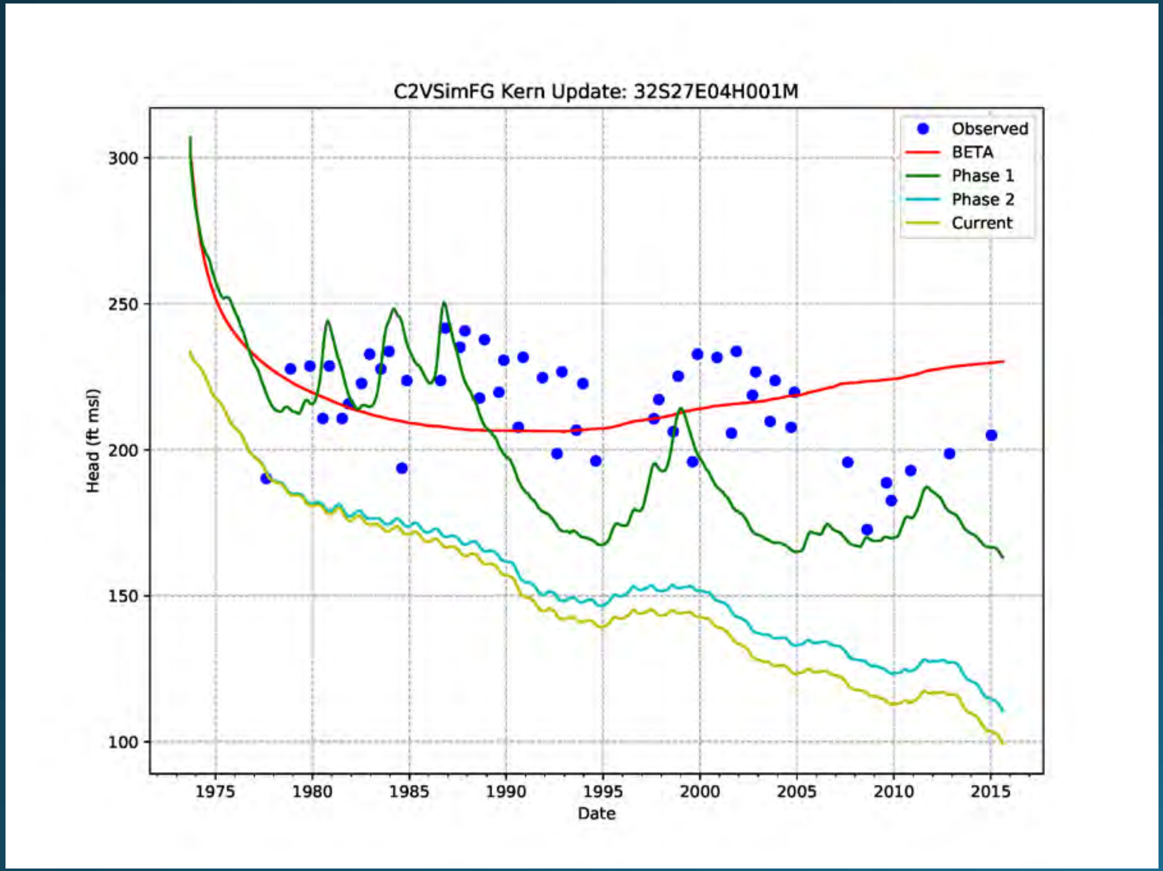


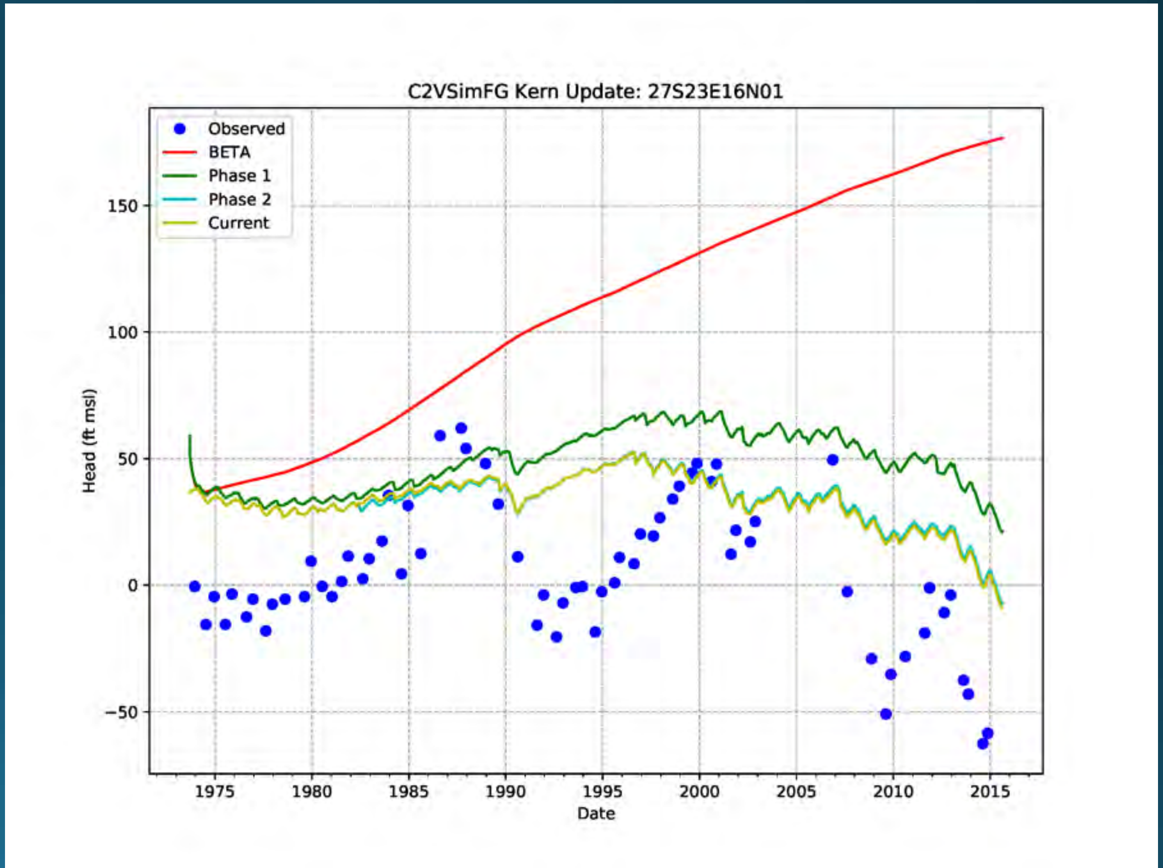


DRAFT

TODD GROUNDWATER

Examples of Remaining Model Issues – Local Areas of Poor Correlation

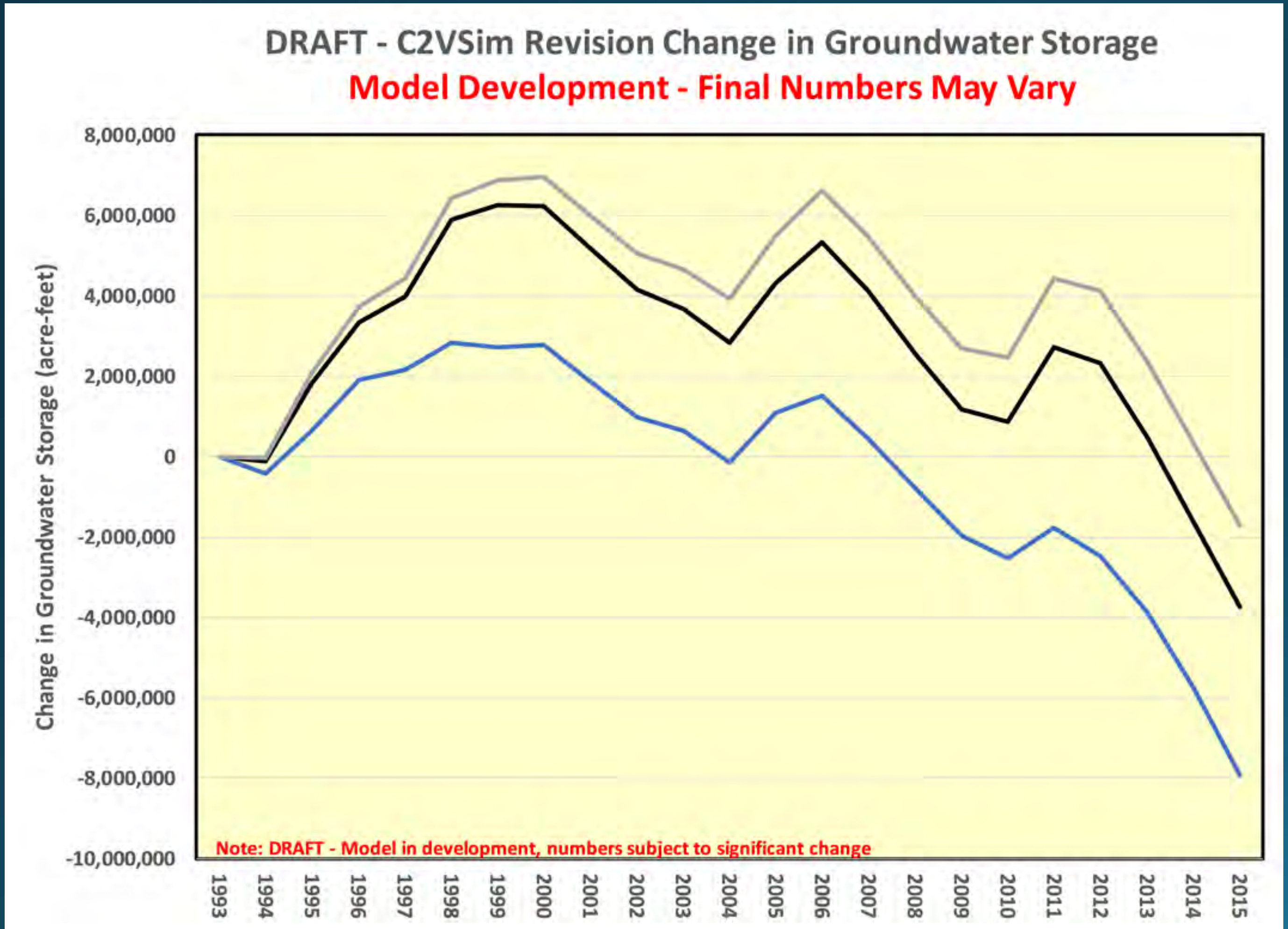




DRAFT

TODD GROUNDWATER

Model Status – Groundwater Storage Change



- Current range gives a guide to final results
  - Anticipate lower storage as remaining issues are resolved
  - Reconcile Draft Model Results with Local water budgets
- Model does not account for Groundwater Banking Accounts
  - Water stored in basin for use by others

DRAFT

TODD GROUNDWATER

Current Model Status

- Phase 1 - Data Input Complete
  - Primary Managed Water Data is Entered
  - Some local data additions are left to do
- Phase 2 and 3 - Working to Improve Model Performance
  - QA/QC of new data input structure still ongoing
  - Reconciling Beta-version issues
  - Limited adjustment to model parameters
- Develop Draft Historical and Current Water Budgets
  - Follow DWR Guidance for Water Budgets
  - Tabular and graphical results
  - Basinwide and Local GSA

Next Steps for Model

- Early November – working to improve model performance
- Nov 13 – Submit for Peer Review
- Nov 22 – Share Draft results
- Early December – Model Update
- Phase 4 – Periodic Model updates as new information is available
- December – Transition to Projected Future Water Budgets

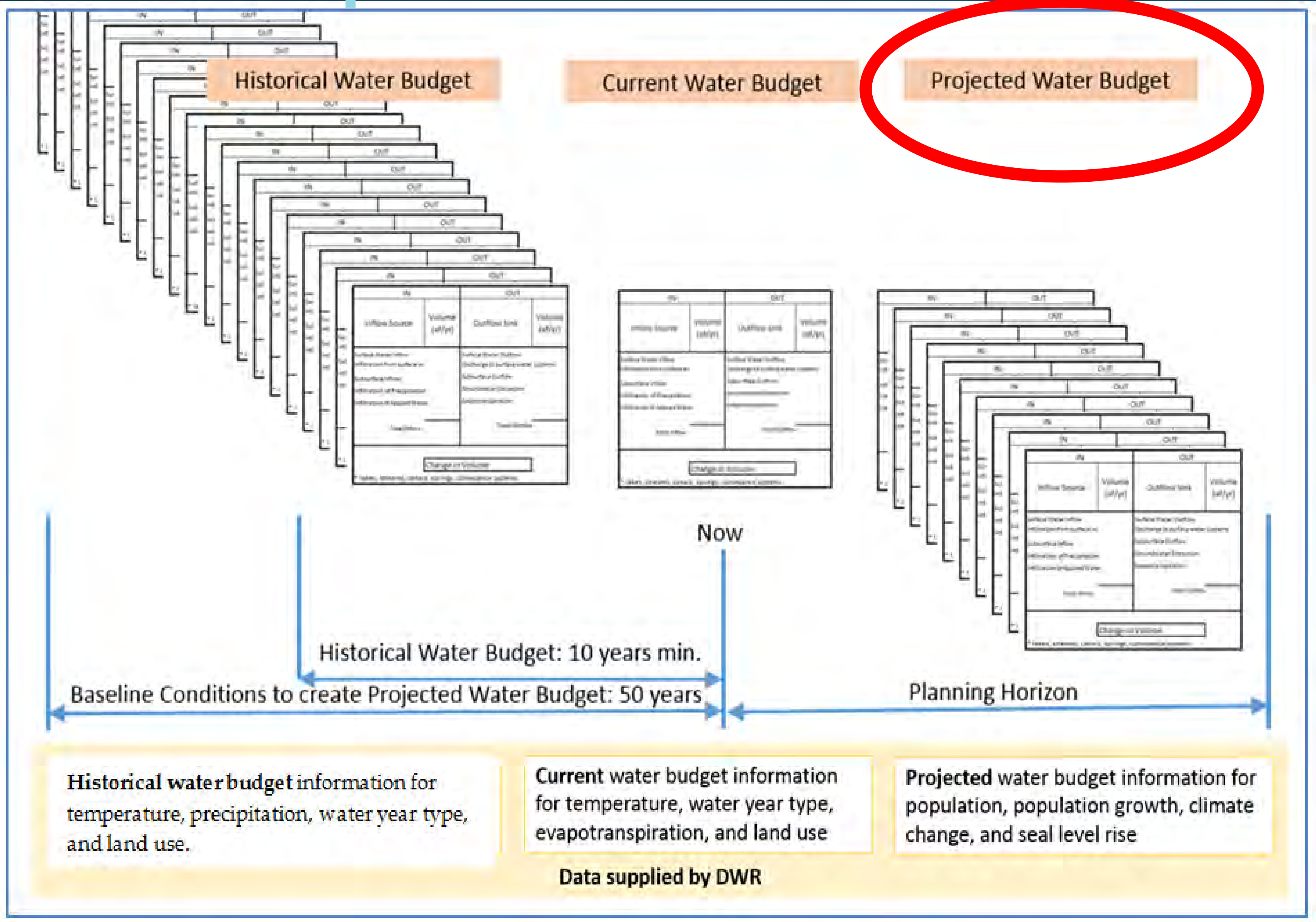
DRAFT

TODD GROUNDWATER

Projected Future Water Budgets

TODD
GROUNDWATER

GSP Requirements for Projected Water Budget



- Baseline
  - Project current land and water use
  - 50-years Historic hydrologic period
- Climate Change
  - DWR Guidance
  - 2030 and 2070 projected climate change
- Projected Sustainability Assessment
  - Test sustainability approach for

DRAFT

TODD GROUNDWATER

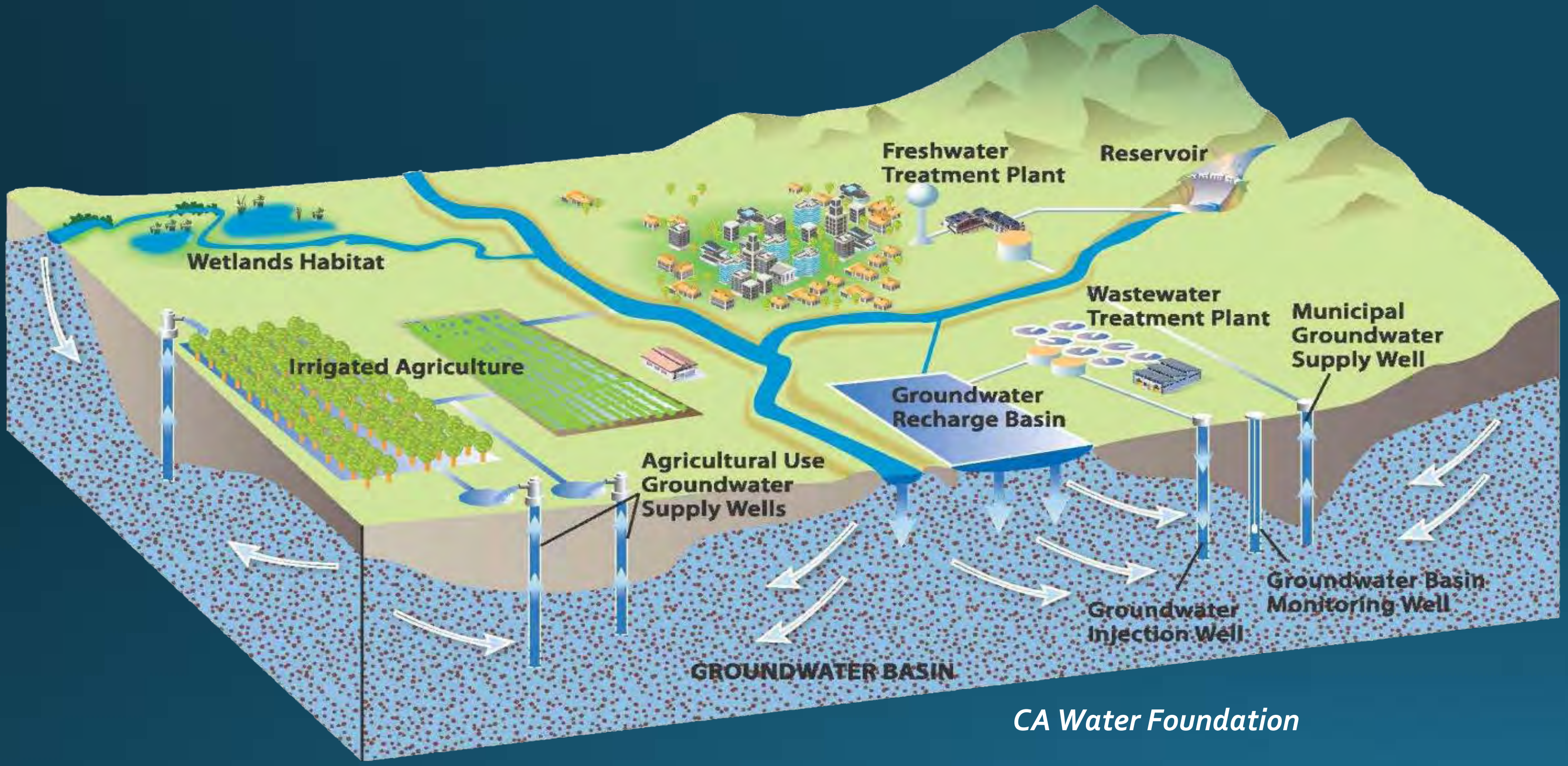
Projected Future Modeling Baseline Development

- Projected Baseline Development
  - Current land use and historic hydrology over 50 year planning horizon
- Climate Change Baseline Development
  - Follow DWR Climate Change Guidance to modify Baseline Condition

DRAFT

TODD GROUNDWATER

Projected Future Sustainability Assessment



CA Water Foundation

- Supply-Side Project
  - Recharge projects
  - Operational changes
  - Recycled Water
- Demand Reduction
  - Urban water reduction
  - Changes in Ag operations
- Variable Changes
  - Imported Water Delivery

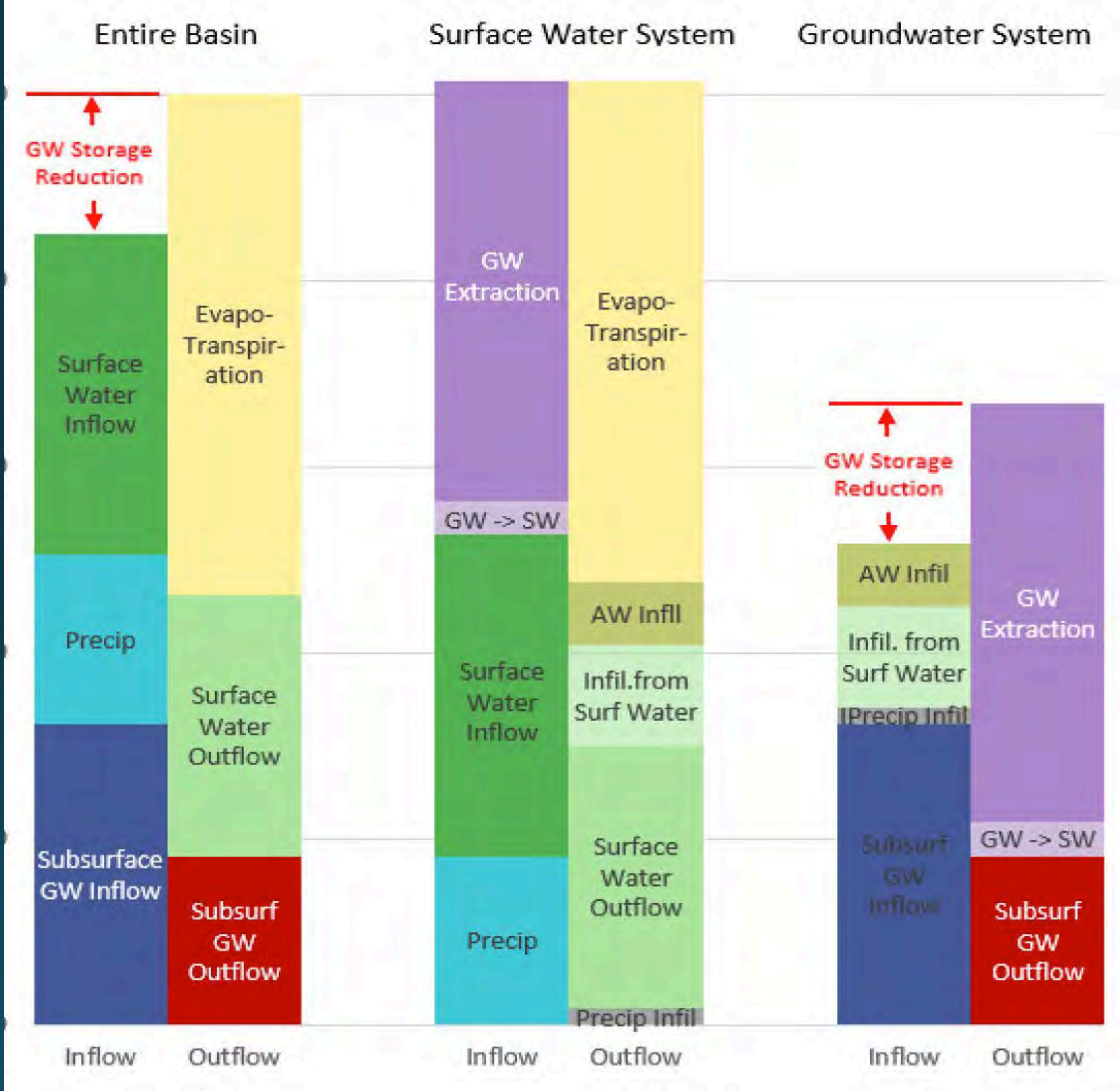
DRAFT

TODD GROUNDWATER

Projected Future Modeling Sustainability Assessment

- Sustainability Alternatives Screening Analysis
  - Early test of potential sustainability alternatives to support GSAs
  - Addresses DWR Uncertainty Analysis requirement
- Projected Future Sustainability Assessment
  - GSAs provide proposed sustainability alternatives
  - Develop basinwide scenarios
- Preferred Sustainability Alternative
  - Finalize scenarios for use in GSPs

DRAFT



Projected Future Water Budgets

- Evaluate baseline conditions
- Viability of Proposed Sustainability Plans
- How may Climate Change affect Proposed Sustainability Plan

DRAFT

TODD GROUNDWATER

Discussion and Questions

Kern River Groundwater Sustainability Agency
Groundwater Workshop

Tuesday, November 13, 2018 at 6:00 p.m.
Bear Mountain Recreation David Head Center
10300 San Diego St., Lamont, CA 93241

AGENDA

6:00 p.m. – 6:05 p.m.	Welcome & Introductions
6:05 p.m. – 6:25 p.m.	California's New Groundwater Law and Groundwater Sustainability Plans (GSP)
6:25 p.m. – 6:45 p.m.	Local Efforts to Comply with SGMA - Kern River Groundwater Sustainability Agency GSP Development Efforts
6:45 p.m. – 7:20 p.m.	Share your Thoughts – Stakeholder Discussion
7:20 p.m. – 7:30 p.m.	Next Steps and Closing Remarks

Agencia de Sostenibilidad de Aguas Subterráneas de Kern River
Taller de Agua Subterránea

Martes, 13 de noviembre, 2018 at 6:00 p.m.
Bear Mountain Recreation David Head Center
10300 San Diego St., Lamont, CA 93241

AGENDA

6:00 p.m. – 6:05 p.m.	Bienvenida y Presentaciones
6:05 p.m. – 6:25 p.m.	Nueva Ley de Aguas Subterráneas de California y Planes de Sostenibilidad de Aguas Subterráneas (GSP)
6:25 p.m. – 6:45 p.m.	Esfuerzos Locales para Cumplir con SGMA - Esfuerzos de Desarrollo del GSP de la Agencia de Sostenibilidad de Aguas Subterráneas de Kern River
6:45 p.m. – 7:20 p.m.	Comparta sus pensamientos - Discusión de las partes interesadas
7:20 p.m. – 7:30 p.m.	Próximos Pasos y Clausura

You're Invited!

GROUNDWATER WORKSHOP

THIS WORKSHOP WILL COVER:

- **California's New Groundwater Law — the Sustainable Groundwater Management Act (SGMA) of 2014**
- **Your Groundwater Sustainability Agency (GSA)**
- **Your Groundwater Sustainability Plan (GSP)**
- **How to participate!**

DATE: Tuesday, November 13, 2018

TIME: 6:00 - 7:30 p.m.

WHERE: Bear Mountain Recreation David Head Center

10300 San Diego St., Lamont, CA 93241

For more information, please contact:

Eva Dominguez (559) 802-1634, EvaD@SelfHelpEnterprises.org or
Maria Herrera (559) 802-1676, MariaH@SelfHelpEnterprises.org

Translation services will be available

Self-Help Enterprises

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

¡Estás Invitado!

TALLER DE AGUA SUBTERRÁNEA

TEMAS DEL TALLER:

- **Nueva ley estatal del agua subterránea: la Ley del Manejo Sostenible del Agua Subterránea (SGMA) de 2014**
- **Su Agencia de Manejo Sostenible de Agua Subterránea**
- **Su Plan de Manejo Sostenible del Agua Subterránea**
- **Como participar!**

FECHA: Martes, 13 de noviembre 2018

HORA: 6:00 - 7:30 p.m.

DÓNDE: Bear Mountain Recreation David Head Center

10300 San Diego St., Lamont, CA 93241

Para mas información, póngase en contacto con:

Eva Dominguez (559) 802-1634, EvaD@SelfHelpEnterprises.org o

Maria Herrera (559) 802-1676, MariaH@SelfHelpEnterprises.org

Servicios de traducción estarán disponibles

Self-Help Enterprises

KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Kern River GSA Groundwater Workshop
Tuesday, November 13, 2018, 6:00 p.m. - 7:30 p.m.
Bear Mountain Recreation David Head Center, 10300 San Diego St., Lamont, CA 93241

	Name/Nombre	Agency/Agencia	Phone/Telefono	Email/Correo Electrónico	Would you like to be notified of future meetings? ¿Desea que le avisemos sobre futuras reuniones?
1	Antone Mattos	El Adobe	661-428-9650	T.MATTOS@TEJONRANCH.COM	X
2	Jana Marquez	KDWD	661 834 4656	Jana@Korndelta.org	
3	Patty Poire	KGA			
4	David Beard	KWA IDH	661 634 1400	dbeard@kcwa.com	
5	Debra Lilly	Horizon	916 465 8074	debra@horizonh2o.com	
6	Pete Kaiser	KDWD			
7	Ken Schwarz	Horizon Water & Environment	510-986-1851	ken@horizonh2o.com	
8	Mark Mulkay	KDWD	661-834-4656		
9	Art Chianello	City of Bakersfield	661-326-3715	achianel@bakersfieldcity.us	
10	Jeevan Muhar	Arvin-Edison WSD	661-854-5573	jmuhar@aewsd.org	X
11	Jasmene del Aguila	LCJA	661-843-7477	jdelaguila@leadershipcounsel.org	X
12	David Hampton	CWD	661-831-6390	dhampton@cawelaw.org	
13	Ramon Zavala	Lamont	661-845-213 (casc)	661-332-7090	
14					
15					
16					

Kern River Groundwater Sustainability Agency

Groundwater Workshop

November 13, 2018

Horizon WATER and ENVIRONMENT

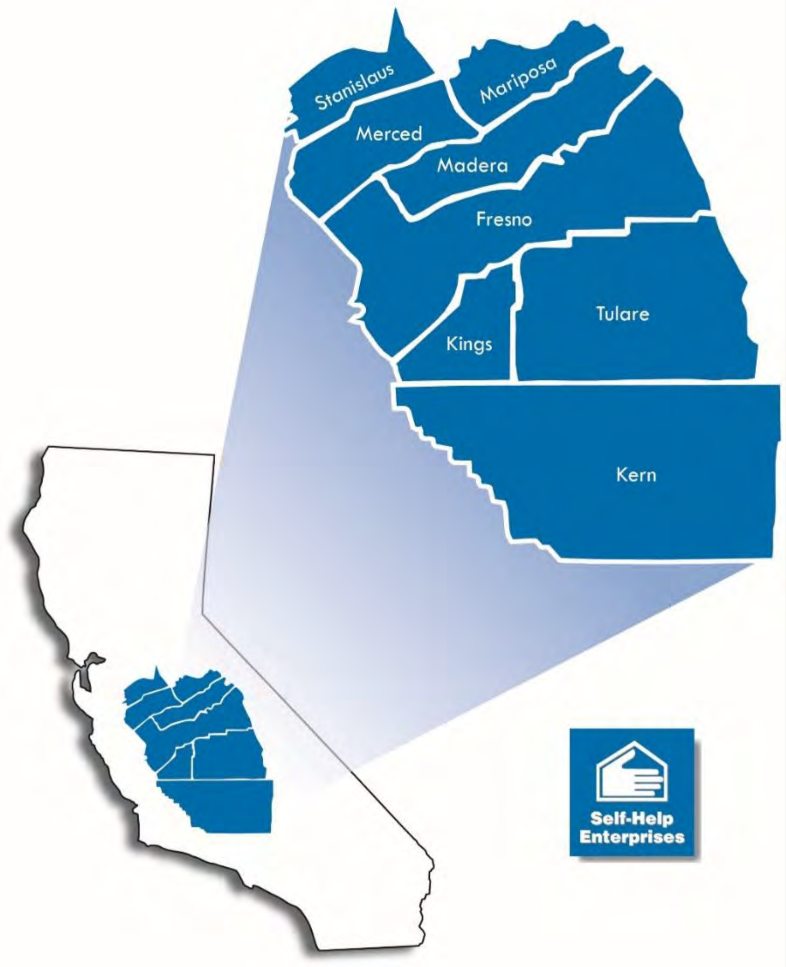
KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Self-Help Enterprises

SELF-HELP ENTERPRISES (SHE)

- SHE is a nationally-recognized non-profit housing and community development organization whose mission is to work together with low-income families to build and sustain healthy homes and communities.
- Community Development Program provides technical assistance and leadership development in rural communities who face clean water, sanitary sewer and other infrastructure challenges.
- Community Engagement and Planning Team supports community participation in regional water management and groundwater sustainability planning as well as building water management capacity and expertise in rural communities.

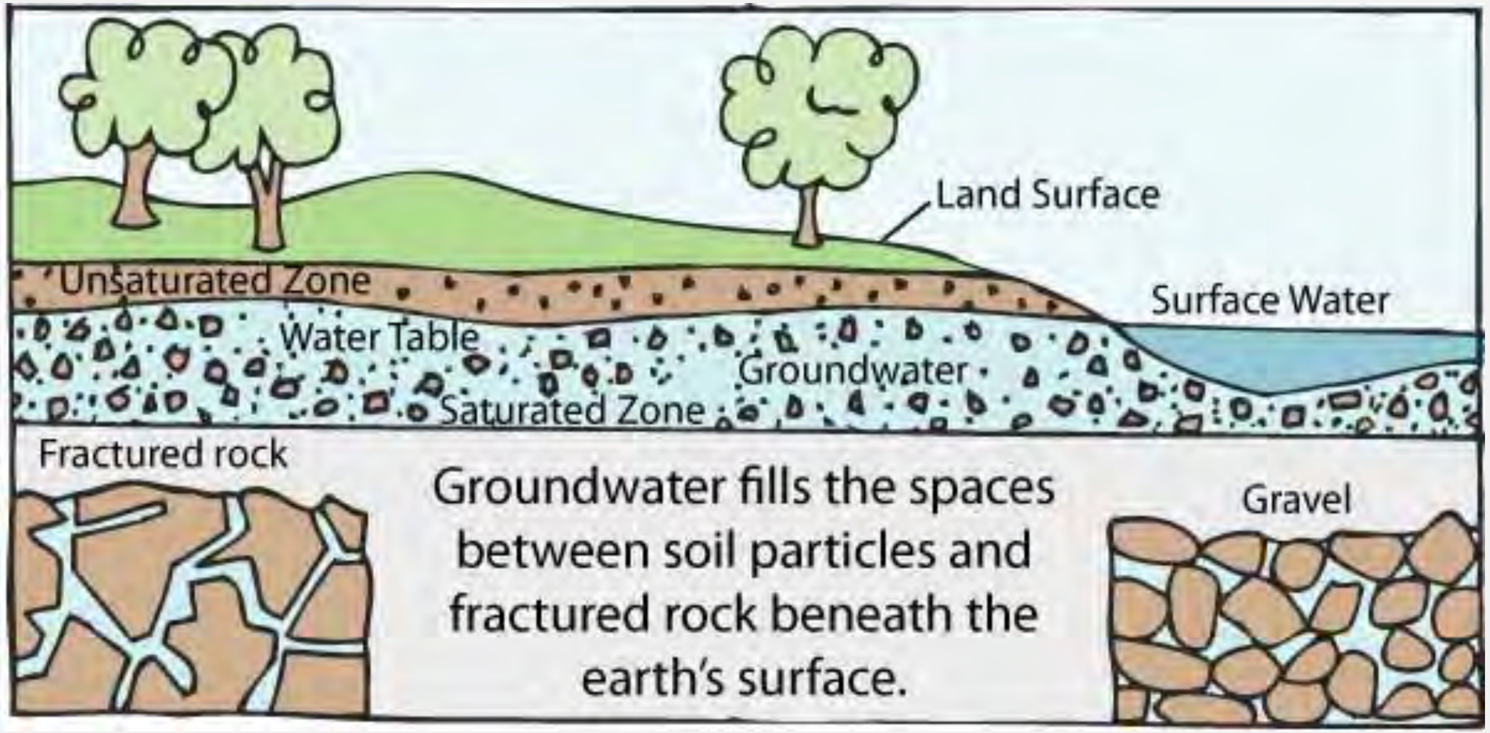


WORKSHOP OVERVIEW

- California’s New Groundwater Law – The Sustainable Groundwater Management Act (SGMA)
- Groundwater Sustainability Plans (GSPs)
- KRGSA’s GSP Development Efforts
- Stakeholder Discussion
- Wrap Up and Closing Remarks

GROUNDWATER MATTERS

On average Californians get **40%** of their water from groundwater. During droughts, that number can go up to **60%.**



- In the Central Valley, we are even more dependent on groundwater than the state as a whole
- **90%** of Central Valley residents rely on groundwater for at least part of their drinking water supply
- Most unincorporated communities are **100%** reliant on groundwater – includes many of our small school districts

HOW COMMUNITIES AND SCHOOLS USE GROUNDWATER

HISTORICAL GROUNDWATER MANAGEMENT

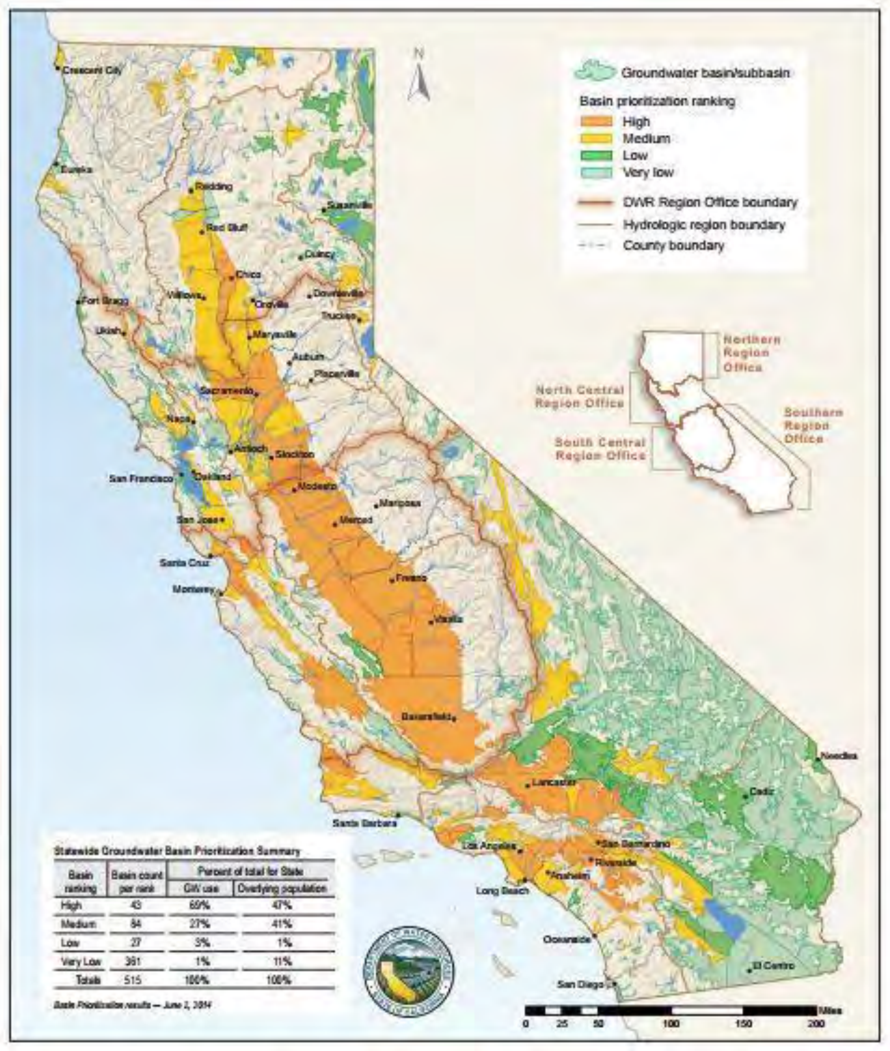
- Previously, groundwater management was voluntary in certain areas of the state
- Groundwater levels have been declining due to over-pumping, less surface water, and not enough recharge
- The drought (2012-2016) had an unprecedented impact on our state
- Dry wells (i.e., Arvin, Lamont area, and many others)
- Subsidence

CALIFORNIA'S SUSTAINABLE GROUNDWATER MANAGEMENT ACT (SGMA)

- Three-bill package: SB 1168 (Pavley), AB 1739 (Dickinson), SB 1319 (Pavley)
- Signed by Governor Brown on September 16, 2014
- Objective: Ensure the long-term reliability of our groundwater resources and connected surface water resources requiring "sustainable" management
- Core Principle: Local control

PREVENT UNDESIRABLE RESULTS

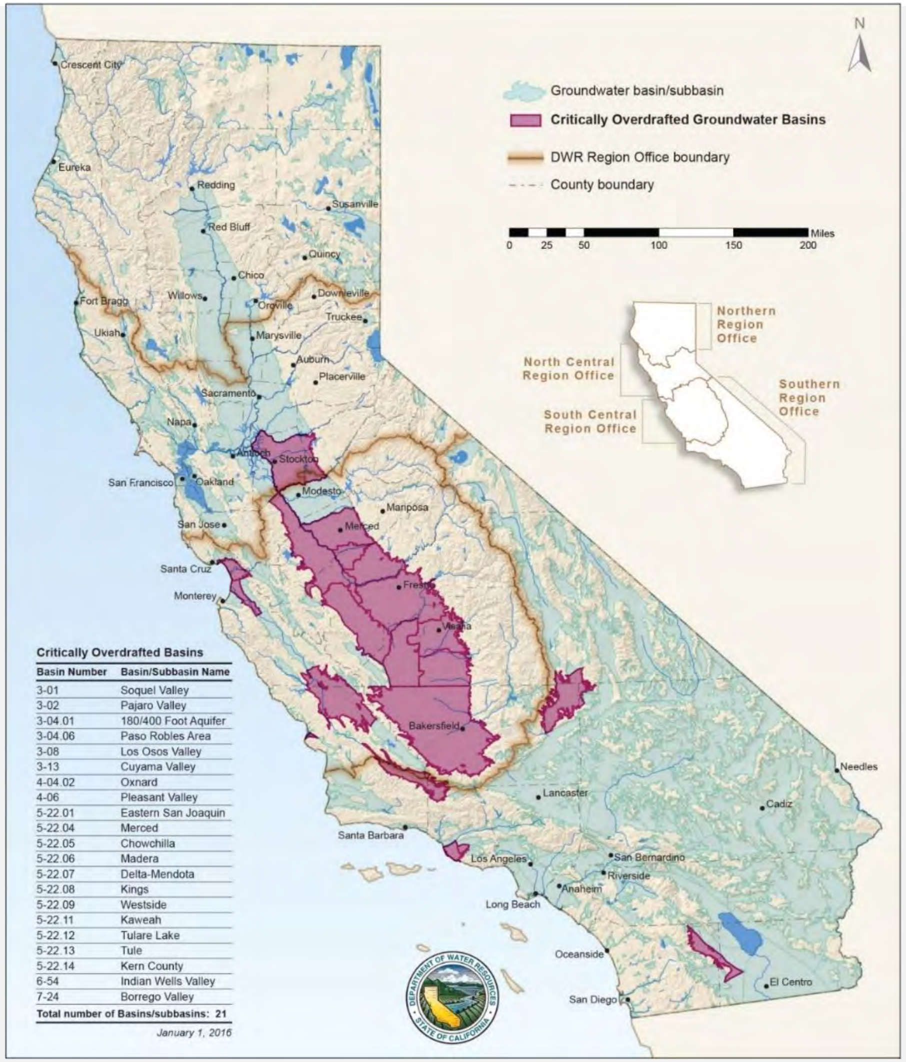
WHO MUST COMPLY WITH SGMA?



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014



Critically Overdrafted Basins

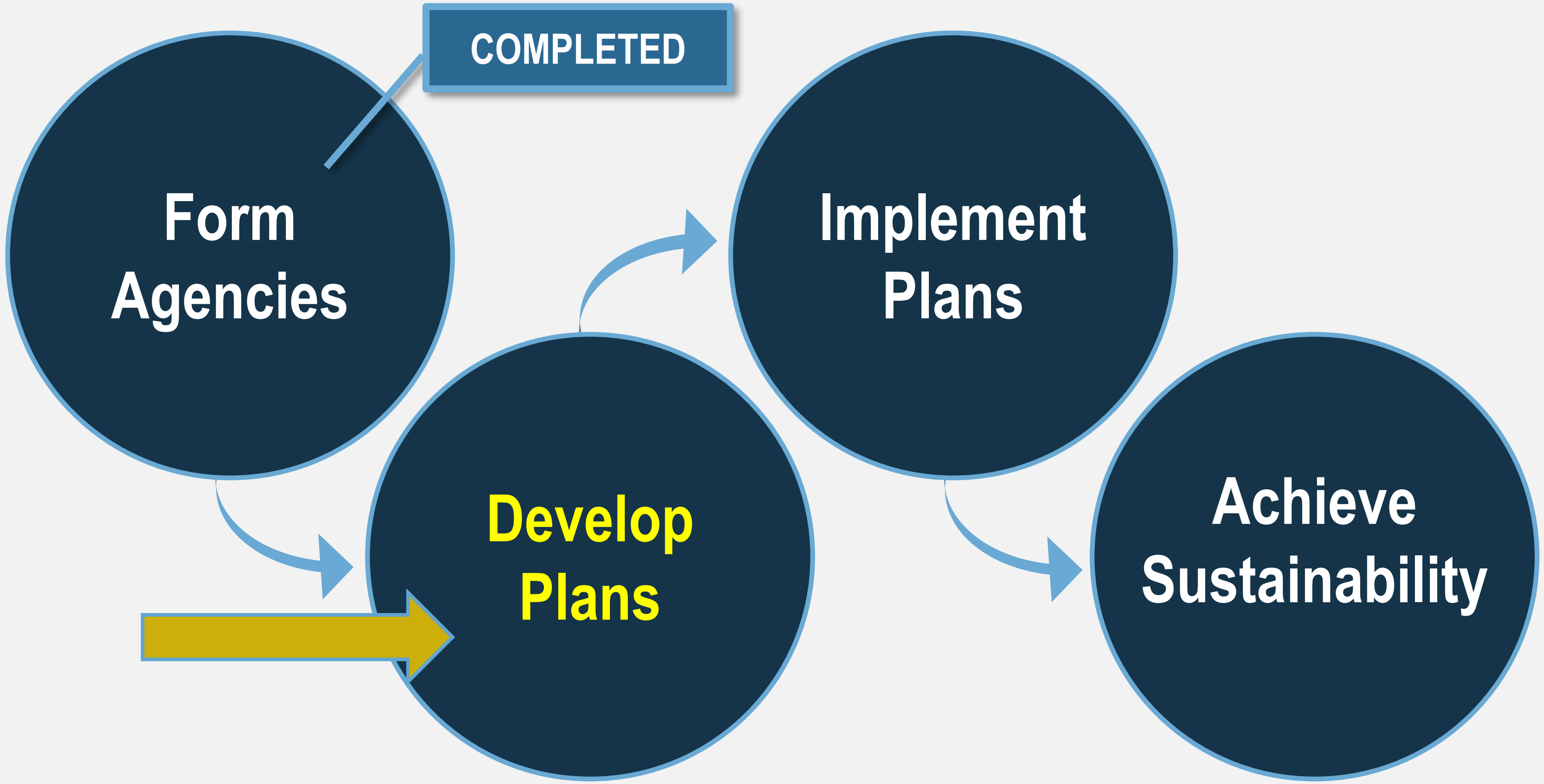
Basin Number	Basin/Subbasin Name
3-01	Soquel Valley
3-02	Pajaro Valley
3-04.01	180/400 Foot Aquifer
3-04.06	Paso Robles Area
3-08	Los Osos Valley
3-13	Cuyama Valley
4-04.02	Oxnard
4-06	Pleasant Valley
5-22.01	Eastern San Joaquin
5-22.04	Merced
5-22.05	Chowchilla
5-22.06	Madera
5-22.07	Delta-Mendota
5-22.08	Kings
5-22.09	Westside
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
6-54	Indian Wells Valley
7-24	Borrego Valley
Total number of Basins/subbasins: 21	

January 1, 2016

WHOSE INTERESTS ARE AT STAKE?

- Holders of overlying groundwater rights (agricultural and domestic)
- Public water systems
- Local land use planning agencies
- Environmental users of groundwater
- Surface water users
- California Native American tribes
- Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems

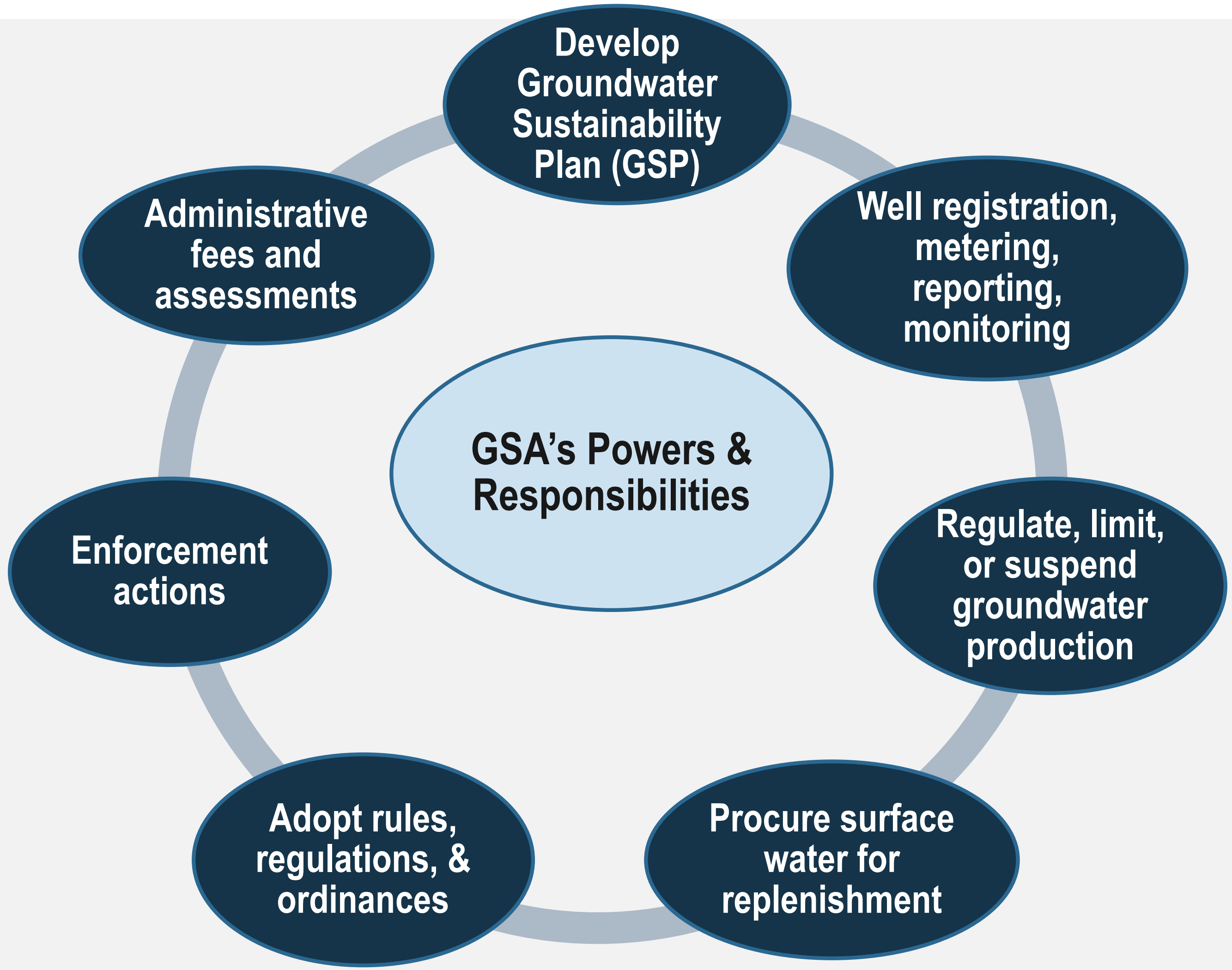
SGMA DESIGN


COMPLETED
Form Agencies
Develop Plans
Implement Plans
Achieve Sustainability

MULTIPLE GSAs IN A SUBBASIN

- More than one GSA can be formed in a sub-basin
- If there are multiple GSAs in a sub-basin, the GSAs can collaborate to write one single plan, or each GSA can write its own plan so long as the GSAs establish a coordination agreement for implementing multiple plans.
- However, GSAs must cover the entire area of the sub-basin, leaving no areas unmanaged
- All GSAs were approved in July 2017

POWERS AND RESPONSIBILITIES OF A GSA



DEVELOPMENT OF GROUNDWATER SUSTAINABILITY PLANS

- GSPs must contain important information:
  - Description of plan area & basin setting
  - Sustainability criteria
  - Monitoring program and projects
- GSPs will serve as the roadmap to achieve sustainability
- GSAs will need to develop GSPs with stakeholder input

GSP SUBMITTAL AND APPROVAL BY DWR

- GSPs must be written by **January 31, 2020 (or January 31, 2022 if the basin is not critically overdrafted)**

- DWR determinations
  - Adequate
  - Conditionally Adequate (minor deficiencies that can be corrected within 180 days)
  - Inadequate

- If the Department of Water Resources decides that a GSP **will not sustainably manage groundwater by 2040 (or 2042 if not in critically overdrafted basins)**…

  → **<u>The State may step in and manage the sub-basin itself!</u>**

  Much more expensive

  Less local control

GSP IMPLEMENTATION AND ACHIEVING SUSTAINABILITY

- After submitting its GSP, a GSA has 20 years to reach sustainability
  - **Sustainability must be reached by 2040 (2042 for areas not in critical overdraft)**
- DWR will review all plans every five years to assess progress and recommend corrective actions as needed
- Annual Reporting

QUESTIONS & ANSWERS

GROUNDWATER SUSTAINABILITY PLANS

1. **Description of the plan area and basin setting:** Groundwater conditions, water budget, hydrogeological conceptual model, management areas

2. **Sustainability criteria:** set sustainability goal, set minimum thresholds for undesirable results, set measurable objectives

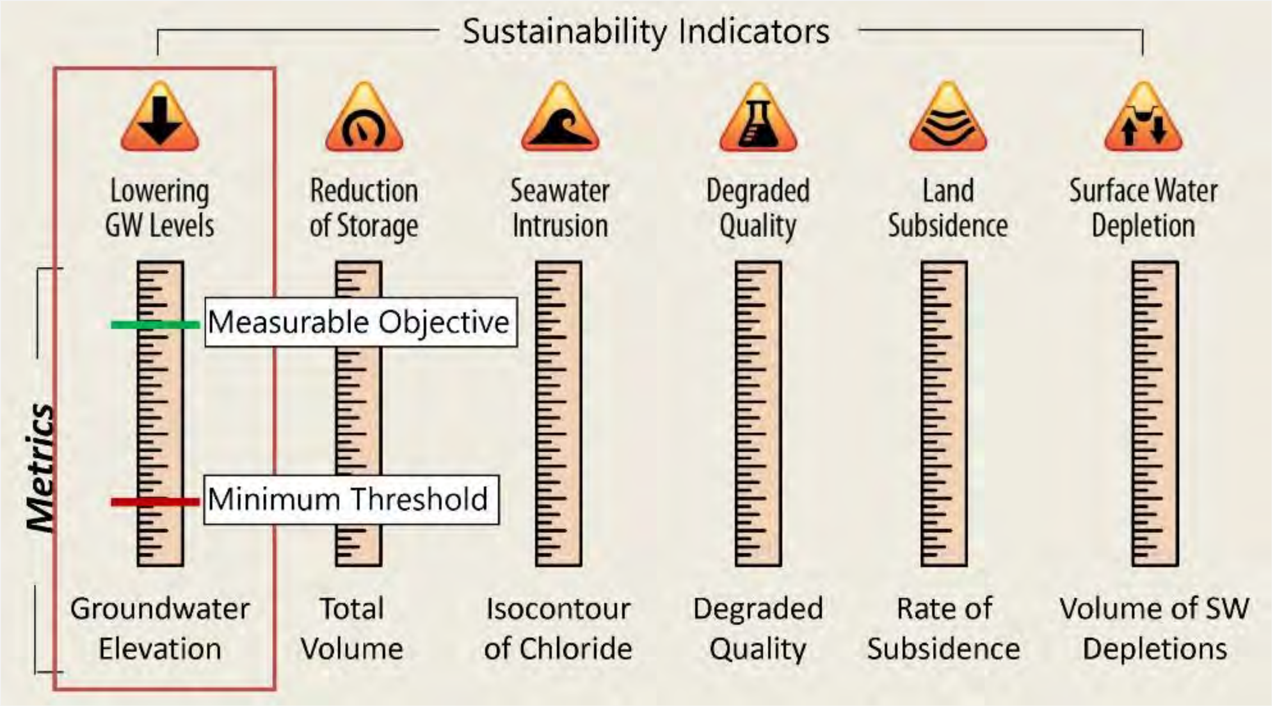
3. **Projects and management actions:** projects, management actions, mitigation measures, monitoring plan

WATER BUDGETS

SUSTAINABILITY CRITERIA
MEASUREABLE OBJECTIVES AND MINIMUM THRESHOLDS

Prevent "Undesirable results that are significant and unreasonable"

At this time, the only undesirable result that we can be certain doesn't apply to the Kern River GSA area is Seawater intrusion



SUSTAINABILITY IS DEFINED LOCALLY

- SGMA requires GSAs to define sustainability using two concepts:
  - **Measurable objectives** are aspirational goals. Technically, you should achieve them by 2040 (or 2042 if not critically overdrafted).
  - **Minimum thresholds** are to be avoided. If they are crossed, you may be out of compliance with your plan and violating the obligation to reach sustainability.

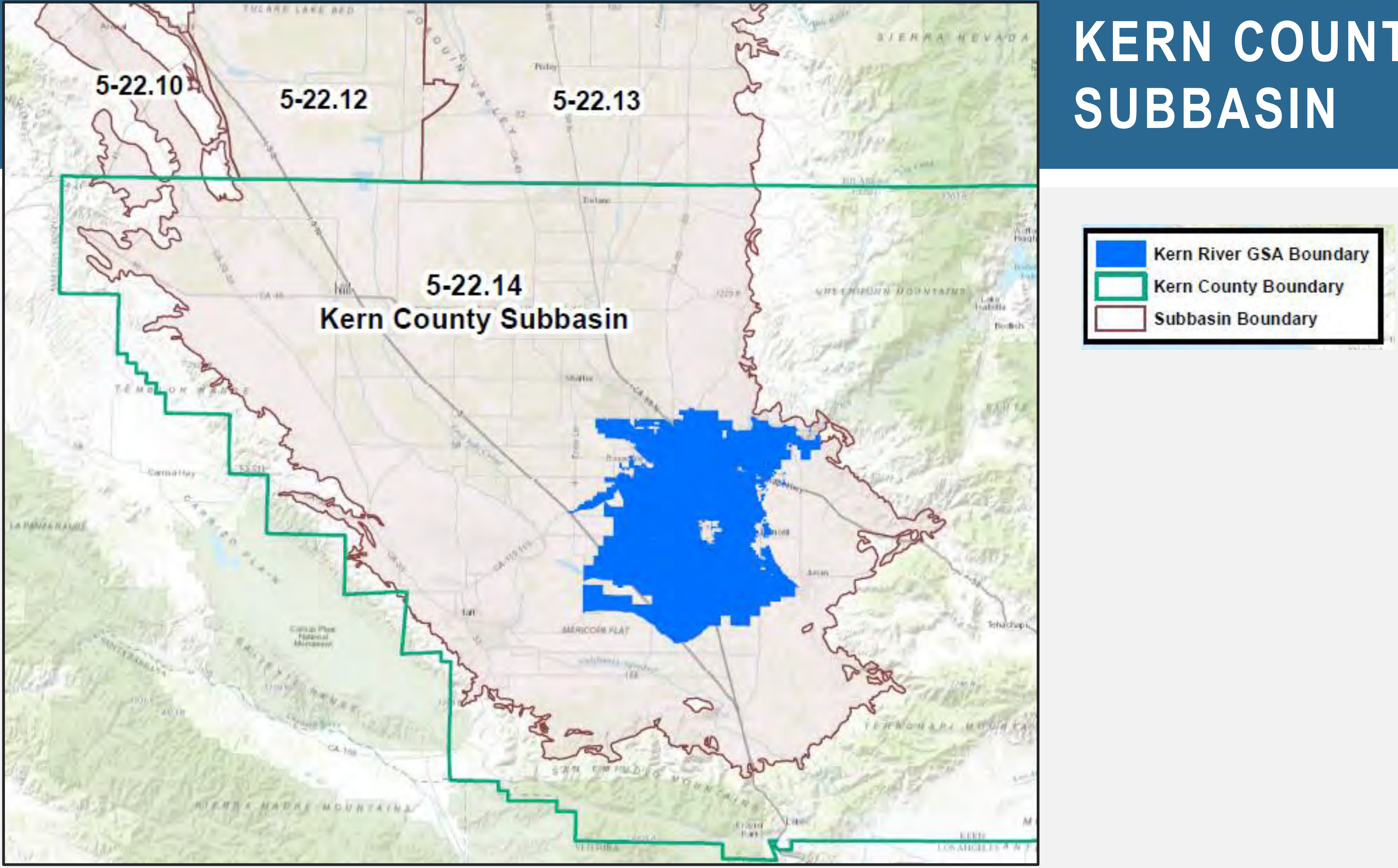
GENERAL PRINCIPLES – MEASURABLE OBJECTIVES AND MINIMUM THRESHOLDS

- Cannot harm sustainability in a neighboring basin
- Cannot continue to be in long-term overdraft
- Cannot deplete surface water

MANAGEMENT ACTIONS AND PROJECTS

KRGSA’s GSP DEVELOPMENT EFFORTS

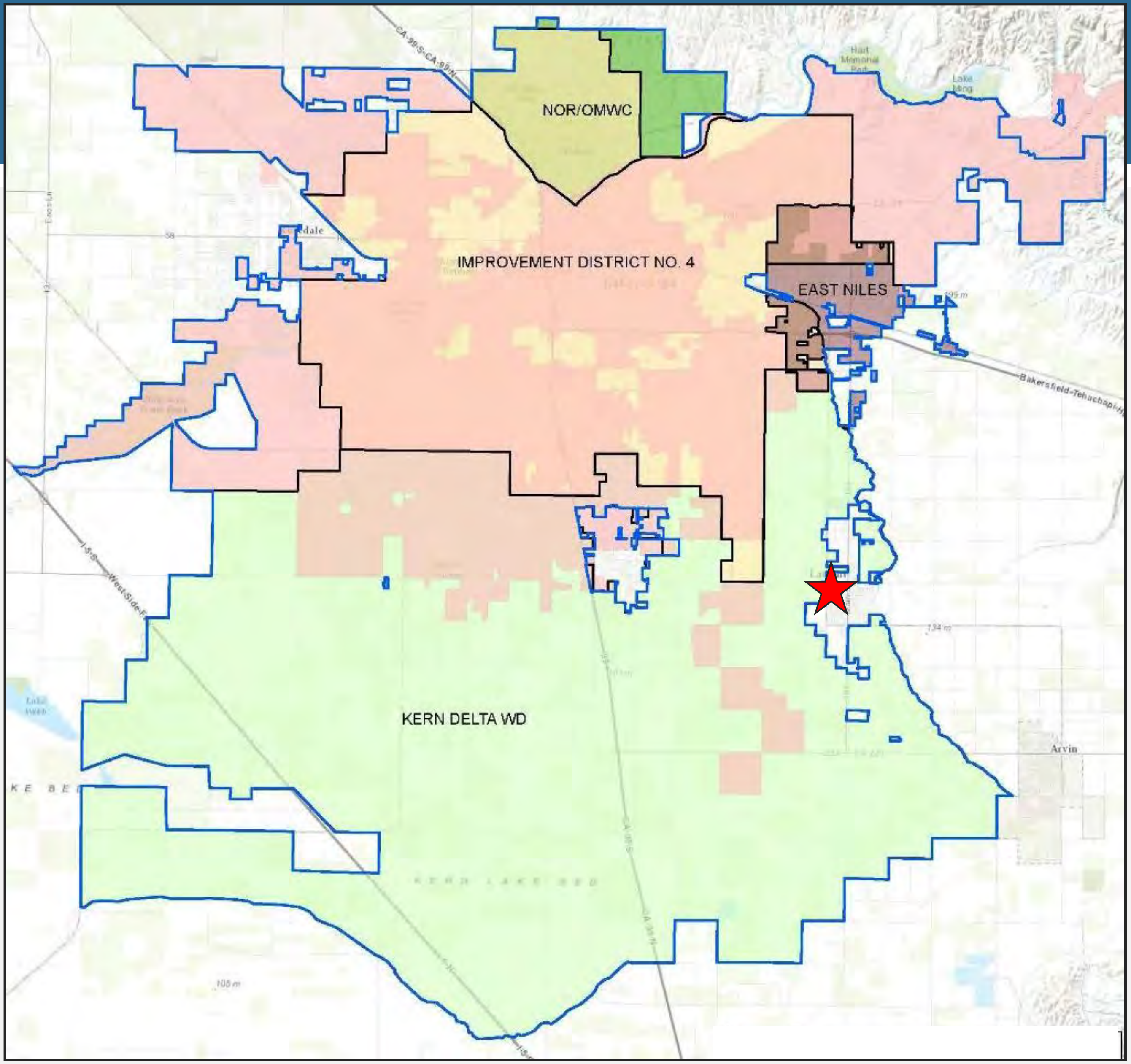
KERN COUNTY SUBBASIN



GSAs AND GSPs IN KERN SUBBASIN
(AS OF OCTOBER 2018)

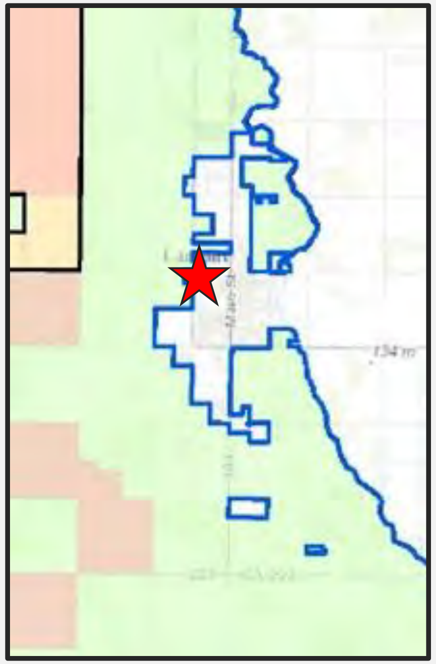
- **GSAs Preparing Their Own GSPs:**
  - Kern River GSA
  - Kern Groundwater Authority GSA
  - Buena Vista Water Service District GSA
  - Cawelo Water District GSA
  - City of McFarland GSA
  - Greenfield County Water District GSA
  - Henry Miller Water District GSA
  - Olcese Water District GSA
  - Pioneer GSA
  - Semitropic Water Storage District GSA
  - West Kern Water District GSA
  - White Wolf GSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY



Members of the Kern River GSA

- City of Bakersfield
- Kern County Water Agency – Improvement District #4 (ID4)
- Kern Delta Water District



Communities in the GSA

- Edison
- Fuller Acres
- Oildale
- Oil Junction
- Rexland Acres
- Weedpatch
- Lamont (small northern portion only)

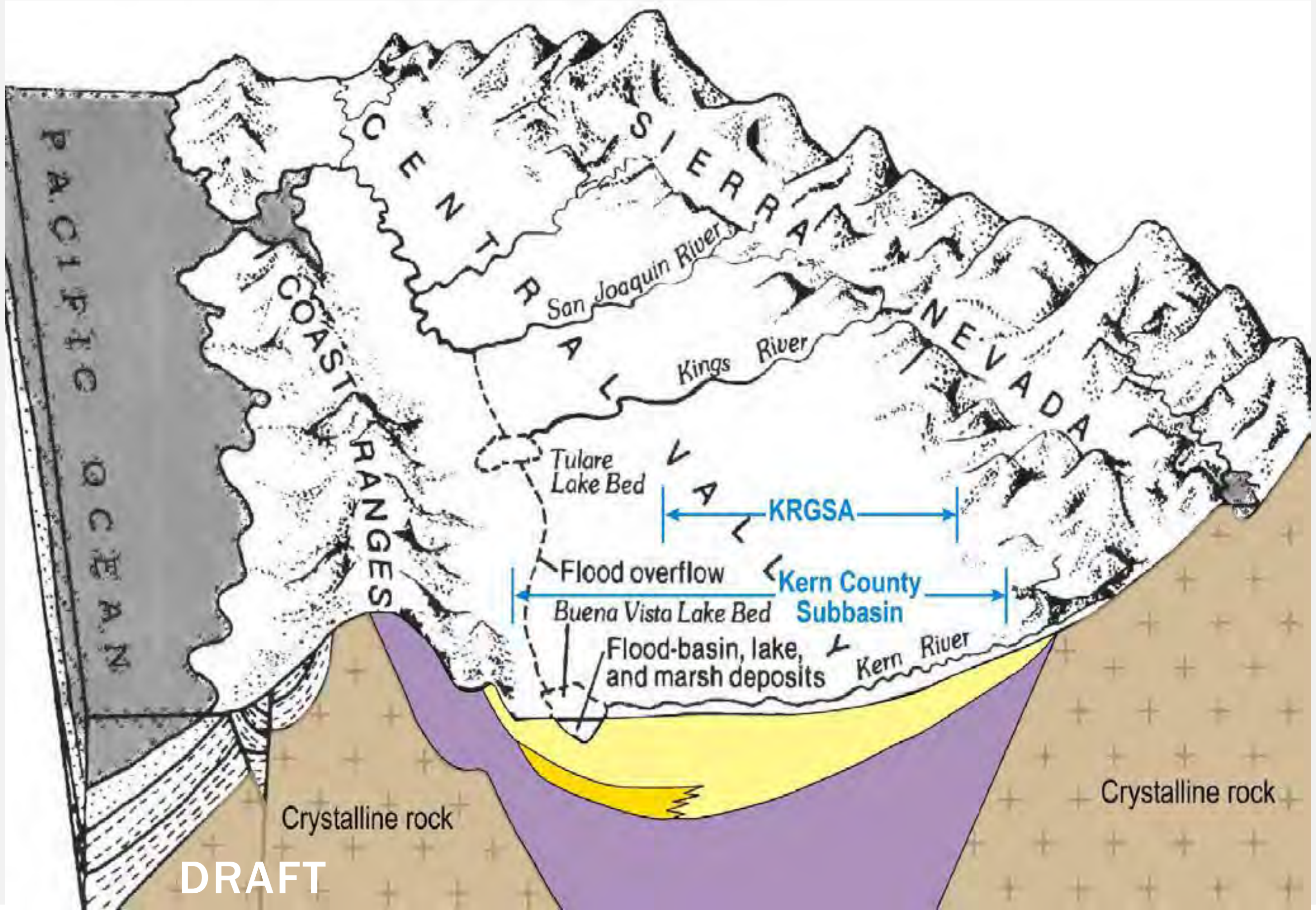
GSP OVERVIEW

- Data Compilation / Data Management System
- Institutional Setting – Water Supply / Plan Area
- Hydrogeologic Conceptual Model / Groundwater
- Water Budget (Current and Historical)
- Sustainability Goals and Criteria
- Management Scenarios Projected Water Budget
- Monitoring Networks Plan Development

Hydrogeologic Conceptual Model, Groundwater Conditions, and Water Budgets collectively inform the Sustainability Analysis

DRAFT

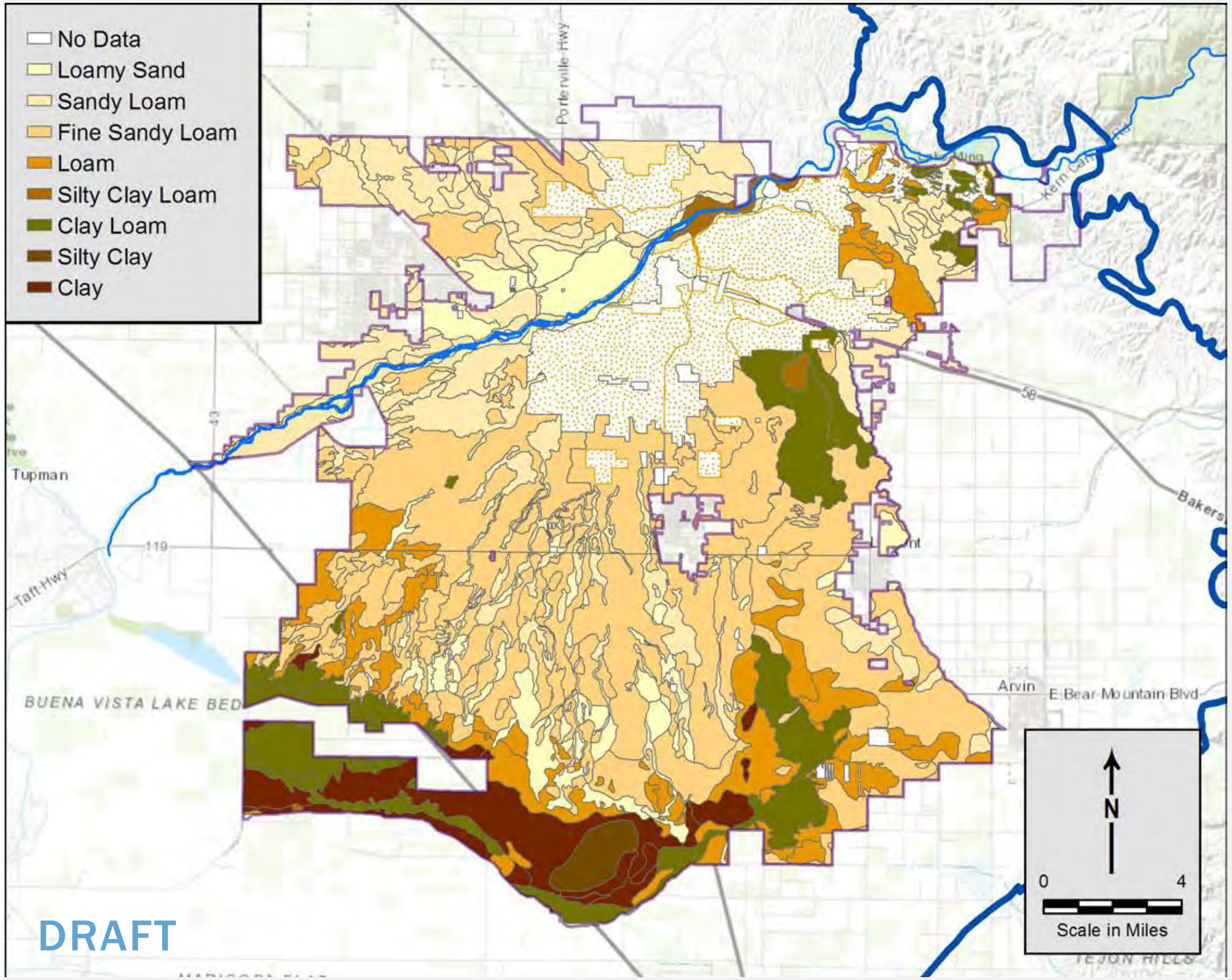
CONCEPTUAL HYDROGEOLOGIC SETTING KERN COUNTY SUBBASIN



- Alluvial-filled trough between the Sierra Nevada and Coast Ranges
- Underlain by older marine sedimentary units
- Flanked by crystalline bedrock

TODD GROUNDWATER

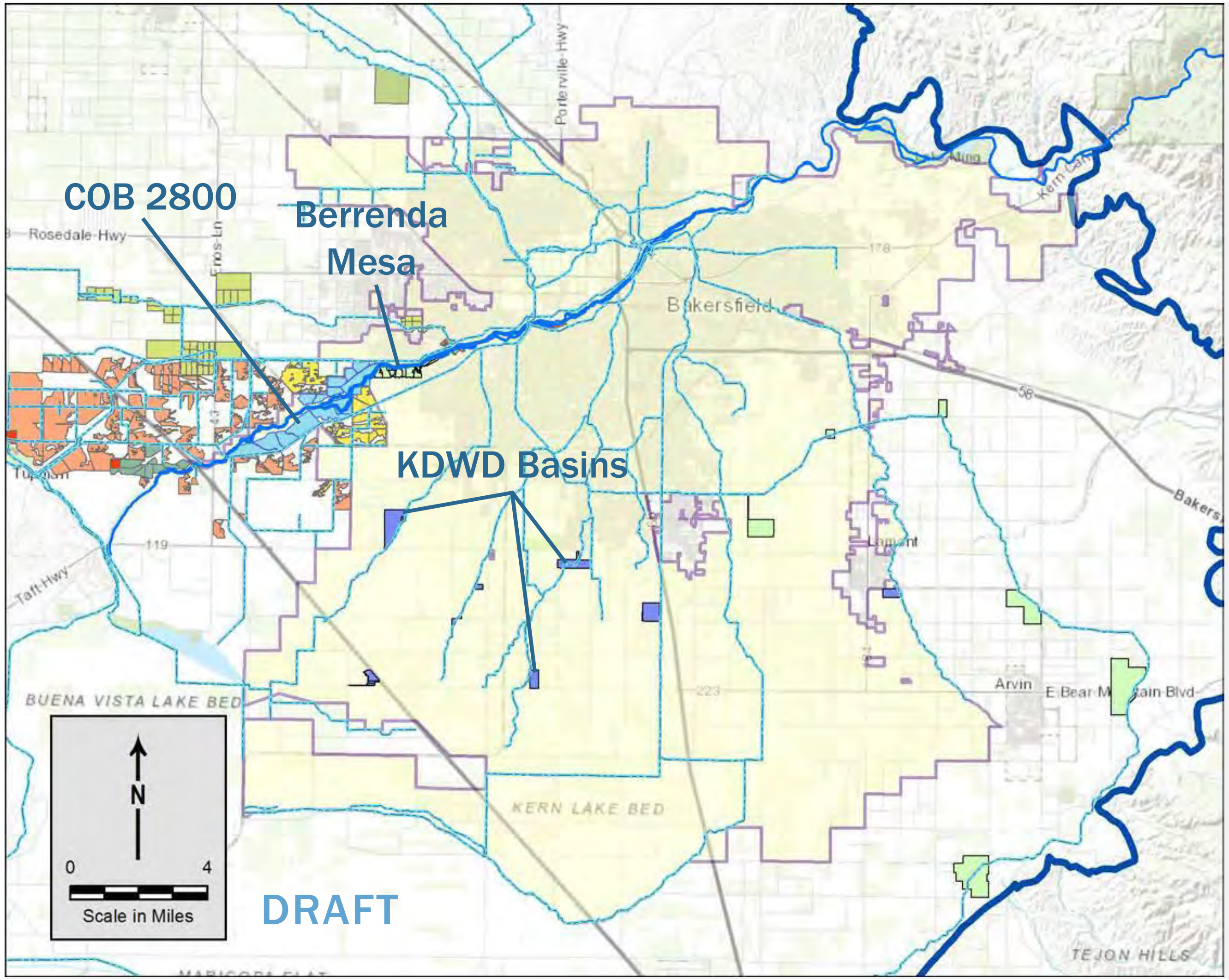
SOIL TEXTURES



- More permeable textures indicated by lighter colors (white, yellow, light orange)
- Lower permeability textures indicated by dark orange, green and brown
- Soil textures agree well with geologic framework

TODD GROUNDWATER

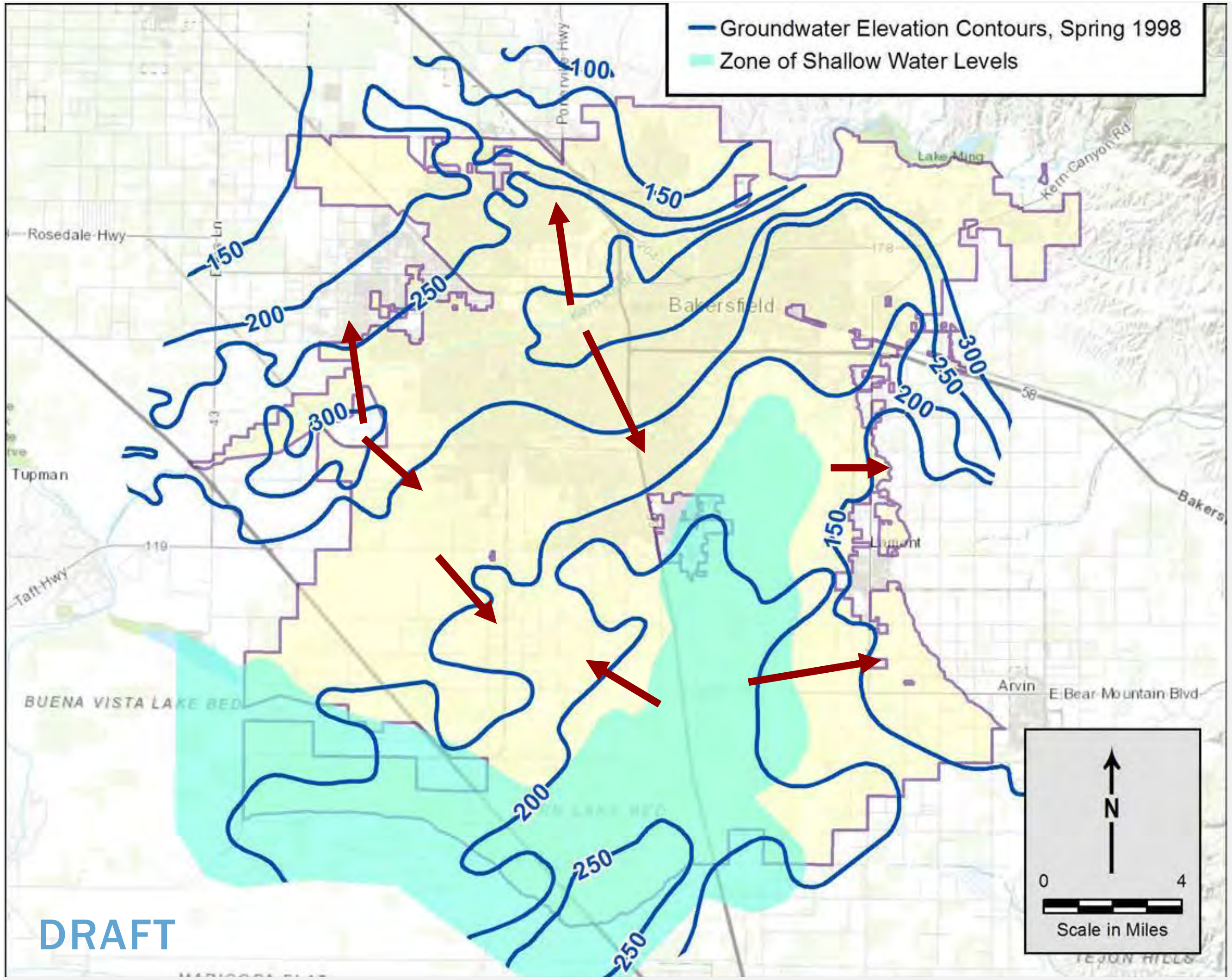
CANALS AND RECHARGE BASINS



- Managed recharge in river channel, unlined canals, and basins
- KRGSA groundwater banking projects:
  - COB 2800 Acres
  - KCWA Berrenda Mesa
  - KDWD Metropolitan Project
- Numerous additional banking projects nearby

TODD GROUNDWATER

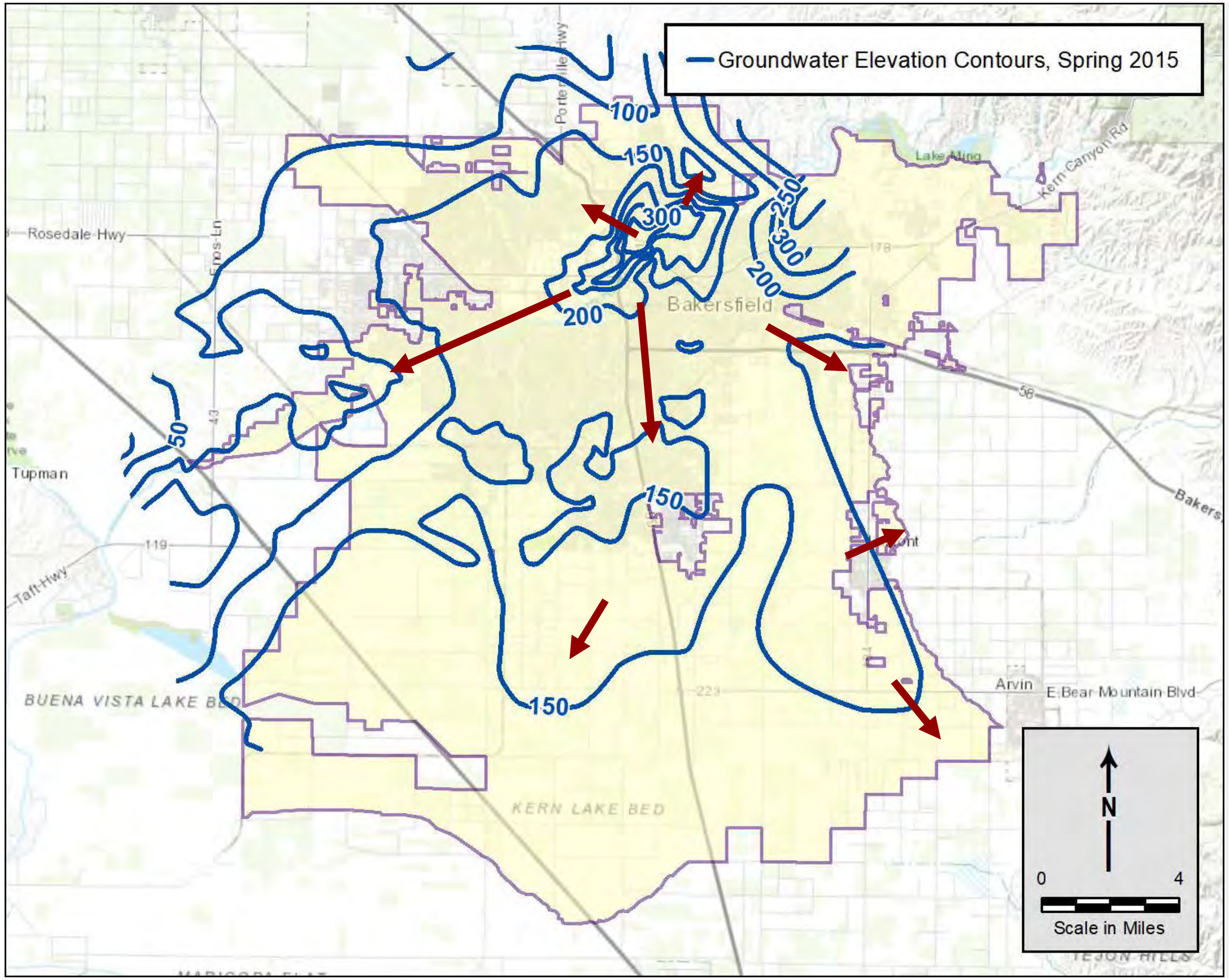
GROUNDWATER ELEVATION CONTOURS 1998



- 20 groundwater elevation contour maps (Spring data)
- Examined maps and data for perched layers (zone of shallow water levels)
- Example for wet year - Spring 1998

TODD GROUNDWATER

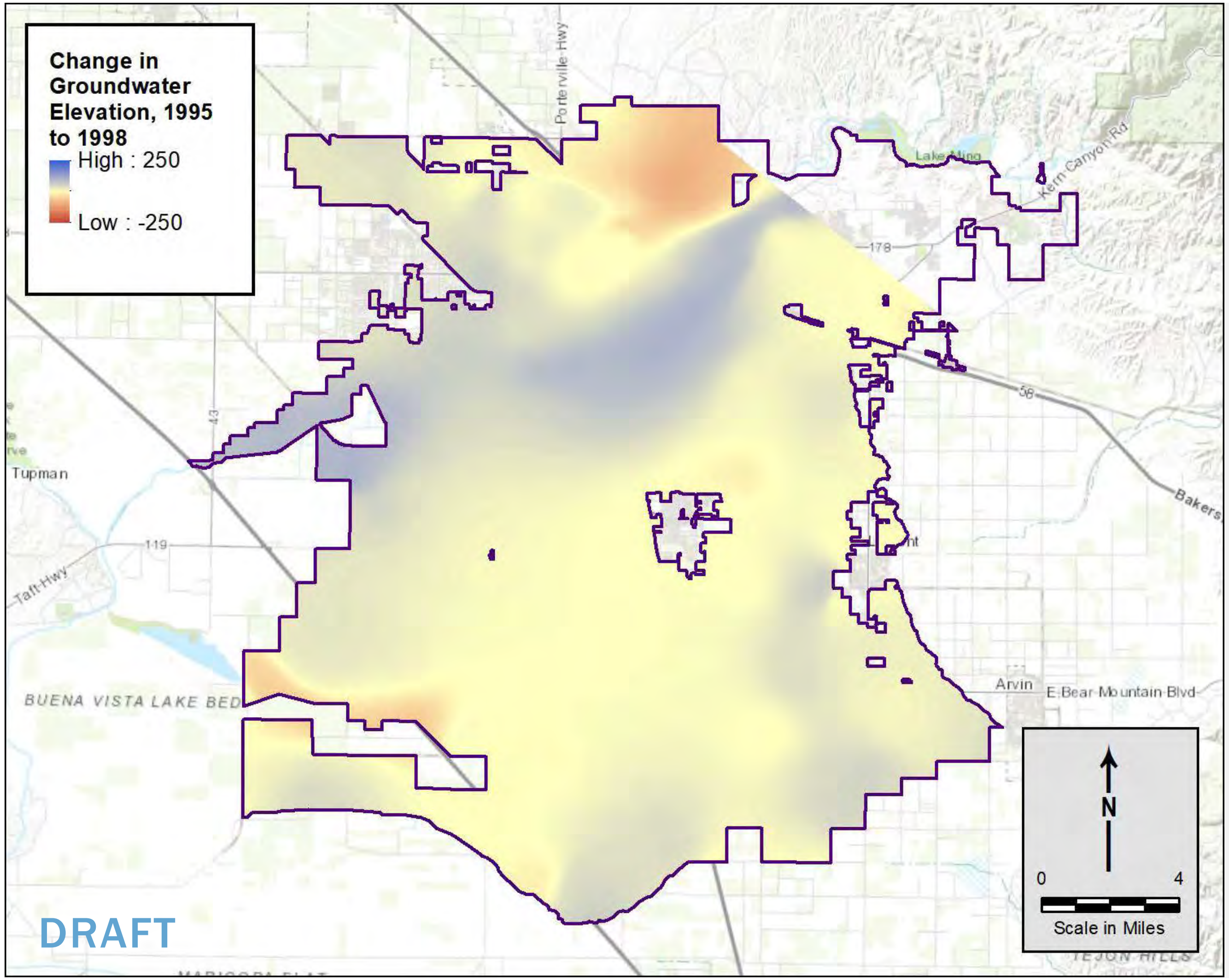
GROUNDWATER ELEVATION CONTOURS 2015



- Severe Drought year
- In general, higher water levels than surrounding areas
- Except for the river, groundwater is flowing out of the KRGSA area

TODD GROUNDWATER

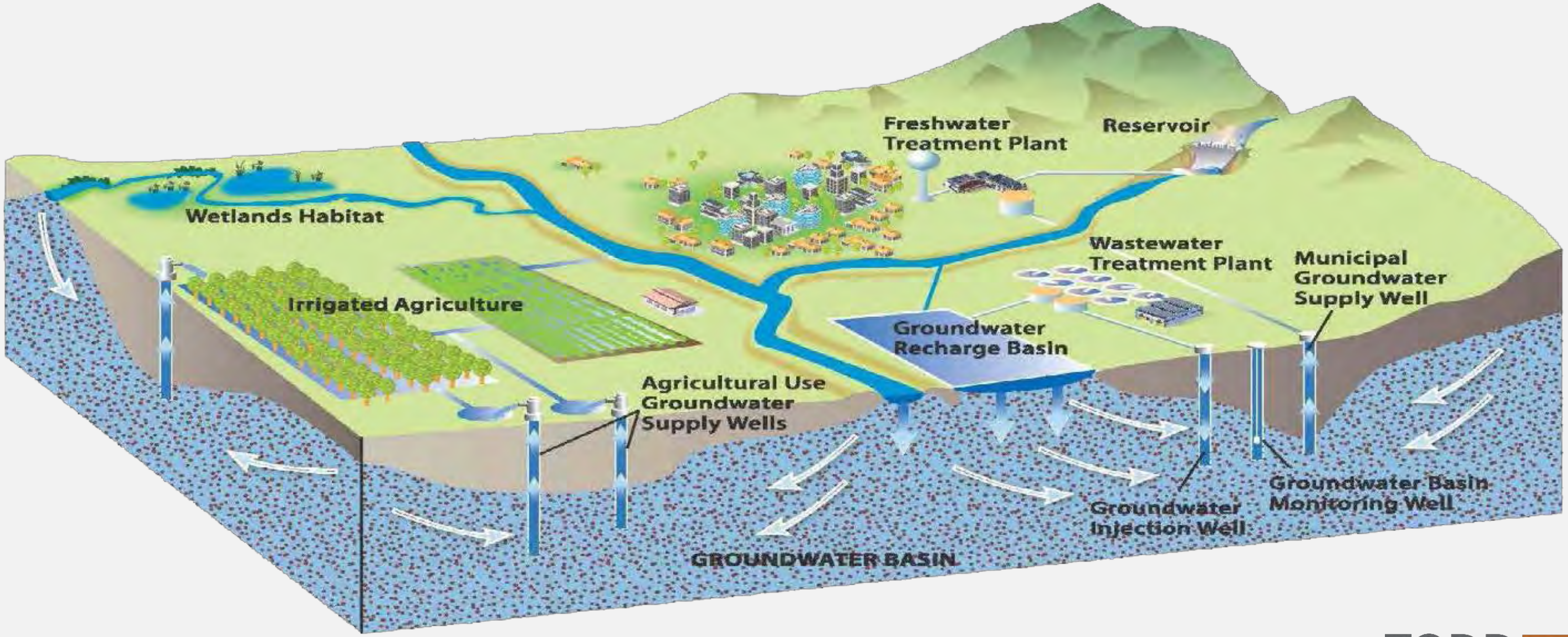
CHANGE IN GROUNDWATER IN STORAGE, 1995-1998



- Created 20 annual water level change maps using KCWA Spring water level contour maps
- Blue areas indicate water level rise; red areas indicate water level declines
- Limited data create uncertainty for some areas and time periods

TODD GROUNDWATER

FINALIZING THE KRGSA WATER BUDGET



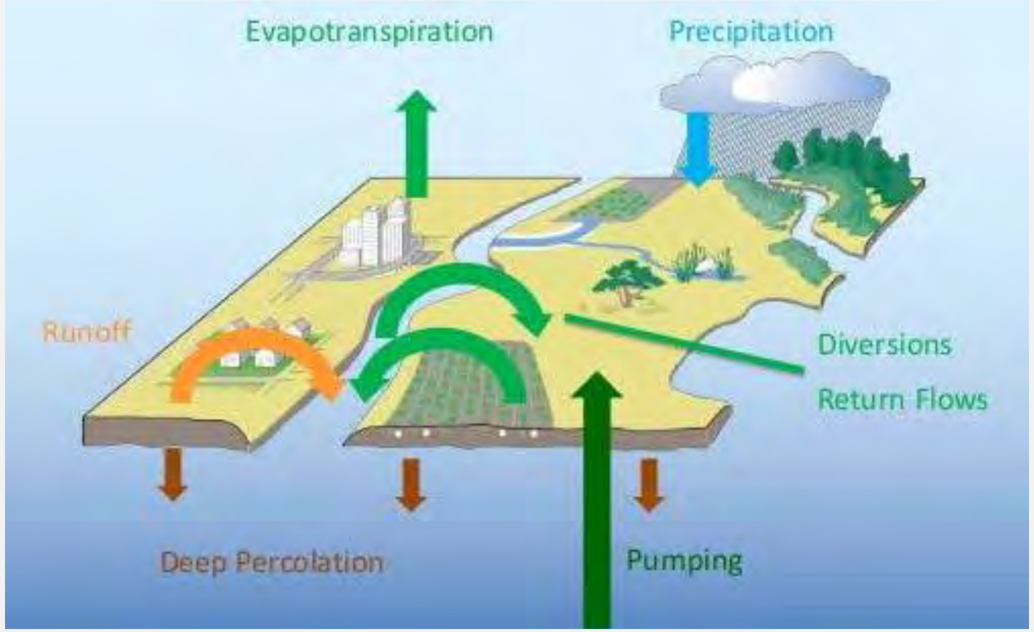
CA Water Foundation

DRAFT

TODD GROUNDWATER

KRGSA WATER BUDGETS – APPROACH

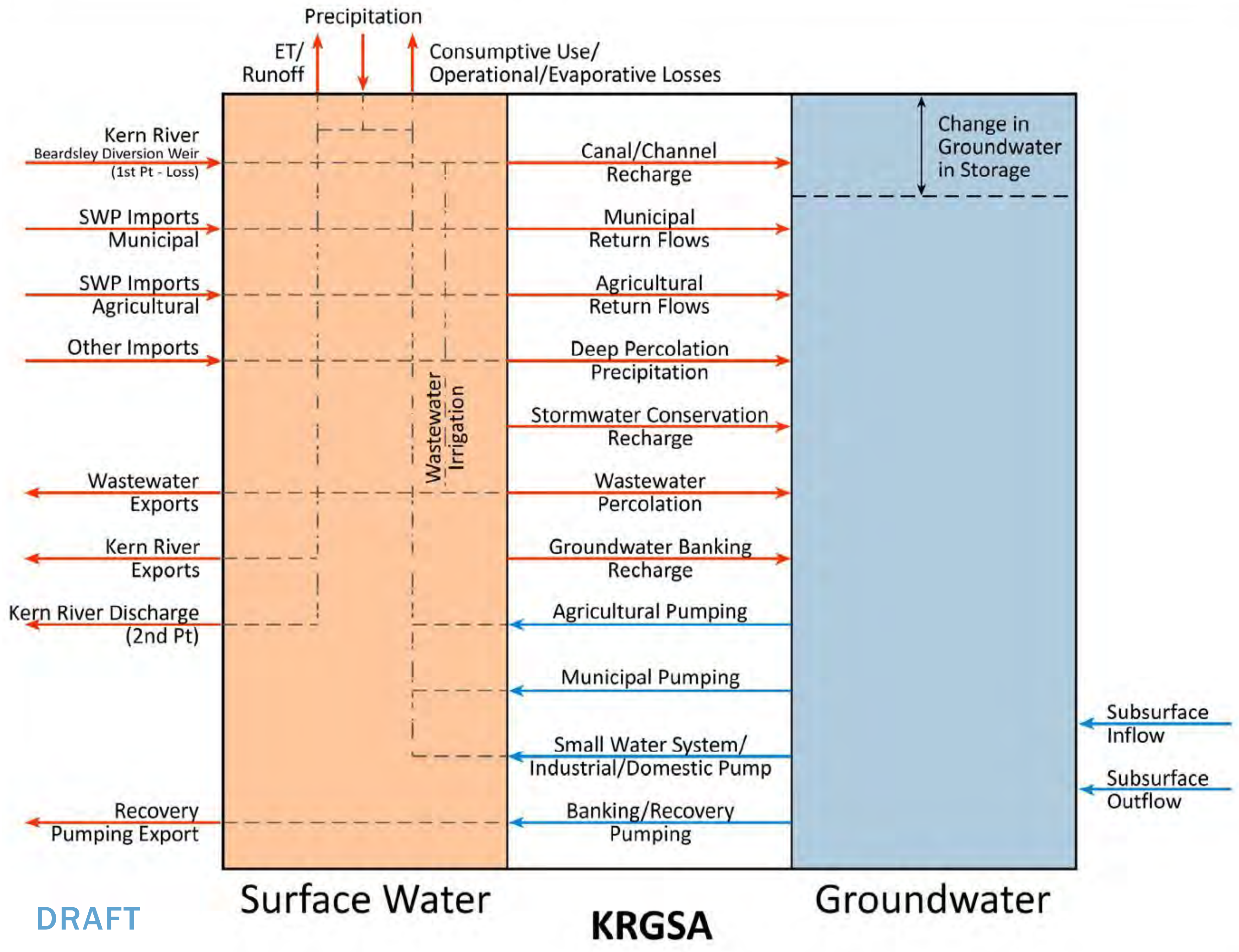
- Kern County water managed in real time for optimal use
- Provides flexibility and optimization of water but results in complex accounting of physical molecules
  - Focus on the physical system
    - Where does the "wet water" go? (not paper exchanges)
    - Water budget process follows the molecules – does not assign "ownership" of the water
    - Prevent "double-counting"



DRAFT

TODD GROUNDWATER

KRGSA COMBINED WATER BUDGET COMPONENTS



DRAFT

TODD GROUNDWATER

NEXT STEPS

- Work with agencies to reconcile data and local water budgets
- Compile for KRGSA
- Format data sets for model

Horizon
WATER and ENVIRONMENT

TODD
GROUNDWATER

QUESTIONS & ANSWERS

PARTICIPATE IN GSP DEVELOPMENT

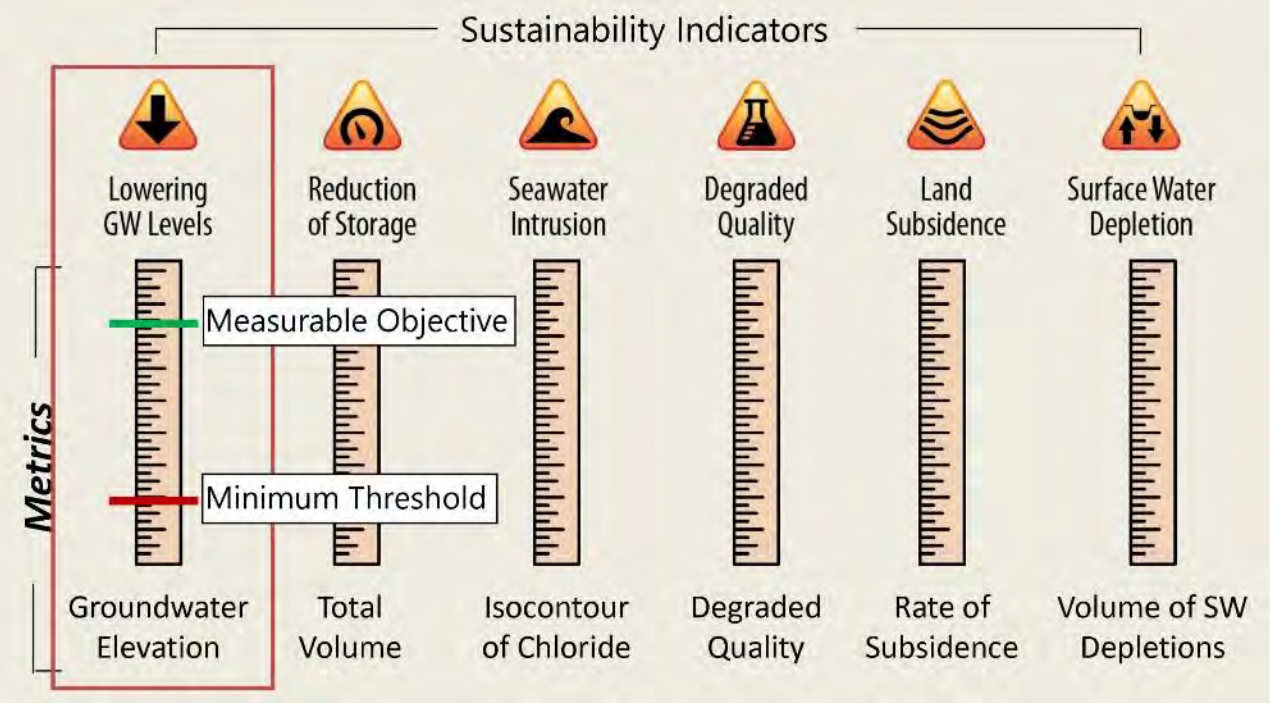
You can help shape what is included in the plan by:

- Providing information about your past or present groundwater challenges
- Sharing information about your water usage and/or water well
- Sharing your vision for sustainability
- Identifying projects that can help address the groundwater conditions
- Completing the Stakeholder Survey

STAKEHOLDER DISCUSSION– UNDESIRABLE RESULTS

Undesirable Results are categorized as:

- Lowered Groundwater Levels
- Reduction of Storage
- Seawater Intrusion (not a factor in Kern County Sub-basin)
- Degraded Water Quality
- Land Subsidence
- Surface Water Depletion



STAKEHOLDER DISCUSSION– UNDESIRABLE RESULTS

We want to hear from you!

- Have you, your community, or your business been affected by any of the undesirable results?
- Which of the undesirable results are the most important to you and why? Are there any more important than others?
- What improvements would you like to see happen in the next twenty years?

STAY INVOLVED

- Attend GSA Meetings
    - KRGSA Board Meetings are held the last Wednesday of each month at 8 a.m. at 1600 Truxtun Avenue, Bakersfield, CA 93301

- Get on the "interested parties" list to receive correspondence and information from the KRGSA

- Visit the website to learn more: http://www.kernrivergsa.org/

- Attend future workshops

ADDITIONAL INFORMATION AND RESOURCES

- Technical Assistance for Severely Disadvantaged Communities
  - Self-Help Enterprises: https://www.selfhelpenterprises.org
    - Eva Dominguez, 559-802-1634, EvaD@selfhelpenterprises.org
    - Maria Herrera, 559-802-1676, MariaH@selfhelpenterprises.org
- Local Information – Kern River GSA: https://kernrivergsa.org
    - Art Chianello, 661-326-3715, AChianel@bakersfieldcity.us
- Statewide Information
  - Department of Water Resources: https://sgma.water.ca.gov/portal/
  - State Water Resources Control Board: https://www.waterboards.ca.gov/water_issues/programs/gmp/sgma.html

THANK YOU!

Agencia de Manejo Sostenible de Agua Subterránea de Kern River

Taller de Agua Subterránea

13 de Noviembre 2018

Horizon WATER and ENVIRONMENT

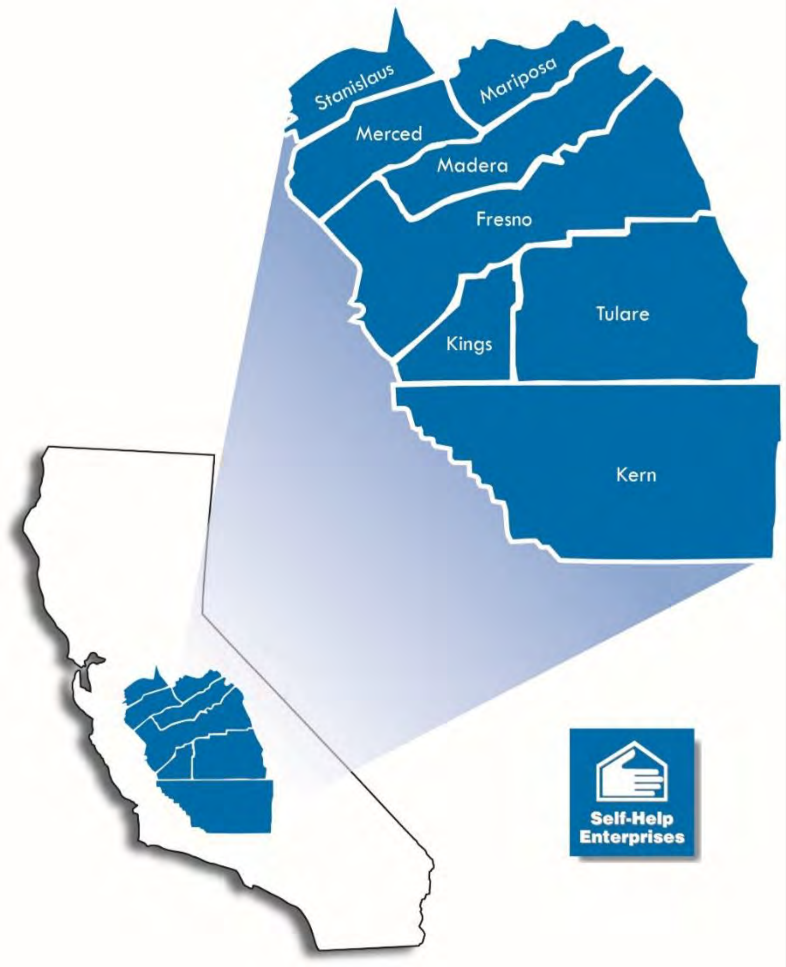
KRGSA

KERN RIVER GROUNDWATER SUSTAINABILITY AGENCY

Self-Help Enterprises

SELF-HELP ENTERPRISES (SHE)

- SHE es una organización de vivienda y desarrollo comunitario reconocida a nivel nacional (organización sin fines de lucro) cuya misión es trabajar junto con familias de bajos ingresos para construir y mantener hogares y comunidades saludables.
- El Programa de Desarrollo Comunitario brinda asistencia técnica y desarrollo de liderazgo en comunidades rurales que enfrentan desafíos para proporcionar agua limpia, alcantarillado sanitario y otra infraestructura.
- El Equipo de Planeación y Participación de la Comunidad apoya la participación de la comunidad en la gestión regional del agua y la planificación de la sostenibilidad del agua subterránea, así como la capacidad y experiencia en la gestión del agua en las comunidades rurales.

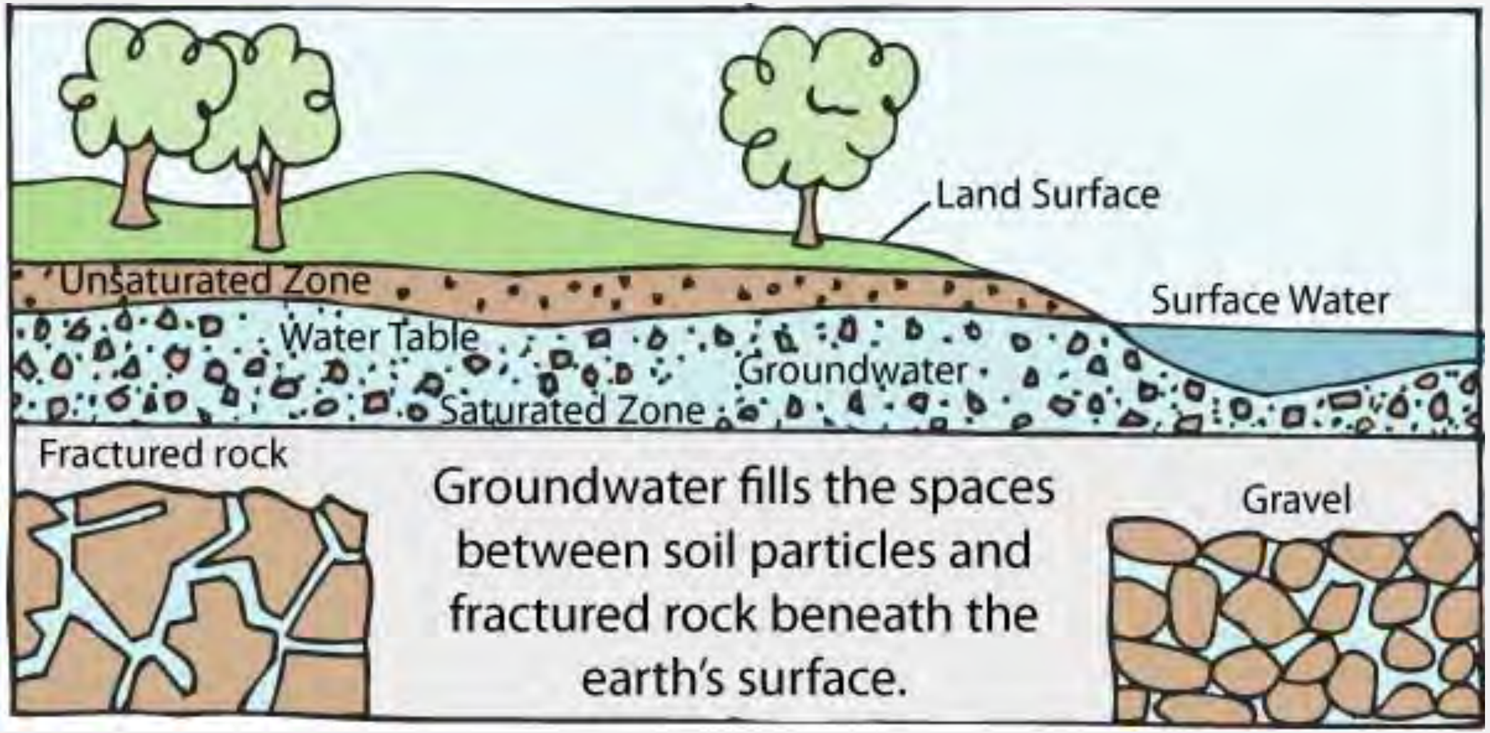


DESCRIPCIÓN GENERAL DEL TALLER

- Nueva Ley Estatal del Agua Subterránea: Ley del Manejo Sostenible del Agua Subterránea (SGMA)
- Planes de Sostenibilidad de Aguas Subterráneas (GSPs)
- Esfuerzos para Desarrollar el GSP de la KRGSA
- Discusión de las Partes Interesadas
- Palabras de Finalización y Cierre

IMPORTANCIA DE AGUA SUBTERRÁNEA

En promedio, California obtienen el 40% de su agua del agua subterránea. Durante las sequías, ese número puede llegar hasta el 60%.



- En el Valle Central, somos aún más dependientes del agua subterránea que el estado en general
- El 90% de los residentes de Central Valley dependen del agua subterránea para al menos parte de su suministro de agua potable
- La mayoría de las comunidades no incorporadas dependen en un 100% de las aguas subterráneas, e incluyen muchos de nuestros distritos escolares pequeños.

CÓMO LAS COMUNIDADES & LAS ESCUELAS UTILIZAN EL AGUA SUBTERRÁNEA

DESAFÍOS DEL AGUA SUBTERRÁNEA: ¿POR QUÉ LA LEY DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA?

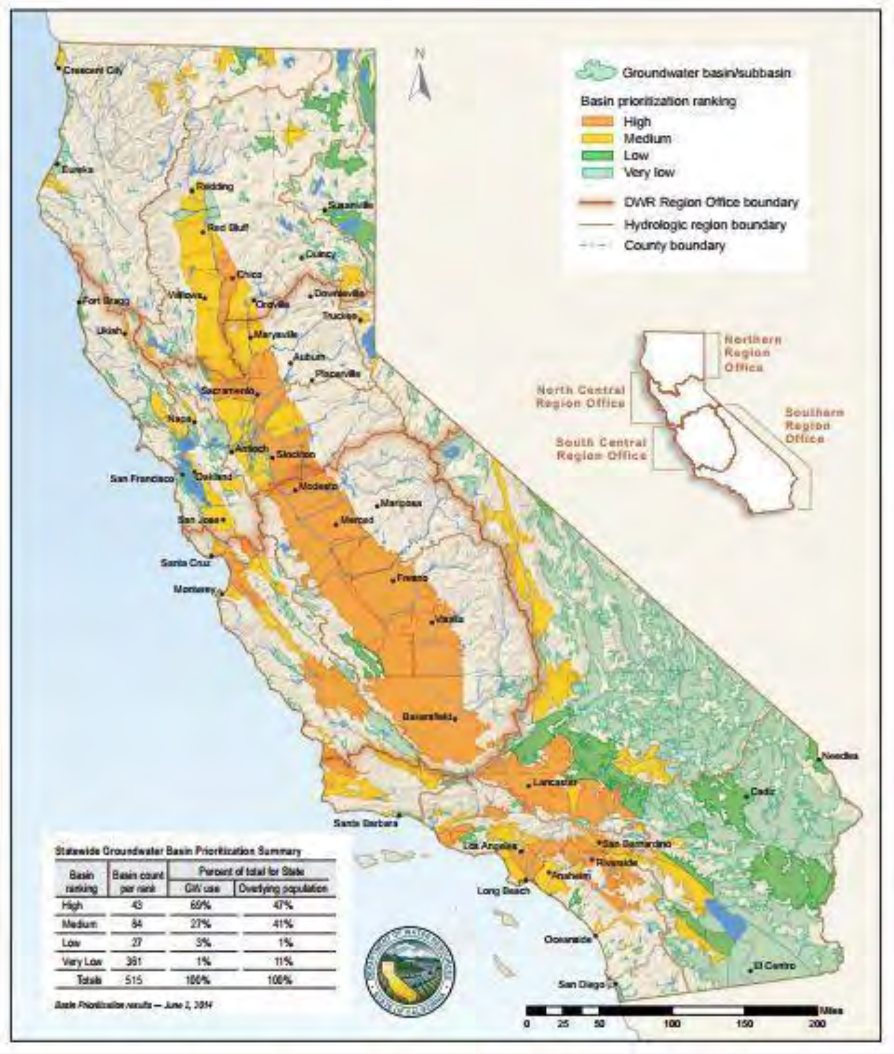
- Anteriormente, el manejo del agua subterránea era voluntaria en ciertas áreas del estado
- Los niveles de agua subterránea han disminuido debido al exceso de bombeo, las restricciones excesivas en las importaciones de agua de superficie y la falta de recarga
- La sequía (2012-2016) tuvo un impacto sin precedentes en nuestro estado.
- Pozos secos (por ejemplo: Arvin, área de Lamont y muchos otros)
- Hundimiento

LEY DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA DE CALIFORNIA (SGMA)

- Paquete de tres leyes: SB 1168 (Pavley), AB 1739 (Dickinson), SB 1319 (Pavley)
- Firmado por el Gobernador Brown el 16 de Septiembre de 2014
- Objetivo: Asegurar la confiabilidad a largo plazo de nuestros recursos de agua subterránea y los recursos hídricos superficiales conectados que requieren manejo "sostenible”
- Principio central: control local

PREVENIR LOS RESULTADOS INDESEABLES

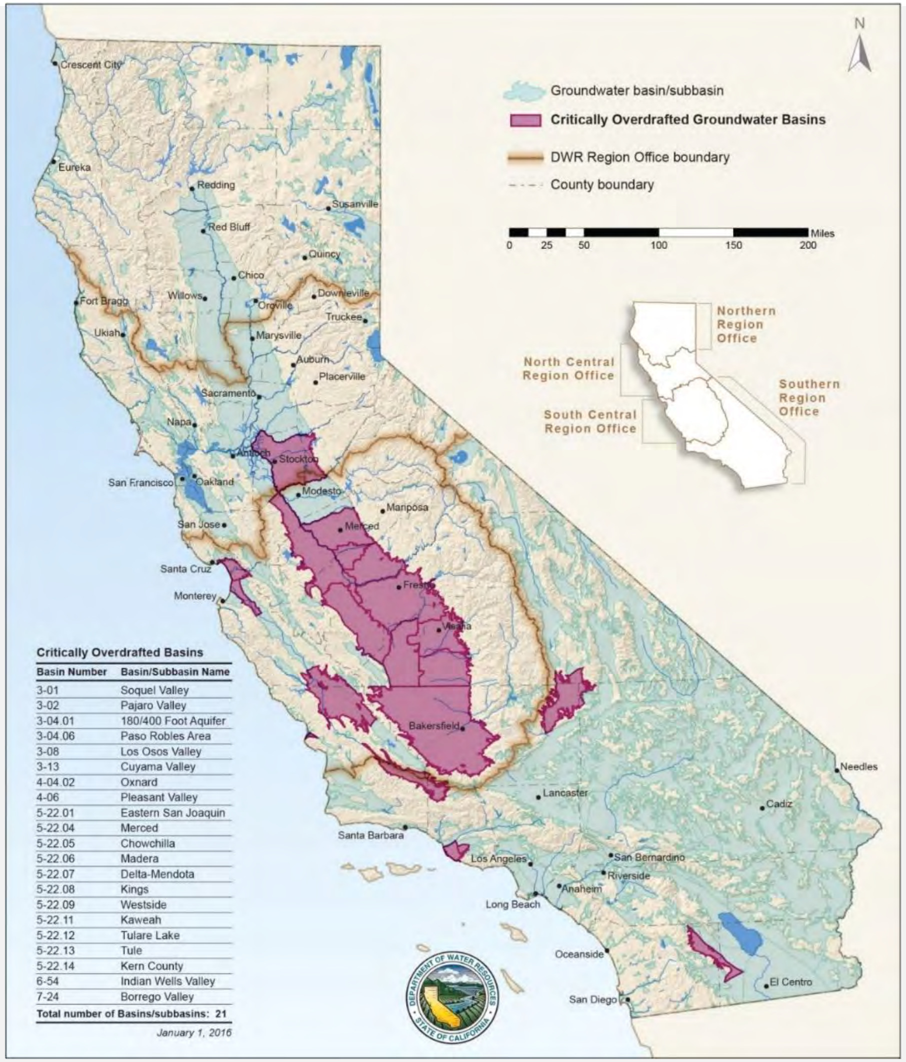
¿QUIÉN DEBE CUMPLIR CON SGMA?



Statewide Groundwater Basin Prioritization Summary

Basin ranking	Basin count per rank	Percent of total for State	
		GW use	Overlying population
High	43	69%	47%
Medium	84	27%	41%
Low	27	3%	1%
Very Low	361	1%	11%
Totals	515	100%	100%

Basin Prioritization results — June 2, 2014



Critically Overdrafted Basins

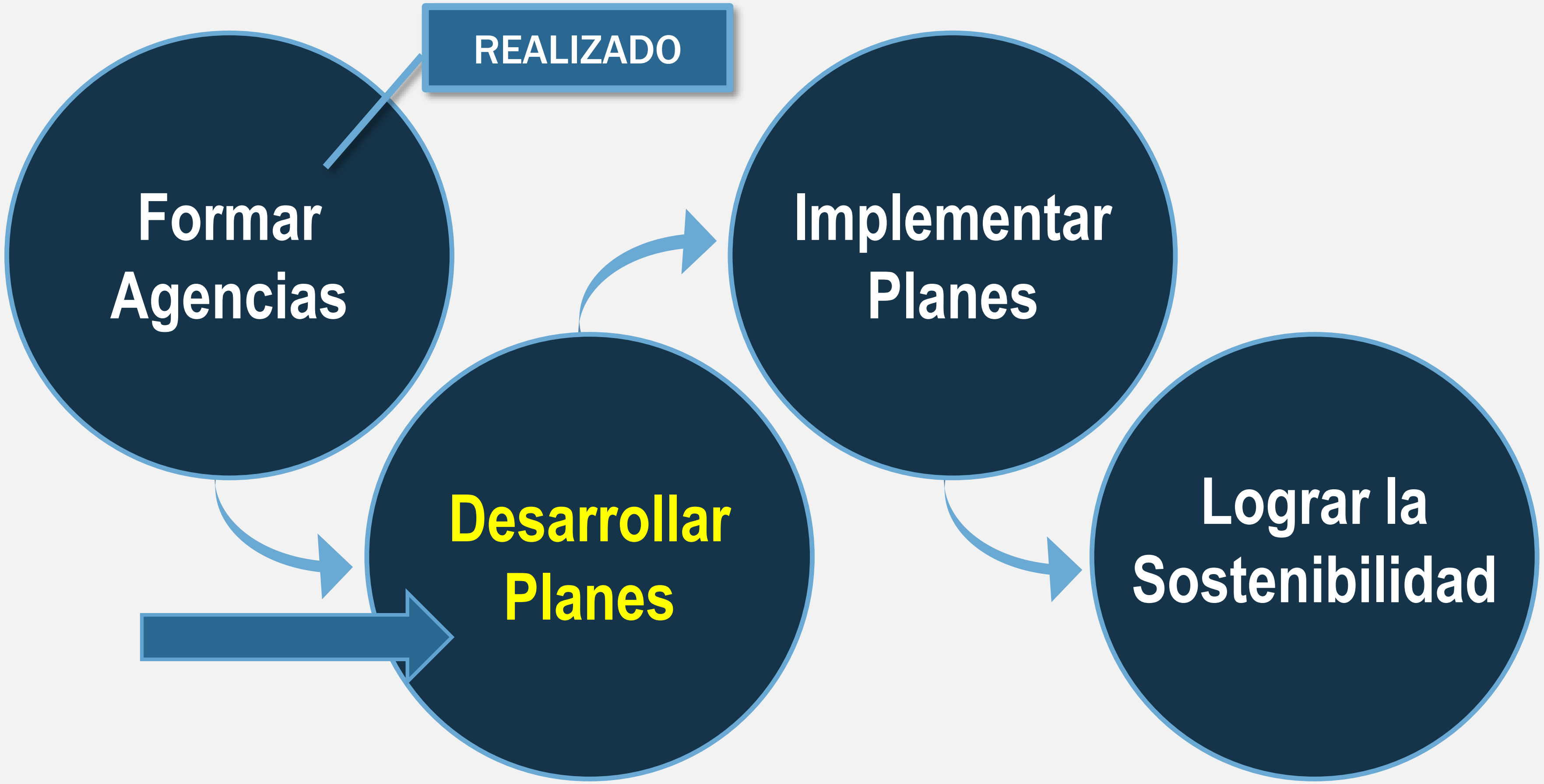
Basin Number	Basin/Subbasin Name
3-01	Soquel Valley
3-02	Pajaro Valley
3-04.01	180/400 Foot Aquifer
3-04.06	Paso Robles Area
3-08	Los Osos Valley
3-13	Cuyama Valley
4-04.02	Oxnard
4-06	Pleasant Valley
5-22.01	Eastern San Joaquin
5-22.04	Merced
5-22.05	Chowchilla
5-22.06	Madera
5-22.07	Delta-Mendota
5-22.08	Kings
5-22.09	Westside
5-22.11	Kaweah
5-22.12	Tulare Lake
5-22.13	Tule
5-22.14	Kern County
6-54	Indian Wells Valley
7-24	Borrego Valley
Total number of Basins/subbasins: 21	

January 1, 2016

¿CUÁLES SON LOS INTERESES EN JUEGO?

- Titulares de derechos de aprovechamiento de agua subterránea (agricultura y doméstico)
- Sistemas de agua públicos
- Agencias locales de planificación del uso de la tierra
- Usuarios del agua subterránea para uso ambientales
- Usuarios de agua superficial
- Tribus de Nativos Americanos de California
- Comunidades de bajo ingresos, incluso las que reciben agua de pozos domésticos privados o pequeños sistemas de agua comunitarios

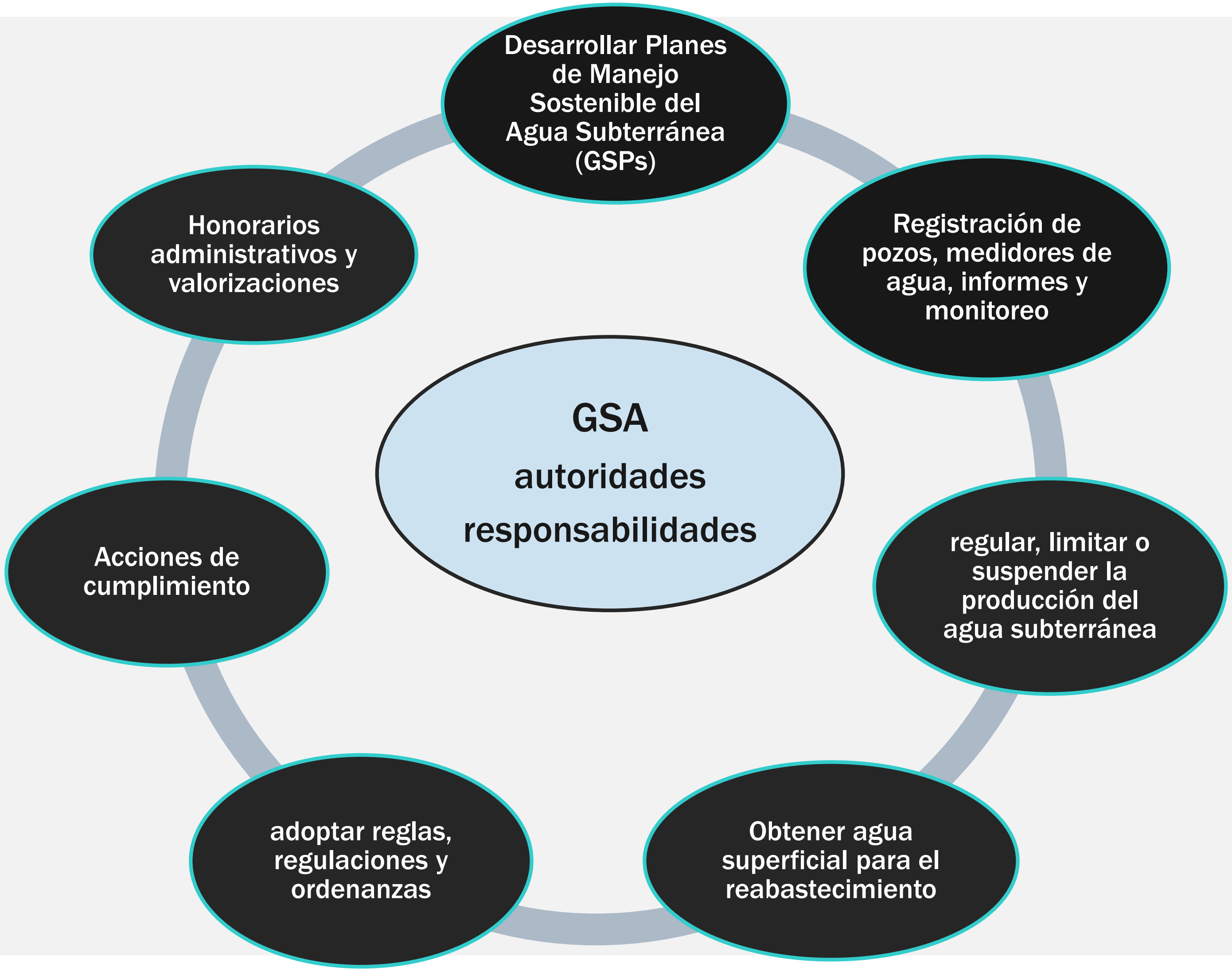
DISEÑO DE SGMA



MÚLTIPLES GSAS EN UNA SUBCUENCA

- Mas de una GSA se puede formar en una subcuenca
- Si existen múltiples GSAs en una subcuenca, las GSAs pueden colaborar para crear un plan único, o cada GSA puede crear su propio plan solo que las GSAs establecen un acuerdo de coordinación para implementar múltiples planes.
- Sin embargo, las GSAs deben cubrir toda el área de la subcuenca, sin dejar áreas sin gestionar
- Todas las GSAs fueron aprobadas en Julio 2018

¿QUÉ PUEDE HACER UNA GSA?



DESARROLLO DEL PLAN DEL MANEJO SOSTENIBLE DEL AGUA SUBTERRÁNEA

- Los GSPs deben incluir información importante:
  - Descripción del área del plan y la colocación del cuenca
  - Criterios de sostenibilidad de la cuenca
  - Programa de monitoreo y proyectos
- Los GSP servirán como una hoja de ruta para lograr la sostenibilidad dentro de 20 años
- Las GSAs deben desarrollar los GSPs con la participación de las partes interesadas

ENVÍO DE GSP Y APROBACIÓN POR DWR

- Los GSPs deben ser escritos antes del **31 de enero 2020 (o 31 de enero 2022 si la cuenca no esta críticamente en exceso)**

- Determinaciones de DWR (Departamento de Recursos Hídricos)
  - Adecuado
  - Condicionalmente Adecuado (deficiencias menores que pueden corregirse dentro de los 180 días)
  - No Adecuado

- Si el Departamento de Recursos Hídricos decide que el GSP **no gestionara de forma sostenible las aguas subterráneas antes del 2040 (o 2042 si la cuenca no esta críticamente en exceso)**…

→ **<u>El Estado puede intervenir y administrar la subcuenca en sí!</u>**

Mucho mas costoso

Menos control local

IMPLEMENTACIÓN DE GSP Y LOGRO DE SOSTENIBILIDAD

- Después de presentar su GSP, una GSA tiene 20 años para alcanzar la sostenibilidad
  - **La sostenibilidad debe alcanzarse para 2040 (2042 para áreas que no están críticamente en exceso)**
- DWR revisará todos los planes cada cinco años para evaluar el progreso y recomendar acciones correctivas según sea necesario
- Reportes Anuales

PREGUNTAS Y RESPUESTAS

PLANES DE SOSTENIBILIDAD DE AGUAS SUBTERRÁNEAS

1. **Descripción del área del plan y la configuración de la cuenca:** Aguas subterráneas, presupuesto hídrico, modelo conceptual hidrogeológico, áreas de manejo

2. **Criterios de sostenibilidad:** establecer un objetivo de sostenibilidad, establecer umbrales mínimos para resultados indeseables, establecer objetivos medibles

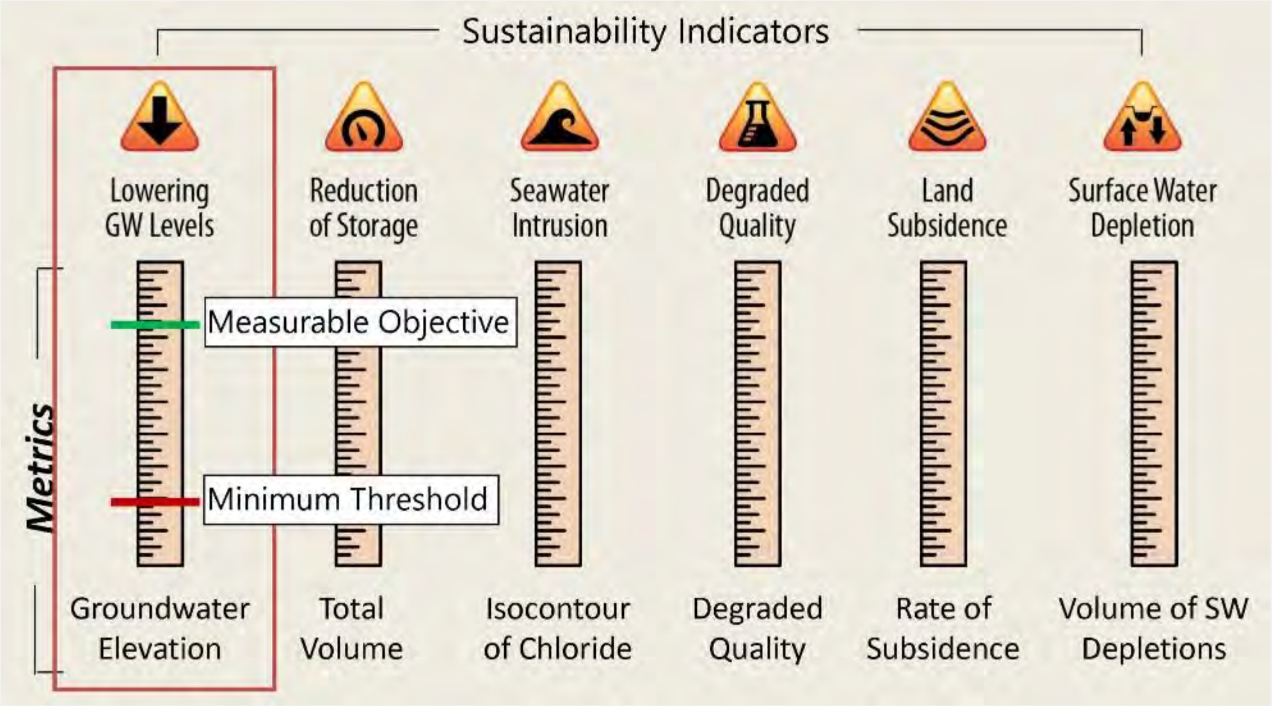
3. **Proyectos y acciones de gestión:** proyectos, acciones de manejo, medidas de mitigación, plan de monitoreo

PRESUPUESTOS DE AGUA

CRITERIOS DE SOSTENIBILIDAD
OBJETIVOS MEDIBLES Y UMBRALES MÍNIMOS

Prevenir "resultados indeseables que son significativos e irrazonables“

En este momento, el único resultado indeseable del que podemos estar seguros no se aplica al área de Kern River GSA es la intrusión de agua de mar



LA SOSTENIBILIDAD SE DEFINE LOCALMENTE

- SGMA requiere que la GSA define la sostenibilidad utilizando dos conceptos:
  - **Objetivos Medibles** son metas aspiracionales. Técnicamente, deberías alcanzarlos para 2040 (o 2042 si no es cuenca críticamente en exceso).
  - **Umbrales Minimos** deben ser evitados Si se cruzan, puede estar fuera del cumplimiento de su plan y violar la obligación de alcanzar la sostenibilidad.

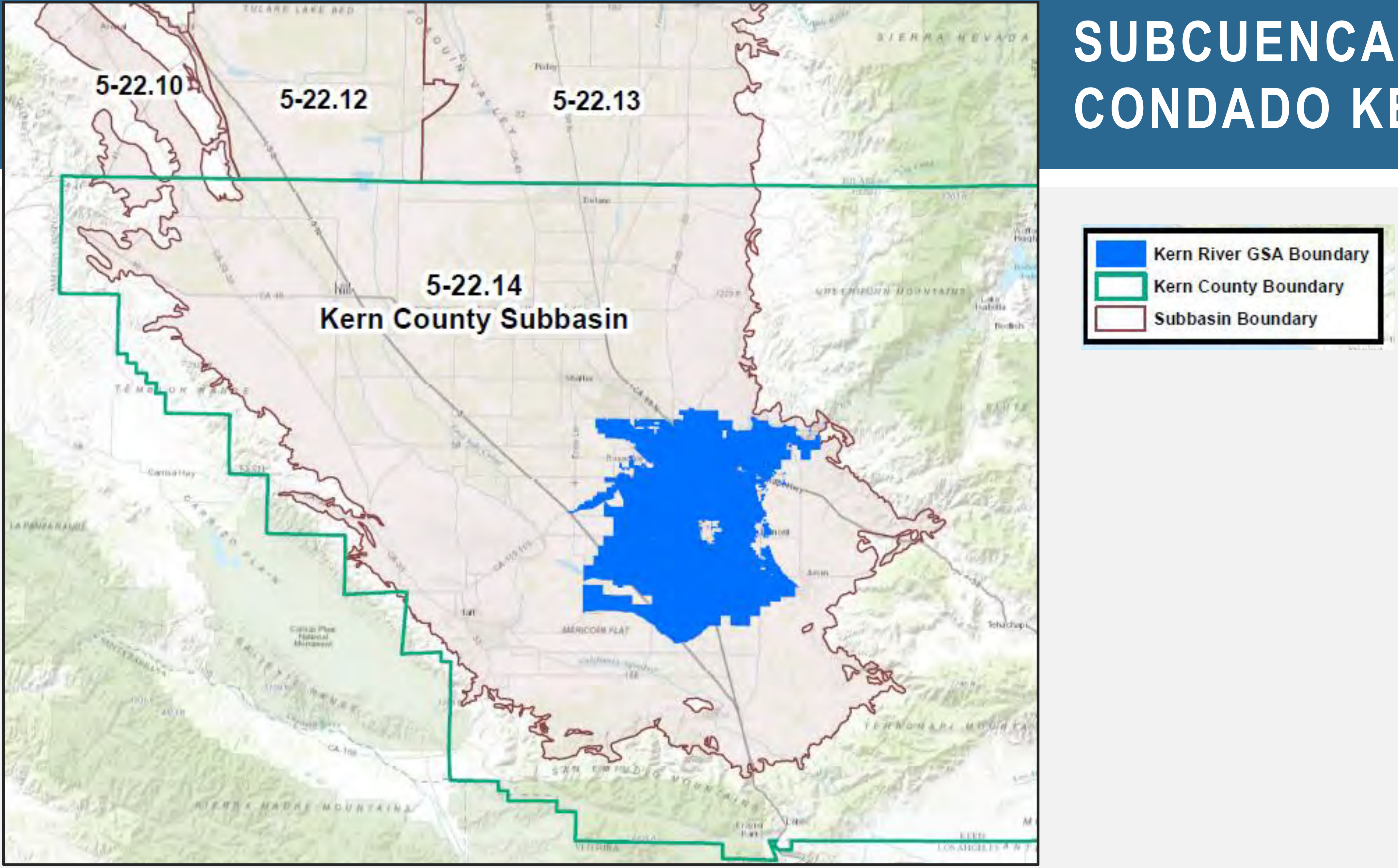
PRINCIPIOS GENERALES - OBJETIVOS MEDIBLES Y UMBRALES MÍNIMOS

- No se puede dañar la sostenibilidad en una cuenca vecina
- No puede seguir estando en exceso a largo plazo
- No se puede agotar el agua superficial

ACCIONES Y PROYECTOS DE GESTIÓN

ESFUERZOS DE DESARROLLO PARA EL GSP DE KRGSA

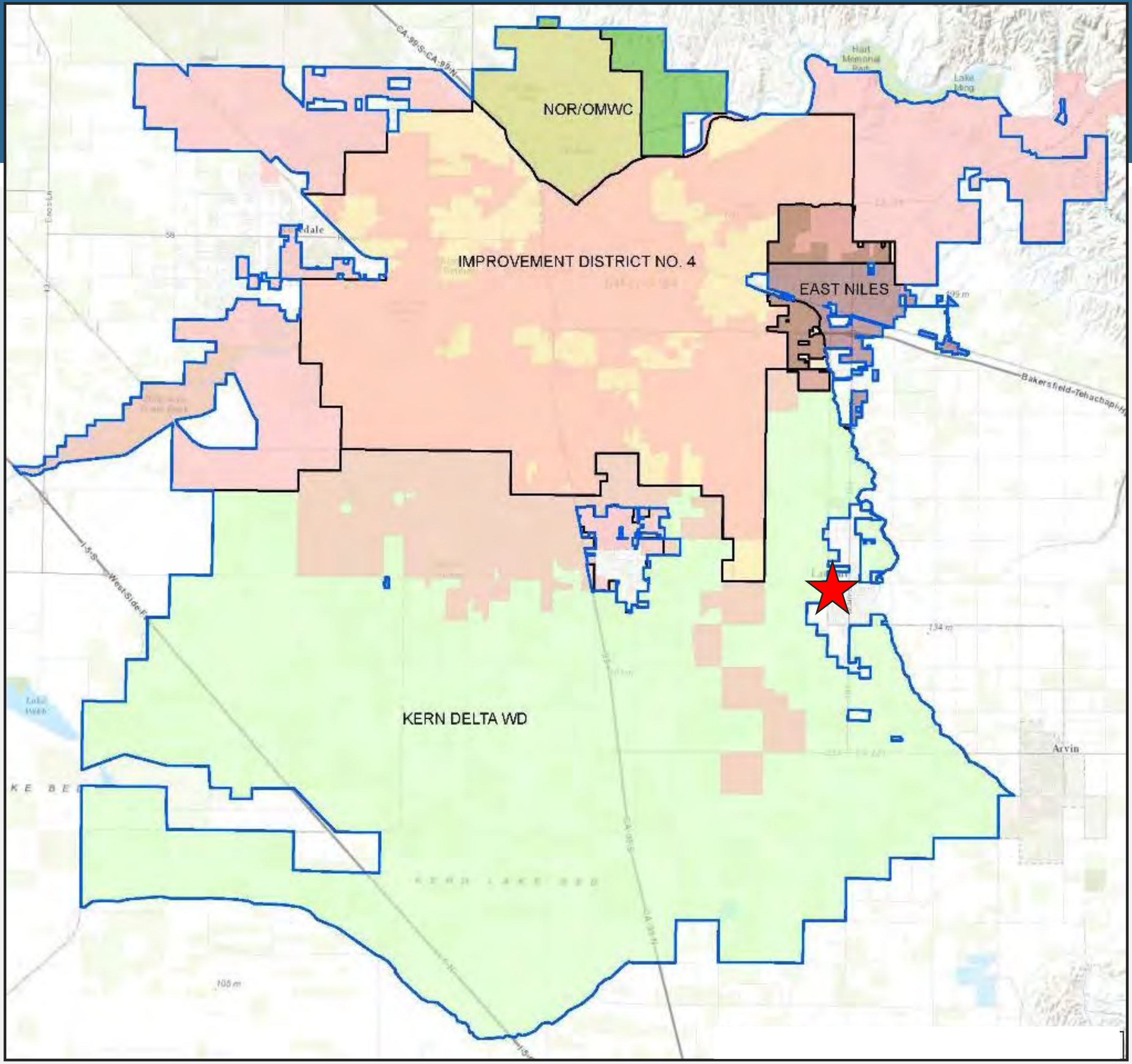
SUBCUENCA DEL CONDADO KERN



GSAs AND GSPs EN LA SUBCUENCA KERN
(A PARTIR DE 2018)

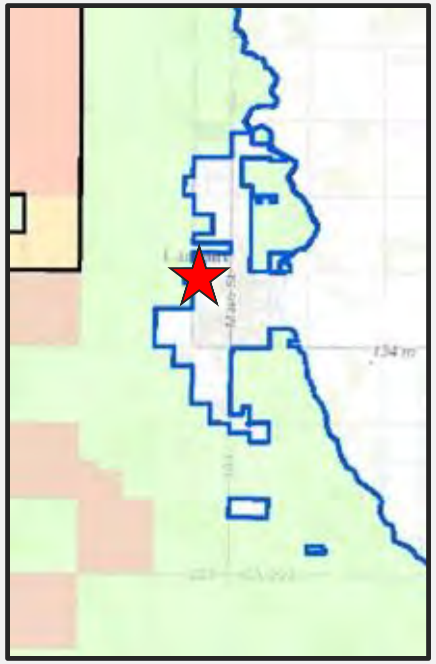
- **GSAs Preparando sus Propios GSPs:**
  - Kern River GSA
  - Kern Groundwater Authority GSA
  - Buena Vista Water Service District GSA
  - Cawelo Water District GSA
  - City of McFarland GSA
  - Greenfield County Water District GSA
  - Henry Miller Water District GSA
  - Olcese Water District GSA
  - Pioneer GSA
  - Semitropic Water Storage District GSA
  - West Kern Water District GSA
  - White Wolf GSA

AGENCIA DE SOSTENIBILIDAD DE AGUAS SUBTERRÁNEAS KERN RIVER (KERN RIVER GSA)



Miembros del Kern River GSA

- Cuidad de Bakersfield
- Agencia de Agua del Condado Kern – Distrito de Mejora #4 (ID4)
- Distrito de Agua Kern Delta



Comunidades en el GSA

- Edison
- Fuller Acres
- Oildale
- Oil Junction
- Rexland Acres
- Weedpatch
- Lamont (parte pequeña al norte)

GSP VISION EN CONJUNTO

Recopilación de datos / Datos Sistema de gestión

Entorno institucional -Área de abastecimiento de agua / plan

Modelo hidrogeológico conceptual/agua subterránea

Presupuesto de agua (actual e histórico)

Objetivos de sostenibilidad y Criterios

¿Escenarios de gestión? Presupuesto de agua proyectado

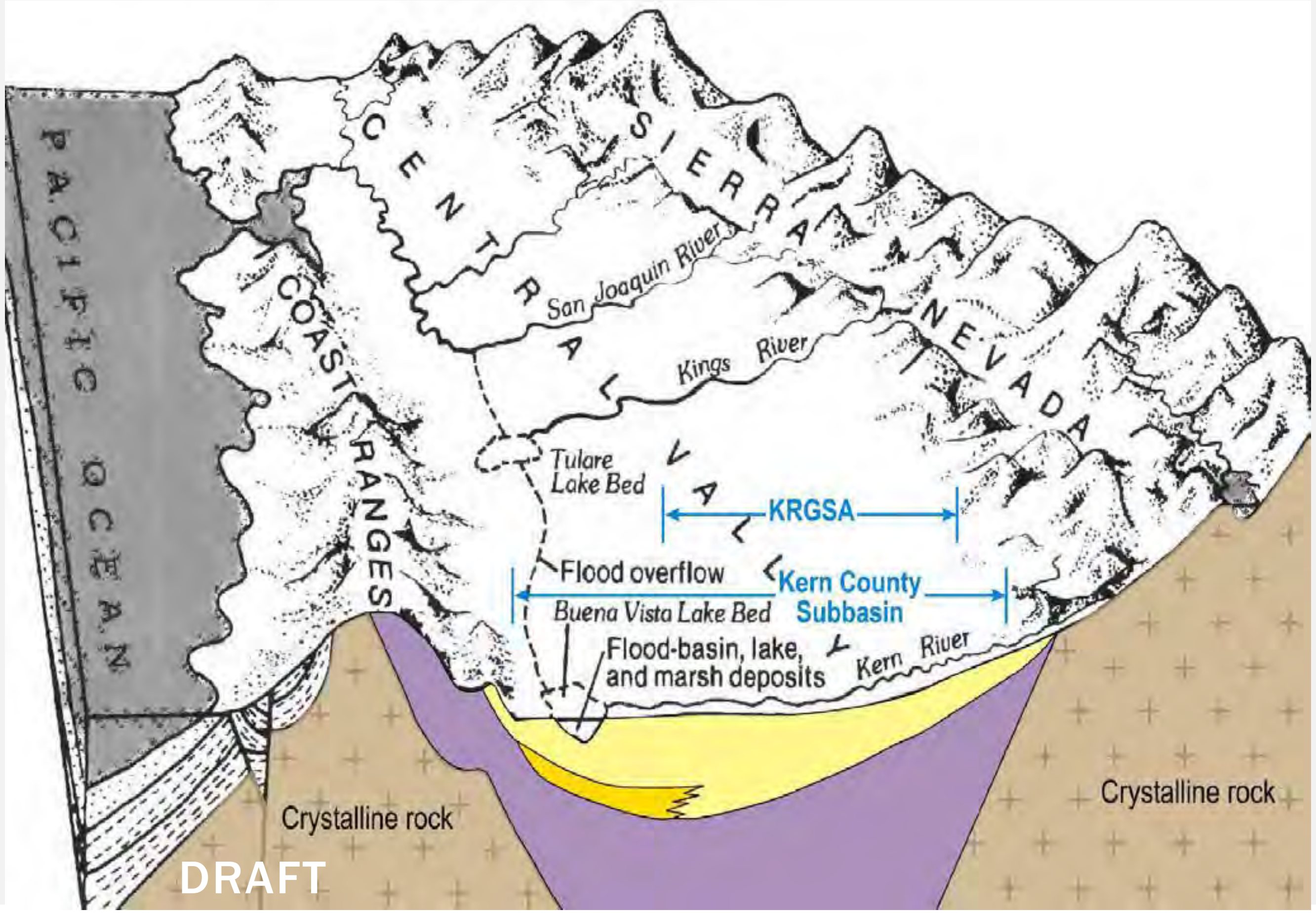
Redes de monitoreo Plan de desarrollo

Modelo conceptual hidrogeológico, condiciones de aguas subterráneas y presupuestos hídricos informan colectivamente el análisis de sostenibilidad

DRAFT

TODD GROUNDWATER

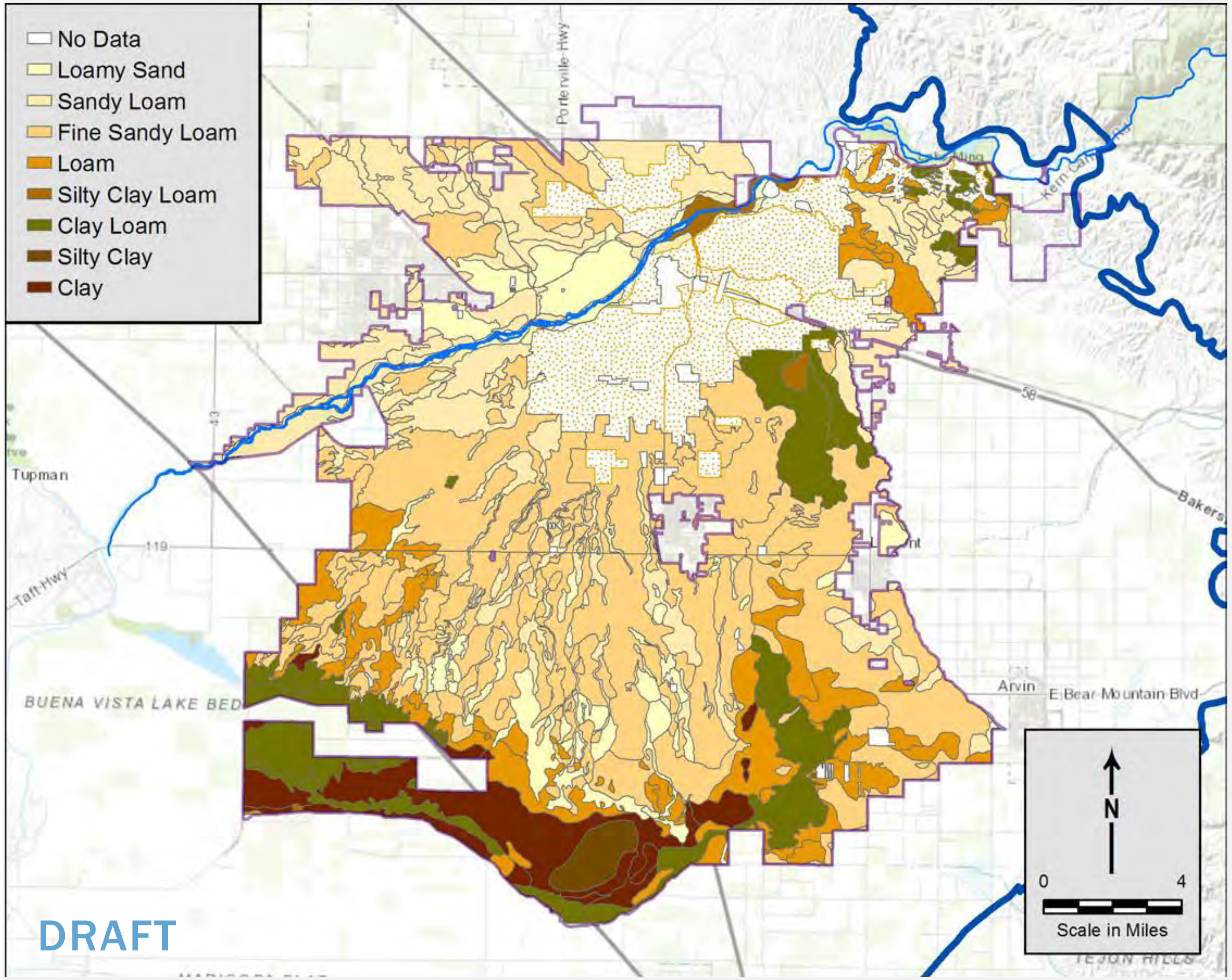
CONFIGURACIÓN HIDROGEOLÓGICA CONCEPTUAL SUBCUENCA DEL CONDADO DE KERN



- Canal lleno de aluviones entre Sierra Nevada y Coast Ranges
- Subyacente por unidades sedimentarias marinas más antiguas
- Flanqueado por un lecho de roca cristalino

TODD GROUNDWATER

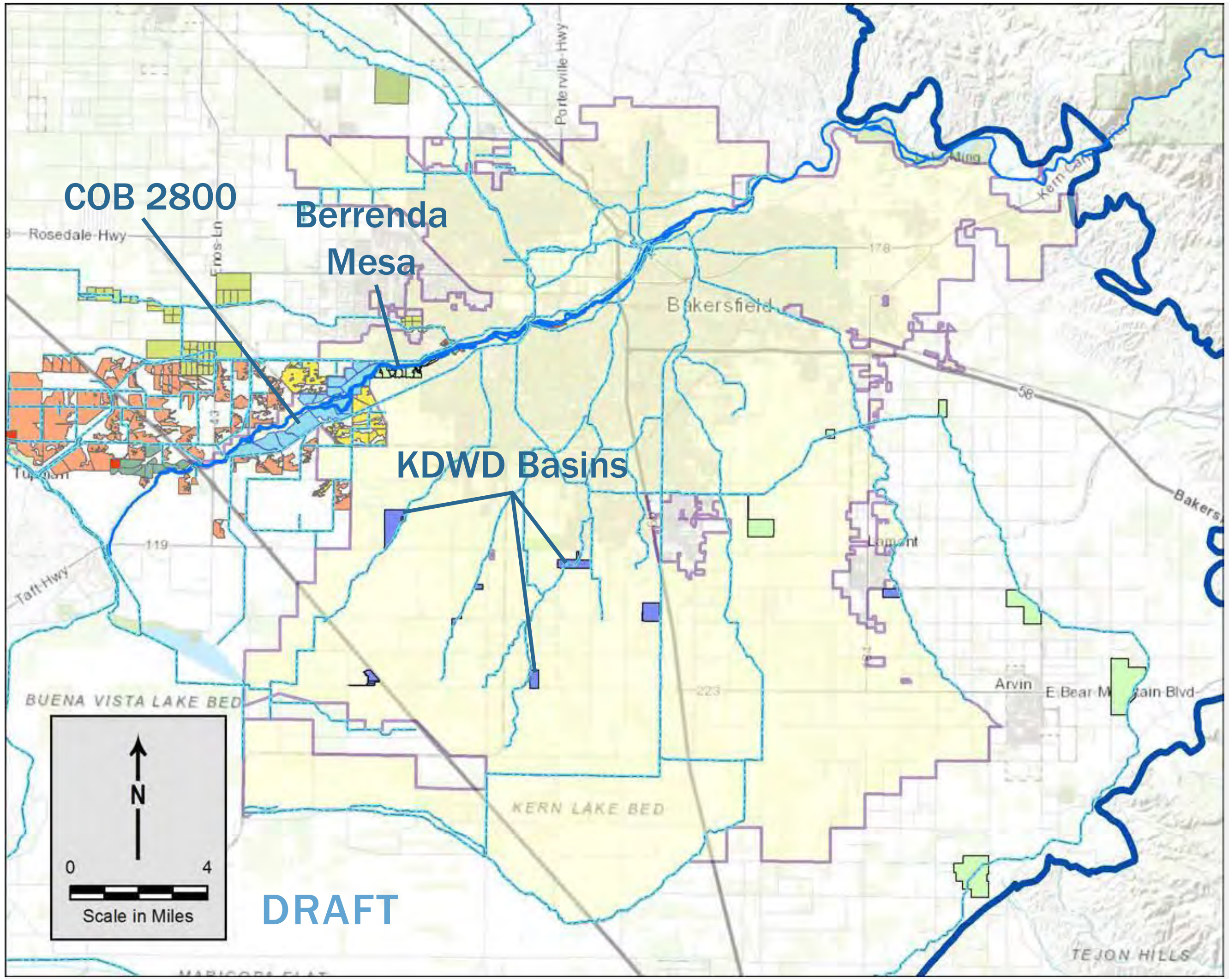
TEXTURAS DEL TIERRA



- Texturas más permeables indicadas por colores más claros (blanco, amarillo, naranja claro)
- Las texturas de baja permeabilidad indicadas por naranja oscuro, verde y marrón
- Las texturas del suelo concuerdan bien con el marco geológico

TODD GROUNDWATER

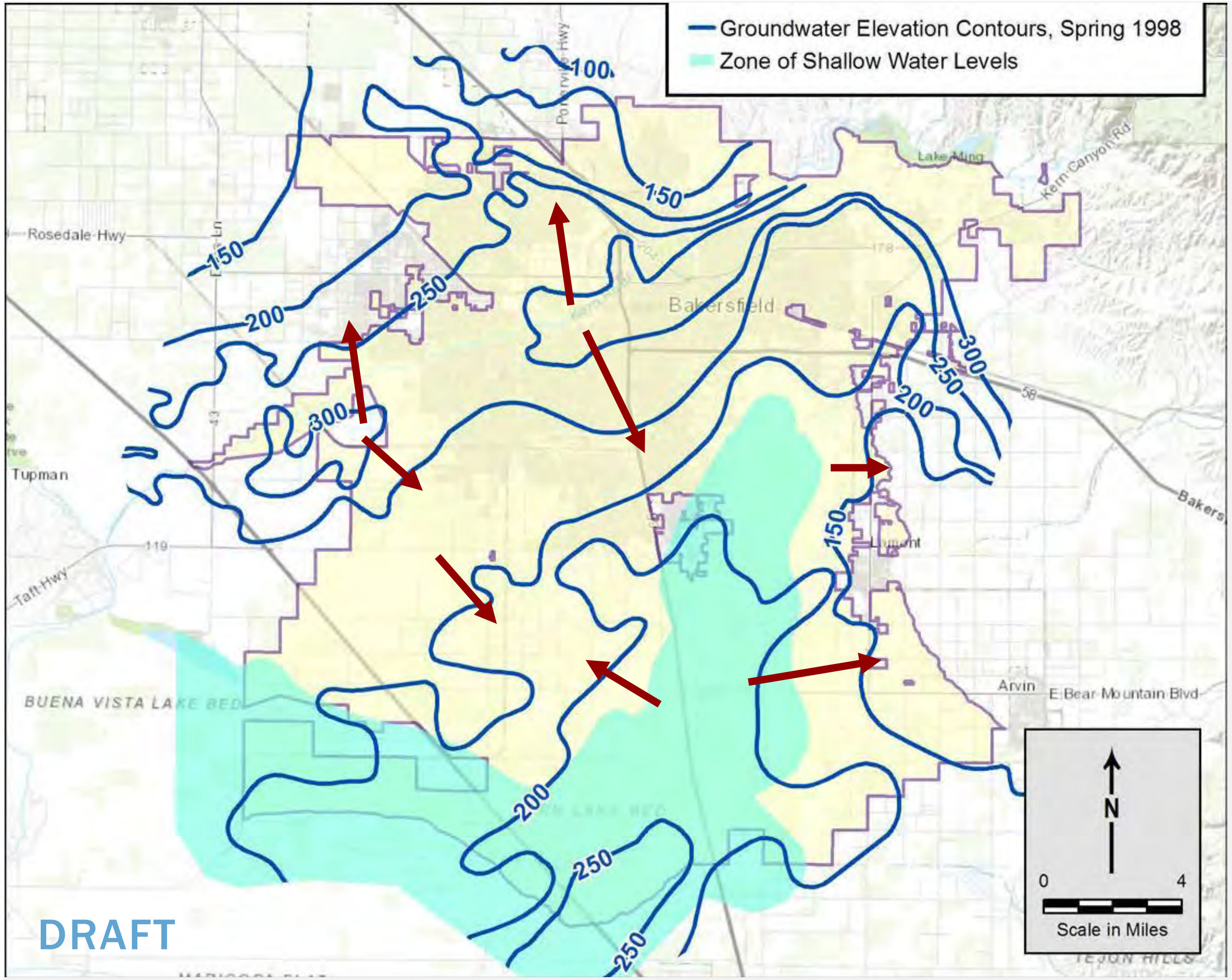
CANALES Y CUENCAS DE RECARGA



- Recarga administrada en el canal del río, canales sin revestimiento y cuencas
- Proyectos de banca de aguas subterráneas KRGSA:
  - COB 2800 Acres
  - KCWA Berrenda Mesa
  - KDWD Proyecto Metropolitano
- Numerosos proyectos bancarios adicionales cerca

TODD GROUNDWATER

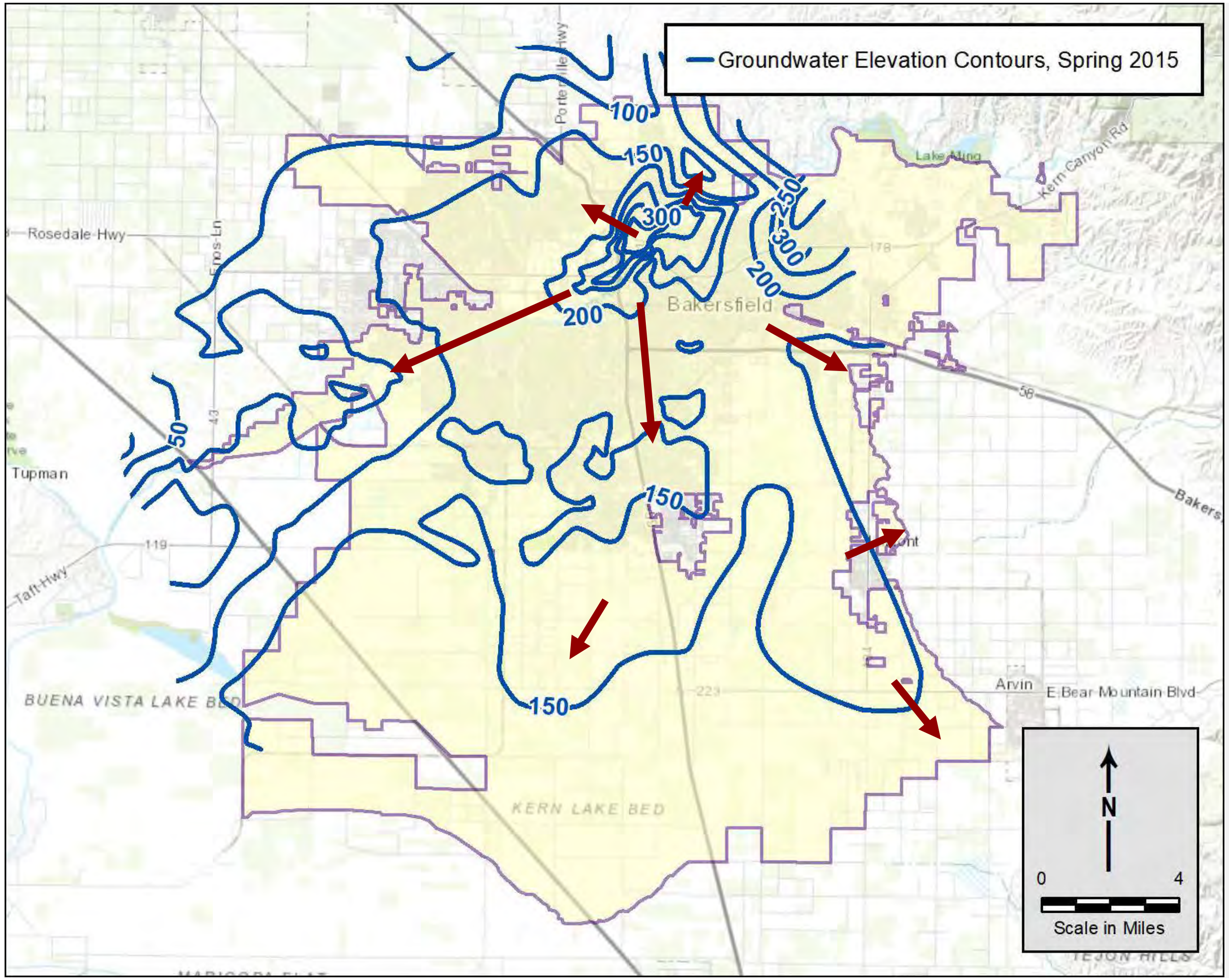
CONTORNOS DE ELEVACIÓN DEL AGUA SUBTERRÁNEA 1998



- 20 mapas de contorno de elevación del agua subterránea (datos de primavera)
- Mapas y datos examinados para capas encaramadas (zona de niveles de aguas poco profundas)
- Ejemplo para el año lluvioso - Primavera de 1998

TODD GROUNDWATER

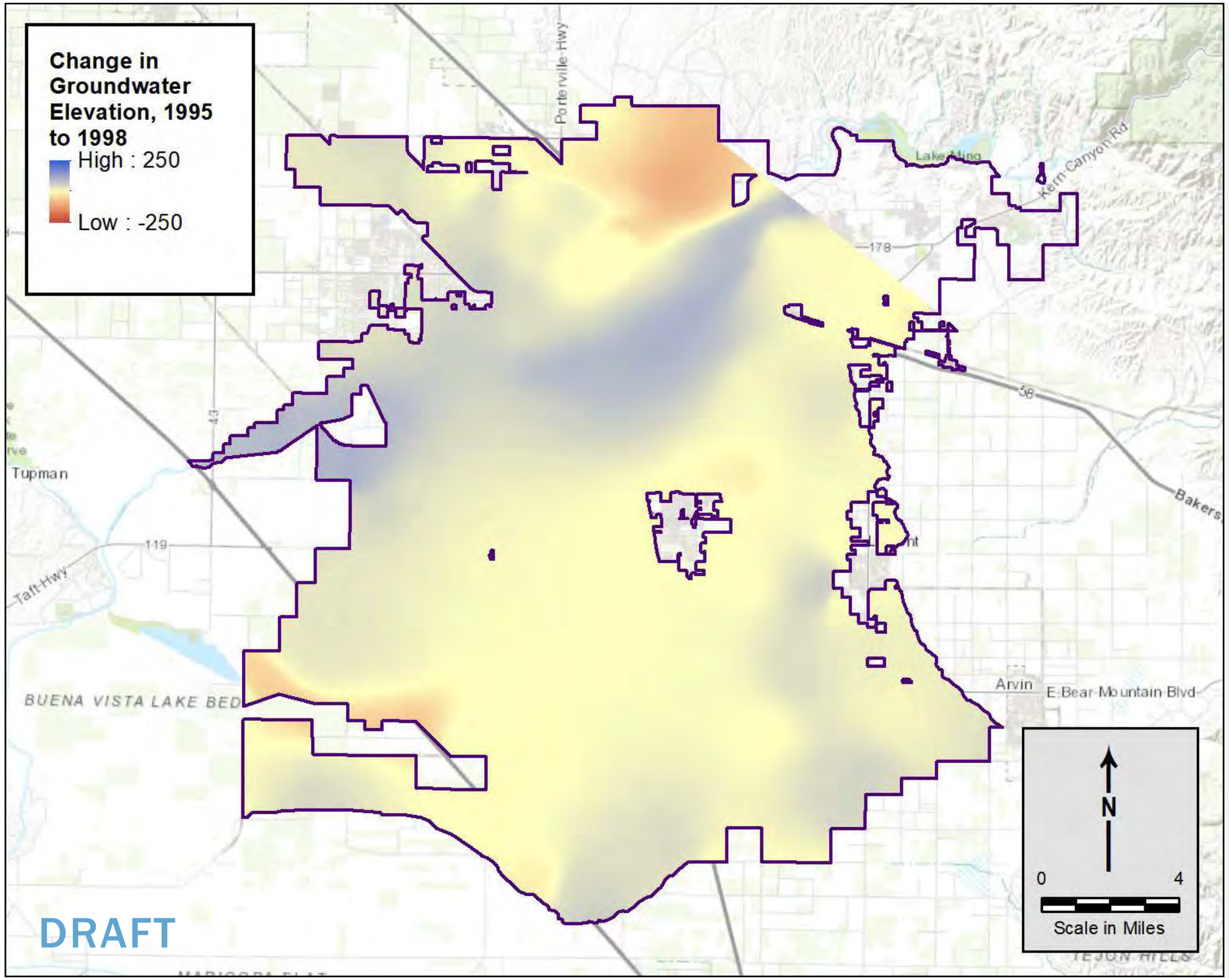
CONTORNOS DE ELEVACIÓN DE AGUA SUBTERRÁNEA 2015



- Año de sequía severa
- En general, niveles de agua más altos que las áreas circundantes
- Excepto por el río, el agua subterránea fluye fuera del área de KRGSA

TODD GROUNDWATER

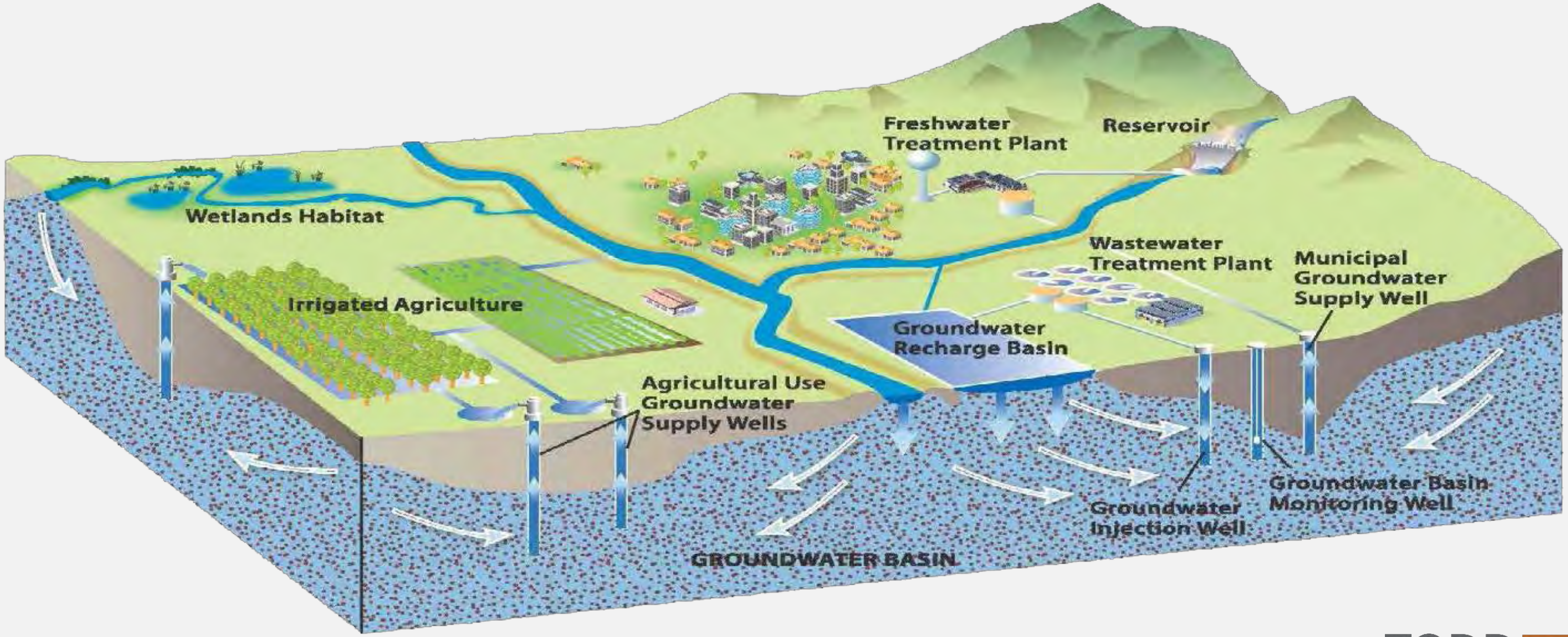
CAMBIO EN LAS AGUAS SUBTERRÁNEAS EN EL ALMACENAMIENTO, 1995-1998



- Se crearon 20 mapas anuales de cambio de nivel de agua utilizando los mapas de contorno de nivel de agua de KCWA Spring
- Las áreas azules indican un aumento en el nivel del agua; las áreas rojas indican una disminución del nivel de agua
- Los datos limitados crean incertidumbre para algunas áreas y períodos de tiempo

TODD GROUNDWATER

FINALIZANDO EL PRESUPUESTO DE AGUA DE KRGSA



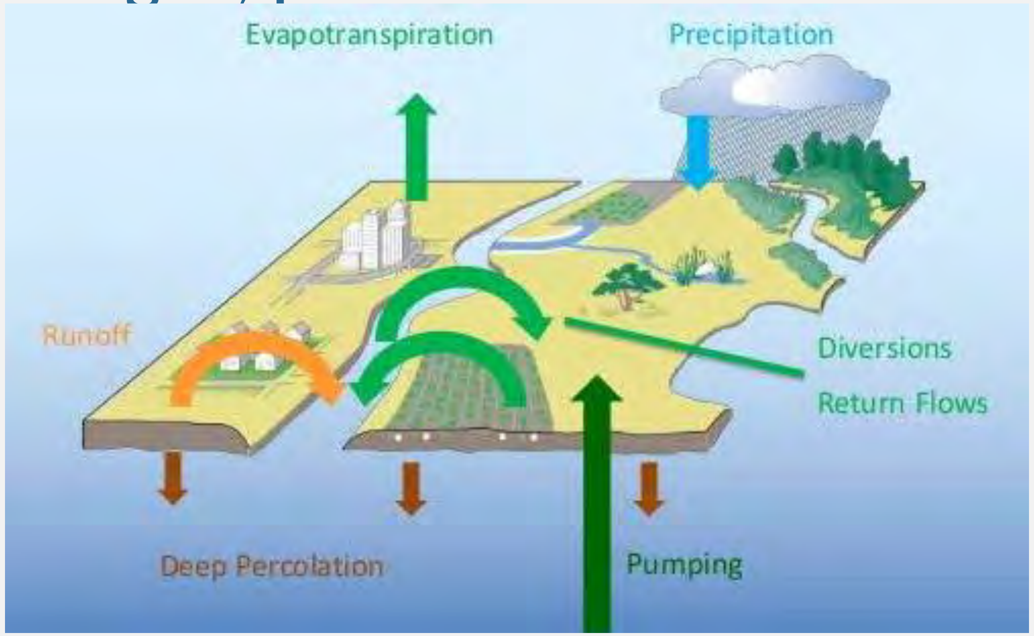
CA Water Foundation

DRAFT

TODD GROUNDWATER

PRESUPUESTOS DE AGUA KRGSA - ENFOQUE

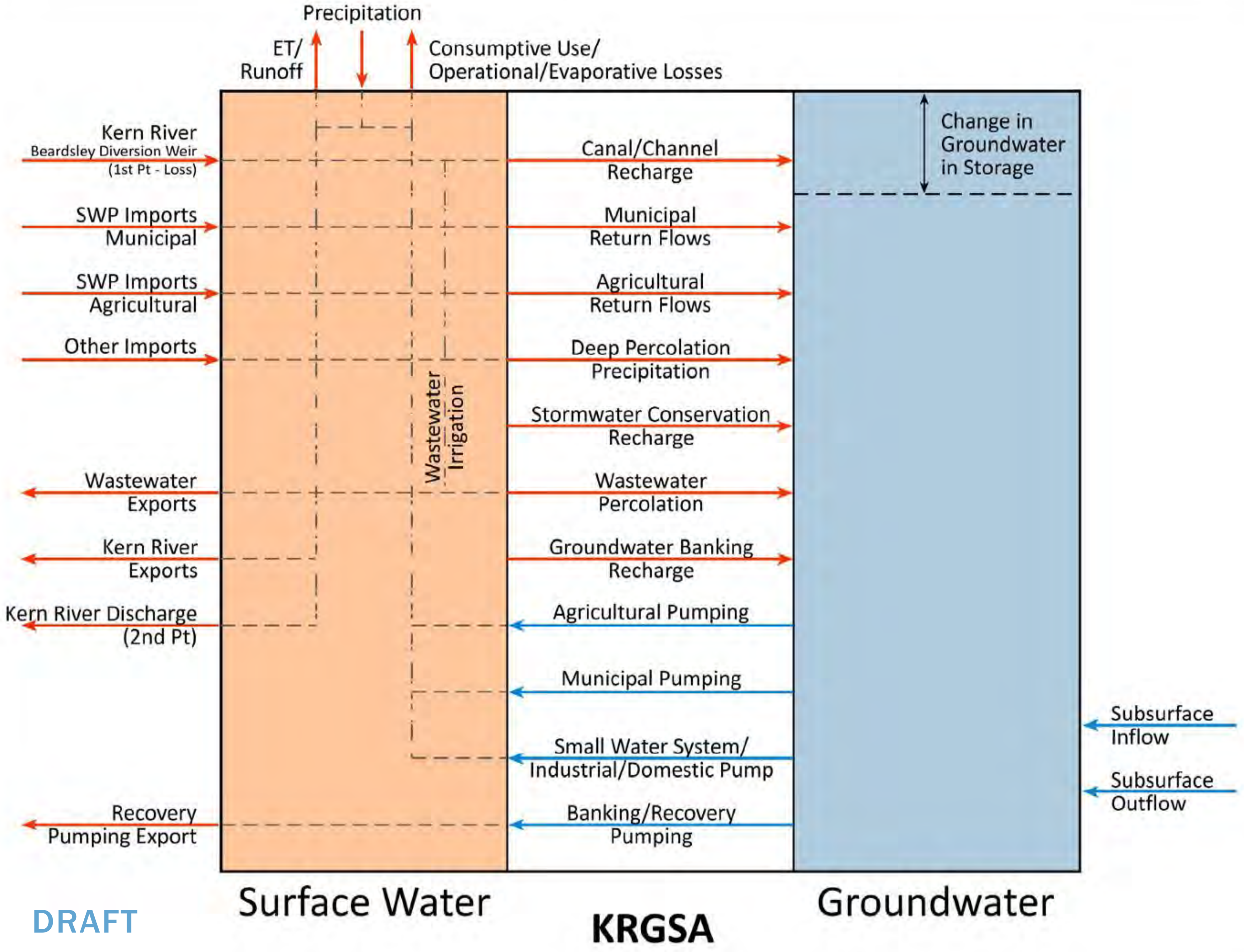
- El agua del Condado de Kern se administra en tiempo real para un uso óptimo
- Proporciona flexibilidad y optimización de agua, pero da como resultado una contabilidad compleja de moléculas físicas
  - Enfoque en el sistema físico
    - ¿A dónde va el "agua mojada"? (no intercambios de papel)
    - El proceso presupuestario del agua sigue las "moléculas": ¿no se le asigna "propiedad" al agua?
    - Evitar el "doble conteo"



DRAFT

TODD GROUNDWATER

COMPONENTES DE PRESUPUESTO COMBINADO DE AGUA DE KRGSA



DRAFT

TODD GROUNDWATER

PROXIMOS PASOS

- Trabajar con agencias para conciliar datos y presupuestos locales de agua
- Compilar para KRGSA
- Formato de conjuntos de datos para el modelo

Horizon WATER and ENVIRONMENT

TODD GROUNDWATER

PREGUNTAS Y RESPUESTAS

PARTICIPE EN EL DESARROLLO DEL GSP

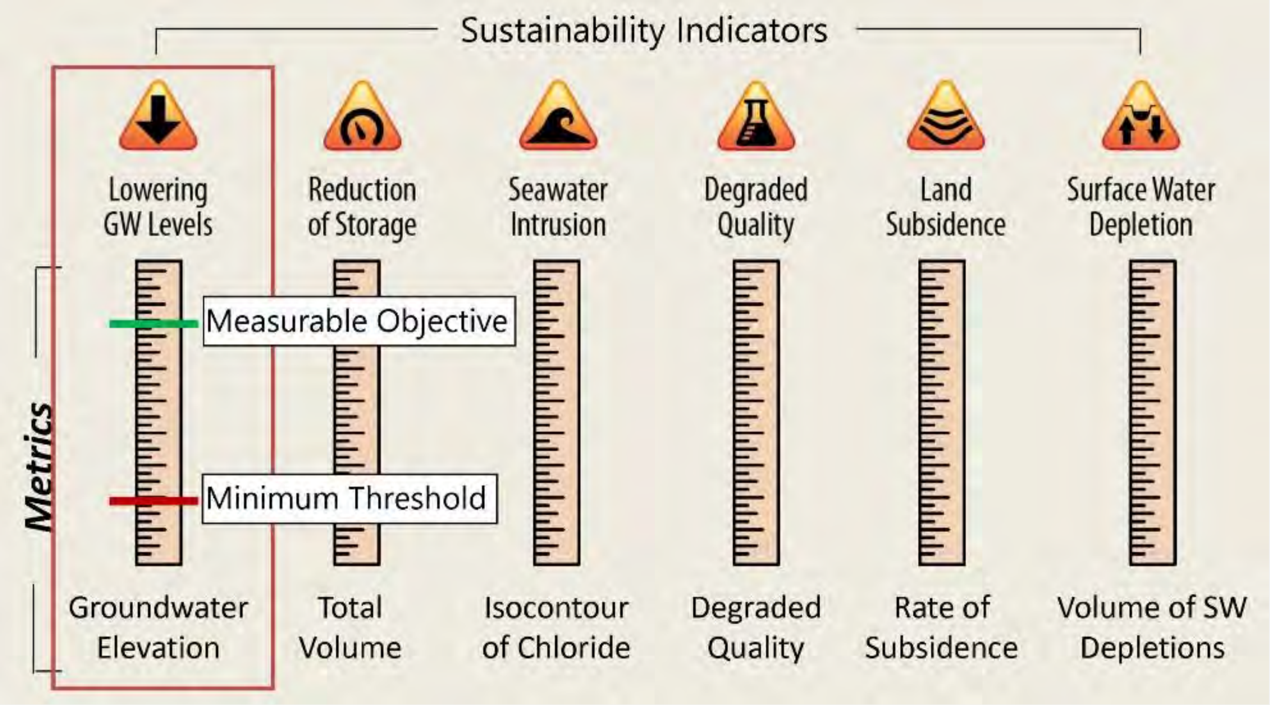
Puede ayudar a dar forma a lo que está incluido en el planificar por :

- Proporcionar información sobre sus desafíos de agua subterránea pasados o presentes
- Compartir información sobre su consumo de agua y / o pozo
- Compartiendo su visión para la sostenibilidad
- Identificar proyectos que pueden ayudar a abordar las condiciones del agua subterránea
- Completando la Encuesta de Parte Interesada

DISCUSIÓN DE LAS PARTES INTERESADAS- RESULTADOS INDESEABLES

Los resultados indeseables se categorizan como :

- Niveles de Agua Subterránea Más Bajos
- Reducción de Almacenamiento
- Intrusión de Agua de Mar (no un factor en la subcuenca del condado de Kern)
- Calidad del Agua Degradada
- Hundimiento de la Tierra
- Agotamiento de Agua Superficial



DISCUSIÓN DE LAS PARTES INTERESADAS- RESULTADOS INDESEABLES

¡Queremos escuchar de ti!

- ¿Usted, su comunidad o su negocio han sido afectados por alguno de los resultados indeseables?
- ¿Cuál de los resultados indeseables es el más importante para usted y por qué? ¿Hay algo más importante que otros?
- ¿Qué mejoras le gustaría ver que sucedan en los próximos veinte años?

MANTENTE INVOLUCRADO

- Asista a las reuniones de GSA
  - Las reuniones de la Mesa Directiva de KRGSA se llevan a cabo el último miércoles de cada mes a las 8 a.m. en 1600 Truxtun Avenue, Bakersfield, CA 93301.
- Ingrese en la lista de "partes interesadas" para recibir correspondencia e información de KRGSA
- Visita el sitio web para saber más: http://www.kernrivergsa.org/
- Asiste a talleres futuros

INFORMACIÓN ADICIONAL Y RECURSOS

- Asistencia técnica para comunidades severamente desfavorecidas
  - Self-Help Enterprises: https://www.selfhelpenterprises.org
    - Eva Dominguez, 559-802-1634, EvaD@selfhelpenterprises.org
    - Maria Herrera, 559-802-1676, MariaH@selfhelpenterprises.org
- Información Local– Kern River GSA: https://kernrivergsa.org
    - Art Chianello, 661-326-3715, AChianel@bakersfieldcity.us
- Información Estatal
  - Department of Water Resources: https://sgma.water.ca.gov/portal/
  - State Water Resources Control Board: https://www.waterboards.ca.gov/water_issues/programs/gmp/sgma.html

GRACIAS!

Kern River Groundwater Sustainability Agency

KERN GROUNDWATER AUTHORITY

DRAFT

Kern County Subbasin
DRAFT C2VSim Modeling Results

January 11, 2019

TODD GROUNDWATER

Presentation Outline

- Background
- Model Results Summary
- Peer Review Report by Woodard & Curran
- Model Performance
- Next Steps

DRAFT

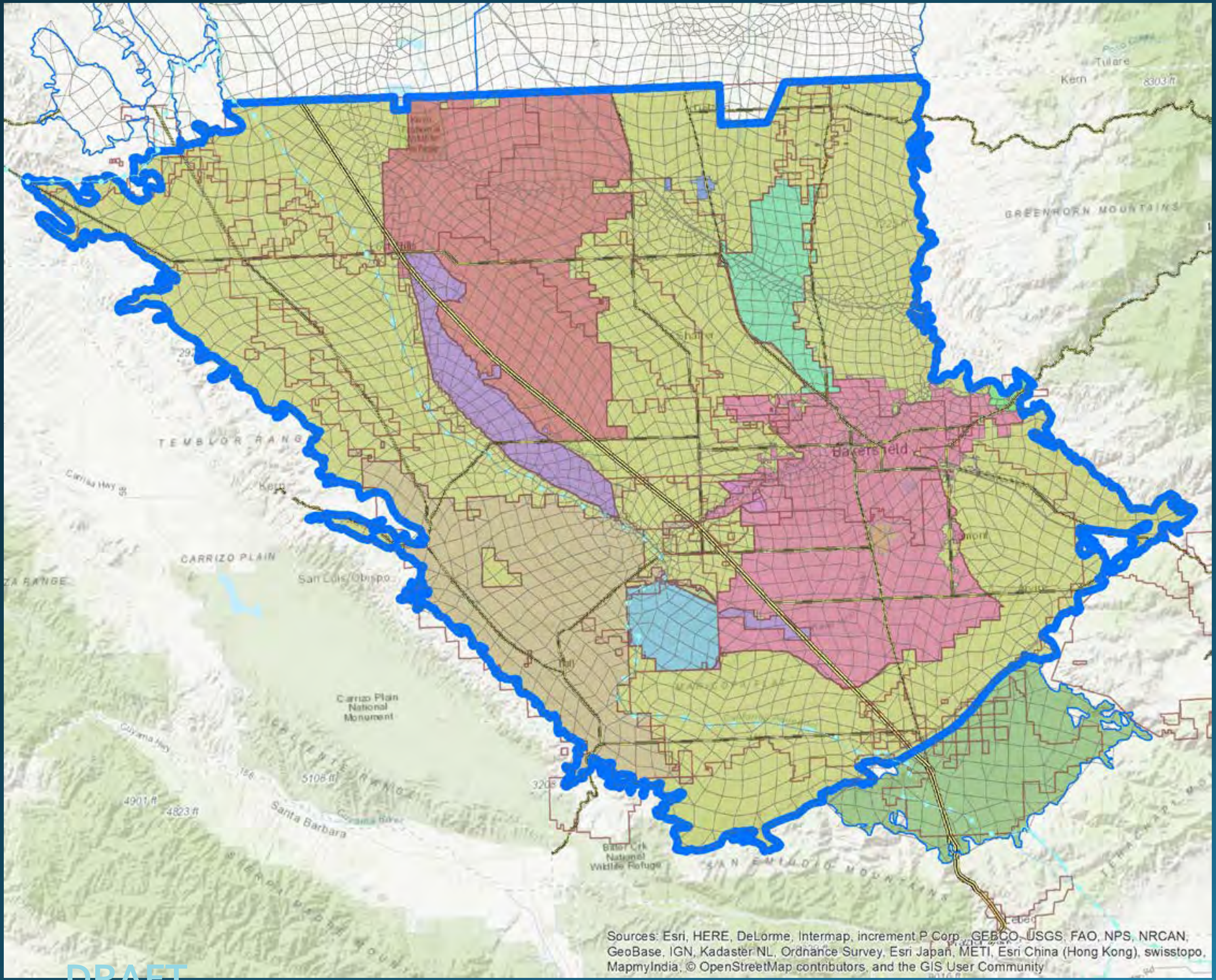
TODD GROUNDWATER

Use C2VSim for Water Budget Analysis

- C2VSim
  - Covers Entire Central Valley
  - Focus to support CVP/SWP Planning
  - Beta-Version released May to support SGMA
- Beta Version
  - DWR has provided the Beta version to support GSP water budget development

TODD GROUNDWATER

Subbasin Water Budget - C2VSim Update

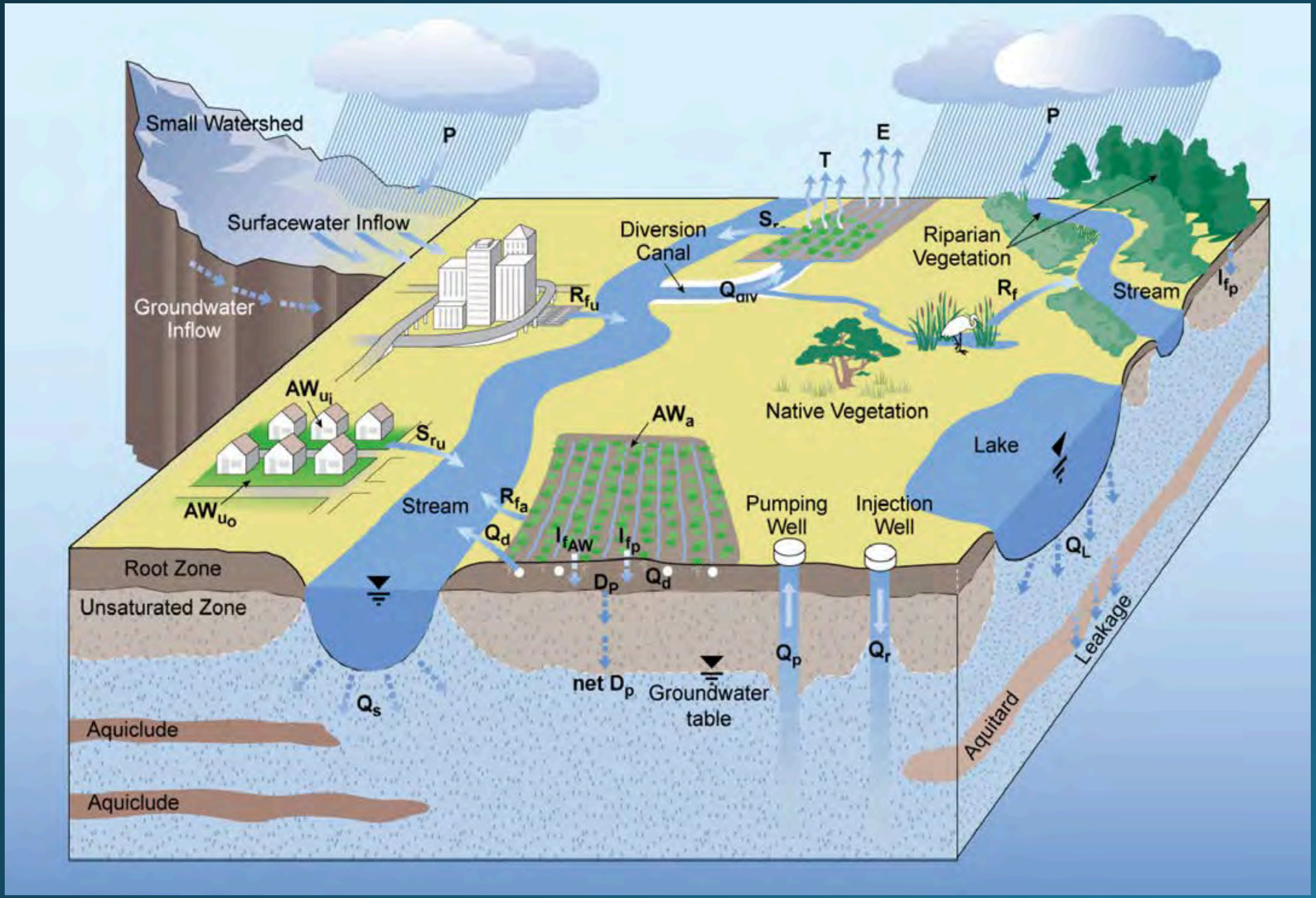


- Kern County Update
  - Update managed water data
  - Localize water distribution
- Update Managed Water Supply and Demand Data
  - Use local subbasin data
  - Focus on physical water
- Retain general C2VSim data structure with Kern County Updates
  - Maintain current model structure (layers and properties)

DRAFT

TODD GROUNDWATER

Managed Water Supply and Demand Data



- Surface water diversions by water district
- Groundwater banking and recharge programs
- Groundwater banking recovery for in-basin use and export
- Crop demand based on METRIC ET data
- Urban M&I water use
- Locally important water budget components

DRAFT

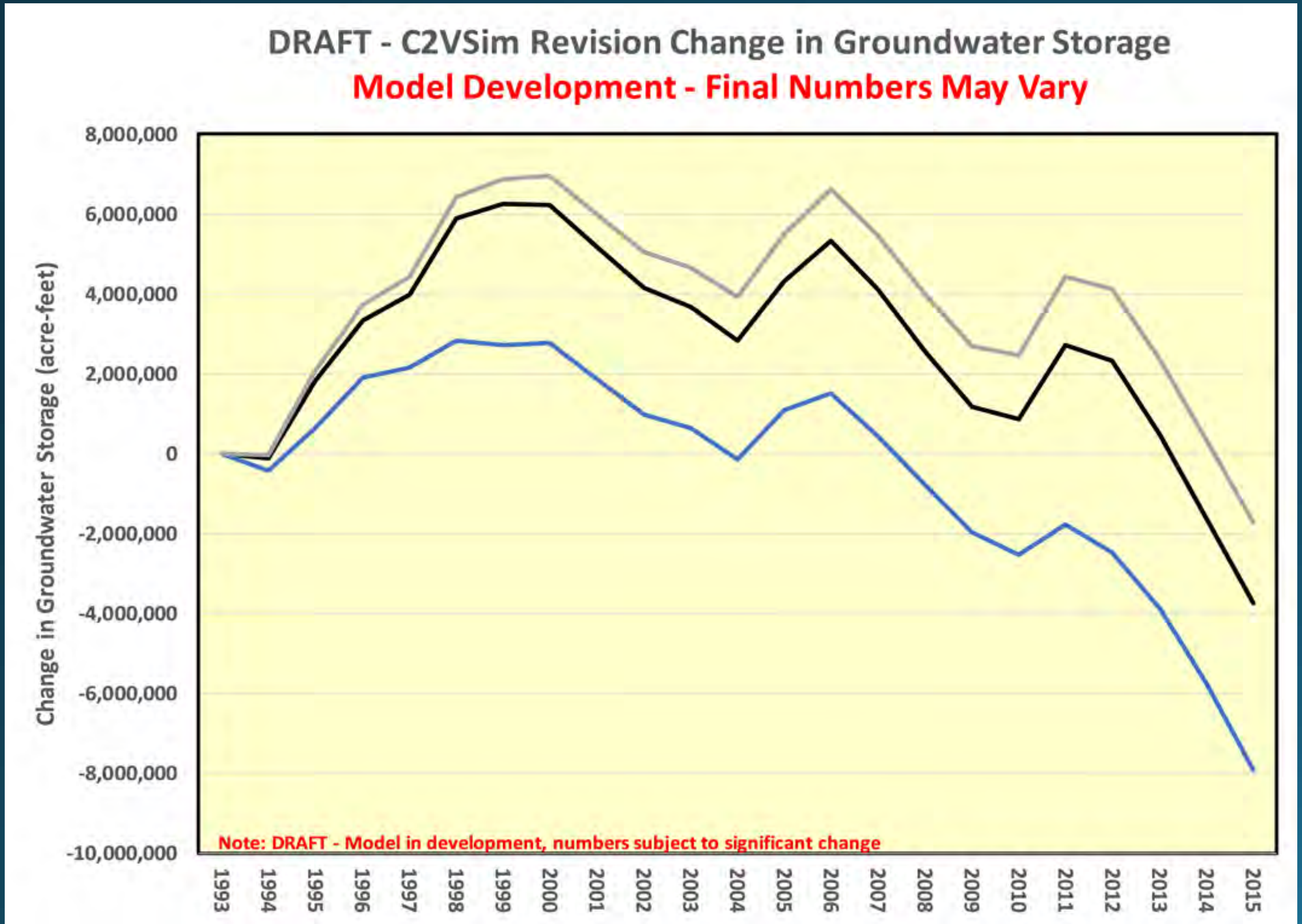
TODD GROUNDWATER

Current Model Status

- Work on model performance
  - Kern River
  - QA of managed water data input
  - Address Beta Version issues
  - Revise Initial Condition
- DRAFT Model Results
  - Develop Draft Historical and Current Water Budgets
  - Basin-wide and Local GSA
- Left to Do
  - Address Questions and Comments
  - Make Final QA and Peer Review Revisions
  - Documentation

TODD GROUNDWATER

Where We Left Off

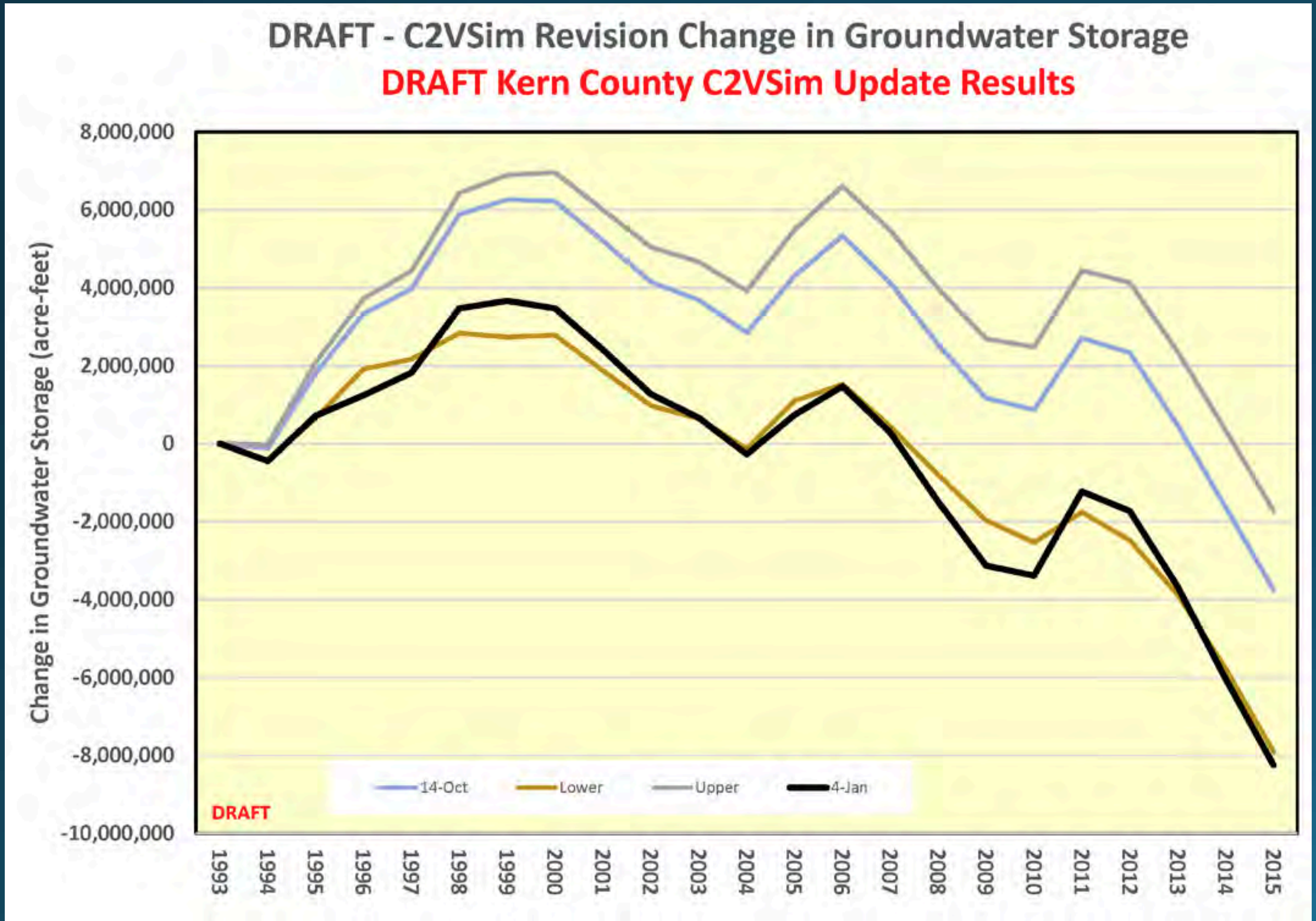


- Primary Managed Water Data was complete
- Ongoing QA/QC of data input
- Reconciling Beta-version issues

DRAFT

TODD GROUNDWATER

DRAFT Results – Groundwater Storage Change

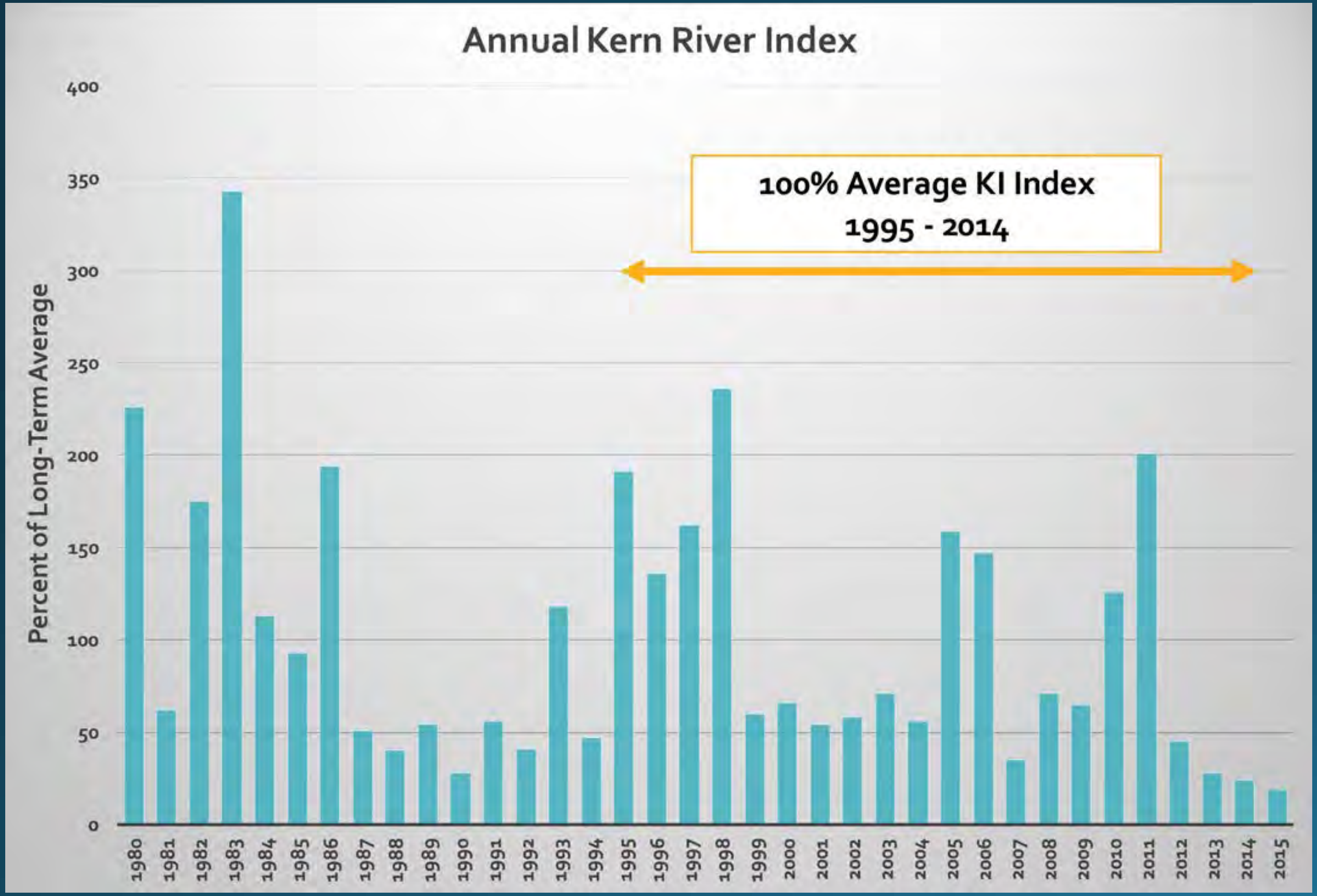


- DRAFT Groundwater Storage
  - Groundwater storage did end up at lower range as remaining issues were resolved
- Data Period Results
  - This graph shows the results over the period of data collection

DRAFT

TODD GROUNDWATER

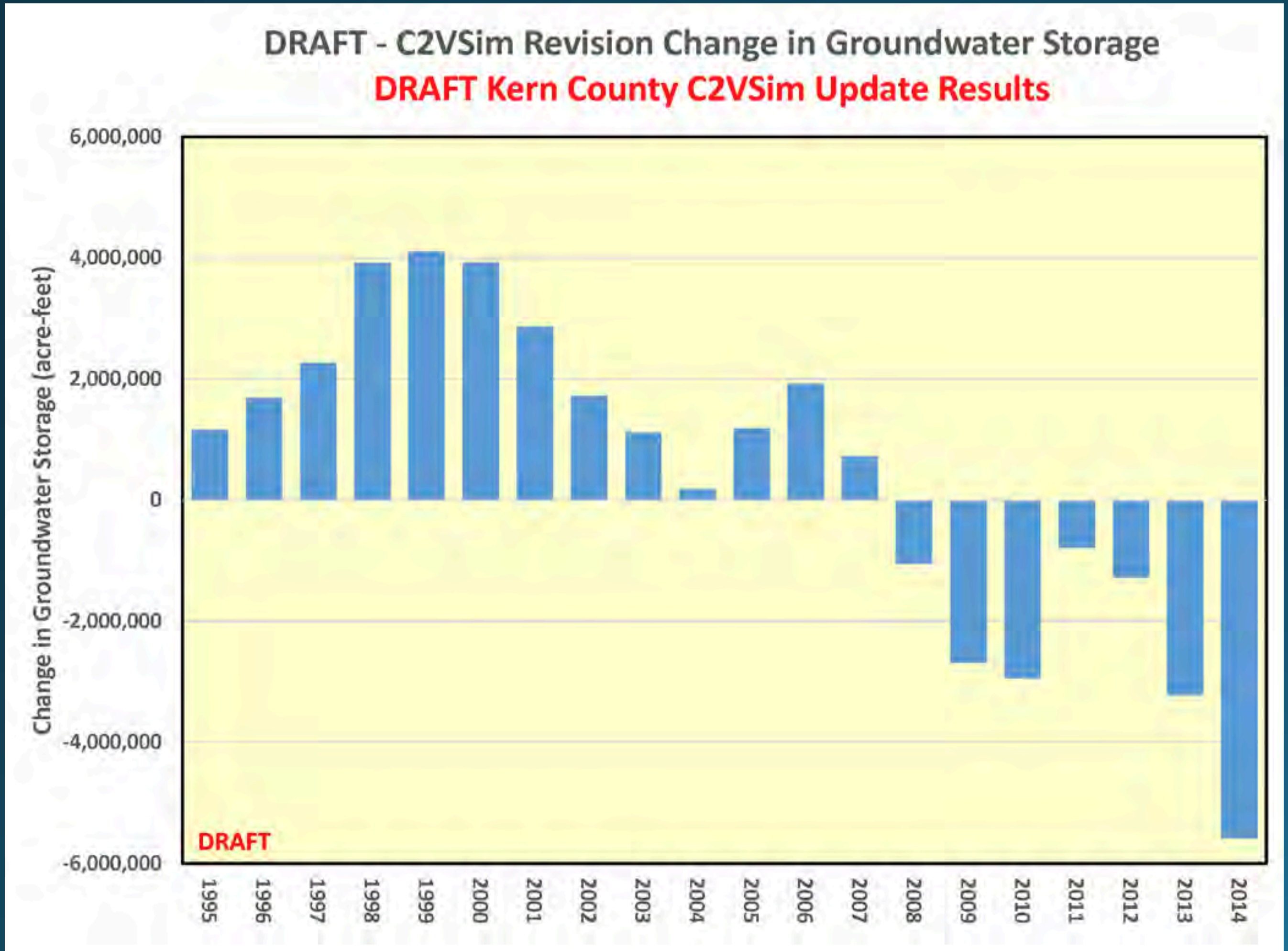
Historical Water Budget Time Period



- Sufficiently long to approximate average hydrologic conditions (Kern River, precipitation)
- Recent time periods - current operations, widely-available and higher-quality data
- Initial conditions of stable (low) water levels

TODD GROUNDWATER

DRAFT Results – Groundwater Storage Change



- 20-Year Assessment Period Results
  - **5,600,000** Acre-foot decline over 20-year Assessment Period
  - **280,000** Average Annual Water Storage Decline
- Model does not account for Groundwater Banking Accounts
  - Water stored in basin for use by others

DRAFT

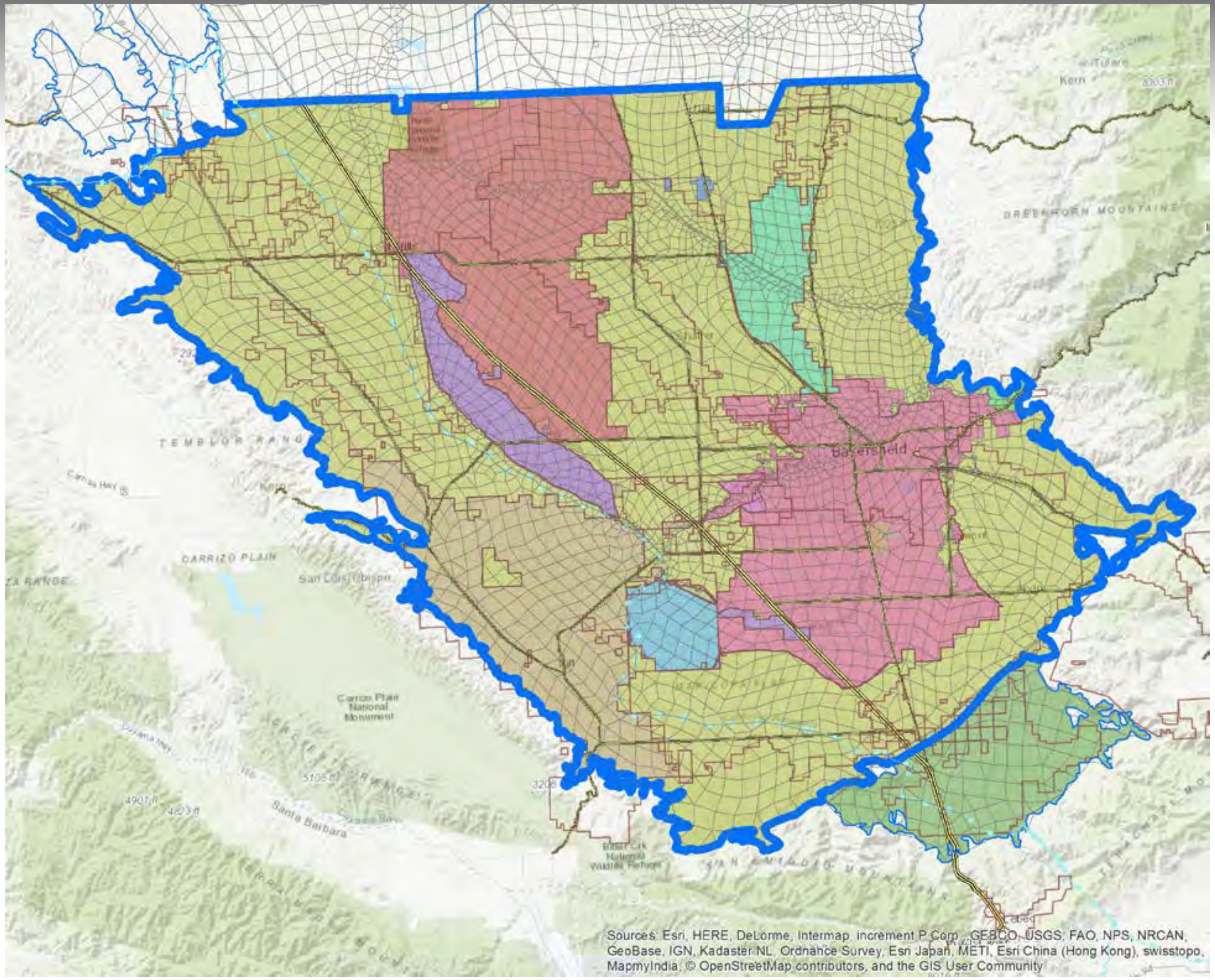
TODD GROUNDWATER

Peer Review Report by Woodard & Curran

DRAFT

TODD GROUNDWATER

Kern C2VSim Peer Review Report



Prepared by

Saquib Najmus
&
Frank Qian

Woodard & Curran

January 11, 2019

Peer Review – Scope of Work

Scope was limited to input data review only

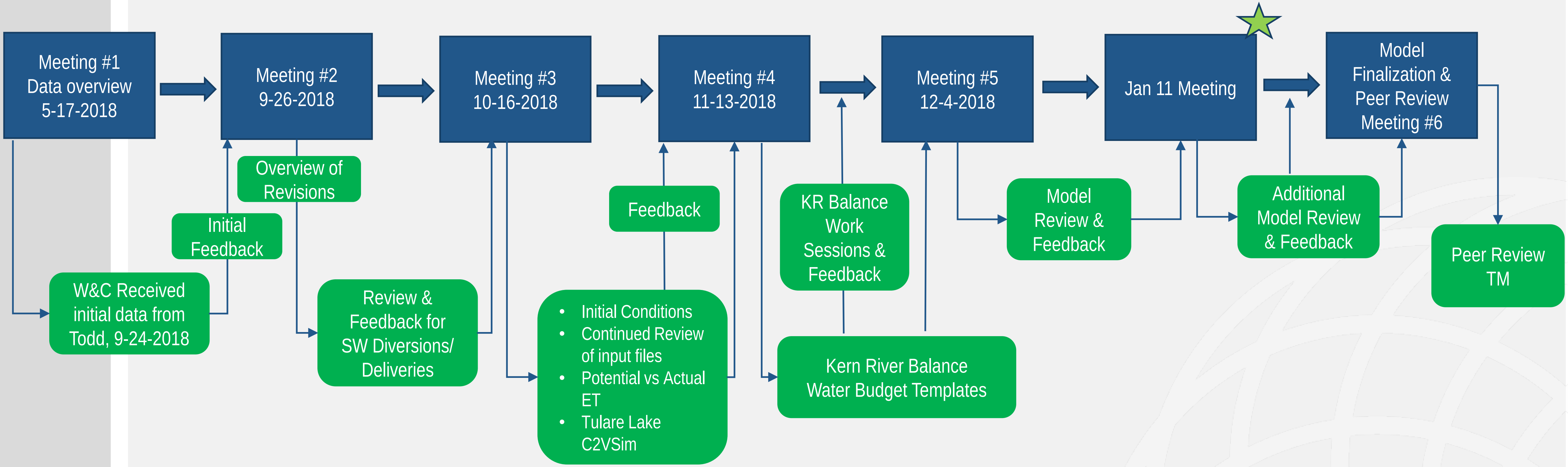
- Task 2.3 - Review of documentation of C2VSim data updates and verification and revisions (as needed) of the following sets of C2VSim input data:
  1. Pumping Data
  2. New Groundwater banking input data
  3. New Managed water Supply data
  4. METRIC data and other land use data, including changes to agricultural water demand
  5. Boundary inflows with updated data
  6. Urban demand data

- ~~Task 2.4 - Review Current and Historical Water Budgets for Kern County Subbasin~~

Peer Review - Purpose

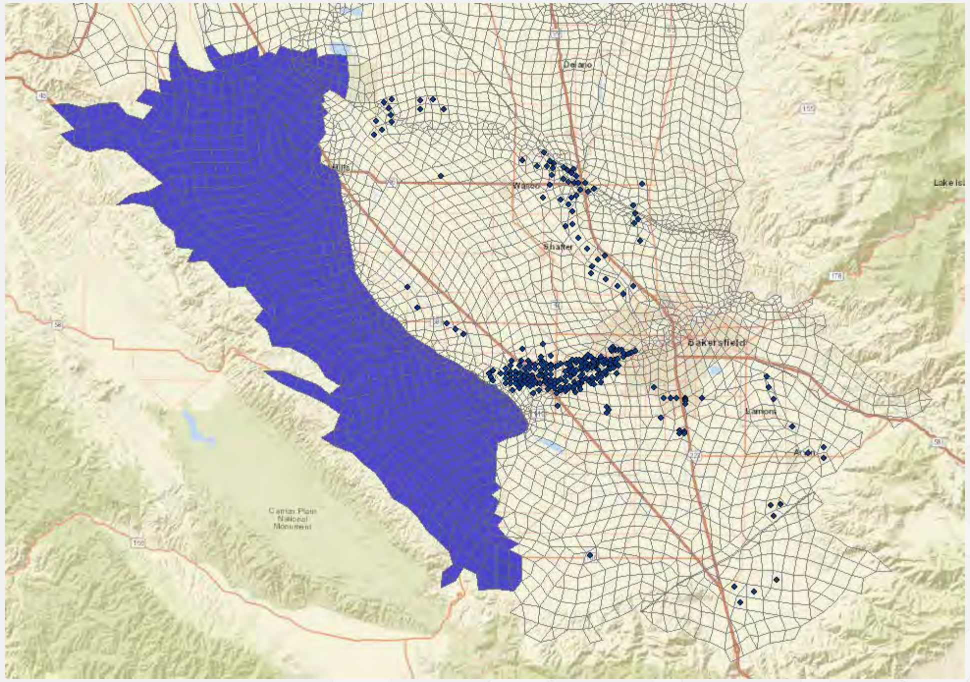
- To verify that the input data update for the Kern Subbasin of the C2VSim Beta version were made correctly and are consistent with model structure requirements

Peer Review – Process



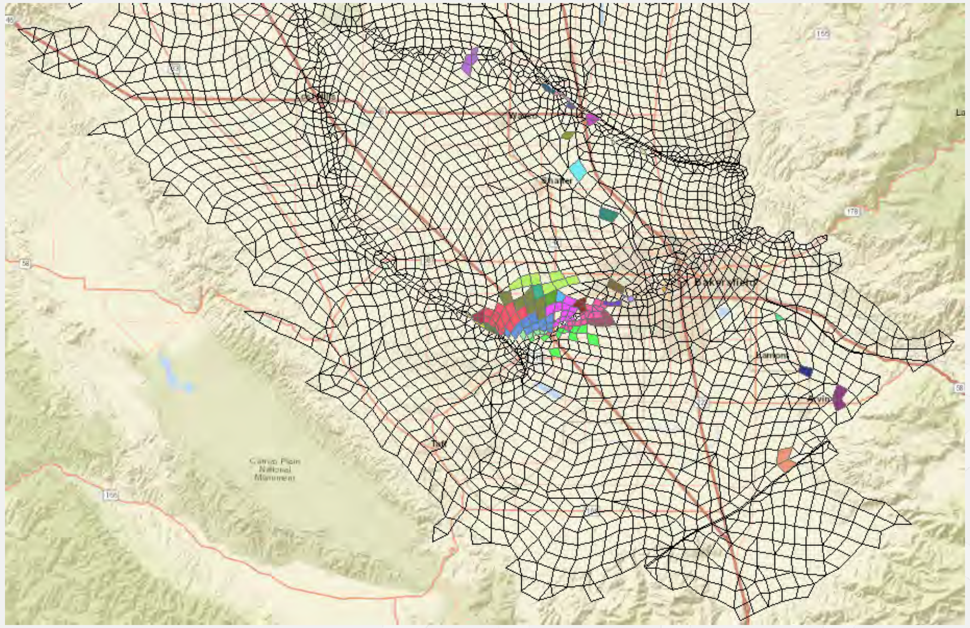
Peer Review - Pumping Data

- Pumping turned off for select elements to represent field data
  - *Checked element pumping spec file in GIS*
- Wells added for extraction
  - *Confirmed locations in GIS*
- Pumping input files changed to reflect data from locals
  - *Checked model timeseries against local data in spreadsheets*
  - *Identified and resolved formatting issues in timeseries files*



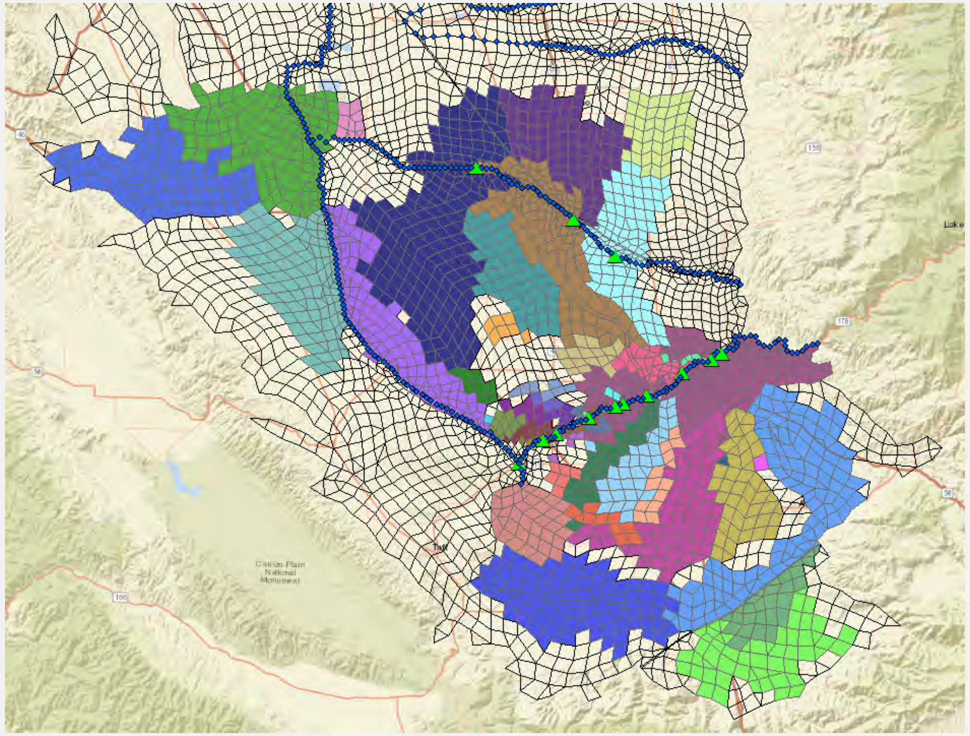
Groundwater Banking

- Delivery and extraction data were incorporated from local data
  - *Checked delivery elements in GIS*
  - *Checked model diversion timeseries against spreadsheet data*
  - *Checked pumping well locations in GIS*
  - *Checked model pumping timeseries against spreadsheet data*



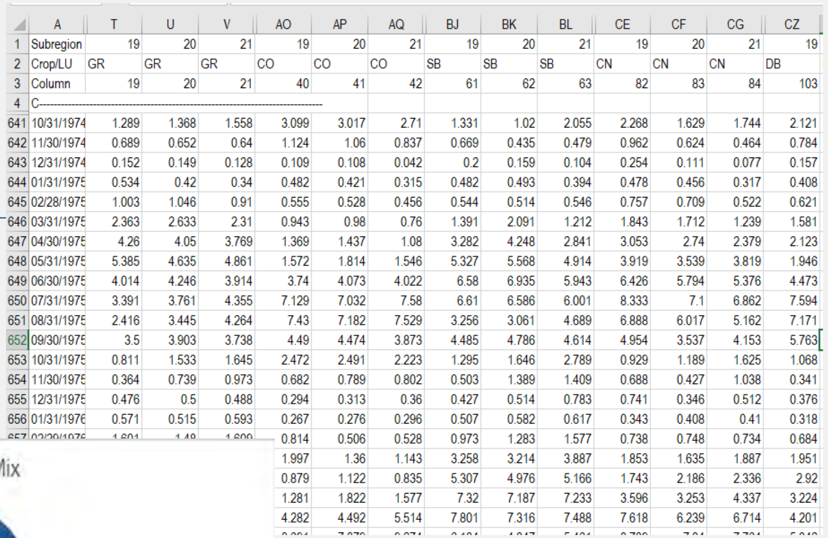
Managed Water Supply

- Pumping records where available
  - *Checked new well locations in GIS and verified timeseries data from spreadsheets*
- Surface water delivery records
  - *Checked delivery elements in GIS*
  - *Checked model diversion timeseries against spreadsheet data*
  - *Worked with Todd GW to develop a modified approach for deliveries to simulate as import/exports to resolve Kern River shortages reported by the model*

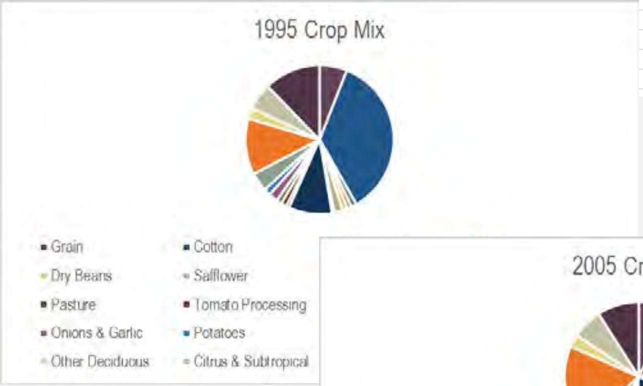


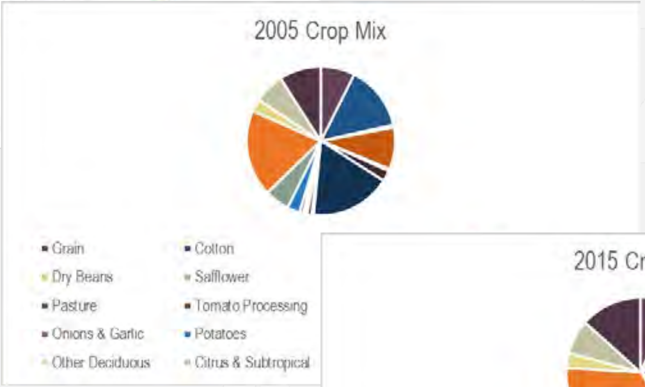
METRIC data and Land Use

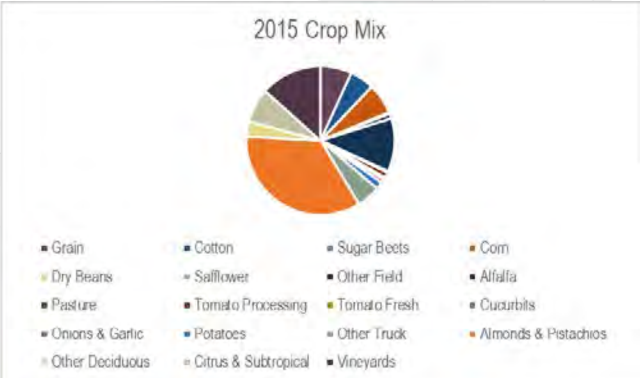
- ET data updated for 1993-2015
  - *Verified approach for mapping METRIC data to model subregions was valid*
- Land use data interpolated between 1993 and 2015
  - *Checked element level ag acreages by year in GIS*
  - *Checked subregion scale ag acreage by crop type*



	A	T	U	V	AO	AP	AQ	BJ	BK	BL	CE	CF	CG	CZ
1	Subregion	19	20	21	19	20	21	19	20	21	19	20	21	19
2	Crop/LU	GR	GR	GR	CO	CO	CO	SB	SB	SB	CN	CN	CN	DB
3	Column	19	20	21	40	41	42	61	62	63	82	83	84	103
4	C---													
641	10/31/1974	1.289	1.368	1.558	3.099	3.017	2.71	1.331	1.02	2.055	2.268	1.629	1.744	2.121
642	11/30/1974	0.689	0.652	0.64	1.124	1.06	0.837	0.669	0.435	0.479	0.962	0.624	0.464	0.784
643	12/31/1974	0.152	0.149	0.128	0.109	0.108	0.042	0.2	0.159	0.104	0.254	0.111	0.077	0.157
644	01/31/1975	0.534	0.42	0.34	0.482	0.421	0.315	0.482	0.493	0.394	0.478	0.456	0.317	0.408
645	02/28/1975	1.003	1.046	0.91	0.555	0.528	0.456	0.544	0.514	0.546	0.757	0.709	0.522	0.621
646	03/31/1975	2.363	2.633	2.31	0.943	0.98	0.76	1.391	2.091	1.212	1.843	1.712	1.239	1.581
647	04/30/1975	4.26	4.05	3.769	1.369	1.437	1.08	3.282	4.248	2.841	3.053	2.74	2.379	2.123
648	05/31/1975	5.385	4.635	4.861	1.572	1.814	1.546	5.327	5.568	4.914	3.919	3.539	3.819	1.946
649	06/30/1975	4.014	4.246	3.914	3.74	4.073	4.022	6.58	6.935	5.943	6.426	5.794	5.376	4.473
650	07/31/1975	3.391	3.761	4.355	7.129	7.032	7.58	6.61	6.586	6.001	8.333	7.1	6.862	7.594
651	08/31/1975	2.416	3.445	4.264	7.43	7.182	7.529	3.256	3.061	4.689	6.888	6.017	5.162	7.171
652	09/30/1975	3.5	3.903	3.738	4.49	4.474	3.873	4.485	4.786	4.614	4.954	3.537	4.153	5.763
653	10/31/1975	0.811	1.533	1.645	2.472	2.491	2.223	1.295	1.646	2.789	0.929	1.189	1.625	1.068
654	11/30/1975	0.364	0.739	0.973	0.682	0.789	0.802	0.503	1.389	1.409	0.688	0.427	1.038	0.341
655	12/31/1975	0.476	0.5	0.488	0.294	0.313	0.36	0.427	0.514	0.783	0.741	0.346	0.512	0.376
656	01/31/1976	0.571	0.515	0.593	0.267	0.276	0.296	0.507	0.582	0.617	0.343	0.408	0.41	0.318
657	02/29/1976	1.601	1.48	1.609	0.814	0.506	0.528	0.973	1.283	1.577	0.738	0.748	0.734	0.684
					1.997	1.36	1.143	3.258	3.214	3.887	1.853	1.635	1.887	1.951
					0.879	1.122	0.835	5.307	4.976	5.166	1.743	2.186	2.336	2.92
					1.281	1.822	1.577	7.32	7.187	7.233	3.596	3.253	4.337	3.224
					4.282	4.492	5.514	7.801	7.316	7.488	7.618	6.239	6.714	4.201







WOODARD & CURRAN

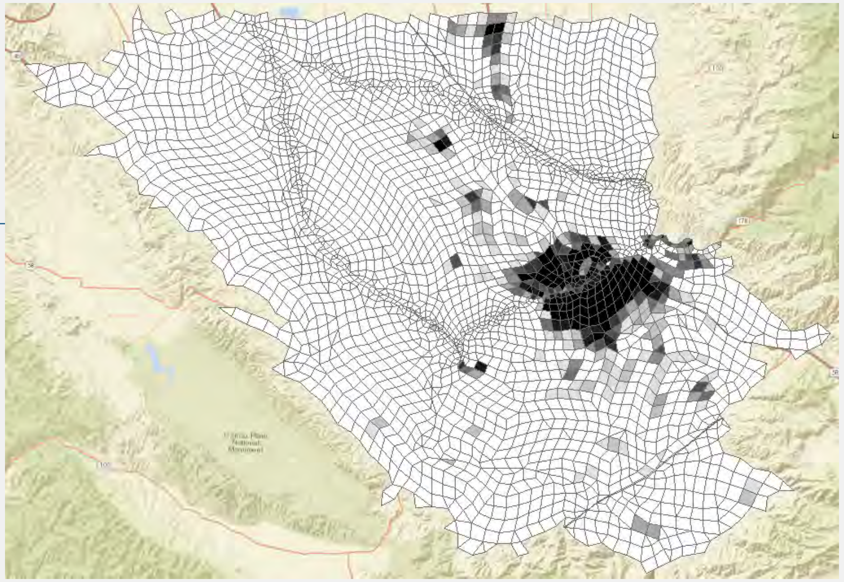
Boundary Inflows

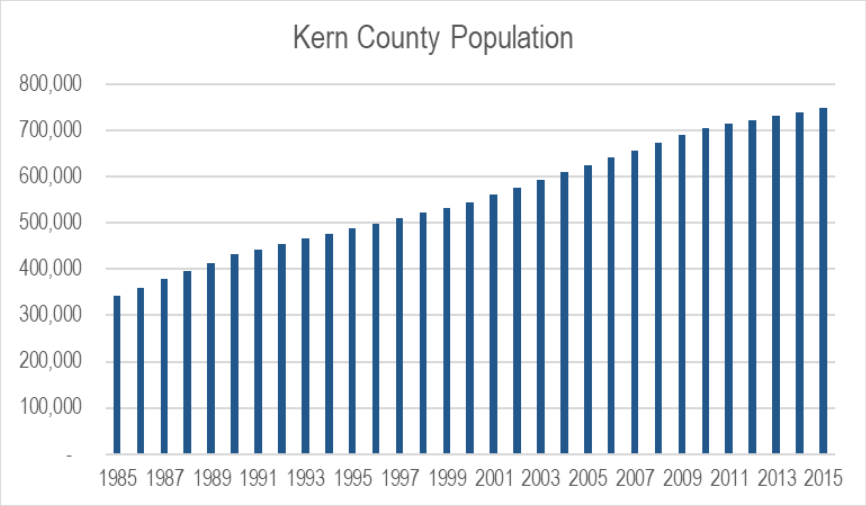
- Small Watersheds
  - *Checked small watershed parameters*
- Flow barrier at White Wolf
  - *Checked aquifer parameters in elements along fault*

```
C*******************************************************************************
C                      Anomaly in Hydraulic Conductivity
C
C   List the groundwater elements and corresponding hydraulic conductivities
C   that will overwrite the above aquifer data
C
C   NEBK;   Number of elements where hydraulic conductivity values will be overwritten
C            (NEBK = 0 if there are no anomalies)
C   FACT;   Conversion factor for the anomaly hydraulic conductivity
C            It is used to convert only the spatial component of the unit;
C            DO NOT include the conversion factor for time component of the unit.
C            * e.g. Unit of anomaly hydraulic conductivity listed in this file = FT/MONTH
C                   Consistent unit used in simulation                      = IN/DAY
C                   Enter FACT (FT/MONTH -> IN/MONTH)                       = 8.33333E-02
C                    (conversion of MONTH -> DAY is performed automatically)
C   TUNITH; Time unit of anomaly hydraulic conductivity.  This should be one of the units
C             recognized by HEC-DSS that are listed in the Main Control File.
C
C-------------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
     15                         / NEBK
     1.0                        / FACT
     1DAY                       / TUNITH
C-------------------------------------------------------------------------------
C
C   The following lists the element numbers and the hydraulic conductivity anomalies
C   at these elements (skip if there are no anomalies, i.e. NEBK = 0)
C
C   IC  ;    Sequential counter for number of overwrite options
C   IEBK;    Element number corresponding to counter IC
C   BK  ;    Hydraulic conductivity at the specified node; [L/T]
C
C-------------------------------------------------------------------------------
C                      LAYER 1 LAYER 2 LAYER 3 LAYER 4
C       IC      IEBK    BK[1]   BK[2]   BK[3]   BK[4]
C--------------------------------------------------------------------------------
        1       32299   0.30    0.03    0.03    0.03
        2       32300   0.30    0.03    0.03    0.03
        3       32301   0.30    0.03    0.03    0.03
        4       32306   0.30    0.03    0.03    0.03
        5       32307   0.30    0.03    0.03    0.03
```

Urban Demand

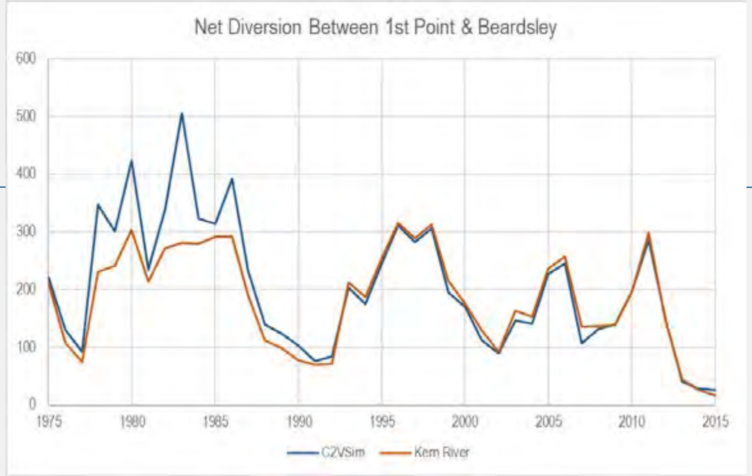
- Urban areas
  - *Checked urban acreage in elements in GIS*
- Urban water use fractions
  - *Verified updates to water use fractions by subregion*
- Urban populations
  - *Checked urban population data in model against spreadsheet data*
- Urban per capita demand
  - *Checked GPCD spreadsheet calculations and implementation into model*

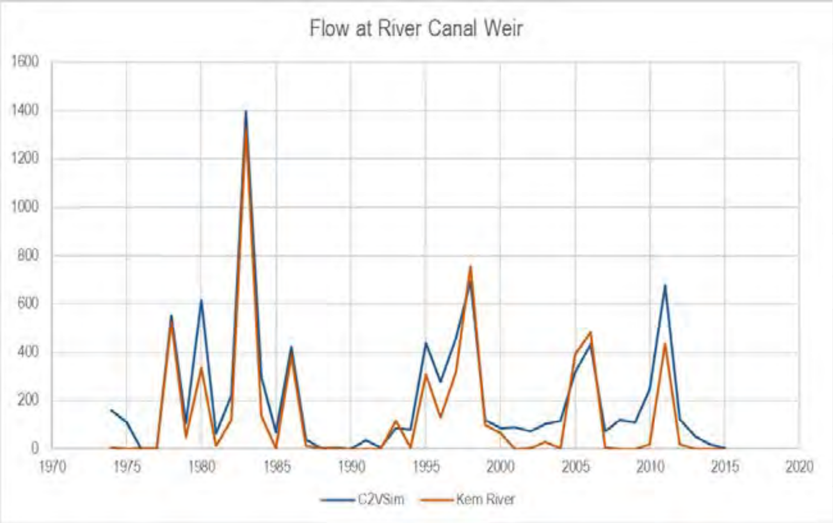




Kern River Deliveries

- *Complex setup & operation*
- *Model generated diversion shortages at stream nodes due to model structure, uncalibrated parameters, and other factors*
- *Worked with Todd GW to identify significance of model reported shortages and developed approach to ensure surface water delivery data provided by locals are properly incorporated*





Diversion ID	Diversion Name	Source Stream Node	Source Stream Name	Average Diversion (TAF/Mo)	Average Shortage (TAF/Mo)	Average Diversion TAF/Year	Average Shortage (TAF/Year)	
416	Kern Delta WD from Kern River at Calloway Weir to Stine SA for Ag	37	KERN RIVER	1.158	0.003	13.896	0.041	
417	Kern Delta WD from Kern River at Calloway Weir to Farmers SA for Ag	37	KERN RIVER	0.345	0.000	4.141	0.006	
452	North Kern WSD Kern River (Calloway) to Ag	37	KERN RIVER	1.999	0.013	23.982	0.158	
497	City of Bakersfield & ID4 from Kern River (Calloway) for Urban Use	37	KERN RIVER	0.736	0.012	8.836	0.144	6.0

Review of Model Results - Ongoing

- Evaluation of water budgets for input data verification
- Water Budget Templates from model results for ease of understanding

Land and Water Use Budget (1990-2015 Average)

Zone	Zone Name	Total Area	Ag Area	Ag Supply Requirement	Ag Water Duty	Ag Pumping	Ag SW Delivery	Total Ag Supply	Urban Area	Urban Supply Requirement	Urban Water Duty	Urban Pumping	Urban SW Delivery
	Units -->	Acres	Acres	Acre-feet	Acre-feet /Acre	Acre-feet	Acre-feet	Acre-feet	Acres	Acre-feet	Acre-feet /Acre	Acre-feet	Acre-feet

Groundwater Budget (1990-2015 Average)

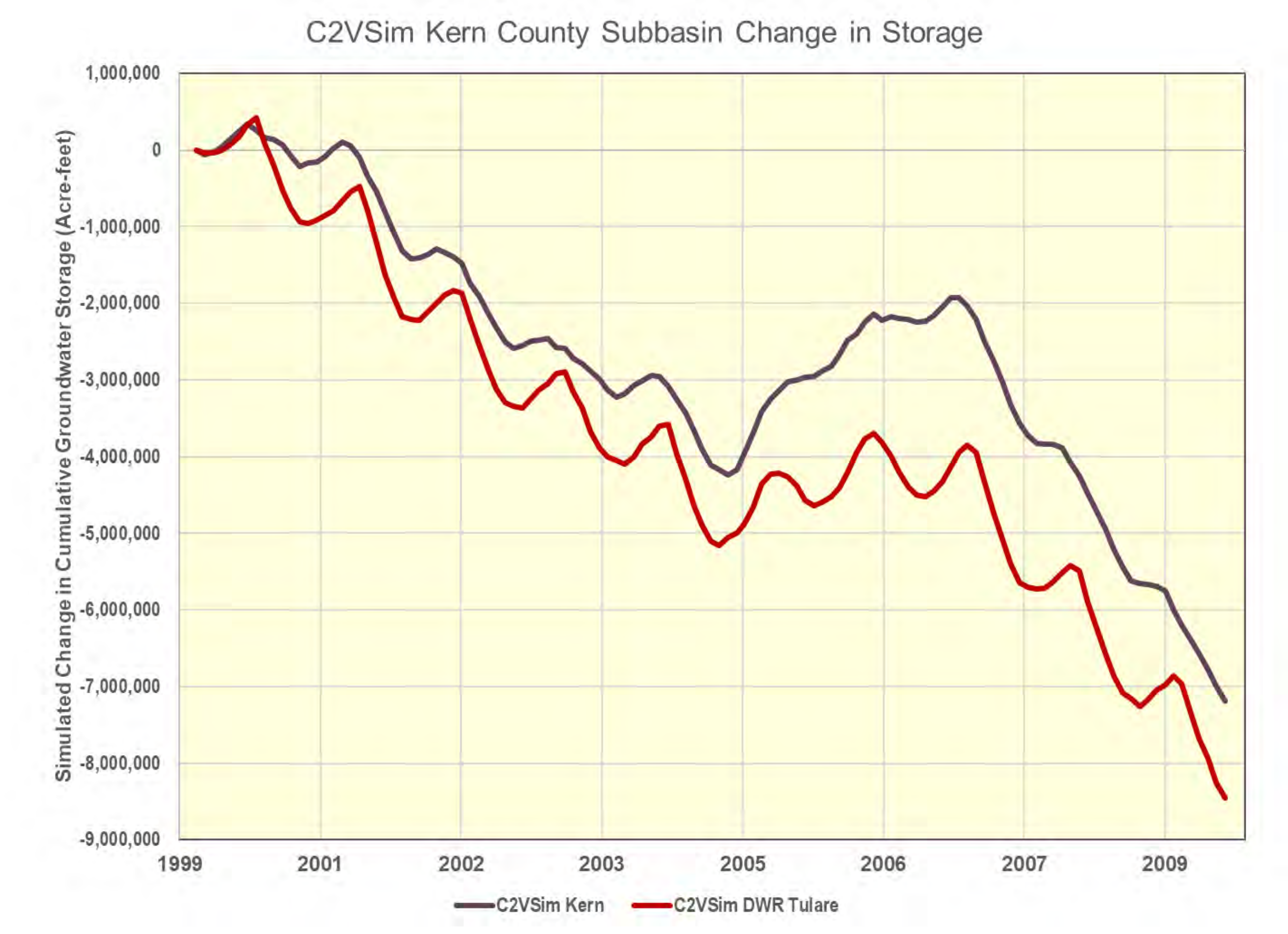
Zone	Zone Name	Total Area	Deep Percolation Inflow (+)	Boundary Condition Inflow (+)/ Outflow (-)	Subsurface Inflow (+)/ Outflow (-)	Gain (+) from Stream or Loss (-) to Stream	Small Watershed Inflow(+)/ Outflow (-)	Tile Drain Inflow(+)/ Outflow (-)	Bank Recharge PLUS Canal Seepage Inflow (+)	GW Pumping Outflow (-) Including Bank Pumping	Model Reported Change in Storage (+) or (-)	Calculated Change in Storage (+) or (-)
	Units -->	Acres	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet

Stream Reach Budget (1990-2015 Average)

Zone	Zone Name	**Upstream Inflow (+)**	**Downstream Outflow (-)**	**Tributary Inflow (+)**	**Tile Drain (+)**	**Runoff (+)**	**Return Flow (+)**	**Gain from Groundwater (+)**	**Gain from Lake (+)**	**Riparian ET (-)**	**Diversion (-)**	**By-pass Flow (-)**	**Discrepancy (=)**
	Units -->	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet	Acre-feet

Review of Model Results - Ongoing

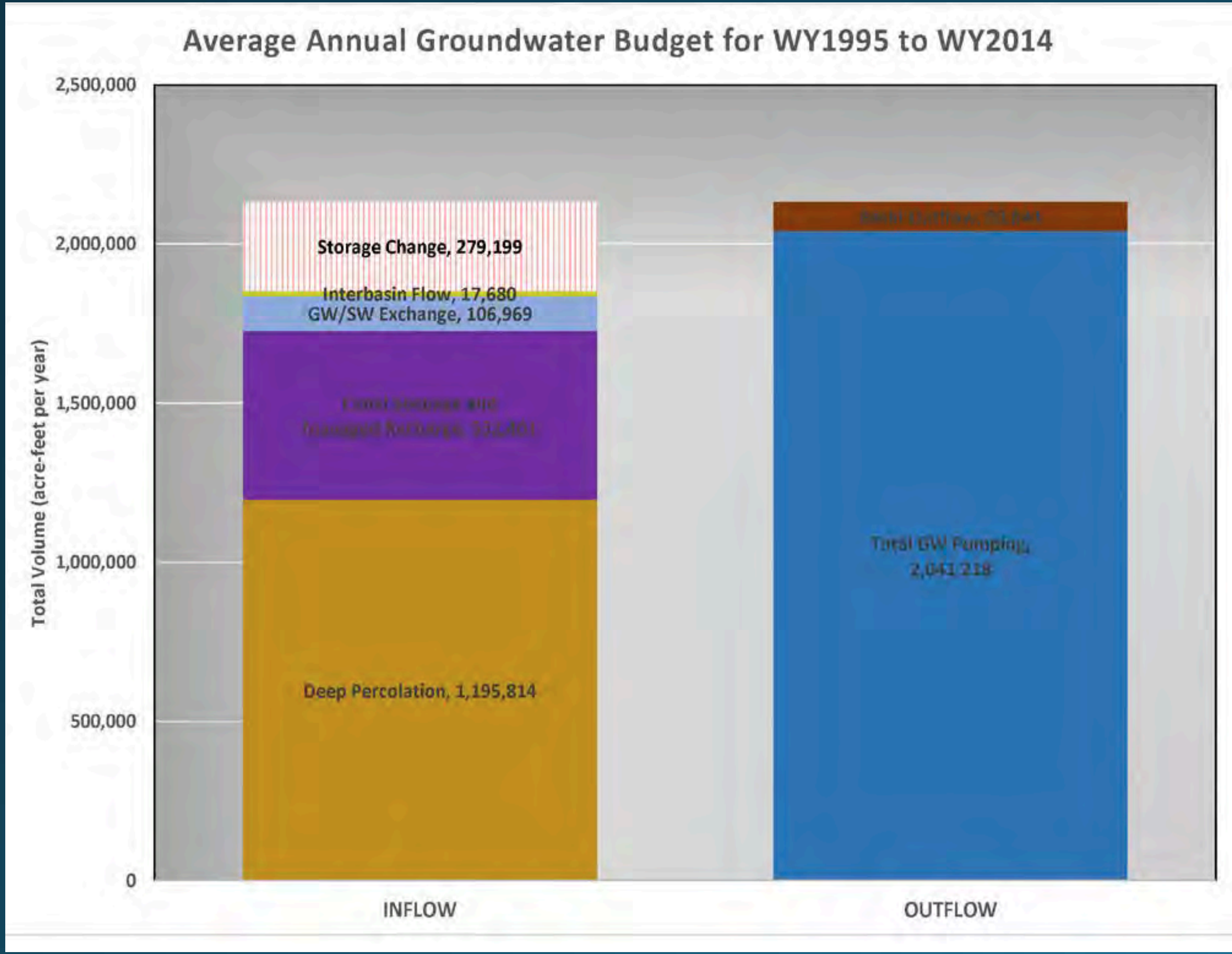
- Change in storage trends
- Comparison with Tulare Lake Pilot Study C2VSim



Next Steps

- Additional Model review following this meeting and local feedback
- Final set of feedback to Todd GW
- Peer Review Technical Memorandum

Basin-Wide Historical Groundwater Budgets

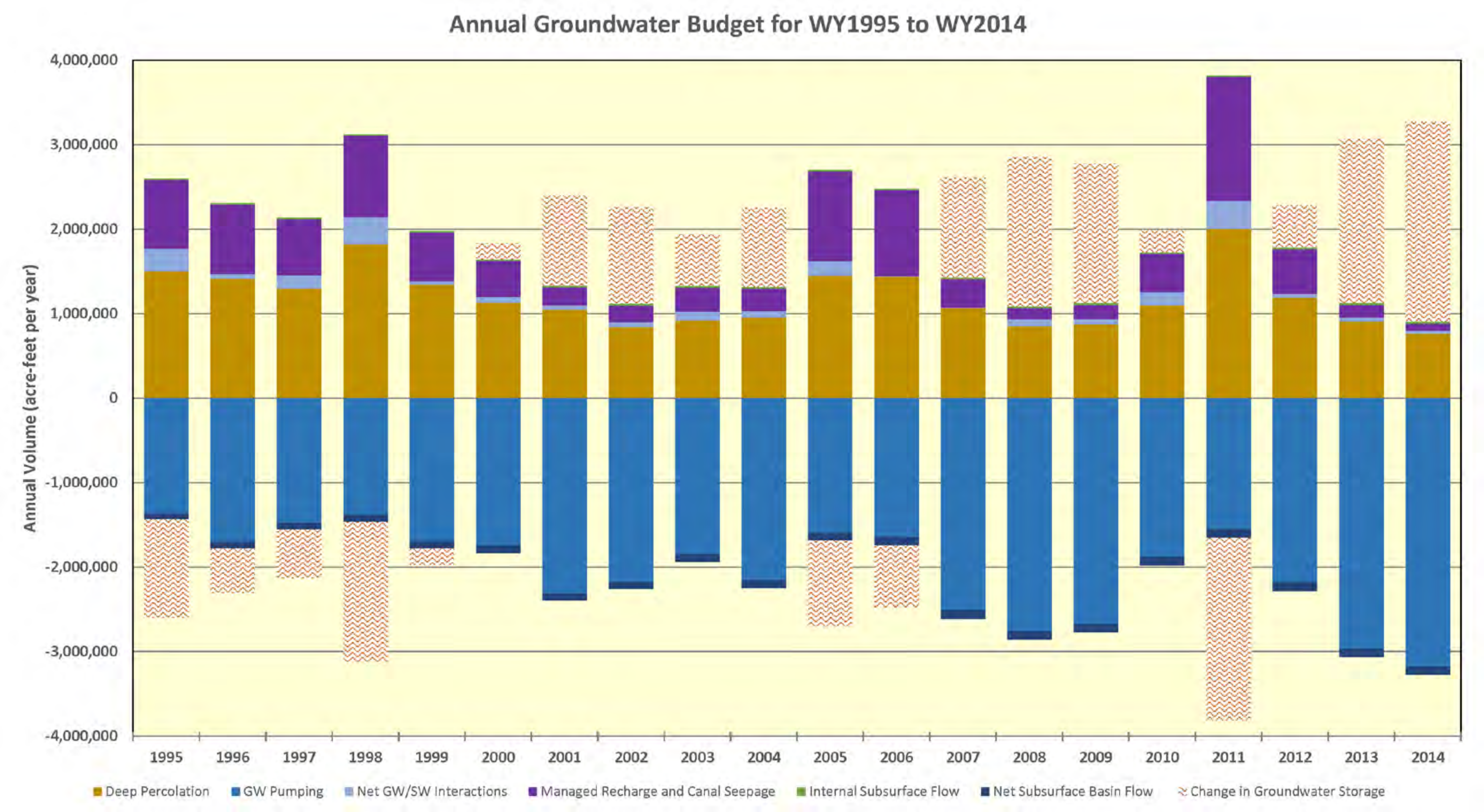


- Inflow
  - Deep Percolation
  - Managed Aquifer Recharge (MAR) and Conveyance Seepage
  - GW/SW Interactions
  - Intra-basin Flow
- Outflow
  - Groundwater Pumping
  - Basin Outflow
- Storage Change
  - Difference of Inflow and Outflow

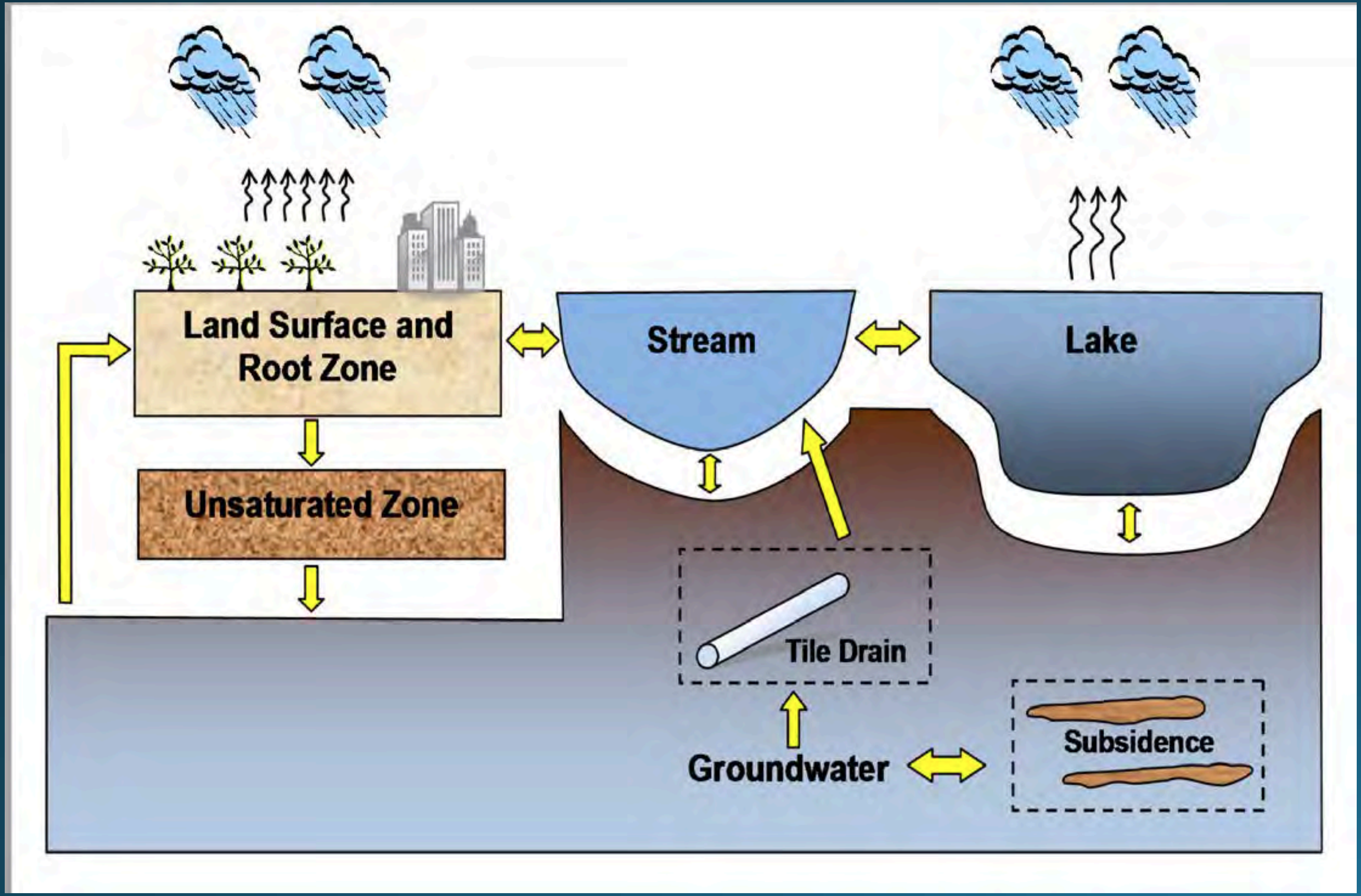
DRAFT

TODD GROUNDWATER

Annual Groundwater Budget



C2VSim Provides Integrated Process-Based Methodology to Develop Water Budgets

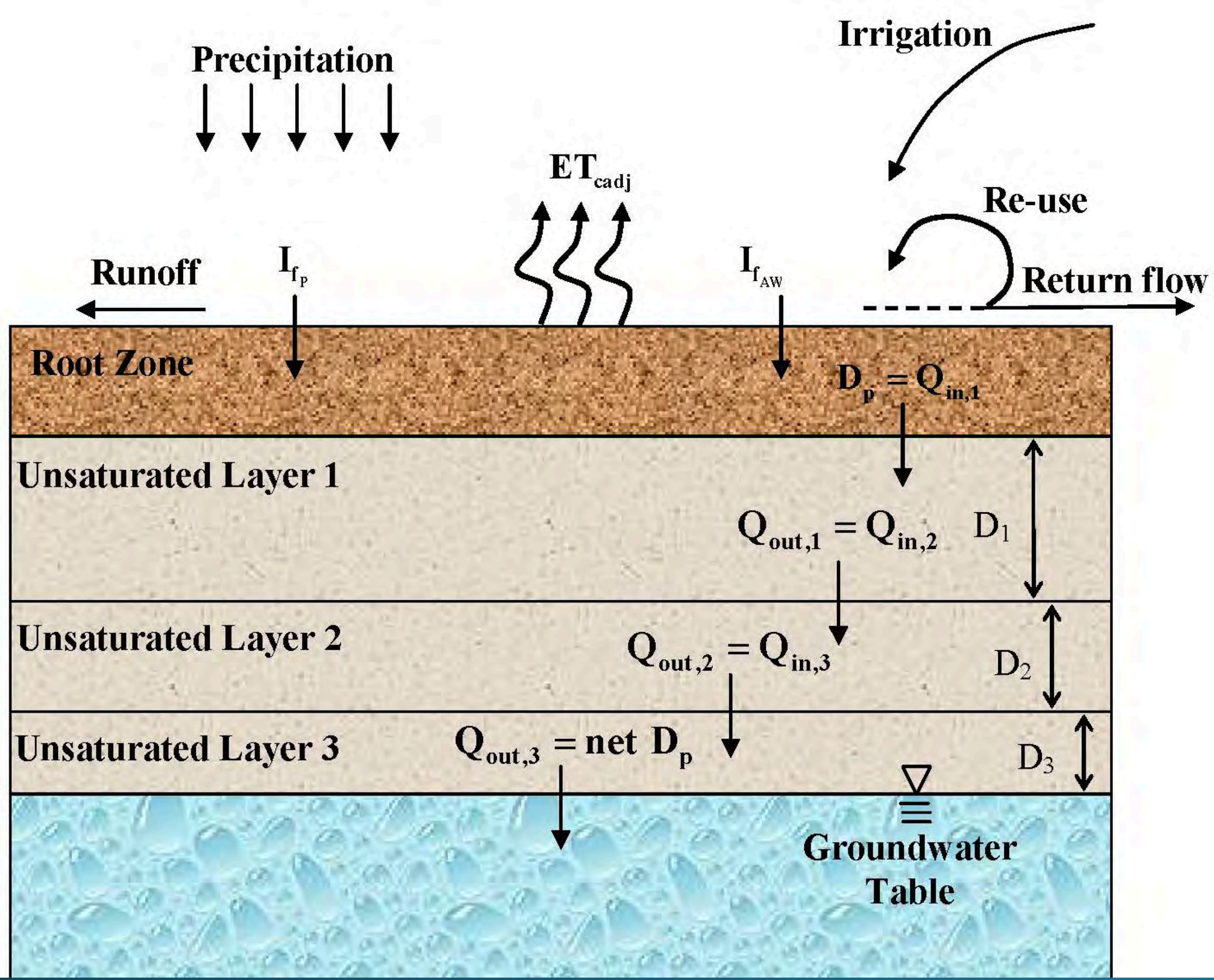


- IWFM Model simulates key hydrological processes
  - Land Surface, Root Zone, and Unsaturated Zone
  - Surface water deliveries from rivers and canals
  - Groundwater flow

DRAFT

TODD GROUNDWATER

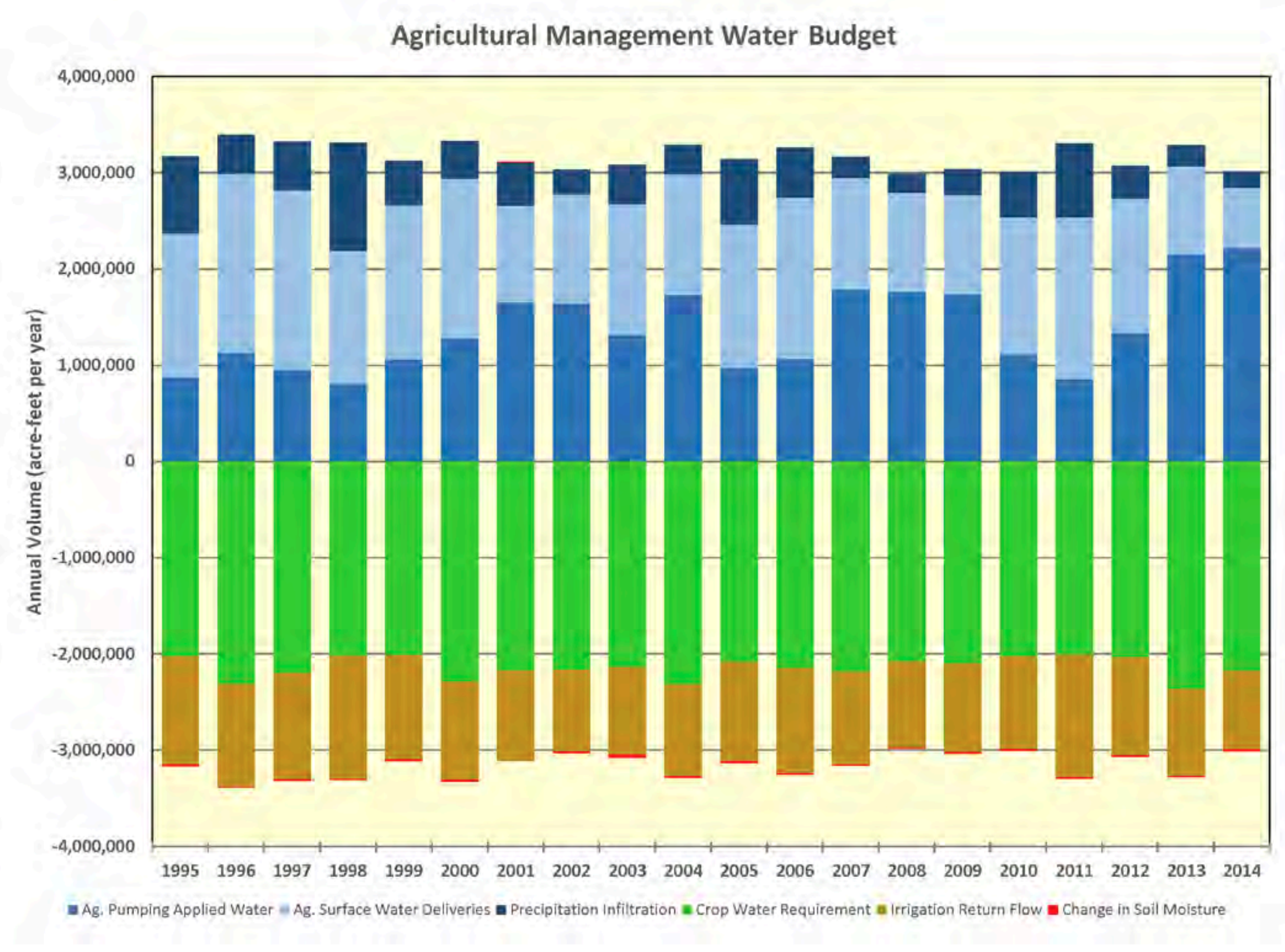
IWFM Demand Calculator (IDC)



- Calculates agricultural demand based on soil moisture budget
  - Monthly crop ET time series
  - Tracks soil moisture content throughout simulation
  - If soil moisture falls below minimum level (wilting point), irrigation water added to reach target level (field capacity) to cover ET, deep percolation and runoff

TODD GROUNDWATER

C2VSim Provides Framework to Determine Water Supply and Demand Requirements

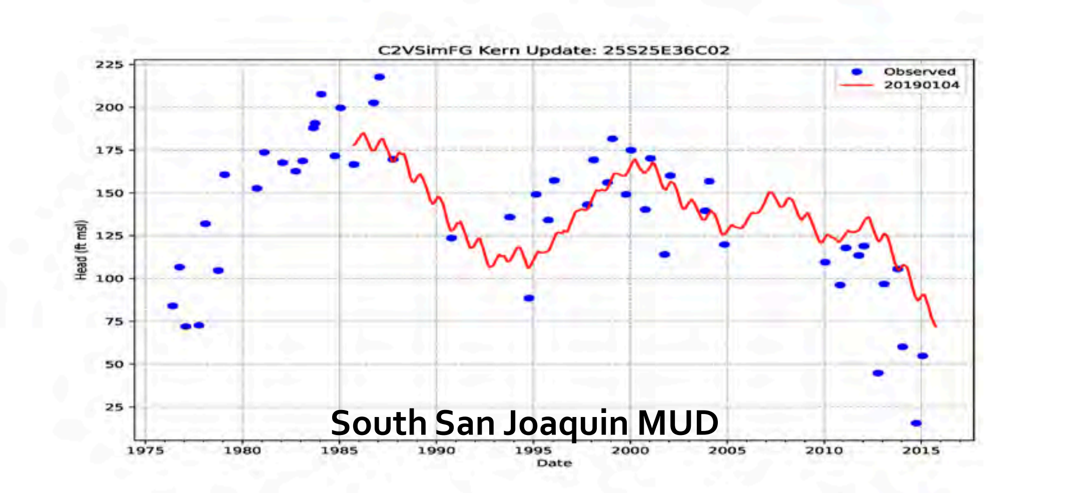


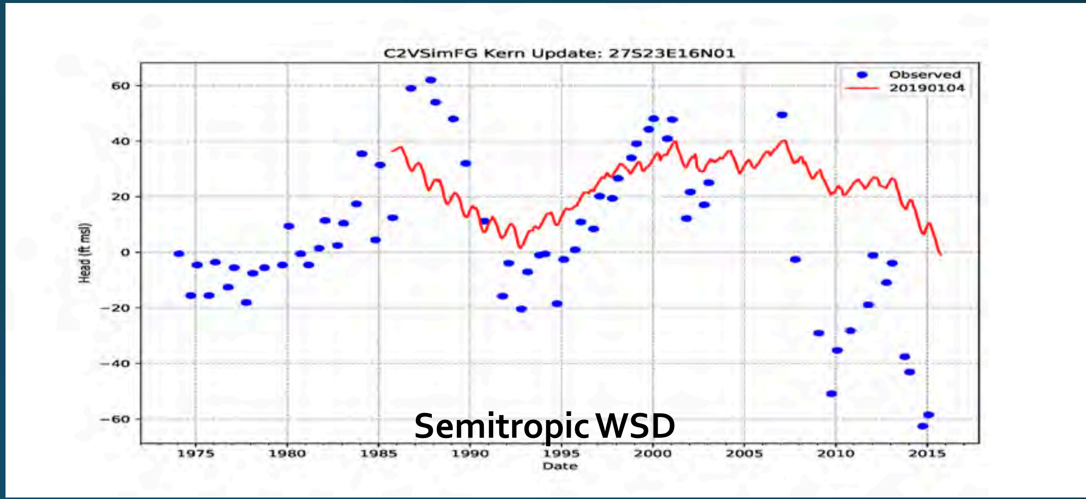
- Surface Water Deliveries are based on local data
- Ag Demand and Pumping based on METRIC data and soil moisture budget
- Effective Precipitation and Return Flow based on soil moisture

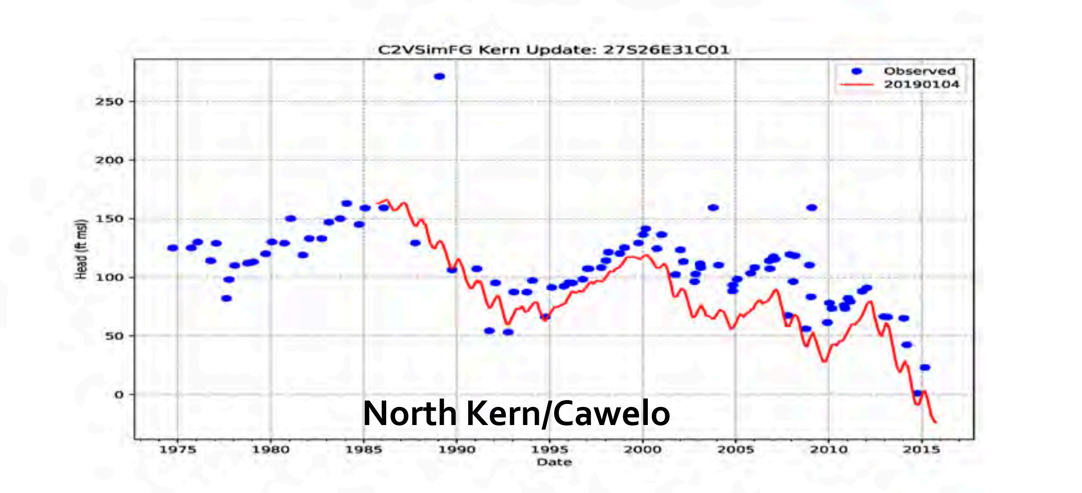
DRAFT

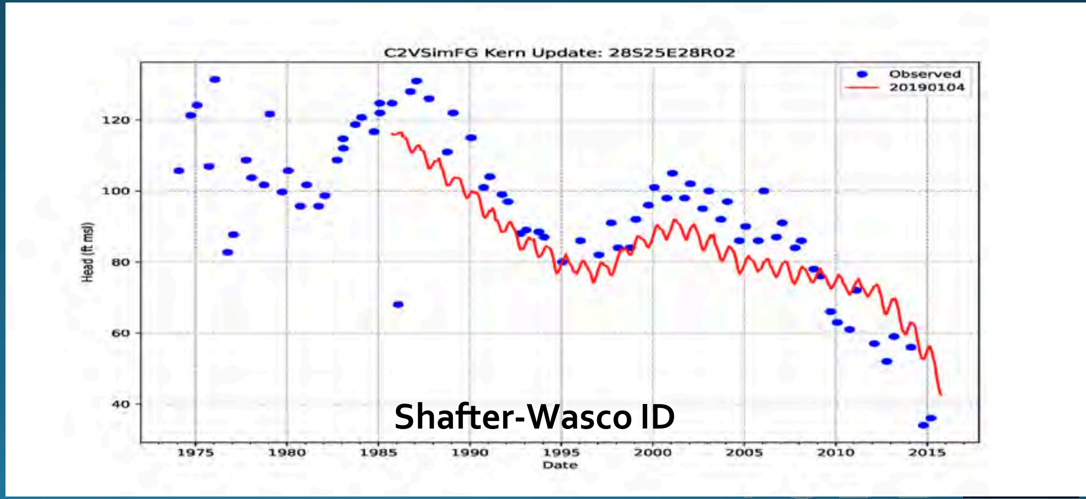
TODD GROUNDWATER

Examples of Model Performance North of the River



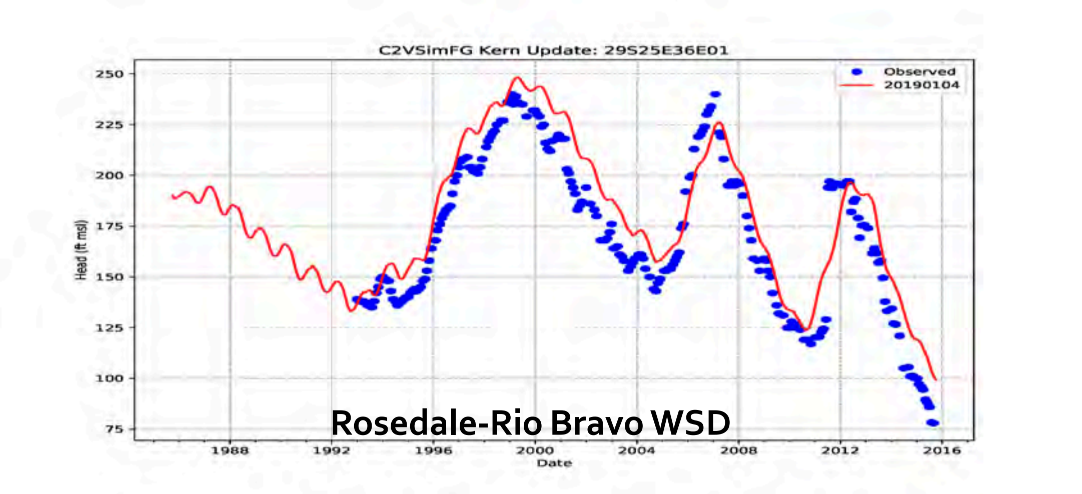


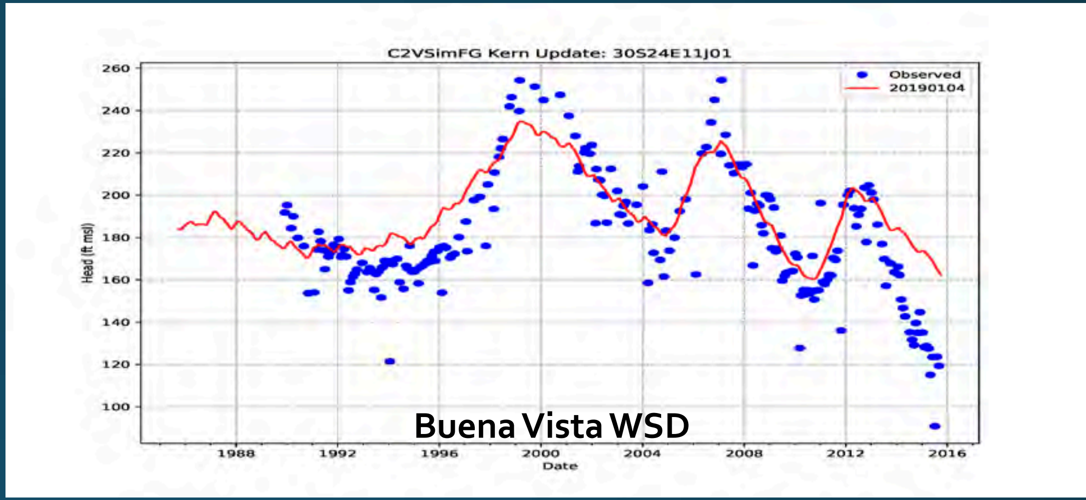


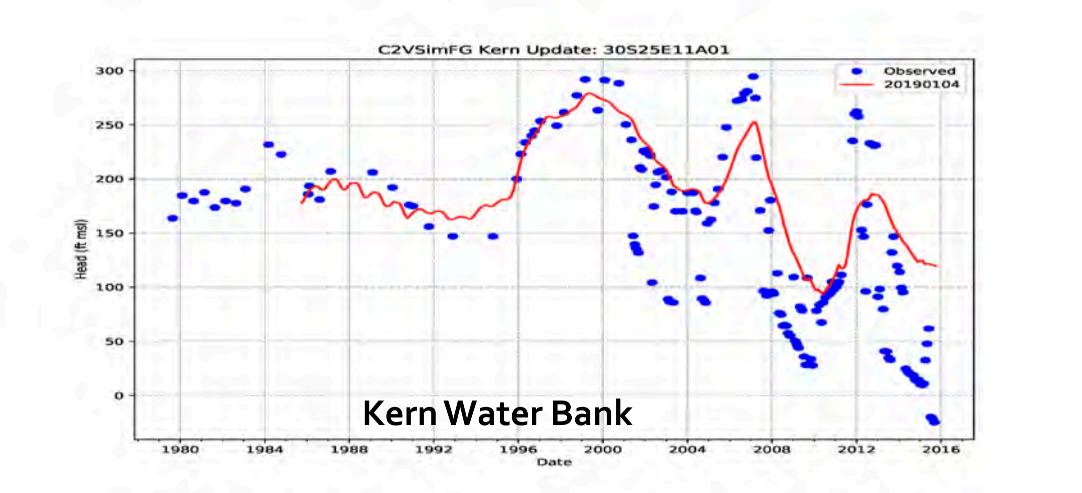


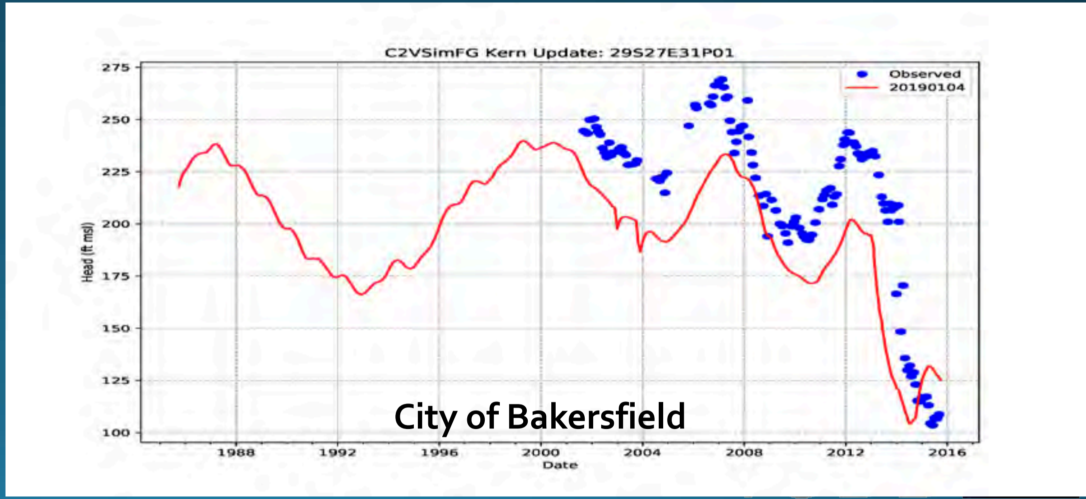
GROUNDWATER

Examples of Model Performance Along the River



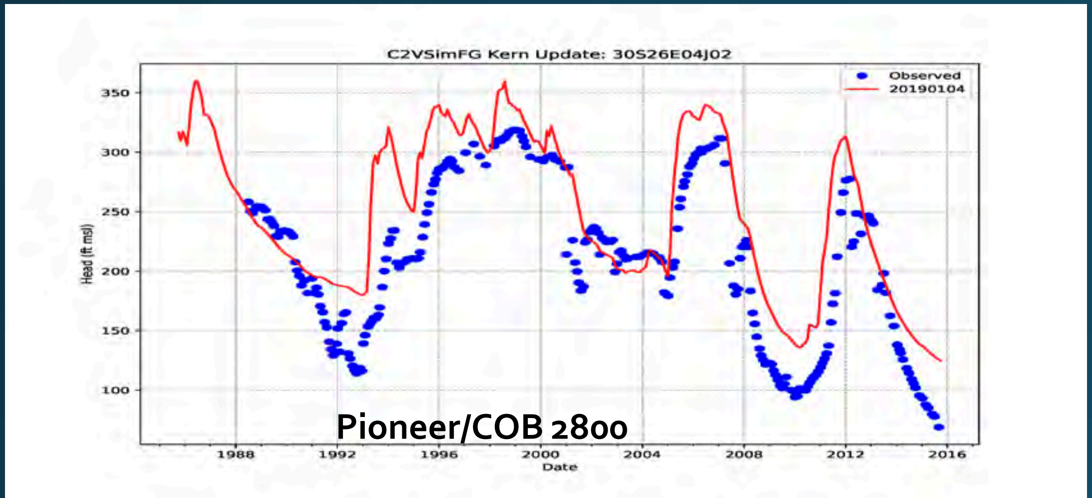


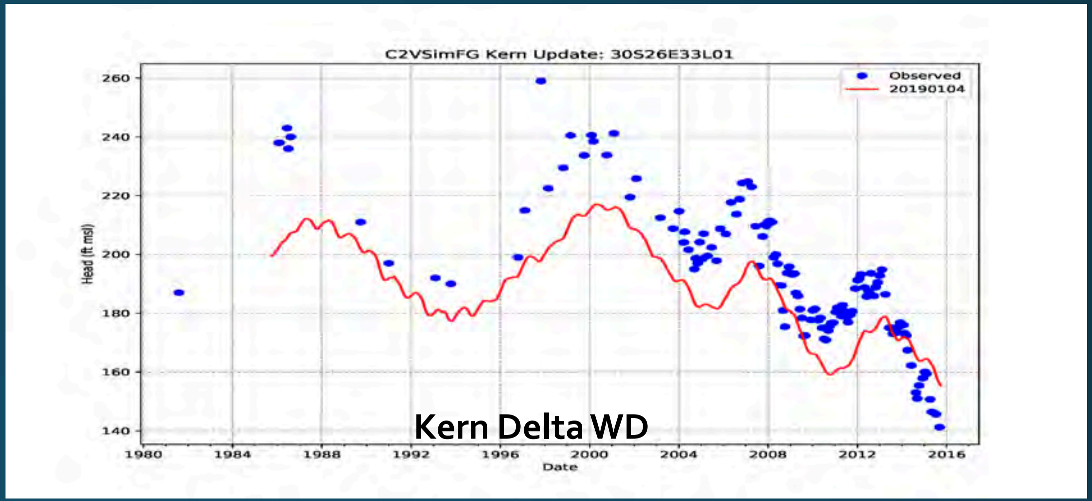


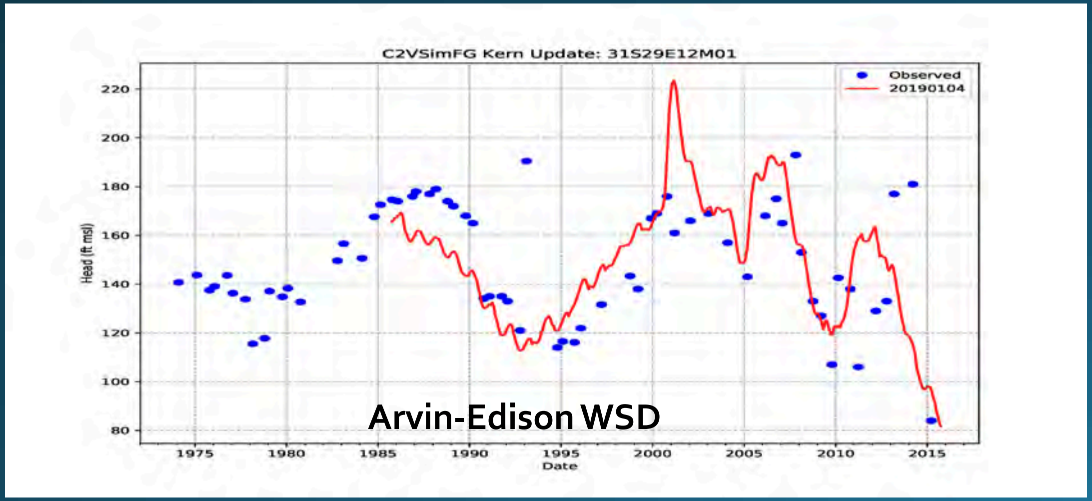


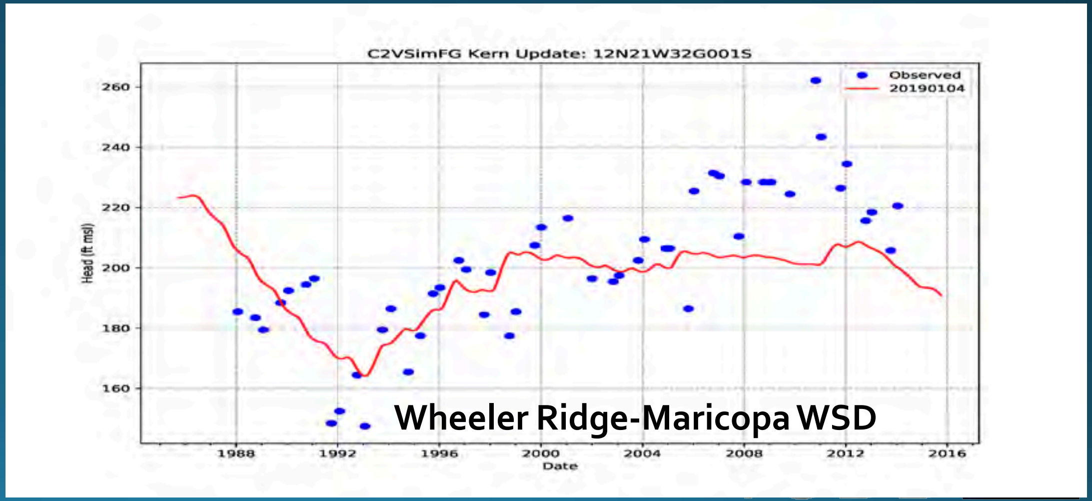
GROUNDWATER

Examples of Model Performance
North Kern WSD and Shafter-Wasco ID









C2VSim-Beta updated for Kern County Provides Appropriate SGMA Water Budget

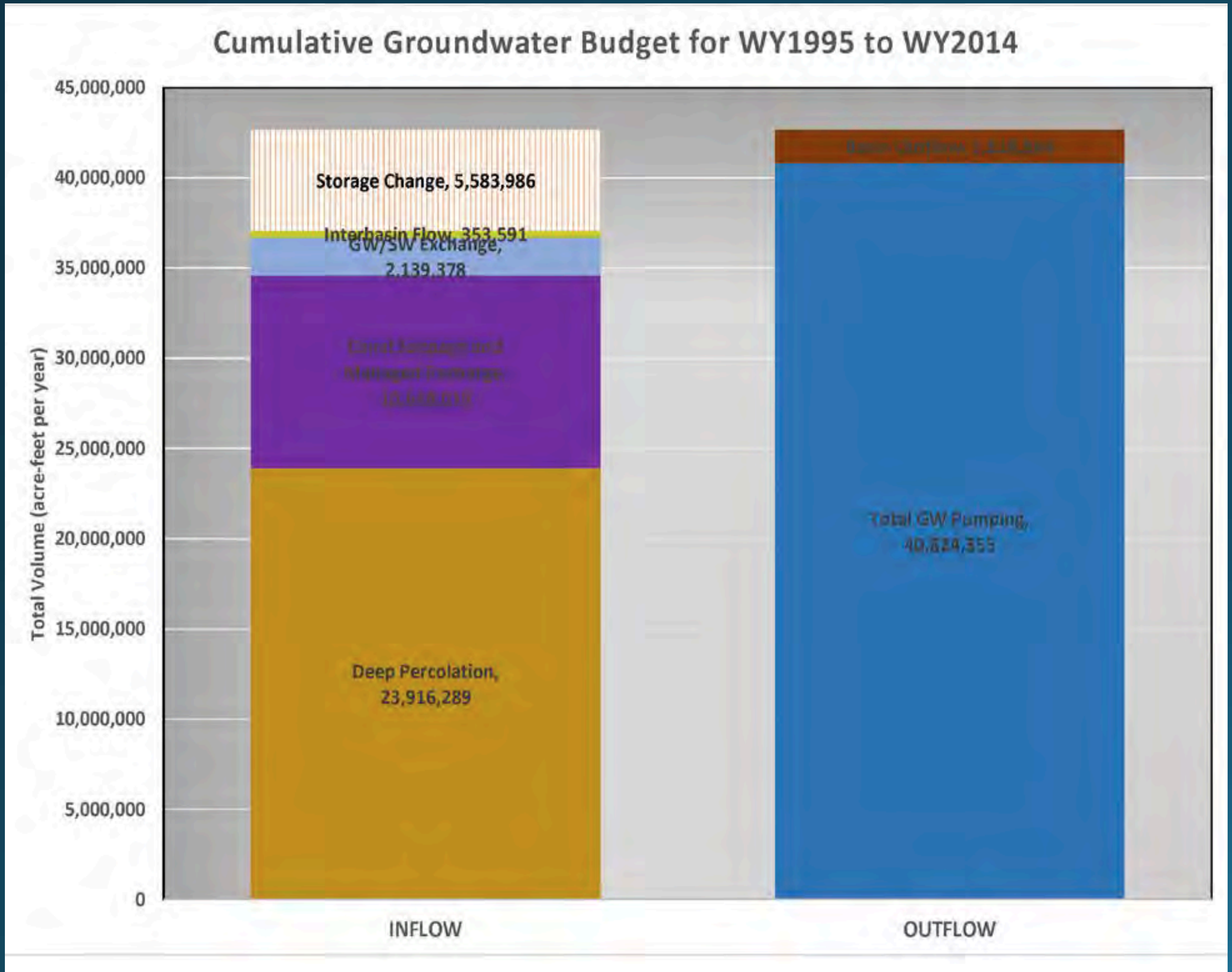
Groundwater Flow Equation

$$\underbrace{\frac{\partial}{\partial x}\left(T_x \frac{\partial h}{\partial x}\right)+\frac{\partial}{\partial y}\left(T_y \frac{\partial h}{\partial y}\right)}_{\text{Groundwater Flow Darcy Law}}\underbrace{+W}_{\text{Inflows \& Outflows - Checkbook}}=\underbrace{S\frac{\partial h}{\partial t}}_{\text{Change in Storage}}$$

- Kern County Subbasin is Highly Managed System
  - Inflows and Outflows (W) dominate the groundwater budget
  - Flow component is small in comparison
- Significant portion of water budget is derived from measured, locally-derived data

TODD GROUNDWATER

Basin-wide Historical Water Budgets

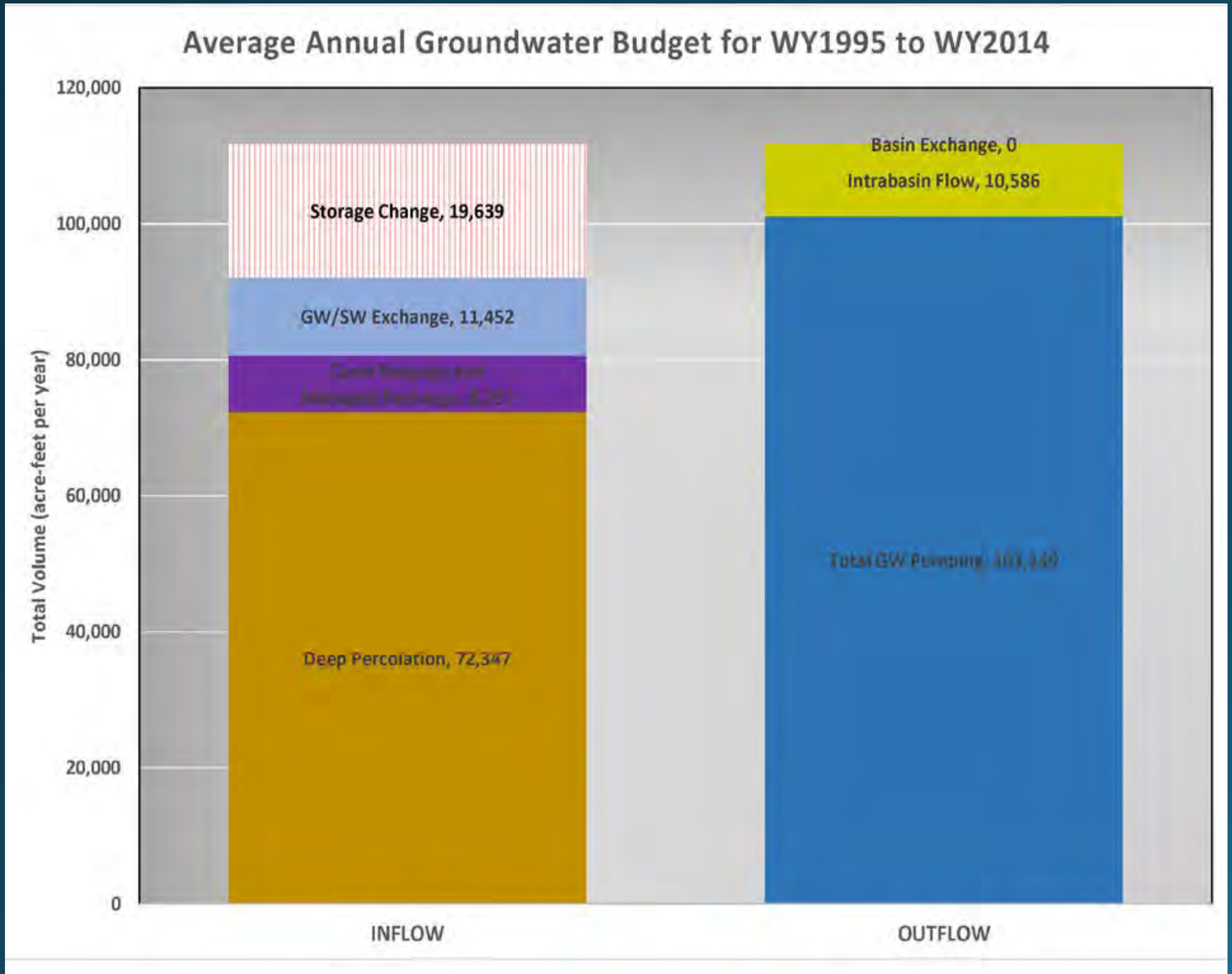


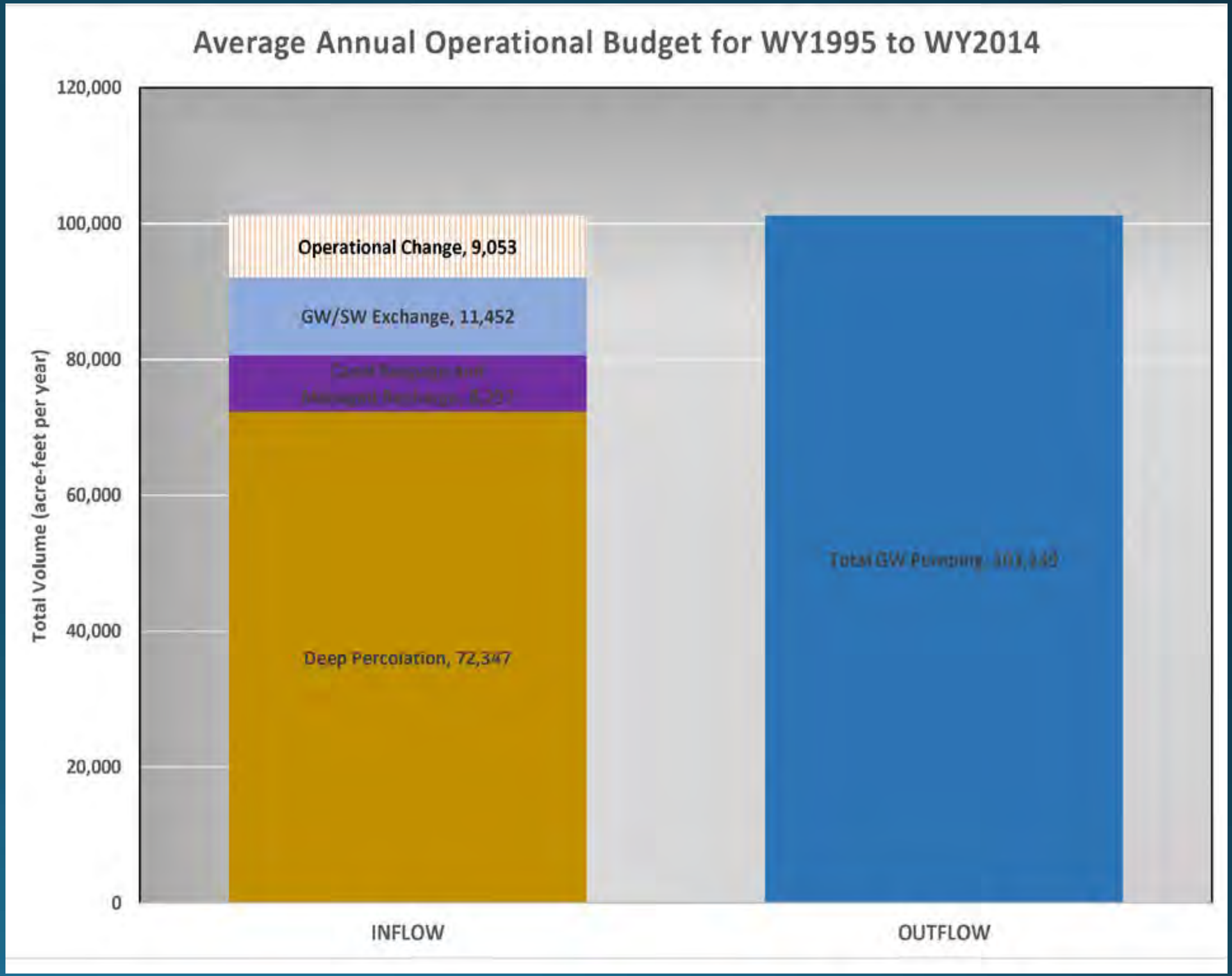
DRAFT

- Managed Water Components are generally well defined
  - largest part of water budget
- Groundwater Flow Components have higher uncertainty
  - smaller portion of the water budget
- Model does not account for Groundwater Banking Accounts
  - Water stored in basin for use by others

TODD GROUNDWATER

Operational Water Budget does not include Subsurface Flow





DRAFT

Defensibility of Water Budgets

- C2VSim utilizes Same Data and Methods across the Subbasin
  - Uses measured, locally-derived data
  - Applies consistent methodology across the subbasin
- Managed Water Supply and Demand Dominate the Subbasin Water Budget
- Model simulation provides reasonable representation of groundwater conditions
- DWR Provided C2VSim Beta-Version Specifically for Development of SGMA Water Budgets

TODD GROUNDWATER

Next Steps for Model

- Historical Water Budgets
  - Coordination with Districts to Address questions and comments
  - Finalize Peer Review
  - Update model results
- Projected Future Water Budgets
  - Finalize hydraulic period
  - Setup Baseline Scenario
  - Update data request
  - Setup Climate Change Scenario

DRAFT

TODD GROUNDWATER

Discussion and Questions

Kern River Groundwater Sustainability Agency

KERN GROUNDWATER AUTHORITY

DRAFT

Kern County Subbasin REVISED C2VSim Historical Water Budgets

March 22, 2019

TODD GROUNDWATER

Revised Historical Groundwater Budget

Kern County Subbasin C2VSim Update - Groundwater Budget
Historical Hydrologic Period from WY1995 to WY2014
March 15, 2019 C2VSim Version
REVISED RESULTS For District Review

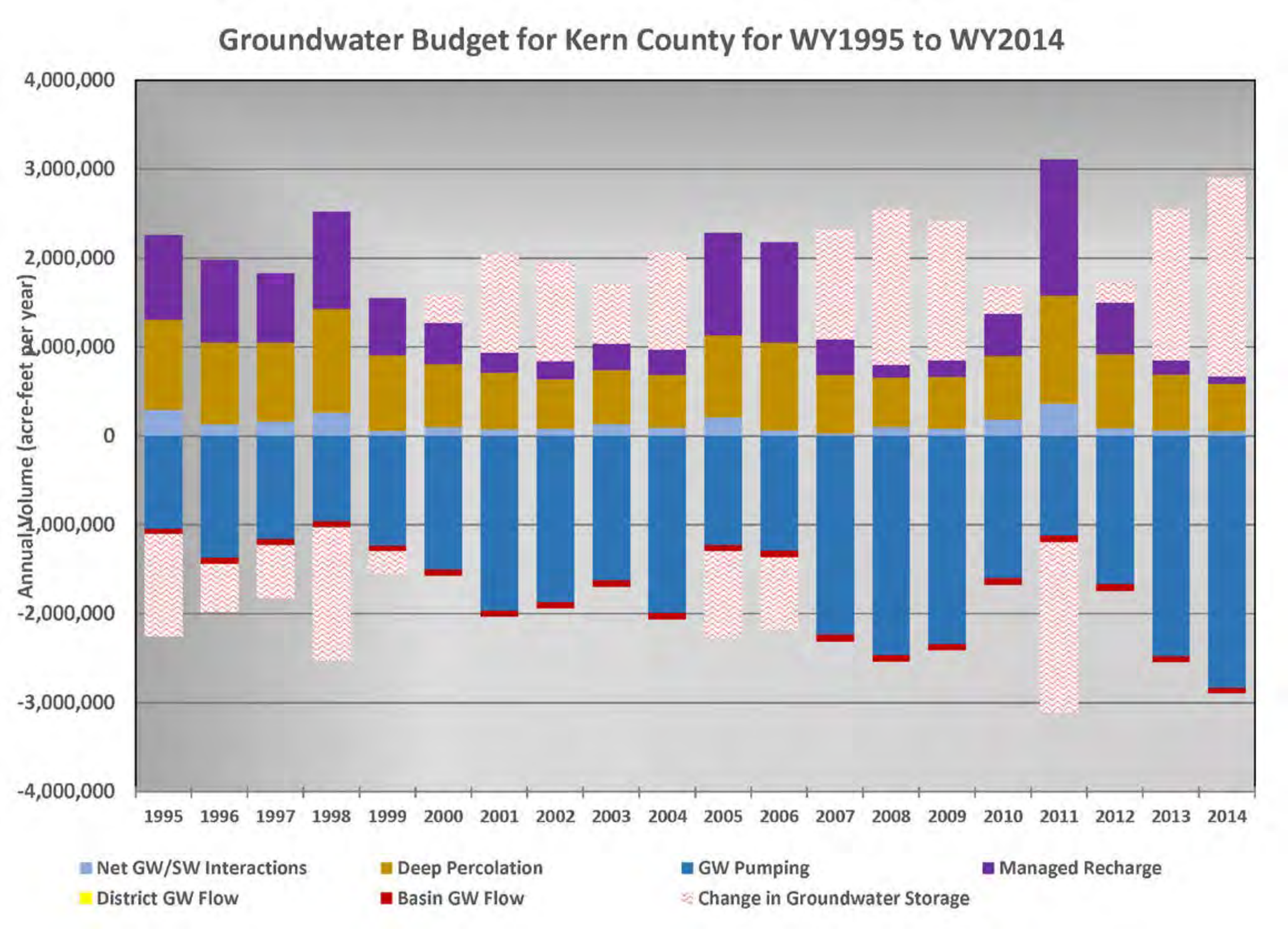
TABLE 1: Groundwater Budget for Kern County for WY1995 to WY2014

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Subsurface Flow within GW Basin	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	1,016,255	944,786	291,898	-1,050,380	0	-57,192	1,145,367
1996	919,089	926,517	130,236	-1,375,387	0	-66,362	534,092
1997	888,099	771,492	162,118	-1,162,635	0	-69,167	589,907
1998	1,163,881	1,097,173	261,886	-959,859	0	-69,065	1,494,017
1999	847,653	643,210	55,360	-1,234,768	0	-66,803	244,655
2000	707,355	466,772	99,916	-1,506,021	0	-65,161	-297,140
2001	638,113	223,096	74,202	-1,970,675	0	-63,346	-1,098,610
2002	556,073	209,605	76,750	-1,874,097	0	-65,355	-1,097,024
2003	604,092	297,667	135,215	-1,628,453	0	-66,985	-658,463
2004	589,227	285,056	94,817	-1,993,485	0	-70,698	-1,095,083
2005	923,495	1,147,344	208,115	-1,231,940	0	-71,271	975,740
2006	984,355	1,125,521	64,651	-1,290,643	0	-77,926	805,958
2007	657,218	403,463	25,786	-2,241,430	0	-72,906	-1,227,873
2008	557,643	146,937	97,235	-2,470,751	0	-67,540	-1,736,477
2009	585,651	185,948	77,822	-2,342,792	0	-66,981	-1,560,358
2010	719,510	467,676	182,389	-1,600,706	0	-75,737	-306,870
2011	1,217,635	1,530,095	361,915	-1,125,876	0	-75,776	1,907,994
2012	828,196	580,250	89,545	-1,666,675	0	-73,943	-242,635
2013	629,761	157,351	60,811	-2,478,882	0	-64,627	-1,695,600
2014	531,345	84,816	51,048	-2,834,025	0	-62,170	-2,228,995
Total	**15,564,646**	**11,694,773**	**2,601,715**	**-34,039,480**	**0**	**-1,369,009**	**-5,547,400**
Average	**778,232**	**584,739**	**130,086**	**-1,701,974**	**0**	**-68,450**	**-277,370**

DRAFT

TODD GROUNDWATER

What was done for the revision?



- Improved Spreadsheet Documentation
  - Added column descriptions
  - Expanded and Improved Tables and Charts
- Addressed Comments and Model Issues
  - Addressed Regional Issues
  - Reconciled district issues and comments

DRAFT

TODD GROUNDWATER

Kern County Subbasin C2VSim Update - Groundwater Budget
Historical Hydrologic Period from WY1995 to WY2014
March 15, 2019 C2VSim Version
REVISED RESULTS For District Review

TABLE 1: Groundwater Budget for Kern County for WY1995 to WY2014

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Subsurface Flow within GW Basin	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	1,016,255	944,786	291,898	-1,050,380	0	-57,192	1,145,367
1996	919,089	926,517	130,236	-1,375,387	0	-66,362	534,092
1997	888,099	771,492	162,118	-1,162,635	0	-69,167	589,907
1998	1,163,881	1,097,173	261,886	-959,859	0	-69,065	1,494,017
1999	847,653	643,210	55,360	-1,234,768	0	-66,803	244,655
2000	707,355	466,772	99,916	-1,506,021	0	-65,161	-297,140
2001	638,113	223,096	74,202	-1,970,675	0	-63,346	-1,098,610
2002	556,073	209,605	76,750	-1,874,097	0	-65,355	-1,097,024
2003	604,092	297,667	135,215	-1,628,453	0	-66,985	-658,463
2004	589,227	285,056	94,817	-1,993,485	0	-70,698	-1,095,083
2005	923,495	1,147,344	208,115	-1,231,940	0	-71,271	975,740
2006	984,355	1,125,521	64,651	-1,290,643	0	-77,926	805,958
2007	657,218	403,463	25,786	-2,241,430	0	-72,906	-1,227,873
2008	557,643	146,937	97,235	-2,470,751	0	-67,540	-1,736,477
2009	585,651	185,948	77,822	-2,342,792	0	-66,981	-1,560,358
2010	719,510	467,676	182,389	-1,600,706	0	-75,737	-306,870
2011	1,217,635	1,530,095	361,915	-1,125,876	0	-75,776	1,907,994
2012	828,196	580,250	89,545	-1,666,675	0	-73,943	-242,635
2013	629,761	157,351	60,811	-2,478,882	0	-64,627	-1,695,600
2014	531,345	84,816	51,048	-2,834,025	0	-62,170	-2,228,995
Total	**15,564,646**	**11,694,773**	**2,601,715**	**-34,039,480**	**0**	**-1,369,009**	**-5,547,400**
Average	**778,232**	**584,739**	**130,086**	**-1,701,974**	**0**	**-68,450**	**-277,370**

NOTES:

Deep Percolation	Precipitation and applied water that reaches the groundwater after simulated transport across the unsaturated zone
Managed Recharge and Canal Seepage	Combined groundwater recharge from managed aquifer recharge operations, groundwater banking, and seepage from canals and other conveyance
Net GW/SW Interactions	Net volumetric exchange of surface water and groundwater from streams: Positive represents a net groundwater recharge, and negative represents a net groundwater discharge to the stream
GW Pumping	Total groundwater pumping by wells. Groundwater banking recovery pumping is specified input whereas agricultural and municipal pumping is calculated by C2VSim based on demand
Subsurface Flow within GW Basin	Net subsurface groundwater flow into a neighboring water district or area within the Kern County Subbasin: negative is a net flow out of the district and positive is a net flow into the district
Subsurface Flow with Adjacent GW Basins	Net subsurface groundwater flow from the Kern County Subbasin with an adjoining groundwater basin: negative is a net flow out of the Basin and positive is a net flow into the Basin
Change in Groundwater Storage	Sum of the inflow components (positive numbers) plus the outflow components (negative numbers): positive is an increase in storage typified by a rise in GW levels whereas a negative is a decrease in storage typified by a decline in GW levels

Added descriptions of each table column

TODD GROUNDWATER

Modified Existing Tables to be more Useful

Kern County Subbasin C2VSim Update - Agricultural Management Water Budget
Historical Hydrologic Period from WY1995 to WY2014
March 15, 2019 C2VSim Version
REVISED RESULTS For District Review

TABLE 3: Agricultural Management Water Budget for Kern County for WY1995 to WY2014

		Water Supply					Water Demand			
Water Year	Irrigated Ag. Area	Effective Precipitation	Ag. Pumping Applied Water	Ag. Surface Water Deliveries	Effective Precipitation per Acre	Total Applied Water Per Acre	Crop Water Requirement	Percolation to Groundwater	Crop Water Demand Per Acre	Percolation to Groundwater per Acre
Units	Acres	Acre-ft	Acre-ft	Acre-ft	ft/acre	ft/acre	Acre-ft	Acre-ft	ft/acre	ft/acre
1995	780,803	511,997	875,865	1,339,629	0.66	2.84	2,031,481	720,791	2.60	0.92
1996	798,735	339,242	1,189,242	1,646,089	0.42	3.55	2,334,047	679,718	2.92	0.85
1997	801,583	345,633	984,027	1,650,210	0.43	3.29	2,204,613	710,430	2.75	0.89
1998	799,230	652,085	790,716	1,200,974	0.82	2.49	2,018,992	774,769	2.53	0.97
1999	803,474	385,355	1,036,793	1,425,118	0.48	3.06	2,031,604	665,434	2.53	0.83
2000	835,206	345,364	1,302,650	1,461,846	0.41	3.31	2,306,622	621,846	2.76	0.74
2001	799,553	344,404	1,584,161	961,988	0.43	3.18	2,184,209	630,138	2.73	0.79
2002	738,420	220,039	1,584,845	1,056,901	0.30	3.58	2,168,362	555,304	2.94	0.75
2003	757,372	321,790	1,315,884	1,200,620	0.42	3.32	2,143,420	580,622	2.83	0.77
2004	769,162	266,231	1,707,768	1,147,322	0.35	3.71	2,337,414	594,258	3.04	0.77
2005	766,330	473,158	963,245	1,335,575	0.62	3.00	2,099,570	666,353	2.74	0.87
2006	816,721	433,899	1,065,518	1,468,445	0.53	3.10	2,154,851	661,919	2.64	0.81
2007	792,925	219,383	1,714,978	1,116,832	0.28	3.57	2,220,358	624,419	2.80	0.79
2008	762,593	165,218	1,704,923	991,935	0.22	3.54	2,100,362	612,113	2.75	0.80
2009	763,660	214,825	1,666,516	991,067	0.28	3.48	2,119,806	617,048	2.78	0.81
2010	755,415	337,579	1,114,858	1,265,554	0.45	3.15	2,030,995	632,526	2.69	0.84
2011	782,699	431,876	871,649	1,490,115	0.55	3.02	2,029,020	784,354	2.59	1.00
2012	790,395	289,340	1,326,877	1,278,762	0.37	3.30	2,054,992	672,386	2.60	0.85
2013	759,168	195,450	2,061,513	921,249	0.26	3.93	2,387,861	607,323	3.15	0.80
2014	723,000	148,116	2,132,157	663,077	0.20	3.87	2,195,110	582,580	3.04	0.81
Total	**15,596,443**	**6,640,985**	**26,994,184**	**24,613,306**			**43,153,687**	**12,994,330**		
Average	**779,822**	**332,049**	**1,349,709**	**1,230,665**	**0.42**	**3.31**	**2,157,684**	**649,716**	**2.77**	**0.83**
Percent		11%	46%	42%			77%	23%		

Added New Tables and Graphs to Provide Additional Water Budget Information

Kern County Subbasin C2VSim Update - Land and Water Use Summary
Historical Hydrologic Period from WY1995 to WY2014
March 15, 2019 C2VSim Version
REVISED RESULTS For District Review

TABLE 4: Land Use and Groundwater Recharge for Kern County for WY1995 to WY2014

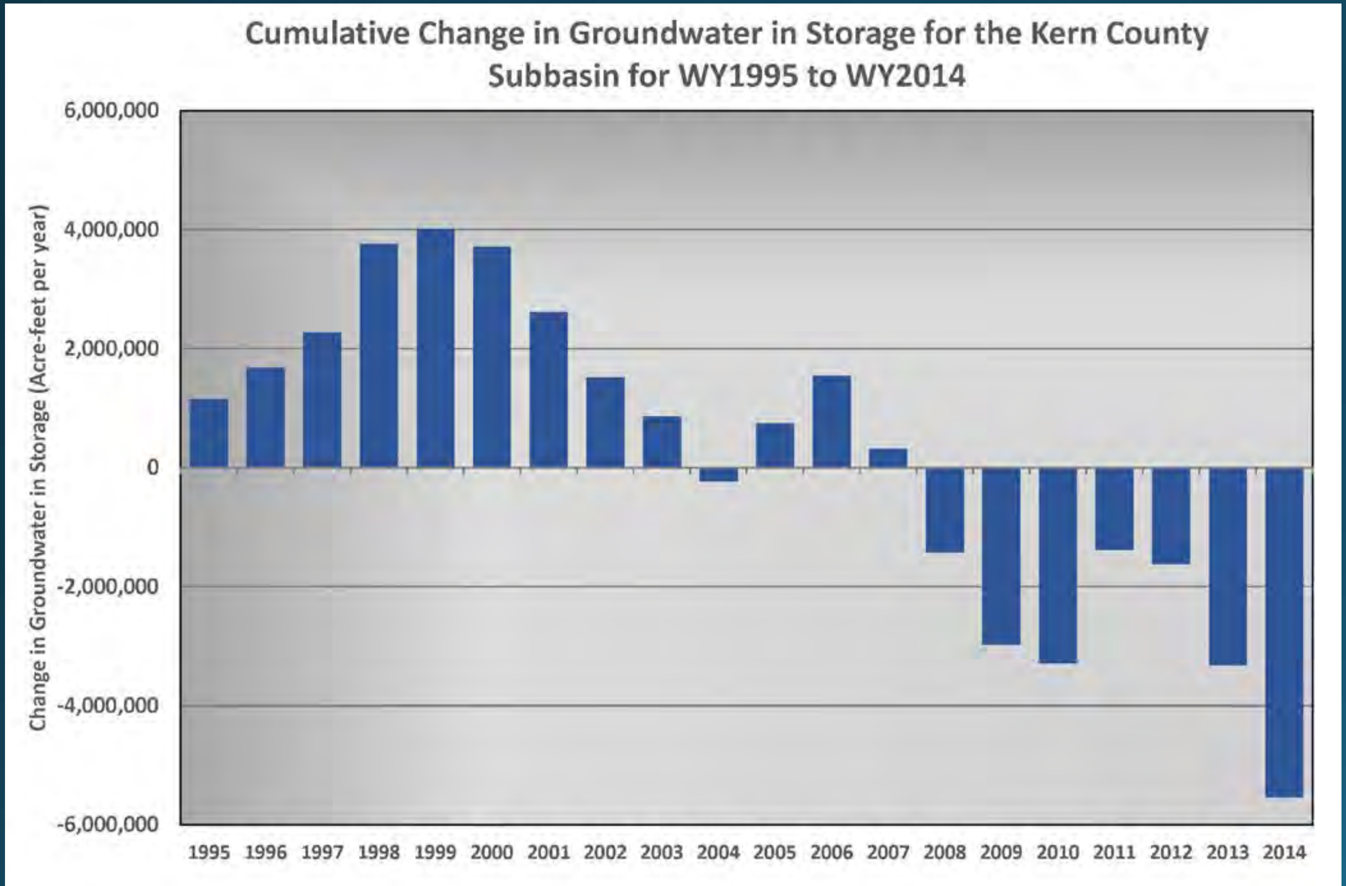
	Land Use Summary				Groundwater Pumping Summary				Surface Water Use Summary			
Water Year	Irrigated Agricultural Area	Urban Area	Native, Undeveloped or Fallow Area	Total Area	Agricultural Pumping	Urban Pumping	GW Banking, Exchanges and "Pump-Ins"	Total Pumping	Agricultural Surface Water Deliveries	Urban Surface Water Deliveries	Other Surface Water Deliveries	Total Surface Water Deliveries
Units	Acres	Acres	Acres	Acres	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	780,803	58,394	963,756	1,802,952	875,865	163,498	11,017	1,050,380	1,339,629	26,158	11,953	1,377,740
1996	798,735	71,339	931,951	1,802,025	1,189,242	173,962	12,184	1,375,387	1,646,089	27,131	14,181	1,687,400
1997	801,583	86,428	914,941	1,802,951	984,027	166,726	11,882	1,162,635	1,650,210	18,447	18,033	1,686,690
1998	799,230	94,070	909,652	1,802,951	790,716	159,223	9,919	959,859	1,200,974	10,595	41,895	1,253,463
1999	803,474	85,993	913,484	1,802,951	1,036,793	186,101	11,874	1,234,768	1,425,118	25,916	12,053	1,463,086
2000	835,206	85,863	881,882	1,802,951	1,302,650	188,030	15,341	1,506,021	1,461,846	29,107	6,073	1,497,026
2001	799,553	84,609	918,789	1,802,951	1,584,161	201,110	185,403	1,970,675	961,988	26,723	11,359	1,000,069
2002	738,420	87,611	976,921	1,802,951	1,584,845	203,989	85,264	1,874,097	1,056,901	28,216	16,859	1,101,976
2003	757,372	92,311	953,269	1,802,951	1,315,884	210,673	101,896	1,628,453	1,200,620	30,171	15,075	1,245,865
2004	769,162	95,981	937,809	1,802,951	1,707,768	207,608	78,110	1,993,485	1,147,322	53,794	19,412	1,220,528
2005	766,330	101,332	935,290	1,802,951	963,245	182,149	86,546	1,231,940	1,335,575	41,246	18,466	1,395,288
2006	816,721	112,056	874,174	1,802,951	1,065,518	205,577	19,548	1,290,643	1,468,445	37,939	18,441	1,524,825
2007	792,925	106,463	903,563	1,802,951	1,714,978	223,167	303,285	2,241,430	1,116,832	52,332	17,019	1,186,184
2008	762,593	103,540	936,819	1,802,951	1,704,923	217,072	548,757	2,470,751	991,935	53,289	14,880	1,060,103
2009	763,660	103,826	935,466	1,802,953	1,666,516	208,473	467,802	2,342,792	991,067	55,707	16,276	1,063,049
2010	755,415	106,423	941,113	1,802,951	1,114,858	202,412	283,436	1,600,706	1,265,554	58,175	19,425	1,343,153
2011	782,699	107,810	912,442	1,802,951	871,649	219,432	34,794	1,125,876	1,490,115	61,185	20,310	1,571,610
2012	790,395	110,511	902,046	1,802,951	1,326,877	237,461	102,336	1,666,675	1,278,762	64,536	15,464	1,358,761
2013	759,168	104,354	939,430	1,802,951	2,061,513	211,687	205,683	2,478,882	921,249	63,531	20,333	1,005,113
2014	723,000	111,830	968,121	1,802,951	2,132,157	215,499	486,370	2,834,025	663,077	52,704	13,044	728,826
Total					**26,994,184**	**3,983,850**	**3,061,446**	**34,039,480**	**24,613,306**	**816,901**	**340,550**	**25,770,756**
Average	**779,822**	**95,537**	**927,546**	**1,802,905**	**1,349,709**	**199,192**	**153,072**	**1,701,974**	**1,230,665**	**40,845**	**17,027**	**1,288,538**
Percent	**43%**	**5%**	**51%**	**100%**	**79%**	**12%**	**9%**	**100%**	**96%**	**3%**	**1%**	**100%**

Revision Focused on Addressing District Comments

- Addressed regional issues
  - Overly high pumping and deep percolation
  - Kern River Recharge
- Reconciled local issues and comments
  - Better aligned Water Budget Areas with district operations
  - Incorporated new or updated data
  - Fixed local data input errors

TODD GROUNDWATER

Revision Provided Minor Difference in Groundwater Storage Change

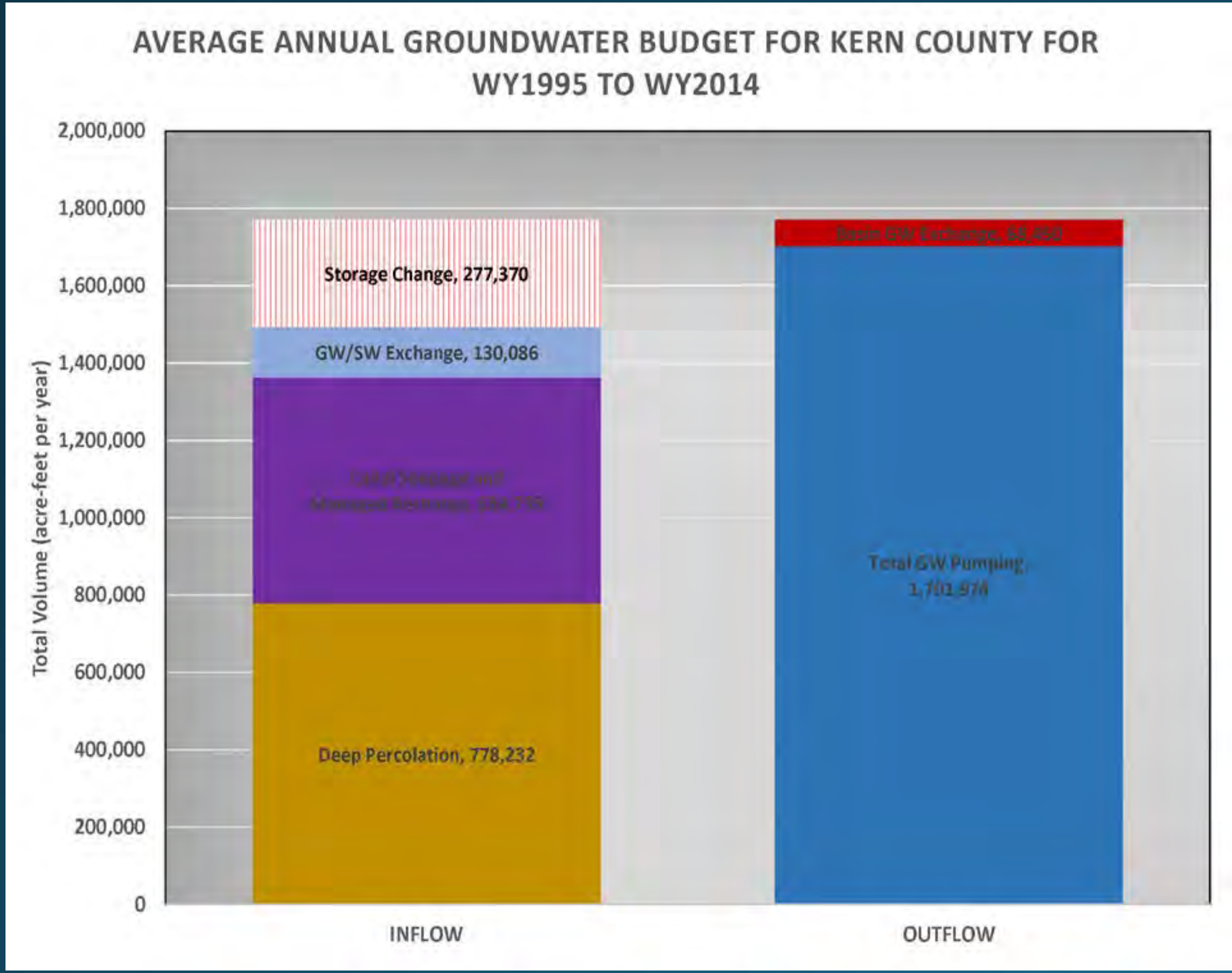


- 20-Year Assessment Period
  - **5,550,000** Acre-foot decline over 20-year Assessment Period
  - **277,000** Average Annual Water Storage Decline
- Model does not account for Groundwater Banking Accounts
  - Water stored in basin for use by others

DRAFT

TODD GROUNDWATER

What Changed in this Revision



- Inflow
  - Deep Percolation (-15%)
  - Canal Seepage and Recharge (+10%)
  - GW/SW Interactions (+22%)
- Outflow
  - Groundwater Pumping (-15%)
  - Basin Outflow (-25%)
- Storage Change (-1%)

DRAFT

TODD GROUNDWATER

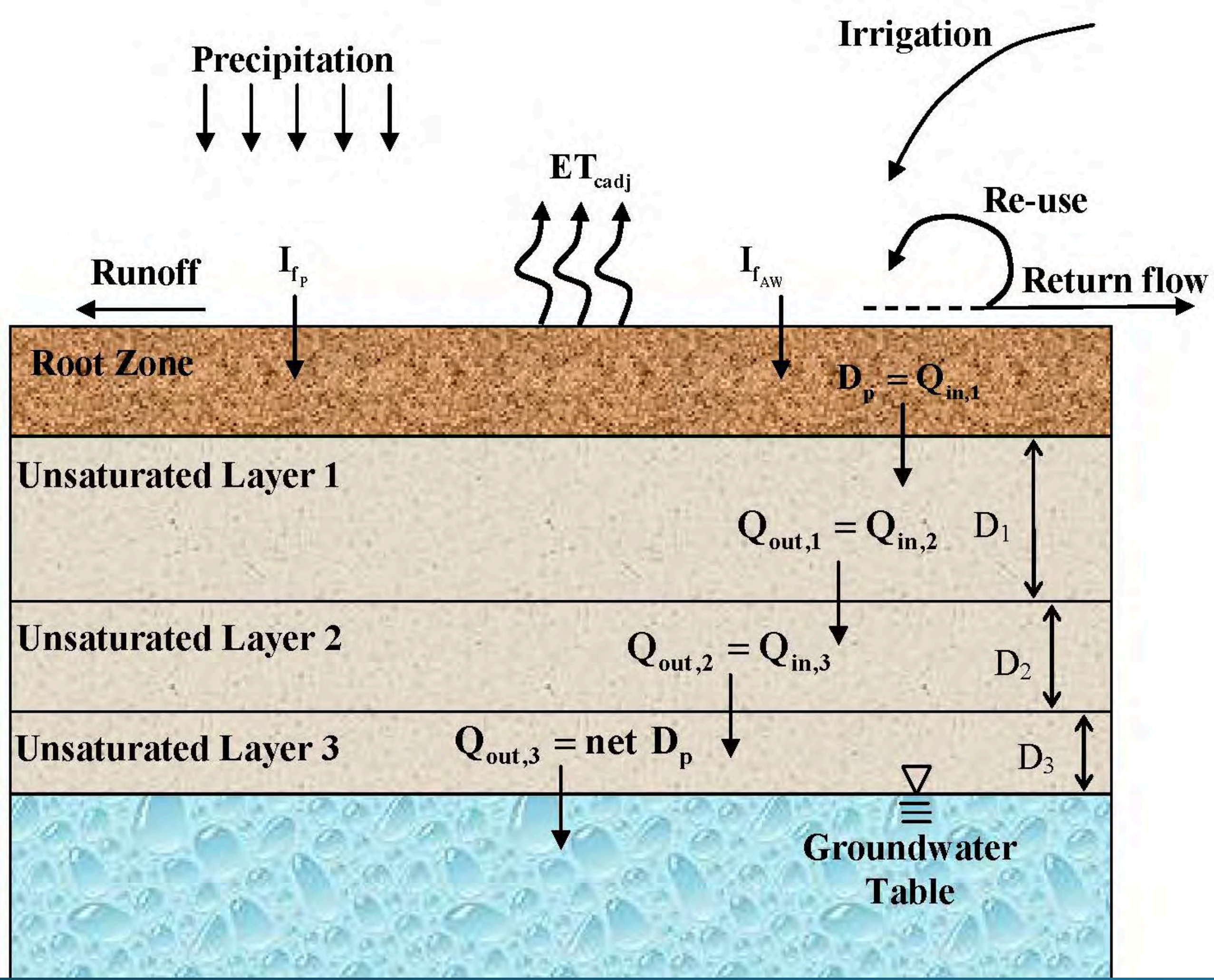
Several Comments Noted Overly-High Pumping and Deep Percolation

- High Soil Hydraulic Conductivity
  - Used soil parameters from Beta Version
  - Found that Soil Hydraulic Conductivity is a Sensitive Parameter
  - Several area in Kern County had overly high values
- Caused Model to Overapply Pumping
  - Model calculates pumping based on crop demand and percolation rate
  - High percolation triggered additional pumping
  - The extra pumpage went back to the groundwater
- Incorrect Setting in a Pumping File Added to the Problem

DRAFT

TODD GROUNDWATER

IWFM Demand Calculator (IDC)



- Calculates agricultural demand based on soil moisture budget
  - Monthly crop ET time series
  - Tracks soil moisture content throughout simulation
  - If soil moisture falls below minimum level (wilting point), irrigation water added to reach target level (field capacity) to cover ET, deep percolation and runoff

DRAFT

TODD GROUNDWATER

Model Crop Demand Correlates Well to ITRC ETc Assessment

Comparison of Annual ETc Volume for Kern County by ITRC (2017) and Revised C2VSim Model (2019)

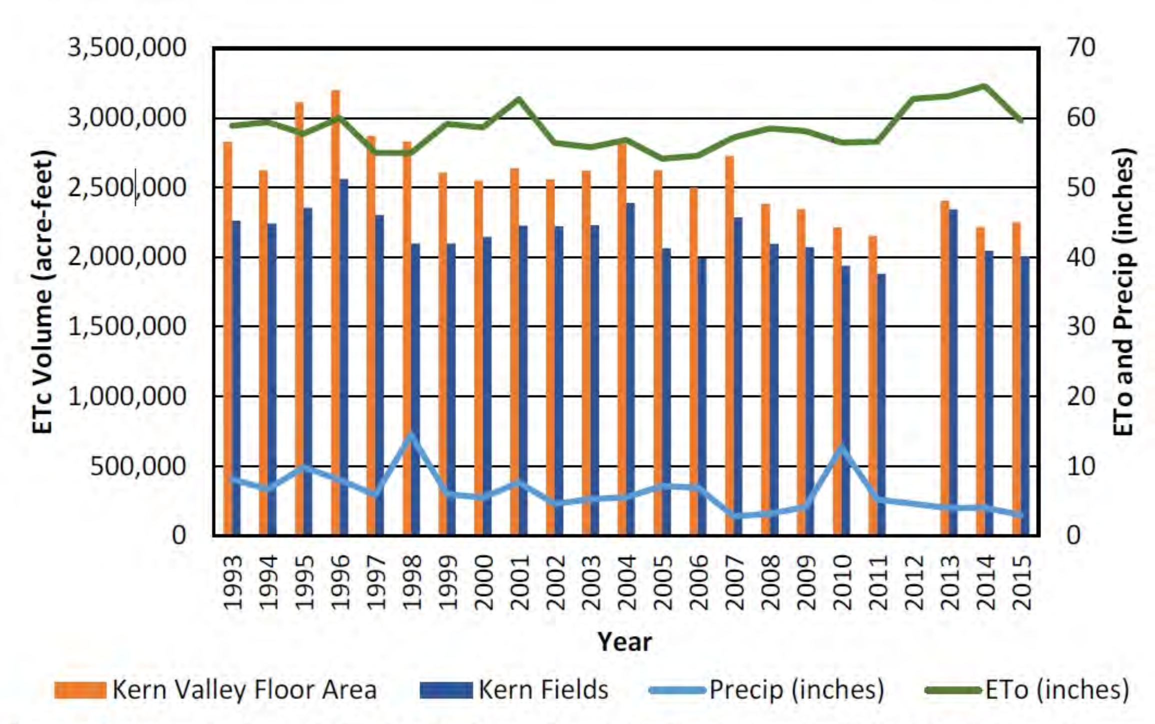
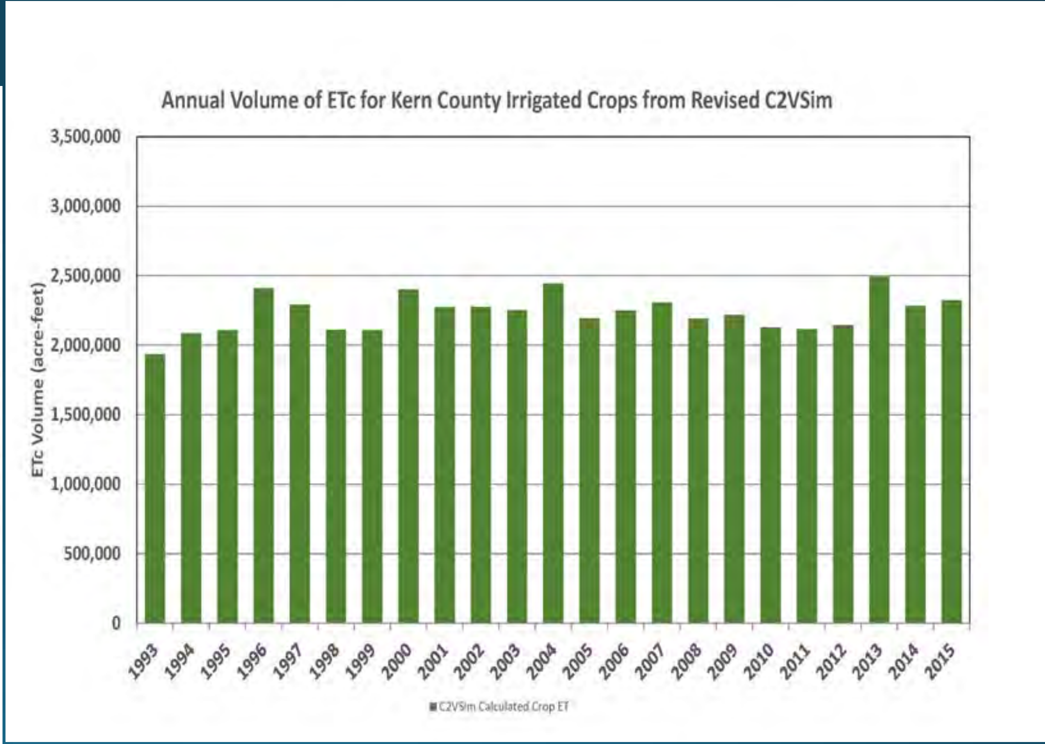


Figure 10. Annual volume of ETc for the Kern County Valley floor and within fields in Kern County. reference ETo and precipitation depths are shown for each year as a reference.



TODD GROUNDWATER

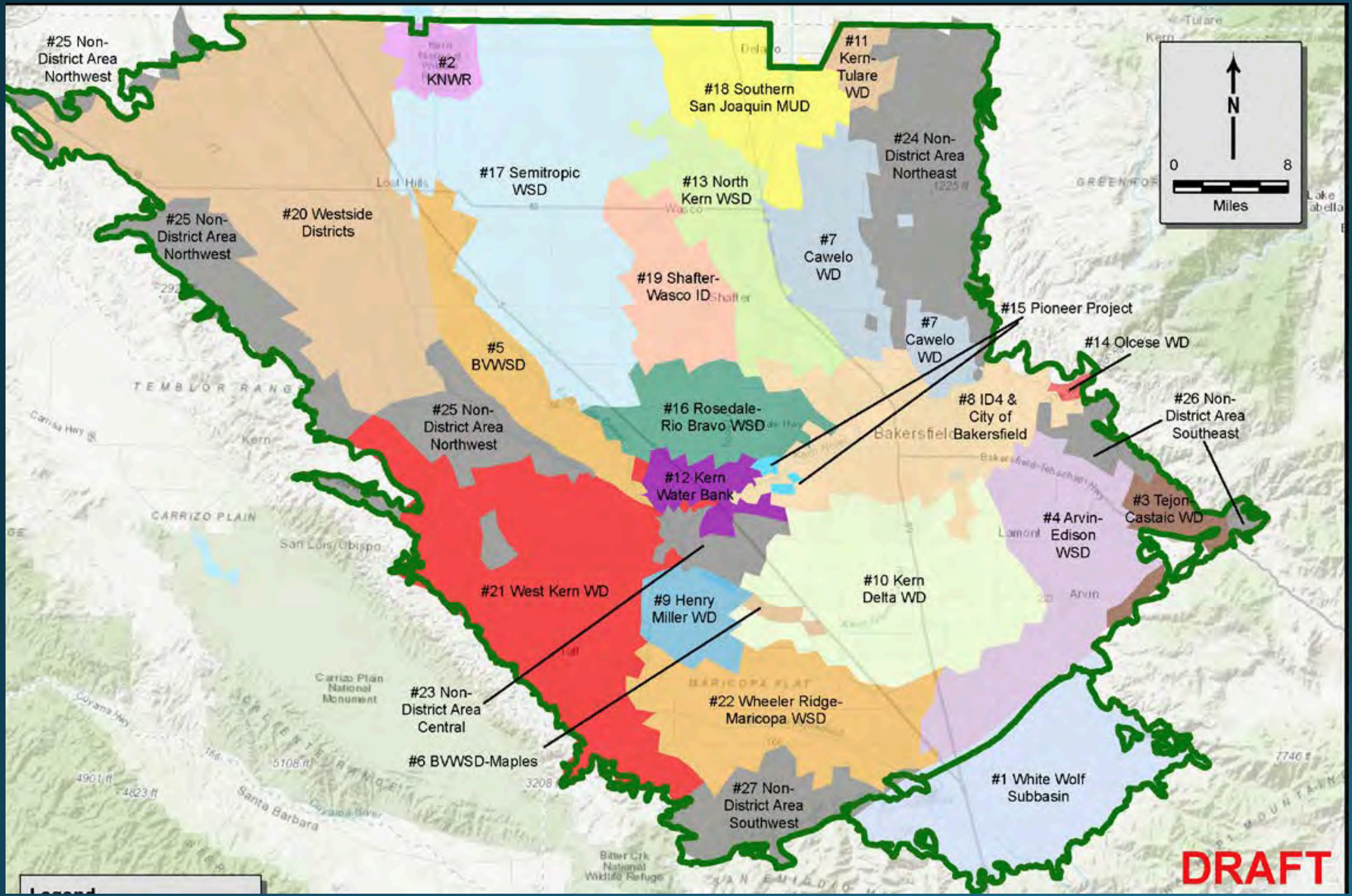
Worked to Improve Kern River Flow Conditions

- Modified Aquifer and Stream Parameters
  - Applied aquifer parameters from existing local models
  - Adjusted streambed parameters to allow more upstream seepage
- Achieved significant improvement
  - Seepage rates from River are more inline with measured data
  - Reduced mounding under Kern Fan Banks
  - Decreased outflows to lower Kern River

DRAFT

TODD GROUNDWATER

Revised Water Budget Areas

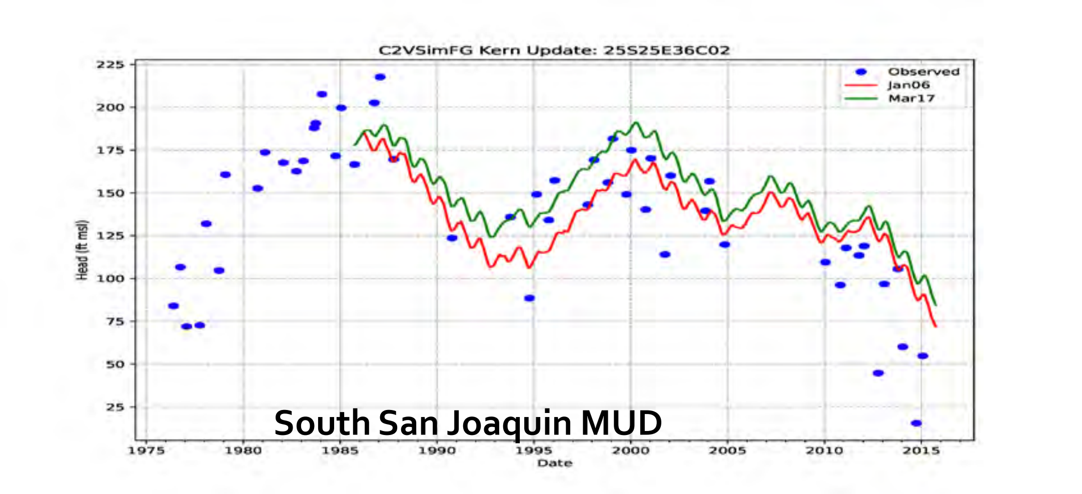


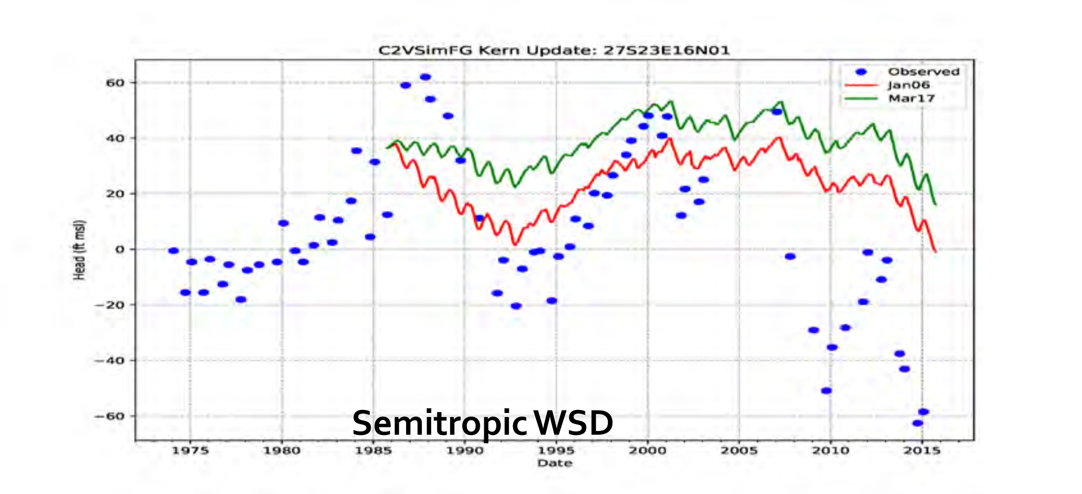
- Aligned with current GSA or district boundaries
  - Update managed water data
  - Localize water distribution
- Included local water management operations
  - Surface water delivery areas
  - Pumping
  - Managed recharge operations

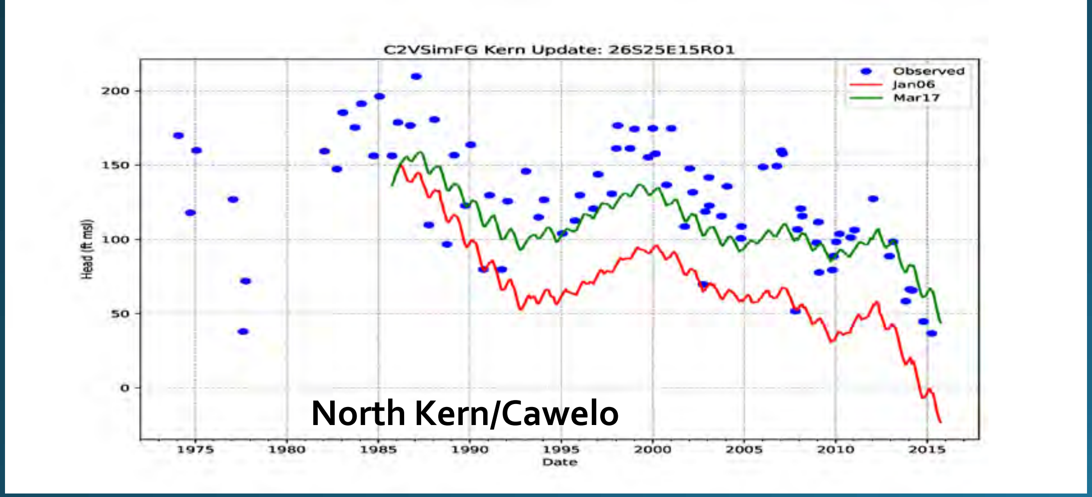
DRAFT

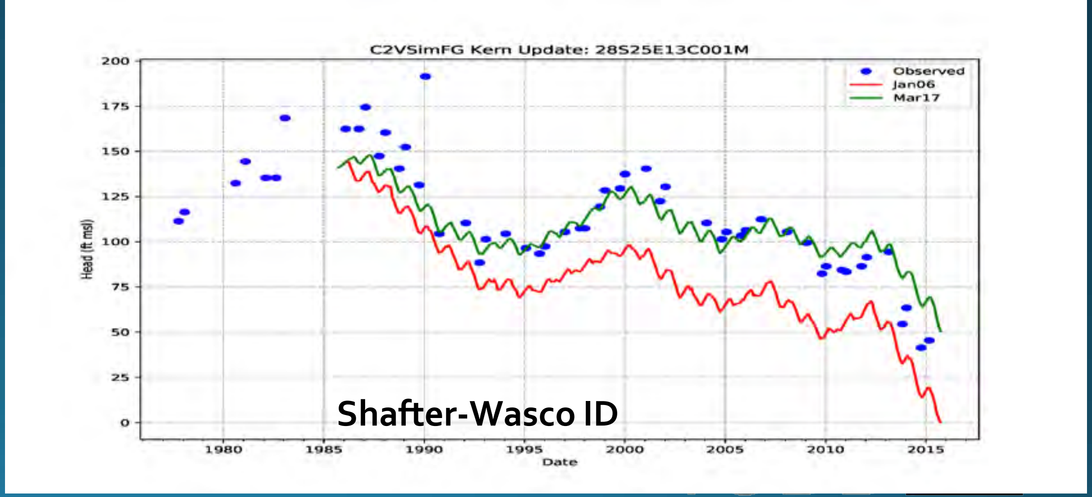
TODD GROUNDWATER

Examples of Model Performance North of the River

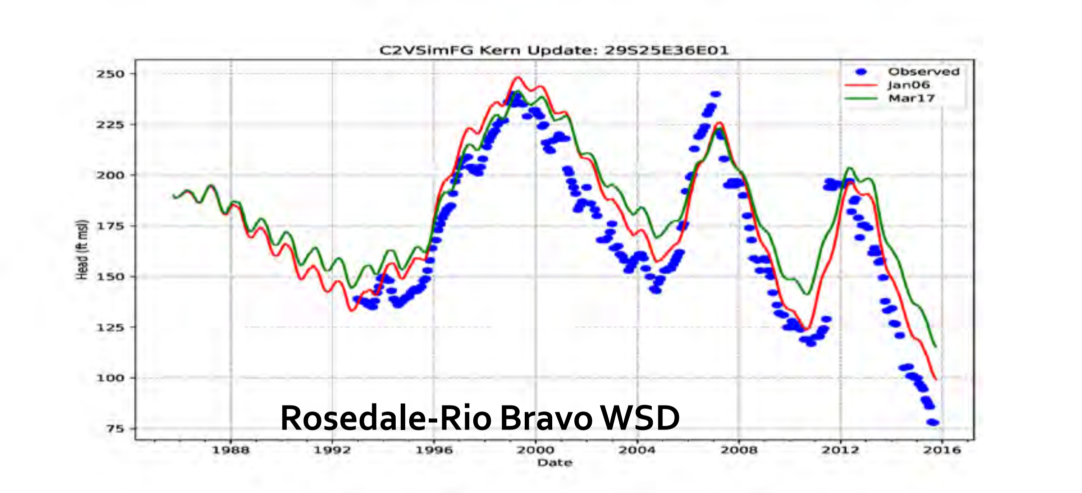


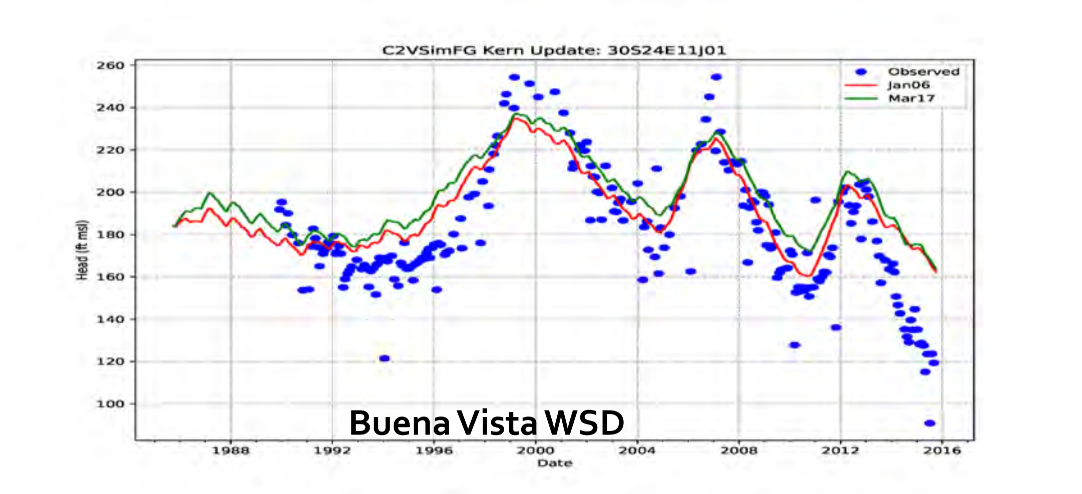


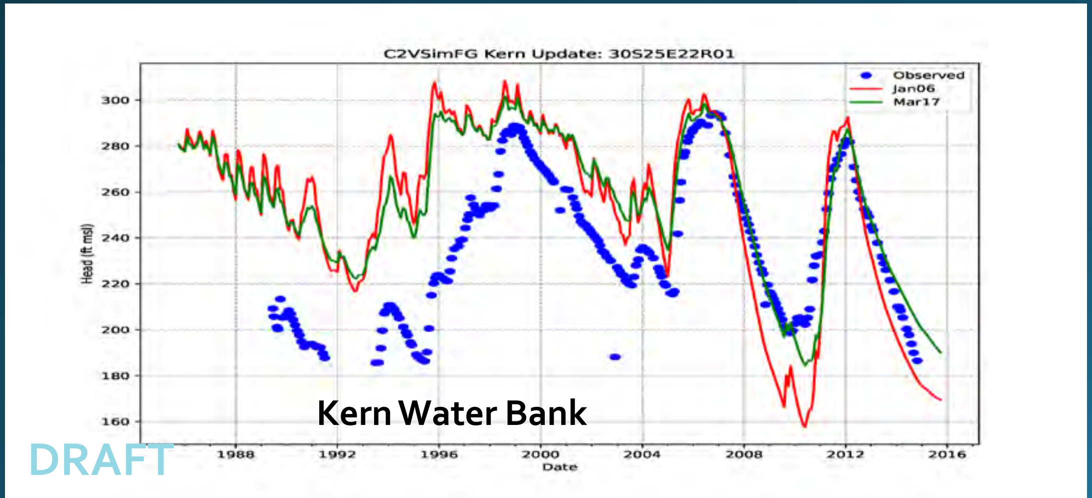


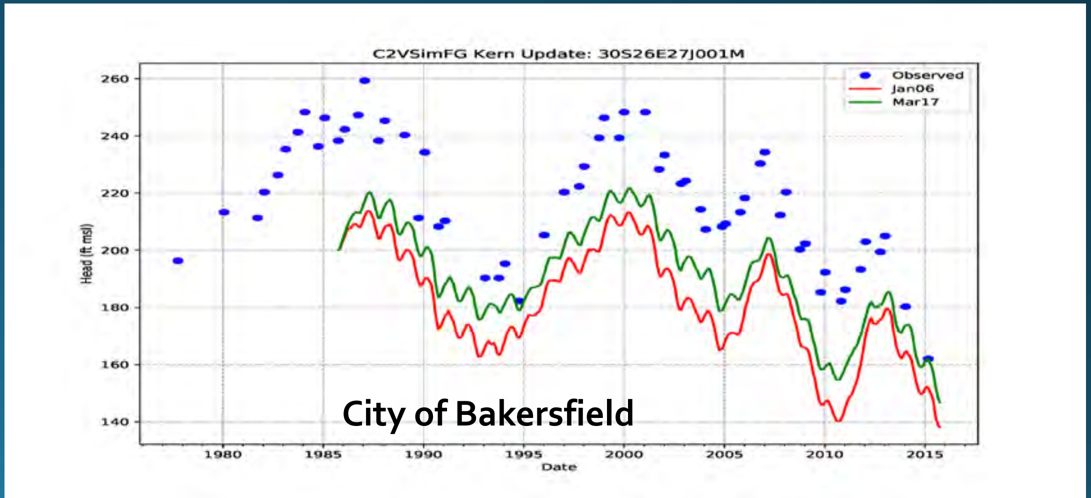


Examples of Model Performance Along the River

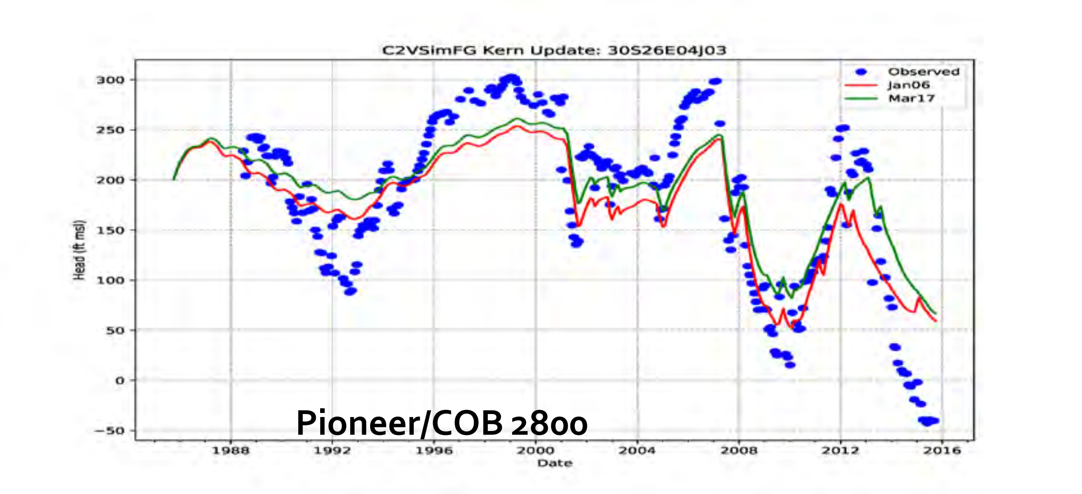


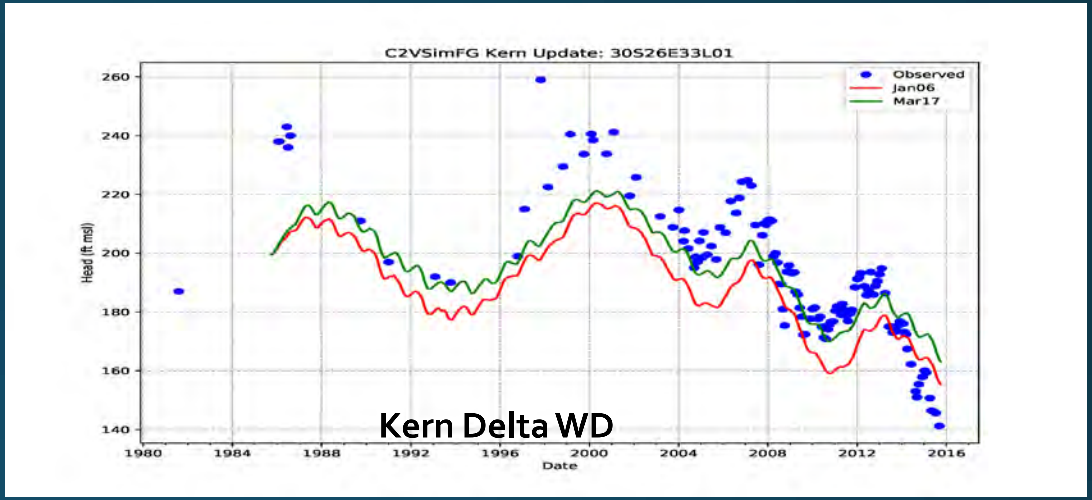


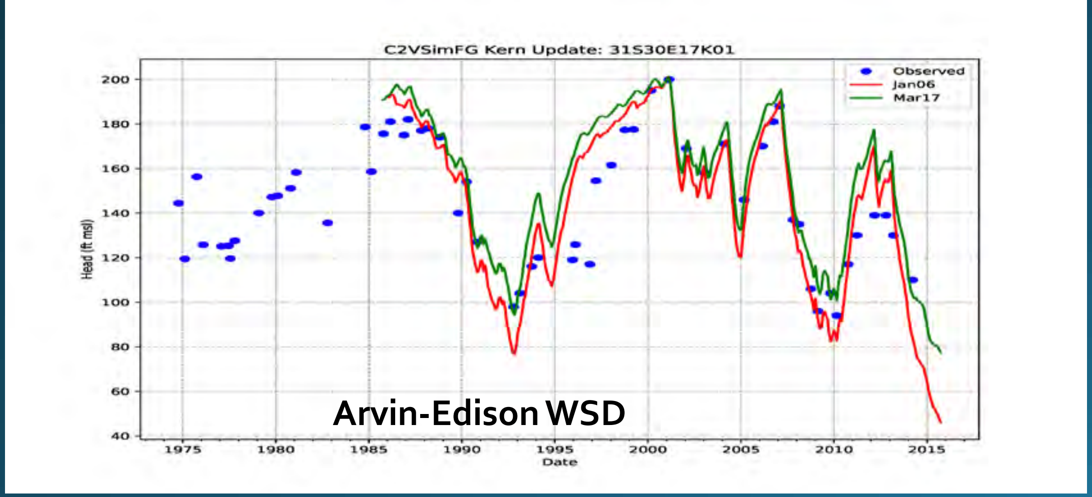


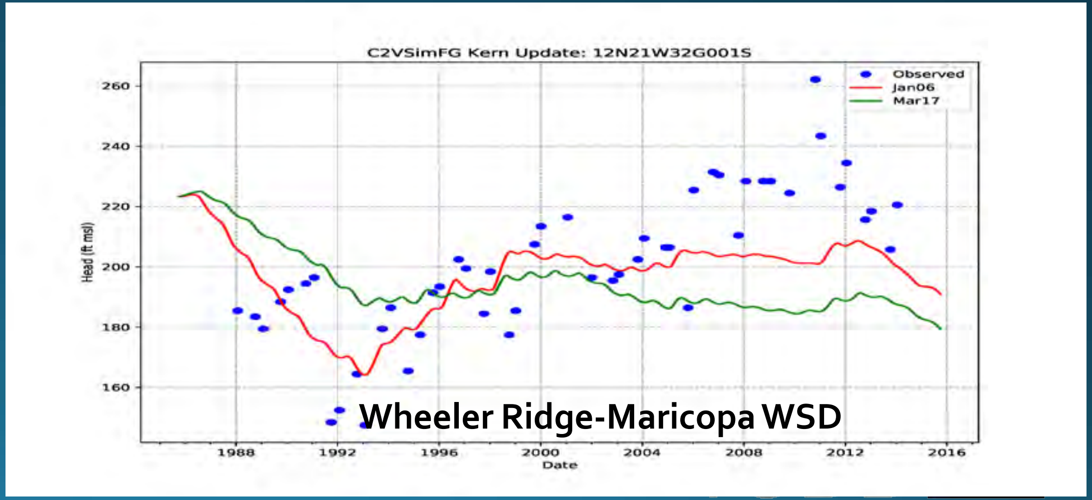


Examples of Model Performance North Kern WSD and Shafter-Wasco ID









GROUNDWATER

Kern County Subbasin C2VSim Update - Basin Yield Analysis
Historical Hydrologic Period from WY1995 to WY2014
March 15, 2019 C2VSim Version
REVISED RESULTS For District Review

TABLE 6: Sustainable and Native Yield Analysis for Kern County for WY1995 to WY2014 Base Pe

Groundwater-Pumping-Based Basin Yield				
Water Year	Total Average Annual Volume	Agricultural Average Annual Volume	Agricultural Average Annual Volume per Ag Acre	Urban Average Annual Volume
Units	Acre-ft	Acre-ft	ft/acre	Acre-ft
	Groundwater Pumping-Based Basin Yield			
Groundwater Pumping	1,548,902	1,349,709	1.73	199,192
Percentage of Pumping		87%		13%
Change in Groundwater in Storage	-277,370	-219,962	-0.28	-32,462
Percentage of Pumping		-16%		-16%
Sustainable Yield	**1,271,532**	**1,129,748**	**1.45**	**166,730**
Recharge-Based Basin Yield				
	Native Yield based on Natural Recharge			
Precipitation Recharge	192,337	167,602	0.21	24,735
Small Watershed Recharge	48,760	42,489	0.05	6,271
Basin Inflow	50,946	44,394	0.06	6,552
Subtotal	292,043	254,486	0.33	37,557
	Natural or Basin Derived Operational Recharge			
Ag Return Flow - Pumped GW	301,099	301,099	0.39	0
Urban Stormwater and Wastewater	57,534	0	0.00	57,534
Urban Return Flow - Pumped GW	44,899	0	0.00	44,899
Subtotal	403,532	301,099	0.39	102,433
	Imported or Allocated Recharge			
Ag Return Flow - Surface Water	274,542	274,542	0.35	0
Urban Return Flow - Surface Water	11,225	0	0.00	11,225
Banking/Canal Seepage	321,606	307,162	0.39	10,195
Stream Recharge	99,047	86,310	0.11	12,738
Subtotal	706,421	668,014	0.86	34,157
	Groundwater Outflow from Basin			
Basin Outflow	-137,118	-108,738	-0.14	-16,048
Subtotal	-137,118	-108,738	-0.14	-16,048
Total	**1,264,877**	**1,114,860**	**1.43**	**158,099**
Natural Native Yield	**292,043**	**254,486**	**0.33**	**37,557**
Operational Native Yield	**695,575**	**555,585**	**0.71**	**139,990**
Sustainable Yield	**558,457**	**446,847**	**1.43**	**123,942**

Basin Yield Analysis

- Applied two different approaches
  - Groundwater Pumping Based
  - Recharge Based
- Compiled model data to support Basin Yield Analysis
- Model results are in line with other estimates

Defensibility of Water Budgets

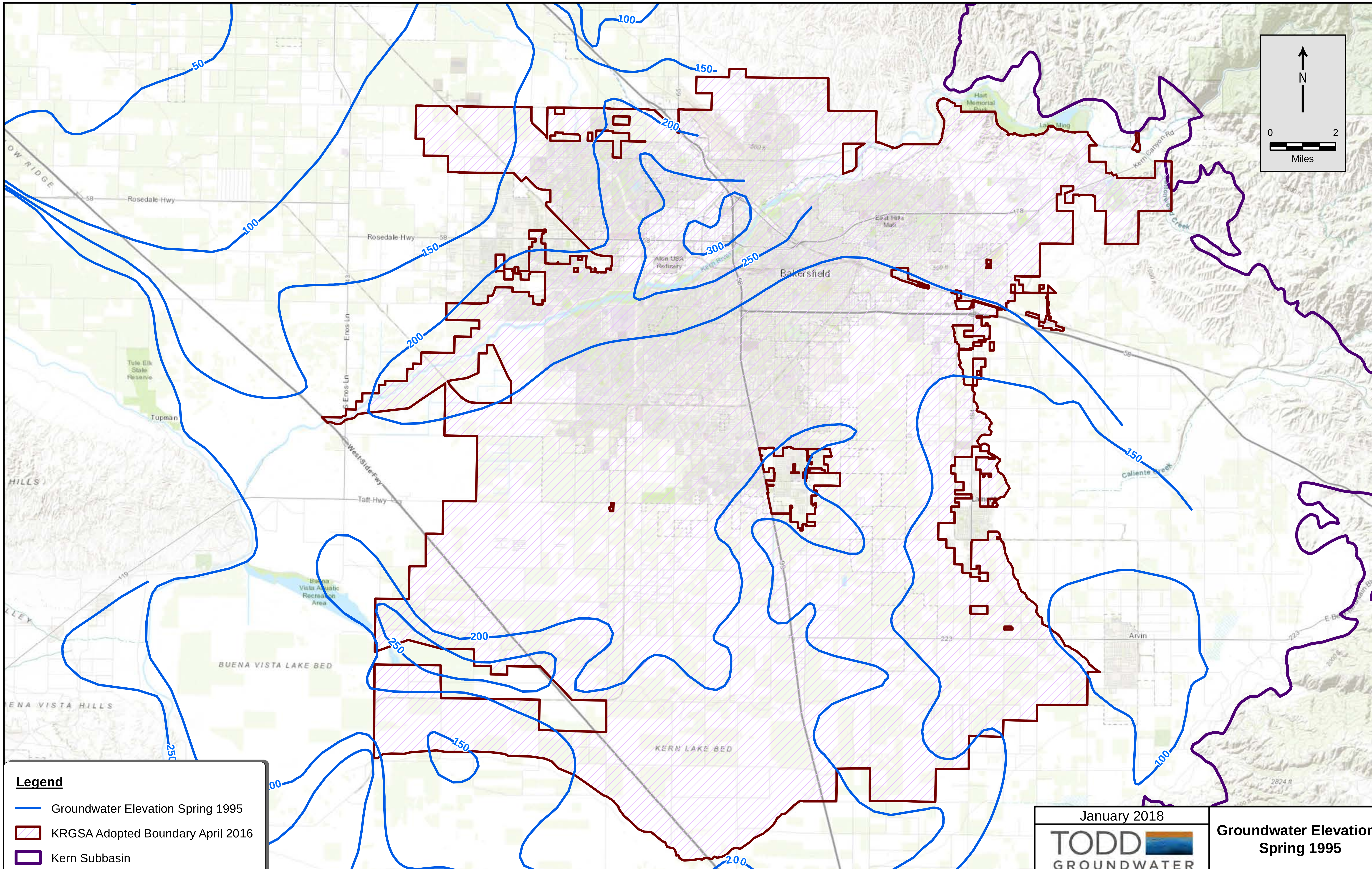
- C2VSim utilizes Same Data and Methods across the Subbasin
  - Uses measured, locally-derived data
  - Applies consistent methodology across the subbasin
- Managed Water Supply and Demand Dominate the Subbasin Water Budget
- Model simulation provides reasonable representation of groundwater conditions
- DWR Provided C2VSim Beta-Version Specifically for Development of SGMA Water Budgets

TODD GROUNDWATER

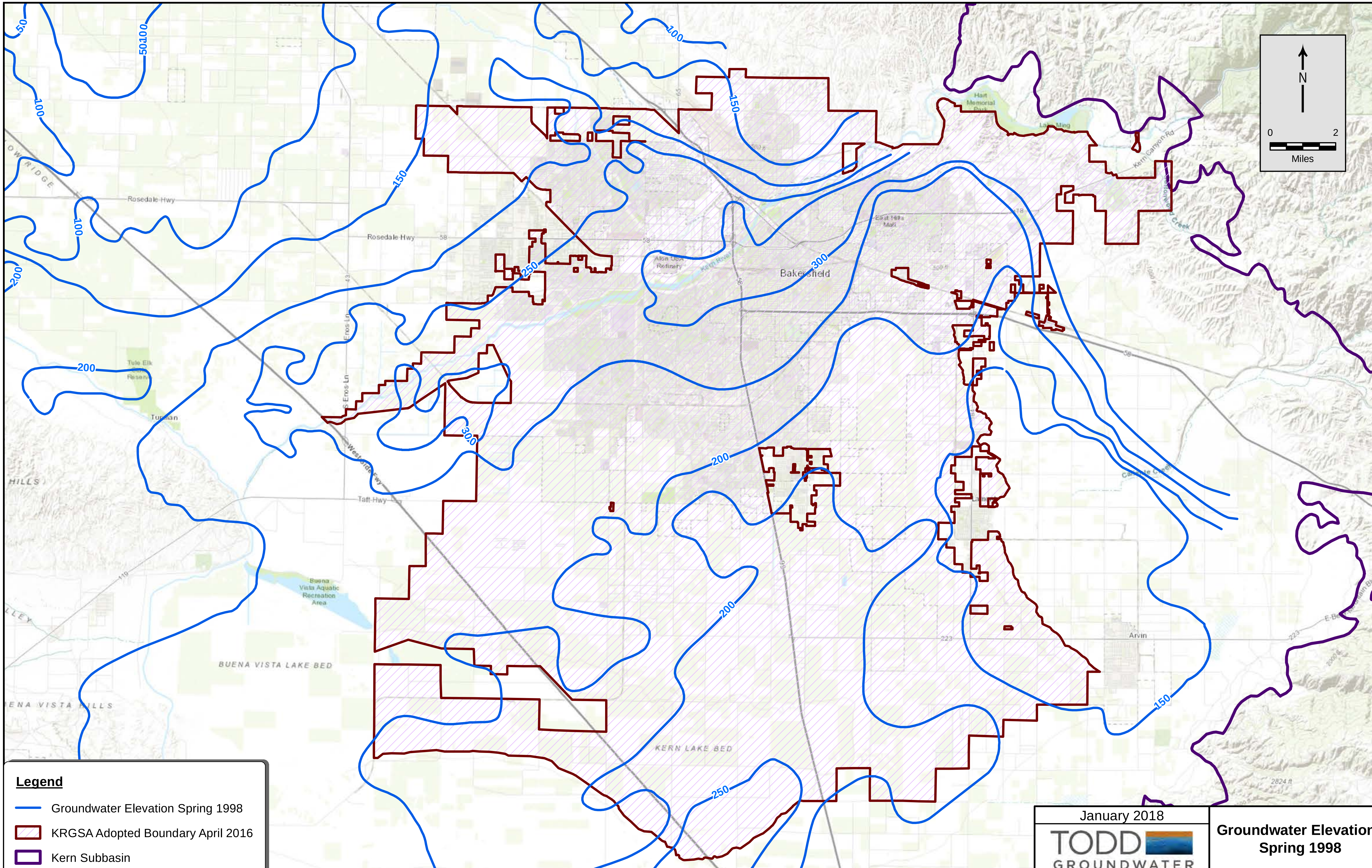
Discussion and Questions

APPENDIX G

Annual Spring Groundwater Elevation Contour Maps, KCWA



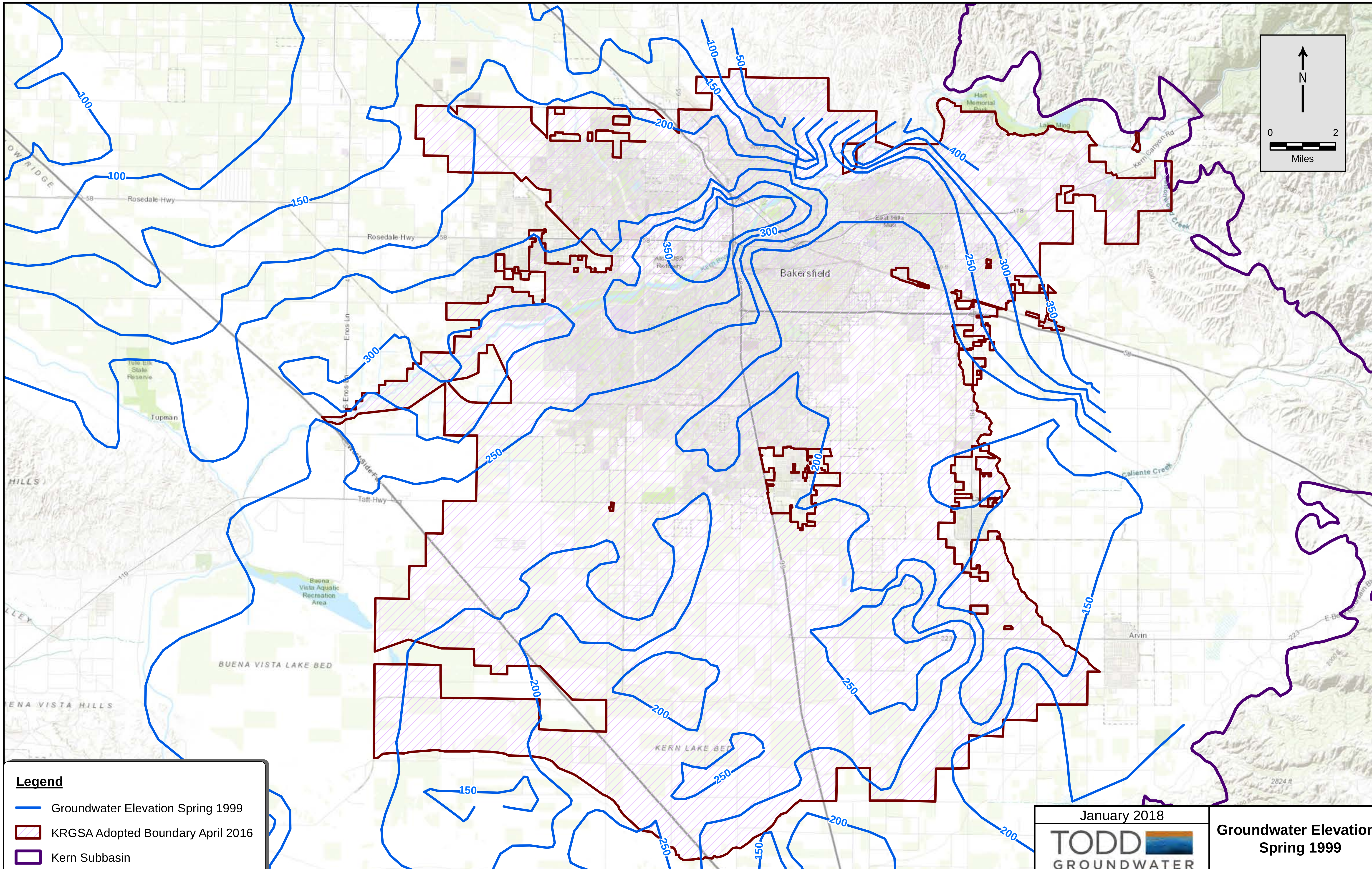
Legend
Groundwater Elevation Spring 1995
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
Arvin
BUENA VISTA LAKE BED
KERN LAKE BED
Buena Vista Aquatic Recreation Area
Tule Elk State Reserve
Alon USA Refinery
East Hills Mall
Hart Memorial Park
Lake Ming
Kern Canyon Rd
Caliente Creek
Kern River
50
100
150
200
250
300
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 1995

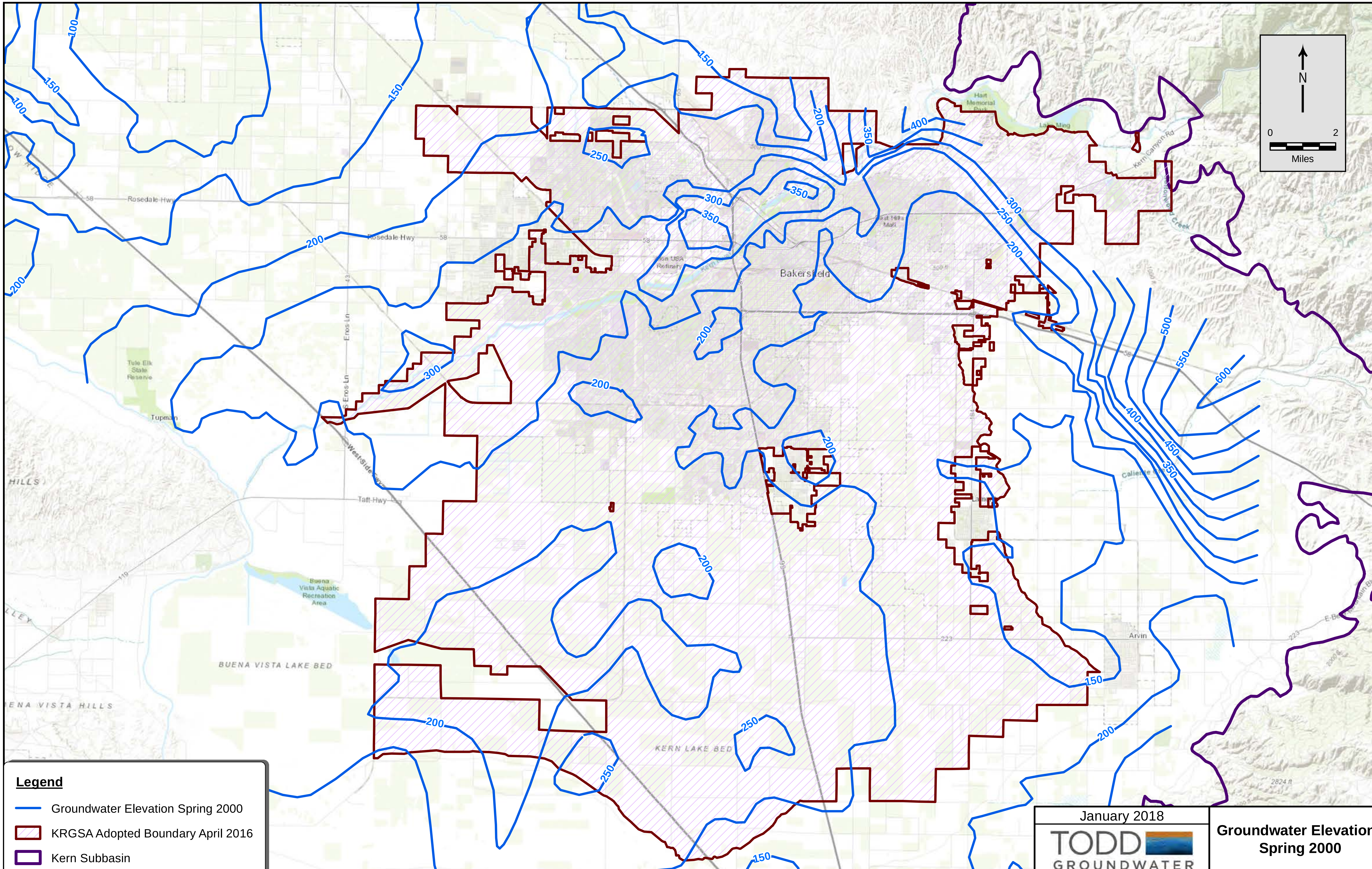


January 2018

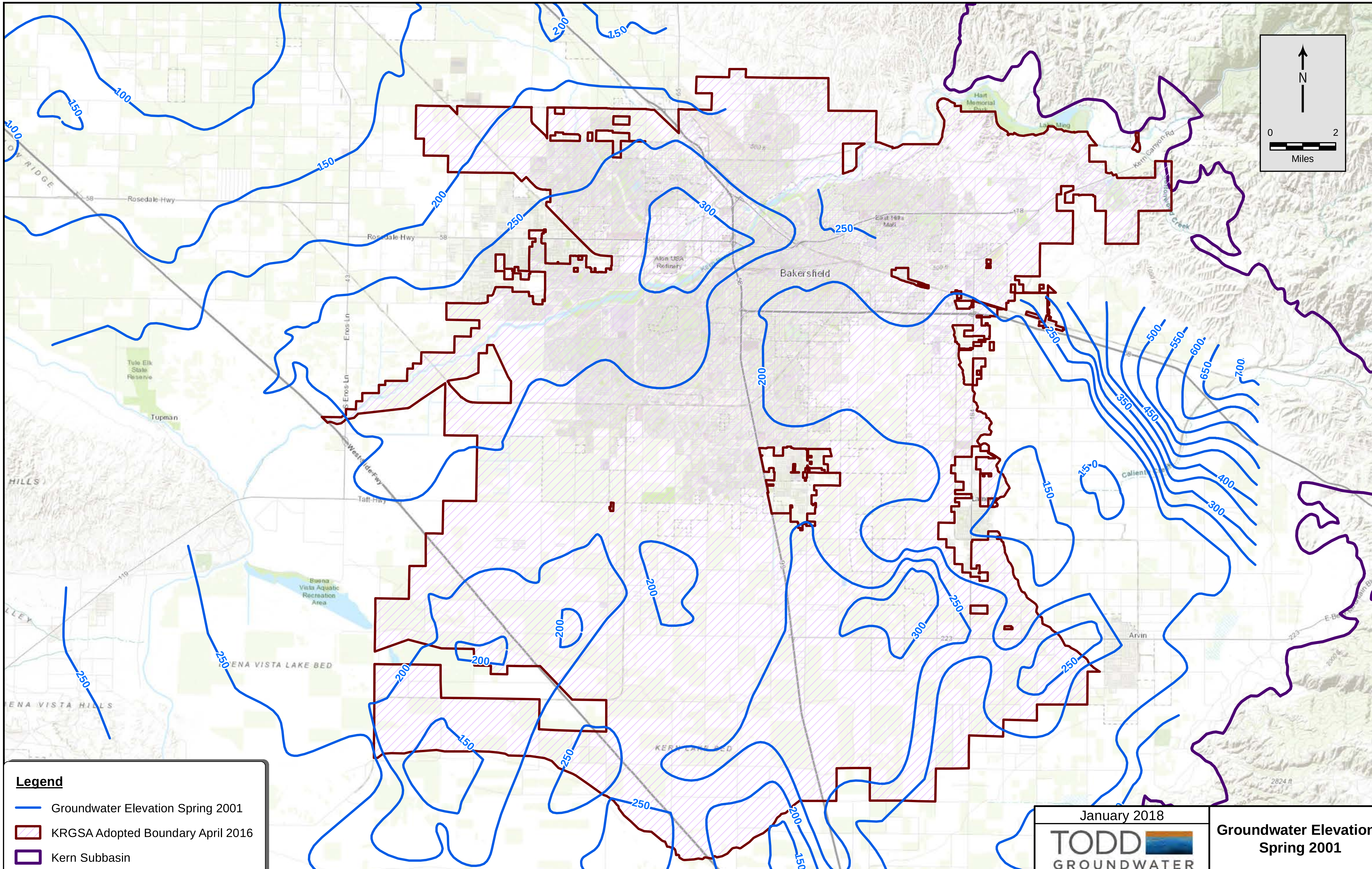
TODD GROUNDWATER

Groundwater Elevations Spring 1998

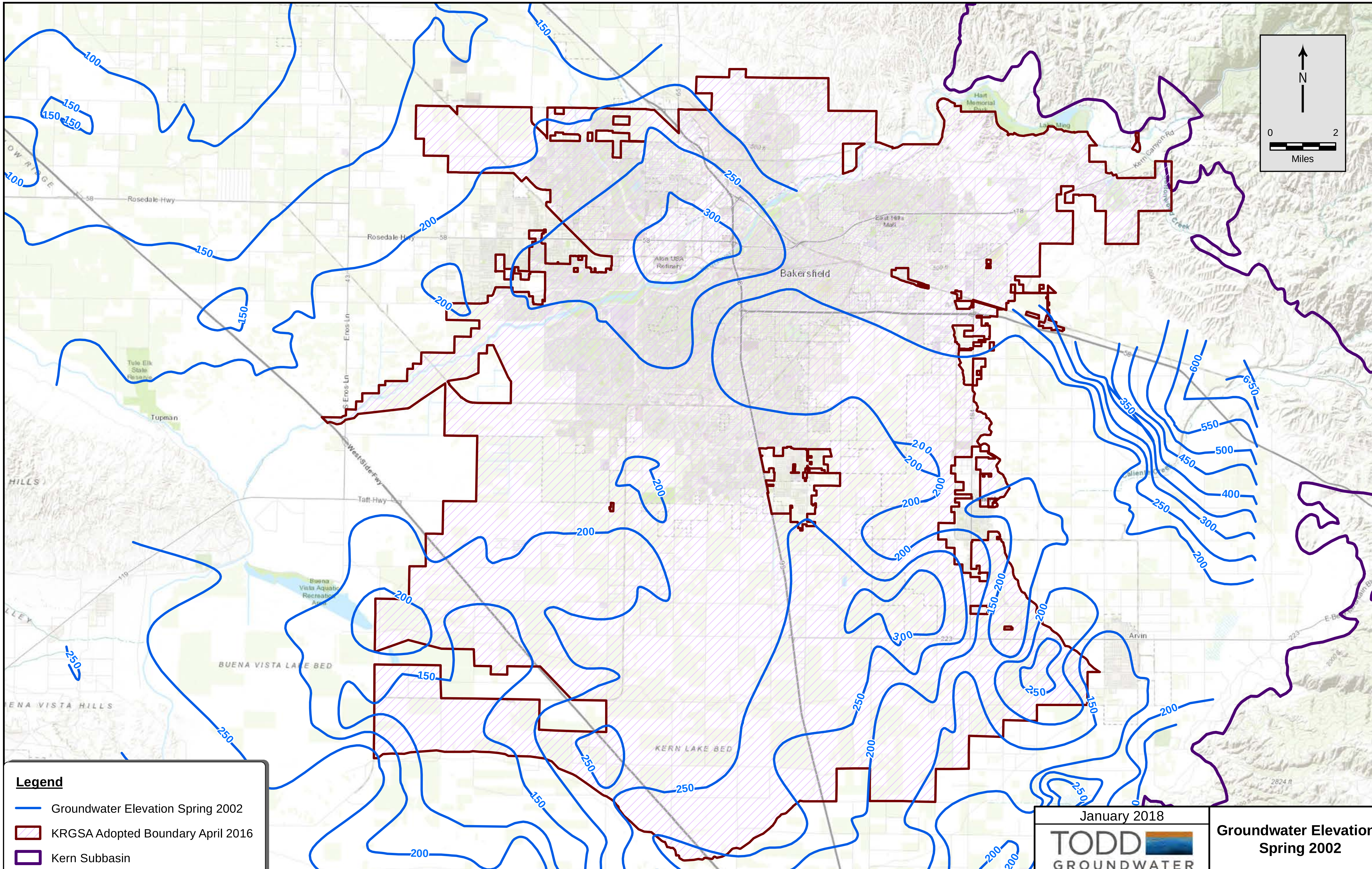

Legend
Groundwater Elevation Spring 1999
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations
Spring 1999
Bakersfield
Rosedale Hwy
Taft Hwy
Tupman
Arvin
Tule Elk State Reserve
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
Hart Memorial Park
Caliente Creek
Kern Canyon Rd
100
150
200
250
300
350
400



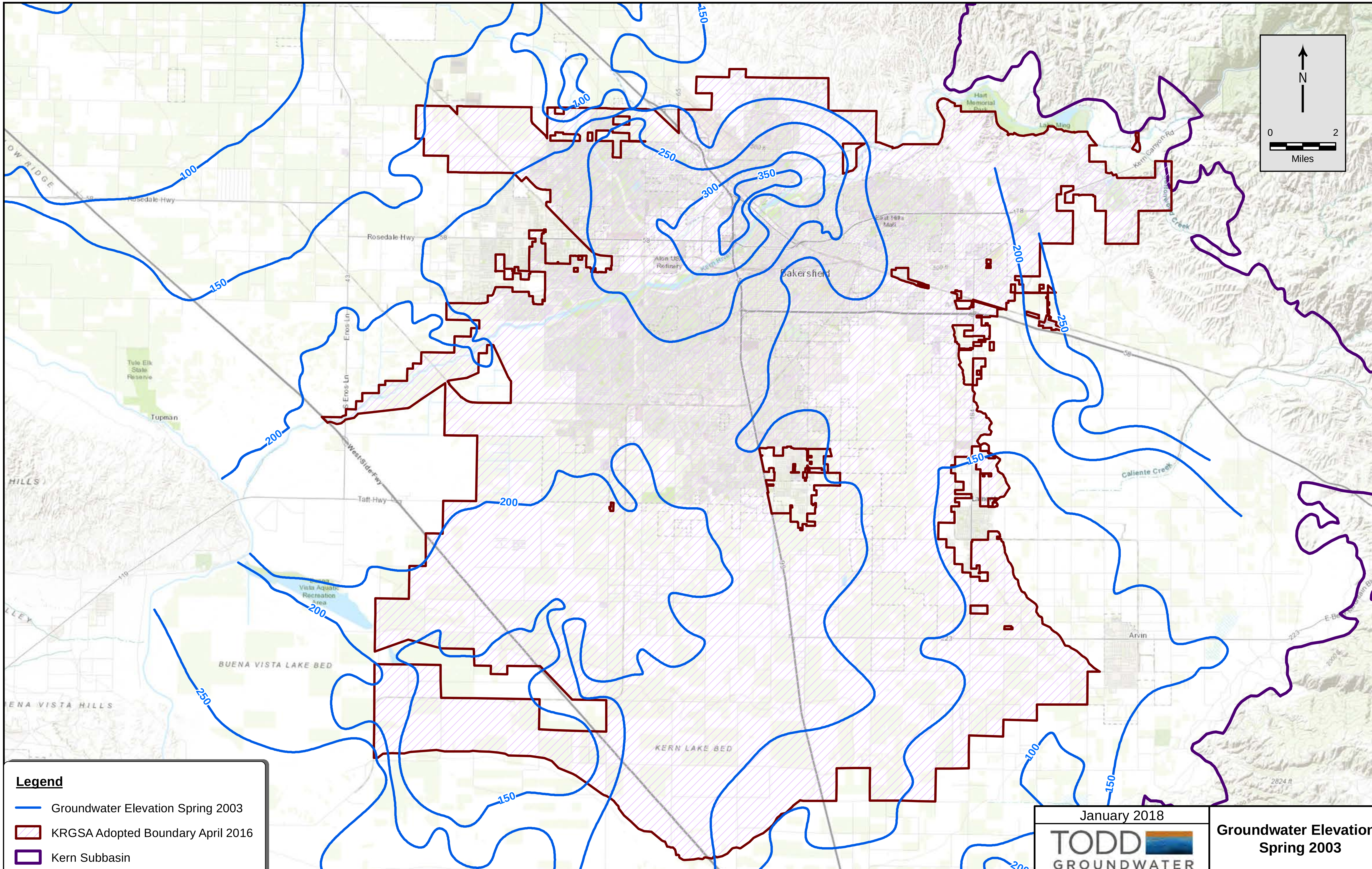
N
0
2
Miles
Bakersfield
Rosedale Hwy
Taft Hwy
Tupman
Arvin
BUENA VISTA LAKE BED
KERN LAKE BED
Tule Elk State Reserve
Buena Vista Aquatic Recreation Area
Hart Memorial Park
Caliente Creek
Kern Canyon Rd
100
150
200
250
300
350
400
450
500
550
600
Legend
Groundwater Elevation Spring 2000
KRGSA Adopted Boundary April 2016
Kern Subbasin
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2000

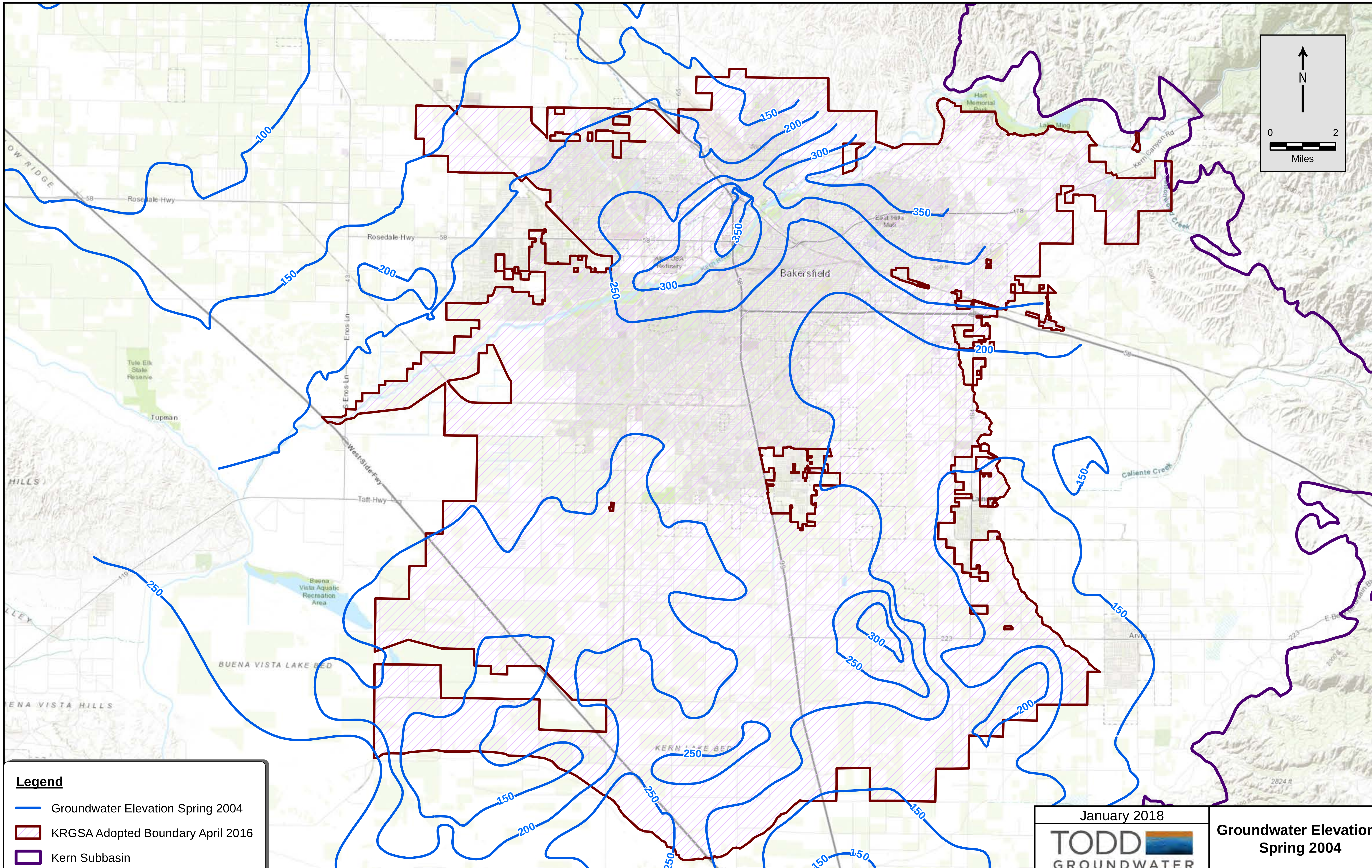


Groundwater Elevations Spring 2001



N
0
2
Miles
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
Arvin
Hart Memorial Park
Lake Ming
Kern Canyon Rd
East Hills Mall
Alon USA Refinery
Tule Elk State Reserve
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Legend
Groundwater Elevation Spring 2002
KRGSA Adopted Boundary April 2016
Kern Subbasin
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2002

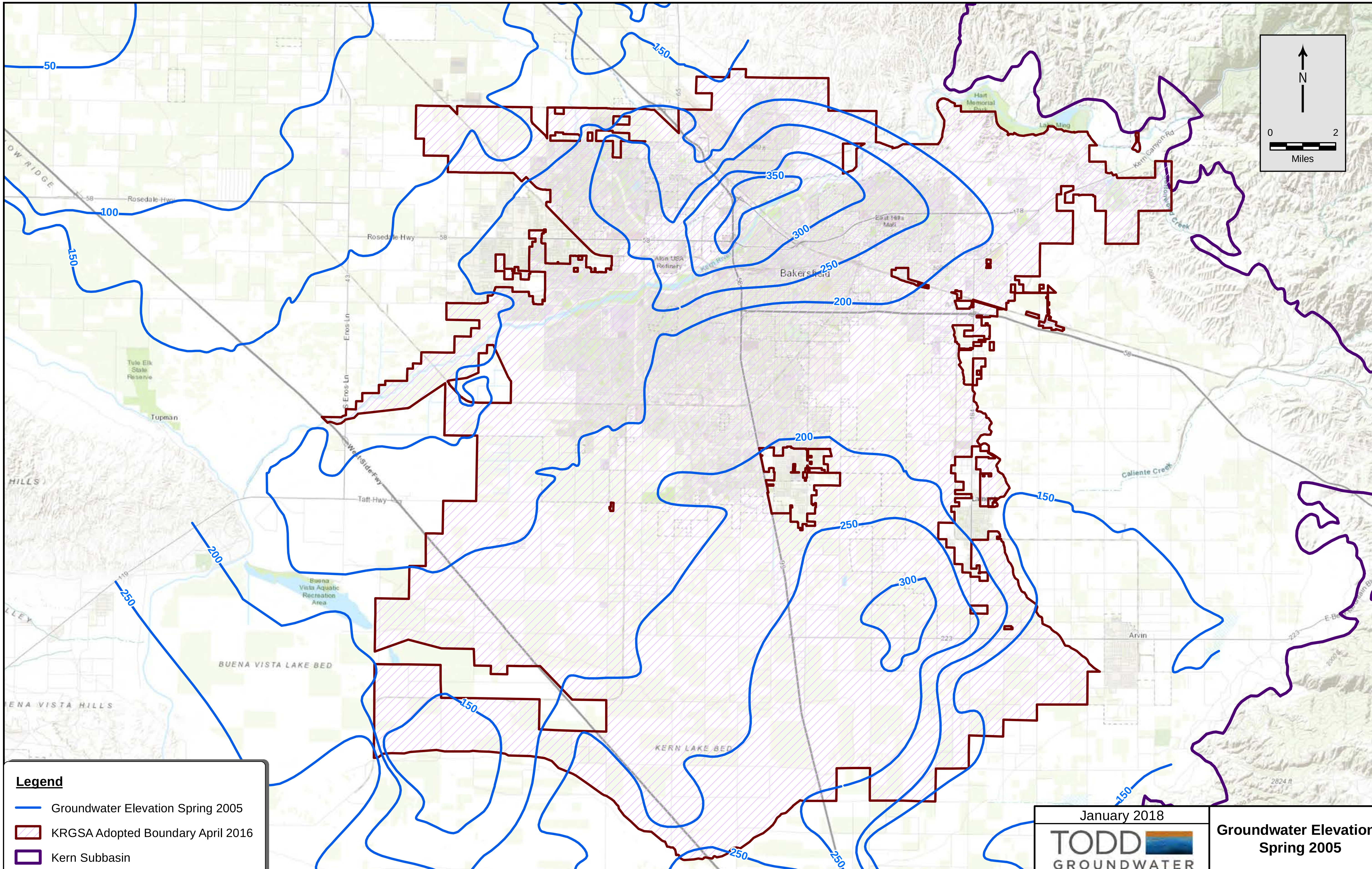

Legend
Groundwater Elevation Spring 2003
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0 2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2003
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
Arvin
Kern Canyon Rd
Caliente Creek
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Tule Elk State Reserve
Hart Memorial Park
Lake Ming
East Hills Mall
Alon US Refinery
Kern River
Enos Ln
Buena Vista Aquatic Recreation Area
100
150
200
250
300
350

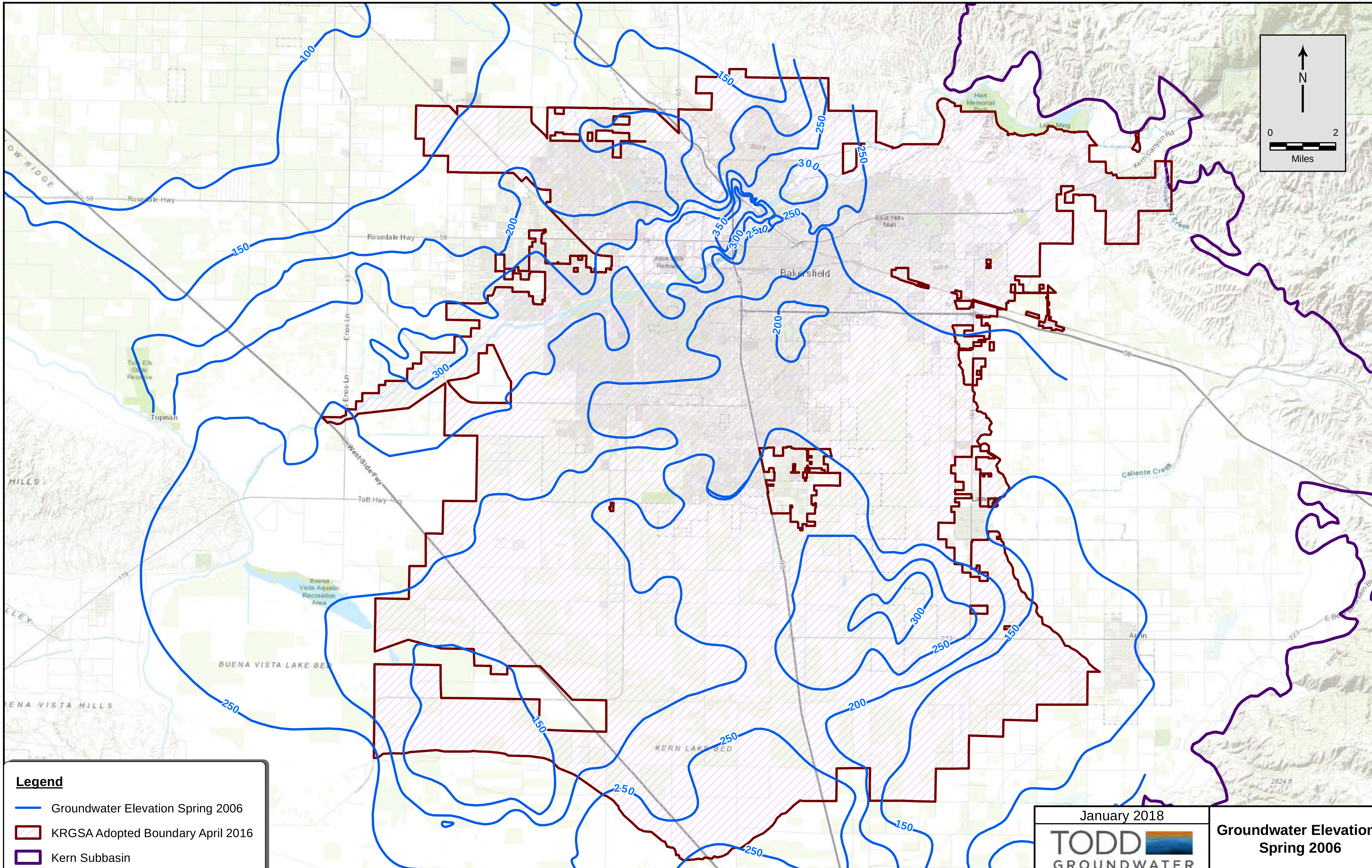


January 2018

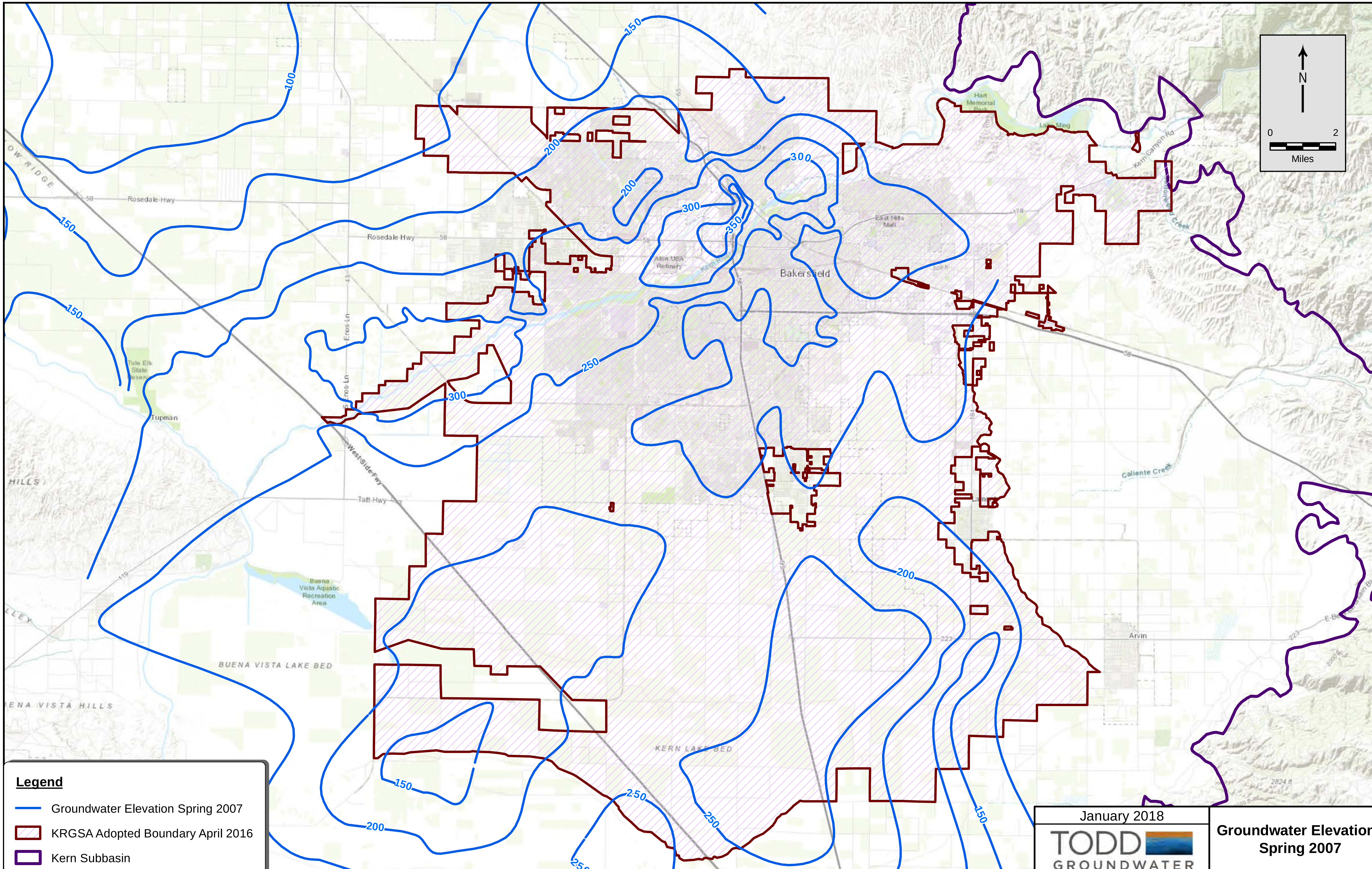
TODD GROUNDWATER

Groundwater Elevations Spring 2004

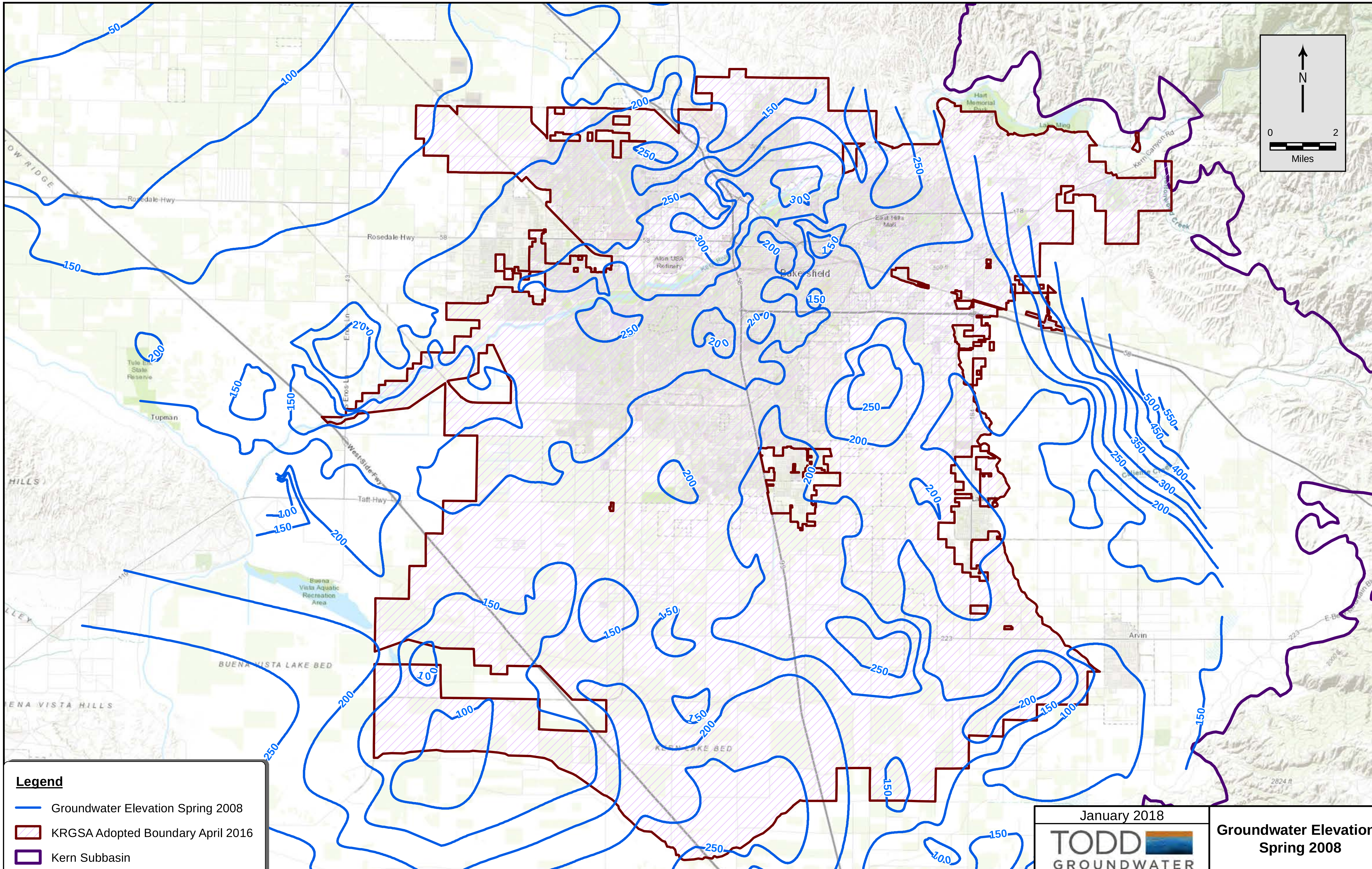

Legend
Groundwater Elevation Spring 2005
KRGSA Adopted Boundary April 2016
Kern Subbasin
January 2018
TODD GROUNDWATER
Groundwater Elevations
Spring 2005
N
0
2
Miles
50
100
150
200
250
300
350
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tule Elk State Reserve
Tupman
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Hart Memorial Park
Lake Ming
Kern Canyon Rd
East Hills Mall
Alon USA Refinery
Caliente Creek
Arvin
Enos Ln

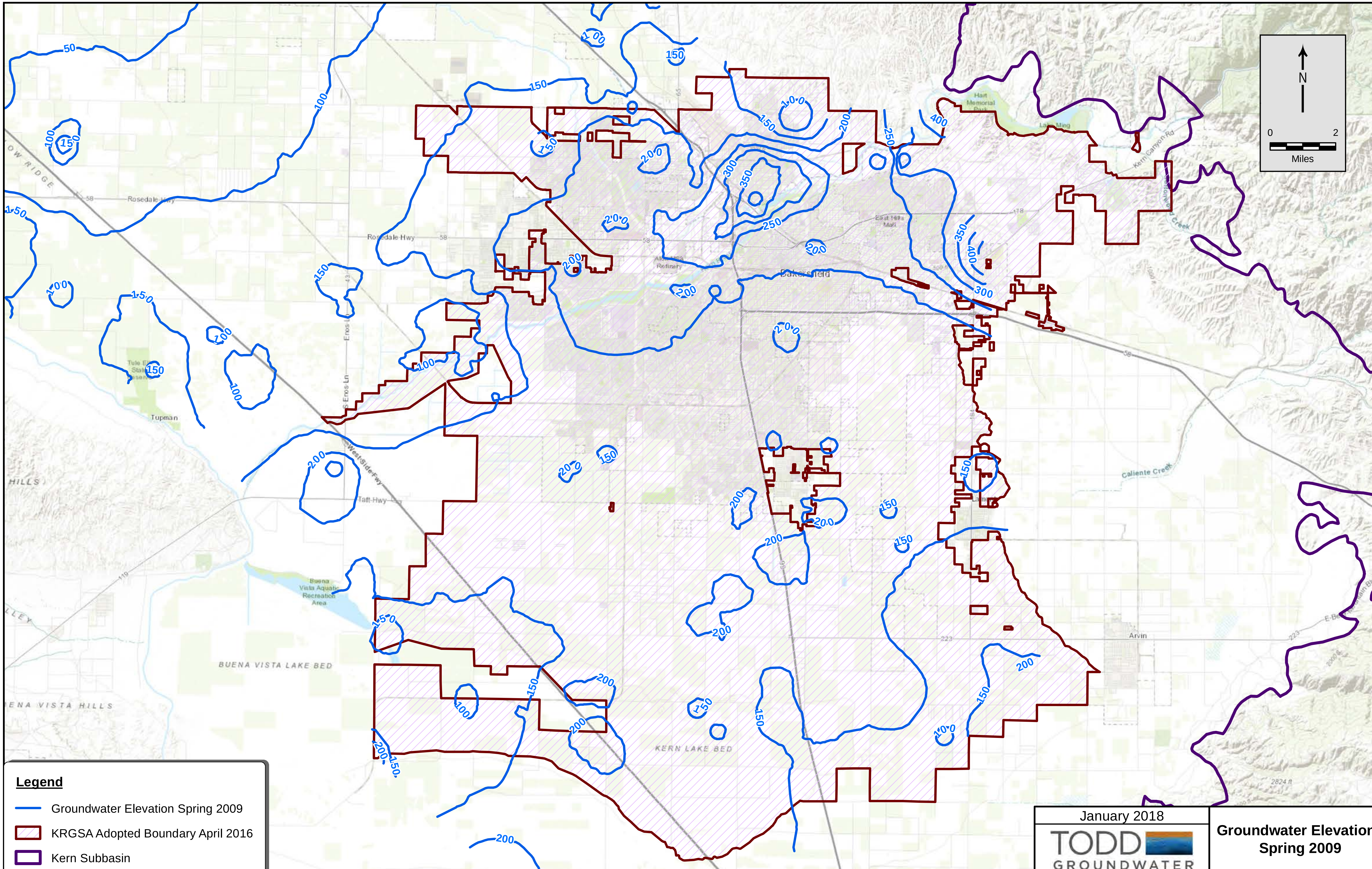


Legend
Groundwater Elevation Spring 2006
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2006
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
BUENA VISTA LAKE BED
BUENA VISTA HILLS
KERN LAKE BED
Caliente Creek
Kern Canyon Rd
Arvin
100
150
200
250
300
350

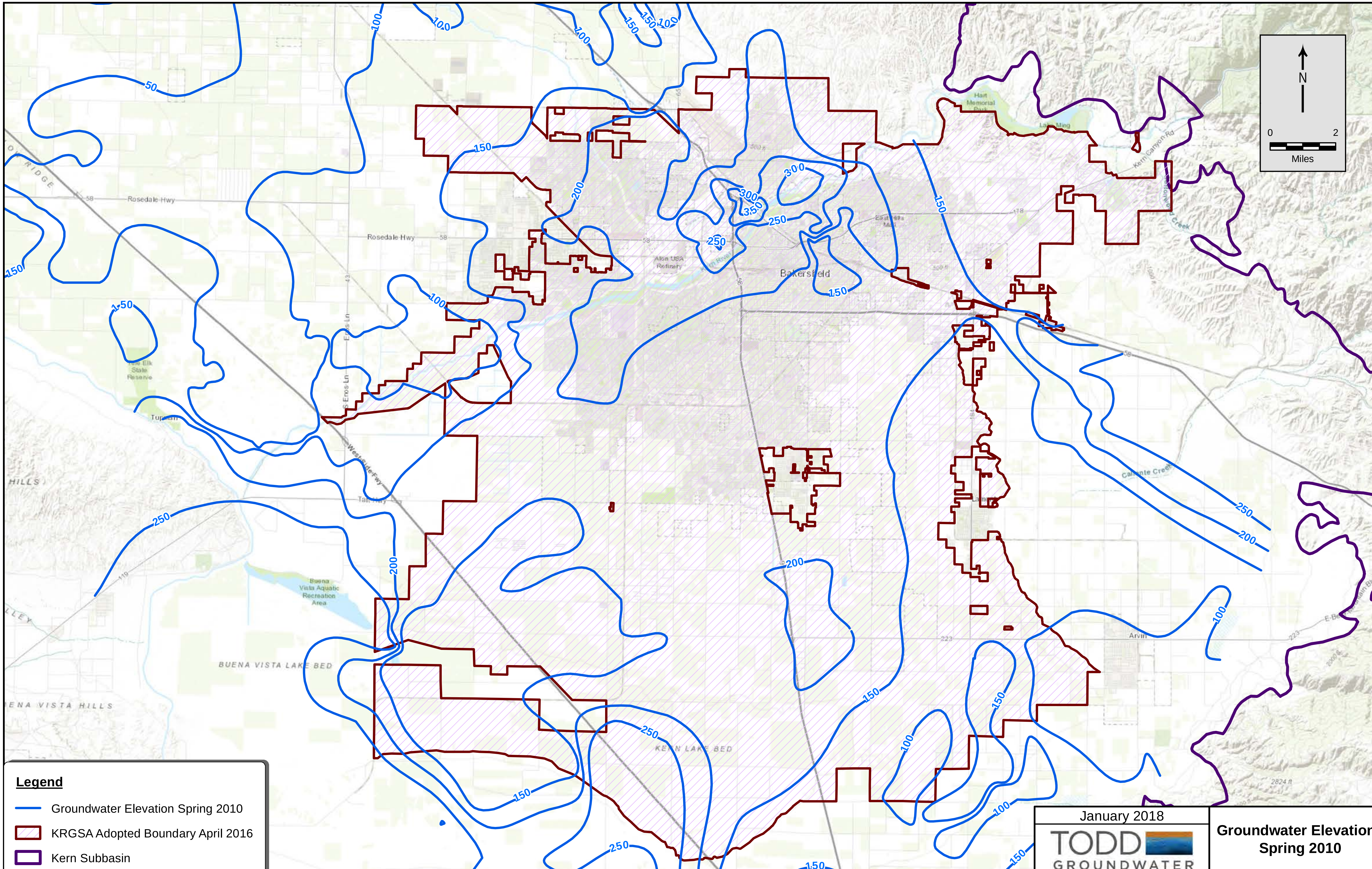


Groundwater Elevations Spring 2007


Legend
Groundwater Elevation Spring 2008
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0 2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2008
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
Arvin
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Tule Elk State Reserve
Hart Memorial Park
Kern Canyon Rd
East Hills Mall
Alon USA Refinery



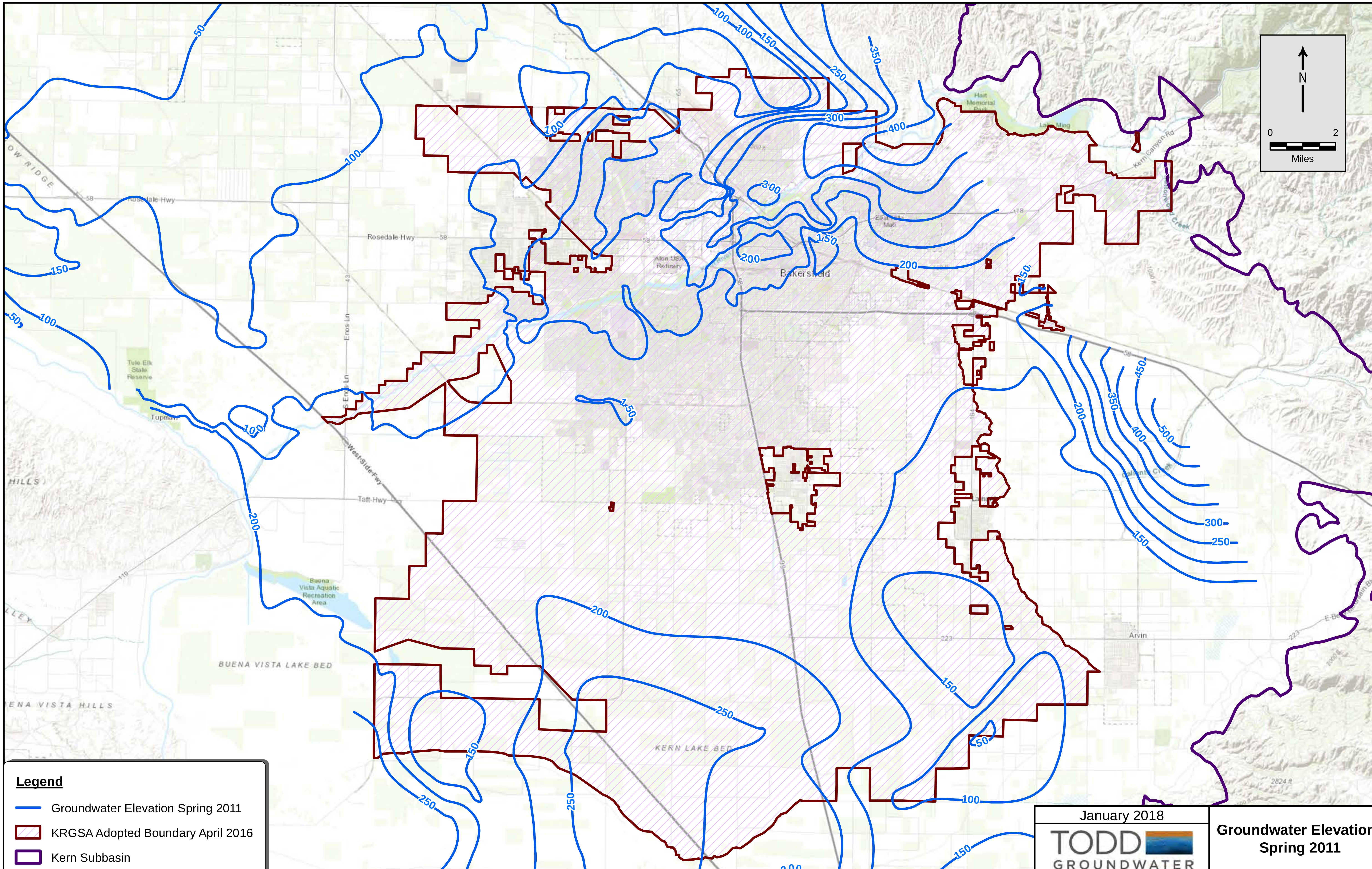
Legend
Groundwater Elevation Spring 2009
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
January 2018
TODD
GROUNDWATER
Groundwater Elevations Spring 2009
Bakersfield
Rosedale Hwy
Taft Hwy
West Side Fwy
Tupman
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
Arvin
Caliente Creek
Kern Canyon Rd
Hart Memorial Park
East Hills Mall



January 2018

TODD GROUNDWATER

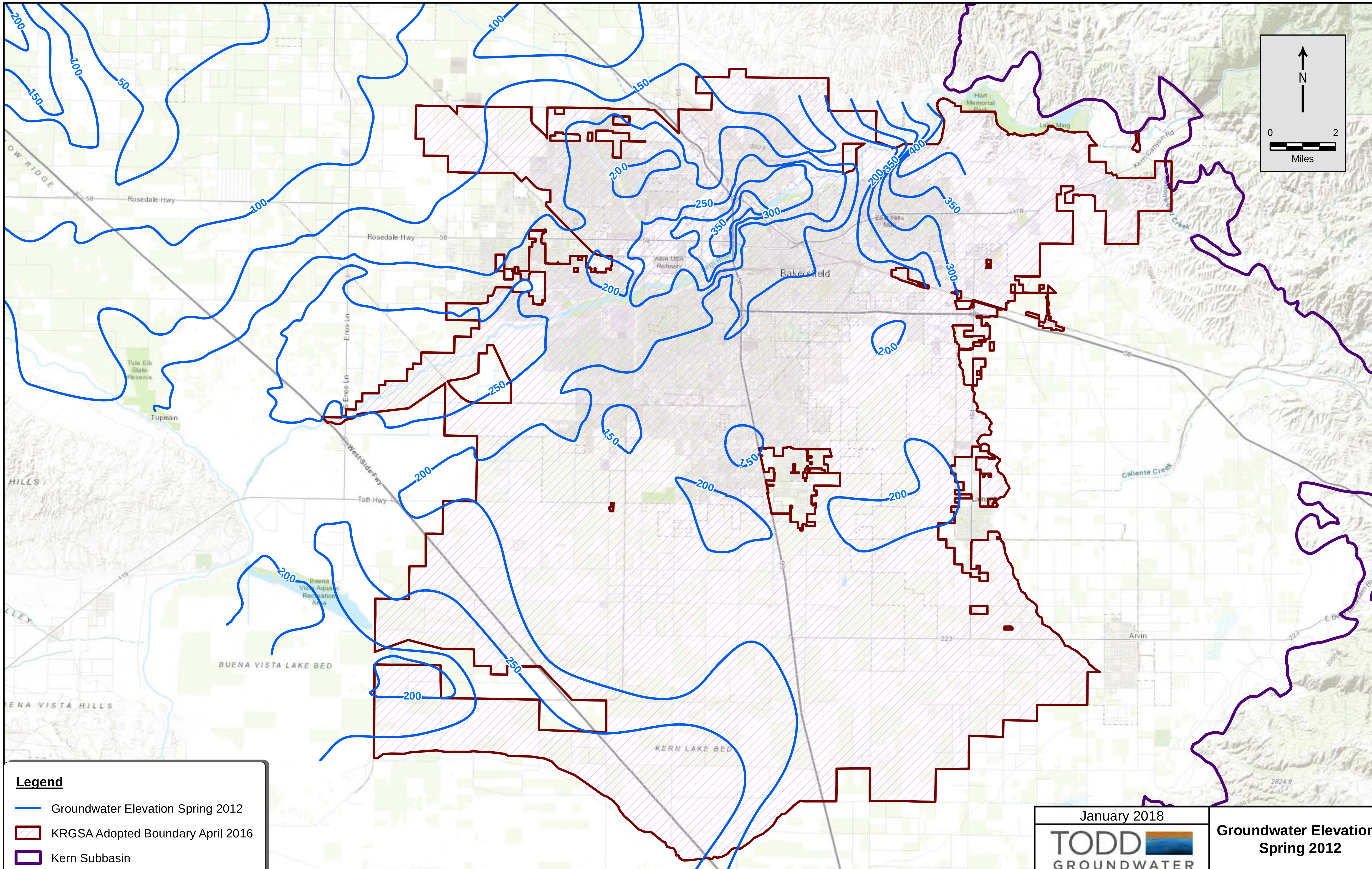
Groundwater Elevations Spring 2010

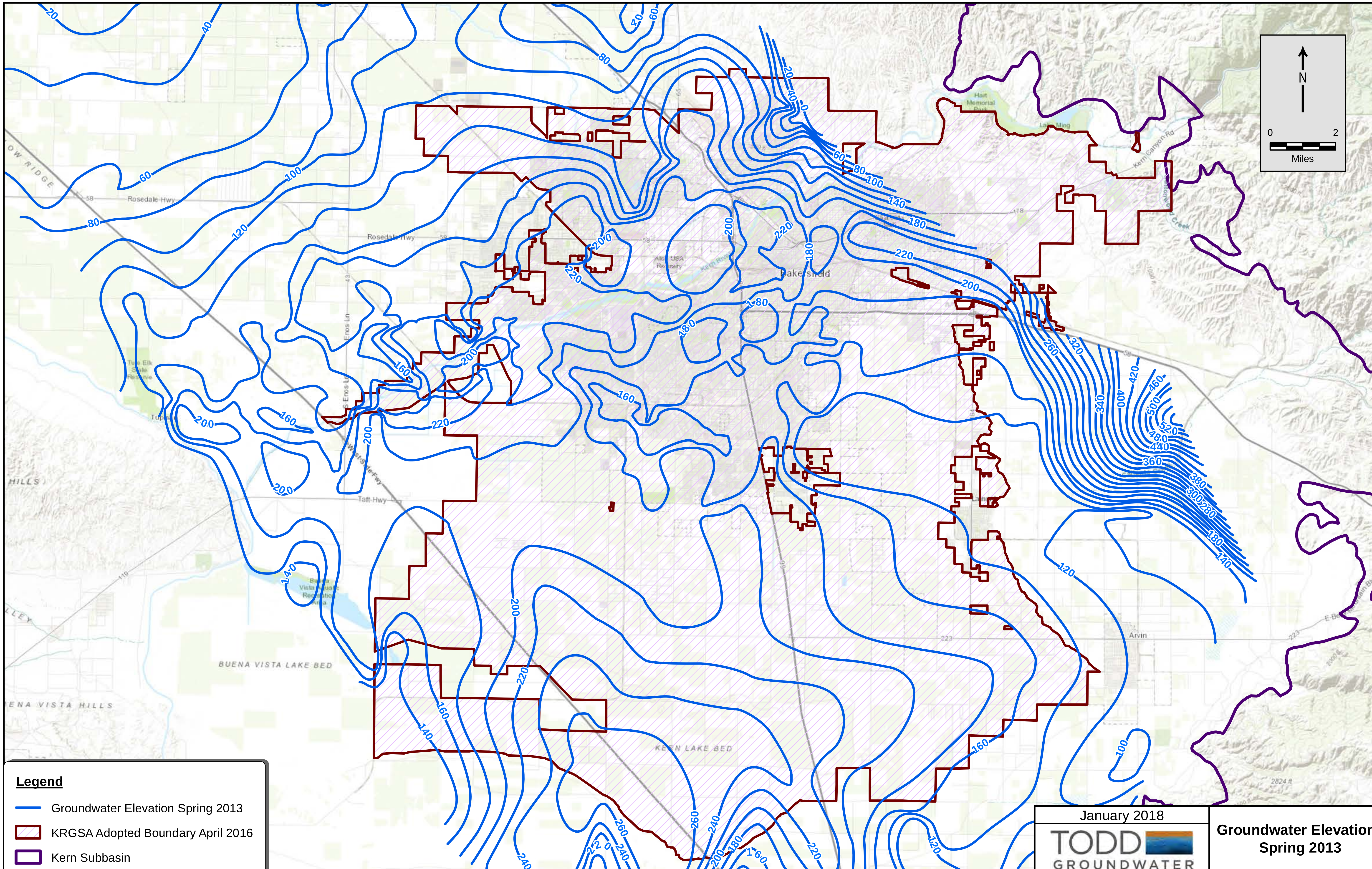


January 2018

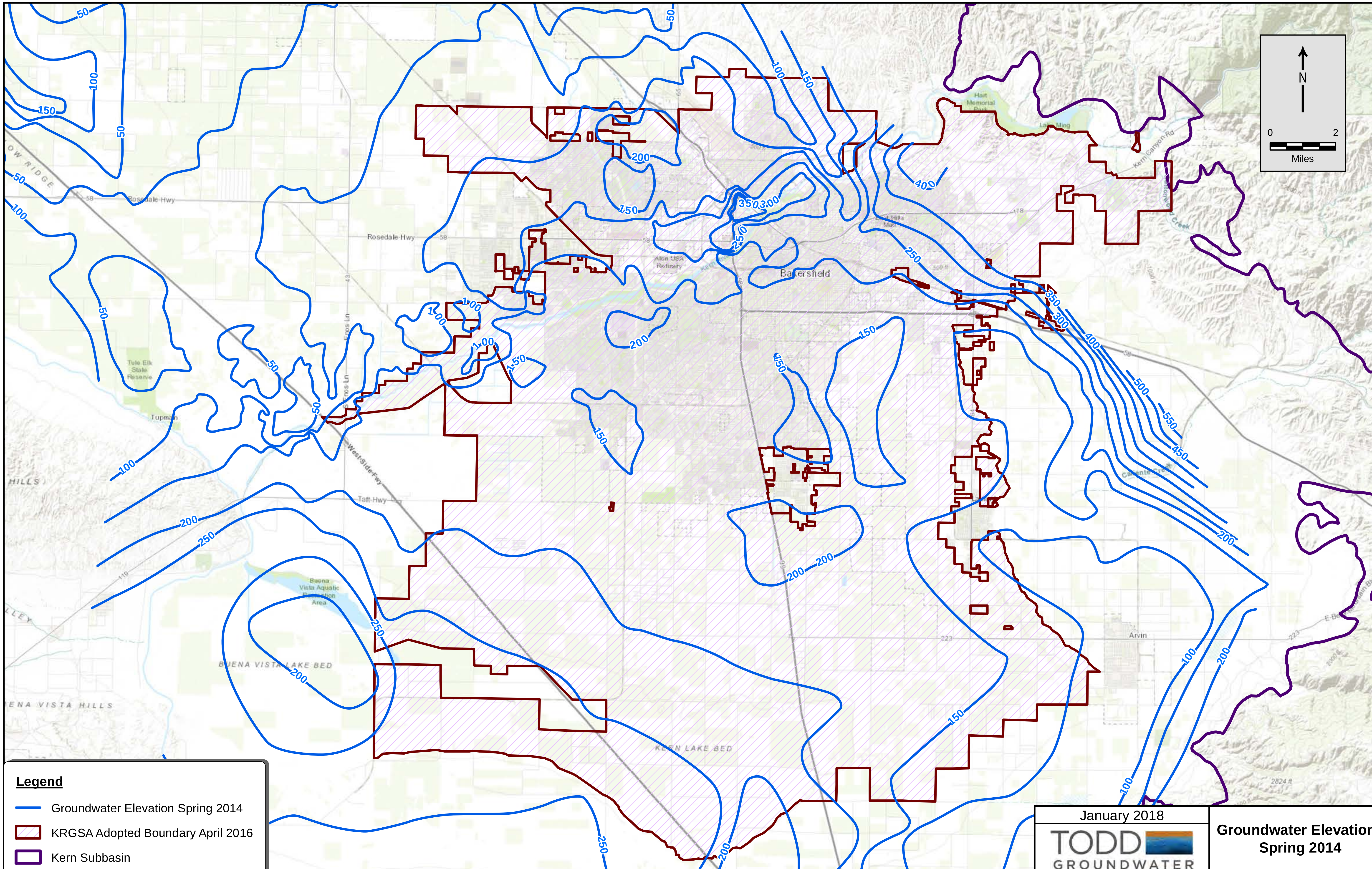
TODD GROUNDWATER

Groundwater Elevations Spring 2011


Legend
Groundwater Elevation Spring 2012
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2012
Bakersfield
Rosedale Hwy
Taft Hwy
Tupman
Arvin
Tule Elk State Reserve
BUENA VISTA LAKE BED
KERN LAKE BED
Caliente Creek
Kern Canyon Rd
West Side Fwy
Enos Ln
100
150
200
250
300
350
400
50



N
0 2
Miles
Legend
Groundwater Elevation Spring 2013
KRGSA Adopted Boundary April 2016
Kern Subbasin
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2013
Bakersfield
Rosedale Hwy
Taft Hwy
Arvin
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Hart Memorial Park
Kern Canyon Rd
Enos Ln



Legend
Groundwater Elevation Spring 2014
KRGSA Adopted Boundary April 2016
Kern Subbasin
N
0
2
Miles
January 2018
TODD GROUNDWATER
Groundwater Elevations Spring 2014
Bakersfield
Arvin
Tupman
Tule Elk State Reserve
Buena Vista Aquatic Recreation Area
BUENA VISTA LAKE BED
KERN LAKE BED
BUENA VISTA HILLS
Rosedale Hwy
Taft Hwy
West Side Fwy
Kern Canyon Rd
Hart Memorial Park
Alon USA Refinery

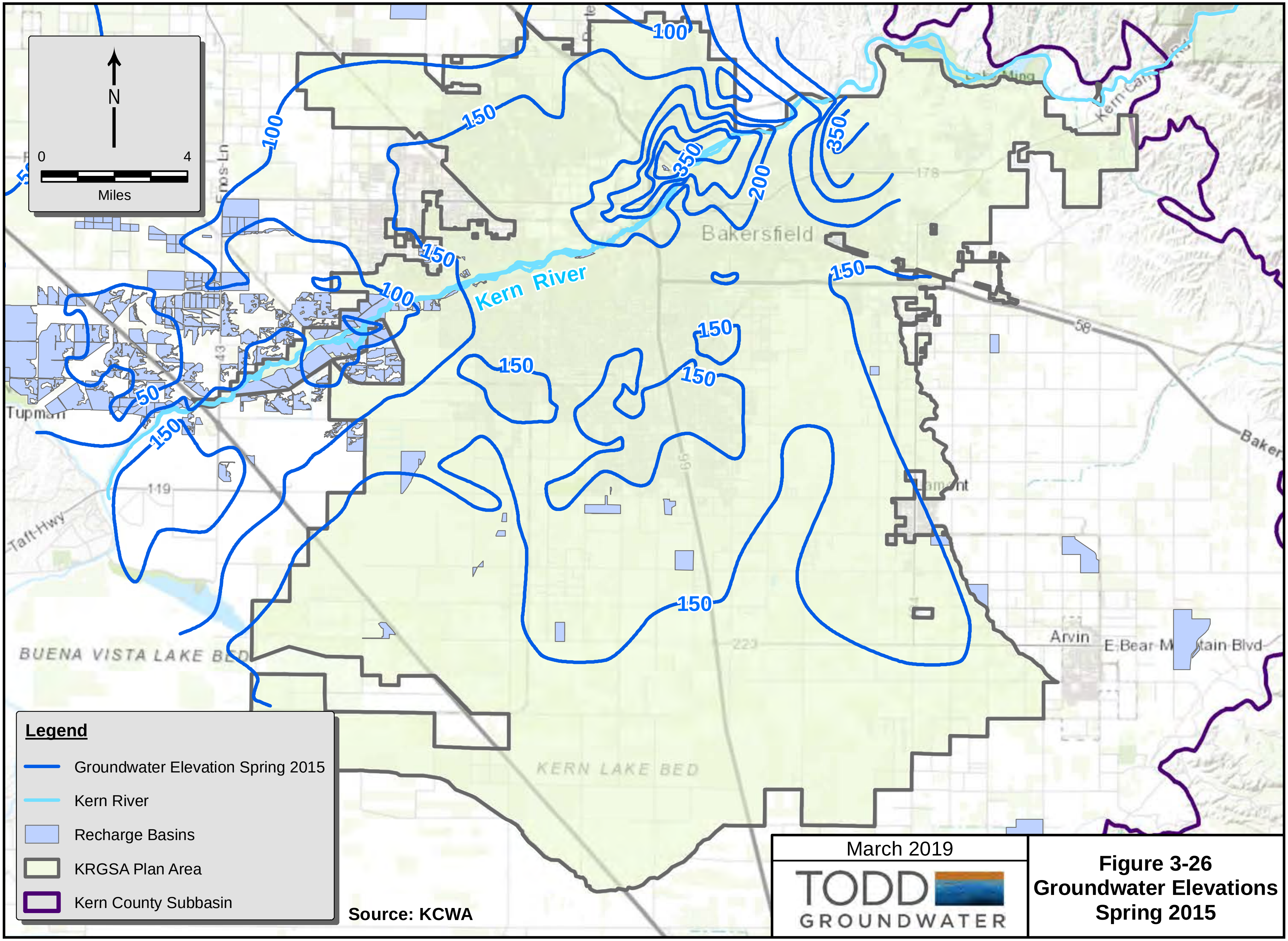
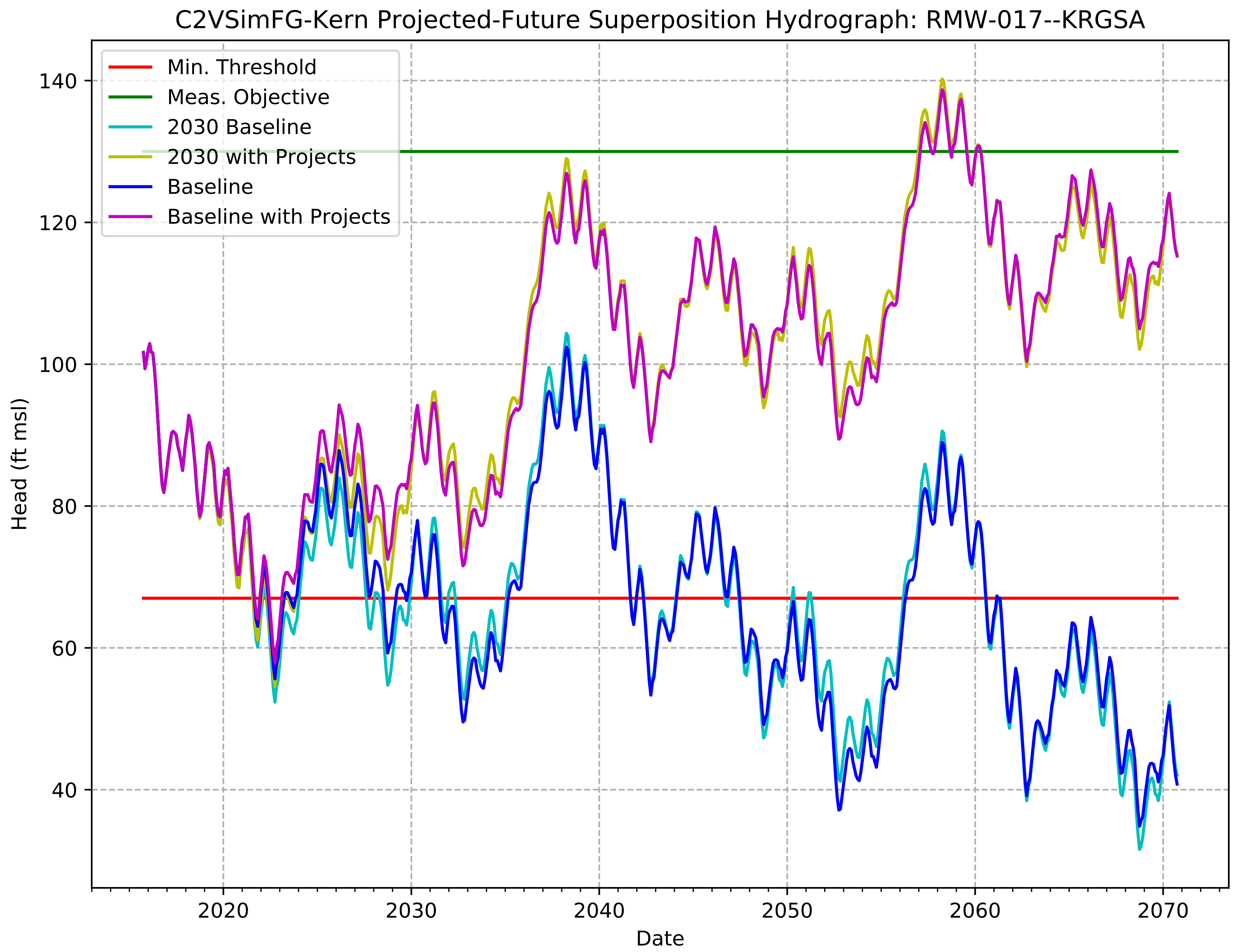
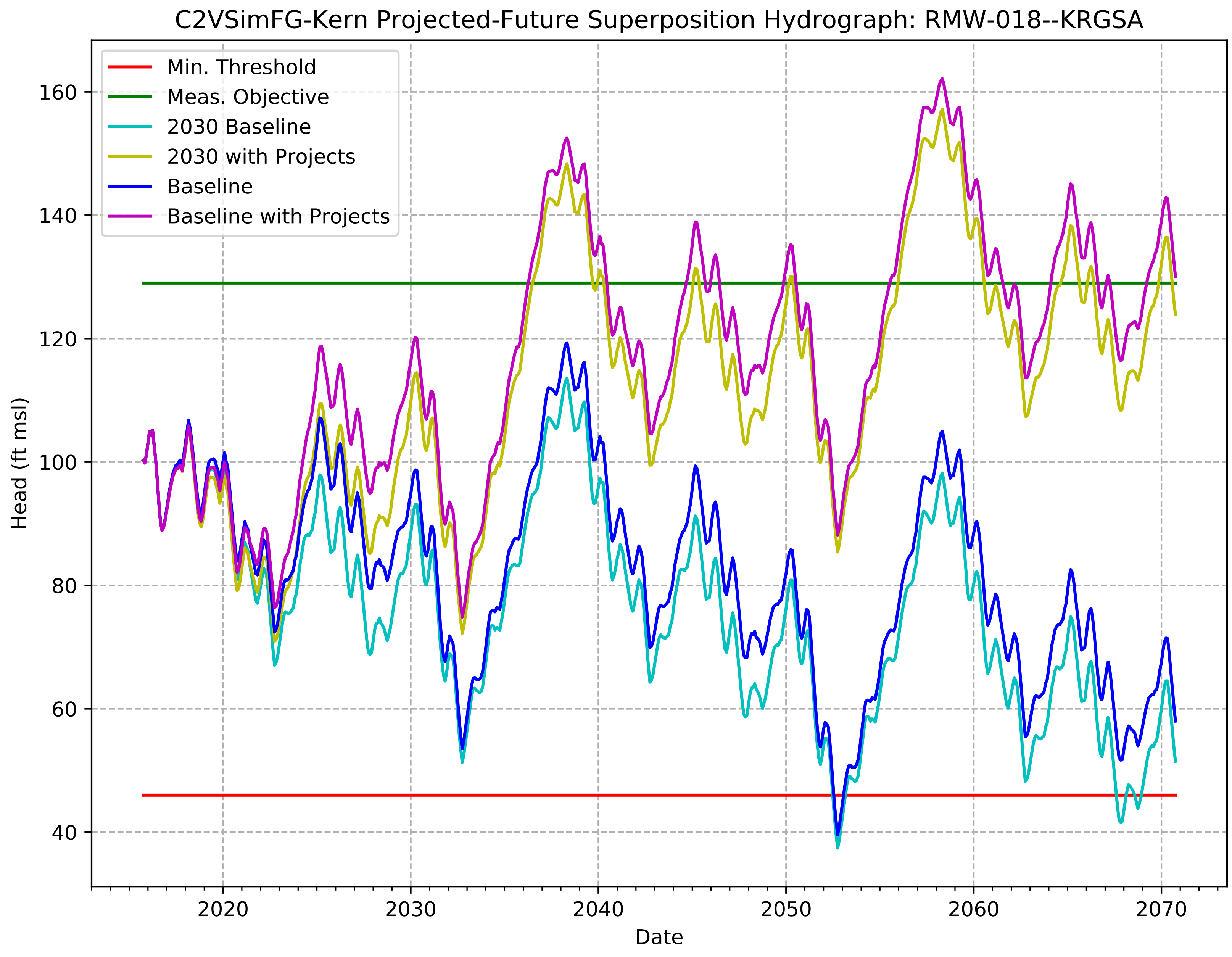


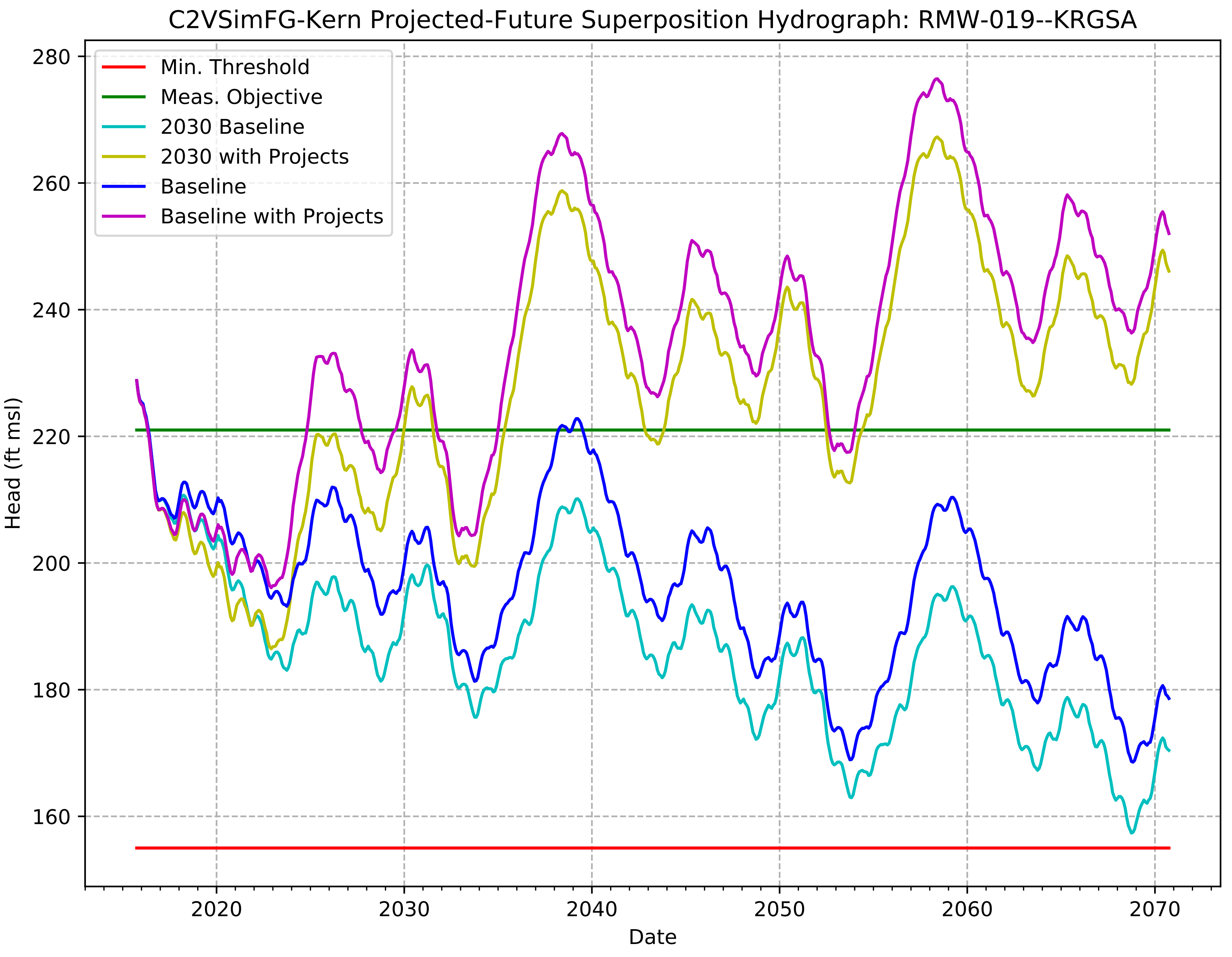
Figure 3-26
Groundwater Elevations
Spring 2015

APPENDIX H

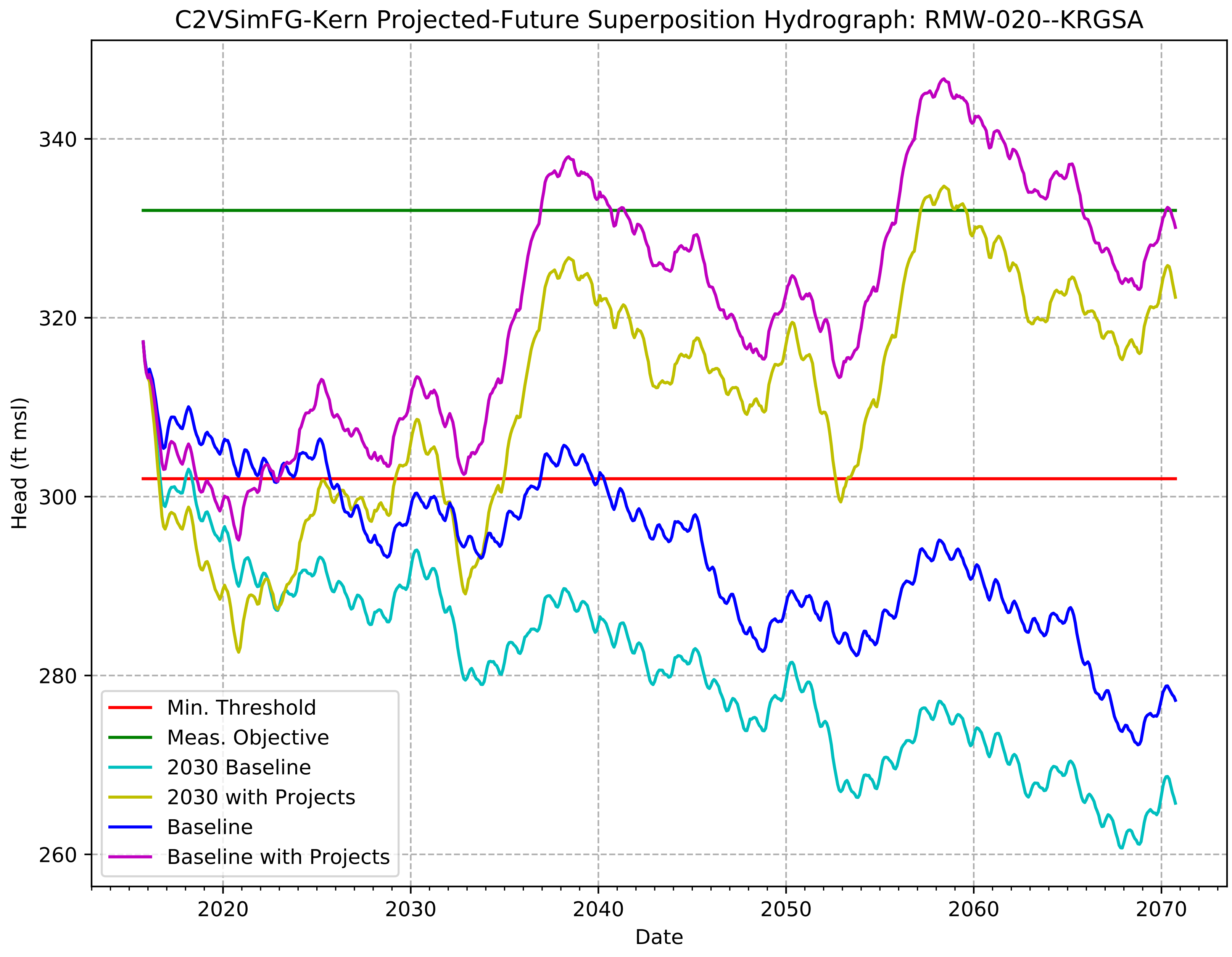
C2VSimFG-Kern Superposition Hydrographs, KRGSA Plan Area

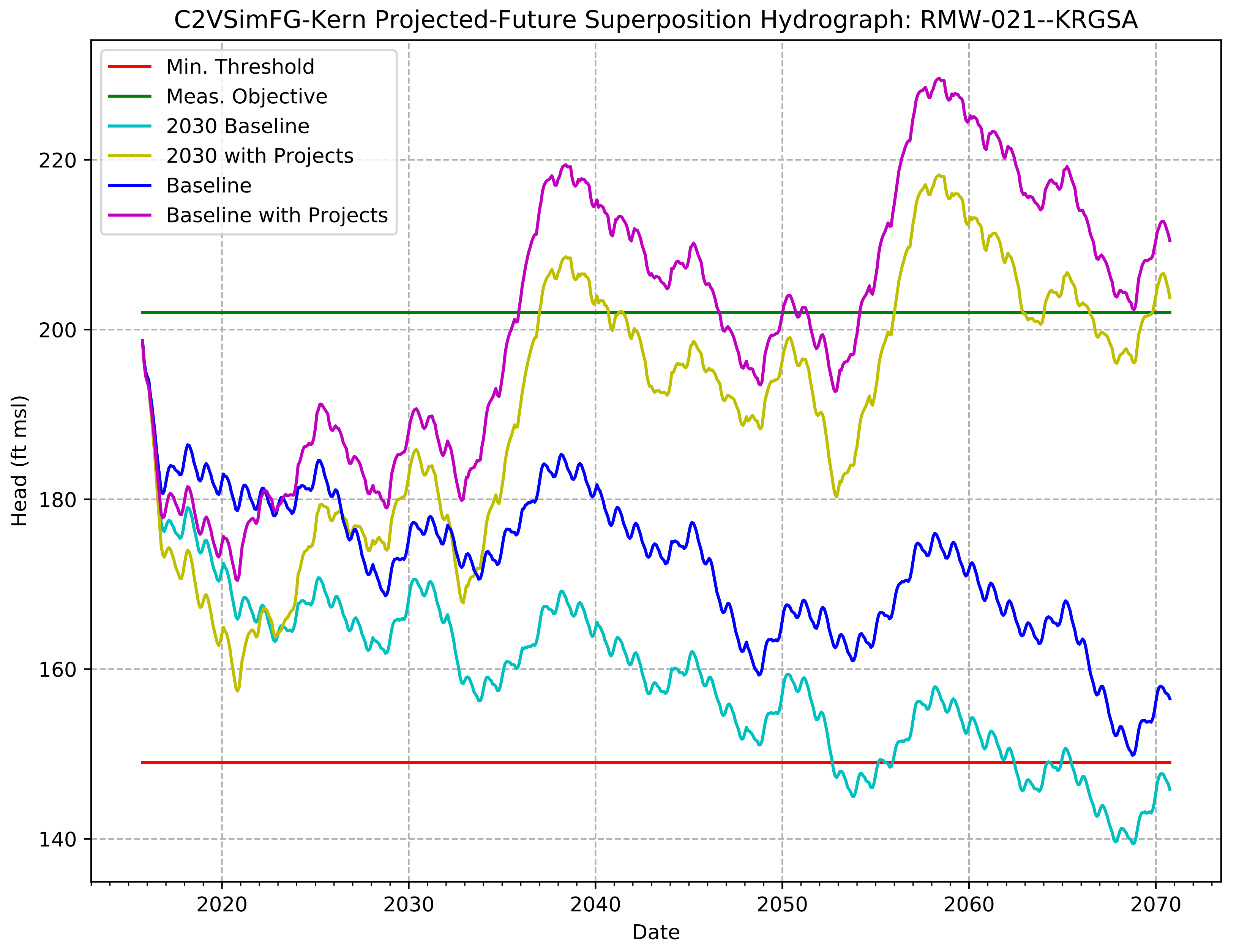

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-017--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
140
120
100
80
60
40
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-018--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
Date
40
60
80
100
120
140
160
2020
2030
2040
2050
2060
2070

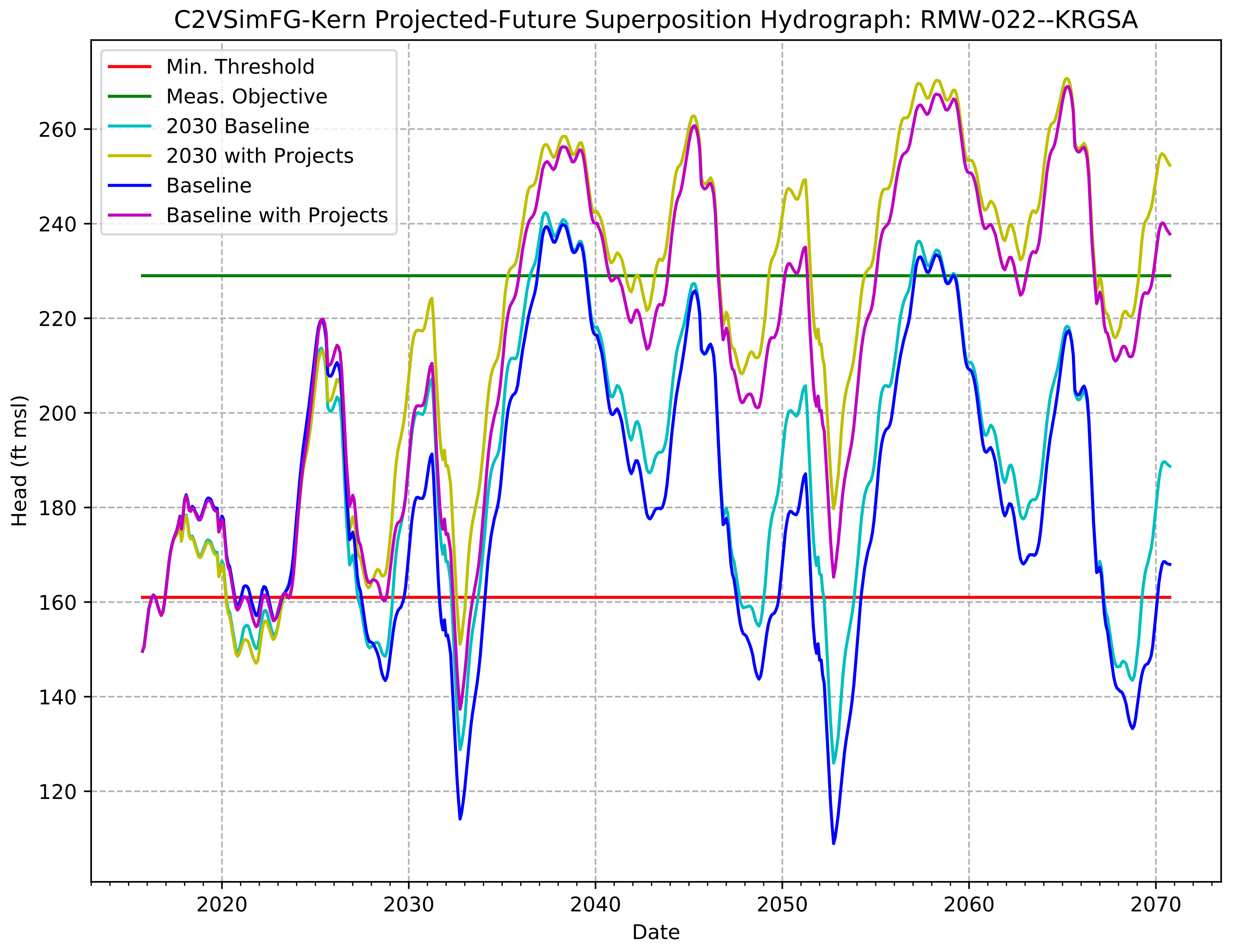


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-019--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
280
260
240
220
200
180
160
2020
2030
2040
2050
2060
2070
Date

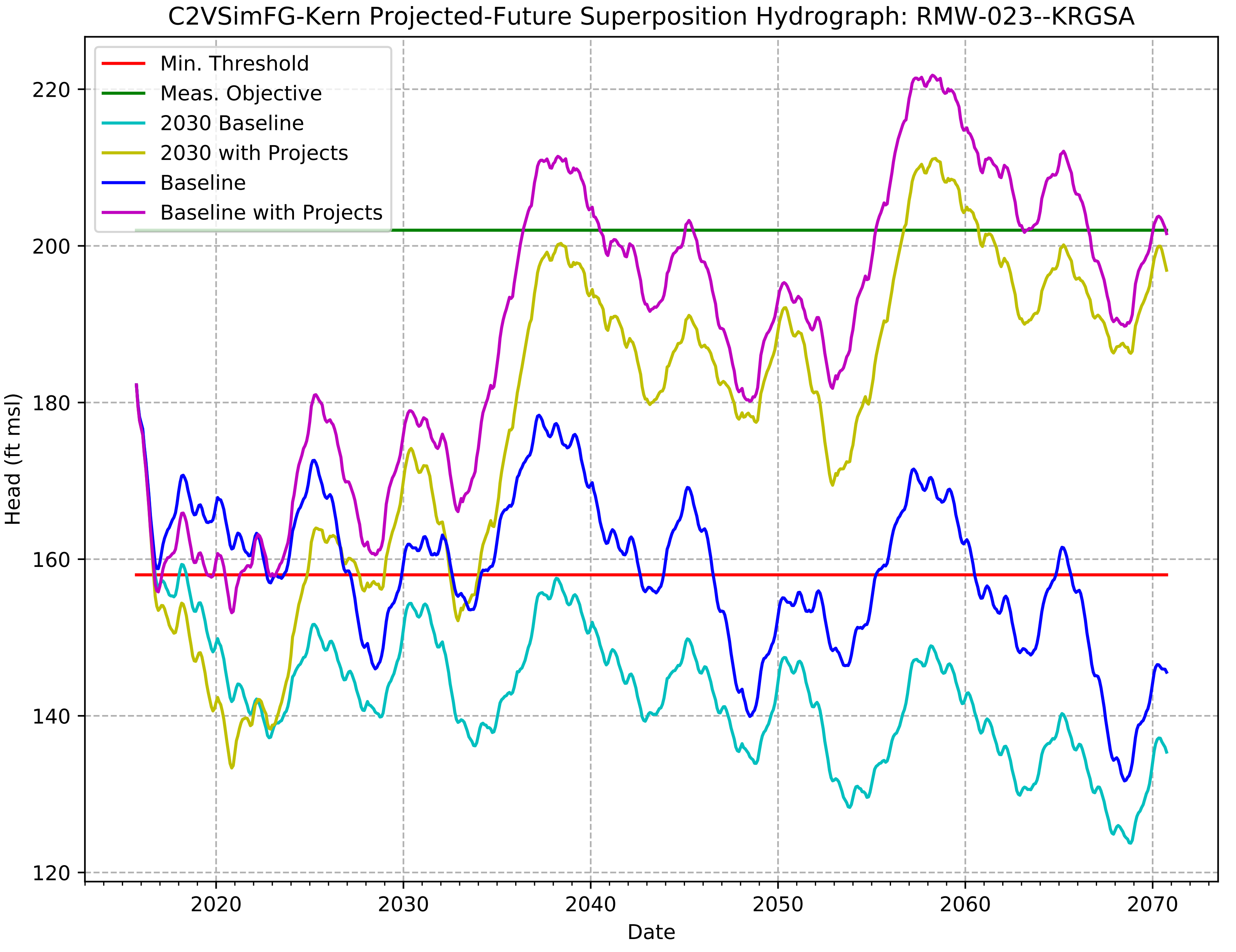

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-020--KRGSA
Head (ft msl)
340
320
300
280
260
2020
2030
2040
2050
2060
2070
Date
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects



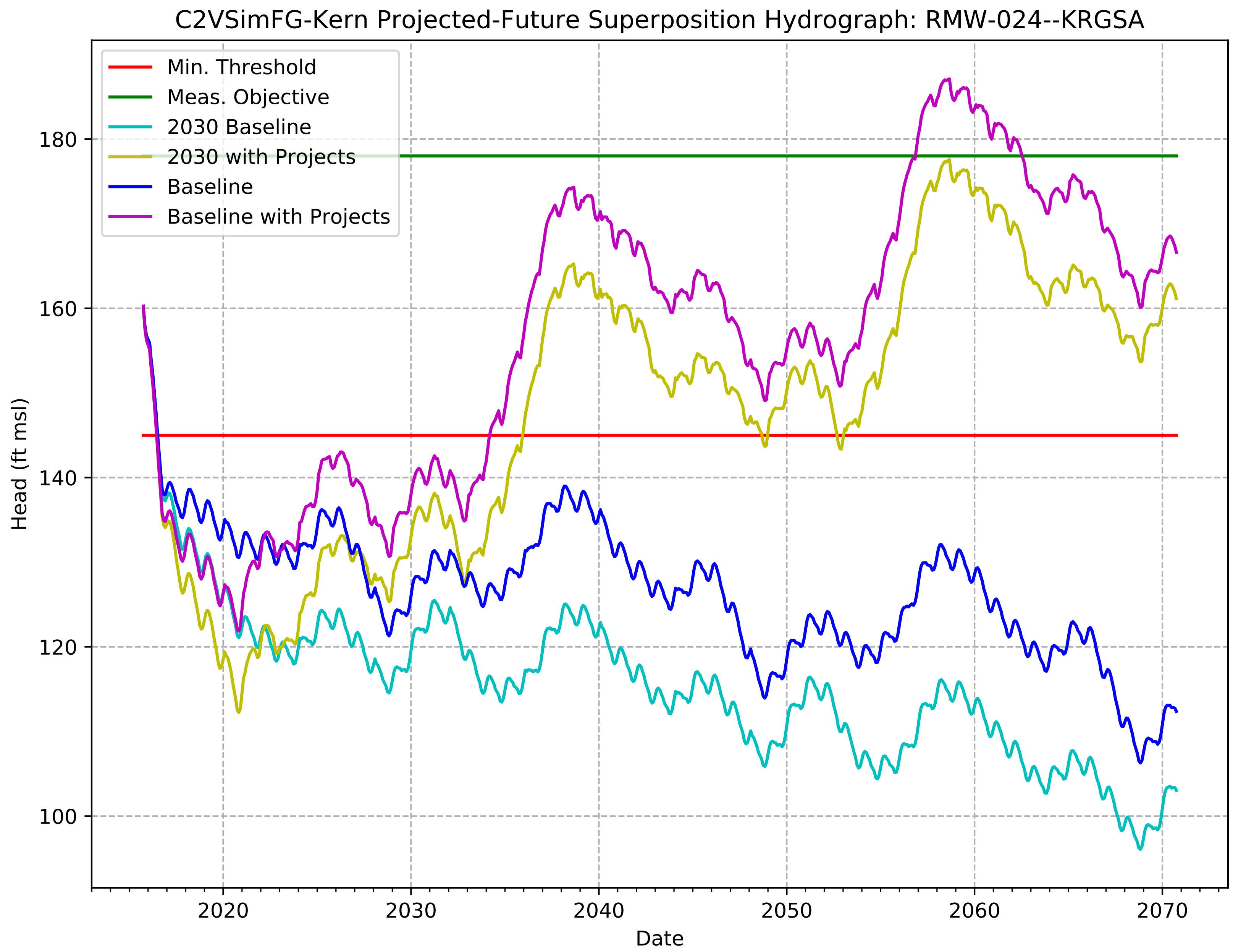
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-021--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
220
200
180
160
140
2020
2030
2040
2050
2060
2070
Date



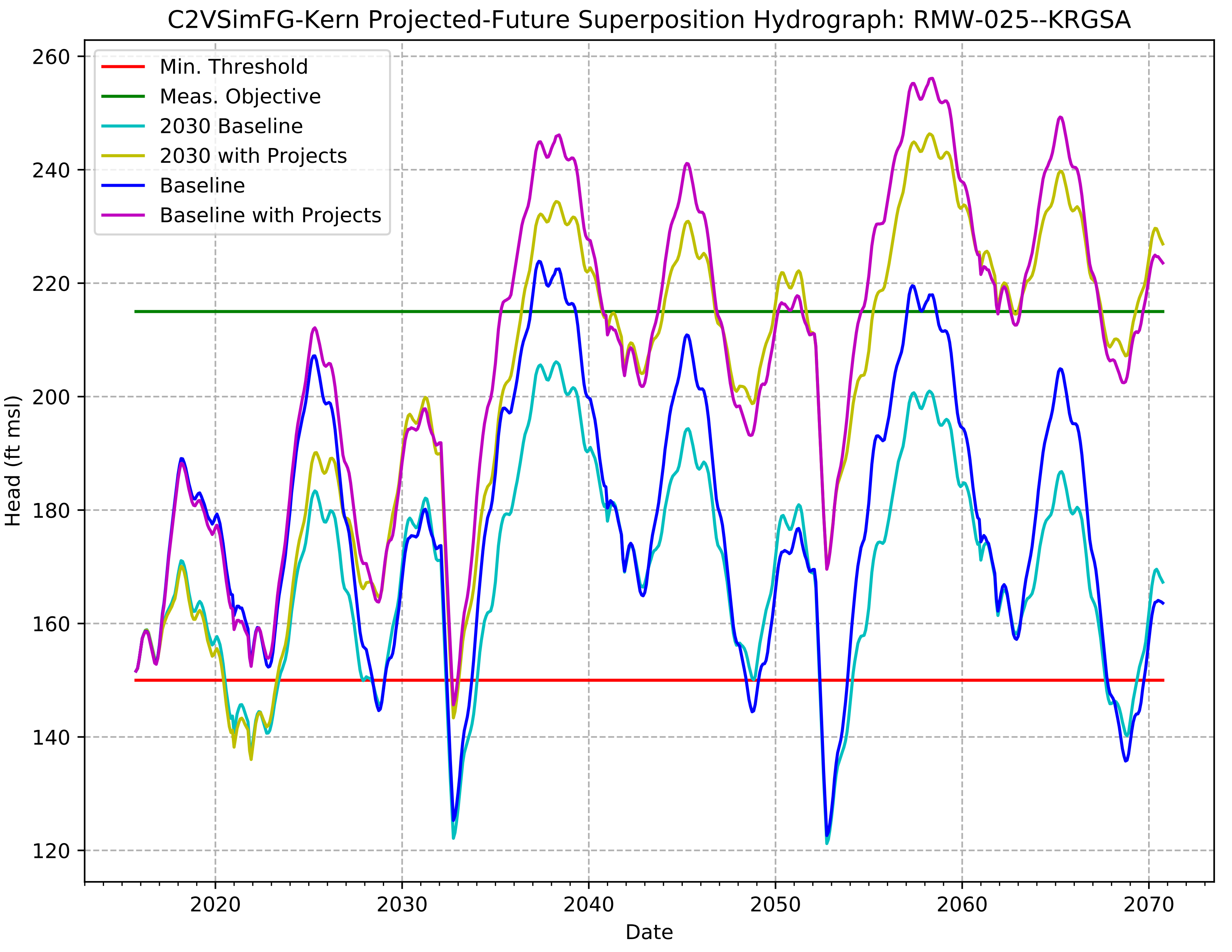
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-022--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
260
240
220
200
180
160
140
120
2020
2030
2040
2050
2060
2070
Date



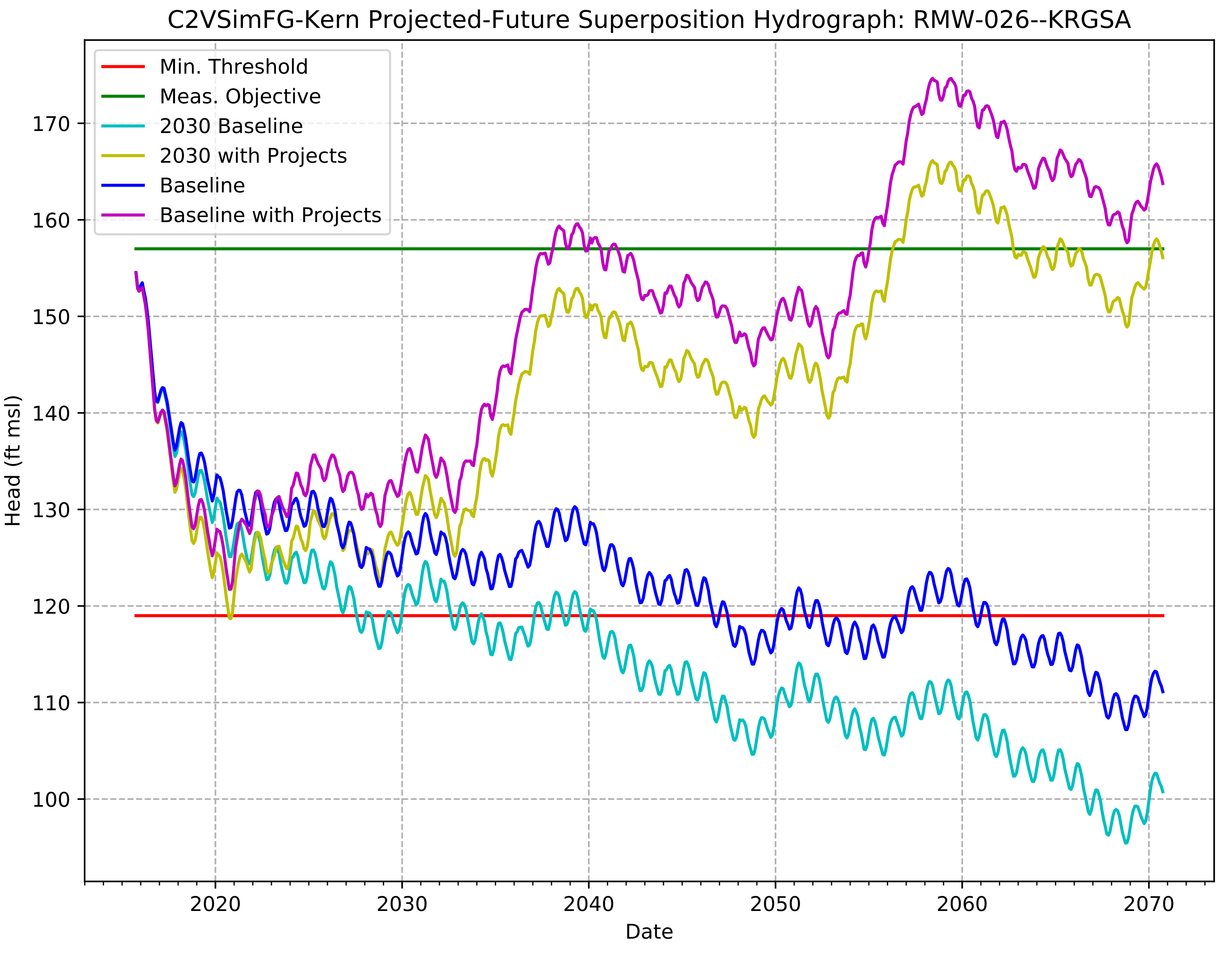
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-023--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
220
200
180
160
140
120
2020
2030
2040
2050
2060
2070
Date



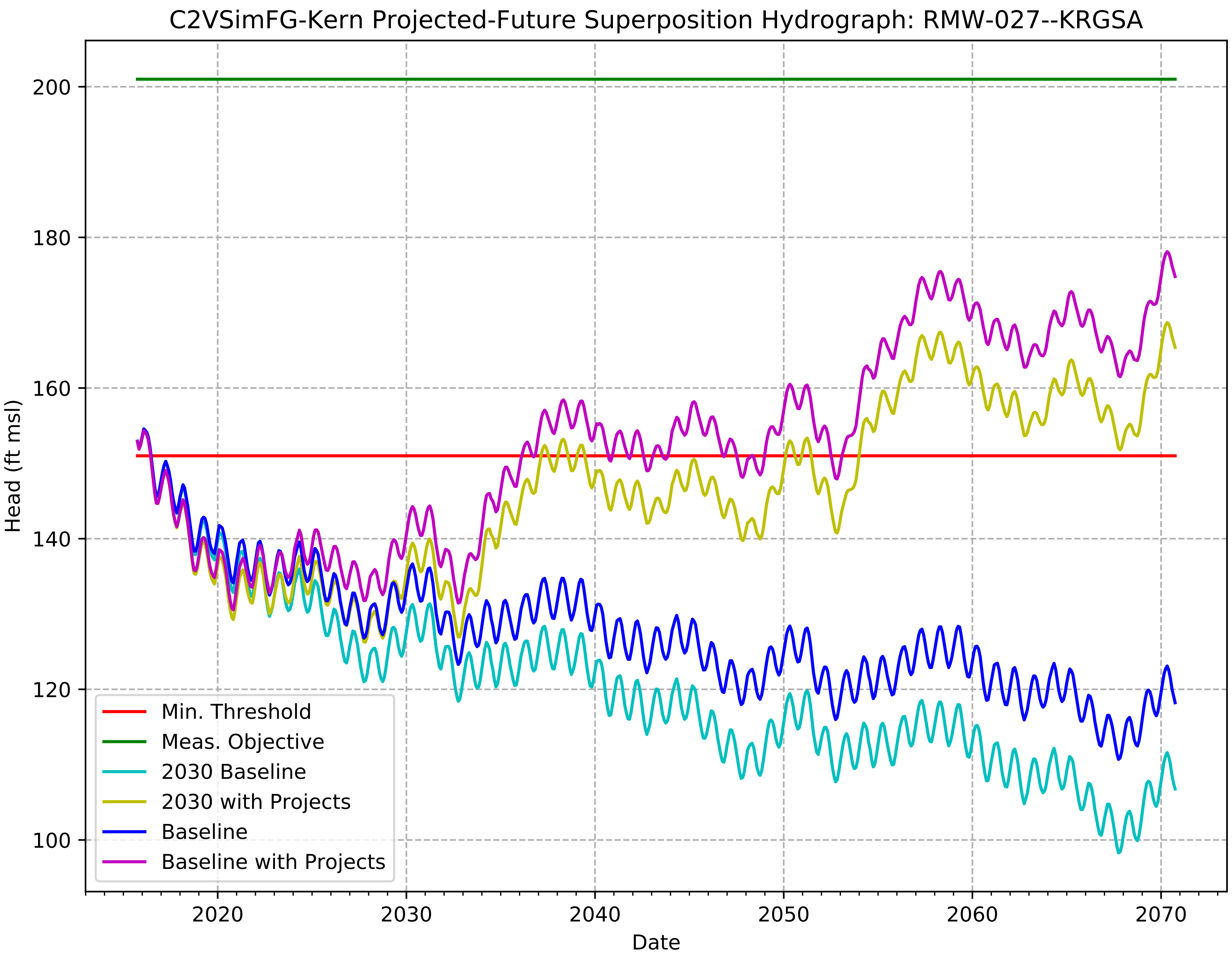
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-024--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
180
160
140
120
100
2020
2030
2040
2050
2060
2070
Date



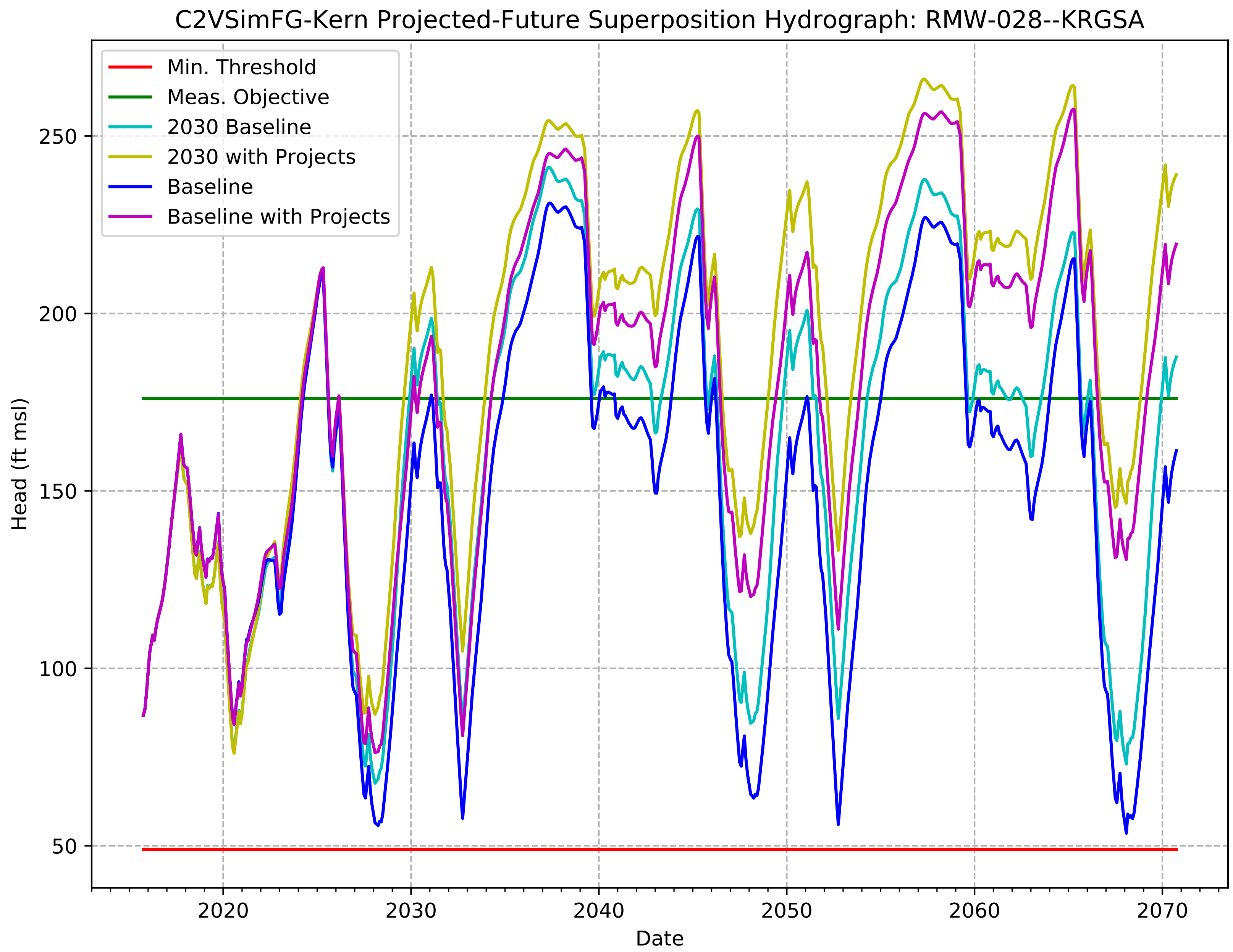
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-025--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
260
240
220
200
180
160
140
120
2020
2030
2040
2050
2060
2070
Date



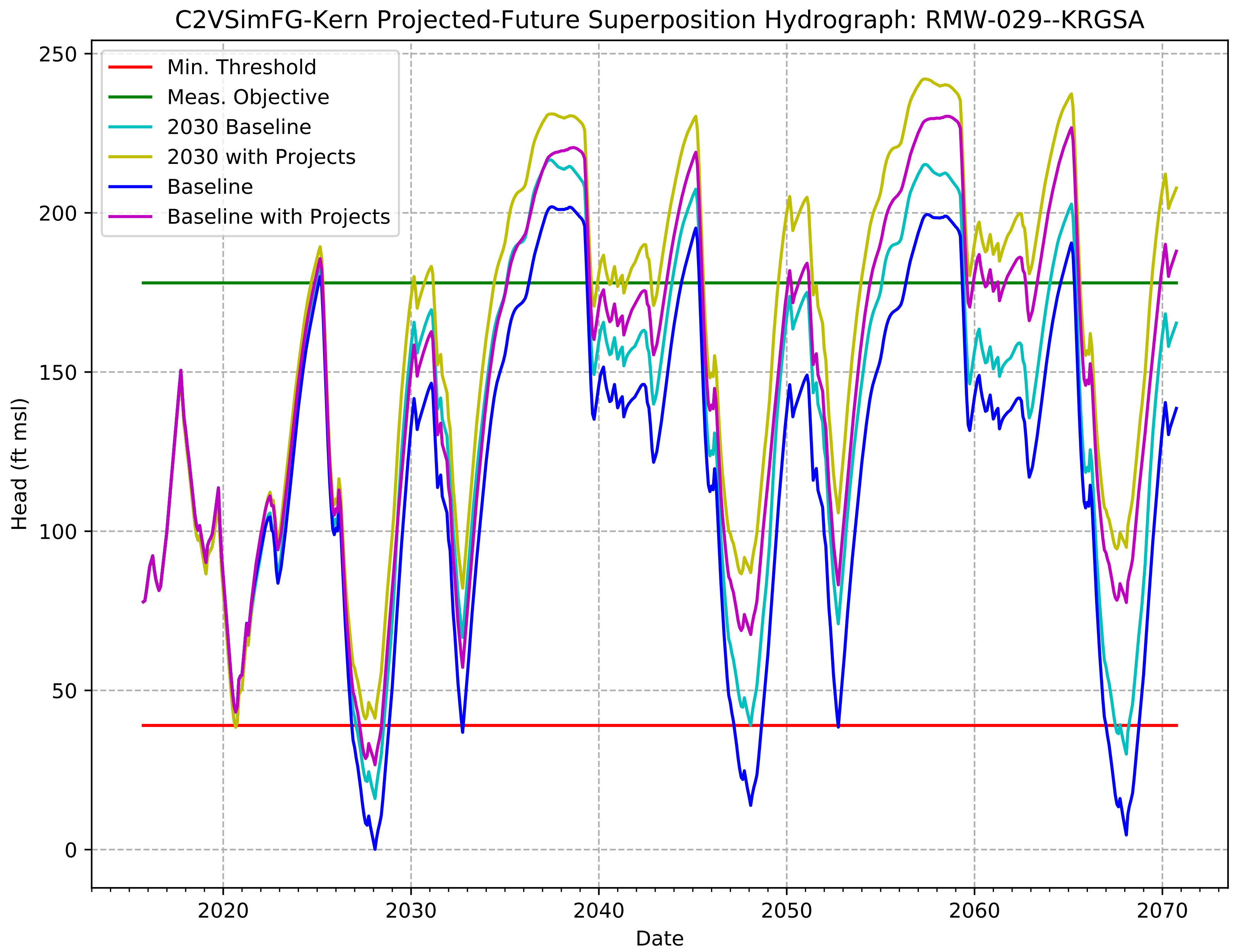
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-026--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
100
110
120
130
140
150
160
170
Date
2020
2030
2040
2050
2060
2070



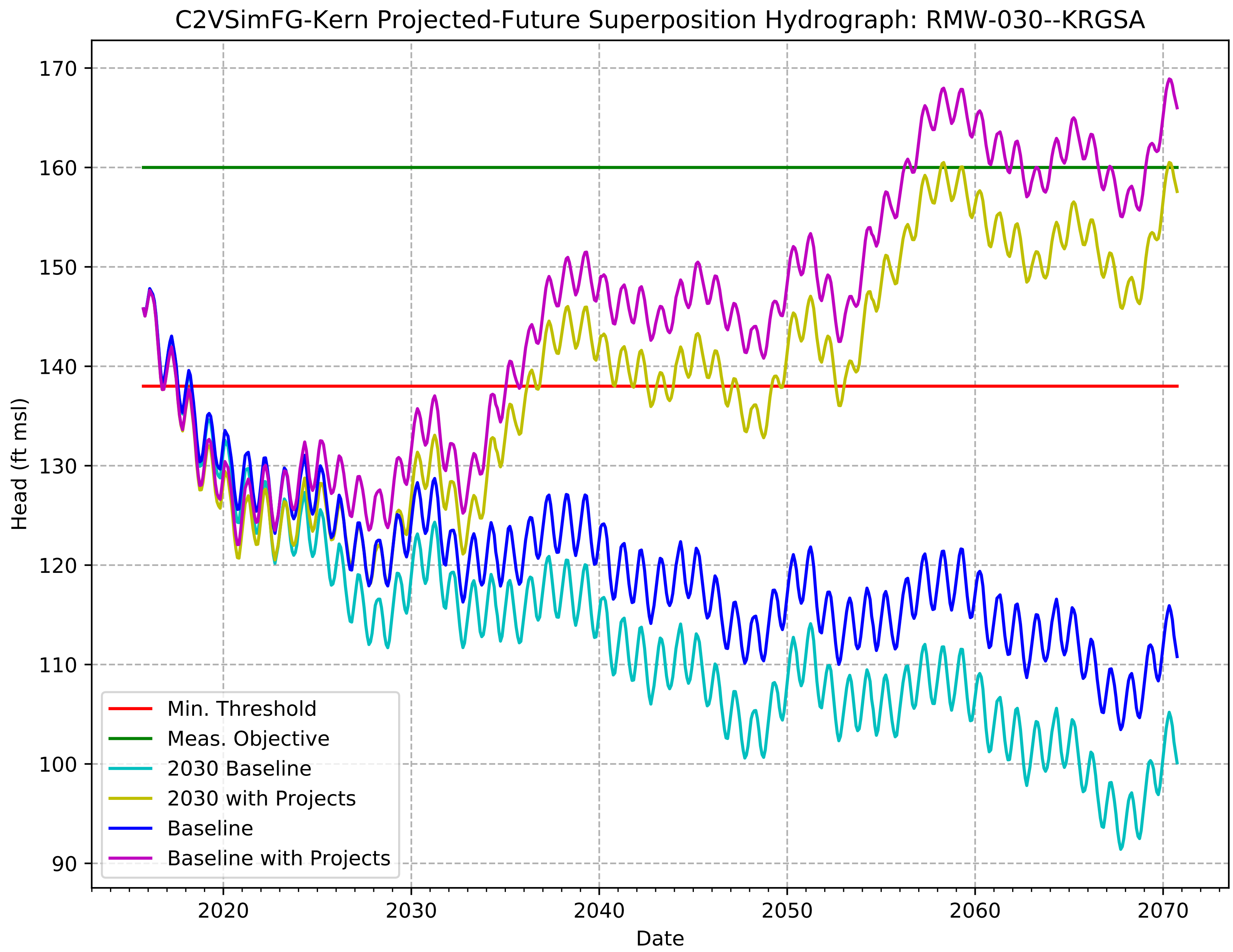
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-027--KRGSA
Head (ft msl)
200
180
160
140
120
100
2020
2030
2040
2050
2060
2070
Date
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects

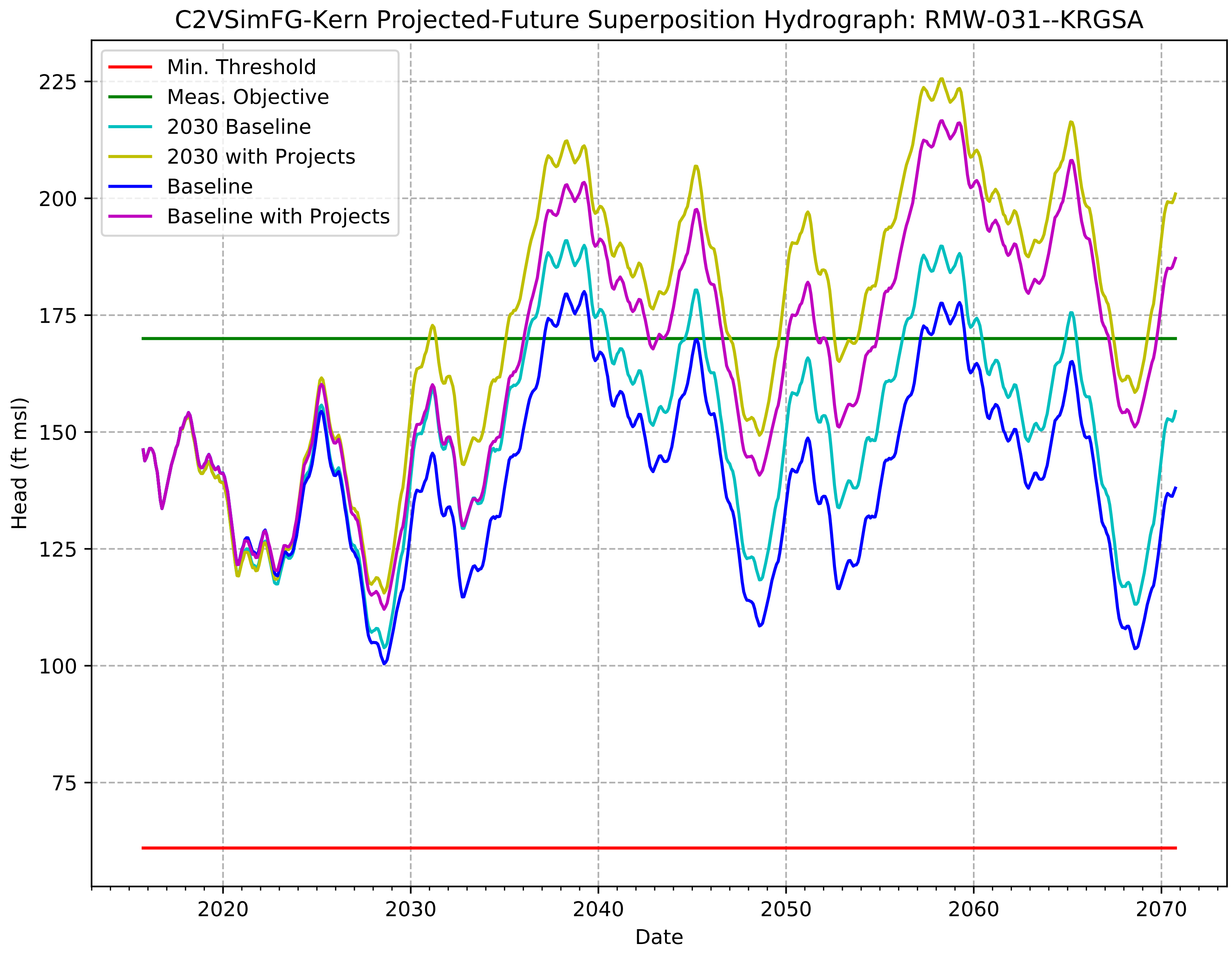


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-028--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
250
200
150
100
50
2020
2030
2040
2050
2060
2070
Date

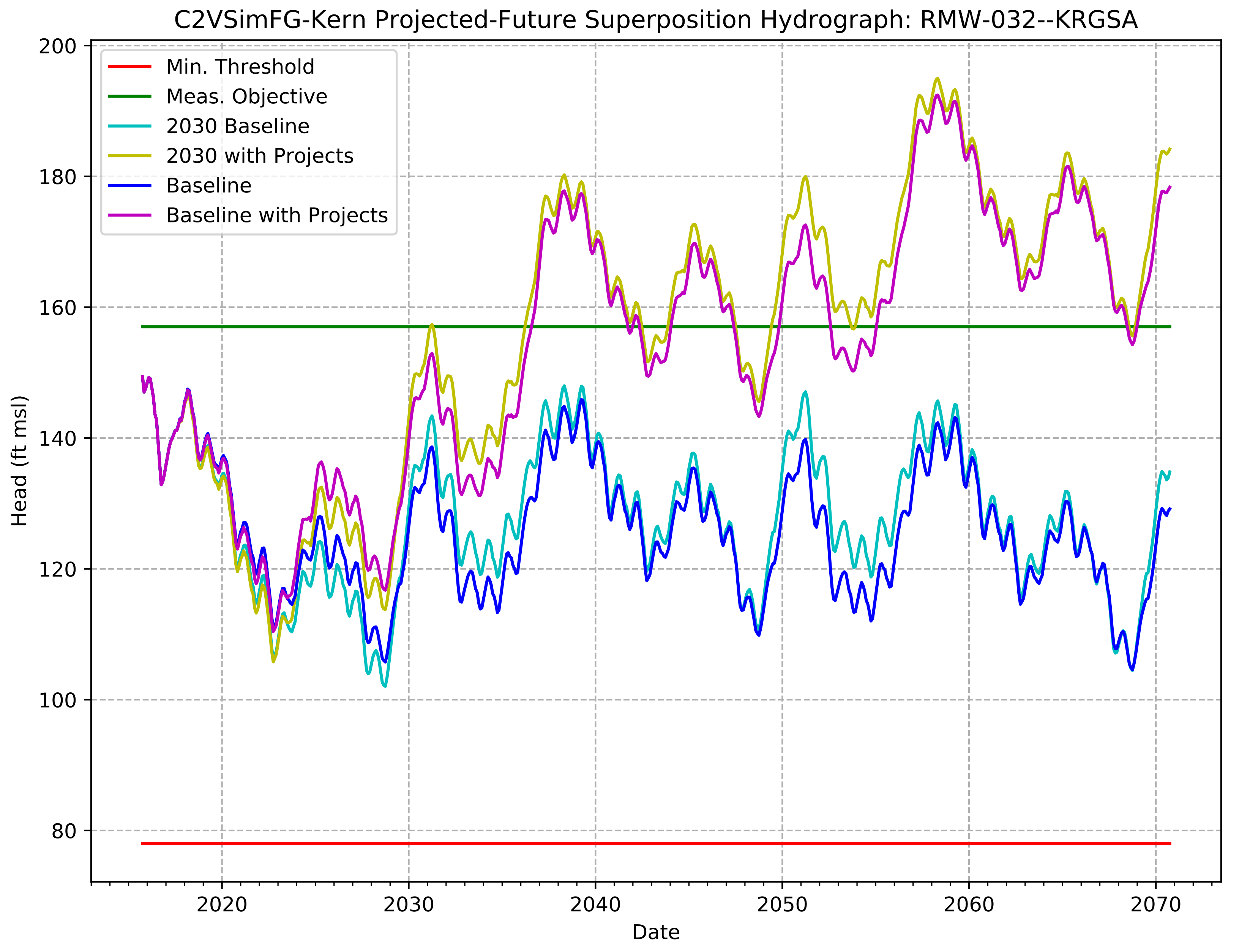


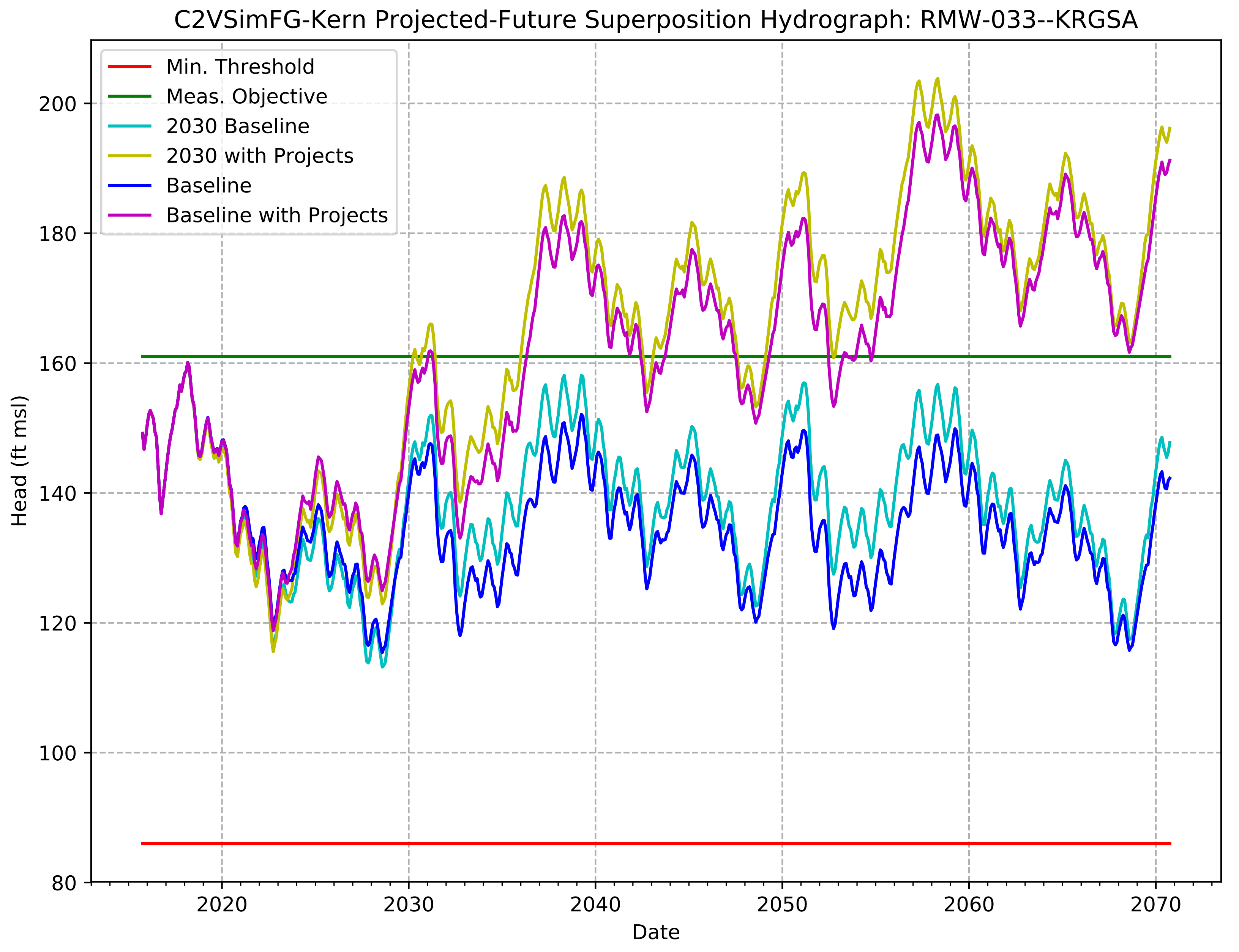
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-029--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
Date
0
50
100
150
200
250
2020
2030
2040
2050
2060
2070

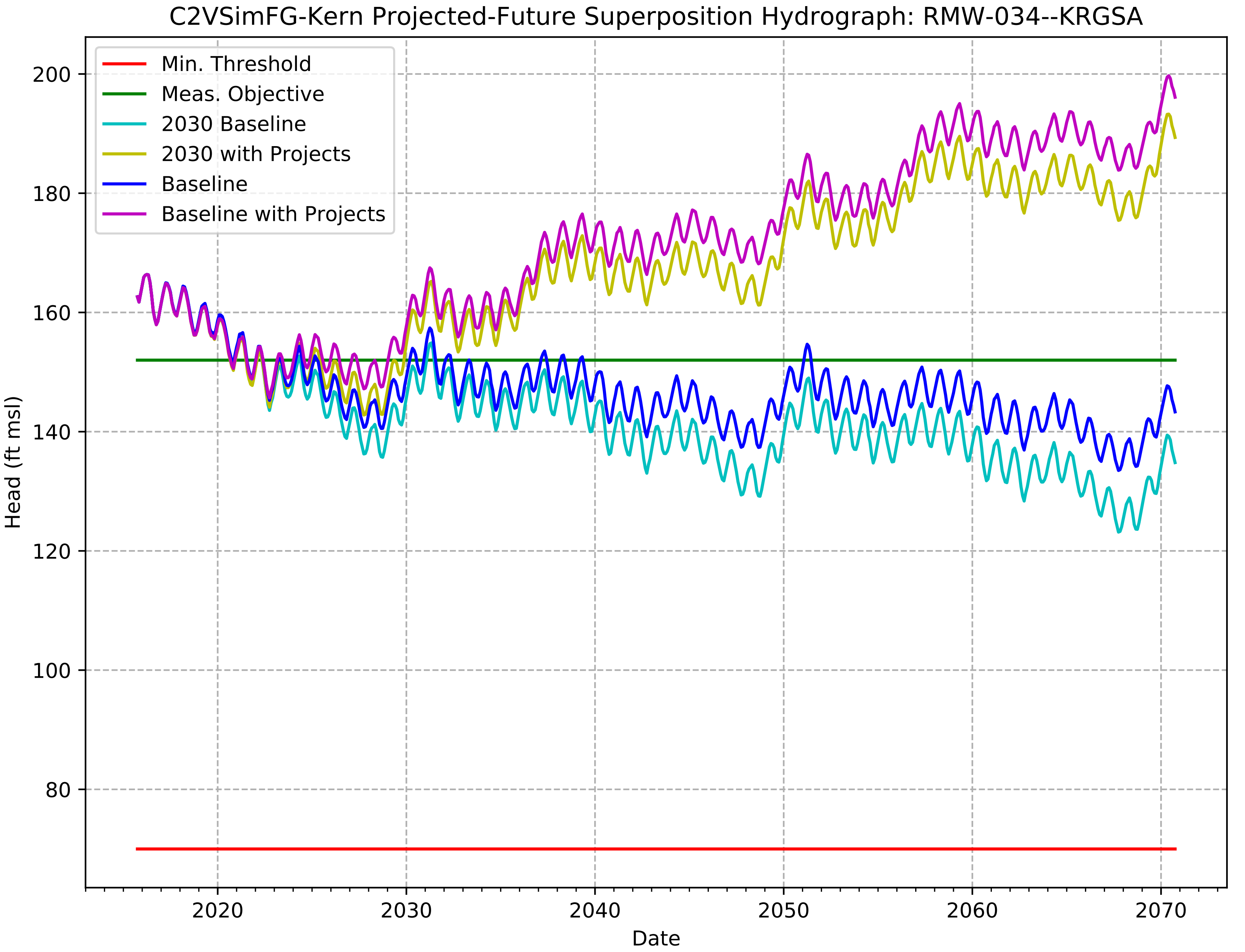

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-030--KRGSA
Head (ft msl)
170
160
150
140
130
120
110
100
90
Date
2020
2030
2040
2050
2060
2070
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects



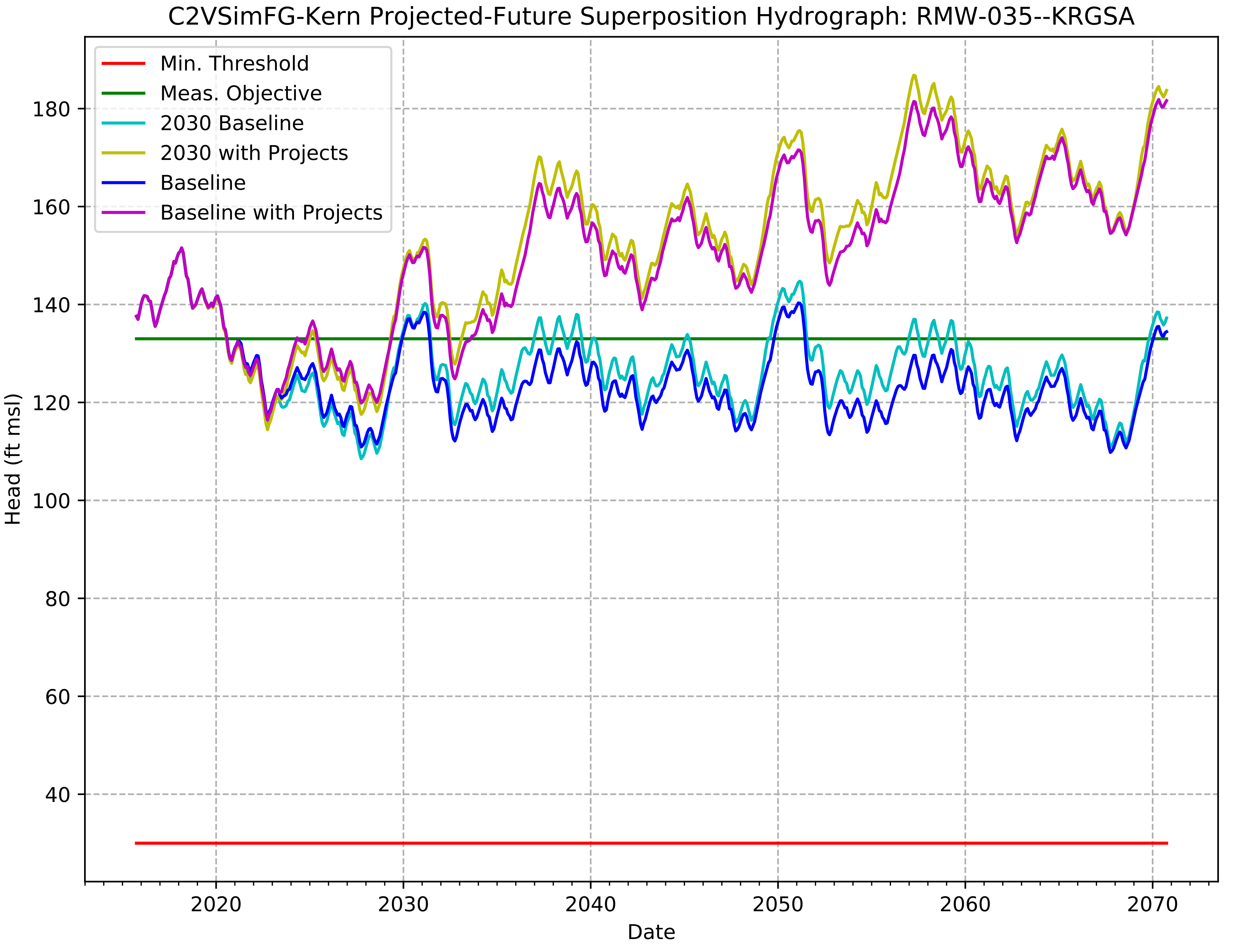
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-031--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
225
200
175
150
125
100
75
2020
2030
2040
2050
2060
2070
Date

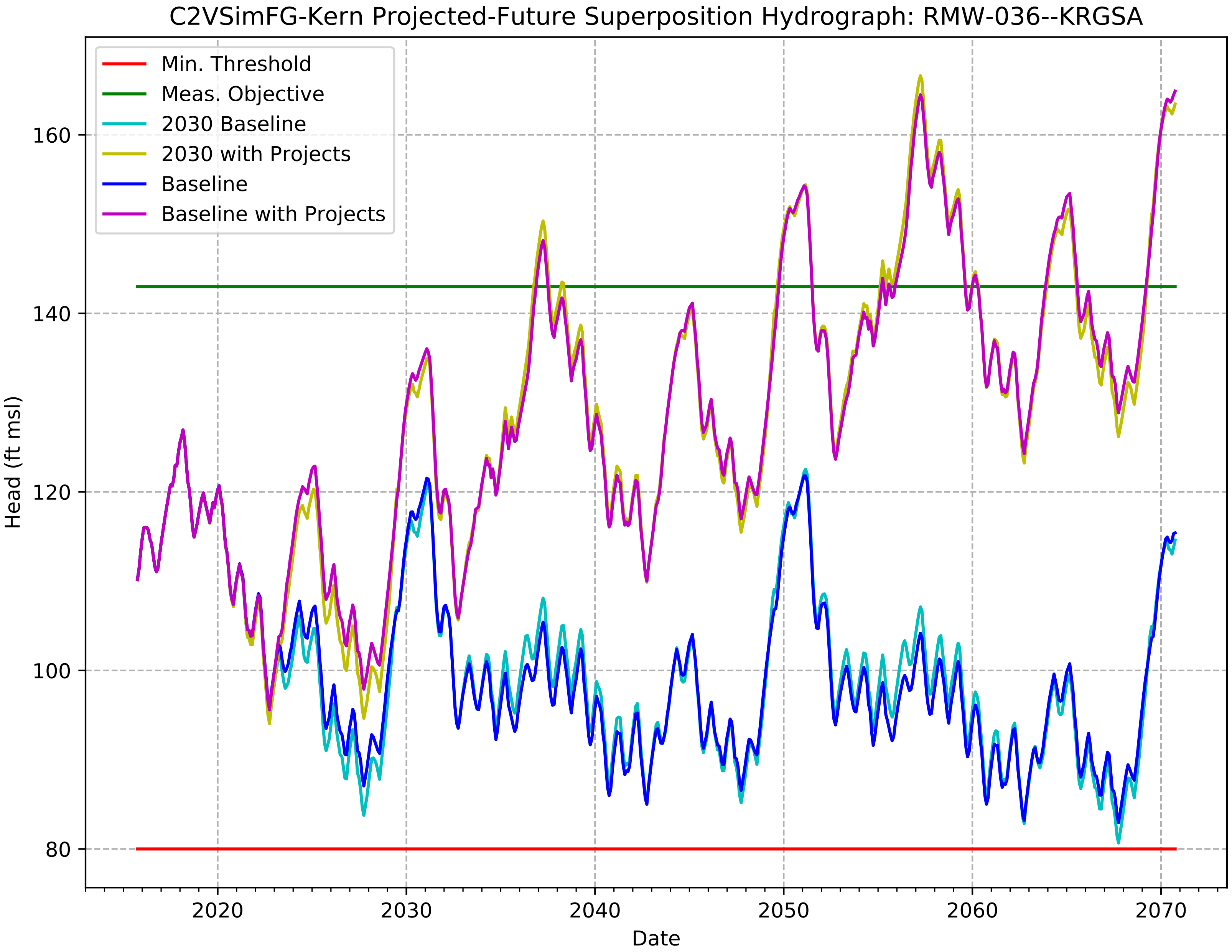

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-032--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
Date
200
180
160
140
120
100
80
2020
2030
2040
2050
2060
2070

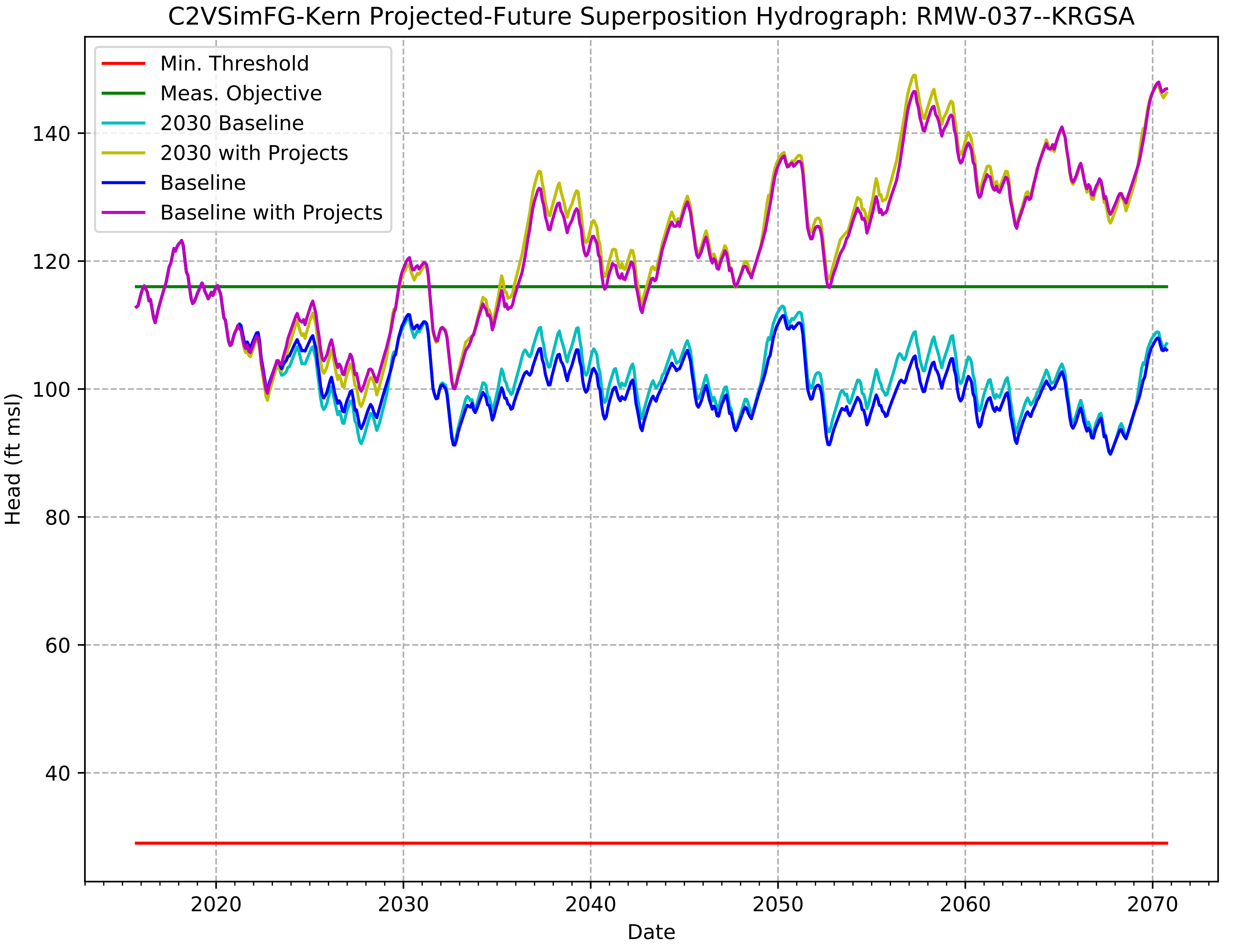

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-033--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
Date
80
100
120
140
160
180
200
2020
2030
2040
2050
2060
2070

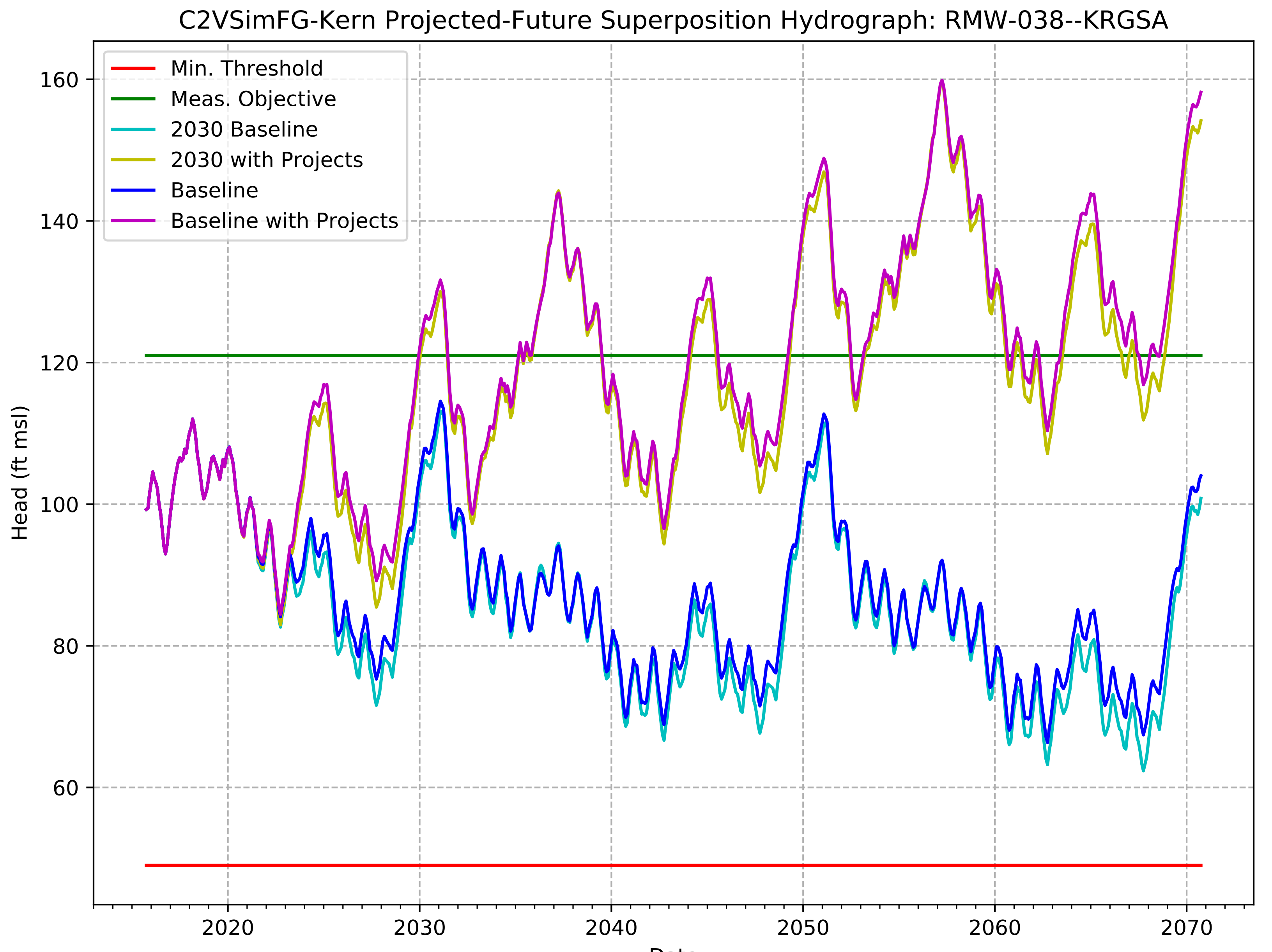


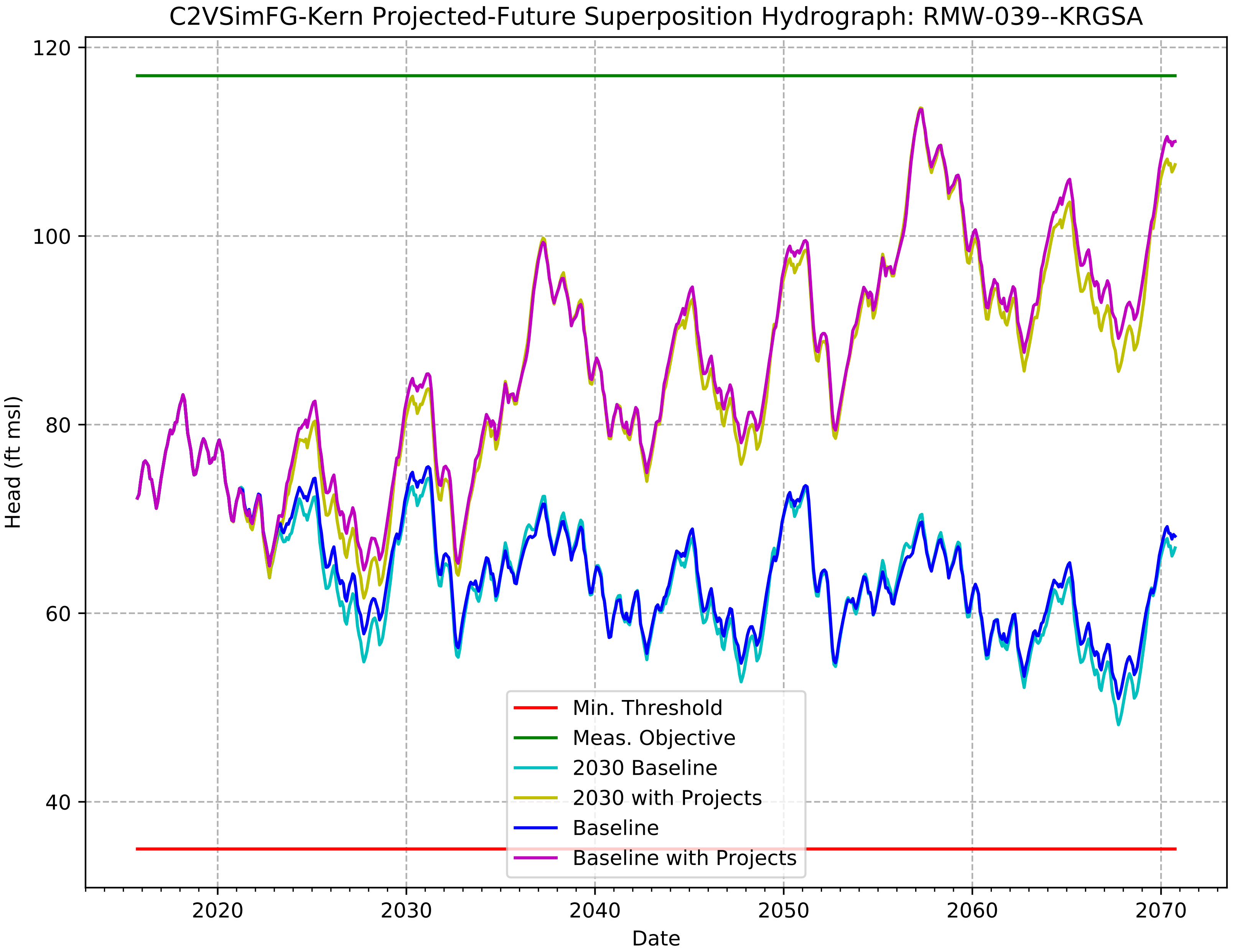
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-034--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
200
180
160
140
120
100
80
2020
2030
2040
2050
2060
2070
Date

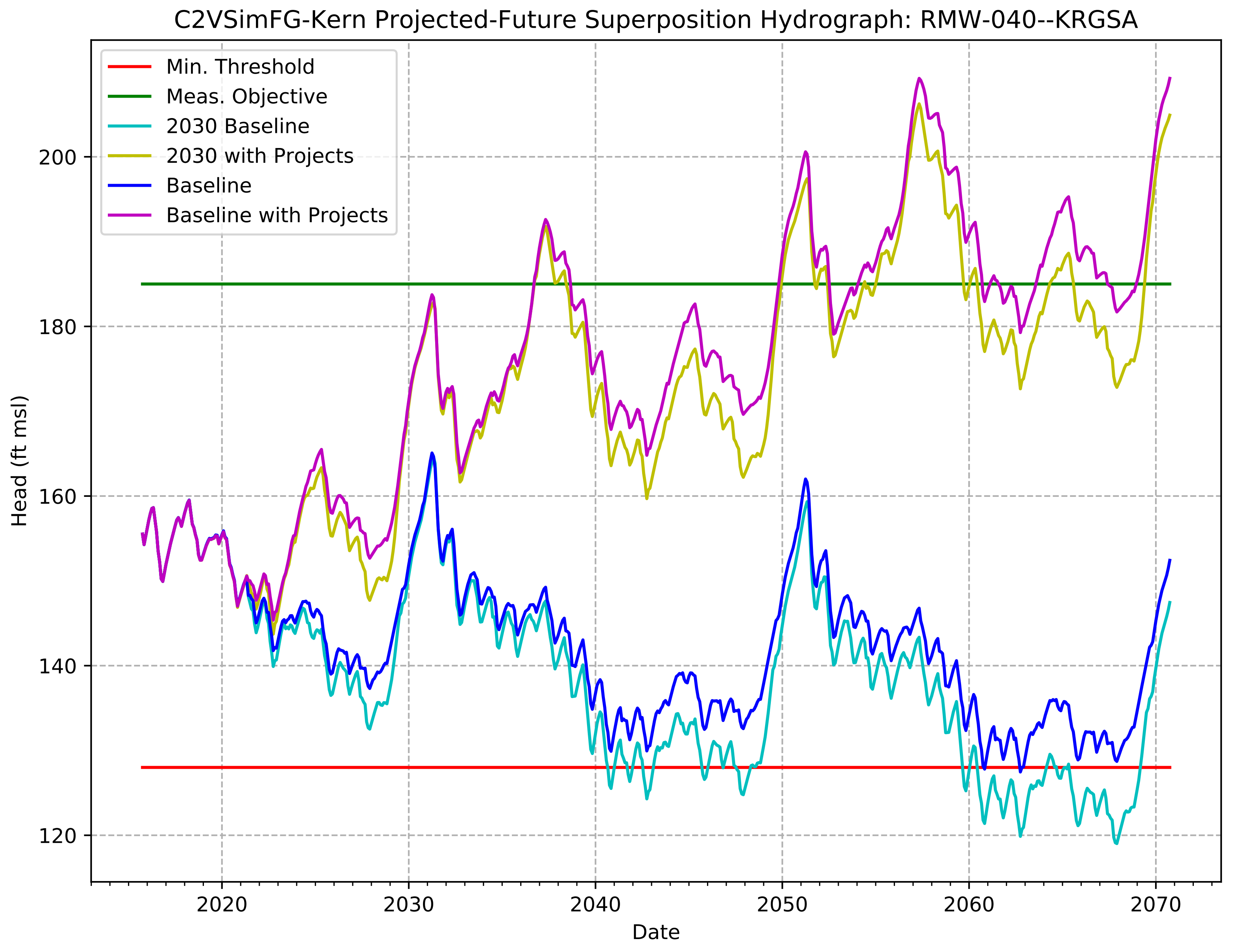

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-035--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
40
60
80
100
120
140
160
180
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-036--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
80
100
120
140
160
2020
2030
2040
2050
2060
2070
Date

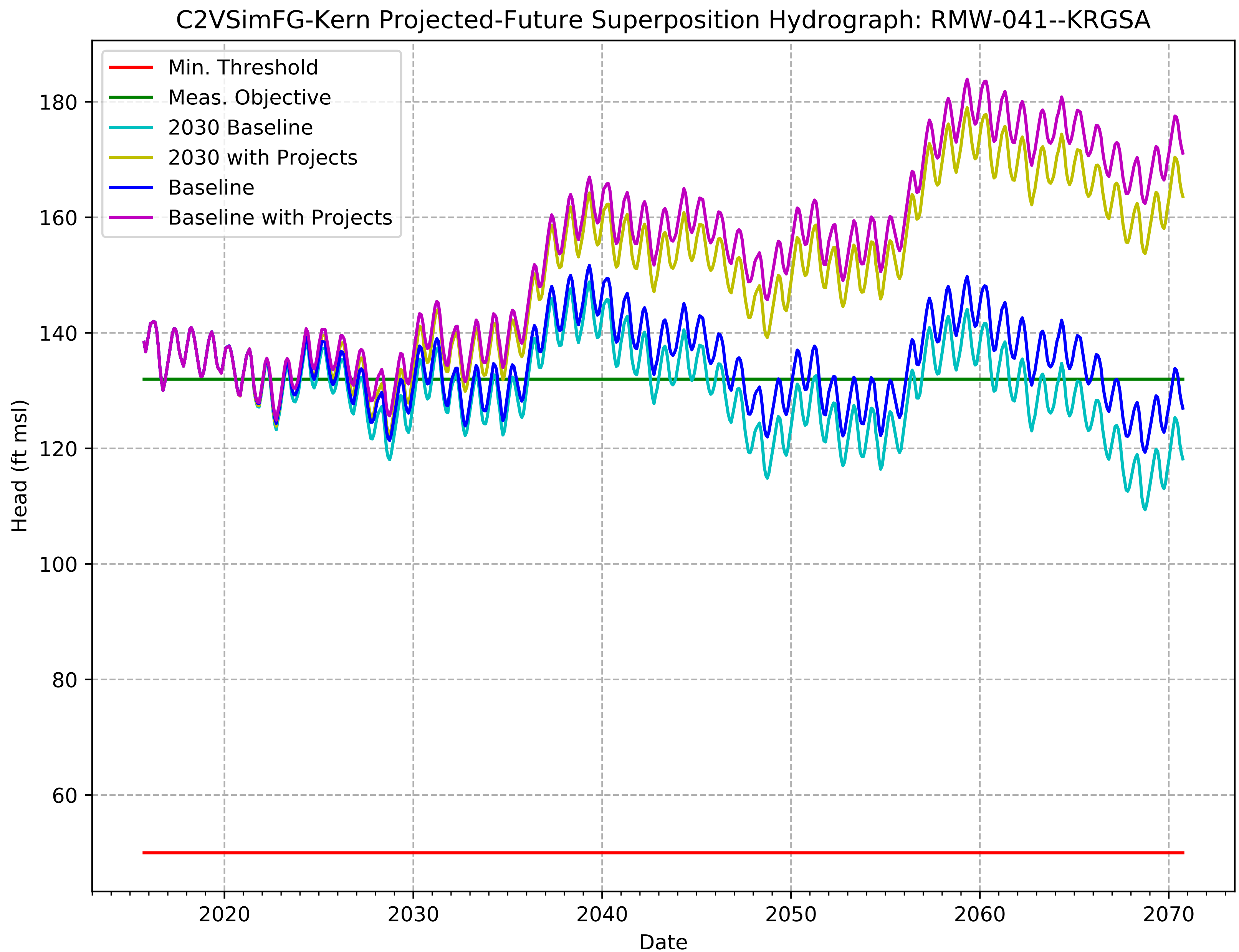

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-037--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
140
120
100
80
60
40
2020
2030
2040
2050
2060
2070
Date

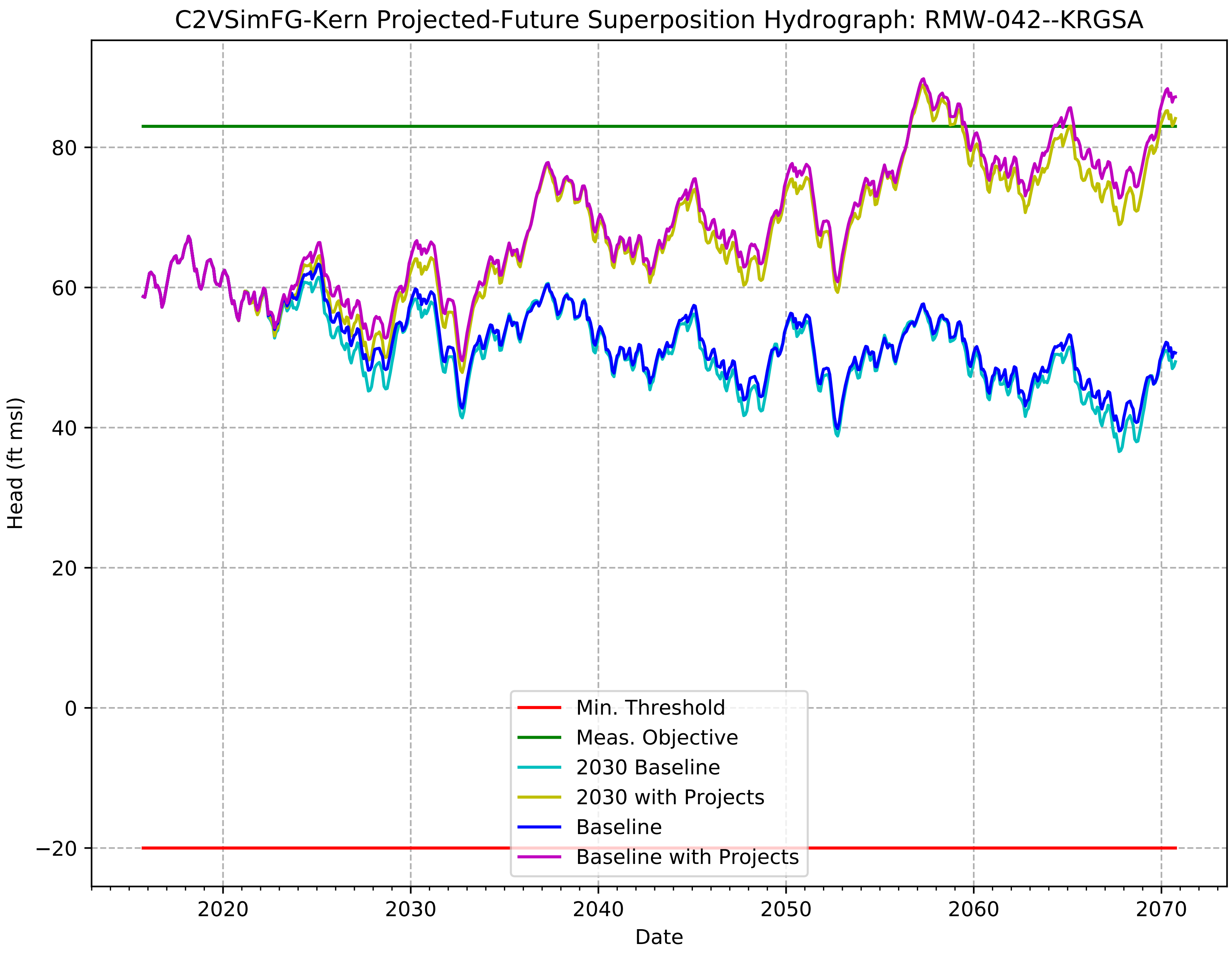

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-038--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
160
140
120
100
80
60
Date
2020
2030
2040
2050
2060
2070


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-039--KRGSA
Head (ft msl)
Date
120
100
80
60
40
2020
2030
2040
2050
2060
2070
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects

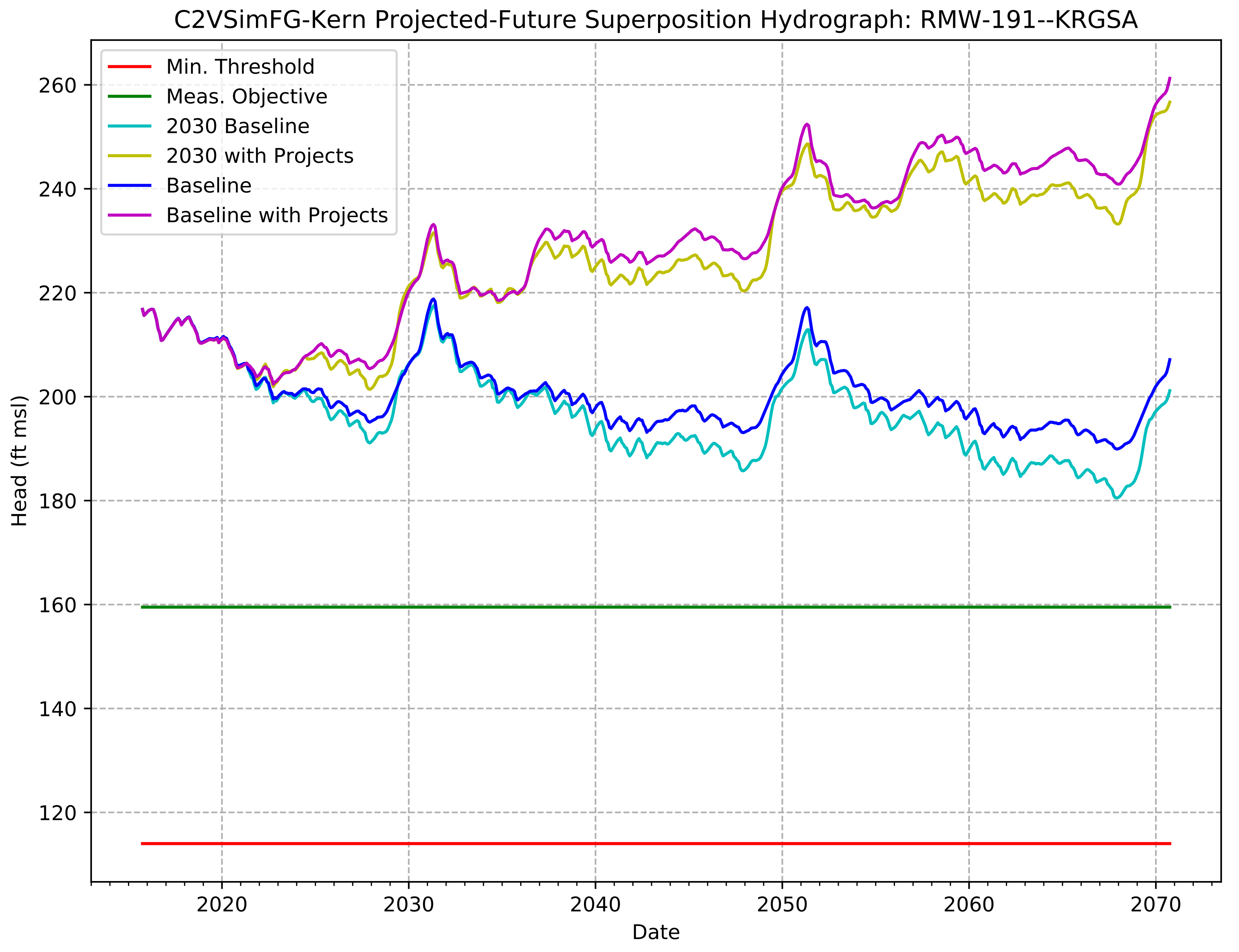


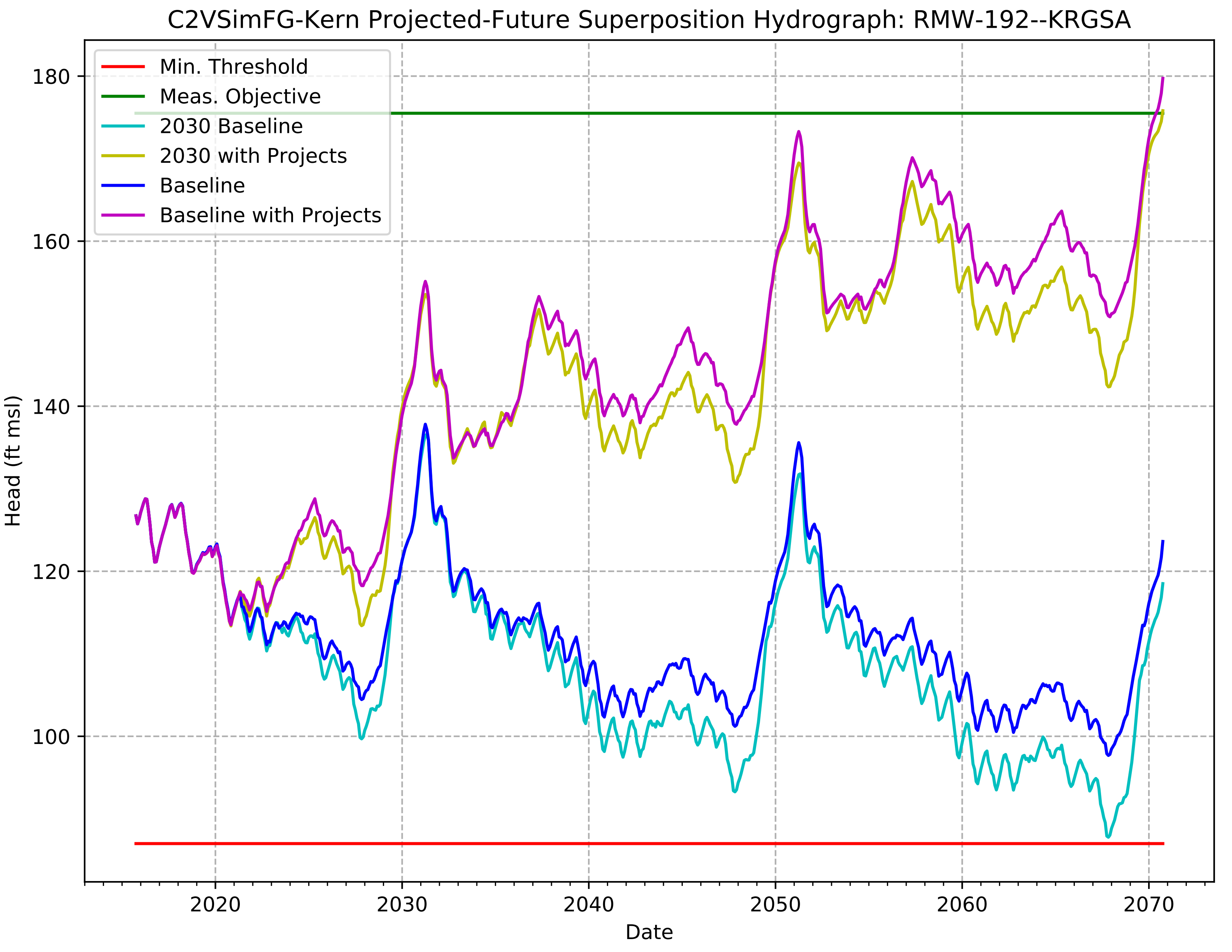
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-040--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
200
180
160
140
120
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-041--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
180
160
140
120
100
80
60
2020
2030
2040
2050
2060
2070
Date

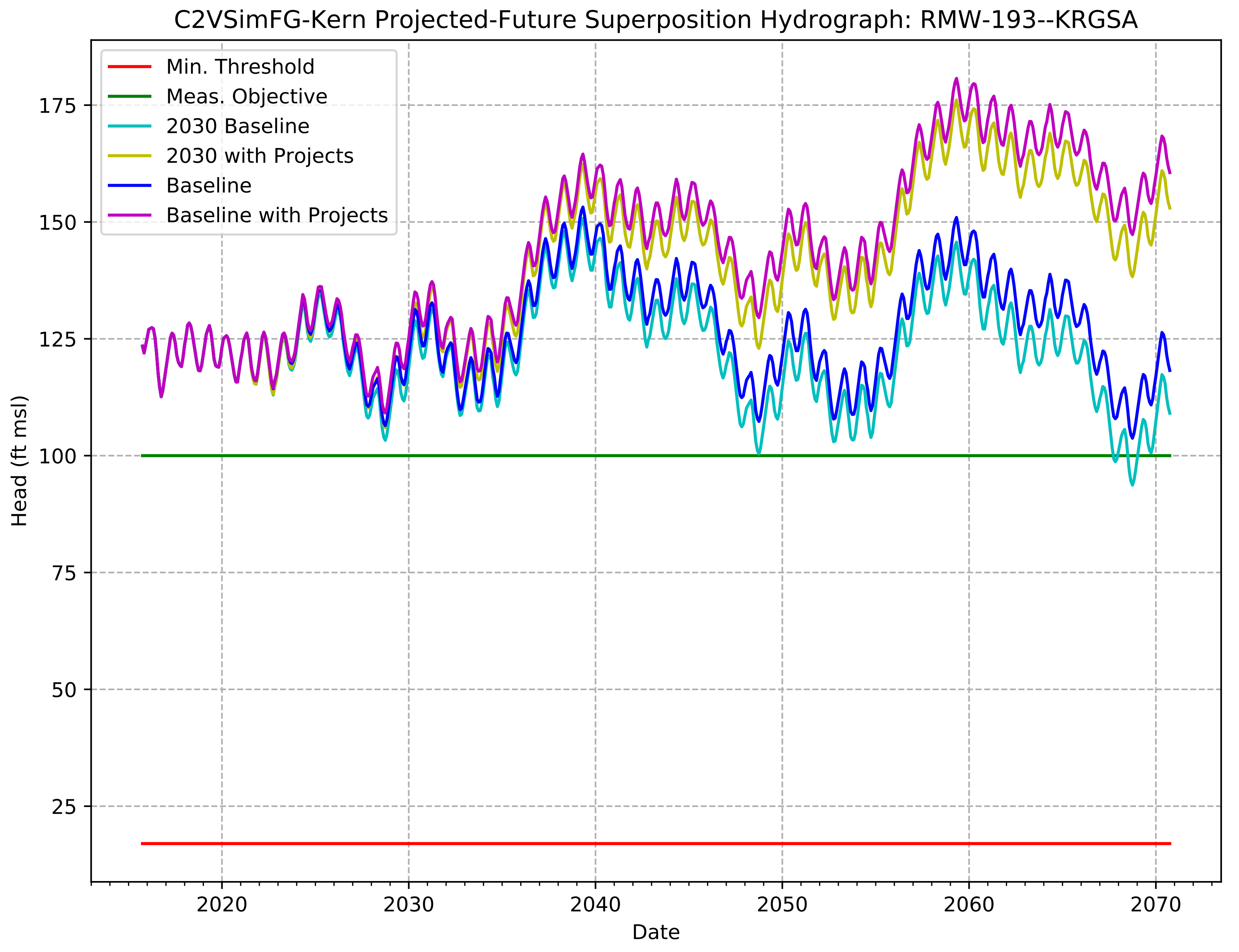


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-042--KRGSA
Head (ft msl)
Date
80
60
40
20
0
−20
2020
2030
2040
2050
2060
2070
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects

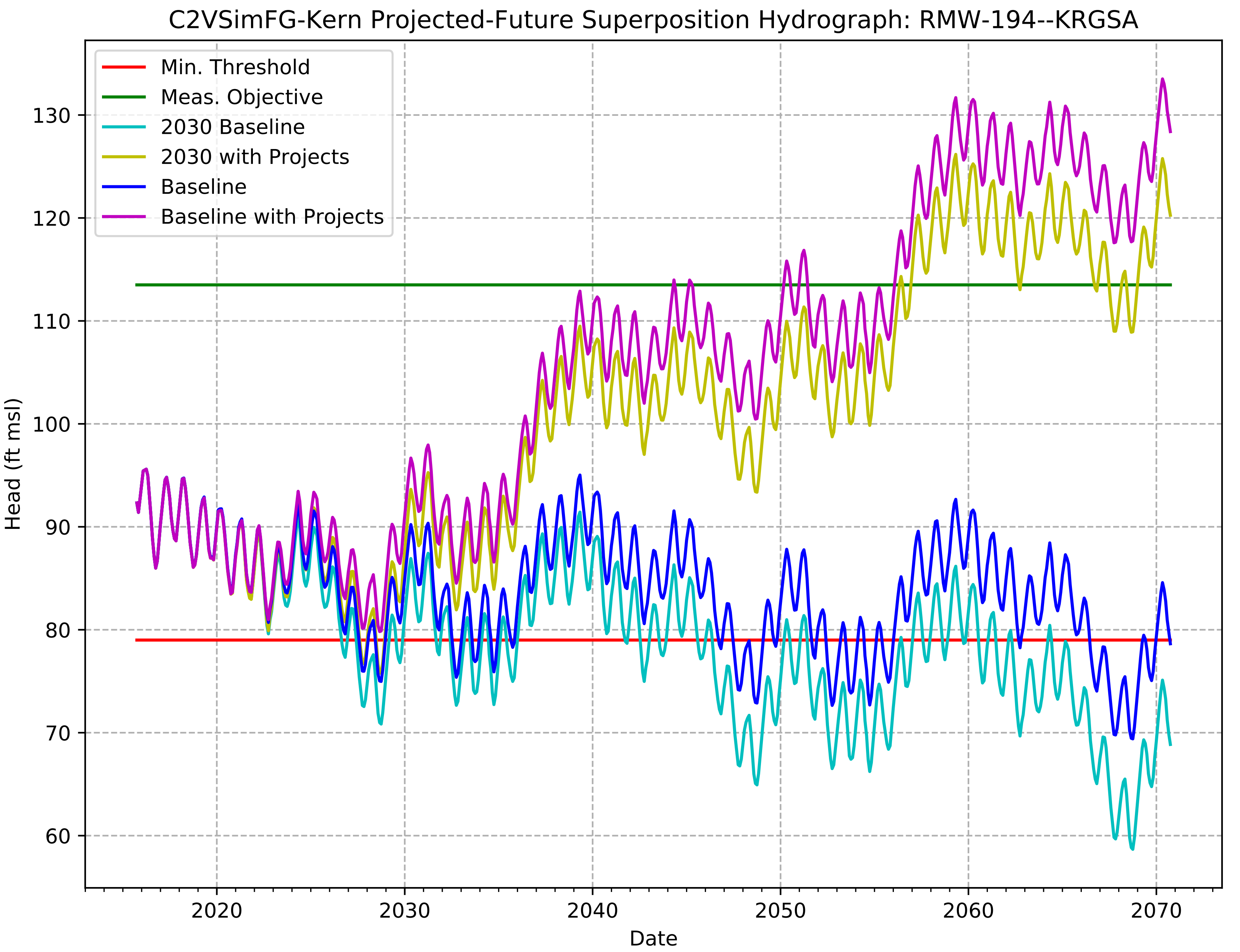

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-191--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
260
240
220
200
180
160
140
120
2020
2030
2040
2050
2060
2070
Date



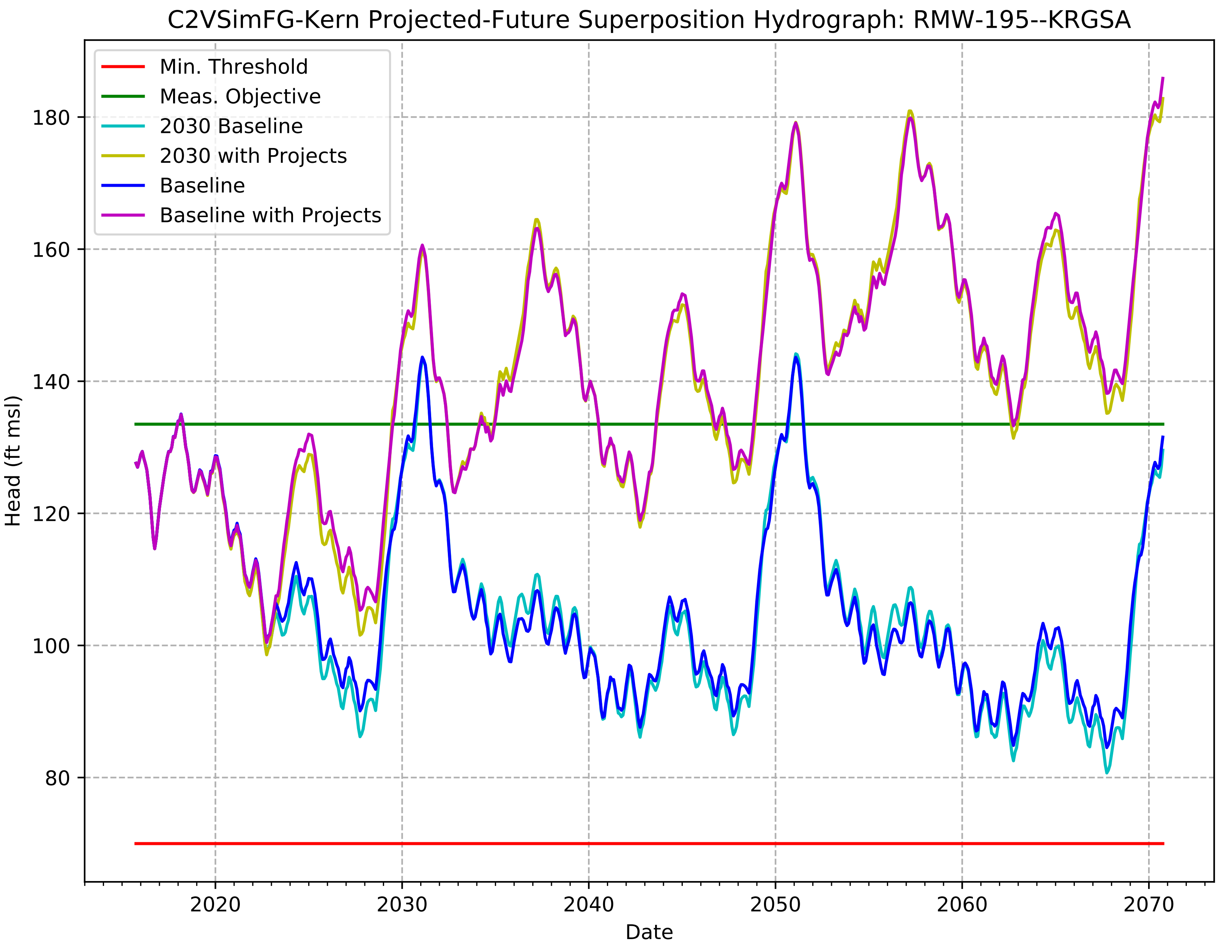
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-192--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
Date
180
160
140
120
100
2020
2030
2040
2050
2060
2070



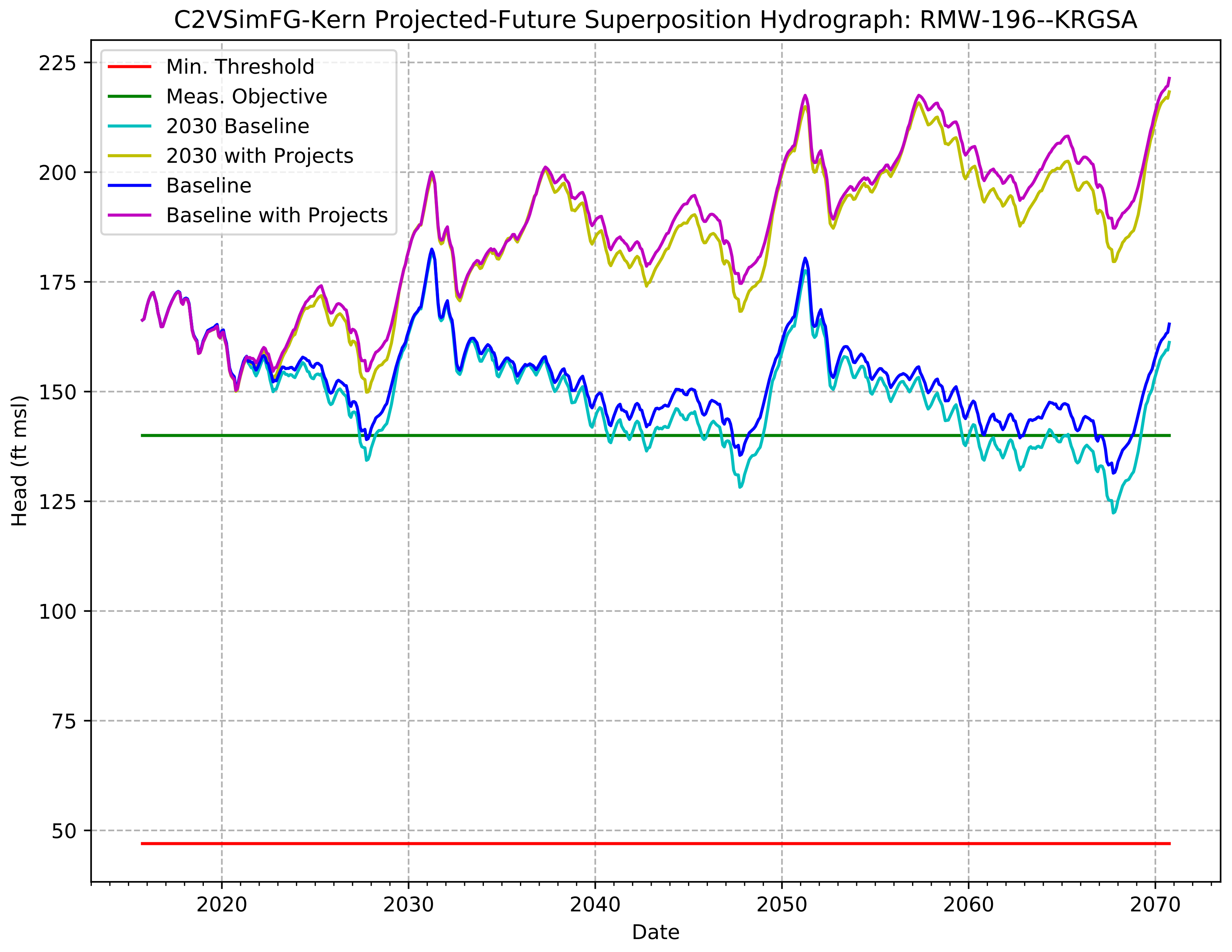
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-193--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
175
150
125
100
75
50
25
2020
2030
2040
2050
2060
2070
Date

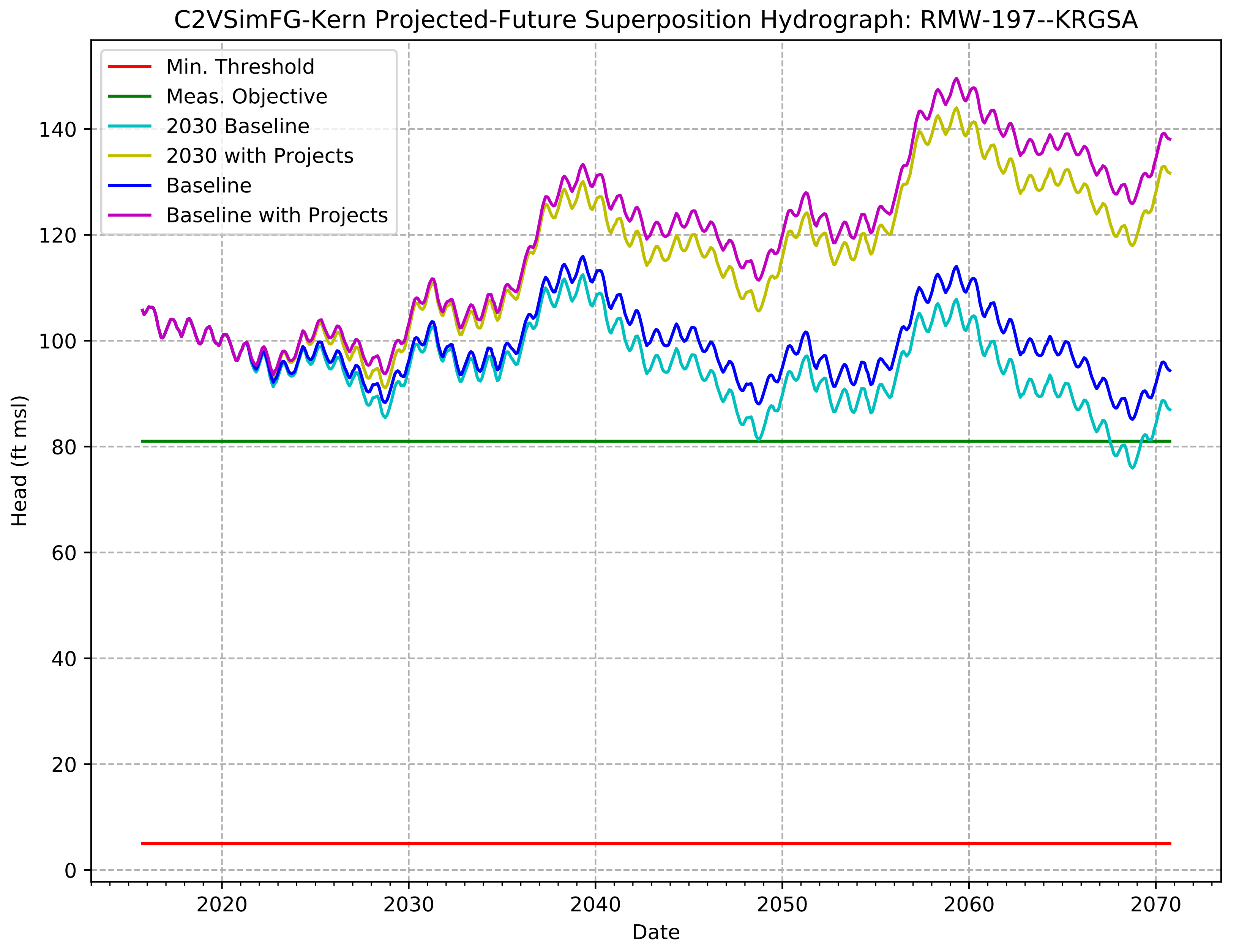


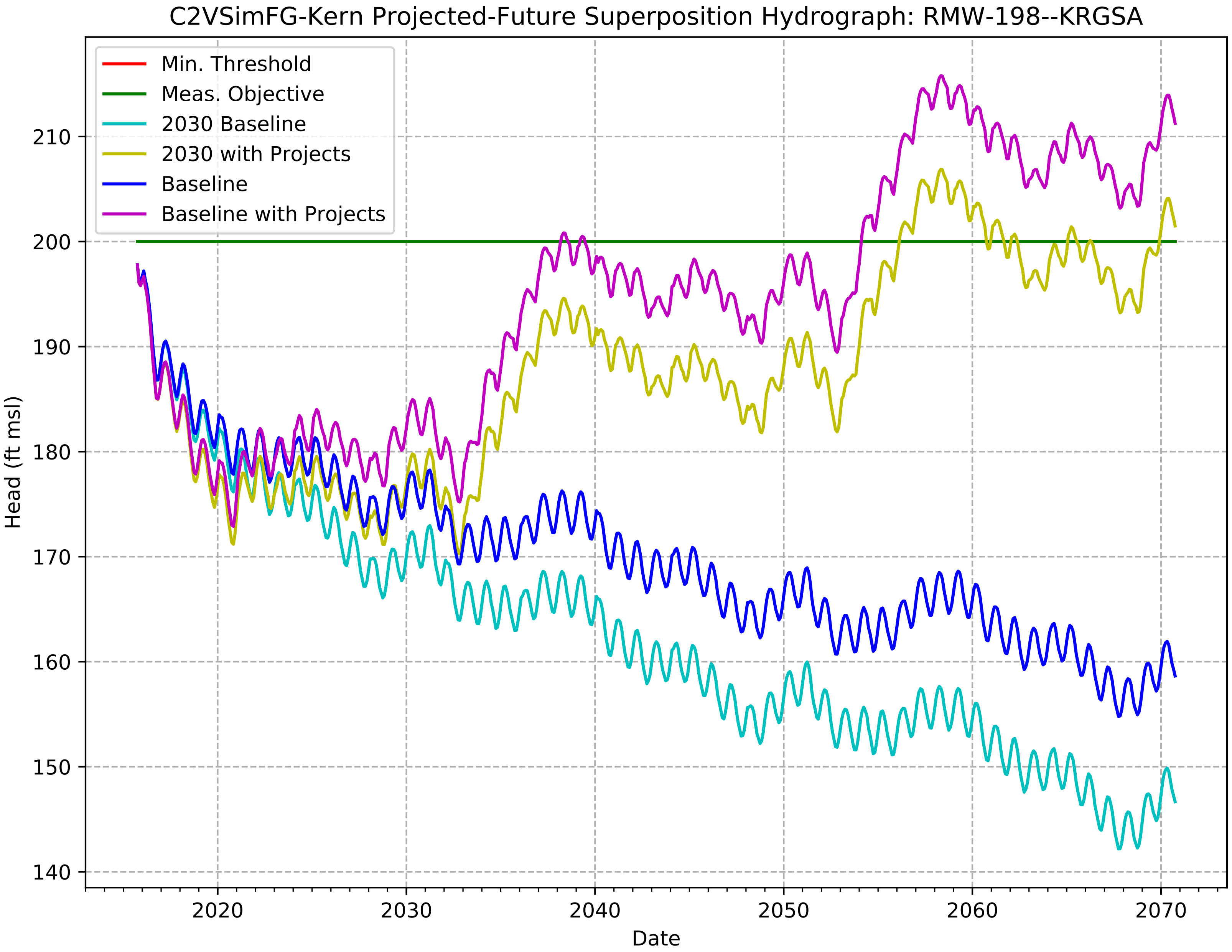
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-194--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
60
70
80
90
100
110
120
130
Date
2020
2030
2040
2050
2060
2070



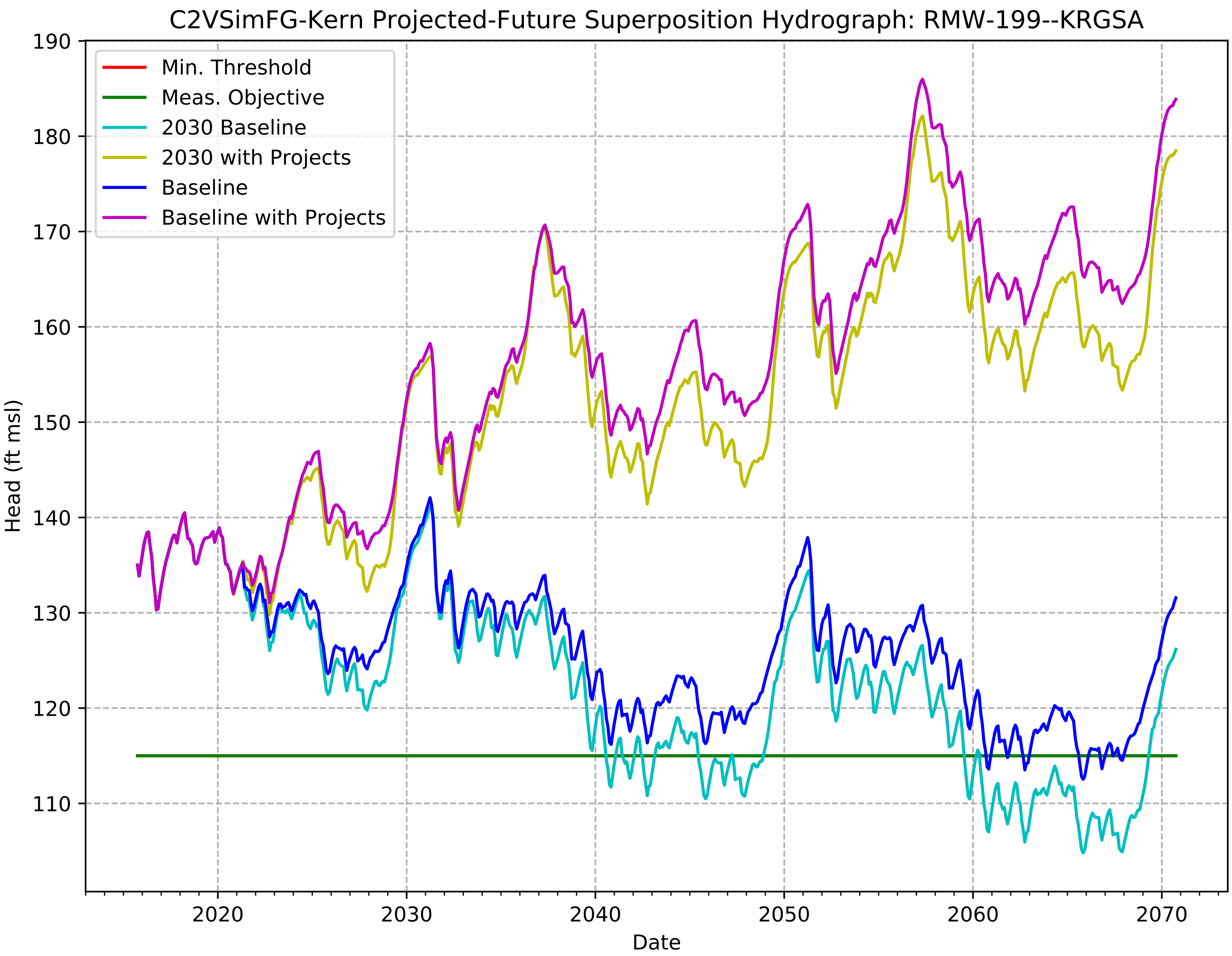
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-195--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
180
160
140
120
100
80
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-196--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
225
200
175
150
125
100
75
50
2020
2030
2040
2050
2060
2070
Date

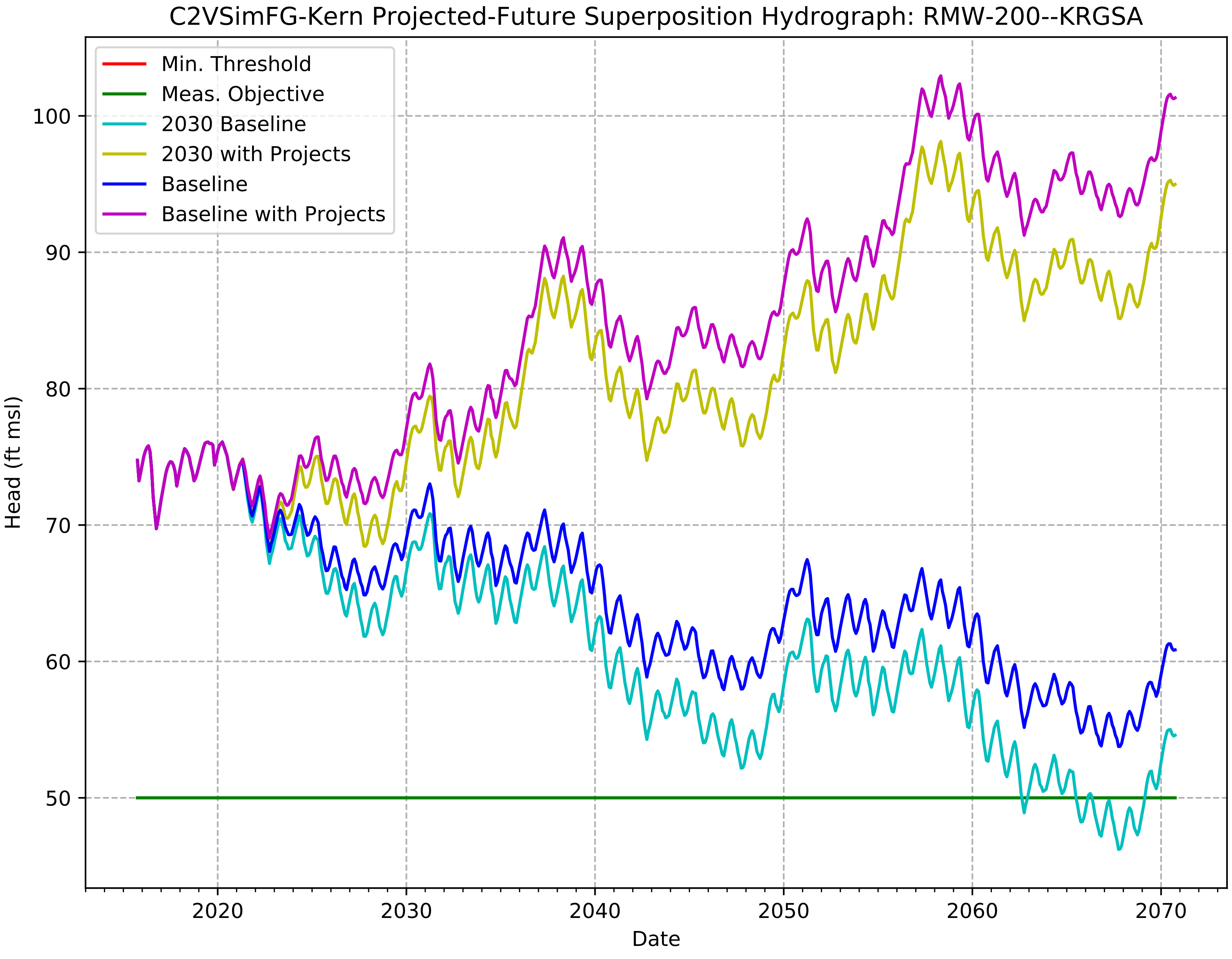

C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-197--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
0
20
40
60
80
100
120
140
2020
2030
2040
2050
2060
2070
Date

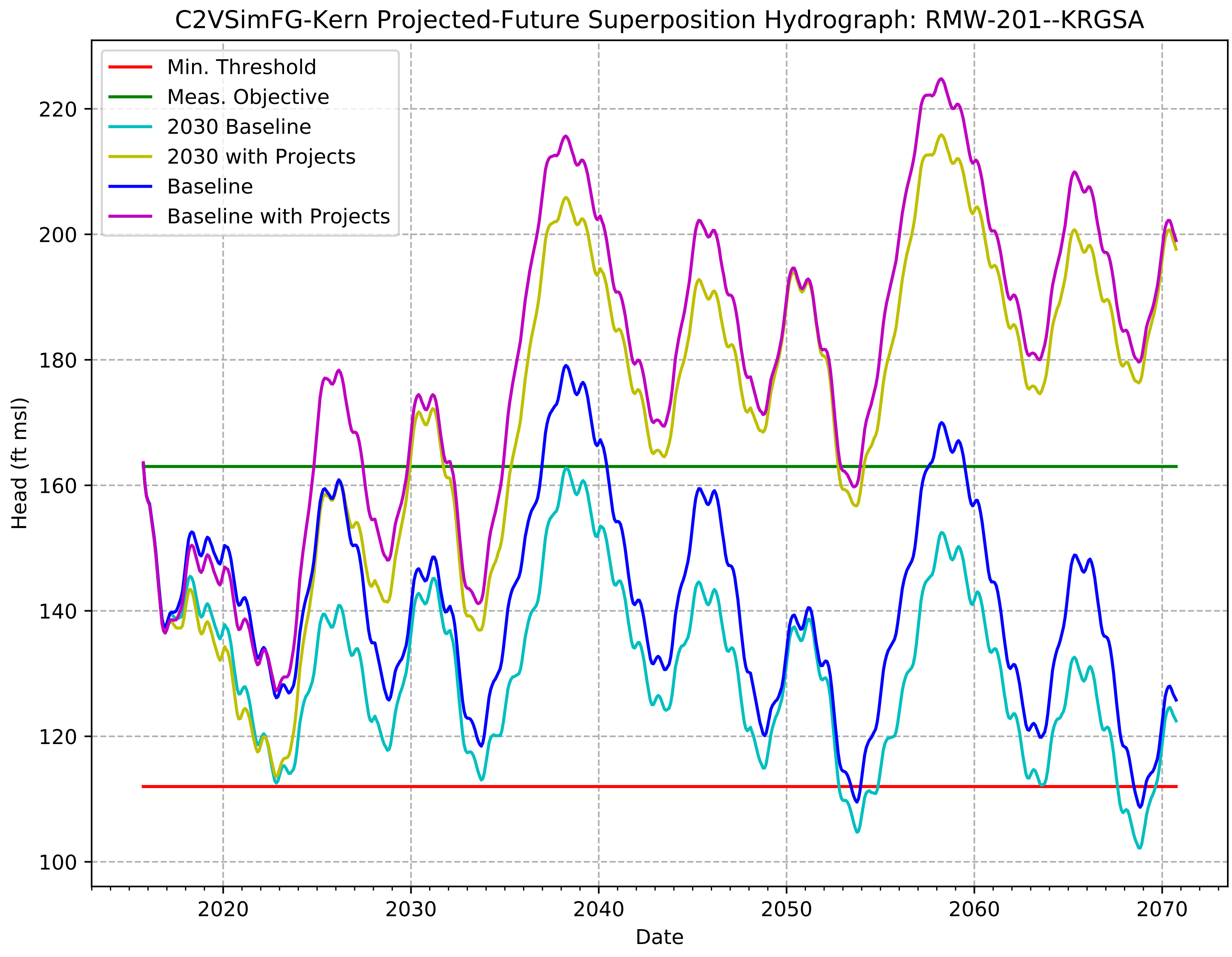


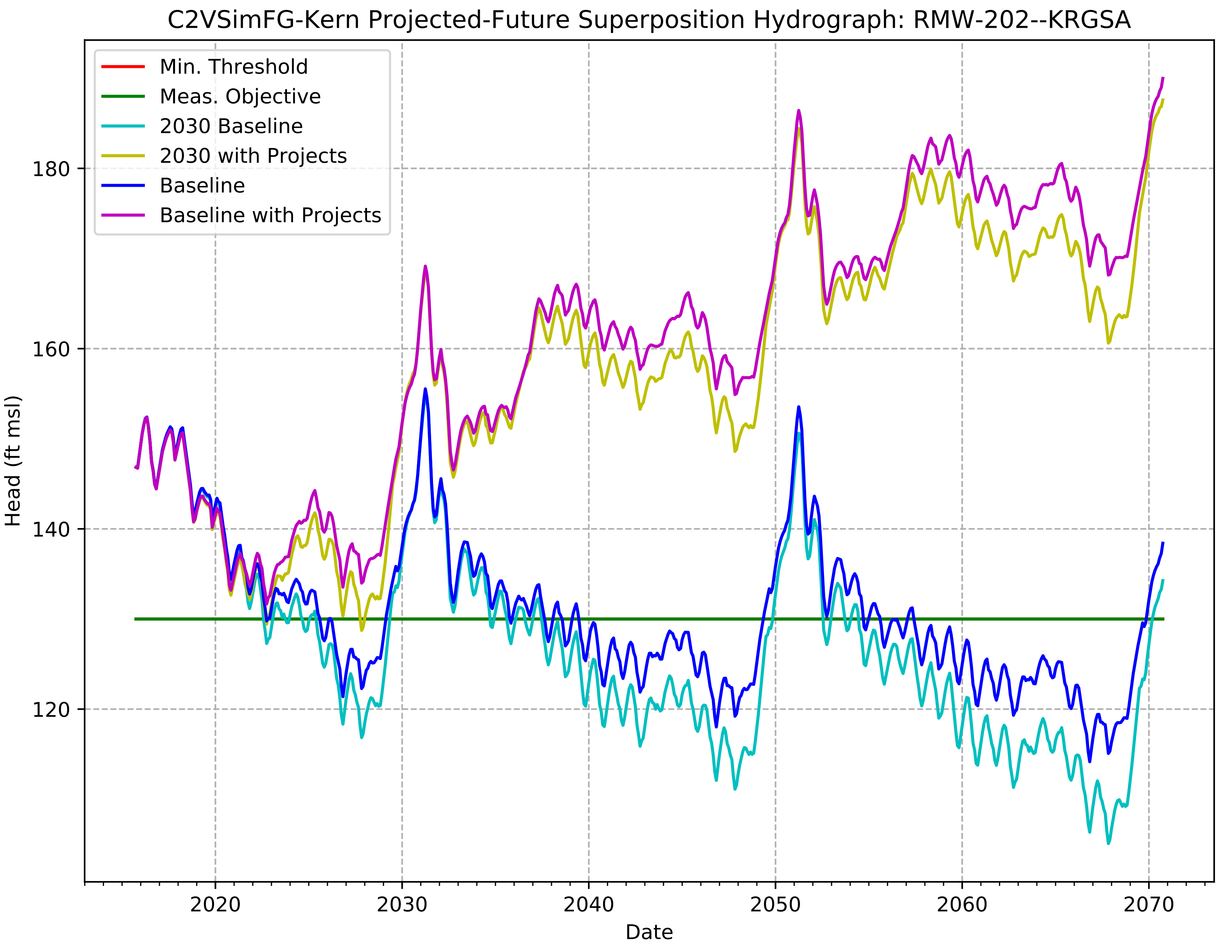
C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-198--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
210
200
190
180
170
160
150
140
2020
2030
2040
2050
2060
2070
Date



C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-199--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
190
180
170
160
150
140
130
120
110
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-200--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
100
90
80
70
60
50
2020
2030
2040
2050
2060
2070
Date


C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-201--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
220
200
180
160
140
120
100
Date
2020
2030
2040
2050
2060
2070



C2VSimFG-Kern Projected-Future Superposition Hydrograph: RMW-202--KRGSA
Min. Threshold
Meas. Objective
2030 Baseline
2030 with Projects
Baseline
Baseline with Projects
Head (ft msl)
180
160
140
120
Date
2020
2030
2040
2050
2060
2070

APPENDIX I

Groundwater Technical Procedures of the U.S. Geological Survey

Sounder Calibration Protocol—KCWA

City of Bakersfield Monitoring Program—Groundwater Elevation Monitoring

USGS
science for a changing world

Office of Groundwater

Groundwater Technical Procedures of the U.S. Geological Survey

Techniques and Methods 1–A1

U.S. Department of the Interior
U.S. Geological Survey

Cover photographs. Clockwise from bottom left. Photographs by W.L. Cunningham, unless otherwise noted.

- Hydrologic technician using a handheld computer to collect water-level data, Clifton Park, New York.
- Hydrologist measuring groundwater level and water temperature to determine stream-aquifer interaction, Smith River near White Sulphur Springs, Montana.
- Hydrologist obtaining calibration measurement at a continuously recording well, West Gardiner, Maine. Photograph by Nicholas Stasulis, U.S. Geological Survey.
- Water-level measurement to calibrate the transducer reading at a continuous water-level measurement site, City of Columbus South Well Field, Columbus, Ohio.
- Hydrologic technician unlocking a USGS well shelter, City of Columbus South Well Field, Columbus, Ohio.
- Hydrologist programming a data logger to record water-level change during a slug test, Charleston, South Carolina.

Groundwater Technical Procedures of the U.S. Geological Survey

Compiled by William L. Cunningham and Charles W. Schalk

Techniques and Methods 1–A1

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
KEN SALAZAR, Secretary

U.S. Geological Survey
Marcia K. McNutt, Director

U.S. Geological Survey, Reston, Virginia: 2011

For more information on the USGS—the Federal source for science about the Earth, its natural and living resources, natural hazards, and the environment, visit http://www.usgs.gov or call 1-888-ASK-USGS

For an overview of USGS information products, including maps, imagery, and publications, visit http://www.usgs.gov/pubprod

To order this and other USGS information products, visit http://store.usgs.gov

Suggested citation:
Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey: U.S. Geological Survey Techniques and Methods 1–A1, 151 p.

Contents

Figures

Tables

Conversion Factors

Inch/Pound to SI

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
	Volume	
gallon (gal)	3.785	liter (L)
gallon (gal)	0.003785	cubic meter (m^3)
gallon (gal)	3.785	cubic decimeter (dm^3)
cubic foot (ft^3)	28.32	cubic decimeter (dm^3)
cubic foot (ft^3)	0.02832	cubic meter (m^3)
cubic foot (ft^3)	28.32	liter (L)
	Flow rate	
gallon per minute (gal/min)	0.06309	liter per second (L/s)
	Hydraulic conductivity	
foot per day (ft/d)	0.3048	meter per day (m/d)
	Force	
pound (lb)	4.4482	newton ($kg*m/sec^3$)
	Pressure	
pounds per square inch (psi)	0.0689	bars (bar)
pounds per square inch (psi)	703.07	kilograms per square meter (kg/m^3)

Vertical coordinate information is referenced to the North American Vertical Datum of 1988 (NAVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

Altitude, as used in this report, refers to distance above the vertical datum.

Specific conductance is given in microsiemens per centimeter at 25 degrees Celsius (µS/cm at 25 °C).

Groundwater Technical Procedures of the U.S. Geological Survey

Compiled by William L. Cunningham and Charles W. Schalk

Abstract

A series of groundwater technical procedures documents (GWPDs) has been released by the U.S. Geological Survey, Water-Resources Discipline, for general use by the public. These technical procedures were written in response to the need for standardized technical procedures of many aspects of groundwater science, including site and measuring-point establishment, measurement of water levels, and measurement of well discharge. The techniques are described in the GWPDs in concise language and are accompanied by necessary figures and tables derived from cited manuals, reports, and other documents. Because a goal of this series of procedures is to remain current with the state of the science, and because procedures change over time, this report is released in an online format only. As new procedures are developed and released, they will be linked to this document.

Introduction

This report is a compilation of groundwater technical procedures documents (GWPDs) that describe measurement and data-handling procedures commonly used by the U.S. Geological Survey (USGS). These technical procedures, which were first compiled in 1995 as an internal tool for USGS technicians and hydrologists, have been collected from common techniques cited in USGS reports, USGS internal memoranda, and USGS training programs for many years. Because of the external demand for documentation of these procedures, and the desire to cite them outside of the USGS, they have been reviewed, edited, and compiled in this document. These techniques are a national resource for USGS Water Science Centers and, as such, may not contain sufficient detail for site-specific complexities for other than USGS users. These techniques are provided as the recommended field procedures for USGS Water Science Centers. Individual Centers are encouraged to document modifications that are made to these procedures in project-specific groundwater quality-assurance plans or the Center's groundwater quality-assurance and quality-control plan.

The GWPDs are written in concise language with step-by-step instructions of sufficient detail so that someone with limited experience with the procedure but with a basic understanding of the measurements and general field work can successfully reproduce the procedure unsupervised. The GWPDs do not provide every detail of an individual field task, as the user is expected to have at least nominal field experience. The user also must be cognizant of local regulations on working in and around groundwater wells. State and local ordinances take precedence over any guidance provided in this report. Each GWPD provides an abbreviated list of references if further detail or background information is required. Figures are included where appropriate, and some GWPDs reference other GWPDs. Hypertext links to illustrations, forms, and reports are provided in the body of each document.

Most GWPDs have the following structure:

- Title
- Version
- Purpose
- Materials and Instruments
- Data Accuracy and Limitations
- Advantages
- Disadvantages
- Assumptions
- Instructions
- Data Recording
- References

This report is designed as an online document for use by groundwater hydrologists, technicians, and data managers. The publication of the GWPDs in this format has several benefits:

- It will provide a reference for citation of techniques used during field investigations;

- It will allow hydrologists, technicians, and data managers from outside the USGS to reference techniques used by the USGS;
- It will provide a consistent set of training materials for those new to the routine aspects of groundwater-data collection and handling;
- It will provide an archive for changes in procedures over time as procedures evolve or as tools and equipment become obsolete.
- It will remain current to state-of-the-science techniques.

This report compiles techniques for groundwater-site establishment, well maintenance, water-level measurements, groundwater-discharge measurements, and single-well aquifer tests. It does not document groundwater-quality techniques. These procedures can be found in "U.S. Geological Survey, National Field Manual for the Collection of Water Quality Data." Many of the methods described in the GWPDs are based on United States Office of Water Data Coordination (1977), Garber and Koopman (1968), and Driscoll (1986).

Purpose and Scope

The purpose of this report is to provide a citable document for technical field procedures used by USGS technicians and hydrologists. These procedures have been used by the USGS as guidance for field work, standardization of measurements and other tasks, training of staff, and quality assurance. USGS Water Science Centers can use these procedures as basic guidance and modify them for their circumstances, hydrologic conditions, project objectives, and Center needs. Modifications to these procedures are documented in project-specific groundwater quality-assurance plans or the Center's groundwater quality-assurance and quality-control plan.

The scope of this report generally is restricted to common field-based procedures. Although instrument calibration in the office environment is an integral part of the quality assurance of USGS field work, office-based calibration procedures are not directly addressed in these field procedures. This report does not provide documentation of all procedures used by the Water Science Centers in the USGS, and it does not cover field techniques that are used to meet special objectives. For instance, a USGS project's objectives may require an accuracy and (or) precision not supported by these methods. In those cases, these methods are modified by the individual project and documented in the accompanying project reports.

Review and Revision

GWPDs, like any standard operating procedure, should remain current. The documents will be updated periodically as errors are detected, equipment changes, or new standard techniques evolve. Each procedure is consecutively numbered and contains a version number/date. Those wishing to cite these procedures should include the version number/date of the procedure as an integral part of the reference. These procedures will change with time, and the version number will change accordingly. New procedures will be made available as they are developed, and general electronic announcements will accompany releases of new GWPDs.

Older versions of updated procedures will be archived, as will GWPDs that no longer are used or followed. Hypertext links will be reassigned to the new versions of GWPDs so that the most up-to-date version of the document will be available online.

Technical Procedures

GWPD 1—Measuring water levels by use of a graduated steel tape

GWPD 2—Identifying a minimum set of data elements to establish a groundwater site

GWPD 3—Establishing a permanent measuring point and other reference marks

GWPD 4—Measuring water levels by use of an electric tape

GWPD 5—Documenting the location of a well

GWPD 6—Recognizing and removing debris from a well

GWPD 7—Estimating discharge from a naturally flowing well

GWPD 8—Estimating discharge from a pumped well by use of the trajectory free-fall or jet-flow method

GWPD 9—Recording minimum and maximum water levels

GWPD 10—Measuring discharge from a pumped well by use of a circular orifice weir

GWPD 11—Measuring well depth by use of a graduated steel tape

GWPD 12—Measuring water levels in a flowing well

GWPD 13—Measuring water levels by use of an air line

GWPD 14—Measuring continuous water levels by use of a float-activated recorder

GWPD 15—Obtaining permission to install, maintain, or use a well on private property

GWPD 16—Measuring water levels in wells and piezometers by use of a submersible pressure transducer

GWPD 17—Conducting an instantaneous change in head (slug) test with a mechanical slug and submersible pressure transducer

Acknowledgments

The field procedures described in this report have been compiled from existing USGS reports, various other reference documents, and the technical expertise of the compilers. In addition to the references provided, important source materials include unpublished USGS training and field manuals and technical memoranda from the Office of Groundwater. The following USGS staff (retired) contributed substantially to the contents of this document: Jilann O. Brunett, David C. Dickerman, Linda H. Geiger, and Julia A. Huff. The compilers also appreciate the important contribution by the staff of the USGS Science Publishing Network, including Kay Hedrick, Bonnie Turcott, and Jeffrey Corbett.

References Cited

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, 149 p.

GWPD 1—Measuring water levels by use of a graduated steel tape

VERSION: 2010.1

PURPOSE: To measure the depth to the water surface below land-surface datum using the graduated steel tape (wetted-tape) method.

Materials and Instruments

1. A steel tape graduated in feet, tenths and hundredths of feet. A black tape is preferred to a chromium-plated tape. If a chromium-plated tape is used, paint the back of the tape with a flat black paint to make reading the wetted chalk mark easier. A break-away weight should be attached to a ring on the end of the tape with wire strong enough to hold the weight, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free. The weight should be made of brass, stainless steel, or iron. Lead weights are not acceptable.
2. Blue carpenter's chalk.
3. Clean rag.
4. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures.
5. Water-level measurement field form, or handheld computer for data entry.
6. Two wrenches with adjustable jaws or other tools for removing well cap.
7. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004).
8. Key for well access.

Data Accuracy and Limitations

1. A graduated steel tape is commonly accurate to 0.01 foot.
2. Most accurate for water levels less than 200 feet below land surface.
3. The steel tape should be calibrated against another acceptable steel tape. An acceptable steel tape is one that is maintained in the office for use only for calibrating steel tapes, and this calibration tape never is used in the field.
4. Oil, ice, or debris may interfere with a water-level measurement.
5. Corrections are necessary for measurements made through angled well casings.
6. When measuring deep water levels (greater than 500 feet), tape expansion and stretch is an additional consideration (Garber and Koopman, 1968).

Advantages

1. The graduated steel tape method is considered to be the most accurate method for measuring water levels in nonflowing wells of moderate depth.
2. Easy to use.
3. Small tape diameter allows access through small ports and provides little interference with pump wiring.

Disadvantages

1. Results may be unreliable if water is dripping into the well or condensing on the well casing.
2. Not recommended for measuring water levels while wells are being pumped.
3. Initial measurement is difficult if estimated water level is not known.

4. Wetted chalk mark may dry before tape is retrieved under hot, dry conditions with large depths to water.

Assumptions

1. An established measuring point (MP) exists and the distance from the MP to land-surface datum (LSD) is known (fig. 1). See GWPD 3 for the technical procedure document on establishing a permanent MP.
2. The MP is clearly marked and described so that a person who has not measured the well will be able to recognize it.
3. For established wells, a water-level measurement taken during the last field visit is available to estimate the length of tape that should be lowered into the well.
4. The black sheen on the steel tape has been dulled so that the tape will retain the chalk.
5. The well is free of obstructions that could affect the plumbness of the steel tape and cause errors in the measurement.
6. The same field method is used for measuring depth below measuring point, or depth relative to vertical datum, but with a different datum correction.
7. The graduated steel tape has been calibrated.

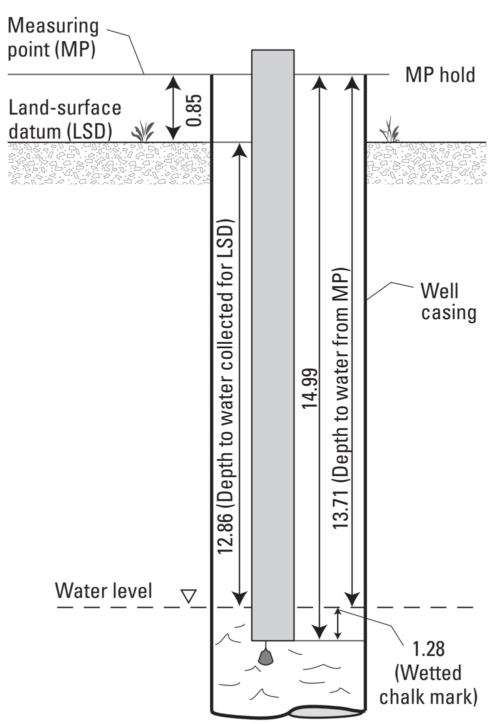


Figure 1. Water-level measurement using a graduated steel tape.

Instructions

1. Open the well.
2. Chalk the lower few feet of the tape by pulling the tape across a piece of blue carpenter's chalk. A wetted chalk mark will identify that part of the tape that was submerged.
3. Review recent measurements from the well, if available, to estimate the hold point on the tape.
4. Refer to figure 1 for an illustration of the elements of a steel tape measurement. Lower the weight and tape into the well until the lower end of the tape is submerged below the water. The weight and tape should be lowered into the water slowly to prevent splashing. Place the thumb and index finger on the tape graduation that is 0.01 less than the next whole foot mark (14.99 in figure 1). Continue to lower the end of the tape into the well until the thumb and index finger meet the MP. Record the graduation value (the HOLD) in the Hold column of the water-level measurement field form (fig. 2).
5. Rapidly bring the tape to the surface before the wetted chalk mark dries and becomes difficult to read. Record the length of the wetted chalk (the CUT) in the Cut row of the water-level measurement field form (fig. 2). Record the time of the measurement in the "Time" row of the form.
6. Subtract the CUT from the HOLD and record this number in the "WL below MP" column of the water-level measurement field form (fig. 2). The difference between the HOLD and the CUT is the depth to water below the MP.
7. If the tape-calibration procedure indicates that a correction is needed at a given water-level depth or for a given water-level range, apply that correction to the "WL below MP" value by adding or subtracting the appropriate correction.
8. Record the MP correction length on the "MP correction" row of the field form (fig. 2); the MP correction is positive if the MP is above land surface and is negative if the MP is below land surface (GWPD 3). Subtract the MP correction from the "WL below MP" value to get the depth to water below or above land-surface datum. Record the water level in the "WL below LSD" column of the water-level measurement field form (fig. 2). If the water level is above LSD, record the depth to water in feet below land surface as a negative number.
9. Make a check measurement by repeating steps 1 through 5. The check measurement should be made using a different HOLD value than that used for the original measurement. If the check measurement does not agree

WATER-LEVEL MEASUREMENT FIELD FORM
Steel Tape Measurement

SITE INFORMATION

SITE ID (C1)

Equipment ID

Date of Field Visit

Station name (C12)

WATER-LEVEL DATA

	1	2	3	4	5
Time					
Hold					
Cut					
Tape correction					
WL below MP					
MP correction					
WL below LSD					

Measured by ________________________ COMMENTS*____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321)

month day year

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

DATE WATER LEVEL MEASURED (C235): month day year

TIME (C709)

STATUS (C238)

METHOD (C239)

TYPE (C243)

WATER LEVEL (C237)

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measurement discon.,	obstruction,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign substance,	well destroyed,	surface water effects,	other	static

Figure 2. Water-level measurement field form for steel tape measurements. This form, or an equivalent custom-designed form, should be used to record field measurements.

with the original measurement within 0.02 foot, continue to make measurements until the reason for lack of agreement is determined or the results are shown to be reliable. If more than two measurements are made, use best judgment to select the measurement most representative of field conditions.

10. Complete the "Final Measurement for GWSI" portion of the field form (fig. 2).

11. After completing the water-level measurement, disinfect and rinse that part of the tape that was submerged below the water surface, as described in the National Field Manual (Wilde, 2004). This will reduce the possibility of contamination of other wells from the tape.

12. Close the well.

13. Maintain the tape in good working condition by periodically checking the tape for rust, breaks, kinks, and possible stretch due to the suspended weight of the tape and the tape weight. The tape should be recalibrated annually and recorded in the calibration logbook.

14. In some pumped wells, a layer of oil may float on the water surface. If the oil layer is a foot or less thick, read the tape at the top of the oil mark and use this value for the water-level measurement instead of the wetted chalk mark. The measurement will differ slightly from the water level that would be measured were the oil not present. However, if several feet of oil are present in the well, or if it is necessary to know the thickness of the oil layer, an electronic "interface probe," or a commercially available water-detector paste can be used that will detect the presence of water in the oil. The paste is applied to the lower end of the tape and will show the top of the oil as a wet line, and the top of the water will show as a distinct color change. Because oil density is about three-quarters that of water, the water level can be estimated by adding the thickness of the oil layer times its density to the oil-water interface altitude.

Data Recording

All calibration and maintenance data associated with steel tape use are recorded in the calibration and maintenance equipment logbook.

All water-level data are recorded on the water-level measurement field form (fig. 2) or by using a handheld computer program such as MONKES. Field measurements are recorded to the nearest 0.01 foot or to the appropriate precision based on the judgment of the hydrographer. When using a handheld computer to record field measurements, the measurement procedure is the same as described in the "Instructions" section.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Katz, B.G., and Jelinski, J.C., 1999, Replacement materials for lead weights used in measuring ground-water levels: U.S. Geological Survey Open-File Report 99–52, 13 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, 149 p.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (version 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed July 17, 2006, at *http://pubs.water.usgs.gov/twri9A3/*.

GWPD 2—Identifying a minimum set of data elements to establish a groundwater site

VERSION: 2010.1

PURPOSE: To specify the minimum amount of information that should be collected during the initial site inventory in the field for an individual groundwater site. These data will be recorded in the National Water Information System (NWIS).

Materials and Instruments

1. Best available paper maps or Global Positioning System (GPS) receiver
2. Groundwater Site Inventory (GWSI) System Groundwater Site Schedule, Form 9-1904-A
3. Spray paint, bright color
4. Metal file for marking well casing; hammer and cold steel chisel, survey monument (nail, spike, tablet)
5. Camera
6. Protractor, calculator, or other tools to calculate angles and lengths
7. Rod, leveling instrument, and leveling notes sheets
8. A steel tape graduated in feet, tenths and hundredths of feet
9. Blue carpenter's chalk
10. Clean rag
11. Field notebook
12. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
13. Water-level measurement field form, or handheld computer for data entry
14. Two wrenches with adjustable jaws or other tools for removing well cap
15. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004)
16. Key for well access

Data Accuracy and Limitations

1. Altitudes determined from topographic maps are accurate to within one-half the map contour interval; latitudes and longitudes are accurate to about 0.5 second.
2. Accuracy of latitude, longitude, and altitudes determined by use of GPS are dependent on each instrument's capabilities.
3. The accuracy of the measuring point, land-surface datum, measuring point correction, and reference marks depends on the measurement method used. See GWPD 3 for additional information.
4. A graduated steel or electric tape commonly is accurate to 0.01 foot. See GWPD 1 and GWPD 4 for additional information.

Assumptions

1. The groundwater site is established by a field visit. At times, a site is established without a field visit. In that instance, less information may be available to establish the site in GWSI.
2. A groundwater site is a single point, not a geographic area or property.
3. All information available for a site will be compiled and entered in GWSI. This includes data and information that are not mandatory for GWSI (*http://nwis.usgs.gov/nwisdocs4_10/gw/gwintrocoding_Sect2-0.pdf*).
4. A GPS unit and (or) paper maps will be used to complete the location-based information needed for Form 9-1904-A (fig. 1). A U.S. Geological Survey (USGS) computer

application is available for this task which automates some of the steps in this procedure. Use of that application is encouraged, but it is not yet available for field use.

5. The hydrographer has gathered all of the information available about the well, including a well-construction log, geologic log, owner information, and has permission to access the well.

Instructions

1. Locate the well as described in GWPD 5.
2. Establish a permanent measuring point, land-surface datum, and nearby reference marks as described in GWPD 3.
3. Measure the total depth of the well, as described in GWPD 11.
4. Measure the water level in the well, as described in GWPD 1 or GWPD 4.
5. Use the information collected prior to the field visit and the measurements collected during the field visit to complete every GWSI component (fig. 1) for which you have information.

Data Recording

Data are recorded in the field on the GWSI Groundwater Site Schedule (Form 9-1904-A, fig. 1). Water levels also are recorded on the appropriate water-level measurement field form.

References

American Society for Testing and Materials, 1994, ASTM standards on ground water and vadose zone investigations (2d ed.): Philadelphia, Pennsylvania, American Society for Testing and Materials, p. 300–304.

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011c, Groundwater technical procedures of the U.S. Geological Survey, GWPD 4—Measuring water levels by use of an electric tape: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011d, Groundwater technical procedures of the U.S. Geological Survey, GWPD 5—Documenting the location of a well: U.S. Geological Survey Techniques and Methods 1–A1, 10 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011e, Groundwater technical procedures of the U.S. Geological Survey, GWPD 11—Measuring well depth by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 10 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (version 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed July 17, 2006, at *http://pubs.water.usgs.gov/twri9A3/*.

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ____________
Date ____________

Coded by ____________
Checked by ____________
Entered by ____________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) U S G S | SITE ID (C1) | PROJECT (C5)

STATION NAME (C12/900)

1 SITE TYPE (C802) Primary - Secondary | DISTRICT (C6) | COUNTRY (C41) | STATE (C7)

COUNTY or TOWN (C8) ____________ County code

LATITUDE (C9) . | LONGITUDE (C10) . | LAT/LONG ACCURACY (C11)

H	1	5	S	R	F	T	M	U
Hndrth sec.	tenth sec.	half sec.	sec.	3 sec.	5 sec.	10 sec.	min.	Un-known

LAT/LONG METHOD (C35)

C	D	G	L	M	N	R	S	U
land net	DGPS	GPS	LORAN	map	inter-polated digital map	reported	survey	un-known

LAT/LONG DATUM (C36)

NAD27	NAD83
North American Datum of 1927	North American Datum of 1983

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17)

A	D	G	I	J	L	M	N	R	U
altimeter	DGPS	GPS	IfSAR	LiDAR	Level	map	DEM	re-ported	un-known

ALTITUDE DATUM (C22)

NGVD29	NAVD88
National Geodetic Vertical Datum of 1929	North American Vertical Datum of 1988

LAND NET (C13) 1/4 | 1/4 | 1/4 | S section | T township | range | merid

TOPO-GRAPHIC SETTING (C19)

A	B	C	D	E	F	G	H	K	L	M	O	P	S	T	U	V	W
alluvial fan	playa	stream channel	depres-sion	dunes	flat	flood-plain	hill-top	sink-hole	lake or swamp	mangrove swamp	off-shore	pedi-ment	hill-side	ter-race	undu-lating	valley flat	upland draw

HYDROLOGIC UNIT CODE (C20) | DRAINAGE BASIN CODE (C801) | STANDARD TIME ZONE (C813) | DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14) | MAP SCALE (C15)

AGENCY USE (C803)

A	D	I	L	M	O	R
active no/na	discon-tinued	inactive site	active written	active oral	inventory site	remediated

2 NATIONAL WATER-USE (C39)

DATA TYPE (C804)
Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box

WL cont	WL int	QW cont	QW int	PR cont	PR int	EV cont	EV int	wind vel.	tide cont	tide int	sed. con	sed. ps	peak flow	low flow	state water use

INSTRUMENTS (C805)
(Place a "Y" in the appropriate box):

digital rec-order	graphic rec-order	tele-metry land line	tele-metry radio	tele-metry satellite	AHDAS	crest-stage gage	tide gage	deflec-tion meter	bubble gage	stilling well	CR type recorder	weigh-ing rain gage	tipping bucket rain gage	acoustic velocity meter	electro-magnetic flowmeter	pressure transducer

DATE INVENTORIED (C711) month — day — year

RECORD READY FOR WEB (C32)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

REMARKS (C806)

FOOTNOTES

1SITE TYPE
(C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal stream				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2

WS	DO	CO	IN	IR	MI	LV	PH	ST	RM	TE	AQ
water supply	domestic	commer-cial	industrial	irrigation	mining	livestock	power hydro-electric	waste water treatment	remedia-tion	thermo-electric power	aqua-culture

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 1. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C (field checked), L (poor location), M (minimal data), U (unchecked)

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A (anode), C (standby emer. supply), D (drain), E (geothermal), G (seismic), H (heat reservoir), M (mine), O (observation), P (oil or gas), R (recharge), S (represurize), T (test), U (unused), V (withdrawal/return), W (withdrawal), X (waste), Z (destroyed)

SECONDARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A (air cond.), B (bottling), C (commercial), D (dewater), E (power), F (fire), H (domestic), I (irrigation), J (industrial (cooling)), K (mining), M (medicinal), N (industrial), P (public supply), Q (aquaculture), R (recreations), S (stock), T (institutional), U (unused), Y (desalination), Z (other)

SECONDARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U (unconfined single), N (unconfined multiple), C (confined single), M (confined multiple), X (mixed)

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27) .

WELL DEPTH (C28) .

SOURCE OF DEPTH DATA (C29): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L (land surface), M (meas. pt.), S (vertical datum)

WATER LEVEL (C237/241/242) .

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 (National Geodetic Vertical Datum 0f 1929), NAVD88 (North American Vertical Datum 0f 1988), Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A (atmos. pressure), B (tide stage), C (ice), D (dry), E (recently flowing), F (flowing), G (nearby flowing), H (nearby recently flowing), I (injector site), J (injector site monitor), M (plugged), N (measurement discontinued), O (obstruction), P (pumping), R (recently pumped), S (nearby pumping), T (nearby recently pumped), V (foreign substance), W (well destroyed), X (affected by surface water), Z (other)

METHOD OF WATER-LEVEL MEASUREMENT(C239): A (airline), B (analog), C (calibrated airline), D (differential GPS), E (estimated), F (transducer), G (pressure gage), H (calibrated press. gage), L (geophysical logs), M (manometer), N (non-rec. gage), O (observed), P (acoustic pulse), R (reported), S (steel tape), T (electric tape), V (calibrated elec. tape), Z (other)

WATER-LEVEL ACCURACY (C276): 0 (foot), 1 (tenth), 2 (hundredth), 9 (not to nearest foot)

SOURCE OF WATER-LEVEL DATA (C244): A (other gov't), D (driller's log), G (geologist), L (geophysical logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y (ready to display), C (conditional), P (proprietary), L (local use only)

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF CONSTRUCTION (C65): A (air-rotary), B (bored or augered), C (cable tool), D (dug), H (hydraulic rotary), J (jetted), P (air percussion), R (reverse rotary), S (sonic), T (trenching), V (driven), W (drive wash), Z (other)

TYPE OF FINISH (C66): C (porous concrete), F (gravel w/perf.), G (gravel screen), H (horiz. gallery), O (open end), P (perf or slotted), S (screen), T (sand point), W (walled), X (open hole), Z (other)

TYPE OF SEAL (C67): B (bentonite), C (clay), G (cement grout), N (none), Z (other)

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A (air-lift pump), B (bailed), C (compressed air), J (jetted), N (none), P (pumped), S (surged), Z (other)

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C (chemicals), D (dry ice), E (explosives), F (deflocculent), H (hydrofracturing), M (mechanical), Z (other)

2 - Groundwater Site Schedule

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE
RECORD SEQUENCE NO. (C724)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) .
DEPTH TO BOTTOM OF INTERVAL (C74) .
DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .
DEPTH TO BOTTOM OF INTERVAL (C74) .
DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .
DEPTH TO BOTTOM OF INTERVAL (C74) .
DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG
RECORD SEQUENCE NO. (C725)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .
DEPTH TO BOTTOM OF CASING (C78) .
DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)
CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .
DEPTH TO BOTTOM OF CASING (C78) .
DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)
CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .
DEPTH TO BOTTOM OF CASING (C78) .
DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)
CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .
DEPTH TO BOTTOM OF CASING (C78) .
DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)
CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN

RECORD SEQUENCE NO. (C726)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

FOOTNOTES:

[5] TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

[6] TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT

RECORD SEQUENCE NO. (C728)

BEGINNING DATE (C321) – –
month day year

ENDING DATE (C322) – –

M.P. HEIGHT (C323)

ALTITUDE OF MEASURING POINT (C325)

ALTITUDE METHOD (C326)

ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)

M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centrifugal	jet	piston	rotary	submersible	turbine	unknown	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gasoline	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Government	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182)

C	D	R	Z
Cooperator's Office,	District Office	Reporting Agency	other

DATA FORMAT (C261)

F	M	P	Z
files,	machine readable,	published,	other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) Q W water quality | BEGINNING YEAR (C115) | ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical properties	common ions	trace elements	pesticides	nutrients	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radioactive	codes B,C&A	other

SOURCE AGENCY (C117) | 7 FREQUENCY OF COLLECTION (C118) | ANALYZING AGENCY (C307) | 8 PRIMARY NETWORK SITE (C257) | 8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) W L water level | BEGINNING YEAR (C115) | ENDING YEAR (C116)

SOURCE AGENCY (C117) | 7 FREQUENCY OF COLLECTION (C118) | 8 PRIMARY NETWORK SITE (C257) | 8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) W D pumpage or withdrawals | BEGINNING YEAR (C115) | ENDING YEAR (C116)

SOURCE AGENCY (C117) | 7 FREQUENCY OF COLLECTION (C118) | METHOD OF COLLECTION (C133) | 8 PRIMARY NETWORK SITE (C257) | 8 SECONDARY NETWORK SITE (C708)

C	E	M	U	Z
calculated	estimated	metered	unknown	other

FOOTNOTES:

7 FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continuously	daily	semi-monthly	inter mittent	monthly	one-time only	quarterly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

8 NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S | RECORD SEQUENCE NO. (C311) | DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S | RECORD SEQUENCE NO. (C311) | DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P pumped, F flow

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E excellent (LT 2%), G good (2%-5%), F fair (5%-8%), P poor (GT 8%)

SOURCE OF DATA (C151): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF DISCHARGE MEASUREMENT (C152): A acoustic meter, B bailer, C current meter, D Doppler meter, E estimated, F flume, M totaling meter, O orifice, P pitot-tube, R reported, T trajectory, U venturi meter, V volumetric meas, W weir, X unknown, Z other

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF WATER-LEVEL MEASUREMENT (C156): A airline, B recorder, C calibrated airline, D differential GP, E estimated, F transducer, G pressure gage, H calibrated press. gage, L geophysical logs, M manometer, N non-rec. gage, O observed, P acoustic pulse, R reported, S steel tape, T electric tape, V calibrated elec. tape, Z other

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P principal aquifer, Q aggregate of lithologic units, S secondary aquifer, N no contribution, U unknown

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section #____________

GWPD 3—Establishing a permanent measuring point and other reference marks

VERSION: 2010.1

PURPOSE: To establish a permanent measuring point at a well from which water levels are measured, to establish a permanent land-surface datum, and to establish nearby reference marks.

Materials and Instruments

1. Groundwater Site Inventory (GWSI) System Groundwater Site Schedule, Form 9-1904-A
2. Measuring tape graduated in feet, tenths and hundredths of feet
3. Field notebook
4. Topographic map or Global Positioning System (GPS) receiver
5. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
6. Spray paint, bright color or permanent marker
7. Metal file for marking well casing; hammer and cold steel chisel, survey monument (nail, spike, tablet)
8. Two wrenches with adjustable jaws or other tools for removing well cap
9. Key for well access
10. Camera
11. Protractor, calculator, or other tools to calculate angles and lengths
12. Rod, leveling instrument, and leveling notes sheets

Data Accuracy and Limitations

The "stickup" of a well is the length of well casing above the plane of the land-surface datum (LSD).

Altitude Accuracy: Vertical Stickup

The accuracy of the measuring point (MP) or LSD altitude depends on the measurement method used. When topographic maps are used, the accuracy typically is about one-half the contour interval of the topographic map. When geodetic differential GPS methods are used, the accuracy can be on the order of a couple of centimeters. When spirit leveling is used the accuracy is dependent on the order (1st, 2nd, 3rd) of surveying and the length of the survey line and typically can vary from tens of centimeters to a millimeter or less. Limitations: A high level of altitude accuracy is not critical when measurements obtained from a single well are compared to one another. Measurement accuracy is important, but altitude accuracy is not. If water-levels are to be compared *among wells*, however, a higher altitude accuracy (such as from spirit leveling) may be needed.

MP Correction Length Accuracy: Vertical Stickup

The MP correction length is the distance the measuring tape travels from the MP to the plane of the LSD (fig. 1). The accuracy of the MP correction length depends on the configuration of the MP with respect to the LSD. In the simplest example of a well with a vertical stickup and the LSD as a monument in the well pad or a file mark on the casing, the MP correction length can be measured directly with a measuring tape. In that instance, the accuracy of the measurement is 0.01 foot. In the case when the vertical distance between LSD and the MP cannot be directly measured with a tape, such as when a protective casing prevents direct measurement, the accuracy is a function of the measurement method used. A visual estimate using a measuring tape likely will have an accuracy slightly greater than 0.01 foot. When spirit leveling is used, the accuracy can vary from tens of centimeters to a millimeter or less. MP correction length accuracy is critical because a well may have more than one MP, all of which should be referenced to a single LSD. Limitations: Special considerations must be made for a well with a non-vertical stickup, when the configuration of the MP at the well does not allow the measuring tape to hang vertically directly from the MP through the plane of the LSD (fig. 2).

Altitude Accuracy: Non-Vertical Stickup

The altitude of the MP of a non-vertical stickup is not used directly, but may be measured for use in combination with the LSD altitude and the MP correction length. In the case of a non-vertical stickup, the accuracy of the LSD altitude is identical to that described in the vertical case. The accuracy of a water-level altitude calculated from the MP altitude and the MP correction length (option in Instruction no. 4) is equivalent to the least accurate measurement.

MP Correction Length Accuracy: Non-vertical Stickup

When the measurement tape does not hang vertically from the MP to the plane of the LSD, the MP correction length must be computed on the basis of the measurement path length and angles of deviation from vertical (fig. 2). The accuracy of this MP correction length is a function of the configuration of the well and the ability of the hydrographer to determine the tape path, but likely is greater than 0.01 foot.

Reference Mark Accuracy

A reference mark (RM) is used to determine whether the MP has moved with reference to LSD and, in extreme cases, to re-establish the LSD or MP at a well, thus the accuracy of the RM should be at least equivalent to that of the water-level measurement. In most instances, this is 0.01 foot. Limitation: comparability of water-level measurements made before and after re-establishment of the LSD or MP is limited by the accuracy of the RM.

Assumptions

1. For comparability to the water level measured in other wells, water-level measurements will be referenced consistently to the same vertical geodetic datum.
2. LSD is a specific type of RM. Once established, the LSD is not changed unless it is destroyed. If a new LSD must be established, the date of this change must be recorded, as well as the vertical distance between the destroyed LSD and the new LSD.
3. Measuring points change from time to time, especially on private wells. If a new MP must be established, the date of this change must be recorded, as well as the distance between the new MP and LSD (MP correction length).
4. Some wells have multiple measuring points or access points, especially production wells. Care must be taken in tracking these multiple MPs.
5. The operator can run leveling equipment in order to establish one or more RMs.

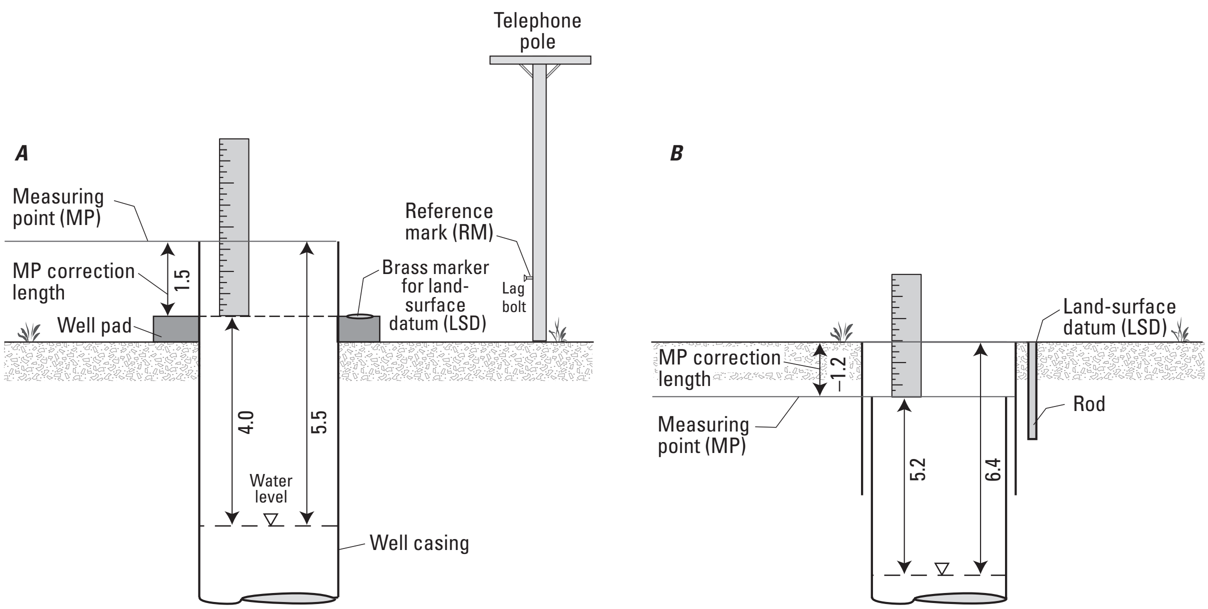


Figure 1. Relations among land-surface (LSD), measuring-point (MP), and reference-mark datums for measuring points above and below land surface. *A*, If the MP is above the LSD, subtract MP correction length to correct the water level to LSD (5.5 – 1.5 = 4.0). *B*, If the MP is below the LSD, subtract MP correction length to correct the water level to LSD (5.2 – (–1.2) = 6.4).

A

B

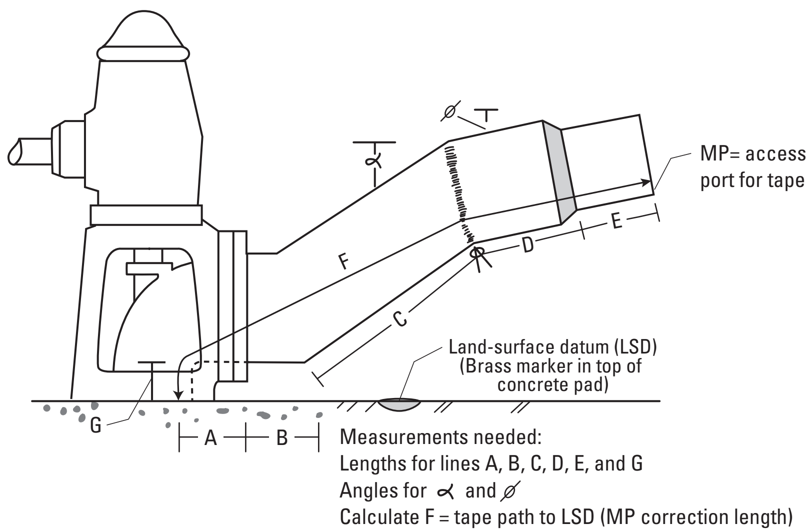


Figure 2. Examples of (*A*) determining a measuring point (MP) correction length when the configuration of the MP at the well does not allow the measuring tape to hang vertically directly from the MP through the plane of the land-surface datum (LSD) and (*B*) the measurements needed to calculate the MP correction length on the basis of the distance a tape would travel from the MP to the plane of the LSD in an irrigation well. (Photograph by E.L. Kuniansky, U.S. Geological Survey.)

Instructions

1. **Establish land-surface datum following these definitions and procedures:**

   a. The LSD at a well is a fixed RM at the well, at or near land surface, that can be used to measure the absolute vertical position (altitude) of the LSD and the distance from the LSD to the MP (the MP correction length).

   b. The LSD must be stable, as permanent as possible, clearly defined, clearly marked, and easily located.

   c. The LSD should be established to facilitate measuring from it to the MP.

   d. The LSD should be established to facilitate setting a survey rod or GPS antenna on the mark.

   e. Mark the LSD. For example, the LSD is noted by an ‘X’ etched into the well casing or is marked with a brass marker or chiseled “+” in the concrete pad at the base of the surface casing. If the landowner does not allow marking of the well, then describe the LSD as accurately as possible.

   f. Take a photograph of the LSD.

2. **Determine the altitude of the land-surface datum.**

    a. The altitude of the LSD must be determined for every site. At a minimum, it can be estimated from a topographic map. Locate the well using GWPD 5. Determine the altitude of the LSD from the topographic map.

    b. Optional: Depending on the use of the measurements from the well, the altitude of the LSD may be surveyed from a geodetic benchmark using spirit leveling or differential GPS techniques.

3. **Establish the measuring point following these definitions and procedures:**

    a. The MP is the most convenient place to measure the water level in a well. It is often at the top of the casing of an observation well, at the top of an access standpipe installed at a production well, or at an access point at the stem of a production well (see figs. 1 and 2).

    b. The MP must be stable, as permanent as possible, clearly defined, clearly marked, and easily located. For example, the MP is noted by a file mark on the well casing. The MP on a casing that does not have a horizontal rim commonly is established on the high or low side of the rim.

    c. If possible, position the MP at a particular point on the casing where a leveling rod could be set directly on it and the measuring tape can hang freely into the well when it is in contact with the MP.

    d. Using a file, lightly mark the MP on the well casing. Optionally, mark the MP by an arrow sprayed with a bright colored paint or permanent marker. If the MP cannot be marked, it must be clearly defined.

    e. Take a photograph of the MP.

    f. If more than one MP exists for a well, all MPs must be documented, and clearly differentiated.

    g. Optional: Depending on the use and storage of measurements from the well, the altitude of the MP of a well with a vertical stickup may be surveyed from a geodetic benchmark using spirit leveling or differential GPS techniques. MP altitude may be determined in two ways, depending on the calculation of the MP correction length described below.

4. **Determine the measuring point correction length following these definitions and procedures:**

    a. The MP correction length is the distance the measuring tape travels from the MP to the plane of the LSD. This is a vertical distance (also known as MP height) for a simple, vertical well. If the well stickup is not vertical, the MP correction length is not a true height above the LSD, but still represents the distance the tape must travel to reach the plane of the LSD.

    b. Measure the MP correction length in feet above or below the LSD (fig. 1). Values for MP correction lengths above LSD (fig. 1*A*) are positive numbers. Values for MP correction lengths below LSD (fig. 1*B*) are negative numbers and should be preceded by a minus sign (–).

        (1) For a well with a vertical stickup, where a water-level tape can hang vertically from the MP through the plane of the LSD (fig. 1), this distance can be measured directly with a steel tape or by leveling. Optional: if the objectives of the measurement require a precise altitude, the altitude of the MP for these wells can be surveyed from a geodetic benchmark using spirit leveling or differential GPS techniques.

        (2) For a well with a non-vertical stickup, where a water-level tape does not hang vertically from the MP through the plane of the LSD (fig. 2), the MP correction length cannot be measured directly. It is the distance between the MP and the plane of the LSD. The length along the measurement path between the MP and LSD must be computed on the basis of the measurement path length and angles of deviation from vertical (fig. 2). The geometry of this measurement path varies widely among this type of well. This will result in an MP correction length greater than the vertical distance between the LSD and the MP. Optional: If the objectives of the measurement require a precise water-level altitude, the altitude of the MP for wells with a non-vertical stickup should not be measured directly.

            (i) Water-level altitude can be referenced to the LSD, in which case the MP altitude is not needed.

            (ii) Water-level altitude can be referenced to the MP, in which case the MP altitude must be calculated by adding the MP correction length to the altitude of the LSD. Note that the MP altitude in this case is not a true altitude, but subtracting a depth to water measurement from this MP altitude will result in a true water-level altitude.

5. **Establish additional reference marks following these definitions and procedures:**

   a. An RM is a nearby datum established by permanent marks and is used to check the MP and (or) LSD or to re-establish the MP and (or) LSD should the original MP or LSD be destroyed or changed.

   b. Check the condition of the rod and leveling instrument.

   c. Establish the vertical relation between the MP and RMs by use of leveling (Kenney, 2010, for example). Establish at least one clearly marked RM near the well; more than one RM is preferable. For example, a benchmark, a lag bolt set in a telephone pole (fig. 1*A*), a spike in a mature tree, a mark on a permanent structure, or a poured concrete post. The RM should be located a suitable distance from the well to assure that a circumstance that damages a well does not also damage the RM.

   d. Take photographs of the RMs and include the photographs in the site field folder.

   e. A visual inspection of the MP, LSD, and RMs should be made at each site visit. Dates of any damage to the MP, LSD, or RMs must be documented. The vertical relation between the MP and RMs should be checked whenever there is evidence of damage to the MP, LSD, or RM. If no damage is apparent, the vertical relation between the MP and RMs should be confirmed at 3–5 year intervals.

Data Recording

Record data by use of appropriate field notebooks, level note sheets, and the GWSI Groundwater Site Schedule (fig. 3, Form 9-1904-A).

1. LSD: Record a description of the LSD in the field notebook, including the altitude, altitude accuracy, and geodetic datum. Final measurements should be documented in figure 3 as follows: (C16) Altitude of land surface, (C17) Method altitude determined, (C18) Altitude accuracy, and (C22) Altitude datum.

2. MP and MP correction length: Record a description of the MP in the field notebook, including the date of MP establishment, MP correction length or altitude, and a detailed description of the MP. Final data should be documented in figure 3 as follows: (C321) Beginning date, (C323) MP height (correction length), and (C324) MP remarks (description of the MP). If the altitude of the MP is determined, also record (C325) Measuring point altitude, (C326) Method altitude determined, (C327) Measuring point altitude accuracy, and (C328) Measuring point altitude datum. If an MP is destroyed or no longer in service, record the date of the destruction in (C322) Ending date.

3. RMs: Record a description of the site RMs in the field notebook, including the date of RM establishment. Document the vertical relation between the MP and RMs. Include the RM level notes in the site folder. Mark the MP and the RMs on the photographs and draw arrows to identify them. Store a copy of the photographs in the site folder.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 5—Documenting the location of a well: U.S. Geological Survey Techniques and Methods 1–A1, 10 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Kenney, T.A., 2010, Levels at gaging stations: U.S. Geological Survey Techniques and Methods 3–A19, 60 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, 149 p.

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ______________
Date ______________

Coded by ______________
Checked by ______________
Entered by ______________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) U S G S
SITE ID (C1)
PROJECT (C5)

STATION NAME (C12/900)

[1] SITE TYPE (C802) - Primary Secondary
DISTRICT (C6)
COUNTRY (C41)
STATE (C7)
County code
COUNTY or TOWN (C8)

LATITUDE (C9) .
LONGITUDE (C10) .
LAT/LONG ACCURACY (C11): H (Hndrth sec.), 1 (tenth sec.), 5 (half sec.), S (sec.), R (3 sec.), F (5 sec.), T (10 sec.), M (min.), U (Un-known)

LAT/LONG METHOD (C35): C (land net), D (DGPS), G (GPS), L (LORAN), M (map), N (inter-polated digital map), R (reported), S (survey), U (un-known)
LAT/LONG DATUM (C36): NAD27 (North American Datum of 1927), NAD83 (North American Datum of 1983)
ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)
ALTITUDE METHOD (C17): A (altimeter), D (DGPS), G (GPS), I (IfSAR), J (LiDAR), L (Level), M (map), N (DEM), R (re-ported), U (un-known)
ALTITUDE DATUM (C22): NGVD29 (National Geodetic Vertical Datum of 1929), NAVD88 (North American Vertical Datum of 1988)

LAND NET (C13): 1/4, 1/4, 1/4, S section, T township, range, merid

TOPOGRAPHIC SETTING (C19): A (alluvial fan), B (playa), C (stream channel), D (depres-sion), E (dunes), F (flat), G (flood-plain), H (hill-top), K (sink-hole), L (lake or swamp), M (mangrove swamp), O (off-shore), P (pedi-ment), S (hill-side), T (ter-race), U (undu-lating), V (valley flat), W (upland draw)

HYDROLOGIC UNIT CODE (C20)
DRAINAGE BASIN CODE (C801)
STANDARD TIME ZONE (C813)
DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14)
MAP SCALE (C15)

AGENCY USE (C803): A (active no/na), D (discon-tinued), I (inactive site), L (active written), M (active oral), O (inventory site), R (remediated)
[2] NATIONAL WATER-USE (C39)

DATA TYPE (C804) Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box: WL cont, WL int, QW cont, QW int, PR cont, PR int, EV cont, EV int, wind vel., tide cont, tide int, sed. con, sed. ps, peak flow, low flow, state water use

INSTRUMENTS (C805) (Place a "Y" in the appropriate box): digital rec-order, graphic rec-order, tele-metry land line, tele-metry radio, tele-metry satellite, AHDAS, crest-stage gage, tide gage, deflec-tion meter, bubble gage, stilling well, CR type recorder, weigh-ing rain gage, tipping bucket rain gage, acoustic velocity meter, electro-magnetic flowmeter, pressure transducer

DATE INVENTORIED (C711) month – day – year
RECORD READY FOR WEB (C32): Y (ready to display), C (condi-tional), P (proprie-tary), L (local use only)

REMARKS (C806)

FOOTNOTES

1 SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal strea m				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2 WS (water supply), DO (domestic), CO (commer-cial), IN (industrial), IR (irrigation), MI (mining), LV (livestock), PH (power hydro-electric), ST (waste water treatment), RM (remedia-tion), TE (thermo-electric power), AQ (aqua-culture)

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 3. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked; L poor location; M minimal data; U un-checked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode; C standby emer. supply; D drain; E geo-thermal; G seismic; H heat reservoir; M mine; O obser-vation; P oil or gas; R recharge; S repres-surize; T test; U unused; V with-drawal/ return; W with-drawal; X waste; Z des-troyed

SECOND-ARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond.; B bottling; C comm-ercial; D de-water; E power; F fire; H domes-tic; I irri-gation; J indus-trial (cooling); K mining; M medi-cinal; N indus-trial; P public supply; Q aqua-culture; R recrea-tions; S stock; T insti-tutional; U unused; Y desalin-ation; Z other

SECOND-ARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single; N unconfined multiple; C confined single; M confined multiple; X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27)

WELL DEPTH (C28)

SOURCE OF DEPTH DATA (C29): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface; M meas. pt.; S vertical datum

WATER LEVEL (C237/241/242)

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929; NAVD88 North American Vertical Datum 0f 1988; Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measure-ment discontinued; O obstruc-tion; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign sub-stance; W well des-troyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; D differ-ential GPS; E esti-mated; F trans-ducer; G pressure gage; H calibrated press. gage; L geophysi-cal logs; M mano-meter; N non-rec. gage; O observed; P acoustic pulse; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER-LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hun-dredth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geol-ogist; L geophysi-cal logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y ready to display; C condi-tional; P proprie-tary; L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

METHOD OF CONSTRUCTION (C65): A air-rotary; B bored or augered; C cable tool; D dug; H hydraulic rotary; J jetted; P air per-cussion; R reverse rotary; S sonic; T trenching; V driven; W drive wash; Z other

TYPE OF FINISH (C66): C porous concrete; F gravel w/perf.; G gravel screen; H horiz. gallery; O open end; P perf or slotted; S screen; T sand point; W walled; X open hole; Z other

TYPE OF SEAL (C67): B bentonite; C clay; G cement grout; N none; Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump; B bailed; C compres-sed air; J jetted; N none; P pumped; S surged; Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chem-icals; D dry ice; E explo-sives; F defloc-culent; H hydro-frac-turing; M mech-anical; Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE RECORD SEQUENCE NO. (C724) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN   RECORD SEQUENCE NO. (C726)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86)   6 TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86)   6 TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86)   6 TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

FOOTNOTES:

5 TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

6 TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT   RECORD SEQUENCE NO. (C728)   BEGINNING DATE (C321) month – day – year   ENDING DATE (C322) – –

M.P. HEIGHT (C323) .   ALTITUDE OF MEASURING POINT (C325)   ALTITUDE METHOD (C326)   ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)   M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centri-fugal	jet	piston	rotary	submer-sible	turbine	un-known	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gaso-line	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Govern-ment	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182)

C	D	R	Z
Cooperator's Office,	District Office	Reporting Agency	other

DATA FORMAT (C261)

F	M	P	Z
files,	machine readable,	published,	other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226) ____

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226) ____

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226) ____

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730)   TYPE OF NETWORK (C706) Q W (water quality)   BEGINNING YEAR (C115)   ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical proper-ties	common ions	trace elements	pesti-cides	nutri-ents	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117)   7 FREQUENCY OF COLLECTION (C118)   ANALYZING AGENCY (C307)   8 PRIMARY NETWORK SITE (C257)   8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730)   TYPE OF NETWORK (C706) W L (water level)   BEGINNING YEAR (C115)   ENDING YEAR (C116)

SOURCE AGENCY (C117)   7 FREQUENCY OF COLLECTION (C118)   8 PRIMARY NETWORK SITE (C257)   8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730)   TYPE OF NETWORK (C706) W D (pumpage or with-drawals)   BEGINNING YEAR (C115)   ENDING YEAR (C116)

SOURCE AGENCY (C117)   7 FREQUENCY OF COLLECTION (C118)   METHOD OF COLLECTION (C133)   8 PRIMARY NETWORK SITE (C257)   8 SECONDARY NETWORK SITE (C708)

C	E	M	U	Z
calcu-lated	esti-mated	meter-ed	un-known	other

FOOTNOTES:

7 FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continu-ously	daily	semi-monthly	inter mittent	monthly	one-time only	quarter-ly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

8 NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S   RECORD SEQUENCE NO. (C311)   DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S   RECORD SEQUENCE NO. (C311)   DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P pumped, F flow

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E excellent (LT 2%), G good (2%-5%), F fair (5%-8%), P poor (GT 8%)

SOURCE OF DATA (C151): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF DISCHARGE MEASUREMENT (C152): A acoustic meter, B bailer, C current meter, D Doppler meter, E estimated, F flume, M totaling meter, O orifice, P pitot-tube, R reported, T trajectory, U venturi meter, V volumetric meas, W weir, X unknown, Z other

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF WATER-LEVEL MEASUREMENT (C156): A airline, B recorder, C calibrated airline, D differ-ential GP, E esti-mated, F trans-ducer, G pressure gage, H calibrated press. gage, L geophysi-cal logs, M mano-meter, N non-rec. gage, O observed, P acoustic pulse, R reported, S steel tape, T electric tape, V calibrated elec. tape, Z other

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P principal aquifer, Q aggregate of lithologic units, S secondary aquifer, N no contrib-ution, U unknown

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

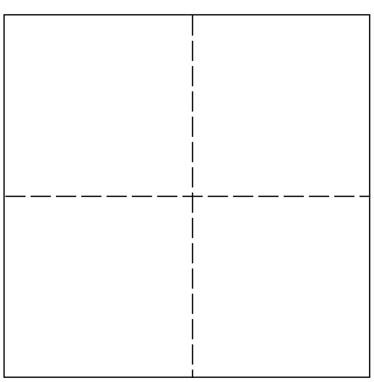
STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section #____________



8 - Groundwater Site Schedule

GWPD 4—Measuring water levels by use of an electric tape

VERSION: 2010.1

PURPOSE: To measure the depth to the water surface below land-surface datum using the electric tape method.

Materials and Instruments

1. An electric tape, double-wired and graduated in feet, tenths and hundredths of feet. Electric tapes commonly are mounted on a hand-cranked and powered supply reel that contains space for the batteries and some device ("indicator") for signaling when the circuit is closed (fig. 1).
2. An older model electric tape, also known as an "M-scope," marked at 5-foot intervals with clamped-on metal bands (fig. 2) has been replaced by newer, more accurate models. Technical procedures for this device are available from the procedures document archives.
3. A steel reference tape for calibration, graduated in feet, tenths and hundredths of feet
4. Electric tape calibration and maintenance equipment logbook
5. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
6. Water-level measurement field form, or handheld computer for data entry
7. Two wrenches with adjustable jaws or other tools for removing well cap
8. Key for well access
9. Clean rag
10. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004)
11. Replacement batteries

Data Accuracy and Limitations

1. A modern graduated electric tape commonly is accurate to +/– 0.01 foot.
2. Most accurate for water levels less than 200 feet below land surface.
3. The electric tape should be calibrated against an acceptable steel tape. An acceptable steel tape is one that is maintained in the office for use only for calibrating tapes, and this calibration tape never is used in the field.
4. If the water in the well has very low specific conductance, an electric tape may not give an accurate reading.
5. Material on the water surface, such as oil, ice, or debris, may interfere with obtaining consistent readings.
6. Corrections are necessary for measurements made from angled well casings.
7. When measuring deep water levels, tape expansion and stretch is an additional consideration (Garber and Koopman, 1968).

Advantages

1. Superior to a steel tape when water is dripping into the well or condensing on the inside casing walls.
2. Superior to a steel tape in wells that are being pumped, particularly with large-discharge pumps, where the splashing of the water surface makes consistent results by the wetted-tape method impossible. Also safer to use in pumped wells because the water is sensed as soon as

Figure 1. An electric tape or cable, double wired and marked the entire length in feet, tenths and hundredths of feet, that can be considered accurate to 0.01 foot at depths of less than 200 feet. Electric tapes commonly are mounted on a hand-cranked and powered supply real that contains space for the batteries and some device ("indicator") for signaling when the circuit is closed. Brand names are for illustration purposes only and do not imply endorsement by the U.S. Geological Survey. (Photographs used with permission of vendors.)

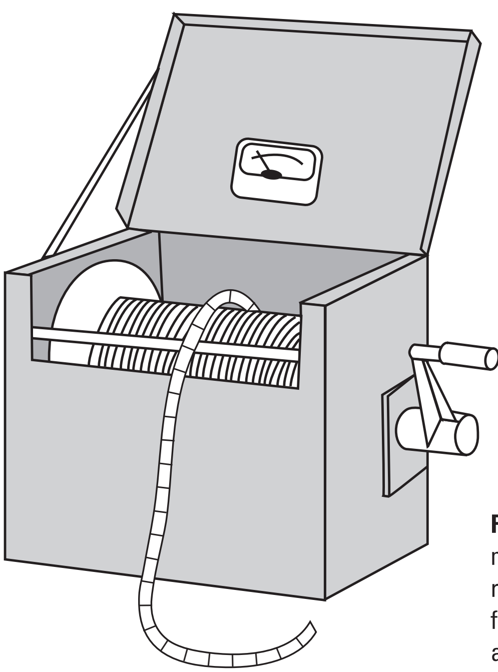


Figure 2. Older model electric tape, also known as "M-scope" marked at 5-foot intervals with clamped-on metal bands, has been replaced by newer, more accurate models. Technical procedures for this device are available from the procedures document archives.

the probe reaches the water surface and there is less danger of lowering the tape into the pump impellers.

3. Superior to a steel tape when a series of measurements are needed in quick succession, such as in aquifer tests, because the electric tape does not have to be removed from the well for each reading.

Disadvantages

1. Harder to keep calibrated than a steel tape.
2. Electric connections require maintenance.
3. Requires battery power.
4. Cable jacket is subject to wear and tear. Continuity of the electrical circuit must be maintained.

Assumptions

1. An established measuring point (MP) exists and the distance from the MP to the land-surface datum (LSD) is known. See GWPD 3 for the technical procedures on establishing a permanent MP.
2. The MP is clearly marked and described so that a person who has not measured the well will be able to recognize it.
3. The well is free of obstructions that could affect the plumbness of the steel tape and cause errors in the measurement.
4. The same field method is used for measuring depth below the MP, or depth relative to vertical datum, but with a different datum correction.
5. The tape is calibrated against a steel reference tape.
6. Field measurements will be recorded on paper forms. When using a handheld computer to record field measurements, the measurement procedure is the same, but the instructions below refer to a specific paper field form.

Tape Calibration And Maintenance

Before using an electric tape in the field, calibrate it against a steel reference tape. A reference tape is one that is maintained in the office only to calibrate other tapes.

1. Calibration of electric tape:
    - Check the distance from the probe's sensor to the nearest foot marker on the tape to ensure that this distance puts the sensor at the zero-foot point for the tape. If it does not, a correction must be applied to all depth-to-water measurements.
    - Compare length marks on the electric tape with those on the steel reference tape while the tapes are laid out straight on level ground, or compare the electric tape with a known distance between fixed points on level ground.
    - Compare water-level measurements made with the electric tape with those made with a calibrated steel tape in several wells that span the range of depths to water that is anticipated. Measurements should agree to within +/– 0.02 foot. If measurements are not repeatable to this standard, then a correction factor based on a regression analysis should be developed and applied to measurements made with the electric tape.
2. Using a repaired/spliced tape: If the tape has been repaired by cutting off a section of tape that was defective and splicing the sensor to the remaining section of the tape, then the depth to water reading at the MP will not be correct. To obtain the correct depth to water, apply the following steps, which is similar to the procedure for using a steel tape and chalk. Using the water-level measurement field form (fig. 3) to record these modifications:
    - Ensure that the splice is completely insulated from any moisture and that the electrical connection is complete.
    - Measure the distance from the sensing point on the probe to the nearest foot marker above the spliced section of tape. Subtract that distance from the nearest foot marker above the spliced section of tape. That value then becomes the "tape correction." For example, if the nearest foot marker above the splice is 20 feet, and the distance from that foot marker to the probe sensor is 0.85 foot, then the tape correction will be 19.15 feet. Write down the tape correction on the water-level measurement field form (fig. 3). Periodically recheck this value by measuring with the steel reference tape.
3. Maintain the tape in good working condition by periodically checking the tape for breaks, kinks, and possible stretch.
4. Carry extra batteries, and check battery strength regularly.
5. The electric tape should be recalibrated annually or more frequently if it is used often or if the tape has been subjected to abnormal stress that may have caused it to stretch.

USGS science for a changing world

WATER-LEVEL MEASUREMENT FIELD FORM

Calibrated Electric Tape Measurement

USGS science for a changing world

SITE INFORMATION

SITE ID (C1)

Equipment ID

Date of Field Visit

Station name (C12)

WATER-LEVEL DATA

	1	2	3	4	5
Time					
Hold					
Tape correction					
WL below MP					
MP correction					
WL below LSD					

Measured by ________________________ COMMENTS*________________________

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)	BEGINNING DATE (C321)	ENDING DATE (C322)	M.P. HEIGHT (C323) NOTE: (-) for MP below land surface
________________	month – day – year	– –	.
________________	– –	– –	.

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243): L below land surface; M below meas. pt.; S sea level

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year					.

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measurement discon.,	obstruction,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign substance,	well destroyed,	surface water effects,	other	static

Figure 3. Water-level measurement field form for calibrated electric tape measurements. This form, or an equivalent custom-designed form, should be used to record field measurements.

Instructions

1. Check the circuitry of the electric tape before lowering the probe into the well by dipping the probe into tap water and observing whether the indicator needle, light, and (or) beeper (collectively termed the "indicator" in this document) are functioning properly to indicate a closed circuit. If the tape has multiple indicators (sound and light, for instance), confirm that they are operating simultaneously. If they are not, determine the most accurate indicator.

2. Make all readings using the same deflection point on the indicator scale, light intensity, or sound so that water levels will be consistent among measurements.

3. Lower the electrode probe slowly into the well until the indicator shows that the circuit is closed and contact with the water surface is made (fig. 4). Place the nail of the index finger on the insulated wire at the MP and read the depth to water.

4. Record the date and time of the measurement. Record the depth to water measurement in the row "Hold" (fig. 3). If the tape has been repaired and spliced or has a calibration correction (see the section above on using a repaired/spliced tape), subtract the "Tape Correction" value from the "Hold" value, and record this difference in the row "WL below MP" (fig. 3).

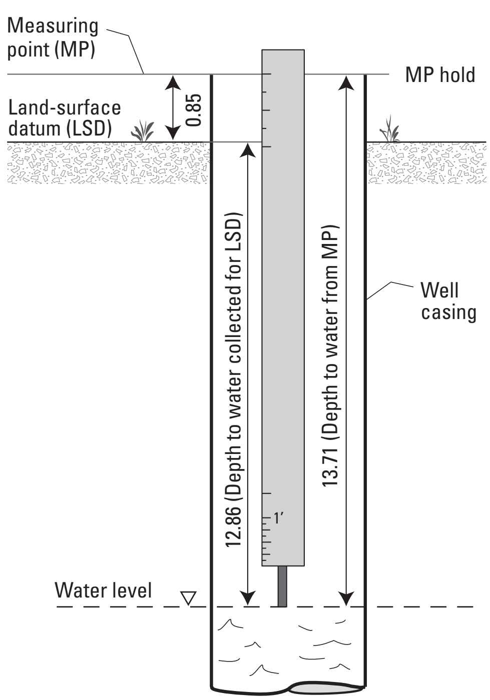


Figure 4. Water-level measurement using a graduated electric tape.

5. Record the MP correction length on the "MP correction" row of the field form (fig. 3). Subtract the MP correction length from the true "WL below MP" value to get the depth to water below or above LSD. The MP correction is positive if the MP is above land surface and is negative if the MP is below land surface (GWPD 3). Record the water level in the "WL below LSD" column of the water-level measurement field form (fig. 3). If the water level is above LSD, record the depth to water in feet above land surface as a negative number.

6. Pull the tape up and make a check measurement by repeating steps 3–5. Record the check measurement in column 2 of the field form. If the check measurement does not agree with the original measurement within 0.02 foot, continue to make measurements until the reason for lack of agreement is determined or the results are shown to be reliable. If more than two measurements are made, use best judgment to select the measurement most representative of field conditions. Complete the "Final Measurement for GWSI" portion of the field form.

7. After completing the water-level measurement, disinfect and rinse that part of the tape that was submerged below the water surface as described in the National Field Manual (Wilde, 2004). This will reduce the possibility of contamination of other wells from the tape. Rinse the tape thoroughly with deionized or tap water to prevent tape damage. Dry the tape and rewind onto the tape reel.

Data Recording

All calibration and maintenance data associated with the electric tape being used are recorded in the calibration and maintenance equipment logbook. All data are recorded in the water-level measurement field form (fig. 3) to the appropriate accuracy for the depth being measured.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Techniques and Methods 1–A1, 13 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, p. 6–11.

Heath, R.C., 1983, Basic ground-water hydrology: U.S. Geological Survey Water-Supply Paper 2220, p. 72–73.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, 149 p.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (version 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, accessed July 17, 2006, at *http://pubs.water.usgs.gov/twri9A3/*.

GWPD 5—Documenting the location of a well

VERSION: 2010.1

PURPOSE: To specify a procedure for documenting the location of a well at a groundwater site.

Materials and Instruments

1. Global Positioning System (GPS) receiver, if available
2. GPS calibration and maintenance equipment logbook
3. Best available paper maps:
   - A state highway map
   - Town or county plat map
   - An aerial photograph or satellite image
   - U.S. Geological Survey (USGS) 7.5-minute topographic quadrangle map
     - USGS 7.5-minute latitude-longitude scale
     - USGS 1:24,000 scale, graduated in miles and feet
4. Orienteering (transparent base) compass
5. Groundwater Site Inventory (GWSI) System Groundwater Site Schedule, Form 9-1904-A
6. Field notebook
7. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
8. Camera

Data Accuracy and Limitations

1. GPS instrument accuracy varies. Handheld, Wide Area Augmentation System (WAAS)-enabled GPS instruments typically are accurate within a few meters horizontally. Instrument manuals and field tests should be used to confirm instrument accuracy.
2. USGS 7.5-minute latitude-longitude scale should be accurate to 0.5 second or about 50 feet.

Assumptions

1. The person locating the well has been trained to use a GPS instrument to determine the latitude and longitude of a point on the ground.
2. The person locating the well has been trained to use a latitude-longitude scale to determine the latitude and longitude of a point on a USGS 7.5-minute topographic quadrangle map.

Instructions

1. Each groundwater site should have a station log containing detailed narrative descriptions of the site, permanent landmarks, the best route to the site, and job hazards in the vicinity of the site.
2. Make two sketch maps of the site, one showing the general location of the site, and the other showing the details of the site. Orient the sketch maps relative to north using a compass. All distances should be shown in feet from permanent landmarks, such as buildings, bridges, culverts, telephone poles, road centerlines, and road intersections (fig. 1).

   a. General location map:

      (1) If a GPS instrument is available, determine the latitude and longitude of the well site.

      (2) Plot the general location of the well on a suitable paper map. If a GPS instrument is not available, the location should be plotted on a USGS 7.5-minute topographic quadrangle map.

      (3) If a GPS instrument is not available, determine the latitude and longitude of the well site from a USGS 7.5-minute topographic quadrangle map using a USGS 7.5-minute latitude-longitude scale.

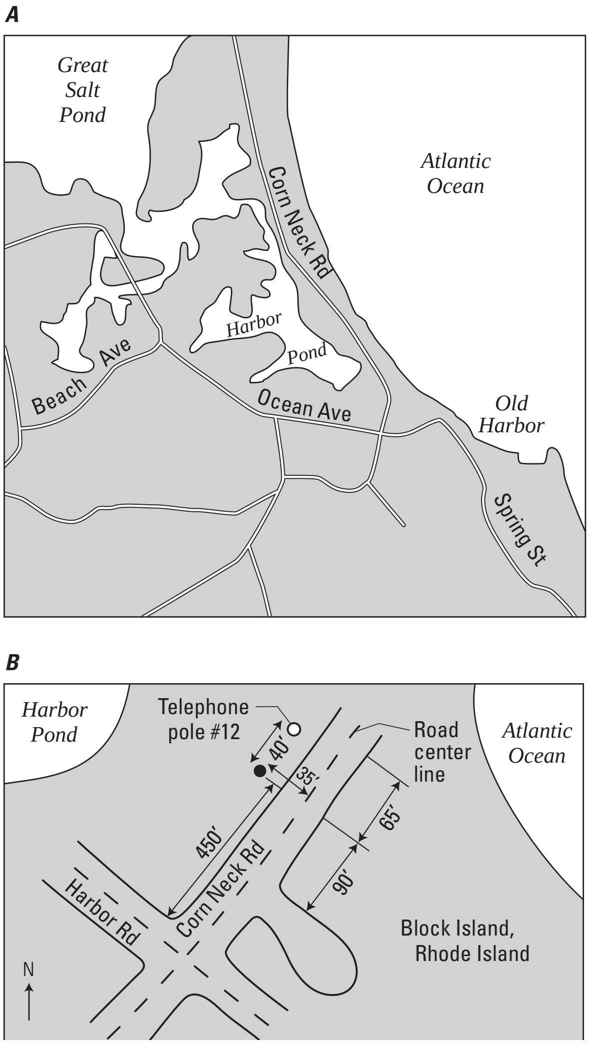


Figure 1. Examples of (*A*) general sketch map and (*B*) detailed sketch map.

b. Detailed site map:

(1) Prepare a detailed sketch map (fig. 1) showing the location of the well site in the field notebook and on the last page of the Groundwater Site Schedule, Form 9-1904-A (fig. 2). The sketch map should contain enough detail so that the site could be found by a person who has never been to the site before.

(2) Take at least two photographs of the well location from different views and indicate on each photograph the direction of view. File location photographs with the GWSI form.

Data Recording

All calibration and maintenance data associated with the GPS instrument use are recorded in the calibration and maintenance equipment logbook. Data are recorded in a field notebook and on the GWSI Groundwater Site Schedule (Form 9-1904-A).

References

Hoopes, B.C., ed., 2004, User’s manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, 149 p.

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ______
Date ______

Coded by ______
Checked by ______
Entered by ______

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) USGS | SITE ID (C1) | PROJECT (C5)

STATION NAME (C12/900)

1 SITE TYPE (C802) Primary - Secondary | DISTRICT (C6) | COUNTRY (C41) | STATE (C7)

COUNTY or TOWN (C8) ______ County code

LATITUDE (C9) . | LONGITUDE (C10) . | LAT/LONG ACCURACY (C11)

H	1	5	S	R	F	T	M	U
Hndrth sec.	tenth sec.	half sec.	sec.	3 sec.	5 sec.	10 sec.	min.	Un-known

LAT/LONG METHOD (C35)

C	D	G	L	M	N	R	S	U
land net	DGPS	GPS	LORAN	map	inter-polated digital map	reported	survey	un-known

LAT/LONG DATUM (C36)

NAD27	NAD83
North American Datum of 1927	North American Datum of 1983

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17)

A	D	G	I	J	L	M	N	R	U
altimeter	DGPS	GPS	IfSAR	LiDAR	Level	map	DEM	re-ported	un-known

ALTITUDE DATUM (C22)

NGVD29	NAVD88
National Geodetic Vertical Datum of 1929	North American Vertical Datum of 1988

LAND NET (C13) 1/4 1/4 1/4 S section T township range merid

TOPO-GRAPHIC SETTING (C19)

A	B	C	D	E	F	G	H	K	L	M	O	P	S	T	U	V	W
alluvial fan	playa	stream channel	depres-sion	dunes	flat	flood-plain	hill-top	sink-hole	lake or swamp	mangrove swamp	off-shore	pedi-ment	hill-side	ter-race	undu-lating	valley flat	upland draw

HYDROLOGIC UNIT CODE (C20) | DRAINAGE BASIN CODE (C801) | STANDARD TIME ZONE (C813) | DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14) | MAP SCALE (C15)

AGENCY USE (C803)

A	D	I	L	M	O	R
active no/na	discon-tinued	inactive site	active written	active oral	inventory site	remediated

2 NATIONAL WATER-USE (C39)

DATA TYPE (C804) Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box

WL cont	WL int	QW cont	QW int	PR cont	PR int	EV cont	EV int	wind vel.	tide cont	tide int	sed. con	sed. ps	peak flow	low flow	state water use

INSTRUMENTS (C805) (Place a "Y" in the appropriate box):

digital rec-order	graphic rec-order	tele-metry land line	tele-metry radio	tele-metry satellite	AHDAS	crest-stage gage	tide gage	deflec-tion meter	bubble gage	stilling well	CR type recorder	weigh-ing rain gage	tipping bucket rain gage	acoustic velocity meter	electro-magnetic flowmeter	pressure transducer

DATE INVENTORIED (C711) month – day – year

RECORD READY FOR WEB (C32)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

REMARKS (C806)

FOOTNOTES

1SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal stream				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2

WS	DO	CO	IN	IR	MI	LV	PH	ST	RM	TE	AQ
water supply	domestic	commer-cial	industrial	irrigation	mining	livestock	power hydro-electric	waste water treatment	remedia-tion	thermo-electric power	aqua-culture

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 2. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked | L poor location | M minimal data | U unchecked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode | C standby emer. supply | D drain | E geo-thermal | G seismic | H heat reservoir | M mine | O obser-vation | P oil or gas | R recharge | S repres-surize | T test | U unused | V with-drawal/return | W with-drawal | X waste | Z des-troyed

SECONDARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond. | B bottling | C comm-ercial | D de-water | E power | F fire | H domes-tic | I irri-gation | J indus-trial (cooling) | K mining | M medi-cinal | N indus-trial | P public supply | Q aqua-culture | R recrea-tions | S stock | T insti-tutional | U unused | Y desalin-ation | Z other

SECONDARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single | N unconfined multiple | C confined single | M confined multiple | X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27) .

WELL DEPTH (C28) .

SOURCE OF DEPTH DATA (C29): A other gov't | D driller | G geol-ogist | L logs | M memory | O owner | R other reported | S reporting agency | Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface | M meas. pt. | S vertical datum

WATER LEVEL (C237/241/242) .

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929 | NAVD88 North American Vertical Datum 0f 1988 | Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure | B tide stage | C ice | D dry | E recently flowing | F flowing | G nearby flowing | H nearby recently flowing | I injector site | J injector site monitor | M plugged | N measure-ment discontinued | O obstruc-tion | P pumping | R recently pumped | S nearby pumping | T nearby recently pumped | V foreign sub-stance | W well des-troyed | X affected by surface water | Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline | B analog | C calibrated airline | D differ-ential GPS | E esti-mated | F trans-ducer | G pressure gage | H calibrated press. gage | L geophysi-cal logs | M mano-meter | N non-rec. gage | O observed | P acoustic pulse | R reported | S steel tape | T electric tape | V calibrated elec. tape | Z other

WATER-LEVEL ACCURACY (C276): 0 foot | 1 tenth | 2 hun-dredth | 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't | D driller's log | G geol-ogist | L geophysi-cal logs | M memory | O owner | R other reported | S reporting agency | Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y ready to display | C condi-tional | P proprie-tary | L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't | D driller | G geol-ogist | L logs | M memory | O owner | R other reported | S reporting agency | Z other

METHOD OF CONSTRUCTION (C65): A air-rotary | B bored or augered | C cable tool | D dug | H hydraulic rotary | J jetted | P air per-cussion | R reverse rotary | S sonic | T trenching | V driven | W drive wash | Z other

TYPE OF FINISH (C66): C porous concrete | F gravel w/perf. | G gravel screen | H horiz. gallery | O open end | P perf or slotted | S screen | T sand point | W walled | X open hole | Z other

TYPE OF SEAL (C67): B bentonite | C clay | G cement grout | N none | Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump | B bailed | C compres-sed air | J jetted | N none | P pumped | S surged | Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chem-icals | D dry ice | E explo-sives | F defloc-culent | H hydro-frac-turing | M mech-anical | Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE RECORD SEQUENCE NO. (C724) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN   RECORD SEQUENCE NO. (C726)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) .   DEPTH TO BOTTOM OF INTERVAL (C84) .   DIAMETER OF INTERVAL (C87) .

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89) .   WIDTH OF OPENING (C88) .

FOOTNOTES:

[5] TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

[6] TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT   RECORD SEQUENCE NO. (C728)   BEGINNING DATE (C321) – – (month day year)   ENDING DATE (C322) – –

M.P. HEIGHT (C323) .   ALTITUDE OF MEASURING POINT (C325)   ALTITUDE METHOD (C326)   ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)   M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centri-fugal	jet	piston	rotary	submer-sible	turbine	un-known	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gaso-line	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Govern-ment	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182) C Cooperator's Office, D District Office R Reporting Agency Z other

DATA FORMAT (C261) F files, M machine readable, P published, Z other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

6 - Groundwater Site Schedule

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W
RECORD SEQUENCE NO. (C730)
TYPE OF NETWORK (C706) Q W water quality
BEGINNING YEAR (C115)
ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical proper-ties	common ions	trace elements	pesti-cides	nutri-ents	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117)
[7] FREQUENCY OF COLLECTION (C118)
ANALYZING AGENCY (C307)
[8] PRIMARY NETWORK SITE (C257)
[8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W
RECORD SEQUENCE NO. (C730)
TYPE OF NETWORK (C706) W L water level
BEGINNING YEAR (C115)
ENDING YEAR (C116)

SOURCE AGENCY (C117)
[7] FREQUENCY OF COLLECTION (C118)
[8] PRIMARY NETWORK SITE (C257)
[8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W
RECORD SEQUENCE NO. (C730)
TYPE OF NETWORK (C706) W D pumpage or with-drawals
BEGINNING YEAR (C115)
ENDING YEAR (C116)

SOURCE AGENCY (C117)
[7] FREQUENCY OF COLLECTION (C118)
METHOD OF COLLECTION (C133)

C	E	M	U	Z
calcu-lated	esti-mated	meter-ed	un-known	other

[8] PRIMARY NETWORK SITE (C257)
[8] SECONDARY NETWORK SITE (C708)

FOOTNOTES:

[7] FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continu-ously	daily	semi-monthly	inter mittent	monthly	one-time only	quarter-ly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

[8] NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S
RECORD SEQUENCE NO. (C311)
DATE OF REMARK (C184) month – day – year
REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S
RECORD SEQUENCE NO. (C311)
DATE OF REMARK (C184) month – day – year
REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P (pumped), F (flow)

DISCHARGE (gpm) (C150) .

ACCURACY OF DISCHARGE MEASUREMENT (C310): E (excellent (LT 2%)), G (good (2%-5%)), F (fair (5%-8%)), P (poor (GT 8%))

SOURCE OF DATA (C151): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF DISCHARGE MEASUREMENT (C152): A (acoustic meter), B (bailer), C (current meter), D (Doppler meter), E (estimated), F (flume), M (totaling meter), O (orifice), P (pitot-tube), R (reported), T (trajectory), U (venturi meter), V (volumetric meas), W (weir), X (unknown), Z (other)

PRODUCTION WATER LEVEL (C153) .

STATIC WATER LEVEL (C154) .

SOURCE OF DATA (C155): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF WATER-LEVEL MEASUREMENT (C156): A (airline), B (recorder), C (calibrated airline), D (differ-ential GP), E (esti-mated), F (trans-ducer), G (pressure gage), H (calibrated press. gage), L (geophysi-cal logs), M (mano-meter), N (non-rec. gage), O (observed), P (acoustic pulse), R (reported), S (steel tape), T (electric tape), V (calibrated elec. tape), Z (other)

PUMPING PERIOD (C157) .

SPECIFIC CAPACITY (C272) .

DRAWDOWN (C309) .

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91) .

DEPTH TO BOTTOM OF UNIT (C92) .

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P (principal aquifer), Q (aggregate of lithologic units), S (secondary aquifer), N (no contrib-ution), U (unknown)

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126) .

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section # ____________

GWPD 6—Recognizing and removing debris from a well

VERSION: 2010.1

PURPOSE: To recognize when a well contains debris and how to remove the debris from the well.

Materials and Instruments

1. Steel tape graduated in feet, tenths and hundredths of feet, or an electric tape
2. Blue carpenter's chalk
3. Clean rag
4. Mirror
5. Flashlight
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Field notebook
8. Water-level measurement field form or handheld computer for data entry
9. A grappling device with wire line or heavy duty treble fishing hook and rope
10. Safety equipment: gloves, safety glasses, first-aid kit

Data Accuracy and Limitations

1. Debris that is present in a well can affect the plumbness of the tape and cause errors in water-level measurements.
2. The quality of water-level data from a well is directly related to well maintenance.
3. Success rate for this procedure increases with increasing well diameter and decreasing well depth.

Assumptions

1. Individual has been trained to make water-level measurements with a graduated steel tape (GWPD 1) or an electric tape (GWPD 4).
2. State or local ordinances do not prevent retrieval of an item in a well.

Instructions

1. Make a water-level measurement as described in GWPD 1 or GWPD 4. Lack of agreement between the original water-level measurement and subsequent water-level check measurements could indicate that the well contains debris. If the measuring tape goes slack as it is being slowly lowered into the well, the weight or probe probably has encountered debris in the well.
2. To check for debris on a sunny day, use a mirror to look into the well. Hold the mirror in the hand and rotate it back and forth until the proper angle is obtained to allow the sun to reflect off the mirror and down the well onto the water surface.
3. If the well is located in a dark enclosed area away from the sun, or the weather is overcast, use a flashlight to look down the well for debris.
4. To remove light- to medium-weight wood debris from a well, use a simple inexpensive device such as a heavy duty treble fishing hook attached to a rope. Lower the hook down the well while using the mirror to see when the hook is below the debris. To remove the debris from the well, move the rope upward with a quick jerking motion until the wood debris becomes snagged on the treble hook. Slowly remove the rope and debris from the well. If the object is below the water surface where it cannot be seen, feel for the debris while trying to snag it.

5. To remove heavy wood or debris that cannot be snagged, use a grappling device similar to a pair of ice tongs. The device shown in figure 1 has been designed and used to remove debris from wells effectively and easily. This type of device can be used to remove blocks of wood, stones, cans, bottles, pipes, and poles from wells and can be constructed by a machine shop from the photographs shown in figure 1. To remove debris from a well, cock the device in the open position (fig. 1*B*) and lower into the well on a suspension cable that is fastened to a shackle. When the tripping rod strikes the debris in the well, the rod pushes upward on the locking bar, releasing it, and the spring opposite the locking bar (fig. 1*B*) pulls the arms together. Figure 1*C* shows the grappling device in the closed position gripping a heavy object (15 pounds). The weight of the debris being lifted from the well holds the arms together. The heavier the object, the tighter the arms grip. In case the tripping rod will not close the arms, the arms can be closed from the surface by attaching a line at the pivot point of the locking bar. Lower the grappling device into the well and pull on the line connected to the locking bar when the arms are in the desired position. The arms will close around the debris without the aid of the tripping rod.

Data Recording

Data are recorded in a field notebook and on a water-level measurement field form (fig. 2).

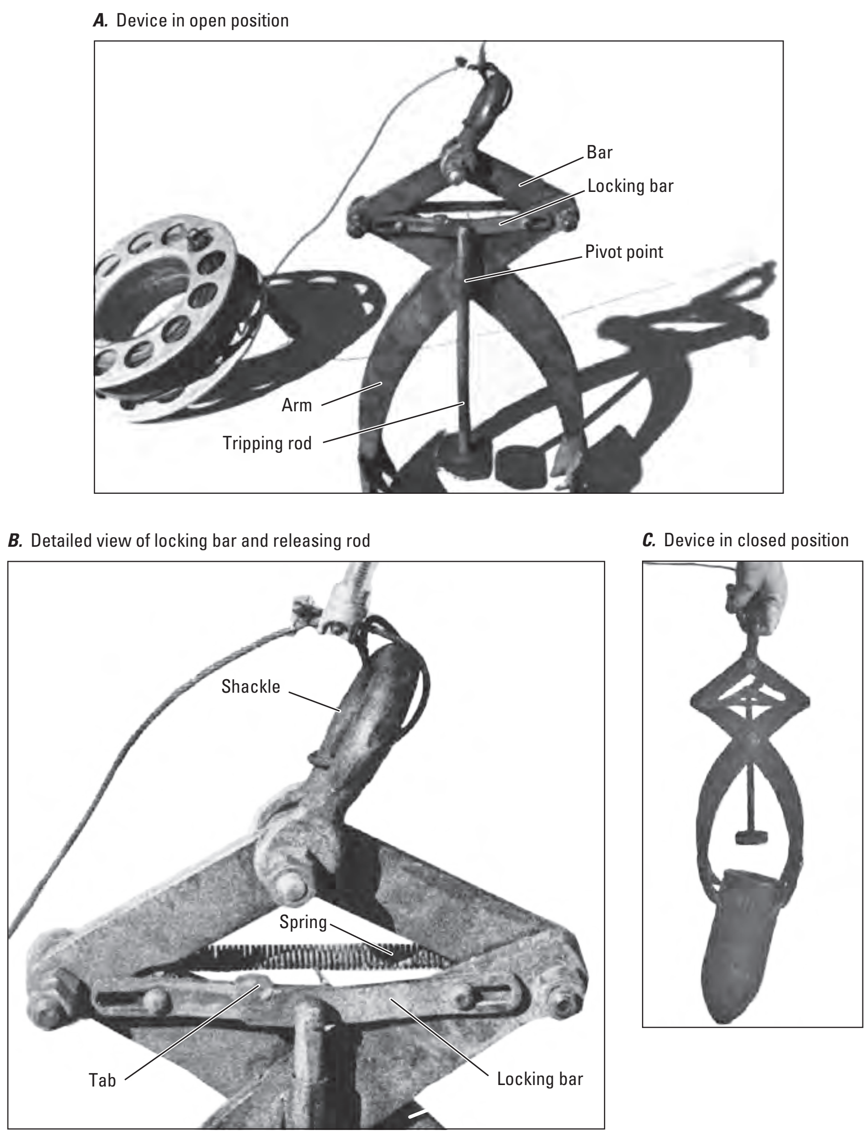


Figure 1. Grappling device for removing debris from wells (Bader, 1966).

WATER-LEVEL MEASUREMENT FIELD FORM

Steel Tape Measurement

SITE INFORMATION

SITE ID (C1) | | | | | | | | | | | | | | |

Equipment ID ____________

Date of Field Visit ____________

Station name (C12) ____________

WATER-LEVEL DATA

	1	2	3	4	5
Time					
Hold					
Cut					
Tape correction					
WL below MP					
MP correction					
WL below LSD					

Measured by ________________________ COMMENTS*____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)	BEGINNING DATE (C321)	ENDING DATE (C322)	M.P. HEIGHT (C323) NOTE: (-) for MP below land surface
____________	☐☐ – ☐☐ – ☐☐☐☐ (month, day, year)	☐☐ – ☐☐ – ☐☐☐☐	☐☐☐.☐☐
____________	☐☐ – ☐☐ – ☐☐☐☐	☐☐ – ☐☐ – ☐☐☐☐	☐☐☐.☐☐

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
☐☐ – ☐☐ – ☐☐☐☐ (month, day, year)	☐☐☐☐	☐	☐	☐	☐☐☐☐.☐☐

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysi-cal logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measure-ment discon.,	obstruc-tion,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign sub-stance,	well des-troyed,	surface water effects,	other	static

Figure 2. Water-level measurement field form for steel tape measurements. This form, or an equivalent custom-designed form, should be used to record field measurements.

References

Bader, J.S., 1966, Device for removing debris from wells, *in* Mesnier, G.N., and Chase, E.B., comps., Selected techniques in water resources investigations, 1965: U.S. Geological Survey Water-Supply Paper 1822, p. 43–46.

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 4—Measuring water levels by use of an electric tape: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

GWPD 7—Estimating discharge from a naturally flowing well

VERSION: 2010.1

PURPOSE: To estimate the discharge from a naturally flowing well from a vertical pipe.

Materials and Instruments

1. Small hand level
2. L-shaped measuring device (carpenter's square), graduated by inches
3. Clamp
4. Support rod for the measuring device
5. Field notebook
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Ground-Water Site-Inventory (GWSI) System Ground-water Site Schedule, Form 9-1904-A

Data Accuracy and Limitations

1. Under ordinary field conditions, with reasonable care, measurements may be made in which the error seldom exceeds 10 percent.
2. Not accurate for small flows of 30 gallons per minute or less, or when the crest of the flow is less than 1.5 inches. For small flows, connect a pipe tee to the top of the well casing and measure the well discharge with a bucket and stopwatch.
3. The most accurate estimated discharge will be obtained when the pipe is truly vertical.

Advantages

1. Fast and simple means of approximating the flow from vertical pipes.
2. No special training needed to use this method.

Disadvantages

1. Method provides only an approximate discharge from wells with vertical pipes.
2. Well flow must be constant so that the height of water above the pipe does not vary appreciably.

Assumptions

1. The discharge pipe does not have a circular orifice weir.
2. The discharge pipe does not have an in-line flowmeter.
3. The pipe is vertical.

Instructions

1. Measure the height of the crest of the water flow, in inches, above the top of the vertical pipe. This measurement can be made using a small hand level, an L-shaped measuring device, a clamp, and a support rod. Figure 1 shows how to set up the equipment to measure the height of the crest of flow from a vertical pipe.

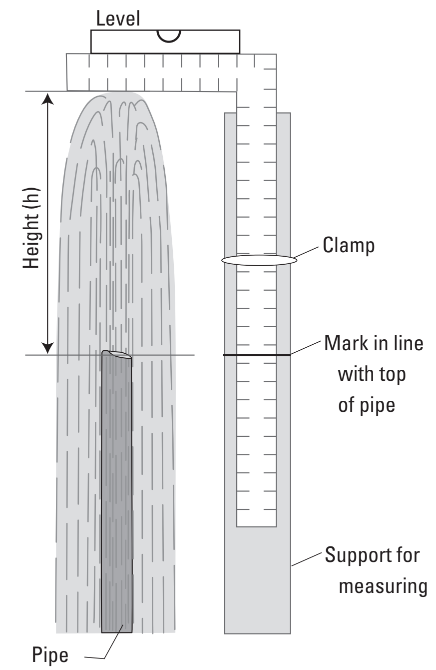


Figure 1. Measuring the height of the crest of flow from a vertical pipe. (Driscoll, 1966, p. 97)

2. Measure the inside diameter of the discharge pipe, in inches.

3. Estimate well discharge from the discharge curves shown in figure 2 for vertical standard pipes. Find the number that corresponds to the height of the crest of the water flow on the y-axis. Move horizontally to the right along that line to the curve that represents the inside diameter of the well. Read the discharge, in gallons per minute, from the x-axis corresponding to that point. If the inside diameter of the well for which discharge is being estimated is not one of the given curves in figure 2, estimate the well discharge by interpolating between the curves. Read the discharge, in gallons per minute, and record the results in the field notebook and in the discharge data section of the GWSI Groundwater Site Schedule (fig. 3, Form 9-1904-A).

Data Recording

Data are recorded in a field notebook. Discharge data also should be recorded in the discharge data section of the GWSI Groundwater Site Schedule (fig. 3, Form 9-1904-A). This is best described as a trajectory method and should be coded as "T" in field C152 on Form 9-1904-A.

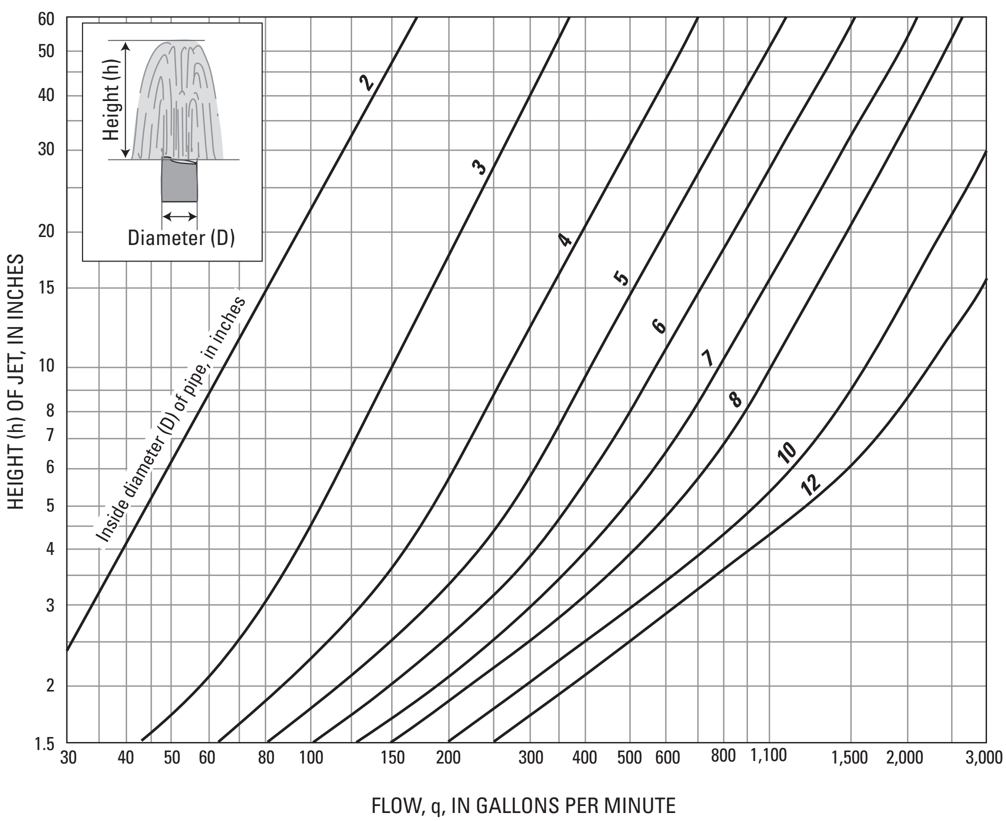


Figure 2. Discharge curves for measurement of flow from vertical standard pipes. The curves are based on data from experiments of Lawrence and Braunworth (1906). (From Bureau of Reclamation. 1967, p. 199)

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ____________
Date ____________

Coded by ____________
Checked by ____________
Entered by ____________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) USGS | SITE ID (C1) | PROJECT (C5)

STATION NAME (C12/900)

1 SITE TYPE (C802) - Primary Secondary | DISTRICT (C6) | COUNTRY (C41) | STATE (C7)

COUNTY or TOWN (C8) ____________ County code

LATITUDE (C9) . | LONGITUDE (C10) . | LAT/LONG ACCURACY (C11)

H	1	5	S	R	F	T	M	U
Hndrth sec.	tenth sec.	half sec.	sec.	3 sec.	5 sec.	10 sec.	min.	Un-known

LAT/LONG METHOD (C35)

C	D	G	L	M	N	R	S	U
land net	DGPS	GPS	LORAN	map	inter-polated digital map	reported	survey	un-known

LAT/LONG DATUM (C36)

NAD27	NAD83
North American Datum of 1927	North American Datum of 1983

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17)

A	D	G	I	J	L	M	N	R	U
altimeter	DGPS	GPS	IfSAR	LiDAR	Level	map	DEM	re-ported	un-known

ALTITUDE DATUM (C22)

NGVD29	NAVD88
National Geodetic Vertical Datum of 1929	North American Vertical Datum of 1988

LAND NET (C13) S T
1/4 1/4 1/4 section township range merid

TOPO-GRAPHIC SETTING (C19)

A	B	C	D	E	F	G	H	K	L	M	O	P	S	T	U	V	W
alluvial fan	playa	stream channel	depres-sion	dunes	flat	flood-plain	hill-top	sink-hole	lake or swamp	mangrove swamp	off-shore	pedi-ment	hill-side	ter-race	undu-lating	valley flat	upland draw

HYDROLOGIC UNIT CODE (C20) | DRAINAGE BASIN CODE (C801) | STANDARD TIME ZONE (C813) | DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14) | MAP SCALE (C15)

AGENCY USE (C803)

A	D	I	L	M	O	R
active no/na	discon-tinued	inactive site	active written	active oral	inventory site	remediated

2 NATIONAL WATER-USE (C39)

DATA TYPE (C804)
Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box

WL cont	WL int	QW cont	QW int	PR cont	PR int	EV cont	EV int	wind vel.	tide cont	tide int	sed. con	sed. ps	peak flow	low flow	state water use

INSTRUMENTS (C805)
(Place a "Y" in the appropriate box):

digital rec-order	graphic rec-order	tele-metry land line	tele-metry radio	tele-metry satellite	AHDAS	crest-stage gage	tide gage	deflec-tion meter	bubble gage	stilling well	CR type recorder	weigh-ing rain gage	tipping bucket rain gage	acoustic velocity meter	electro-magnetic flowmeter	pressure transducer

DATE INVENTORIED (C711) — —
month day year

RECORD READY FOR WEB (C32)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

REMARKS (C806)

FOOTNOTES

1SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal stream				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2

WS	DO	CO	IN	IR	MI	LV	PH	ST	RM	TE	AQ
water supply	domestic	commer-cial	industrial	irrigation	mining	livestock	power hydro-electric	waste water treatment	remedia-tion	thermo-electric power	aqua-culture

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 3. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked; L poor location; M minimal data; U unchecked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode; C standby emer. supply; D drain; E geothermal; G seismic; H heat reservoir; M mine; O observation; P oil or gas; R recharge; S repressurize; T test; U unused; V withdrawal/return; W withdrawal; X waste; Z destroyed

SECONDARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond.; B bottling; C commercial; D dewater; E power; F fire; H domestic; I irrigation; J industrial (cooling); K mining; M medicinal; N industrial; P public supply; Q aquaculture; R recreations; S stock; T institutional; U unused; Y desalination; Z other

SECONDARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single; N unconfined multiple; C confined single; M confined multiple; X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27)

WELL DEPTH (C28)

SOURCE OF DEPTH DATA (C29): A other gov't; D driller; G geologist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface; M meas. pt.; S vertical datum

WATER LEVEL (C237/241/242)

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929; NAVD88 North American Vertical Datum 0f 1988; Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measurement discontinued; O obstruction; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign substance; W well destroyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; D differential GPS; E estimated; F transducer; G pressure gage; H calibrated press. gage; L geophysical logs; M manometer; N non-rec. gage; O observed; P acoustic pulse; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER-LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hundredth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geologist; L geophysical logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y ready to display; C conditional; P proprietary; L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): CONS

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't; D driller; G geologist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

METHOD OF CONSTRUCTION (C65): A air-rotary; B bored or augered; C cable tool; D dug; H hydraulic rotary; J jetted; P air percussion; R reverse rotary; S sonic; T trenching; V driven; W drive wash; Z other

TYPE OF FINISH (C66): C porous concrete; F gravel w/perf.; G gravel screen; H horiz. gallery; O open end; P perf or slotted; S screen; T sand point; W walled; X open hole; Z other

TYPE OF SEAL (C67): B bentonite; C clay; G cement grout; N none; Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump; B bailed; C compressed air; J jetted; N none; P pumped; S surged; Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chemicals; D dry ice; E explosives; F deflocculent; H hydrofracturing; M mechanical; Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE — RECORD SEQUENCE NO. (C724) — SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) — DEPTH TO BOTTOM OF INTERVAL (C74) — DIAMETER OF INTERVAL (C75)

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) — DEPTH TO BOTTOM OF INTERVAL (C74) — DIAMETER OF INTERVAL (C75)

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) — DEPTH TO BOTTOM OF INTERVAL (C74) — DIAMETER OF INTERVAL (C75)

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG — RECORD SEQUENCE NO. (C725) — SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) — DEPTH TO BOTTOM OF CASING (C78) — DIAMETER OF CASING (C79)

4 CASING MATERIAL (C80) — CASING THICKNESS (C81)

RECORD SEQUENCE NO. (C725) — SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) — DEPTH TO BOTTOM OF CASING (C78) — DIAMETER OF CASING (C79)

4 CASING MATERIAL (C80) — CASING THICKNESS (C81)

RECORD SEQUENCE NO. (C725) — SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) — DEPTH TO BOTTOM OF CASING (C78) — DIAMETER OF CASING (C79)

4 CASING MATERIAL (C80) — CASING THICKNESS (C81)

RECORD SEQUENCE NO. (C725) — SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) — DEPTH TO BOTTOM OF CASING (C78) — DIAMETER OF CASING (C79)

4 CASING MATERIAL (C80) — CASING THICKNESS (C81)

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN
RECORD SEQUENCE NO. (C726)
SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83)
DEPTH TO BOTTOM OF INTERVAL (C84)
DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)
[6] TYPE OF OPENING (C85)
LENGTH OF OPENING (C89)
WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)
DEPTH TO BOTTOM OF INTERVAL (C84)
DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)
[6] TYPE OF OPENING (C85)
LENGTH OF OPENING (C89)
WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)
DEPTH TO BOTTOM OF INTERVAL (C84)
DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)
[6] TYPE OF OPENING (C85)
LENGTH OF OPENING (C89)
WIDTH OF OPENING (C88)

FOOTNOTES:

[5] TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

[6] TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT
RECORD SEQUENCE NO. (C728)
BEGINNING DATE (C321) month – day – year
ENDING DATE (C322)

M.P. HEIGHT (C323)
ALTITUDE OF MEASURING POINT (C325)
ALTITUDE METHOD (C326)
ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)
M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centri-fugal	jet	piston	rotary	submer-sible	turbine	un-known	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gaso-line	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Govern-ment	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182)

C	D	R	Z
Cooperator's Office,	District Office	Reporting Agency	other

DATA FORMAT (C261)

F	M	P	Z
files,	machine readable,	published,	other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) Q W water quality — BEGINNING YEAR (C115) — ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical properties	common ions	trace elements	pesticides	nutrients	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — ANALYZING AGENCY (C307) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) W L water level — BEGINNING YEAR (C115) — ENDING YEAR (C116)

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) W D pumpage or withdrawals — BEGINNING YEAR (C115) — ENDING YEAR (C116)

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — METHOD OF COLLECTION (C133) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

C	E	M	U	Z
calculated	estimated	metered	unknown	other

FOOTNOTES:

[7] FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continuously	daily	semi-monthly	inter mittent	monthly	one-time only	quarterly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

[8] NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S — RECORD SEQUENCE NO. (C311) — DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S — RECORD SEQUENCE NO. (C311) — DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P pumped, F flow

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E excellent (LT 2%), G good (2%-5%), F fair (5%-8%), P poor (GT 8%)

SOURCE OF DATA (C151): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF DISCHARGE MEASUREMENT (C152): A acoustic meter, B bailer, C current meter, D Doppler meter, E estimated, F flume, M totaling meter, O orifice, P pitot-tube, R reported, T trajectory, U venturi meter, V volumetric meas, W weir, X unknown, Z other

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF WATER LEVEL MEASUREMENT (C156): A airline, B recorder, C calibrated airline, E estimated, G pressure gage, H calibrated press. gage, L geophysical logs, M manometer, N non-rec. gage, R reported, S steel tape, T electric tape, U unknown, V calibrated elec. tape, Z other

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P principal aquifer, S secondary aquifer, N no contribution, U unknown

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ___________ Range ___________

Section #___________

8 - Ground-water site schedule

References

Bureau of Reclamation, 1967, Water measurement manual, A water resources technical publication: Washington, D.C., U.S. Government Printing Office, p. 199.

Driscoll, F.G., 1966, Groundwater and wells: St. Paul, Minnesota, Johnson Filtration Systems, Inc., 440 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Lawrence, F.E., and Braunworth, P.L., 1906, Fountain flow of water in vertical pipes: Transactions of the American Society of Civil Engineers, v. 57, p. 265–306.

GWPD 8—Estimating discharge from a pumped well by use of the trajectory free-fall or jet-flow method

VERSION: 2010.1

PURPOSE: To estimate the discharge from a pumped well from a non-vertical standard pipe by using the trajectory free-fall or jet-flow method.

Materials and Instruments

1. L-shaped measuring device (carpenter's square)
2. Support for measuring device
3. Small hand level
4. Clamp
5. Field notebook
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Groundwater Site Inventory (GWSI) System Groundwater Site Schedule, Form 9-1904-A

Data Accuracy and Limitations

1. Under ordinary field conditions, with reasonable care, measurements can be made in which the error seldom exceeds 10 percent.
2. The most accurate estimated discharge will be obtained when the pipe is truly horizontal.
3. The discharge pipe should be a straight length of standard pipe at least 5 feet long, so that the open end is at least this distance from the nearest elbow or bend in the pipe.
4. If the discharge pipe slopes upward, the estimated discharge will be too high; if it slopes downward, the estimated discharge will be too low.
5. The principal difficulty with using this method is in measuring the coordinates (X and Y) of the jet-flow stream accurately.
6. Well flow should be constant so that the top of the stream at the open end of the pipe does not vary appreciably.
7. Not accurate for small flows. For small flows, measure the well discharge with a flowmeter or a bucket and stopwatch.

Advantages

1. This method provides a simple, inexpensive, and practical means of estimating flow from horizontal and inclined pipes for field tests.
2. No special training is needed to use this method.

Disadvantages

1. This method provides only an approximate discharge from wells with horizontal or inclined pipes.
2. Well flow should be constant. The top of the stream at the open end of the pipe should not vary appreciably.

Assumptions

1. The discharge pipe does not have a circular orifice weir.
2. The discharge pipe does not have an in-line flowmeter.

Instructions

1. Measure the inside diameter (D) of the pipe accurately, in inches (fig. 1*A*).
2. Measure the distance (X) that the jet flow of water travels, in inches parallel to the top of the pipe for a 12-inch vertical drop (Y; fig. 1*B*).
3. If the jet flow is brooming or spreading from the end of the horizontal pipe, the center of the falling stream (P) can be located more reliably than can a point on the surface of the stream. When brooming or spreading flow occurs, measure X from the center of the pipe for a 12-inch vertical drop, and measure Y from the center of the pipe to the center of the falling stream (fig. 1*C*).
4. Estimate well discharge by using the discharge curves for measurement of flow from non-vertical standard pipes (fig. 2). For example, see the sample calculation in figure 2 for a 5-inch well with a jet stream of 16 inches (X) and a 12-inch vertical drop (Y). Discharge from this well is about 330 gallons per minute.
5. For partially filled non-vertical pipes, measure the freeboard (F) and the inside diameter (D) of the pipe (fig. 1C). Calculate the ratio of F/D as a percentage. Measure the distance X of the jet stream for a 12-inch vertical drop (Y), and estimate a well discharge using the discharge curves in figure 2. The actual estimated discharge will be the value for a full pipe multiplied by a correction factor obtained from table 1. Use the correction factor in the column opposite the ratio of F/D calculated above for the partially filled non-vertical pipe.
6. Record estimated discharge in the field notebook and in the discharge data section on the GWSI Groundwater Site Schedule (fig. 3, Form 9-1904-A).

Data Recording

Data are recorded in a field notebook. Discharge data should also be recorded in the discharge data section of the GWSI Groundwater Site Schedule (Form 9-1904-A). This is best described as a trajectory method and should be coded as "T" in field C152 on Form 9-1904-A.

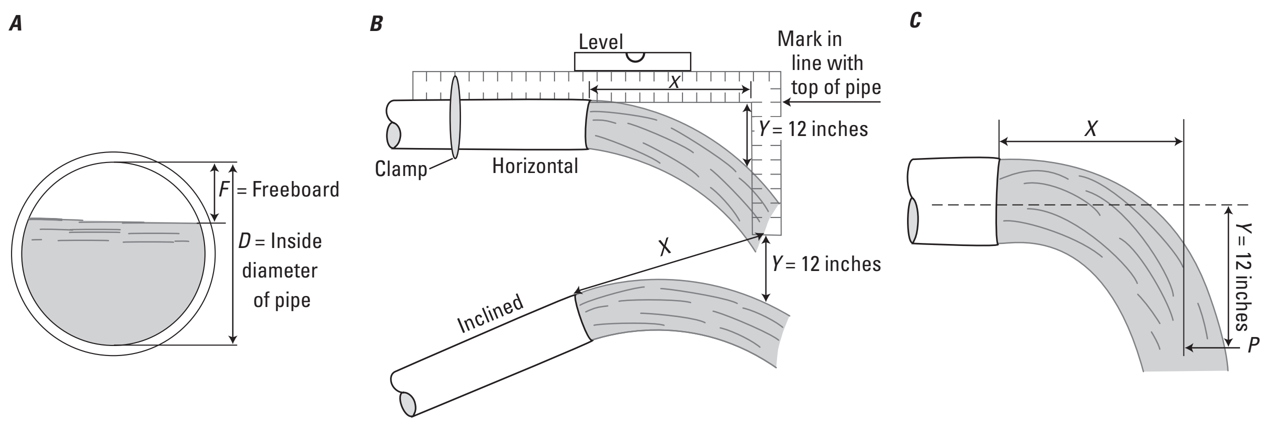


Figure 1. Measurements for estimating flow from (*A*) a partially filled pipe (Anderson, 1963), (*B*) a horizontal or inclined pipe with steady flow (Anderson, 1963), and (*C*) a horizontal pipe when brooming or spreading flow occurs (Driscoll, 1986).

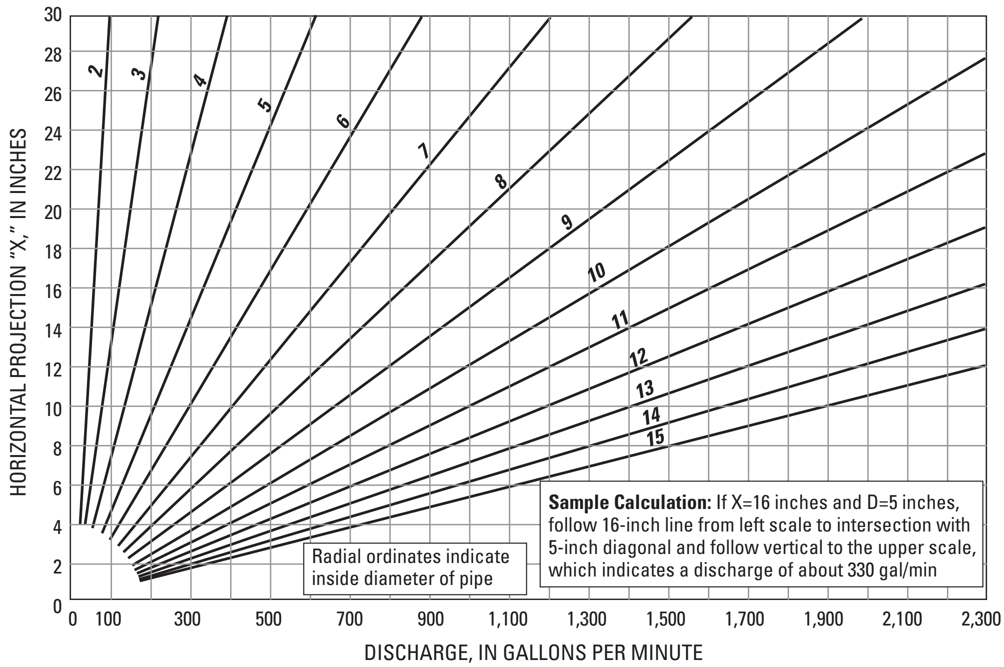


Figure 2. Discharge curves for measurement of flow from non-vertical standard pipes based on a constant value of 12 inches for *Y*. If the discharge in the pipe is not flowing full, multiply the discharge by the correction factor found in table 1 (McDonald, 1950).

Table 1. Correction factors for percentages of discharge (see fig. 2).

[F, freeboard; D, inside diameter]

F/*D* percent	Correction factor
5	0.981
10	.948
15	.905
20	.858
25	.805
30	.747
35	.688
40	.627
45	.564
50	.500
55	.436
60	.375
65	.312
70	.253
75	.195
80	.142
85	.095
90	.052
95	.019
100	.000

References

Anderson, K.E., 1963, Water well handbook (2d ed.): Missouri Water Well Drillers Association, p. 156.

Bureau of Reclamation, 1975, Water measurement manual, A water resources technical publication (2d ed., reprinted): U.S. Department of the Interior, p. 200.

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

McDonald, H.R., 1950, How to estimate flow from pipes: Engineering News-Record, August 31, 1950, p. 48.

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ______________
Date ______________

Coded by ______________
Checked by ______________
Entered by ______________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) U S G S
SITE ID (C1)
PROJECT (C5)

STATION NAME (C12/900)

SITE TYPE (C802) [1] — Primary - Secondary

DISTRICT (C6)
COUNTRY (C41)
STATE (C7)

COUNTY or TOWN (C8) ______________ County code

LATITUDE (C9) .

LONGITUDE (C10) .

LAT/LONG ACCURACY (C11)

H	1	5	S	R	F	T	M	U
Hndrth sec.	tenth sec.	half sec.	sec.	3 sec.	5 sec.	10 sec.	min.	Un-known

LAT/LONG METHOD (C35)

C	D	G	L	M	N	R	S	U
land net	DGPS	GPS	LORAN	map	inter-polated digital map	reported	survey	un-known

LAT/LONG DATUM (C36)

NAD27	NAD83
North American Datum of 1927	North American Datum of 1983

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17)

A	D	G	I	J	L	M	N	R	U
altimeter	DGPS	GPS	IfSAR	LiDAR	Level	map	DEM	re-ported	un-known

ALTITUDE DATUM (C22)

NGVD29	NAVD88
National Geodetic Vertical Datum of 1929	North American Vertical Datum of 1988

LAND NET (C13) — 1/4, 1/4, 1/4, S section, T township, range, merid

TOPOGRAPHIC SETTING (C19)

A	B	C	D	E	F	G	H	K	L	M	O	P	S	T	U	V	W
alluvial fan	playa	stream channel	depres-sion	dunes	flat	flood-plain	hill-top	sink-hole	lake or swamp	mangrove swamp	off-shore	pedi-ment	hill-side	ter-race	undu-lating	valley flat	upland draw

HYDROLOGIC UNIT CODE (C20)

DRAINAGE BASIN CODE (C801)

STANDARD TIME ZONE (C813)

DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14)

MAP SCALE (C15)

AGENCY USE (C803)

A	D	I	L	M	O	R
active no/na	discon-tinued	inactive site	active written	active oral	inventory site	remediated

[2] NATIONAL WATER-USE (C39)

DATA TYPE (C804)
Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box

WL cont	WL int	QW cont	QW int	PR cont	PR int	EV cont	EV int	wind vel.	tide cont	tide int	sed. con	sed. ps	peak flow	low flow	state water use

INSTRUMENTS (C805)
(Place a "Y" in the appropriate box):

digital rec-order	graphic rec-order	tele-metry land line	tele-metry radio	tele-metry satellite	AHDAS	crest-stage gage	tide gage	deflec-tion meter	bubble gage	stilling well	CR type recorder	weigh-ing rain gage	tipping bucket rain gage	acoustic velocity meter	electro-magnetic flowmeter	pressure transducer

DATE INVENTORIED (C711) month – day – year

RECORD READY FOR WEB (C32)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

REMARKS (C806)

FOOTNOTES

1SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC -CO	Coastal	GW -CR	Collector or Ranney type well	SB- CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW -EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW -HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW -IW	Interconnected wells	SB-UZ	Unsaturated zone
LA -EX	Excavation	ST	Stream	GW -TH	Test hole not completed as a well		
LA -OU	Outcrop	ST -CA	Canal	GW -MW	Multiple wells		
LA -SNK	Sinkhole	ST -DCH	Ditch				
LA -SH	Soil hole	ST -TS	Tidal strea m				
LA -SR	Shore	FA-WIW	Waste-Injection well				

2

WS	DO	CO	IN	IR	MI	LV	PH	ST	RM	TE	AQ
water supply	domestic	commer-cial	industrial	irrigation	mining	livestock	power hydro-electric	waste water treatment	remedia-tion	thermo-electric power	aqua-culture

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 3. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked; L poor location; M minimal data; U unchecked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode; C standby emer. supply; D drain; E geo-thermal; G seismic; H heat reservoir; M mine; O obser-vation; P oil or gas; R recharge; S repres-surize; T test; U unused; V with-drawal/return; W with-drawal; X waste; Z des-troyed

SECOND-ARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond.; B bottling; C comm-ercial; D de-water; E power; F fire; H domes-tic; I irri-gation; J indus-trial (cooling); K mining; M medi-cinal; N indus-trial; P public supply; Q aqua-culture; R recrea-tions; S stock; T insti-tutional; U unused; Y desalin-ation; Z other

SECOND-ARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single; N unconfined multiple; C confined single; M confined multiple; X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27)

WELL DEPTH (C28)

SOURCE OF DEPTH DATA (C29): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface; M meas. pt.; S vertical datum

WATER LEVEL (C237/241/242)

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929; NAVD88 North American Vertical Datum 0f 1988; Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measure-ment discontinued; O obstruc-tion; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign sub-stance; W well des-troyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; D differ-ential GPS; E esti-mated; F trans-ducer; G pressure gage; H calibrated press. gage; L geophysi-cal logs; M mano-meter; N non-rec. gage; O observed; P acoustic pulse; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER-LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hun-dredth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geol-ogist; L geophysi-cal logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y ready to display; C condi-tional; P proprie-tary; L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

METHOD OF CONSTRUCTION (C65): A air-rotary; B bored or augered; C cable tool; D dug; H hydraulic rotary; J jetted; P air per-cussion; R reverse rotary; S sonic; T trenching; V driven; W drive wash; Z other

TYPE OF FINISH (C66): C porous concrete; F gravel w/perf.; G gravel screen; H horiz. gallery; O open end; P perf or slotted; S screen; T sand point; W walled; X open hole; Z other

TYPE OF SEAL (C67): B bentonite; C clay; G cement grout; N none; Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump; B bailed; C compres-sed air; J jetted; N none; P pumped; S surged; Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chem-icals; D dry ice; E explo-sives; F defloc-culent; H hydro-frac-turing; M mech-anical; Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) H O L E   RECORD SEQUENCE NO. (C724)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) .   DEPTH TO BOTTOM OF INTERVAL (C74) .   DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .   DEPTH TO BOTTOM OF INTERVAL (C74) .   DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .   DEPTH TO BOTTOM OF INTERVAL (C74) .   DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) C S N G   RECORD SEQUENCE NO. (C725)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .   DEPTH TO BOTTOM OF CASING (C78) .   DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)   CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .   DEPTH TO BOTTOM OF CASING (C78) .   DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)   CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .   DEPTH TO BOTTOM OF CASING (C78) .   DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)   CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .   DEPTH TO BOTTOM OF CASING (C78) .   DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)   CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN RECORD SEQUENCE NO. (C726) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

FOOTNOTES:

5 TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

6 TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT RECORD SEQUENCE NO. (C728) BEGINNING DATE (C321) – – month day year ENDING DATE (C322) – –

M.P. HEIGHT (C323) . ALTITUDE OF MEASURING POINT (C325) ALTITUDE METHOD (C326) ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328) M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centri-fugal	jet	piston	rotary	submer-sible	turbine	un-known	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gaso-line	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Govern-ment	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182)

C	D	R	Z
Cooperator's Office,	District Office	Reporting Agency	other

DATA FORMAT (C261)

F	M	P	Z
files,	machine readable,	published,	other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

DATA FORMAT (C225)

F	M	P	Z
files	machine readable	published	other

OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehole deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730) ___   TYPE OF NETWORK (C706) Q W (water quality)   BEGINNING YEAR (C115) ____   ENDING YEAR (C116) ____

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical proper-ties	common ions	trace elements	pesti-cides	nutri-ents	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117) _____   [7]FREQUENCY OF COLLECTION (C118) _   ANALYZING AGENCY (C307) _____   [8]PRIMARY NETWORK SITE (C257) _   [8]SECONDARY NETWORK SITE (C708) _

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730) ___   TYPE OF NETWORK (C706) W L (water level)   BEGINNING YEAR (C115) ____   ENDING YEAR (C116) ____

SOURCE AGENCY (C117) _____   [7] FREQUENCY OF COLLECTION (C118) _   [8] PRIMARY NETWORK SITE (C257) _   [8] SECONDARY NETWORK SITE (C708) _

RECORD TYPE (C780) N E T W   RECORD SEQUENCE NO. (C730) ___   TYPE OF NETWORK (C706) W D (pumpage or with-drawals)   BEGINNING YEAR (C115) ____   ENDING YEAR (C116) ____

SOURCE AGENCY (C117) _____   [7]FREQUENCY OF COLLECTION (C118) _   METHOD OF COLLECTION (C133)

C	E	M	U	Z
calcu-lated	esti-mated	meter-ed	un-known	other

[8] PRIMARY NETWORK SITE (C257) _   [8]SECONDARY NETWORK SITE (C708) _

FOOTNOTES:

[7]FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continu-ously	daily	semi-monthly	inter mittent	monthly	one-time only	quarter-ly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

[8] NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S   RECORD SEQUENCE NO. (C311) ___   DATE OF REMARK (C184) __ – __ – ____ (month, day, year)

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S   RECORD SEQUENCE NO. (C311) ___   DATE OF REMARK (C184) __ – __ – ____ (month, day, year)

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month — day — year

TYPE OF DISCHARGE (C703): P pumped, F flow

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E excellent (LT 2%), G good (2%-5%), F fair (5%-8%), P poor (GT 8%)

SOURCE OF DATA (C151): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF DISCHARGE MEASUREMENT (C152): A acoustic meter, B bailer, C current meter, D Doppler meter, E estimated, F flume, M totaling meter, O orifice, P pitot-tube, R reported, T trajectory, U venturi meter, V volumetric meas, W weir, X unknown, Z other

PRODUCTION WATER LEVEL (C153) .

STATIC WATER LEVEL (C154) .

SOURCE OF DATA (C155): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF WATER LEVEL MEASUREMENT (C156): A airline, B recorder, C calibrated airline, E estimated, G pressure gage, H calibrated press. gage, L geophysical logs, M manometer, N non-rec. gage, R reported, S steel tape, T electric tape, U unknown, V calibrated elec. tape, Z other

PUMPING PERIOD (C157) .

SPECIFIC CAPACITY (C272) .

DRAWDOWN (C309) .

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91) .

DEPTH TO BOTTOM OF UNIT (C92) .

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P principal aquifer, S secondary aquifer, N no contribution, U unknown

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month — day — year

STATIC WATER LEVEL (C126) .

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section #____________

GWPD 9—Recording minimum and maximum water levels

VERSION: 2010.1

PURPOSE: To determine the minimum and maximum water level in a well between site visits.

Materials and Instruments

1. Plastic spool of nylon fishing leader, 15- or 18-pound test
2. Standard 2 1/2-inch water-level float
3. Transparent 3/8-inch polyethylene tubing
4. Powdered cork
5. Brass tubing, 1/4-inch inside diameter
6. Non-lead shot pellets
7. Hammer, nails, and screw-eye hooks
8. Hacksaw
9. Graduated steel tape
10. Permanent, water-resistant marker
11. Field notebook
12. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
13. Safety equipment: gloves, safety glasses, first-aid kit

Data Accuracy and Limitations

1. Devices were tested in a well having a continuous recorder and found to measure water levels to an accuracy of 0.1 foot.
2. Use should be limited to wells with water-level depths of 50 feet or less.
3. The well diameter is limited to 3 inches or larger with a standard 2 1/2-inch water-level float. In smaller diameter wells, a weighted dowel could be used in place of the standard float.

Advantages

1. Three water-level measurements can be obtained for each visit to the site regardless of the length of time between visits.
2. Devices are inexpensive and easy to install.
3. Devices can last indefinitely.

Disadvantages

1. If kinks occur in the polyethylene tubing, they may prevent the movement of the powdered cork and could cause anomalous readings.
2. If these devices are used in wells with water levels deeper than 50 feet, the nylon leader may stretch and give anomalous readings.
3. Dates of the minimum and maximum water levels cannot be determined.

Assumptions

1. No continuous recorder is available or necessary.
2. Dates of the maximum and minimum water levels are not critical.
3. The well has a shelter that contains a wooden base or subfloor.

Instructions

1. Construct the device for measuring maximum water levels (fig. 1, items 1–4).

    a. The maximum water-level device consists of a length of transparent 3/8-inch polyethylene tubing, two lengths of 1/4-inch inside diameter brass tubing, non-lead shot, powdered cork, and a nail.

    b. Crimp one end of an 8- to 12-inch length of brass tubing, slot the brass tubing with a hacksaw over the lower 3/4 of its length, fill the brass tubing with non-lead shot, and attach it to the lower end of the polyethylene tubing. Be sure to place enough non-lead shot in the polyethylene tubing so that the tubing hangs taut in the well and contains no kinks. The length of polyethylene tubing selected must be long enough to keep the lower 12 inches of the brass tubing submerged below the water surface at all times.

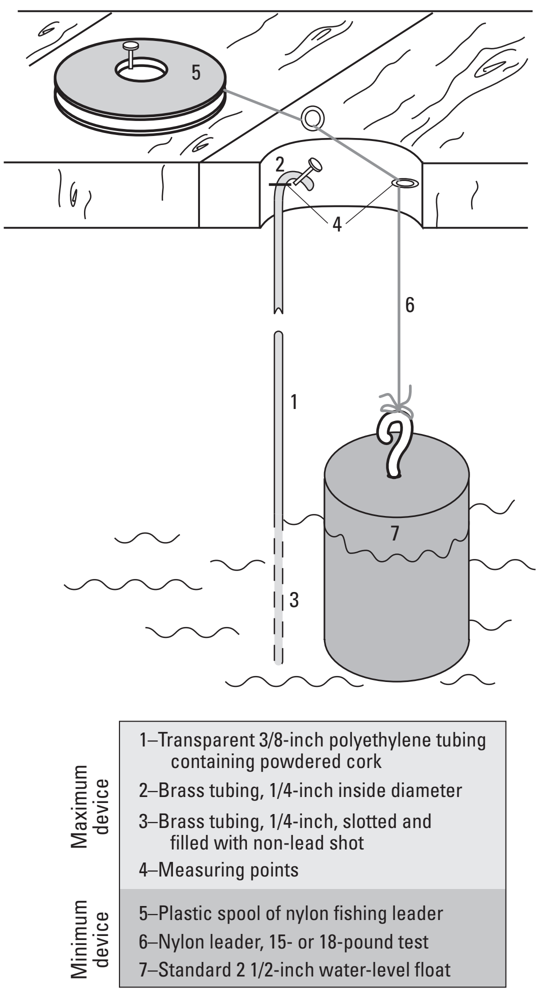


Figure 1. Devices for measuring maximum and minimum water levels in wells (modified from Kelly, 1968).

    c. Put several pinches of powdered cork in the polyethylene tubing.

    d. Bend a short length of brass tubing to form an elbow and insert the brass elbow into the upper end of the polyethylene tubing.

    e. Insert a nail in the wood base or subfloor of the well shelter to use as a measuring point. Mark the measuring point on the tubing with the permanent marker.

    f. Suspend the maximum water-level device in the well by hanging the brass elbow over the measuring point nail.

2. Determine the maximum water level for the well. The powdered cork adheres to the walls of the polyethylene tubing as the water level in the well rises, thereby marking the maximum water level. The maximum water-level device is a modification of a crest-stage gage.

    a. Gently withdraw the tubing assembly from the well.

    b. Measure the distance between the measuring point and the top of the powdered cork with a graduated steel tape.

    c. Record the maximum water level in the field notebook.

    d. Shake the powdered cork to the bottom of the device and re-install the maximum water-level device.

3. Construct the device for measuring minimum water levels (fig. 1, items 5–7).

    a. The minimum water-level device consists of nylon fishing leader wound on a disc-shaped spool, a standard 2 1/2-inch water-level float, a nail, and two screw-eye hooks.

    b. Attach the disc-shaped spool to the wooden base or shelter subfloor with a nail.

    c. Attach the two screw-eye hooks to the subfloor as shown in figure 1. The lower eye hook is used as a measuring point.

    d. Thread the nylon fishing leader from the disc-shaped spool through the screw-eye hooks and secure the nylon leader to the top of the float.

    e. Mark the waterline on the float with a permanent, water resistant marker before installing the float in the well.

4. Determine the minimum water level for the well. The water-level float pulls the nylon fishing leader from the spool as the water level declines and the nylon leader becomes slack. Spool friction prevents the nylon leader from rewinding.

   a. Place the nail of the index finger on the nylon leader at the eye hook measuring point to mark the leader.

   b. Hold your index finger on the leader mark and gently withdraw the nylon leader from the well.

   c. Measure the amount of nylon leader between the measuring point and the float plus the distance from the float-leader connection to the float waterline with a graduated steel tape.

   d. Record the minimum water level in the field notebook.

   e. Rewind the spool and re-install the minimum water-level device.

Data Recording

Record minimum and maximum water levels in the field notebook.

References

Kelly, T.E., 1968, Minimum and maximum water-level recording devices, *in* Chase, E.B., and Payne, F.N., comps., Selected techniques in water resources investigations, 1966–67: U.S. Geological Survey Water-Supply Paper 1892, p. 83–86.

GWPD 10—Estimating discharge from a pumped well by use of a circular orifice weir

VERSION: 2010.1

PURPOSE: To estimate the discharge from a pumped well from a non-vertical standard pipe by using a circular orifice weir.

Materials and Instruments

1. Steel orifice plate
2. Hand level
3. Piezometer tube, 1/8-inch or 1/4-inch diameter
4. Glass tube, 1/8-inch or 1/4-inch diameter
5. Accurate yardstick, or other suitable ridged scale
6. Graduated tape
7. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
8. Field notebook
9. Groundwater Site Inventory (GWSI) System Groundwater Site Schedule, Form 9-1904-A

Data Accuracy and Limitations

1. The circular orifice weir method is accurate to within 2 percent.
2. The hole in the steel plate of the orifice weir must be accurately cut, be centered, be circular, and have a beveled edge. The steel plate restricts the flow through the orifice and creates a pressure head in the discharge pipe.
3. For the orifice weir to function properly, the gate valve that controls the rate of discharge must be placed at least 10 pipe diameters from the piezometer tube connection to keep pipe turbulence to a minimum.
4. The piezometer tube must be completely free of any obstruction and free of air bubbles when a reading of the pressure head is made. The head in the line is correlated with discharge by use of tables calibrated for the particular ratio between the orifice and the discharge pipe diameters (table 1).
5. The discharge pipe must be level, and the water flow from the end of the discharge pipe must fall freely.

Advantages

1. This method provides an accurate means of determining the discharge rate from turbine or centrifugal pumps.
2. No special training is needed to use this method.

Disadvantages

1. This method cannot be used to measure the pulsating flow from a piston pump.
2. Well flow must be constant.

Assumptions

1. An appropriately sized orifice plate is available and was built accurately.
2. The diameter of the orifice plate is less than eight-tenths of the inside diameter of the pipe that serves as the channel of approach.
3. The last 6 feet of the discharge line is level and contains a fitting that is screwed into a 1/8-inch or 1/4-inch tapped hole centered on the discharge line, exactly 24 inches from the orifice plate.

Instructions

1. Figure 1 shows the essential details for setting up a circular orifice weir for measuring the discharge rate of a well that is being pumped with a turbine or centrifugal pump.
2. Select an appropriately sized circular orifice weir and attach it to the end of the discharge pipe. Table 1 lists 3- to 10-inch circular orifice weirs that can be used with discharge pipes ranging from 4- to 12-inches in diameter.
3. Place a short piece of glass tubing into the upper end of the piezometer tube. Attach the lower end of the piezometer tube to the fitting on the discharge line that is located 24 inches from the orifice plate (fig. 1). Tape the piezometer tube to the scale making sure that the zero mark on the scale lines up with the center of the piezometer fitting in the discharge pipe.
4. The water level in the piezometer tube represents the pressure in the approach pipe when water is being pumped through the orifice. The water level can be observed in the glass tube.
5. To read the pressure head in the glass tube, hold the piezometer tube in an upright position perpendicular to the discharge pipe. Read the water level using the attached scale.
6. Determine the well discharge from table 1. For example, if the pressure head is 25.5 inches, the orifice plate is 5 inches in diameter and the discharge pipe is 8 inches in diameter; follow the 25.5-inch line from the left scale until it intersects with the 5-inch orifice and 8-inch pipe column. The well discharge rate obtained from table 1 is 500 gallons per minute.
7. Between water-level readings, check for air bubbles in the piezometer tube. If air bubbles are present, they can be eliminated from the piezometer tube by dropping the tube between readings so that water flows from it.
8. Record estimated discharge in the field notebook and in the discharge data section of the GWSI Groundwater Site Schedule (fig. 2, Form 9-1904-A).

Data Recording

Data are recorded in a field notebook. Discharge data should also be recorded in the discharge data section of the GWSI Groundwater Site Schedule (Form 9-1904-A).

References

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

Hoopes, B.C., ed., 2004, User’s manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Layne & Bowler, Inc., 1958, Measurement of water flow through pipe orifice with free discharge: Memphis, TN, Layne & Bowler, Inc., Bulletin 501, p. 22–25.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, p. 2-17.

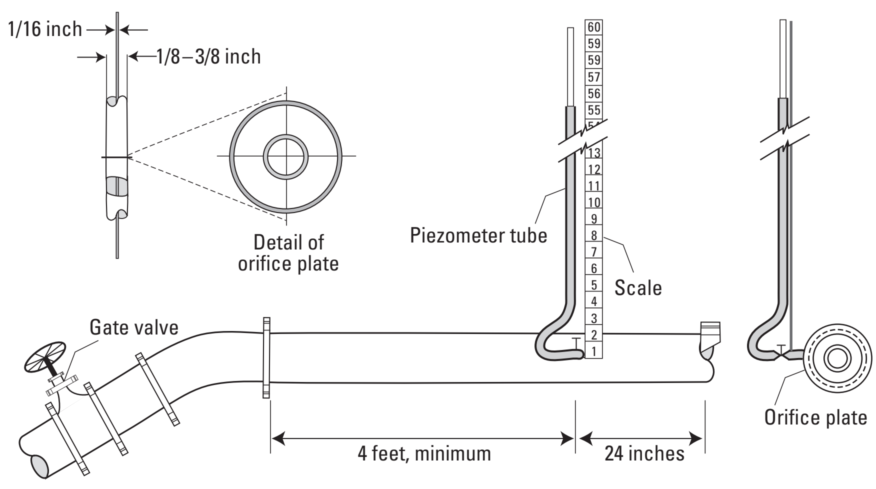


Figure 1. Essential details of the circular orifice weir commonly used for measuring well discharge when pumping by means of a turbine pump. Discharge pipe must be level (Driscoll, 1986).

Table 1. Orifice table for measurement of water through pipe orifices with free discharge. Values are in gallons per minute to the nearest whole number. (Compiled by the Engineering Department of Layne and Bowier, Inc., from original calibrations by Purdue University)

[—; no data]

Head, in inches	3-inch orifice		4-inch orifice		5-inch orifice		6-inch orifice		7-inch orifice	8-inch orifice	9-inch orifice	10-inch orifice
	4-inch pipe	6-inch pipe	6-inch pipe	8-inch pipe	6-inch pipe	8-inch pipe	8-inch pipe	10-inch pipe	10-inch pipe	10-inch pipe	12-inch pipe	12-inch pipe
5	100	76	145	140	280	220	380	320	—	—	825	1,100
5.5	104	79	153	145	293	230	394	333	—	—	860	1,150
6	108	82	160	150	305	240	408	345	—	—	895	1,200
6.5	111	85	167	155	316	250	421	358	—	—	930	1,250
7	115	88	172	160	328	260	433	370	—	—	965	1,300
7.5	119	91	179	165	339	270	446	383	—	—	1,000	1,350
8	122	94	185	170	350	280	458	395	600	935	1,032	1,400
8.5	125	96	190	175	361	289	471	408	617	963	1,065	1,440
9	128	99	195	180	372	298	483	420	633	992	1,093	1,480
9.5	130	102	200	185	383	307	495	433	650	1,016	1,120	1,520
10	133	104	205	190	393	316	508	445	666	1,040	1,148	1,560
10.5	137	107	210	195	402	324	521	458	682	1,060	1,172	1,600
11	140	109	215	200	412	330	533	470	698	1,080	1,200	1,635
11.5	143	111	220	204	421	338	545	480	713	1,100	1,225	1,670
12	146	114	225	208	430	346	556	490	728	1,120	1,250	1,705
12.5	149	116	230	212	439	354	567	500	743	1,139	1,277	1,740
13	151	118	234	216	448	362	578	510	757	1,158	1,303	1,775
13.5	154	121	239	219	457	369	589	520	771	1,176	1,328	1,810
14	157	123	243	224	465	376	599	530	785	1,194	1,352	1,845
14.5	159	126	247	227	473	383	609	540	799	1,212	1,376	1,875
15	162	128	250	231	480	390	618	550	812	1,230	1,400	1,905
15.5	164	130	254	234	488	396	627	559	825	1,248	1,421	1,940
16	167	132	257	238	495	402	636	568	838	1,266	1,441	1,970
16.5	170	134	261	241	503	408	645	577	851	1,284	1,460	2,000
17	172	136	264	245	510	414	654	586	863	1,302	1,480	2,030
17.5	175	138	268	249	517	420	663	595	875	1,319	1,500	2,060
18	178	140	271	252	524	426	672	604	887	1,336	1,520	2,089
18.5	180	142	275	256	530	432	681	612	899	1,353	1,540	2,118
19	183	144	278	259	536	438	690	620	910	1,370	1,560	2,146
19.5	185	146	282	263	542	444	699	628	922	1,387	1,580	2,175
20	187	148	285	266	548	449	708	636	933	1,404	1,600	2,204
20.5	190	150	289	270	554	455	717	643	945	1,421	1,620	2,232
21	192	152	292	273	560	460	726	650	956	1,438	1,640	2,260
21.5	195	154	295	275	566	465	735	657	968	1,455	1,659	2,288
22	197	156	299	279	572	470	744	664	979	1,471	1,677	2,316
22.5	199	158	302	282	578	475	752	671	990	1,486	1,695	2,343
23	201	160	305	285	584	479	760	678	1,001	1,500	1,714	2,360
23.5	203	162	307	288	590	484	768	685	1,012	1,515	1,732	2,382
24	205	164	310	291	596	488	776	692	1,022	1,529	1,750	2,409
24.5	207	165	314	294	602	492	784	699	1,033	1,543	1,767	2,435
25	210	167	317	297	608	496	791	706	1,043	1,557	1,783	2,461
25.5	212	169	320	300	614	500	798	713	1,059	1,571	1,799	2,487
26	214	171	323	303	620	504	805	720	1,064	1,585	1,815	2,513
26.5	216	173	326	305	626	508	812	727	1,074	1,599	1,830	2,539
27	219	174	329	308	632	512	818	734	1,084	1,613	1,845	2,565

Table 1. Orifice table for measurement of water through pipe orifices with free discharge. Values are in gallons per minute to the nearest whole number. (Compiled by the Engineering Department of Layne and Bowier, Inc., from original calibrations by Purdue University)—Continued

[—; no data]

Head, in inches	3-inch orifice		4-inch orifice		5-inch orifice		6-inch orifice		7-inch orifice	8-inch orifice	9-inch orifice	10-inch orifice
	4-inch pipe	6-inch pipe	6-inch pipe	8-inch pipe	6-inch pipe	8-inch pipe	8-inch pipe	10-inch pipe	10-inch pipe	10-inch pipe	12-inch pipe	12-inch pipe
27.5	221	176	332	311	638	516	825	741	1,094	1,627	1,860	2,590
28	222	177	335	314	644	520	831	747	1,104	1,641	1,875	2,610
28.5	224	179	337	317	650	524	838	754	1,114	1,655	1,890	2,630
29	226	180	340	320	656	528	844	760	1,124	1,669	1,905	2,650
29.5	228	182	343	323	662	532	851	767	1,134	1,683	1,920	2,670
30	230	183	346	325	668	536	857	773	1,143	1,697	1,935	2,690
30.5	232	185	348	328	674	540	863	780	1,153	1,711	1,950	2,713
31	235	186	351	330	680	544	869	786	1,162	1,725	1,965	2,736
31.5	236	188	354	333	686	548	876	793	1,172	1,739	1,980	2,759
32	239	189	357	335	692	552	882	799	1,181	1,753	2,005	2,782
32.5	240	191	360	338	697	556	889	806	1,191	1,767	2,020	2,805
33	242	192	363	340	703	560	895	812	1,200	1,791	2,040	2,828
33.5	244	194	366	342	709	564	901	818	1,209	1,795	2,050	2,850
34	246	195	369	345	715	568	907	824	1,218	1,809	2,060	2,873
34.5	248	196	372	247	720	572	913	830	1,227	1,823	2,075	2,896
35	250	197	375	349	726	576	919	836	1,235	1,837	2,090	2,919
35.5	252	198	377	351	732	580	925	842	1,243	1,851	2,100	2,941
36	254	200	380	354	737	584	931	847	1,251	1,865	2,112	2,964
36.5	256	201	383	356	743	588	937	852	1,259	1,879	2,124	2,980
37	257	203	385	358	748	592	943	857	1,266	1,893	2,136	3,002
37.5	259	204	388	360	754	596	949	862	1,274	—	2,148	3,024
38	260	205	390	363	759	600	955	867	1,281	—	2,160	3,046
38.5	262	206	393	365	765	604	961	872	1,289	—	2,173	3,068
39	263	208	396	367	770	608	967	877	1,295	—	2,185	3,088
39.5	265	209	398	369	776	612	974	882	1,304	—	2,197	3,110
40	266	210	401	371	781	616	979	887	1,311	—	2,210	3,130
40.5	267	211	403	373	786	620	985	891	1,319	—	2,225	3,146
41	269	212	406	375	790	624	990	896	1,326	—	2,233	3,160
41.5	271	213	408	378	795	628	996	901	1,334	—	2,245	3,179
42	272	214	411	380	800	631	1001	906	1,341	—	2,257	3,199
42.5	274	216	413	382	805	635	1007	910	1,349	—	2,273	3,219
43	275	217	415	384	810	638	1012	915	1,356	—	2,285	3,230
43.5	277	218	418	386	815	642	1018	920	1,364	—	2,397	3,250
44	278	219	420	388	820	645	1023	925	1,371	—	2,309	3,263
44.5	280	220	422	390	824	649	1029	929	1,379	—	2,326	3,280
45	281	222	425	392	828	652	1034	934	1,387	—	2,338	3,298
45.5	283	223	427	394	832	656	1040	939	1,394	—	2,350	3,316
46	284	224	429	396	837	659	1045	944	1,401	—	2,363	3,334
46.5	285	225	432	399	842	663	1051	948	1,409	—	2,375	3,351
47	287	227	434	401	847	666	1056	953	1,416	—	2,387	3,368
47.5	289	228	437	403	851	669	1062	958	1,424	—	2,399	3,389
48	290	229	440	405	855	672	1067	963	1,431	—	2,411	3,405
48.5	292	230	442	407	859	676	1073	967	1,439	—	2,423	3,426
49	293	231	444	409	863	679	1078	972	1,446	—	2,434	3,443
49.5	294	232	446	411	868	683	1084	977	1,454	—	2,444	3,460

Table 1. Orifice table for measurement of water through pipe orifices with free discharge. Values are in gallons per minute to the nearest whole number. (Compiled by the Engineering Department of Layne and Bowier, Inc., from original calibrations by Purdue University)—Continued

[—; no data]

Head, in inches	3-inch orifice		4-inch orifice		5-inch orifice		6-inch orifice		7-inch orifice	8-inch orifice	9-inch orifice	10-inch orifice
	4-inch pipe	6-inch pipe	6-inch pipe	8-inch pipe	6-inch pipe	8-inch pipe	8-inch pipe	10-inch pipe	10-inch pipe	10-inch pipe	12-inch pipe	12-inch pipe
50	296	234	448	413	872	686	1089	982	1,461	—	2,454	3,477
50.5	298	235	450	415	876	690	1095	986	1,469	—	2,464	3,494
51	300	236	453	417	880	693	1100	991	1,476	—	2,474	3,511
51.5	301	237	455	419	884	697	1105	996	1,484	—	2,486	3,527
52	302	238	457	421	888	700	1110	1000	1,491	—	2,498	3,544
52.5	303	239	459	423	892	704	1115	1005	1,499	—	2,510	3,560
53	304	240	461	425	896	707	1,120	1,009	1,506	—	2,522	3,575
53.5	305	241	463	427	900	711	1,125	1,014	1,513	—	2,534	3,591
54	307	243	465	429	904	714	1,130	1,018	1,520	—	2,545	3,602
54.5	309	244	467	431	908	718	1,135	1,023	1,527	—	2,555	3,618
55	310	246	469	433	912	721	1,140	1,027	1,534	—	2,565	3,634
55.5	311	247	471	435	915	725	1,145	1,032	1,541	—	2,575	3,650
56	313	248	472	437	919	727	1,150	1,036	1,548	—	2,586	3,667
56.5	314	249	474	439	923	730	1,155	1,040	1,554	—	2,597	3,684
57	315	250	476	441	927	733	1,160	1,044	1,560	—	2,608	3,702
57.5	316	251	478	443	930	736	1,165	1,046	1,567	—	2,619	3,719
58	317	252	480	445	934	739	1,170	1,052	1,574	—	2,630	3,736
58.5	319	253	482	447	938	742	1,175	1,056	1,580	—	2,641	3,752
59	320	254	485	449	942	745	1,180	1,060	1,586	—	2,653	3,768
59.5	321	256	487	451	945	748	1,185	1,064	1,592	—	2,665	3,784
60	323	257	489	453	948	751	1,190	1,068	1,598	—	2,676	3,800
60.5	324	258	491	455	951	754	1,195	1,072	—	—	—	—
61	325	259	492	457	955	757	1,200	1,076	—	—	—	—
61.5	326	261	494	459	958	760	1,205	1,080	—	—	—	—
62	328	262	496	461	961	763	1,209	1,084	—	—	—	—
62.5	329	263	498	463	964	766	1,214	1,088	—	—	—	—
63	330	264	500	465	968	769	1,218	1,092	—	—	—	—
63.5	331	265	502	467	971	772	1,223	1,096	—	—	—	—
64	333	266	504	469	974	775	1,227	1,099	—	—	—	—
64.5	334	267	507	471	977	778	1,232	1,103	—	—	—	—
65	335	268	509	472	981	781	1,236	1,106	—	—	—	—
65.5	336	269	511	474	984	784	1,241	1,110	—	—	—	—
66	338	271	513	475	988	787	1,245	1,113	—	—	—	—
66.5	339	272	515	477	991	790	1,250	1,117	—	—	—	—
67	340	273	517	479	995	793	1,254	1,120	—	—	—	—
67.5	341	274	518	481	998	796	1,259	1,124	—	—	—	—
68	343	275	520	483	1,002	799	1,263	1,127	—	—	—	—
68.5	344	276	521	485	1,005	802	1,268	1,131	—	—	—	—
69	346	277	523	487	1,009	805	1,272	1,134	—	—	—	—
69.5	347	278	524	489	1,012	808	1,276	1,137	—	—	—	—
70	349	280	525	491	1,016	811	1,280	1,140	—	—	—	—

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ______________
Date ______________

Coded by ______________
Checked by ______________
Entered by ______________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) USGS SITE ID (C1) PROJECT (C5)

STATION NAME (C12/900)

1 SITE TYPE (C802) - Primary Secondary DISTRICT (C6) COUNTRY (C41) STATE (C7)

COUNTY or TOWN (C8) ______________ County code

LATITUDE (C9) . LONGITUDE (C10) . LAT/LONG ACCURACY (C11): H Hndrth sec. | 1 tenth sec. | 5 half sec. | S sec. | R 3 sec. | F 5 sec. | T 10 sec. | M min. | U Un-known

LAT/LONG METHOD (C35): C land net | D DGPS | G GPS | L LORAN | M map | N inter-polated digital map | R reported | S survey | U un-known

LAT/LONG DATUM (C36): NAD27 North American Datum of 1927 | NAD83 North American Datum of 1983

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17): A altimeter | D DGPS | G GPS | I IfSAR | J LiDAR | L Level | M map | N DEM | R re-ported | U un-known

ALTITUDE DATUM (C22): NGVD29 National Geodetic Vertical Datum of 1929 | NAVD88 North American Vertical Datum of 1988

LAND NET (C13): 1/4 | 1/4 | 1/4 | S section | T township | range | merid

TOPO-GRAPHIC SETTING (C19): A alluvial fan | B playa | C stream channel | D depres-sion | E dunes | F flat | G flood-plain | H hill-top | K sink-hole | L lake or swamp | M mangrove swamp | O off-shore | P pedi-ment | S hill-side | T ter-race | U undu-lating | V valley flat | W upland draw

HYDROLOGIC UNIT CODE (C20) DRAINAGE BASIN CODE (C801) STANDARD TIME ZONE (C813) DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14) MAP SCALE (C15)

AGENCY USE (C803): A active no/na | D discon-tinued | I inactive site | L active written | M active oral | O inventory site | R remediated

2 NATIONAL WATER-USE (C39)

DATA TYPE (C804) Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box: WL cont | WL int | QW cont | QW int | PR cont | PR int | EV cont | EV int | wind vel. | tide cont | tide int | sed. con | sed. ps | peak flow | low flow | state water use

INSTRUMENTS (C805) (Place a "Y" in the appropriate box): digital rec-order | graphic rec-order | tele-metry land line | tele-metry radio | tele-metry satellite | AHDAS | crest-stage gage | tide gage | deflec-tion meter | bubble gage | stilling well | CR type recorder | weigh-ing rain gage | tipping bucket rain gage | acoustic velocity meter | electro-magnetic flowmeter | pressure transducer

DATE INVENTORIED (C711) month – day – year

RECORD READY FOR WEB (C32): Y ready to display | C condi-tional | P proprie-tary | L local use only

REMARKS (C806)

FOOTNOTES

1SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal stream				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2

WS	DO	CO	IN	IR	MI	LV	PH	ST	RM	TE	AQ
water supply	domestic	commer-cial	industrial	irrigation	mining	livestock	power hydro-electric	waste water treatment	remedia-tion	thermo-electric power	aqua-culture

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 2. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked; L poor location; M minimal data; U unchecked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode; C standby emer. supply; D drain; E geo-thermal; G seismic; H heat reservoir; M mine; O obser-vation; P oil or gas; R recharge; S repres-surize; T test; U unused; V with-drawal/return; W with-drawal; X waste; Z des-troyed

SECOND-ARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond.; B bottling; C comm-ercial; D de-water; E power; F fire; H domes-tic; I irri-gation; J indus-trial (cooling); K mining; M medi-cinal; N indus-trial; P public supply; Q aqua-culture; R recrea-tions; S stock; T insti-tutional; U unused; Y desalin-ation; Z other

SECOND-ARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single; N unconfined multiple; C confined single; M confined multiple; X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27) .

WELL DEPTH (C28) .

SOURCE OF DEPTH DATA (C29): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface; M meas. pt.; S vertical datum

WATER LEVEL (C237/241/242) .

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929; NAVD88 North American Vertical Datum 0f 1988; Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measure-ment discontinued; O obstruc-tion; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign sub-stance; W well des-troyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; D differ-ential GPS; E esti-mated; F trans-ducer; G pressure gage; H calibrated press. gage; L geophysi-cal logs; M mano-meter; N non-rec. gage; O observed; P acoustic pulse; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER-LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hun-dredth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geol-ogist; L geophysi-cal logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858): Y ready to display; C condi-tional; P proprie-tary; L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't; D driller; G geol-ogist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

METHOD OF CONSTRUCTION (C65): A air-rotary; B bored or augered; C cable tool; D dug; H hydraulic rotary; J jetted; P air per-cussion; R reverse rotary; S sonic; T trenching; V driven; W drive wash; Z other

TYPE OF FINISH (C66): C porous concrete; F gravel w/perf.; G gravel screen; H horiz. gallery; O open end; P perf or slotted; S screen; T sand point; W walled; X open hole; Z other

TYPE OF SEAL (C67): B bentonite; C clay; G cement grout; N none; Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump; B bailed; C compres-sed air; J jetted; N none; P pumped; S surged; Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chem-icals; D dry ice; E explo-sives; F defloc-culent; H hydro-frac-turing; M mech-anical; Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE

RECORD SEQUENCE NO. (C724)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80)

CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) O P E N RECORD SEQUENCE NO. (C726) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83) . DEPTH TO BOTTOM OF INTERVAL (C84) . DIAMETER OF INTERVAL (C87) .

5 MATERIAL TYPE (C86) 6 TYPE OF OPENING (C85) LENGTH OF OPENING (C89) . WIDTH OF OPENING (C88) .

FOOTNOTES:

5 TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

6 TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) M P N T RECORD SEQUENCE NO. (C728) BEGINNING DATE (C321) month – day – year ENDING DATE (C322) – –

M.P. HEIGHT (C323) . ALTITUDE OF MEASURING POINT (C325) ALTITUDE METHOD (C326) ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328) M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centrifugal	jet	piston	rotary	submersible	turbine	unknown	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gasoline	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Government	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Cooperator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Cooperator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736) OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736) OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182) C Cooperator's Office, D District Office R Reporting Agency Z other

DATA FORMAT (C261) F files, M machine readable, P published, Z other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S RECORD SEQUENCE NO. (C739) TYPE OF LOG (C199)

BEGINNING DEPTH (C200) . ENDING DEPTH (C201) . SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S RECORD SEQUENCE NO. (C739) TYPE OF LOG (C199)

BEGINNING DEPTH (C200) . ENDING DEPTH (C201) . SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S RECORD SEQUENCE NO. (C739) TYPE OF LOG (C199)

BEGINNING DEPTH (C200) . ENDING DEPTH (C201) . SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) Q W water quality | BEGINNING YEAR (C115) | ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical properties	common ions	trace elements	pesticides	nutrients	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radioactive	codes B,C&A	other

SOURCE AGENCY (C117) | [7] FREQUENCY OF COLLECTION (C118) | ANALYZING AGENCY (C307) | [8] PRIMARY NETWORK SITE (C257) | [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) W L water level | BEGINNING YEAR (C115) | ENDING YEAR (C116)

SOURCE AGENCY (C117) | [7] FREQUENCY OF COLLECTION (C118) | [8] PRIMARY NETWORK SITE (C257) | [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W | RECORD SEQUENCE NO. (C730) | TYPE OF NETWORK (C706) W D pumpage or withdrawals | BEGINNING YEAR (C115) | ENDING YEAR (C116)

SOURCE AGENCY (C117) | [7] FREQUENCY OF COLLECTION (C118) | METHOD OF COLLECTION (C133) | [8] PRIMARY NETWORK SITE (C257) | [8] SECONDARY NETWORK SITE (C708)

C	E	M	U	Z
calculated	estimated	metered	unknown	other

FOOTNOTES:

[7] FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continuously	daily	semimonthly	inter mittent	monthly	one-time only	quarterly	semiannually	weekly	other	biannually	every 3 years	every 4 years	every 5 years	every 10 years

[8] NETWORK SITE CODES

1	2	3	4
national,	district,	project,	cooperator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S | RECORD SEQUENCE NO. (C311) | DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S | RECORD SEQUENCE NO. (C311) | DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P (pumped), F (flow)

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E (excellent (LT 2%)), G (good (2%-5%)), F (fair (5%-8%)), P (poor (GT 8%))

SOURCE OF DATA (C151): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF DISCHARGE MEASUREMENT (C152): A (acoustic meter), B (bailer), C (current meter), D (Doppler meter), E (estimated), F (flume), M (totaling meter), O (orifice), P (pitot-tube), R (reported), T (trajectory), U (venturi meter), V (volumetric meas), W (weir), X (unknown), Z (other)

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF WATER-LEVEL MEASUREMENT (C156): A (airline), B (recorder), C (calibrated airline), D (differ-ential GP), E (esti-mated), F (trans-ducer), G (pressure gage), H (calibrated press. gage), L (geophysi-cal logs), M (mano-meter), N (non-rec. gage), O (observed), P (acoustic pulse), R (reported), S (steel tape), T (electric tape), V (calibrated elec. tape), Z (other)

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P (principal aquifer), Q (aggregate of lithologic units), S (secondary aquifer), N (no contrib-ution), U (unknown)

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section #____________

GWPD 11—Measuring well depth by use of a graduated steel tape

VERSION: 2010.1

PURPOSE: To measure the total depth of a well below land-surface datum by using a weighted graduated steel tape.

Materials and Instruments

1. A steel tape graduated in feet, tenths and hundredths of feet. A break-away weight should be attached to a ring on the end of the tape with wire strong enough to hold the weight, but not as strong as the tape, so that if the weight becomes lodged in the well the tape can still be pulled free. The weight should be made of brass, stainless steel, or iron. A lead weight should not be used. The weight should be heavy enough to amplify the weight-transfer sensation when the bottom of the well is struck.
2. Clean rag
3. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004)
4. Two wrenches with adjustable jaws or other tools for removing well cap
5. Key for well access
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Field notebook
8. Groundwater Site Inventory (GWSI) System, Groundwater Site Schedule Form 9-1904-A

Data Accuracy and Limitations

1. A graduated steel tape is commonly accurate to 0.01 foot. Accuracy of well-depth measurement decreases with increasing depth.
2. The steel tape should be calibrated against another acceptable steel tape. An acceptable steel tape is one that is maintained in the office for use only for calibrating steel and electric tapes.
3. Corrections are necessary for measurements made in angled well casings.
4. When measuring well depth in deep wells, tape expansion and stretch is an additional consideration (Garber and Koopman, 1968).

Advantages

1. The weighted graduated steel tape is considered to be the most accurate method of measuring well depth.
2. Easy to use.

Disadvantages

1. Not recommended for measuring the depth of wells that are being pumped.

Assumptions

1. An established measuring point (MP) exists. See GWPD 3 for technical procedures on establishing an MP.
2. The MP is clearly marked and described.
3. The steel tape has been calibrated.
4. The well is free of obstructions that could affect the plumbness of the steel tape and cause errors in the measurement.

Instructions

1. Measure from the zero point on the tape to the bottom of the weight. Record this number in the field notebook as the length of the weight interval.
2. Lower the weight and tape into the well until the weight reaches the bottom of the well and the tape slackens.
3. Partially withdraw the tape from the well until the weight is standing in a vertical position, but still touching the bottom of the well. A slight jerking motion will be felt as the weight moves from the horizontal to the vertical position.
4. Repeat step 3 several times by lowering and withdrawing the tape to obtain a consistent reading.
5. Record the tape reading held at the MP.
6. Withdraw the tape from the well 1 to 2 feet, so that the weight will hang freely above the bottom of the well. Repeat steps 2–4 until two consistent depth readings are obtained.
7. Calculate total well depth below land-surface datum (LSD) as follows:

Tape reading held at the MP	84.30 feet
Length of the weight interval	+1.20 feet
Total well depth below MP	85.50 feet
MP correction	–3.40 feet
Total well depth below LSD	82.10 feet

8. After completing the well-depth measurement, disinfect and rinse that part of the tape that was submerged below the water surface, as described in the National Field Manual (Wilde, 2004). This will reduce the possibility of contamination of other wells from the tape.

Data Recording

Data are recorded in a field notebook. Well-depth data are recorded in the groundwater site data section of the GWSI Groundwater Site Schedule (fig. 1, Form 9-1904-A). Recommended precision is depth dependent and should be shown in field C28 on Form 9-1904-A (fig. 1).

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Katz, B.G., and Jelinski, J.C., 1999, Replacement materials for lead weights used in measuring ground-water levels: U.S. Geological Survey Open-File Report 99–52, 13 p.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (version 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, section 3.3.8., p. 50–53, accessed May 17, 2010, at *http://pubs.water.usgs.gov/twri9A3/*.

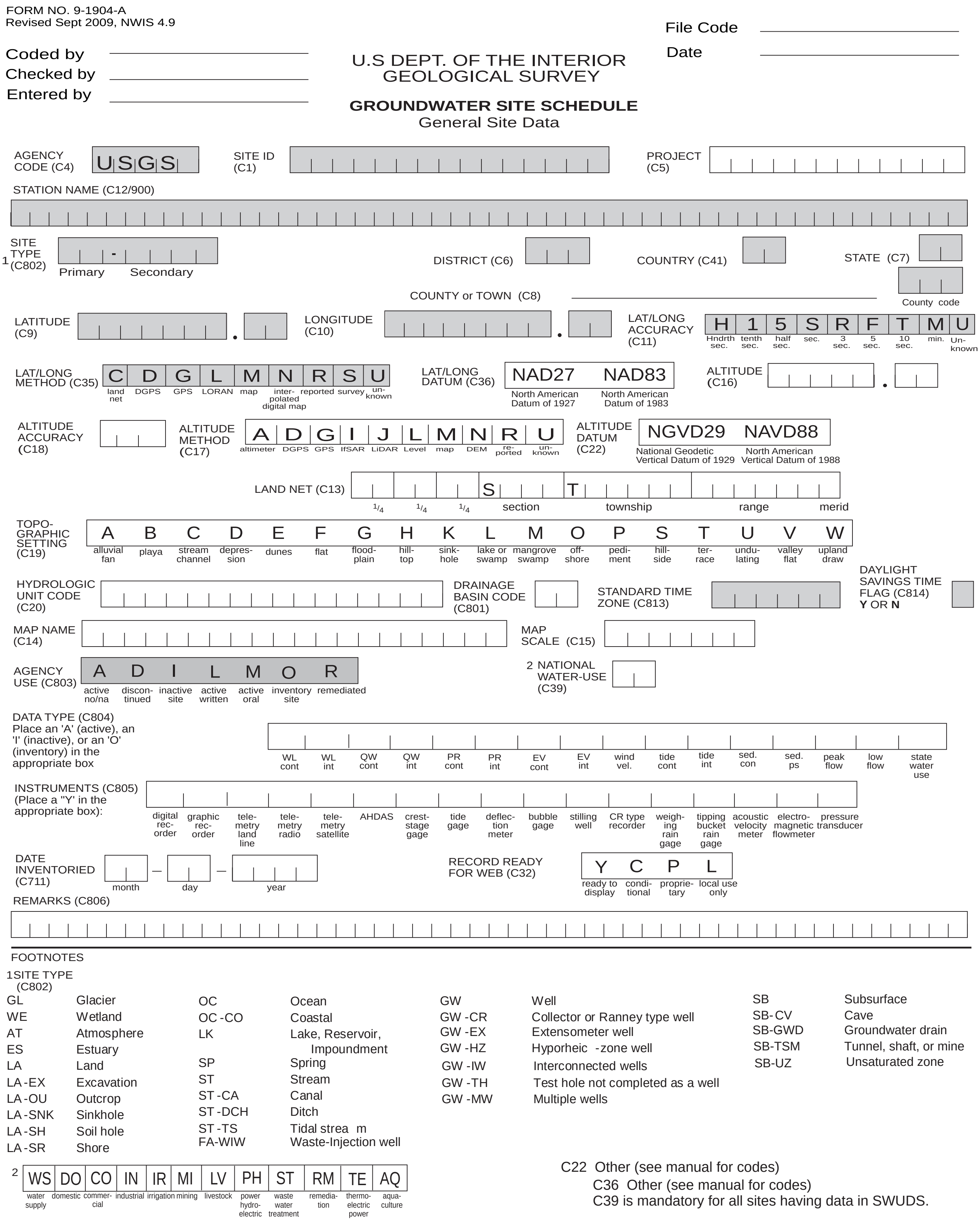


Figure 1. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3): C field checked; L poor location; M minimal data; U unchecked

DATE OF FIRST CONSTRUCTION (C21): month – day – year

USE OF SITE (C23): A anode; C standby emer. supply; D drain; E geothermal; G seismic; H heat reservoir; M mine; O observation; P oil or gas; R recharge; S repressurize; T test; U unused; V withdrawal/return; W withdrawal; X waste; Z destroyed

SECONDARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24): A air cond.; B bottling; C commercial; D dewater; E power; F fire; H domestic; I irrigation; J industrial (cooling); K mining; M medicinal; N industrial; P public supply; Q aquaculture; R recreations; S stock; T institutional; U unused; Y desalination; Z other

SECONDARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713): U unconfined single; N unconfined multiple; C confined single; M confined multiple; X mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27) ____ . __

WELL DEPTH (C28) ____ . __

SOURCE OF DEPTH DATA (C29): A other gov't; D driller; G geologist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235): month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243): L land surface; M meas. pt.; S vertical datum

WATER LEVEL (C237/241/242) ____ . __

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S): NGVD29 National Geodetic Vertical Datum 0f 1929; NAVD88 North American Vertical Datum 0f 1988; Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238): A atmos. pressure; B tide stage; C ice; D dry; E recently flowing; F flowing; G nearby flowing; H nearby recently flowing; I injector site; J injector site monitor; M plugged; N measurement discontinued; O obstruction; P pumping; R recently pumped; S nearby pumping; T nearby recently pumped; V foreign substance; W well destroyed; X affected by surface water; Z other

METHOD OF WATER-LEVEL MEASUREMENT(C239): A airline; B analog; C calibrated airline; D differential GPS; E estimated; F transducer; G pressure gage; H calibrated press. gage; L geophysical logs; M manometer; N non-rec. gage; O observed; P acoustic pulse; R reported; S steel tape; T electric tape; V calibrated elec. tape; Z other

WATER-LEVEL ACCURACY (C276): 0 foot; 1 tenth; 2 hundredth; 9 not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244): A other gov't; D driller's log; G geologist; L geophysical logs; M memory; O owner; R other reported; S reporting agency; Z other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char) ____

REMARKS (C267) (256 char) ____

RECORD READY FOR WEB (C858): Y ready to display; C conditional; P proprietary; L local use only

CONSTRUCTION DATA

RECORD TYPE (C754): C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60): month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64): A other gov't; D driller; G geologist; L logs; M memory; O owner; R other reported; S reporting agency; Z other

METHOD OF CONSTRUCTION (C65): A air-rotary; B bored or augered; C cable tool; D dug; H hydraulic rotary; J jetted; P air percussion; R reverse rotary; S sonic; T trenching; V driven; W drive wash; Z other

TYPE OF FINISH (C66): C porous concrete; F gravel w/perf.; G gravel screen; H horiz. gallery; O open end; P perf or slotted; S screen; T sand point; W walled; X open hole; Z other

TYPE OF SEAL (C67): B bentonite; C clay; G cement grout; N none; Z other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69): A air-lift pump; B bailed; C compressed air; J jetted; N none; P pumped; S surged; Z other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71): C chemicals; D dry ice; E explosives; F deflocculent; H hydrofracturing; M mechanical; Z other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE

RECORD SEQUENCE NO. (C724)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) .

DEPTH TO BOTTOM OF INTERVAL (C74) .

DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

[4] CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

[4] CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

[4] CASING MATERIAL (C80)

CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) .

DEPTH TO BOTTOM OF CASING (C78) .

DIAMETER OF CASING (C79) .

[4] CASING MATERIAL (C80)

CASING THICKNESS (C81) .

FOOTNOTE:

[4] CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) OPEN

RECORD SEQUENCE NO. (C726)

SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)

DEPTH TO BOTTOM OF INTERVAL (C84)

DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)

[6] TYPE OF OPENING (C85)

LENGTH OF OPENING (C89)

WIDTH OF OPENING (C88)

FOOTNOTES:

[5] TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

[6] TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) MPNT

RECORD SEQUENCE NO. (C728)

BEGINNING DATE (C321) month – day – year

ENDING DATE (C322)

M.P. HEIGHT (C323)

ALTITUDE OF MEASURING POINT (C325)

ALTITUDE METHOD (C326)

ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)

M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) LIFT

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43)

A	B	C	J	P	R	S	T	U	X	Z
air	bucket	centri-fugal	jet	piston	rotary	submer-sible	turbine	un-known	no lift	other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45)

D	E	G	H	L	N	S	W	Z
diesel	electric	gaso-line	hand	LP gas	natural gas	solar	windmill	other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) OWNR

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350)

CP	GV	IN	MI	OT	TG	WS
Corporation	Govern-ment	Individual	Military	Other	Tribal	Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359)

0	1	2	3	4
Public Access	Coop-erator	USGS Only	District Only	Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) VIST

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182) C Cooperator's Office, D District Office R Reporting Agency Z other

DATA FORMAT (C261) F files, M machine readable, P published, Z other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226) ____________

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226) ____________

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226) ____________

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W RECORD SEQUENCE NO. (C730) TYPE OF NETWORK (C706) Q W water quality BEGINNING YEAR (C115) ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical proper-ties	common ions	trace elements	pesti-cides	nutri-ents	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117) 7 FREQUENCY OF COLLECTION (C118) ANALYZING AGENCY (C307) 8 PRIMARY NETWORK SITE (C257) 8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W RECORD SEQUENCE NO. (C730) TYPE OF NETWORK (C706) W L water level BEGINNING YEAR (C115) ENDING YEAR (C116)

SOURCE AGENCY (C117) 7 FREQUENCY OF COLLECTION (C118) 8 PRIMARY NETWORK SITE (C257) 8 SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W RECORD SEQUENCE NO. (C730) TYPE OF NETWORK (C706) W D pumpage or with-drawals BEGINNING YEAR (C115) ENDING YEAR (C116)

SOURCE AGENCY (C117) 7 FREQUENCY OF COLLECTION (C118) METHOD OF COLLECTION (C133)

C	E	M	U	Z
calcu-lated	esti-mated	meter-ed	un-known	other

8 PRIMARY NETWORK SITE (C257) 8 SECONDARY NETWORK SITE (C708)

FOOTNOTES:

7 FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continu-ously	daily	semi-monthly	inter mittent	monthly	one-time only	quarter-ly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

8 NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S RECORD SEQUENCE NO. (C311) DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S RECORD SEQUENCE NO. (C311) DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P (pumped), F (flow)

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E (excellent (LT 2%)), G (good (2%-5%)), F (fair (5%-8%)), P (poor (GT 8%))

SOURCE OF DATA (C151): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF DISCHARGE MEASUREMENT (C152): A (acoustic meter), B (bailer), C (current meter), D (Doppler meter), E (estimated), F (flume), M (totaling meter), O (orifice), P (pitot-tube), R (reported), T (trajectory), U (venturi meter), V (volumetric meas), W (weir), X (unknown), Z (other)

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A (other gov't), D (driller), G (geologist), L (logs), M (memory), O (owner), R (other reported), S (reporting agency), Z (other)

METHOD OF WATER-LEVEL MEASUREMENT (C156): A (airline), B (recorder), C (calibrated airline), D (differential GP), E (estimated), F (transducer), G (pressure gage), H (calibrated press. gage), L (geophysical logs), M (manometer), N (non-rec. gage), O (observed), P (acoustic pulse), R (reported), S (steel tape), T (electric tape), V (calibrated elec. tape), Z (other)

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P (principal aquifer), Q (aggregate of lithologic units), S (secondary aquifer), N (no contribution), U (unknown)

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ___________ Range ___________

Section #___________

GWPD 12—Measuring water levels in a flowing well

VERSION: 2010.1

PURPOSE: To measure low-pressure or high-pressure hydraulic head in flowing wells.

Materials and Instruments

1. Low-pressure head measurement
   - Short length of transparent plastic tubing
   - Hose clamps
   - Measuring scale
2. High-pressure head measurement
   - Flexible hose with a 3-way valve
   - Hose clamps
   - Altitude or pressure gauge with proper pressure range, and spare gauges
   - Small open end wrench
   - Soil-pipe test plug, also known as a sanitary seal, is a length of small-diameter pipe, generally 0.75 inch, surrounded by a rubber packer. The packer can be expanded by an attached wingnut to fit tightly against the inside of the well casing or discharge pipe. Soil-pipe test plugs are available from most plumbing-supply stores in 2- to 10-inch diameter sizes. The small-diameter pipe is threaded so that it can be attached to a valve, hose, or pressure gauge.
3. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
4. Calibration and maintenance logbook
5. Water-level measurement field form

Data Accuracy and Limitations

1. Low-pressure head measurements are most feasible with heads less than 6 feet above land surface.
2. With care and experience, low-pressure head measurements can be measured to an accuracy of 0.1 foot.
3. Accuracy is a function of calibration, maintenance, and the quality and range of the pressure gauge. High-pressure head measurements using a pressure gauge can be as accurate as 0.1 foot, but may only be accurate to 1 foot or more, depending on the gauge accuracy and range.
4. A pressure gauge is the most accurate in the middle third of the gauge's range. Never let the well pressure exceed the altitude/pressure gauge limits.
5. Never connect a gauge to a well that uses a booster pump in the system, because the pump could start automatically and the resulting pressure surge may ruin the gauge.
6. Closing or opening a valve or test plug in a flowing well should be done gradually. If pressure is applied or released suddenly, the well could be permanently damaged by the "water-hammer effect" by caving of the aquifer material, breakage of the well casing, or damage to the distribution lines or gauges. To reduce the possibility of water-hammer effect, a pressure-snubber should be installed ahead of the altitude/pressure gauge.
7. Ideally, all flow from the well should be shut down so that a static water-level measurement can be made. However, because of well owner objections or system leaks, this is not always possible. If the well does not have a shut-down valve, it can be shut-in by temporarily installing a soil-pipe test plug on the well or discharge line.
8. If a well has to be shut down, the time required to reach static pressure after shut-in may range from hours to days. Since it may be impractical or impossible to reach true static conditions, record the shut-in time for each gauge reading. During return visits to a particular well, it is desirable to duplicate the previously used shut-in time before making an altitude/pressure-gauge reading.

Advantages

1. Low-pressure head measurement
   - Simpler, faster, safer, and more accurate than the high-pressure head method.
2. High-pressure head measurement
   - Can be used on wells with heads greater than 5 to 6 feet above land surface.

Disadvantages

1. Low-pressure head measurement
   - Impractical for wells with heads greater than 5 to 6 feet above land surface.
2. High-pressure head measurement
   - More complex, slower, less accurate, and more dangerous to make than low-pressure head measurements.
   - Pressure gauges are delicate, easily broken, and subject to erroneous readings if dropped or mistreated.
   - Difficult to calibrate.

Assumptions

1. An established measuring point (MP) exists. See GWPD 3 for technical procedures on establishing an MP.
2. Pressure gauges have been calibrated with a dead-weight tester.
3. A logbook containing all calibration and maintenance records is available for each pressure gauge.
4. Field measurements are recorded on paper forms or handheld computer.
5. The same procedure is used for measurements referenced to altitude or measuring points, but with a different datum correction.
6. The water level is above land surface but referenced to land-surface datum (LSD). Measurements above LSD are recorded as negative numbers.

Instructions

1. Low-pressure head measurement (direct measurement)
   a. Connect a short length of transparent plastic tubing tightly to the well with hose clamps.
   b. Raise the free end of the tubing until the flow stops.
   c. Rest the measuring scale on the MP.
   d. Place the hose against the measuring scale and read the water level directly. Record the measurement time and WL above MP in the appropriate row of the water-level measurement field form for a low-pressure flowing well measurement (fig. 1)—WL above MP.
   e. Add the MP correction to get the depth to water below LSD. An MP correction above LSD is recorded as a negative number by convention.
   f. Repeat steps b–e for a second check reading. If the check measurement does not agree with the original measurement within 0.1 or 0.2 of a foot, continue to make check measurements until the reason for the lack of agreement is determined or until the results are shown to be repeatable. If more than two readings are taken, use best judgment to select the measurement most representative of field conditions.
2. High-pressure head measurement (indirect measurement)
   a. Make sure that all well valves are closed except the one to the pressure gauge. This will prevent use of the well during the measurement period and assure an accurate water-level reading. Record the original position of each valve that is closed (full open, half open, closed, etc.), so that the well can be restored to its original operating condition.
   b. Connect a flexible hose with a 3-way valve to the well with hose clamps. Expanders/reducers are okay.
   c. Select a gauge where the expected water pressure in the well will fall in the middle third of the gauge range. If in doubt, use a pressure gauge with a 100-pound per square inch (psi) range to make an initial measurement, then select the gauge with the proper range for more accurate measurements.
   d. Attach the pressure gauge to one of the two “open” valve positions using a wrench. Never tighten or loosen the gauge by twisting the case because the strain will disturb the calibration and give erroneous readings.
   e. Bleed air from the hose, using the other “open” valve position.

WATER-LEVEL MEASUREMENT FIELD FORM

Low-Pressure Flowing Well Measurement

SITE INFORMATION

SITE ID (C1)

Equipment ID

Date of Field Visit

Station name (C12)

WATER-LEVEL DATA

	1	2	3	4	5
Time					
WL below MP					
MP correction					
WL below LSD					

Measured by ________________________ COMMENTS*____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321)

month – day – year

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

DATE WATER LEVEL MEASURED (C235)

month – day – year

TIME (C709)

STATUS (C238)

METHOD (C239) M

TYPE (C243)

WATER LEVEL (C237)

(GWPD12) (GWPD12) (GWPD1) (GWPD4)

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S	T	V	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measurement discon.,	obstruction,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign substance,	well destroyed,	surface water effects,	other	static

Figure 1. Water-level measurement field form for low-pressure flowing well measurements. This form, or an equivalent custom-designed form, should be used to record field measurements.

f. Open the pressure gauge valve slowly to reduce the risk of damage by the water-hammer effect to the well, distribution lines, and gauges. Once the needle stops moving, tap the glass face of the gauge lightly with a finger to make sure that the needle is not stuck.

g. Make sure that the well is not being used by checking to see that there are no fluctuations in pressure.

h. Hold the pressure gauge in a vertical position, with the center of the gauge at the exact height of the MP (fig. 2). Read the pressure gauge and record in the Gauge Reading row of the water-level measurement field form for a pressure gauge measurement (fig. 3). Record measurement time.

i. If the pressure gauge has a calibration correction factor, document it in the Gauge Correction row, and record the Corrected Gauge Reading. Multiply by –2.307 under common freshwater temperatures to convert pounds per square inch to feet of water.

j. Apply the MP correction to get the depth to water above LSD. An MP correction above LSD is recorded as a negative number by convention.

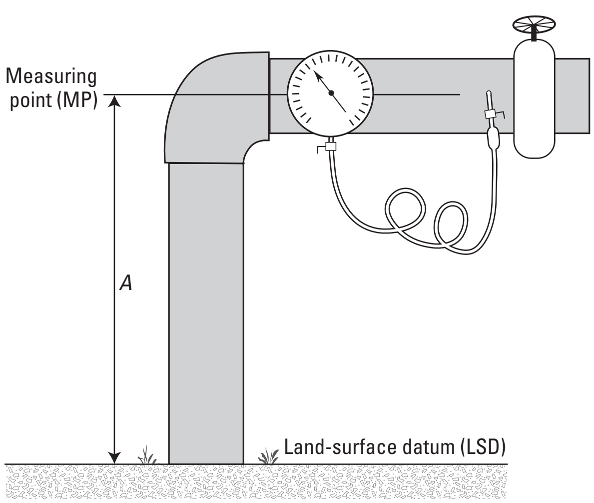


Figure 2. Orientation and position of pressure gauge for measuring water levels in a flowing well.

k. Shut off the well pressure and repeat steps e–i for a second check reading. The measurement should be repeatable within a pressure range based on the range of scale and graduation of the gauge. If more than two readings are taken, use best judgment to select the measurement most representative of field conditions. Document the estimated accuracy of the pressure measurement based on the pressure reading, instrument calibration, the range of the pressure gauge, and manufacturer’s guidance.

l. Record the identification number of the pressure gauge with each water-level measurement so that the reading can be back-referenced to the calibration record, if necessary.

Data Recording

All calibration and maintenance data for the pressure gauges are recorded in the calibration logbook. All water-level data are recorded on the water-level measurement field forms (figs. 1 and 2).

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Hoopes, B.C., ed., 2004, User’s manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, p. 2-11 and 2-12.

WATER-LEVEL MEASUREMENT FIELD FORM
Pressure Gauge Measurement

SITE INFORMATION

SITE ID (C1)

Equipment ID

Date of Field Visit

Station name (C12)

WATER-LEVEL DATA

	1	2	3	4	5
Time					
Gauge Reading					
Gauge Correction					
Corrected Gauge Reading					
Conversion to Feet × (–2.307)					
WL below MP					
MP correction					
WL below LSD					

Measured by ________________________ COMMENTS*______________________________

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321) month – day – year

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

DATE WATER LEVEL MEASURED (C235): month – day – year

TIME (C709)

STATUS (C238)

METHOD (C239)

TYPE (C243)

WATER LEVEL (C237)

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H (GWPD12)	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysi-cal logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measure-ment discon.,	obstruc-tion,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign sub-stance,	well des-troyed,	surface water effects,	other	static

Figure 3. Water-level measurement field form for pressure gauge measurements. This form, or an equivalent custom-designed form, should be used to record field measurements.

GWPD 13—Measuring water levels by use of an air line

VERSION: 2010.1

PURPOSE: To measure the depth to the water surface below a measuring point using the submerged air line method.

Materials and Instruments

1. 1/8 or 1/4-inch diameter, seamless copper tubing, brass tubing, or galvanized pipe with a suitable pipe tee for connecting an altitude or pressure gauge. Flexible plastic tubing also can be used, but is less desirable.
2. Calibrated altitude or pressure gauge, and spare gauges. Gauges that are filled with either oil or silicone work best and are most durable.
3. Compressed air source and corresponding valve stem, usually a Schrader valve. A tire pump can be used on shallow wells and piezometers, but a more substantial source of compressed air is needed where depth to water is hundreds of feet.
4. Small open-end wrench
5. Wire or electrician's tape
6. A steel tape graduated in feet, tenths and hundredths of feet
7. Blue carpenter's chalk
8. Clean rag
9. Field notebook
10. Pencil or pen, blue or black ink. Strikethrough, date and initial errors; no erasures
11. Water-level measurement field form

Data Accuracy and Limitations

1. Accuracy of the water-level measurement is a function of the quality and range of the gauge and the precision to which the length of the air line is known.
2. Water-level measurements using an altitude or pressure gauge can be as accurate as 0.1 foot, but may only be accurate to 1 foot or more, depending on the gauge accuracy and range.
3. Water-level measurements using a pressure gauge are approximate and should not be considered accurate to more than the nearest foot.
4. When measuring deep water levels, corrections for fluid temperatures and vertical differences in air density are additional considerations (Garber and Koopman, 1968).

Advantages

1. Especially useful in pumped wells where water turbulence may preclude using a more precise method.
2. Method can be used while the well is being pumped, when splashing of water makes the wetted-tape method useless.
3. Bends or spirals in the air line do not influence the accuracy of this method as long as the position of the tubing opening is not changed.
4. Can be convenient and is nonintrusive.
5. Air line can be installed once and left in the well for future measurements.

Disadvantages

1. Less accurate than the wetted tape or the electric tape methods.
2. Requires time to install the air line and equipment.
3. Requires careful calculations.

Assumptions

1. An established measuring point (MP) exists and the MP correction length (distance from MP to land-surface datum (LSD)) is known. See GWPD 3 for the technical procedure on establishing a permanent MP.
2. The MP is clearly marked and described so that a person who has not measured the well will be able to recognize it.
3. The air line already is installed, your agency owns the well, or your agency has permission to install the air line.
4. The air line extends far enough below the water level that the lower end remains submerged during pumping of the well.
5. The altitude or pressure gauge and steel tape are calibrated.
6. The same procedure is used for measurements referenced to altitude or measuring points, but with a different datum correction.

Instructions

Figure 1 shows a typical installation for measuring water levels by the air line method.

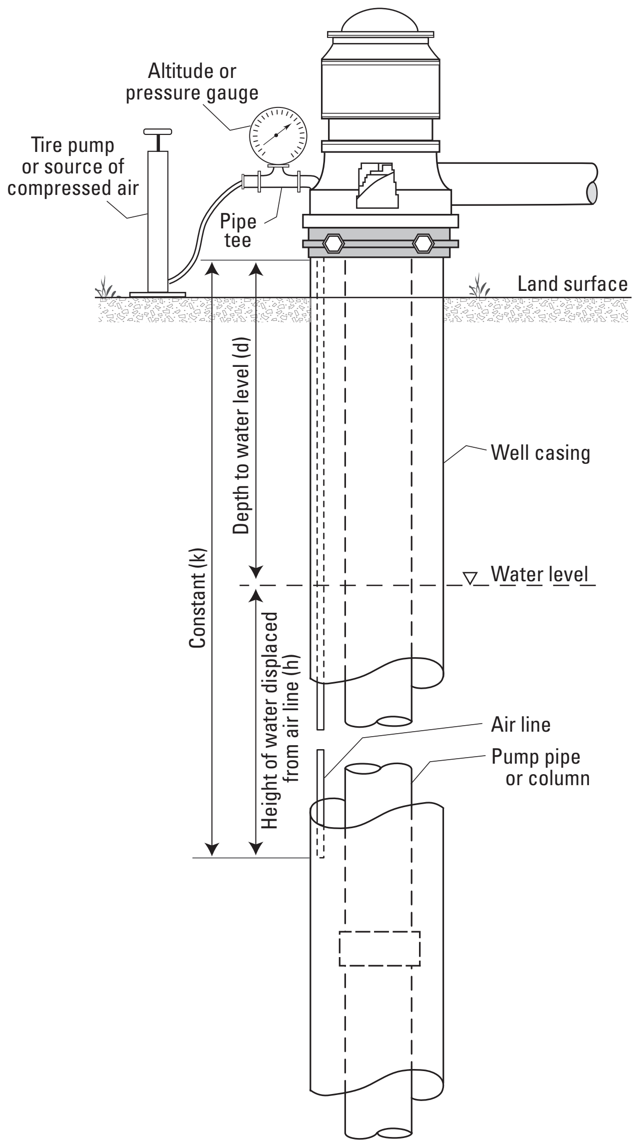
1. Install an air line pipe or tube in the well. The air line can be installed by either lowering it into the annular space between the pump column and casing after the pump has been installed in the well or by securing it to sections of the pump and pump column with wire or tape as it is lowered into the well.
2. Attach a pipe tee to the top end of the air line. On the opposite end of the pipe tee, attach a Schrader valve stem.
3. Use a wrench to connect an altitude gauge that reads in feet or a pressure gauge that reads in pounds per square inch (psi) to the fitting on top of the pipe tee.
4. Connect a compressed air source to the Schrader valve stem fitting on the pipe tee.
5. Preparatory steps: When pressurizing the air line system (step 8 below), ensure that you supply enough air pressure to purge the water from the air line tubing before a reading is recorded. This can be done by observing the gauge readings while pressurizing the system. After application of pressure, the gauge reading initially will increase to a certain pressure, and when the pressure source is removed, the gauge reading will decrease to a certain pressure. Repeat this process two or three times to ensure that the gauge reads consistently. If the tubing is plugged or crushed, the gauge reading will not decrease after the pressure source is removed. If the tubing is cut or severed, the gauge reading will decrease quickly to zero after the pressure source is removed. In either case, the air line readings will be in error. Also, do not assume that the air line tubing length reported to you is valid. Instead, make water-level measurements by use of steel tape and air line reading simultaneously. This step provides a verified water-level measurement that is relative to the pressure gauge reading. If the two measurements differ, then a correction factor can be calculated. The correction factor will be unique to the well and the gauge.
6. As the water level in the well changes, the gauge reading (h) and the water level below MP (d; fig. 1) must change in a manner such that their sum remains the same. Their sum is a constant (k), which is determined at the same time as a simultaneous wetted-steel tape and pressure gauge measurement is made.
7. To calibrate the air line system, make an initial depth-to-water (d) measurement, with a wetted-steel tape, and an initial air gauge reading (h). Apply any needed correction to the wetted-steel tape measurement. Add d and h to determine the constant value for k. Use the compressed air source to force air into the air line until all the water is expelled from the line. Once all water is displaced from the air line, record the maximum gauge reading.
   - Example 1.—Using an altitude gauge. The initial measured depth to the water level, d, is 25.86 ft; the initial altitude gauge reading, h, is 75.5 ft. Then the constant k = 25.9 ft + 75.5 ft = 101.4 ft (fig. 1).
   - Example 2.—Using a pressure gauge. The initial measured depth to the water level, d, is 85.85 ft; the initial pressure gauge reading, h, is 28 psi. Then the constant k = 86 ft + (2.307 ft/psi x 28 psi) = 86 ft + 64 ft = 150 ft (fig. 1).
8. To measure the water-level depth in a well with an air line, subsequent air line readings are subtracted from the constant k to determine the depth to the water level below the MP. Use a compressed air source to pump compressed air into the air line until all the water is expelled from the line, and record the maximum gauge reading. Apply any correction factor resulting from the calibration process.
   - Example 1.—Depth to the water level in a well using an altitude gauge with a constant k of 101.4 ft. During a later pumping period, the maximum altitude gauge h reads 50.0 ft; therefore, the water level, d, is 101.4 ft – 50.0 ft = 51.4 ft (fig. 2).

- Example 2.—Depth to the water level in a well using a pressure gauge with a constant k of 150 ft. During a later pumping period, the maximum pressure gauge h reads 18 psi; therefore, the water level, d, is 150 ft – (2.307 ft/psi x 18 psi) = 150 ft – 41 ft = 109 ft (fig. 3).

9. Apply the MP correction to get the depth to water below or above LSD.

Data Recording

All data are recorded in the field notebook and on the water-level measurement field forms (fig. 2 or 3) to the appropriate accuracy.



Calculation of air line constant

k = Air line constant, in feet
d = Water level below MP, in feet (using GWPD 1)
h = Height of water displaced from air line, in feet
k = d + h

Altitude Gauge

Water level below MP (d)			
Altitude gauge reading (h)			
Air line constant (k)			

Final air line constant (k) ____________

Pressure Gauge

Water level below MP (d)			
Pressure gauge reading			
Conversion to feet (h) (x 2.307)			
Air line constant (k)			

Final air line constant (k) ____________

Figure 1. Typical installation for measuring water levels by the air line method and relation of measured depth to water level (d), height of water displaced from air line (h), and constant (k). Constant is calculated by use of altitude gauge or pressure gauge.

USGS science for a changing world

WATER-LEVEL MEASUREMENT FIELD FORM
Air Line Measurement: Altitude Gauge

USGS science for a changing world

SITE INFORMATION

Equipment ID & Altitude Range

k =
Air-line Constant (k)

Date of Field Visit

SITE ID (C1)

Station name (C12)

WATER-LEVEL DATA	1	2	3	4	5
Time					
Gauge Reading					
Gauge Correction					
Corrected Gauge Reading					
Air-Line Constant, K					
WL Below MP					
MP Correction					
WL Above LSD					

Measured by ______________________ COMMENTS* ____

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321)

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE (-) for MP below land surface

month day year

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	TIME DATUM (C402)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year				A		.

GWPD 13

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S	T	V	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysi-cal logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measure-ment discon.,	obstruc-tion,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign sub-stance,	well des-troyed,	surface water effects,	other	static

Figure 2. Water-level measurement field form for air line measurement using an altitude gauge. This form, or an equivalent custom-designed form, should be used to record field measurements.

USGS science for a changing world

WATER-LEVEL MEASUREMENT FIELD FORM

Air Line Measurement: Pressure Gauge

USGS science for a changing world

SITE INFORMATION

______________ Equipment ID & Pressure Range

k = ______________ Air-line Constant (k)

______________ Date of Field Visit

SITE ID (C1) [| | | | | | | | | | | | | |]

______________ Station name (C12)

WATER-LEVEL DATA	1	2	3	4	5
Time					
Gauge Reading					
Gauge Correction					
Corrected Gauge Reading					
Conversion to Feet (x 2.307)					
Air-Line Constant, K					
WL Below MP					
MP Correction					
WL Above LSD					

Measured by ______________ COMMENTS* ______________

*Comments should include quality concerns and changes in: M.P., ownership, access, locks, dogs, measuring problems, et al.

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

____

____

BEGINNING DATE (C321)	ENDING DATE (C322)	M.P. HEIGHT (C323) NOTE: (-) for MP below land surface
month – day – year	– –	.
– –	– –	.

Final Measurement for GWSI

WATER LEVEL TYPE CODE (C243): L (below land surface), M (below meas. pt.), S (sea level)

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year			A		.

GWPD 13

METHOD OF WATER-LEVEL MEASUREMENT (C239)

A	B	C	E	G	H	L	M	N	R	S	T	V	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysi-cal logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently	flowing,	nearby	nearby	injector	injector	plugged,	measure-	obstruc-	pumping,	recently	nearby	nearby	foreign	well	surface	other	static

Figure 3. Water-level measurement field form for air line measurement using a pressure gauge. This form, or an equivalent custom-designed form, should be used to record field measurements.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Driscoll, F.G., 1986, Groundwater and wells (2d ed.): St. Paul, Minnesota, Johnson Filtration Systems, Inc., 1089 p.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, p. 6–11.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Lohman, S.W., 1953, Measurement of ground-water levels by air-line method: U.S. Geological Survey Open-File Report 53–159, 5 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, p. 2-10.

GWPD 14—Measuring continuous water levels by use of a float-activated recorder

VERSION: 2010.1

PURPOSE: To make continuous water-level measurements in a well using a float-activated recorder.

For some hydrogeologic studies, frequent and uninterrupted water-level measurements may be needed to identify unique properties of the groundwater flow system. In studies in which a more complete picture of water-level fluctuations is needed, automatic float-activated water-level recorders can be installed. Float-activated recorders sense changes in water level by the movement of a weight-balanced float that is lowered into the well.

Materials and Instruments

There are several types of float-activated recording devices. The float or water-level sensing mechanism has not changed much through time. The recording devices have evolved over time from graphical devices to punch tapes to electronic data loggers.

1. Float and non-lead counterweight
2. Small diameter stranded cable or a flat steel tape
3. Graphic recorder, data logger and incremental encoder, integrated data logger/encoder unit, or data collection platform (DCP)
4. Battery, spares, and wiring to connect battery to recording device
5. Tools, including digital multimeter, connectors, crimping tool, and contact-burnishing tool
6. Watch
7. A water-level tape (steel or electric) graduated in hundredths of feet and other materials necessary for depth-to-water measurement
8. Recorder shelter with lock and key
9. Field notebook
10. Pencil or pen, blue or black ink. Strikethrough, date and initial errors; no erasures
11. Water-level measurement field form

Data Accuracy and Limitations

1. The initial water-level setting for a float-activated recorder should be determined using a graduated steel or electric tape which is commonly accurate to 0.01 foot.
2. Each time a float-activated recorder is serviced, calibration check water-level measurements should be made. Data recorded using this procedure are only as accurate as the calibration measurements.
3. Where depth to water is greater than a few feet below the top of the casing, special care should be taken to minimize friction between the float cable and the walls of the well. The float selected should be the largest diameter that can be accommodated by the well casing without excessive friction.
4. Although float-activated recorders can be used successfully in wells that are 2 inches in diameter, in order to avoid friction between the float cable and the walls of the well, 3-inch diameter wells and larger are preferable.
5. Float-activated recorders cannot be used in flowing wells, angled wells, or wells with very deep water levels.

Advantages

1. Graphic recorder
    a. Simplest recording device.
    b. Recorder chart gives a true continuous water-level trace.
    c. Immediate visualization of water-level fluctuations.
    d. Accurate and reliable.
2. Data logger
    a. Stores data in digital form.
    b. Expandable data memory.
    c. Programmable recording intervals.
    d. Accurate and reliable.
3. Data Collection Platform
    a. Provides near real-time data.
    b. Satellite or other transmittal of data.
    c. Accurate and reliable.
    d. Automatic data storage.

Disadvantages

1. Graphic recorder
    a. Limited data-collection time, 1 month versus several months.
    b. Data must be determined manually. Difficult to store in database.
    c. If the graphic recorder clock fails, data will be lost.
    d. This device is archaic, and thus repair is difficult.
2. Data logger and incremental encoders
    a. Rapidly changing water-level peaks may be missed due to programmed preselected time intervals.
    b. Many data loggers require a field computer or a digital interface to download data.
    c. If the memory backup battery fails, data may be lost. Data can be overwritten in some systems.
3. DCP
    a. Transmittal of real-time data can be affected by computer, telephone, or satellite downtime.
    b. Rapidly changing water-level peaks may be missed due to programmed preselected time intervals.
    c. Data transmittal to the satellite can be compromised due to satellite access, tree canopy, ice on antenna, or power supply.
    d. If the memory backup battery fails, data may be lost.

Assumptions

1. A permanent clearly marked measuring point has been established as described in GWPD 3.
2. The user has been trained in making water-level measurements using the graduated steel-tape method as described in GWPD 1, or the electric tape method as described in GWPD 4.
3. Field measurements will be recorded on paper forms. When using a handheld computer to record field measurements, the measurement procedure is the same, but the instructions below refer to specific paper field forms.

Instructions

A wire attached to the float passes over a pulley on the recorder and a counterweight is attached to the other end of the wire and hangs in the well. When the clearance between the float and the well casing is small, the float cable should be set so that the counterweight does not have to pass the float, but is always above or below the water level. If the counterweight is immersed below the water level, a little extra weight should be added to offset the water's buoyancy.

1. The types of float-activated recorders differ by the way in which they record the water level:
    a. Chart or graphic recorder—This type of recorder (fig. 1*A*) is the simplest device, but it is not commonly in use. It is a drum chart that is actuated mechanically by a float that follows the water level. The graphic recorder provides a continuous pen and ink trace of the water level on a chart, which is graduated to record both water level and time. Battery operated clocks for graphic recorders can be set to record a wide variety of intervals, ranging from a few hours to 1 month. The pulley is connected to the

recorder drum by gears. A wide range of drum gears are available to set up the chart so that its rotation is proportional to the movement of the float. Figure 1 shows a typical setup for a graphic water-level recorder using a guide pulley assembly (fig. 1*B*) in a small diameter well, as well as a standard position setup (fig. 1*C*). Data are retrieved by changing the paper chart.

b. Data logger and incremental encoder (fig. 2*A*)—Because the data logger and the encoder are separate units connected by a communication cable, this combination of instrumentation allows for a variety of types of equipment to be used. Water-level changes sensed by the float are transferred into a digital signal by the incremental encoder. The digital signal from the incremental encoder is stored on the data logger. This instrumentation suite commonly requires a field computer or a digital interface to download the data.

c. Integrated data logger/incremental encoder units (fig. 2*B*)—This type of recorder combines a data logger and an incremental encoder into one unit. This instrumentation package has replaced the automated digital recorder (ADR punch tape) system. This instrument also requires a field computer or a digital interface to download data.

d. Data collection platform (DCP; fig. 2*C*)—A DCP provides real-time telemeter data using the Geostationary Orbiting Environmental Satellite (GOES) system and can be interfaced with either an incremental encoder or integrated data logger/incremental encoder unit. Data are stored on a data logger and are transmitted to the satellite (GOES) on a fixed schedule (commonly 1 to 4-hour intervals) during a specific time "window." Provided there are no data transmission problems, retrieval of the data is necessary only as a backup. A DCP also may use telephone or other communications technology for data transmission.

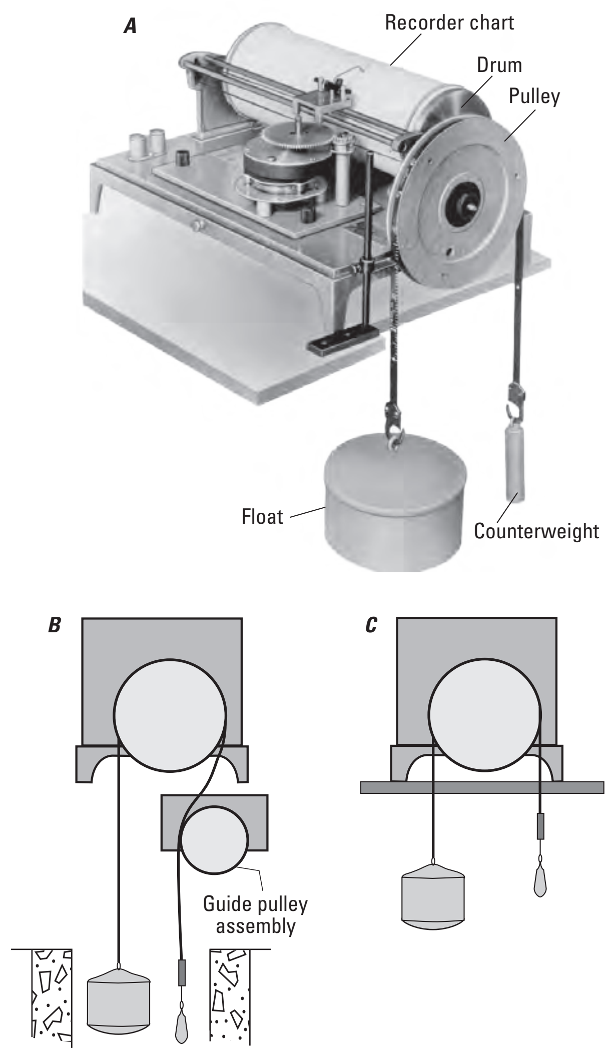


Figure 1. *A*, Standard float-activated graphic water-level recorder (U.S. Bureau of Reclamation, 2001). *B*, Use of a guide pulley assembly to position counterweight inside a small diameter well. *C*, Standard position setup.

2. Select the recording device that best suits the water-level collection needs of the project.

3. Initial installation of the float-activated recorder:

a. Confirm that the well is unobstructed.

b. If the depth of the well is not known, measure the total depth as described in GWPD 11.

c. Install a suitable locking shelter that will protect instruments from weather and vandalism.

d. Establish a measuring point (MP) as described in GWPD 3. Record the MP in the well shelter.

e. Measure the depth to water in the well using either GWPD 1 or GWPD 4 to obtain an accurate water-level measurement with which to calibrate the recorder water level (initial calibration). Record the water-level measurement on the Inspection of Continuous Record Well field form (fig. 3).

f. Orient the wheel containing the float tape or float wire and counterweight over the well opening. The float and counterweight must hang freely within the well casing; lack of freedom for the float and counterweight is one of the most common sources of error. The length of float tape or wire should be determined from the expected range of water-level fluctuation; the float should always rest on the water

A. Data logger and incremental encoder

B. Integrated data logger/encoder,

C. Data logger, encoder, and satellite-transmission equipment

Figure 2. *A*, Data logger and incremental encoder. *B*, Integrated data logger/encoder. *C*, Data logger, encoder, and satellite-transmission equipment. Brand names are for illustration purposes only and do not imply endorsement by the U.S. Geological Survey. (Photographs by W.L. Cunningham.)

surface, and the counterweight should always be suspended between the wheel and the water surface. A guide pulley assembly (fig. 1*B*) may be needed for the counterweight. Orient the wheel appropriately, and secure the wheel device and guide pulley assembly to the well shelter to prevent future movement.

g. Balance the float and cable on one side of the pulley against the weight and cable hanging on the opposite side of the pulley. Test the movement of the float wheel by carefully rotating it several inches and releasing it. The tape/recorder should quickly return to the initial value. If it does not return to within 0.01 foot of the initial value, inspect the float tape/wire, float, and counterweight and repair as necessary.

USGS science for a changing world

INSPECTION OF CONTINUOUS RECORD WELL
Steel Tape or Calibrated Electric Tape Measurement

USGS science for a changing world

SITE INFORMATION

SITE ID (C1) [ ]

Measurement Tape ID ________ Date of Field Visit ________

Station name (C12) ________

	1	2	3
Time			
Hold			
Cut			
Tape correction			
WL below MP			
MP correction			
WL below LSD			

Measured by ________

Remarks ________

Barometric Pressure ________ Air Temperature ________

Battery Voltage ________ Replaced? Y / N

Measurement Method: Transducer Float

Checked Float/encoder? Y / N Checked Transducer? Y / N

DATA LOGGER VISIT INFO:

Local time: ________ GMT________ Data logger time: ______

Sensor reading on arrival: ______ Sensor reading on departure: ______ RESET? Y / N

Datum Correction Needed: ________

Retreive data From: ________ To: ________
date/time date/time

Datafile: ________

Remarks: ________

MEASURING POINT DATA (for MP Changes)
M.P. REMARKS (C324)

BEGINNING DATE (C321) month – day – year

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

DATE WATER LEVEL MEASURED (C235)	TIME (C709)	STATUS (C238)	METHOD (C239)	TYPE (C243)	WATER LEVEL (C237)
month – day – year					

WATER LEVEL TYPE CODE (C243): L M S — L below land surface, M below meas. pt., S sea level

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysical logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measurement discon.,	obstruction,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign substance,	well destroyed,	surface water effects,	other	static

Figure 3. Water-level measurement field form for inspection of continuous record wells. This form, or an equivalent custom-designed form, should be used for continuous recorder inspections and field measurements.

h. Confirm that the direction of the wheel movement is properly recorded (on the display, or by the data logger). For example, when recording depth to water, if the depth to water reading increases as the float is raised, the float was put on in reverse. Correct this error by reversing the direction of the float tape/wire.

i. Set the data logger to the depth to water measured in (e) above using the datum of choice and set the correct time.

j. Measure again to confirm, reset if necessary.

k. Record the water-level measurement on the Inspection of Continuous Record Well field form (fig. 3).

l. Document the equipment serial numbers or other identifiers in the field notebook or on appropriate field forms.

m. Check the battery voltage. Replace if necessary.

n. Confirm that the data logger is operating prior to departure.

4. Subsequent visits to the float-activated recorder:

a. Retrieve groundwater data by using instrument or data logger software.

b. Inspect the equipment to confirm that installation is operating properly. Document the current water level recorded by the sensor (not the most recent water level recorded by the data logger).

c. Measure the depth to water in the well by using either GWPD 1 or GWPD 4 to obtain an accurate water-level measurement with which to check the recorder water level (calibration measurement)

d. Record the water-level measurement on the Inspection of Continuous Record Well field form (fig. 3).

e. Test the movement of the float wheel by carefully rotating it several inches and releasing it. The tape/recorder should return to the same value. If it does not return to within 0.01 foot of the initial value, then inspect the float tape/wire, float, and counterweight and rebalance as necessary

f. Confirm that the direction of the wheel movement is properly recorded (on the display or by the data logger). If the depth to water reading increases as the float is raised, the float was put on in reverse. Correct this error by reversing the direction of the float tape/wire.

g. If the tape measurement differs from the instantaneous instrumentation reading by an amount specified in the groundwater quality assurance procedures of the local office, record it on the inspection sheet and reset the instrumentation to reflect the proper depth to water.

h. Check the battery voltage. Replace if necessary.

i. Make sure the data logger is operating prior to departure.

Data Recording

All data are recorded in the field notebook and on the appropriate field form.

References

Bureau of Reclamation, 2001, Water measurement manual, A water resources technical publication (2d ed. rev. reprinted): U.S. Department of the Interior, 485 p., accessed December 17, 2010, at *http://www.usbr.gov/pmts/hydraulics_lab/pubs/wmm/*.

Garber, M.S., and Koopman, F.C., 1968, Methods of measuring water levels in deep wells: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A1, 23 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011c, Ground-Water technical procedures of the U.S. Geological Survey, GWPD 4—Measuring water levels by use of an electric tape: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

U.S. Geological Survey, Office of Water Data Coordination, 1977, National handbook of recommended methods for water-data acquisition: Office of Water Data Coordination, Geological Survey, U.S. Department of the Interior, chap. 2, p. 2-12–2-14.

GWPD 15—Obtaining permission to install, maintain, or use a well on private property

VERSION: 2010.1

PURPOSE: To describe a procedure for properly obtaining permission to install, maintain, or use a well on private property, for activities such as geophysical explorations, water-level monitoring, and collection of water samples.

U.S. Geological Survey (USGS) policy for access to private lands is governed by Chapter 500.11 in the Survey Manual. It is USGS policy to obtain written permission before drilling, collecting groundwater samples, maintaining a continuous recorder, or making a groundwater-level measurement on private property, restricted public property, and leased Federal land. Test drilling and data collection preferably should be confined to public lands (Federal, State, county, or municipally owned) when the location will serve as well as one on privately owned land. However, if the information needed can be obtained only at a site on private property, that site may be used if permission to drill test wells, sample, or operate observation wells is obtained in advance.

Materials and Instruments

1. Form 9-1483, Well Drilling/Sampling Agreement
2. Permission to Collect Water Samples form
3. Form 9-3106, Well Transfer Agreement
4. Site location map
5. Field notebook
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures

Data Accuracy and Limitations

When public land is not suitable, the use of private property is permitted if, prior to drilling, sampling, or data collection operations, a signed agreement for access to and installation, maintenance, and use of the test hole or observation well is obtained from the property owner.

Assumptions

1. Needed information can be collected only at a site on private property.
2. The person requesting permission to install, maintain, or use a well on private property is familiar with Office of Ground Water Technical Memorandum 2003.03 and associated policies.
3. The requestor is also familiar with State law requirements to notify the local One Call Center (in some States referred to as, “call before you dig”) before blasting, boring, digging, drilling, trenching, or other earth moving operations.

Instructions

1. If seeking permission to drill: Complete all the information on the Well Drilling/Sampling Agreement form (fig. 1, Form 9-1483). Attach to the agreement a site map showing the location of each proposed test hole and (or) observation well. Form 9-1483 must be signed by the landowner and a USGS representative.
   a. Each agreement is assigned a number consisting of the first four digits of the cost center, hyphen, a sequential number beginning with 01, and the year in which the agreement is processed. For example, 4563-0110.
   b. Form 9-1483 or an equivalent form must be signed by the landowner and a USGS representative.
   c. When work at a well is completed and the conditions outlined in Office of Ground Water Technical Memorandum 2003.03 are met, ownership of a well may

Tips on Help Using This Form

Form 9-1483

Revised (October 2002)

Agreement Number:

Well Drilling/Sampling Agreement

The landowner agrees that the U.S. Geological Survey (USGS), District may install and maintain a monitoring well on the landowner's property at a mutually agreed-upon site at the location listed below. The landowner also agrees that the USGS will have access to the site, as it reasonably deems necessary for water-level measurements, geophysical measurements and/or water-quality sampling purposes during the life of this agreement.

The monitoring well will be a hole extending into the earth produced by drilling or auguring. The hole may be cased and screened at an appropriate depth for water level measurements and/or sampling. The well water may be sampled for multiple constituents.

Excavation and/or installation of the well may begin at any time after this agreement is fully executed. The well shall be excavated, installed, and properly maintained by the USGS at its own expense. This agreement shall be regarded as granting a license or easement, whichever may be most appropriately characterizes it under applicable state law, in favor of USGS to enter landowner's property for the purposes noted herein.

At the expiration of this Agreement, the well may be abandoned in one of the following ways:

1. The well may be removed, filled and/or plugged, according to federal, state, and local regulations, by the USGS at its own expense within a reasonable time after the expiration of this Agreement. The USGS, soon thereafter, shall restore the property, again at its own expense, as nearly as possible to the same condition as existed prior to the excavation and/or installation of the well, or

2. At the request of the Landowner, and if the well has been in existence for five years or more, ownership of the well may be transferred to the Landowner under a separate Well Transfer Agreement.

During the life of this Agreement, the Federal Government will be liable for any loss related to the installation, operation, maintenance, or other activities associated with the well described above in accordance with, and to the extent permitted, under the Federal tort Claims Act (28 U.S.C. 1346(b) and 2671 *et seq.*).

This agreement shall be come effective when fully executed and shall continue in force for 5 years unless terminated earlier by the USGS upon 60 days written notice. After 5 years, the Agreement remains in force until terminated by either the USGS or the Landowner upon 60 days written notice to the other party.

Description of well located at Lat. Long. (Attach Drawing)

Landowner:

Address:

Tel. Number: Fax Number

USGS Center Director:

Address:

Tel. Number: Fax Number

USGS Project Chief

Tel. Number: Fax Number

U.S. GEOLOGICAL SURVEY

By:

____________________ Date: ____________________

(Name)

LANDOWNER

By:

____________________ Date: ____________________

Notary Seal:

Figure 1. Well Drilling/Sampling Agreement, Form 9-1483.

As consideration for the rights and privileges granted herein, the USGS shall make a one-time payment to the Landowner in the sum of $ ______. This Agreement shall be binding upon Landowner's devises, heirs, successors, and assigns.

Landowner:

Address:

Tel. Number: Fax Number:

USGS Center Director:

Address:

Tel. Number: Fax Number:

USGS Project Chief:

Tel. Number: Fax Number:

U.S. GEOLOGICAL SURVEY
By

______________________ Date: ______________

(Name)

LANDOWNER
By

______________________ Date: ______________

Notary Seal:

Figure 1. Well Drilling/Sampling Agreement, Form 9-1483.—Continued

be transferred back to the landowner. Form 9-3106 (fig. 2, Well Transfer Agreement) provides for transfer of well ownership. Form 9-3106 must be signed by the landowner and a USGS representative.

2. If seeking permission to collect water samples from a well: Experience has shown that oral permission to collect water samples is easier to obtain, but written permission provides stronger legal protection. Form 9-1483 includes permission for the USGS to take water-quality samples from a well being drilled. However, if an existing well is used instead of drilling a well, use of the Permission to Collect Water Samples form (fig. 3) is warranted. Strong consideration should be used to incorporate this form even when Form 9-1483 is in place. Figure 2 or an equivalent form must be signed by the permitter (landowner) and a USGS representative.

3. If seeking permission to maintain a continuous recorder or make a groundwater-level measurement on private property, restricted public property, or leased Federal land: The USGS preferred business practice is that permission for this activity be obtained in writing using Form 9-1483 or equivalent. Long-standing oral agreements and oral agreements made in situations where obtaining written permission would be prohibitive can be documented by using the form shown in figure 4 (Format for Letter Requesting Permission To Enter Private Property) or by obtaining the information included in figure 5 (Documentation of Oral Permission to Access Private Lands) and documenting the oral permission as soon as possible.

(Tips for Using this Form)

Form 9 3106 U.S. DEPARTMENT OF THE INTERIOR
(October 2002) U.S. Geological Survey

Agreement Number

Well Transfer Agreement

The U.S. Geological Survey (USGS) agrees to transfer ownership of the observation well(s), hereinafter referred to as "the well," or "wells" located at Lat. Long. , and/or

(Provide other location description and/or attach map, plat, drawings, photographs, or other descriptive information)

to , hereinafter referred to
(Name of Landowner)

as "Landowner," giving the Landowner all ownership rights to the wells.

Landowner agrees to assume responsibility for the noted wells(s). Landowner agrees to accept the well(s) "as is" and to not hold USGS or the U.S. Government responsible in any way for any construction deficiencies or repairs that may be needed to make the well to meet any safety, government, or other standards. Landowner agrees to: (a) accept responsibility for any liability, such as liens, fines, damages, penalties, forfeitures or judgments arising from the continued use of existence of the well(s); (b) release the USGS and the U.S. Government for liability for any injuries or damage to persons and /or property of any kind arising out of the continued use of existence of the well(s); and (c) indemnify the USGS and the U.S. Government from any claims arising out of the use of existence of the well(s). If Landowner chooses or is forced to abandoned a well, Landowner agrees to assume full responsibility for its disposition in compliance with applicable federal, state, and local laws,

The transfer of the noted well(s) is effective on the date this agreement is fully executed.

U.S. GEOLOGICAL SURVEY
By

Date:

(Name)

Transferee
By

Date:

(Name)

Notary Seal:

Figure 2. Well Transfer Agreement Form 9-3106 for transfer of well ownership.

Unnumbered form (from WRD Memo No. 90.34)

U.S. GEOLOGICAL SURVEY

Permission to Collect Water Samples.

I (we) ______________________________________ hereby give my (our) permission to the U.S. Geological Survey to collect a water sample (s) from my well, spring, stream, lake, or reservoir. I understand that this sample will be analyzed by the U.S. Geological Survey and that the data will be used for scientific purposes. I also understand that I will be furnished a copy of the analysis and that the data will be stored in the Geological Survey's computer storage files and become public information at that time. The U.S. Geological Survey has also informed me (us) that some results of the analysis that exceed the U.S. Environmental Protection Agency's Primary Drinking Water Standard Maximum Contaminant Levels may be reported to a local, State, or Federal regulatory agency.

In addition to collecting a sample (s) for a laboratory analysis, the U.S. Geological Survey may also make a series of concurrent physical measurements such as water level, streamflow, pH, and temperature.

If I (we) have any questions about this program of the U.S. Geological Survey,

I can contact ______________________________________

At the following telephone number ______________________________

____

Signature, Permitter Date

____

Signature, U.S. Geological Survey Date

Local address

____

____

____

Figure 3. Form to use to obtain permission to collect water samples.

USGS
science for a changing world

U.S. Geological Survey Manual

Figure 500.11.1

Format for Letter Requesting Permission To Enter Private Property (to be printed on Official Letterhead)

(Insert Name of Private Landowner) (Insert Date)
(Insert Address of Private Landowner)

Dear (Insert Name of Private Landowner):

The U.S. Geological Survey requires employees to obtain written permission from landowners in certain cases before entering onto private property to conduct new surveys or scientific sampling. Consequently, we are hereby requesting your approval to enter your land for the purpose described below. The data and/or samples collected will be used for scientific purposes and will be provided to you upon request.

Specific information regarding this request is as follows:

1. (proposed date and time of entry and departure, or period of time during which recurring visits will be necessary).

2. (kind and number of vehicles to be used).

3. (number of persons in the party).

4. (name, office address, and contact information of chief of party).

5. (purpose of the work).

6. (locations on the property where work is to be done).

7. (approximate frequency of aircraft flights along lines of sight for temperature and pressure measurements, in connection with geodimeter or similar work, if applicable).

We will make every effort to minimize disturbance or disruption to your property. However, in the unlikely event that property damage results, you are entitled to file a claim to recover your damages (tort claim). Please contact (insert name and telephone number of tort claims contact) immediately if property damage should occur.

If you have any questions about this program of the U.S. Geological Survey, you may contact (insert name of chief of project) at the following telephone number: (insert number).

If you consent to this request, please sign below and (list method of return, e.g., envelope provided, leave at a designated location, etc.). Thank you for your cooperation.

Sincerely,

____

(Signature and Printed Name of Requestor)

Approval: ____

Landowner Signature Date

Figure 4. Format for letter requesting permission to enter private property (U.S. Geological Survey Manual 500.11).

U.S. Geological Survey Manual

Figure 500.11.2
Documentation of Oral Permission to Access Private Lands

The U.S. Geological Survey obtained oral permission to access private lands as follows:

Description of the work and/or project title, to include date and time of entry and departure or anticipated duration of the work if recurring visits will be made:

Printed name and address of landowner contacted:

____ The landowner was provided with the following information:

1. (proposed date and time of entry and departure, or period of time during which recurring visits will be necessary).

2. (kind and number of vehicles to be used).

3. (number of persons in the party).

4. (name, office address, and contact information of chief of party).

5. (purpose of the work).

6. (locations on the property where work is to be done).

7. (approximate frequency of aircraft flights along lines of sight for temperature and pressure measurements, in connection with geodimeter or similar work, if applicable).

Date permission was granted:

Office location of initiating party:

Name and signature of member of field party who obtained permission:

Other persons in the party who witnessed the oral permission (as applicable):

The documentation of an oral agreement should be retained in the project file by the initiating office until the project is completed and in accordance with the *Handbook for Managing USGS Records*, 432-1-H.

Figure 5. Documentation of oral permission to access private lands (U.S. Geological Survey Manual 500.11).

Data Recording

Permission details are recorded on the associated forms. The original form is kept in the office, and a copy is included in the well folder that is brought to the field.

The Agency Use Code (C803) on the Groundwater Site Schedule (Form 9-1904-A; fig. 6) should be used to indicate the type of agreement in place. If the well is not owned by the USGS, use codes A, L, or M when coding the site in the National Water Information System. For further information, refer to USGS Water Resources Discipline Policy Memorandum 2009.02.

Agency use code (C803)	Short description	Long description
A	Active - no/na	Active data collection site with undocumented or unneeded landowner agreement
L	Active - Written	Active data collection site with written landowner agreement (Form 9-1483)
M	Active - Oral	Active data collection site with memo documenting oral landowner agreement

Reference

U.S. Geological Survey, 2003, Agreement forms for gaging station and observation well installations and transfers: Office of Ground Water Technical Memorandum 2003.03, accessed December 17, 2010, at *http://water.usgs.gov/admin/memo/GW/gw03.03.html*.

U.S. Geological Survey, 2008, U.S. Geological Survey Manual 500.11—Obtaining permission for access to private lands, accessed December 17, 2010, at *http://www.usgs.gov/usgs-manual/500/500-11.html*.

U.S. Geological Survey, 2009, Maintaining an auditable record of USGS discontinued water monitoring station liabilities: Water Resources Discipline Policy Memorandum No. 2009.02, accessed at *http://water.usgs.gov/admin/memo/policy/wrdpolicy09.02.pdf*.

FORM NO. 9-1904-A
Revised Sept 2009, NWIS 4.9

File Code ______
Date ______

Coded by ______
Checked by ______
Entered by ______

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE SCHEDULE
General Site Data

AGENCY CODE (C4) U S G S
SITE ID (C1)
PROJECT (C5)

STATION NAME (C12/900)

SITE TYPE (C802) [1] — Primary - Secondary
DISTRICT (C6)
COUNTRY (C41)
STATE (C7)
County code

COUNTY or TOWN (C8) ______

LATITUDE (C9) .
LONGITUDE (C10) .

LAT/LONG ACCURACY (C11): H (Hndrth sec.), 1 (tenth sec.), 5 (half sec.), S (sec.), R (3 sec.), F (5 sec.), T (10 sec.), M (min.), U (Unknown)

LAT/LONG METHOD (C35): C (land net), D (DGPS), G (GPS), L (LORAN), M (map), N (interpolated digital map), R (reported), S (survey), U (unknown)

LAT/LONG DATUM (C36): NAD27 (North American Datum of 1927), NAD83 (North American Datum of 1983)

ALTITUDE (C16) .

ALTITUDE ACCURACY (C18)

ALTITUDE METHOD (C17): A (altimeter), D (DGPS), G (GPS), I (IfSAR), J (LiDAR), L (Level), M (map), N (DEM), R (reported), U (unknown)

ALTITUDE DATUM (C22): NGVD29 (National Geodetic Vertical Datum of 1929), NAVD88 (North American Vertical Datum of 1988)

LAND NET (C13): 1/4, 1/4, 1/4, S section, T township, range, merid

TOPOGRAPHIC SETTING (C19): A (alluvial fan), B (playa), C (stream channel), D (depression), E (dunes), F (flat), G (floodplain), H (hilltop), K (sinkhole), L (lake or swamp), M (mangrove swamp), O (offshore), P (pediment), S (hillside), T (terrace), U (undulating), V (valley flat), W (upland draw)

HYDROLOGIC UNIT CODE (C20)
DRAINAGE BASIN CODE (C801)
STANDARD TIME ZONE (C813)
DAYLIGHT SAVINGS TIME FLAG (C814) **Y** OR **N**

MAP NAME (C14)
MAP SCALE (C15)

AGENCY USE (C803): A (active no/na), D (discontinued), I (inactive site), L (active written), M (active oral), O (inventory site), R (remediated)

NATIONAL WATER-USE (C39) [2]

DATA TYPE (C804)
Place an 'A' (active), an 'I' (inactive), or an 'O' (inventory) in the appropriate box: WL cont, WL int, QW cont, QW int, PR cont, PR int, EV cont, EV int, wind vel., tide cont, tide int, sed. con, sed. ps, peak flow, low flow, state water use

INSTRUMENTS (C805)
(Place a "Y" in the appropriate box): digital recorder, graphic recorder, telemetry land line, telemetry radio, telemetry satellite, AHDAS, crest-stage gage, tide gage, deflection meter, bubble gage, stilling well, CR type recorder, weighing rain gage, tipping bucket rain gage, acoustic velocity meter, electromagnetic flowmeter, pressure transducer

DATE INVENTORIED (C711): month – day – year

RECORD READY FOR WEB (C32): Y (ready to display), C (conditional), P (proprietary), L (local use only)

REMARKS (C806)

FOOTNOTES

1 SITE TYPE (C802)

GL	Glacier	OC	Ocean	GW	Well	SB	Subsurface
WE	Wetland	OC-CO	Coastal	GW-CR	Collector or Ranney type well	SB-CV	Cave
AT	Atmosphere	LK	Lake, Reservoir, Impoundment	GW-EX	Extensometer well	SB-GWD	Groundwater drain
ES	Estuary			GW-HZ	Hyporheic -zone well	SB-TSM	Tunnel, shaft, or mine
LA	Land	SP	Spring	GW-IW	Interconnected wells	SB-UZ	Unsaturated zone
LA-EX	Excavation	ST	Stream	GW-TH	Test hole not completed as a well		
LA-OU	Outcrop	ST-CA	Canal	GW-MW	Multiple wells		
LA-SNK	Sinkhole	ST-DCH	Ditch				
LA-SH	Soil hole	ST-TS	Tidal strea m				
LA-SR	Shore	FA-WIW	Waste-Injection well				

2 WS (water supply), DO (domestic), CO (commercial), IN (industrial), IR (irrigation), MI (mining), LV (livestock), PH (power hydroelectric), ST (waste water treatment), RM (remediation), TE (thermoelectric power), AQ (aquaculture)

C22 Other (see manual for codes)
C36 Other (see manual for codes)
C39 is mandatory for all sites having data in SWUDS.

Figure 6. Groundwater Site Schedule, Form 9-1904-A.

GENERAL SITE DATA

DATA RELIABILITY (C3)

C	L	M	U
field checked	poor location	minimal data	un-checked

DATE OF FIRST CONSTRUCTION (C21) — month – day – year

USE OF SITE (C23)

A	C	D	E	G	H	M	O	P	R	S	T	U	V	W	X	Z
anode	standby emer. supply	drain	geo-thermal	seismic	heat reservoir	mine	obser-vation	oil or gas	recharge	repres-surize	test	unused	with-drawal/return	with-drawal	waste	des-troyed

SECOND-ARY USE OF SITE (C301) (See use of site)

TERTIARY USE OF SITE (C302) (See use of site)

USE OF WATER (C24)

A	B	C	D	E	F	H	I	J	K	M	N	P	Q	R	S	T	U	Y	Z
air cond.	bottling	comm-ercial	de-water	power	fire	domes-tic	irri-gation	indus-trial (cooling)	mining	medi-cinal	indus-trial	public supply	aqua-culture	recrea-tions	stock	insti-tutional	unused	desalin-ation	other

SECOND-ARY USE OF WATER (C25) (see use of water)

TERTIARY USE OF WATER (C26) (see use of water)

AQUIFER TYPE (C713)

U	N	C	M	X
unconfined single	unconfined multiple	confined single	confined multiple	mixed

PRIMARY AQUIFER (C714)

NATIONAL AQUIFER (C715)

HOLE DEPTH (C27)

WELL DEPTH (C28)

SOURCE OF DEPTH DATA (C29)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

WATER-LEVEL DATA

DATE WATER-LEVEL MEASURED (C235) — month – day – year

TIME (C709)

WATER-LEVEL TYPE CODE (C243)

L	M	S
land surface	meas. pt.	vertical datum

WATER LEVEL (C237/241/242)

MP SEQUENCE NO. (C248) (Mandatory if WL type=M)

WATER-LEVEL DATUM (C245) (Mandatory if WL type=S)

NGVD29	NAVD88	
National Geodetic Vertical Datum 0f 1929	North American Vertical Datum 0f 1988	Other (See manual for codes)

SITE STATUS FOR WATER LEVEL (C238)

A	B	C	D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z
atmos. pressure	tide stage	ice	dry	recently flowing	flowing	nearby flowing	nearby recently flowing	injector site	injector site monitor	plugged	measure-ment discontinued	obstruc-tion	pumping	recently pumped	nearby pumping	nearby recently pumped	foreign sub-stance	well des-troyed	affected by surface water	other

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	D	E	F	G	H	L	M	N	O	P	R	S	T	V	Z
airline	analog	calibrated airline	differ-ential GPS	esti-mated	trans-ducer	pressure gage	calibrated press. gage	geophysi-cal logs	mano-meter	non-rec. gage	observed	acoustic pulse	reported	steel tape	electric tape	calibrated elec. tape	other

WATER-LEVEL ACCURACY (C276)

0	1	2	9
foot	tenth	hun-dredth	not to nearest foot

SOURCE OF WATER-LEVEL DATA (C244)

A	D	G	L	M	O	R	S	Z
other gov't	driller's log	geol-ogist	geophysi-cal logs	memory	owner	other reported	reporting agency	other

PERSON MAKING MEASUREMENT (C246) (WATER LEVEL PARTY)

MEASURING AGENCY (C247) (SOURCE)

EQUIP ID (C249) (20 char)

REMARKS (C267) (256 char)

RECORD READY FOR WEB (C858)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION DATA

RECORD TYPE (C754) C O N S

RECORD SEQUENCE NO. (C723)

DATE OF COMPLETED CONSTRUCTION (C60) — month – day – year

NAME OF CONTRACTOR (C63)

SOURCE OF DATA (C64)

A	D	G	L	M	O	R	S	Z
other gov't	driller	geol-ogist	logs	memory	owner	other reported	reporting agency	other

METHOD OF CONSTRUCTION (C65)

A	B	C	D	H	J	P	R	S	T	V	W	Z
air-rotary	bored or augered	cable tool	dug	hydraulic rotary	jetted	air per-cussion	reverse rotary	sonic	trenching	driven	drive wash	other

TYPE OF FINISH (C66)

C	F	G	H	O	P	S	T	W	X	Z
porous concrete	gravel w/perf.	gravel screen	horiz. gallery	open end	perf or slotted	screen	sand point	walled	open hole	other

TYPE OF SEAL (C67)

B	C	G	N	Z
bentonite	clay	cement grout	none	other

BOTTOM OF SEAL (C68)

METHOD OF DEVELOPMENT (C69)

A	B	C	J	N	P	S	Z
air-lift pump	bailed	compres-sed air	jetted	none	pumped	surged	other

HOURS OF DEVELOPMENT (C70)

SPECIAL TREATMENT (C71)

C	D	E	F	H	M	Z
chem-icals	dry ice	explo-sives	defloc-culent	hydro-frac-turing	mech-anical	other

CONSTRUCTION HOLE DATA (3 sets shown)

RECORD TYPE (C756) HOLE RECORD SEQUENCE NO. (C724) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

RECORD SEQUENCE NO. (C724)

DEPTH TO TOP OF INTERVAL (C73) . DEPTH TO BOTTOM OF INTERVAL (C74) . DIAMETER OF INTERVAL (C75) .

CONSTRUCTION CASING DATA (4 sets shown)

RECORD TYPE (C758) CSNG RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

RECORD SEQUENCE NO. (C725) SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF CASING (C77) . DEPTH TO BOTTOM OF CASING (C78) . DIAMETER OF CASING (C79) .

4 CASING MATERIAL (C80) CASING THICKNESS (C81) .

FOOTNOTE:

4 CASING MATERIAL CODES

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y	Z	4	6
abs	brick	concrete	copper	PTFE	Fiber-glass	galv. iron	Fiber-glass plastic	wrought iron	Fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC or plastic	FEP	rock or stone	steel	tile	coated steel	stain-less steel	wood	steel carbon	steel galva-nized	other mat.	stain-less 304	stain-less 316

CONSTRUCTION OPENINGS DATA (3 sets shown)

RECORD TYPE (C760) O P E N   RECORD SEQUENCE NO. (C726)   SEQUENCE NO. OF PARENT RECORD (C59)

DEPTH TO TOP OF INTERVAL (C83)   DEPTH TO BOTTOM OF INTERVAL (C84)   DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89)   WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)   DEPTH TO BOTTOM OF INTERVAL (C84)   DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89)   WIDTH OF OPENING (C88)

RECORD SEQUENCE NO. (C726)

DEPTH TO TOP OF INTERVAL (C83)   DEPTH TO BOTTOM OF INTERVAL (C84)   DIAMETER OF INTERVAL (C87)

[5] MATERIAL TYPE (C86)   [6] TYPE OF OPENING (C85)   LENGTH OF OPENING (C89)   WIDTH OF OPENING (C88)

FOOTNOTES:

[5] TYPE OF MATERIAL CODES FOR OPEN SECTIONS

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Q	R	S	T	V	W	X	Y	Z	4	6
ABS	brass or bronze	concrete	ceramic	PTFE	fiber-glass	galv. iron	fiber-glass plastic	wrought iron	fiber-glass epoxy	PVC thread-ed	glass	other metal	PVC glued	PVC	FEP	stain-less steel	steel	tile	brick	mem-brane	steel carbon	steel galva-nized	other	stain-less 304	stain-less 316

[6] TYPE OF OPENINGS CODES

F	L	M	P	R	S	T	W	X	Z
fractured rock	louvered or shutter-type	mesh screen	perforated, porous or slotted	wire-wound screen	screen (unk.)	sand point screen	walled or shored	open hole	other

CONSTRUCTION MEASURING POINT DATA

RECORD TYPE (C766) M P N T   RECORD SEQUENCE NO. (C728)   BEGINNING DATE (C321) month – day – year   ENDING DATE (C322)

M.P. HEIGHT (C323)   ALTITUDE OF MEASURING POINT (C325)   ALTITUDE METHOD (C326)   ALTITUDE ACCURACY (C327)

ALTITUDE DATUM (C328)   M.P. REMARKS (C324)

RECORD READY FOR WEB (C857)

Y	C	P	L
ready to display	condi-tional	proprie-tary	local use only

CONSTRUCTION LIFT DATA

RECORD TYPE (C752) L I F T

RECORD SEQUENCE NO. (C254)

TYPE OF LIFT (C43): A air; B bucket; C centri-fugal; J jet; P piston; R rotary; S submer-sible; T turbine; U un-known; X no lift; Z other

DATE RECORDED (C38) month – day – year

PUMP INTAKE DEPTH (C44)

TYPE OF POWER (C45): D diesel; E electric; G gaso-line; H hand; L LP gas; N natural gas; S solar; W windmill; Z other

HORSE-POWER RATING (C46) .

MANUFACTURER (C48)

SERIAL NO. (C49)

POWER COMPANY (C50)

POWER COMPANY ACCOUNT NUMBER (C51)

POWER METER NUMBER (C52)

PUMP RATING (C53) (million gallons/units of fuel) .

ADDITIONAL LIFT (C255)

PERSON OR COMPANY MAINTAINING PUMP (C54)

RATED PUMP CAPACITY (gpm) (C268)

STANDBY POWER (C56) (see TYPE OF POWER)

HORSEPOWER OF STANDBY POWER SOURCE (C57) .

MISCELLANEOUS OWNER DATA

RECORD TYPE (C768) O W N R

RECORD SEQUENCE NO. (C718)

DATE OF OWNERSHIP (C159) – –

WU OWNER TYPE (C350): CP Corporation; GV Govern-ment; IN Individual; MI Military; OT Other; TG Tribal; WS Water Supplier

END DATE OF OWNERSHIP (C374) – –

OWNER'S NAME (C161)

EXAMPLES: JONES, RALPH A.
JONES CONSTRUCTION COMPANY

OWNER'S PHONE NUMBER (C351)

ACCESS TO OWNER'S NAME (C352): 0 Public Access; 1 Coop-erator; 2 USGS Only; 3 District Only; 4 Proprietary

OWNER'S ADDRESS (LINE 1) (C353)

OWNER'S ADDRESS (LINE 2) (C354)

OWNER'S CITY NAME (C355)

STATE (C356)

OWNER'S ZIP CODE (C357) –

OWNER'S COUNTRY NAME (C358)

ACCESS TO OWNER'S PHONE/ADDRESS (C359): 0 Public Access; 1 Coop-erator; 2 USGS Only; 3 District Only; 4 Proprietary

MISCELLANEOUS VISIT DATA

RECORD TYPE (C774) V I S T

RECORD SEQUENCE NO. (C737)

DATE OF VISIT (C187) month – day – year

NAME OF PERSON (C188)

MISCELLANEOUS OTHER ID DATA (2 sets shown)

RECORD TYPE (C770) O T I D

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

RECORD SEQUENCE NO. (C736)

OTHER ID (C190)

ASSIGNER (C191)

MISCELLANEOUS OTHER DATA

RECORD TYPE (C772) O T D T

RECORD SEQUENCE NO. (C312)

OTHER DATA TYPE (C181)

OTHER DATA LOCATION (C182) C Cooperator's Office, D District Office R Reporting Agency Z other

DATA FORMAT (C261) F files, M machine readable, P published, Z other

MISCELLANEOUS LOGS DATA (3 sets shown)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

RECORD TYPE (C778) L O G S

RECORD SEQUENCE NO. (C739)

TYPE OF LOG (C199)

BEGINNING DEPTH (C200) .

ENDING DEPTH (C201) .

SOURCE OF DATA (C202) A other gov't D driller G geol-ogist L logs M memory O owner R other reported S reporting agency Z other

DATA FORMAT (C225) F files M machine readable P published Z other

OTHER DATA LOCATION (C226)

ACOUSTIC LOG:
AS Sonic
AV Acoustic velocity
AW Acoustic waveform
AT Acoustic televiewer

CALIPER LOG:
CP Caliper
CS Caliper, single arm
CT Caliper, three arm
CM Caliper, multi arm
CA Caliper, acoustic

DRILLING LOG:
DT Drilling time
DR Drillers
DG Geologists
DC Core

ELECTRIC LOG:
EE Electric
ER Single-point resistance
EP Spontaneous potential
EL Long-normal resistivity
ES Short-normal resistivity
EF Focused resistivity
ET Lateral resistivity
EN Microresistivity
EC Microresistivity, forused
EO Microresistivity, lateral
ED Dipmeter

ELECTROMAGNETIC LOG:
MM Magnetic log
MS Magnetic susceptibiity log
MI Electromagnetic induction log
MD Electromagnetic dual induction log
MR Radar reflection image log
MV Radar direct-wave velocity log
MA Radar direct-wave amplitude log

FLUID LOG:
FC Fluid conductivity
FR Fluid resistivity
FT Fluid temperature
FF Fluid differential temperature
FV Fluid velocity
FS Spinner flowmeter
FH Heat-pulse flowmeter
FE Electromagnetic flowmeter
FD Doppler flowmeter
FA Radioactive tracer
FY Dye tracer
FB Brine tracer

NUCLEAR LOG:
NG Gamma
NS Spectral gamma
NA Gamma-gamma
NN Neutron
NT Neutron activitation
NM Neuclear magnetic resonance

OPTICAL LOG:
OV Video
OF Fisheye video
OS Sidewall video
OT Optical televiewer

COMBINATION LOG:
ZF Gamma, fluid resistivity, temperature
ZI Gamma, electromagnetic induction
ZR Long/short normal resistivity
ZT Fluid resistivity, temperature
ZM Electromagnetic flowmeter, fluid resistivity, temperature
ZN Long/short normal resistivity, spontaneous potential
ZP Single-point resistance, spontaneous potential
ZE Gamma, long/short normal resistivity, spontaneous potential, single-point resistance, fluid resitivity, temperature

WELL CONSTRUCTION LOG:
WC Casing collar
WD Borehold deviation

OTHER LOG:
OR Other

MISCELLANEOUS NETWORK DATA (3 types shown)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) Q W (water quality) — BEGINNING YEAR (C115) — ENDING YEAR (C116)

TYPE OF ANALYSIS (C120)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	P	Z
physical proper-ties	common ions	trace elements	pesti-cides	nutri-ents	sanitary analysis	codes D&B	codes B&E	codes B&C	codes B&F	codes D&E	codes C,D&E	all or most	codes B&C& radio-active	codes B,C&A	other

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — ANALYZING AGENCY (C307) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) W L (water level) — BEGINNING YEAR (C115) — ENDING YEAR (C116)

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

RECORD TYPE (C780) N E T W — RECORD SEQUENCE NO. (C730) — TYPE OF NETWORK (C706) W D (pumpage or with-drawals) — BEGINNING YEAR (C115) — ENDING YEAR (C116)

SOURCE AGENCY (C117) — [7] FREQUENCY OF COLLECTION (C118) — METHOD OF COLLECTION (C133) — [8] PRIMARY NETWORK SITE (C257) — [8] SECONDARY NETWORK SITE (C708)

C	E	M	U	Z
calcu-lated	esti-mated	meter-ed	un-known	other

FOOTNOTES:

[7] FREQUENCY OF COLLECTION CODES

A	B	C	D	F	I	M	O	Q	S	W	Z	2	3	4	5	X
annually	bi monthly	continu-ously	daily	semi-monthly	inter mittent	monthly	one-time only	quarter-ly	semi-annually	weekly	other	bi-annually	every 3 years	every 4 years	every 5 years	every 10 years

[8] NETWORK SITE CODES

1	2	3	4
national,	district,	project,	co-operator,

MISCELLANEOUS REMARKS DATA (4 types shown)

RECORD TYPE (C788) R M K S — RECORD SEQUENCE NO. (C311) — DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

RECORD TYPE (C788) R M K S — RECORD SEQUENCE NO. (C311) — DATE OF REMARK (C184) month – day – year

REMARKS (C185)

Subsequent entries may be used to continue the remark. Miscellaneous remarks field is limited to 256 characters.

DISCHARGE DATA

RECORD SEQUENCE NO. (C147)

DATE DISCHARGE MEASURED (C148) — month – day – year

TYPE OF DISCHARGE (C703): P pumped, F flow

DISCHARGE (gpm) (C150)

ACCURACY OF DISCHARGE MEASUREMENT (C310): E excellent (LT 2%), G good (2%-5%), F fair (5%-8%), P poor (GT 8%)

SOURCE OF DATA (C151): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF DISCHARGE MEASUREMENT (C152): A acoustic meter, B bailer, C current meter, D Doppler meter, E estimated, F flume, M totaling meter, O orifice, P pitot-tube, R reported, T trajectory, U venturi meter, V volumetric meas, W weir, X unknown, Z other

PRODUCTION WATER LEVEL (C153)

STATIC WATER LEVEL (C154)

SOURCE OF DATA (C155): A other gov't, D driller, G geologist, L logs, M memory, O owner, R other reported, S reporting agency, Z other

METHOD OF WATER-LEVEL MEASUREMENT (C156): A airline, B recorder, C calibrated airline, D differential GP, E estimated, F transducer, G pressure gage, H calibrated press. gage, L geophysical logs, M manometer, N non-rec. gage, O observed, P acoustic pulse, R reported, S steel tape, T electric tape, V calibrated elec. tape, Z other

PUMPING PERIOD (C157)

SPECIFIC CAPACITY (C272)

DRAWDOWN (C309)

GEOHYDROLOGIC DATA

RECORD TYPE (C748): G E O H

RECORD SEQUENCE N0. (C721)

DEPTH TO TOP OF UNIT (C91)

DEPTH TO BOTTOM OF UNIT (C92)

UNIT IDENTIFIER (C93)

LITHOLOGY (C96)

CONTRIBUTING UNIT (C304): P principal aquifer, Q aggregate of lithologic units, S secondary aquifer, N no contribution, U unknown

LITHOLOGIC MODIFIER (C97)

GEOHYDROLOGIC AQUIFER DATA

RECORD TYPE (C750): A Q F R

RECORD SEQUENCE NO. (C742)

SEQUENCE NO. OF PARENT RECORD (C256)

DATE (C95) — month – day – year

STATIC WATER LEVEL (C126)

CONTRIBUTION (C132)

SITE LOCATION SKETCH AND DIRECTIONS

Township ____________ Range ____________

Section # ____________

GWPD 16—Measuring water levels in wells and piezometers by use of a submersible pressure transducer

VERSION: 2010.1

PURPOSE: To make continuous water-level measurements in a well or piezometer by using a submersible pressure transducer.

Materials and Instruments

1. Vented submersible pressure transducer, data logger or data collection platform (DCP), cables, suspension system for the transducer and cables (wire ties or other semipermanent devices), and power supply
2. Data-readout device (i.e., computer loaded with correct software) and data storage modules or other media
3. Locked well cover or recorder shelter and key
4. A water-level tape (steel or electric) graduated in feet, tenths and hundredths of feet, and other materials necessary for depth-to-water measurement
5. Forms including:
    a. Well completion form
    b. Logbook with records of previous measurements for comparison
    c. Transducer calibration worksheet
    d. Water-level measurement field form or groundwater inspection sheet
6. Pencil or pen, blue or black ink. Strikethrough, date, and initial errors; no erasures
7. Calculator
8. Watch
9. Field notebook
10. Spare dessicant
11. Replacement batteries
12. Cleaning supplies for water-level tapes as described in the National Field Manual (Wilde, 2004)
13. Tools including:
    a. High-impedance (digital) multimeter
    b. Connectors
    c. Crimping tool
    d. Contact-burnishing tool or artist's eraser

Data Accuracy and Limitations

1. Water-level measurements for the in-place calibration of pressure transducers should be made to the nearest 0.01 foot.
2. The accuracy of a pressure transducer differs with the manufacturer, measurement range, and depth to water. The measurement error and accuracy standard for most situations are 0.01 foot, 0.1 percent of range in water-level fluctuation, or 0.01 percent of depth to water above or below a measuring point (MP), whichever is least restrictive.
3. Pressure transducers are subject to drift, offset and slippage of the suspension system. For this reason, the transducer readings should be checked against the water level in the well on every visit, and the transducer should be recalibrated periodically and at the completion of monitoring.

Advantages

1. Water levels can be collected at user-defined time scales without making individual manual measurements.
2. Small size allows water levels to be measured in wells or piezometers that are of small diameter, crooked, angled, or that contain pumps or other equipment.
3. The data logger can be left unattended for prolonged periods until data can be downloaded to a portable computer in the field.
4. Some pressure transducers with integrated data loggers are small enough to be placed inside the protective well casing and do not require a separate shelter. Good for high visibility, secure, or below-ground installations.
5. Downloaded data can be imported directly into a spreadsheet or database.
6. Can be interfaced with a DCP to transmit data collected via satellite for near real-time data reporting.
7. Can be installed in a flowing well.

Disadvantages

1. It may be necessary to correct the data for instrument drift, hysteresis, temperature effects, and offsets.
2. Transducers only operate in a limited water-level (pressure) range. The unit must be installed at the appropriate depth in a well so that the water level occurs within the measurement range of the pressure transducer. Wells with a large difference between maximum and minimum water levels may be monitored with reduced resolution using a pressure transducer with a higher range or may require frequent resetting of the depth of the transducer during site visits.
3. Materials in the transducer and cable may react with substances present in the water, causing damage or failure of the instrument.
4. Rapid water-level fluctuations may be missed if they occur between the programmed water-level measurement times.
5. With some data loggers, stored water-level measurements may be lost if the power supply fails.

Assumptions

1. A permanent MP has been established as described in GWPD 3.
2. The user is familiar with the transducer specifications and limitations and has evaluated the required accuracy of the measurements in accordance with the objectives of the study. The transducer's range is appropriate for the range of water levels expected in the observation well (the operating range will not be exceeded).
3. The transducer has been calibrated, either by the manufacturer or by the user, for the conditions expected in the field installation.
4. The transducer is vented to the atmosphere. Data from an absolute transducer must be adjusted to account for changes in atmospheric pressure.
5. If the user is visiting an existing installation, the vent tube is unobstructed, the desiccant is in place, and the well is free of obstructions.

Instructions

This procedure is limited to the installation of vented pressure transducers in observation wells and piezometers for long-term monitoring of water levels (fig. 1). For additional information, and for other applications, see Freeman and others (2004, p. 25–34).

1. If preparing a new installation:
   a. Check that the well is unobstructed. Clear obstructions as described in GWPD 6.
   b. If the well depth is not known, measure the total well depth as described in GWPD 11.
   c. If necessary, install an instrument shelter that will protect the transducer and data logger from vandalism and weather.
   d. Keep the transducer packaged in its original shipping container until it is installed. Connect the transducer, data logger, power supply, and ancillary equipment. Record the model, serial number, and pressure range of the transducer in the field notebook.
   e. Install the pressure transducer by lowering it into the well so that it is submerged below the water surface. Avoid dropping the transducer or permitting sharp contacts with the sides of the well casing. Do not allow the transducer to free fall into the well.

f. Conduct a field calibration of the transducer by raising and lowering it over the anticipated range of water-level fluctuations (Freeman and others, 2004, p. 29). Take three readings at a minimum of five intervals each, during both the raising and lowering of the transducer. Record the data on a calibration worksheet (fig. 2). Calculate a calibration equation for the transducer using the results in figure 2 and a regression equation. If a correction is necessary, apply the correction to the data logger or during post-processing of the water-level record.

g. The transducer should be installed at a point in the well that will not go dry. Estimate the lowest expected water level, and lower the transducer to the desired depth below the water level.

h. Fasten the cable or suspension system to the well head using tie wraps or a weatherproof strain-relief system. If the vent tube is incorporated in the cable, make sure not to pinch the cable too tightly or the vent tube may be obstructed.

i. Make a permanent mark on the cable at the hanging point so that future slippage, if any, can be determined.

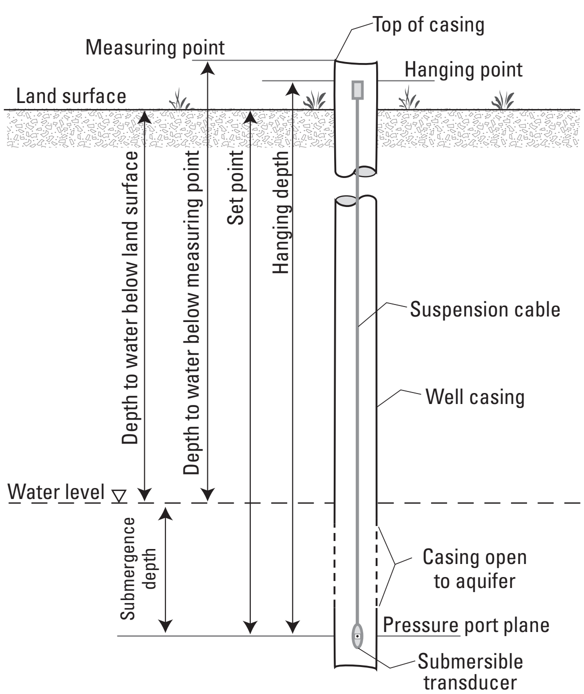


Figure 1. Submersible transducer in an observation well (Freeman and others, 2004, p. 27).

j. Record the well and measuring point (MP) configuration, by drawing a sketch (GWPD 3). Include the MP correction length above the land surface, the hanging point, and the hanging depth (fig. 1).

k. Measure the static water level in the monitor well with a steel (GWPD 1) or electric tape (GWPD 4).

l. Configure the data logger to ensure the channel, scan intervals, and other functions selected are correct. Activate the data logger and set the correct time.

2. If visiting an existing installation:

a. Retrieve groundwater data by using instrument or data logger software.

b. Inspect the equipment to confirm that installation is operating properly. Document the current water level recorded by the sensor (not the most recent water level recorded by the data logger).

c. Measure the depth to water in the well using either GWPD 1 or GWPD 4 to obtain an accurate water-level measurement to compare with the water level measured by the transducer.

d. Record the final water-level measurement on the Inspection of Continuous Record Well field form (fig. 3).

e. If the water-level measurement and transducer reading differ, raise the transducer in the well slightly and take a reading to confirm that the sensor is working. Observe for possible cable kinks or slippage. Return transducer exactly to its original position.

f. Recalibrate the transducer as described in part 1f if necessary (fig. 2).

g. If the water-level measurement differs from the instrumentation reading by an amount specified in the groundwater quality assurance procedures of the local office, record it on the inspection sheet and reset the instrumentation to reflect the proper depth to water.

h. Use the multimeter to check the charge on the battery, and the charging current supply to the battery. Check connections to the data logger, and tighten as necessary. Burnish contacts if corrosion is occurring. Check dessicant. Replace if necessary.

i. Verify the logger channel and scan intervals, document any changes to the data logger program, and reactivate the data logger. Make sure the data logger is operating prior to departure.

U.S. GEOLOGICAL SURVEY
CALIBRATION WORKSHEET FOR SUBMERSIBLE TRANSDUCERS

Data Processing No: ________
Page ______ of ___________

Site Name: Official USGS site name   Site ID and Number: _8 or 15 digit USGS Site ID

M.P. used: Nested piezometers often have multiple measuring points   Party:

Date (mm/dd/yy): ____ / ____ / ____   Julian: ____________   Watch Time: ________   EST CST MST PST Daylight UTC (circle)

Measuring Device: i.e. Calibrated steel tape, calibrated electric tape.

Transducer Information:
Date: ______________ Type: ______________ Length: _________________ Serial No. __________ Output ____________

Units of reading: mv, psi, ma   Range: i.e.0-5 psi   Conversion to feet: 2.3067 x psi = range of 0 to 11.534 ft.

Calibration marks: Describe what was used to mark the transducer cable for measuring distance moved during the calibration process.

Out-of water reading: ________ / __________   Set Point reading: _______ / _________   Scan Rate: ______   Reset? Yes No

Time	Measured Water Level	Cal. Mark	Dist. btwn. Marks	Total Dist.	Readings		
1014	22.35 DBLS		1.00		0.4334 psi		
1015		1		1.00	0.4337		
1016	22.35		1.50		0.4332		
1022	22.35				1.0838 psi		
1023		2		2.50	1.0841		
1024	22.35		1.50		1.0840		
1030	22.34				1.7341 psi		
1031		3		4.00	1.7337		
1032	22.34		1.50		1.7339		
1039	22.33				2.3843		
1040		4		5.50	2.3846		
1041	22.33		1.50		2.3844		
1047	22.33				3.0346		
1048		5		7.00	3.0342		
1049	22.33		1.00		3.0351		
1058	22.32				3.4682		
1059		6		8.00	3.4685		
1100	22.32		1.00		3.4678		
1106	22.32				3.0392		
1107		5		7.00	3.0388		
1108	22.32		1.50		3.0390		
1114	22.32				2.3887		
1115		4		5.50	2.3889		
1116	22.32		1.50		2.3891		
1120	22.31				1.7514		
1121		3		4.00	1.7516		
1122			1.50		1.7517		
1126	22.31				1.1011		
1127		2		2.50	1.1013		
1128	22.31		1.50		1.1010		
1134	22.31				0.4509		
1135		1		1.00	0.4507		WL rise of 0.04 ft. during calib.
1136	22.31 DBLS		1.00		0.4507		

Figure 2. Calibration worksheet for submersible transducers (Freeman and others, 2004, p. 30).

USGS science for a changing world

INSPECTION OF CONTINUOUS RECORD WELL

Steel Tape or Calibrated Electric Tape Measurement

USGS science for a changing world

SITE INFORMATION

SITE ID (C1)

Measurement Tape ID

Date of Field Visit

Station name (C12)

	1	2	3
Time			
Hold			
Cut			
Tape correction			
WL below MP			
MP correction			
WL below LSD			

Measured by ______________________

Remarks ______________________

Barometric Pressure _________ Air Temperature _________

Battery Voltage __________ Replaced? Y / N

Measurement Method: Transducer Float

Checked Float/encoder? Y / N Checked Transducer? Y / N

DATA LOGGER VISIT INFO:

Local time: _________ GMT_________ Data logger time: ______

Sensor reading on arrival: _______ Sensor reading on departure: ________ RESET? Y / N

Datum Correction Needed: ____________________

Retreive data From: ______________ To: _________________
date/time date/time

Datafile: __________________________________

Remarks: ____

MEASURING POINT DATA (for MP Changes)

M.P. REMARKS (C324)

BEGINNING DATE (C321)

month day year

ENDING DATE (C322)

M.P. HEIGHT (C323) NOTE: (-) for MP below land surface

Final Measurement for GWSI

DATE WATER LEVEL MEASURED (C235) — month, day, year

TIME (C709)

STATUS (C238)

METHOD (C239)

TYPE (C243)

WATER LEVEL (C237)

WATER LEVEL TYPE CODE (C243)

L	M	S
below land surface	below meas. pt.	sea level

METHOD OF WATER-LEVEL MEASUREMENT(C239)

A	B	C	E	G	H	L	M	N	R	S (GWPD1)	T	V (GWPD4)	Z
airline,	analog,	calibrated airline,	estimated,	pressure gage,	calibrated press. gage,	geophysi-cal logs,	manometer,	non-rec. gage,	reported,	steel tape,	electric tape,	calibrated elec. tape	other

SITE STATUS FOR WATER LEVEL (C238)

D	E	F	G	H	I	J	M	N	O	P	R	S	T	V	W	X	Z	BLANK
dry,	recently flowing,	flowing,	nearby flowing	nearby recently flowing,	injector site,	injector site monitor,	plugged,	measure-ment discon.,	obstruc-tion,	pumping,	recently pumped,	nearby pumping,	nearby recently pumped,	foreign sub-stance,	well des-troyed,	surface water effects,	other	static

Figure 3. Water-level measurement field form for inspection of continuous record wells. This form, or an equivalent custom-designed form, should be used for continuous recorder inspections and field measurements.

Data Recording

All data times of measurement are recorded in the field notebook or trip log and on the Inspection of Continuous Record Well field form or water-level measurement field form. Depending on the type of data logger used, data from the data logger are transferred to the office computer via field computer or a data module.

References

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 4—Measuring water levels by use of an electric tape: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011c, Groundwater technical procedures of the U.S. Geological Survey, GWPD 6—Recognizing and removing debris from a well: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011d, Groundwater technical procedures of the U.S. Geological Survey, GWPD 11—Measuring well depth by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 10 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011e, Groundwater technical procedures of the U.S. Geological Survey, GWPD 14—Measuring continuous water levels by use of a float-activated recorder: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

Freeman, L.A., Carpenter, M.C., Rosenberry, D.O., Rousseau, J.P., Unger, Randy, and McLean, J.S., 2004, Use of submersible pressure transducers in water-resources investigations: U.S. Geological Survey Techniques of Water-Resources Investigations, book 8, chap. A3, 50 p.

Lapham, W.W., Wilde, F.D., and Koterba, M.T., 1995, Ground-water data-collection protocols and procedures for the National Water-Quality Assessment Program—Selection, installation, and documentation of wells, and collection of related data: U.S. Geological Survey Open-File Report 95–398, 69 p. + errata.

Wilde, F.D., ed., 2004, Cleaning of equipment for water sampling (version 2.0): U.S. Geological Survey Techniques of Water-Resources Investigations, book 9, chap. A3, section 3.3.8, accessed May 17, 2010, at *http://pubs.water.usgs.gov/twri9A3/*.

GWPD 17—Conducting an instantaneous change in head (slug) test with a mechanical slug and submersible pressure transducer

VERSION: 2010.1

PURPOSE: To obtain data from which an estimate of hydraulic conductivity of an aquifer can be calculated.

During a slug test the water level in a well is changed rapidly, and the rate of water-level response to that change is measured. From these data, an estimate of hydraulic conductivity can be calculated using appropriate analytical methods (for example, Ferris and Knowles, 1963).

A slug test requires a rapid ("instantaneous") water-level change and measurement of the water-level response at high frequency. A rapid change in water level can be induced in many ways, including injecting or withdrawing water, increasing or decreasing air pressure in the well casing, or adding a mechanical device like a plastic rod to displace water. The water-level changes can be measured with many methods, including steel tape, electric tape, air line, wireline/float, and submersible pressure transducers.

One of the most common methods in use is displacement of water with a mechanical slug, measurement of water levels with a submersible pressure transducer, and recording water levels with a data logger. This method combines ease of use, accuracy, and rapidity of water-level measurement. This document describes the mechanical slug/pressure transducer method. This technical procedure can be used with slight modifications if other approaches are used to instantaneously change the water level or measure water-level change.

Materials and Instruments

1. Tools or key to open the well.
2. Field notebook; Pencil or pen, blue or black ink. Strike-through, date, and initial errors; no erasures.
3. Well-construction diagram.
4. Data logger and submersible pressure transducer. A 10-pound-per-square-inch (psi) pressure transducer commonly is used for slug tests because it combines adequate accuracy with an acceptable range of measurement.
5. Slug of polyvinyl chloride (PVC) or other relatively inert material (fig. 1). A slug of solid PVC (fig. 1*C*) is ideal because PVC caps (fig. 1*A*) can catch the well casing during insertion, and PVC plugs (fig. 1*B*) can come loose during the rapid removal of the slug.

   Select the largest diameter and length of slug that will fit in the well without disturbing the transducer. The slug should have a displacement that will provide an adequate change in water level. The slug should displace enough water to provide a measurable change in water level, but not so large as to significantly increase the saturated thickness of the aquifer, disturb the transducer, or affect the speed at which one can raise or lower the slug. A water-level rise between 0.5 and 3 feet (ft) often is adequate. In low permeability formations, a smaller displacement will take less time for full recovery. In high permeability formations (1 to 100 ft per day), a larger displacement is desirable and practical. This usually can be generated with a slug diameter about 1 inch less than the well diameter and a length of 3 ft or more (lengths greater than 5 ft are awkward to handle in the field). Tables 1 and 2, respectively, provide theoretical displacement volumes for various slugs and volumes necessary for specific water-level changes.
6. Nylon cord or other strong line of sufficient length to reach below the water level in order to secure the slug.
7. Wooden rod, or 2 by 4 to secure the slug line.
8. Tripod or other device to support the slug line (optional).
9. Bungee cord or other device to secure the transducer cable and support line.
10. Water level measuring device (steel or electric tape).
11. Appropriate decontamination equipment, if necessary.
12. Field computer (optional).
13. Stopwatch (optional).

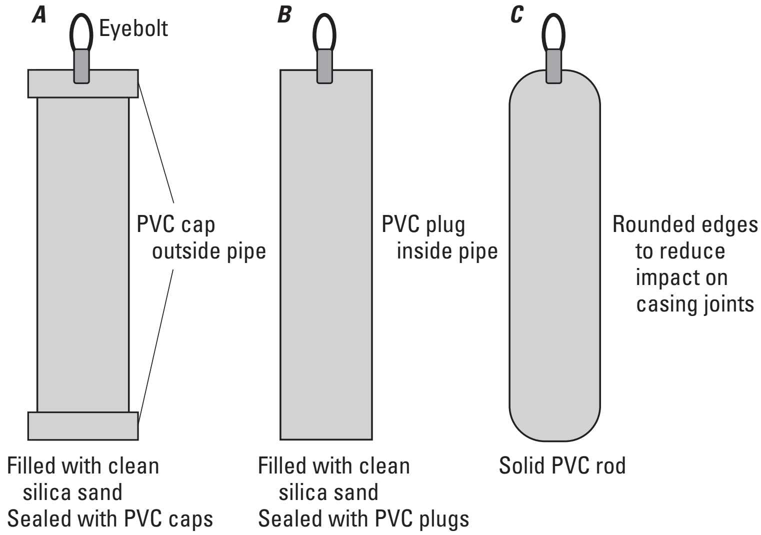


Figure 1. Polyvinyl chloride (PVC) plastic slug. *A*, Solid 2-inch PVC pipe with external cap. *B*, Solid 2-inch PVC pipe with internal plug. *C*, Solid 2-inch PVC rod.

Table 1. Slug displacement volume, in cubic feet, for a specific slug diameter and length.

Slug length (feet)	Slug diameter (inches)						
	1	1.5	2	2.5	3	3.5	4
2	0.011	0.025	0.044	0.068	0.098	0.134	0.175
3	0.016	0.037	0.065	0.102	0.147	0.200	0.262
4	0.022	0.049	0.087	0.136	0.196	0.267	0.349
5	0.027	0.061	0.109	0.170	0.245	0.334	0.436
6	0.033	0.074	0.131	0.205	0.295	0.401	0.524

Table 2. Volume of water, in cubic feet, required to raise the water level a prescribed distance within a specific well diameter.

Well diameter (inches)	0.3-foot rise	0.5-foot rise	1-foot rise	1.5-foot rise	2-foot rise	3-foot rise
2	0.007	0.011	0.022	0.033	0.044	0.065
3	0.015	0.025	0.049	0.074	0.098	0.147
4	0.026	0.044	0.087	0.131	0.175	0.262
6	0.059	0.098	0.196	0.295	0.393	0.589
8	0.105	0.175	0.349	0.524	0.698	1.047
10	0.164	0.273	0.545	0.818	1.091	1.636

Data Accuracy and Limitations

1. The accuracy of a slug test is a function of many factors, including well construction, field procedures, and analysis method. Rapidly changing the water level in a well can be done by submerging an object (slug) in the water, causing the water level to rise instantaneously. Displaced water will move from the well to the geologic formation until the hydraulic head falls to the original static or equilibrium level. This is called a falling head test or "slug in test." After the water level reaches equilibrium, quickly removing the slug causes the water level to fall instantaneously. Water will move from the formation into the well until the hydraulic head returns to the equilibrium level. This is called a rising head test, "slug-out test," or bailer test. Because the early-time data for these tests are most important for the subsequent analysis, the data logger should begin collecting data just before the slug is submerged or removed from the well. The initial time can be adjusted during analysis, but the logger must be collecting data at a frequency of at least several samples per second when the water level begins to change. After the first minute or two of data collection, the sampling interval can be increased. Data loggers designed for aquifer tests and slug tests frequently have internal programs that allow for rapid data collection at early time and gradual increase of the sampling interval over time (a logarithmic time scale).

2. Some transducers have more rapid recording rates than others. If the slug test is being done in a formation of high hydraulic conductivity, select a transducer that can transmit at very small time increments (tenths of a second).

3. Due to the accuracy limitations of slug tests, results should be reported to one significant figure.

Advantages

1. Potentially contaminated water requiring special disposal is not removed from the well.

2. The slug test can be conducted quickly and is therefore relatively inexpensive.

3. Only one well is needed for the test (no need for other observation wells), and a pump is not required.

4. Because the slug-test data to be analyzed for an estimate of hydraulic conductivity are collected within a few minutes of the test initiation, this technique can be used near pumped wells or where well interference is expected, as long as the expected water-level changes occur slowly in comparison to the time for which the slug-test data will be analyzed.

Disadvantages

1. The collected data represent only a small volume of aquifer material near the tested well.

2. The test may be influenced by the well filter pack, skin effects, or poor well development.

Assumptions

1. Operator is familiar with the operation of data loggers and submersible pressure transducers. The data logger/transducer can measure and record at a high frequency (less than or equal to one second in highly transmissive formations).

2. The well is free of obstructions which might hinder water-level measurement or introduction or removal of the mechanical slug.

3. The water level is easily accessible from the surface (within approximately 100 ft) and is within the length of the transducer cable.

4. Column of water in the well is long enough to cover the transducer and the slug.

5. The well is properly constructed and developed.

6. Well construction details such as well depth, screen length, borehole radius, filter pack, and well radius are known.

7. The hydraulic conductivity of the aquifer is not extremely low. A slug test is an acceptable method in low-permeability formations, but a transducer may not be necessary in this situation. The water level in the well should recover within minutes or hours for this procedure.

Instructions

1. Confirm well identification with well-construction diagram.

2. Measure the total depth of the well (see GWPD 11).

3. Measure the water level in the well (see GWPD 1 or GWPD 4). This should be repeated at the end of the test for long duration slug tests. The column of water in the well should be long enough to cover the transducer and the slug.

4. Document the static water level, well diameter, well depth, and screened interval in field notebook. The diameter of the hole, nature of filter pack, and type of screen also are documented, if known.

5. Place the transducer in the well below the level at which the slug will be submerged, but not so low that the range of transducer might be exceeded at the highest anticipated water level. Secure the transducer in place. The transducer should not move during the test.

6. Measure (estimate) the maximum length of slug line that will be used. This length should allow the slug to completely submerge, about 1 ft below water surface.

7. Allow the transducer to adjust to the new pressure and temperature following manufacturer's guidance. This also provides time for the water level to recover prior to the test.

8. If needed, set up a tripod or some other device from which the slug can be lowered and raised in the well. Lower the clean, decontaminated slug to a point just above the water level and secure it in place. Take care not to move or kink the transducer line (fig. 2*A*). A simple approach of securing the slug is to tie a loop of cord that would hold the slug about 1 ft above the water surface and then tie off a second loop at the length of cord required for the entire slug to submerge. Put both of these loops over a rod or a wooden 2 by 4 that can rest across the top of the well casing.

9. Prepare the data logger. The data logger should be set to record data as frequently as possible during the first minutes of the test, and it can be set to record less frequently during later time. Recording in seconds on a logarithmic time scale meets this objective.

10. Establish a starting water level for the transducer and data logger. Data analysis is based on the change in water level rather than a comparison to a standard datum. The transducer starting water level can be set to zero, a value equal to the head of water above the transducer, or any other value.

Slug In Test

11. Begin the test by starting the data logger and nearly simultaneously submerging the slug quickly but gently into the water to minimize disturbance at the water surface or movement of the transducer cable (fig. 2*B*). Secure the slug cord to the wooden rod to maintain its position below the water level.

12. After 1 minute and periodically thereafter, check the status of the water-level reading with the data logger/transducer or with a water-level measuring tape.

13. When the water level is equal to the initial water level, or when readings change less than 0.01 ft per 10 minutes, stop the test. This is the end of the falling head, or slug in test. You are now ready to begin the rising head, or slug out test.

Slug Out Test

14. Establish a starting water level for the transducer and data logger. Data analysis is based on the change in water level rather than a comparison to a standard datum. The transducer starting water level can be set to zero, a value equal to the head of water above the transducer, or any other value.

15. Prepare the data logger. The data logger should be set to record data as frequently as possible during the first minutes of the test, and it can be set to record less frequently during later time. Recording in seconds on a logarithmic time scale meets this objective.

16. Begin the test by starting the data logger and nearly simultaneously withdrawing the slug quickly but gently from the water to minimize disturbance at the water surface or movement of the transducer cable. The slug need not be withdrawn completely out of the well, but should

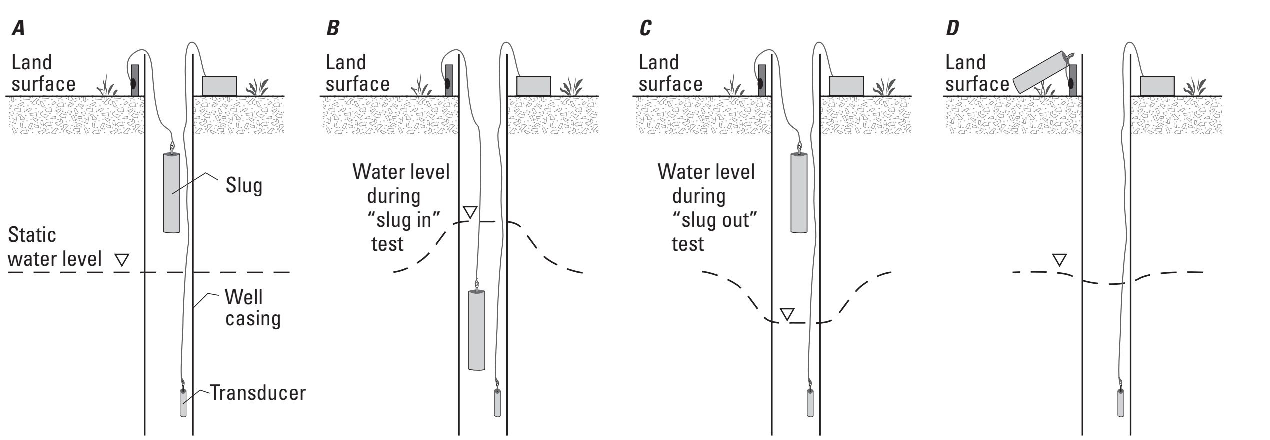


Figure 2. Well diagram with polyvinyl chloride (PVC) plastic slug (*A*) poised just above the water level for falling head or slug in test, (*B*) submerged below the water level for falling head or slug in test, (*C*) removed just above the water level for rising head or slug out test, and (*D*) removed from the well for rising head or slug out test.

be out of the water (fig. 2*C* or 2*D*). Secure the slug cord to the wooden rod to maintain its position above the water level.

17. After 1 minute and periodically thereafter, check the status of the water-level reading with the data logger/transducer or with a measuring tape.

18. When the water level is equal to the initial water level, or when readings change less than 0.01 ft per 10 minutes, stop the test. This is the end of the rising head, or slug out test.

19. Review the data for completeness and accuracy. This can be done on the data logger or on a field computer (preferred). Optionally, the test can be analyzed in the field on a field computer using aquifer test software.

20. Repeat the entire procedure at least once as time permits, so two complete sets of falling and rising head test data are collected (four tests).

Data Recording

1. All calibration and maintenance data associated with the data logger, steel or electric tape, and submersible pressure transducer are recorded in calibration and maintenance equipment logbooks.

2. Complete a field report with date, time, well identifier, type of test (rising or falling head), composition and dimensions (or volume) of the slug, and the name of data files. (Use site ID or well name, date, and year in the file name: for example, 424531077564201.19960101, or Well8.19960101.)

3. Data are downloaded to an office computer for processing. Results are interpreted and submitted for Bureau approval. Original data are stored in the office aquifer test archive, and result is recorded on the Groundwater Site Inventory form (fig. 3, Form 9-1904-D1).

FORM NO. 9-1904-D1
Revised January 2010, NWIS 4.9

Coded by ______________ File Code ______________

Checked by ______________ Date ______________

Entered by ______________ Regional approval date ______________

U.S DEPT. OF THE INTERIOR
GEOLOGICAL SURVEY

GROUNDWATER SITE INVENTORY
Hydraulics Data

AGENCY CODE (C4) [| | | |] SITE ID (C1) [| | | | | | | | | | | | | |]

RECORD TYPE (C744) [H|Y|D|R] RECORD SEQUENCE NO. (C790) [| |]

HYDRAULIC UNIT IDENTIFIER (C100) [| | | | | | |] DEPTH TO TOP OF INTERVAL (C101) [| | |] . [|] DEPTH TO BOTTOM OF INTERVAL (C102) [| | |] . [|]

HYDRAULICS UNIT TYPE (C103) [A C]
aquifer, confining unit

REMARKS - Method of determining hydraulics data (C104)

[| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |]

HYDRAULICS SOURCE AGENCY (C305) [| | | |] WEB-READY FLAG (C874) [Y C P L]
ready to display, condi- tional, propri- etary, local use only

---

RECORD TYPE (C746) [C|O|E|F] SEQUENCE NO. OF PARENT RECORD (C99) [| |] RECORD SEQUENCE NO. (C106) [| |]

TRANSMISSIVITY(C107) [| | | | | | |]

HORIZONTAL CONDUCTIVITY (C108) [| | | | | | | |] . [| |] VERTICAL CONDUCTIVITY (C109) [| | | | | |] . [| | | | |]

STORAGE COEFFICIENT (C110) . [| | | | | | |] LEAKANCE (C111) [| | |] . [| | |]

DIFFUSIVITY (C112) [| | | | | | | | | | | | |] SPECIFIC STORAGE (C113) . [| | | | | | | | |]

BAROMETRIC EFFICIENCY (Percent) (C271) [| |] POROSITY (C306) . [| |]

WEB-READY FLAG (C875) [Y C P L]
ready to display, condi- tional, propri- etary, local use only

Figure 3. Groundwater Site Inventory for Hydraulics Data, Form 9-1404-D1.

Procedures References

Cunningham, W.L., and Schalk, C.W., comps., 2011a, Groundwater technical procedures of the U.S. Geological Survey, GWPD 1—Measuring water levels by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 4 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011b, Groundwater technical procedures of the U.S. Geological Survey, GWPD 3—Establishing a permanent measuring point and other reference marks: U.S. Geological Survey Techniques and Methods 1–A1, 13 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011c, Groundwater technical procedures of the U.S. Geological Survey, GWPD 4—Measuring water levels by use of an electric tape: U.S. Geological Survey Techniques and Methods 1–A1, 6 p.

Cunningham, W.L., and Schalk, C.W., comps., 2011d, Groundwater technical procedures of the U.S. Geological Survey, GWPD 11—Measuring well depth by use of a graduated steel tape: U.S. Geological Survey Techniques and Methods 1–A1, 10 p.

Method References

American Society for Testing of Materials, 1991, ASTM Method D4044-91: Philadelphia, Pennsylvania, American Society for Testing of Materials.

Ferris, J.G., and Knowles, D.B., 1963, The slug-injection test for estimating the coefficient of transmissibility of an aquifer, *in* Bentall, Ray, comp., Methods of determining permeability, transmissibility, and drawdown: U.S. Geological Survey Water-Supply Paper 1536–I, p. 299–304.

Hoopes, B.C., ed., 2004, User's manual for the National Water Information System of the U.S. Geological Survey, Ground-Water Site-Inventory System (version 4.4): U.S. Geological Survey Open-File Report 2005–1251, 274 p.

Analysis References

Bouwer, Herman, 1989, The Bouwer and Rice slug test—An update: Ground Water, v. 27, no. 3, p. 304–309.

Bouwer, Herman, and Rice, R.C., 1976, A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: Water Resources Research, v. 12, no. 3, p. 423–428.

Butler, J.J., Jr., 1997, The design, performance, and analysis of slug tests: Boca Raton, Florida, Lewis Publishers, 252 p.

Cooper, H.H., Bredehoeft, J.D., and Papodopulos, S.S., 1967, Response of a finite-diameter well to an instantaneous charge of water: Water Resources Research, v. 3, no. 1, p. 263–269.

Dawson, K.J., and Istok, J.D., 1991, Aquifer testing—Design and analysis of pumping and slug tests: Chelsea, Michigan, Lewis Publishers, 344 p.

Halford, K.J., and Kuniansky, E.L., 2002, Documentation of spreadsheets for the analysis of aquifer-test and slug-test data: U.S. Geological Survey Open-File Report 02–197, 54 p. (Also available at *http://pubs.usgs.gov/of/2002/ofr02197/*.)

Hvorslev, M.J., 1951, Time lag and soil permeability in ground-water observations: Vicksburg, Mississippi, U.S. Army Corps of Engineers, Waterways Experiment Station, Bulletin No. 36, p. 1–50.

HydroSOLVE, Inc., 1998, AQTESOLV for Windows User's Guide: Reston, Virginia, HydroSOLVE, 128 p.

Krusman, G.P., and deRidder, N.A., 1990, Analysis and evaluation of pumping test data (2d ed.): Wageningen, The Netherlands, International Institute for Land Reclamation and Improvement, 377 p.

Manuscript was approved for publication on October 26, 2010.

Prepared by:
U.S. Geological Survey
Science Publishing Network
Raleigh Publishing Service Center
3916 Sunset Ridge Road
Raleigh, NC 27607

Cover design and illustrations: Bonnie J. Turcott
Layout: Kay E. Hedrick

A PDF version of this publication is available online at
http://pubs.usgs.gov/tm/1a1/

Cunningham and Schalk—**Groundwater Technical Procedures of the U.S. Geological Survey**—Techniques and Methods 1–A1

Sounder Calibration Protocol - KCWA

Background: Sounders and ploppers are the main tools utilized for groundwater measurements. These measurements are utilized to create the maps in KCWA reports. These maps drive discussions and policy decisions for the region. As such, care needs to be taken to ensure accurate, reliable, and quality data are made with these tools.

Sounders should be housed in temperature controlled secure areas when not in use. Sounders need to be identified by a number to differentiate them from each other. Each sounder also has a Calibration and Maintenance Logbook associated with it that houses all written history on problems, repairs, calibrations associated with the sounder. Do not keep sounders in bed of a truck or exposed to heat, cold, or wet conditions while not in use. If a sounder wire gets stuck in a well, loses a tip, or could become stretched in any way, calibration must be done before further measurements are taken.

Materials:

Personal Protective Equipment (steel-toed boots, long pants)

Steel Tape (never used in field, housed in an office)

Sounder

Electrical Tape (red, yellow, white)

Calibration and Maintenance Logbook (housed in sounder casing, always with sounder)

Clean rag

Measuring tape in 0.1 feet increments

Calibration Station Set-up:

Use dedicated steel tape to measure out 100 ft. distance on flat concrete surface (pipe gallery in Train B), ensuring steel tape is as flat and straight as possible.

Sounder Calibration:

1. Turn sounder on, test sounder electrical system and verify that any repairs were made. All repairs, calibrations, and field sounder issues are to be recorded in the Calibration and Maintenance Logbook.
2. Gently unravel sounder to 100 ft. and place taut, parallel to the steel tape. Check if the marking tape on the sounder corresponds with the 10 ft. marks on the steel tape (or written value if unaltered dual wire sounder).
3. If, at any location, the center of the tape (or the center of the group of tapes) varies from the steel tape by more than 0.1 ft., recalibration must start and continue through to the end of the sounders total range.

4. Repeat steps 3 and 4 for subsequent 100 ft. lengths through to the end of the sounders total range. Remember if at any point the sounder is "off" by more than 0.1 ft. all remaining taped locations will need to be adjusted.
5. Sounders are to be recalibrated any time stretch is suspected of occurring, after a repair, tip replacement, or at least quarterly. The calibration, repairs, and observations of equipment are recorded in Calibration and Maintenance Logbook along with the initials of the person performing the work.

Measurement:

1. Prior to going in the field, confirm that:
   -battery and electrical system is working properly
   -calibration is recorded in Calibration and Maintenance Logbook
2. Make all measurements using the same deflection point on the indicator scale, or sound so that water levels will be consistent.
3. Lower the probe into the well until the indicator reads as contact with the water surface is made. Read the depth to water on the sounder for when contact is verified at the reference point (usually top of pipe or structure).
4. Continue to lower the sounder wire an additional 10 ft. or so to verify that the indicator does not go off. If the indicator does become interrupted the reading is a false reading. Redo step 3 until no interruption in indicator.
5. Record the measurement, date, time, operator onto field sheets, books, or iPad.
6. Pull sounder wire out at least 10 ft. and repeat step 3 to verify measurement. Resulting measurement should be within 0.1 ft. of original. If difference is more than 0.1 ft. repeat measurements starting with step 3 until a confident consistent value is reached. It may be necessary to pull wire completely out of well and start over.
7. After completing the measurement, dry the wire and probe and rewind on the reel.

City of Bakersfield Monitoring Program – Groundwater Elevation Monitoring

Water Level Devices

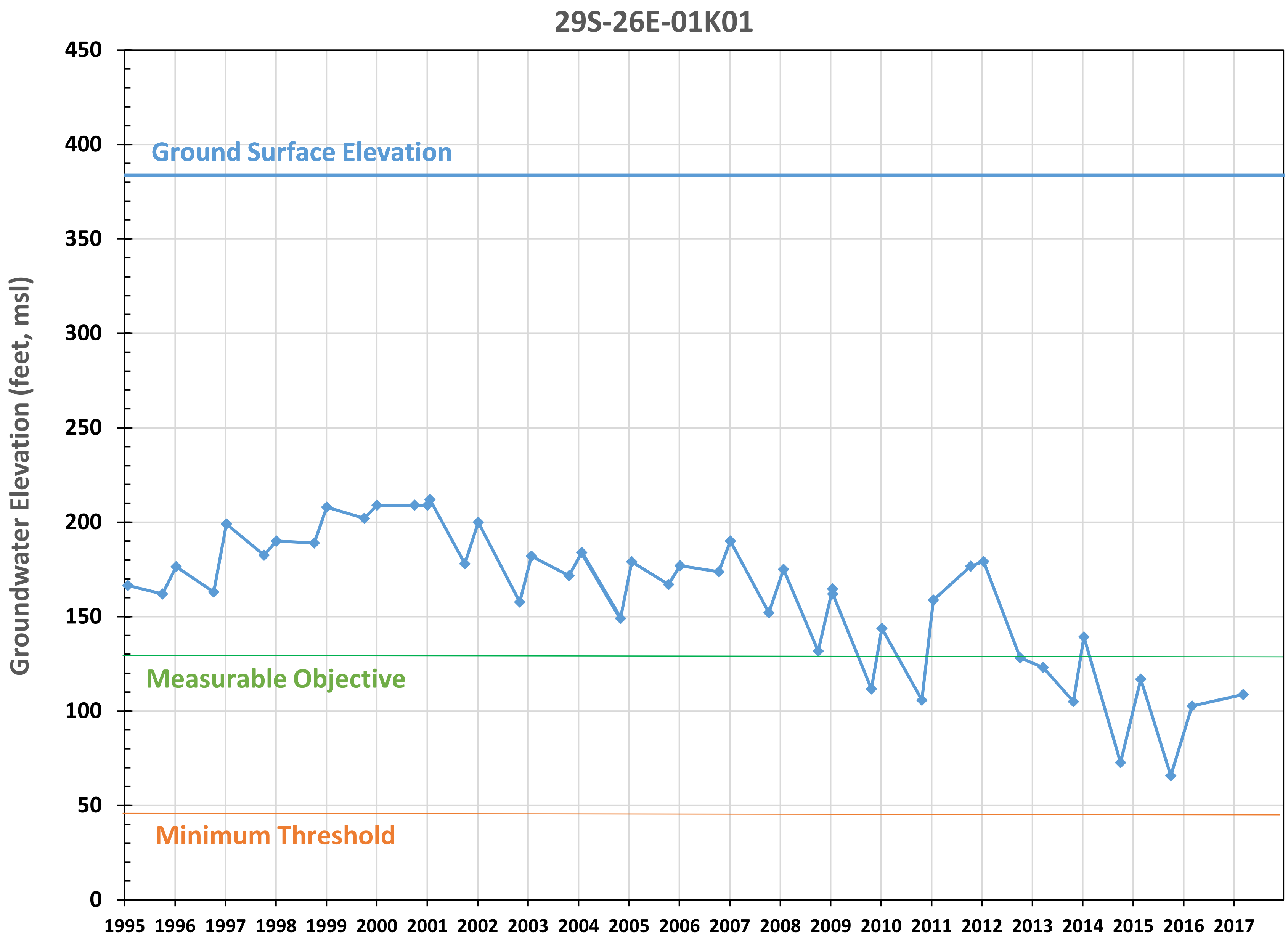
1. Portable Water Level Meter - electronic instrument that is designed to accurately determine the static level, the draw-down level, and the recovery rate levels in water wells. The cable, with an electrode attached to the end, is lowered into the well. When the electrode makes contact with the water level, a milliampere reading will register on the analog meter and an audible beeper will sound. The depth of the water can be read using the calibrations marked on the cable. (Information provided by *Powers Electric Products Company*).

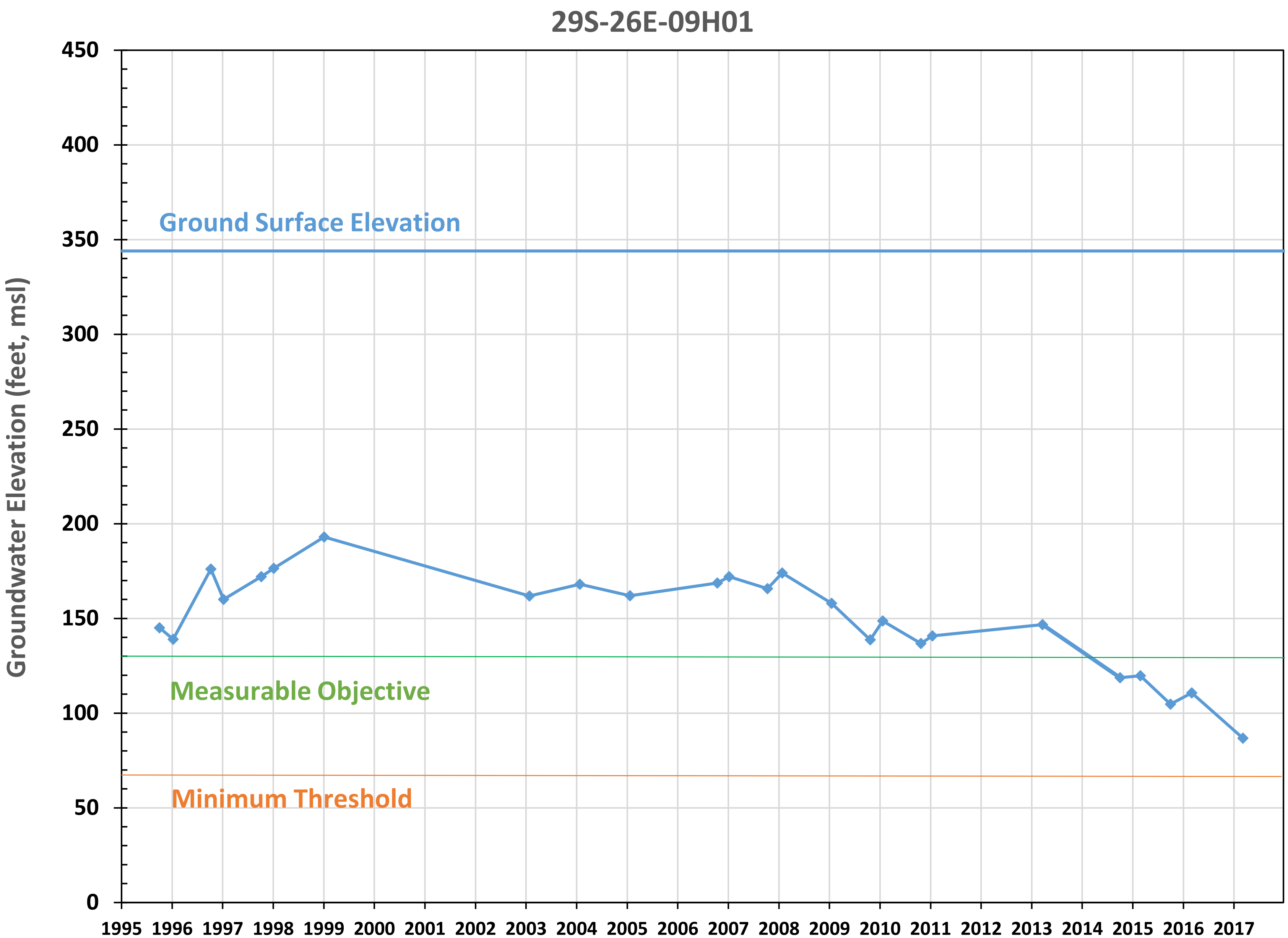
2. Sonic Water Level Meter - a self-contained, battery operated meter that uses sound waves to measure well water level. Fast, accurate measurements are possible in the field or anywhere without the use of down-hole water level meters. The Sonic Water Level Meters are lightweight, compact, versatile, and easy to operate. Select either the NORMAL (10-500 feet) or DEEP (200 to 1,200 feet) setting on the DEPTH switch. Then, to measure a capped well, simply insert the duct into the 5/8 inch wide access port and push the power-on switch. In a few seconds the water level will appear on the water level meter's digital display. In the NORMAL setting, the sonic water level meter stays activated for 5 seconds or 5 pings. Using the DEEP mode, the water level meter emits 4 pings in 16 seconds. (Information provided by *Global Water*).

3. Air Pump Pressure Reading - connect an air pump to the air valve and fill the air line up until the pressure gauge at the well stabilizes. After you stop pumping air into the air line, the gauge reading will slowly rise. Once the dial has stabilized again, record the number in feet that is on the gauge. This will be your water depth.

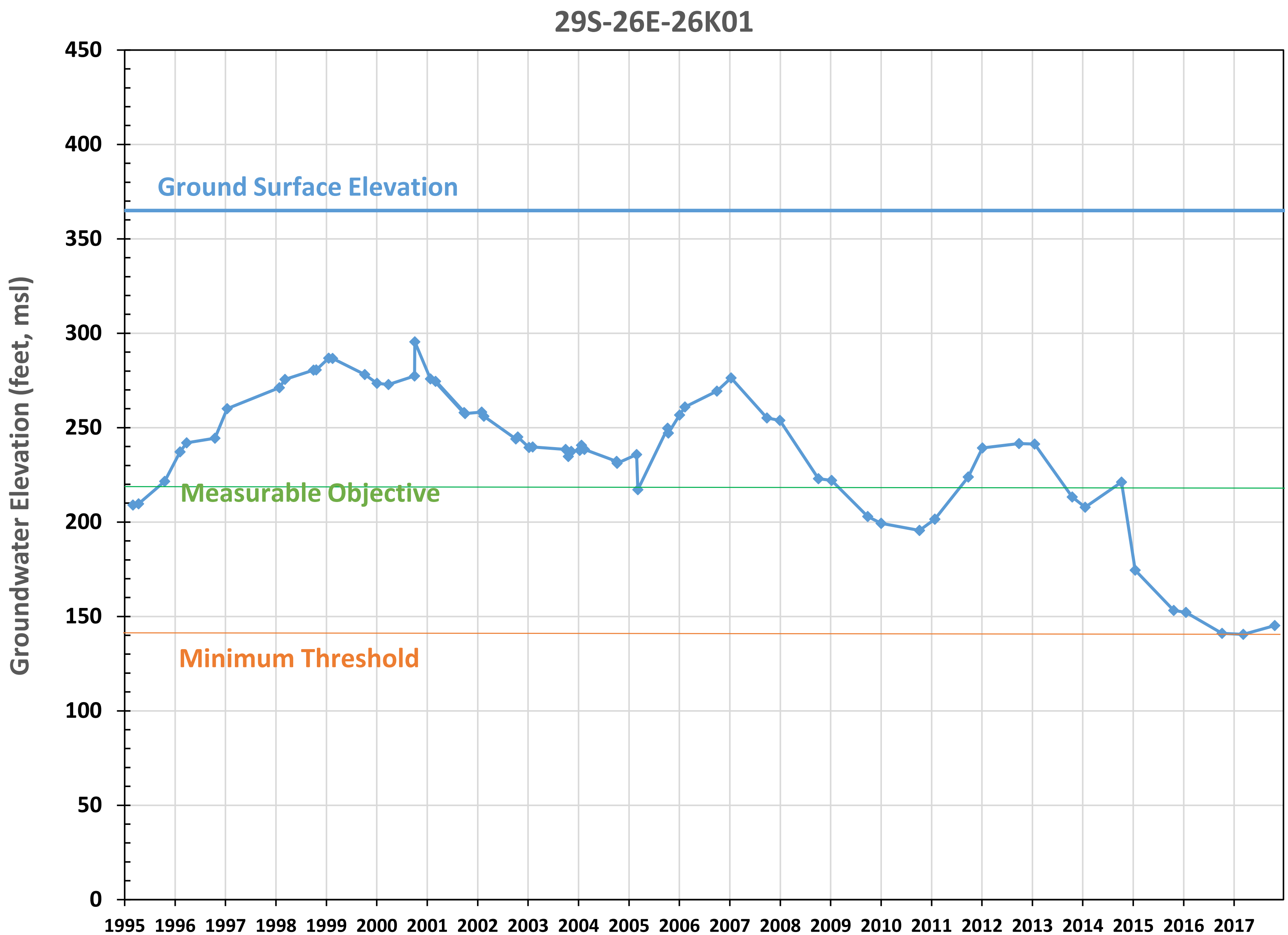
APPENDIX J

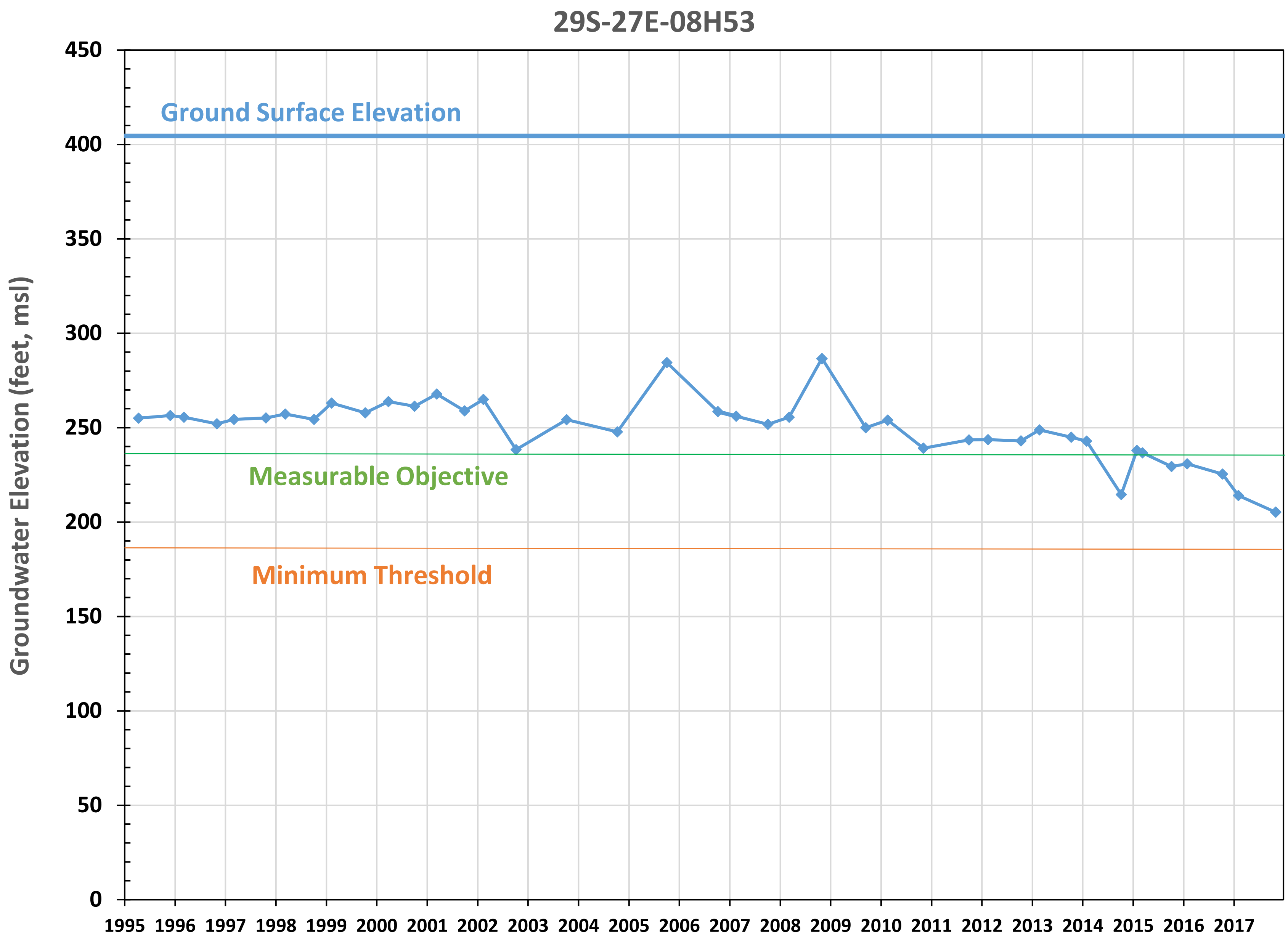
Monitoring Network Hydrographs with Sustainable Management Criteria


29S-26E-01K01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

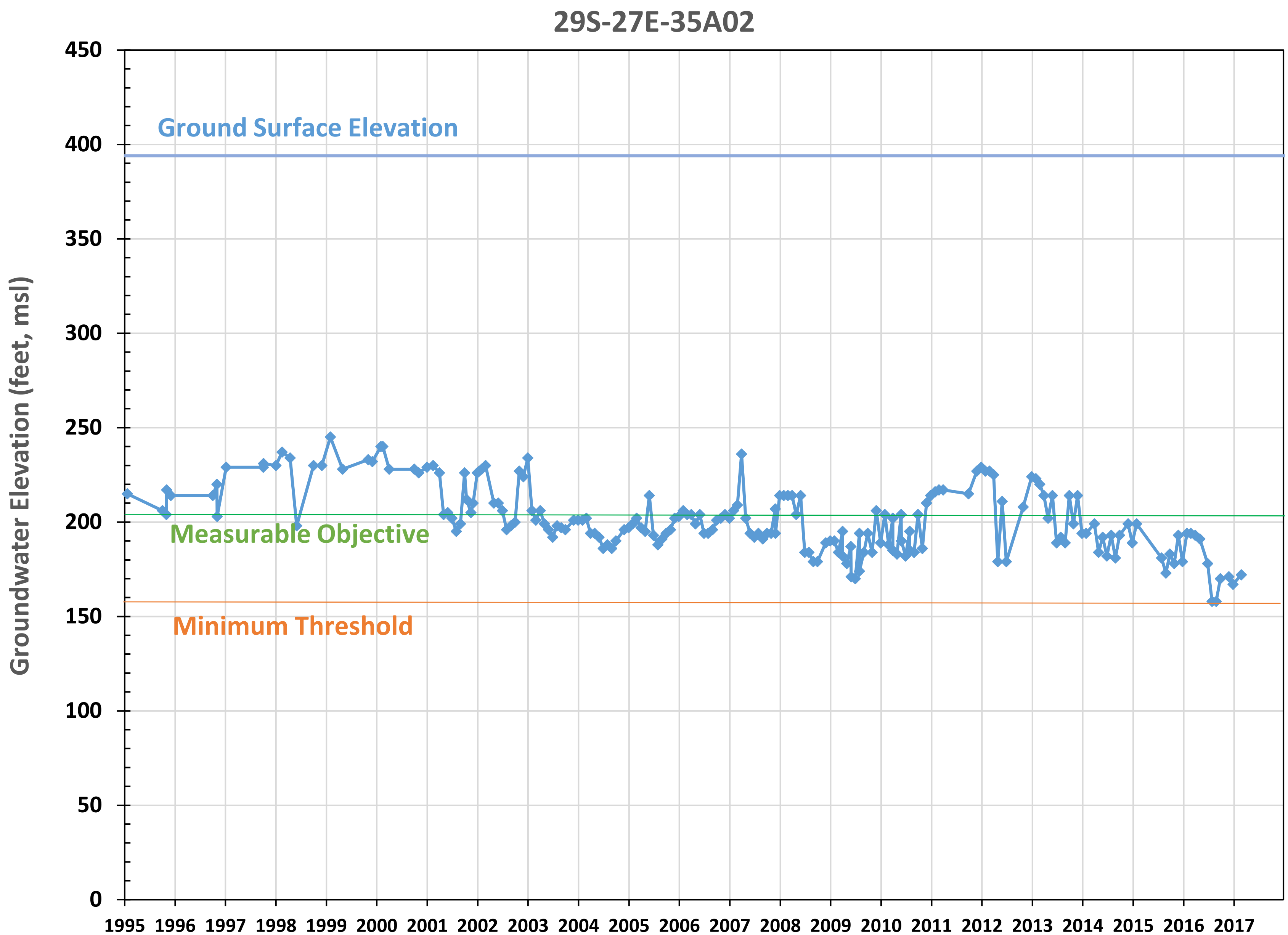


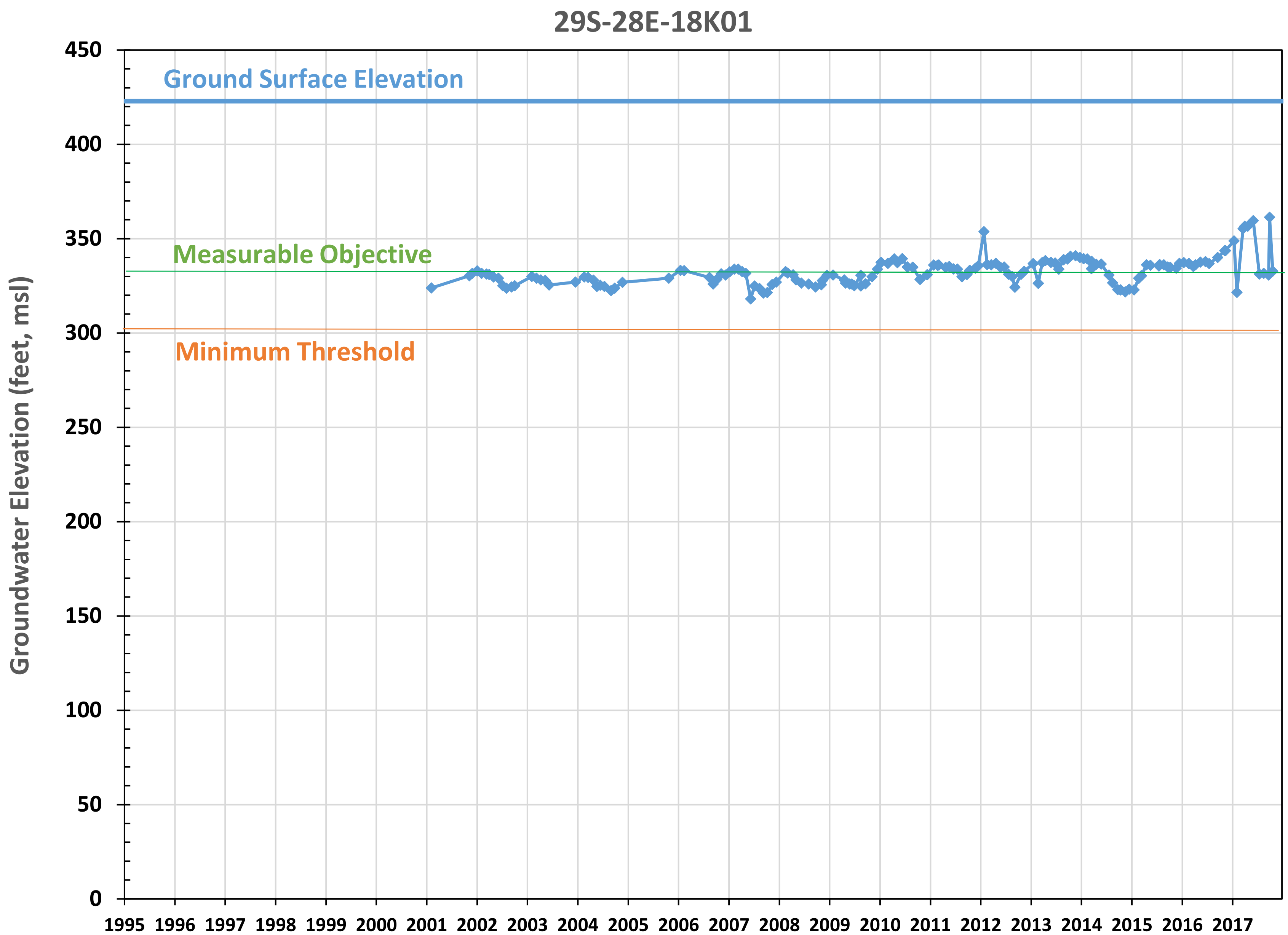
29S-26E-09H01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

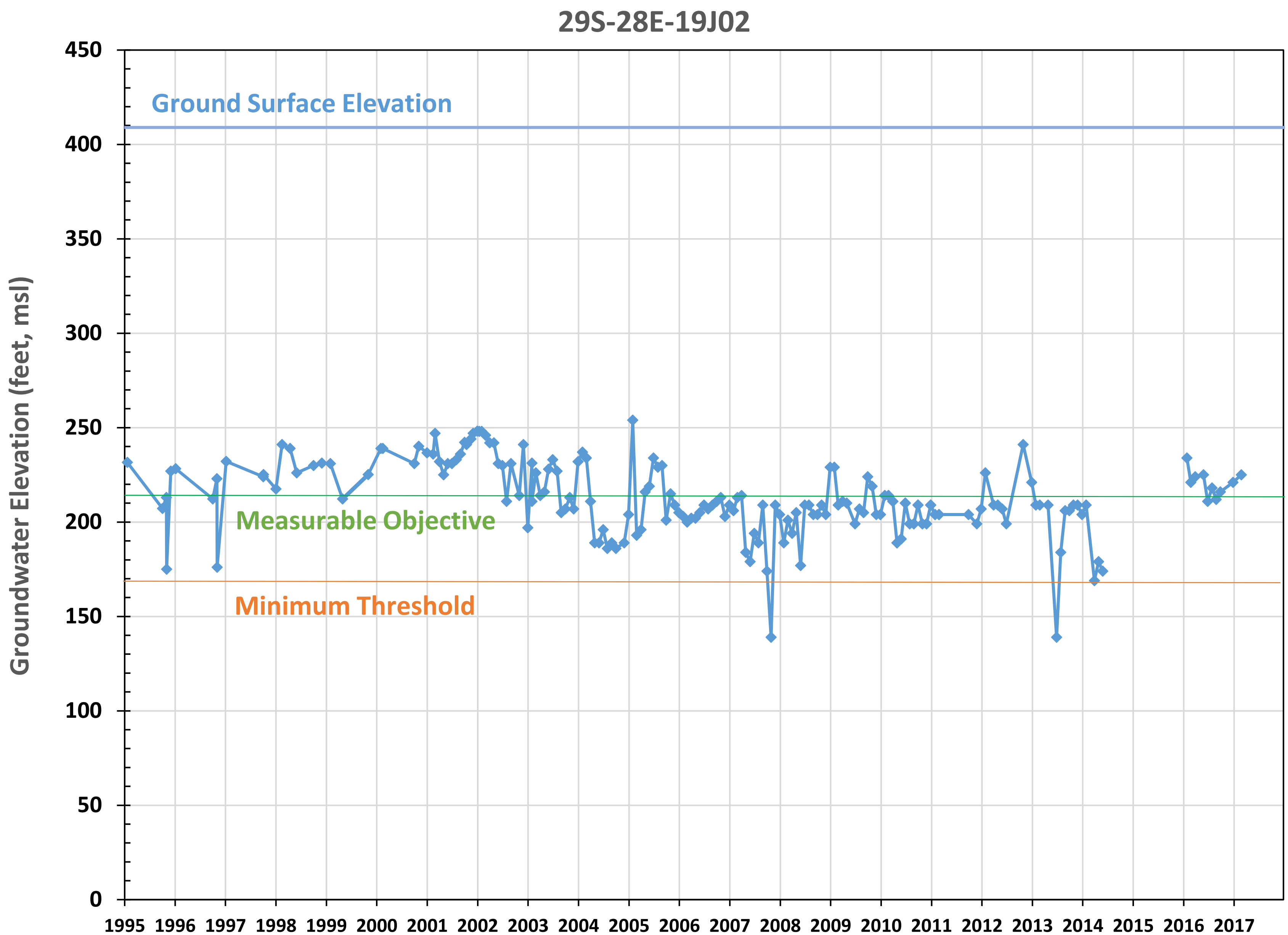

29S-26E-26K01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



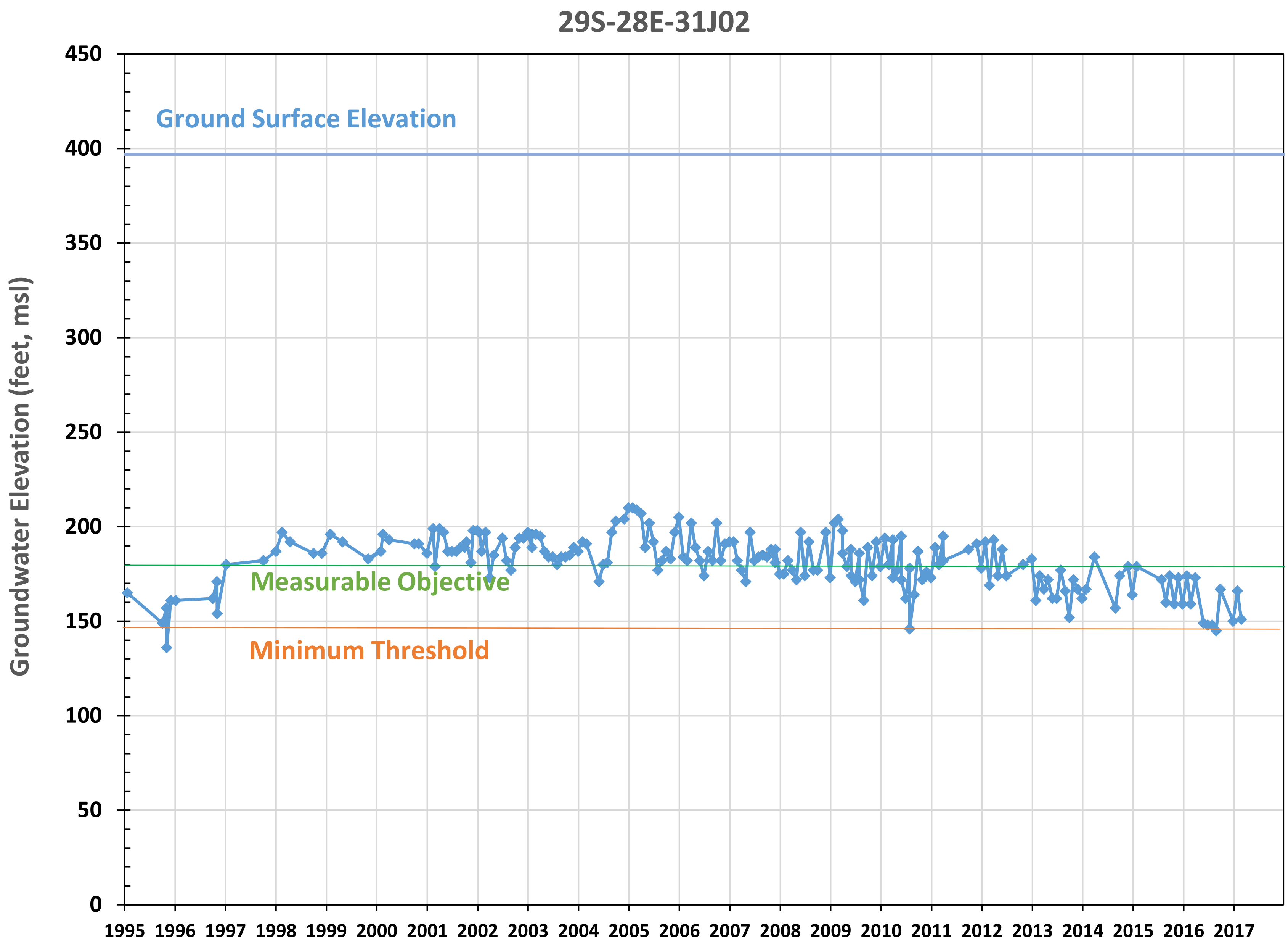
29S-27E-08H53
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


29S-27E-35A02
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

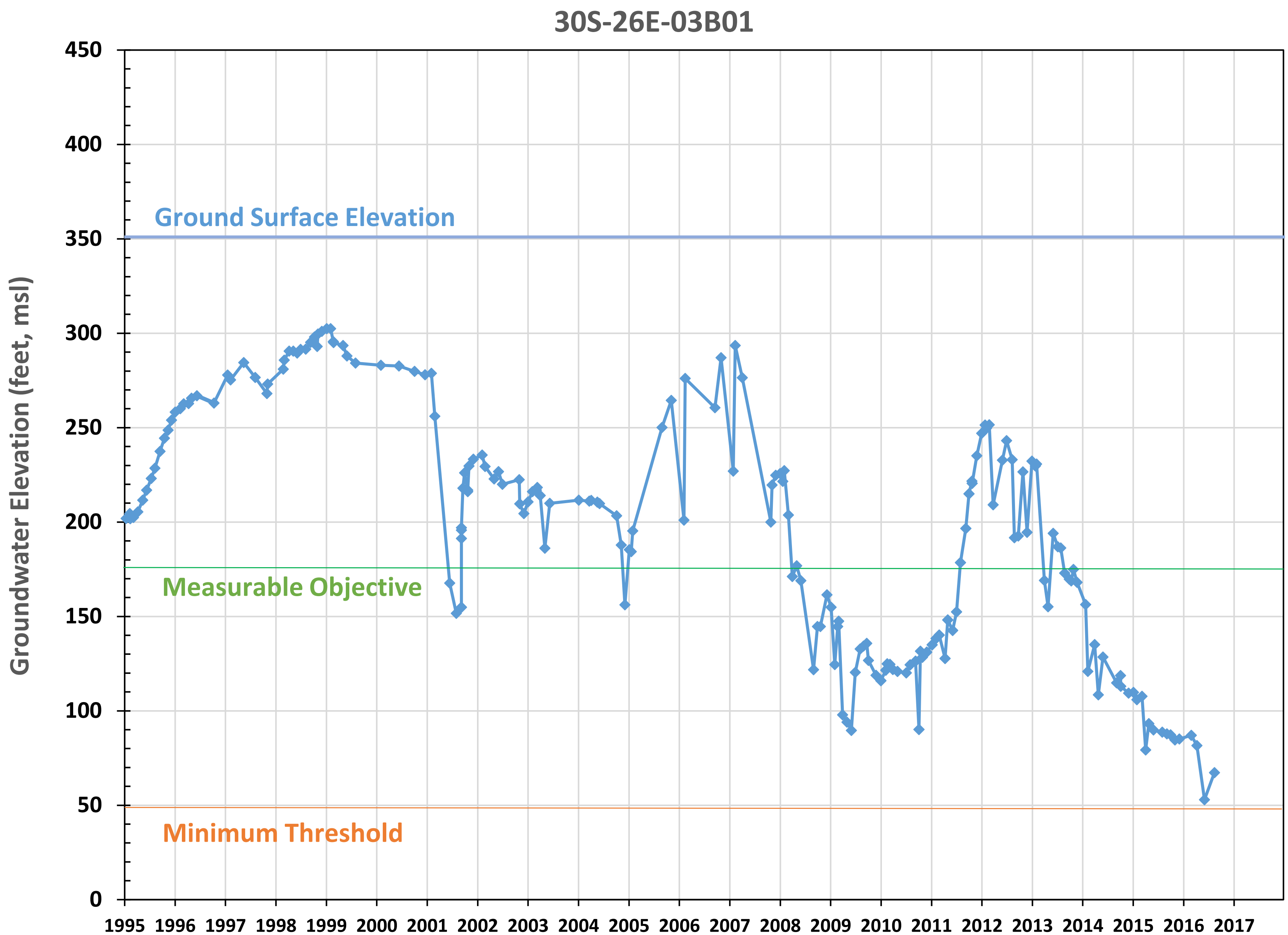

29S-28E-18K01
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
0
50
100
150
200
250
300
350
400
450
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

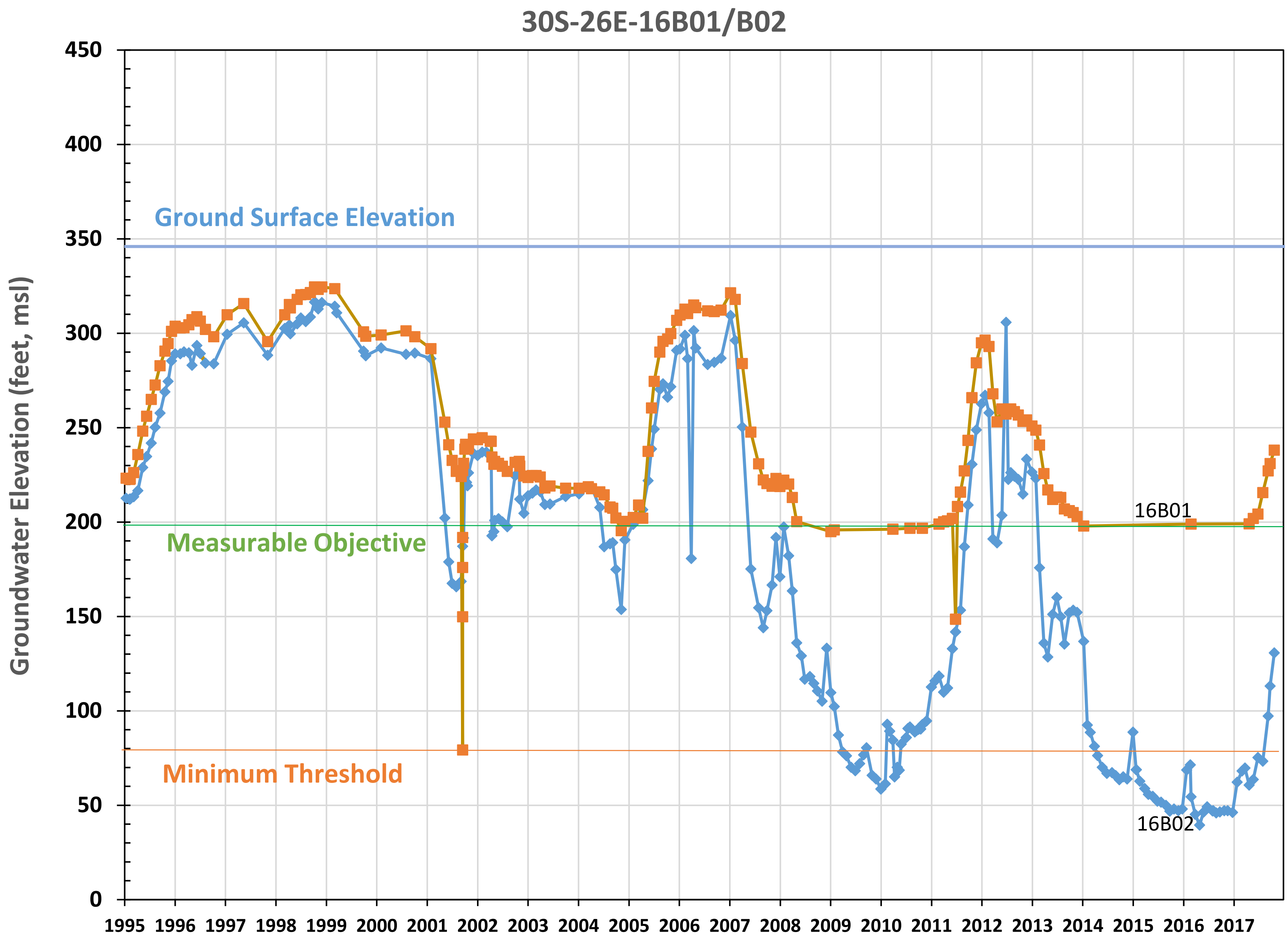


29S-28E-19J02
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

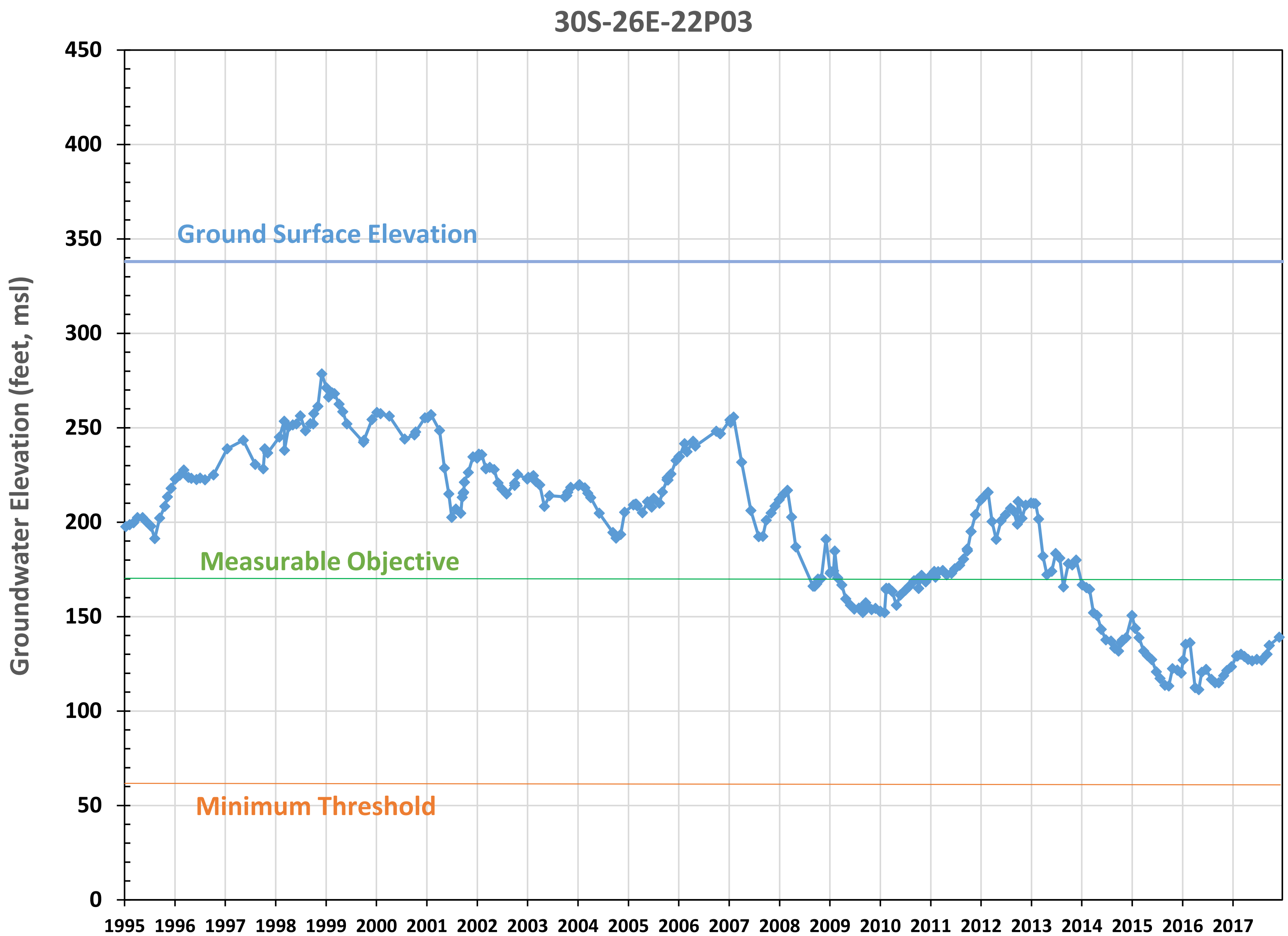


29S-28E-31J02
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

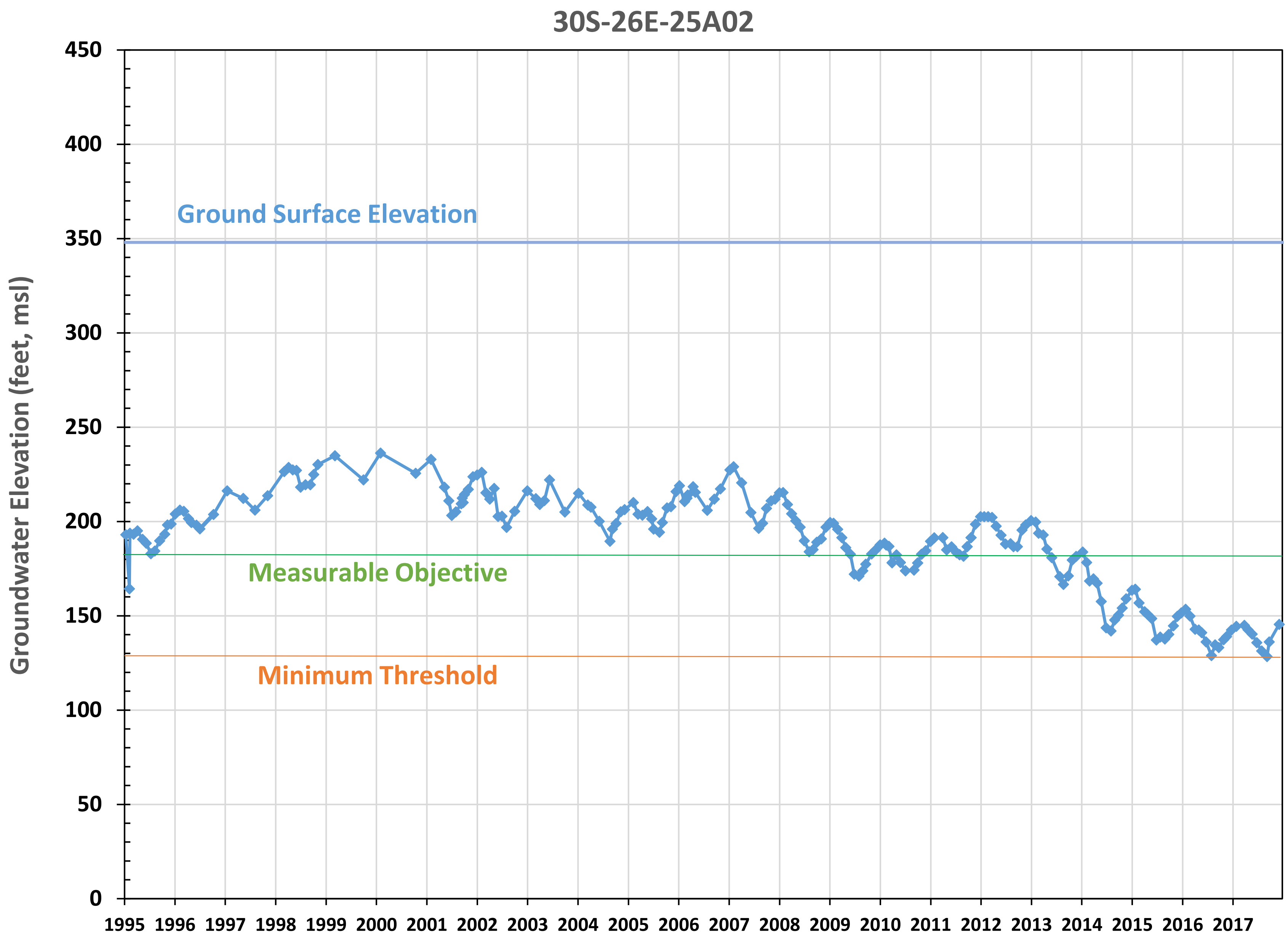

30S-26E-03B01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



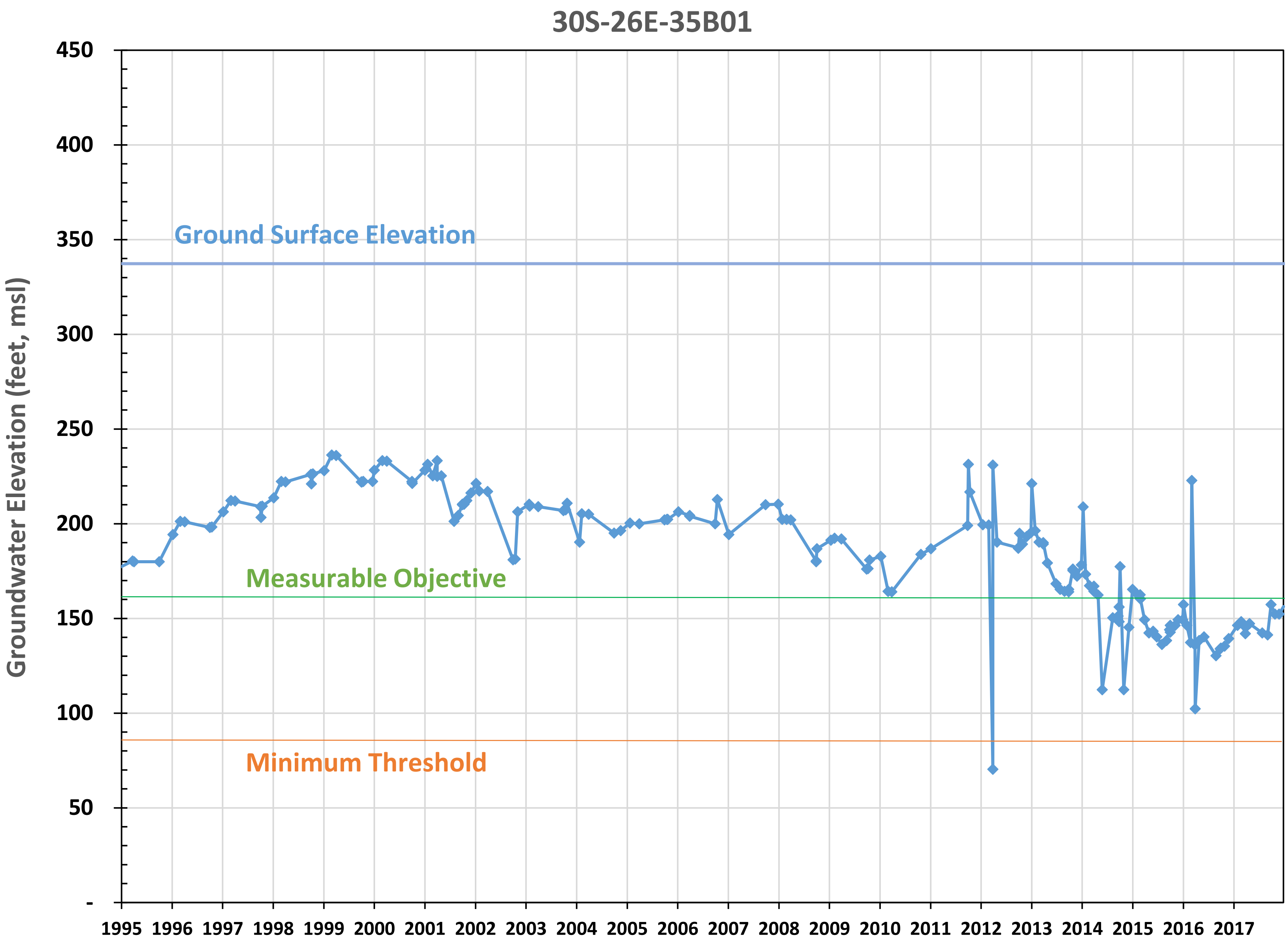
30S-26E-16B01/B02
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Ground Surface Elevation
Measurable Objective
Minimum Threshold
16B01
16B02

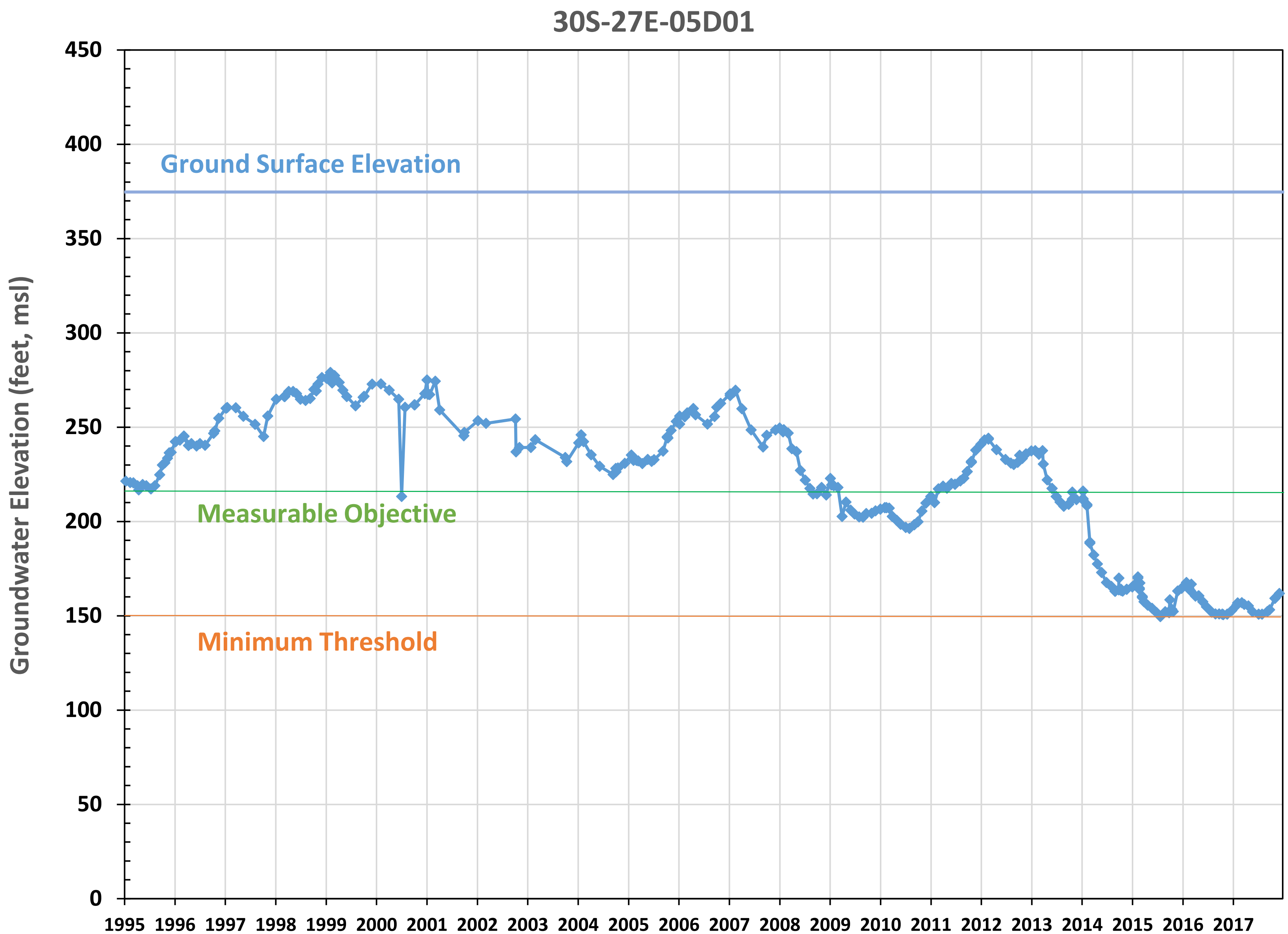


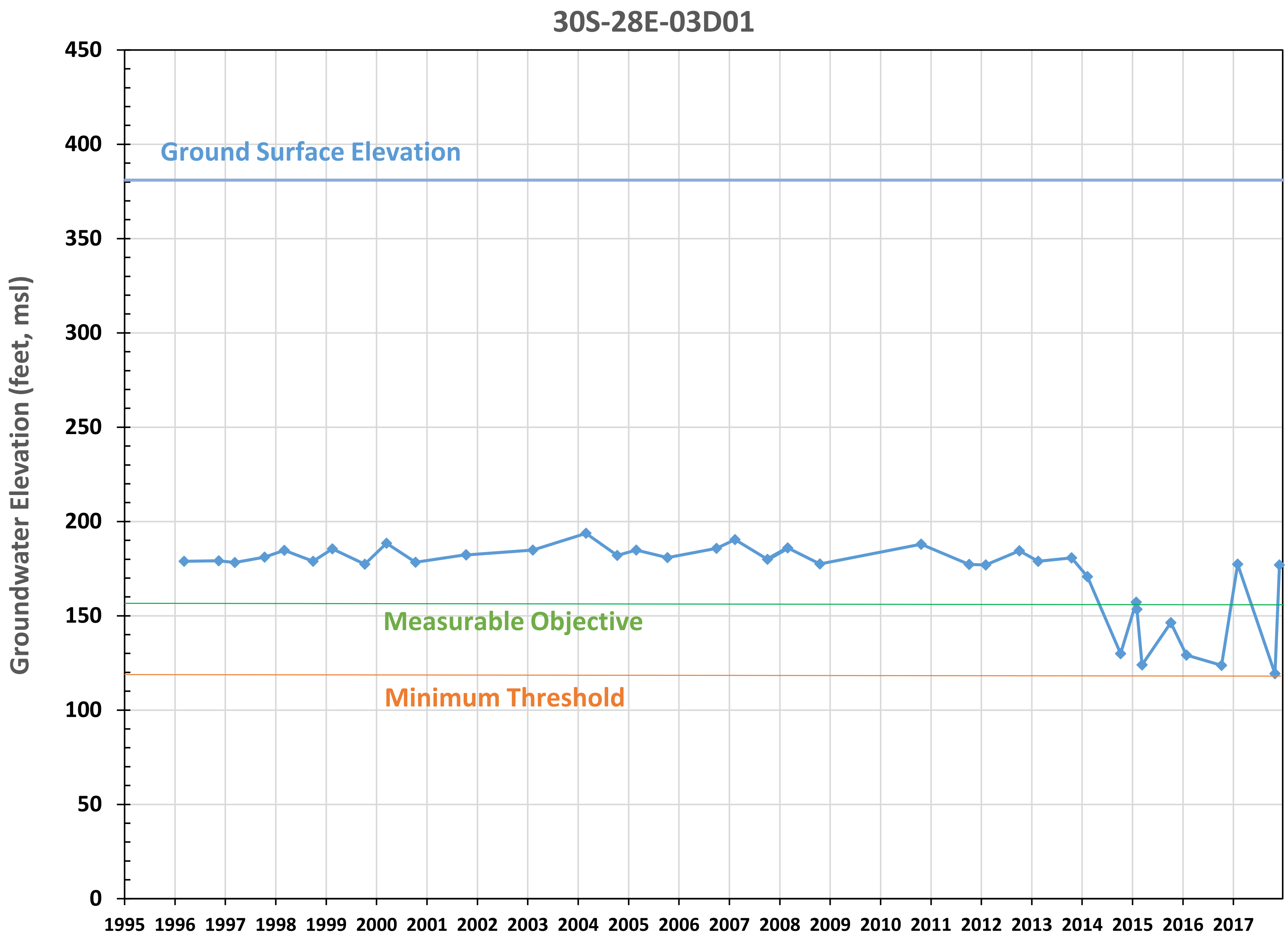
30S-26E-22P03
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

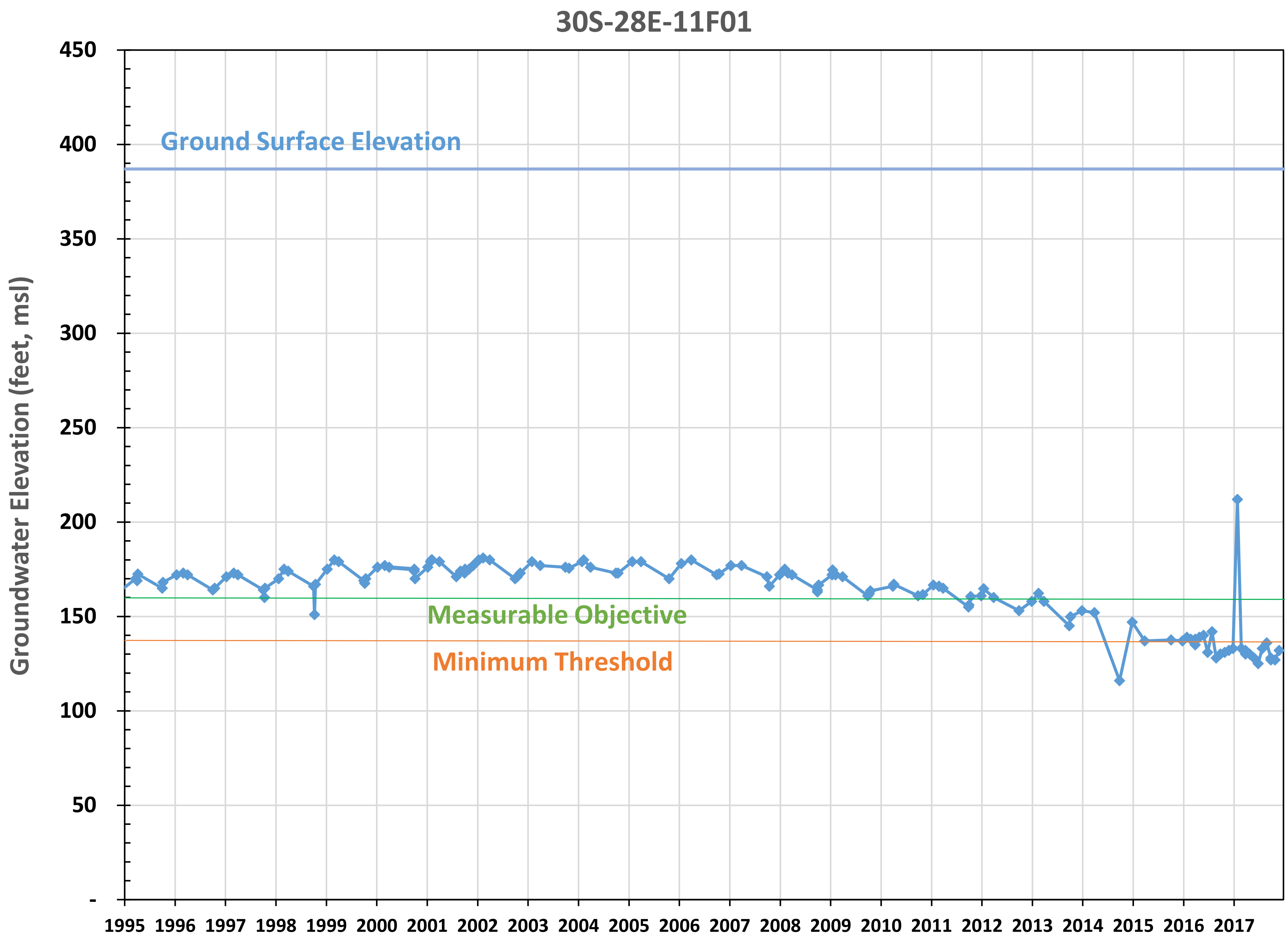


30S-26E-25A02
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

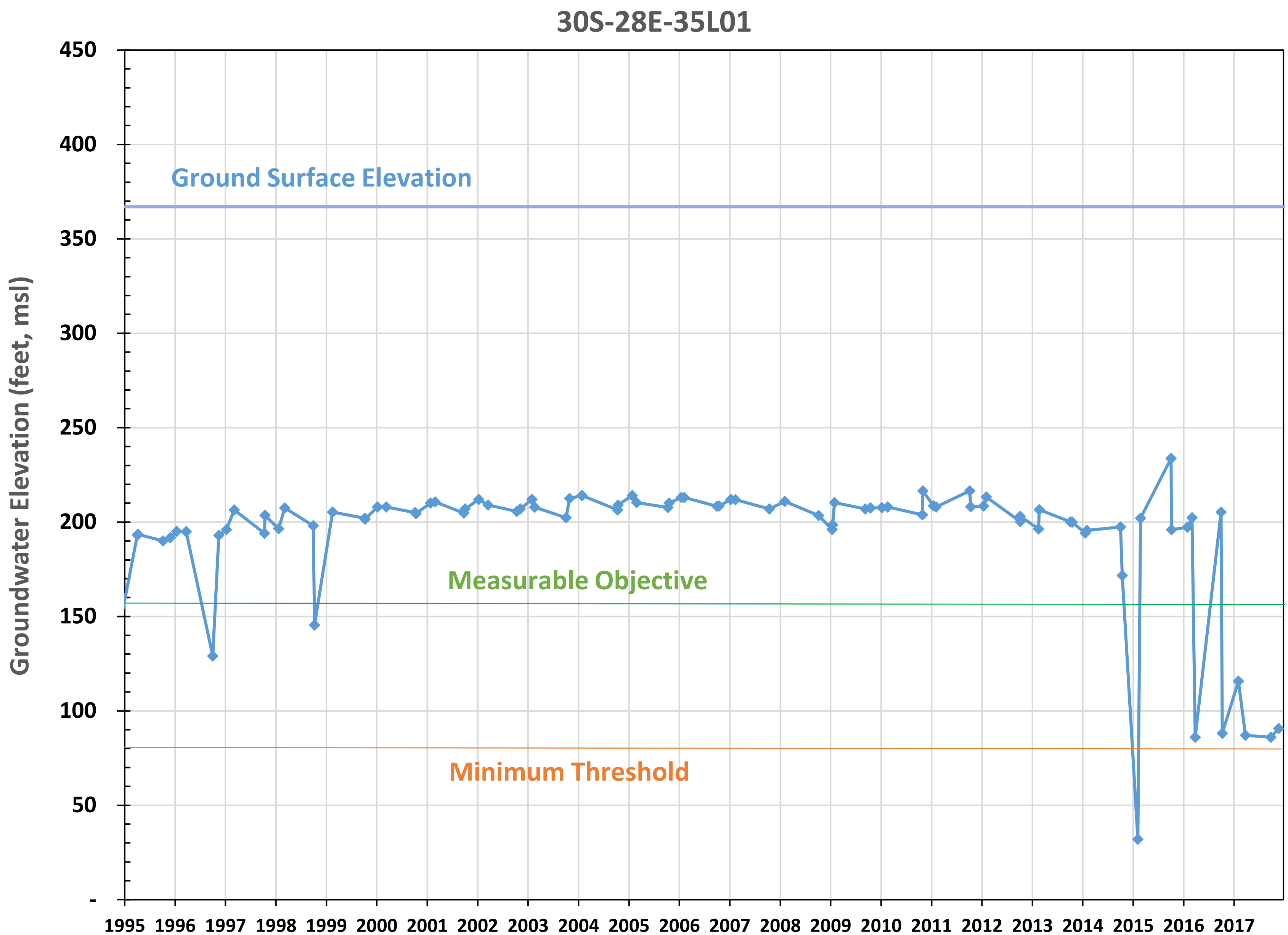

30S-26E-35B01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

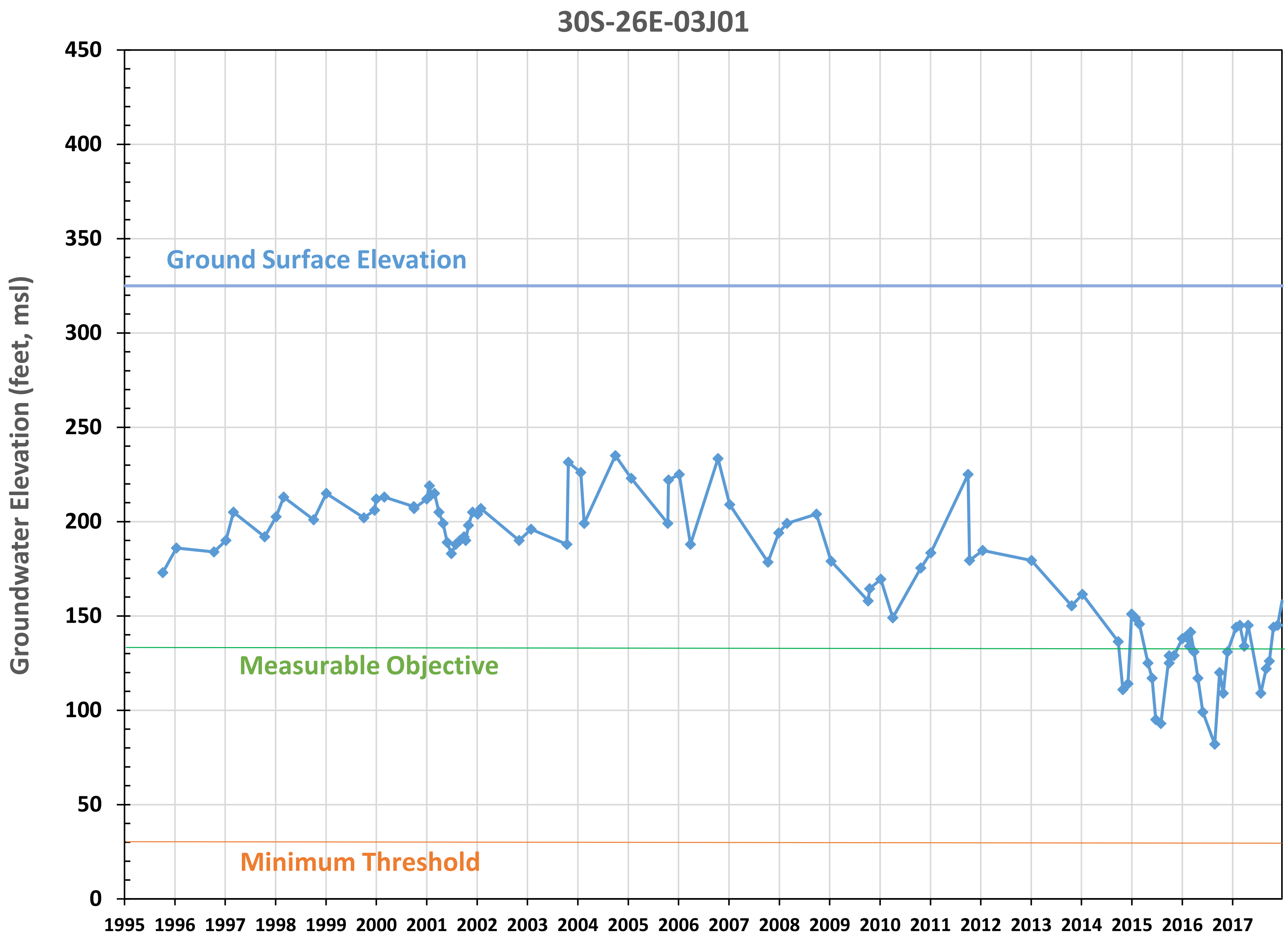

30S-27E-05D01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


30S-28E-03D01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

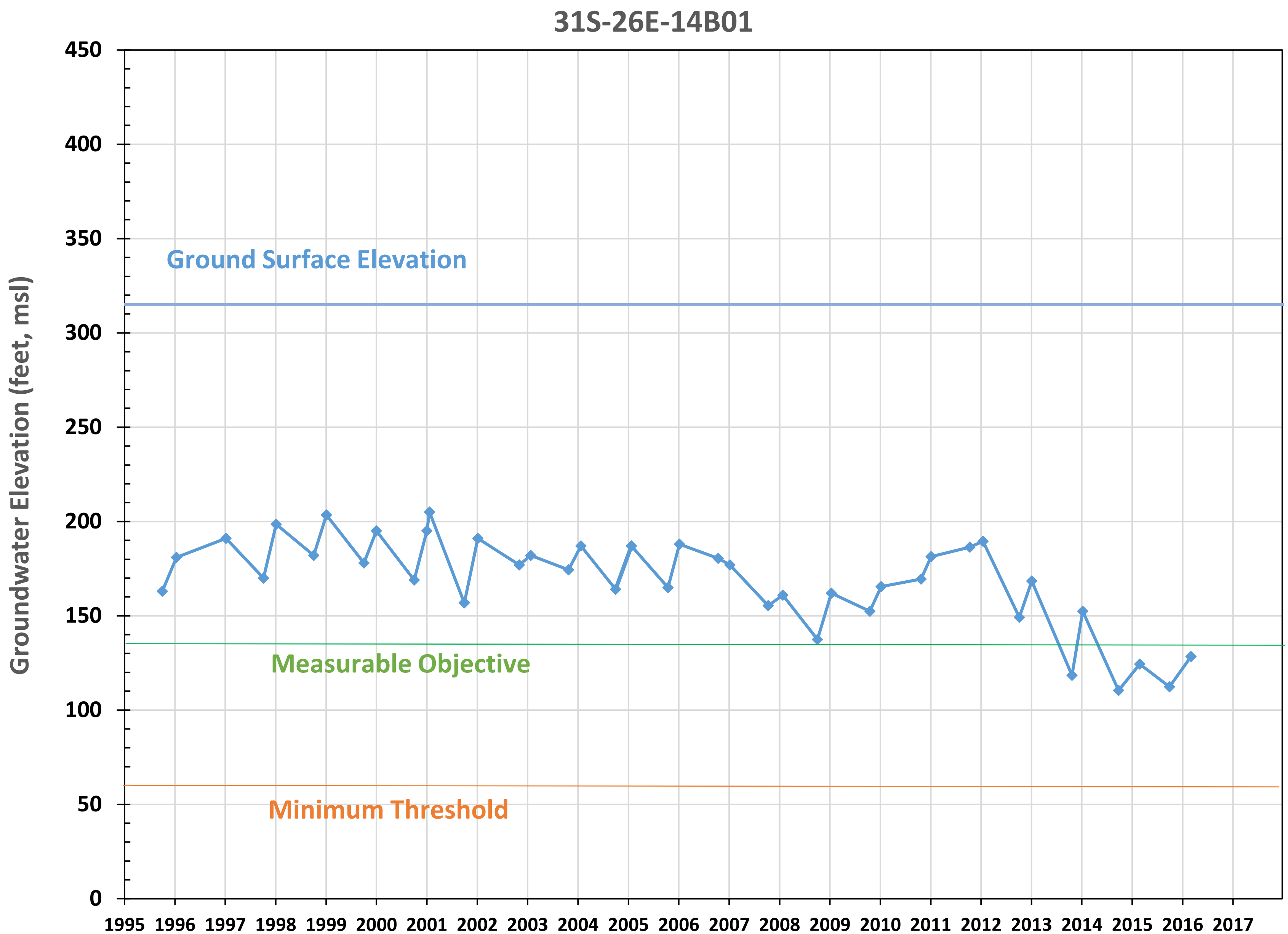


30S-28E-11F01
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

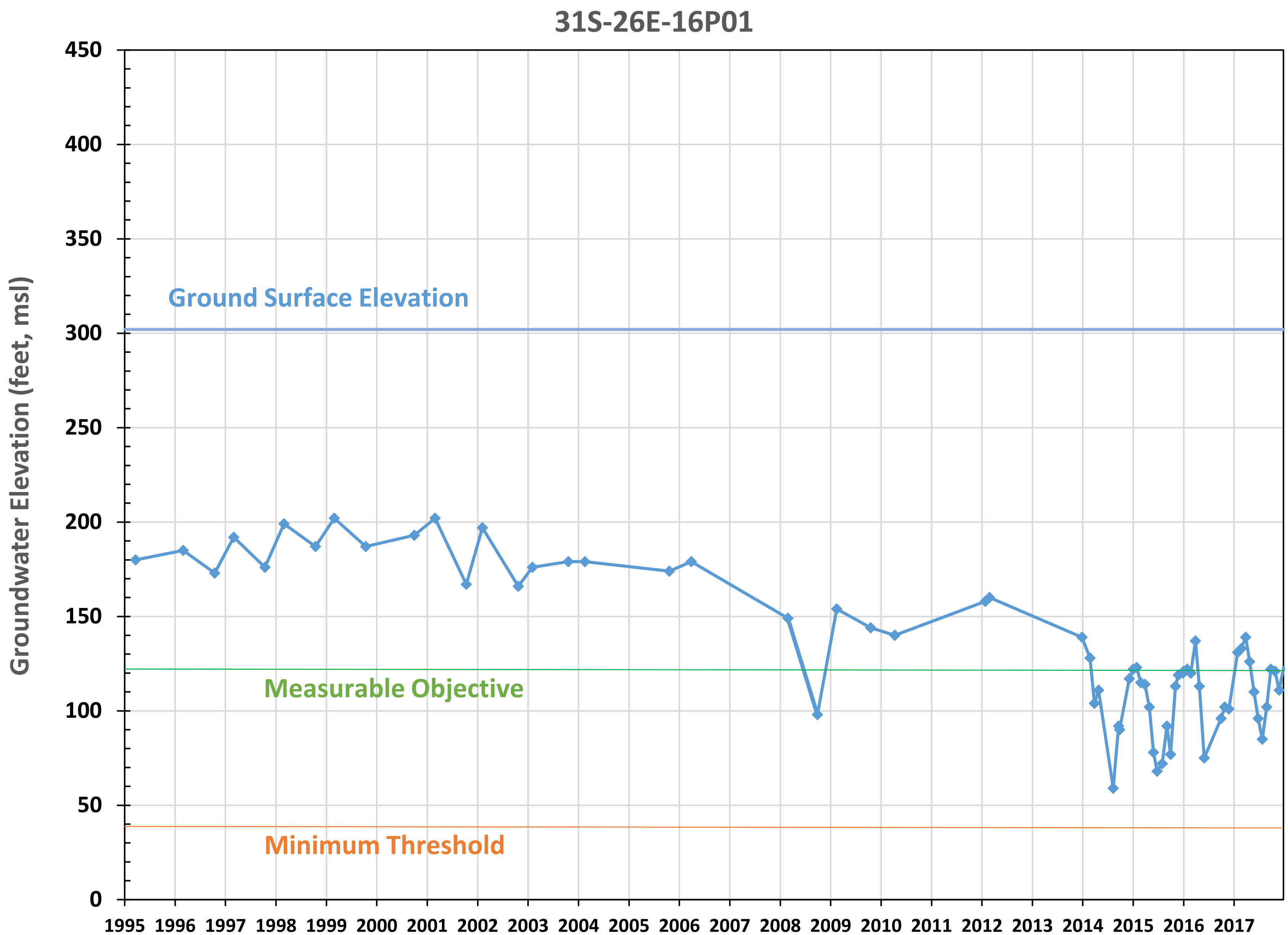

30S-28E-35L01
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Ground Surface Elevation
Measurable Objective
Minimum Threshold

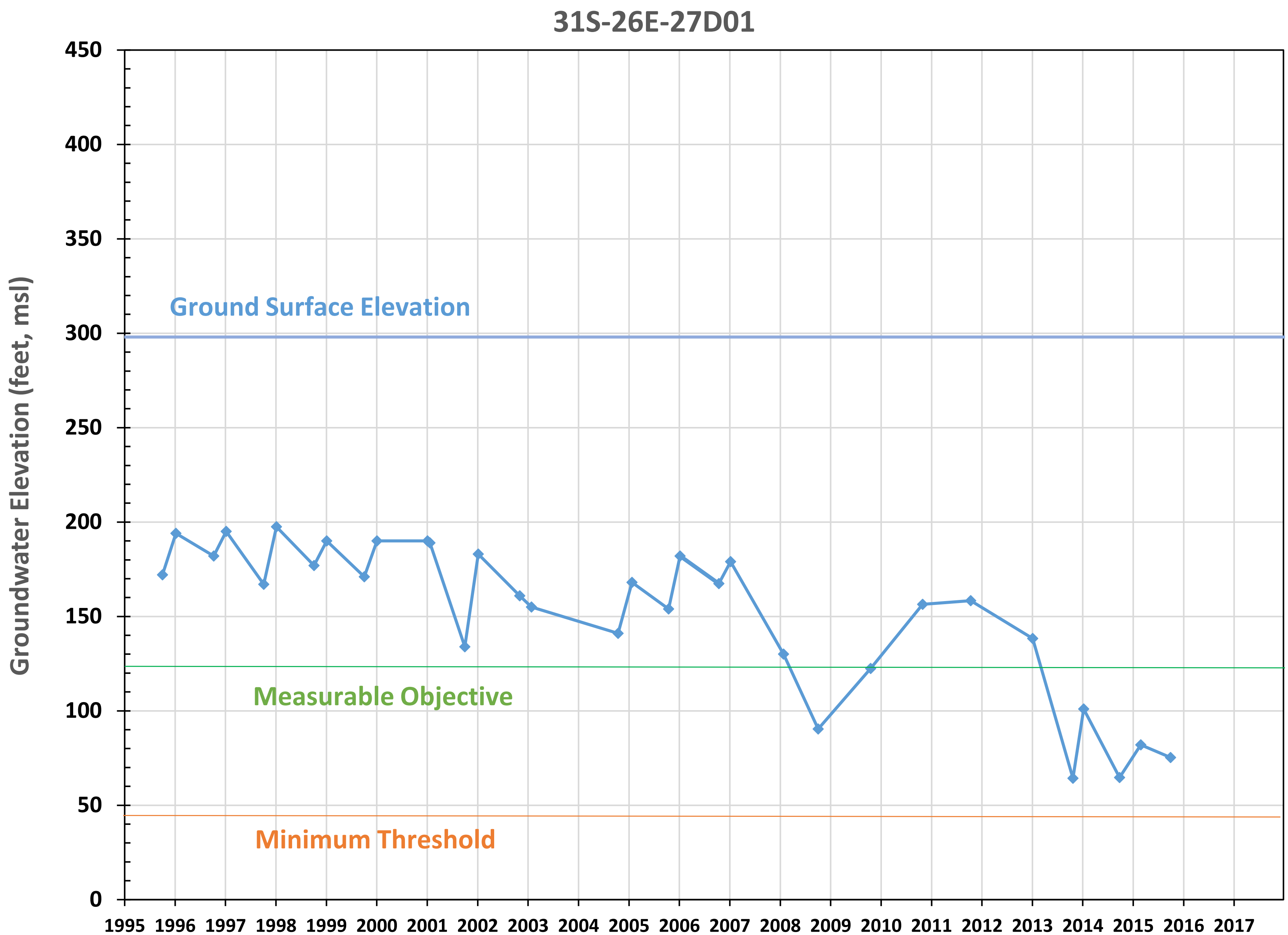


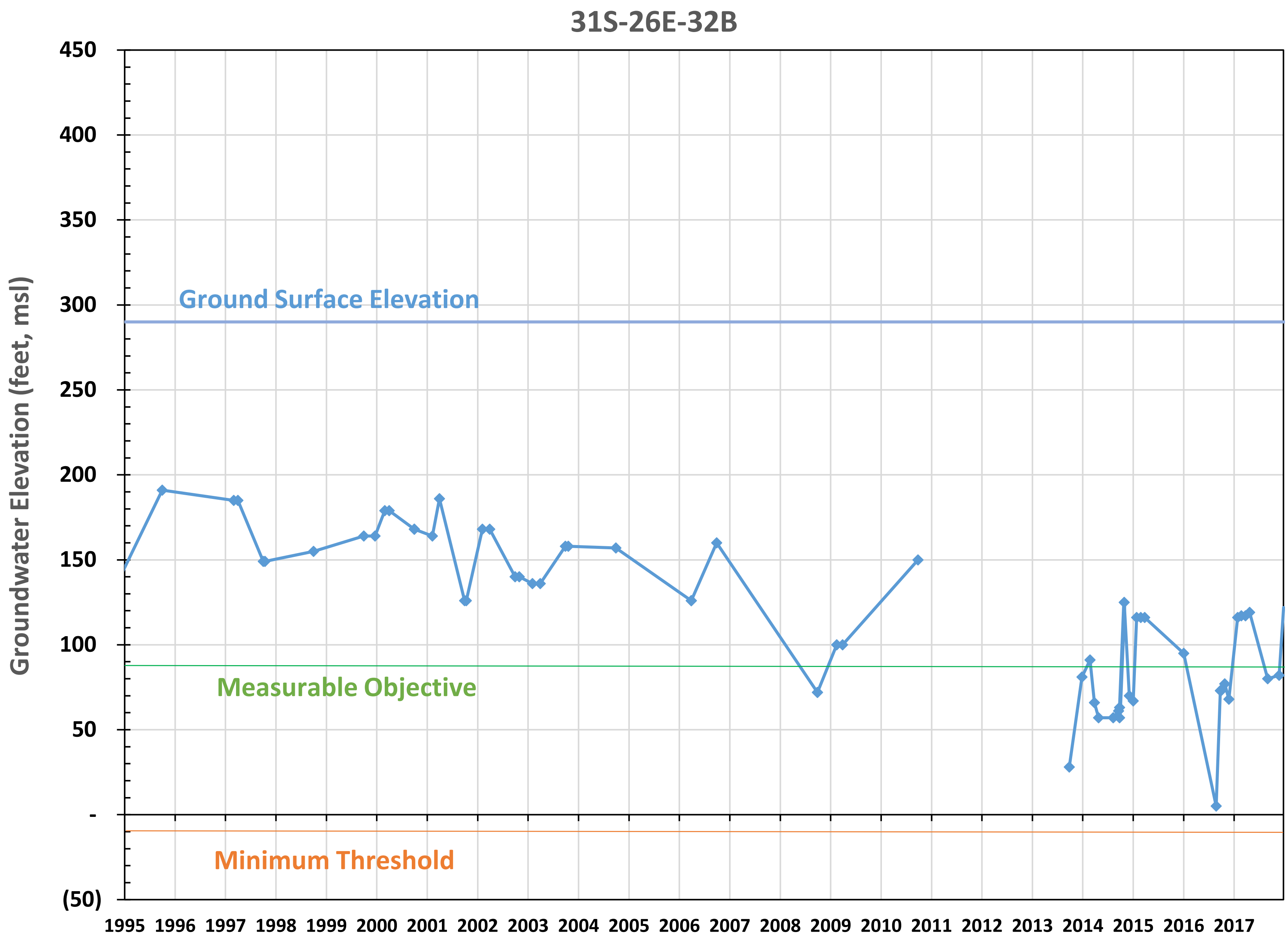
30S-26E-03J01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



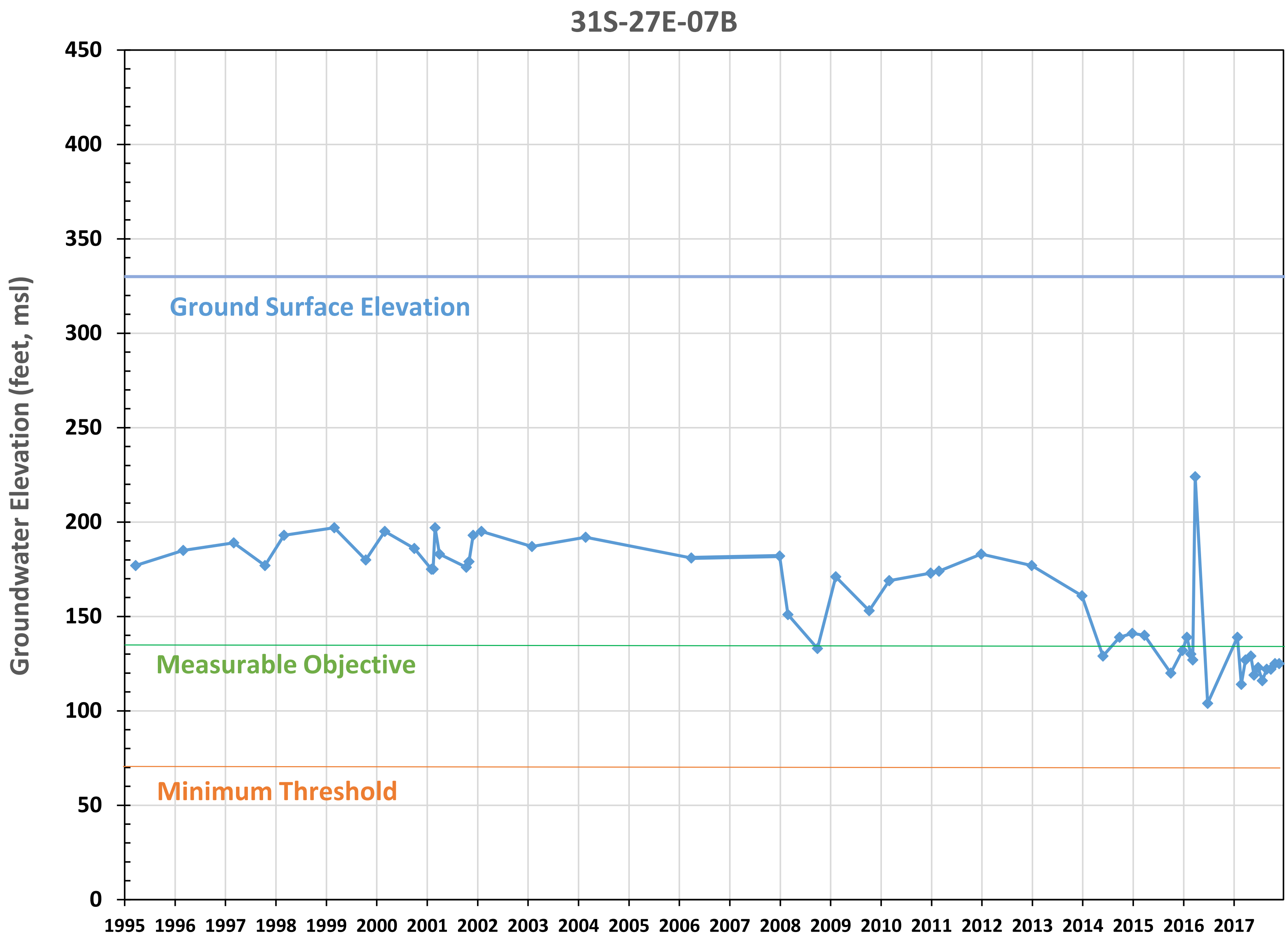
31S-26E-14B01
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
Ground Surface Elevation
Measurable Objective
Minimum Threshold
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


31S-26E-16P01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

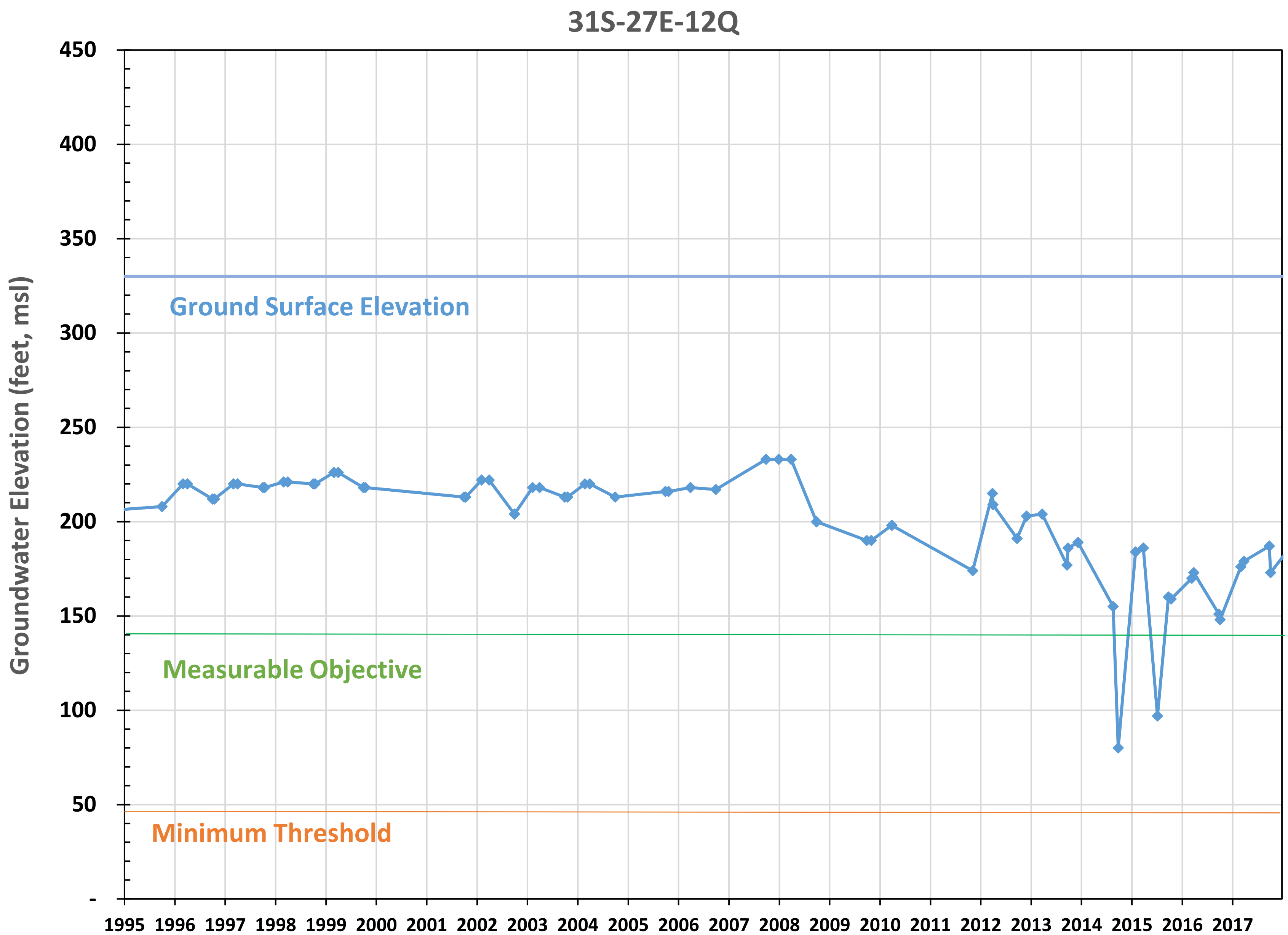

31S-26E-27D01
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
Ground Surface Elevation
Measurable Objective
Minimum Threshold
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017

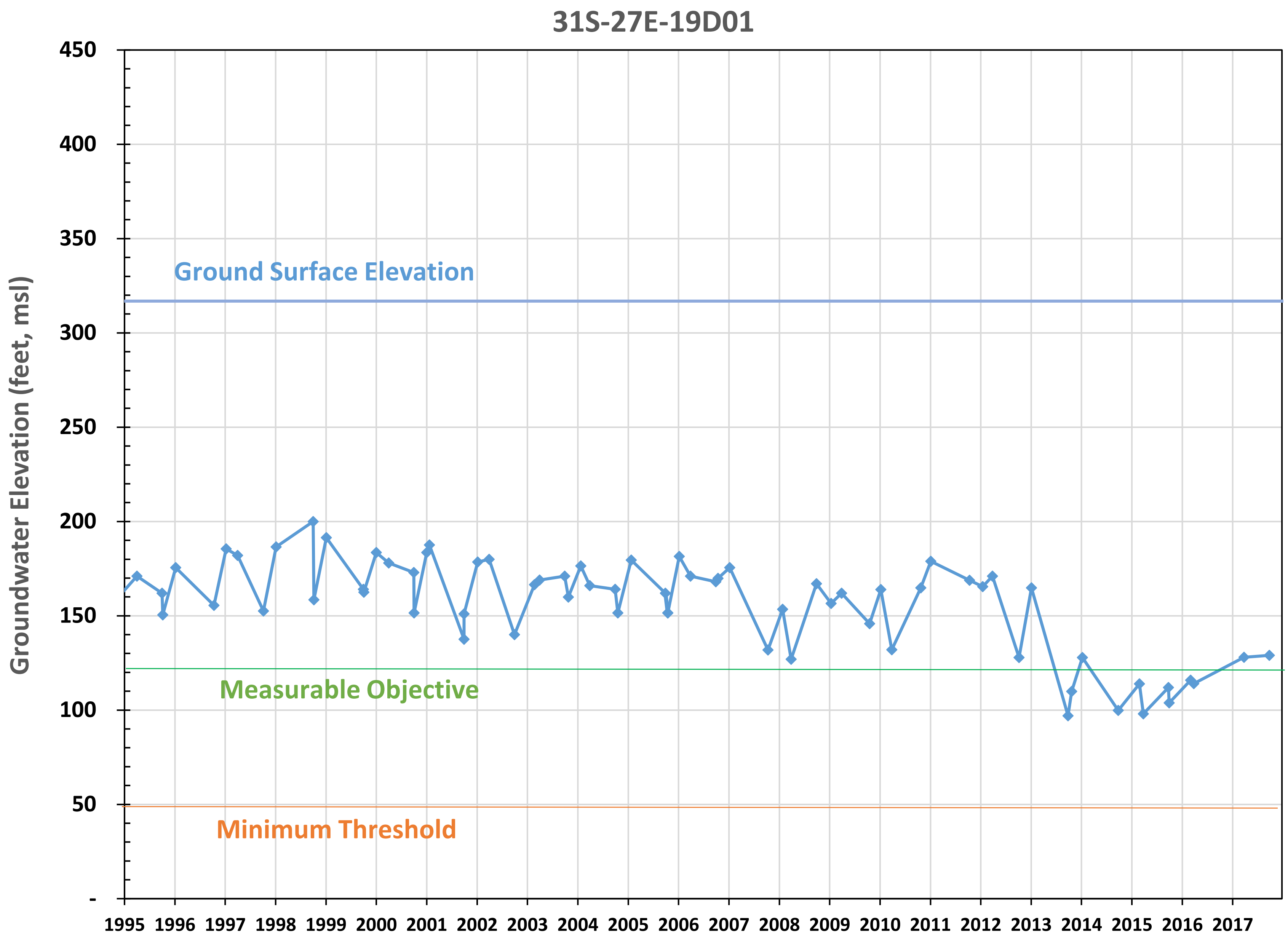


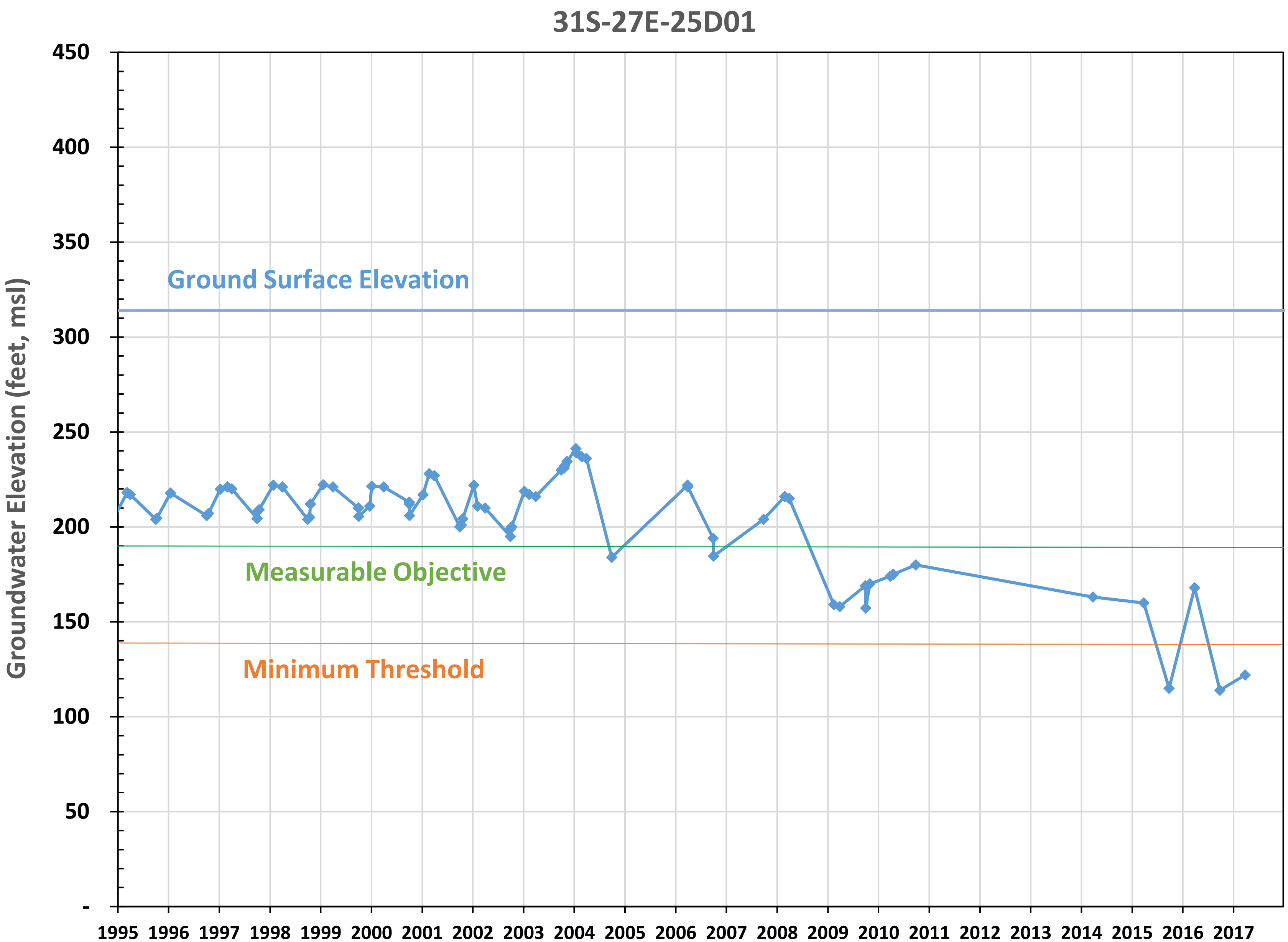
31S-26E-32B
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
(50)
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017
Ground Surface Elevation
Measurable Objective
Minimum Threshold



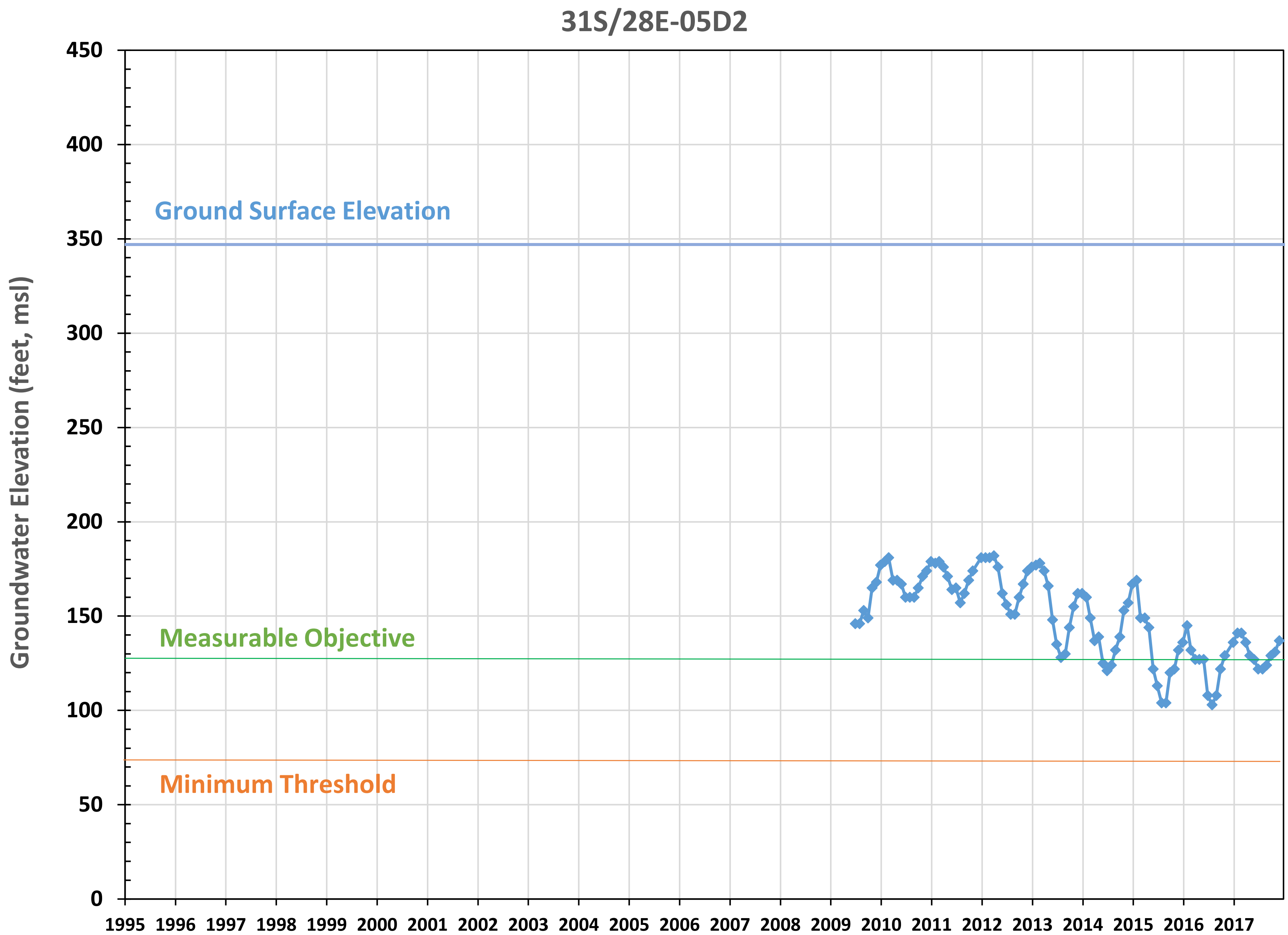
31S-27E-07B
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
Ground Surface Elevation
Measurable Objective
Minimum Threshold
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017


31S-27E-12Q
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Ground Surface Elevation
Measurable Objective
Minimum Threshold

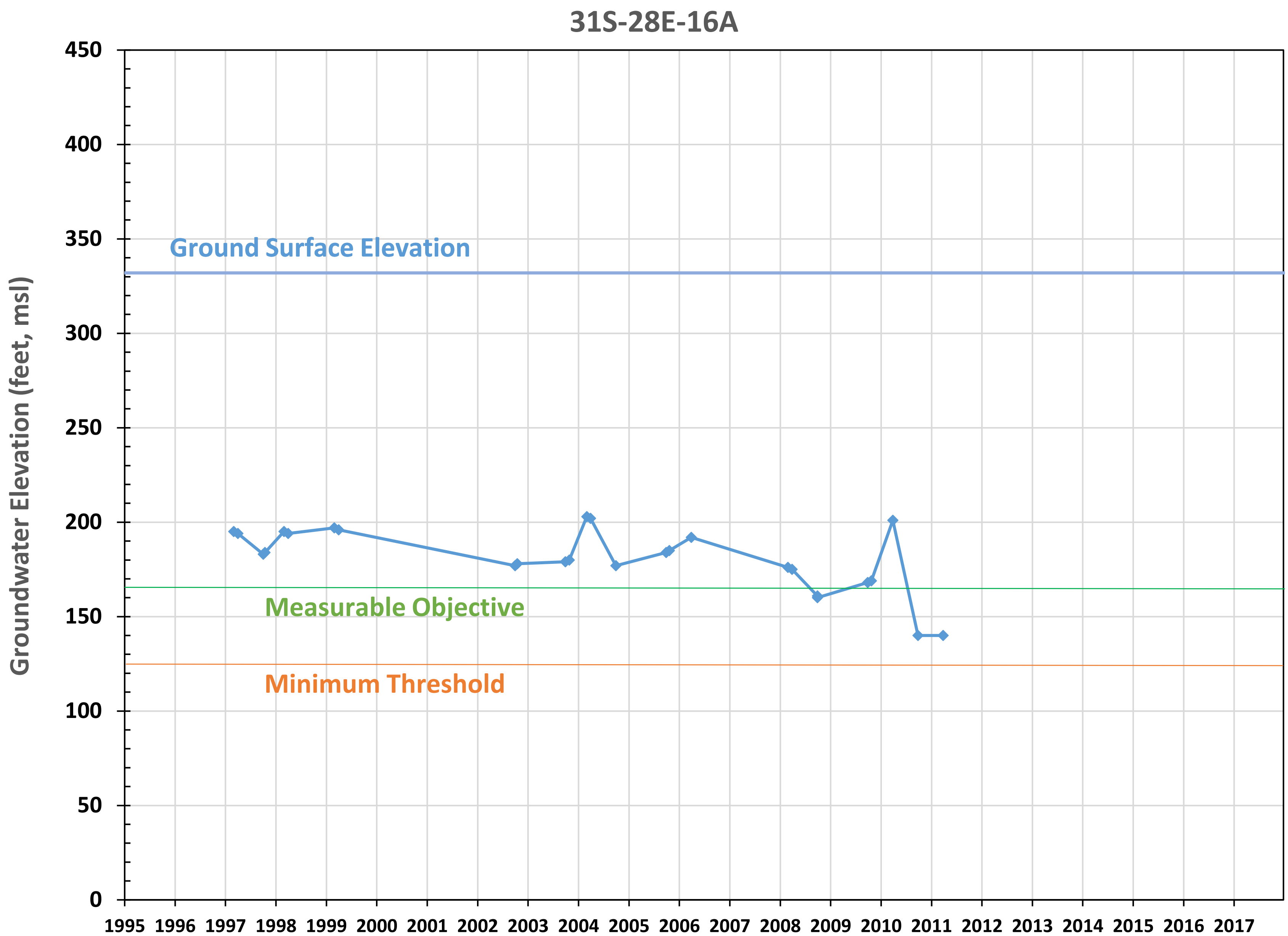

31S-27E-19D01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



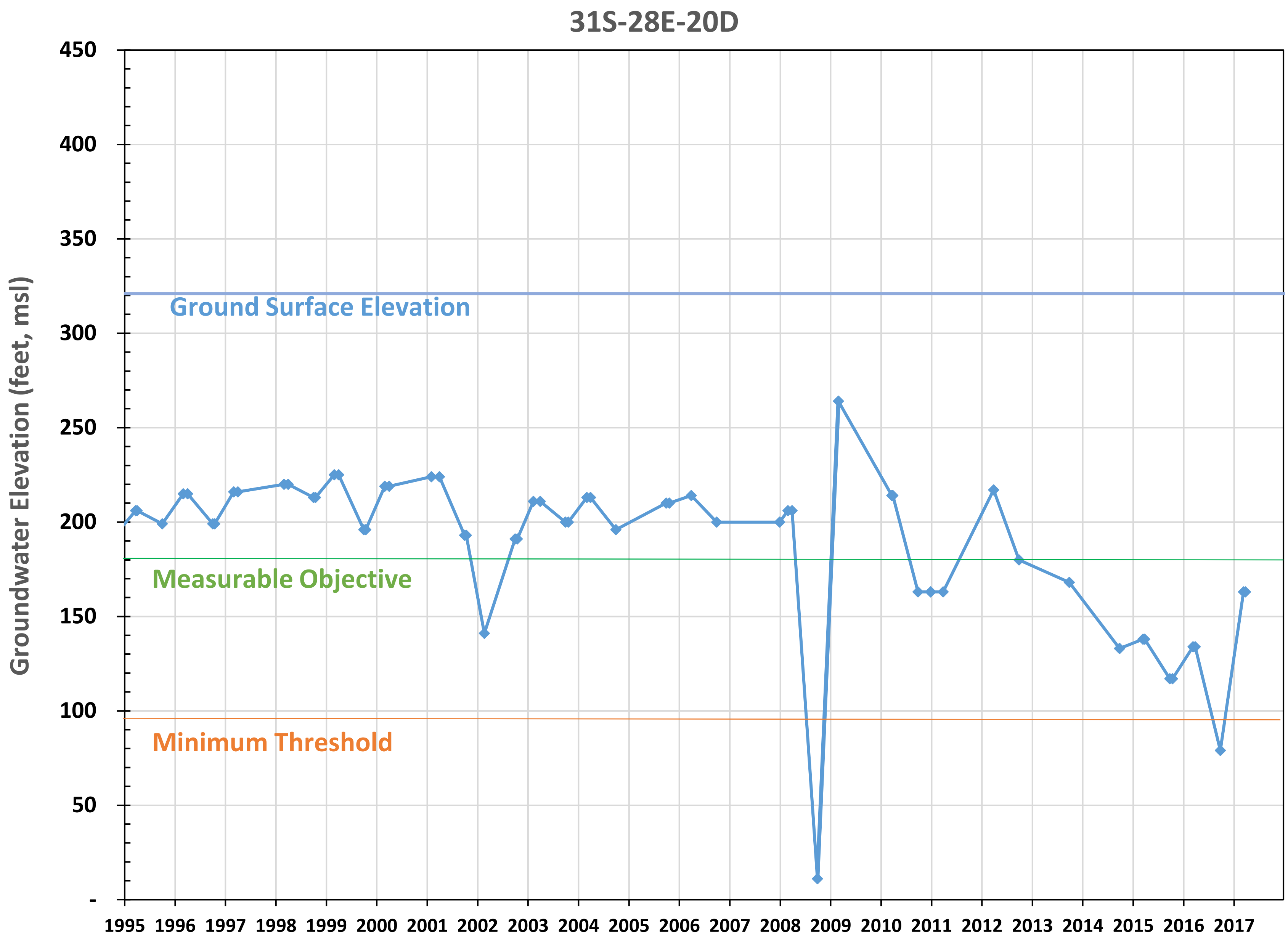
31S-27E-25D01
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017



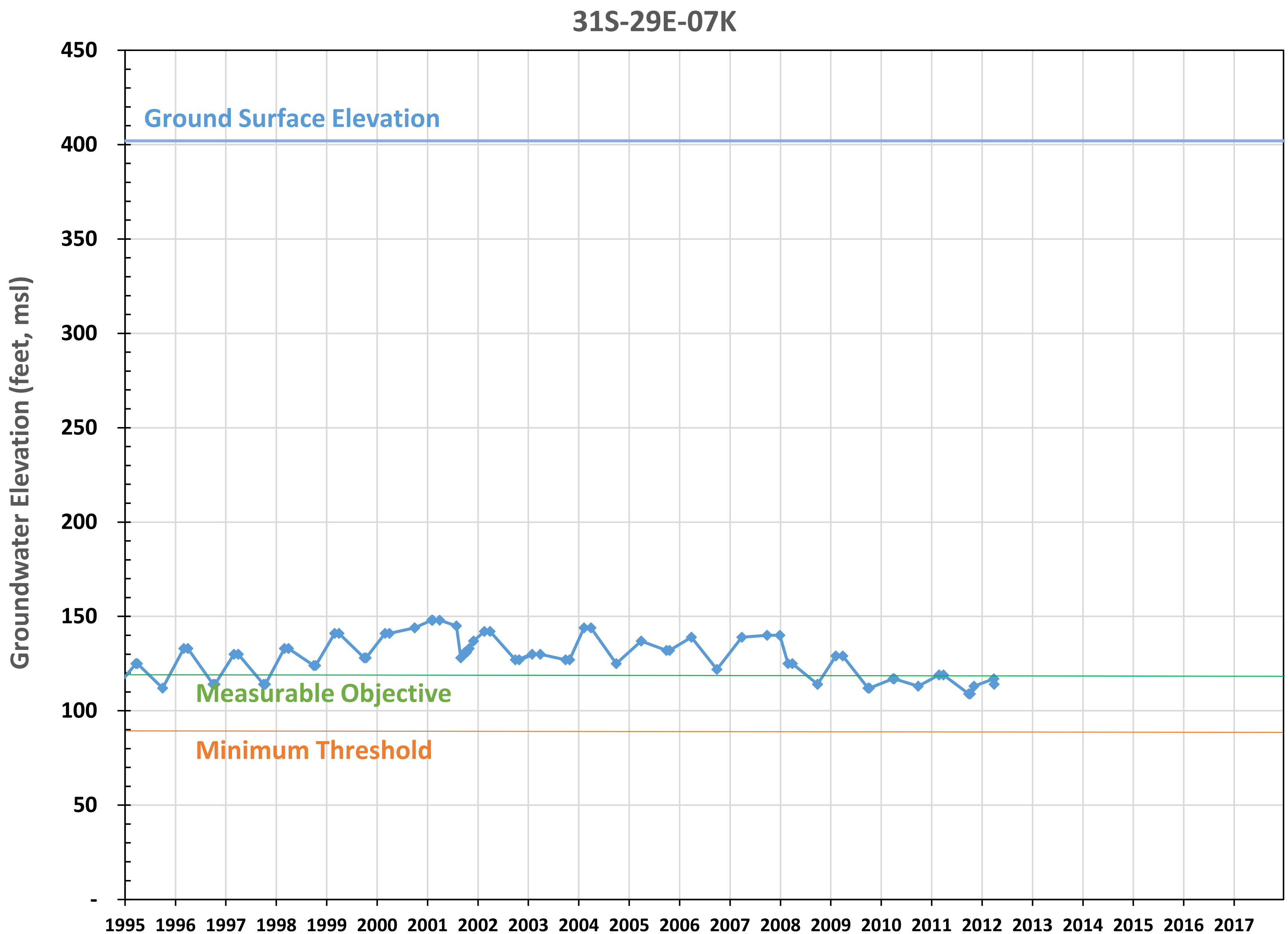
31S/28E-05D2
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
0
50
100
150
200
250
300
350
400
450
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017



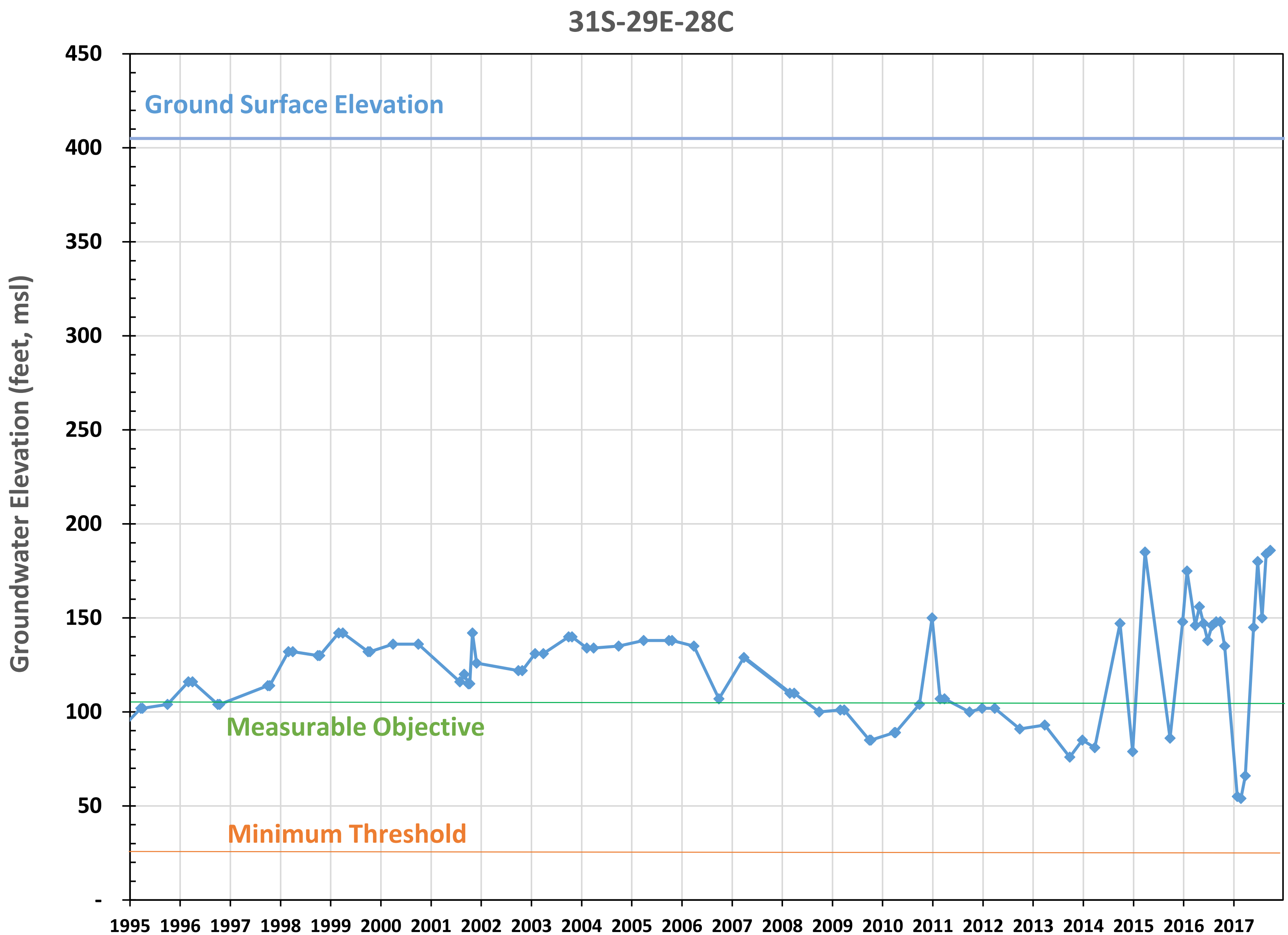
31S-28E-16A
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
Ground Surface Elevation
Measurable Objective
Minimum Threshold
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017



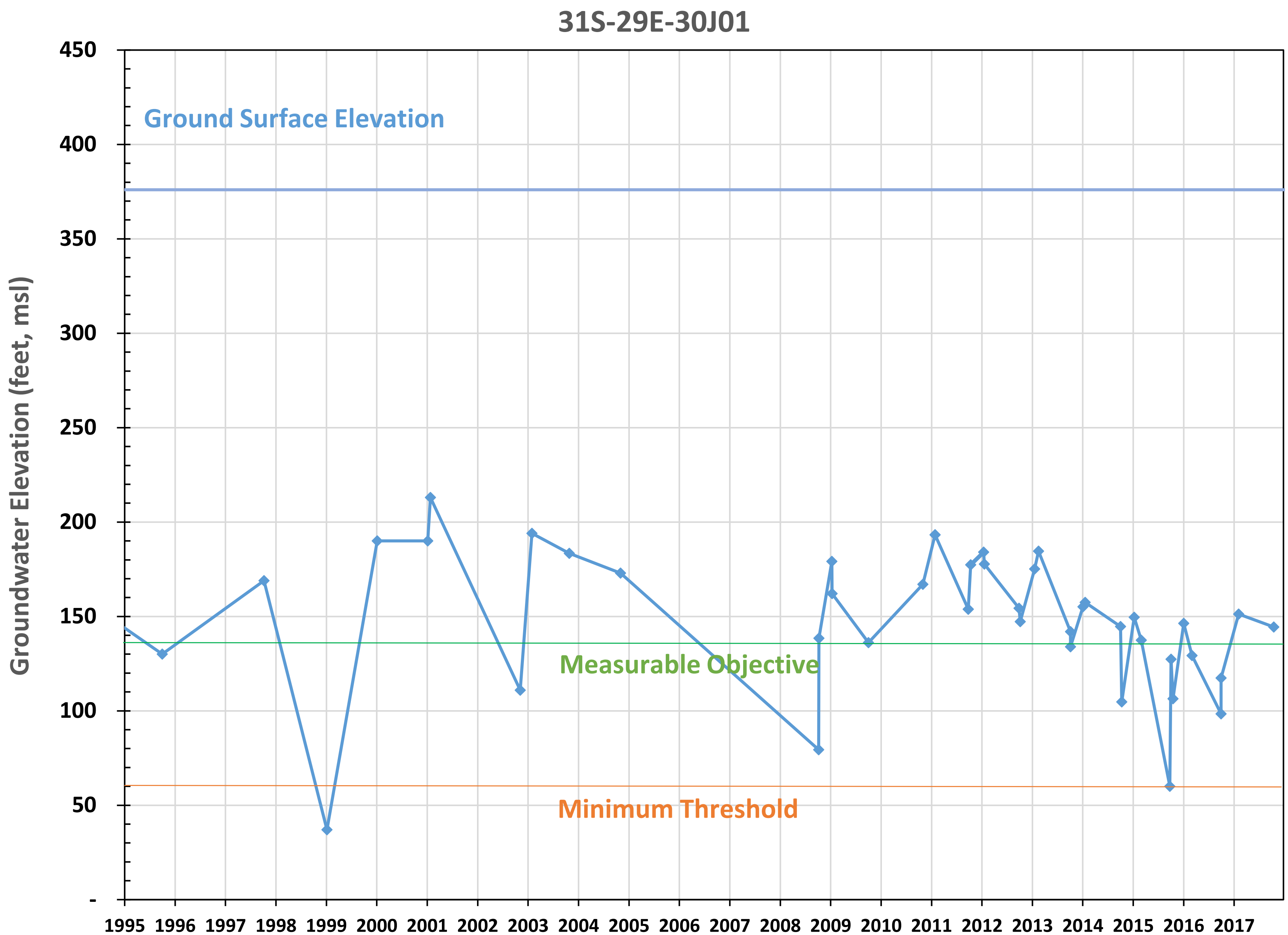
31S-28E-20D
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017



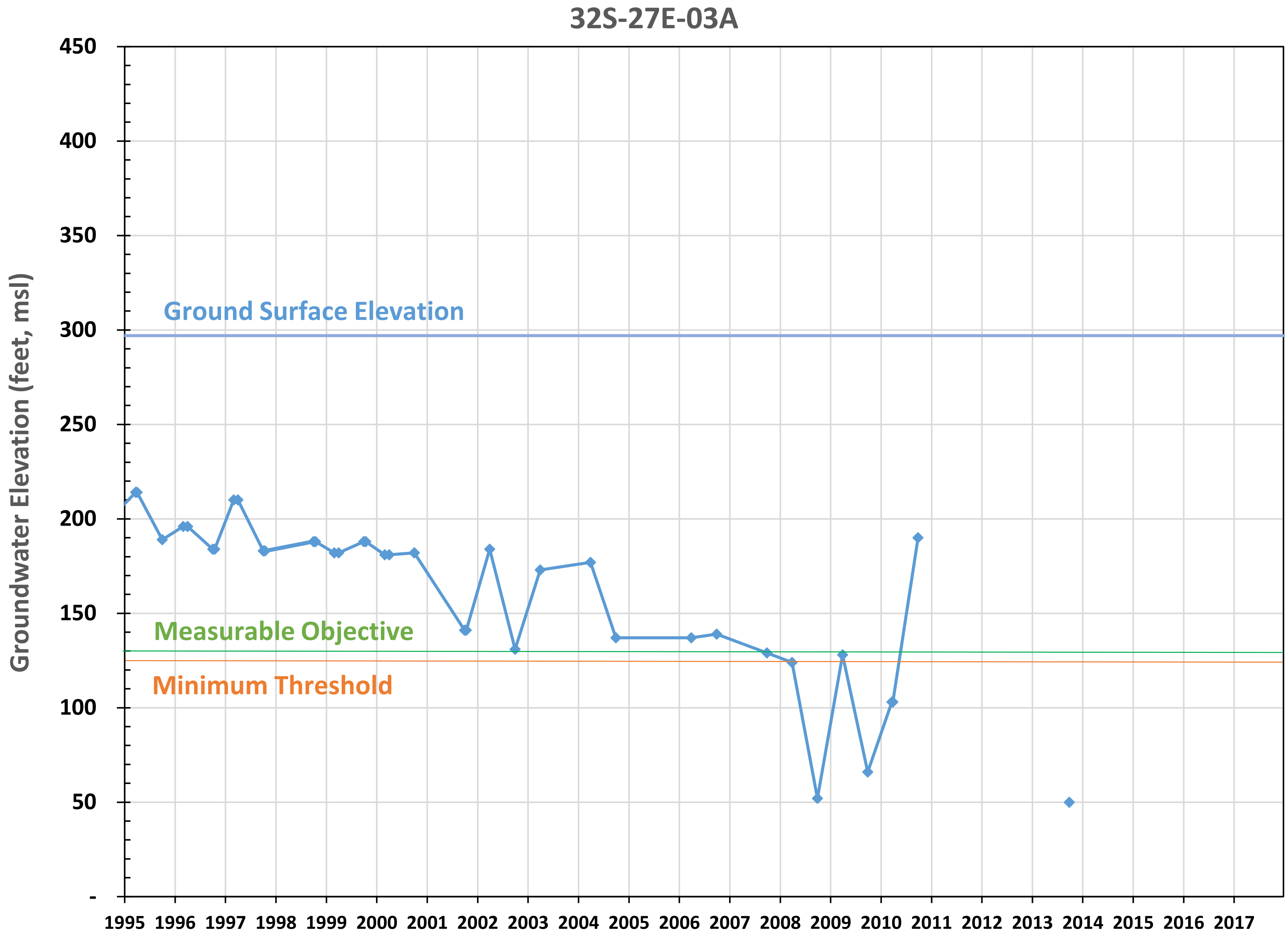
31S-29E-07K
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

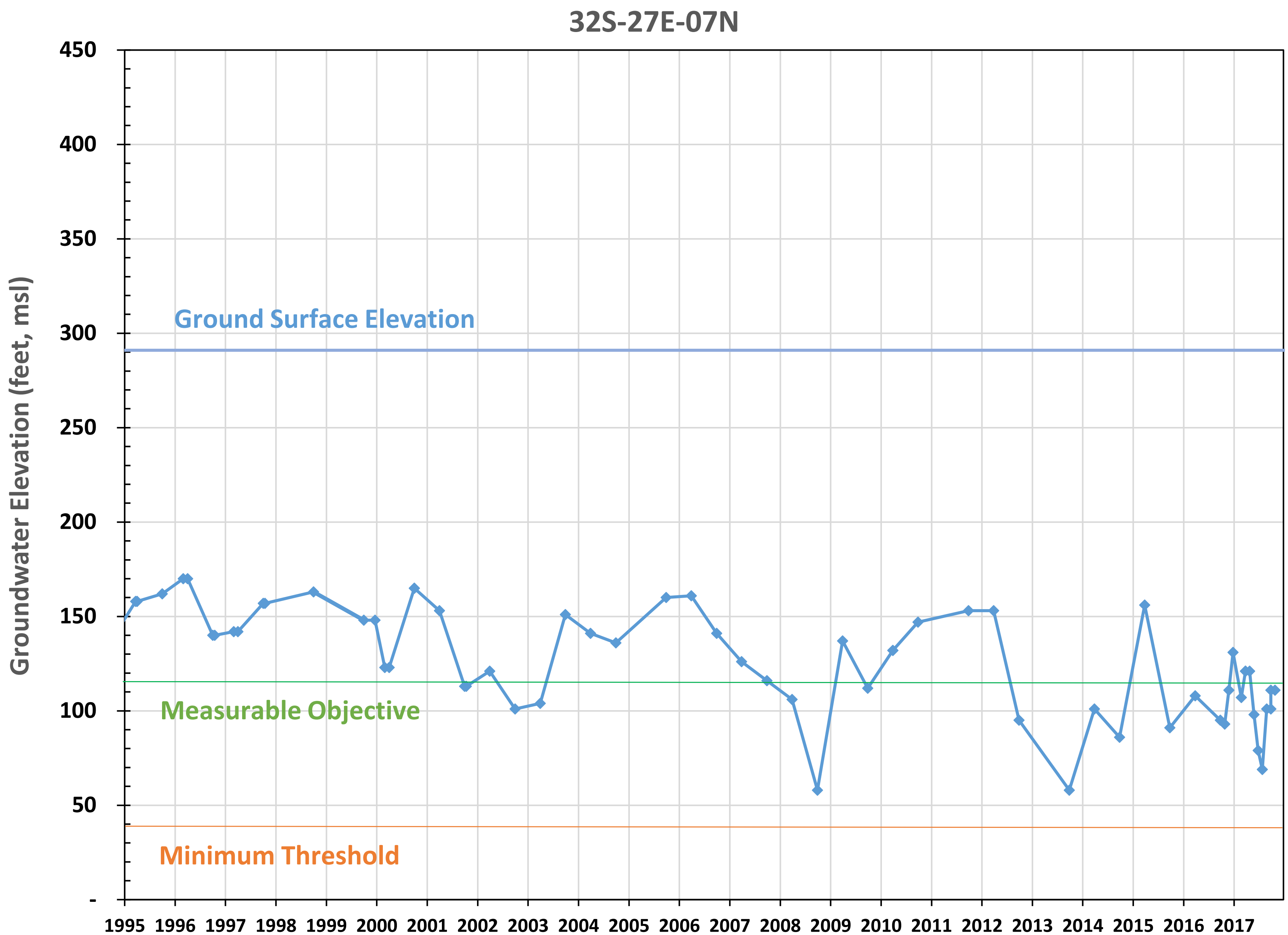


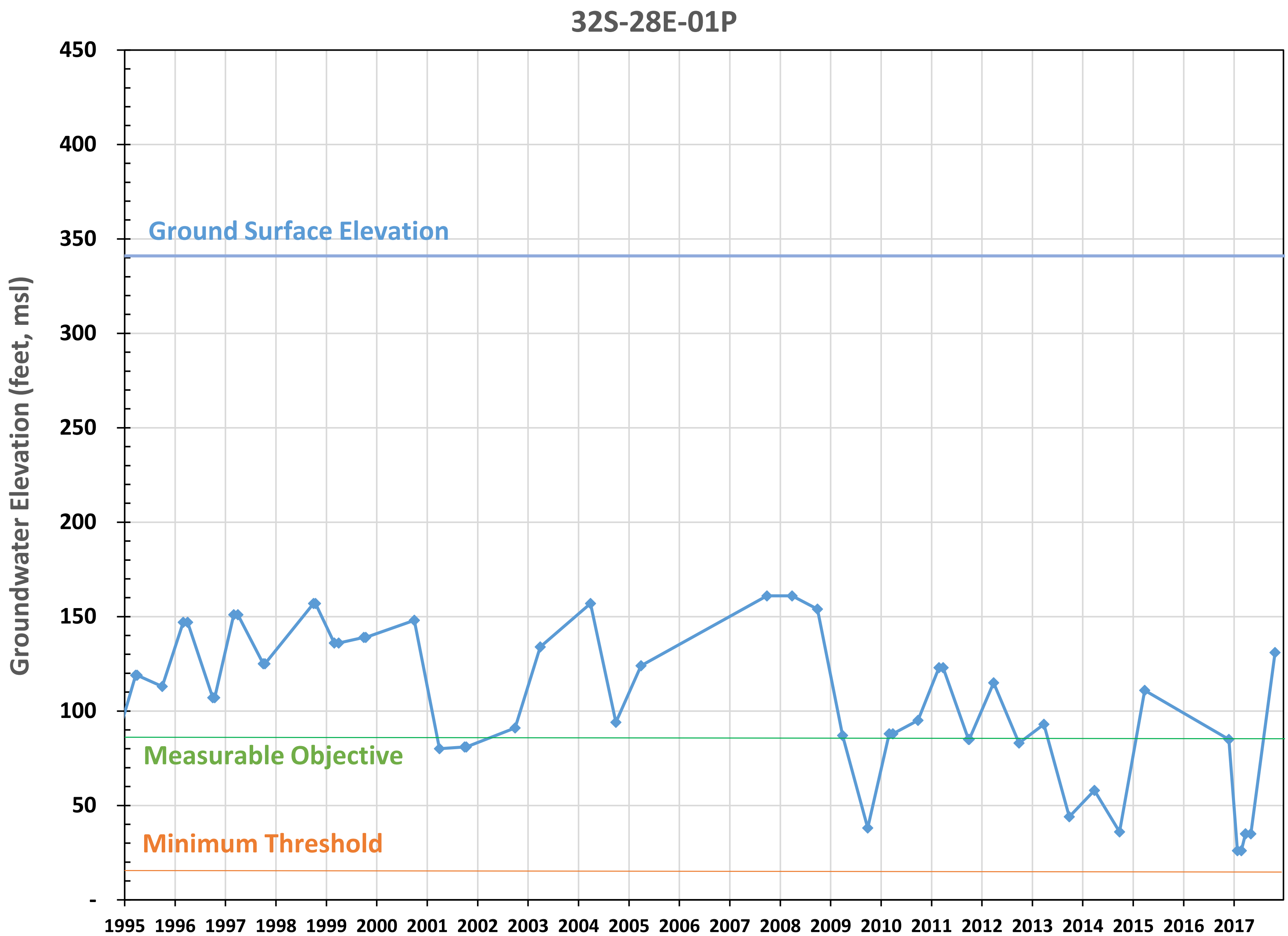
31S-29E-28C
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017



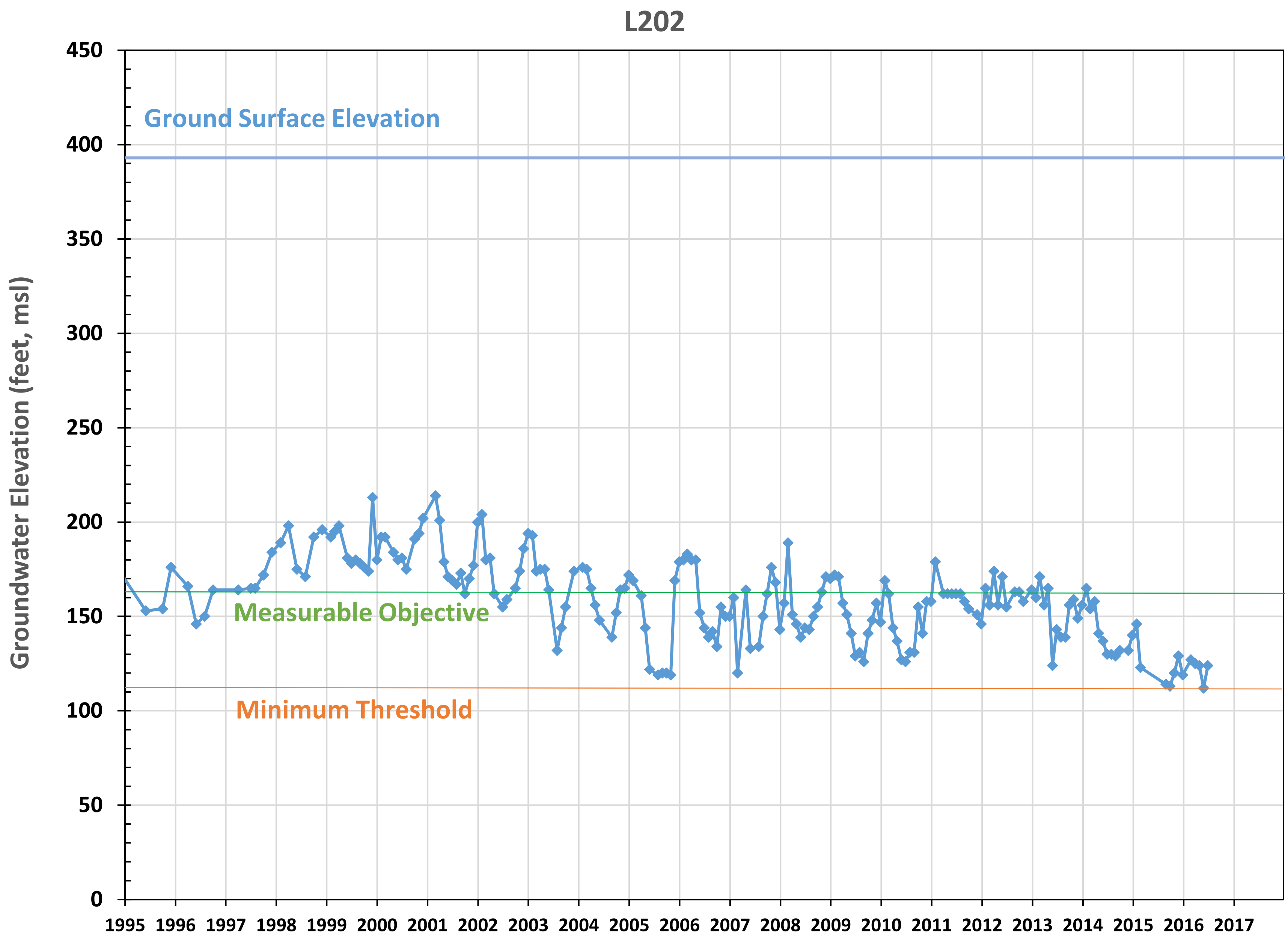
31S-29E-30J01
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017


32S-27E-03A
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
Ground Surface Elevation
Measurable Objective
Minimum Threshold
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017


32S-27E-07N
Groundwater Elevation (feet, msl)
Ground Surface Elevation
Measurable Objective
Minimum Threshold
450
400
350
300
250
200
150
100
50
-
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017



32S-28E-01P
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
-
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
Ground Surface Elevation
Measurable Objective
Minimum Threshold


L202
Ground Surface Elevation
Measurable Objective
Minimum Threshold
Groundwater Elevation (feet, msl)
450
400
350
300
250
200
150
100
50
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

ATTACHMENT 1

Historical and Projected Future Water Budget Development with C2VSimFG-Kern Kern County Subbasin SGMA Compliance

TODD GROUNDWATER

ADMINISTRATIVE DRAFT

August 20, 2019

MEMORANDUM

To: Mark Mulkay, Kern River GSA
Patty Poire, Kern Groundwater Authority GSA

From: Michael Maley, Todd Groundwater
Charles Brush, Hydrolytics LLC

Re: **Historical and Projected Future Water Budget Development with C2VSimFG-Kern**
Kern County Subbasin SGMA Compliance

1. Introduction

The Sustainable Groundwater Management Act (SGMA) regulations require that water budget analyses for Groundwater Sustainability Plans (GSPs) be conducted on a basin-wide basis. The California Central Valley Groundwater-Surface Water Simulation Model (C2VSim) is anticipated to be DWR's primary tool for evaluating water management in the Central Valley and is specifically referenced in the GSP regulations for application to GSP water budgets (§354.18(f)); therefore, utilizing C2VSim was deemed to be advantageous for GSP compliance.

C2VSimFG-Beta generally has good historical precipitation, stream inflow, land use and crop acreage for the entire Central Valley. Historical water supply and demand data are generally good in the Sacramento Valley and San Joaquin River hydrologic regions; however, it is considered less reliable in the Tulare Lake hydrologic region including Kern County. To address this concern, Todd Groundwater has updated the Kern County portion of the C2VSim Fine Grid Public Beta model released by DWR on May 18, 2018 (C2VSimFG-Beta) for the water years (WY) 1985-2015. This updated version of C2VSim for Kern County (C2VSimFG-Kern) was used to develop historical and current water budgets for the Kern County Subbasin SGMA compliance.

The groundwater sustainability agencies (GSAs) in the Kern County Subbasin (**Figure 1**) agreed to update C2VSimFG-Beta with locally derived data on managed water supply and demand to provide water budgets for GSP development. The Central Valley portion of Kern County holds two groundwater subbasins, the Kern County Subbasin (5-022.14) and the White Wolf Subbasin (5-22.18). All of the agencies that deliver water in White Wolf Subbasin also deliver water in the Kern County Subbasin and participated in the C2VSim update. The White Wolf Subbasin portion of the C2VSim model was included in this update to ensure coordination of groundwater conditions assessment in the two subbasins.

1.1 General Approach

The current C2VSim model has a detailed finite element mesh that closely follows local hydrologic features. As a regional model, the C2VSimFG-Beta may over-generalize local conditions within the Kern County Subbasin. As a result, C2VSim results may not be consistent with local site-specific data and knowledge. To address this concern, the general approach is to update managed water supply and demand inputs to better represent the local water balance. To do this, the more general assumptions in C2VSimFG-Beta were replaced with local data and knowledge that are regionally or locally significant over the 1995-2015 Hydrology Period. Our approach is to collect local data on the managed water supply input data (e.g., surface water deliveries, land use, irrigation demand, return flows, and groundwater banking) and apply this to C2VSim. Improvement of Kern County data focused on incorporating:

- Surface water delivery volumes, application areas and use by water district
- Groundwater banking recharge, recovery and application of recovered water
- Irrigation demand from recent remote sensing analyses in the Kern County Subbasin based on ITRC METRIC data
- Urban demand for the subbasin but focusing on Metropolitan Bakersfield
- Data on other water sources and demands of local significance to individual Districts/GSAs

Todd Groundwater updated the Kern County portion of C2VSimFG-Beta for the water years (WY) 1995 to 2015. Data were provided by local GSAs based on their own water budget data to improve model accuracy on a local basis. The managed water supply and demand revisions required major structural changes to C2VSimFG-Beta. Todd Groundwater also coordinated data collection and model revision efforts with a Technical Peer Review Team and local agencies to ensure input data were accurately represented in the model. Tabulated input data, model files and model-derived water budgets were provided to the Technical Peer Review Team for review of accuracy and appropriateness. Model input data and results were provided to Kern County Subbasin water districts and purveyor's local for their review. Comments and data issues were reconciled and incorporated into the revised C2VSimFG-Kern model.

1.2 Acknowledgements

These regional model revisions were enhanced by the participation of the many agencies that provided local water budget input data. Todd Groundwater worked with the member agencies, and their consultants, of the Kern River Groundwater Sustainability Agency (KRGSA), Kern Groundwater Authority (KGA) and independent GSAs to coordinate acquisition of input data from other agencies in formats that could be easily incorporated into the C2VSim model. On-going review of interim model results by these agencies, including local zonal water budgets, groundwater hydrographs and other model results, helped ensure that the revised model reproduced local mass balance estimates across the subbasin.

Todd Groundwater also worked with Woodard & Curran throughout the model development process as Woodard & Curran conducted an on-going peer review of model input files. The updated C2VSimFG-Kern input files for the Kern Subbasin were provided to DWR for incorporation into future C2VSim public releases.

2. C2VSim

C2VSim simulates the full hydrologic cycle, calculating water demands and tracking water movement through surface water and groundwater systems, and is well suited to GSP development. C2VSim uses DWR's modeling code Integrated Water Flow Model (IWFM) and covers the entire California Central Valley (**Figure 2**).

2.1 C2VSim Background

DWR developed the C2VSim to simulate water movement through the linked land surface, surface water and groundwater flow systems of the Central Valley. Kern County is located at the far southern end of the Central Valley (**Figure 2**). C2VSim is an application of DWR's Integrated Water Flow Model (IWFM) software. IWFM is an integrated hydrologic model that simulates water flows on the linked land surface, groundwater, unsaturated zone, and surface water flow systems. A key feature of IWFM is DWR's agricultural and urban water supply and demand management module that dynamically simulates the delivery of both surface water and groundwater supplies based on both water availability and calculated water demands, as affected by usage and climatic conditions.

The groundwater flow system is modeled using the finite element method. The IWFM land surface simulation process was developed with input from California irrigation management professionals, and IWFM uses a highly efficient solver developed at UC Davis. Given DWR's emphasis on water management, detailed water budgets produced by C2VSim provide strong representations of the surface water and groundwater flow systems and make it a preferred platform for developing water budgets.

2.2 C2VSImFG-Beta Model

The C2VSim Fine Grid Beta Model (C2VSimFG-Beta) is derived from a series of Central Valley hydrologic models developed by DWR and other agencies beginning in the early 1990s. Each model in this series has incorporated significant improvements over the previous version. C2VSimFG Beta includes historical input data for WY1922-2015. These data include monthly precipitation and annual land use for each model element and estimated monthly evapotranspiration for each modeled land use type and agricultural crop. Historical surface water data include monthly surface water inflow for each river entering the model boundary and monthly surface water diversions.

The C2VSimFG-Beta finite element grid divides the Central Valley into 32,537 model elements (**Figure 2**). Element areas are small near streams and in developed areas and expand to larger areas in undeveloped areas. Element sizes average 407 acres and range from 4 to 1,770 acres. Central Valley rivers and streams are represented with a network of 110 stream reaches. Surface water and groundwater inflows from uplands along the model boundary are simulated with 1,033 small watersheds.

Land surface altitude and layer thicknesses vary across the model domain. Within the Kern County Subbasin, the land surface altitude varies from 208 feet above sea level in the north to 3,922 feet above sea level in the foothills. The aquifer thickness in the Kern County Subbasin varies from 857 to 9,054 feet and the deepest aquifer location is 8,752 feet below sea level. The Central Valley aquifer is simulated with the following hydrostratigraphic layers, listed from top to bottom:

- Shallow, unconfined aquifer
- Regional confining layers
- Active confined aquifer (contains high level of pumping)
- Inactive confined aquifer (contains limited pumping), and
- Saline confined aquifer.

C2VSimFG-Beta includes annual land use and crop acreages and monthly precipitation, evapotranspiration, stream inflows, surface water deliveries and groundwater pumping rates for WY1922-2015. C2VSim uses this information to dynamically calculate distributed monthly water demands, allocate available water supplies to meet these demands, and calculate any additional groundwater pumping that may be required to satisfy unmet demands. C2VSimFG-Beta produces detailed monthly water budgets for arbitrary sets of elements grouped into zones.

Water demands are calculated dynamically for each model element for agricultural, urban, native and riparian land use types. Agricultural land use is specified for 20 upland crops and two ponded crops. Urban demands are calculated based on population and per-capita water demands. Water demands for other land uses are calculated from monthly evapotranspiration rates. Water demands are then satisfied from soil moisture (partly derived from precipitation), specified surface water applications and specified groundwater pumping. If water demands in an element are not satisfied from these sources, the C2VSim model can adjust groundwater pumping to eliminate any deficit.

C2VSimFG Beta was released after a preliminary model calibration. The distribution of aquifer parameters was based on a texture analysis of lithologic well logs compiled by the US Geological Survey (USGS 2009) from Well Completion Reports submitted to DWR by well drillers. The texture analysis interpolated the percentage of coarse-grained material at each well location and depth of the C2VSim model mesh. Aquifer parameters were then calculated for the model mesh based on the percentage of coarse-grained material and estimated properties for pure coarse- and fine-grained materials. Transmissivities were estimated using specific capacity tests, where available. Soil properties for each model element were derived from digitized soil maps published by the US Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS 2018).

3. KERN COUNTY UPDATES

C2VSimFG Beta input files have been modified to incorporate locally-derived managed water supply and demand data to better represent the local water balance for the Kern County Subbasin (**Figure 3**). The following provides a summary of the model revisions. Additional details on the model updates are provided in **Attachment A**.

3.1 C2VSimFG-Kern Model

C2VSimFG Beta input files have been modified to incorporate locally-derived managed water supply and demand data to better represent local water balance. Historical surface water diversion, water bank recharge and water bank withdrawal information were collected from Kern County water purveyors. The revised model that includes the Kern County revisions is referred to as C2VSimFG Kern, which includes revised data for the Kern County and White Wolf Subbasins to better represent local water conditions. C2VSimFG Kern was not changed for areas outside of Kern County.

Historical surface water diversion, water bank recharge and water bank withdrawal information were collected from Kern County water purveyors. Urban land use was restricted to developed areas, and urban populations and per-capita water demands were updated. Model structure (elements, streams, stratigraphy, etc.) was not modified. Model parameters were not calibrated, although some model parameters were adjusted to improve model performance in specific geographic areas.

3.2 Simulation Time Period

The period of interest for this study is WY1995 to WY2015. C2VSimFG-Beta simulation period ran from October 1973 through September 2015 (WY1974 to WY2015). The C2VSimFG-Kern simulation period contains historical data for WY1985 to WY2015.

GSP requirements indicate a need to identify an average hydrologic Study Period for purposes of the groundwater analyses in the basin-wide water budgets. In order to select a consistent study period, the Kern County Subbasin GSAs agreed on an average hydrologic study period covering WY1995 through WY2014. The historical average hydrologic study period of WY1995 through WY2014 covers 20 years on a water year basis, from October 1, 1994 through September 30, 2014. The selection of the study period was based on a variety of technical criteria including:

- 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent (**Figure 4**)
- About 104 percent of long-term average precipitation (NOAA Bakersfield Meadows Field Airport Station)
- Sufficiently short time period associated with widely-available and higher-quality data
- Inclusion of recent time periods to capture ongoing water management practices and more recent land use patterns
- Covers at least 10 years consistent with GSP regulations (§354.18(c)(2)(B))
- Contains 10 years characterized as above normal or wet years based on precipitation; also contains 10 years of below normal or dry years, including 4 critically-dry years
- Begins in a time of relatively stable water levels (October 1994)
- Overlaps time period with consistently-developed basin-wide contour maps by Kern County Water Agency (KCWA).

For the historical water budget, it is desirable to define a base period when natural hydrology represents average conditions. C2VSimFG-Kern incorporates this 20-year base period of WY1995 through WY2015 with a 10-year spin-up period (WY1985 to WY1994). Kern County water agencies provided high-quality water budget data for WY1995 to WY2015 for this study. Good-quality water budget data for WY1984 to WY1994 was also collected, but detailed water budget data for WY1974 to WY1983 were not available. The simulation period was set to WY1986 to WY2015, allowing a 10-year spin-up before the period of interest.

3.3 Data Compilation

Participating agencies compiled water budget input data sets (using their staff, consultants or other resources) and provided them to Todd Groundwater. Where appropriate, Todd Groundwater developed data templates that conformed to IWFM model data needs and used them to facilitate obtaining input data from local agencies. This included monthly data for the following:

- Surface water imports and diversions (inflows and outflows) by source, conveyance and application area,
- Groundwater banking and managed aquifer recharge by water district or agency,
- Groundwater banking pumping for export from the basin,
- Metered district groundwater recovery pumping,
- Urban area population and per capita water use, and
- ET rates based an analysis of satellite data.

In addition, groundwater banking data were compiled for the large Kern Fan banking projects. Recently-developed crop evapotranspiration rates derived from remote sensing data were used to develop monthly crop evapotranspiration rates for agricultural crops. Urban land use was restricted to developed areas, urban populations and per-capita water demands were updated, and urban wastewater recharge operations were added.

3.4 Surface Water Diversions

Kern County surface water diversions in C2VSimFG-Beta were grouped by project or water source; however, deliveries were applied to specific water districts. In addition, several local surface water deliveries were missing from the model. For C2VSimFG-Kern, the 43 Kern County surface water diversions to the Kern County and White Wolf subbasins from C2VSimFG-Beta were replaced with 113 surface water diversions developed with data provided by local agencies.

3.4.1 Data Compilation

Monthly surface water diversion data for WY1995 to WY2015 were collected for 21 agencies and recharge projects in Kern County. The data from each water district or agency included monthly surface water inflow by source and monthly surface water outflow by destination.

The monthly surface water inflow and outflow data collected for this study did not have sufficient detail to track this water and create an accurate historical water balance for each canal for each month. The data do provide sufficient information to identify monthly surface water diversions from each source and deliveries to each end use. Therefore,

- All diversions from the Kern River were exported from the model and treated as imports at delivery locations,
- Diversions from Poso Creek and the Kern River Flood Channel (or Main Drain) were diverted from the appropriate stream nodes, and
- All other surface water deliveries (SWP, CVP, oil field recovery water, etc.) were treated as imports.

Each C2VSim surface water diversion is linked to two groups of model elements: the elements of the end use and the elements receiving the recoverable losses. For the C2VSim Kern County Update, a single set of elements was used for both purposes. Model elements for agricultural, urban and refuge deliveries were selected by overlaying the model grid on delivery areas maps. Model elements for recharge diversions were selected by overlaying the model grid on recharge basin maps.

3.4.2 Surface Water Diversions

Monthly water delivery data for the State Water Project (SWP), Central Valley Project (CVP) and Kern River were also provided by many agencies. Monthly turnout-level deliveries for the SWP were compiled from the monthly SWP Report of Operations published by DWR. Monthly CVP deliveries were compiled from the USBR Report of Operations. Monthly Kern River flow and diversions were compiled from Kern River Hydrologic Reports. Water agencies in the Kern County and White Wolf subbasins trade and wheel water in real time to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. Water delivery reports from water suppliers (such as the CVP and SWP) generally identify the owner of delivered water, not where it was actually delivered.

Some surface water conveyances discharge water into stream or river channels for re-diversion downstream. A key part of the surface water system in Kern County is the Kern River. Kern River operations data were reviewed for 1970 to 2015. While Table 1 summarizes surface water deliveries, **Table 2** summarizes Kern River diversions by turnout location as applied in C2VSimFG-Kern.

3.4.3 Surface Water Deliveries

Water flow through the Kern River and its associated canal system is very complex. Water is diverted from the Kern River into a parallel canal system at several locations, with some diverted water flowing back to the river. Some water from the CVP and SWP are discharged into the Kern River for diversion downstream. Some water agencies are served from multiple diversion points along the Kern River. Several canals that receive water diverted from the Kern River also exchange water with other canals and receive some water from groundwater pump-in, so deliveries from many canals cannot be attributed to a single source.

Each surface water diversion is allocated to a specified destination and water use. Five water use types are simulated: agricultural, urban, refuge, recharge and export. Agricultural and refuge diversions are applied to a group of model elements that corresponds to a surface water service area within a specific water district or refuge (**Figure 5**). Urban diversions are allocated to an urban service area. Groundwater recharge diversions are allocated to the model element or elements where the receiving recharge basin is located. Three delivery fractions apportion each surface water diversion to application, loss to groundwater (recoverable loss), and loss to evaporation (non-recoverable loss). **Table 1** summarizes the annual surface water deliveries for agricultural use by water district in Kern County. **Table 3** summarizes surface water diversions for urban use, wastewater land disposal and wildlife refuge management in Kern County.

3.5 Groundwater Banking and Managed Aquifer Recharge Operations

In our preliminary discussions with the C2VSim developers at DWR, it was revealed that significant model uncertainty was related to incomplete data regarding groundwater banking and other managed aquifer recharge (MAR) operations in the Kern County Subbasin. Recognizing the importance of these groundwater banking projects on simulating groundwater conditions, the approach is to update data for groundwater banking and MAR operations using the earliest available records.

3.5.1 Recharge and Recovery Data

A monthly time-series of recharge rates was determined for each recharge project. Recharge rates were allocated to individual recharge basins using the initial data whenever possible or were shared proportionally between basins based on historical rates. All Kern County recharge basin surface water deliveries were simulated as imports.

Recharge basin locations and recovery well locations were provided by each agency or project (**Figure 6**). The C2VSim finite element grid was overlaid onto a map of recharge basins to determine the model elements for each recharge location. Well location coordinates were added to C2VSimFG-Kern.

Monthly volumes for recharge at groundwater banking and managed aquifer recharge facilities were compiled for 16 agencies and projects (**Table 4**). This information originated from multiple sources, and included data provided by agencies, compiled from agency reports, and compiled from Kern River Hydrologic Reports. The data include monthly recharge for years prior to 1995 for many projects. Several agencies and projects provided data for multiple recharge basins. Some groundwater wells used for recovery of banked water are also used for other purposes such as supplementing agricultural or urban surface water deliveries.

Recognizing that several of the large groundwater banking projects (especially those on the Kern Fan) pre-date the 20-year base period, and that future studies might simulate periods prior to 1985, all available historical data for groundwater banking operations was reviewed and updated. This included incorporating pre-1985 data for banking operations at

- Arvin-Edison WSD (1966-2015),
- Berrenda Mesa Project (1977-2015),
- Buena Vista WSD (1963-2015),
- City of Bakersfield 2800 Recharge Facilities (1973-2015)
- North Kern WSD (1956-2017) and
- Rosedale-Rio Bravo WSD (1980-2015).

3.5.2 Groundwater Recovery

Two types of recovery wells were added to the C2VSimFG-Kern. These include District-operated water wells that were used for out-of-district transfers or out-of-basin exports of groundwater, and wells used for recovering banked groundwater and distributing the pumped groundwater via the district's water conveyance system to provide water supply, typically for agricultural use, within the district. The locations of the specified groundwater recovery wells are shown on **Figure 6**. The specified groundwater recovery pumping input into C2VSimFG-Kern is summarized as follows:

- 229 time series for Kern County groundwater banking withdrawals was added;
- 313 simulated pumping wells and 225 pumping time series for local groundwater pumping by district-operated recovery wells were added; and
- Elemental agricultural, refuge and urban pumping was eliminated in areas where it does not occur.

Recharge and withdrawal data for the Kern Fan banking projects, including the Kern Water Bank, Berrenda Mesa Project, Pioneer Project, and the City of Bakersfield 2800 Recharge Facilities were shared with the local banking authorities for verification. Banking data for district-specific groundwater banking projects were provided by these districts. A summary of the data input for groundwater recovery pumped added to C2VSimFG-Kern is provided in **Table 5**.

3.5.3 Model Application

A separate C2VSim diversion was created to deliver surface water to each recharge basin or set of geographically close jointly managed basins. A diversion time series of monthly application rates was then created for each recharge diversion from the available data. Each recharge diversion delivers water to the model elements coinciding with the receiving recharge basin(s). Recharge basins were simulated in C2VSim by setting the application delivery fraction to zero, the recoverable loss fraction to 94% and the evaporation loss to 6%.

Monthly groundwater recovery was generally provided by well field and destination (e.g. agriculture, urban, canal pump-in, or export). This information was used to develop a C2VSim pumping time series for each well field and destination that is summarized in **Table 6**. Recovery well locations and screen intervals were used to enter each recovery well into the C2VSim model. Recovery pumping time series were then allocated equally to all of the wells in each field.

Some well fields supply water to two different end uses, for example supplementing surface water deliveries within the district in some months and exporting water from the district in other months. This is handled in the C2VSim model by entering the well two times. Each entry is associated with a separate time series of pumping rates and delivery destination.

3.5.4 Groundwater Banking Obligations

The general operation of groundwater banking facilities is to recharge excess available surface water supplies during wet years by recharging to the groundwater, and this water is recovered by pumping in dry years when surface water supplies are limited. In Kern County, groundwater banking stores water in the Kern County Subbasin for use by local agencies, but also for out-of-basin entities.

In consideration for evaluating the groundwater sustainability, any water stored in the Kern County Subbasin that is contractually obligated to an out-of-basin entity does not contribute the long-tern groundwater sustainability because the owner of that water could call for its return at any time. However, this can be difficult to track because a common practice is to recover groundwater for local use to replace imported surface water that sent to the out-of-basin entity.

C2VSimFG-Kern does not have a mechanism to track these complex contractual exchanges, so the tracking is done as a post processing step by assigning the portion of the groundwater recharge as an out-of-basin banking obligation.

The Kern County Subbasin GSAs provided the total out-of-basin banking obligation for their operations as of September 2014 for the historical assessment. As of September 2014, the out-of-basin banking obligation for the Kern County Subbasin totaled of 1,719,307 acre-feet, which, when averaged over the 20-year period, was 85,965 AFY. The 85,965 AFY is applied during post-processing of C2VSimFG-Kern historical water budget results.

3.6 Urban Water Demand

The C2VSim model calculates urban water demands for specified urban delivery zones, allocates specified surface water and groundwater supplies to meet these demands, and can optionally pump additional groundwater to satisfy unmet urban demands in each zone. Urban demands were represented with nine urban zones in C2VSimFG-Beta. These zones were reconfigured, and a tenth urban zone was added representing Metropolitan Bakersfield. Historical urban populations and per capita water use rates were reviewed and updated.

3.6.1 Urban Zones

The C2VSim model dynamically calculates urban water demands for urban zones using time-series data of urban populations and monthly per capita water use. The urban delivery zones of C2VSimFG-Beta were modified to better represent Kern County population centers, jurisdictional boundaries and urban water sources. Although Kern County urban water delivery systems are operated by many diverse entities, their water generally comes from two sources: surface water deliveries and agency-operated groundwater wells.

The nine Kern County urban zones in C2VSimFG-Beta for Kern County were numbered 97-105. The Urban Zone boundaries were adjusted, as shown on **Figure 7**, as follows:

- Portions of Urban Zones 97, 99, 100, and 102 in C2VSimFG-Beta were used to create Urban Zone 106 representing the Metropolitan Bakersfield area;
- Urban Zone 98 was extended southeast to near the Stockdale Highway to include unincorporated urban areas;
- The boundary of Urban Zone 99 was extended eastward to California State Route 65 to include small communities in this area, removing them from Urban Zone 100; and
- The northern boundary of Urban Zone 104 was moved north to correspond to the West Kern WD service area.

3.6.2 Urban Population and Per Capita Use

Historical annual urban populations for the ten urban zones were estimated using United States Census total population data from 1990, 2000 and 2010 (US Department of Commerce). Tabular historical census data and census block shapefiles were obtained from the IPUMS National Historical Geographic Information System Database. These data were combined to produce maps of the geographic distributions of populations within Kern County. The historical populations for each Urban Zone were estimated by mapping census block centroids to the ten Urban Zones using ArcGIS. The 1990, 2000 and 2010 population of each Urban Zone was then estimated as the sum of the populations of the associated census blocks. Populations for other years were estimated using interpolation and extrapolation. The population values by urban zone used for C2VSimFG-Kern are listed in **Table 7**.

3.6.3 Urban Water Use Specifications

Monthly historical urban water demands for Urban Zone 106 were calculated using water delivery data from the water purveyors in the Metropolitan Bakersfield area. Monthly historical urban water demands for the other urban zones in the Kern County Subbasin were estimated using available water use data from published urban water management plans for the communities served in those zones. The historical monthly water use in each zone was then divided by the historical population to obtain the monthly per capita urban water demand. Monthly historical per capita water demands for zones without urban water management data were estimated using the per capita water demand from zones with similar demographics.

The urban water use specifications indicate the portion of total urban water that is used indoors. In the C2VSim model, the portion used indoors becomes urban return flow, and the remainder is added to the urban root zone where it contributes to evapotranspiration and deep percolation. C2VSimFG-Beta included monthly urban water use specifications for each model subregion. The urban per capita water use was based on local water supply data and urban water management plans. **Table 8** lists the per capita water use data used for C2VSimFG-Kern.

3.6.4 Model Application

Historical annual urban population estimates were placed in the C2VSim urban population input file. Historical monthly urban per capita water demand estimates for each urban zone were placed in the C2VSim urban per capita water use file. Urban demand was calculated by C2VSimFG-Kern and the water supply was met first by specified surface water and groundwater pumping deliveries for urban use. The remaining water demand was met with local groundwater pumping calculated by C2VSimFG-Kern and applied to the same element as the remaining water demand.

3.7 Agricultural Crop Water Demand

The C2VSim model dynamically calculates agricultural crop water demands and allocates supplies to meet these demands for each model element. Agricultural demands are calculated for 20 crops using historical crop acreage data and crop evapotranspiration (ETc) rates. Crop water demands in each model element are first met with stored soil moisture, surface water deliveries and specified groundwater deliveries. If the agricultural demands are not satisfied, the model can optionally calculate the additional groundwater pumping required to satisfy the unmet demands and extract that water from the groundwater component of the model element.

C2VSimFG-Beta contained one set of monthly ETc rates for each model subregion that were repeated each year. New monthly ETc rates for three model subregions (northeast, northwest, south) in Kern County were calculated for 1993-2015 using monthly remote sensing imagery and detailed annual crop maps. ETc for 1974-1992 were estimated by using the values for similar water year types based on the San Joaquin Index.

The 20-year time period is also advantageous for incorporation of newly available crop evapotranspiration (ETc) data. A remote sensing study of historical ETc rates across the entire Kern County Subbasin by the Irrigation and Training Research Center (ITRC 2017) provided detailed basin-wide agricultural demands that corresponded to the WY 1995-2014 base period. These data were used to develop monthly ETc rates for the Kern County portion of the C2VSim model.

3.7.1 ET Rates

The Irrigation Training and Research Center (ITRC) at California Polytechnic State University, San Luis Obispo, has developed a procedure to use remote sensing imagery from Landsat satellites to calculate historic ETc rates (ITRC 2017). The Mapping of Evapotranspiration with Internal Calibration (METRIC) method was originally developed by Richard Allen of the University of Idaho. ITRC made several modifications to the original METRIC method to better match California data and conditions (named the ITRC-METRIC method). These modifications include using grass for reference evapotranspiration (ETo), incorporating a semi-automated calibration procedure and spatially interpolating ETo rates. An example of the METRIC ET data for the total annual ET in 2013 is provided in **Figure 8**.

ITRC used Landsat imagery for 1994-2015 (except 2012 when no imagery was available) and the ITRC-METRIC method to develop monthly raster maps of ETc at 30 x 30 meter resolution for the Kern County portion of the Central Valley (ITRC 2017). The monthly ETc raster maps were used with annual DWR crop maps to calculate the average ETc by crop type for the three Kern County C2VSim subregions. ITRC-METRIC raster data were used to determine the exact areas of applied irrigation and total annual ETc. A raster pixel was assumed to be irrigated if the total annual ETc was greater than 20 inches.

The following data processing steps were used to determine monthly ETc rates for each crop and C2VSim subregion:

- Create irrigation coverages – ITRC-METRIC monthly ETc raster data were summed to calculate total annual ETc for each year for each raster location. The ArcGIS Reclassify tool was then used on each annual ETc raster to create a binary polygon coverage for each year for 1994-2015 (except 2012), setting the attribute “IRR” to 1 if total annual ETc was over 20 in/year, and to 0 if total annual ETc was equal to or less than 20 in/year.

- Create land use coverages – Annual DWR land use rasters were converted to polygon coverages with the attribute “Crop” set to the corresponding integer crop value used in the C2VSim model. The land use rasters were checked against GIS maps produced by the Kern County Agricultural Commissioner and consistent errors in the DWR land use rasters were corrected. DWR land use maps for 1994-1997 were missing large areas of data, so the 1998 land use map was used to approximate the land use for 1994-1997.
- Create monthly zone maps – One Zone shapefile was created for each month by using the ArcGIS Union tool to combine a shapefile of the three C2VSim subregions with the irrigation coverage (produced in step 1) and the land use coverages (produced in step 2). Each monthly zone polygon shapefile has three attributes: C2VSim subregion, binary irrigation indicator, and a land use crop value. The dissolve function was used to combine zones with identical parameters.
- Calculate average monthly ETc for each zone – The ArcGIS Zonal Statistics by Table tool was used to calculate the average ETc value for each zone for each month. The individual pixels in each monthly ETc raster were averaged within each zone (produced in step 3). ITRC-METRIC data for 2013 were used in place of missing data for 2012.
- Combine tables – The MS Access Append function was used to combine the monthly ETc tables into a master table of monthly ETc by crop and C2VSim subregion.
- Output data – Data from the Access database was exported in a form consistent with the C2VSim input files. The output was also summarized to show the average monthly ETc for the irrigated area of each crop type in each model subregion.

The monthly ETc rates for the three Kern County subregions for WY 1993-2015 were then replaced with the monthly ETc rates calculated using ITRC-METRIC data. The annual ETc rates applied to C2VSimFG-Kern by crop are listed in **Table 9**.

3.7.2 Irrigation Periods

The C2VSim Irrigation Periods file contains monthly parameters for each crop and subregion that indicate whether or not the crop is irrigated in that month. C2VSimFG-Beta irrigation periods for the three Kern County subregions were adjusted to match crop irrigation practices from ITRC-METRIC water usage. Refuge irrigation periods for the three Kern County subregions were also adjusted to match Kern NWR practices. Simulated irrigation water usage for the C2VSimFG-Kern better reflects observed irrigation practices.

3.8 Local Changes

Several locally significant issues were identified that affected the historical water budget, and these were modified in C2VSimFG-Kern to improve the model performance. A brief summary is provided below, and additional information is provided in **Attachment A**.

3.8.1 Kern River Streambed Parameters

For much of the Kern River, the amount of streambed seepage is estimated based on daily weir information. Initial streambed parameters did not allow for this measured seepage to occur. The streambed parameters were manually adjusted until a reasonable approximation of the measured streambed seepage was provide by C2VSimFG-Kern.

3.8.2 Poso Creek Inflow

C2VSimFG-Beta contained Poso Creek inflows for WY 1961-1986. Poso Creek inflows for WY 1987-2015 were estimated from flow records for the Coffee Creek gage and were added to the C2VSim model.

3.8.3 Small Watershed Runoff

Small watershed contribution to the area was considered to be too high. Although this was not part of the originally-planned model revisions, it is affecting the model results. Todd Groundwater revised the corresponding model parameters more representative of the local arid conditions in Kern County.

3.8.4 Root Zone Parameters

Areas of overly high root zone hydraulic parameters led to high volumes of deep percolation that required additional groundwater pumping to meet the overall water demand for irrigation. This issue was noted by local water district staff who recognized that the groundwater pumping and deep percolation from preliminary model results were significantly higher than what was found in practice. A review found areas of overlying hydraulic conductivity and other hydraulic parameters that caused this high percolation rate. Two types of issues were found. First, very high parameters were found in parts of the basin that were not consistent with local soil data. Second, the root zone parameters for the lake bed and other heavy clay soil areas were too high. These areas were manually adjusted to be more in line with observed conditions. A more rigorous development of root zone parameters should be considered in the future as this issue demonstrates that it is a sensitive parameter.

3.8.5 Land Use Modifications

The agricultural land use and crop type distribution in the model for early period (1974-1990, and 1992-1996) from C2VSimFG-Beta used a regional distribution and did not accurately represent historical practices. This resulted in agricultural water use being distributed across the entire Kern County Subbasin including areas that did not have irrigated agriculture. To correct for this, land use and crop type data were modified to conform with irrigated agricultural areas in the early 1990s. The crop types were adjusted to be consistent with the Kern County Agricultural Commissioner reports for these years.

3.8.6 Westside Pumping Limits

Western Kern County contains several areas with poor groundwater quality. Little or no agricultural or urban groundwater pumping occurs in these areas. Groundwater pumping was turned off in the areas with poor groundwater quality in western Kern County. Pumping was enabled in a limited area where groundwater pumping occurs; this poor-quality water is mixed with surface water. The pumping rate in this area was estimated to be 10% of the surface water deliveries. Automated groundwater pumping adjustment was also turned off for these areas.

3.8.7 Kern Wildlife Refuge pumping

C2VSimFG-Beta enabled groundwater pumping in the model elements representing the Kern National Wildlife Refuge. The Kern National Wildlife Refuge Water Management Plan (USBR 2011) indicates that during the simulation time period, the refuge was sustained entirely on imported surface water and occasional diversions of Poso Creek flood waters. No groundwater was pumped at the refuge during the simulation period 1985-2015. Groundwater pumping was used at some time in the past. Groundwater pumping was turned off for all model elements in the Kern National Wildlife Refuge.

3.9 C2VSimFG-Beta Modifications

Minor changes were made to the C2VSim hydrogeological conceptual model and natural water budget components. These are listed in **Table 10** and additional information on these modifications are provided in **Attachment A**. The architecture of the model including layering, discretization, boundary conditions, and aquifer properties was not revised. Aquifer parameters were adjusted in several areas to better match observed historical conditions, especially in areas with high historic recharge volumes such as the Kern Fan. Extremely high soil hydraulic conductivities in a small set of elements were reduced to more reasonable values. Stream-bed conductance values were modified in some stream reaches to better match simulated stream gains and losses to observed values. Minor adjustments to small watershed parameters were also made to match surface runoff to observed values.

4. HISTORICAL AND CURRENT WATER BUDGETS FROM C2VSIMFG-KERN

C2VSimFG-Kern was used to develop historical (WY1995 to WY2014) and current (WY2015) water budgets for the Kern County Subbasin. The following summarizes the simulated water budgets from C2VSimFG-Kern. Additional information is provided in **Attachment B.**

4.1 Historical and Current Water Budget

The simulated historical and current water budgets based on C2VSimFG-Kern are presented in **Tables 11A and 11B** and are presented graphically on **Figures 9 and 10**. The results for the historical water budget are summarized under the following categories that are defined as:

- **Deep Percolation** – Precipitation and applied water that reaches the groundwater after simulated transport across the unsaturated zone. The simulated historical 20-year average is a net inflow of 669,398 AFY.
- **Managed Recharge and Canal Seepage**- Combined groundwater recharge from managed aquifer recharge operations, groundwater banking, and seepage from canals and other conveyance. The simulated historical 20-year average is a net inflow of 583,598 AFY.
- **Net Groundwater-Surface Water (GW/SW) Interactions** - Net volumetric exchange of surface water and groundwater from streams: Positive represents a net groundwater recharge, and negative represents a net groundwater discharge to the stream. The simulated historical 20-year average is a net inflow of 98,606 AFY.
- **Groundwater (GW) Pumping** - Total groundwater pumping by wells. Groundwater banking recovery pumping is specified input whereas agricultural and municipal pumping is calculated by C2VSim based on demand. The simulated historical 20-year average is a net outflow of 1,590,373 AFY.
- **Small Watershed Inflow** – Runoff, small stream inflow and subsurface inflow from the small watersheds and areas surrounding the groundwater basin. The simulated historical 20-year average is a net inflow of 48,760 AFY.
- **Subsurface Flow with Adjacent Groundwater (GW) Basins** - Net subsurface groundwater flow from the Kern County Subbasin with an adjoining groundwater basin: negative is a net flow out of the Basin and positive is a net flow into the Basin. The simulated historical 20-year average is a net outflow of 87,102 AFY.
- **Change in Groundwater Storage** - Sum of the inflow components (positive numbers) plus the outflow components (negative numbers): positive is an increase in storage typified by a rise in groundwater levels whereas a negative is a decrease in storage typified by a decline in

groundwater levels. The simulated historical 20-year average is a decline in groundwater storage of 277,114 AFY.

Figure 10 presents the average annual historical water budget for the Kern County Subbasin. This includes the out-of-basin groundwater banking obligation of 85,965 AFY. This is shown by reassigning the out-of-basin banking obligations from the Managed Recharge and Canal Seepage.

The simulated change in groundwater storage varies over the 20-year historical period and is closely related to climatic conditions and surface water supply availability (**Figure 11**). During the periods WY1995 to WY2000, WY2005 to WY2006 and WY2010 and WY2011, the groundwater storage volume was stable to increasing and correlates to the above average rainfall and surface water availability during these times. During the periods WY2001 to WY2004, WY2007 to WY2009 and WY2002 to WY2015, groundwater storage volume decreases, correlated to periods of drought and low surface water availability. The simulated historical groundwater recharge also reflects this climatic pattern with high deep percolation to groundwater and steep increases in managed aquifer recharge and canal seepage during the above average rainfall periods and lower groundwater recharge during the drought years (**Figure 12**).

Groundwater pumping for agriculture shows a general increasing trend from WY1995 to WY2014; however, groundwater pumping is lower in above average rainfall years and higher during droughts (**Figure 13)**. This general increasing trend follows a comparable decreasing trend in surface water deliveries over this same period. As shown on **Figure 14**, surface water deliveries show a general decreasing trend from WY1995 to WY2014; however, the surface water deliveries are higher in the above average rainfall years and lower during the droughts.

4.2 Sustainable Yield

Section 354.18(b)(7) of the GSP Regulations requires that an estimate of the basin's sustainable yield be provided in the GSP (or in the coordination agreement for basins with multiple GSPs). SGMA defines "Sustainable yield" as:

> "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable e result."

SGMA does not incorporate sustainable yield estimates directly into sustainable management criteria. Sustainable yield is referenced in SGMA as part of the estimated basinwide water budget and as the outcome of avoiding undesirable results. Basinwide pumping within the sustainable yield estimate is neither a measure of, nor proof of, sustainability. Sustainability under SGMA is only demonstrated by avoiding undesirable results for the six sustainability indicators.

To determine the sustainable yield for the Kern County Subbasin, the results of the C2VSimFG-Kern model were used with two methods to estimate the amount of groundwater pumping that would avoid the undesirable result of a reduction in groundwater storage over the historical base period 1995 to 2014. The results are shown in **Table 12** and are summarized below:

- **Sustainable Yield from Groundwater Pumping –** The model results produced an average annual groundwater pumping in the Kern County Subbasin of 1,416,077 AFY with a decline in groundwater storage of 277,114 AFY. In addition, 85,965 AFY of out-of-basin groundwater banking obligations were documented remaining in the Subbasin. Subtracting the groundwater storage decline and out-of-basin groundwater banking obligations from groundwater pumping produced a sustainable yield of approximately 1,052,998 AFY.

- **Sustainable Yield from Groundwater Recharge –** The model results produced an average annual groundwater recharge in the Cawelo GSA of 1,351,602 AFY. The combined groundwater banking exports, out-of-basin banking obligations along with the subsurface outflow from the GSA total 347,339 AFY. Subtracting these losses from the groundwater recharge produced a sustainable yield of approximately 1,004,262 AFY.

Sustainable yield estimates are part of SGMA's required basinwide water budget. In general, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. This sustainable yield estimate can be helpful for estimating the projects and programs needed to achieve sustainability. Although the SGMA regulations require a single value of sustainable yield calculated basinwide, it should be noted that the sustainable yield can be changed by implementation of recharge projects, variations in climate, or changes in stream flow conditions.

Using WY 1995-2015 as the base period, C2VSimFG-Kern results show declining groundwater levels and long-term reduction of groundwater storage. During this period, average annual inflow to the aquifer is 1.47 MAF, and outflow is 1.74 MAF. This yields an average annual deficit of 0.26 MAF. Based on these historical C2VSimFG-Kern results, the sustainable yield of the basin is approximately 1,050,000 AFY, plus or minus 10%.

4.2.1 Native Yield

Although not a SGMA requirement, the native yield is being used in Kern County GSAs for determining a portion of the groundwater allocation within the basin. The native yield is comparable to the sustainable yield except that the only recharge that is included in the calculation is the natural, unallocated portion of the groundwater recharge. For the Kern County Subbasin, this includes the groundwater recharge derived from precipitation or runoff from unallocated streams. The Kern River and Poso Creek, however, are allocated streams where specific agencies or parties have rights to specific volumes of flow.

The C2VSimFG-Kern model results over the historical base period 1995 to 2014 was again used for estimation of native yield. The model results were used to determine the amount of precipitation recharge over irrigated agricultural areas and the native/urban/undeveloped areas. The total and average annual volume of precipitation that percolates to groundwater during the 1995 to 2014 base period are listed in Table 13. The basinwide contribution is the relative proportion of the runoff along the basin margins from small, unallocated watersheds and inflow from the surrounding basin margin (from areas not defined as DWR groundwater basins). The results of this assessment based on the C2VSimFG-Kern results are shown in **Table 13** and are summarized below:

- The volume of precipitation that recharge the groundwater in the irrigated agricultural areas is 77,780 AFY.
- The volume of precipitation that recharges groundwater in the other areas is 132,981 AFY.

- The volume of inflow from unallocated small watersheds that recharges the groundwater in the irrigated agricultural areas is 48,760 AFY.

Totaling these inputs results in a native yield for the Kern County Subbasin is 259,520 AFY. The contribution per acre of approximately 0.144 acre-feet per acre is estimated by dividing the average annual contribution by the total area of the Kern County Subbasin (**Table 13**).

5. APPROACH FOR PROJECTED FUTURE WATER BUDGETS

Projected future baseline water budgets for the Kern County Subbasin were developed using the C2VSimFG-Kern. These projected water budgets establish expected baseline conditions to evaluate the impacts of GSP implementation. Three predictive scenarios were developed for the Kern County Subbasin, each representing a different expected future hydrologic condition, by adapting C2VSimFG-Kern as follows:

- Future Baseline Conditions: Repeat historical hydrology with expected future water supply
- 2030 Climate Conditions: 2030 climatic conditions and expected water supply
- 2070 Climate Conditions: 2070 climatic conditions and expected water supply

Projected future water budgets were developed for Baseline conditions and expected 2030 Climate Conditions and 2070 Climate Conditions over a 50-year planning and implementation horizon. These scenario models provide a basis of comparison for evaluating proposed sustainability management actions and projects over the SGMA planning and implementation horizon.

5.1 Assumptions

The C2VSim model was modified to incorporate projected future hydrology and land use using analog data from the historical C2VSim model. This approach meets GSP requirements using:

- A 50-year time-series of historical precipitation, evapotranspiration and stream flow information as the future baseline hydrology conditions;
- The most recent land use, METRIC-based evapotranspiration, crop coefficient and urban population growth information as the baseline condition for estimating future water demands;
- The most recent water supply projections as the baseline condition for estimating future surface water supply;
- DWR Climate Change Guidance and Data Sets to incorporate estimated climate change conditions for the Kern County Subbasin;
- Specialized analysis of the Kern River watershed and estimated runoff volumes under climate change conditions;
- Specialized analysis of CVP deliveries to Kern County under climate change conditions incorporating implementation of the San Joaquin River Restoration Program;
- Specialized analysis of SWP deliveries to Kern County under climate change conditions incorporating implementation of the OCAP Biological Opinion and recent changes in Table A and Article 21 allocations.

5.2 Projected Future SGMA Projects

Projected water budgets for the Kern County Subbasin were developed using the C2VSimFG-Kern to evaluate the performance of proposed management actions with respect to achieving groundwater sustainability. Participating agencies provided a list of projected future management actions to be implemented between WY 2021 and 2040. These projects were simulated under Baseline conditions and 2030 Climate Conditions and 2070 Climate Conditions using the C2VSimFG-Kern.

Proposed future projects and management actions were provided by 14 agencies. The types of proposed SGMA projects and management actions are summarized as follows:

- Demand Reduction is the volume of water reduced by changing the land use. These include:
    - Agricultural demand reduction projects include incentives or actions to reduce crop water use
    - Fallowing of agricultural land and conversion of agricultural land to recharge basins, and
    - Conversion of agricultural land to urban land.
- New Supply groups together planned increases in imported water supplies. These include:
    - Increased surface water imports generally resulting from projected water purchases.
    - New water conveyance facilities including pipelines and reservoirs to increase flexibility, and expansion of surface water delivery areas to reduce groundwater usage.
- Other Supply groups together proposed projects to increase local water supplies. These include:
    - Treated waste waters derived from both urban areas and oil production operations. Increased recharge occurs in both existing and new locations.
    - Increased stream flow diversions; these include exercising riparian water rights and diverting flood flows.
    - Reallocation of water; generally reducing sales of surface water and banked groundwater and using this water within the agency.
    - Brackish groundwater in areas not currently overdrafted will be treated and mixed with surface water to augment surface water supplies.

Some management actions are implemented gradually over many years, with savings increasing each year over the implementation period. Some management actions are implemented only in certain years (wet years, for example). The anticipated water supply benefit of the proposed SGMA projects and management actions steadily increases over the 20-year period from 2021 to 2040 to represent the implementation of the Kern County Subbasin GSPs as follows:

- about 87,000 AFY after the first five-year period (2021-2025)
- about 168,000 AFY after the second five-year period (2026-2030)
- about 300,000 AFY after the third five-year period (2031-2035)
- about 330,000 AFY after the fourth five-year period (2036-2040)

The anticipated water supply benefit of the proposed SGMA projects and management actions included in the C2VSimFG-Kern projected future simulations is 405,000 AFY over the period from 2041 to 2070. Implementation of these projects and management actions is staged over the 20-year implementation period are summarized in **Figure 15**.

6. PROJECTED FUTURE BASELINE DEVELOPMENT

Projected water budgets are required by GSP regulations to represent future conditions over a 50-year GSP planning and implementation horizon. A baseline condition was developed that projects water supply, demand and operations based on current land use requirements over the subsequent 50 years. The baseline then serves as a basis of comparison for evaluating proposed sustainability management actions and projects for achieving sustainability over the planning and implementation horizon. Each predictive scenario model simulates the 50-year planning and implementation period WY 2021-2070.

Development of the projected future baseline conditions is summarized below, and additional information is provided in **Attachment C**.

6.1 Projected Future Time Period Development

Water years 1995-2014 were chosen as a historical hydrology period because detailed demand and supply data are available for this period, and most subbasin water delivery infrastructure was fully developed by the middle of this period. The average Kern River inflow for this period is also very close to the long-term average Kern River inflow.

The projected future simulation period is based on repeating the WY2015 to 2014 historical study period. This period is only 20 years long, so a 50-year sequence of historical hydrology was developed by repeating data from this period in the sequence as shown in **Table 14**. The development of this sequence is summarized as follows:

- Simulation period WY2021 to WY2032 used the historical period WY2003 to WY2014.
- Simulation period WY202133 to WY2052 used the historical period WY 1995 to WY2014.
- Simulation period WY2053 to WY2070 used the historical period WY1995 to WY2012.

This sequence was developed to match long-term average flows on the Kern River, and to ensure that the baseline does not end in an extreme drought or extreme wet year. By starting the projected future simulation time sequence with WY2003, the 50-year hydrology period was approximately 100 percent of the long-term average streamflow conditions on the Kern River, as indicated by an average annual Kern River Index of 100 percent. The sequence includes the appropriate range of hydrologic conditions including extremely wet years and extended periods of drought.

C2VSimFG-Kern simulation results for the last timestep for the historical simulation (for September 30, 2015) were used as initial conditions for all projected future simulations, including initial conditions for the root zone, saturated and unsaturated aquifer zones, and small watersheds. Since the Historical C2VSimFG-Kern simulation period ends with WY 2015, all projected future scenarios also include estimated hydrology for WY 2016-2020. Model input data for WY 2016-2020 was developed by repeating model input data for recent years based on correlation with the San Joaquin Index (DWR, 2019). Additional information on the projected future time period development is provided in **Attachment C**.

6.2 Development of Key Baseline Data Sets

. Key required components for the Projected Future Baseline, as summarized in the DWR Water Budget BMP, include the following:

- The projected baseline hydrology conditions are based on 50-years of historical precipitation and streamflow.
- Surface water supply are based on available information from DWR and others to project future water imports from the State Water Project (SWP), Central Valley Project (CVC) - Friant-Kern (FK) and Kern River diversions. For the Kern River, recent diversion practices based on entitlements are used to develop a water use consistent with the baseline hydrology.
- WY 2013 land use was used as current land use for all scenarios as drought conditions likely reduced agricultural production in 2014 and 2015.
- Consumptive use for agriculture and undeveloped lands was based on the recent land use and METRIC-based evapotranspiration. Following DWR guidance, METRIC data over the baseline period was varied according to varying hydrologic conditions (e.g., water year type).
- Urban water demand was based on projections from recent urban water management plans and recent regulations for estimating future water use. Urban demand was estimated in the model based on projected urban population growth and per capita water demand information (including recent regulatory guidance).
- Small watershed inflows used the same parameters as the historical C2VSimFG-Kern model; however, volumes would vary based on changes in the precipitation and ET under the 2030 and 2070 climate change conditions.

Time-series input data were first developed for the Baseline scenario model for WY 2021-2070. The following time-series data were developed for each scenario:

- Precipitation rates
- Evapotranspiration rates
- Surface water inflow rates
- Surface water diversion and delivery rates
- Specified groundwater pumping rates

Development of this time-series input data generally involved repeating time-series data from the historical C2VSim model in the appropriate sequence. Baseline scenario model time-series data files were then modified following DWR guidelines to produce time-series input data for the 2030 Climate Conditions and 2070 Climate Conditions scenario models. C2VSim input data were modified only in Kern County. C2VSim input data for areas outside of Kern County were not modified. Details on how each data set was modified are provided below. Additional information on the projected future baseline development is provided in **Attachment C**.

6.2.1 Precipitation Rates

Precipitation rates for the Baseline scenario model were developed by repeating input precipitation rates from the C2VSim model in the appropriate sequence. DWR provided monthly change factors for precipitation under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km VIC grid for calendar years 1915 through 2011. The VIC grid ID for each C2VSim element in the Kern County Subbasin Zone of Interest was identified and the Baseline scenario precipitation rates were multiplied by the appropriate factors to produce time-series precipitation rates for the 2030 Climate Conditions and 2070 Climate Conditions scenarios. Factors for calendar years 1959-1961 were used as analogs for 2012-2014.

6.2.2 Evapotranspiration Rates

Evapotranspiration rates for the Baseline scenario model were developed by repeating input evapotranspiration rates from the C2VSim model in the appropriate sequence. DWR provided monthly change factors for ETo values under 2030 and 2070 central tendency climatic conditions on a 6 km x 6 km VIC grid for calendar years 1915 through 2011. The VIC grid IDs for each C2VSim subregion in the Kern County Subbasin Zone of Interest were identified and area-weighted monthly ETo change factors were calculated for each subregion. Baseline scenario ETc rates for each subregion were then multiplied by the appropriate area-weighted ETo change factors to produce time-series ETc rates for the 2030 Climate Conditions and 2070 Climate Conditions scenarios. Factors for calendar years 1959-1961 were used as analogs for 2012-2014.

6.2.3 Surface Water Inflow Rates

Surface water inflow rates for the Baseline scenario model were developed by repeating input inflow rates from the C2VSim model in the appropriate sequence. DWR provided unimpaired streamflow change factor datasets for Central Valley streams, and an Excel spreadsheet tool to correct basin unimpaired streamflow with these change factors. These unimpaired, streamflow change factors and spreadsheet were used to modify Baseline inflows to produce 2030 Climate Conditions and 2070 Climate Conditions scenario time series inflows for Poso Creek and White River.

Kern River flows at First Point for the Baseline scenario model were developed by repeating historical inflow rates from the C2VSim model in the appropriate sequence. Flows on the Kern River are regulated, so the unimpaired streamflow method was not appropriate for estimating future flows under 2030 and 2070 climatic conditions. Projected Kern River flows at First Point under 2030 and 2070 central tendency conditions were estimated by GEI (2018) for calendar years 1956-2010 hydrology. This analysis considered the impacts of reduced runoff in each sub-watershed contributing to the Kern River to develop revised streamflow estimates for Kern River at First Point. Future scenario Kern River at First Point flows for 2011-2014 were estimated using flows for analog years with similar annual flows and monthly flow pattern. Analog years 1986, 1991, 1990 and 1961 respectively were used for 2011-2014 in the future scenarios.

6.2.4 Surface Water Deliveries

Surface water delivery rates for the Baseline scenario model were developed by first repeating input surface water delivery rates from the C2VSimFG-Kern in the appropriate sequence, and then modifying selected data sets. Surface water deliveries from in-basin sources such as Oil Field Recovery were held constant at 2015 rates for all future scenarios.

The Kern County Subbasin is served by both the CVP and the SWP. Recent changes in CVP and SWP operations and their impacts on future surface water supplies are reflected in surface water diversion rates for the three scenarios. Future CVP deliveries will be affected by implementation of the San Joaquin River Restoration Program (SJRRP). Future SWP deliveries will be affected by operational changes implemented between 2004 and 2008 including the OCAP Biological Opinion, reduced Table A contract amounts and reduced Article 21 deliveries. DWR provided projected future deliveries from the CVP and SWP for water years 1922-2003, derived from CalSim-II modeling conducted for WSIP. DWR's CVP and SWP projections as provided do not fully incorporate these operational changes.

The Friant Water Authority (2018) used CalSim-II to develop projected surface water deliveries with SJRRP implementation under hydrological conditions representing the Current Baseline, 2030 and 2070 climate conditions by delivery class for water years 1922-2003, and estimated allocations to each CVP contractor (FWUA 2018). The 2015.c data set was used for Baseline scenario CVP deliveries, the 2030.c data set was used for 2030 Climate Conditions scenario CVP deliveries, and the 2070.c data set was used for the 2070 Climate Conditions scenario CVP deliveries. CVP deliveries for water years 2004-2014 were estimated using deliveries for analog years 1951-1961; these analog years have a similar distribution of water availability.

The SWP projections representing 2030 and 2070 climatic conditions provided by DWR were modified to incorporate the impacts of SWP operational changes in the three scenarios. 2019 SWP Table A contract amounts were used to allocate these SWP deliveries to individual districts. In summary:

- Baseline Hydrologic Conditions
    - WY1995to WY2003 conditions are based on 2030-Level CALSIM increased by 3.03 %
    - WY2004 to WY2007 conditions are based on historical data adjusted for OCAP BO
    - WY2008 to WY2014 conditions are based on historical data with assumption that OCAP BO adjustment are already factored into the data
- 2030 Climate Change Hydrologic Conditions
    - WY1995to WY2003 conditions are based on 2030-Level CALSIM Projection
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 3.03 %
    - WY2008 to WY2014 conditions are based on historical data reduced by 3.03%
- 2070 Climate Change Hydrologic Conditions
    - WY1995to WY2003 conditions are based on 2070-Level CALSIM Projection
    - WY2004 to WY2007 conditions are based on OCAP BO adjustment reduced by 8.09%
    - WY2008 to WY2014 conditions are based on historical data reduced by 8.09%

Within the Kern County Subbasin, water users engage in complex real-time water trading and wheeling activities to maximize water utilization, minimize waste and energy consumption, and meet immediate water needs. It would be difficult to project future surface water deliveries in the Kern County Subbasin without the use of a surface water allocation model that simulates these water trading and wheeling activities. Therefore, for this modeling effort, monthly future scenario agricultural, urban and recharge deliveries from sources originating outside the basin were estimated by adjusting historical deliveries by the ratio of (total scenario inflows)/(total historical inflows) for each month, where total inflows are the sum of CVP deliveries, SWP deliveries and Kern River at First Point. In addition, Kern River at First Point flows above historical flows under the 2030 Climate Conditions and 2070 Climate Conditions scenarios were proportionally added to selected recharge deliveries. This method is deemed adequate for subbasin-level future scenario analyses.

Some future scenario data sets did not cover the entire period from October 1994 through September 2014. In these cases, data from an analog historical period with similar water availability was used to fill in the missing data. The analog years for each data type are summarized as:

- For CVP deliveries (CalSim-II data), water years 1951 through 1961 were used as analogs for missing water years; these analog years have a similar distribution of water availability.
- Projected future Kern River at First Point flows for calendar years 1986, 1991, 1990 and 1961 were used as analogs to missing years 2011 through 2014; each of these analog years had a similar historical annual flow volume and monthly distribution.
- For climatic data, water years 1959 through 1961 were used as analogs to 2012 through 2014.

6.3 Development of Climate Change Conditions

Input data for the C2VSimFG-Kern were modified to simulate three future climatic scenarios. Historical precipitation, evapotranspiration, land use, population, surface water inflow and surface water delivery rates were replaced with projected future values for WY 2016-2070 for Future Baseline Conditions. The Future Baseline Conditions were then modified to simulate 2030 Climate Conditions and 2070 Climate Conditions for WY 2021-2070. Water management agencies in the Kern County Subbasin provided a broad suite of proposed water management and conservation projects to increase water supplies and reduce water management demands. These projects are added to the C2VSimFG-Kern to assess the long-term impacts of these projects under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios.

Projected water budgets under Future Baseline Conditions, 2030 and 2070 Climate conditions are used to evaluate the potential effects of future baseline and extended dry conditions with respect to achieving sustainability. DWR published a *Modeling Best Management Practices* Guidance Document (DWR 2016B) that outlines DWR recommendations for developing and running predictive scenarios. The C2VSimFG-Kern was modified following these recommendations to develop the Baseline scenario model. DWR also issued the *Guidance for Climate Change Data Use During Sustainability Plan Development* Guidance Document (DWR 2018A) that outlines how DWR recommends that climate change be addressed under SGMA. Baseline scenario data sets were modified using DWR climate change data sets for Kern County following procedures outlined in the Guidance Documents to develop the 2030 Climate Conditions and 2070 Climate Conditions scenario models.

6.3.1 Groundwater Banking Assumptions

Groundwater banking operations are simulated in the C2VSimFG-Kern with surface water diversions to recharge basins and specified pumping rates for groundwater extractions. All surface water deliveries were adjusted under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios. Surface water deliveries to recharge basins were first adjusted by the same amount as other surface water deliveries, then increased if Kern River flows were greater than historical flows. Specified pumping rates for groundwater extraction were not modified.

The out-of-basin banking obligations were assumed to follow a similar pattern where groundwater banking recharge would be affected by the limitation on surface water deliveries, but that banking recovery would remain similar to historical volumes. Therefore, the historical groundwater banking obligation were adjusted under the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios by the same percentage as the surface water deliveries; however, the groundwater banking recovery was assumed to remain the same. For the projected future scenarios, the out-of-basin banking obligations were calculated as follows:

- For the Baseline scenarios, the out-of-basin banking obligations were calculated as 69,632 AFY based on surface water deliveries of about 81% of historical.
- For the 2030 Climate scenarios, the out-of-basin banking obligations were calculated as 67,913 AFY based on surface water deliveries of about 79% of historical.
- For the 2070 Climate scenarios, the out-of-basin banking obligations were calculated as 64,474 AFY based on surface water deliveries of about 75% of historical.

The tracking is done using the same post processing process as applied to the historical groundwater assessment by assigning the portion of the groundwater recharge as an out-of-basin banking obligation.

7. PROJECTED FUTURE C2VSIMFG-KERN SIMULATION RESULTS

The C2VSimFG-Kern was run for three scenario that estimate hydrologic conditions of Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios both with and without the proposed SGMA projects and management actions for a total of six projected future scenarios.

7.1 Projected Future Water Budgets

C2VSimFG-Kern calculates water budget components each month of the simulation period for each future scenario. Projected future water budgets were developed based on the C2VSImFG-Kern simulation results both with and without the proposed SGMA management actions were then compared to results for the baseline future scenarios to assess how these changes enhance groundwater sustainability within the Kern County Subbasin.

The average annual value of each water budget component summarizes the impacts over 50 years with current water demands. The water budget results for the six Projected Future Scenarios are presented in **Tables 15 through 20**, and include averages over three different periods, which include:

- **WY2021 to WY2040** – Implementation Period representing the 20-year period required by the SGMA regulations to implement projects and management actions to achieve sustainability.
- **WY2041 to WY2070** – Sustainability Period representing the 30-year hydrologic period following the Implementation Period to assess the long-term sustainability of the proposed projects and management actions with variable climatic conditions including periods with above average rainfall and extended droughts.
- **WY2021 to WY2070** – Simulation Period representing the entire 50-year projected future hydrologic conditions.

Changes to surface water diversions included monthly increases or reductions to 37 model diversions and the addition of 7 new diversions. Ten new groundwater pumping wells were added to simulate a new groundwater pumping program. Agricultural land use was converted to native vegetation in ten management areas, and to urban land use in three management areas. These changes were applied to the Baseline, 2030 Climate Conditions and 2070 Climate Conditions scenarios.

A brief summary for each of the six projected future water budgets is provided below. The following provides a summary of the projected future simulations using C2VSimFG-Kern. Additional information is provided in **Attachments D** (Baseline scenarios) **and E** (2030 and 2070 Climate Change Scenarios).

7.1.1 Baseline Condition Water Budgets

The Baseline Scenarios simulate how the Kern County Subbasin aquifer would respond if the recent hydrology were repeated with current expected surface water availability and current land use. The Baseline Scenarios were run both with and without SGMA Projects.

For the Baseline Scenario without SGMA Projects, the groundwater budget for WY2021 to WY2040 (**Table 15**) repeats the 20-year historical hydrologic period so it provides a direct comparison of the differences between the projected future baseline without SGMA Projects and the historical condition. The primary difference in setting up the projected future baseline is a nearly 20% decrease in imported surface water deliveries primarily from the SWP due to the OCAP Biological Opinion. As a result, total net outflows increase about 43,000 AFY and total net inflows for the projected future baseline are about 101,000 AFY lower. This is mostly because of increased groundwater pumping and decreased managed aquifer recharge due to a decline in imported SWP water. Over this period, the average groundwater pumping of 1,634,816 AFY, which includes agricultural pumping, urban pumping and exported water. As a result, the change in groundwater storage for projected future baseline results in an additional loss of about 144,000 AFY over the 20 year period representing about a 50% increase in groundwater storage decline for the baseline conditions.

The Baseline Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the Baseline Scenario. No other changes were made except for the addition of the SGMA projects to provide a direct comparison of the relative benefits of the over 400,000 AFY of proposed SGMA projects and management actions. The groundwater budget for the Baseline Scenario with SGMA Projects is provided in **Table 16**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 16**) with the same period from the Baseline Scenario (**Table 15**) provides an evaluation of groundwater conditions after the SGMA projects and management actions have been fully implemented. As a result, total net inflows increase about 109,000 AFY due to increased managed aquifer recharge and deep percolation. The total net outflows decrease about 281,000 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

The change in groundwater storage for projected future baseline with SGMA Projects improves by about 390,000 AFY. This change results in a net gain in groundwater in aquifer storage over the WY2041 to WY2070 sustainability period of about 35,000 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is presented in **Figure 16**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070.

A comparison of the average annual water budget components for the two different Baseline Scenarios is presented in **Figure 17**. Over this period, the average groundwater pumping of 1,294,485 AFY for the Baseline Scenario with SGMA Projects (which includes agricultural pumping, urban pumping and exported water) is over 300,000 AFY less than in the Baseline Scenario.

7.1.2 2030 Climate Change Water Budgets

The 2030 Scenarios simulate how the Kern County Subbasin aquifer would respond assuming hydrologic conditions representing potential climate change based on the DWR Climate Change Guidance (DWR 2018A). The 2030 DWR climate change factors were applied to the Baseline Scenario Conditions. Additional adjustments were made to the imported surface water supplies from the SWP, CVP and Kern River, but these accounted for about an additional 2% decrease from the Baseline Conditions. The 2030 Climate Change Scenarios were run both with and without SGMA Projects. Results for climate change budgets are illustrated in Figures 19, 20, and 21.

The groundwater budget for the 2030 Climate Scenario without SGMA Projects over WY2041 to WY2070 (**Table 17**) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in inflows of about 45,000 AFY, however, the net outflows increase by about 104,000 AFY. This is mostly attributed to the climate shift to earlier rainfall making more surface water available for managed aquifer recharge during the winter but less available for irrigation in the summer resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 59,000 AFY due to the climate change assumptions.

The 2030 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the 2030 climate change conditions. No other changes to this scenario. The groundwater budget for the 2030 Climate Scenario with SGMA Projects is provided in **Table 18**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 17**) between the two 2030 Climate Scenarios, the total net inflows increase about 93,000 AFY due to increased managed aquifer recharge and deep percolation. The total net outflows decrease about 302,000 AFY due mostly to decreased groundwater pumping with agricultural demand reduction management actions.

The change in groundwater storage for the 2030 Climate Scenario with SGMA Projects improves by about 396,000 AFY. This change results in a net decline in groundwater in aquifer storage over WY2041 to WY2070 of about 17,000 AFY. A comparison of the annual change in groundwater storage over the 50-year hydrologic period is presented in **Figure 21**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline Scenario with SGMA Projects.

A comparison of the average annual water budget components for the two different Baseline Scenarios is presented in **Figure 19**. Over this period, the average groundwater pumping of 1,384,263 AFY for the 2030 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 340,000 AFY less than in the 2030 Climate Scenario without SGMA Projects.

7.1.3 2070 Climate Change Water Budgets

The 2070 Scenarios simulate how the Kern County Subbasin aquifer would respond assuming hydrologic condition representing potential climate change based on the DWR Climate Change Guidance (DWR 2018A). The 2070 DWR climate change factors were applied to the Baseline Scenario Conditions. Additional adjustments were made to the imported surface water supplies from the SWP, CVP and Kern River, but these accounted for an additional 6% decrease from the Baseline Conditions. The 2070 Climate Change Scenarios were run both with and without SGMA Projects.

The groundwater budget for the 2070 Climate Scenario without SGMA Projects over WY2041 to WY2070 (**Table 19**) is compared the same period for the Baseline Scenario without SGMA Projects to assess the relative change due to the climate change assumptions. The results show a net increase in inflows of about 68,000 AFY, however, the net outflows increase by about 235,000 AFY. This is mostly attributed to an even greater climate shift to earlier rainfall making more surface water available for managed aquifer recharge during the winter but less available for irrigation in the summer resulting in higher groundwater pumping. The net change in groundwater storage is an additional decline of about 167,000 AFY due to the climate change assumptions.

The 2070 Climate Scenario with SGMA Projects simulates the proposed SGMA projects and management actions applied to the 2070 climate change conditions. No other changes to this scenario. The groundwater budget for the 2070 Climate Scenario with SGMA Projects is provided in **Table 20**. Comparing the groundwater budget for WY2041 to WY2070 (**Table 19**) between the two 2070 Climate Scenarios, the total net inflows increase about 80,000 AFY due to increased managed aquifer recharge and deep percolation. The total net outflows decrease about 327,000 AFY due mostly to decreased groundwater pumping due to agricultural demand reduction management actions.

The change in groundwater storage for 2070 Climate Scenario with SGMA Projects improves by about 407,000 AFY. This change results in a net decline in groundwater in aquifer storage over the WY2041 to WY2070 of about 115,000 AFY. A comparison of the annual change in groundwater storage over the 50-

year hydrologic period is presented in **Figure 21**. The time series shows that change in groundwater storage has stabilized to slightly increasing over the period from WY2041 to WY2070, but at a level below the results for the Baseline and 2030 Scenarios with SGMA Projects.

A comparison of the average annual water budget components for the two different Baseline Scenarios is presented in **Figure 20**. Over this period, the average groundwater pumping of 1,491,837 AFY for the 2070 Climate Scenario with SGMA Projects, which includes agricultural pumping, urban pumping and exported water, is over 360,000 AFY less than in the 2070 Climate Scenario without SGMA Projects.

7.2 Projected Future Sustainability Assessment

To assess the sustainability of the proposed GSP plans, the C2VSimFG-Kern model future scenario input files were modified to incorporate all of the proposed SGMA projects and management actions.

7.2.1 Change in groundwater storage

Groundwater sustainability for the Kern County Subbasin was assessed using annual changes in groundwater storage. As discussed in Section 7.1, the decline in groundwater storage of the three future baseline scenarios is significantly mitigated by the implementation of the proposed SGMA projects and management actions. An assessment of the projected future groundwater storage change for the six projected future scenarios is summarized in **Table 21**.

The Change in Net Operational Budget presented in **Table 21** provides the net difference in inflows and outflows without consideration of subsurface flow with adjacent groundwater basins. This provides a measure of the natural and managed water supply within the groundwater basin without being influenced either positively or negatively by the subsurface flow. For the Kern County Subbasin, the net operational flow varies by about 50,000 to 80,000 AFY indicating that most of the groundwater storage change is due to conditions within the basin.

The Adjustments to Groundwater (GW) Storage Change are made to account for limitations in either the underlying conceptual model of C2VSimFG-Kern or the setup of the projected future scenarios. The two adjustments made to the projected future water budgets include:

- **Adjustment for Excess Basin Outflows** is the difference in simulated basin outflow that is attributed to addition of SGMA projects in Kern County without comparable SGMA projects added to adjacent basins. Adjustment assumes that this difference is due to limitation of simulation, and that this difference would remain in Kern County when SGMA projects from adjacent basin are included in simulation.
- **Adjustment for Excess Kern River Outflow** is the increase in simulated groundwater outflows to Kern River relative to Baseline condition that are attributed to SGMA Projects and Climate Change. The model is not optimized for river management. Because the Kern River is a highly managed system, the assumption is that in practice this water would be recovered for beneficial use rather than be tolerated as a loss of water from the basin.

These adjustments resulted in an overall improvement in the change in groundwater storage for the projected future water budgets. For the scenarios that include the SGMA Projects, the change in groundwater storage improves by 38,000 AFY (Baseline), 51,000 AFY (2030 Climate Change), and 63,000 AFY (2070 Climate Change). As a result of these adjustments, the adjusted change in groundwater storage for the 2030 Climate Scenario with SGMA Projects changes from a decline of 17,170 AFY to an increase of 34,012 AFY.

7.2.2 Sustainability Assessment

As defined by SGMA, the sustainable yield of a basin is the amount of groundwater that can be withdrawn annually without causing undesirable results. Although the SGMA regulations require that a single value of sustainable yield must be calculated basinwide, it should be noted that the sustainable yield can be changed with implementation of recharge projects, variations in climate, or changes in stream flow conditions. For the projected future scenarios, both the climate and the managed water supply operations are significantly affected which would lead to a change in the sustainable yield for the basin.

For the sustainability assessment, the sustainable yield was recalculated using the method described in Section 4.2, and the results are presented in **Table 22**. Without the SGMA projects and management actions, the percentage of the Average Annual Difference to the total groundwater pumping provides context to compare the significance of the level of groundwater pumping for the basin. For the scenarios without SGMA projects and management actions, the groundwater pumping exceeds the sustainable yield on the order of 40% to 50% (**Table 22**). However, with the proposed SGMA projects and management actions, the groundwater pumping is equal to near equal to the sustainable yield of the basin for the baseline and 2030 climate scenarios and is within 10% of the sustainable yield for the 2070 climate scenario (**Table 22**). This assessment indicates that the proposed SGMA projects and management actions are of sufficient magnitude that, if fully implemented, would lead to groundwater sustainability for the Kern County Subbasin after 2040.

7.2.3 Minimum Thresholds and Measurable Objectives

Another requirement of SGMA is for groundwater levels not to cross their minimum thresholds to the extent that undesirable results would occur in the basin, and moreover, that proposed SGMA projects and management actions would lead to meeting the measurable objectives. For the Kern County Subbasin, 190 representative monitoring locations have been defined by each of the GSAs across the Kern County Subbasin. Each of these 190 locations has a minimum threshold and measurable objective assigned to it.

The C2VSimFG-Kern results were used to assess whether the simulated groundwater levels would meet the minimum threshold and measurable objective for each well. Because C2VSimFG-Kern is not fully calibrated, the results are presented as relative change (which does not require calibration) instead of simulated groundwater levels. Future change in groundwater level was determined for each of the 190 locations for each of the six projected future simulations. The change was calculated from the simulated March 2015 groundwater levels from the model. The change in groundwater level was then applied the measured March 2015 groundwater level at the monitoring location.

Figure 22 provides four representative examples of the simulated hydrographs using this method. Hydrographs of the simulated groundwater levels relative to the minimum thresholds and measurable objectives for all 190 locations are provided in **Attachment F**. In general, across most areas of the basin, groundwater levels fall near or below the minimum thresholds without the SGMA projects but are typically above the minimum threshold for the simulations that include the SGMA projects.

Some locations, especially along the eastern and western basin margins, show an unusual pattern that is likely influenced by issues with the conceptual model incorporated into C2VSimFG-Kern for these locations. The hydrographs for these areas are not considered to be representative of actual conditions that would physically occur. This is a limitation to the model that should be addressed in the future.

8. VALIDATION OF C2VSIMFG-KERN PERFORMANCE

The C2VSimFG-Kern performs well within the central part the Kern Subbasin and the White Wolf Subbasin. The model does not perform as well east of the Friant-Kern Canal or west of the California Aqueduct. The geologic and hydrogeologic conceptual models within the central part of the Kern Subbasin and the White Wolf basin appear to be generally realistic. The geologic and hydrogeologic conceptual models appear to be very poor in the areas where the model does not perform well.

8.1 C2VSimFG-Kern Validation

One of the concerns for the modeling is the overall calibration of C2VSimFG-Beta in Kern County. As discussed above, the assumption is that C2VSimFG-Beta was developed using reasonable care in developing the geologic framework and developing a consistent regional methodology for determining aquifer properties. An identified weakness of the C2VSimFG-Beta is the quality of data used in developing the overall water balance such as the extent of the groundwater banking operations in Kern County. The issues with the water balance are considered the primary contributing factor affecting the calibration of the C2VSimFG-Beta; the hydrogeologic conceptualization is reasonably accurate for a regional planning analysis.

To address these concerns, a validation analysis was performed for C2VSimFG-Kern by comparing simulations results to field measured groundwater level data collected during the Study Period and comparing those to a similar set of residuals from the C2VSimFG-Beta model. The statistical results of this analysis should be comparable, if not better, for C2VSimFG-Kern compared to the C2VSimFG-Beta results.

The analysis used 42,058 groundwater levels measurements collected from 558 monitoring wells in the Kern County and White Wolf Subbasins. The data were collected by Kern County Water Agency, the Kern Fan Monitoring Committee, the DWR Water Data Library, and local agencies. For each location, the residual was calculated as the simulated groundwater level minus the measured groundwater level based on the well measurement date. A brief of the statistical measures used to evaluate the calibration results (shown on **Table 23**) is summarized below:

- The residual mean is computed by dividing the sum of the residuals by the number of residual data values. The closer this value is to zero, the better the calibration especially as related to the water balance and estimating the change in aquifer storage. The residual mean of 17.3 feet for C2VSimFG-Kern is an improvement of 47% over the 32.6 feet from C2VSimFG-Beta.
- The absolute residual mean is the arithmetic average for the absolute value of the residual, so it provides a measure of the overall error in the model. The absolute residual mean of 37.4 feet for C2VSimFG-Kern is an improvement of 34% over the 56.8 feet from C2VSimFG-Beta.
- The residual standard deviation evaluates the scatter of the data. A lower standard deviation indicates a closer fit between the simulated and observed data. The standard deviation for the calibrated model is 45.5 feet for C2VSimFG-Kern, which is an improvement of 16% over the 54.0 feet from C2VSimFG-Beta.

- The Root Mean Square (RMS) Error is the square root of the arithmetic mean of the squares of the residuals and provides another measure of the overall error in the model. The RMS Error for the calibrated model is 50.0 feet for C2VSimFG-Kern, which is an improvement of 32% over the 73.5 feet from C2VSimFG Beta.
- The correlation coefficient ranges from 0 to 1 and is a measure of the closeness of fit of the data to a 1 to 1 correlation. A correlation of 1 is a perfect correlation. The correlation coefficient of 0.76 for C2VSimFG-Kern is an improvement of 34% over the 0.52 from C2VSimFG Beta.
- Another statistical measure is the ratio of the standard deviation of the mean error divided by the range of observed groundwater elevations. This ratio shows how the model error relates to the overall hydraulic gradient across the model. The ratio for C2VSimFG-Kern is 0.061 feet, which is an improvement of 34% over the 0.92 from C2VSimFG Beta.

Considering these results in context with the overall range of measurements of 616 feet, the residual mean of 17.3 feet represents a relative percentage difference of less than three percent. For the absolute residual mean of 37.4 feet, the relative percentage difference is about six percent. Despite this improvement in model performance, the model is not considered fully calibrated. However, C2VSimFG-Kern is reasonably validated for assessing groundwater level changes on the scale for the purposes of SGMA planning.

8.2 Sensitivity Analysis

The C2VSim Kern County Update model was not formally calibrated. Some physical parameters were adjusted to improve model performance in specific areas. A sensitivity analysis was conducted on the adjusted model to understand how variations in model parameters affect model results. Eight physical parameter sets were systematically varied and model results compared to the base model for a selected group of groundwater hydrographs. The root mean squared error between observed and simulated values was calculated for the original parameter set and after varying each parameter set upward and downward by a set factor. Results are presented in **Attachment G**. This sensitivity analysis shows that the hydrologic parameter values in the C2VSim Kern Subbasin Update are generally within an acceptable range. A full model calibration would likely improve model performance.

8.3 Peer Review Process

Todd Groundwater worked with Woodard and Curran (W&C) throughout the model development process as W&C conducted an on-going peer review of model input files. W&C staff have developed several IWFM-based models and worked with DWR to develop C2VSimFG-Beta. Their reviews helped ensure that the model update used best practices when incorporating new data. Documentation of the peer review process is provided in **Attachment H**. The updated C2VSimFG-Kern input files for the Kern Subbasin were shared with DWR for incorporation into future C2VSim public releases.

The more general assumptions in C2VSimFG-Beta were replaced with local data and knowledge that are regionally or locally significant for WY 1995-2015. This update employed a phased approach.

1) Phase 1 revisions address components of Regional Significance that require significant changes to the overall model input file structure. These include
   a) Surface water delivery volumes, application areas and use by water district
   b) Groundwater banking recharge, recovery and application of recovered water
   c) Evapotranspiration rates and irrigation demand based on ITRC METRIC data (ITRC 2017);

   d) Urban population and per capita demand, including addition of an urban zone for Metropolitan Bakersfield; and
   e) Addition of groundwater extraction wells for groundwater banking projects.

2) Interim Review
   a) The Woodard & Curran Peer Review Team
   b) Kern County Subbasin water districts and purveyor's local data review
   c) Stakeholder input

3) Phase 2 revisions address components of Local Significance that generally require modifications of parameters within the existing C2VSim model input file structure.
   a) Local water sources and demands of significance to individual Districts/GSAs;
   b) District pumping for in-district delivery via surface water canals where significant;
   c) District recharge operations utilizing canals, stream channels, and basins;
   d) Wastewater disposal and land application; and
   e) Review and limited adjustment of model parameters.

4) Interim Review by same reviewers listed in item

5) Phase 3 revisions include addressing comments and incorporating new data from the Interim Reviews

6) Interim Review by same reviewers listed in item 2

7) Tabulate model-derived water budgets for Peer-Review and GSP Use

In each update phase, current and historical water budgets for zones representing water agency service areas were produced with the revised C2VSim model incorporating corrected local data. These water budgets were shared with participating agencies for review, to ensure that C2VSim correctly represented local water balances. Where necessary, participating agencies provided additional data which was incorporated into the C2VSim model.

8.4 Limitations to C2VSimFG-Kern

The C2VSimFG-Kern performs well in the Kern Subbasin, producing simulated water budget components that generally match historical values compiled by local agencies. The C2VSimFG-Kern also produces groundwater hydrographs that closely match observed hydrographs in the central part of the Kern Subbasin. The model is well suited to estimating the impacts of management actions on subbasin groundwater storage.

The C2VSim model update was limited in scope, and some model components do not perform well. These components do not reduce model capabilities with respect to GSP development but limit the usefulness of the model for other types of studies. The Kern Subbasin portion of the C2VSim model is not calibrated, and although the land surface water budget components are generally accurate, groundwater conditions and stream flows are poorly simulated in much of the subbasin; this is not significant as it is a very small volume.

The C2VSimFG-Kern is a reliable and defensible tool to support planning future groundwater conditions and estimating the potential hydrological impacts of future climate conditions and management actions at the subbasin level. DWR recommends updating and refining models used in GSPs to incorporate new data including that in annual updates. Refining Kern Subbasin hydrologic modelling tools to replicate district-level historical conditions will provide a reliable means of assessing future effects of management actions at the district level for future GSP development. The following actions and model improvements are recommended:

- **Improve streamflow simulations of the Kern River and Poso Creek.** Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. Some rejected recharge occurs in the Kern Fan area in very wet years, with significant outflow of groundwater to the Kern River especially in the Kern Fan banking area (i.e., rejected recharge). This has been an ongoing issue and needs to be addressed for the projected future water budgets so that banking recharge volumes can be better matched in the model.
- **Improve the geologic and hydrogeologic conceptual model of the Kern County portion of the Central Valley.** A hydrogeologic conceptual model is a framework for understanding where groundwater exists, where it flows, and how groundwater interacts with surface water bodies and the land surface. A geologic conceptual model provides a framework for understanding the geologic features that control groundwater movement. Quantitative analysis of Kern Subbasin groundwater flow is severely hampered by the lack of detailed geologic and hydrogeologic conceptual models of the areas outside the central alluvial basin. Geologic and hydrogeologic conceptual models will provide a foundation for the quantitative analysis of the groundwater flow system, and the framework for modeling the system. Key steps are:
    - Develop detailed geologic and hydrogeologic conceptual models of the Kern Subbasin.
    - Identify the locations and characteristics of natural features that affect groundwater recharge and movement (faults, ridges, clays).
    - Understand water occurrence and movement in areas outside the central Kern subbasin.
    - Develop water quality maps (natural constituents and anthropogenic constituents).
    - Modify the Kern Subbasin model to conform to the updated conceptual models.
- **Simulation of deep percolation and small watersheds.** Unreasonably high deep percolation (return flows) of the applied water in some areas has led to unreasonably elevated pumping rates to compensate. One problem is high root zone parameters in certain areas that were identified and corrected to better reflect local soil conditions. Because the excess pumping was returning to groundwater, the change has little effect on the basin change in storage, but the pumping and deep percolation are now more in line with local estimate.
- **Investigate development of a stand-alone Kern Subbasin model.** The C2VSim model provided by DWR and updated with local data is adequate for GSP preparation. However, this model may not meet all of the groundwater modeling needs of Kern Subbasin stakeholders. In addition, running a full Central Valley simulation model imposes longer model run times and reduces model flexibility. Stakeholders should undertake a comprehensive study to develop a list of their integrated (groundwater and surface water) modeling needs, and then decide whether further improving the C2VSim model or developing a new integrated hydrologic model is the best way to address subbasin modeling needs. This decision should be made before the end of 2020 to allow sufficient time to develop a new model or improve the C2VSim model in time for use in development of the 2025 GSP.
- **Adjust the finite element grid to honor water management boundaries.** The C2VSim model grid is a randomly generated grid that does not conform to any local features other than natural

surface water channels. This limits the spatial accuracy of model inputs and the precision and flexibility of water budget outputs. Adjusting the grid to match district and agency boundaries, historical delivery areas, water management units within districts, and geologic and hydrologic features would greatly enhance model capabilities.

- **Quantify boundary flows.** Significant uncertainty exists regarding the rates and timing of groundwater flows into the Kern Subbasin from surrounding watersheds, and groundwater flows from the Kern Subbasin to Kings and Tulare counties to the north. Reliable estimates of boundary flows will improve model performance in boundary areas.
- **Utilize more complex water management features of IWFM.** The Kern Update process modified information within the existing C2VSim model structure to improve model performance within the Kern Subbasin. The IWFM application has several features that could be further utilized to improve model performance.
    - Adjust the agricultural crops to better match the Kern County crop mix (for example, create separate crop categories for carrots, young and mature almonds, young and mature pistachios, etc.).
    - Implement multi-cropping with semiannual or quarterly land use.
    - Some C2VSim data are organized by DWR subregions, which represent heterogeneous areas with homogeneous data. Developing Kern Subbasin subregions and organizing model input data by these subregions may provide a better representation of local hydrologic conditions.
- **Calibrate the improved model for the Kern Subbasin**. DWR did not fully calibrate the Kern County portion of the C2VSim model, owing to both poor historical input data and a lack of calibration data sets. The Kern Update process significantly improved the historical data in the model, developed some calibration data sets, and included limited adjustment of model parameters. The updated model performs adequately in the central part of the Kern Subbasin and poorly in areas outside the central part of the basin. Once the above improvements are completed, the Kern County portion of the resulting model should be fully calibrated to ensure that it performs well throughout the Kern Subbasin.

9. CONCLUSIONS

This brief summary provides an overview of the findings and conclusions of the modeling results for the Kern County Subbasin using C2VSimFG-Kern.

9.1 Findings of the C2VSimFG-Kern Application and Results

The subbasin-wide update of C2VSimFG-Kern incorporated data from many local agencies. Each participating agency provided data for their jurisdiction for use in improving the model. This included managed water supply data (e.g., surface water deliveries, land use, irrigation demand, return flows, and groundwater banking), stream and groundwater monitoring data, geologic data, and other relevant data. This information was compiled and used to improve C2VSimFG-Kern performance in the Kern County Subbasin.

The C2VSimFG-Kern model development and the water budget analysis were designed to fulfill the GSP requirement for a coordinated subbasin-wide water budget analysis, while also providing information required to fulfill other GSP requirements. The C2VSimFG-Kern was provided to DWR so the Kern Subbasin revisions can be incorporated into their master version of the C2VSim model.

The historical water budget analysis indicates that the Kern County Subbasin was in a state of overdraft equivalent to the long-term decline in groundwater storage from WY1995 to WY2014 of 277,144 AFY. Projected Future simulations indicate that the proposed SGMA projects and management actions in the Kern County GSPs are sufficient for the Kern County Subbasin to achieve sustainability under Baseline and 2030 Climate Change conditions.

9.2 Applicability of C2VSimFG-Kern Simulation Results

Based on the model validation, C2VSimFG-Kern provides a useful planning tool to evaluate potential future trends in groundwater in the Kern County Subbasin. The model validation demonstrated the capability of C2VSimFG-Kern to reasonably simulate the groundwater elevations and trends during the period from 1995 through 2015 based on the comparison to measured data.

The ability to reasonably simulate historical conditions provides confidence that C2VSimFG-Kern can be used to simulate potential future conditions. The model has the capability to simulate the most beneficial application of water projects that would provide the long-term benefit to the area. For the future case scenarios, the general practice is to evaluate model results with respect to long-term trends. Therefore, as a planning tool, it is most beneficial to run the model in relation to a base case and to evaluate the relative difference between the model scenario and the base case. The base case would assume a selected set of climatic, hydrologic and pumping conditions. Commonly, the calibration base period is assumed to repeat; however, any number of variations can be constructed.

It is important to note that in some cases the model results may vary from those measured in individual well due to the geologic complexity of the Kern County Subbasin. However, the model is capable of evaluating the impacts of changes in pumping and water use practices in the Kern County Subbasin that are useful for SMGA planning purposes.

9.3 Limitations and Uncertainty of C2VSimFG-Kern

The C2VSimFG-Kern performs well in the Kern Subbasin, producing simulated water budget components that generally match historical values compiled by local agencies. The C2VSimFG-Kern also produces groundwater hydrographs that closely match observed hydrographs in the central part of the Kern Subbasin. The model is well suited as a planning tool to estimate the impacts of the proposed SGMA projects and management actions on groundwater conditions in the Kern County Subbasin.

The C2VSim model update was limited in scope, and some model components do not perform well. These components do not reduce model capabilities with respect to GSP development but limit the usefulness of the model for other types of studies. Flows in the Kern River channel, including local stream-groundwater interactions, are not well replicated and surface water diversions are not dynamically simulated. The Kern Subbasin portion of the C2VSim model is not calibrated, and although the land surface water budget components are generally accurate, groundwater conditions and stream flows are poorly simulated in much of the subbasin. Some rejected recharge occurs in the Kern Fan area in very wet years, but this is not significant as it is a very small volume.

10. References

Brush, CF, EC Dogrul and TN Kadir. 2013. C2VSim model. California Department of Water Resources Technical Memorandum.

California Department of Water Resources (DWR). Monthly Operations Reports. https://water.ca.gov/programs/state-water-project/operations-and-maintenance/monthly-and-annual-operations-reports.

California Department of Water Resources (DWR). 2016A. California's Groundwater, Bulletin 118 Interim Update 2016. Sacramento, CA: Technical Memorandum.

California Department of Water Resources (DWR). 2016B. Management Practices for the Sustainable Management of Groundwater, Modeling BMP. Sacramento, CA: Technical Memorandum.

California Department of Water Resources (DWR). 2018A. Guidance for Climate Change Data Use During Groundwater Sustainability Plan Development. Sacramento, CA: Technical Memorandum.

California Department of Water Resources (DWR). 2018B. Resource Guide, DWR-Provided Climate Change Data and Guidance for Use During Groundwater Sustainability Plan Development. Sacramento, CA: Technical Memorandum.

City of Bakersfield (COB) Water Resources Department. Kern River Hydrology Reports.

Friant Water Users Authority (FWUA). 2018. Estimate of Future Friant Division Supplies for use in Groundwater Sustainability Plans. Fresno, CA.

GEI Consultants. 2018. Kern River Hydrology Under Climate Change. Bakersfield, CA.

IPUMS. National Historical Geographic Information System Database. http://www.ipums.org.

Irrigation Training and Research Center (ITRC). 2017. 1993-2015 ITRC-METRIC ETc for Kern County. California Polytechnic State University, San Luis Obispo, CA.

Nady, P, and LL Larragueta. 1983. Estimated average annual streamflow into the Central Valley of California. USGS Hydrologic Atlas HA-657.

US Bureau of Reclamation (USBR). Central Valley Operations. http://www.usbr.gov/mp/cvo. http://www.usbr.gov/mp/cvo.

US Bureau of Reclamation (USBR). 2011. Kern National Wildlife Refuge Water Management Plan. https://www.usbr.gov/mp/watershare/docs/2010/refuges/kern-national-wildlife-refuge.pdf

US Department of Agricultura Natural Resources Conservation Service (NRCS). 2018. Published Soil Surveys for California. https://www.nrcs.usda.gov/wps/portal/nrcs/surveylist/soils/survey/state/?stateid-CA.

US Department of Commerce. Census data for 1990, 2000 and 2010. https://www.census.gov/data/developers/data-sets/decennial-census.html

US Geologic Survey (USGS). 2009. Central Valley Hydrologic Model: Texture Model. https://ca.water.usgs.gov/projects/central-valley/cvhm-texture-model.html.

List of Tables (following text)

List of Figures (following text)

Attachments (following text)

Tables

TABLE 1 - Summary of data input for surface water diversion to agriculture by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Belridge WSD	Berrenda Mesa WSD	Buena Vista WSD	Cawelo WD	Kern River Canal Co.	Henry Miller WD	Kern Delta WD	Kern-Tulare WD	Lost Hills WD	North Kern WSD	Rosedale Rio Brave WSD	Semi-tropic WSD	Shafter-Wasco ID	So. San Joaquin MUD	Wheeler Ridge - Maricopa WSD	Olcese WD	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	144,722	106,293	90,909	162,444	78,084	14,994	43,242	183,471	27,131	103,268	198,865	0	74,487	149,252	112,888	177,348	1,493	1,668,891
1987	127,333	106,293	90,909	142,274	89,117	12,113	43,242	137,458	27,131	123,981	112,432	0	53,753	172,161	76,193	161,949	1,493	1,477,832
1988	114,321	106,293	90,909	141,152	77,106	4,203	43,242	135,078	27,131	111,872	81,580	0	47,071	164,192	71,243	154,030	1,417	1,370,840
1989	114,591	106,293	90,909	150,341	85,190	11,096	43,242	140,360	27,131	122,044	61,797	0	50,495	190,990	94,729	178,129	1,480	1,468,817
1990	70,816	106,293	90,909	124,845	67,867	14,757	43,242	114,531	27,131	88,963	51,926	0	34,381	49,992	73,000	170,693	1,480	1,130,826
1991	40,698	106,293	90,909	100,517	50,621	10,416	43,242	117,287	27,131	9,553	28,931	0	40,595	7,926	11,683	31,030	1,480	718,312
1992	52,839	106,293	90,909	108,874	54,406	9,909	43,242	118,190	27,131	52,853	34,291	0	45,851	94,467	65,310	96,514	1,480	1,002,559
1993	137,479	93,344	85,549	151,653	75,490	11,596	43,973	174,003	26,034	77,793	181,920	5,040	72,120	226,462	108,767	137,221	1,425	1,609,869
1994	171,856	110,017	93,092	125,084	62,968	13,862	53,471	132,865	28,017	87,636	117,580	2,362	47,111	110,951	83,680	151,368	1,685	1,393,606
1995	134,559	110,993	78,521	189,797	73,155	6,600	29,047	159,595	27,333	85,963	174,020	5,591	62,105	235,347	108,778	153,783	1,425	1,636,611
1996	166,288	112,412	115,132	184,597	90,229	11,591	39,539	179,052	28,749	145,349	202,199	5,722	72,231	313,420	128,865	189,454	1,987	1,986,816
1997	185,820	143,146	97,233	197,871	88,202	11,134	50,584	179,388	29,998	122,140	191,871	4,563	67,407	313,717	124,456	188,455	1,778	1,997,763
1998	120,808	79,387	85,885	152,455	69,758	4,959	30,260	124,464	24,422	80,845	153,662	4,756	53,064	240,072	89,373	148,174	849	1,463,194
1999	152,909	101,786	93,199	142,271	86,667	10,085	53,858	141,626	28,093	108,563	146,395	4,679	57,625	307,686	110,686	166,018	1,248	1,713,394
2000	158,008	111,057	87,200	135,689	87,894	12,833	44,302	152,338	29,948	119,828	133,872	3,920	61,358	315,833	119,597	179,278	1,382	1,754,337
2001	158,432	91,642	65,734	76,718	70,873	10,048	31,379	113,044	30,109	68,302	74,725	0	48,772	70,879	98,104	136,390	1,588	1,146,739
2002	158,197	107,617	63,705	78,735	75,042	9,058	31,724	116,181	25,443	67,574	62,006	0	55,121	165,448	103,849	133,652	1,702	1,255,054
2003	139,412	103,724	64,267	96,601	75,749	8,371	33,941	161,162	24,120	62,007	106,436	1,000	55,511	265,110	106,779	120,733	2,041	1,426,964
2004	155,531	118,543	68,902	86,119	78,558	9,383	39,101	138,664	25,541	67,607	99,610	1,739	58,351	174,605	106,537	138,771	1,637	1,369,199
2005	136,887	105,523	69,372	125,522	78,101	6,037	39,248	169,747	21,445	60,844	207,612	2,784	58,711	294,595	109,716	127,846	1,939	1,615,929
2006	140,411	115,146	84,869	149,851	96,249	5,317	46,538	172,882	22,525	73,422	199,626	0	68,468	332,115	120,106	150,416	2,048	1,779,988
2007	158,526	118,036	102,971	91,196	70,811	4,574	48,482	112,341	23,348	83,116	89,195	552	37,391	146,826	75,642	164,924	1,496	1,329,426
2008	157,604	114,525	86,217	70,032	62,437	4,380	18,156	145,633	22,788	74,554	86,051	0	47,623	29,675	87,776	168,211	1,700	1,177,361
2009	145,184	113,385	86,439	73,530	67,340	4,340	12,129	126,039	21,803	83,740	84,727	0	44,265	30,808	116,967	159,502	1,781	1,171,979
2010	132,462	117,589	88,556	102,109	76,351	3,604	29,694	166,787	19,272	88,191	171,744	1,543	65,238	168,870	120,394	159,162	1,756	1,513,322
2011	130,306	121,808	87,344	121,329	88,617	4,617	39,642	192,069	20,213	92,149	173,305	4,466	74,413	337,724	124,678	156,216	1,530	1,770,425
2012	148,146	130,559	87,953	96,407	89,745	3,988	41,553	195,763	21,682	91,720	81,584	1,329	35,369	227,901	81,602	168,753	1,783	1,505,837
2013	159,887	138,131	93,311	33,558	49,978	3,585	18,533	94,682	22,252	93,322	23,343	0	26,194	81,279	58,923	170,033	1,966	1,068,977
2014	144,605	123,390	82,731	410	41,223	2,645	2,246	70,367	14,067	82,546	11,290	0	8,303	5,748	14,249	152,372	1,238	757,429
2015	114,350	117,357	81,535	134	38,195	2,663	0	68,228	10,274	80,631	9,901	0	0	12,226	3,020	145,842	1,462	685,817

TABLE 2 - Summary of data input for surface water diversion from Kern River at different diversion and turnouts applied to C2VSimFG-Kern Historical simulation

Water Year	Kern River to Beardsley Canal	Kern River to Carrier Canal at Rocky Point	Kern River to Carrier Canal at Calloway Weir	Kern River to CVC at Turnout #4	Kern River to River Canal	Kern River to Rio Vista at River Walk	Kern River to Rosedale Channel	Kern River to North Lake	Kern River to Pioneer Canal	Kern River to Berrenda Mesa WSD	Kern River to Pioneer Project	Kern River to Kern Water Bank	Kern River to Kern Water Bank	Kern River to 2800 Acre Facility	Kern River to Buena Vista WSD BSA	Kern River to Aqueduct at Intertie	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	291,715	199,035	238,877	181,392	0	0	65,684	0	63,232	0	0	0	0	97,866	86,736	0	1,224,537
1987	190,539	76,888	179,876	58,811	0	0	19,893	0	756	0	0	0	0	21,592	86,736	0	635,091
1988	111,679	25,813	163,938	21,851	0	0	345	0	0	0	0	0	0	0	86,736	0	410,362
1989	98,796	28,696	168,926	23,291	0	0	0	0	0	0	0	0	0	0	86,736	0	406,445
1990	77,389	5,373	128,753	6,577	0	0	0	0	0	0	0	0	0	0	86,736	0	304,828
1991	69,736	180,189	56,331	13,944	0	0	5,869	0	0	0	0	0	0	0	86,736	0	412,805
1992	71,521	194,315	690	11,008	0	0	3,598	0	0	0	0	0	0	0	86,736	0	367,868
1993	213,099	241,104	43,555	59,099	50,897	0	54,936	0	27,803	0	0	0	0	64,852	64,488	0	819,833
1994	187,380	213,631	18,103	26,829	67	0	0	0	0	9,882	0	0	0	28,046	38,745	0	522,683
1995	256,234	248,113	65,360	144,230	136,516	0	91,721	0	40,366	23,822	45,284	0	0	60,476	103,429	11,850	1,227,401
1996	315,988	255,792	105,845	108,405	119,999	0	78,824	0	14,286	17,382	55,074	0	0	24,037	92,768	0	1,188,400
1997	288,746	280,471	123,771	130,336	123,333	0	62,841	0	23,271	14,977	45,600	0	0	27,212	134,320	52,848	1,307,726
1998	312,857	244,337	143,422	131,398	23,346	0	95,706	0	51,802	18,483	69,637	0	0	95,160	115,019	188,048	1,489,215
1999	214,847	180,856	71,974	46,274	58,082	0	33,938	0	839	6,915	21,343	0	0	17,891	77,220	0	730,179
2000	175,718	169,844	38,793	31,596	38,147	0	20,213	0	0	1,396	15,929	0	0	30,660	47,882	0	570,178
2001	130,052	188,404	23,762	14,050	4,631	0	3,177	0	2,179	0	0	0	0	0	32,686	0	398,941
2002	91,980	203,010	4,149	23,609	7,878	0	581	0	199	431	871	0	0	0	29,404	0	362,112
2003	164,112	206,448	15,893	14,088	31,451	0	12,306	0	0	1,045	0	0	0	0	38,307	0	483,650
2004	153,148	198,769	29,338	18,247	2,301	589	1,503	165	0	2,545	2,005	0	0	0	39,412	0	448,022
2005	236,776	228,885	73,215	62,146	60,019	0	141,022	1,442	1,942	39,702	102,111	21,548	23,125	77,127	72,865	0	1,141,925
2006	257,590	247,806	53,872	122,931	33,872	3,942	87,318	1,442	9,962	24,636	116,108	25,165	34,358	42,587	97,955	0	1,159,544
2007	135,525	189,169	1,049	10,483	7,752	2,746	0	0	0	13,099	17,809	7,507	0	4,568	47,914	0	437,621
2008	137,813	229,304	53,824	22,700	0	544	0	0	0	0	0	0	0	0	34,549	0	478,734
2009	139,246	238,103	31,342	28,635	115	712	109	0	0	0	0	0	0	0	18,418	0	456,680
2010	196,135	241,876	70,315	68,944	60,087	820	10,816	776	1,775	1,165	0	0	0	13,748	66,441	0	732,898
2011	298,003	266,684	75,784	160,243	90,048	1,752	101,209	787	20,479	26,223	121,857	23,951	47,187	84,876	98,416	0	1,417,499
2012	148,513	241,953	20,495	55,303	409	1,001	10,998	0	0	7,594	20,162	582	0	7,871	45,173	0	560,054
2013	45,141	153,474	706	25,758	0	247	0	0	0	3,529	0	0	0	155	0	0	229,010
2014	26,041	122,044	0	8,356	0	283	0	0	0	0	0	0	0	0	0	0	156,724
2015	16,883	104,841	0	0	0	195	0	0	0	0	0	0	0	0	0	0	121,919

TABLE 3 - Summary of data input for surface water diversions for various purposes applied to C2VSimFG-Kern Historical simulation

Water Year	Metro Bakersfield Urban Water Supply	Metro Bakersfield Wastewater Land Disposal	Kern Nat'l Wildlife Reguge SWP Supply	Kern Nat'l Wildlife Reguge Surface Water Inflows	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	24,416	29,235	0	1,611	30,846
1987	25,298	30,832	0	247	31,079
1988	28,563	32,304	0	65	32,369
1989	27,818	33,785	0	136	33,921
1990	27,426	35,756	0	0	35,756
1991	20,959	36,837	0	123	36,960
1992	25,867	37,801	0	10	37,811
1993	30,261	38,774	120	852	39,746
1994	29,111	39,684	16,861	95	56,640
1995	27,248	40,709	12,097	896	53,702
1996	28,261	41,667	12,776	4,536	58,979
1997	19,216	40,832	7,964	13,811	62,607
1998	11,036	40,355	12,268	90,926	143,549
1999	26,996	39,629	14,827	1,876	56,332
2000	30,963	41,497	7,489	58	49,044
2001	28,611	41,559	13,179	0	54,738
2002	30,185	42,043	19,299	1	61,343
2003	32,206	42,962	20,945	22	63,929
2004	56,861	43,735	23,461	0	67,196
2005	43,727	44,021	23,310	9,025	76,356
2006	40,294	44,614	21,829	11,734	78,177
2007	55,334	44,643	21,607	2,440	68,690
2008	56,335	44,936	17,728	18	62,682
2009	58,834	45,416	19,494	9	64,919
2010	61,314	45,527	21,808	536	67,871
2011	64,388	46,429	26,599	7,691	80,719
2012	68,013	46,666	18,451	9	65,126
2013	66,998	45,513	23,701	0	69,214
2014	55,692	44,645	13,877	0	58,522
2015	44,981	43,256	9,203	0	52,459

TABLE 4 - Summary of data input for surface water diversion to Groundwater Banking and Managed Aquifer Recharge for different facilities applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Berrenda Mesa Project	Buena Vista WSD	Cawelo WD	Kern Delta WD	Kern River GSA	North Kern WSD	Rosedale-Rio Bravo WSD	Semi-tropic WSD	West Kern WD	City of Bakers-field	Pioneer Project	Kern Water Bank	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	63,708	0	28,948	0	0	107,936	115,498	103,384	0	25,559	164,861	0	0	609,894
1987	18,800	0	7,487	0	0	62,084	47,206	47,731	0	23,249	50,585	0	0	257,142
1988	1,434	0	227	0	0	49,926	11,171	19,026	0	24,594	18,294	0	0	124,672
1989	3,358	0	3,532	0	0	58,640	804	27,984	0	28,604	14,148	0	0	137,070
1990	4,660	0	0	0	0	35,825	0	11,530	0	22,368	9,564	0	0	83,947
1991	2,404	0	0	0	0	54,577	1,224	5,931	0	14,754	19,768	0	0	98,658
1992	3,886	0	799	0	0	48,497	10,236	11,880	0	10,368	23,482	0	0	109,148
1993	99,714	0	19,229	0	0	83,472	25,220	88,065	0	24,420	126,544	0	0	466,664
1994	28,968	0	11,485	0	0	60,217	12,333	26,016	0	29,233	67,418	0	0	235,670
1995	87,910	17,808	49,623	0	0	98,122	149,948	119,339	0	28,201	143,019	62,274	121,465	877,709
1996	69,472	23,398	18,253	0	0	102,034	103,277	116,704	0	37,351	75,468	51,330	232,355	829,642
1997	58,069	9,801	38,015	7,524	0	103,578	102,050	108,711	0	18,555	53,470	38,169	132,457	670,399
1998	97,098	9,493	63,868	9,136	0	90,233	196,469	136,250	0	23,133	149,426	57,357	236,320	1,068,783
1999	81,398	11,489	8,904	6,110	0	83,858	69,080	78,941	0	29,249	41,516	21,884	116,663	549,092
2000	95,786	1,027	238	3,446	0	74,926	163	44,501	0	23,082	51,444	22,032	36,551	353,196
2001	38,774	0	99	2,683	0	59,411	0	5,653	0	8,747	22,005	1,253	10,029	148,654
2002	4,437	0	1,065	2,596	0	63,427	0	1,404	0	19,467	11,840	0	13,439	117,675
2003	44,030	0	424	3,314	4,177	73,362	367	27,154	0	17,766	20,133	0	5,369	196,096
2004	7,160	3,172	0	5,172	1,380	65,335	3,039	9,626	0	3,513	22,480	10,768	53,070	184,715
2005	100,311	19,663	33,153	7,882	7,274	98,474	74,241	151,136	0	29,552	164,991	93,466	308,092	1,088,235
2006	90,722	28,268	22,966	4,219	1,224	95,246	138,698	174,051	0	14,385	113,166	64,388	308,877	1,056,210
2007	20,012	15,292	0	5,241	488	51,678	80,467	20,348	0	4,209	31,534	19,386	70,553	319,208
2008	4,409	0	0	5,069	0	53,118	0	0	92	0	8,787	0	0	71,475
2009	34,000	0	3,000	5,239	0	48,217	2,596	2,354	0	5,075	18,730	0	0	119,211
2010	101,606	323	19,127	6,252	11,038	97,829	18,377	76,399	0	10,419	40,113	0	8,272	389,755
2011	99,559	19,373	73,880	29,630	46,690	158,694	147,576	227,775	17,276	24,880	144,869	132,320	397,029	1,519,551
2012	27,799	20,055	0	7,162	54,573	83,460	60,613	88,019	1,865	30,166	37,046	27,293	83,991	522,042
2013	3,947	5,750	0	9,345	14,726	46,298	5,078	5,622	22	2,500	11,518	0	0	104,806
2014	3,518	0	0	2,102	0	46,654	0	0	0	0	9,176	0	0	61,450
2015	401	0	0	5,893	0	40,368	4,768	0	22	0	18,840	0	0	70,292

TABLE 5 - Summary of data input for groundwater recovery pumping for local water supply by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD	Berrenda Mesa Project	Buena Vista WSD	City of Bakers-field	Cawelo WD	KCWA ID4	Kern Delta WD	Kern Water Bank	Lost Hills PUD	North Kern WSD	Olcese WD	Pioneer Project	Rosedale Rio Brave WSD	Semi-tropic WSD	West Kern WD	Wheeler Ridge - Maricopa WSD	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	1,955	0	0	0	0	0	0	0	274	0	101	0	0	0	12,073	0	14,403
1987	21,660	0	0	0	0	0	0	0	278	41,963	101	0	0	0	12,195	0	76,196
1988	27,486	0	960	0	0	0	0	0	281	67,609	138	0	0	0	12,316	0	108,790
1989	38,231	0	2,507	0	0	0	0	0	285	79,674	132	0	0	0	12,438	0	133,266
1990	78,769	0	2,605	0	957	0	0	0	292	73,635	132	0	0	0	12,560	0	168,949
1991	82,566	0	2,511	0	4,666	0	0	0	307	80,432	132	0	0	0	12,546	0	183,160
1992	94,444	0	4,146	0	7,124	0	0	0	306	72,926	132	0	0	0	12,533	5,419	197,029
1993	21,035	0	222	0	3,469	0	0	0	308	3,950	66	0	0	0	12,530	150	41,730
1994	67,679	0	1,732	0	7,805	0	0	0	321	37,251	123	0	0	0	12,078	2,705	129,693
1995	14,191	0	73	0	4,628	0	0	0	322	4,176	66	0	0	0	11,638	0	35,094
1996	1,095	0	175	0	2,475	0	0	0	322	4,726	143	0	0	2,373	13,642	0	24,950
1997	0	0	0	0	2,406	0	0	0	322	4,261	112	0	0	5,824	13,962	0	26,887
1998	245	0	0	0	1,008	0	0	0	307	318	232	0	0	1,499	13,404	76	17,089
1999	915	0	0	0	2,099	0	0	0	333	773	105	0	0	1,241	14,692	2,806	22,963
2000	2,119	0	855	0	6,406	0	0	0	336	15,864	81	0	0	689	17,125	0	43,475
2001	100,492	19,482	6,115	13,950	8,533	0	0	86,404	350	61,988	103	52,034	0	0	15,714	6,507	371,673
2002	86,809	3,436	4,453	13,972	10,047	0	0	24,664	360	70,804	94	9,578	0	2,082	16,247	0	242,545
2003	30,906	0	1,619	3,211	5,484	1,892	0	53,591	364	21,811	56	16,181	0	2,828	17,733	24	155,699
2004	75,399	0	3,848	7,147	8,920	3,345	0	27,736	393	49,888	120	1,985	0	2,879	20,809	41	202,510
2005	25,104	589	430	0	3,563	0	0	21,553	400	6,121	111	12,951	0	2,145	20,843	0	93,809
2006	174	0	228	0	4,202	0	0	0	416	2,645	77	0	0	156	22,108	0	30,007
2007	101,515	23,022	5,858	10,000	11,039	6,220	0	167,291	419	88,841	149	54,150	2,302	0	23,107	0	493,914
2008	141,081	27,850	6,066	13,400	12,222	9,478	9,744	246,249	423	100,465	115	77,533	7,470	0	22,340	0	674,436
2009	128,043	29,745	5,315	9,086	742	5,582	15,117	166,703	389	111,798	144	78,033	6,001	449	21,629	0	578,777
2010	37,081	15,117	841	3,896	2,078	1,886	4,466	97,576	362	20,897	112	41,021	0	375	21,334	0	247,041
2011	445	0	290	0	146	0	0	0	378	683	115	0	0	500	20,801	1,037	24,395
2012	43,589	6,362	1,835	3,960	2,058	1,319	3,148	94,381	393	103,236	107	14,257	0	0	21,107	14,579	310,330
2013	123,971	1,379	4,261	5,571	20,994	2,252	19,809	171,627	373	146,543	118	41,743	14,231	0	19,494	16,518	588,883
2014	146,319	23,891	3,269	7,997	18,120	30,884	34,160	183,235	359	133,769	472	78,603	21,604	0	33,129	16,020	731,830
2015	123,618	26,298	1,267	3,516	24,146	38,294	32,918	154,687	358	118,342	109	56,634	17,237	0	20,344	13,857	631,624

TABLE 6 - Summary of data input for groundwater pumping for basin export by water district applied to C2VSimFG-Kern Historical simulation

Water Year	Arvin-Edison WSD to Aqueduct	DWR to Aqueduct	North Kern WSD to Friant-Kern Canal	Rosedale Rio Brave WSD to CVC	Semi-tropic WSD to Aqueduct	Wheeler Ridge - Maricopa WSD to Aqueduct	County of Kern to BVARA	TOTAL
	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1986	0	0	0	0	0	0	0	2,056
1987	0	0	0	0	0	0	673	63,724
1988	0	0	0	0	0	0	6,301	96,193
1989	0	0	0	0	0	0	5,879	120,544
1990	0	0	0	0	0	0	8,836	156,097
1991	0	0	0	0	0	0	22,114	170,307
1992	0	0	0	0	0	0	25,025	184,191
1993	0	0	0	0	0	0	7,521	28,892
1994	0	0	0	0	0	0	3,261	117,295
1995	0	2,319	0	0	0	0	4,748	23,134
1996	0	0	0	0	0	0	0	10,986
1997	0	0	0	0	0	0	0	12,603
1998	0	0	0	0	0	0	0	3,378
1999	0	0	0	0	0	0	0	7,938
2000	0	0	0	0	0	0	56	26,013
2001	0	0	0	0	1,457	638	10,024	355,608
2002	0	0	0	0	21,819	0	22,402	225,938
2003	12,380	0	0	0	0	0	9,886	137,602
2004	11,573	0	0	0	8,965	0	13,643	181,308
2005	13,939	0	0	0	19,103	0	6,071	72,567
2006	0	0	0		0	0	0	7,482
2007	7,609	0	7,276	0	6,282	0	10,437	470,388
2008	42,615	0	4,612	0	92,169	0	17,351	651,673
2009	43,080	0	5,880	0	86,194	7,243	7,786	556,758
2010	56,229	0	73	0	37,995	12,404	7,019	225,345
2011	16,065	0	0	0	0	0	369	3,217
2012	10,010	0	6,803	0	0	1,340	1,889	288,831
2013	15,111	0	7,471	12,116	5,610	3,815	9,786	569,016
2014	45,195	0	12,071	28,818	95,611	18,236	21,567	698,342
2015	67,142	0	9,752	26,314	89,453	26,943	23,330	610,923

0

TABLE 7 - Summary of population data input by Urban Zone applied to C2VSimFG-Kern Historical simulation

Water Year	Urban Zone 97	Urban Zone 98	Urban Zone 99	Urban Zone 100	Urban Zone 102	Urban Zone 103	Urban Zone 104	Urban Zone 105	Urban Zone 106	Total	Annual Growth Rate
	Population	Population	Population	Population	Population	Population	Population	Population	Population	Population	percent
1985	18,266	4,545	54,766	199	11,589	1,845	15,756	443	229,085	336,493	
1986	18,506	4,565	56,021	184	11,631	1,868	16,127	443	245,095	354,441	5.3%
1987	18,747	4,586	57,277	170	11,673	1,892	16,498	443	261,105	372,389	5.1%
1988	18,987	4,607	58,532	155	11,715	1,915	16,869	442	277,114	390,337	4.8%
1989	19,227	4,627	59,788	141	11,758	1,939	17,240	442	293,124	408,285	4.6%
1990	19,467	4,648	61,043	126	11,800	1,962	17,611	442	309,134	426,233	4.4%
1991	19,808	4,662	64,110	132	12,190	2,023	17,570	475	316,532	437,502	2.6%
1992	20,150	4,676	67,178	138	12,581	2,084	17,528	507	323,930	448,771	2.6%
1993	20,491	4,690	70,245	144	12,971	2,145	17,487	540	331,328	460,041	2.5%
1994	20,832	4,704	73,313	150	13,362	2,206	17,445	572	338,726	471,310	2.4%
1995	21,174	4,718	76,380	156	13,752	2,268	17,404	605	346,124	482,579	2.4%
1996	21,515	4,732	79,447	161	14,142	2,329	17,363	637	353,522	493,848	2.3%
1997	21,856	4,746	82,515	167	14,533	2,390	17,321	670	360,920	505,117	2.3%
1998	22,197	4,760	85,582	173	14,923	2,451	17,280	702	368,318	516,387	2.2%
1999	22,539	4,774	88,650	179	15,314	2,512	17,238	735	375,716	527,656	2.2%
2000	22,880	4,788	91,717	185	15,704	2,573	17,197	767	383,114	538,925	2.1%
2001	23,154	4,887	94,141	193	16,313	2,601	17,609	742	395,409	555,047	3.0%
2002	23,429	4,985	96,564	200	16,922	2,628	18,020	717	407,703	571,169	2.9%
2003	23,703	5,084	98,988	208	17,532	2,656	18,432	692	419,998	587,291	2.8%
2004	23,977	5,182	101,412	215	18,141	2,683	18,844	667	432,292	603,413	2.7%
2005	24,252	5,281	103,836	223	18,750	2,711	19,256	643	444,587	619,536	2.7%
2006	24,526	5,379	106,259	230	19,359	2,738	19,667	618	456,882	635,658	2.6%
2007	24,800	5,478	108,683	238	19,968	2,766	20,079	593	469,176	651,780	2.5%
2008	25,074	5,576	111,107	245	20,578	2,793	20,491	568	481,471	667,902	2.5%
2009	25,349	5,675	113,530	253	21,187	2,821	20,902	543	493,765	684,024	2.4%
2010	25,623	5,773	115,954	260	21,796	2,848	21,314	518	506,060	700,146	2.4%
2011	25,815	5,802	117,403	261	21,959	2,862	21,474	519	512,386	708,482	1.2%
2012	26,009	5,831	118,871	261	22,124	2,877	21,635	521	518,791	716,919	1.2%
2013	26,204	5,860	120,357	262	22,290	2,891	21,797	522	525,275	725,458	1.2%
2014	26,400	5,889	121,861	263	22,457	2,905	21,961	523	531,841	734,102	1.2%
2015	26,598	5,919	123,385	263	22,626	2,920	22,125	525	538,489	742,850	1.2%

TABLE 8 - Summary of data input of Per Capita Water Use by Urban Zone applied to C2VSimFG-Kern Historical simulation

Water Year	Urban Zone 97	Urban Zone 98	Urban Zone 99	Urban Zone 100	Urban Zone 102	Urban Zone 103	Urban Zone 104	Urban Zone 105	Urban Zone 106
	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc	gdpc
1985	228	196	245	159	180	159	293	159	508
1986	228	196	245	159	180	159	293	159	480
1987	228	196	245	159	180	159	293	159	450
1988	228	196	245	159	180	159	293	159	439
1989	228	196	245	159	180	159	293	159	419
1990	228	196	245	159	180	159	293	159	438
1991	228	196	245	159	180	159	293	159	409
1992	228	196	245	159	180	159	293	159	417
1993	228	196	245	159	180	159	293	159	414
1994	228	196	245	159	180	159	293	159	421
1995	228	196	245	159	180	159	293	159	381
1996	228	196	245	159	180	159	293	159	401
1997	228	196	245	159	180	159	293	159	348
1998	228	196	245	159	180	159	293	159	304
1999	228	196	248	159	159	159	237	159	388
2000	228	196	248	159	159	159	237	159	367
2001	228	196	248	159	159	159	237	159	364
2002	228	196	248	159	159	159	237	159	362
2003	228	196	248	159	159	159	237	159	358
2004	228	196	248	159	159	159	237	159	386
2005	228	196	248	159	159	159	237	159	314
2006	228	196	248	159	159	159	237	159	338
2007	228	196	248	159	159	159	237	159	375
2008	228	196	248	159	159	159	237	159	367
2009	228	196	248	159	159	159	237	159	344
2010	228	196	248	159	159	159	237	159	328
2011	228	196	248	159	159	159	237	159	351
2012	228	196	248	159	159	159	237	159	378
2013	228	196	248	159	159	159	237	159	330
2014	228	196	248	159	159	159	237	159	314
2015	228	196	248	159	159	159	237	159	261

TABLE 9 - Summary of data input for crop evapotranspiration (ET) by crop type based on METRIC satellite data applied to C2VSimFG-Kern Historical simulation

Water Year	Grain	Cotton	Sugar Beets	Cotton	Dry Beans	Saf-flower	Other Field Crops	Alfalfa	Pasture	Tomoto-Processed	Tomato-Fresh	Curcubits	Onions & Garlic	Potatoes	Other Truck	Almonds & Pistachios	Orchards	Citrus	Vineyards	Idle	Rice	Refuge	Urban	Native
Units	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr	in/yr
1985	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
1986	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1987	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1988	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1989	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1990	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1991	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
1992	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
1993	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1994	29.5	34.0	36.9	37.0	31.9	24.0	36.5	37.6	31.4	32.4	27.3	27.4	34.1	28.7	31.6	37.2	37.5	38.7	29.1	33.3	26.6	23.9	27.0	27.3
1995	30.1	32.4	35.8	34.4	30.7	26.6	30.7	36.6	32.6	29.4	29.0	28.1	33.1	27.4	30.2	35.8	35.5	35.8	28.7	32.2	31.6	36.3	27.5	29.6
1996	35.0	37.1	39.7	39.2	38.2	32.6	35.8	42.3	38.7	36.1	32.7	28.7	35.3	30.4	33.0	39.3	40.1	39.4	32.1	32.8	34.1	36.4	30.2	31.0
1997	31.3	35.5	39.1	37.7	33.9	29.3	37.2	43.5	36.0	33.2	28.1	28.8	29.7	28.8	30.1	33.7	34.0	38.1	26.1	30.6	34.1	34.0	28.1	31.1
1998	28.2	28.9	36.4	32.8	28.0	26.2	29.2	39.3	35.5	29.8	28.8	27.7	26.5	26.2	27.9	35.1	33.6	36.8	26.9	27.1	39.3	36.2	27.8	26.8
1999	30.0	31.6	34.6	35.4	30.8	28.0	27.9	38.9	35.8	28.8	27.3	24.9	28.7	27.6	29.3	31.6	29.7	36.5	25.0	27.4	35.8	31.6	28.1	27.5
2000	31.1	34.6	36.0	33.2	29.4	28.7	33.8	44.0	38.6	32.2	32.3	27.3	30.5	29.4	29.5	37.0	34.6	41.0	28.9	27.6	41.2	31.4	32.3	33.0
2001	31.9	33.4	36.3	32.0	29.3	27.2	32.1	44.5	33.8	30.2	29.9	26.5	28.8	28.1	28.8	39.9	36.0	40.7	29.7	28.0	41.7	30.8	30.5	31.6
2002	33.8	35.2	39.5	33.3	31.0	26.3	31.4	44.5	33.2	34.2	28.3	27.2	31.3	30.9	31.2	41.4	37.1	43.4	32.1	30.6	40.7	32.2	32.3	33.0
2003	33.0	35.5	35.6	33.2	33.5	28.0	31.7	42.9	30.6	31.0	26.2	27.8	29.7	27.2	28.4	39.6	32.8	38.8	30.4	29.7	37.0	32.1	28.5	30.4
2004	34.5	36.6	37.3	33.5	33.3	32.8	35.6	46.4	36.1	33.1	26.4	26.1	32.4	30.3	33.1	44.2	36.7	40.0	33.1	35.5	39.0	31.5	30.1	32.4
2005	31.8	35.4	40.6	30.5	31.8	27.8	33.0	40.7	32.3	28.4	23.7	26.8	29.6	28.4	28.0	35.1	30.2	34.8	28.0	29.6	37.3	34.1	28.2	30.0
2006	30.9	33.7	33.7	31.4	31.3	24.9	31.1	41.4	33.2	25.4	26.9	29.5	26.9	31.9	28.2	33.9	28.6	35.0	27.6	27.3	39.6	39.3	27.9	29.0
2007	34.3	36.5	33.9	36.1	31.6	28.9	35.3	44.1	35.3	29.4	24.4	26.7	29.1	27.8	32.5	34.5	29.6	37.6	29.6	29.7	38.0	34.0	27.7	31.5
2008	35.2	34.1	30.6	35.3	29.7	25.1	36.0	43.8	37.2	28.0	25.1	25.7	29.7	29.1	31.3	33.2	31.5	37.9	29.6	26.9	34.2	29.9	28.3	31.4
2009	35.3	34.1	25.1	34.2	32.4	32.6	33.9	42.2	30.9	26.5	24.4	24.9	27.1	29.3	29.6	34.5	31.9	37.8	30.4	28.9	35.8	30.5	27.9	32.0
2010	31.6	28.9	25.8	30.2	28.5	23.7	29.8	38.7	26.8	23.2	23.4	26.2	25.4	26.5	27.0	37.3	31.0	35.5	32.3	28.3	33.7	30.8	27.1	30.2
2011	30.1	28.2	23.9	28.3	27.0	21.8	29.6	36.0	25.1	22.6	27.0	24.4	25.5	25.8	25.2	36.2	32.0	33.6	30.9	26.6	38.1	33.6	26.9	32.7
2012	30.2	27.3	22.5	28.7	26.3	23.0	31.0	35.8	26.1	22.6	28.1	24.3	25.8	26.1	26.1	36.6	31.7	33.9	31.2	26.0	38.4	33.8	27.5	33.0
2013	35.7	35.5	28.0	34.7	32.7	33.2	36.4	44.0	33.1	27.2	30.7	29.1	32.4	30.1	30.1	43.6	35.5	39.9	38.6	29.5	36.3	36.8	29.1	35.2
2014	33.9	33.6	25.2	32.9	28.4	28.8	36.0	40.4	28.8	25.2	28.2	28.3	28.6	28.7	29.8	42.5	33.0	37.8	34.1	28.5	36.0	35.8	29.2	34.2
2015	33.4	34.2	28.3	36.3	31.9	33.9	37.0	43.2	29.0	24.0	26.4	27.1	34.8	27.5	30.7	38.8	31.8	38.3	31.0	28.1	29.6	32.2	27.9	32.4
Average	**32.4**	**33.4**	**33.0**	**33.4**	**30.9**	**27.8**	**32.9**	**41.5**	**33.0**	**28.8**	**27.5**	**26.9**	**29.3**	**28.5**	**29.5**	**37.3**	**33.3**	**37.7**	**30.3**	**29.1**	**37.1**	**33.6**	**28.8**	**31.3**
BETA	**21.6**	**39.8**	**39.2**	**32.3**	**31.1**	**34.9**	**36.4**	**48.0**	**50.4**	**31.6**	**40.6**	**32.0**	**36.5**	**35.4**	**31.6**	**48.1**	**45.9**	**42.5**	**42.0**	**57.1**	**50.2**	**76.1**	**52.0**	**57.1**
Difference	**10.8**	**-6.4**	**-6.3**	**1.1**	**-0.2**	**-7.2**	**-3.5**	**-6.5**	**-17.4**	**-2.8**	**-13.0**	**-5.0**	**-7.2**	**-6.9**	**-2.1**	**-10.9**	**-12.6**	**-4.8**	**-11.7**	**-28.0**	**-13.1**	**-42.6**	**-23.2**	**-25.8**

TABLE 10 - Summary of Other C2VSimFG Beta Modifications in the Kern County Update

File Name	Change to Model Input File
C2VSimFG.in	
*	Change simulation starting time to 09/30/1985_24:00
C2VSimFG_Unsat.dat	
*	Replaced initial condition values with more representative values for revised starting time
C2VSimFG_Groundwater1985.dat	
*	Added hydrologic flow barrier at White Wolf Fault
*	Set Corcoran Clay thickness to 0 ft in areas where it is not present
*	New 10/1/1985 initial condition
*	Modified hydraulic conductivity and specific storage in Layer 1 in the Kern Water Bank area based on local calibrated model data to improve groundwater-surface water interactions along the Kern River to better match measured data in this key area.
C2VSimFG_BypassSpecs.dat	
*	Removed bypass #17
C2VSimFG_RootZone.dat	
*	Native return flow is sent to either nearby stream nodes as runoff or out-of-model as ET loss due to internal drainage to old lake beds
C2VSimFG_ReturnFlowFrac.dat	
*	Changed return flow fraction of Kern Ag to 0.06 as a slightly more conservative assumption that helps with overall validation to groundwater levels.
C2VSimFG_Urban_Area.dat	
*	Changed Kern County oil fields from urban to native vegetation
C2VSimFG_Urban_WaterUseSpecs.dat	
*	Set fractions for SRs 19-21 based on local info
C2VSimFG_NonPondedCrop.dat	
*	Return flow = 0 for Kern County
C2VSimFG_PondedCrop_Area.dat	
*	Modified distribution of rice to be limited to areas in northwest Kern County with historical rice production rather than uniform distribution across county
C2VSimFG_NativeVeg_Area.dat	
*	Rebalanced native veg distribution after redistribution of non-ponded crop area to maintain 1997 to 2017 native veg distribution

Table 11A - Historical Groundwater Budget for the Kern County Subbasin for Water Years 1995 to 2014 based on the C2VSimFG-Kern Historical Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Small Watershed Inflow	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	880,480	944,800	185,777	-946,782	122,287	-75,299	1,111,263
1996	801,572	926,537	106,692	-1,247,471	41,190	-84,675	543,845
1997	766,667	771,510	126,405	-1,068,169	50,548	-87,372	559,587
1998	1,034,867	1,097,180	121,413	-884,593	155,312	-87,515	1,436,665
1999	755,674	633,676	39,704	-1,109,310	32,155	-85,211	266,692
2000	617,018	462,522	91,454	-1,375,733	25,956	-83,759	-262,541
2001	551,880	222,131	66,647	-1,839,000	24,633	-81,896	-1,055,605
2002	466,463	202,687	76,147	-1,760,186	18,882	-83,943	-1,079,950
2003	502,831	297,019	118,149	-1,492,816	34,003	-85,638	-626,452
2004	488,327	284,862	83,294	-1,860,344	27,959	-89,250	-1,065,153
2005	799,614	1,147,287	132,785	-1,108,382	93,557	-89,912	974,946
2006	839,390	1,125,277	44,657	-1,149,877	40,846	-96,591	803,702
2007	560,860	403,611	26,260	-2,099,953	17,882	-91,566	-1,182,908
2008	463,721	146,763	78,841	-2,341,780	36,058	-86,260	-1,702,659
2009	485,234	186,548	73,848	-2,206,377	21,586	-85,764	-1,524,923
2010	599,434	467,683	141,715	-1,470,205	58,145	-94,664	-297,892
2011	1,073,963	1,530,123	259,404	-984,968	118,303	-94,981	1,901,842
2012	713,826	580,590	88,581	-1,583,369	19,020	-93,041	-274,395
2013	538,356	156,704	59,483	-2,447,479	19,043	-83,619	-1,757,511
2014	447,782	84,456	50,857	-2,830,674	17,832	-81,081	-2,310,831
Total	**13,387,959**	**11,671,966**	**1,972,113**	**-31,807,470**	**975,198**	**-1,742,039**	**-5,542,280**
Average	**669,398**	**583,598**	**98,606**	**-1,590,373**	**48,760**	**-87,102**	**-277,114**

Table 11B - Current Groundwater Budget for the Kern County Subbasin for Water Year 2015 based on the C2VSimFG-Kern Historical Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	GW Pumping	Subsurface Flow within GW Basin	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
2015	429,983	89,744	46,344	-2,740,237	0	-51,201	-2,225,366

NOTES:

Deep Percolation	Precipitation and applied water that reaches the groundwater after simulated transport across the unsaturated zone
Managed Recharge and Canal Seepage	Combined groundwater recharge from managed aquifer recharge operations, groundwater banking, and seepage from canals and other conveyance
Net GW/SW Interactions	Net volumetric exchange of surface water and groundwater from streams: Positive represents a net groundwater recharge, and negative represents a net groundwater discharge to the stream
GW Pumping	Total groundwater pumping by wells. Groundwater banking recovery pumping is specified input whereas agricultural and municipal pumping is calculated by C2VSim based on demand
Subsurface Flow within GW Basin	Net subsurface groundwater flow into a neighboring water district or area within the Kern County Subbasin: negative is a net flow out of the district and positive is a net flow into the district
Subsurface Flow with Adjacent GW Basins	Net subsurface groundwater flow from the Kern County Subbasin with an adjoining groundwater basin: negative is a net flow out of the Basin and positive is a net flow into the Basin
Change in Groundwater Storage	Sum of the inflow components (positive numbers) plus the outflow components (negative numbers): positive is an increase in storage typified by a rise in GW levels whereas a negative is a decrease in storage typified by a decline in GW levels

TABLE 12: Sustainable Yield for Kern County Subbasin for WY1995 to WY2014 Base Period based on C2VSimFG-Kern Historical Simulation

Water Year	Total Average Annual Volume	Agricultural Average Annual Volume	Agricultural Average Annual Volume per Ag Acre	Urban Average Annual Volume
Units	Acre-ft	Acre-ft	ft/acre	Acre-ft
	Sustainable Yield from Groundwater Pumping			
Groundwater Pumping	1,416,077	1,239,931	1.59	176,146
Percentage of Pumping		88%		12%
Change in Groundwater in Storage	-277,114	-242,644	-0.31	-34,470
Out-of-Basin Banking Obligations	-85,965	-75,272	-0.10	-10,693
Percentage of Pumping		-20%		-20%
Sustainable Yield	**1,052,998**			
Average Annual Difference	**-363,079**			
Percent Difference	**-34%**			
	Sutainable Yield from Basin Recharge and Outflow			
Groundwater Recharge	1,351,602	1,183,476	1.52	168,126
Groundwater Banking Exports	-174,272	-152,595	-0.20	-21,678
Out-of-Basin Banking Obligations	-85,965	-75,272	-0.10	-10,693
Subsurface Outflow	-87,102	-76,267	-0.10	-10,835
Sustainable Yield	**1,004,262**			
Average Annual Difference	**-411,815**			
Percent Difference	**-41%**			

NOTES:

Sustainable Yield from Groundwater Pumping	Approach assumes that adjusting total groundwater pumping by the change in storage provides an reasonable approximation of the Basin Sustainable
Sutainable Yield from Basin Recharge and Outflow	Approach assumes that the Basin Sustainable Yield can be reasonably approximated by adding up the different recharge components and non-

TABLE 13: Assessment of Potential Native Yield for Kern County Subbasin for WY1995 to WY2014 based on C2VSimFG-Kern Historical Simulation

	Ag Precipitation Recharge			Other Area Precipitation Recharge			Small Watershed Inflows			
Water Year	Precipitation in Agricultural Area	Precipitation to ET Demand	Precipitation to Groundwater in Agricultural Area	Precipitation in Other Areas	Precipitation to ET Demand	Precipitation to Groundwater in Other Areas	Small Watershed Subsurface Inflow	Small Watershed Runoff Percolation	Small Watershed Recharge to Groundwater	Native Yield
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
1995	702,794	521,974	180,820	1,108,386	824,558	283,828	17,540	104,746	122,287	586,934
1996	381,496	351,540	29,956	526,809	422,541	104,268	17,512	23,679	41,190	175,414
1997	482,117	356,589	125,528	637,266	487,128	150,138	17,524	33,024	50,548	326,214
1998	966,485	663,632	302,853	1,492,576	1,024,918	467,658	17,840	137,472	155,312	925,823
1999	433,456	400,669	32,786	589,454	464,061	125,393	17,812	14,343	32,155	190,334
2000	384,158	357,496	26,661	476,308	398,994	77,315	17,757	8,200	25,956	129,933
2001	431,757	353,840	77,917	579,440	488,081	91,358	17,722	6,911	24,633	193,908
2002	255,111	227,877	27,234	382,463	317,069	65,394	17,679	1,203	18,882	111,510
2003	400,953	331,300	69,653	599,314	506,451	92,863	17,683	16,320	34,003	196,519
2004	301,023	275,258	25,765	422,514	339,652	82,862	17,661	10,298	27,959	136,586
2005	653,833	486,132	167,701	964,382	785,465	178,917	17,808	75,750	93,557	440,175
2006	499,756	447,319	52,437	657,647	546,950	110,697	17,783	23,063	40,846	203,981
2007	216,658	227,752	-11,095	292,814	241,483	51,331	17,725	157	17,882	58,119
2008	189,035	170,649	18,385	305,703	248,514	57,189	17,697	18,361	36,058	111,633
2009	268,010	221,348	46,663	405,160	336,116	69,044	17,674	3,913	21,586	137,293
2010	457,031	346,082	110,949	683,456	543,580	139,876	17,731	40,414	58,145	308,969
2011	649,878	441,717	208,161	1,023,701	692,781	330,919	17,932	100,370	118,303	657,382
2012	335,227	299,191	36,036	446,686	372,675	74,012	17,851	1,169	19,020	129,067
2013	214,951	203,005	11,946	303,560	246,644	56,916	17,787	1,257	19,043	87,906
2014	167,800	152,566	15,234	263,824	214,181	49,642	17,713	120	17,832	82,708
Total	**8,391,529**	**6,835,938**	**1,555,591**	**12,161,462**	**9,501,842**	**2,659,620**	**354,429**	**620,769**	**975,198**	**5,190,409**
Average	**419,576**	**341,797**	**77,780**	**608,073**	**475,092**	**132,981**	**17,721**	**31,038**	**48,760**	**259,520**
Use (ft/acre)	**0.54**	**0.44**	**0.10**	**0.59**	**0.46**	**0.13**	**0.01**	**0.02**	**0.03**	**0.144**

NOTES:

Simulation of Recharge	IWFM applies two processes to simulate the movement of water from the surface to the groundwater. The root zone simulates calculates the volume of water that will percolate below the root zone based on local soil properties. This water bases to the unsaturated zone that applies a 1-D vadose zone flow that simulates the rate that water will reach the groundwater based on subsurface properties and soil moisture content.
Percolation from Agricultural Area	Total volume of rainfall and applied water calculated to meet the total agricultural demand that percolates below the root zone in irrigated agricultural areas based on C2VSim simulation.
Percolation from Urban Area	Total volume of rainfall and applied water calculated to meet urban outdoor use that percolates below the root zone in urban areas based on C2VSim simulation.
Percolation from Native, Undeveloped or Fallow Areas	Total volume of rainfall and applied water that percolates below the root zone in native, undeveloped and fallow areas based on C2VSim simulation.
Percolation to Unsaturated Zone	Total volume of rainfall and applied water that percolates below the root zone from all areas based on C2VSim simulation.
GW Recharge from Unsaturated Zone	Volume of water going from the unsaturated zone to groundwater
GW Banking, Managed Recharge and Canal Seepage	Managed aquifer recharge and groundwater banking is simulated in C2VSim by applying a high recoverable loss factor for surface water diversions. For Kern County, these operations generally assumes that 88% to 94% of surface water deliveries physically recharge groundwater. This recharge is applied directly to the groundwater without passing through the unsaturated zone.
Net GW/SW Interactions	Net volumetric exchange between surface water in Kern River or Poso Creek and the groundwater. A positive number is surface water to groundwater, and a negative is groundwater discharge to the stream. This recharge is applied directly to the groundwater without passing through the unsaturated zone.
Total GW Recharge	Total volume to water reaching the groundwater as recharge

Table 14 - Hydrologic Year Correlation with Relevant River Indices for Projected Future Simulation Period

Project Year	Hydrology Year	Annual Kern River Index	San Joaquin River Index
2021	**2003**	71	Below Normal
2022	**2004**	56	Dry
2023	**2005**	159	Wet
2024	**2006**	147	Wet
2025	**2007**	35	Critical
2026	**2008**	71	Critical
2027	**2009**	65	Below Normal
2028	**2010**	126	Above Normal
2029	**2011**	201	Wet
2030	**2012**	45	Dry
2031	**2013**	28	Critical
2032	**2014**	24	Critical
2033	**1995**	191	Wet
2034	**1996**	136	Wet
2035	**1997**	162	Wet
2036	**1998**	236	Wet
2037	**1999**	60	Above Normal
2038	**2000**	66	Above Normal
2039	**2001**	54	Dry
2040	**2002**	58	Dry
2041	**2003**	71	Below Normal
2042	**2004**	56	Dry
2043	**2005**	159	Wet
2044	**2006**	147	Wet
2045	**2007**	35	Critical
2046	**2008**	71	Critical
2047	**2009**	65	Below Normal
2048	**2010**	126	Above Normal
2049	**2011**	201	Wet
2050	**2012**	45	Dry
2051	**2013**	28	Critical
2052	**2014**	24	Critical
2053	**1995**	191	Wet
2054	**1996**	136	Wet
2055	**1997**	162	Wet
2056	**1998**	236	Wet
2057	**1999**	60	Above Normal
2058	**2000**	66	Above Normal
2059	**2001**	54	Dry
2060	**2002**	58	Dry
2061	**2003**	71	Below Normal
2062	**2004**	56	Dry
2063	**2005**	159	Wet
2064	**2006**	147	Wet
2065	**2007**	35	Critical
2066	**2008**	71	Critical
2067	**2009**	65	Below Normal
2068	**2010**	126	Above Normal
2069	**2011**	201	Wet
2070	**2012**	45	Dry

Table 15 - Projected Future Groundwater Budget for Kern County Subbasin under Baseline Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	30,942,871	26,407,594	6,504,806	2,457,805	-81,187,349	-4,201,244	**-19,075,537**
Average	618,857	528,152	130,096	49,156	-1,623,747	-84,025	**-381,511**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,951,352	10,419,890	2,658,980	948,239	-32,696,313	-1,708,561	**-8,426,431**
Average	597,568	520,995	132,949	47,412	-1,634,816	-85,428	**-421,322**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,991,518	15,987,704	3,845,827	1,509,566	-48,491,035	-2,492,683	**-10,649,106**
Average	633,051	532,923	128,194	50,319	-1,616,368	-83,089	**-354,970**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	431,092	257,161	124,707	38,770	-1,673,022	-90,042	-911,335
2022	475,816	310,451	81,251	28,596	-1,968,878	-87,024	-1,159,794
2023	654,987	865,602	188,611	97,803	-1,150,982	-84,077	571,939
2024	755,746	916,321	261,679	67,141	-1,054,808	-89,930	856,146
2025	487,187	300,980	76,771	18,060	-2,054,989	-86,462	-1,258,455
2026	441,440	153,041	79,202	36,473	-2,354,582	-76,814	-1,721,244
2027	503,691	251,642	74,302	21,942	-2,088,012	-76,503	-1,312,939
2028	577,793	486,698	142,758	35,496	-1,540,870	-79,169	-377,289
2029	1,000,215	1,465,457	112,006	119,558	-919,492	-90,199	1,687,546
2030	679,312	559,960	65,194	19,157	-1,431,696	-90,169	-198,241
2031	552,058	159,876	110,399	19,161	-2,469,186	-84,621	-1,712,314
2032	430,890	109,862	67,123	18,134	-2,887,650	-74,477	-2,336,117
2033	716,021	804,684	191,530	126,420	-1,082,677	-80,985	674,993
2034	615,806	746,086	205,884	42,156	-1,428,698	-88,747	92,487
2035	698,211	678,351	313,314	52,652	-1,137,639	-92,037	512,853
2036	843,395	1,059,047	202,784	103,683	-895,891	-93,743	1,219,275
2037	617,698	522,642	112,063	32,114	-1,246,673	-92,793	-54,950
2038	531,115	385,956	107,663	26,241	-1,397,233	-88,354	-434,612
2039	500,386	192,061	66,474	25,370	-1,931,072	-83,306	-1,230,087
2040	438,493	194,012	75,262	19,311	-1,982,263	-79,110	-1,334,294
2041	479,844	257,242	125,640	34,980	-1,631,792	-77,464	-811,551
2042	528,753	310,511	81,592	28,467	-1,960,174	-77,542	-1,088,393
2043	715,343	865,642	187,950	100,835	-1,144,519	-76,758	648,492
2044	817,195	916,342	243,192	68,630	-1,049,968	-84,464	910,927
2045	521,353	300,980	73,340	18,136	-2,050,665	-82,645	-1,219,502
2046	467,689	153,041	79,662	36,599	-2,350,525	-74,132	-1,687,666
2047	523,562	251,642	74,726	22,117	-2,084,572	-74,541	-1,287,067
2048	597,206	486,698	143,075	35,645	-1,536,980	-77,817	-352,174
2049	1,020,598	1,465,459	113,006	121,871	-916,413	-89,595	1,714,926
2050	691,733	559,960	65,288	19,216	-1,428,479	-90,136	-182,419
2051	567,327	159,876	110,671	19,218	-2,464,464	-84,725	-1,692,096
2052	447,074	109,862	67,348	18,007	-2,850,102	-74,614	-2,282,424
2053	724,472	804,684	191,978	127,393	-1,079,363	-81,325	687,840
2054	621,450	746,086	206,284	42,236	-1,424,676	-89,360	102,020
2055	697,310	678,351	313,884	52,738	-1,133,782	-93,038	515,463
2056	931,689	1,059,143	211,748	169,221	-844,773	-94,849	1,432,180
2057	655,811	522,642	112,759	33,376	-1,242,088	-94,073	-11,573
2058	554,562	385,956	107,881	26,454	-1,393,471	-89,712	-408,330
2059	518,487	192,061	66,598	25,586	-1,926,935	-84,290	-1,208,493
2060	455,206	194,012	75,379	19,353	-1,919,531	-80,126	-1,255,706
2061	491,662	257,242	125,741	34,990	-1,628,261	-78,506	-797,132
2062	540,767	310,511	81,687	28,658	-1,956,080	-78,583	-1,073,040
2063	730,572	865,642	188,317	103,344	-1,141,145	-77,884	668,846
2064	776,159	916,342	246,850	42,092	-1,080,869	-86,054	814,520
2065	513,728	300,980	74,551	18,276	-2,046,249	-84,491	-1,223,205
2066	470,743	153,041	79,921	36,483	-2,346,330	-76,100	-1,682,242
2067	528,523	251,642	74,935	22,151	-2,080,910	-76,831	-1,280,490
2068	661,663	486,698	142,804	60,396	-1,436,648	-79,047	-164,134
2069	1,040,160	1,465,459	113,460	123,705	-913,375	-91,621	1,737,788
2070	700,878	559,960	65,558	19,394	-1,427,896	-92,362	-174,470

p

Table 16 - Projected Future Groundwater Budget for Kern County Subbasin under Baseline Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	33,387,078	29,420,682	5,852,965	2,457,805	-67,979,441	-5,642,551	**-2,503,487**
Average	667,742	588,414	117,059	49,156	-1,359,589	-112,851	**-50,070**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,673,404	11,430,370	2,465,543	948,239	-29,144,885	-1,914,551	**-3,541,904**
Average	633,670	571,518	123,277	47,412	-1,457,244	-95,728	**-177,095**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	20,713,673	17,990,313	3,387,422	1,509,566	-38,834,555	-3,728,000	**1,038,418**
Average	690,456	599,677	112,914	50,319	-1,294,485	-124,267	**34,614**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	438,506	285,229	124,696	38,770	-1,588,405	-92,056	-793,259
2022	484,943	332,923	81,401	28,596	-1,869,400	-89,635	-1,031,173
2023	747,565	929,925	181,044	97,803	-1,055,850	-86,957	813,528
2024	822,429	979,290	228,277	67,141	-970,427	-93,017	1,033,691
2025	485,883	305,310	74,786	18,060	-1,922,678	-90,920	-1,129,567
2026	428,742	193,801	78,064	36,473	-2,246,543	-81,991	-1,591,454
2027	488,986	295,184	72,924	21,942	-1,980,297	-83,041	-1,184,303
2028	589,504	560,246	139,196	35,496	-1,411,249	-86,090	-172,895
2029	1,117,096	1,534,485	97,777	119,558	-766,833	-97,039	2,005,045
2030	679,411	565,264	63,373	19,157	-1,290,734	-98,635	-62,164
2031	541,540	162,351	110,189	19,161	-2,282,247	-96,146	-1,545,155
2032	441,935	112,432	67,508	18,134	-2,691,050	-90,556	-2,141,604
2033	859,254	919,119	182,854	126,420	-870,791	-94,090	1,122,766
2034	668,322	822,664	192,280	42,156	-1,173,675	-101,692	450,056
2035	784,526	798,773	284,615	52,652	-897,225	-105,253	918,089
2036	1,034,843	1,210,706	153,014	103,683	-650,599	-108,011	1,743,636
2037	644,248	560,331	94,651	32,114	-1,006,357	-108,561	216,426
2038	516,204	433,971	97,288	26,241	-1,129,713	-106,833	-162,843
2039	489,932	215,829	66,245	25,370	-1,664,753	-103,525	-970,903
2040	409,536	212,534	75,360	19,311	-1,676,059	-100,504	-1,059,821
2041	453,324	299,058	124,597	34,980	-1,341,636	-100,007	-529,684
2042	502,042	341,354	81,470	28,467	-1,640,917	-101,775	-789,360
2043	814,606	983,531	170,389	100,835	-895,370	-101,316	1,072,674
2044	910,857	1,034,642	180,887	68,630	-835,118	-109,430	1,250,469
2045	521,915	315,448	64,301	18,136	-1,739,889	-109,783	-929,871
2046	441,299	203,570	78,166	36,599	-2,059,728	-102,966	-1,403,060
2047	508,422	304,623	73,192	22,117	-1,807,101	-105,348	-1,004,096
2048	627,841	599,489	138,742	35,645	-1,279,707	-109,328	12,682
2049	1,207,124	1,582,570	92,749	121,871	-699,689	-120,788	2,183,838
2050	715,904	572,082	62,576	19,216	-1,147,620	-123,585	98,574
2051	566,731	169,466	109,535	19,218	-2,098,372	-122,310	-1,355,733
2052	460,099	118,999	67,410	18,007	-2,475,354	-117,801	-1,928,640
2053	911,979	930,151	181,291	127,393	-779,720	-120,542	1,250,552
2054	706,309	828,896	186,647	42,236	-1,026,541	-129,010	608,538
2055	815,225	808,705	273,436	52,738	-820,029	-132,486	997,588
2056	1,220,307	1,220,810	143,076	169,221	-583,006	-134,619	2,035,787
2057	728,598	563,409	84,816	33,376	-925,334	-135,590	349,275
2058	575,169	435,811	93,112	26,454	-1,041,644	-134,076	-45,174
2059	537,607	217,172	65,865	25,586	-1,522,045	-130,703	-806,518
2060	443,476	214,412	75,216	19,353	-1,486,408	-127,955	-861,906
2061	476,733	299,707	124,039	34,990	-1,256,091	-127,367	-447,988
2062	522,517	342,004	81,198	28,658	-1,494,732	-129,480	-649,837
2063	842,570	984,995	164,987	103,344	-865,981	-128,285	1,101,631
2064	912,864	1,036,106	168,792	42,092	-824,554	-136,560	1,198,740
2065	536,563	316,098	60,871	18,276	-1,633,199	-137,469	-838,861
2066	459,136	204,216	77,908	36,483	-1,928,338	-130,987	-1,281,582
2067	523,840	305,272	72,906	22,151	-1,681,701	-133,885	-891,417
2068	756,365	600,955	138,230	60,396	-1,152,716	-136,113	267,118
2069	1,256,008	1,584,033	90,058	123,705	-677,244	-147,778	2,228,780
2070	758,243	572,731	60,963	19,394	-1,114,770	-150,662	145,898

Table 17 - Projected Future Groundwater Budget for Kern County Subbasin under 2030 Climate Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	30,406,971	29,339,119	6,327,055	2,517,393	-86,788,414	-3,819,475	**-22,017,372**
Average	608,139	586,782	126,541	50,348	-1,735,768	-76,389	**-440,347**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,794,171	11,577,682	2,566,294	967,011	-34,895,955	-1,620,997	**-9,611,815**
Average	589,709	578,884	128,315	48,351	-1,744,798	-81,050	**-480,591**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,612,800	17,761,437	3,760,762	1,550,382	-51,892,459	-2,198,478	**-12,405,557**
Average	620,427	592,048	125,359	51,679	-1,729,749	-73,283	**-413,519**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	429,801	266,621	147,726	42,134	-1,760,507	-89,485	-963,710
2022	495,782	350,434	98,398	31,229	-2,063,486	-85,888	-1,173,532
2023	657,377	938,152	192,323	100,122	-1,262,715	-83,042	542,211
2024	699,315	964,377	183,699	64,551	-1,207,497	-88,046	616,394
2025	453,515	298,894	70,475	18,068	-2,099,053	-84,337	-1,342,442
2026	438,475	211,691	132,834	37,800	-2,421,834	-74,881	-1,675,915
2027	475,056	242,088	116,257	23,732	-2,243,832	-73,567	-1,460,266
2028	584,278	554,269	191,570	39,445	-1,707,009	-74,319	-411,764
2029	1,184,130	1,838,027	119,236	122,295	-1,141,893	-85,285	2,036,509
2030	551,212	516,323	55,121	19,641	-1,526,323	-84,001	-468,028
2031	515,256	195,193	77,160	18,143	-2,435,739	-79,350	-1,709,339
2032	412,101	141,644	46,910	17,968	-2,917,906	-68,881	-2,368,165
2033	705,949	858,275	183,650	122,210	-1,221,991	-75,654	572,438
2034	608,912	835,355	151,564	45,764	-1,553,837	-82,718	5,039
2035	736,051	805,594	299,717	55,297	-1,318,053	-86,250	492,354
2036	856,734	1,179,748	139,319	102,926	-1,048,605	-88,527	1,141,594
2037	549,368	496,346	84,153	32,384	-1,359,301	-86,074	-283,124
2038	517,749	434,834	86,857	27,413	-1,508,027	-81,722	-522,896
2039	486,869	213,407	87,775	26,084	-2,058,425	-76,725	-1,321,014
2040	436,242	236,409	101,552	19,804	-2,039,923	-72,244	-1,318,160
2041	468,388	265,794	147,815	39,151	-1,718,118	-70,242	-867,212
2042	539,545	352,187	98,721	31,228	-2,054,079	-69,819	-1,102,217
2043	708,149	936,725	187,725	103,193	-1,256,110	-69,228	610,454
2044	752,733	964,701	141,049	65,724	-1,202,714	-76,356	645,137
2045	478,985	298,488	59,556	18,138	-2,094,488	-74,534	-1,313,855
2046	460,252	211,504	133,158	37,870	-2,417,639	-66,341	-1,641,195
2047	491,476	242,301	116,368	23,946	-2,240,282	-66,079	-1,432,270
2048	598,731	553,200	191,811	39,636	-1,702,832	-67,702	-387,155
2049	1,195,910	1,840,650	110,980	124,949	-1,138,391	-79,663	2,054,435
2050	559,732	517,261	52,409	19,693	-1,522,960	-79,133	-452,999
2051	523,154	195,193	77,219	18,193	-2,431,497	-74,903	-1,692,640
2052	422,530	137,917	46,976	17,931	-2,886,044	-64,842	-2,325,533
2053	707,015	859,779	184,316	123,682	-1,218,433	-72,058	584,301
2054	609,414	833,943	150,995	45,880	-1,549,633	-79,575	11,025
2055	732,232	805,822	298,010	55,392	-1,314,039	-83,611	493,807
2056	928,888	1,178,928	149,824	169,164	-993,641	-86,087	1,347,076
2057	576,909	493,935	84,196	33,640	-1,355,384	-83,745	-250,448
2058	538,662	437,650	87,066	27,628	-1,504,171	-79,389	-492,554
2059	503,402	214,796	87,753	26,299	-2,054,234	-74,306	-1,296,288
2060	451,522	236,977	101,432	19,792	-1,984,344	-70,103	-1,244,725
2061	478,796	265,975	147,869	39,158	-1,714,445	-68,401	-851,049
2062	550,809	351,281	98,718	31,426	-2,049,977	-68,093	-1,085,837
2063	722,818	938,420	188,697	104,939	-1,252,649	-67,820	634,404
2064	715,791	963,206	146,069	41,649	-1,229,743	-75,400	561,571
2065	475,418	298,806	61,265	18,289	-2,090,191	-73,868	-1,310,281
2066	465,005	211,102	133,136	37,782	-2,413,360	-65,953	-1,632,289
2067	498,090	242,117	116,493	23,923	-2,236,433	-65,997	-1,421,808
2068	670,255	553,410	192,083	65,542	-1,609,843	-66,655	-195,208
2069	1,217,773	1,839,574	115,521	126,664	-1,135,132	-79,491	2,084,909
2070	570,417	519,795	53,528	19,883	-1,521,656	-79,082	-437,115

Table 18 - Projected Future Groundwater Budget for Kern County Subbasin under 2030 Climate Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	32,439,318	32,289,237	5,616,681	2,517,393	-72,758,546	-5,302,496	**-5,198,445**
Average	648,786	645,785	112,334	50,348	-1,455,171	-106,050	**-103,969**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,469,935	12,560,244	2,378,883	967,011	-31,230,653	-1,828,732	**-4,683,343**
Average	623,497	628,012	118,944	48,351	-1,561,533	-91,437	**-234,167**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	19,969,383	19,728,994	3,237,798	1,550,382	-41,527,893	-3,473,764	**-515,102**
Average	665,646	657,633	107,927	51,679	-1,384,263	-115,792	**-17,170**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	441,652	292,996	147,069	42,134	-1,671,535	-91,596	-839,279
2022	503,391	371,339	98,721	31,229	-1,962,336	-88,496	-1,046,156
2023	753,413	1,002,660	184,247	100,122	-1,165,732	-85,624	789,081
2024	759,876	1,024,098	159,689	64,551	-1,120,136	-90,877	797,201
2025	450,559	302,266	67,803	18,068	-1,965,427	-88,796	-1,215,531
2026	427,255	252,554	132,707	37,800	-2,311,777	-79,914	-1,541,375
2027	476,442	285,312	116,391	23,732	-2,129,441	-80,216	-1,307,785
2028	591,734	625,082	188,060	39,445	-1,574,434	-81,148	-211,265
2029	1,289,576	1,905,958	98,151	122,295	-976,046	-92,153	2,347,781
2030	542,503	521,613	50,945	19,641	-1,379,429	-92,754	-337,488
2031	501,396	197,443	77,459	18,143	-2,252,423	-90,623	-1,548,606
2032	426,472	144,335	47,362	17,968	-2,715,519	-84,772	-2,164,155
2033	864,855	970,952	180,158	122,210	-999,603	-88,821	1,049,751
2034	649,853	908,366	135,371	45,764	-1,291,972	-95,791	351,590
2035	815,853	925,239	267,880	55,297	-1,067,406	-99,481	897,381
2036	1,040,723	1,329,469	101,824	102,926	-786,905	-102,460	1,685,577
2037	556,956	534,420	62,036	32,384	-1,113,410	-102,222	-29,835
2038	500,495	478,749	73,664	27,413	-1,237,898	-100,665	-258,241
2039	475,271	235,303	87,425	26,084	-1,780,634	-97,586	-1,054,138
2040	401,662	252,089	101,921	19,804	-1,728,590	-94,737	-1,047,853
2041	444,635	305,751	148,046	39,151	-1,417,821	-93,784	-574,022
2042	511,794	381,811	98,698	31,228	-1,732,709	-94,600	-803,778
2043	814,085	1,054,879	164,977	103,193	-981,693	-94,228	1,061,212
2044	840,227	1,081,322	89,637	65,724	-951,613	-101,997	1,023,300
2045	469,643	312,573	47,742	18,138	-1,792,701	-102,528	-1,047,133
2046	435,603	262,180	132,908	37,870	-2,120,184	-95,827	-1,347,449
2047	486,874	294,995	116,428	23,946	-1,946,133	-97,562	-1,121,453
2048	607,958	663,346	188,107	39,636	-1,411,843	-99,958	-12,754
2049	1,352,884	1,956,195	71,870	124,949	-850,441	-112,046	2,543,410
2050	551,433	529,184	41,023	19,693	-1,229,490	-113,831	-201,988
2051	512,537	204,559	77,384	18,193	-2,067,798	-113,040	-1,368,166
2052	429,928	147,354	47,320	17,931	-2,501,030	-108,107	-1,966,604
2053	904,991	983,485	179,758	123,682	-884,881	-111,900	1,195,134
2054	672,032	913,349	123,349	45,880	-1,118,165	-120,278	516,169
2055	838,683	935,521	251,597	55,392	-953,395	-124,317	1,003,480
2056	1,179,632	1,338,655	91,523	169,164	-689,640	-126,838	1,962,496
2057	615,797	535,086	49,219	33,640	-1,010,391	-126,902	96,449
2058	549,760	483,296	65,719	27,628	-1,125,055	-125,593	-124,246
2059	509,922	237,931	86,168	26,299	-1,633,859	-122,678	-896,216
2060	426,496	254,555	101,961	19,792	-1,541,056	-120,134	-858,386
2061	460,712	306,605	148,114	39,158	-1,322,148	-119,371	-486,930
2062	524,936	381,579	98,394	31,426	-1,601,565	-120,728	-685,959
2063	835,547	1,057,875	157,729	104,939	-945,160	-119,767	1,091,162
2064	842,924	1,081,555	77,039	41,649	-935,533	-127,694	979,940
2065	480,247	313,450	44,212	18,289	-1,670,834	-128,903	-943,540
2066	447,484	262,406	132,774	37,782	-1,985,427	-122,696	-1,227,678
2067	494,592	295,496	116,447	23,923	-1,814,397	-125,148	-1,009,086
2068	739,200	665,024	188,483	65,542	-1,281,311	-125,683	251,254
2069	1,401,442	1,956,602	63,193	126,664	-825,735	-137,931	2,584,235
2070	587,384	532,378	37,980	19,883	-1,185,886	-139,694	-147,956

Table 19 - Projected Future Groundwater Budget for Kern County Subbasin under 2070 Climate Conditions with NO SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	29,855,454	31,748,130	5,838,562	2,495,122	-93,484,380	-3,716,462	**-27,263,599**
Average	597,109	634,963	116,771	49,902	-1,869,688	-74,329	**-545,272**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	11,667,139	12,563,708	2,365,431	960,586	-37,578,197	-1,596,743	**-11,618,097**
Average	583,357	628,185	118,272	48,029	-1,878,910	-79,837	**-580,905**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	18,188,315	19,184,423	3,473,131	1,534,536	-55,906,182	-2,119,719	**-15,645,502**
Average	606,277	639,481	115,771	51,151	-1,863,539	-70,657	**-521,517**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	416,481	252,197	140,505	38,275	-1,916,977	-89,491	-1,159,011
2022	479,395	367,510	96,033	30,903	-2,196,603	-85,085	-1,307,854
2023	664,962	1,025,761	190,043	97,206	-1,442,091	-82,544	453,337
2024	724,274	1,071,819	165,600	64,640	-1,325,764	-88,575	611,993
2025	437,410	310,633	66,267	18,095	-2,191,088	-84,783	-1,443,470
2026	453,984	314,891	142,497	42,165	-2,485,140	-75,450	-1,607,054
2027	442,110	216,204	111,416	22,713	-2,402,106	-72,832	-1,682,495
2028	574,563	607,420	195,132	37,491	-1,835,239	-73,491	-494,127
2029	1,202,516	1,957,433	104,229	120,391	-1,309,793	-83,999	1,990,777
2030	513,581	494,042	52,038	18,406	-1,660,571	-82,431	-664,937
2031	502,891	213,163	80,419	18,510	-2,511,904	-77,804	-1,774,725
2032	393,359	107,286	41,452	17,864	-3,092,461	-66,511	-2,599,013
2033	696,126	930,068	185,421	124,666	-1,400,033	-73,829	462,419
2034	634,583	972,610	136,241	48,403	-1,641,946	-81,216	68,676
2035	739,613	887,147	260,766	52,829	-1,536,041	-84,062	320,252
2036	824,846	1,288,751	80,025	95,355	-1,252,333	-86,150	950,494
2037	522,211	536,271	63,057	33,462	-1,479,140	-83,545	-407,683
2038	538,747	524,392	76,691	30,839	-1,626,331	-79,651	-535,314
2039	491,330	261,821	87,605	29,526	-2,123,486	-75,076	-1,328,280
2040	414,155	224,291	89,995	18,846	-2,149,151	-70,217	-1,472,081
2041	438,445	251,405	141,679	34,801	-1,877,457	-67,674	-1,078,801
2042	509,477	369,168	96,294	30,811	-2,187,705	-66,710	-1,248,664
2043	696,160	1,024,387	177,104	99,819	-1,435,142	-66,441	495,888
2044	756,947	1,072,105	106,435	65,709	-1,320,828	-74,548	605,820
2045	457,262	310,212	51,441	18,140	-2,186,589	-72,831	-1,422,366
2046	474,254	314,643	142,906	42,210	-2,480,901	-64,826	-1,571,714
2047	456,940	216,525	111,535	22,758	-2,398,002	-63,398	-1,653,643
2048	586,068	606,321	195,452	37,553	-1,830,906	-65,169	-470,681
2049	1,188,964	1,960,048	91,267	122,702	-1,306,273	-76,827	1,979,882
2050	517,131	494,976	48,720	18,437	-1,656,734	-76,179	-653,649
2051	510,486	213,163	80,487	18,541	-2,507,662	-72,026	-1,757,012
2052	403,735	103,564	41,526	17,846	-3,061,164	-61,436	-2,555,929
2053	695,014	931,618	185,940	125,947	-1,396,428	-69,356	472,735
2054	633,902	971,316	135,132	48,546	-1,637,822	-77,280	73,794
2055	732,625	887,092	261,025	53,236	-1,531,884	-80,730	321,364
2056	900,739	1,288,161	93,033	163,750	-1,192,877	-83,188	1,169,618
2057	545,822	533,858	64,903	34,610	-1,476,198	-80,687	-377,693
2058	554,199	527,156	78,060	31,051	-1,622,403	-76,836	-508,777
2059	505,085	263,151	87,864	29,722	-2,119,167	-72,159	-1,305,505
2060	430,917	224,893	90,023	18,987	-2,096,758	-67,709	-1,399,646
2061	450,288	251,640	141,681	34,761	-1,873,608	-65,447	-1,060,686
2062	521,238	368,299	96,344	30,984	-2,183,668	-64,671	-1,231,474
2063	708,640	1,025,986	180,653	100,139	-1,431,345	-64,816	519,256
2064	718,253	1,070,667	117,470	41,720	-1,344,539	-73,390	530,181
2065	452,517	310,495	54,738	18,277	-2,181,935	-72,048	-1,417,957
2066	477,892	314,225	142,888	41,907	-2,476,370	-64,278	-1,563,735
2067	463,710	216,282	111,638	22,808	-2,394,356	-63,020	-1,642,938
2068	662,509	606,642	195,649	66,128	-1,739,184	-63,466	-271,721
2069	1,210,375	1,958,939	100,259	124,017	-1,302,864	-76,483	2,014,244
2070	528,721	497,487	50,984	18,619	-1,655,415	-76,092	-635,695

Table 20 - Projected Future Groundwater Budget for Kern County Subbasin under 2070 Climate Conditions WITH SGMA Projects based on C2VSimFG-Kern Simulation

Water Year	Deep Percolation	Managed Recharge and Canal Seepage	Net GW/SW Interactions	Small Watershed Inflow	GW Pumping	Subsurface Flow with Adjacent GW Basins	Change in Groundwater Storage
Units	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft	Acre-ft
SUMMARY: WY2021 to WY2070 Simulatation Period							
Total	31,493,119	34,676,204	5,023,196	2,495,122	-78,465,457	-5,281,242	**-10,059,104**
Average	629,862	693,524	100,464	49,902	-1,569,309	-105,625	**-201,182**
SUMMARY: WY2021 to WY2040 Implementation Period							
Total	12,261,512	13,537,356	2,149,791	960,586	-33,710,341	-1,821,159	**-6,622,296**
Average	613,076	676,868	107,490	48,029	-1,685,517	-91,058	**-331,115**
SUMMARY: WY2041 to WY2070 Sustainability Period							
Total	19,231,606	21,138,848	2,873,405	1,534,536	-44,755,117	-3,460,083	**-3,436,808**
Average	641,054	704,628	95,780	51,151	-1,491,837	-115,336	**-114,560**
Annual Simulation Results for WY2021 to WY2070 Simulation Period							
2021	422,584	279,759	140,794	38,275	-1,825,598	-91,619	-1,035,805
2022	488,253	387,562	96,265	30,903	-2,091,767	-87,769	-1,176,558
2023	760,000	1,090,884	181,941	97,206	-1,338,893	-85,110	706,028
2024	773,005	1,131,177	139,187	64,640	-1,234,584	-91,304	782,116
2025	434,474	313,620	63,094	18,095	-2,054,146	-89,407	-1,314,285
2026	445,787	355,840	141,941	42,165	-2,372,644	-80,742	-1,467,659
2027	439,786	259,693	111,505	22,713	-2,274,718	-80,113	-1,521,134
2028	583,608	676,951	191,628	37,491	-1,697,617	-80,739	-288,677
2029	1,303,985	2,026,066	79,306	120,391	-1,131,751	-91,248	2,306,749
2030	503,719	499,229	45,905	18,406	-1,499,669	-91,675	-524,087
2031	490,364	215,537	80,773	18,510	-2,320,939	-90,191	-1,605,946
2032	403,661	110,577	41,677	17,864	-2,869,425	-84,801	-2,380,448
2033	842,198	1,041,181	181,775	124,666	-1,160,289	-88,517	941,013
2034	666,308	1,042,279	113,056	48,403	-1,373,274	-95,543	401,229
2035	798,592	1,006,455	226,577	52,829	-1,274,011	-98,591	711,850
2036	1,003,079	1,437,909	43,126	95,355	-970,366	-101,265	1,507,839
2037	517,484	574,060	39,346	33,462	-1,219,067	-101,319	-156,042
2038	522,992	565,610	57,977	30,839	-1,340,898	-100,165	-263,645
2039	476,901	282,303	83,746	29,526	-1,835,107	-97,127	-1,059,757
2040	384,733	240,665	90,169	18,846	-1,825,578	-93,914	-1,185,079
2041	415,234	291,710	141,934	34,801	-1,558,507	-92,234	-767,063
2042	488,101	398,308	96,079	30,811	-1,853,284	-92,666	-932,652
2043	795,992	1,142,687	149,122	99,819	-1,130,721	-92,492	964,407
2044	827,366	1,187,351	53,341	65,709	-1,040,595	-101,396	991,776
2045	446,716	324,312	38,470	18,140	-1,865,630	-102,037	-1,140,029
2046	454,194	365,422	142,233	42,210	-2,175,138	-95,467	-1,266,545
2047	444,486	269,482	111,552	22,758	-2,081,680	-96,538	-1,329,940
2048	602,382	715,182	191,735	37,553	-1,523,098	-98,688	-74,935
2049	1,322,298	2,075,690	44,846	122,702	-980,786	-110,495	2,474,256
2050	506,042	506,798	33,881	18,437	-1,348,791	-112,175	-395,808
2051	497,261	222,653	80,767	18,541	-2,135,563	-111,952	-1,428,294
2052	412,782	113,602	41,562	17,846	-2,646,693	-107,795	-2,168,698
2053	878,381	1,053,760	180,055	125,947	-1,020,278	-111,749	1,106,115
2054	680,355	1,047,604	96,547	48,546	-1,201,766	-120,116	551,169
2055	808,384	1,016,456	211,305	53,236	-1,126,260	-123,937	839,183
2056	1,103,522	1,447,318	34,076	163,750	-841,985	-126,343	1,780,338
2057	560,571	574,729	27,201	34,610	-1,104,554	-126,628	-34,071
2058	554,438	570,084	51,089	31,051	-1,215,417	-125,923	-134,678
2059	500,014	284,874	80,658	29,722	-1,681,951	-122,984	-909,668
2060	403,999	243,162	90,080	18,987	-1,629,275	-120,297	-993,343
2061	427,754	292,603	141,811	34,761	-1,441,130	-119,027	-663,230
2062	497,998	398,114	95,618	30,984	-1,716,447	-119,828	-813,562
2063	812,053	1,145,589	142,445	100,139	-1,073,331	-119,247	1,007,647
2064	825,436	1,187,643	45,517	41,720	-1,020,722	-128,395	951,199
2065	448,678	325,153	36,161	18,277	-1,751,430	-129,714	-1,052,875
2066	461,891	365,635	142,103	41,907	-2,036,884	-123,666	-1,149,015
2067	458,166	269,922	111,553	22,808	-1,942,466	-125,187	-1,205,203
2068	717,810	716,972	192,414	66,128	-1,381,278	-125,575	186,470
2069	1,353,720	2,076,064	37,797	124,017	-944,642	-137,837	2,509,119
2070	525,583	509,971	31,455	18,619	-1,284,815	-139,693	-338,879

TABLE 21: Evaluation of Change in Groundwater Storage Model Results for Kern County Subbasin

	Model Results 2041-2070 Sustainability Period		**Adjustments to GW Storage Change** 2041-2070 Sustainability Period			**Adjustments for Banking** 2041-2070 Sustainability Period	
Scenario	**Change in Groundwater Storage**	**Change in Net Operational Budget**	Adjustment for Excess Basin Outflows	Adjustment for Excess Kern River Outflow	**Adjusted Change in GW Storage**	Adjusted Banking Obligation	**Δ Total Operational Storage**
units	**AFY**	**AFY**	AFY	AFY	**AFY**	AFY	**AFY**
Historic	**-277,114**	**-190,012**	0	0	**-277,114**	85,965	**-363,079**
Baseline	**-354,970**	**-271,881**	0	0	**-354,970**	69,632	**-424,602**
Base Projects	**34,614**	**158,881**	28,894	9,454	**72,963**	69,632	**3,331**
2030 Climate	**-413,519**	**-340,236**	0	6,242	**-407,276**	67,913	**-475,189**
2030 Projects	**-17,170**	**98,622**	29,952	21,230	**34,012**	67,913	**-33,901**
2070 Climate	**-521,517**	**-450,859**	0	13,879	**-507,637**	64,474	**-572,111**
2070 Projects	**-114,560**	**776**	32,076	31,385	**-51,099**	64,474	**-115,573**

NOTE:

"Change in *Groundwater Storage* " DOES include both subsurface flow with adjacent basins

"*Operational Storage* " DOES NOT include subsurface flow with adjacent basins

"Adjustment for *Excess Basin Outflows* " is the difference in simulated basin outflow that is attributed to addition of SGMA

"Adjustment for *Excess Kern River Outflow* " is the increase in simulated groundwater outflows to Kern River relative to Baseline

"*Adjusted Banking Obligation* " assumes that recharge operations are affected by reductions in imported water sources, but that banking recovery would be comparable to historical, resulting in decreased excess banking obligations in future conditions.

"*Δ Total Operational Storage* " is the Adjusted Change in GW Storage reduced by the volume of stored groundwater obligated to out-of-basin agencies.

TABLE 22: Evaluation of Sustainable Yield based on C2VSimFG-Kern Model Results for Kern County Subbasin

Scenario	Model Results 2041-2070 Sustainability Period			
	Groundwater Pumping	**Sustainable Yield**	**Average Annual Difference**	**Percent Difference**
units	**AFY**	AFY	AFY	**AFY**
Historic	**1,416,077**	**1,052,998**	**-363,079**	**-34%**
Baseline	**1,430,885**	**1,006,283**	**-424,602**	**-42%**
Base Projects	**1,103,639**	**1,106,970**	**3,331**	**0%**
2030 Climate	**1,544,256**	**1,069,067**	**-475,189**	**-44%**
2030 Projects	**1,193,412**	**1,159,511**	**-33,901**	**-3%**
2070 Climate	**1,678,037**	**1,105,925**	**-572,111**	**-52%**
2070 Projects	**1,300,977**	**1,185,404**	**-115,573**	**-10%**

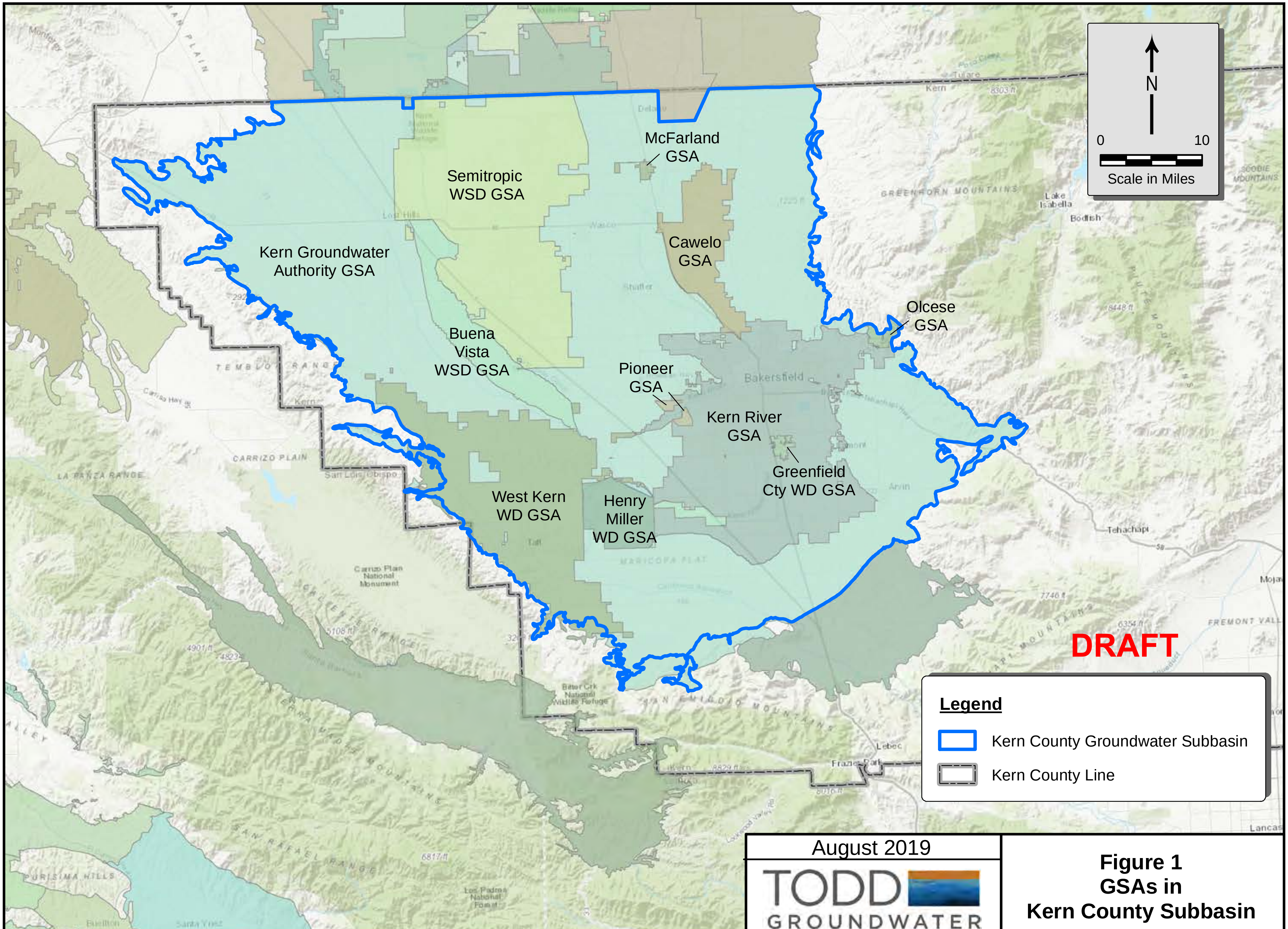
NOTES:

Sustainable Yield from Groundwater Pumping	Approach assumes that adjusting total groundwater pumping by the change in storage provides an reasonable approximation of the Basin Sustainable Yield
Sutainable Yield from Basin Recharge and Outflow	Approach assumes that the Basin Sustainable Yield can be reasonably approximated by adding up the different recharge components and non-pumping outflow components
Sutainable Yield	Sustainable yield is defined is the amount of pumping that can be
Average Annual Difference	The difference between the sustainable yield and the simulated groundwater pumping. A negative value is pumping in excess of the
Percent Difference	The percentage of the Average Annual Difference to the total groundwater pumping to provide context and a method to compare the

TABLE 23: Summary of Statistical Analysis for Validation of C2VSimFG-Kern Historical Simulation

Validation Measure	C2VSimFG-Kern	C2VSimFG-Beta	Percent Change
Units	Feet	Feet	Percent
Residual Mean	17.3	32.6	47%
Residual Standard Deviation	45.5	54.0	16%
Absolute Residual Mean	37.4	56.8	34%
Root Mean Square (RMS) Error	50.0	73.5	32%
Scaled Absolute Residual Mean	0.061	0.092	34%
Correlation Coefficient	0.76	0.52	47%
Number of Monitor Wells	558	558	same
Number of Observations	42,075	42,075	same

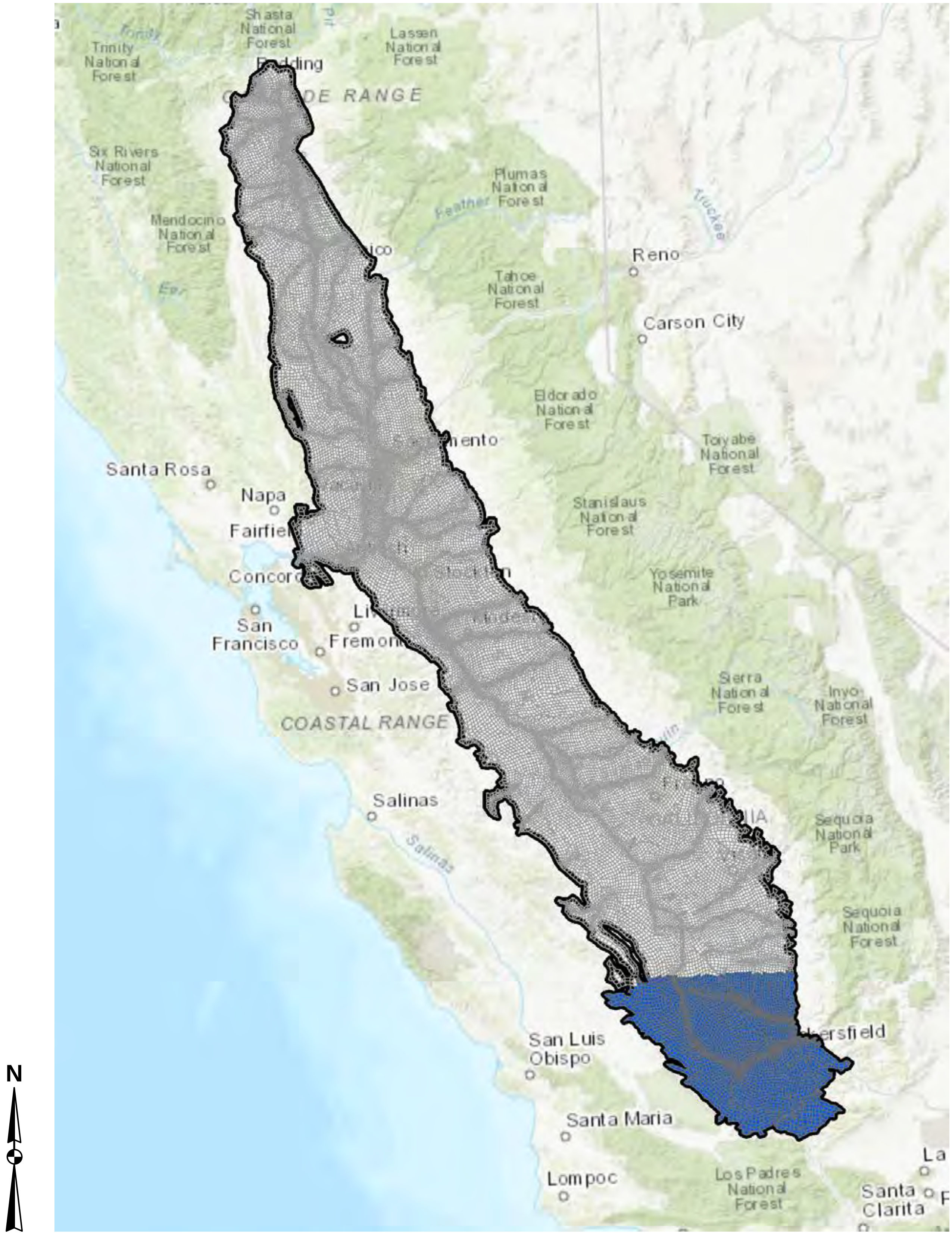
Figures



August 2019

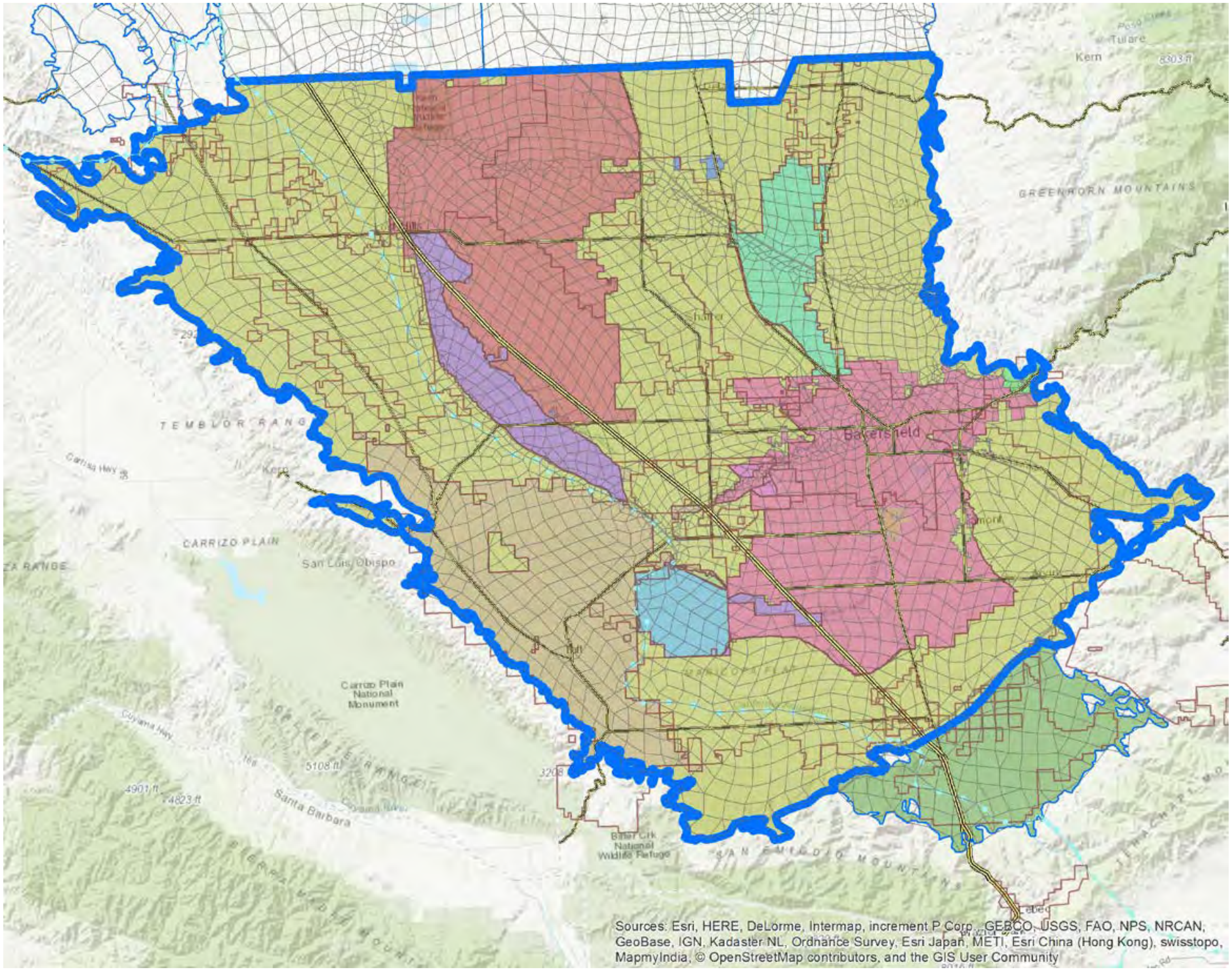
TODD GROUNDWATER

Figure 1
GSAs in
Kern County Subbasin



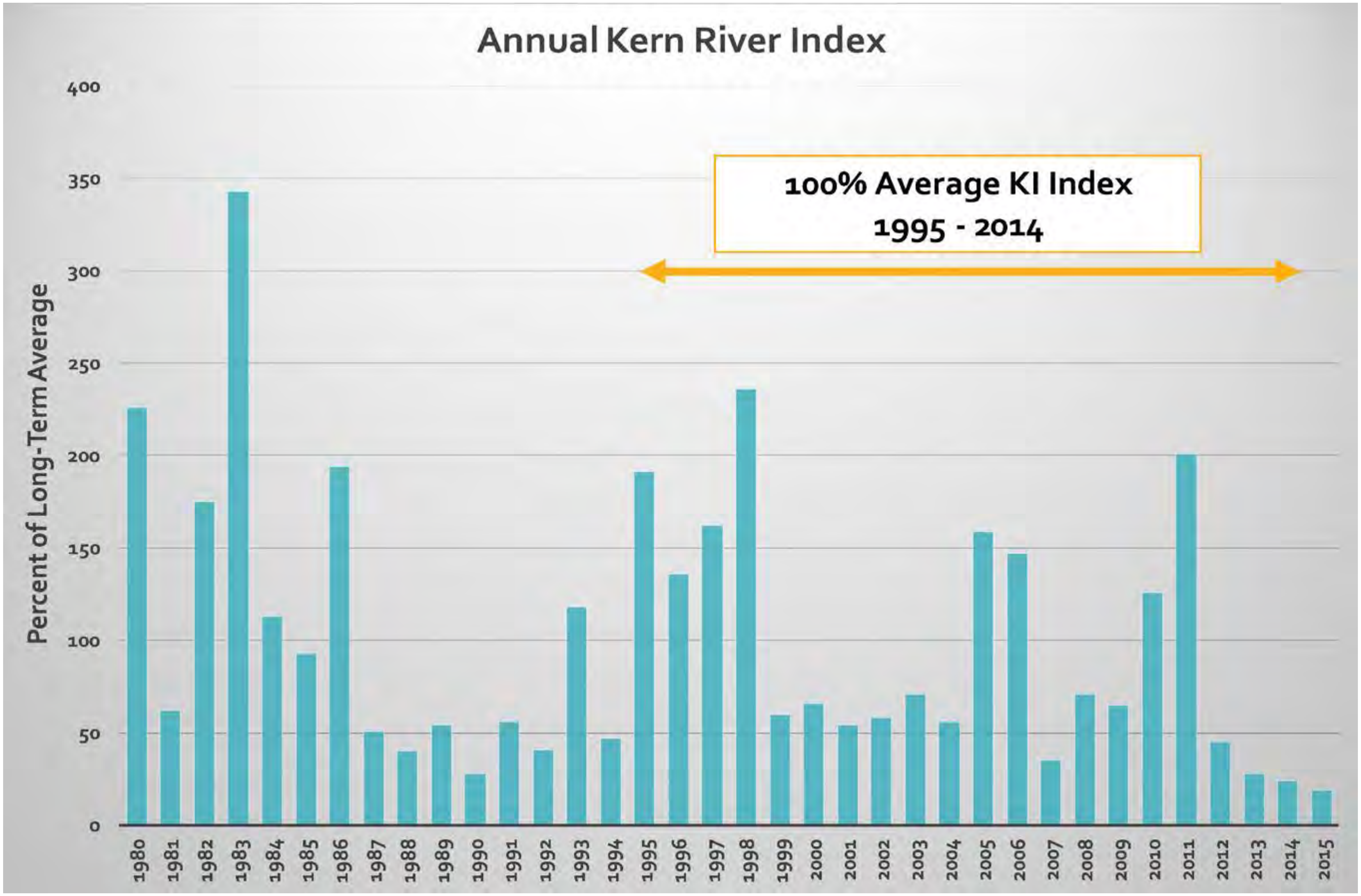
DRAFT

August 2019	Figure 2 C2VSimFG Simulation Grid for Central Valley Showing Kern County Subbasin
TODD GROUNDWATER	



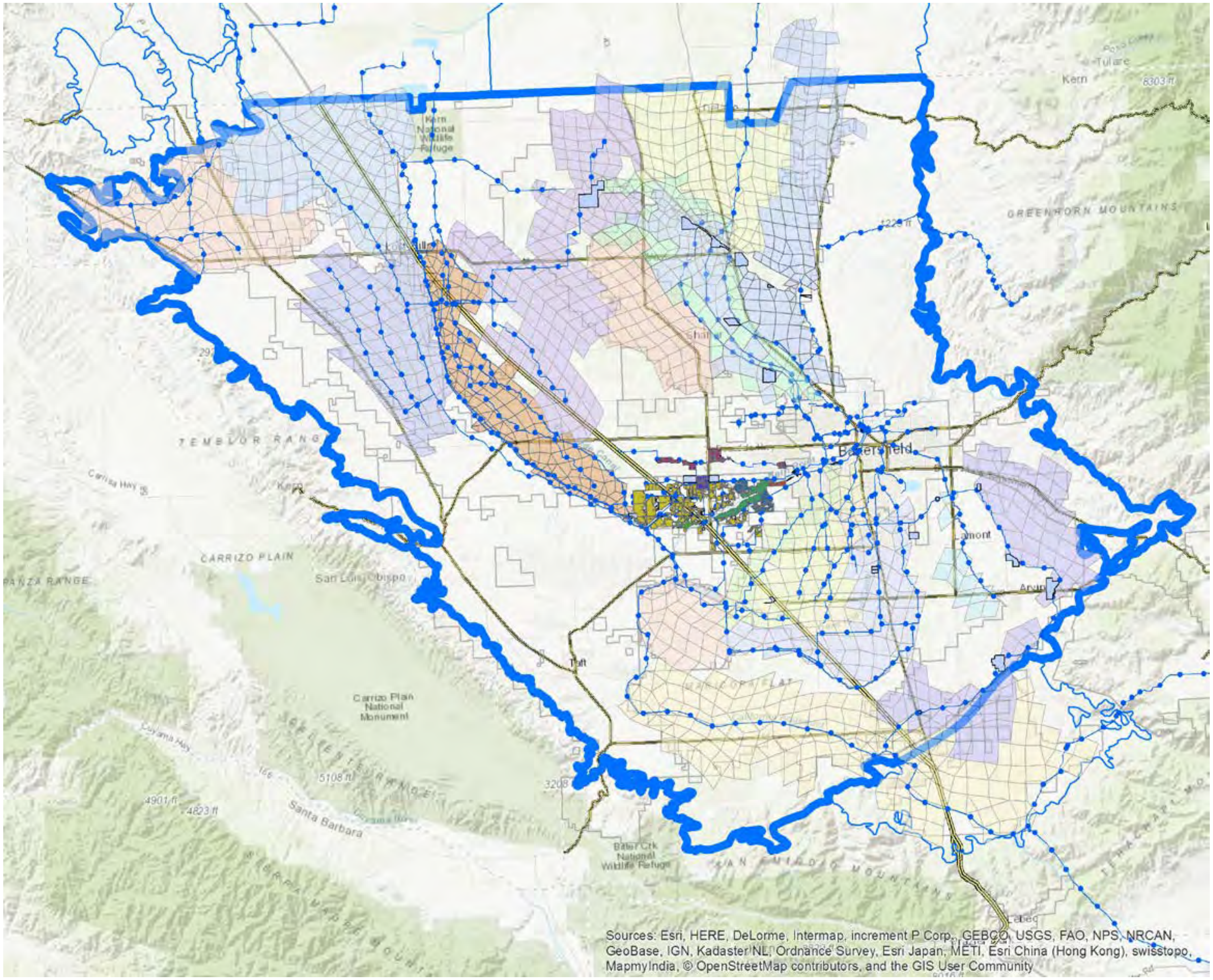
DRAFT

August 2019	Figure 3 C2VSimFG-Kern Simulation Grid with Kern County Subbasin GSAs
TODD GROUNDWATER	



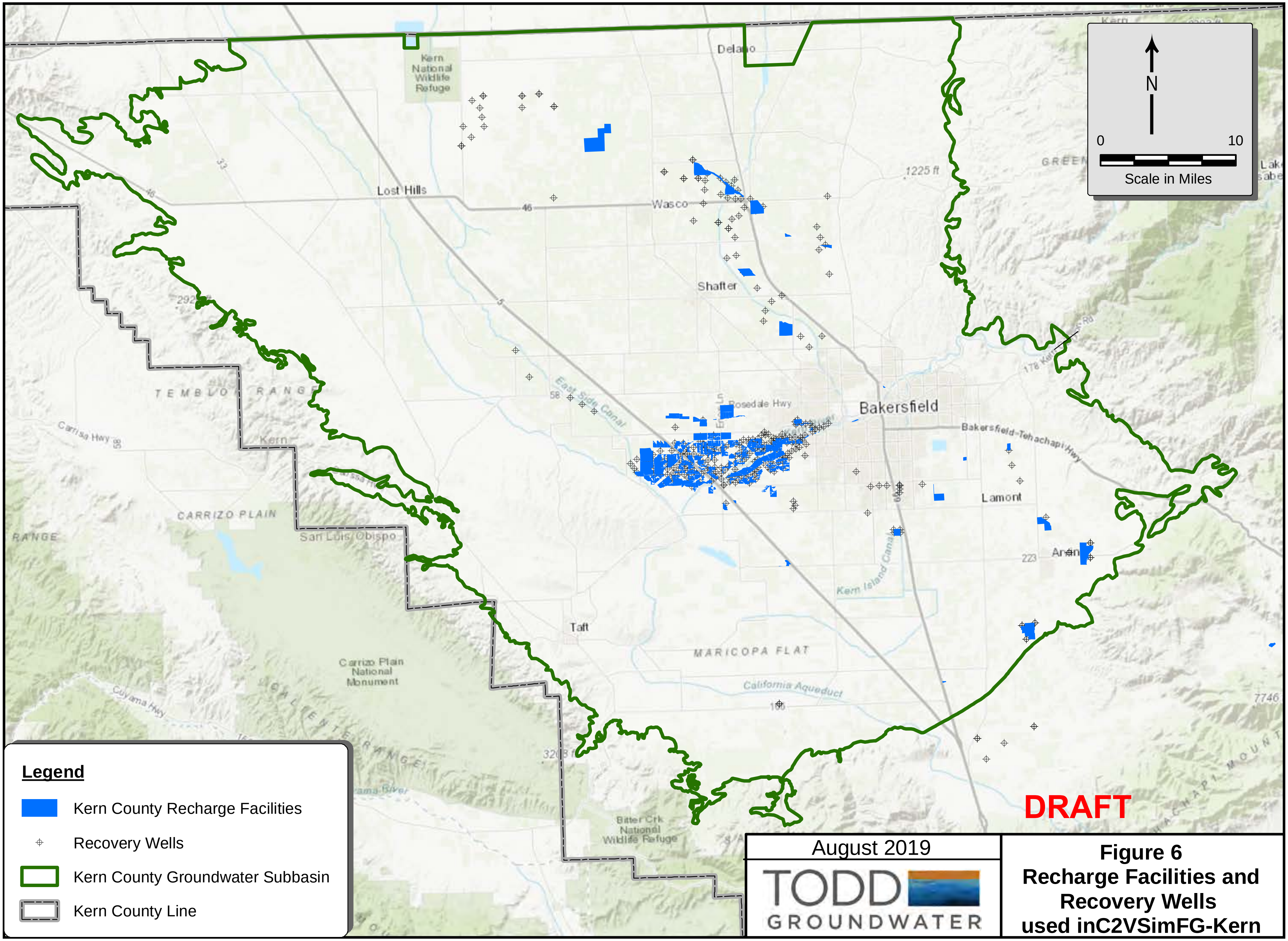
DRAFT

August 2019	Figure 4
TODD GROUNDWATER	Annual Kern River Index used to Define 20-Year Historical Study Period



DRAFT

August 2019	Figure 5 C2VSimFG-Kern Simulation Surface Water Application Areas with Conveyance
TODD GROUNDWATER	



August 2019

TODD GROUNDWATER

Figure 6
Recharge Facilities and Recovery Wells used inC2VSimFG-Kern

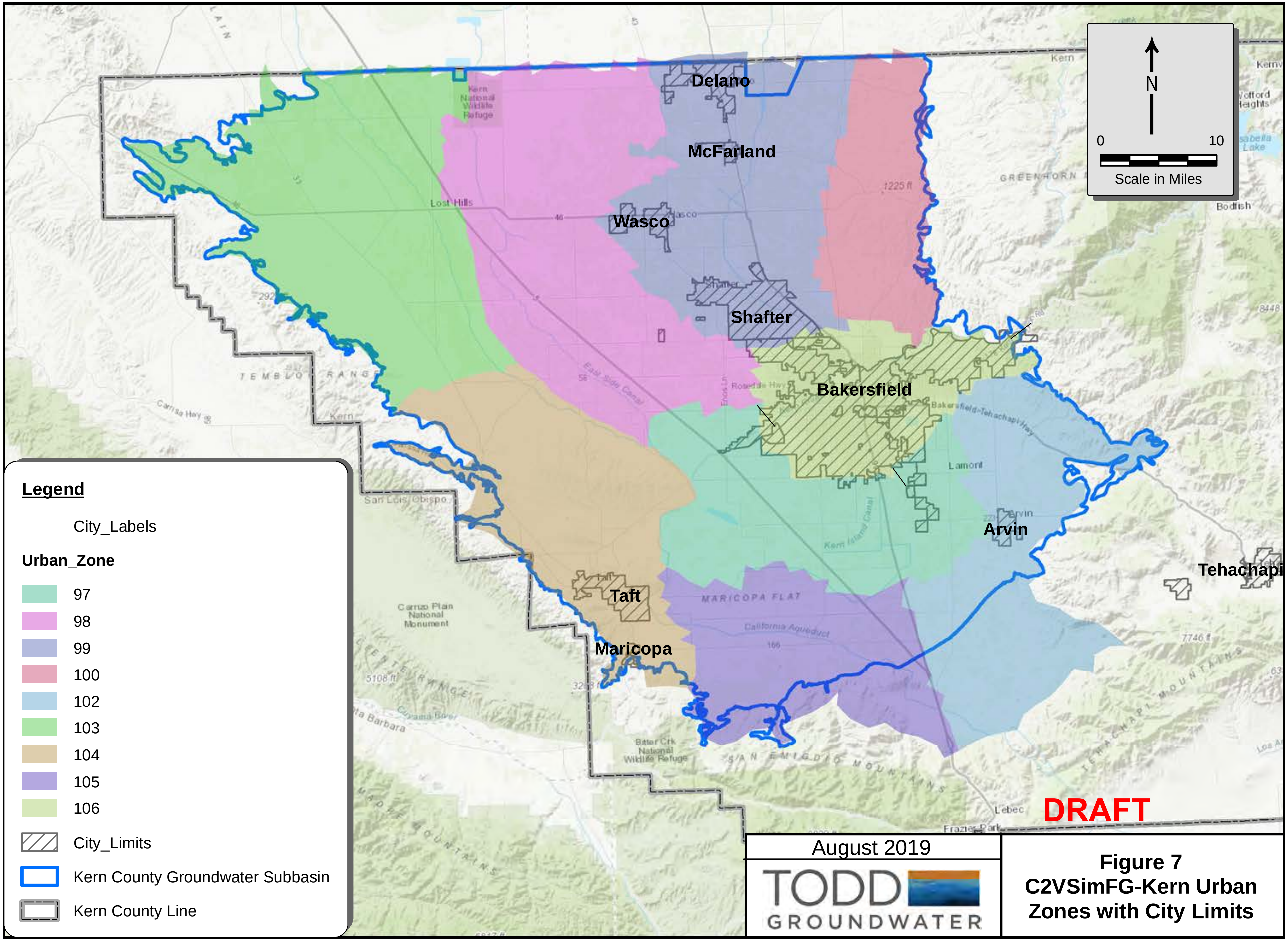
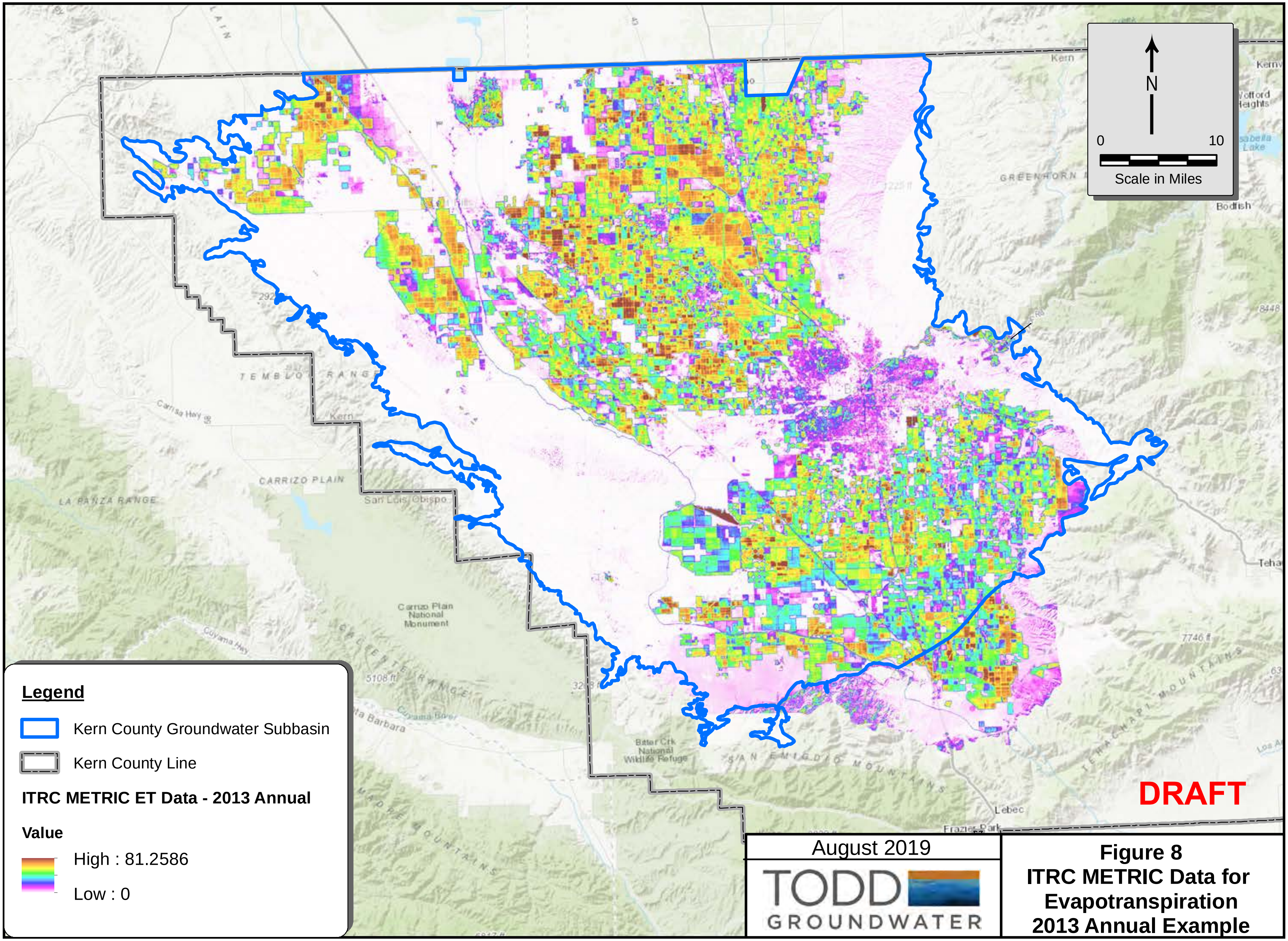


Figure 7
C2VSimFG-Kern Urban Zones with City Limits



Legend

Kern County Groundwater Subbasin

Kern County Line

ITRC METRIC ET Data - 2013 Annual

Value

High : 81.2586

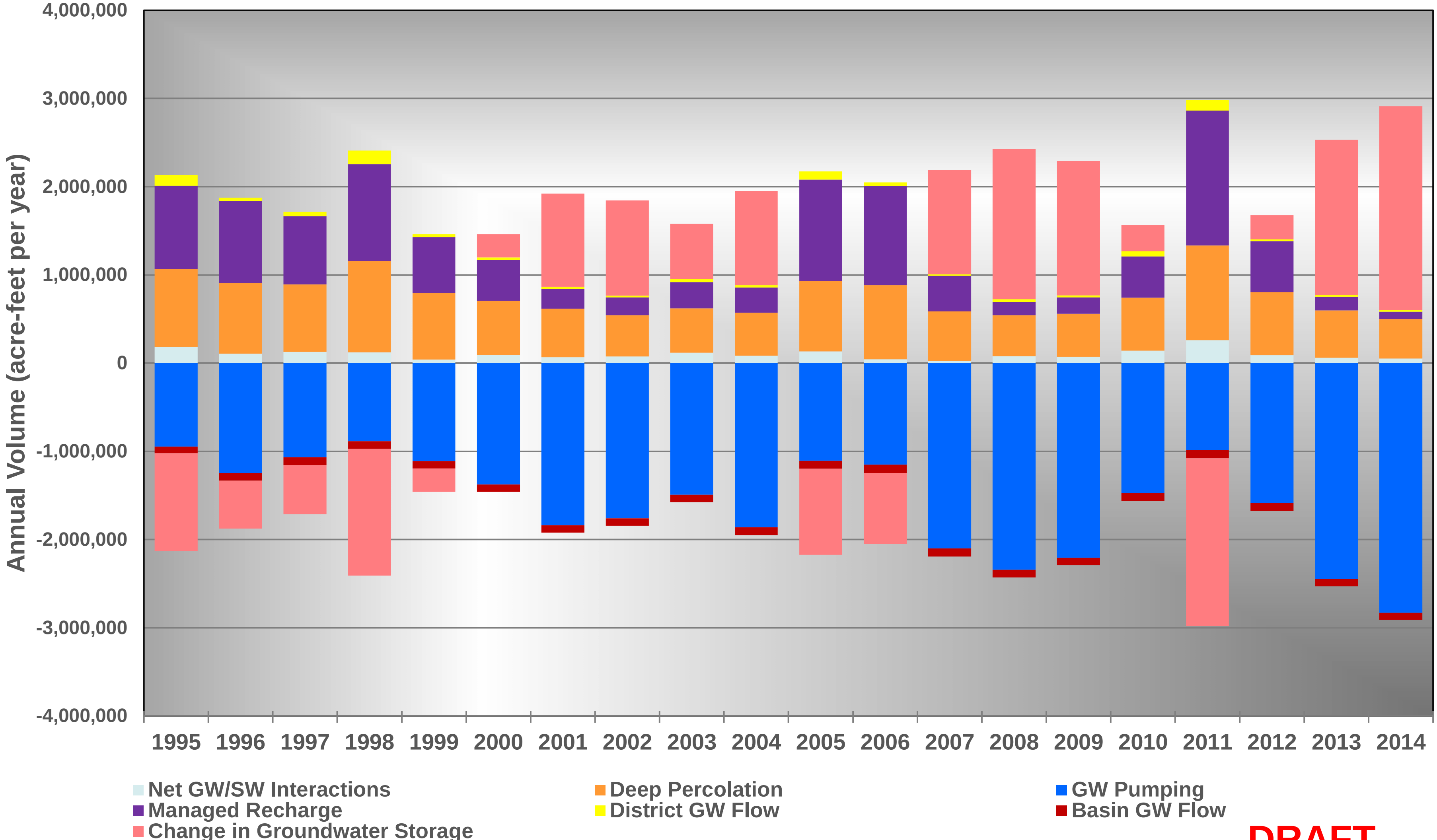
Low : 0

August 2019

TODD GROUNDWATER

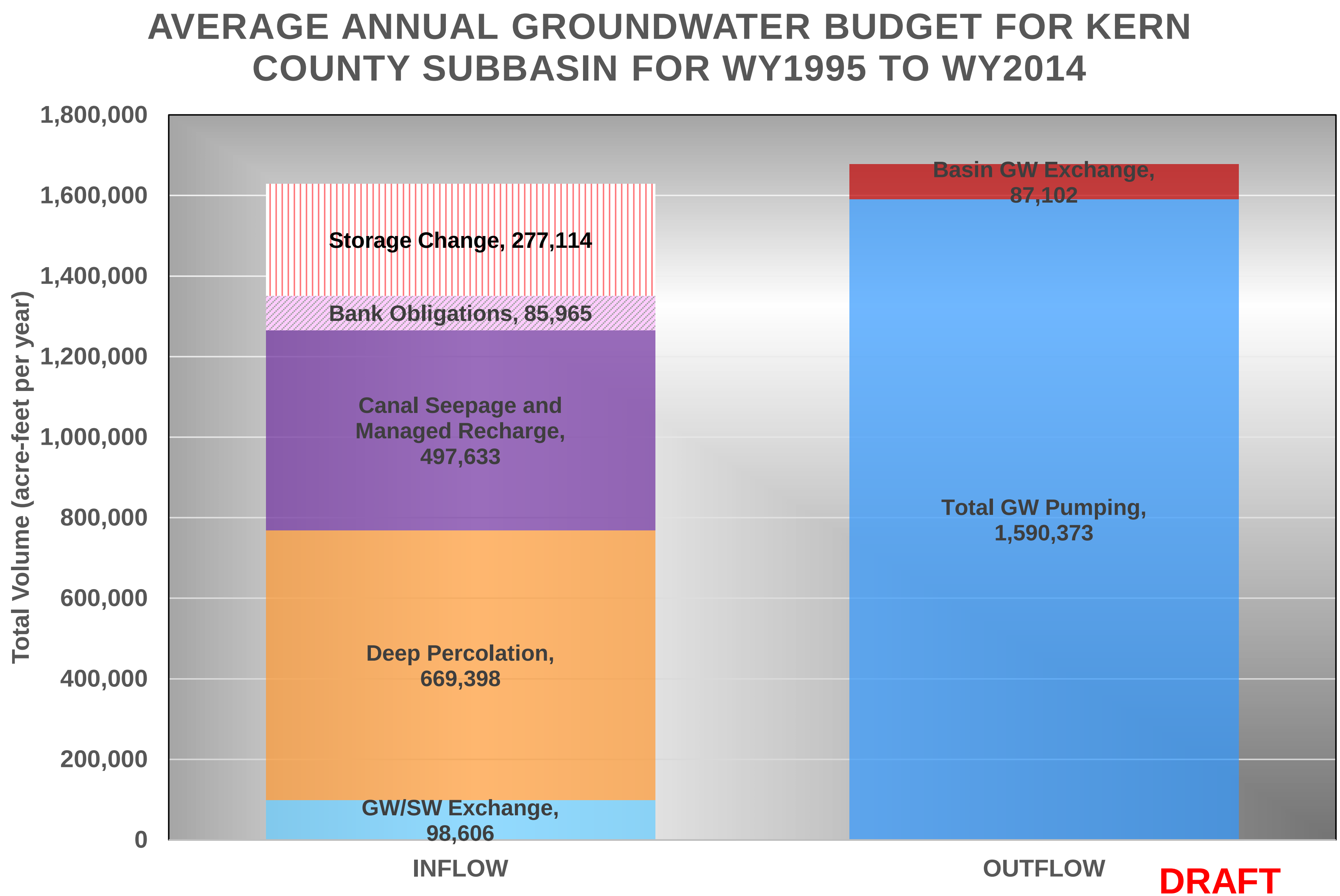
Figure 8
ITRC METRIC Data for Evapotranspiration 2013 Annual Example

Historical Groundwater Budget for Kern County Subbasin for WY1995 to WY2014



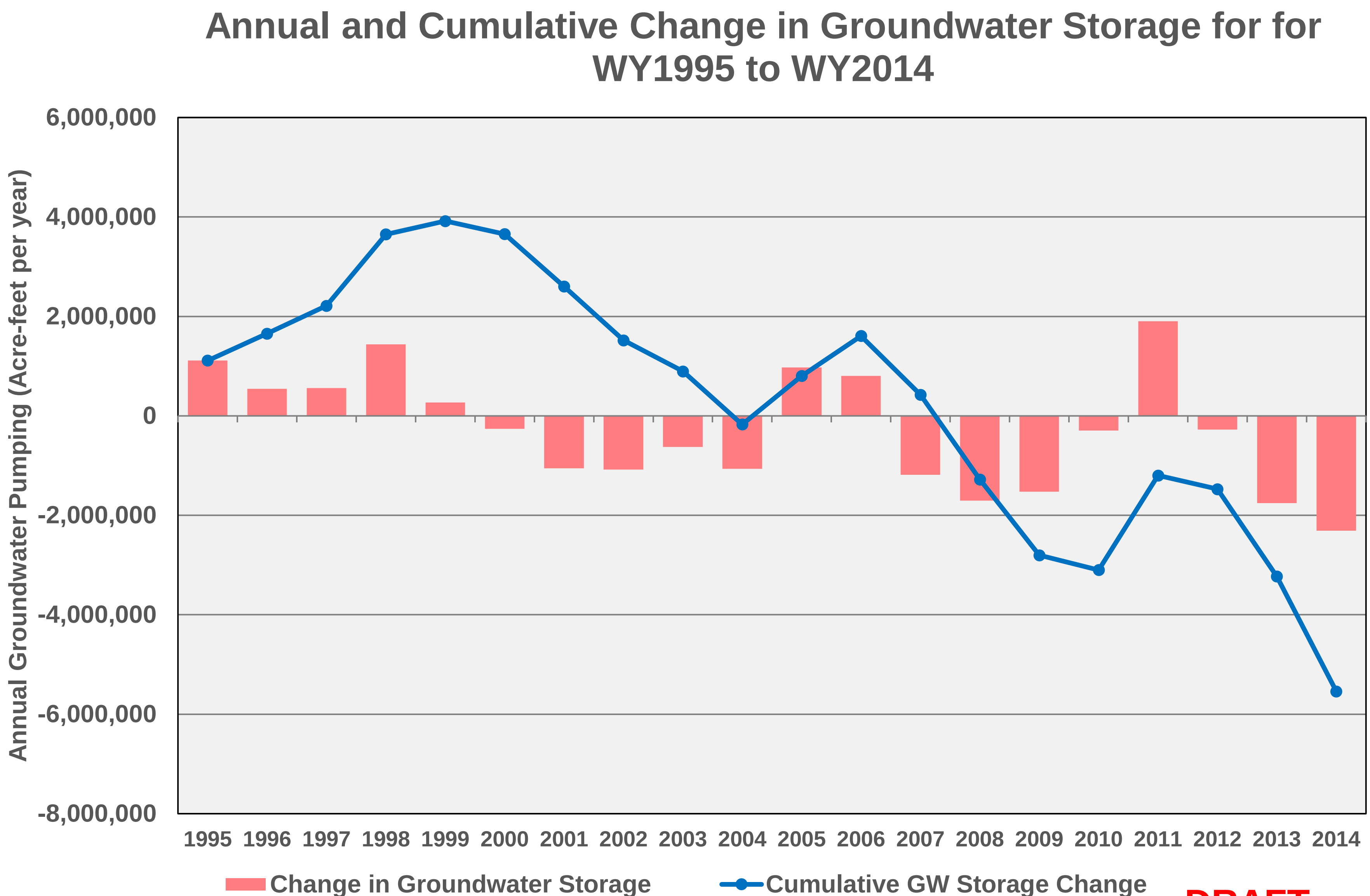
DRAFT

August 2019	Figure 9
TODD GROUNDWATER	C2VSimFG-Kern Historical Groundwater Budget for Kern County Subbasin



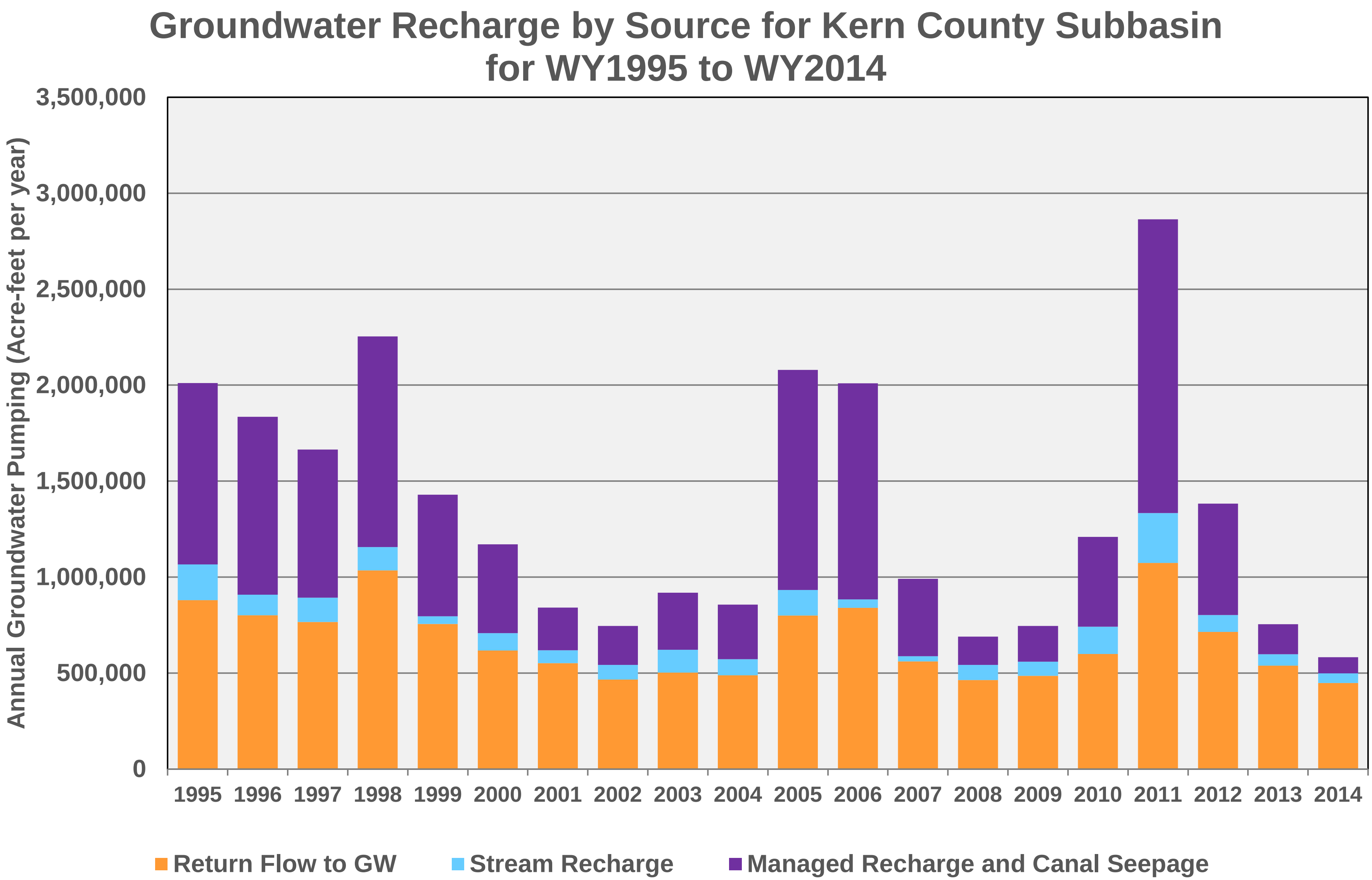
DRAFT

August 2019	Figure 10 C2VSimFG-Kern Average Annual Water Budget for Kern County Subbasin
TODD GROUNDWATER	



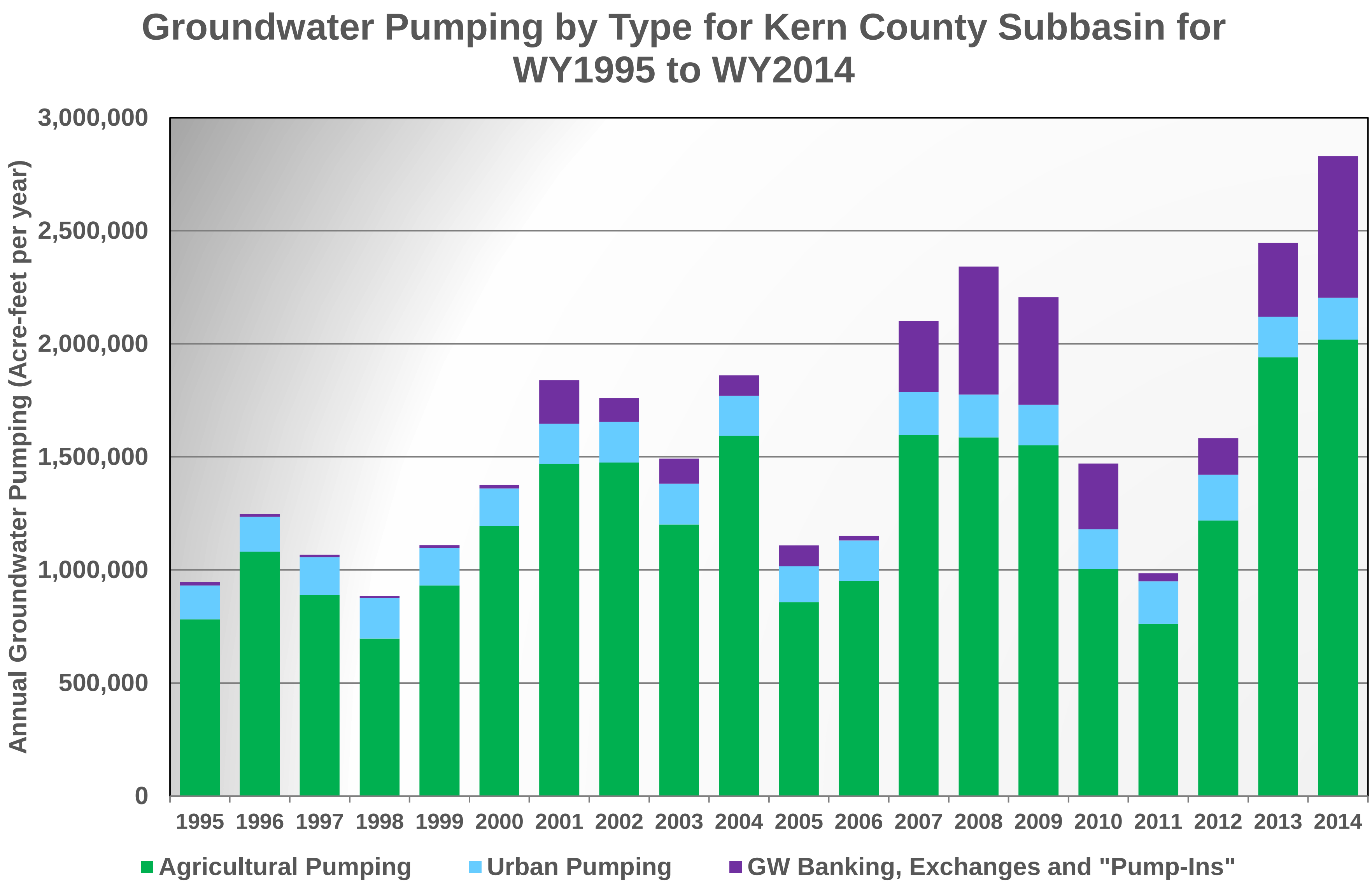
DRAFT

August 2019	Figure 11 Simulated Historical Change in Groundwater Storage for Kern County Subbasin
TODD GROUNDWATER	



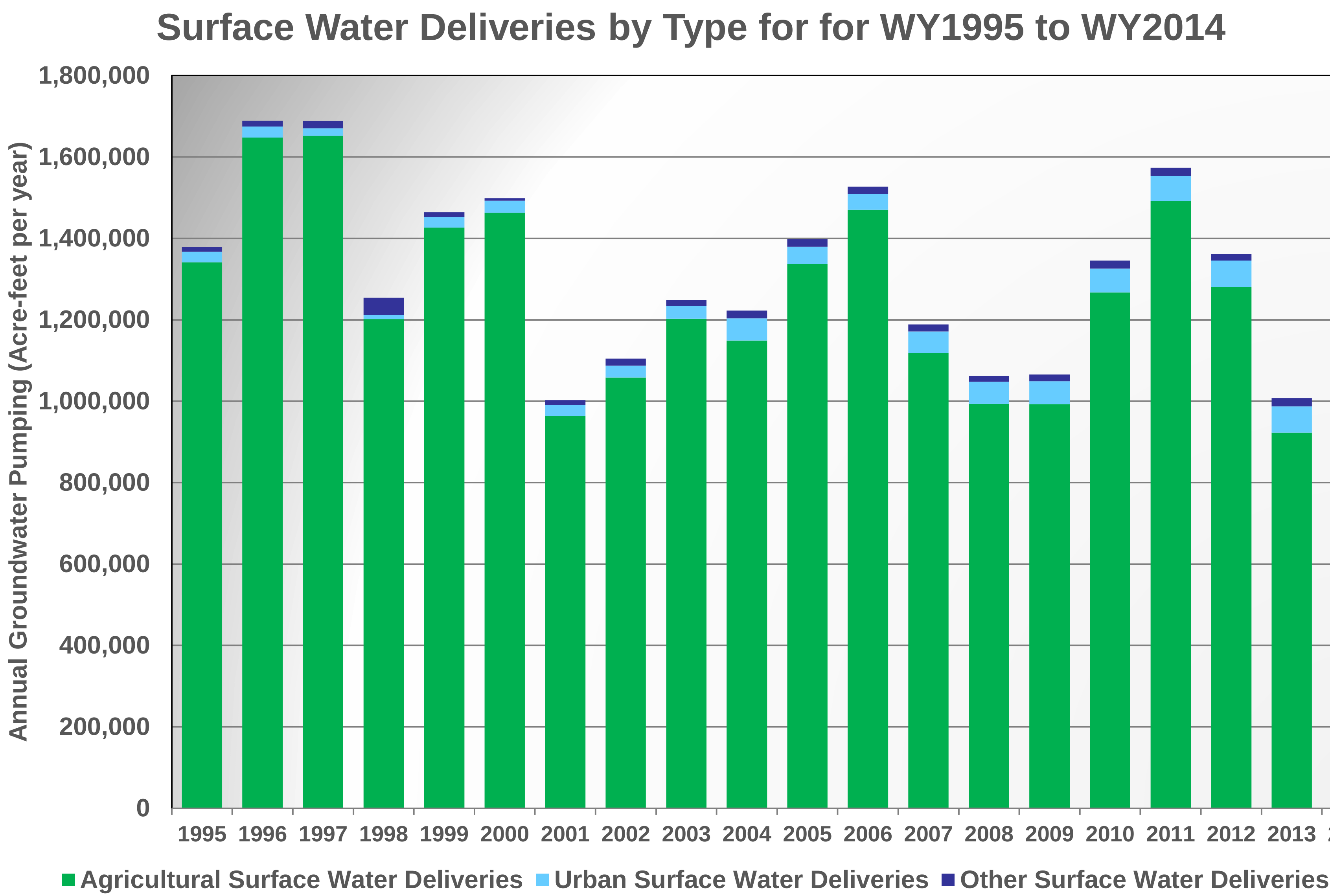
DRAFT

August 2019	Figure 12 Simulated Historical Recharge Operations for Kern County Subbasin
TODD GROUNDWATER	



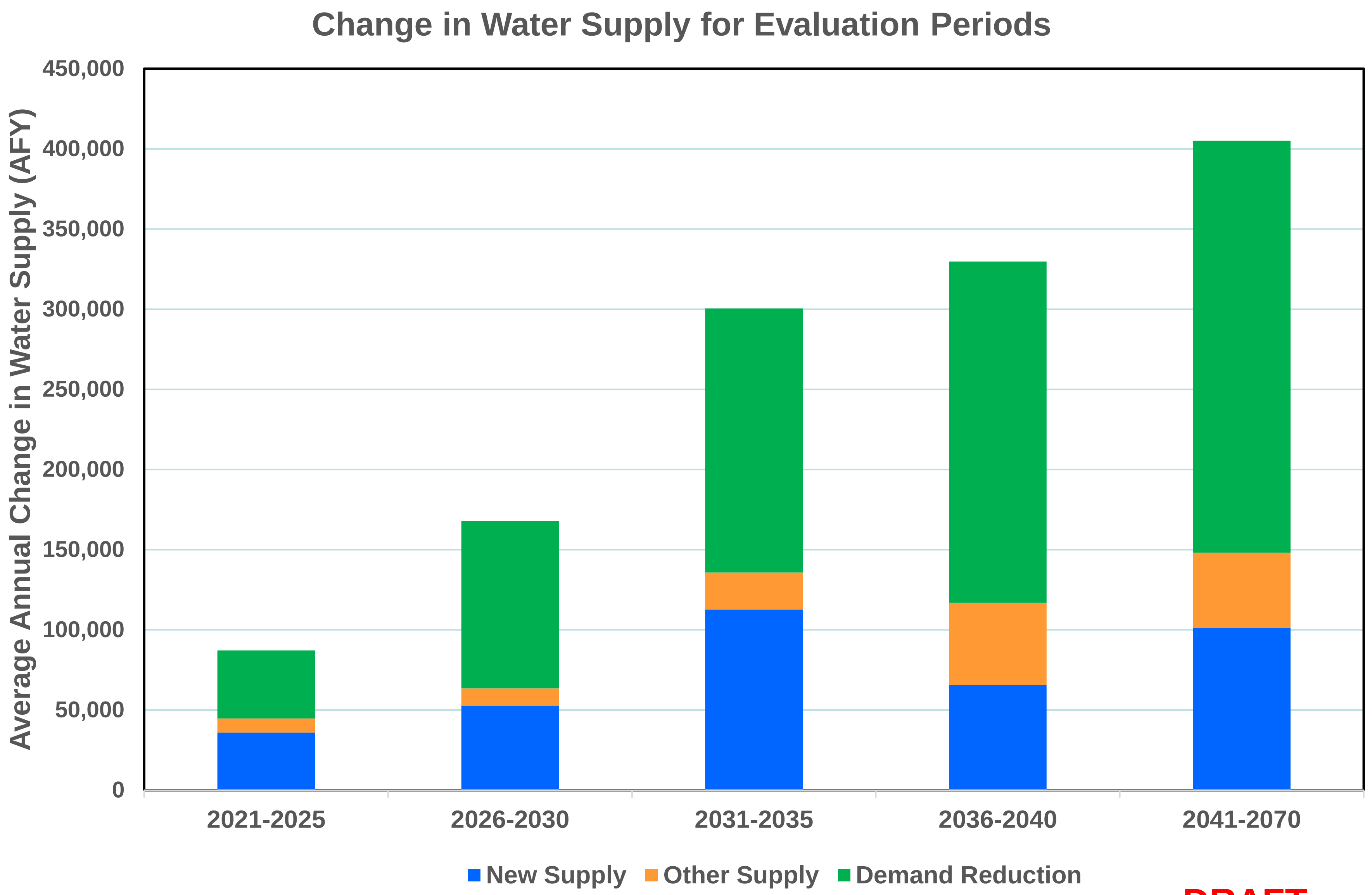
DRAFT

August 2019	Figure 13 Simulated Historical Groundwater Pumping for Kern County Subbasin
TODD GROUNDWATER	



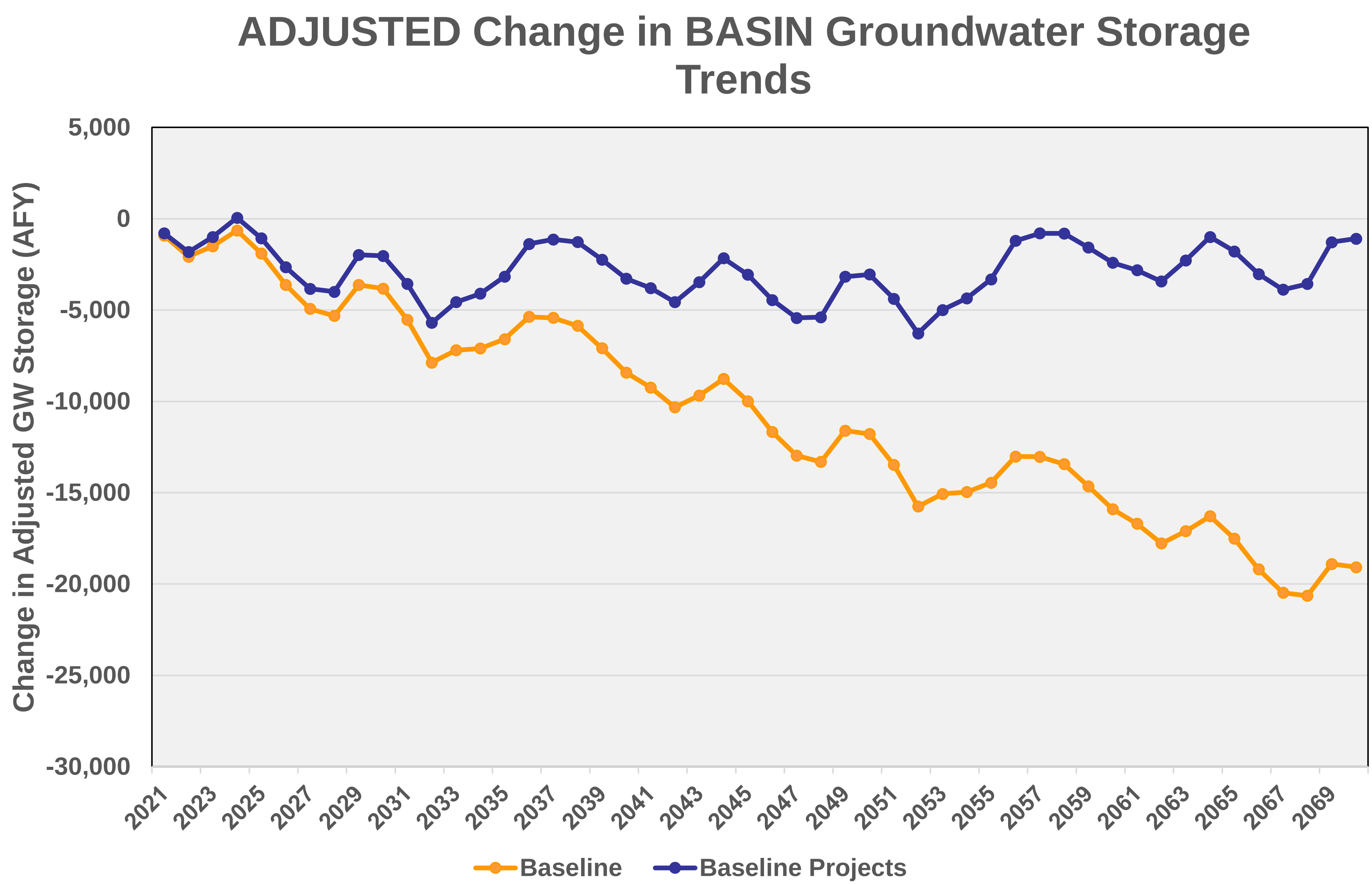
DRAFT

August 2019	Figure 14 Simulated Historical Surface Water Deliveries for Kern County Subbasin
TODD GROUNDWATER	



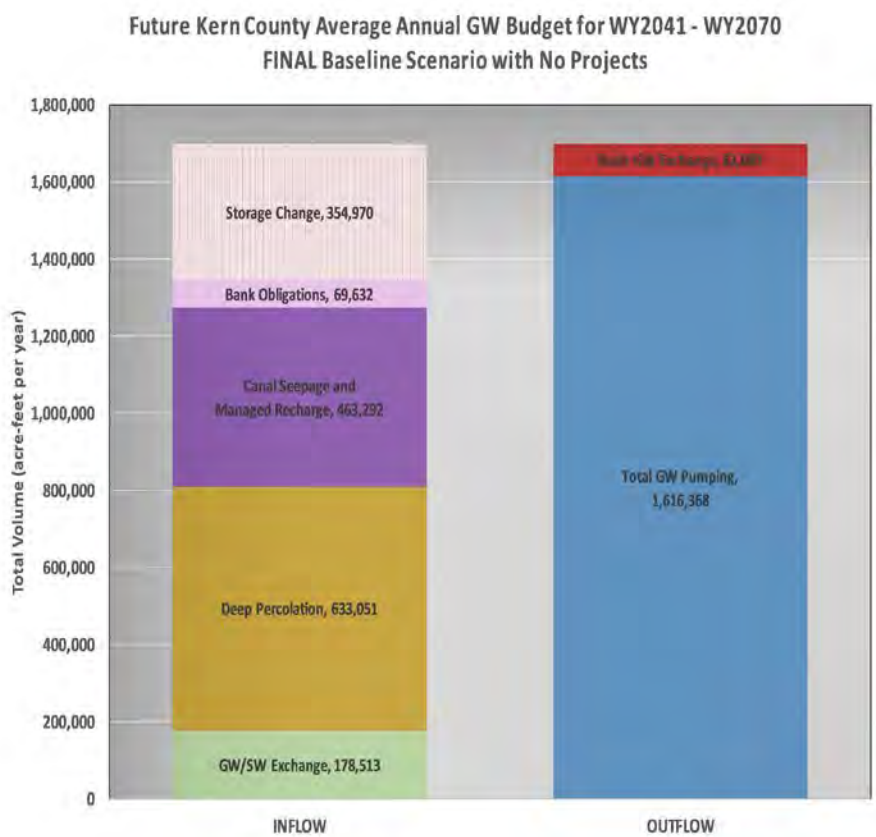
DRAFT

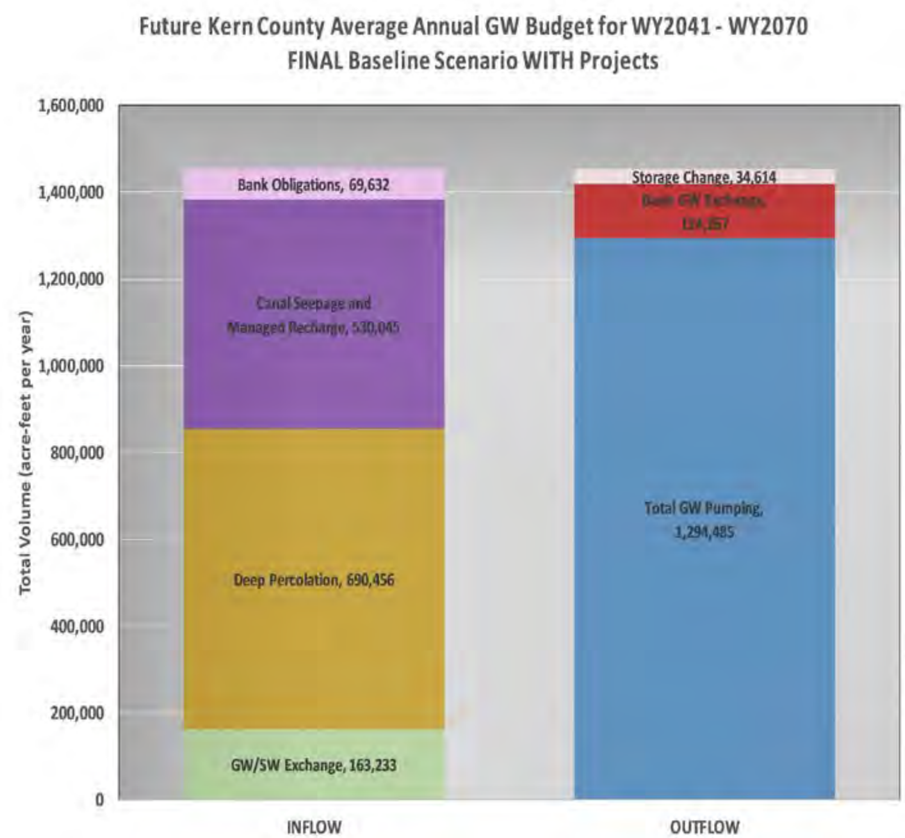
August 2019	Figure 15 Average Annual Benefit of Proposed SGMA Projects and Management Actions
TODD GROUNDWATER	



DRAFT

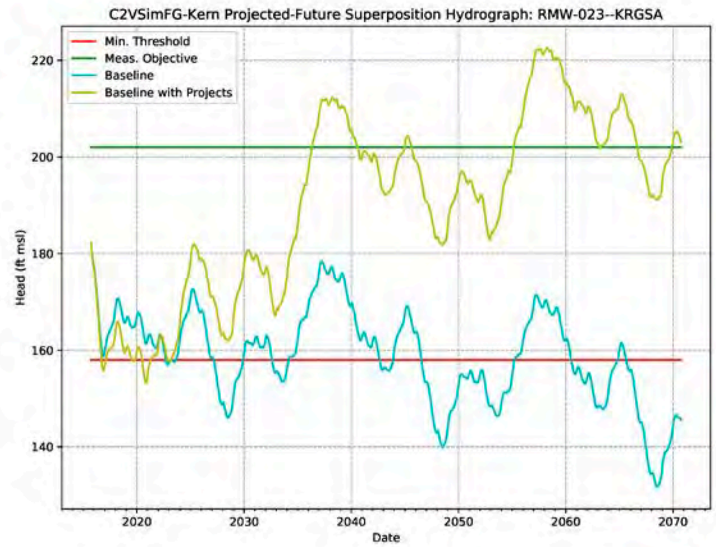
August 2019	Figure 16
TODD GROUNDWATER	Projected Future Change in Groundwater Storage for Baseline Conditions

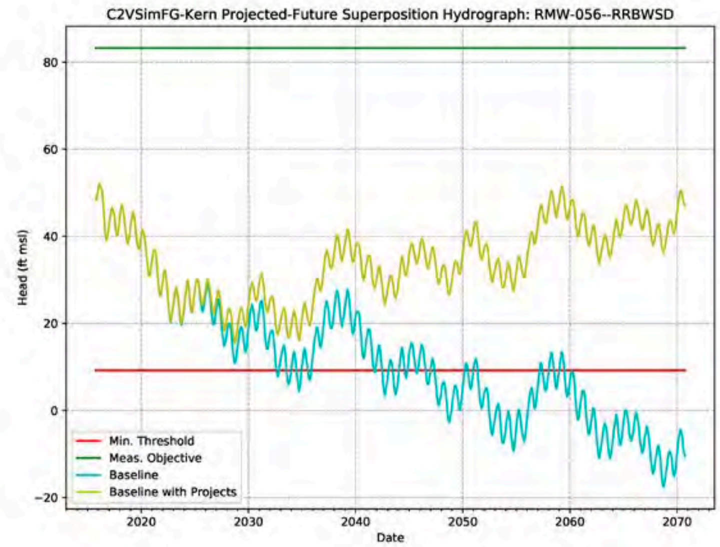


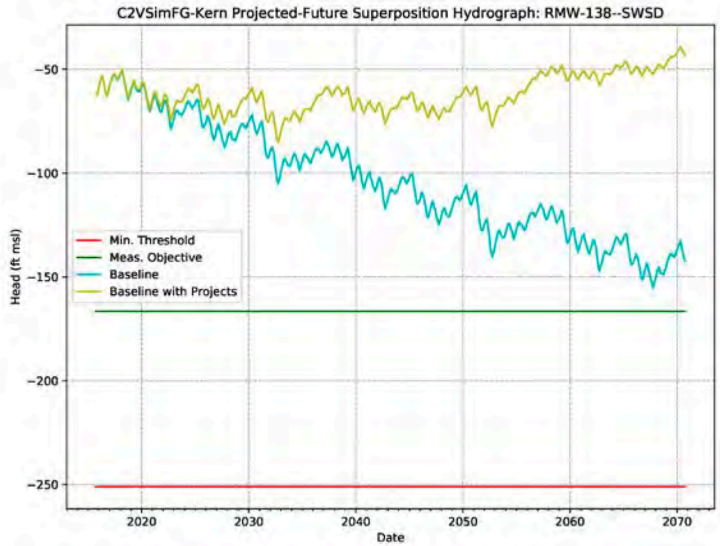


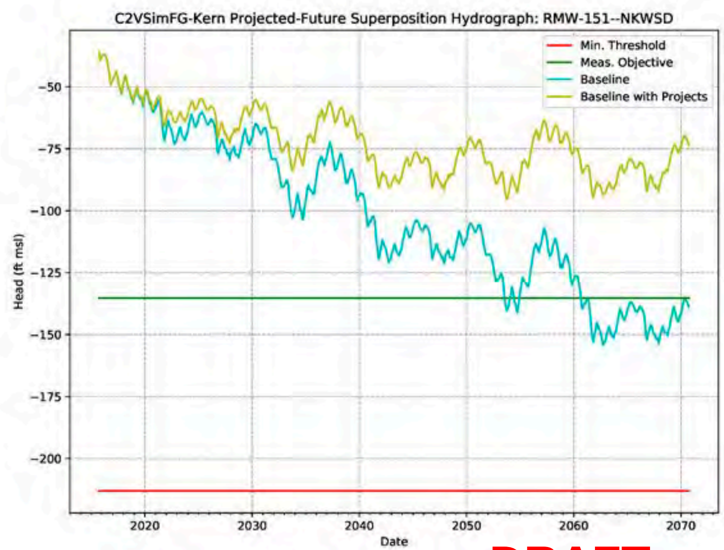
DRAFT

August 2019	Figure 17
TODD GROUNDWATER	Baseline Projected Future Average Annual Groundwater Budget for WY2041-2070



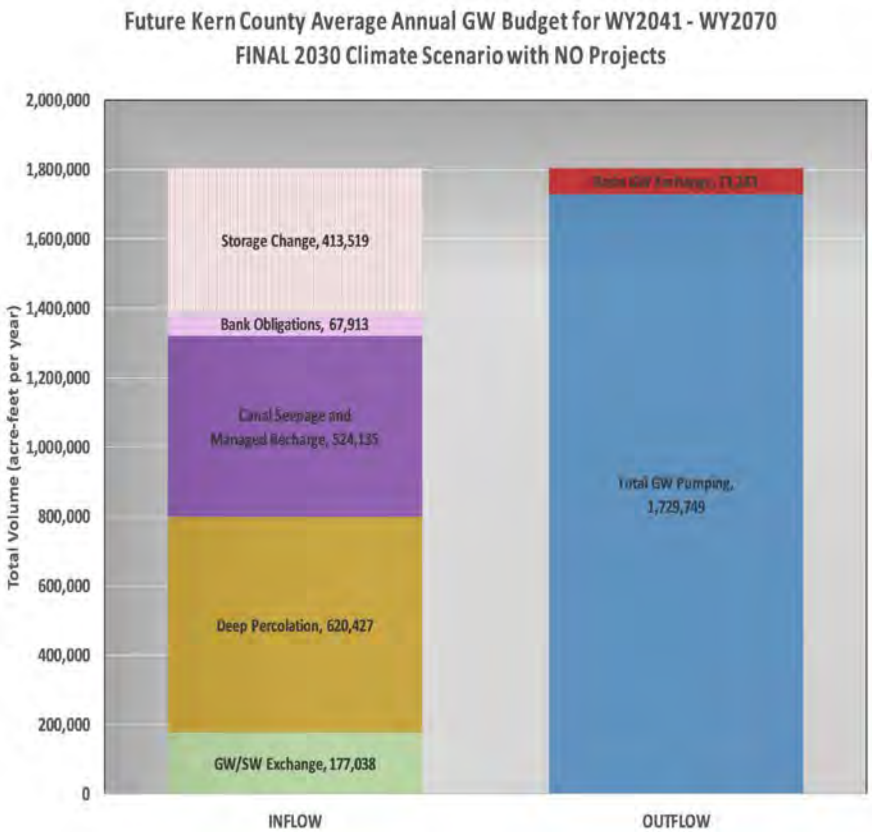


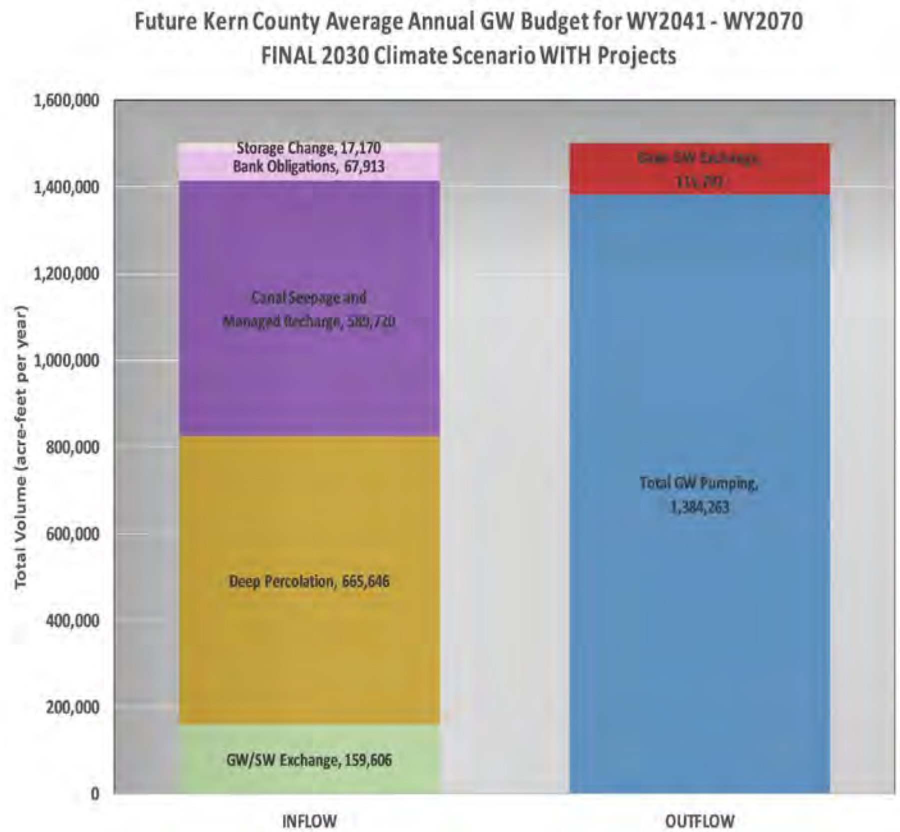




DRAFT

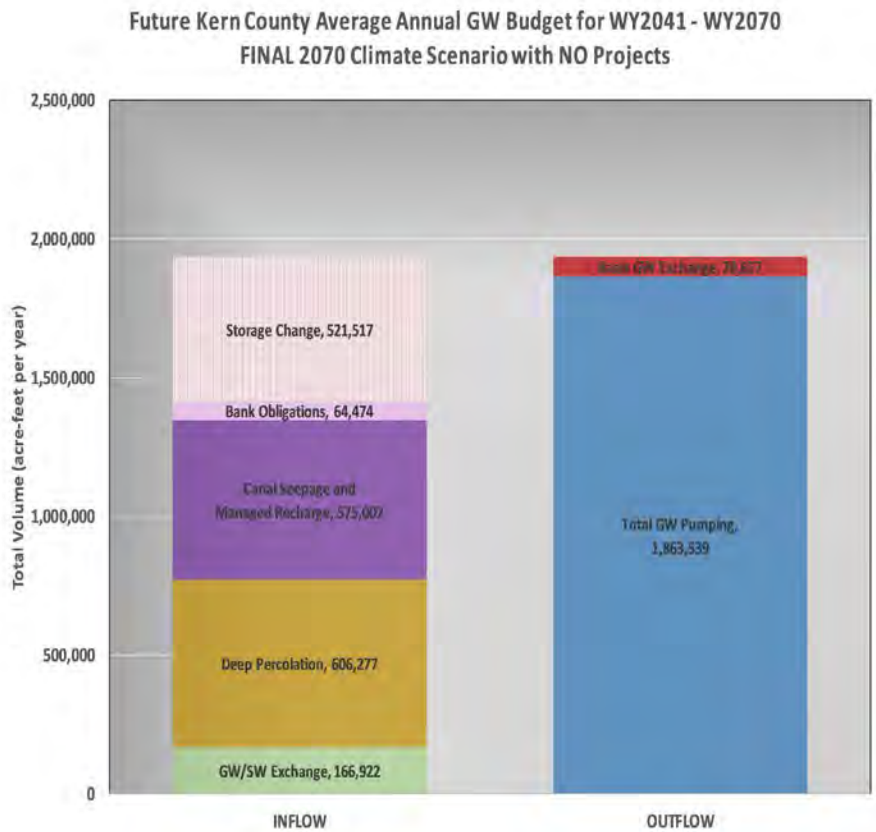
August 2019	Figure 18 Baseline Projected Future Hydrographs with SGMA Sustainability Criteria
TODD GROUNDWATER	

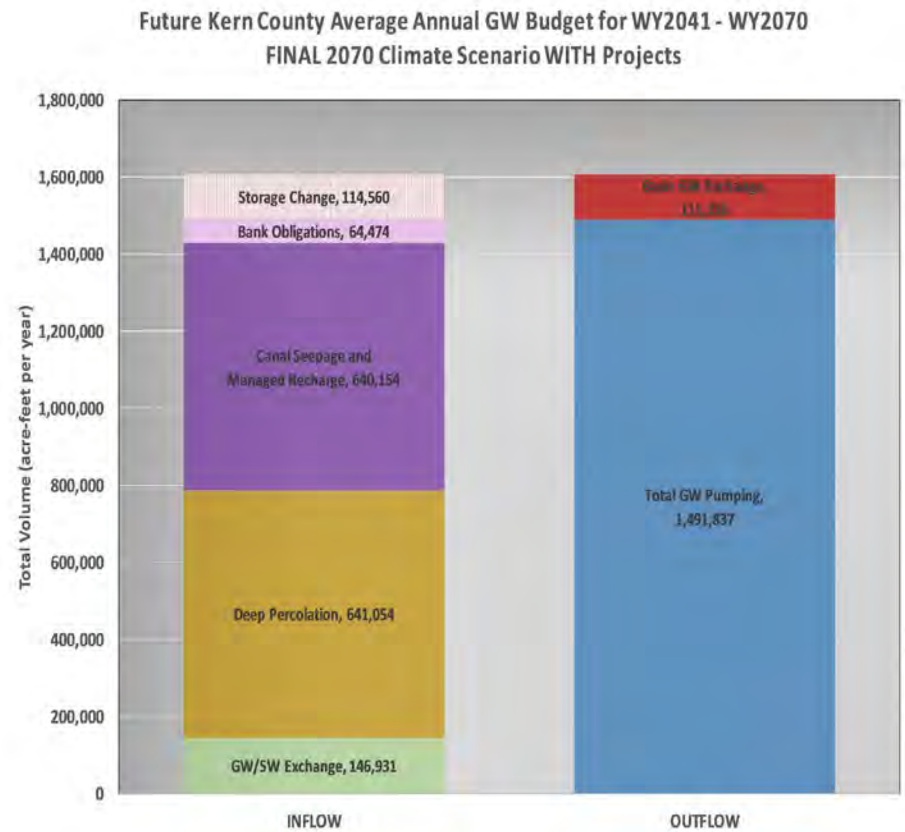




DRAFT

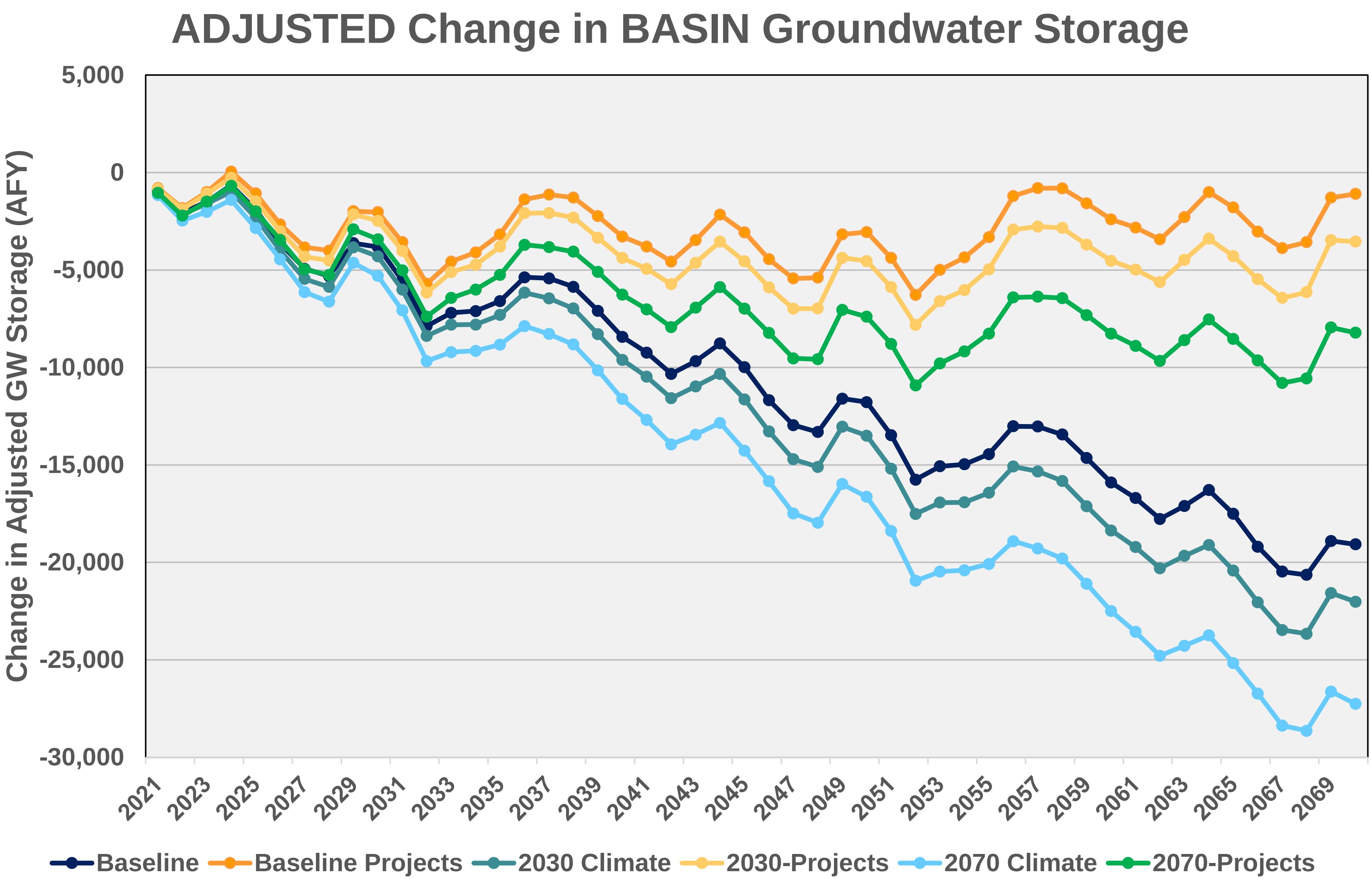
August 2019	Figure 19 2030 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070
TODD GROUNDWATER	





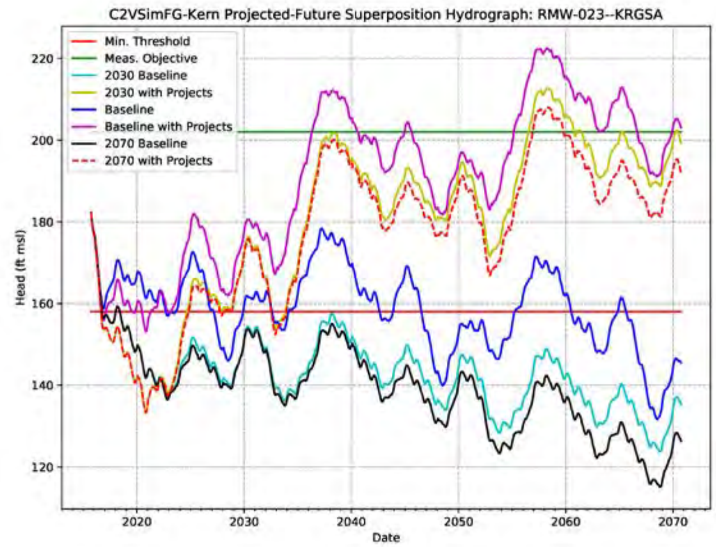
DRAFT

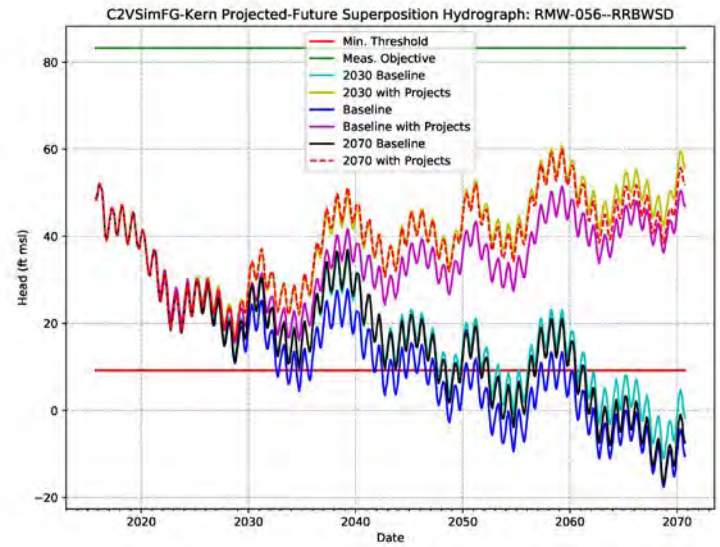
August 2019	Figure 20 2070 Climate Projected Future Average Annual Groundwater Budget for WY2041-2070
TODD GROUNDWATER	

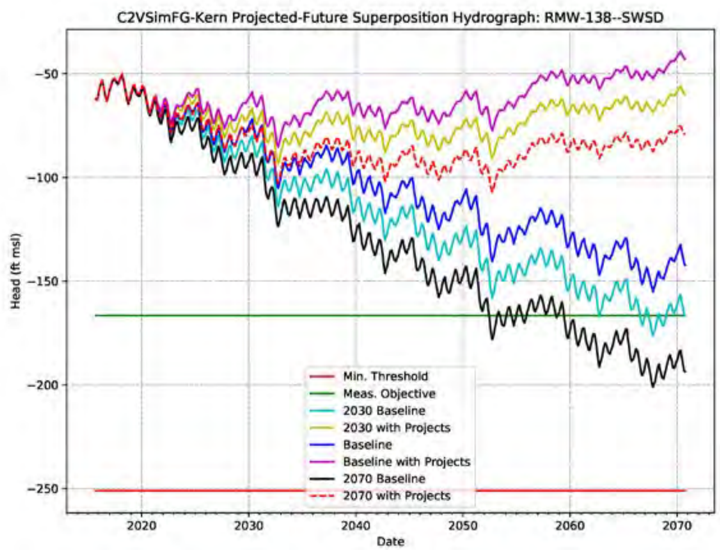


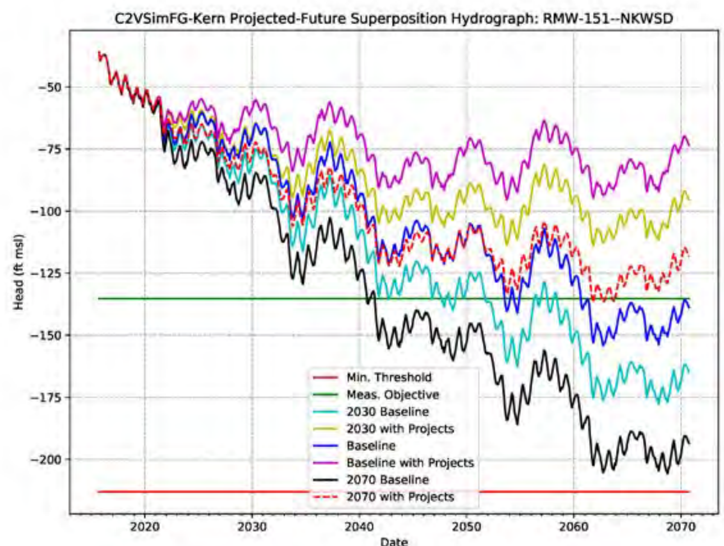
DRAFT

August 2019	Figure 21 Projected Future Change in Groundwater Storage for All Conditions
TODD GROUNDWATER	









DRAFT

August 2019	Figure 22 Hydrographs for all Projected Future Conditions with SGMA Sustainability Criteria
TODD GROUNDWATER	