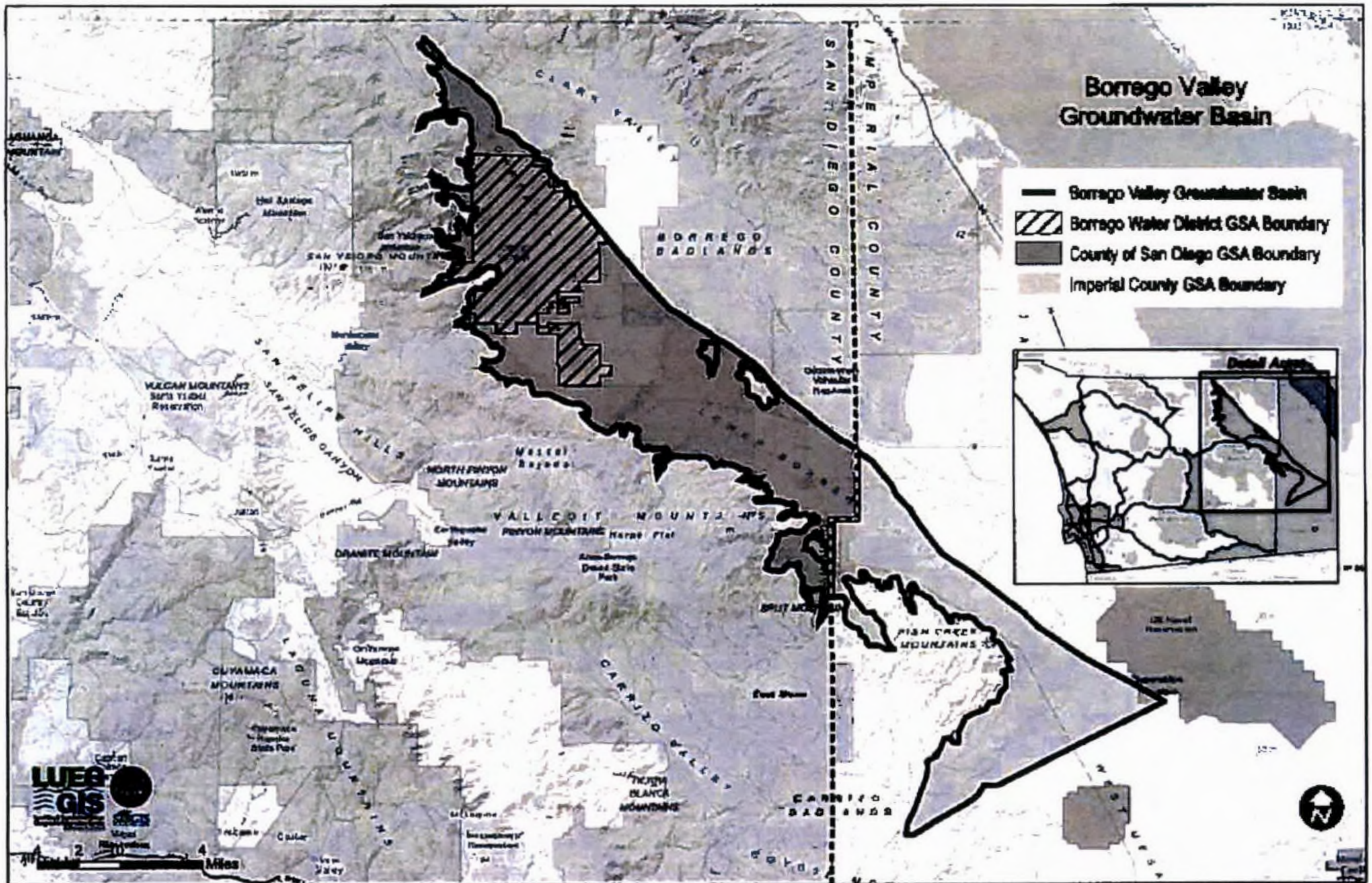
BE IT FURTHER RESOLVED that the Clerk of the Board of Supervisors is hereby directed to submit to DWR, on behalf of the County, a notice of this action to become a GSA and undertake sustainable groundwater management in accordance with SGMA for the portion of DWR Basin No. 7-24 within the jurisdiction of the County of San Diego.

BE IT FURTHER RESOLVED that the notification to DWR shall include the boundary of the portion of DWR Basin No. 7-24 within the jurisdiction of the County of San Diego that the County intends to sustainably manage, a copy of this Resolution, and the initial list of interested parties developed pursuant to California Water Code Section 10723.2, including an explanation of how their interests will be considered in the development and implementation of the GSP.

Approved as to form and legality

Senior Deputy County Counsel
By: Justin Crumley

Exhibit A


Borrego Valley
Groundwater Basin
Borrego Valley Groundwater Basin
Borrego Water District GSA Boundary
County of San Diego GSA Boundary
Imperial County GSA Boundary
SAN DIEGO COUNTY
IMPERIAL COUNTY
BORREGO BADLANDS
CARRIZO BADLANDS
FISH CREEK MOUNTAINS
VALLECITO MOUNTAINS
CARRIZO VALLEY
SAN FELIPE HILLS
SAN FELIPE CANYON
NORTH PINYON MOUNTAINS
PINYON MOUNTAINS
GRANITE MOUNTAIN
CUYAMACA MOUNTAINS
Detail Area
Miles

ON MOTION of Supervisor D. Roberts, seconded by Supervisor Jacob, the above Resolution was passed and adopted by the Board of Supervisors, County of San Diego, State of California, on this 6th day of January, 2016, by the following vote:

AYES: Cox, Jacob, D. Roberts, R. Roberts, Horn

\- - -

STATE OF CALIFORNIA)
County of San Diego)^{SS}

I hereby certify that the foregoing is a full, true and correct copy of the Original Resolution entered in the Minutes of the Board of Supervisors.

DAVID HALL
Clerk of the Board of Supervisors

By:
Elizabeth Miller, Deputy

Resolution No. 16-001
Meeting Date: 01/06/16 (1)

Attachment 2 – Proof of Publication

THE DAILY TRANSCRIPT

This space for filing stamp only

2652 4TH AVE 2ND FL, SAN DIEGO, CA 92103
Telephone (619) 232-3486 / Fax (619) 270-2503

Jim Bennett
SD CO CLERK OF THE BOARD
1600 PACIFIC HWY., RM. 402
SAN DIEGO, CA - 92101

SD #: 2825264

NOTICE IS HEREBY GIVEN that the Board of Supervisors of the County of San Diego (County) will consider whether to elect to become a Groundwater Sustainability Agency (GSA) for the Borrego Valley Groundwater Basin. Pursuant to California Government Code section 6066 and California Water Code section 10723, the resolution to become a GSA will be considered for adoption on January 6, 2016. After the public hearing the Board may elect to submit a notice of intent for the County to become a GSA to the California Department of Water Resources (DWR). The notice of intent shall be posted by DWR pursuant to Water Code Section 10733.3 and will include a description of the proposed boundaries of the basin for which the County will be the GSA. The Board of Supervisors meets at 9:00 a.m. in Room 310, County Administration Center, 1600 Pacific Highway, San Diego, California. Interested persons are encouraged to review the text of the proposed resolution. A copy of the full text is posted in the office of the Clerk of the Board of Supervisors, Room 402, of the County Administration Center.
12/21, 12/28/15

SD 2825264#

PROOF OF PUBLICATION

(2015.5 C.C.P.)

State of California)
County of SAN DIEGO) ss

Notice Type: GOV - GOVERNMENT LEGAL NOTICE

Ad Description:

AUTHORIZATION TO BECOME A GROUNDWATER SUSTAINABILITY AGENCY OVER

I am a citizen of the United States and a resident of the State of California; I am over the age of eighteen years, and not a party to or interested in the above entitled matter. I am the principal clerk of the printer and publisher of THE DAILY TRANSCRIPT, a newspaper published in the English language in the city of SAN DIEGO, and adjudged a newspaper of general circulation as defined by the laws of the State of California by the Superior Court of the County of SAN DIEGO, State of California, under date of 05/13/2003, Case No. GIC808715. 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:

12/21/2015, 12/28/2015

Executed on: 12/28/2015
At Los Angeles, California

I certify (or declare) under penalty of perjury that the foregoing is true and correct.

Signature

January 2020A *A000003967003*

APPENDIX B6

Borrego Water District Notice of Election to Serve as Groundwater Sustainability Agency

BORREGO WATER DISTRICT

October 26, 2015

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

RE: Notice of Election to Serve as a Groundwater Sustainability Agency

Dear Mr. Nordberg:

Pursuant to Water Code section 10723.8, the Borrego Water District (District), provides this notice of its election to serve as the Groundwater Sustainability Agency (GSA) for the portion of the Borrego Valley Groundwater Basin (number 7-24) within the boundaries of the District and wholly within the County of San Diego, as identified in the attached Exhibit A.

The District is a California Water District formed and operating under the provisions of the California Water Code 35565 and has the authority to exercise powers related to groundwater management. The District adopted an AB3030 Groundwater Management Plan is 2002. The District territory lies entirely within San Diego County and is the sole source water supply for the unincorporated community of Borrego Springs.

On October 20, 2015, the District held a public hearing to consider applying for the GSA status. The District noticed this hearing in both the bi-weekly Borrego Sun and the daily San Diego Union Tribune newspapers, as required by Water Code section 10723(b). A copy of the notice is provided in Exhibit B.

The District also mailed courtesy copies to the Counties of Imperial and San Diego which are the only other local agencies with groundwater authority in the Bulletin 118-2003 configuration of the Borrego Valley Groundwater Basin. A copy of the resolution through which the District elected to become a GSA is attached as Exhibit C. Please note that, under separate cover, the District, the County of Imperial, and the County of San Diego will jointly request the Department of Water Resources adjust the basin boundaries in Bulletin 118-2003 so as to split the basin so that the District and the County of San Diego will manage the portion within the County of San Diego and the County of Imperial will manage the portion within its boundaries.

P O BOX 1870 / 806 PALM CANYON DRIVE, BORREGO SPRINGS, CA 92004 (760) 767-5806 FAX (760) 767-5994 www borregowd org

The District will work cooperatively with the two Counties, along with all interested stakeholders pursuant to Water Code 10723.2. These interested parties include, but are not limited to, the following:

a) Holders of overlying groundwater rights
1) agricultural users - 17 property owners encompassing 3,976 acres
2) domestic well owners - approximately 75 wells located within the District boundary
b) Municipal well operators - no incorporated cities within District boundary
c) Public water systems - Borrego Water District
d) Local land planning agencies - San Diego County Department of Planning and Development Services, Borrego Springs Community Sponsor Group
e) Environmental users of groundwater - Anza-Borrego Desert State Park
f) surface water users - Anza-Borrego Desert State park
g) The federal government - none
h) California Native American Tribes - none
i) Disadvantaged Communities - all ratepayers of the Borrego Water District
j) Entities listed in Section 10927 - the Borrego Water District has filed and maintains CASGEM monitoring data with the Department of Water Resources.

The District will consider the interests of all users of groundwater within its boundaries and will maintain a list of interested parties to be included in the formation of the Groundwater Sustainability Plan.

If the DWR has any question, or requires additional information regarding this notification, please feel free to contact me.

Sincerely,

Jerry Rolwing
General Manager
760/767-5806
jerry@borregowd.org

RESOLUTION 2015-10-02

Electing to Become a Groundwater Sustainability Agency

WHEREAS the Legislature recently adopted the Sustainable Groundwater Management Act of 2014, which authorizes local agencies to manage groundwater in a sustainable fashion; and

WHEREAS, in order to use the authority granted in the Sustainable Groundwater Management Act, a local agency must elect to become a groundwater sustainability agency; and

WHEREAS, where more than one local agency overlies a groundwater basin, the Sustainable Groundwater Management Act calls on local agencies to cooperate to manage the groundwater basin in a sustainable manner for the common good; and

WHEREAS, the District together with the Counties of Imperial and San Diego overlies the Borrego Valley groundwater basin; and

WHEREAS, it is the intent of the District to work cooperatively with community interests (including but not limited to the Borrego Water Coalition), the County of Imperial, and the County of San Diego, to manage the Borrego Valley groundwater basin in a sustainable fashion; and

WHEREAS, the District has provided informal notice of its intent to serve as a groundwater sustainability agency for the Borrego Valley Groundwater Basin (the "Basin" as defined in DWR Bulletin 118-80) by means of written communications to the Borrego Water Coalition and the Counties of Imperial and San Diego; and

WHEREAS, on October 5th and October 12th, 2015, the District caused notice of its election to serve as a groundwater sustainability agency for the Basin in the San Diego *Union-Tribune*; and

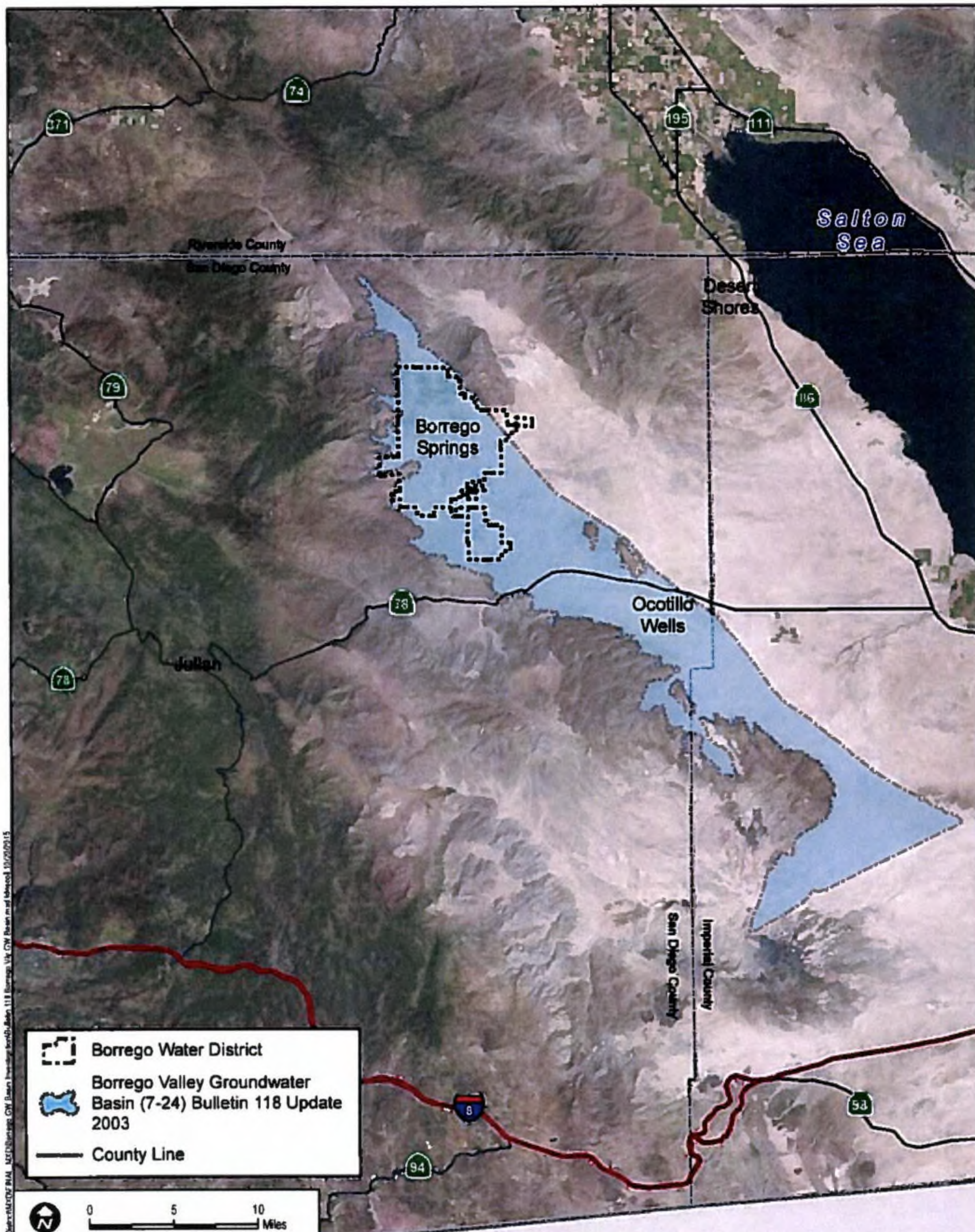
WHEREAS, on October 20, 2015, the District held a public hearing to consider whether it should elect to become a groundwater sustainability agency for the Basin.

NOW, THEREFORE, BE IT RESOLVED by the Board of Directors of the Borrego Water District as follows:

1. The District hereby elects to become a groundwater sustainability agency for the Basin.

2. District staff are hereby directed to provide notice of this election to the California Department of Water Resources in the manner required by law.

3. District staff are hereby directed to promptly meet with the Borrego Water Coalition and the Counties of Imperial and San Diego in order to begin the process of developing a groundwater sustainability plan for the Basin. District staff are further directed to develop that plan in consultation and close coordination with the California Department of Water Resources,



DUDEK

SOURCE: BING 2014; DWR 2003

FIGURE 1
Borrego Valley Groundwater Basin (7-24)

OCTOBER 2015
January 2020

Borrego Water District

the Regional Water Quality Control Board, the State Water Resources Control Board, and other interested stakeholders, as contemplated by the Sustainable Groundwater Management Act.

4. District staff are hereby directed to report back to the Board of Directors at least quarterly on the progress toward developing the groundwater sustainability plan for the Basin. The Board of Directors wishes to move forward aggressively to complete the development of this plan as quickly as may be feasible and to ensure that the groundwater basin will be managed in a sustainable fashion at the earliest possible date.

ADOPTED, SIGNED AND APPROVED this 20th day of October, 2015.

Beth A Hart

Beth Hart, President
Board of Directors of Borrego Water District

ATTEST:

Joseph Tatusko

Joseph Tatusko, Secretary
Board of Directors of Borrego Water District

{Seal}

STATE OF CALIFORNIA)
) ss.
COUNTY OF SAN DIEGO)

I, Joseph Tatusko, Secretary of the Board of Directors of the Borrego Water District, do hereby certify that the foregoing resolution was duly adopted by the Board of Directors of said District at a regular meeting held on the 20th day of October, 2015, and that it was so adopted by the following vote:

AYES: DIRECTORS: Hart, Brecht, Tatusko, Delahay

NOES: DIRECTORS:

ABSENT: DIRECTORS: Estep

ABSTAIN: DIRECTORS:

Joseph Tatusko, Secretary of the Board of Directors
of Borrego Water District

STATE OF CALIFORNIA)
) ss.
COUNTY OF SAN DIEGO)

I, Joseph Tatusko, Secretary of the Board of Directors of the Borrego Water District, do hereby certify that the above and foregoing is a full, true and correct copy of RESOLUTION NO. 2015-10-2, of said Board, and that the same has not been amended or repealed.

Dated: October 20, 2015

Joseph Tatusko, Secretary of the Board of Directors
of Borrego Water District

APPENDIX C
Stakeholder Engagement

C1: Stakeholder Engagement Plan

C2: List of Public Meetings

APPENDIX C1

Stakeholder Engagement Plan

The Stakeholder Engagement Plan has been superseded. Upon completion of the final draft GSP, the final Advisory Committee meeting was held on October 4, 2019, and the Advisory Committee was dissolved. Public meetings of the Watermaster Board and TAC will be conducted under the Stipulated Judgment.

STAKEHOLDER ENGAGEMENT PLAN
BORREGO VALLEY GROUNDWATER BASIN (7-24)
SAN DIEGO COUNTY, CALIFORNIA

SUSTAINABLE GROUNDWATER MANAGEMENT ACT (SGMA) PROGRAM

Prepared for

Prepared by

County of San Diego
Planning & Development Services
5510 Overland Avenue, Suite 310
San Diego, CA 92123

March 20, 2017

TABLE OF CONTENTS

Page

TABLE

1 INTRODUCTION

This Stakeholder Engagement Plan (Engagement Plan) summarizes the strategies to educate and involve stakeholders (those individuals and representatives of organizations who have a direct stake in the outcome of the planning process) and other interested parties in the preparation of a Groundwater Sustainability Plan (GSP) for the Borrego Valley Groundwater Basin (Borrego Basin). This GSP will be prepared in accordance with the Sustainable Groundwater Management Act (SGMA), which was signed by Governor Brown in September 2014 and became effective January 1, 2015.

SGMA provides a framework to regulate groundwater for the first time in California's history. The intent of SGMA is to strengthen local management of specified groundwater basins that are most critical to the state's water needs by regulating groundwater and land use management activities. SGMA also aims to preserve the jurisdictional authorities of cities, counties and water agencies within groundwater basins while protecting existing surface water and groundwater rights.

The County of San Diego (County) and Borrego Water District (the District) elected to become a Multi-Agency Groundwater Sustainability Agency (GSA) for the Borrego Basin – Department of Water Resources (DWR) Basin No. 7-24. The primary purpose of a GSA under SGMA is to develop a GSP to achieve long-term groundwater sustainability. Additionally, SGMA requires and directs GSAs to involve stakeholders and interested parties in the process to regulate groundwater.

2 PURPOSE

The purpose of the outreach activities described in this Engagement Plan is to provide individual stakeholders and stakeholder organizations, and other interested parties an opportunity to be involved in the development and evaluation of the GSP for the Borrego Basin. As a Multi-Agency GSA, the County and the District intend to develop and implement a basin-specific GSP for the Borrego Basin. This GSP is required under SGMA to be completed by no later than January 31, 2020. The projects and management actions necessary to implement the GSP could affect numerous individuals and groups who have a stake in ensuring the basin is sustainably managed as required by SGMA.

In an effort to understand and involve stakeholders and their concerns in the decision-making and activities of the GSA, the County and the District have prepared this Engagement Plan to achieve broad, enduring and productive involvement during the GSP development and implementation phases. This Engagement Plan will assist the County and the District in providing timely information to stakeholders and receive input from interested parties during GSP development. This Engagement Plan will identify stakeholders who have an interest in groundwater in the Borrego Basin, and recommend outreach, education and communication strategies for engaging those stakeholders during the development and implementation of the GSP. The plan also includes an approach for evaluating the overall success of stakeholder engagement and education of both stakeholders and the general public. In consideration of the interests of all beneficial uses and users of groundwater in the basin, this Engagement Plan has been developed pursuant to California Water Code Section 10723.2.

3 GENERAL INFORMATION

The following personnel at the County will serve as contacts for the public during preparation of the GSP.

3.1 SGMA Coordinator

The County's SGMA Coordinator will serve as the central contact for stakeholders and the public. For information on the GSP, contact:

Jim Bennett, Groundwater Geologist
Planning & Development Services
County of San Diego
PDS.groundwater@sdcounty.ca.gov
(858) 694-3820

3.2 Media Contact

Media inquiries should be addressed to:

Alex Bell, Group Communications Officer
Land Use and Environment Group
County of San Diego
Alex.Bell@sdcounty.ca.gov
(619) 531-5410

4 OUTREACH ACTIVITIES

The County and the District will implement the following outreach activities to maximize stakeholder involvement during the development of the GSP and throughout SGMA implementation.

4.1 Public Notices

To ensure that the general public is apprised of local activities and allow stakeholders to access information, SGMA specifies several public notice requirements for GSAs. Refer to Table 1 for a summary of statutory requirements. Three sections of the California

Water Code require public notice before establishing a GSA, adopting (or amending) a GSP, or imposing or increasing fees:

- Section 10723(b). Before electing to be a groundwater sustainability agency, and after publication of notice pursuant to Section 6066 of the Government Code, the local agency or agencies shall hold a public hearing in the county or counties overlying the basin.

- Section 10728.4. A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing, held at least 90 days after providing notice to a city or county within the area of the proposed plan or amendment.

- Section 10730(b)(1). Prior to imposing or increasing a fee, a groundwater sustainability agency shall hold at least one public meeting, at which oral or written presentations may be made as part of the meeting….(3) At least 10 days prior to the meeting, the groundwater sustainability agency shall make available to the public data upon which the proposed fee is based.

In accordance with California Water Code Section 10723(b), the following was noticed to the public:

- On October 20, 2015, the District held a public hearing to consider becoming a GSA for the portion of the Borrego Basin within their boundaries. The District noticed the hearing in both the bi-weekly Borrego Sun and the daily San Diego Union Tribune newspapers.

- On January 6, 2016, the County Board of Supervisors held a public hearing to consider becoming a GSA over the portion of the Borrego Basin within San Diego County. The public hearing was noticed in the Daily Transcript in accordance with Government Code Section 6066.

- On September 20, 2016, the District held a public hearing to consider adopting a Memorandum of Understanding (MOU) between the District and the County. The District noticed the hearing in both the bi-weekly Borrego Sun and the daily San Diego Union Tribune newspapers.

- On October 19, 2016, the County Board of Supervisors held a public hearing to also consider adopting a MOU between the District and the County. The public hearing was noticed in the Daily Transcript in accordance with Government Code Section 6066.

Future noticing will occur as required by SGMA.

4.2 Stakeholder Identification

SGMA mandates that a GSA 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. The County and the District compiled a list of interested persons wishing to receive information that will be maintained throughout the GSA formation and GSP development phases. An initial list of stakeholders and interested parties include, but are not limited to, the following:

a) Holders of overlying groundwater rights, including:

1) Agricultural users.

2) Domestic well owners.

3) Borrego Water District – From the purchase of private water companies

b) Municipal well operators – No incorporated cities within the GSA boundary.

c) Public water systems – Borrego Water District.

d) Local land use planning agencies – County of San Diego and Borrego Springs Community Sponsor Group.

e) Environmental users of groundwater – Anza-Borrego Desert State Park.

f) Surface water users, if there is a hydrologic connection between surface and groundwater bodies – No hydrologic connection.

g) The federal government, including, but not limited to, the military and managers of federal lands – None.

h) California Native American tribes – None.

i) Disadvantaged communities, including, but not limited to, those served by private domestic wells or small community water systems – Borrego Water District ratepayers and domestic well owners.

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 – The District and County have filed and maintain California Statewide Groundwater Elevation Monitoring (CASGEM) monitoring data with the DWR.

The County intends to work cooperatively with stakeholders and interested parties to develop and implement the GSP for the Borrego Basin and will maintain a list of stakeholders and interested parties to be included in the formation of the GSP.

4.3 Town Hall Meetings

The District hosts an annual town hall meeting for the public each March. The County and the District will continue outreach efforts to identify stakeholders and interested parties and conduct a stakeholder assessment during the town hall meeting on March 29, 2017. Some key questions for the stakeholder assessment will be:

- What are their interests, concerns, and priorities?
- What is the best way to communicate with them?
- How involved would they like to be in development of the GSP?
- What information would be helpful for engagement of stakeholders and interested parties to better participate in the development and/or implementation of the GSP?

4.4 Planning Group

The Borrego Springs Community Sponsor Group is actively involved in the community on matters dealing with planning and land use in Borrego Valley. Since this group provides a forum for the discussion of land use planning that directly impacts GSP issues that are important to the community, it is important for this group to be well informed throughout GSP development. County/District team members will attend these meetings at key milestones to provide up-to-date information and hear feedback from group members.

4.5 Public Hearings/Meetings

4.5.1 Planning Commission

On April 22, 2016, County staff presented an informational item about SGMA to the County's Planning Commission. The presentation served to inform the commission and community on SGMA and what impacts the legislation has on San Diego County. Periodic updates on SGMA implementation will be provided to the commission and the public will be invited to listen. No action will be taken during these meetings. Planning Commission hearings can be viewed online at: http://www.sandiegocounty.gov/pds/PC/sop/PCHearing_stream.html.

4.5.2 District Board Hearings and Meetings

On October 20, 2015, the Board of Directors for the District held a public hearing and voted to become a GSA for the portion of the Borrego Basin within their boundaries. On September 20, 2016, the District held a public hearing and adopted a MOU between the District and the County, which serves to memorialize each agency's role and responsibilities for developing a GSP. SGMA has been, and will continue to be, an agenda item at the regular meetings of the District's Board of Directors. These meetings are held every third Tuesday and fourth Wednesday of the month at 9:00 a.m. at the District office, 806 Palm Canyon Drive, Borrego Springs, CA. Each meeting has a scheduled time for public comments. Information about upcoming meetings can be found on the District's website (http://www.borregowd.org/). Additionally, on most third Tuesdays of each month, an informal workshop is held for the public to discuss SGMA and GSP-related issues.

4.5.3 County Board of Supervisors Hearings

On January 6, 2016, the County Board of Supervisors held a public hearing and voted to become a GSA over the portion of the Borrego Basin within San Diego County. On October 19, 2016, the County Board of Supervisors held a public hearing to also consider adopting a MOU between the District and the County. Additional Board of Supervisors Hearings will be scheduled at key stages during SGMA implementation, including adoption of the GSP for Borrego Basin. Hearings can be viewed online at: http://www.sandiegocounty.gov/content/sdc/general/board-meeting-video.html.

4.6 Direct Mailings/Email

Advisory committee meetings and project information will be disseminated through email. This communication will provide information for the Borrego Valley community, public agencies, and other interested persons/organizations about milestones, meetings, and the progress of GSP development. Property owners with groundwater wells within the basin will be notified via email and/or direct mailings about the establishment of an interested persons list and given the opportunity to receive future notices.

4.7 Newsletters/Columns

Recurring updates in the *Borrego Sun* newspaper and County Planning & Development Services (PDS) newsletter, *eBlast*, will be provided to advise, educate, and inform the public on SGMA implementation in Borrego Valley. The latest County PDS *eBlast* can be found online at http://www.sandiegocounty.gov/pds/.

4.8 SGMA Website

A variety of information about SGMA and groundwater conditions will be produced by the County and the District. This information will include maps, timelines, frequently asked questions, groundwater information, and schedules/agenda of upcoming meetings and milestones. This information will be accessible on the County's SGMA webpage located at: http://www.sandiegocounty.gov/pds/SGMA.html. County staff will update the website regularly and invite users to request information or be added to the interested persons list. Additionally, the District maintains a repository of groundwater, economic, and GSP-related technical studies on its website at: http://www.borregowd.org/Groundwater_Management_EY7H.php.

4.9 Database

To distribute information about GSP development, a mailing list and email list has been compiled into a database of interested persons and stakeholders. The database will be updated regularly to add names of attendees at sponsor group or town hall meetings along with those requesting information via email or through the SGMA website.

4.10 Advisory Committee

Comprehensive stakeholder involvement will include the establishment of an Advisory Committee to aid in developing and implementing the GSP. In addition to signing up to receive information about GSP development at the County's SGMA webpage, interested parties may participate in the development and implementation of the GSP by attending public Advisory Committee meetings in Borrego Springs, in accordance with Water Code Section 10727.8(a). The Multi-Agency GSA approved nine-member Borrego Valley Advisory Committee (Advisory Committee) comprises the following members:

- Borrego Water Coalition - 1 agricultural member; 1 recreation member; 1 independent pumper; 1 at large member,
- 1 member Borrego Springs Community Sponsor Group,
- 1 member Borrego Valley Stewardship Council,
- 1 member District representative for ratepayers/property owners,
- 1 member San Diego County Farm Bureau, and
- 1 member California State Parks, Colorado Desert Region.

The Borrego Water Coalition represents a broad cross-section of groundwater pumpers and users of the Borrego Basin who together represent approximately 80% of annual withdrawals from the Borrego Basin. The Borrego Springs Community Sponsor Group is the officially appointed representative body charged with addressing land use issues to the County. The Borrego Valley Stewardship Council represents community groups associated with the Anza-Borrego Desert State Park and geotourism economic development initiative. The District represents over 2,000 ratepayers/property owners in Borrego Springs. Through the Agricultural Alliance for Water and Resource Education (AAWARE), the San Diego County Farm Bureau represents farming interests in Borrego Springs who, at present, collectively use approximately 70% of annual withdrawals from the Borrego Basin. The California State Parks represent the approximately 600,000 acre Anza-Borrego Desert State Park that surrounds Borrego Springs.

5 EVALUATION

To determine the level of success of the Engagement Plan, the County and the District will implement the following measures:

5.1 Attendance/Participation

A record of those attending public and Advisory Committee meetings will be maintained throughout the GSP development process. The County and the District will utilize sign-in sheets and request feedback from attendees to determine adequacy of public education and productive engagement in the GSP development and implementation process. Meeting minutes will also be prepared and will be provided on the SGMA website once approved.

5.2 Adherence to Schedule

Public participation in developing projects and management actions for inclusion in the GSP is instrumental to the success of the GSP. Keeping these tasks on schedule will be an important indicator of stakeholder involvement. Early identification of milestones and due dates will be important in ensuring a commitment from Advisory Committee members.

6 REFERENCES

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

TABLE

Table 1. Summary of Statutory Requirements for Stakeholder Engagement in SGMA[1]

During GSA Formation:	
"Before electing to be a groundwater sustainability agency… the local agency or agencies shall hold a public hearing."	Water Code Sec. 10723 (b)
"A list of interested parties [shall be] developed [along with] an explanation of how their interests will be considered."	Water Code Sec. 10723.8.(a)(4)
During GSP Development and Implementation:	
"A groundwater sustainability agency may adopt or amend a groundwater sustainability plan after a public hearing".	Water Code Sec. 10728.4
"Prior to imposing or increasing a fee, a groundwater sustainability agency shall hold at least one public meeting".	Water Code Sec. 10730(b)(1)
"The groundwater sustainability agency 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".	Water Code Sec. 10723.4
"Any federally recognized Indian Tribe… may voluntarily agree to participate in the preparation or administration of a groundwater sustainability plan or groundwater management plan… A participating Tribe shall be eligible to participate fully in planning, financing, and management under this part".	Water Code Sec. 10720.3(c)
"The groundwater sustainability agency shall make available to the public and the department a written statement describing the manner in which interested parties may participate in the development and implementation of the groundwater sustainability plan".	Water Code Sec. 10727.8(a)
Throughout SGMA Implementation:	
"The groundwater sustainability agency shall consider the interests of all beneficial uses and users of groundwater".	Water Code Sec. 10723.2
"The groundwater sustainability agency shall encourage the active involvement of diverse social, cultural, and economic elements of the population within the groundwater basin".	Water Code Sec. 10727.8(a)

[1] Source: Community Water Center. *Collaborating for Success: Stakeholder Engagement for Sustainable Groundwater Management Act Implementation.* July 2015.

APPENDIX C2

List of Public Meetings

Appendix C2 - List of Public Meetings

Date	Location	Start Time	End Time	**Topics** (Not listed are opening/closing procedures and certain administrative/informational items)	Meeting Type	Attendance			
						Advisory Committee Members	Core Team Members	Staff	Public / Stakeholders
3/6/2017	Borrego High School	10:00 AM	2:25 PM	Brown Act Training; Collaborative Problem Solving and Consensus Decision Making; Draft Advisory Committee Bylaws	Advisory Committee	8	4		10
4/10/2017	Borrego High School	10:00 AM	2:55 PM	Support for A/C Members; Review, Discussion and Possible Adoption of A/C By-Laws; GSP Update, Overview and Informational Presentation	Advisory Committee	7	5	2	9
5/15/2017	Borrego Water District	10:00 AM	3:10 PM	Review, Discussion and Possible Adoption of A/C By-Laws ; Review and Discussion of Draft A/C Agenda Development Schedule and Interaction with Constituent Group (CG); Borrego Valley Stewardship Council (BVSC); Receive Updates from A/C Members on CG Engagement; Presentation on the Borrego Basin Groundwater Sustainability Plan	Advisory Committee	8	4	2	13
6/29/2017	Borrego Water District	10:00 AM	2:45 PM	Review, Discussion and Possible Adoption of A/C By-Laws; Proposition 1 Grant Funding Opportunity – Flow Metering; Groundwater Sustainability Plan: Discuss Proposed Management Areas; Receive A/C Input on Roger Mann Study; 2018 Statewide Water Bond Update; Receive Updates from A/C Members on Constituent Group Discussions	Advisory Committee	8	5	3	3

Appendix C2 - L[illegible] Public Meetings

Date	Location	Start Time	End Time	<u>Topics</u> (Not listed are opening/closing procedures and certain administrative/informational items)	Meeting Type	Attendance			
						Advisory Committee Members	Core Team Members	Staff	Public / Stakeholders
7/27/2017	Borrego Water District	10:00 AM	3:00 PM	Continued Discussion and Potential Actions: Proposition 1 Grant Funding Opportunity; Requiring the Metering of all Wells in Borrego Springs Subbasin and Proposed Monitoring Program; Benchmarking under SGMA Presentation; Policy on Projects Creating Additional Water Use post January 1, 2015 Pending Determination of Existing Allocations; Review Timeline for GSP Development and Milestones for AC Input/Recommendations on High-level Topics	Advisory Committee	7	4	3	7
9/28/2017	Borrego Water District	10:00 AM	3:00 PM	Metering Requirements for Non-de Minimis Wells; Baseline Pumping Allocations; Sustainability Indicators, Measurable Objectives, and Minimum Thresholds; Proposition One Grant Application Update; Revisions to SGMA Frequently Asked Questions (FAQ) Document	Advisory Committee	7	4	4	14
10/26/2017	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	2:50 PM	Metering Requirements for Non-de Minimis Wells; Baseline Pumping Allocation; Water Budget and Reduction Period; Proposition One Grant Application Update	Advisory Committee	8	4	3	16
11/27/2017	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	2:50 PM	Metering Requirements for Non-de Minimis Wells; Baseline Pumping Allocation; Pumping Allowance; Sustainability Period and Reduction Period; Streamflow	Advisory Committee	9	4	4	7

Appendix C2 - List of Public Meetings

Date	Location	Start Time	End Time	Topics (Not listed are opening/closing procedures and certain administrative/informational items)	Meeting Type	Attendance			
						Advisory Committee Members	Core Team Members	Staff	Public / Stakeholders
1/25/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	3:00 PM	Sustainability Indicators; Water Credits Program; Projects and Management Actions to be Considered; Water Quality Presentation	Advisory Committee	9	4	5	8
3/5/2018	Steele/Burnand Anza-Borrego Desert Research Center	5:30 PM	7:30 PM	SGMA Overview, GSP Timeline, Prop 1 Grant, community outreach, Community QA/C Session	Community Meeting	8	5	7	85
3/16/2018	Steele/Burnand Anza-Borrego Desert Research Center	5:30 PM	7:30 PM	Rising water rates; Economic impacts; Land use designations; Water use allocations; Sustainability strategies; Water quality; Environmental impacts; GSP development; Community meetings	Community Meeting	8	5	7	102
3/29/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	2:50 PM	Considering Human Right to Water Use; Municipal Allocations; Projects and Management Actions to be Considered	Advisory Committee	8	4	5	12
4/27/2018	Borrego Springs Library	1:00 PM	3:00 PM	Ad Hoc Committee on Severely Disadvantaged Community (SDAC) Involvement	SDAC	Unknown			
5/31/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	3:05 PM	Baseline Pumping Allocation Update; Projects and Management Actions to be Considered; Well Metering Plan; Groundwater Dependent Ecosystems Presentation	Advisory Committee	8	4	4	11

Appendix C2 - L[illegible] Public Meetings

Date	Location	Start Time	End Time	Topics (Not listed are opening/closing procedures and certain administrative/informational items)	Meeting Type	Attendance			
						Advisory Committee Members	Core Team Members	Staff	Public / Stakeholders
7/26/2018	Borrego Springs Resort	10:00 AM	3:00 PM	Review of GSP Development Progress Over Last Year; Baseline Pumping Allocation Update; Groundwater Monitoring Network Spring 2018 Results; Socioeconomic Efforts; Groundwater Dependent Ecosystems	Advisory Committee	8	5	5	7
8/30/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	12:00 PM	Baseline Pumping Allocations & Reductions; CEQA Process Presentation; BWD SDAC Grant Tasks 2 and 3 Presentation; Community Engagement Efforts; Water Vulnerability & New Extraction Well Site Feasibility Analysis Presentation	Advisory Committee (SDAC)	8	3	6	8
8/31/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM		Model/Water Budget Presentation	Technical Meeting	Unknown			
9/19/2018	Borrego Springs Unified School District	5:00 PM	8:00 PM	Rising water rates; Economic impacts; Land use designations; Water use allocations; Sustainability strategies; Water quality; Environmental impacts; GSP development; Community meetings	Community Meeting	1	1	3	34
10/4/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	2:40 PM	Socioeconomic Efforts: Community Engagement Efforts Update; EIR and CEQA Process; GSP Ch. 1-3 Presentation	Advisory Committee	8	5	5	14

Appendix C2 - List of Public Meetings

Date	Location	Start Time	End Time	Topics (Not listed are opening/closing procedures and certain administrative/informational items)	Meeting Type	Attendance			
						Advisory Committee Members	Core Team Members	Staff	Public / Stakeholders
11/29/2018	Steele/Burnand Anza-Borrego Desert Research Center	10:00 AM	3:00 PM	Review of Chapters 2 & 3: Key Concept Slides from Oct. 4th AC Meeting; Opportunity to Clarify Technical/Informational Material presented on 10-04-2018; Ch. 4 Presentation	Advisory Committee	7	5	4	11
1/31/2019	Borrego Springs Library	10:00 AM	3:00 PM	GSP: Review of Draft Chapters; Chapter 5; GSP Appendices; Groundwater Dependent Ecosystems Presentation	Advisory Committee	8	4	3	14
5/10/2019	San Diego County Planning & Development Services	1:00 PM	3:00 PM	AAWARE Technical Questions Meeting	Technical Meeting	Unknown			
7/25/2019	Borrego Springs Library	10:00 AM	2:00 PM	Review of Draft GSP Response to Comments	Advisory Committee	7	5	4	16

AC meeting agendas and minutes are available on County website at: https://www.sandiegocounty.gov/content/sdc/pds/SGMA/borrego-valley.html

Appendix C.2 – List of Public Meetings

Date	Location	Start Time	End Time	Topics	Meeting type	Board Members	Public/ Stakeholders	Staff	
10/04/19	Borrego Springs Library	10.00 AM	12:30 PM	Consider a Consensus Recommendation on the draft-final GSP	Final Advisory Committee meeting	9 Advisory Committee members		2 Staff/ Consultants	
10/22/19	Borrego Water District	9.00 AM	11 00 AM	Borrego Springs Sub Basin Stipulation Schedule Update	Regular Board Meeting	5			
11/12/19	Borrego Water District	9:00 AM	11:00 AM	Borrego Springs Sub Basin 1. Update on Release of Stipulated Agreement Between Borrego Springs Pumpers a. Overview of how public input has been handled in other adjudicated basins b. Discussion of Public Meeting Schedule and Structure for 30-day review period	Regular Board Meeting	5			
11/20/19	Borrego Water District	9 30 AM	11:30 AM	Public Release of Borrego Springs Subbasin Sustainable Groundwater Management Act (SGMA) alternative to a Groundwater Sustainability Plan (GSP) Stipulation Documents Authorization to Commence Analysis of 5 Year Annual Groundwater Production Exhibit by Pumper as required under the Stipulation Judgment	Special Board Meeting	5			
12/3/19	Borrego High School	6:00 PM	7:30 PM	Overview of Stipulation Judgment (Questions, Comments and Queries)	Public Meeting				

Appendix C.2 – List of Public Meetings

Date	Location	Start Time	End Time	Topics	Meeting type	Board Members	Public/ Stakeholders	Staff	
12/10/19	Borrego High School	6:00 PM	7:30 Pm	Overview of Stipulation Judgment (Questions, Comments and Queries) Public Comment on Proposed Stipulated Judgment for Borrego Spring Sub Basin	Public Meeting Special Board Meeting				
12/17/19	Borrego Water District	9:00 AM	11:00 AM	Overview of 30-Day Stipulated Agreement Public Review Period	Regular Board meeting	5			
12/17/19	Borrego High School	6:00 PM	7:30 PM	Overview of Stipulation Judgment (Questions, Comments and Queries)	Public Meeting				
1/7/20	Borrego Water District	9:00 AM	9:45 AM	Acknowledge receipt of Comment Letters and Draft Responses. Approve Settlement Agreement unanimously	Public Meeting				

APPENDIX D

Technical Appendices

D1: Update to the USGS Borrego Valley Hydrologic Model

D2: BWD Water Quality Review and Assessment

D3: Groundwater Hydrographs

D4: Borrego Springs Subbasin Groundwater Dependent Ecosytems

The conclusions reached regarding Water Budget components and recommendations for further data and study contained in these Technical Appendices are to be periodically updated by the Watermaster through the Technical Advisory Committee processes, as set forth in Sections II.E and III.F of the Judgment.

APPENDIX D1

Update to the USGS Borrego Valley Hydrologic Model

DRAFT FINAL

Update to United States Geological Survey Borrego Valley Hydrologic Model for the Borrego Valley Sustainability Agency

Prepared for:

County of San Diego
Planning & Development Services
5510 Overland Avenue
San Diego, California 92123
Contact: Jim Bennett PG, CHG; Leanne Crow, PG

Prepared by:

DUDEK
605 Third Street
Encinitas, California 92024
Contact: Trey Driscoll, PG, CHG; Steven Stuart, PE

JULY 2019

TABLE OF CONTENTS

Section **Page No.**

ATTACHMENTS

FIGURES

TABLE

1 INTRODUCTION

In 2009, the United States Geological Survey (USGS) initiated a study of the Borrego Valley Groundwater Basin (BVGB) with the Borrego Water District (BWD). The goals of the study were to enhance the understanding of groundwater conditions in BVGB, and develop a numerical model as a tool to manage groundwater resources and evaluate possible future conditions in the basin. The USGS used the MODFLOW numerical modeling code One-Water Hydrologic Flow Model, or MF-OWHM, to simulate the interaction between surface water (e.g., stream flow and applied irrigation) and groundwater in Borrego Valley. From a Sustainable Groundwater Management Act (SGMA) perspective, MF-OWHM provides a fully integrated numerical modelling system capable of simulating the full hydrologic cycle to evaluate potential undesirable effects like declining groundwater storage, declining groundwater levels in areas with groundwater-dependent habitat, subsidence, and seawater intrusion.

[The conclusions reached regarding Water Budget components and recommendations for further data and study contained in this Update are to be periodically updated by the Watermaster through the Technical Advisory Committee processes, as set forth in Sections II.E and III.F of the Judgment.]

INTENTIONALLY LEFT BLANK

2 2015 BORREGO VALLEY HYDROLOGIC MODEL

The Borrego Valley Hydrologic Model (BVHM) was developed as part of a cooperative study between the USGS and the BWD. The study began in 2009, with the objectives of 1) improving the understanding of groundwater conditions and land subsidence in the BVGB, 2) using the BVHM to assist in the management of groundwater resources in the BVGB, and 3) using the BVHM to evaluate several management scenarios (Faunt et al. 2015). The BVHM simulates the use, movement, and storage of water throughout the BVGB through time. The BVHM is a finite-difference groundwater model that was developed using the MODFLOW numerical code MF-OWHM. The BVHM was used as part of the development of the Groundwater Sustainability Plan for the Borrego Springs Subbasin to help develop historical water budgets and to assist basin planning for future climate change and basin development following the guidelines outlined in SGMA.

2.1 Simulation Period

The BVHM simulated conditions using monthly stress periods from October 1929 to December 2010. There were 975 monthly stress periods in the simulation. Faunt et al. (2015) noted that, "the first 192 stress periods (years 1930–1945) are considered a model spin-up period, and the model calibration as well as the target simulation period used for analysis was October 1945 through December 2010." Faunt et al. (2015) stated that the 16-year "spin-up" was used in the model to "eliminate significant effects caused by uncertainty in the initial conditions" defined in the model. Because there was groundwater development and irrigation before the simulation period (1945–2010), the initial conditions defined in the model, per groundwater levels mapped in 1945, may not have represented steady-state conditions.

Each monthly stress period has two time steps, with the exception of the first stress period with 16 time steps. The time step multiplier was 0.75 for each stress period, meaning that the duration of the first time step (excluding the first stress period) ranged from 16 days to 17.7 days depending on the number of days in the month. The second time step ranged from 12 days to 13.3 days.

2.2 Model Domain

The boundaries of the active model domain of the BVHM were defined by the Coyote Creek fault on the northeast and east of the alluvial valley, the Vallecito Mountains to the south, and the San Ysidro Mountains to the west and northwest. The southeastern boundary of the model was defined at a surface-water divide southwest of Ocotillo Wells. This boundary marks an area of the alluvial valley where subsurface flow leaves the basin.

The model domain is defined by a finite-difference grid of uniform cells, or nodes, with each cell being 2,000-feet by 2,000-feet, or approximately 92 acres in area. The model domain includes 30 rows and 75 columns with 2,250 active cells (Figure 1). The total area simulated in the model is

73,876 acres. The model was divided vertically into three layers. The top layer represents the upper unconfined aquifer unit consisting of Quaternary alluvium. The thickness of the top layer ranged from 50 feet to 643 feet. The middle aquifer unit (Layer 2) is Pleistocene age continental deposits with a thickness ranging from 50 feet to 908 feet. The lower aquifer unit (Layer 3) includes the lower Palm Spring and Imperial Formations with a thickness ranging from 50 feet to 3,831 feet.

2.3 Hydrogeologic Characteristics

Layer 1 represents the upper unconfined aquifer, which historically has been the main source of water in the valley with well yields as high as 2,000 gallons per minute (GPM). The upper aquifer includes unconsolidated gravel, sand, silt, and clay of Holocene to Pleistocene age. Layer 2 represents the middle aquifer, which includes Pleistocene age continental deposits of gravel to silt with moderate amounts of consolidation and cementation. The middle aquifer yields moderate amounts of water north of San Felipe Creek. Layer 3 represents the lower aquifer and includes deposits of the lower Palm Springs and Imperial Formations. It is comprised of sandstone, siltstone, and conglomerate with low well yields. All three layers were simulated as convertible between unconfined and confined, meaning that when the water table declines below the top elevation of a layer that was fully saturated (i.e., confined), then the layer was converted to unconfined to account for a change in the saturated thickness and unsaturated portion of the layer.

The USGS used a geostatistical approach on grain size and texture characterized from various lithologic and geophysical logs recorded in Borrego Valley to simulate the heterogeneity of the aquifer units in the Borrego Basin. The textural map was based on the percentage of coarse-grain material described in each lithologic log. Coarse-grained sediments were characterized with having primarily boulders, cobbles, pebbles, gravel, and sand.

The distribution of coarse-grain sediment across the basin was interpolated between locations of borings and geophysical logs using kriging or cokriging algorithms over a grid matching the finite-difference gird utilized in the BVHM. Coarse-grain sediments were predominantly defined at the base of the foothills in the alluvial valley, and along major streambeds like Coyote Creek. The upper aquifer had the largest percentage of coarse-grain sediment, which reflected the depositional and geomorphic environments originating from the watersheds and drainages tributary to Borrego Valley. The middle and lower aquifers had finer sediments.

2.3.1 Hydraulic Conductivity

Hydraulic conductivity in the BVHM was defined based on the distribution of coarse-grain sediments defined by the textural map created from lithologic and geophysical logs. Horizontal hydraulic conductivity was "calculated as the weighted arithmetic mean of the hydraulic conductivities of the coarse-grained and fine-grained lithologic end members and the distribution of sediment texture for each model cell" (Faunt et al. 2015). Faunt et al. (2015) noted that, "hydraulic conductivities generally decrease with depth and with increasing distances from the original source of the sediments in adjacent mountain ranges and river channels, which is consistent with the fining-down and fining-toward-the-basin-center sequences observed in the aquifer sediments and texture model. Coarser grained sediments were assumed to be present near stream channels in the alluvium in the upper reaches of all three aquifers."

The saturated horizontal hydraulic conductivity in the upper aquifer ranged from 0.3 feet per day to 184 feet per day. The highest hydraulic conductivities were defined in the central portion of the valley where sand deposits of Quaternary age were characterized and older fan deposits at the base of the San Ysidro and Vallecito Mountains (Figure 2). Lower hydraulic conductivities were identified in areas characterized with younger fan deposits and consolidated continental deposits. The Borrego Sink was characterized with a uniform hydraulic conductivity of 6 feet per day in all three aquifer units. The saturated hydraulic conductivity in the middle and lower aquifer units ranged from 0.02 feet per day to 7 feet per day. The lower hydraulic conductivity in the middle and lower aquifers relative to the upper aquifer were based on a lower energy depositional environment to the valley prior to activity along the Coyote Creek fault that opened the northern portion of the valley to sediment deposition from Coyote Creek.

Faunt et al. (2015) reported estimated hydraulic conductivities based on previous aquifer tests conducted in the valley. Four constant-rate aquifer tests yielded an estimated hydraulic conductivity of 2 feet per day in a clay interbedded with sand to 336 feet per day in a coarse sand unit. The lower aquifer unit, which included the Palm Springs Formation characterized with cemented interbedded clays and gravels, had an estimated hydraulic conductivity of 10 feet per day. Previous studies cited in the USGS model report included hydraulic conductivities that ranged from 0.1 to 178 feet per day, with a ratios of horizontal to vertical hydraulic conductivity ranging from 10 to 100 for the upper and middle aquifers, and from 1 to 100 for the lower aquifer (Faunt et al. 2015).

2.3.2 Aquifer Storage Properties

Specific yield, which represents unconfined aquifer storage and equals the percentage of bulk aquifer volume that would drain under gravity, ranged from 12% to 17% (average was 15%) for the upper aquifer. Specific yield was defined in the BVHM similarly to how hydraulic conductivity was defined using a textural map to simulate the heterogeneity of the aquifer units. The specific yield for the middle aquifer ranged from 15% to 21% with an average of 17.5% (Figure 3). The specific yield for the lower aquifer ranged from 0.7% to 5.6% with an average of 3%. A specific yield was defined for each aquifer unit because of the possibility that portions (i.e., model nodes) of each aquifer unit, or model layer, could become unconfined (i.e., not fully saturated) when the hydraulic head fell below the top elevation at each model node.

Faunt et al. (2015) reported that the specific storage defined for each aquifer unit under confined conditions ranged from $5.1x10^{-7}$ in the upper aquifer to $1.6x10^{-6}$ in the middle aquifer. The specific storage represents the amount of water that would be released from storage per unit volume of aquifer for a unit change in hydraulic head while the aquifer remains fully saturated. The specific storage terms were defined uniformly for each layer.

2.4 Boundary Conditions

The boundaries of the model domain were mostly defined as no-flow boundaries coinciding with the Coyote Creek fault and the foothills of the San Ysidro and Vallecito Mountains. There were a few exceptions: specified fluxes were defined at 44 cells representing underflow originating from the upstream watersheds draining to Borrego Valley, 24 stream flow entry points were defined at nodes representing the locations where stream flow entered the valley via Coyote Creek, San Felipe Creek, Borrego Palm Creek, and other drainages, and three constant-head boundary nodes simulating the outflow of groundwater at the southern end of the BVHM. The natural recharge of underflow and surface water runoff from the adjoining watersheds was estimated from data obtained from the regional-scale USGS Basin Characterization Model (BCM).

2.4.1 Basin Characterization Model

The BCM was developed by the USGS in 2004 and provides a "deterministic water-balance approach to estimate recharge and runoff in a basin" on a regional scale (Faunt et al. 2015). The BCM "uses the distribution of precipitation, snow accumulation and melt, [potential evapotranspiration] PET, soil-water storage, and bedrock permeability to estimate a monthly water balance for the groundwater system" (Faunt et al. 2015). The result is an estimate of water recharging a basin (of which some may leave the basin as underflow to an adjacent basin) and potential runoff. Potential underflow and runoff to Borrego Valley was estimated from the BCM using the watersheds surrounding Borrego Valley. Water entering BVGB via underflow was represented by 44 cells along the mountain boundaries in the valley each defined with a constant specified flux based on estimates from the BCM. Water entering BVGB via surface water runoff was represented by 24 cells defined as entry points to the stream segments defined in the stream-flow routing (SFR) package (Figure 4).

Runoff and underflow entering the BVGB, as estimated by the BCM, were "simulated for the watersheds draining into the Borrego Valley on a monthly basis for years 1940–2007 as spatially distributed among the watersheds draining into Borrego Basin" (Faunt et al. 2015). The average annual underflow entering the BVGB was approximately 900 acre-feet per year (AFY), or 10% of the estimated recharge to the adjacent watersheds estimated by the BCM. There was little to no stream flow to the BVGB from 1940 to 2007. Only after major wet seasons or large individual rainfall events did runoff to BVGB exceed 10,000 AFY or more. This only occurred during 7 years between 1940 and 2007. Runoff to the BVGB ranged from less than 10 AFY to 44,000 AFY with an average annual rate of 3,600 AFY. The BVHM includes perennial flow entering Coyote Creek at 0.014 cubic feet per second (cfs; approximately 10 AFY) and an unnamed tributary at 0.002 cfs (approximately 1.4 AFY) from a minor watershed to the southwest of the BVGB.

2.5 Farm Process

MF-OWHM is a fully coupled integrated hydrologic numerical modeling code capable of simulating all interactions of surface water and groundwater in the hydrosphere. Integrated within MF-OWHM is the Farm Process Package, or FMP, which simulates the movement of water over a landscape. Water may originate from natural (e.g., rainfall) and/or anthropogenic sources (e.g., applied irrigation) and move via surface water runoff, evapotranspiration, and infiltration into the unsaturated zone. A landscape is characterized by a land-use type (e.g., farm, golf course) with certain characteristics defined like rooting depth, soil moisture characteristics, and application inefficiencies defined for irrigation and precipitation. The FMP simulates the water budget over a landscape defined at each cell, or node, in the model domain. Water inputs may include rainfall, applied irrigation, and stream flow. Water outputs may include evapotranspiration, surface water runoff, and infiltration in the unsaturated zone and groundwater pumping from the saturated zone.

The USGS (2015) defined 52 water-balance subregions (WBS), or "farms," in the BVHM. These 52 "farms" were defined based on a parcel map showing land ownership from 2010. The definition of these "farms" in the model domain were held constant throughout the simulation. Each "farm" was assigned one or more land-use types, of which there were 15 classifications that included golf course, urban, fallow, native, and certain crop types like grapes, citrus, and palm. The USGS redefined land-use types on a near annual basis, with some land uses changing due to urbanization, zoning, and/or farming restrictions through the simulation. For example, Faunt et al. (2015) noted that "before development, about 10 percent of land use consisted of phreatophytes, and 90 percent was other types of native vegetation and bare ground. In 2009, 78 percent was natural vegetation (6 percent phreatophytes and 72 percent other native types), 11 percent residential/municipal, 8 percent developed agricultural land, and about 3 percent recreational uses (golf courses)."

Land-use type was assigned on a cell-by-cell basis (Figure 5). The coarse grid of the BVHM, with cells of uniform dimensions of 2,000 feet by 2,000 feet (or 92 acres), however, meant that the land-use type that comprised the largest fraction of a cell was assigned to that cell. For example, the WBS representing Rams Hill Golf Course included 10 cells comprising a total of 920 acres, but only two of those cells (total of 184 acres) were assigned a golf course land-use type after 2009. The other 8 cells were assigned a "native classes" land-use type designation.

Pumping data for agricultural uses was not available to the USGS when designing the BVHM. Instead, the FMP in the MODFLOW-OWHM code was used to estimate pumping for agricultural uses in the BVHM. The FMP estimates agricultural pumping by calculating estimated water demands for the various crop types receiving applied irrigation. The FMP calculates the water demand for a specific crop using potential evapotranspiration (PET) provided by the BCM and crop coefficients assigned to each crop type. The FMP then calculates a crop irrigation requirement (CIR), or residual water demand, after accounting for water supplied via precipitation and root uptake via groundwater. The CIR was increased to compensate for evaporative losses and estimated inefficiencies of delivering water for irrigation supply. The result is a total farm delivery requirement (TFDR) defined for each WBS, or "farm," that is satisfied in the BVHM via estimated pumping in the FMP.

2.6 Water Budget

An annual water budget was calculated for the BVGB for every water year. A water year spans the year from October 1 to the subsequent September 30.

2.6.1 Inflow from Stream Leakage

Faunt et al. (2015) noted that "the primary source of natural recharge to the basin is infiltration from the ephemeral stream and washes entering the Borrego Valley from the adjacent mountains." Surface water runoff entering the model domain was estimated using data from the BCM and introduced into the model domain using the SFR package. The SFR package is a head-dependent boundary condition that can simulate stream flow routing, groundwater discharges in reaches characterized as gaining streams, stream flow leakage in reaches characterized as losing streams, and the capture and conveyance of surface runoff. The BVHM includes 84 stream segments defined in the SFR package, where multiple segments were joined to represent stream flow in Coyote Creek, San Felipe Creek, Borrego Palm Creek, and other minor tributaries. The streams received inflow at 24 entry points that represented runoff from the adjoining upstream watersheds in the San Ysidro and Vallecito Mountains.

Recharge from stream leakage during the model simulation period (1945–2010) ranged from 112 acre-feet (AF) in 1948 to 22,500 AF in 1978 (Figure 6). The annual average recharge rate from stream leakage was 4,028 AFY with a standard deviation of 5,142 AFY.

2.6.2 Inflow from Applied Irrigation Return Flows

Another source of inflow to the basin, particularly as the valley became more developed, was return flow from applied irrigation at agricultural areas. Applied irrigation at agricultural areas was estimated using the FMP. The volume of applied water in excess of losses to evapotranspiration, irrigation inefficiencies, and surface runoff was simulated as infiltrating below the root zone and entering the unsaturated zone. The FMP was linked to the unsaturated zone flow package, or UZF, of MODFLOW. The UZF simulates the movement of water through the unsaturated zone based on soil moisture characteristics and a uniform definition of vertical hydraulic conductivity in the unsaturated zone.

Early versions of MODFLOW simulated an instantaneous contribution of infiltrating water from land surface to the water table. However, water does not infiltrate instantaneously, but moves through an unsaturated zone where the movement of water is a function of soil moisture content (i.e., degree of saturation) and highly variable hydraulic conductivities based on the moisture content. Faunt et al. (2015) noted, "depending on the unsaturated-zone thickness, permeability, and residual moisture content, it can take years to decades for irrigation return flow to pass through the unsaturated zone." The UZF provides a more realistic estimation of irrigation return flows in the BVHM.

Recharge from applied irrigation return flows ranged from 572 AF to 3,706 AF during the model simulation period (1945–2010; Figure 6). The annual average recharge rate from the unsaturated zone was 1,486 AFY with a standard deviation of 737 AFY.

2.6.3 Septic System Return Flows

The USGS cited a previous study that estimated an average use of 100 gallons per day per household and assumed that 50% of the water used was lost to evaporation and transpiration. Therefore, the USGS estimated that return flow from septic tank systems in the valley was constant at 0.056 AFY per home, or 0.19 cubic meters per day (m^3/day). The USGS identified residential and/or developed areas in the valley and estimated a number of septic tank systems associated with those land use types on a per node basis in the numerical model. The number of septic tank systems were periodically defined in the model and used for subsequent monthly stress periods until the next count. The last count of septic tank systems defined in the numerical model was based on development identified in 2009. The USGS reported that, "the infiltration from irrigation of municipal lawns and treated and untreated wastewater was assumed to be negligible."

2.6.4 Inflow from Subsurface Flow

Underflow entering the BVGB from the adjoining upstream watersheds was simulated using the Flow Head Boundary (FHB) package. Underflow from these watersheds was distributed over 44 cells aligned at the model domain boundaries with the San Ysidro and Vallecito Mountains. The rate of underflow entering the BVHM for each cell was based on monthly data obtained from the BCM. The USGS defined an average rate of underflow at each cell to the model domain and held these rates constant throughout the simulation. The total underflow to the model domain was 3.7 AF per day, or 1,367 AFY (Figure 6). Variations in monthly underflow in the model represent differences in the lengths of the months and do not indicate variations in the rate of underflow into the basin.

2.6.5 Outflow via Pumping

The BVHM simulated municipal pumping using metered data obtained from BWD, and agricultural and recreational pumping estimated using the FMP. Before 1944, groundwater pumping in the basin averaged less than 300 AFY, which was used mostly for domestic purposes (Faunt et al. 2015). No pumping was simulated in the BVHM from 1929 to 1943. Population growth in Borrego Valley after World War II led to increasing groundwater production with the majority of water produced for irrigation purposes. Groundwater production in the model ramped up from essentially 0 AFY in 1943 to over 10,000 AFY in 1955 (Figure 7). Annual production declined to less than 7,000 AFY beginning in 1965, but began increasing again in the mid-1970s with a peak production of almost 20,000 AFY in 2006. Faunt et al. (2015) reported that, "about 70 percent of the groundwater used each year has been for agriculture, about 20 percent for golf courses and other recreational uses, and about 10 percent for municipal and domestic use (residential, commercial, and the Anza-Borrego Desert State Park)."

Pumping for agricultural, recreational and municipal uses were simulated using the MODFLOW multi-node well package (MNW2). The MNW2 package simulates the effects of pumping from wells that intersect multiple aquifer units that contribute flow under different hydraulic heads. A number of wells were completed in more than one of the aquifer units in Borrego Valley. Faunt et al. (2015) identified up to 82 wells operating in the basin. Seventy of those wells were linked to farms identified in the model domain with pumping determined from the FMP package. These wells represented pumping for agricultural and recreational uses in Borrego Valley. Municipal pumping, which was based on metered data, was provided by BWD.

2.6.6 Outflow via Evapotranspiration

Monthly potential evapotranspiration data was obtained from the BCM and included as part of the water-balance calculations in the FMP. Direct evapotranspiration from groundwater was estimated in the FMP by calculating the monthly PET values by monthly crop coefficients assigned to each land-use type (e.g., phreatophytes, citrus, golf courses, native), the rooting depths defined for each land-use type, the depth to groundwater and height of capillary fringe. Phreatophytes, found mostly in the northern part of Borrego Valley and around the Borrego Sink, had the deepest rooting depth at 15.3 feet. They were responsible for most of the groundwater losses from the basin prior to the mid-1940s. Faunt et al. (2015) reported that approximately 4,300 AFY was lost via evapotranspiration from phreatophytes before 1946. The amount of water extracted by pumping from the basin surpassed losses by evapotranspiration by 1954 (Figure 7). This was attributed to declining water levels in the basin, which reduced the amount of water available for transpiration. Evapotranspiration losses were less than 2,000 AFY by 1990 and less than 1,000 AFY by 2000.

2.6.7 Outflow at Southern Boundary of BVGB

A constant-head boundary condition was assigned to three cells marking the southern boundary of the BVGB. This boundary was identified by the USGS based on water level data from other sources that indicated this area was not influenced by water level fluctuations and hydraulic conditions to the north. The average outflow at this boundary throughout the simulation was 1.4 AF per day. No water flowed into the model domain at this boundary.

Annual outflow from the BVGB at the southern boundary of the basin ranged from 499 AF to 573 AF. The annual average was 525 AFY with a standard deviation of 15 AFY.

2.6.8 Water Balance

The annual average water balance for the model period (1945–2010) is presented in Table 1. The BVGB has experienced more in water losses via pumping and evapotranspiration than inflows from stream leakage and underflow from the adjoining watersheds since the 1929–1930 water year (Figure 8). The exceptions were during more-than-normal wet years, like 1976, 1978, and 1991, when stream flow leakage was a significant contributor of inflow to the basin. In those years, there was a net influx of 13,000 to 18,000 AF of water to the basin. Outside of those wet years, the average annual loss from the basin was approximately 13,100 AFY (Attachment A).

Faunt et al. (2015) reported that the average annual natural recharge of water reaching the saturated zone, which includes stream leakage and infiltrating water through the unsaturated zone, was 5,700 AFY. This estimate was derived from a "pre-development" run of the model, where the model was run with all land uses being replaced with native vegetation and phreatophytes, and the model being run for the full simulation period from 1945 to 2010.

The average annual loss in storage in the BVGB from 1945 to 2010 was approximately 6,800 AFY.

Table 1
Summarized Water Budget

Water Budget Components (Units in Acre-Feet per Year)	Original USGS Model (1945–2010)	Model Update (1945–2016)	Most Recent 20 Years (1997–2016)	Most Recent 10 Years (2007–2016)
Inflows				
Stream Recharge	4,028	3,905	2,749	1,865
Unsaturated Zone Recharge [a]	1,486	1,497	1,635	1,505
Underflow from Adjacent Basins	1,367	1,367	1,367	1,367
Total Average Annual Inflow	**6,881**	**6,770**	**5,751**	**4,737**
Outflows				
Pumping	10,128	10,597	16,466	16,856

Table 1
Summarized Water Budget

Water Budget Components (Units in Acre-Feet per Year)	Original USGS Model (1945–2010)	Model Update (1945–2016)	Most Recent 20 Years (1997–2016)	Most Recent 10 Years (2007–2016)
Evapotranspiration [b]	3,032	2,815	759	498
Underflow (Flow Out of Southern End)	522	522	520	523
Total Average Annual Outflow	**13,682**	**13,934**	**17,745**	**17,877**
Average Annual Deficit				
Change in Storage	**-6,801**	**-7,164**	**-11,994**	**-13,140**

Notes: USGS = U.S. Geological Survey.

a Consists of flow from the unsaturated zone into groundwater. Includes direct precipitation recharge (negligible), leakage from some streams within the model domain, and irrigation return flows (Distributed Recharge).

b Consumptive use of water calculated by the Farm Process Package for all land use type; primarily represents evapotranspiration.

2.7 Model Calibration and Sensitivity

2.7.1 Calibration

The model was calibrated to observed hydraulic heads (i.e., measured groundwater levels at wells) collected from 1945 to 2010. Faunt et al. (2015) reported that 2,224 groundwater level measurements were obtained from databases maintained by BWD, USGS, and California Department of Water Resources. The groundwater level data was collected at 73 wells in the basin. Model calibration was evaluated by calculating the difference (i.e., residual) between the observed groundwater level measured at a well to the corresponding simulated groundwater level. The USGS employed a combination of manual modifications and the use of an automated parameterization algorithm, or parameter estimation tool (PEST), to adjust parameters (e.g., hydraulic conductivity, storage, stream inflows) over a series of simulation runs to minimize the residuals between observed and simulated hydraulic heads.

Faunt et al. (2015) reported that "the overall model fit for groundwater-level comparisons is generally good when the simulated head values are compared against the measured groundwater levels. About 90 percent of the residuals were between -20 and +20 feet, and more than 50 percent were between -5 and +5 feet" (Attachment C). The mean residual from 1945 to 2010 was +2.41 feet (from 2,258 residuals ranging from -249.48 to +235.9 feet), indicating that the model tended to underestimate hydraulic heads compared to observed values (Figure 9).

A plot of simulated versus observed hydraulic heads from 1945 to 2010 shows a bias of the model to overestimate lower observed hydraulic heads and underestimate higher observed hydraulic heads (Figure 10). A perfect match of simulated heads with observed heads would yield a uniform slope. A linear trend line fitted to the observed and simulated hydraulic head data had a slope of

0.65, which may indicate a flatter hydraulic gradient simulated across the basin than one estimated from the observed hydraulic heads.

A measure of the average error in the model simulating observed hydraulic heads is indicated by the root mean squared error (RMSE) of the residuals. The RMSE is the best measure of error if the residuals are normally distributed in the basin. An acceptable error is gaged by the magnitude of the change in hydraulic head in the simulation compared to the RMSE. The RMSE was 17.88 feet between observed and simulated hydraulic heads from 1945 to 2010. Hydraulic heads declined 10 feet to 130 feet from the 1950s to 2010 with an average decline of 57.3 feet. The ratio of the RMSE (17.88 feet) to the average decline in hydraulic head in the basin (57.3 feet) is 0.31, which is an acceptable level of error given the coarse grid (2,000 feet by 2,000 feet) and layer thicknesses of 50 feet to 643 feet in the upper aquifer (layer 1) of the model domain.

2.7.2 Sensitivity

The parameter estimation process using PEST was used to evaluate the sensitivity of the BVHM to parameters defined in the model. A sensitivity analysis, as conducted by the USGS for the BVHM, provides a measure of the uncertainty in the model results arising from the assumptions made in defining the hydrogeology and parameters in the model. Faunt et al. (2015) reported that the BVHM was most sensitive to scaling factors used in estimating runoff from precipitation and applied irrigation, crop coefficients, and irrigation efficiency, all of which were included in the FMP and contribute to calculating the water demand for the various land-use types defined in the model. The next most sensitive parameters were specific yield and scaling factors used to adjust the amount of runoff and underflow estimated by the BCM that entered the BVGB.

The highest levels of uncertainty in the model were from agricultural pumping, specific yield, and stream flow entering the valley. Agricultural pumping (and to a lesser extent recreational pumping) was estimated using the FMP package, which calculates a water demand on a cell-by-cell basis for each land-use type. The water demand is based on an estimated water consumption factoring in evapotranspiration, applied water (via irrigation or rainfall), efficiencies of applied irrigation water, soil moisture content, rooting depth, and potential runoff. The following measures could be taken to improve the uncertainty in the model: (1) information on actual pumping for agricultural and recreational uses can be used to improve the accuracy of the FMP in estimating pumping, (2) long-term constant-rate aquifer tests in the upper and middle aquifer units would improve the estimates of specific yield, and (3) the installation of stream gaging stations in Coyote Creek and other major drainages to the valley would improve the estimates of runoff to the basin.

INTENTIONALLY LEFT BLANK

3 UPDATE OF THE BORREGO VALLEY HYDROLOGIC MODEL

The BVHM was updated to extend the simulation period to September 2016. This required increasing the number of monthly stress periods from 975 to 1,044. The additional stress periods were configured with the same number of time steps (2) and time-step multiplier (0.75) used in the original stress periods of the model. Inflow from subsurface flow representing underflow to the basin and outflow represented by the constant-heads at the southern end of the basin were maintained at their same respective constant rates and heads defined in the original model from January 2011 to September 2016. No changes were made to hydraulic properties like saturated hydraulic conductivity and storativity (specific yield and specific storage) and to hydraulic properties of the unsaturated zone.

Monthly precipitation and evapotranspiration data for January 2011 to September 2016 were obtained from the BCM. The Farm Process package was updated to incorporate the monthly precipitation and evapotranspiration data, and changes to land-use type were made in the FMP based on a review of aerial imagery and documented fallowed land through the BWD and County of San Diego (County) Water Credits Program. Municipal pumping by District wells from January 2011 to September 2016 was included in the updated files.

3.1 Updating the Farm Process Package

3.1.1 Land Use Types

Land use types were updated after reviewing aerial imagery of the Borrego Valley from 2011 to 2016, and reviewing Water Credits filed with the County. The following modifications were made to the last land use type characterization from the original file: in September 2013, the land use at one cell was changed from citrus to fallow; in August 2014, one cell was changed from native to residential; in December 2014, one cell was changed from citrus to fallow; in July 2015, one cell was changed from palms to fallow; and in May 2016, one cell was changed from citrus to fallow. All other land-use types defined in the original model remained the same.

3.1.2 Precipitation and Evapotranspiration

Monthly precipitation and evapotranspiration data were obtained from the BCM for January 2011 to September 2016. The precipitation and evapotranspiration data were compiled in separate files for each month. The FMP was updated to read each precipitation and evapotranspiration data file corresponding to the additional stress periods in the updated model. The FMP used the monthly precipitation and evapotranspiration data to calculate a water balance on a cell-by-cell basis. The data from the BCM are in units of millimeters per month. The FMP includes a multiplier of $3.29e^{-5}$ that is applied to each value from the BCM to convert it to units of meters per day.

3.2 Stream Flow

Runoff to the 24 stream flow entry points were taken from historical stream gage and precipitation data. An attempt was made to repeat the methodology the USGS used in defining runoff to the 24 stream flow entry points using BCM data, but the process utilized by the USGS could not be discerned when comparing BCM data to runoff values used in the numerical model for earlier stress periods.

Therefore, stream flow entering the valley after December 2010 was simulated based on historical rainfall compared to runoff. Precipitation data recorded at climatic stations from 2011 to 2016 in the BVGB were compared to historical (i.e., pre-2011) monthly precipitation data recorded at the same climatic stations to find months with similar precipitation. These months were then used to pull stream gage data from stream gages on Coyote Creek, Palm Canyon Creek, and San Filipe Creek during historical periods when these stream gages were active. These monthly values were added to the appropriate stress periods for the extended model simulation.

3.3 Pumping

Monthly municipal pumping data from January 2011 to September 2016 was obtained from BWD. The pumping data was converted from AF per month to cubic meters per day and incorporated in the updated BVHM. The average monthly pumping rates for municipal wells ranged from 0 m^3/day to 2,011 m^3/day at well ID4-11. Agricultural and recreational pumping continued to be estimated using the FMP.

3.4 Septic System Return Flows

The number of septic tank systems were periodically defined in the model and used for subsequent monthly stress periods until the next count. The last count of septic tank systems defined in the numerical model was based on development identified in 2009. The updated model repeated this information from 2009 during the extended period from January 2011 to September 2016.

4 WATER BALANCE OF UPDATED MODEL

An annual water balance from the 2010–2011 to 2015–2016 water years was calculated for the BVGB using the updated BVHM. In addition, average annual water balance estimates for the entire model period (1945–2016) are presented in Table 1. Stream leakage was the largest contributor of inflow to the basin, which ranged from 1,180 AF to 6,500 AF. The 6,500 AF occurred during the winter of 2011. The average annual inflow from stream leakage was 2,550 AFY. Recharge from the unsaturated zone, including irrigation return flows, averaged 1,630 AFY. Underflow was held constant from the original model and averaged 1,400 AFY. The average annual total inflow, or recharge, to the BVGB was 5,550 AFY from the 2010–2011 to 2015–2016 water years (Attachment B).

Pumping was the largest outflow component from the basin. The average annual outflow via pumping from the basin was 15,800 AFY. Other sources of outflow included evapotranspiration (435 AFY) and the southern constant-head boundary of the basin (520 AFY). Pumping constituted 94% of the total outflow. The average annual total outflow from the BVGB was 16,700 AFY from the 2010–2011 to 2015–2016 water years.

The average annual water balance from the 2010–2011 to 2015–2016 water years was a deficit of 11,000 AFY, which further contributed to a decline in groundwater storage in the BVGB (Figure 13).

INTENTIONALLY LEFT BLANK

5 MODEL VALIDATION

All hydraulic head and stream flow data collected up through 2010 were used to calibrate the numerical model. No exercise was conducted by the USGS to verify, or validate, the results of the BVHM. Model validation is a method to evaluate the model's accuracy in predicting future conditions. "A model is verified if its accuracy and predictive capability have been proven to lie within acceptable limits of error by tests independent of the calibration data" (Anderson 1992). Updating the BVHM with data collected outside the calibration period from January 2011 to September 2016 presented the opportunity of validating the model. As described previously, only climatic parameters (precipitation, evapotranspiration, stream flow) and metered pumping were added to the additional stress periods defined in the updated model. Parameters defining hydraulic properties (hydraulic conductivity, storage) and uniform boundary conditions (constant underflow and heads at the southern boundary) were consistent in the updated model.

The simulation results from January 2011 to September 2016 were compared to observed hydraulic heads recorded in this period to validate the numerical model. The mean residual from October 2010 to September 2016, which included the 2010–2011 to 2015–2016 water years, was +6.18 feet (from 225 residuals ranging from -55.72 to +52.71 feet), indicating that the model continued to underestimate hydraulic heads compared to observed values (Figure 11, Attachment C).

A plot of simulated versus observed hydraulic heads from 1945 to September 2016 continues to show a bias of the model to overestimate lower observed hydraulic heads and underestimate higher observed hydraulic heads (Figure 12). A linear trend line fitted to the observed and simulated hydraulic head data from January 2011 to September 2016 was parallel (slope of 0.65) to the linear trend line matched to the 1945 to 2010 data. The BVHM, updated with recent data outside the calibration period, provided similar results with similar error.

When residual at key wells from Spring 2016 are plotted on a map, other trends in potential model bias emerge (Figure 14). A plot of these wells shows that, in general, wells in the northeastern portion of the basin (particularly in the northern management area) tend to have heads that are underestimated compared to manual observations, while wells that are in the southwestern portion of the basin have heads that tend to be overestimated. The northeastern portion of the basin, where heads tend to be underestimated, is the area with the most intensive pumping. Given this bias, future updates to the model should focus on improving estimates of head in this area by including more precise pumping and aquifer data.

The RMSE between observed and simulated hydraulic heads from January 2011 to September 2016 was 18.78 feet, which was comparable to the RMSE of 17.88 feet calculated for the residuals from 1945 to 2010. Hydraulic heads declined an additional 2 to 18.5 feet from 2011 to 2016 with an average decline of 9.3 feet over the 6-year period.

INTENTIONALLY LEFT BLANK

6 RECOMMENDATIONS

The sensitivity analysis conducted by the USGS indicated the greatest uncertainty in the numerical model was in agricultural pumping, stream flow leakage, and storage. The FMP estimates agricultural pumping using precipitation and evapotranspiration data obtained from the BCM, assumptions about soil types and their associated soil moisture characteristics, rooting depths, crop coefficients, overland runoff, and estimated efficiencies of applied irrigation. Additionally, the coarse uniform grid of the model domain may overstate the water demands of certain land-use types, like golf courses, and, consequently, overestimate the amount of groundwater pumped to meet the water demand.

The simulated hydraulic heads compared to observed hydraulic heads indicated a slight bias of the model in underestimating hydraulic heads. This may be the result of the model simulating too much pumping compared to actual usage, or underestimating storage values like specific yield for the upper aquifer, or underestimating the amount of recharge to the BVGB, or a combination of all three. A spatial view of modeled residuals indicates that simulated heads may be underestimated where most agricultural pumping occurs. To improve the accuracy of the BVHM in simulating conditions in the basin and provide greater confidence in predictive simulations, the following are recommended actions to undertake to obtain additional data and further study the hydrogeology of the basin:

- Collect actual agricultural pumping data using existing flow meters or installing new flow meters at wells used for irrigation purposes. The pumping data may be incorporated in the numerical model to calibrate the FMP to more accurately estimate the water demands for the various crops and golf courses being irrigated.
- Install stream gaging stations at major drainages that convey most of the surface water runoff to the valley, either from perennial flows or flash flows from major precipitation events. The goal would be to install two gaging streams in the same creek to measure differences in flow. This information would provide a more accurate estimate of stream leakage.
- Conduct aquifer tests at wells screened only in the upper aquifer and only in the middle aquifer to obtain site-specific estimates of hydraulic conductivity and specific yield for each aquifer unit. This information may be used to enhance the calibration of the model to these hydraulic properties and our understanding of storage in the BVGB.

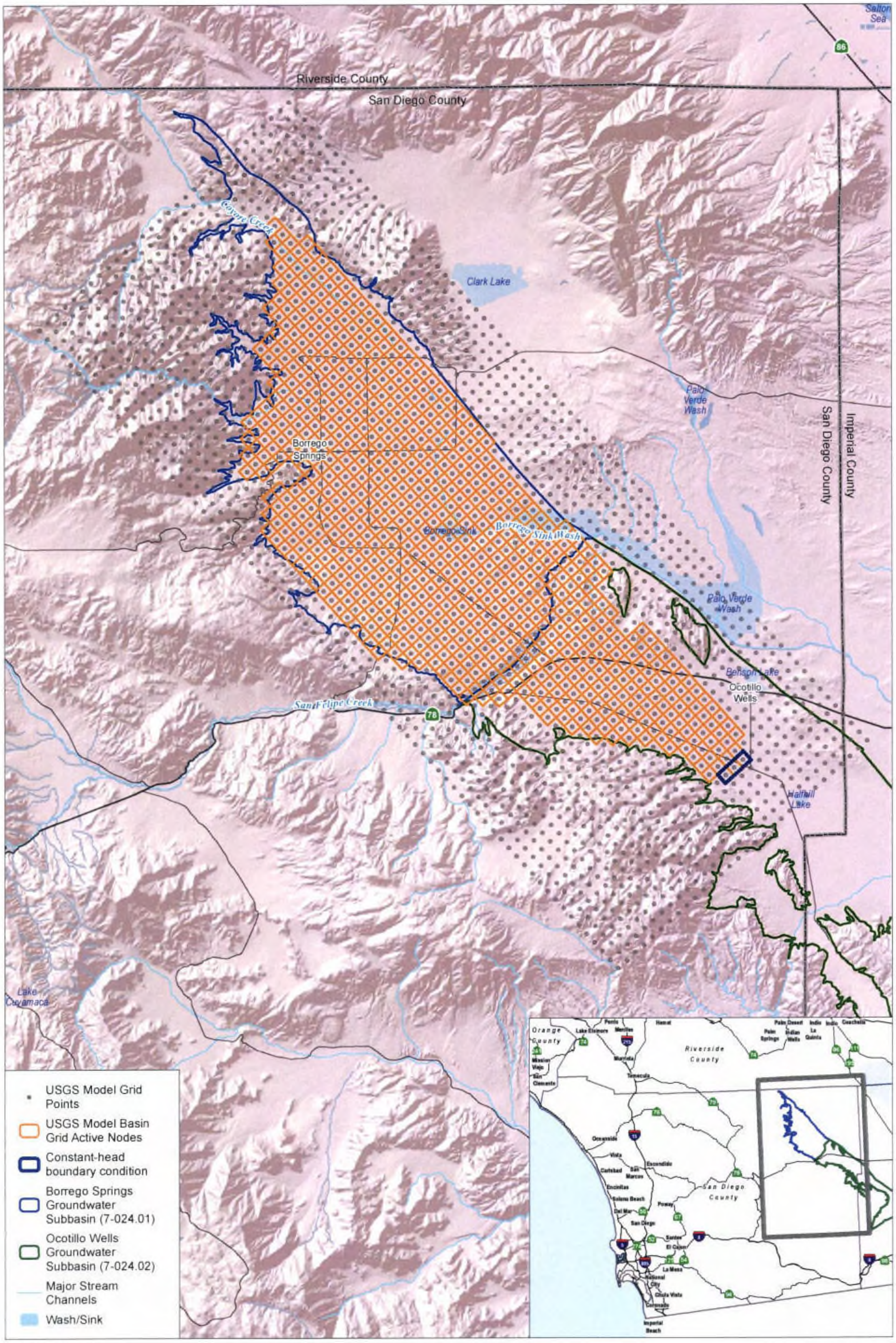
INTENTIONALLY LEFT BLANK

7 REFERENCES CITED

Anderson, M.P., and W.W. Woessner. 1992. *Applied Groundwater: Modeling Simulation of Flow and Advective Transport*. San Diego: Academic Press Inc.

Faunt, C.C., C.L. Stamos, L.E. Flint, M.T. Wright, M.K. Burgess, M. Sneed, J. Brandt, P. Martin, and A.L. Coes. 2015. Hydrogeology, hydrologic effects of development, and simulation of groundwater flow in the Borrego Valley, San Diego County, California: U.S. Geological Survey Scientific Investigations Report 2015-5150, 135 p.

INTENTIONALLY LEFT BLANK



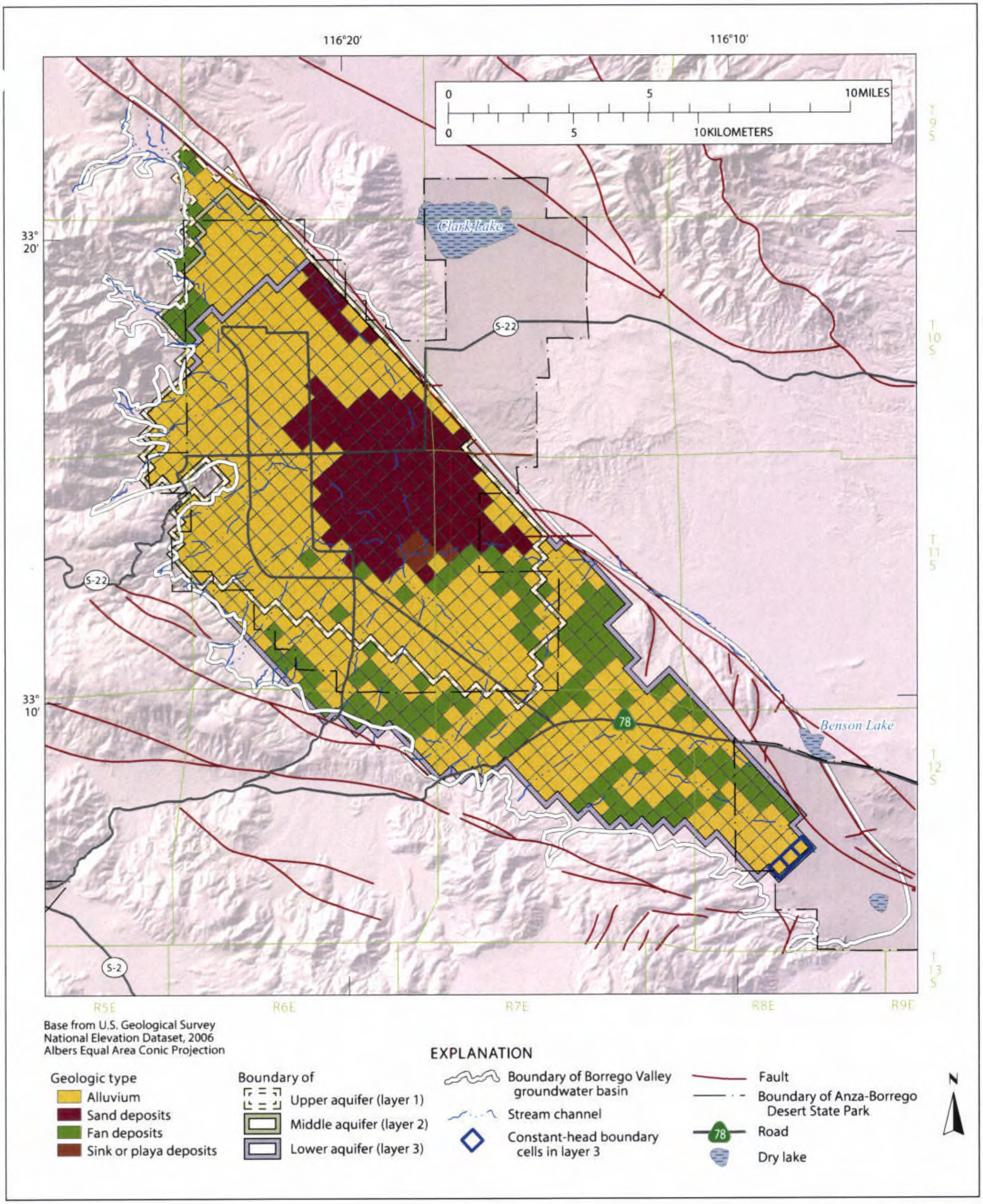
SOURCE: Faunt et al. 2015

DUDEK January 2020

0 10,000 20,000 Feet

Figure 1
Model Domain for Borrego Valley Hydrologic Model
Update to United States Geologic Survey Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK

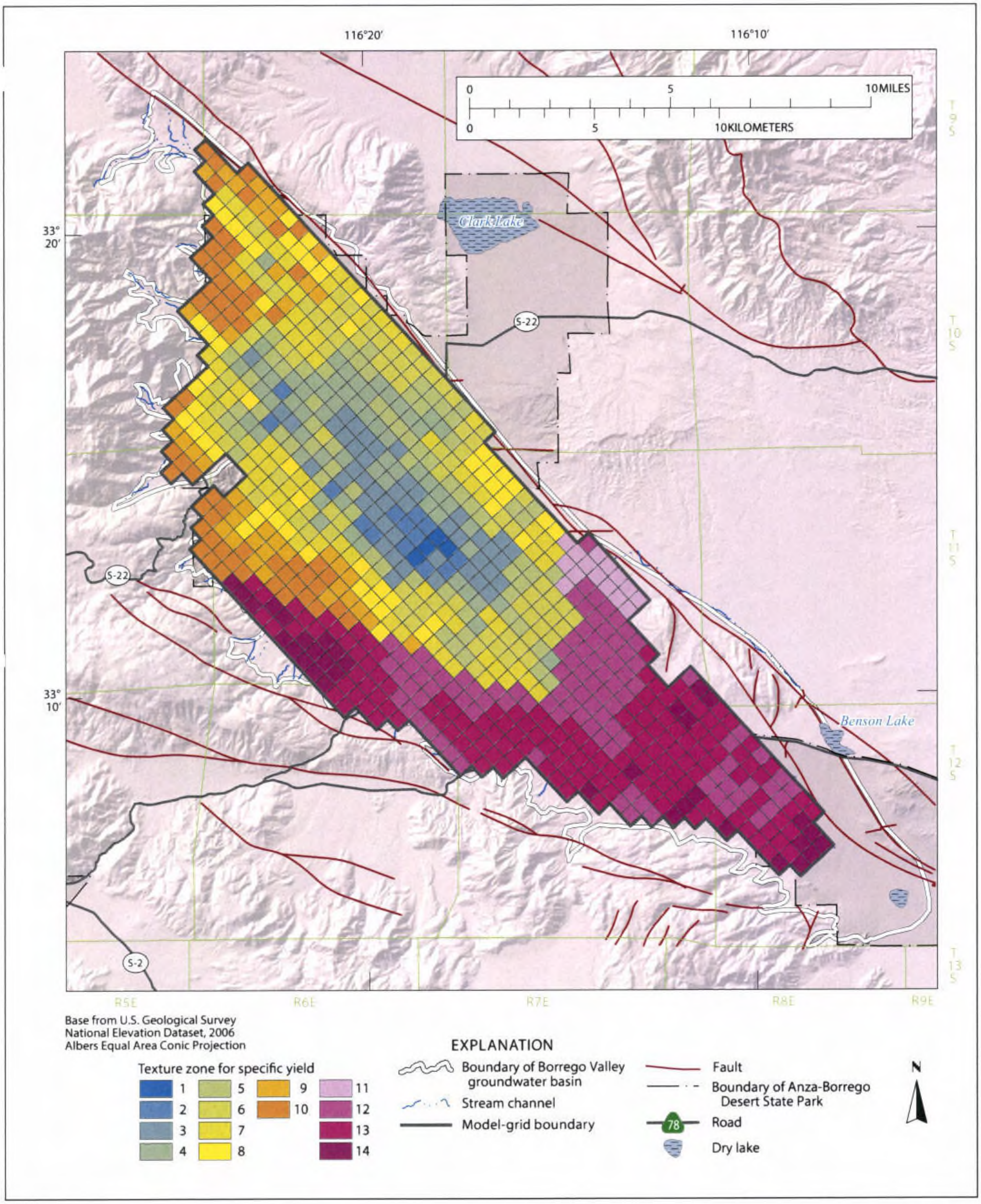


SOURCE: Faunt et al., 2015

FIGURE 2

Hydrogeologic Parameter Zones in Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK



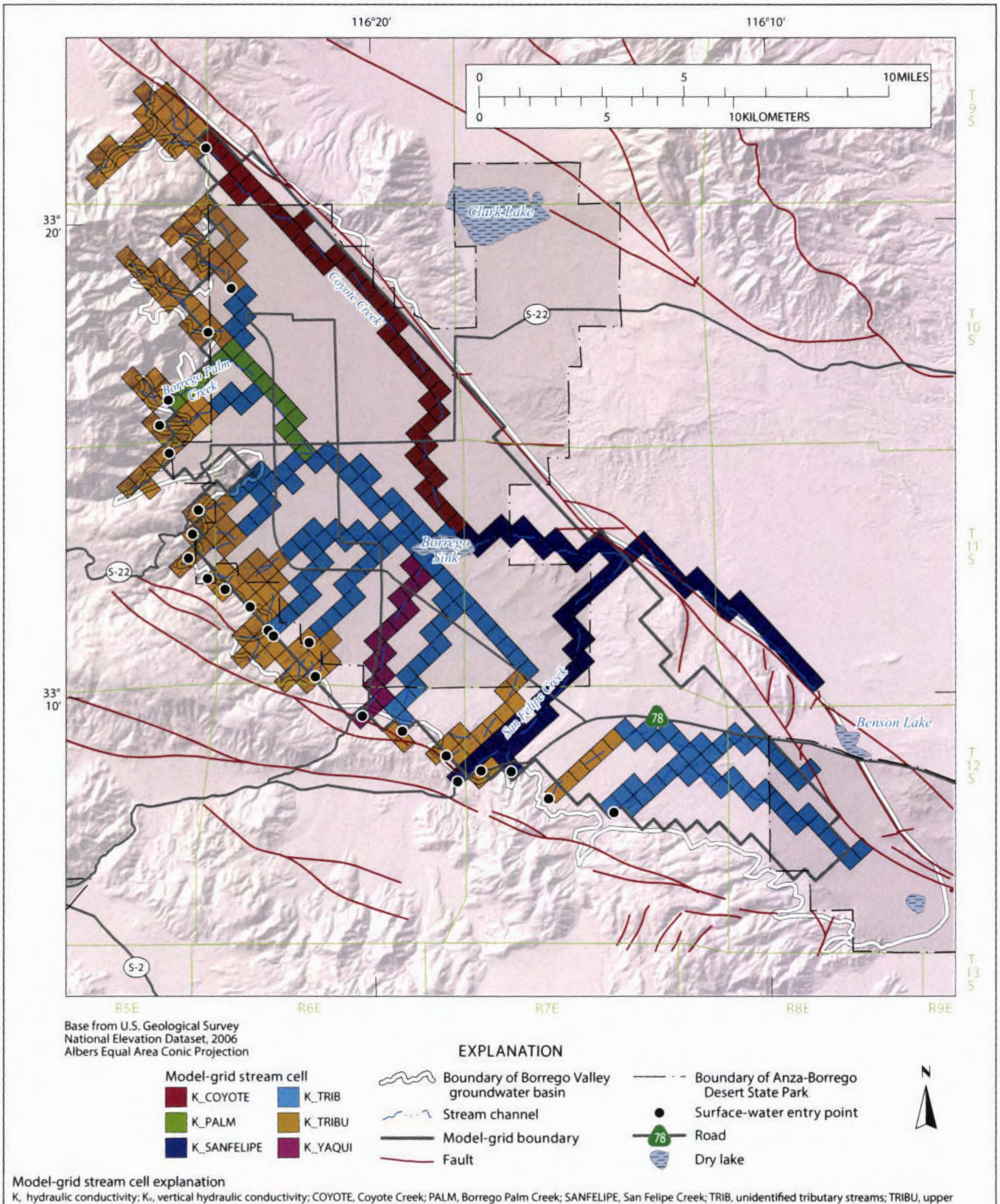
SOURCE: Faunt et al., 2015

FIGURE 3

Textural Map of Specific Yield in Borrego Valley Hydrologic Model

Update to United States Geologic Survey Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK



Model-grid stream cell explanation

K, hydraulic conductivity; K_v, vertical hydraulic conductivity; COYOTE, Coyote Creek; PALM, Borrego Palm Creek; SANFELIPE, San Felipe Creek; TRIB, unidentified tributary streams; TRIBU, upper portions of unidentified tributary streams; YAQUI, Yaqui Creek

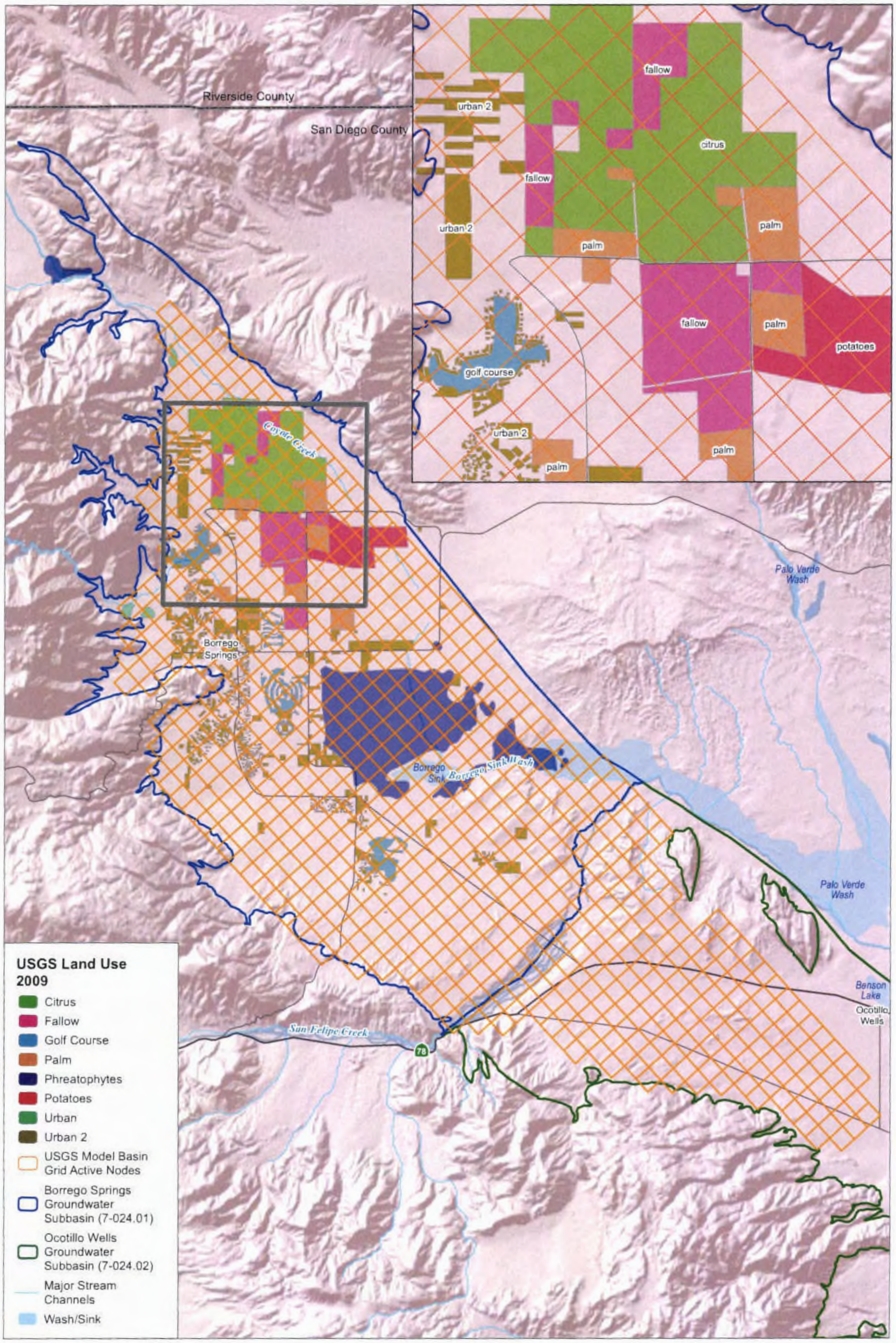
SOURCE: Faunt et al., 2015

FIGURE 4

Simulated Stream Flow in Borrego Valley Hydrologic Model

Update to United States Geological Survey Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK



SOURCE: Faunt et al. 2015

January 2020

DUDEK

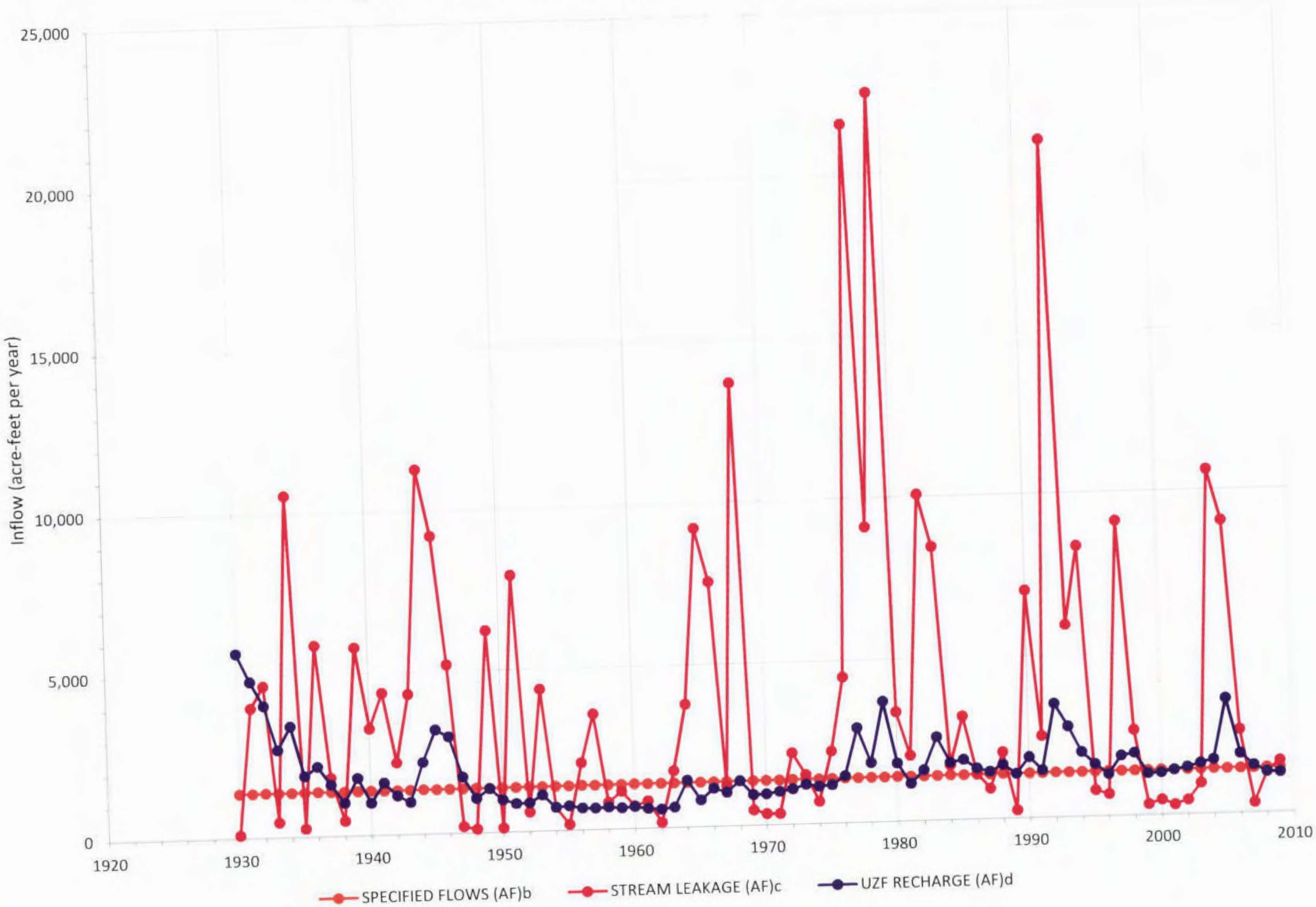
Figure 5

Land-Use Types in the Borrego Valley Hydrologic Model

Update to United States Geologic Survey Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK

Figure 6. Inflows to Borrego Valley Groundwater Basin



INTENTIONALLY LEFT BLANK

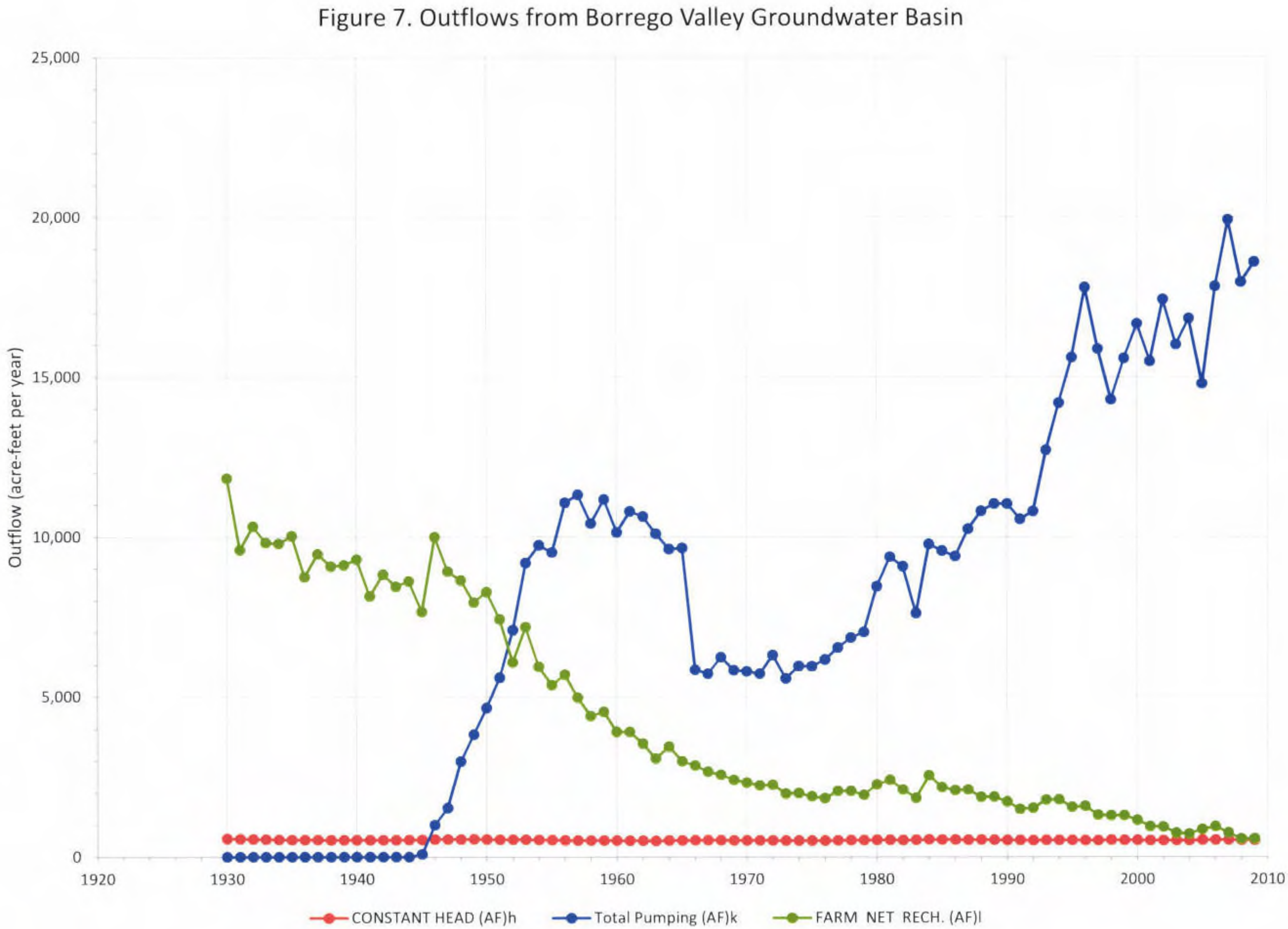
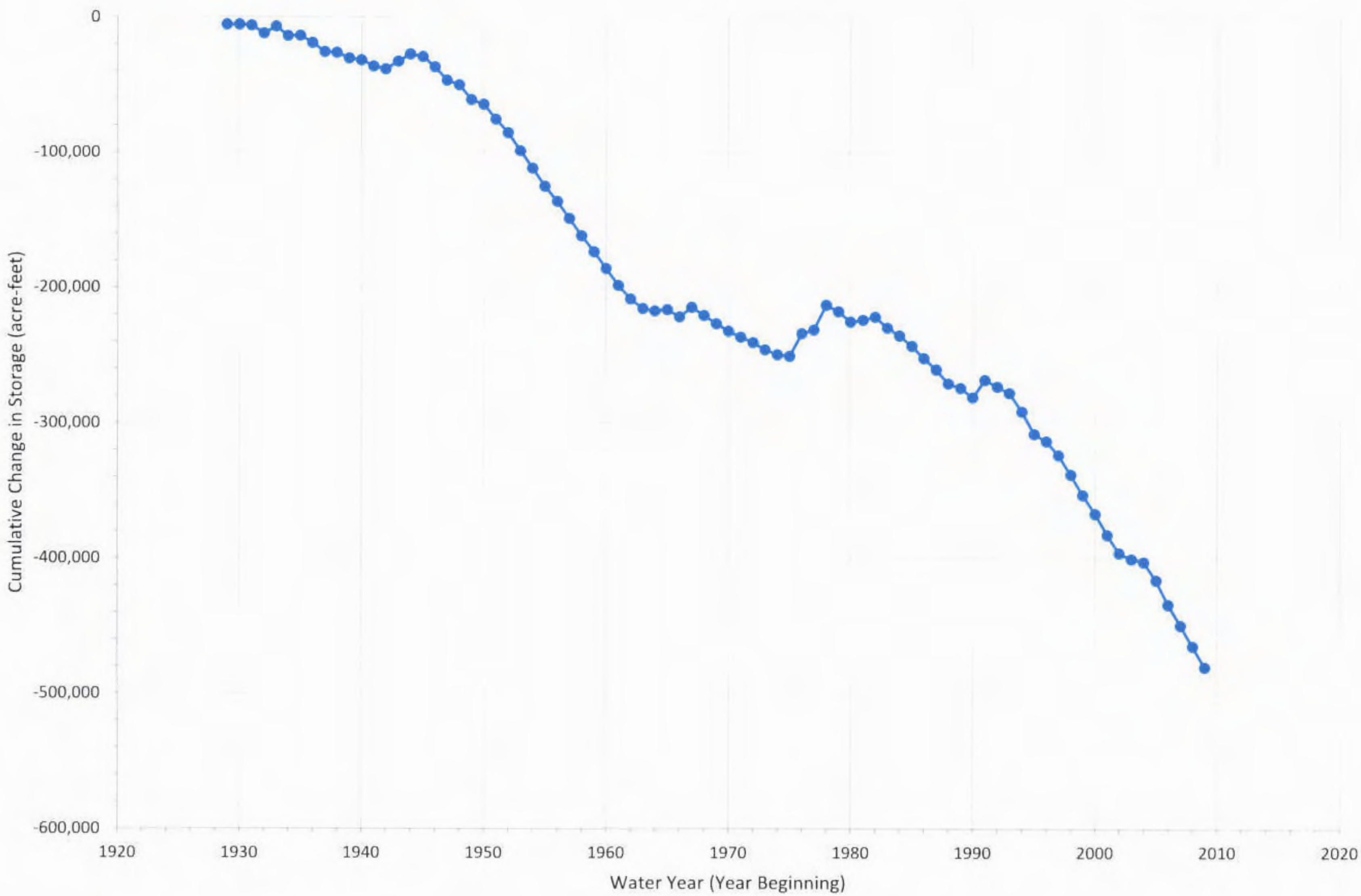


Figure 7. Outflows from Borrego Valley Groundwater Basin
25,000
20,000
15,000
10,000
5,000
0
Outflow (acre-feet per year)
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
CONSTANT HEAD (AF)h
Total Pumping (AF)k
FARM NET RECH. (AF)l

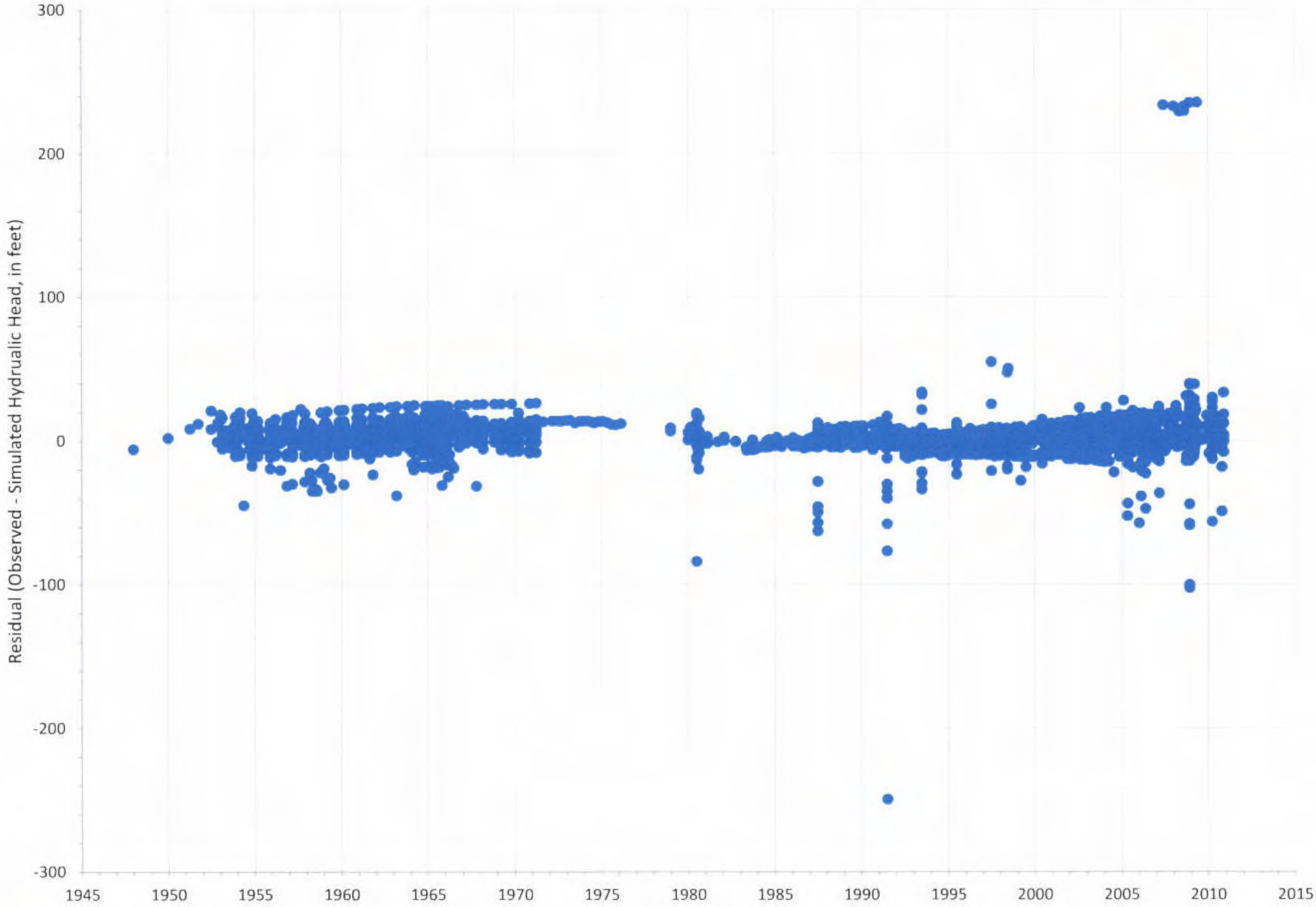
INTENTIONALLY LEFT BLANK

Figure 8. Cumulative Change in Storage in Borrego Valley Groundwater Basin from 1945 to 2010



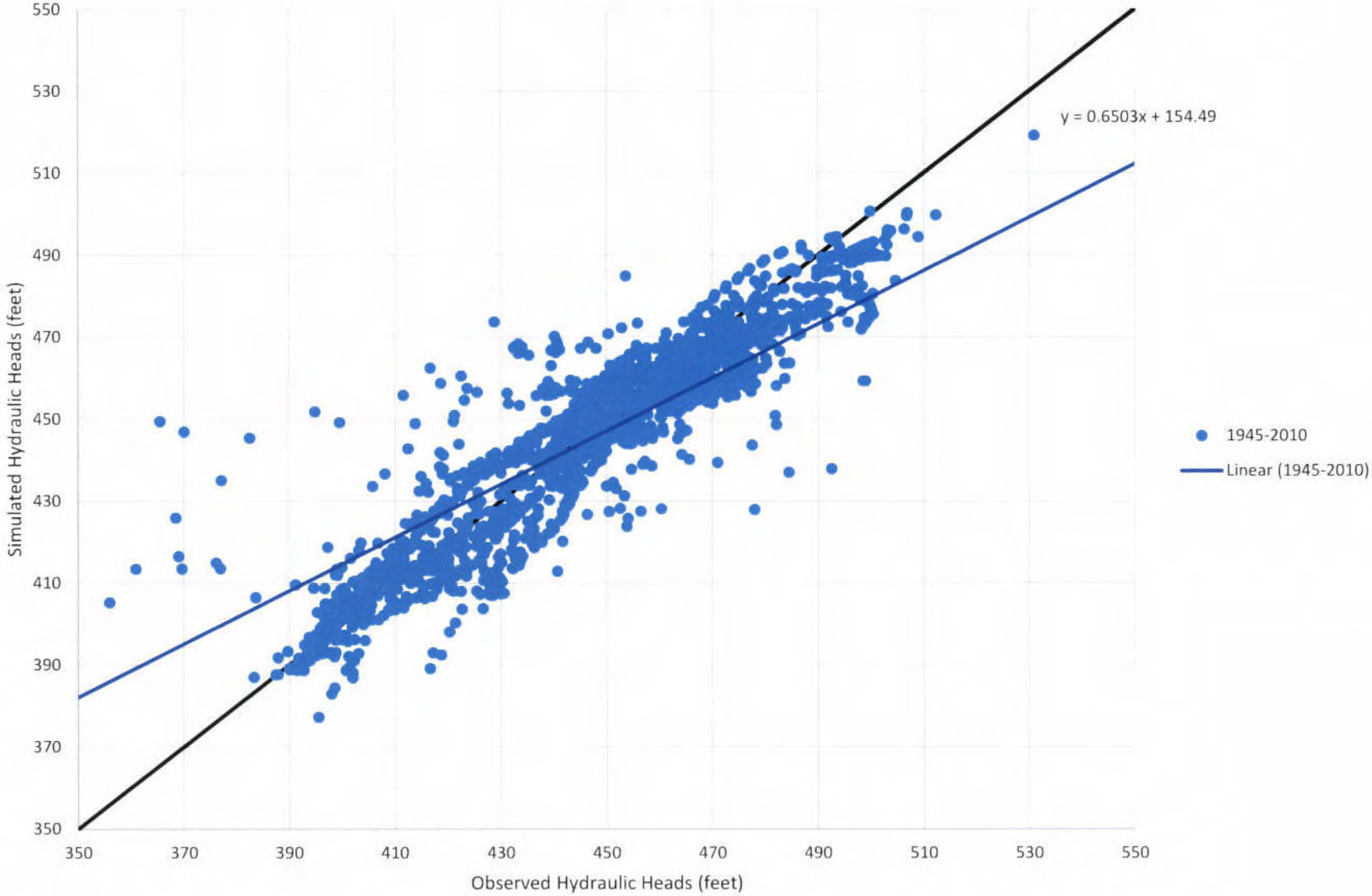
INTENTIONALLY LEFT BLANK

Figure 9. Observed - Simulated Hydraulic Heads (Residuals) from 1945 to 2010



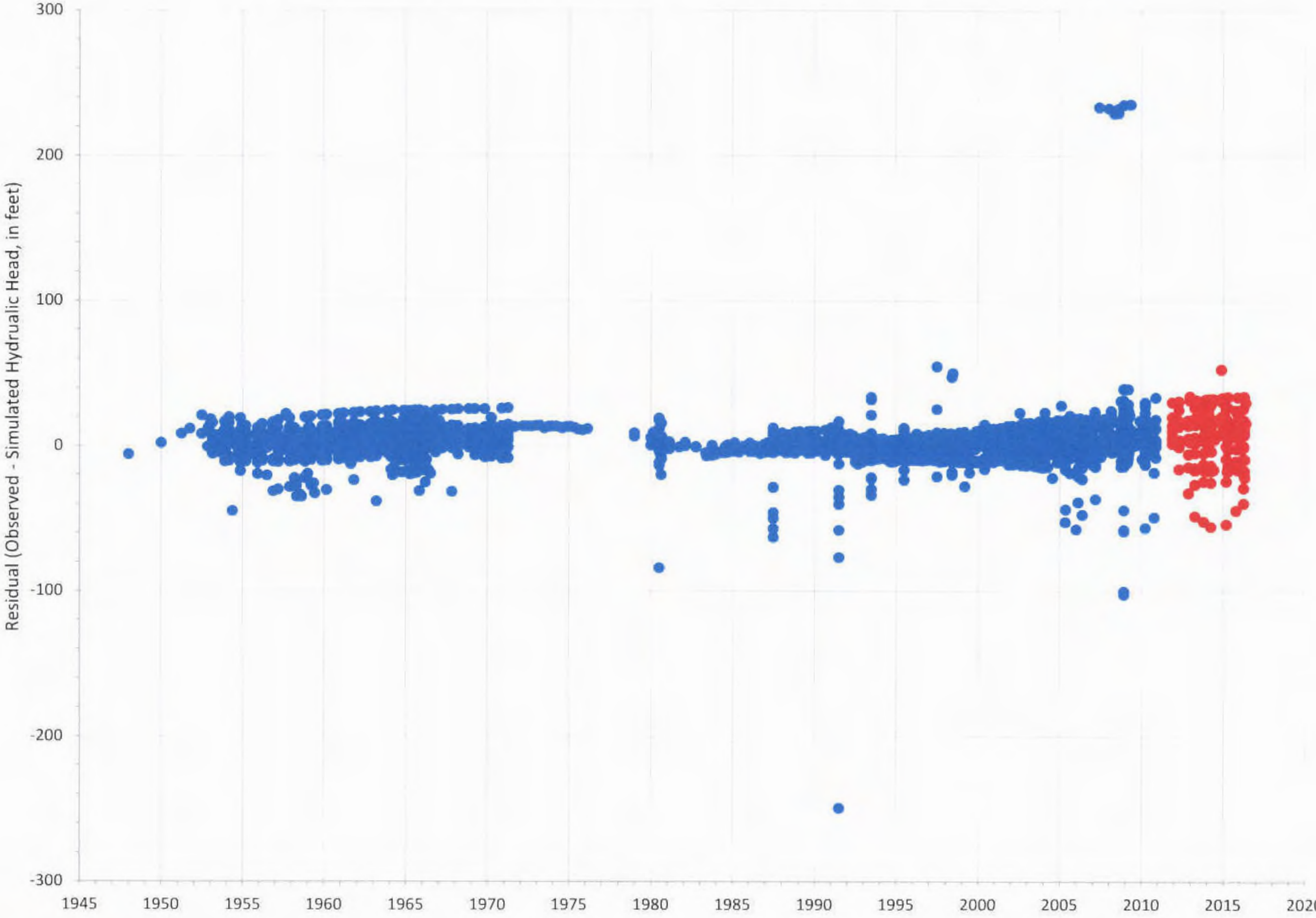
INTENTIONALLY LEFT BLANK

Figure 10. Observed vs. Simulated Hydraulic Heads in the Borrego Valley Groundwater Basin from 1945 to 2010



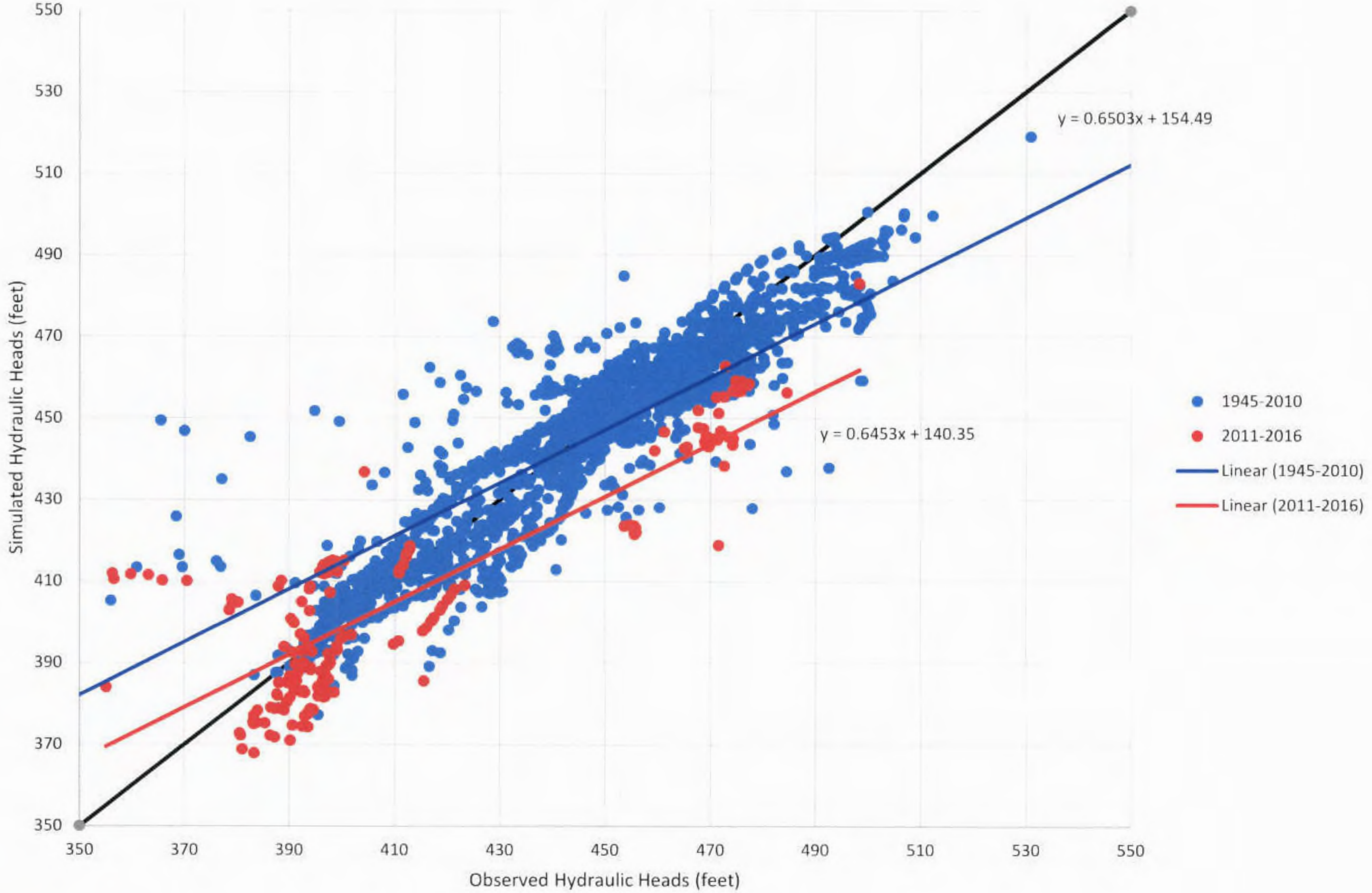
INTENTIONALLY LEFT BLANK

Figure 11. Observed - Simulated Hydraulic Heads (Residuals) from 1945 to 2016



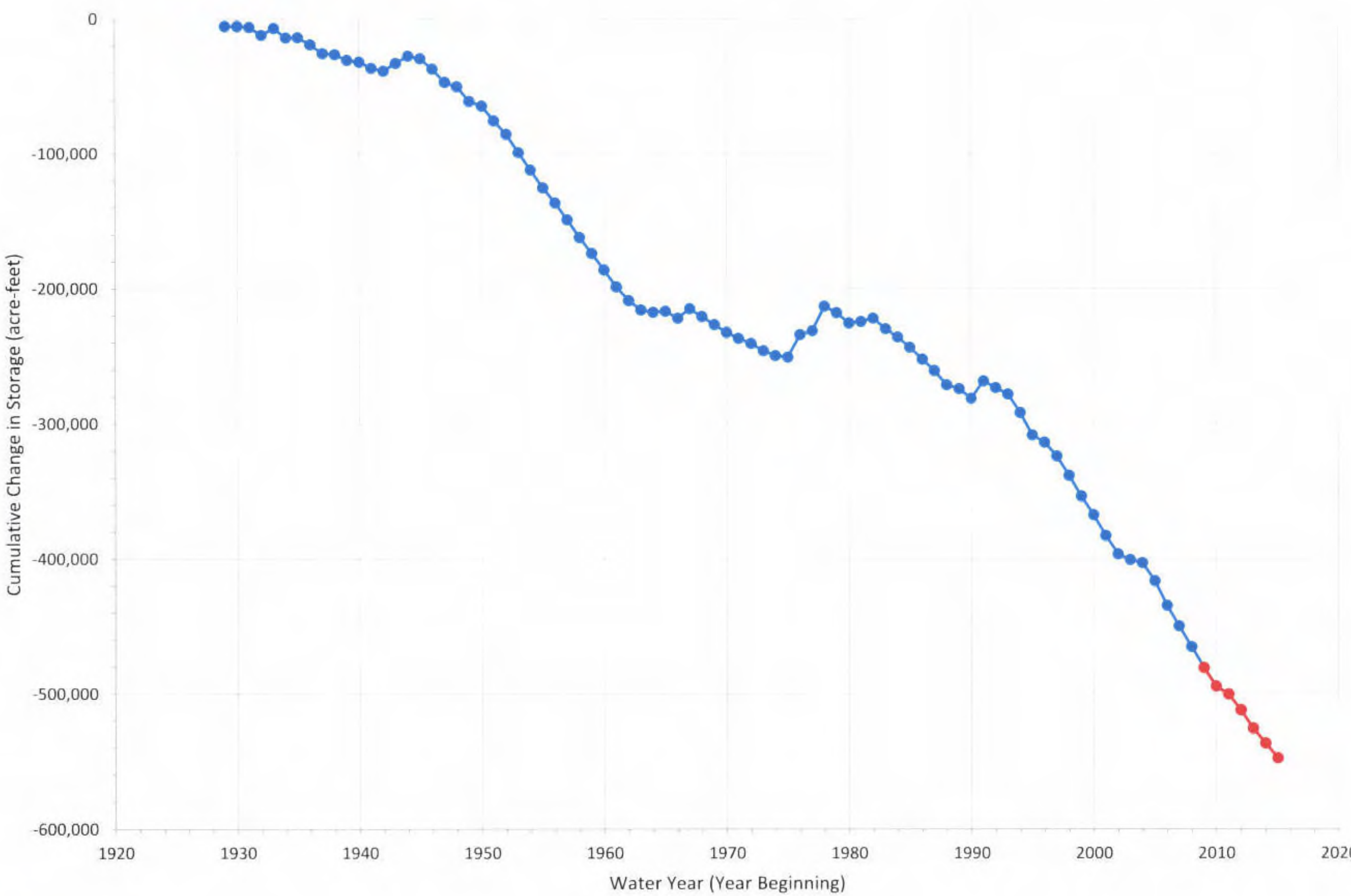
INTENTIONALLY LEFT BLANK

Figure 12. Observed vs. Simulated Hydraulic Heads in the Borrego Valley Groundwater Basin from 1945 to 2016

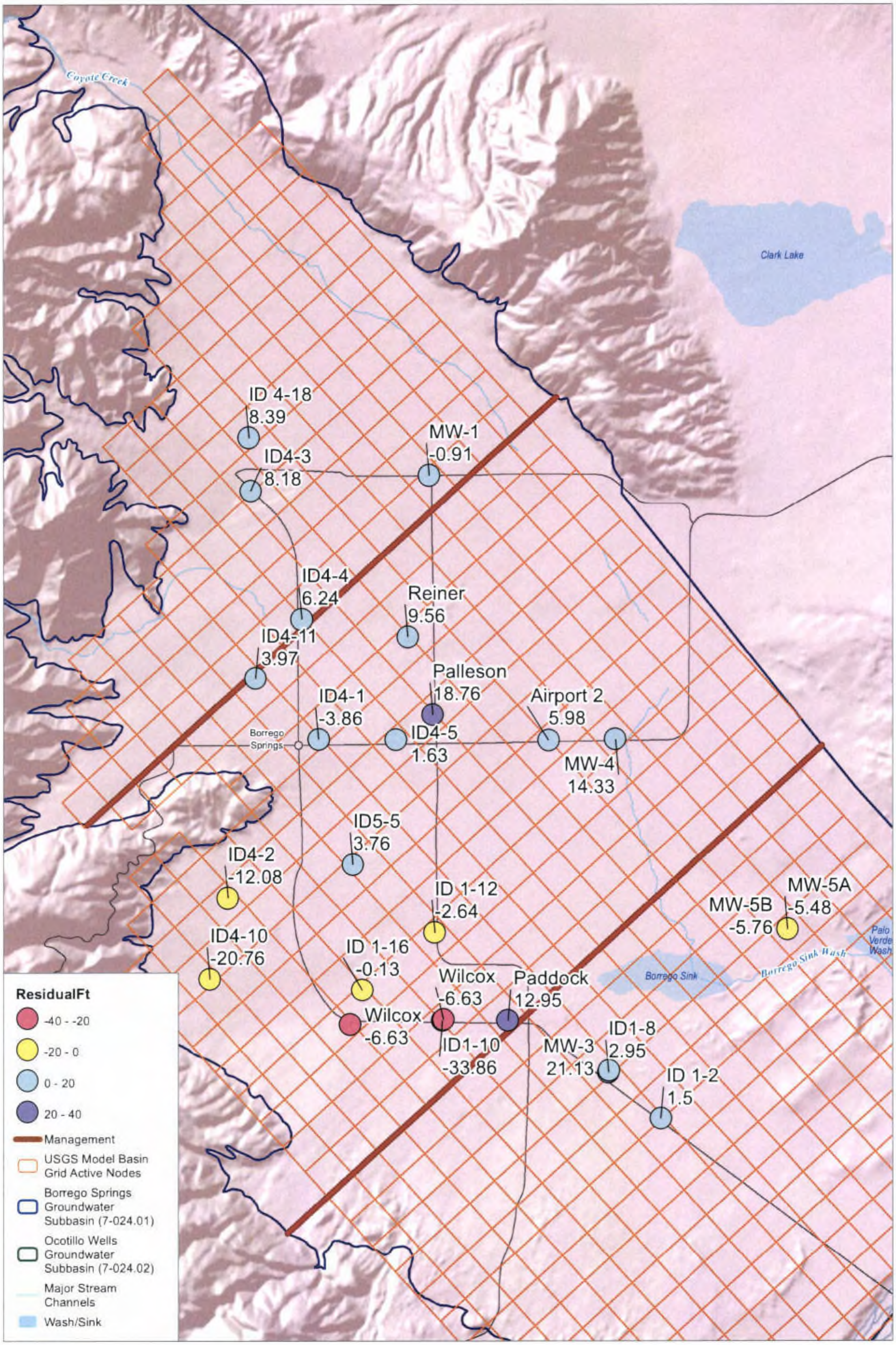


INTENTIONALLY LEFT BLANK

Figure 13. Cumulative Change in Storage in Borrego Valley Groundwater Basin from 1945 to 2016



INTENTIONALLY LEFT BLANK



SOURCE: Faunt et al. 2015

DUDEK January 2020

Figure 14
Spring 2016 Residuals from Key Wells in the BVHM
Update to United States Geologic Survey Borrego Valley Hydrologic Model

INTENTIONALLY LEFT BLANK

ATTACHMENT A

Annual Water Balance from 1929 to 2010 for Borrego Valley Hydrologic Model

Attachment A. Annual Water Balance for Borrego Valley Hydrologic Model

Water Year Beginning	INFLOWS							OUTFLOWS								Δ Storage[n]
	STORAGE (AF)[a]	SPECIFIED FLOWS (AF)[b]	STREAM LEAKAGE (AF)[c]	UZF RECHARGE (AF)[d]	MNW2 (AF)[e]	TOTAL IN (AFY)	Recharge (AF)[f]	STORAGE (AF)[g]	CONSTANT HEAD (AF)[h]	MNW2 (AF)[i]	FARM WELLS (AF)[j]	Total Pumping (AF)[k]	FARM NET RECH (AF)[l]	Total Out (AF)	Discharge (AF)[m]	
1930	11,164 65	1,366 27	97 40	5 702 64	0.00	18 330 95	7,166.30	5,730 49	573 29	0.00	0 00	0 00	11,822.97	18 126 75	12,396 26	-5,434 16
1931	6 564 56	1,366 27	4 006 82	4 815 95	0 00	16,753 60	10 189 04	6 587 16	566 45	0 00	0 00	0 00	9,589.55	16 743 15	10 155 99	22 60
1932	7,727 41	1,370 01	4,671 00	4,069 45	0 00	17,837 87	10,110 46	6,963 86	559 46	0.00	0.00	0 00	10,325 88	17,849 20	10,885 34	-763.55
1933	7,489 29	1,366 27	470 35	2,704 38	0 00	12,030 29	4,541.00	1,745 51	545 31	0 00	0.00	0 00	9,816.30	12,107.12	10,361 61	-5,743 78
1934	8,391 33	1,366 27	10,540 11	3,422 88	0.00	23,720 59	15,329 26	13,392 66	544.34	0 00	0 00	0 00	9,789.97	23,726 97	10,334 31	5,001 33
1935	8,687 88	1,366 27	259 12	1,869 70	0 00	12,182 96	3,495 08	1,670 78	535 83	0 00	0 00	0 00	10,028.54	12,235 15	10,564 36	-7,017 09
1936	7,055 88	1,370 01	5,893 96	2,154 58	0 00	16,474 44	9,418 56	7,207 68	537 00	0 00	0.00	0 00	8,739.95	16,484 63	9,276.95	151 80
1937	8 147 76	1,366 27	1,802.50	1,585.55	0 00	12,902 08	4,754 32	2,938 35	532 92	0 00	0 00	0 00	9,464 21	12,935 47	9,997 13	-5,209 41
1938	8,229 59	1,366 27	466.59	1,019 48	0 00	11,081 93	2,852.33	1,523 34	526 04	0 00	0.00	0 00	9,078.35	11,127 72	9,604.38	-6,706.25
1939	8 007 00	1,366 27	5 807 98	1,777 60	0 00	16,958 85	8 951 85	7,330 01	529 87	0 00	0.00	0 00	9,114 70	16,974 59	9,644 57	-676 99
1940	8,323 85	1,370 01	3,291 39	1,002 93	0.00	13,988.19	5,664 34	4,200 11	526 55	0 00	0 00	0 00	9,292 28	14,018 95	9,818 84	-4,123 74
1941	6,902 92	1,366 27	4,380 06	1,607.52	0.00	14,256 77	7,353 85	5,596 57	527 83	0.00	0 00	0 00	8,142.31	14,266 71	8,670 14	-1,306.35
1942	7,727 33	1,366 27	2,222 73	1,206 88	0 00	12,523 21	4,795 88	3,191 10	529 21	0 00	0 00	0 00	8,821 64	12,541 96	9,350 85	-4,536 23
1943	7,872 03	1,366 27	4,324 76	994 25	0 00	14,557 31	6,685 28	5,613 54	525 80	0 00	0 00	0 00	8,441 68	14,581 03	8,967 49	-2,258 49
1944	8 781 49	1,370 01	11 249 22	2 215 77	0 00	23 616 49	14 835 00	14 475 99	532 46	0 00	0.00	0 00	8 608 10	23 616 55	9 140 56	5,694 50
1945	6 743 86	1,366 27	9 181 62	3 212.55	1.27	20 505 56	13 760 43	12,220.58	532 26	88 63	0 00	88 63	7,658 60	20,500 07	8,279 49	5,476 72
1946	10,236 99	1,366 27	5,201 31	2,988.91	1 71	19,795 20	9,556.49	8,252 91	549 24	996 16	0 00	996 16	9,998 39	19,796 71	11,543 80	-1,984.08
1947	9 334 75	1,366 27	196.05	1,730 47	1 77	12 629 31	3 292 79	1,627 18	550 88	1,534.08	0 00	1,534 08	8 917 02	12 629 16	11,001 99	-7,707 57
1948	10,922 73	1,370 01	112.19	1 059 47	0 93	13,465 33	2,541.68	1,287 80	550 77	2,770 43	215 03	2,985 45	8 642 13	13,466 16	12,178 36	-9,634 93
1949	10,476 17	1,366 27	6,232 29	1,350 82	0 68	19,426 23	8,949 37	7,099 47	555 20	3,589 05	231.55	3,820 60	7,949 71	19,424 98	12,325 50	-3,376 70
1950	12,127 20	1,366 27	126 71	989 46	0 64	14,610 27	2,482.44	1,141 28	546 61	4,425 95	223.31	4,649 26	8,274 42	14,611 58	13,470 29	-10,985 91
1951	11,335 03	1,366 27	7,915 42	871 22	0.50	21,488 43	10,152 90	7,926 75	541 98	5,260.83	336 44	5,597 27	7,421.59	21,487 60	13,560 84	-3,408 27
1952	13,059 68	1,370 01	594 36	876 51	0 80	15,901.37	2,840 89	2,189 66	542 09	6 596 19	493 44	7,089 63	6 079 95	15 901 33	13,711 67	-10 870 02
1953	15,186 40	1,366 27	4,375 11	1,108 86	1 63	22,038 27	6,850 24	5,129 63	538 02	8,173 89	1,012.42	9,186.31	7,183 63	22,037 59	16 907 96	-10,056 76
1954	14,817 73	1,366 27	724 52	718 10	3 68	17,630 29	2,808.89	1,419 82	530 85	8,633 96	1,109 13	9,743 09	5,937.38	17,631 14	16,211 32	-13,397 90
1955	14,477 67	1,366 27	174 09	749 18	4 06	16,771 27	2,289 55	1,359 66	524 91	8,462.30	1,059 26	9,521 56	5,366 80	16,772 94	15,413 28	-13 118 00
1956	15,506 87	1,370 01	2,067 48	669 49	2.76	19,616 61	4,106 98	2,335 93	520 56	9 896 81	1,173 85	11,070 66	5,692 14	19 619 28	17,283 36	13,170 94
1957	14,959 72	1,366 27	3,565 63	656 46	2.78	20,550 86	5,588.36	3,745 89	515 57	9,945 73	1,371.60	11,317 32	4,972.94	20,551 72	16,805 83	-11,213 83
1958	14 065 91	1,366 27	828 34	676.13	2 99	16 939 64	2,870.74	1,605 74	512 90	8,979 94	1,443 77	10 423 71	4,397 77	16 940 12	15 334 38	12,460 18
1959	14,598 36	1,366 27	1,150 74	644 93	2.61	17,762.91	3,161.93	1,550 67	508 96	9,518 32	1,655 41	11,173 73	4,531 07	17,764 42	16 213 75	-13,047 69
1960	13,640 41	1,370 01	695 95	669 55	2.77	16,378 69	2,735.51	1,829 93	509 20	8,642.83	1,501 45	10,144 28	3,903.23	16,386.64	14,556 71	11,810 47
1961	13,760 82	1,366 27	835 39	607 24	2 18	16,571 90	2,808 90	1,378.33	504 82	9,197 43	1,598 39	10 795.83	3,905 18	16 584 16	15,205 82	-12,382 48
1962	13,546 30	1,366 27	162.71	572.10	2.19	15,649.57	2 101 08	970 00	501 92	9,071.85	1,568.97	10 640 82	3,538 32	15,651 06	14,681 06	-12,576 30
1963	12,212 91	1,366 27	1,741 39	622 76	2.04	15,945.36	3,730 41	2,279 58	498 78	8,628 29	1,469 48	10,097 77	3,075 17	15,951 29	13,671 72	-9 933 33
1964	12,227 76	1,370 01	3,785 26	1,438 11	3 15	18,824 29	6,593 38	5,239 41	515 77	8,152 32	1,471 47	9,623 79	3,444 70	18.823 67	13,584 26	-6 988 35
1965	11,695 82	1,366 27	9,204 15	820 80	5 73	23,092 77	11,391 22	9,935 95	510 02	8,163 31	1,494 93	9,658.23	2,988 73	23,092 93	13,156.98	-1,759.87
1966	8,827 72	1,366 27	7,548 36	1,165 22	7 21	18,914 78	10,079 85	9,702 20	516 95	4,400 06	1,441.40	5,841 46	2,852 77	18,913 38	9,211 18	874 48
1967	7,302 93	1,366 27	1,230 53	1,035 33	3 91	10,938 96	3,632.13	2,044 91	516 18	4,244 66	1,474 20	5,718 86	2,659 44	10,939 38	8,894 48	-5,258 02
1968	8,257 79	1,370 01	13,665 71	1,378 84	9 31	24,681 67	16,414 57	15,356 16	515 97	4,860 43	1,380 11	6,240.54	2,566.51	24,679 18	9,323 02	7,098 37
1969	8 646.63	1,366 27	458 96	933 04	5 98	11 410 88	2,758 27	2 671 12	514 10	4 493 98	1 338 48	5 832 46	2 404.05	11 421 73	8,750 62	-5,975 52
1970	6 974 17	1,366 27	337 26	951 13	4 10	9 632.93	2 654 66	1 014 47	512 40	4 193 85	1 602.89	5,796 74	2,318 17	9 641 78	8 627.31	-5,959 70
1971	6,678 45	1,366 27	330 25	1,016 85	3 59	9,395 42	2,713 37	948.17	508 73	4,065 23	1,654 84	5,720 07	2,227.37	9,404 34	8,456 17	-5,730 29
1972	6,932.95	1,370 01	2,192 97	1,076 44	3 21	11,575 57	4,639 41	2,519 07	509 38	4,578.80	1,720 91	6,299 70	2,250 31	11,578.45	9 059.38	-4,413.88
1973	6,091 90	1,366 27	1,511 96	1,211.05	3 28	10,184 47	4,089 29	2,135 59	506 74	3 976 97	1,593 72	5,570 68	1,977 73	10,190 74	8,055 16	-3,956 31
1974	6,402.21	1,366 27	670 80	1,139 95	4 02	9,583 24	3,177 01	1,145 68	504 91	4,317 47	1,641 45	5,958.92	1,987 13	9,596 64	8,450.96	-5,256 54
1975	6,105 25	1,366 27	2,215 20	1,170 82	3 47	10 861 01	4,752 29	2,528.92	503 19	4 358 26	1 598 76	5,957.02	1 888 94	10,878.07	8,349 14	-3,576 33
1976	6 430 62	1,370 01	4 482 20	1 432 99	4.53	13,720 35	7,285 19	5 220 02	505 38	4,678 19	1,488 74	6,166 93	1,828 76	13 721 09	8,501.07	-1,210 61
1977	7,221 49	1,366 27	21,545 32	2,910 56	10 00	33,053 63	25,822.15	23,955 63	514 80	4,975.02	1,558 62	6,533 64	2,056 57	33,060 65	9,105.02	16,734 15
1978	8 608.59	1,366 27	9 100 41	1,822 69	10 69	20,908 65	12 289 36	11 482 01	522 51	5,287 61	1,562.36	6,849 97	2 051.80	20 906.29	9,424 28	2 873 42
1979	9 980 94	1,366 27	22,504 37	3,706 44	12.78	37,570 81	27,577 08	28,103 65	521 61	5,569 13	1,456 47	7,025 60	1,931.97	37,582 82	9,479 17	18,122 71
1980	11,578 46	1,370 01	3,372 44	1,784 84	10 35	18,116 10	6,527 29	6,864 35	528.64	6,728 95	1,720.93	8,449.88	2,260 29	18,103 16	11,238.81	-4 714 11
1981	10,116 67	1,366 27	2,010 57	1,147 53	5 82	14,646 86	4,524 37	2,367 07	524 58	7,415.02	1,956 47	9,371 49	2,402 89	14,666 03	12,298.96	-7,749 60
1982	8 678.39	1,366 27	10,070 52	1,555 96	6 25	21,677.39	12,992.75	9 994 00	521 12	7,238 96	1,834.55	9,073 51	2,095 53	21,684 16	11,690 16	1,315 61
1983	8,301.78	1,366 27	8,442 66	2,562 94	20 54	20 694 18	12,371 87	10,715 07	529 12	6 183 12	1,427 62	7,610 74	1 838 47	20 693 41	9 978 34	2,413 29
1984	10,566.72	1,370 01	1,678 92	1,755 96	19 09	15,390 69	4 804 88	2,547 39	538 13	7,815 70	1,954 79	9,770 48	2,540 05	15 396 06	12 848.67	-8,019 32
1985	9,629 04	1,366 27	3,182 71	1,841 77	18.69	16,038 47	6,390 74	3,761 00	533 87	7,722 91	1,849 74	9,572 65	2,172 11	16,039 63	12,278 63	-5 868 03
1986	9 910.09	1,366 27	1,402 37	1,559 51	20 46	14,258 70	4 328 15	2,251 65	533 98	7 588 52	1 810 21	9,398 73	2 074 40	14 258.76	12,007 11	-7,658 44

Attachment A. Annual Water Balance for Borrego Valley Hydrologic Model

Water Year Beginning	INFLOWS							OUTFLOWS									Δ Storage[n]
	STORAGE (AF)[a]	SPECIFIED FLOWS (AF)[b]	STREAM LEAKAGE (AF)[c]	UZF RECHARGE (AF)[d]	MNW2 (AF)[e]	TOTAL IN (AFY)	Recharge (AF)[f]	STORAGE (AF)[g]	CONSTANT HEAD (AF)[h]	MNW2 (AF)[i]	FARM WELLS (AF)[j]	Total Pumping (AF)[k]	FARM NET RECH (AF)[l]	Total Out (AF)	Discharge (AF)[m]		
1987	10,375.36	1,366 27	926 43	1,454 34	19 45	14,141 85	3,747 04	1,266 15	530.20	8 282.97	1,966 51	10,249 48	2,096 30	14,142 13	12,875 97		-9,109 21
1988	10 934 85	1,370 01	2,038 69	1,654 10	22 53	16 020 18	5 062.80	2,820.28	531 26	8,983 53	1,822 15	10,805 67	1,863 77	16,020 97	13,200 70		-8,114 57
1989	11,506 53	1,366 27	233 41	1 364 98	23 74	14,494 92	2,964 65	1 064 87	524.27	9 030.12	2,005 64	11,035 76	1,872.89	14,497 78	13,432 91		10,441 66
1990	10,826 51	1,366 27	7,016 01	1,868 39	24 50	21,101 68	10,250 67	7,827 69	521 45	9 069 61	1,965 15	11,034 76	1,721 44	21,105.34	13 277 65		-2,998.81
1991	10 636 74	1,366 27	2,515.30	1,453 41	19.05	15,990 77	5,334 98	3,434 20	518 06	8,772.85	1,776 15	10,549 00	1,489 41	15,990 68	12,556 48		-7,202 54
1992	11,707.80	1,370 01	20,913 16	3,494 77	36.82	37,522 57	25,777.94	24,694 41	513 90	9 018.37	1,778.19	10 796 56	1,520 21	37,525 08	12,830 67		12 986 60
1993	14,569 90	1,366 27	5,915 43	2,785 29	44 27	24,681 15	10,066 99	9 666 34	521.54	10,959 33	1,755 96	12,715 29	1,777 29	24 680 47	15,014 12		-4 903 56
1994	12 610 91	1,366 27	8 347 66	1,978 52	29 77	24,333 13	11,692 44	7,845 73	517 77	12,333 54	1,847 84	14,181 38	1,788 13	24,333 00	16,487 28		-4,765 18
1995	15 805 11	1,366 27	787 19	1,592 92	31 50	19,582 99	3,746 37	1,903 71	516 31	13,780 52	1,828.68	15 609 20	1 553 51	19 582 72	17 679 01		-13 901 40
1996	17,536 31	1,370 01	656 24	1,277 18	30 93	20,870 67	3,303 42	973 73	515 34	15,772.36	2 022.79	17,795 15	1 581 69	20 865.91	19 892 18		-16 562 58
1997	14,585 62	1,366 27	9 087 98	1 834 52	28 05	26 902 44	12,288 78	9,214 69	511.86	14,041 17	1,826.88	15,868 05	1,307 77	26,902.36	17,687 67		-5,370 93
1998	14,384 23	1,366 27	2 625 43	1,909 47	36 17	20,321 56	5,901 16	4,221.20	523 49	12,565 50	1,718.59	14,284 08	1,292 65	20 321 42	16,100.23		-10,163 03
1999	15,335 63	1,366 27	317 60	1,268 15	27 95	18,315 60	2,952 01	935.58	520.86	13,650 77	1,926 98	15,577 76	1,291 44	18,325 64	17,390 05		-14 400 05
2000	16 190 26	1,370 01	450 22	1,280 74	34 00	19,325 23	3,100 97	1,014 02	519 23	14,507 72	2,155 29	16,663 01	1,146 80	19,343.05	18,329 04		-15,176 24
2001	15,569 67	1 366 27	283 49	1 362 17	29 63	18,611 23	3 011 93	1 659 64	515 78	13 413 67	2 067 40	15 481 07	950 13	18 606 61	16 946 98		-13,910 03
2002	16,905 68	1,366 27	428 29	1,434 40	33 98	20,168 62	3,228 96	1,292.43	512.82	15,108 61	2,320 53	17,429 14	934 45	20,168.84	18,876 41		15,613 25
2003	15,642 91	1,366 27	931 91	1,551 15	33 38	19,525 63	3,849 33	2 265.52	510 42	13 675 08	2,331 81	16,006 89	744 89	19,527 72	17,262 20		-13,377 39
2004	15,308 80	1,370 01	10,614 50	1,655 06	35 78	28,984 15	13,639.57	10 928 22	509 89	14 373 88	2 454 67	16,828 55	719 22	28,985 88	18,057 66		-4,380 58
2005	15,596 97	1,366 27	9 034 46	3,529.99	45 84	29,573 53	13,930 71	13,394 40	527 26	12,873 56	1,916.17	14,789 73	862.87	29,574 25	16,179 86		-2,202 58
2006	16,951 16	1,366 27	2,563 05	1,820 33	34 10	22,734 91	5,749 64	3 423 90	529 56	15 473 65	2,359 42	17 833 08	946 16	22,732 70	19,308.81		-13,527 26
2007	19,091 07	1,366 27	291 71	1,448 80	31 62	22,229 47	3,106 78	1 040 39	524 86	17,389 64	2,521.67	19 911 31	752.59	22,229 15	21,188 76		-18 050 68
2008	17,754 85	1,370 01	1,228.89	1,239.57	35 87	21,629 19	3,838 48	2,579 28	522 74	15,650 88	2,316.60	17,967 48	562.38	21,631.88	19,052.60		-15,175 57
2009	18,160 59	1,366 27	1,572 16	1,215 03	37 57	22,351 62	4,153 46	2,665 27	522 44	16 220 74	2 370.20	18 590 94	571 12	22 349 77	19 684 50		-15,495 32
2010	17,393 45	1,366 27	234 31	1,378 10	35 75	20,407 88	2,978 68	1,868 07	520 48	15,179 83	2 377 39	17,557 21	487 48	20 433 23	18,565 17		-15,525 38

MIN (1930 - 2010)	6 092	1,366	97	572	0	9,395	2,101	936	499	0	0	0	487	9 404	8,055	-18 051
MAX (1930 - 2010)	19,091	1,370	22,504	5,703	46	37,571	27,577	28,104	573	17,390	2,522	19 911	11,823	37,583	21,189	18,123
AVG (1930 - 2010)	11,292	1,367	4 016	1 657	12	18,344	7,040	5,358	525	6,982	1,271	8,253	4,212	18,348	12,990	5 814
STDEV (1930 - 2010)	3,556	2	4 853	973	14	5,681	5,363	5 487	15	5 053	824	5,780	3,798	5,676	3,577	7,138

MIN (1945 - 2010)	6,092	1 366	112	572	1	9 395	2,101	936	499	89	0	89	487	9,404	8,055	-18,051
MAX (1945 - 2010)	19,091	1,370	22,504	3,706	46	37,571	27,577	28,104	555	17,390	2,522	19,911	9 998	37 583	21,189	18 123
AVG (1945 - 2010)	12,024	1,367	4,028	1,486	15	18,919	6,881	5,240	522	8,569	1,560	10,128	3 032	18 922	13,682	-6,783
STDEV (1945 - 2010)	3,518	2	5,142	737	14	5,884	5 673	5 811	13	4 198	614	4 672	2,361	5,883	3,597	7,489

NOTES:

[a] Water into the aquifer system from storage (water is removed from storage)

[b] Inflow from adjacent basins

[c] Leakage from streams directly to groundwater (Stream Recharge)

[d] Flow from the unsaturated zone into groundwater. Includes precipitation recharge, leakage from some streams within the model domain, and irrigation return flows (Distributed Recharge)

[e] Flow within the borehole for wells screened across multiple aquifer layers

[f] Sum of major inflows: Specified flows, Stream Leakage and Unsaturated Zone Flows

[g] Water out of the aquifer system into storage (water is added to storage)

[h] Flow out of the southern end of the basin

[i] Pumping from wells in the model with specific construction information, includes all municipal wells and most recreation and agricultural wells

[j] Pumping calculated by the Farm Process Package (FMP) in Modflow for wells with no construction information. Primarily agricultural and recreational pumping

[k] The Sum of MNW2 (Column K) pumping and Farm Wells (Column L) pumping

[l] Consumptive use of water calculated by the Farm Process Package for all land use type. Primarily represents evapotranspiration.

[m] Sum of major outflows: Constant Head, Pumping, and farm net recharge

[n] Change in storage calculated by subtracting Storage In (Column B) from Storage Out (Column I)

ATTACHMENT B

Annual Water Balance from 1929 to 2016 for Borrego Valley Hydrologic Model

Attachment B. Annual Water Budget from 1929 to 2016 for Borrego Valley Hydrologic Model

Water Year Beginning	INFLOWS							OUTFLOWS								Δ Storage[n]
	STORAGE (AF)[a]	SPECIFIED FLOWS (AF)[b]	STREAM LEAKAGE (AF)[c]	UZF RECHARGE (AF)[d]	MNW2 (AF)[e]	TOTAL IN (AFY)	Recharge (AF)[f]	STORAGE (AF)[g]	CONSTANT HEAD (AF)[h]	MNW2 (AF)[i]	FARM WELLS (AF)[j]	Total Pumping (AF)[k]	FARM NET RECH (AF)[l]	Total Out (AF)	Discharge (AF)[m]	
1930	11,164 65	1,366 27	97 40	5,702 64	0 00	18 330 95	7,166 30	5,730 49	573 29	0 00	0 00	0 00	11,822 97	18,126 75	12 396 26	-5,434 16
1931	6,564 56	1,366 27	4,006 82	4 815 95	0 00	16,753 60	10,189 04	6,587 16	566 45	0.00	0.00	0.00	9,589.55	16,743 15	10,155 99	22.60
1932	7,727 41	1,370 01	4 671 00	4,069 45	0 00	17,837.87	10,110 46	6,963.86	559 46	0 00	0 00	0 00	10 325 88	17,849 20	10,885 34	-763 55
1933	7,489 79	1,366 27	470 35	2,704 38	0 00	12 030 29	4,541 00	1,745.51	545 31	0.00	0.00	0.00	9,816.30	12,107 12	10,361 61	-5,743 78
1934	8,391.33	1,366 27	10,540 11	3,422 88	0 00	23 720 59	15,329 26	13 392 66	544 34	0.00	0.00	0 00	9,789 97	23,726 97	10,334.31	5,001 33
1935	8,687 88	1,366 27	259 12	1,869 70	0 00	12,182 96	3 495 08	1 670 78	535 83	0.00	0.00	0.00	10,028 54	12,235 15	10,564.36	-7,017 09
1936	7,055 88	1,370 01	5,893 96	2,154 58	0 00	16,474 44	9,418.56	7,207 68	537 00	0.00	0.00	0 00	8 739 95	16 484 63	9 276 95	151 80
1937	8 147 76	1,366 27	1 802 50	1 585 55	0 00	12,902.08	4 754 32	2 938 35	532 92	0.00	0.00	0.00	9 464.21	12 935 47	9 997 13	-5,209 41
1938	8,229 59	1,366 27	466 59	1,019 48	0 00	11,081 93	2,852.33	1,523.34	526 04	0 00	0.00	0 00	9 078.35	11,127 72	9 604 38	-6,706.25
1939	8,007 00	1 366 27	5,807 98	1,777 60	0 00	16,958.85	8 951 85	7,330.01	529 87	0.00	0.00	0.00	9,114 70	16,974 59	9 644 57	-676 99
1940	8,323 85	1,370 01	3 291 39	1,002 93	0 00	13,988 19	5,664 34	4,200 11	526 55	0.00	0 00	0 00	9 292.28	14 018 95	9 818 84	-4 123 74
1941	6 902 92	1 366.27	4 380 06	1 607 52	0 00	14 256 77	7 353 85	5 596 57	527 83	0 00	0 00	0 00	8,142.31	14 766 71	8,670 14	-1 306 35
1942	7,727 33	1,366 27	2,222.73	1,206.88	0 00	12,523 21	4,795 88	3,191 10	529 21	0.00	0.00	0 00	8 821.64	12,541.96	9 350 85	-4,536.23
1943	7 872.03	1,366.27	4 324 76	994 25	0 00	14 557 31	6 685 28	5 613 54	525 80	0 00	0.00	0.00	8 441 68	14 581.03	8 967 49	-2,258 49
1944	8,781.49	1,370 01	11,249 22	2,215 77	0 00	23,616 49	14,835 00	14,475 99	532 46	0.00	0.00	0.00	8,608 10	23,616.55	9,140 56	5,694 50
1945	6,743 86	1,366.27	9,181 62	3 212 55	1 27	20 505 56	13,760 43	12,220.58	532 26	88 63	0 00	88 63	7,658 60	20,500.07	8 279 49	5,476.72
1946	10,236 99	1,366 27	5,201.31	2,988 91	1 71	19,795 20	9,556 49	8,252 91	549 24	996 16	0.00	996 16	9,998.39	19,796 71	11,543.80	-1,984 08
1947	9 334 75	1,366 27	196 05	1,730 47	1 77	12 629 31	3 292 79	1 627 18	550.88	1,534 08	0 00	1,534 08	8 917 02	12,629 16	11 001 99	-7,707 57
1948	10,922 73	1,370 01	112 19	1,059 47	0 93	13,465.33	2,541 68	1,287.80	550 77	2,770 43	215 03	2,985 45	8,642 13	13,466 16	12,178.36	-9,634 93
1949	10 476 17	1,366.27	6,232 29	1 350 82	0 68	19 426 23	8 949 37	7,099.47	555 20	3,589 05	231 55	3,820 60	7,949 71	19,424.98	12,325 50	-3,376 70
1950	12,127 20	1,366.27	126 71	989 46	0 64	14,610 27	2,482 44	1,141.28	546.61	4,425 95	223 31	4,649 26	8,274 42	14,611.58	13,470 29	10,985 91
1951	11,335 03	1,366 27	7 915 42	871.22	0 50	21 488 43	10 152.90	7 926 75	541 98	5,260 83	336 44	5 597 27	7,421.59	21,487 60	13,560.84	-3 408 27
1952	13 059 68	1 370 01	594 36	876 51	0 80	15 901 37	2 840 89	2,189 66	542 09	6 596 19	493 44	7 089 63	6,079 95	15,901.31	13,711 67	10,870 02
1953	15,186 40	1,366 27	4,375 11	1,108.86	1 63	22,038 27	6,850.24	5,129 63	538 02	8,173 89	1,012 42	9,186.31	7,183 63	22,037.59	16,907 96	10,056 76
1954	14 817 73	1 366 27	724 52	718 10	3 68	17,630 29	2 808 89	1 419.82	530 85	8 633 96	1,109 13	9 743 09	5,937.38	17 631 14	16,211.32	-13 397 90
1955	14,477 67	1,366 27	174 09	749 18	4 06	16,771 27	2,289 55	1,359 66	524 91	8,462 30	1 059 26	9,521 56	5 366.80	16,772 94	15,413 28	-13 118 00
1956	15 506 87	1,370 01	2 067 48	669 49	2 76	19 616 61	4,106 98	2,335 93	520 56	9,896.81	1,173 85	11 070 66	5 692 14	19 619 28	17,283 36	-13 170 94
1957	14 959 72	1,366 27	3 565 63	656 46	2 78	20,550 86	5,588.36	3,745 89	515 57	9,945 73	1,371 60	11,317.32	4 972 94	20 551 72	16,805 83	-11,213 83
1958	14 065 91	1,366.27	828 34	676 13	2 99	16 939 64	2 870 74	1,605 74	512 90	8 979 94	1,443 77	10 423 71	4 397 77	16 940 12	15 334.38	-12 460 18
1959	14,598 36	1,366.27	1,150 74	644 93	2 61	17,762 91	3,161.93	1,550 67	508.96	9,518.32	1,655 41	11,173 73	4,531.07	17,764 42	16,213 75	13,047 69
1960	13 640.41	1,370.01	695 95	669 55	2 77	16,378 69	2,735.51	1,829 93	509 20	8,642 83	1,501 45	10,144 28	3 903 23	16 386 64	14,556 71	11,810 47
1961	13,760.82	1,366.27	835 39	607 24	2 18	16,571 90	2,808 90	1,378.33	504 82	9,197 43	1,598.39	10,795 83	3,905 18	16,584 16	15,205.82	-12,382 48
1962	13,546.30	1,366.27	162 71	572 10	2 19	15 649 57	2,101 08	970 00	501 92	9,071 85	1 568 97	10,640 82	3 538 32	15 651 06	14 681.06	-12 576 30
1963	12,212 91	1,366.27	1,741.39	622 76	2 04	15,945 36	3,730 41	2,279 58	498.78	8,628.29	1,469 48	10,097 77	3,075 17	15,951 29	13,671 72	-9,933 33
1964	12,227 76	1,370 01	3,785.26	1,438 11	3 15	18 824 29	6,593 38	5,239 41	515 77	8,152.32	1,471 47	9 623 79	3,444 70	18 823 67	13,584 26	-6 988 35
1965	11,695 82	1,366.27	9,204 15	820 80	5 73	23 092 77	11,391.22	9 935 95	510 02	8,163 31	1,494 93	9,658.23	2,988 73	23 092 93	13,156 98	1,759 87
1966	8 827 72	1,366 27	7,548.36	1,165 22	7 21	18 914 78	10 079.85	9 702 20	516 95	4 400 06	1,441 40	5 841 46	2,852 77	18 913 38	9,211.18	874 48
1967	7,302.93	1,366.27	1,230.53	1,035 33	3 91	10 938.96	3 632 13	2,044 91	516 18	4,244 66	1,474 20	5,718.86	2,659 44	10,939.38	8,894.48	-5,258 02
1968	8 257 79	1,370 01	13 665 71	1,378 84	9 31	24 681 67	16 414.57	15 356 16	515 97	4,860 43	1,380 11	6,240 54	2,566 51	24 679 18	9,323 02	7 098 37
1969	8,646 63	1,366.27	458.96	933 04	5 98	11,410 88	2,758 27	2,671 12	514 10	4,493 98	1,338 48	5,832.46	2,404.05	11,421 73	8,750 62	-5,975 52
1970	6 974 17	1,366 27	337 26	951 13	4 10	9 632 93	2,654 66	1,014 47	512 40	4 193 85	1 602.89	5,796 74	2,318 17	9 641 78	8 627 31	5 959 70
1971	6 678 45	1,366.27	330.25	1,016 85	3 59	9 395 42	2,713 37	948 17	508.73	4,065.23	1,654 84	5,720.07	2,227 37	9,404 34	8,456.17	5,730 29
1972	6,932 95	1,370 01	2,192 97	1,076 44	3 21	11,575 57	4,639 41	2,519 07	509 38	4 578.80	1,720.91	6,299 70	2,250 31	11,578 45	9,059 38	-4 413 88
1973	6,091 90	1,366 27	1 511 96	1 211 05	3 28	10 184 47	4 089 29	2 135 59	506.74	3 976 97	1 593 72	5 570 68	1 977 73	10 190 74	8,055.16	3 956 31
1974	6,402 21	1,366.27	670.80	1,139 95	4 02	9 583 24	3,177.01	1,145 68	504 91	4 317 47	1,641 45	5,958 92	1,987 13	9 596 64	8 450.96	5,256 54
1975	6 105 25	1,366.27	2 215.20	1,170 82	3 47	10 861 01	4 752 29	2,528 92	503 19	4 358.26	1,598 76	5 957 02	1,888 94	10 878 07	8,349 14	-3 576 33
1976	6 430 62	1,370 01	4,482.20	1,432 99	4 53	13,720 35	7,285 19	5,220 02	505 38	4 678.19	1,488 74	6,166 93	1,828 76	13,721 09	8,501.07	-1,210 61
1977	7,221 49	1,366 27	21,545 32	2 910 56	10 00	33 053 63	25 822 15	23 955 63	514 80	4 975 02	1,558 62	6 533 64	7,056 57	33 060 65	9,105.02	16 734 15
1978	8 608.59	1,366.27	9,100 41	1,822 69	10 69	20,908.65	12,289.36	11,482.01	522 51	5,287 61	1,562.36	6,849 97	2,051 80	20,906.29	9 424.28	2,873.42
1979	9 980 94	1 366 27	22 504 37	3 706 44	12 78	37 570 81	27,577.08	28 103 65	521 61	5 569 13	1 456 47	7,025 60	1,931 97	37,582 82	9 479 17	18 122 71
1980	11,578.46	1,370 01	3,372 44	1,784 84	10 35	18,116.10	6,527 29	6,864 35	528 64	6,728 95	1,720 93	8,449 88	2,260 29	18,103 16	11,238 81	-4,714 11
1981	10 116 67	1 366 27	2 010.57	1 147 53	5 82	14 646 86	4 524 37	2 367 07	524 58	7 415 02	1 956 47	9 371 49	2,402.89	14 666 03	12,298.96	7,749 60
1982	8,678.39	1,366 27	10,070 52	1,555 96	6 25	21,677 39	12,992 75	9 994 00	521 12	7,238 96	1,834 55	9,073.51	2,095 53	21,684 16	11,690.16	1,315 61
1983	8,301 78	1,366 27	8,442 66	2,562 94	20.54	20 694 18	12,371.87	10 715.07	529 12	6 183 12	1,427 62	7,610 74	1,838 47	20,693 41	9 978 34	2,413 29
1984	10,566.72	1,370 01	1,678 92	1,755 96	19 09	15,390 69	4,804 88	2,547 39	538 13	7,815 70	1,954 79	9,770 48	2,540 05	15,396 06	12,848 67	-8,019 32
1985	9 629 04	1 366 27	3 182 71	1 841 77	18 69	16 038 47	6,390 74	3,761 00	533 87	7 722.91	1 849 74	9 572 65	2 172 11	16 039 63	12,278.63	5 868 03
1986	9,910.09	1,366 27	1,402.37	1,559.51	20 46	14,258.70	4,328 15	2,251 65	533 98	7,588 52	1,810 21	9,398 73	2,074 40	14,258.76	12,007 11	-7,658 44
1987	10 375 36	1,366 27	926.43	1,454 34	19 45	14,141 85	3,747 04	1,266 15	530 20	8 282.97	1,966 51	10,249 48	2,096 30	14,142.13	12,875 97	-9,109 21
1988	10,934 85	1,370 01	2,038 69	1,654 10	22 53	16,020 18	5 062 80	2,820 28	531 26	8,983.53	1,822 15	10 805 67	1,863 77	16 020 97	13,200.70	-8,114.57
1989	11 506.53	1 366 27	233 41	1 364 98	23 74	14 494 92	2,964 65	1 064 87	524 27	9 030 12	2,005 64	11 035 76	1,872 89	14 497 78	13 432 91	-10 441 66
1990	10,876.51	1,366 27	7,016.01	1,868.39	24 50	21,101.68	10,250 67	7,827 69	521 45	9,069 61	1,965 15	11 034 76	1,721 44	21,105 34	13,277 65	2,998 81
1991	10 636.74	1 366 27	2,515 30	1 453 41	19 05	15 990 77	5 334 98	3 434 20	518 06	8 772 85	1,776 15	10 549 00	1,489 41	15 990 68	12,556 48	-7 202.54
1992	11,707 80	1,370 01	20 913 16	3,494 77	36.82	37,522 57	25,777 94	24 694 41	513 90	9,018.37	1,778 19	10 796.56	1,520.71	37,525 08	12,830 67	12 986 60

Attachment B Annual Water Budget from 1929 to 2016 for Borrego Valley Hydrologic Model

Water Year Beginning	INFLOWS							OUTFLOWS									Δ Storage[n]
	STORAGE (AF)[a]	SPECIFIED FLOWS (AF)[b]	STREAM LEAKAGE (AF)[c]	UZF RECHARGE (AF)[d]	MNW2 (AF)[e]	TOTAL IN (AFY)	Recharge (AF)[f]	STORAGE (AF)[g]	CONSTANT HEAD (AF)[h]	MNW2 (AF)[i]	FARM WELLS (AF)[j]	Total Pumping (AF)[k]	FARM NET RECH (AF)[l]	Total Out (AF)	Discharge (AF)[m]		
1993	14,569 90	1,366 27	5 915 43	2,785 29	44 27	24,681 15	10 066.99	9 666 34	521 54	10 959 33	1,755 96	12,715 29	1,777 29	24,680.47	15,014 12		-4,903 56
1994	12 610 91	1 366 27	8 347 66	1 978 52	29 77	24,333 13	11,692 44	7,845 73	517 77	12,333 54	1,847 84	14,181 38	1,788 13	24 333 00	16,487 28		-4,765 18
1995	15 805 11	1,366 27	787 19	1,592 92	31 50	19,582 99	3 746.37	1,903 71	516 31	13,780 52	1,828 68	15,609 20	1,553 51	19,582.72	17,679 01		-13,901 40
1996	17,536.31	1 370 01	656 24	1,277 18	30 93	20,870 67	3 303 42	973 73	515 34	15,772 36	2,022 79	17,795 15	1 581 69	20 865 91	19 892 18		-16,562 58
1997	14,585 62	1,366.27	9 087 98	1,834 52	28 05	26,902 44	12,288 78	9,214 69	511 86	14,041 17	1,826.88	15,868 05	1,307 77	26,902.36	17,687 67		-5,370 93
1998	14 384 23	1 366 27	2,625 43	1 909 47	36 17	20 321 56	5 901 16	4,221.20	523 49	12,565 50	1,718 59	14,284 08	1,292 65	20 321 42	16,100 23		-10 163 03
1999	15 335.63	1 366 27	317 60	1 268 15	27 95	18 315 60	2 952 01	935.58	520 86	13 650.77	1,926 98	15,577 76	1,291 44	18,325 64	17,390 05		14,400 05
2000	16 190 26	1 370 01	450 22	1,280 74	34 00	19,325 23	3,100 97	1 014 02	519 23	14 507 72	2,155 29	16 663 01	1,146 80	19 343 05	18 329.04		15,176 24
2001	15 569 67	1 366.27	283 49	1,362 17	29 63	18 611 23	3 011 93	1 659 64	515 78	13 433 67	2,067 40	15,481 07	950 13	18,606 61	16,946 98		13,910 03
2002	16,905 68	1,366.27	428 29	1,434 40	33 98	20 168 62	3,228 96	1 292 43	512 82	15,108.61	2,320 53	17,429 14	934 45	20,168 84	18 876 41		15 613 25
2003	15 642 91	1,366 27	931 91	1 551 15	33 38	19 525 63	3 849 33	2,265 52	510 42	13,675 08	2,331 81	16,006 89	744.89	19,527 72	17,262 20		13,377 39
2004	15,308.80	1,370 01	10,614 50	1,655.06	35 78	28 984 15	13,639 57	10,928 22	509 89	14 373 88	2,454 67	16,828 55	719 22	28 985 88	18.057 66		-4,380 58
2005	15,596 97	1,366 27	9,034 46	3,529 99	45 84	29 573 53	13 930 71	13,394 40	527 26	12,873 56	1,916 17	14,789 73	862.87	29,574 25	16,179 86		-2,202.58
2006	16 951 16	1,366 27	2,563 05	1,820.33	34 10	22 734 91	5,749 64	3 423 90	529 56	15 473 65	2,359 42	17,833 08	946 16	22 732 70	19 308 81		-13 527 26
2007	19 091.07	1 366 27	291 71	1 448.80	31 62	22,229 47	3 106.78	1 040.39	524 86	17,389 64	2,521 67	19 911 31	752.59	22 229 15	21,188 76		18,050 68
2008	17,754.85	1,370 01	1,228 89	1,239.57	35 87	21 629 19	3,838.48	2 579 28	522 74	15,650 88	2,316 60	17,967 48	562.38	21 631 88	19 052 60		15 175 57
2009	18 160 59	1,366 27	1,572 16	1 215 03	37 57	22 351 62	4 153 46	2 665 27	522 44	16,220.74	2,370 20	18,590 94	571 12	22,349 77	19,684 50		-15,495 32
2010	17,393 45	1,366 27	234 31	1,378 10	35 75	20 407 88	2,978.68	1 868 07	520 48	15 179 83	2,377 39	17,557 21	487 48	20 433 23	18,565 17		15 525 38
2011	16,130 33	1,366 27	1,181 97	1 302 35	34 87	20,015 79	3 850.58	2 417 32	516 93	14 400 91	2,294 19	16,695 10	424 42	20,051.78	17,636 46		-13,713 01
2012	13,210.35	1,370.01	6,492 76	1,919 11	35 17	23,027 41	9,781.88	7,214 16	528 96	12,638 51	2,126 67	14 765 18	494 37	23,002.67	15 788 51		-5 996 20
2013	14 318 19	1,366 27	1 947 54	1,801 13	29 37	19 462 48	5,114 93	2 682 44	524 77	13 544 96	2,246.37	15,791.33	488 45	19 486 99	16 804 55		-11,635 75
2014	14 970 90	1,366 27	1 617 06	1,542 79	29 50	19 526 52	4 526 12	1 596 00	522 11	14 584 80	2,380 29	16 965 08	464 46	19 547 65	17 951 66		13 374 90
2015	13 948 97	1 366 27	2 312 90	1 594 99	35 10	19 258 23	5 274 16	2,819 32	520 15	13 388.54	2,166.69	15,555 23	364 41	19,259 11	16 439 79		-11,129 64
2016	14,067 64	1,370 01	1,768.14	1,603 61	29 27	18,838 67	4,741 76	3,184 87	522 85	12,634 53	2,124 42	14 758 95	373 53	18,840 20	15 655 32		10 882 77

MIN (2011 - 2016)	13,210	1,366	1,182	1,302	29	18,839	3,851	1,596	517	12,635	2,124	14,759	364	18 840	15 655	-11 614 36
MAX (2011 - 2016)	16 130	1,370	6 493	1 919	35	23 027	9,782	7,214	529	14 585	2,380	16 965	494	23 003	17 952	-8 916 18
AVG (2011 - 2016)	14 441	1,368	2,553	1,627	37	20,022	5,548	3,319	523	13,532	2,223	15,755	435	20,032	16,713	-11 122 05
STDEV (2011 - 2016)	1 005	2	1,966	214	3	1,521	2,134	1 981	4	835	102	934	57	1 508	943	976 70

MIN (1945 2016)	6 092	1,366	112	572	1	9,395	2,101	936	499	89	0	89	364	9 404	8,055	-5,156
MAX (1945 - 2016)	19 091	1,370	22,504	3,706	46	37,571	27,577	28,104	555	17,390	2,522	19,911	9,998	37,583	21 189	9 013
AVG (1945 - 2016)	12.225	1,367	3 905	1,497	17	19 011	6 770	5 080	522	8 983	1,615	10 597	2 815	19 015	13 934	7,145
STDEV (1945 - 2016)	3 443	2	4 965	708	14	5 653	5 470	5 610	12	4,253	617	4,744	2,372	5,652	3,552	2,167

MIN (1997 - 2016)	13,210	1 366	234	1 215	28	18,316	2 952	936	510	12,565	1,719	14,284	364	18,326	15,655	-12,275
MAX (1997 2016)	19,091	1,370	10,615	3,530	46	29,574	13,931	13 394	530	17,390	2,522	19 911	1,308	29,574	21 189	5,697
AVG (1997 - 2016)	15 776	1 367	2 749	1 635	34	21 561	5,751	3 821	520	14,266	2 200	16,466	759	21,566	17,745	7,435
STDEV (1997 - 2016)	1,550	2	3,270	502	4	3,319	3,614	3,530	6	1,290	218	1 453	319	3 314	1 436	1,981

NOTES:

[a] Water into the aquifer system from storage (water is removed from storage)

[b] Inflow from adjacent basins

[c] Leakage from streams directly to groundwater (Stream Recharge)

[d] Flow from the unsaturated zone into groundwater. Includes precipitation recharge, leakage from some streams within the model domain, and irrigation return flows (Distributed Recharge)

[e] Flow within the borehole for wells screened across multiple aquifer layers

[f] Sum of major inflows: Specified flows, Stream Leakage, and Unsaturated Zone Flows

[g] Water out of the aquifer system into storage (water is added to storage)

[h] Flow out of the southern end of the basin.

[i] Pumping from wells in the model with specific construction information; includes all municipal wells and most recreation and agricultural wells

[j] Pumping calculated by the Farm Process Package (FMP) in Modflow for wells with no construction information. Primarily agricultural and recreational pumping.

[k] The Sum of MNW2 (Column K) pumping and Farm Wells (Column L) pumping

[l] Consumptive use of water calculated by the Farm Process Package for all land use type. Primarily represents evapotranspiration.

[m] Sum of major outflows: Constant Head, Pumping, and farm net recharge

[n] Change in storage calculated by subtracting Storage In (Column B) from Storage Out (Column I)

ATTACHMENT C

Residuals

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
7/21/1965	145.59	144.07	-1.52	5E25R010008
7/21/1965	145.04	144.02	-1.02	5E36A010009
4/27/1987	142.49	142.86	0.37	5E36A010010
7/27/1987	142.26	142.77	0.51	5E36A010011
11/19/1987	142.00	142.37	0.37	5E36A010012
1/20/1988	141.90	142.22	0.32	5E36A010013
4/1/1988	141.77	142.04	0.27	5E36A010014
6/8/1988	141.63	141.92	0.29	5E36A010015
10/25/1988	141.24	141.55	0.31	5E36A010016
8/8/1989	140.61	140.82	0.21	5E36A010017
10/26/1989	140.42	140.64	0.21	5E36A010018
2/6/1990	140.21	140.82	0.61	5E36A010019
9/1/1990	141.06	139.75	-1.31	5E36A010020
1/14/1991	140.66	140.27	-0.39	5E36A010021
2/19/1991	140.52	140.27	-0.25	5E36A010022
3/5/1991	140.48	140.27	-0.21	5E36A010023
3/19/1991	140.43	140.24	-0.19	5E36A010024
4/11/1991	140.37	140.24	-0 13	5E36A010025
5/9/1991	140.29	139.48	-0.81	5E36A010026
5/30/1991	140.24	139.51	-0.73	5E36A010027
7/23/1991	140.69	139.36	-1.34	5E36A010028
1/7/1992	140.52	139.26	-1.26	5E36A010029
3/12/1992	140.29	139.33	-0.97	5E36A010030
5/12/1992	140.37	139.11	-1.26	5E36A010031
7/7/1992	142.37	139.02	-3.35	5E36A010032
9/2/1992	142.62	138.87	-3.75	5E36A010033
10/13/1992	142.39	138.87	-3.53	5E36A010034
12/8/1992	142.06	138.69	-3.37	5E36A010035
1/12/1993	141.94	138.93	-3.01	5E36A010036
2/3/1993	142.03	139.02	-3.01	5E36A010037
2/12/1993	142.04	139.08	-2.96	5E36A010038
2/24/1993	142.03	139.17	-2.85	5E36A010039
3/11/1993	141.98	139.26	-2.71	5E36A010040
3/27/1993	141.91	139.39	-2.52	5E36A010041
4/16/1993	141.83	139.36	-2.47	5E36A010042
5/11/1993	141.72	139.42	-2.30	5E36A010043
7/2/1993	141.49	139.30	-2.19	5E36A010044
8/19/1993	141.28	139.23	-2.05	5E36A010045
10/20/1993	141.03	139.08	-1.95	5E36A010046
12/24/1993	140.79	139.08	-1.71	5E36A010047
2/11/1994	140.63	139.02	-1.61	5E36A010048
3/25/1994	140.51	139.26	-1.25	5E36A010049
5/25/1994	140.94	139.36	-1.58	5E36A010050
8/24/1994	142.13	138.84	-3.29	5E36A010051
10/6/1994	142.01	138.66	-3.35	5E36A010052
12/21/1994	141.57	138.44	-3.13	5E36A010053
2/24/1995	141.24	138.38	-2.86	5E36A010054
4/4/1995	141.07	138.56	-2.51	5E36A010055
6/21/1995	140.75	138.53	-2.21	5E36A010056
10/2/1995	140.31	138.20	-2.11	5E36A010057

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
12/28/1995	139.95	137.86	-2.09	5E36A010058
4/11/1996	139.59	137.53	-2.06	5E36A010059
8/9/1996	139.17	137.16	-2.01	5E36A010060
10/23/1996	138.88	136.67	-2.20	5E36A010061
1/3/1997	138.60	136.67	-1.93	5E36A010062
9/3/1997	139.12	135.79	-3.33	5E36A010063
12/3/1997	138.88	135.64	-3.24	5E36A010064
5/13/1998	138.27	135.30	-2.97	5E36A010065
11/12/1998	137.60	135.09	-2.51	5E36A010066
3/12/1999	137.20	135.09	-2.11	5E36A010067
5/17/1999	137.02	134.24	-2.78	5E36A010068
11/22/1999	136.48	133.38	-3.10	5E36A010069
3/24/2000	136.15	133.14	-3.01	5E36A010070
6/29/2000	135.92	132.71	-3.21	5E36A010071
12/18/2000	135.45	132.10	-3.35	5E36A010072
11/14/2001	134.65	130.76	-3.89	5E36A010073
2/22/2002	134.40	130.49	-3.91	5E36A010074
8/30/2002	133.95	129.88	-4.07	5E36A010075
12/13/2002	133.66	129.48	-4.18	5E36A010076
3/17/2003	133.42	129.45	-3.97	5E36A010077
6/30/2003	133.18	128.93	-4.25	5E36A010078
10/6/2003	132.96	128.57	-4.40	5E36A010079
12/29/2003	132.76	128.20	-4.56	5E36A010080
2/12/2004	132.65	128.17	-4.48	5E36A010081
4/8/2004	132.55	128.14	-4.41	5E36A010082
7/23/2004	134.47	127.74	-6.73	5E36A010083
8/23/2005	133.46	127.74	-5.72	5E36A010084
1/5/2006	133.09	127.68	-5.41	5E36A010085
6/14/2006	132.60	129.11	-3.49	5E36A010086
2/24/1993	139.54	137.45	-2.09	6E04Q010087
6/25/1998	130.43	145.68	15.25	6E04Q010088
4/10/2005	125.43	123.74	-1.69	6E04Q010089
2/23/2006	123.62	122.53	-1.09	6E04Q010090
5/12/2008	119.40	118.22	-1.18	6E04Q010091
12/1/2008	118.12	118.08	-0.04	6E04Q010092
12/2/2008	118.14	118.22	0.08	6E04Q010093
10/1/1951	158.23	161.84	3.61	6E05F010094
12/4/2008	118.69	122.31	3.63	6E05F010095
11/28/1955	149.19	150.99	1.79	6E08B010096
11/16/1956	147.78	151.70	3.91	6E08B010097
11/16/1956	147.78	138.26	-9.53	6E08B010098
11/26/1957	147.02	150.98	3.96	6E08B010099
3/15/1958	147.30	150.95	3.66	6E08B010100
11/5/1958	145.92	144.76	-1.16	6E08B010101
11/24/1959	144.60	148.64	4.04	6E08B010102
2/27/1960	144.90	149.08	4.19	6E08B010103
11/22/1960	143.51	148.36	4.85	6E08B010104

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/8/1961	143.54	148.11	4.58	6E08B010105
10/26/1961	142.20	147.15	4.94	6E08B010106
3/15/1962	142.46	142.10	-0.36	6E08B010107
11/2/1962	141.13	143.05	1.92	6E08B010108
3/15/1963	141.30	146.39	5.08	6E08B010109
10/31/1963	140.42	143.04	2.62	6E08B010110
3/20/1964	140.63	144.42	3.79	6E08B010111
11/12/1964	139.55	145.24	5.69	6E08B010112
3/19/1965	139.81	145.74	5.94	6E08B010113
7/23/1965	140.61	144.81	4.20	6E08B010114
10/26/1965	140.68	144.79	4.10	6E08B010115
3/3/1966	141.28	144.78	3.49	6E08B010116
10/26/1966	142.55	144.57	2.01	6E08B010117
3/23/1967	142.35	144.63	2.28	6E08B010118
10/24/1967	142.02	144.57	2.56	6E08B010119
3/13/1968	141.60	144.82	3.23	6E08B010120
11/8/1968	143.92	144.56	0.65	6E08B010121
3/27/1969	143.86	145.13	1.27	6E08B010122
10/28/1969	142.87	145.09	2.22	6E08B010123
3/23/1970	142.71	145.33	2.63	6E08B010124
11/12/1970	141.91	145.17	3.26	6E08B010125
3/30/1971	141.77	145.32	3.56	6E08B010126
12/5/2008	117.90	122.52	4.62	6E08F010127
3/12/2009	118.29	122.52	4.23	6E08F010128
3/25/2010	116.71	121.31	4.60	6E08F010129
11/18/2010	114.98	120.54	5.56	6E08F010130
12/2/2008	117.95	116.81	-1.15	6E09C010129
7/26/1965	140.59	141.92	1.33	6E09L010130
5/26/1983	142.61	140.51	-2.09	6E09L010131
9/30/1983	142.39	140.39	-2.00	6E09L010132
12/11/1983	142.27	140.51	-1.76	6E09L010133
4/6/1984	142.02	140.73	-1.30	6E09L010134
7/19/1984	141.53	140.27	-1.26	6E09L010135
2/18/1985	141.16	140.82	-0 35	6E09L010136
5/26/1985	140.86	140.58	-0 29	6E09L010137
1/20/1986	140.38	140.36	-0.02	6E09L010138
4/22/1986	140.30	140.06	-0.25	6E09L010139
9/11/1986	139.65	139.42	-0.23	6E09L010140
12/8/1986	139.51	139.78	0.27	6E09L010141
4/27/1987	139.30	139.75	0.46	6E09L010142
7/27/1987	138.84	139.42	0.58	6E09L010143
11/15/1987	138.59	139.54	0.95	6E09L010144
1/20/1988	138.62	139.78	1.17	6E09L010145
4/1/1988	138.47	139.63	1.16	6E09L010146
6/8/1988	138.12	139.42	1 30	6E09L010147
10/25/1988	137.39	138.93	1.54	6E09L010148
2/3/1989	137.36	139.14	1.79	6E09L010149

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
8/8/1989	136.51	138.47	1.96	6E09L010150
10/26/1989	136.22	138.23	2.01	6E09L010151
2/6/1990	136.16	139.23	3.07	6E09L010152
9/1/1990	137.35	137.53	0.18	6E09L010153
1/14/1991	136.76	138.20	1.43	6E09L010154
2/19/1991	136.75	138.26	1.51	6E09L010155
3/5/1991	136.76	138.44	1.68	6E09L010156
3/19/1991	136.73	138.47	1.75	6E09L010157
4/11/1991	136.60	138.38	1.78	6E09L010158
5/9/1991	136.35	138.17	1.82	6E09L010159
5/30/1991	136.17	137.19	1.02	6E09L010160
7/23/1991	135.71	136.64	0.93	6E09L010161
10/31/1991	135.43	136.84	1.41	6E09L010162
1/7/1992	135.65	137.25	1.61	6E09L010163
3/12/1992	135.83	137.41	1.57	6E09L010164
5/12/1992	136.30	136.86	0.56	6E09L010165
7/7/1992	139.64	136.51	-3.13	6E09L010166
9/2/1992	139.03	136.06	-2.97	6E09L010167
10/13/1992	138.69	135.94	-2.75	6E09L010168
12/8/1992	138.47	136.43	-2.04	6E09L010169
1/21/1993	138.63	136.61	-2.01	6E09L010170
2/3/1993	138.70	136.52	-2.18	6E09L010171
2/12/1993	138.69	136.80	-1.89	6E09L010172
2/24/1993	138.67	136.70	-1.96	6E09L010173
3/11/1993	138.51	136.55	-1.96	6E09L010174
3/27/1993	138.31	136.43	-1.88	6E09L010175
4/16/1993	138.03	136.22	-1.81	6E09L010176
5/11/1993	137.68	136.06	-1.61	6E09L010177
7/2/1993	136.92	135.58	-1.34	6E09L010178
8/19/1993	136.29	135.12	-1.17	6E09L010179
10/20/1993	135.92	135.00	-0.92	6E09L010180
12/24/1993	135.93	135.24	-0.69	6E09L010181
2/11/1994	135.84	135.06	-0.78	6E09L010182
3/25/1994	135.67	135.03	-0.64	6E09L010183
5/25/1994	136.15	135.03	-1.12	6E09L010184
8/24/1994	135.14	133.99	-1.15	6E09L010185
10/6/1994	134.87	133.87	-1.00	6E09L010186
12/21/1994	134.99	134.21	-0.79	6E09L010187
2/24/1995	135.15	134.54	-0.61	6E09L010188
4/12/1995	134.89	134.33	-0.56	6E09L010189
6/21/1995	133.84	133.87	0.03	6E09L010190
10/2/1995	132.59	132.80	0.21	6E09L010191
12/26/1995	132.61	132.83	0.23	6E09L010192
4/11/1996	132.22	132.71	0.49	6E09L010193
8/9/1996	130.45	131.43	0.98	6E09L010194
10/23/1996	130.09	131.43	1.34	6E09L010195
1/3/1997	130.34	131.74	1.40	6E09L010196
9/3/1997	130.22	130.85	0.64	6E09L010197
12/3/1997	130.49	131.19	0.70	6E09L010198
5/13/1998	130.40	131.16	0.76	6E09L010199

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/12/1998	129.05	130 03	0.98	6E09L010200
3/12/1999	129.12	129.88	0.76	6E09L010201
5/17/1999	128.63	130.09	1.46	6E09L010202
11/22/1999	127.53	128.47	0.94	6E09L010203
2/17/2000	127.71	129.63	1.93	6E09L010204
3/24/2000	127.66	129.05	1.40	6E09L010205
6/29/2000	126.58	128.02	1.44	6E09L010206
9/15/2000	126.04	127.77	1.73	6E09L010207
12/18/2000	126.27	128.05	1.78	6E09L010208
10/17/2001	124.89	126.98	2.09	6E09L010209
11/14/2001	124.99	127.23	2.24	6E09L010210
2/22/2002	125.17	127.65	2.48	6E09L010211
8/30/2002	123.41	125.12	1.71	6E09L010212
9/27/2002	123 42	125.15	1.73	6E09L010213
12/13/2002	123.79	125.70	1.91	6E09L010214
3/17/2003	124.09	126.49	2.40	6E09L010215
6/30/2003	123.00	124.60	1.60	6E09L010216
12/29/2003	122.97	124.97	2.00	6E09L010217
2/12/2004	123.11	125.46	2.35	6E09L010218
4/8/2004	122.92	124.63	1.72	6E09L010219
11/18/2004	124.41	124.15	-0.27	6E09L010220
2/10/2005	125.18	124.85	-0.33	6E09L010221
1/5/2006	123.33	123.60	0.26	6E09L010222
	140.31	134.49	-5.82	6E09N010223
2/12/2004	124.50	127.38	2.88	6E10L010224
2/10/2005	125.93	126.77	0.84	6E10L010225
1/5/2006	124.39	129.66	5.28	6E10L010226
8/23/1980	143 33	148.15	4.81	6E10M010227
2/12/2004	124.21	131.22	7.01	6E10M010228
2/10/2005	125.83	134.33	8.50	6E10M010229
5/5/2005	125.33	130.77	5.43	6E10M010230
8/24/2005	124.09	130.40	6.31	6E10M010231
1/5/2006	124.14	129.85	5.71	6E10M010232
5/15/2009	119.20	122.61	3.41	6E17J010235
6/30/1987	138.54	140.96	2.42	6E18J010236
6/30/1991	135.31	138.52	3.21	6E18J010237
6/30/1993	136.04	136.08	0.04	6E18J010238
6/30/1995	134.09	135.29	1.20	6E18J010239
6/30/1997	130.49	133.22	2.73	6E18J010240
6/2/1998	130.71	132.03	1.32	6E18J010241
6/29/1999	128.76	130.93	2.17	6E18J010242
6/5/2000	127.71	129.74	2.03	6E18J010243
6/8/2001	126.65	128.98	2.33	6E18J010244
7/29/2002	124.77	128.22	3.45	6E18J010245
7/31/2003	123.81	126.66	2.86	6E18J010246

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/10/2004	123.64	122.95	-0.69	6E18J010247
2/12/2005	125.18	125.81	0.63	6E18J010248
3/3/2006	123.78	124.68	0.91	6E18J010249
5/21/2006	123.42	120.96	-2.46	6E18J010250
3/8/2007	122.15	123.01	0.85	6E18J010251
12/1/2008	119.48	121.47	1.98	6E18J010252
12/3/2008	119.50	122.29	2.79	6E18J010253
3/25/2010	118.48	122.37	3.89	6E18J010254
10/12/2010	117.14	121.48	4.34	6E18J010255
4/9/2013	115.06	119.96	4.90	6E18J010256
10/18/2013	114.12	119.62	5.50	6E18J010257
3/28/2014	114.07	119.96	5.89	6E18J010258
3/10/2015	113.09	118.92	5.83	6E18J010259
10/12/2015	112.13	116.82	4.69	6E18J010260
3/23/2016	112.42	116.12	3.70	6E18J010261
6/30/1980	142.69	144.68	1.99	6E18R010254
6/30/1987	138.40	140.72	2.32	6E18R010255
6/30/1991	135.33	138.28	2.95	6E18R010256
6/30/1993	136.02	134.62	-1.40	6E18R010257
6/30/1995	134.26	134.95	0.69	6E18R010258
6/30/1997	131.16	133.86	2.70	6E18R010259
6/2/1998	130.91	131.88	0.97	6E18R010260
6/29/1999	129.60	130.96	1.36	6E18R010261
6/5/2000	128.30	132.82	4.52	6E18R010262
7/31/2003	124.55	128.10	3.55	6E18R010263
5/13/2005	125.21	124.87	-0.34	6E18R010264
3/3/2006	124.23	124.62	0.39	6E18R010265
5/21/2006	123.87	116.91	-6.96	6E18R010266
3/8/2007	122.84	122.88	0.04	6E18R010267
12/1/2008	120.74	121.93	1.20	6E18R010268
12/3/2008	120.75	122.64	1.89	6E18R010269
5/14/2009	120.67	123.24	2.57	6E18R010270
3/25/2010	119.72	122.86	3.14	6E18R010271
11/18/2010	118.44	122.13	3.69	6E18R010272
11/14/2012	116.36	120.98	4.62	6E18R010273
4/9/2013	116.30	120.88	4.58	6E18R010274
11/13/2013	115.37	120.26	4.89	6E18R010275
11/25/2013	115.39	120.26	4.87	6E18R010276
2/5/2014	115.44	120.10	4.66	6E18R010277
4/9/2014	115.25	120.00	4.75	6E18R010278
6/3/2014	114.90	119.77	4.87	6E18R010279
4/15/2015	114.21	119.05	4.84	6E18R010280
11/19/2015	113.33	118.02	4.69	6E18R010281
4/12/2016	113.44	117.74	4.30	6E18R010282
7/27/1987	138.41	140.73	2.32	6E20L010271
11/19/1987	138.23	140.54	2.31	6E20L010272
1/20/1988	138.26	141.06	2 81	6E20L010273
4/1/1988	138.15	140.30	2.15	6E20L010274

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/8/1988	137.87	140.33	2.46	6E20L010275
10/25/1988	137.31	140.24	2.93	6E20L010276
2/3/1989	137.26	140.30	3.04	6E20L010277
8/8/1989	136.66	139.69	3.04	6E20L010278
10/26/1989	136.46	139.63	3.17	6E20L010279
2/6/1990	136.40	139.57	3.17	6E20L010280
9/1/1990	135.84	139.23	3.39	6E20L010281
1/14/1991	135.94	139.84	3.90	6E20L010282
2/19/1991	136.06	139.78	3.73	6E20L010283
3/5/1991	136.09	139.87	3.79	6E20L010284
3/19/1991	136.09	139.81	3.73	6E20L010285
4/11/1991	136.07	139.72	3.65	6E20L010286
5/30/1991	135.95	138.87	2.92	6E20L010287
7/23/1991	135.80	137.53	1.73	6E20L010288
10/31/1991	135.68	137.44	1.76	6E20L010289
1/7/1992	135.75	138.11	2.36	6E20L010290
3/12/1992	135.83	138.41	2.59	6E20L010291
5/12/1992	135.72	137.53	1.81	6E20L010292
7/7/1992	135.75	137.04	1.29	6E20L010293
9/2/1992	135.79	137.01	1.22	6E20L010294
12/8/1992	136.16	137.47	1.31	6E20L010295
1/21/1993	136.43	138.02	1.58	6E20L010296
2/3/1993	136.52	138.02	1.49	6E20L010297
2/12/1993	136.56	138.08	1.52	6E20L010298
2/24/1993	136.62	138.11	1.49	6E20L010299
3/11/1993	136.65	138.02	1.37	6E20L010300
3/27/1993	136.67	137.83	1.17	6E20L010301
4/16/1993	136.67	137.50	0.83	6E20L010302
5/11/1993	136.65	137.19	0.54	6E20L010303
7/2/1993	136.52	136.98	0.46	6E20L010304
8/19/1993	136.35	136.89	0.54	6E20L010305
10/20/1993	136.21	136.95	0.74	6E20L010306
12/24/1993	136.17	137.19	1.02	6E20L010307
2/11/1994	136.15	137.34	1.19	6E20L010308
3/25/1994	136.11	137.71	1.60	6E20L010309
5/25/1994	135.92	137.10	1.18	6E20L010310
8/24/1994	135.67	136.67	1.01	6E20L010311
10/6/1994	135.60	136.64	1.04	6E20L010312
12/21/1994	135.61	136.67	1.07	6E20L010313
2/24/1995	135.66	137.01	1.35	6E20L010314
4/12/1995	135.60	136.70	1.10	6E20L010315
6/21/1995	135.29	136.16	0.86	6E20L010316
10/2/1995	134.74	135.94	1.20	6E20L010317
12/25/1995	134.53	136.06	1.53	6E20L010318
4/11/1996	134.26	135.82	1.56	6E20L010319
8/9/1996	133.52	134.97	1.45	6E20L010320
10/23/1996	133.16	134.94	1.78	6E20L010321
1/3/1997	132.99	135.09	2.10	6E20L010322
5/9/1997	132.60	134.48	1.87	6E20L010323
9/3/1997	132.16	134.05	1.89	6E20L010324

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
12/3/1997	132.21	134.24	2.02	6E20L010325
5/13/1998	132.20	133.93	1.73	6E20L010326
11/12/1998	131.61	133.23	1.62	6E20L010327
3/12/1999	131.45	133.17	1.72	6E20L010328
5/17/1999	131.24	132.74	1.50	6E20L010329
11/22/1999	130.54	131.98	1.44	6E20L010330
2/17/2000	130.40	131.98	1.58	6E20L010331
3/24/2000	130.33	132.01	1.68	6E20L010332
6/29/2000	129.89	131.16	1.26	6E20L010333
9/15/2000	129.56	131.25	1.69	6E20L010334
12/18/2000	129.39	131.04	1.64	6E20L010335
5/17/2001	129.12	130.88	1.76	6E20L010336
10/17/2001	128.49	130.67	2.18	6E20L010337
11/14/2001	128.44	129.48	1.04	6E20L010338
2/22/2002	128.30	129.88	1.58	6E20L010339
8/30/2002	127.50	128.63	1.13	6E20L010340
12/13/2002	127.31	128.66	1.34	6E20L010341
3/17/2003	127.21	128.78	1.57	6E20L010342
6/30/2003	126.80	128.05	1.25	6E20L010343
10/6/2003	126.42	127.93	1.51	6E20L010344
12/29/2003	126.31	127.83	1.53	6E20L010345
2/12/2004	126.27	127.80	1.54	6E20L010346
7/23/2004	125.91	126.80	0.89	6E20L010347
2/10/2005	126.38	127.35	0.97	6E20L010348
8/23/2005	125.93	126.34	0.41	6E20L010349
1/5/2006	125.74	126.34	0.60	6E20L010350
6/14/2006	125.28	125.46	0.18	6E20L010351
1/10/2007	124.53	125.09	0.57	6E20L010352
6/4/2007	123.97	123.60	-0.37	6E20L010353
9/21/2007	123.39	122.47	-0.92	6E20L010354
1/8/2008	123.18	122.44	-0.74	6E20L010355
5/8/2008	122.84	122.32	-0.53	6E20L010356
8/12/2008	122.36	122.32	-0.05	6E20L010357
12/1/2008	122.06	122.73	0.67	6E20L010358
12/3/2008	122.06	123.08	1.02	6E20L010359
4/15/2009	121.87	123.13	1.27	6E20L010360
2/5/2014	116.63	119.77	3.14	6E20L010361
6/24/1952	150.88	153.37	2.48	6E21A010361
1/3/1953	150.70	155.14	4.44	6E21A010362
5/1/1953	150.33	152.56	2.23	6E21A010363
5/15/1953	150.20	152.25	2.05	6E21A010364
5/28/1953	150.09	152.03	1.94	6E21A010365
6/11/1953	149.96	151.83	1.86	6E21A010366
6/25/1953	149.83	151.62	1.78	6E21A010367
7/1/1953	149.78	148.42	-1.37	6E21A010368
7/3/1953	149.75	151.50	1.75	6E21A010369
7/11/1953	149.63	151.29	1.66	6E21A010370
7/25/1953	149.43	151.14	1.71	6E21A010371
8/3/1953	149.33	151.41	2.08	6E21A010372

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
8/5/1953	149.31	148.82	-0.49	6E21A010373
8/19/1953	149.23	150.39	1.16	6E21A010374
9/2/1953	149.15	151.36	2.21	6E21A010375
9/17/1953	149.14	151.45	2.31	6E21A010376
10/1/1953	149.13	151.81	2.68	6E21A010377
10/16/1953	149.17	151.96	2.79	6E21A010378
10/21/1953	149.18	149.60	0.42	6E21A010379
10/29/1953	149.20	152.28	3.09	6E21A010380
11/11/1953	149.23	152.47	3.24	6E21A010381
11/19/1953	149.24	150.03	0.79	6E21A010382
11/25/1953	149.26	152.70	3.44	6E21A010383
12/10/1953	149.29	152.92	3.63	6E21A010384
12/17/1953	149.31	150.27	0.97	6E21A010385
12/21/1953	149.31	152.93	3.61	6E21A010386
1/6/1954	149.36	152.74	3.38	6E21A010387
1/7/1954	149.36	152.72	3.36	6E21A010388
1/21/1954	149.42	152.40	2.98	6E21A010389
2/3/1954	149.46	152.55	3.09	6E21A010390
2/18/1954	149.46	150.95	1.50	6E21A010391
2/24/1954	149.46	152.62	3.17	6E21A010392
3/4/1954	149.45	152.26	2.81	6E21A010393
3/17/1954	149.43	152.20	2.77	6E21A010394
4/2/1954	149.41	152.39	2.98	6E21A010395
4/15/1954	149.29	151.23	1.94	6E21A010396
5/17/1954	149.01	150.08	1.07	6E21A010397
5/28/1954	148.92	149.62	0.70	6E21A010398
8/13/1954	148.18	148.11	-0.07	6E21A010399
8/27/1954	148.08	148.08	0.00	6E21A010400
10/21/1954	148.05	149.60	1.55	6E21A010401
11/9/1954	148.09	149.76	1.67	6E21A010402
11/19/1954	148.13	150.03	1.90	6E21A010403
12/17/1954	148.18	150.27	2.10	6E21A010404
1/12/1955	148.23	150.49	2.26	6E21A010405
2/10/1955	148.29	149.66	1.37	6E21A010406
3/7/1955	148.25	149.30	1.05	6E21A010407
3/16/1955	148.20	149.39	1.20	6E21A010408
4/14/1955	148.02	147.32	-0.71	6E21A010409
5/19/1955	147.76	146.34	-1.42	6E21A010410
6/29/1955	147.42	145.73	-1.69	6E21A010411
7/20/1955	147.18	145.92	-1.26	6E21A010412
8/3/1955	147.04	146.10	-0.94	6E21A010413
9/20/1955	146.85	146.80	-0.05	6E21A010414
10/25/1955	146.85	149.18	2.32	6E21A010415
11/28/1955	146.89	150 09	3.20	6E21A010416
11/29/1955	146.89	150.12	3.23	6E21A010417
1/4/1956	146.97	150.73	3.76	6E21A010418
2/7/1956	147.00	149.76	2.76	6E21A010419
3/8/1956	146.95	148.84	1.89	6E21A010420
3/18/1956	146.89	148.23	1.34	6E21A010421
4/4/1956	146.80	148.51	1.71	6E21A010422

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
5/3/1956	146.61	146.83	0.22	6E21A010423
6/6/1956	146.32	145.82	-0.49	6E21A010424
7/2/1956	146.09	145.67	-0.43	6E21A010425
8/2/1956	145.71	145.55	-0.16	6E21A010426
9/4/1956	145.51	146.74	1.23	6E21A010427
10/3/1956	145.49	148.20	2.71	6E21A010428
11/1/1956	145.55	148.84	3.29	6E21A010429
11/16/1956	145.58	149.21	3.63	6E21A010430
12/3/1956	145.61	149.51	3.90	6E21A010431
1/3/1957	145.68	149.91	4.23	6E21A010432
2/4/1957	145.80	149.39	3.59	6E21A010433
3/1/1957	145.80	149.63	3.84	6E21A010434
3/15/1957	145.72	147.87	2.15	6E21A010435
3/27/1957	145.67	147.29	1.62	6E21A010436
4/25/1957	145.48	145.70	0.22	6E21A010437
5/27/1957	145.25	145.34	0.09	6E21A010438
6/26/1957	144.99	144.24	-0.76	6E21A010439
7/24/1957	144.65	143.75	-0.90	6E21A010440
8/22/1957	144.42	143.75	-0.67	6E21A010441
9/3/1957	144.35	151.10	6.75	6E21A010442
9/26/1957	144.36	146.04	1.68	6E21A010443
11/6/1957	144.51	147.50	2.99	6E21A010444
11/26/1957	144.56	147.98	3.42	6E21A010445
12/11/1957	144.60	148.29	3.69	6E21A010446
1/7/1958	144.68	148.57	3.89	6E21A010447
2/11/1958	144.78	148.14	3.36	6E21A010448
3/15/1958	144.84	148.62	3.78	6E21A010449
4/21/1958	144.74	145.70	0.96	6E21A010450
5/5/1958	144.66	145.55	0.89	6E21A010451
6/23/1958	144.28	143.78	-0.50	6E21A010452
7/23/1958	143.99	143.54	-0.45	6E21A010453
8/14/1958	143.81	143.26	-0.55	6E21A010454
9/23/1958	143.67	143.11	-0.56	6E21A010455
10/20/1958	143.70	145.64	1.94	6E21A010456
11/5/1958	143.72	146.21	2.49	6E21A010457
11/12/1958	143.73	146.13	2.40	6E21A010458
12/3/1958	143.76	145.55	1.79	6E21A010459
1/5/1959	143.82	147.10	3.28	6E21A010460
1/26/1959	143.87	146.49	2.62	6E21A010461
2/18/1959	143.95	146.28	2.34	6E21A010462
3/12/1959	143.93	147.29	3.36	6E21A010463
3/19/1959	143.89	147.26	3.36	6E21A010464
4/16/1959	143.77	146.25	2.48	6E21A010465
5/12/1959	143.64	144.60	0.97	6E21A010466
6/11/1959	143.46	144.00	0.53	6E21A010467
7/28/1959	143.09	144.09	1.00	6E21A010468
8/11/1959	143.01	143.05	0.04	6E21A010469
9/8/1959	142.90	141.89	-1.01	6E21A010470
10/6/1959	142.88	144.97	2.09	6E21A010471
11/10/1959	142.94	145.76	2.83	6E21A010472

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/24/1959	142.95	145.76	2.81	6E21A010473
12/10/1959	142.99	145.76	2.77	6E21A010474
12/29/1959	143.05	146.25	3.20	6E21A010475
1/13/1960	143.09	145.70	2.61	6E21A010476
2/11/1960	143.15	144.85	1.69	6E21A010477
2/27/1960	143.18	145.13	1.96	6E21A010478
3/8/1960	143.15	146.37	3.23	6E21A010479
3/23/1960	143.08	146.22	3.14	6E21A010480
4/4/1960	143.04	144.76	1.72	6E21A010481
4/21/1960	142.95	143.81	0.86	6E21A010482
5/2/1960	142.90	142.38	-0.52	6E21A010483
5/17/1960	142.81	142.59	-0.21	6E21A010484
6/2/1960	142.71	142.84	0.12	6E21A010485
6/16/1960	142.62	141.83	-0.79	6E21A010486
6/30/1960	142.54	142.20	-0.34	6E21A010487
7/14/1960	142.40	142.23	-0.17	6E21A010488
8/11/1960	142.18	142.59	0.41	6E21A010489
9/19/1960	142.07	143.63	1.56	6E21A010490
10/21/1960	142.07	144.12	2.05	6E21A010491
11/17/1960	142.11	144.48	2.37	6E21A010492
11/22/1960	142.12	144.53	2.41	6E21A010493
12/16/1960	142.15	145.06	2.92	6E21A010494
1/16/1961	142.18	144.88	2.70	6E21A010495
2/14/1961	142.20	143.60	1.40	6E21A010496
3/8/1961	142.17	143.78	1.61	6E21A010497
3/13/1961	142.15	144.94	2.79	6E21A010498
5/5/1961	141.90	141.62	-0.29	6E21A010499
5/29/1961	141.77	141.62	-0.15	6E21A010500
6/28/1961	141.58	140.73	-0.84	6E21A010501
8/20/1961	141.17	137.35	-3.82	6E21A010502
10/8/1961	141.09	143.05	1.96	6E21A010503
10/26/1961	141.10	143.43	2.33	6E21A010504
11/30/1961	141.12	143.02	1.90	6E21A010505
12/28/1961	141.19	143.14	1.95	6E21A010506
1/30/1962	141.25	141.83	0.58	6E21A010507
3/6/1962	141.28	144.18	2.90	6E21A010508
3/15/1962	141.24	144.12	2.88	6E21A010509
4/6/1962	141.16	141.74	0.58	6E21A010510
6/28/1962	140.68	140.58	-0.10	6E21A010511
7/25/1962	140.43	140.34	-0.09	6E21A010512
8/23/1962	140.24	140.31	0.07	6E21A010513
9/25/1962	140.16	141.53	1.36	6E21A010514
10/22/1962	140.18	142.90	2.72	6E21A010515
11/2/1962	140.18	143.26	3.07	6E21A010516
1/10/1963	140.28	142.62	2.34	6E21A010517
2/12/1963	140.32	141.82	1.50	6E21A010518
3/11/1963	140.30	143.81	3.51	6E21A010519
3/15/1963	140.29	144.07	3.78	6E21A010520
4/10/1963	140.20	142.29	2.09	6E21A010521
5/7/1963	140.07	141.17	1.10	6E21A010522

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/18/1963	139.81	140.49	0.68	6E21A010523
7/2/1963	139.73	139.97	0.24	6E21A010524
7/9/1963	139.66	140.12	0.47	6E21A010525
7/15/1963	139.59	140.15	0.56	6E21A010526
7/16/1963	139.58	140.28	0.69	6E21A010527
8/1/1963	139.44	139.97	0.54	6E21A010528
8/8/1963	139.42	140.18	0.76	6E21A010529
8/15/1963	139.40	139.70	0.29	6E21A010530
9/1/1963	139.35	140.00	0.65	6E21A010531
9/4/1963	139.35	140.31	0.96	6E21A010532
9/16/1963	139.38	141.22	1.84	6E21A010533
10/3/1963	139.40	142.01	2.61	6E21A010534
10/8/1963	139.43	142.26	2.82	6E21A010535
10/15/1963	139.48	142.01	2.54	6E21A010536
10/31/1963	139.56	143.47	3.91	6E21A010537
11/1/1963	139.56	142.65	3.09	6E21A010538
11/12/1963	139.59	142.93	3.34	6E21A010539
11/15/1963	139.59	142.87	3.28	6E21A010540
12/1/1963	139.62	143.14	3.52	6E21A010541
12/5/1963	139.63	143.37	3.74	6E21A010542
12/15/1963	139.64	145.15	5.51	6E21A010543
1/2/1964	139.67	143.17	3.50	6E21A010544
1/6/1964	139.68	142.74	3.07	6E21A010545
1/15/1964	139.69	142.93	3.23	6E21A010546
2/1/1964	139.72	142.01	2.29	6E21A010547
2/5/1964	139.72	142.00	2.28	6E21A010548
2/18/1964	139.73	140.83	1.09	6E21A010549
3/1/1964	139.74	143.08	3.34	6E21A010550
3/9/1964	139.72	143.31	3.59	6E21A010551
3/15/1964	139.71	143.17	3.46	6E21A010552
3/20/1964	139.70	144.02	4.32	6E21A010553
4/1/1964	139.67	141.07	1.40	6E21A010554
4/3/1964	139.66	141.07	1.41	6E21A010555
4/15/1964	139.60	141.71	2.11	6E21A010556
5/1/1964	139.53	140.64	1.12	6E21A010557
5/8/1964	139.48	140.37	0.88	6E21A010558
5/11/1964	139.47	141.34	1.88	6E21A010559
5/15/1964	139.44	140.06	0.62	6E21A010560
6/1/1964	139.35	139.73	0.38	6E21A010561
6/3/1964	139.34	139.61	0.27	6E21A010562
6/15/1964	139.27	139.42	0.16	6E21A010563
6/30/1964	139.18	139.15	-0.03	6E21A010564
7/7/1964	139.12	140.25	1.13	6E21A010565
7/23/1964	138.96	139.48	0.52	6E21A010566
8/5/1964	138.86	139.48	0.61	6E21A010567
9/11/1964	138.73	140.58	1.85	6E21A010568
9/30/1964	138.72	141.51	2.79	6E21A010569
11/2/1964	138.76	142.54	3.78	6E21A010570
12/1/1964	138.87	143.14	4.27	6E21A010571
1/6/1965	138.89	143.18	4.29	6E21A010572

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/1/1965	138.92	142.72	3.80	6E21A010573
3/3/1965	138.93	143.40	4.47	6E21A010574
3/16/1965	138.97	141.80	2.84	6E21A010575
4/5/1965	139.15	143.47	4.33	6E21A010576
5/5/1965	139.37	140.93	1.56	6E21A010577
5/24/1965	139.38	141.71	2.33	6E21A010578
6/29/1965	139.30	141.48	2 18	6E21A010579
7/7/1965	139.25	141.72	2 47	6E21A010580
7/20/1965	139.15	140.28	1.12	6E21A010581
7/22/1965	139.14	138.39	-0.75	6E21A010582
8/3/1965	139.06	140.89	1.82	6E21A010583
10/4/1965	138.94	142.66	3.72	6E21A010584
10/25/1965	138.96	142.72	3 76	6E21A010585
10/26/1965	138.96	142.82	3.87	6E21A010586
11/5/1965	138.98	143.00	4.02	6E21A010587
12/10/1965	139.14	143.18	4.03	6E21A010588
1/4/1966	139.23	143.00	3.77	6E21A010589
2/1/1966	139.31	143.00	3.68	6E21A010590
3/3/1966	139.38	142.93	3.55	6E21A010591
3/10/1966	139.40	142 94	3.55	6E21A010592
4/5/1966	139.46	142.32	2.86	6E21A010593
5/3/1966	139.66	142.39	2.73	6E21A010594
6/2/1966	139.94	141.13	1.19	6E21A010595
7/6/1966	140.12	142.32	2.20	6E21A010596
8/1/1966	140.18	142.67	2.49	6E21A010597
9/7/1966	140.21	142.82	2.61	6E21A010598
10/5/1966	140.22	143.11	2.90	6E21A010599
10/26/1966	140.22	143.32	3.11	6E21A010600
1/13/1967	140.23	143.72	3.49	6E21A010601
2/13/1967	140.24	143.84	3.60	6E21A010602
3/7/1967	140.24	143.75	3.51	6E21A010603
3/23/1967	140.24	143.87	3.64	6E21A010604
4/24/1967	140.23	143.78	3.55	6E21A010605
8/17/1967	140.14	143.45	3.30	6E21A010606
10/13/1967	140.10	143.78	3.68	6E21A010607
3/13/1968	140.07	144.33	4.26	6E21A010608
6/27/1968	141.15	144.12	2.96	6E21A010609
11/8/1968	142.08	144.15	2.07	6E21A010610
3/26/1969	141.76	144.39	2.63	6E21A010611
3/27/1969	141.76	144.60	2.85	6E21A010612
10/3/1969	141.32	144.48	3.16	6E21A010613
10/28/1969	141.27	144.79	3.51	6E21A010614
1/29/1970	141.14	144.45	3.32	6E21A010615
3/23/1970	141.07	144.76	3.68	6E21A010616
4/3/1970	141.06	144.51	3.45	6E21A010617
8/6/1970	140.89	144.42	3.54	6E21A010618
11/10/1970	140.74	144.48	3.74	6E21A010619
3/30/1971	140.61	144.60	3.99	6E21A010620
5/19/1971	140.56	144.54	3.99	6E21A010621
9/1/1971	140.41	144.48	4.07	6E21A010622

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/1/1972	140.22	144.42	4.20	6E21A010623
6/15/1972	140.11	144.33	4.22	6E21A010624
9/7/1972	139.99	144.18	4.19	6E21A010625
12/20/1972	139.90	144.21	4.30	6E21A010626
3/16/1973	139.89	144.24	4.35	6E21A010627
6/21/1973	139.86	143.66	3.80	6E21A010628
9/25/1973	139.78	143.90	4.13	6E21A010629
12/14/1973	139.72	143.90	4.18	6E21A010630
3/20/1974	139.67	143.84	4.17	6E21A010631
6/20/1974	139.57	143.54	3.97	6E21A010632
8/6/1974	139.50	143.29	3.79	6E21A010633
10/29/1974	139.40	143.48	4.07	6E21A010634
1/30/1975	139.36	143.45	4.09	6E21A010635
5/8/1975	139.28	143.14	3.86	6E21A010636
8/5/1975	139.16	142.62	3.47	6E21A010637
10/31/1975	139.08	142.44	3.36	6E21A010638
2/17/1976	139.04	142.72	3.67	6E21A010639
12/26/1978	140.80	142.86	2.06	6E21A010640
7/22/1980	142.20	140.70	-1.50	6E21A010641
8/25/1980	142.00	140.76	-1.24	6E21A010642
2/12/1981	141.76	141.19	-0.57	6E21A010643
9/22/1981	140.77	140.53	-0.23	6E21A010644
2/4/1982	140.84	140.86	0.02	6E21A010645
10/1/1982	140.23	140.12	-0.11	6E21A010646
9/27/1983	140.56	140.31	-0.25	6E21A010647
9/17/1984	139.92	139.66	-0.25	6E21A010648
2/26/1985	140.03	140.19	0.15	6E21A010649
9/12/1985	139.28	139.28	0.00	6E21A010650
5/7/1986	139.24	139.33	0.09	6E21A010651
2/18/1987	138.75	139.43	0.68	6E21A010652
9/17/1987	137.91	138.16	0.26	6E21A010653
3/10/1988	138.09	138.70	0.62	6E21A010654
9/27/1988	137.16	137.55	0.40	6E21A010655
3/31/1989	137.05	137.74	0.69	6E21A010656
9/27/1989	136.20	137.21	1.00	6E21A010657
3/13/1990	136.16	137.51	1.35	6E21A010658
9/27/1990	136.28	136.65	0.37	6E21A010659
3/11/1991	136.44	137.12	0.68	6E21A010660
9/23/1991	135.47	136.22	0.76	6E21A010661
3/16/1992	135.61	136.60	0.99	6E21A010662
9/24/1992	137.42	135.75	-1.67	6E21A010663
4/12/1993	137.40	135.65	-1.75	6E21A010664
9/17/1993	136.21	135.20	-1.00	6E21A010665
4/28/1994	135.60	135.00	-0.60	6E21A010666
7/15/2004	125.40	124.56	-0.84	6E21A020667
8/1/2004	125.35	124.23	-1.12	6E21A020668
8/15/2004	125.33	124.20	-1.13	6E21A020669
9/1/2004	125.30	124.02	-1.28	6E21A020670
9/15/2004	125.32	124.59	-0.72	6E21A020671

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/1/2004	125.33	124.41	-0.92	6E21A020672
10/15/2004	125.46	124.41	-1.05	6E21A020673
11/5/2004	125.65	124.83	-0.83	6E21A020674
11/15/2004	125.72	124.98	-0.74	6E21A020675
12/1/2004	125.81	124.98	-0.83	6E21A020676
12/15/2004	125.90	125.53	-0.37	6E21A020677
1/1/2005	126.01	126.11	0.10	6E21A020678
1/15/2005	126.08	126.30	0 21	6E21A020679
2/1/2005	126.17	126.00	-0.17	6E21A020680
2/10/2005	126.21	125.68	-0.53	6E21A020681
2/15/2005	126.23	126.08	-0.15	6E21A020682
3/1/2005	126.29	126.33	0.03	6E21A020683
3/15/2005	126.23	124.99	-1.24	6E21A020684
4/1/2005	126.15	124.19	-1.96	6E21A020685
4/16/2005	126.06	124.39	-1 67	6E21A020686
5/1/2005	125.97	124.23	-1 73	6E21A020687
5/16/2005	125.84	124.45	-1.39	6E21A020688
5/31/2005	125.72	124.29	-1.43	6E21A020689
6/15/2005	125.60	124.20	-1.40	6E21A020690
7/1/2005	125.47	123.54	-1.93	6E21A020691
7/15/2005	125.37	123.09	-2.27	6E21A020692
8/1/2005	125.25	123.09	-2.16	6E21A020693
8/15/2005	125.19	123.99	-1.19	6E21A020694
9/1/2005	125.11	122.73	-2.38	6E21A020695
9/15/2005	125.07	122.72	-2.35	6E21A020696
9/30/2005	125.02	122.83	-2.19	6E21A020697
10/15/2005	125.08	123.32	-1.76	6E21A020698
10/25/2005	125.12	123.97	-1.15	6E21A020699
12/23/2005	125.17	124.13	-1.04	6E21A020700
12/31/2005	125.17	123.95	-1.22	6E21A020701
1/15/2006	125.15	124 12	-1.03	6E21A020702
1/26/2006	125.13	123.90	-1.23	6E21A020703
2/16/2006	125.09	123.81	-1.28	6E21A020704
3/1/2006	125.06	123.96	-1.10	6E21A020705
3/15/2006	125.04	124.60	-0.44	6E21A020706
3/30/2006	125.01	123.44	-1.57	6E21A020707
5/6/2006	124.80	122.88	-1.93	6E21A020708
5/15/2006	124.72	122.83	-1.90	6E21A020709
6/1/2006	124.59	122.04	-2.54	6E21A020710
6/15/2006	124.47	121.84	-2.63	6E21A020711
7/1/2006	124.34	122.10	-2.23	6E21A020712
7/15/2006	124.22	122.13	-2.09	6E21A020713
8/1/2006	124.08	121.75	-2.33	6E21A020714
8/9/2006	124.03	121.72	-2.31	6E21A020715
10/6/2006	123.81	122.11	-1.70	6E21A020716
10/20/2006	123.80	123.26	-0.54	6E21A020717
10/31/2006	123.78	123.33	-0.45	6E21A020718
11/15/2006	123.79	122.25	-1.54	6E21A020719
11/30/2006	123.79	122.42	-1.37	6E21A020720
12/15/2006	123.79	122.47	-1.32	6E21A020721

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
12/31/2006	123.78	122.52	-1.27	6E21A020722
1/15/2007	123.77	122.13	-1.64	6E21A020723
1/31/2007	123.76	122.36	-1.40	6E21A020724
2/15/2007	123.72	122.14	-1.58	6E21A020725
2/28/2007	123.69	122.37	-1.32	6E21A020726
3/15/2007	123.62	121.63	-1.99	6E21A020727
3/27/2007	123.57	121.77	-1.80	6E21A020728
4/12/2007	123.47	121.39	-2.07	6E21A020729
5/16/2007	123.19	121.13	-2.06	6E21A020730
5/21/2007	123.14	121.04	-2.10	6E21A020731
5/31/2007	123.05	121.35	-1.71	6E21A020732
6/14/2007	122.92	121.14	-1.78	6E21A020733
6/30/2007	122.78	120.47	-2.31	6E21A020734
7/12/2007	122.67	120.82	-1.86	6E21A020735
8/9/2007	122.44	120.86	-1.58	6E21A020736
8/14/2007	122.41	120.91	-1.49	6E21A020737
8/31/2007	122.29	121.19	-1.10	6E21A020738
9/13/2007	122.25	121.05	-1.20	6E21A020739
12/5/2007	122.21	123.32	1.11	6E21A020740
12/14/2007	122.23	123.61	1.39	6E21A020741
12/31/2007	122.25	122.49	0.23	6E21A020742
1/15/2008	122.32	122.83	0.51	6E21A020743
1/31/2008	122.40	123.20	0.81	6E21A020744
2/14/2008	122.37	122.80	0.43	6E21A020745
2/21/2008	122.35	122.53	0.18	6E21A020746
2/29/2008	122.33	122.10	-0.23	6E21A020747
3/14/2008	122.26	121.82	-0.44	6E21A020748
3/20/2008	122.23	121.81	-0.43	6E21A020749
4/11/2008	122.09	121.41	-0.68	6E21A020750
4/15/2008	122.06	121.57	-0.49	6E21A020751
4/30/2008	121.95	120.91	-1.04	6E21A020752
5/14/2008	121.85	121.25	-0.59	6E21A020753
5/31/2008	121.73	120.73	-0.99	6E21A020754
6/14/2008	121.60	120.64	-0.96	6E21A020755
6/30/2008	121.45	120.85	-0.61	6E21A020756
7/15/2008	121.33	120.92	-0.41	6E21A020757
7/31/2008	121.21	120.74	-0.47	6E21A020758
8/14/2008	121.12	120.39	-0.73	6E21A020759
8/31/2008	121.02	120.31	-0.71	6E21A020760
9/11/2008	120.98	120.80	-0.19	6E21A020761
9/16/2008	120.97	120.54	-0.43	6E21A020762
9/30/2008	120.92	120.54	-0.38	6E21A020763
10/14/2008	120.91	120.00	-0.90	6E21A020764
10/31/2008	120.89	120.44	-0.45	6E21A020765
11/15/2008	120.90	120.82	-0.08	6E21A020766
11/30/2008	120.92	121.58	0 66	6E21A020767
12/1/2008	120.92	120.88	-0.04	6E21A020768
12/2/2008	120.93	120.87	-0.06	6E21A020769
12/5/2008	120.94	120.88	-0.07	6E21A020770
12/14/2008	121.00	121.22	0.22	6E21A020771

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
12/29/2008	121.09	121.82	0.74	6E21A020772
1/14/2009	121.09	121.48	0.39	6E21A020773
1/29/2009	121.07	121.48	0.41	6E21A020774
2/14/2009	121.07	122.09	1.02	6E21A020775
2/28/2009	121.08	121.38	0.30	6E21A020776
3/14/2009	121 03	120.88	-0.15	6E21A020777
3/31/2009	120.96	120.72	-0.24	6E21A020778
4/14/2009	120.86	120.79	-0.07	6E21A020779
4/30/2009	120.76	120.99	0.24	6E21A020780
5/15/2009	120.62	120.52	-0.10	6E21A020781
5/31/2009	120.47	120.35	-0.11	6E21A020782
6/15/2009	120.34	120.48	0.14	6E21A020783
6/30/2009	120.21	120.68	0.47	6E21A020784
7/14/2009	120.09	120.54	0.45	6E21A020785
7/31/2009	119.94	120.04	0.10	6E21A020786
8/14/2009	119.85	120.01	0.16	6E21A020787
8/31/2009	119.73	120.11	0.38	6E21A020788
9/14/2009	119.70	120.08	0.38	6E21A020789
9/30/2009	119.66	119.88	0.22	6E21A020790
10/14/2009	119.66	120.03	0.38	6E21A020791
10/31/2009	119.65	120.28	0.63	6E21A020792
11/15/2009	119.67	120.34	0.67	6E21A020793
11/30/2009	119.69	120.72	1.03	6E21A020794
12/25/2009	119.77	120.89	1.12	6E21A020795
12/31/2009	119.79	120.99	1.20	6E21A020796
1/15/2010	119.78	120.46	0.68	6E21A020797
1/31/2010	119.77	121.20	1.43	6E21A020798
2/15/2010	119.78	121.54	1.76	6E21A020799
2/28/2010	119.79	121.31	1.51	6E21A020800
3/15/2010	119.75	121.31	1 56	6E21A020801
3/31/2010	119.69	120.53	0.85	6E21A020802
4/15/2010	119.59	120.39	0.80	6E21A020803
4/30/2010	119.50	120.25	0.75	6E21A020804
5/14/2010	119.37	119.92	0.55	6E21A020805
5/31/2010	119.22	120.06	0.83	6E21A020806
6/15/2010	119.10	119.88	0.78	6E21A020807
6/30/2010	118.98	119.50	0.52	6E21A020808
7/15/2010	118.86	119.31	0.46	6E21A020809
7/31/2010	118.72	119.30	0.58	6E21A020810
8/15/2010	118.63	118.91	0.28	6E21A020811
8/31/2010	118.53	119.22	0.69	6E21A020812
9/15/2010	118.49	118.91	0.42	6E21A020813
9/30/2010	118.46	119.29	0.83	6E21A020814
10/15/2010	118.45	119.32	0.87	6E21A020815
10/31/2010	118.44	119.67	1.22	6E21A020816
11/15/2010	118.46	119.70	1.23	6E21A020817
11/18/2011	117.50	119.29	1.79	6E21A020818
4/17/2012	117.49	118.78	1.29	6E21A020819
5/3/2012	117.38	118.26	0.88	6E21A020820
11/14/2012	116.51	118.15	1.64	6E21A020821

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
4/9/2013	116.44	118.18	1.75	6E21A020822
11/13/2013	115.46	118.02	2.56	6E21A020823
11/25/2013	115.48	118.25	2.78	6E21A020824
2/5/2014	115.52	117.79	2.27	6E21A020825
4/9/2014	115.32	117.02	1.70	6E21A020826
6/3/2014	114.94	116.80	1.86	6E21A020827
8/6/2014	114.45	116.75	2.30	6E21A020828
12/9/2014	114.37	117.44	3.07	6E21A020829
3/30/2015	114.40	116.97	2.57	6E21A020830
4/15/2015	114.31	116.78	2.47	6E21A020831
11/19/2015	113.46	116.03	2.57	6E21A020832
4/12/2016	113.62	115.97	2.35	6E21A020833
11/9/1954	148.23	147.74	-0.49	6E21B010817
2/12/2004	125.38	127.62	2.25	6E21B010818
8/25/1980	142.05	139.41	-2.64	6E21B020819
2/12/2004	125.60	124.06	-1.54	6E21B020820
2/10/2005	125.79	123.51	-2.28	6E21B020821
5/5/2005	125.73	123.48	-2.26	6E21B020822
8/23/2005	125.06	122.53	-2.52	6E21B020823
1/5/2006	124.99	122.68	-2.31	6E21B020824
6/14/2006	124.46	121.86	-2.60	6E21B020825
8/25/1980	142.04	141.92	-0.12	6E21F010826
7/26/1965	138.91	141.93	3.02	6E23M010827
3/25/1994	136.72	134.68	-2.05	6E23M010828
8/24/1994	136.35	134.34	-2.01	6E23M010829
10/6/1994	136.27	134.40	-1.86	6E23M010830
12/21/1994	136.13	134.22	-1.91	6E23M010831
4/12/1995	135.60	134.25	-1.35	6E23M010832
6/21/1995	135.02	134.13	-0.89	6E23M010833
10/2/1995	134.61	133.92	-0.69	6E23M010834
12/28/1995	134.55	134.07	-0.48	6E23M010835
4/11/1996	134.29	133.31	-0.98	6E23M010836
8/9/1996	133.64	133.18	-0.46	6E23M010837
10/23/1996	133.50	134.01	0.51	6E23M010838
1/3/1997	133.49	133.28	-0.21	6E23M010839
5/9/1997	132.97	132.30	-0.67	6E23M010840
9/3/1997	132.67	132.15	-0.53	6E23M010841
12/3/1997	132.97	132.36	-0.61	6E23M010842
5/13/1998	132.74	132.21	-0.54	6E23M010843
11/12/1998	132.32	131.90	-0.41	6E23M010844
3/12/1999	132.16	123.67	-8.48	6E23M010845
5/17/1999	131.91	131.26	-0.64	6E23M010846
11/12/1999	131.56	130.99	-0.57	6E23M010847
9/15/2000	131.04	129.89	-1.15	6E23M010848
12/18/2000	130.85	129.80	-1.05	6E23M010849
5/17/2001	130.29	130.38	0.09	6E23M010850

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/17/2001	130.17	129.65	-0.53	6E23M010851
11/14/2001	130.13	129.83	-0.30	6E23M010852
2/12/2002	129.82	129.19	-0.63	6E23M010853
8/30/2002	129.28	129.16	-0.12	6E23M010854
12/13/2002	129.12	129.04	-0.08	6E23M010855
3/17/2003	128.77	128.86	0.08	6E23M010856
6/30/2003	128.30	128.79	0.50	6E23M010857
10/6/2003	128.36	128.76	0.40	6E23M010858
12/29/2003	128.18	128.64	0.46	6E23M010859
2/12/2004	128.01	128.86	0.85	6E23M010860
4/8/2004	127 57	128.25	0.67	6E23M010861
11/18/2004	127.81	128.15	0.34	6E23M010862
2/10/2005	127.95	128.49	0 54	6E23M010863
8/24/2005	127.27	127.79	0.52	6E23M010864
1/5/2006	127.04	127.94	0 90	6E23M010865
6/14/2006	126.08	127.21	1.13	6E23M010866
8/17/2006	126.28	126.14	-0.13	6E23M010867
1/10/2007	125.93	126.42	0.48	6E23M010868
6/1/2007	124.94	125.87	0.93	6E23M010869
9/21/2007	125.07	126.11	1.05	6E23M010870
5/8/2008	123.86	126.17	2.31	6E23M010871
8/12/2008	123.96	125.62	1.66	6E23M010872
5/13/1998	134.68	135.31	0.62	6E25R010890
11/12/1998	134.40	135.15	0.75	6E25R010891
3/12/1999	134.20	134.97	0.77	6E25R010892
5/17/1999	134.10	134.94	0.84	6E25R010893
11/22/1999	133.77	134.39	0.62	6E25R010894
3/24/2000	133.55	134.48	0.93	6E25R010895
6/29/2000	133.37	134.24	0.87	6E25R010896
9/15/2000	133.22	133.99	0.77	6E25R010897
12/18/2000	133.04	134.03	0.98	6E25R010898
5/17/2001	132.75	133.81	1.06	6E25R010899
10/17/2001	132.45	135.79	3.35	6E25R010900
11/17/2001	132.39	135.76	3.38	6E25R010901
2/12/2002	132.21	135.64	3.43	6E25R010902
8/20/2002	131.82	133.29	1.47	6E25R010903
12/13/2002	131.57	133.20	1.63	6E25R010904
3/17/2003	131.37	133.05	1.68	6E25R010905
6/30/2003	131.15	132.87	1.72	6E25R010906
10/6/2003	130.94	132.75	1.80	6E25R010907
12/29/2003	130.77	132.56	1.79	6E25R010908
2/12/2004	130.67	132.47	1.80	6E25R010909
4/8/2004	130.55	132.38	1.83	6E25R010910
11/18/2004	130.22	132.17	1.95	6E25R010911
5/5/2005	129.98	131.80	1.82	6E25R010912
8/23/2005	129.77	131.59	1.82	6E25R010913
10/12/2005	129.67	131.54	1.87	6E25R010914
1/5/2006	129.56	130.61	1.05	6E25R010915
2/22/2006	129.47	131.37	1.90	6E25R010916

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/12/2006	129.25	131.22	1.98	6E25R010917
6/14/2006	129.24	131.31	2.07	6E25R010918
8/17/2006	129.11	131.31	2.21	6E25R010919
1/10/2007	128.79	130.89	2.10	6E25R010920
2/12/2004	128.59	129.71	1.11	6E28Q010921
2/21/2008	124.89	127.45	2.56	6E28Q010922
12/1/2008	123.96	126.91	2.95	6E28Q010923
12/3/2008	123.97	127.11	3.14	6E28Q010924
5/20/2016	116.66	121.47	4.81	6E28Q010925
6/30/1980	140.65	140.99	0.33	6E29K020925
6/30/1987	138.11	141.90	3.79	6E29K020926
6/30/1991	135.99	139.46	3.47	6E29K020927
6/30/1993	136.61	134.71	-1.90	6E29K020928
6/30/1997	133.46	150.13	16.67	6E29K020929
6/2/1998	133.18	147.66	14.48	6E29K020930
6/29/1999	132.22	132.15	-0.07	6E29K020931
6/5/2000	131.25	131.60	0.35	6E29K020932
6/8/2001	130.27	130.62	0.36	6E29K020933
7/29/2002	129.42	128.58	-0.84	6E29K020934
7/31/2003	127.98	127.97	-0.01	6E29K020935
2/10/2004	127.75	127.67	-0.08	6E29K020936
2/12/2005	127.73	126.91	-0.82	6E29K020937
2/17/2006	126.90	126.57	-0.33	6E29K020938
5/21/2006	126.44	126.51	0.07	6E29K020939
3/8/2007	125.23	125.20	-0.03	6E29K020940
12/1/2008	122.92	123.13	0.21	6E29K020941
12/3/2008	122.91	123.45	0.54	6E29K020942
3/25/2010	121.68	122.51	0.83	6E29K020943
10/12/2010	120.70	121.53	0.83	6E29K020944
4/9/2013	118.37	119.49	1.12	6E29K020945
10/18/2013	118.39	119.49	1.10	6E29K020946
3/28/2014	117.58	119.15	1.57	6E29K020947
3/10/2015	116.27	118.91	2.64	6E29K020948
3/23/2016	115.33	118.57	3.24	6E29K020949
11/19/1952	152.31	156.15	3.84	6E29N010943
11/19/1953	151.26	154.34	3.08	6E29N010944
2/3/1954	151.21	153.37	2.16	6E29N010945
2/24/1954	151.16	153.57	2.41	6E29N010946
11/9/1954	150.11	153.34	3.23	6E29N010947
11/29/1955	148.96	150.85	1.89	6E29N010948
3/18/1956	148.80	151.40	2.60	6E29N010949
11/16/1956	147.82	150.97	3.15	6E29N010950
3/15/1957	147.76	149.29	1.53	6E29N010951
11/26/1957	146.90	149.96	3.06	6E29N010952
3/15/1958	146.86	149.30	2.44	6E29N010953
11/5/1958	145.81	145.78	-0 03	6E29N010954
11/24/1959	144.68	148.04	3.37	6E29N010955

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/27/1960	144.76	147.75	2.99	6E29N010956
11/22/1960	143.71	147.19	3.48	6E29N010957
3/8/1961	143.65	146.75	3.10	6E29N010958
10/26/1961	142.69	146.33	3.63	6E29N010959
3/15/1962	142.69	146.09	3.41	6E29N010960
11/2/1962	141.68	146.34	4.66	6E29N010961
3/15/1963	141.65	145.58	3.93	6E29N010962
10/31/1963	140.95	146.14	5.19	6E29N010963
3/20/1964	140.94	145.87	4.93	6E29N010964
11/12/1964	140.03	144.91	4.88	6E29N010965
3/19/1965	140.45	145.32	4.87	6E29N010966
7/29/1965	140.40	141.27	0.87	6E29N010967
7/30/1965	140.39	141.27	0.88	6E29N010968
10/26/1965	140.05	144.41	4.37	6E29N010969
3/3/1966	140.24	144.58	4.34	6E29N010970
10/26/1966	140.14	144.36	4.22	6E29N010971
3/23/1967	140.23	144.46	4.24	6E29N010972
10/24/1967	139.98	144.33	4.35	6E29N010973
3/13/1968	140.07	144.35	4.27	6E29N010974
11/8/1968	140.69	144.34	3.65	6E29N010975
3/27/1969	140.77	144.51	3.74	6E29N010976
10/28/1969	140.54	144.57	4.03	6E29N010977
3/23/1970	140.62	144.68	4.07	6E29N010978
11/10/1970	140.33	144.59	4.26	6E29N010979
3/30/1971	140.39	144.65	4.26	6E29N010980
3/10/2009	123.60	125.67	2.07	6E29N020981
6/30/1995	137.68	137.69	0.01	6E32D010982
6/30/1997	135.19	135.55	0.36	6E32D010983
6/2/1998	135.04	134.46	-0.59	6E32D010984
6/29/1999	133.19	133.51	0.32	6E32D010985
6/5/2000	132.54	132.38	-0.16	6E32D010986
6/8/2001	131.75	131.35	-0.40	6E32D010987
7/29/2002	129.19	130.07	0.88	6E32D010988
7/31/2003	128.19	128.24	0.04	6E32D010989
5/13/2005	127.13	127.60	0.47	6E32D010990
5/21/2006	127.42	126.99	-0.44	6E32D010991
10/12/2010	120.61	122.24	1.63	6E32D010992
4/9/2013	119.52	121.15	1.63	6E32D010993
10/18/2013	116.67	121.15	4.48	6E32D010994
3/28/2014	117.65	121.15	3.50	6E32D010995
3/10/2015	117.08	120.54	3.46	6E32D010996
3/23/2016	116.38	120.54	4.16	6E32D010997
6/30/1980	139.95	138.93	-1.02	6E32R010992
5/10/1983	140.23	138.81	-1.42	6E32R010993
5/26/1983	140.21	138.75	-1.46	6E32R010994
9/30/1983	140.46	138.81	-1.65	6E32R010995
12/11/1983	140.34	138.87	-1.47	6E32R010996

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
4/6/1984	140.26	138.90	-1.36	6E32R010997
7/19/1984	140.11	138.75	-1.36	6E32R010998
9/21/1984	140.01	138.72	-1.29	6E32R010999
2/16/1985	140.00	138.90	-1.10	6E32R011000
5/26/1985	139.89	138.59	-1.29	6E32R011001
1/20/1986	139.65	138.44	-1.20	6E32R011002
4/22/1986	139.60	138.41	-1.19	6E32R011003
9/11/1986	139.33	137.77	-1.56	6E32R011004
12/8/1986	139.24	137.92	-1.32	6E32R011005
4/27/1987	139.13	137.83	-1.30	6E32R011006
6/30/1987	139.01	138.02	-0.99	6E32R011007
7/27/1987	138.95	137.74	-1.21	6E32R011008
11/19/1987	138.83	137.89	-0.94	6E32R011009
1/20/1988	138.81	137.92	-0.88	6E32R011010
4/1/1988	138.75	137.34	-1.40	6E32R011011
6/8/1988	138.63	137.28	-1.35	6E32R011012
10/25/1988	138.33	137.10	-1.23	6E32R011013
2/3/1989	138.21	137.25	-0.95	6E32R011014
8/8/1989	137.90	136.40	-1.50	6E32R011015
10/26/1989	137.73	136.31	-1.42	6E32R011016
2/6/1990	137.59	136.49	-1.10	6E32R011017
9/1/1990	137.78	135.85	-1.93	6E32R011018
1/14/1991	137.36	136.73	-0.63	6E32R011019
2/19/1991	137.30	136.40	-0.90	6E32R011020
3/5/1991	137.28	136.61	-0 67	6E32R011021
3/19/1991	137.27	136.49	-0.78	6E32R011022
4/11/1991	137.24	136.48	-0.76	6E32R011023
5/30/1991	137.16	135.63	-1.52	6E32R011024
6/30/1991	137.10	135.58	-1.52	6E32R011025
10/31/1991	136.88	135.67	-1.21	6E32R011026
1/7/1992	136.81	135.85	-0.96	6E32R011027
3/12/1992	136.78	135.97	-0.80	6E32R011028
5/12/1992	136.91	135.55	-1.37	6E32R011029
7/7/1992	137.73	135.39	-2.34	6E32R011030
9/2/1992	137.44	135.23	-2.22	6E32R011031
10/13/1992	137.26	135.21	-2.05	6E32R011032
12/8/1992	137.10	135.30	-1.80	6E32R011033
1/21/1993	137.32	135.52	-1.80	6E32R011034
2/3/1993	137.48	135.52	-1.96	6E32R011035
2/12/1993	137.49	135.52	-1.97	6E32R011036
2/24/1993	137.48	135.55	-1.94	6E32R011037
3/11/1993	137.45	135.39	-2.06	6E32R011038
3/27/1993	137.41	135.18	-2.23	6E32R011039
4/16/1993	137.35	135.09	-2.27	6E32R011040
5/11/1993	137.29	135.09	-2.20	6E32R011041
6/30/1993	137.16	135.58	-1.58	6E32R011042
7/2/1993	137.15	134.88	-2.28	6E32R011043
8/19/1993	137.03	134 81	-2.22	6E32R011044
10/20/1993	136.91	134.75	-2.16	6E32R011045
12/24/1993	136.85	134.75	-2.10	6E32R011046

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/11/1994	136.82	134.97	-1.86	6E32R011047
3/25/1994	136.81	134.85	-1.96	6E32R011048
5/25/1994	137.13	134.54	-2.59	6E32R011049
8/24/1994	137.00	134.36	-2.65	6E32R011050
10/6/1994	136.87	134.36	-2.52	6E32R011051
12/21/1994	136.74	134.27	-2.47	6E32R011052
2/24/1995	136.71	134.36	-2.35	6E32R011053
4/4/1995	136.68	134.21	-2.48	6E32R011054
6/21/1995	136.57	133.96	-2.61	6E32R011055
10/2/1995	136.36	133.84	-2.52	6E32R011056
12/28/1995	136.24	133.75	-2.49	6E32R011057
4/11/1996	136.10	133.47	-2.62	6E32R011058
8/9/1996	135.76	133.14	-2.62	6E32R011059
10/23/1996	135.53	133.14	-2.39	6E32R011060
1/3/1997	135.36	133.11	-2.25	6E32R011061
5/9/1997	135.11	132.71	-2.40	6E32R011062
9/3/1997	135.23	132.32	-2.92	6E32R011063
12/3/1997	135.04	132.38	-2.66	6E32R011064
5/13/1998	134.78	132.04	-2.74	6E32R011065
6/2/1998	134.72	132.19	-2.53	6E32R011066
11/12/1998	134.20	131.61	-2.59	6E32R011067
3/12/1999	133.92	131.49	-2.43	6E32R011068
2/22/2002	130.87	129.48	-1.38	6E32R011069
12/5/2008	124.16	123.96	-0.19	6E32R011070
3/11/2009	124.02	123.96	-0.06	6E32R011071
2/9/2010	122.90	123.51	0.61	6E32R011072
3/25/2010	122.80	123.29	0.49	6E32R011073
11/18/2010	121.93	122.49	0.56	6E32R011074
11/18/2011	120.97	122.48	1.51	6E32R011075
2/6/2012	120.88	122.08	1.20	6E32R011076
5/3/2012	120.67	121.88	1.21	6E32R011077
11/14/2012	120.07	121.64	1.57	6E32R011078
4/9/2013	119.83	121.66	1.83	6E32R011079
11/13/2013	119.18	121.24	2.06	6E32R011080
4/9/2014	118.84	121.26	2.42	6E32R011081
6/3/2014	118.67	121.05	2 37	6E32R011082
12/9/2014	118.09	120.94	2.86	6E32R011083
3/30/2015	117.87	121.00	3.13	6E32R011084
4/15/2015	117.83	120.91	3 08	6E32R011085
11/18/2015	117.23	120.85	3.62	6E32R011086
3/23/2016	117.04	108.22	-8.82	6E32R011087
4/12/2016	117.00	120.53	3.53	6E32R011088
2/12/2004	128.49	126.19	-2.30	6E33C021072
2/10/2005	127.92	126.16	-1.76	6E33C021073
12/1/2008	123.45	122.77	-0.68	6E33C021074
12/3/2008	123.48	123.30	-0.18	6E33C021075
2/12/2004	128.54	131.85	3.31	6E33J011076
2/10/2005	127.90	132.88	4.98	6E33J011077

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/12/2005	127.27	132.18	4.91	6E33J011078
2/17/2006	127.08	129.98	2.91	6E33J011079
2/22/2006	127.07	132.22	5.15	6E33J011080
6/12/2006	126.80	131.87	5.07	6E33J011081
1/23/2007	126.07	131.72	5.65	6E33J011082
1/26/2007	126.07	131.75	5.69	6E33J011083
2/22/2007	126.04	131.76	5.72	6E33J011084
9/28/2007	125.28	131.02	5.74	6E33J011085
2/13/2008	125.05	131.13	6.08	6E33J011086
2/21/2008	125.05	131.08	6.03	6E33J011087
12/1/2008	124.16	130.61	6.45	6E33J011088
12/2/2008	124.16	131.05	6.89	6E33J011089
4/14/2009	124.03	130.57	6.53	6E33J011090
3/25/2010	123.05	130.02	6.97	6E33J011091
5/20/2016	117.50	126.65	9.15	6E33J011092
6/30/1980	138.70	140.20	1.50	6E33Q011090
6/30/1987	137.73	140.81	3.08	6E33Q011091
6/30/1991	135.92	134.41	-1.51	6E33Q011092
6/30/1993	135.92	132.89	-3.04	6E33Q011093
6/30/1995	135.45	132.89	-2.57	6E33Q011094
2/12/2004	127.45	125.66	-1.79	6E33Q011095
2/10/2005	127.23	125.36	-1.88	6E33Q011096
2/21/2008	123.81	122.88	-0.93	6E33Q011097
12/1/2008	122.74	122.50	-0.24	6E33Q011098
3/25/2010	121.74	121.56	-0.18	6E33Q011099
11/18/2010	120.06	120.80	0.74	6E33Q011100
11/18/2011	119.72	120.19	0.47	6E33Q011101
4/17/2012	119.76	119.52	-0.24	6E33Q011102
12/21/2012	118.87	119.70	0.83	6E33Q011103
4/9/2013	118.77	119.24	0.47	6E33Q011104
11/13/2013	117.87	118.91	1.03	6E33Q011105
6/25/2014	117.36	118.80	1.44	6E33Q011106
12/9/2014	116.79	119.15	2.36	6E33Q011107
3/30/2015	116.76	119.71	2.95	6E33Q011108
4/15/2015	116.70	119.56	2.86	6E33Q011109
11/19/2015	115.93	118.73	2.80	6E33Q011110
4/12/2016	115.94	118.72	2.78	6E33Q011111
2/16/1985	139.15	139.82	0.67	6E34D011099
5/26/1985	139.10	138.42	-0.68	6E34D011100
1/20/1986	138.86	139.48	0.62	6E34D011101
4/22/1986	138.83	138.08	-0.75	6E34D011102
9/11/1986	138.66	138.51	-0.15	6E34D011103
12/8/1986	138.56	138.97	0.40	6E34D011104
4/27/1987	138.46	138.57	0.11	6E34D011105
7/27/1987	138.34	138.63	0.29	6E34D011106
11/19/1987	138.18	138.72	0.54	6E34D011107
1/20/1988	138.15	139.30	1.15	6E34D011108
4/1/1988	138.11	137.78	-0.33	6E34D011109

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/8/1988	138.03	137.14	-0.89	6E34D011110
10/25/1988	137.80	136.31	-1.49	6E34D011111
2/3/1989	137.67	137.20	-0.47	6E34D011112
8/8/1989	137.37	137.56	0.19	6E34D011113
10/26/1989	137.22	138.17	0.96	6E34D011114
2/6/1990	137.08	137.99	0.91	6E34D011115
9/1/1990	136.74	137.81	1.06	6E34D011116
1/14/1991	136 61	139.00	2.38	6E34D011117
2/19/1991	136.60	138.78	2.18	6E34D011118
3/5/1991	136.59	139.21	2.62	6E34D011119
3/19/1991	136.59	138.65	2.06	6E34D011120
4/11/1991	136.58	138.91	2.33	6E34D011121
5/9/1991	136.56	138.95	2.39	6E34D011122
5/30/1991	136.53	138.36	1.82	6E34D011123
7/23/1991	136.46	138.48	2.02	6E34D011124
10/31/1991	136.32	138.69	2.38	6E34D011125
1/7/1992	136.25	138.69	2.44	6E34D011126
3/12/1992	136.21	138.65	2.43	6E34D011127
5/12/1992	136.16	138.45	2 29	6E34D011128
7/7/1992	136.18	137.84	1.66	6E34D011129
9/2/1992	136.25	137.84	1.59	6E34D011130
10/13/1992	136 30	137.78	1.47	6E34D011131
12/8/1992	136.38	137.96	1.58	6E34D011132
1/21/1993	136.46	138.30	1.84	6E34D011133
2/3/1993	136.49	138.20	1.72	6E34D011134
2/12/1993	136.51	138.23	1.73	6E34D011135
2/24/1993	136.53	138.20	1 67	6E34D011136
3/11/1993	136.56	137.96	1.40	6E34D011137
3/27/1993	136.58	137.90	1.32	6E34D011138
4/16/1993	136.61	137.44	0.84	6E34D011139
5/11/1993	136.63	137.69	1.06	6E34D011140
7/2/1993	136.63	137.72	1.08	6E34D011141
8/19/1993	136.61	137.87	1.26	6E34D011142
10/20/1993	136.57	137.99	1.42	6E34D011143
12/24/1993	136.55	138.05	1.51	6E34D011144
2/11/1994	136.53	138.05	1.52	6E34D011145
3/25/1994	136.52	137.29	0.77	6E34D011146
5/25/1994	136.48	136.71	0.23	6E34D011147
8/24/1994	136.39	136.68	0.29	6E34D011148
10/6/1994	136.33	136.95	0.62	6E34D011149
12/21/1994	136.25	136.95	0.70	6E34D011150
2/24/1995	136.21	137.35	1.14	6E34D011151
4/12/1995	136.17	137.17	1.00	6E34D011152
6/21/1995	136.07	137.26	1.19	6E34D011153
10/2/1995	135.84	137.35	1 51	6E34D011154
12/28/1995	135.66	137.41	1.76	6E34D011155
4/11/1996	135.47	138.08	2.61	6E34D011156
8/9/1996	135.18	137.05	1.86	6E34D011157
10/23/1996	134.97	137.08	2.11	6E34D011158
1/3/1997	134.80	137.14	2.34	6E34D011159

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
5/9/1997	134.55	136.92	2.38	6E34D011160
9/3/1997	134.27	136.80	2.54	6E34D011161
12/3/1997	134.10	136.83	2.74	6E34D011162
5/13/1998	133.92	135.46	1.54	6E34D011163
11/12/1998	133.54	135.31	1.77	6E34D011164
3/12/1999	133.33	135.67	2.35	6E34D011165
11/22/1999	132.73	134.76	2.03	6E34D011166
3/24/2000	132.49	134.94	2.45	6E34D011167
6/29/2000	132.27	134.70	2.43	6E34D011168
9/15/2000	132.03	134.58	2.55	6E34D011169
5/17/2001	131.50	135.00	3.50	6E34D011170
10/17/2001	131.07	134.88	3.82	6E34D011171
11/14/2001	130.99	134.85	3.86	6E34D011172
2/12/2002	130.79	134.76	3.97	6E34D011173
8/30/2002	130.28	134.61	4.33	6E34D011174
12/13/2002	129.98	133.21	3.23	6E34D011175
3/17/2003	129.79	133.02	3.23	6E34D011176
6/30/2003	129.53	132.63	3.09	6E34D011177
10/6/2003	129.22	132.81	3.59	6E34D011178
12/29/2003	129.00	132.96	3.96	6E34D011179
4/8/2004	128.80	132.66	3.86	6E34D011180
10/7/2004	128.30	132.47	4.17	6E34D011181
2/10/2005	128.16	131.80	3.64	6E34D011182
1/5/2006	127.48	131.68	4.21	6E34D011183
6/14/2006	127.12	131.04	3.92	6E34D011184
8/17/2006	126.88	130.92	4.04	6E34D011185
1/10/2007	126.49	131.10	4.61	6E34D011186
6/4/2007	126.16	130.92	4.76	6E34D011187
8/12/2007	125.89	130.10	4.21	6E34D011188
9/21/2007	125.74	130.58	4.85	6E34D011189
1/8/2008	125.48	130.89	5.41	6E34D011190
5/8/2008	125.26	130.52	5.26	6E34D011191
12/1/2008	124.57	130.42	5.85	6E34D011192
12/4/2008	124.57	130.83	6.26	6E34D011193
6/26/1952	147.43	153.83	6.39	6E34K011194
2/24/1954	146.48	152.52	6.04	6E34K011195
11/9/1954	145.99	151.82	5.83	6E34K011196
7/29/1965	139.19	145.49	6.30	6E34K011197
8/27/1980	139.39	141.37	1.98	6E34K011198
12/1/2008	125.17	130.07	4.90	6E34K011199
12/4/2008	125.16	130.57	5.40	6E34K011200
7/19/1984	139.14	139.02	-0.11	6E34M011202
2/16/1985	139.05	139.30	0.25	6E34M011203
5/26/1985	138.98	137.71	-1.27	6E34M011204
1/20/1986	138.75	139.08	0.33	6E34M011205
4/22/1986	138.73	137.92	-0.81	6E34M011206
9/11/1986	138.53	137.89	-0.63	6E34M011207
12/8/1986	138.44	138.53	0.09	6E34M011208

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
4/27/1987	138.36	138.23	-0.13	6E34M011209
7/27/1987	138.21	138.29	0.08	6E34M011210
11/19/1987	138.06	138.75	0.69	6E34M011211
1/20/1988	138.06	138.87	0.81	6E34M011212
4/1/1988	138.03	137.53	-0.50	6E34M011213
6/8/1988	137.93	137.59	-0.34	6E34M011214
10/25/1988	137.68	138.14	0.46	6E34M011215
2/3/1989	137.56	138.35	0.79	6E34M011216
8/8/1989	137.22	137.71	0.49	6E34M011217
10/26/1989	137.06	138.14	1.08	6E34M011218
2/6/1990	136.95	137.92	0.97	6E34M011219
9/1/1990	136.62	136.49	-0.13	6E34M011220
1/14/1991	136.52	139.11	2.59	6E34M011221
2/19/1991	136.52	138.96	2.44	6E34M011222
3/5/1991	136.52	139.19	2.66	6E34M011223
3/19/1991	136.52	138.78	2.25	6E34M011224
4/11/1991	136.52	138.88	2.37	6E34M011225
5/9/1991	136.49	138.75	2.26	6E34M011226
5/30/1991	136.46	138.14	1.68	6E34M011227
7/23/1991	136.37	138.08	1.71	6E34M011228
10/31/1991	136.21	138.08	1.86	6E34M011229
1/7/1992	136.16	138.08	1.91	6E34M011230
3/12/1992	136.14	138.29	2.15	6E34M011231
5/12/1992	136.10	137.83	1.74	6E34M011232
7/7/1992	136.12	137.50	1.38	6E34M011233
9/2/1992	136.18	137.65	1.47	6E34M011234
9/13/1992	136.19	137.62	1.42	6E34M011235
12/8/1992	136.29	137.83	1.54	6E34M011236
1/21/1993	136.38	138.11	1.73	6E34M011237
2/3/1993	136.41	138.05	1.63	6E34M011238
2/12/1993	136.44	138.08	1.64	6E34M011239
2/24/1993	136.46	138.05	1.58	6E34M011240
3/11/1993	136.49	137.86	1.37	6E34M011241
3/27/1993	136.52	137.77	1.25	6E34M011242
4/16/1993	136.54	137.47	0.93	6E34M011243
5/11/1993	136.55	137.59	1.04	6E34M011244
7/2/1993	136.53	137.56	1.03	6E34M011245
8/19/1993	136.48	137.53	1.04	6E34M011246
10/20/1993	136.43	137.68	1.25	6E34M011247
12/24/1993	136.41	137.74	1.33	6E34M011248
2/11/1994	136.42	137.83	1.42	6E34M011249
3/25/1994	136.41	137.80	1.39	6E34M011250
5/25/1994	136.38	137.56	1.18	6E34M011251
8/24/1994	136.29	137.50	1.21	6E34M011252
10/6/1994	136.23	137.50	1.27	6E34M011253
12/21/1994	136.17	137.50	1.33	6E34M011254
2/24/1995	136.15	137.53	1.38	6E34M011255
4/12/1995	136.11	137.41	1.29	6E34M011256
6/21/1995	136.00	137.25	1.25	6E34M011257
10/2/1995	135.76	137.28	1.52	6E34M011258

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
12/26/1995	135.61	137.28	1.68	6E34M011259
4/11/1996	135.44	137.10	1.66	6E34M011260
8/9/1996	135.11	136.95	1.83	6E34M011261
10/23/1996	134.89	136.92	2.03	6E34M011262
1/3/1997	134.74	136.95	2.21	6E34M011263
5/9/1997	134.51	136.73	2.22	6E34M011264
9/3/1997	134.23	136.58	2.36	6E34M011265
12/3/1997	134.08	136.73	2.66	6E34M011266
5/13/1998	133.93	136.58	2.65	6E34M011267
11/12/1998	133.48	136.34	2.86	6E34M011268
3/12/1999	133.28	136.25	2.96	6E34M011269
11/22/1999	132.62	135.73	3.10	6E34M011270
2/17/2000	132.47	135.73	3.26	6E34M011271
3/24/2000	132.41	135.67	3.25	6E34M011272
6/29/2000	132.15	135.30	3.15	6E34M011273
9/15/2000	131.87	135.24	3.37	6E34M011274
12/18/2000	131.62	135.27	3.66	6E34M011275
5/17/2001	131.37	135.18	3.81	6E34M011276
10/17/2001	130.87	135.03	4.16	6E34M011277
11/17/2001	130.79	135.00	4.21	6E34M011278
2/12/2002	130.62	134.88	4.26	6E34M011279
8/30/2002	130.06	134.69	4.63	6E34M011280
12/13/2002	129.76	134.57	4.81	6E34M011281
3/17/2003	129.61	134.48	4.87	6E34M011282
6/30/2003	129.34	133.96	4.62	6E34M011283
10/6/2003	128.99	134.14	5.15	6E34M011284
12/29/2003	128.78	133.96	5.18	6E34M011285
2/12/2004	128.71	133.93	5.22	6E34M011286
4/8/2004	128.62	133.75	5.13	6E34M011287
7/23/2004	128.33	133.29	4.96	6E34M011288
11/16/2004	128.01	133.44	5.43	6E34M011289
2/10/2005	128.03	133.35	5.32	6E34M011290
8/23/2005	127.60	132.99	5.38	6E34M011291
10/20/2005	127.41	130.04	2.63	6E34M011292
1/5/2006	127.29	131.71	4.41	6E34M011293
6/12/2006	126.95	132.32	5.37	6E34M011294
6/14/2006	126.95	131.95	5.00	6E34M011295
8/17/2006	126.67	132.22	5.55	6E34M011296
1/10/2007	126.27	132.10	5.83	6E34M011297
9/21/2007	125.51	128.44	2.94	6E34M011298
12/1/2008	124.35	128.31	3.96	6E34M011299
12/4/2008	124.35	128.77	4.42	6E34M011300
12/21/1954	145.09	149.48	4.39	6E35N011301
3/7/1955	145.03	149.26	4.23	6E35N011302
11/28/1955	144.63	148.44	3.81	6E35N011303
3/18/1956	144.51	147.19	2.68	6E35N011304
11/16/1956	144.04	148.05	4.00	6E35N011305
3/15/1957	143.90	145.78	1.88	6E35N011306
11/26/1957	143.42	144.30	0.89	6E35N011307

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/15/1958	143.29	145.59	2.30	6E35N011308
4/21/1958	143.25	145.30	2.06	6E35N011309
5/5/1958	143.22	146.31	3.09	6E35N011310
6/23/1958	143.13	141.31	-1.82	6E35N011311
7/22/1958	143.08	142.01	-1.06	6E35N011312
8/14/1958	143.03	141.34	-1.69	6E35N011313
9/23/1958	142.95	141.49	-1.45	6E35N011314
10/20/1958	142.90	142.65	-0.25	6E35N011315
11/12/1958	142.86	144.21	1.34	6E35N011316
1/5/1959	142.79	146.22	3.43	6E35N011317
1/26/1959	142.76	146.64	3.88	6E35N011318
2/18/1959	142.74	146.71	3.97	6E35N011319
3/12/1959	142.71	144.33	1.62	6E35N011320
3/19/1959	142.70	144.42	1.72	6E35N011321
5/12/1959	142.60	142.07	-0.53	6E35N011322
6/11/1959	142.54	142.86	0.32	6E35N011323
11/24/1959	142.23	144.95	2.72	6E35N011324
2/27/1960	142.15	143.41	1 26	6E35N011325
11/22/1960	141.69	144.74	3.05	6E35N011326
3/8/1961	141.56	143.07	1 51	6E35N011327
10/26/1961	141.14	133.97	-7.17	6E35N011328
3/15/1962	140.97	145.39	4.42	6E35N011329
11/2/1962	140.55	144.31	3.76	6E35N011330
1/23/1963	140.45	145.55	5.10	6E35N011331
2/12/1963	140.42	145.39	4.97	6E35N011332
3/15/1963	140.38	128.78	-11.61	6E35N011333
4/10/1963	140.35	142.41	2.07	6E35N011334
8/8/1963	140.13	144.84	4.71	6E35N011335
9/4/1963	140.08	144.15	4.07	6E35N011336
10/31/1963	140.05	144.59	4.54	6E35N011337
11/12/1963	140.05	144.69	4.64	6E35N011338
12/5/1963	140 04	144.56	4.52	6E35N011339
1/6/1964	140.02	145.03	5.01	6E35N011340
2/5/1964	139.99	137.65	-2.34	6E35N011341
3/9/1964	139.96	133.80	-6.17	6E35N011342
3/20/1964	139.95	144.40	4.45	6E35N011343
4/3/1964	139.94	135.41	-4.53	6E35N011344
7/7/1964	139.80	143.70	3.90	6E35N011345
7/17/1964	139.78	143.69	3.91	6E35N011346
8/5/1964	139.75	139.61	-0 14	6E35N011347
11/2/1964	139.61	144.51	4.91	6E35N011348
12/1/1964	139.58	144.62	5.04	6E35N011349
1/6/1965	139.54	141.76	2.22	6E35N011350
2/1/1965	139.51	134.25	-5.27	6E35N011351
4/5/1965	139.44	144.48	5.04	6E35N011352
5/24/1965	139.37	144.37	5.00	6E35N011353
6/24/1965	139.33	144.50	5.18	6E35N011354
6/29/1965	139.32	144.50	5.18	6E35N011355
7/30/1965	139.27	144.22	4.95	6E35N011356
8/3/1965	139.27	141.61	2.35	6E35N011357

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/4/1965	139.18	144.41	5.23	6E35N011358
10/26/1965	139.15	129.70	-9.45	6E35N011359
12/10/1965	139.14	144.39	5.25	6E35N011360
1/10/1966	139.13	142.50	3.37	6E35N011361
2/1/1966	139.12	144.39	5.27	6E35N011362
3/4/1966	139.10	143.97	4.87	6E35N011363
3/10/1966	139.09	131.43	-7.66	6E35N011364
7/6/1966	138.94	144.19	5.25	6E35N011365
8/1/1966	138.91	144.58	5.67	6E35N011366
10/26/1966	138.82	138.56	-0.25	6E35N011367
1/13/1967	138.80	144 14	5.35	6E35N011368
3/23/1967	138.77	140.83	2.06	6E35N011369
10/24/1967	138.58	128.96	-9.62	6E35N011370
11/8/1968	138.39	138.14	-0.25	6E35N011371
3/27/1969	138.49	140.41	1.92	6E35N011372
10/28/1969	138.43	137.50	-0.93	6E35N011373
3/23/1970	138.48	142.99	4.51	6E35N011374
11/12/1970	138.39	136.33	-2.06	6E35N011375
3/30/1971	138.40	142.97	4.58	6E35N011376
12/26/1978	137.92	140.68	2.76	6E35N011377
8/8/1980	139.04	140.27	1.23	6E35N011378
2/12/2004	129.96	131.40	1.44	6E35N011379
2/10/2005	129.33	131.10	1.77	6E35N011380
5/5/2005	129.25	130.58	1.33	6E35N011381
10/12/2005	128.91	130.26	1.35	6E35N011382
6/12/2006	128.45	129.90	1.44	6E35N011383
6/9/2009	125.91	128.68	2.76	6E35N011384
11/19/2015	120.48	125.21	4.73	6E35N011385
4/12/2016	120.25	124.91	4.66	6E35N011386
12/11/2008	127.10	130.08	2.98	6E35Q011385
12/1/2009	126.31	129.45	3.14	6E35Q011386
5/4/2010	125.96	129.11	3.15	6E35Q011387
11/18/2010	125.47	129.06	3.59	6E35Q011388
11/18/2011	124.66	129.04	4.38	6E35Q011389
4/11/2012	124.38	128.47	4.09	6E35Q011390
11/14/2012	123.91	128.23	4.31	6E35Q011391
4/9/2013	123.60	128.04	4.44	6E35Q011392
11/13/2013	123.11	127.75	4.64	6E35Q011393
4/10/2014	122.79	127.60	4.80	6E35Q011394
12/9/2014	122.23	127.24	5.01	6E35Q011395
3/30/2015	121.99	127.14	5.15	6E35Q011396
4/15/2015	121.96	127.09	5.13	6E35Q011397
11/19/2015	121.50	126.82	5.32	6E35Q011398
4/12/2016	121.22	126.60	5.38	6E35Q011399
4/4/1951	145.55	148.10	2.55	6E36Q011387
11/19/1953	144.72	146.68	1.96	6E36Q011388
2/24/1954	144.62	146.54	1.93	6E36Q011389
11/9/1954	144.30	144.34	0.04	6E36Q011390

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/7/1955	144 21	145.57	1.37	6E36Q011391
11/28/1955	143.89	144.20	0.31	6E36Q011392
3/18/1956	143.78	143.42	-0.36	6E36Q011393
7/2/1956	143.61	143.85	0.23	6E36Q011394
11/16/1956	143.38	143.69	0.30	6E36Q011395
3/15/1957	143.24	143.32	0.08	6E36Q011396
11/26/1957	142.84	142.63	-0.21	6E36Q011397
3/15/1958	142.72	143.27	0.55	6E36Q011398
4/21/1958	142.67	142.43	-0.24	6E36Q011399
5/5/1958	142.65	141.39	-1.26	6E36Q011400
6/23/1958	142.59	140.81	-1.77	6E36Q011401
7/22/1958	142.54	142.00	-0.54	6E36Q011402
8/14/1958	142.51	140.42	-2.09	6E36Q011403
9/23/1958	142.45	140.51	-1 94	6E36Q011404
10/20/1958	142.41	140.39	-2.02	6E36Q011405
11/5/1958	142.39	141.02	-1.36	6E36Q011406
11/12/1958	142.38	140.94	-1.44	6E36Q011407
1/5/1959	142.31	142.67	0.37	6E36Q011408
1/26/1959	142.28	143.19	0.91	6E36Q011409
3/12/1959	142.22	143.34	1.12	6E36Q011410
3/19/1959	142.22	142.67	0.46	6E36Q011411
5/12/1959	142.14	141.51	-0.62	6E36Q011412
6/11/1959	142.09	140.87	-1.21	6E36Q011413
11/24/1959	141.82	141.74	-0.07	6E36Q011414
2/27/1960	141.72	141.71	-0.01	6E36Q011415
11/22/1960	141.34	141.47	0.13	6E36Q011416
3/8/1961	141.21	142.43	1.22	6E36Q011417
10/26/1961	140.85	141.86	1.01	6E36Q011418
3/15/1962	140.67	142.43	1.77	6E36Q011419
11/2/1962	140.32	141.90	1.58	6E36Q011420
1/10/1963	140.23	142.79	2.57	6E36Q011421
2/12/1963	140.19	142.62	2.43	6E36Q011422
3/11/1963	140.15	142.22	2.06	6E36Q011423
3/15/1963	140.15	142.32	2.18	6E36Q011424
4/10/1963	140.11	141.79	1.68	6E36Q011425
5/7/1963	140.08	141.62	1.54	6E36Q011426
6/18/1963	140.01	140.88	0.87	6E36Q011427
7/9/1963	139.98	141.03	1.04	6E36Q011428
8/8/1963	139.94	140.93	0.99	6E36Q011429
9/4/1963	139.89	140.92	1.03	6E36Q011430
10/8/1963	139.86	141.15	1.28	6E36Q011431
10/31/1963	139.87	142.18	2.30	6E36Q011432
11/12/1963	139.88	141.89	2.01	6E36Q011433
12/5/1963	139.87	142.03	2.16	6E36Q011434
1/6/1964	139.84	142.89	3.05	6E36Q011435
2/5/1964	139.81	142 30	2.49	6E36Q011436
3/9/1964	139.78	141.80	2.02	6E36Q011437
3/20/1964	139.77	142.39	2.62	6E36Q011438
4/3/1964	139.76	141.60	1.84	6E36Q011439
5/8/1964	139.72	141.04	1.32	6E36Q011440

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/3/1964	139.69	140.31	0.62	6E36Q011441
7/7/1964	139.65	139.91	0.26	6E36Q011442
8/5/1964	139.61	139.89	0.28	6E36Q011443
9/11/1964	139.56	140.24	0.67	6E36Q011444
9/30/1964	139.54	140.42	0.89	6E36Q011445
11/2/1964	139.49	141.28	1 79	6E36Q011446
12/1/1964	139.46	141.78	2.33	6E36Q011447
1/6/1965	139.41	141.98	2.56	6E36Q011448
2/1/1965	139.38	142.04	2.66	6E36Q011449
3/3/1965	139.35	141.93	2.58	6E36Q011450
4/5/1965	139.31	141.29	1.98	6E36Q011451
5/5/1965	139.28	141.03	1.76	6E36Q011452
5/24/1965	139.25	140.78	1.53	6E36Q011453
6/29/1965	139.21	140.88	1.68	6E36Q011454
7/23/1965	139.18	140.73	1.55	6E36Q011455
8/3/1965	139.16	140.56	1.40	6E36Q011456
9/7/1965	139.12	140.28	1.16	6E36Q011457
10/4/1965	139.09	140.49	1.40	6E36Q011458
10/26/1965	139.06	141.02	1.96	6E36Q011459
11/5/1965	139.05	141.29	2.24	6E36Q011460
12/10/1965	139.03	141.42	2.40	6E36Q011461
1/10/1966	139.01	141.86	2.85	6E36Q011462
2/1/1966	139.00	141.85	2.85	6E36Q011463
3/4/1966	138.98	141.63	2.65	6E36Q011464
3/10/1966	138.97	141.39	2.42	6E36Q011465
4/5/1966	138.95	141.39	2.44	6E36Q011466
5/3/1966	138.93	141.11	2.18	6E36Q011467
6/2/1966	138.90	140.97	2.07	6E36Q011468
7/6/1966	138.86	140.56	1.69	6E36Q011469
8/1/1966	138.84	140.48	1.64	6E36Q011470
10/26/1966	138.75	141.36	2.61	6E36Q011471
1/13/1967	138.68	141.73	3.04	6E36Q011472
3/23/1967	138.64	141.82	3.18	6E36Q011473
10/24/1967	138.47	141.60	3.13	6E36Q011474
3/13/1968	138.39	141.83	3.44	6E36Q011475
11/8/1968	138.27	141.64	3.37	6E36Q011476
3/27/1969	138.26	141.74	3.48	6E36Q011477
10/28/1969	138.23	141.42	3.19	6E36Q011478
3/23/1970	138.21	141.62	3.42	6E36Q011479
11/12/1970	138.15	141.29	3.14	6E36Q011480
3/30/1971	138.12	141.05	2.93	6E36Q011481
8/8/1980	138.87	138.41	-0.46	6E36Q011482
2/12/2004	130.99	128.26	-2.73	6E36Q011483
10/12/2005	130.02	127.98	-2.04	6E36Q011484
3/10/2009	127.55	124.84	-2.70	6E36Q011485
1/7/1953	145.14	150.70	5.56	6E01C011522
11/19/1953	144.79	149.85	5.06	6E01C011523
1/1/1980	138.86	140.64	1.78	6E01C011524
5/5/2005	130.17	132.16	1.98	6E01C011525

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/12/2005	129.90	131.92	2.01	6E01C011526
1/5/2006	129.79	112.29	-17.50	6E01C011527
2/22/2006	129.70	131.74	2.03	6E01C011528
6/12/2006	129.51	131.59	2.08	6E01C011529
9/26/2007	128.54	130.89	2.35	6E01C011530
2/13/2008	128.23	130.76	2.52	6E01C011531
12/2/2008	127.60	130.27	2.67	6E01C011532
3/24/2009	127.37	130.14	2.77	6E01C011533
12/8/1992	136.77	134.64	-2.13	6E02C031534
1/12/1993	136.78	134.85	-1.93	6E02C031535
2/3/1993	136.82	134.88	-1.93	6E02C031536
2/12/1993	136.82	134.88	-1.94	6E02C031537
2/24/1993	136.83	134.88	-1.95	6E02C031538
3/11/1993	136.84	134.82	-2.01	6E02C031539
3/27/1993	136.84	134.61	-2.23	6E02C031540
4/16/1993	136.83	134.43	-2.40	6E02C031541
5/11/1993	136.82	134.34	-2 48	6E02C031542
7/2/1993	136.78	134.18	-2.59	6E02C031543
8/19/1993	136.73	134.09	-2.64	6E02C031544
10/20/1993	136.67	134.00	-2.67	6E02C031545
12/24/1993	136.63	134.00	-2.62	6E02C031546
2/11/1994	136.59	134.15	-2.44	6E02C031547
3/25/1994	136.57	134.15	-2.41	6E02C031548
5/25/1994	136.53	133.91	-2.62	6E02C031549
8/24/1994	136.45	133.67	-2.79	6E02C031550
10/6/1994	136.40	133.54	-2.86	6E02C031551
12/21/1994	136.33	133.48	-2.84	6E02C031552
2/24/1995	136.27	133.70	-2.58	6E02C031553
4/12/1995	136.23	133.48	-2.75	6E02C031554
6/21/1995	136.15	133.24	-2.91	6E02C031555
10/2/1995	136.01	132.99	-3.01	6E02C031556
12/28/1995	135.89	132.93	-2.95	6E02C031557
4/11/1996	135.73	132.78	-2.95	6E02C031558
8/9/1996	135.50	132.42	-3.09	6E02C031559
10/23/1996	135.34	132.32	-3.02	6E02C031560
1/3/1997	135.21	132.29	-2.92	6E02C031561
5/9/1997	134.99	131.96	-3.03	6E02C031562
9/3/1997	134.77	131.53	-3.24	6E02C031563
12/3/1997	134.64	131.59	-3.05	6E02C031564
5/13/1998	134.45	131.38	-3.07	6E02C031565
11/12/1998	134.11	130.74	-3.37	6E02C031566
3/12/1999	133.91	130.71	-3.20	6E02C031567
5/17/1999	133.80	130.47	-3.33	6E02C031568
11/22/1999	133.39	129.95	-3.44	6E02C031569
3/24/2000	133.17	129.98	-3.19	6E02C031570
9/15/2000	132.74	129.43	-3.31	6E02C031571
12/18/2000	132.52	129.12	-3.40	6E02C031572
5/17/2001	132.25	129.18	-3.06	6E02C031573
10/17/2001	131.87	128.85	-3.02	6E02C031574

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/14/2001	131.80	128.58	-3.22	6E02C031575
2/22/2002	131.60	128.58	-3.03	6E02C031576
8/30/2002	131.16	127.78	-3.37	6E02C031577
12/13/2002	130.90	127.69	-3.21	6E02C031578
3/17/2003	130.72	127.90	-2.82	6E02C031579
11/18/2004	129.38	125.95	-3.43	6E02C031580
2/10/2005	129.34	126.26	-3.08	6E02C031581
2/22/2006	128.70	128.06	-0.65	6E02C031582
1/10/2007	127.94	123.97	-3.97	6E02C031583
2/12/2004	125.20	130.09	4.89	6E04F011584
2/10/2005	126.42	129.94	3.52	6E04F011585
4/6/2006	123.01	128.83	5.82	6E04F011586
2/22/2007	122.00	128.43	6.43	6E04F011587
2/26/2008	121.32	128.11	6.79	6E04F011588
12/2/2008	119.61	127.62	8.02	6E04F011589
3/26/2009	119.76	127.16	7.39	6E04F011590
3/25/2010	118.58	126.98	8.40	6E04F011591
2/18/1953	150.07	148.40	-1.67	6E05P011590
11/19/1953	149.59	147.33	-2.26	6E05P011591
2/3/1954	149.45	147.15	-2.30	6E05P011592
2/24/1954	149.42	147.11	-2.30	6E05P011593
11/9/1954	148.98	146.30	-2.68	6E05P011594
3/7/1955	148.78	146.13	-2.65	6E05P011595
11/29/1955	148.33	145.43	-2.90	6E05P011596
3/18/1956	148.15	145.32	-2.82	6E05P011597
11/16/1956	147.72	144.79	-2.93	6E05P011598
3/15/1957	147.50	144.71	-2.79	6E05P011599
11/26/1957	147.04	144.08	-2.96	6E05P011600
3/15/1958	146.85	144.02	-2.83	6E05P011601
11/5/1958	146.40	143.42	-2.98	6E05P011602
3/12/1959	146.14	143.35	-2.80	6E05P011603
11/24/1959	145.63	142.98	-2.65	6E05P011604
2/28/1960	145.45	142.64	-2.82	6E05P011605
11/22/1960	144.96	142.37	-2.59	6E05P011606
3/8/1961	144.75	142.40	-2.36	6E05P011607
10/26/1961	144.31	142.22	-2.09	6E05P011608
3/15/1962	144.03	142.26	-1.77	6E05P011609
11/2/1962	143.60	142.08	-1.53	6E05P011610
3/15/1963	143.35	142.15	-1.20	6E05P011611
10/31/1963	143.44	141.99	-1.44	6E05P011612
3/20/1964	143.30	142.03	-1 27	6E05P011613
11/12/1964	142.73	141.74	-1.00	6E05P011614
3/19/1965	142.45	141.79	-0.66	6E05P011615
8/11/1965	142.19	141.53	-0.66	6E05P011616
10/26/1965	142.06	141.33	-0.73	6E05P011617
3/3/1966	142.15	141.33	-0.82	6E05P011618
10/26/1966	141.75	140.43	-1.31	6E05P011619
3/23/1967	141.54	141.07	-0.47	6E05P011620

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/24/1967	141.23	140.79	-0.44	6E05P011621
3/13/1968	141.06	140.76	-0.29	6E05P011622
11/8/1968	140.89	140.74	-0.15	6E05P011623
3/27/1969	140.78	140.52	-0.26	6E05P011624
10/28/1969	140.61	140.26	-0.35	6E05P011625
3/23/1970	140.47	140.19	-0.29	6E05P011626
11/10/1970	140.27	139.95	-0.32	6E05P011627
3/30/1971	140.14	139.86	-0.28	6E05P011628
8/7/1980	139.86	137.61	-2.25	6E05P011629
6/30/1980	137.76	133.68	-4.08	6E07K031630
6/30/1987	136.14	135.20	-0.93	6E07K031631
6/30/1991	134.99	133.99	-1.00	6E07K031632
6/30/1993	134.28	131.91	-2.37	6E07K031633
6/30/1995	132.24	131.55	-0.69	6E07K031634
6/30/1997	130.80	128.29	-2.51	6E07K031635
6/2/1998	131.14	127.83	-3.31	6E07K031636
6/29/1999	130.01	127.25	-2.76	6E07K031637
6/8/2001	128.07	125.48	-2.58	6E07K031638
7/29/2002	127.17	124.51	-2.67	6E07K031639
7/31/2003	126.47	123.87	-2.61	6E07K031640
5/13/2005	126.14	121.88	-4.25	6E07K031641
3/3/2006	126.00	121.61	-4.39	6E07K031642
5/21/2006	125.92	121.70	-4 22	6E07K031643
3/8/2007	125.58	121.52	-4.06	6E07K031644
12/1/2008	124.57	120.25	-4.32	6E07K031645
12/3/2008	124.57	120.90	-3.67	6E07K031646
3/25/2010	124.10	121.60	-2.50	6E07K031647
11/18/2010	125.77	125.61	-0.16	6E07K031648
4/17/2012	126.43	121.57	-4.86	6E07K031649
11/14/2012	126.52	122.07	-4.45	6E07K031650
4/9/2013	126.52	121.38	-5.14	6E07K031651
11/13/2013	126.44	121.30	-5.14	6E07K031652
11/25/2013	126.44	121.29	-5.15	6E07K031653
2/5/2014	126.41	121.22	-5.19	6E07K031654
4/9/2014	126.38	121.16	-5.22	6E07K031655
6/3/2014	126.36	121.38	-4.98	6E07K031656
3/30/2015	126.18	120.87	-5.31	6E07K031657
4/15/2015	126.17	120.91	-5.26	6E07K031658
11/19/2015	126.08	120.99	-5.09	6E07K031659
4/13/2016	126 05	120.82	-5.23	6E07K031660
2/12/2004	126.14	124.77	-1.37	6E09E011647
4/13/2007	123.32	122.43	-0 89	6E09E011648
2/22/2008	122.75	122.02	-0.74	6E09E011649
10/12/2010	119.56	120.41	0.85	6E09E011650
4/9/2013	118.33	120.11	1.78	6E09E011651
10/18/2013	118.48	120.11	1.63	6E09E011652
11/13/2013	118.47	119.57	1.10	6E09E011653
3/28/2014	118.66	121.14	2.48	6E09E011654

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
4/9/2014	118.60	119.85	1.25	6E09E011655
3/10/2015	118.21	120.72	2.51	6E09E011656
4/15/2015	118.10	119.35	1.25	6E09E011657
11/19/2015	117.41	119.15	1.74	6E09E011658
3/23/2016	117.50	120.80	3.30	6E09E011659
2/18/1953	146.19	146.46	0.28	6E10N011650
12/8/1953	145.79	144.64	-1.16	6E10N011651
2/28/1960	143.00	140.49	-2.51	6E10N011652
11/22/1960	142.53	140.49	-2.04	6E10N011653
3/8/1961	142.42	141.22	-1.20	6E10N011654
10/26/1961	141.98	140.99	-0.99	6E10N011655
3/15/1962	141.89	141.56	-0.33	6E10N011656
11/2/1962	141.45	141.25	-0.20	6E10N011657
3/15/1963	141.35	141.62	0.27	6E10N011658
10/31/1963	141.10	141.49	0.39	6E10N011659
3/20/1964	141.00	141.64	0.64	6E10N011660
11/12/1964	140.61	140.53	-0.08	6E10N011661
3/19/1965	140.47	140.94	0.47	6E10N011662
8/4/1965	140.18	140.12	-0.06	6E10N011663
10/25/1965	140.08	140.17	0.09	6E10N011664
3/3/1966	140.12	140.52	0.40	6E10N011665
10/26/1966	139.75	140.17	0.43	6E10N011666
3/23/1967	139.65	140.76	1.11	6E10N011667
10/24/1967	139.33	140.11	0.77	6E10N011668
3/12/1968	139.29	140.45	1.16	6E10N011669
11/8/1968	139.01	140.20	1.19	6E10N011670
3/27/1969	139.03	140.44	1.42	6E10N011671
10/28/1969	138.74	140.12	1.37	6E10N011672
3/23/1970	138.87	140.29	1.42	6E10N011673
11/12/1970	138.74	139.95	1.22	6E10N011674
3/30/1971	138.72	139.92	1.19	6E10N011675
8/13/1980	137.99	138.41	0.43	6E10N011676
3/11/2009	122.65	123.25	0.61	6E10N011677
3/11/2009	122.69	121.67	-1.03	6E10N041678
11/16/1953	144.68	146.46	1.78	6E11D021679
2/24/1954	144.60	145.86	1.27	6E11D021680
5/14/1954	144.38	130.69	-13.69	6E11D021681
11/8/1954	144.27	138.94	-5.33	6E11D021682
3/7/1955	144.25	145.79	1.54	6E11D021683
11/29/1955	143.93	138.03	-5.90	6E11D021684
3/18/1956	143.75	144.46	0.71	6E11D021685
7/2/1956	143.49	137.25	-6.24	6E11D021686
11/16/1956	143.41	144.07	0.65	6E11D021687
3/14/1957	143.31	134.17	-9.14	6E11D021688
11/27/1957	142.93	134.28	-8.65	6E11D021689
3/15/1958	142.87	136.10	-6.77	6E11D021690
4/21/1958	142.75	134.34	-8.41	6E11D021691

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
5/1/1958	142.73	132.08	-10.65	6E11D021692
6/23/1958	142.57	131.90	-10.67	6E11D021693
7/22/1958	142.53	132.29	-10.23	6E11D021694
8/14/1958	142.45	131.81	-10.64	6E11D021695
9/23/1958	142.43	139.46	-2.97	6E11D021696
10/20/1958	142.42	135.68	-6.74	6E11D021697
11/5/1958	142.41	140.25	-2.17	6E11D021698
11/12/1958	142.42	140.01	-2.42	6E11D021699
1/5/1959	142.42	136.56	-5.86	6E11D021700
1/26/1959	142.40	143.85	1.45	6E11D021701
2/18/1959	142.39	143.66	1.27	6E11D021702
3/12/1959	142.32	134.46	-7.86	6E11D021703
3/19/1959	142.28	133.97	-8 31	6E11D021704
5/12/1959	142.12	134.24	-7.87	6E11D021705
6/11/1959	142.05	132.08	-9.97	6E11D021706
11/24/1959	141.93	142.17	0.25	6E11D021707
2/28/1960	141.92	132.68	-9 24	6E11D021708
11/22/1960	141.46	141.45	-0.01	6E11D021709
3/8/1961	141.33	142.03	0.70	6E11D021710
10/26/1961	140.91	141.55	0.65	6E11D021711
3/15/1962	140.82	140.67	-0.15	6E11D021712
11/2/1962	140.39	141.62	1.23	6E11D021713
3/15/1963	140.31	142.30	1.99	6E11D021714
10/31/1963	140.19	142.02	1.83	6E11D021715
1/6/1964	140.09	142.52	2.43	6E11D021716
2/5/1964	140.06	135.08	-4.98	6E11D021717
3/9/1964	140.01	141.39	1.38	6E11D021718
3/20/1964	139.98	142.23	2.25	6E11D021719
4/3/1964	139.95	135.13	-4.82	6E11D021720
5/8/1964	139.83	138.22	-1.61	6E11D021721
7/7/1964	139.70	139.48	-0.22	6E11D021722
9/11/1964	139.57	136.57	-3.00	6E11D021723
9/30/1964	139.58	134.02	-5.56	6E11D021724
11/2/1964	139.55	141.65	2.10	6E11D021725
12/1/1964	139.63	142.11	2.48	6E11D021726
1/6/1965	139.57	141.90	2.34	6E11D021727
2/1/1965	139.54	142.28	2.74	6E11D021728
3/3/1965	139.49	141.36	1.86	6E11D021729
4/2/1965	139.43	133.49	-5.94	6E11D021730
4/5/1965	139.43	133.49	-5.93	6E11D021731
5/24/1965	139.30	133.84	-5 45	6E11D021732
6/29/1965	139.24	134.53	-4 72	6E11D021733
7/1/1965	139.24	142.28	3.05	6E11D021734
7/30/1965	139 19	133.51	-5.68	6E11D021735
8/3/1965	139.18	135.19	-3 99	6E11D021736
9/7/1965	139.10	133.52	-5 58	6E11D021737
10/4/1965	139.11	140.51	1.39	6E11D021738
10/25/1965	139.09	136.71	-2.38	6E11D021739
11/5/1965	139.12	141.44	2.32	6E11D021740
12/10/1965	139.28	141.73	2.45	6E11D021741

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/1/1966	139.22	135.98	-3.23	6E11D021742
3/4/1966	139.18	134.06	-5.12	6E11D021743
3/10/1966	139.16	135.33	-3.83	6E11D021744
4/5/1966	139.11	136.24	-2.87	6E11D021745
5/3/1966	139.03	134.15	-4.88	6E11D021746
6/2/1966	138.95	133.67	-5.28	6E11D021747
7/6/1966	138.90	133.10	-5.79	6E11D021748
10/27/1966	138.80	141.47	2.68	6E11D021749
1/13/1967	138.83	141.78	2.95	6E11D021750
3/23/1967	138.73	141.82	3.09	6E11D021751
6/22/1967	138.56	141.46	2.90	6E11D021752
9/26/1967	138.49	141.52	3.03	6E11D021753
9/27/1967	138.49	141.52	3.03	6E11D021754
10/24/1967	138.46	141.45	2.99	6E11D021755
3/13/1968	138.46	141.86	3.39	6E11D021756
11/8/1968	138.25	141.51	3.26	6E11D021757
3/27/1969	138.30	142.06	3.76	6E11D021758
10/28/1969	138.11	141.30	3.19	6E11D021759
3/13/1970	138.20	138.55	0.35	6E11D021760
3/23/1970	138.20	138.55	0.35	6E11D021761
11/12/1970	138.06	141.20	3.14	6E11D021762
3/30/1971	138.07	141.30	3.23	6E11D021763
12/26/1978	137.50	139.52	2.02	6E11D021764
12/27/1978	137.50	139.52	2.02	6E11D021765
7/22/1980	138.22	138.57	0.35	6E11D021766
8/13/1980	138.18	132.14	-6.03	6E11D021767
2/12/1981	138.30	139.20	0.90	6E11D021768
2/4/1982	138.23	139.00	0.77	6E11D021769
10/1/1982	138.08	137.87	-0.21	6E11D021770
9/27/1983	138.29	138.49	0.20	6E11D021771
9/17/1984	137.98	138.28	0.30	6E11D021772
2/26/1985	138.06	138.55	0.49	6E11D021773
9/13/1985	137.79	137.59	-0.20	6E11D021774
5/7/1986	137.71	136.76	-0.95	6E11D021775
2/18/1987	137.55	137.87	0.32	6E11D021776
9/17/1987	137.23	137.09	-0.14	6E11D021777
3/10/1988	137.29	136.97	-0.31	6E11D021778
9/27/1988	136.94	136.71	-0.23	6E11D021779
3/31/1989	136.92	136.74	-0.18	6E11D021780
9/27/1989	136.67	136.19	-0.48	6E11D021781
3/13/1990	136.51	136.33	-0.18	6E11D021782
9/29/1990	136.30	135.33	-0.98	6E11D021783
3/11/1991	136.12	136.21	0.09	6E11D021784
9/23/1991	135.85	135.56	-0.29	6E11D021785
3/16/1992	135.72	135.93	0.21	6E11D021786
9/24/1992	136.18	135.24	-0.94	6E11D021787
4/12/1993	136.34	134.86	-1.48	6E11D021788
9/17/1993	136.17	134.67	-1.50	6E11D021789
4/28/1994	136.09	134.66	-1.43	6E11D021790
2/10/2005	128.91	129.03	0.12	6E11D021791

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/3/2006	128.21	128.12	-0.09	6E11D021792
3/10/2009	125.76	126.36	0.60	6E11D021793
3/18/2009	125.75	126.26	0.51	6E11D021794
2/18/1953	144.44	146.60	2.16	6E11M011795
12/8/1953	144.03	146.25	2.22	6E11M011796
2/3/1954	143.98	146.27	2.29	6E11M011797
2/24/1954	143.85	145.42	1.57	6E11M011798
11/8/1954	143.62	144.97	1.35	6E11M011799
3/7/1955	143.60	145.46	1.87	6E11M011800
11/29/1955	143.39	144.02	0.63	6E11M011801
3/18/1956	143.13	144.12	0.99	6E11M011802
11/16/1956	142.91	143.71	0.79	6E11M011803
3/14/1957	142.81	142.19	-0.62	6E11M011804
11/27/1957	142.54	141.74	-0.80	6E11M011805
3/15/1958	142.44	142.71	0.27	6E11M011806
11/4/1958	142.08	140.85	-1.23	6E11M011807
3/12/1959	141.99	141.94	-0 04	6E11M011808
11/24/1959	141.67	142.25	0.59	6E11M011809
2/28/1960	141.69	140.64	-1.05	6E11M011810
11/22/1960	141.26	141.52	0.27	6E11M011811
3/8/1961	141.15	141.89	0.74	6E11M011812
10/26/1961	140.77	141.24	0.47	6E11M011813
3/15/1962	140.70	141.77	1.07	6E11M011814
11/2/1962	140.32	141.10	0.78	6E11M011815
3/15/1963	140.24	141.67	1.43	6E11M011816
10/31/1963	140.23	141.38	1.15	6E11M011817
3/20/1964	140.02	141.59	1.57	6E11M011818
11/13/1964	139.63	141.02	1.40	6E11M011819
3/19/1965	139.51	140.94	1.43	6E11M011820
7/30/1965	139.27	139.41	0.14	6E11M011821
10/25/1965	139.17	140.06	0.89	6E11M011822
3/4/1966	139.28	140.60	1.32	6E11M011823
10/27/1966	138.91	140.29	1.38	6E11M011824
3/23/1967	138.84	140.69	1.84	6E11M011825
10/24/1967	138.58	139.77	1.19	6E11M011826
3/13/1968	138.56	140.32	1.77	6E11M011827
3/27/1969	138.35	140.23	1.88	6E11M011828
10/28/1969	138.14	139.26	1.11	6E11M011829
3/23/1970	138.19	136.85	-1.34	6E11M011830
3/30/1970	138.19	139.59	1.41	6E11M011831
11/12/1970	138.06	139.19	1.13	6E11M011832
8/13/1980	137.99	135.90	-2.09	6E11M011833
7/31/1965	138.64	137.27	-1.36	6E12G011834
3/13/1968	137.96	136.22	-1.74	6E12G011835
3/27/1969	137.76	135.80	-1.96	6E12G011836
10/28/1969	137.65	135.32	-2.33	6E12G011837
3/23/1970	137.62	135.40	-2.22	6E12G011838
11/12/1970	137.53	134.93	-2.60	6E12G011839

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
3/30/1971	137.51	135.01	-2.50	6E12G011840
3/10/2009	128.76	127.13	-1.63	6E12G011841
3/26/2009	128.74	127.26	-1.47	6E12G011842
12/9/1953	145.55	144.88	-0.68	6E15E021843
9/17/1954	145.21	143.37	-1.83	6E15E021844
3/26/1956	144.75	142.15	-2.59	6E15E021845
3/29/1957	144.31	142.76	-1.54	6E15E021846
6/1/1961	142.36	141.51	-0.84	6E15E021847
6/25/1961	142.31	141.64	-0.68	6E15E021848
10/17/1963	141.30	140.22	-1.08	6E15E021849
8/4/1965	140.55	140.33	-0.22	6E15E021850
12/8/1986	136.35	135.81	-0.54	6E15E021851
4/27/1987	136.54	135.91	-0.64	6E15E021852
7/27/1987	135.92	135.78	-0.13	6E15E021853
11/19/1987	136.07	135.75	-0.32	6E15E021854
1/20/1988	136.22	135.72	-0.50	6E15E021855
4/1/1988	135.87	135.66	-0.21	6E15E021856
6/8/1988	135.30	135.51	0.21	6E15E021857
10/25/1988	134.85	135.39	0.54	6E15E021858
2/3/1989	135.29	135.36	0.07	6E15E021859
8/8/1989	134.61	134.99	0.38	6E15E021860
10/26/1989	134.39	134.81	0.42	6E15E021861
2/6/1990	134.63	134.78	0.15	6E15E021862
9/1/1990	134.03	134.50	0.47	6E15E021863
1/14/1991	133.86	135.08	1.22	6E15E021864
2/19/1991	133.98	134.81	0.83	6E15E021865
3/5/1991	133.98	134.84	0.86	6E15E021866
3/19/1991	133.98	134.75	0.76	6E15E021867
4/11/1991	133.94	134.69	0.75	6E15E021868
5/9/1991	133.83	134.47	0.65	6E15E021869
7/23/1991	133.49	133.64	0.14	6E15E021870
10/31/1991	133.33	133.56	0.23	6E15E021871
1/7/1992	133.31	133.83	0.52	6E15E021872
3/12/1992	133.88	134.02	0.14	6E15E021873
5/12/1992	133.95	133.62	-0.33	6E15E021874
7/7/1992	134.00	133.41	-0.59	6E15E021875
9/2/1992	133.94	133.32	-0.62	6E15E021876
10/13/1992	133.74	133.25	-0.49	6E15E021877
12/8/1992	133.83	133.35	-0.48	6E15E021878
1/21/1993	134.20	133.50	-0.70	6E15E021879
2/3/1993	134.42	133.53	-0.89	6E15E021880
2/12/1993	134.49	133.53	-0.96	6E15E021881
2/24/1993	134.56	133.56	-1.00	6E15E021882
3/11/1993	134.58	133.50	-1.08	6E15E021883
3/27/1993	134.59	133.44	-1.15	6E15E021884
4/16/1993	134.57	133.38	-1.19	6E15E021885
5/11/1993	134.54	133.28	-1.26	6E15E021886
7/2/1993	134.38	133.13	-1.25	6E15E021887
8/19/1993	134.23	133.01	-1.22	6E15E021888

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/20/1993	134.13	132.83	-1 30	6E15E021889
12/24/1993	134.15	132.89	-1.27	6E15E021890
2/11/1994	134.30	132.92	-1 38	6E15E021891
3/25/1994	134.40	132.95	-1 45	6E15E021892
5/25/1994	134.31	132.77	-1.54	6E15E021893
8/24/1994	134.21	132.28	-1.93	6E15E021894
10/6/1994	134.18	132.13	-2.06	6E15E021895
12/2/1994	133.92	131.91	-2.00	6E15E021896
2/24/1995	134.26	132.22	-2.04	6E15E021897
4/12/1995	134.25	131.94	-2.31	6E15E021898
6/21/1995	134.07	131.61	-2.46	6E15E021899
10/2/1995	133.72	131.12	-2.59	6E15E021900
12/28/1995	133.67	130.85	-2.83	6E15E021901
4/11/1996	133.65	130.66	-2.98	6E15E021902
8/9/1996	133.30	130.39	-2.91	6E15E021903
10/23/1996	133.21	130.24	-2.98	6E15E021904
1/3/1997	133.02	130.15	-2.87	6E15E021905
5/9/1997	133.07	130.08	-2.98	6E15E021906
9/3/1997	132.71	129.57	-3.14	6E15E021907
12/3/1997	132.61	129.47	-3.13	6E15E021908
5/13/1998	132.47	129.23	-3.24	6E15E021909
11/12/1998	131.96	128.56	-3.40	6E15E021910
3/12/1999	132.02	128.56	-3 46	6E15E021911
5/17/1999	131.72	128.59	-3.13	6E15E021912
11/12/1999	131.11	127.86	-3.25	6E15E021913
3/24/2000	131.08	127.89	-3.19	6E15E021914
6/30/2000	130.67	127.52	-3.15	6E15E021915
9/15/2000	130.33	127.22	-3.11	6E15E021916
12/18/2000	130.03	127.10	-2.93	6E15E021917
5/17/2001	129.85	127.16	-2.69	6E15E021918
10/17/2001	129.33	126.67	-2.66	6E15E021919
11/14/2001	129.23	126.64	-2.59	6E15E021920
2/22/2002	128.94	126.52	-2.42	6E15E021921
8/30/2002	127.75	126.00	-1.75	6E15E021922
12/13/2002	127.49	125.76	-1.74	6E15E021923
3/17/2003	127.48	125.79	-1.70	6E15E021924
6/30/2003	126.76	125.48	-1.28	6E15E021925
10/6/2003	126.17	124.87	-1.30	6E15E021926
12/29/2003	126.46	124.63	-1.83	6E15E021927
2/12/2004	126.48	124.60	-1.88	6E15E021928
4/8/2004	126.39	124.54	-1.85	6E15E021929
7/23/2004	125.86	124.17	-1.69	6E15E021930
11/18/2004	126.03	123.74	-2.28	6E15E021931
1/2/1950	146.84	147.41	0.57	6E15F011932
2/19/1953	145.84	146.26	0.42	6E15F011933
12/8/1953	145.50	144.76	-0.74	6E15F011934
3/7/1955	145.11	144.04	-1.07	6E15F011935
11/29/1955	144.79	143.50	-1.30	6E15F011936
3/18/1956	144.73	144.06	-0.67	6E15F011937

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/16/1956	144.38	141.62	-2.76	6E15F011938
3/15/1957	144.31	143.16	-1.15	6E15F011939
11/27/1957	143.95	142.55	-1.40	6E15F011940
3/5/1958	143.89	142.90	-0.99	6E15F011941
11/4/1958	143.57	140.62	-2.95	6E15F011942
8/5/1965	140.73	140.30	-0.43	6E15F011943
3/11/2009	125.52	124.83	-0.70	6E15G011944
6/30/1987	136.29	134.92	-1.37	6E16A021945
6/30/1991	133.42	138.58	5.16	6E16A021946
6/30/1993	133.70	136.38	2.68	6E16A021947
6/30/1995	133.15	131.05	-2.10	6E16A021948
6/30/1997	131.72	129.74	-1.98	6E16A021949
6/2/1998	131.44	128.70	-2.74	6E16A021950
6/29/1999	130.15	127.55	-2.61	6E16A021951
6/5/2000	129.51	127.00	-2.52	6E16A021952
7/29/2002	126.39	125.11	-1.29	6E16A021953
7/31/2003	124.60	124.56	-0.05	6E16A021954
5/13/2005	125.20	123.86	-1.34	6E16A021955
5/21/2006	124.33	123.16	-1.18	6E16A021956
3/8/2007	123.51	122.00	-1.51	6E16A021957
3/10/2008	122.91	121.51	-1.40	6E16A021958
12/1/2008	121.35	121.08	-0.27	6E16A021959
10/12/2010	120.35	119.74	-0.61	6E16A021960
4/9/2013	121.01	119.52	-1.49	6E16A021961
10/18/2013	120.07	118.58	-1.49	6E16A021962
3/28/2014	120.72	119.74	-0.98	6E16A021963
3/10/2015	119.80	119.77	-0.03	6E16A021964
10/12/2015	119.64	119.06	-0.58	6E16A021965
3/23/2016	120.05	120.01	-0.04	6E16A021966
6/30/1991	136.82	135.23	-1.59	6E16N011960
6/30/1993	128.06	134.62	6.56	6E16N011961
6/30/1995	126.67	129.81	3.14	6E16N011962
6/30/1997	125.57	128.40	2.84	6E16N011963
6/2/1998	126.83	127.25	0.42	6E16N011964
6/29/1999	126.05	126.79	0.74	6E16N011965
6/5/2000	123.73	124.84	1.11	6E16N011966
6/8/2001	126.41	125.23	-1.17	6E16N011967
7/29/2002	122.56	124.32	1.76	6E16N011968
7/31/2003	122.24	124.02	1.77	6E16N011969
2/10/2005	124.40	123.69	-0.71	6E16N011970
5/13/2005	123.44	122.83	-0.61	6E16N011971
5/21/2006	124.02	123.25	-0.77	6E16N011972
3/8/2007	123.11	121.27	-1.84	6E16N011973
3/20/2008	121.49	120.75	-0.74	6E16N011974
12/1/2008	119.37	119.41	0.04	6E16N011975
12/2/2008	119.42	119.93	0.51	6E16N011976
3/25/2010	120.76	121.86	1.10	6E16N011977

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
10/12/2010	119.85	118.78	-1.07	6E16N011978
10/18/2013	123.42	119.60	-3.82	6E16N011979
3/10/2015	121.85	119.15	-2.70	6E16N011980
10/12/2015	122.15	118.97	-3.18	6E16N011981
3/23/2016	122.74	120 06	-2.68	6E16N011982
6/30/1991	139.24	138.27	-0.97	6E18L011976
6/30/1993	137.51	136.14	-1.37	6E18L011977
6/30/1995	134.29	135.53	1.24	6E18L011978
6/30/1997	133.09	133.33	0.24	6E18L011979
6/2/1998	131.80	126.35	-5.45	6E18L011980
6/29/1999	130.02	126.23	-3.79	6E18L011981
6/5/2000	129.39	125.56	-3.83	6E18L011982
6/8/2001	128.04	125.29	-2.76	6E18L011983
7/29/2002	126.79	124.83	-1.96	6E18L011984
7/31/2003	125.66	124.16	-1.51	6E18L011985
5/13/2005	127.96	123.00	-4.96	6E18L011986
3/3/2006	127.62	121.08	-6.54	6E18L011987
5/21/2006	127.42	122.88	-4.54	6E18L011988
3/8/2007	126.81	122.39	-4.42	6E18L011989
12/1/2008	125.91	94.67	-31.24	6E18L011990
12/3/2008	125.91	95.33	-30.57	6E18L011991
3/25/2010	125.53	121.64	-3.89	6E18L011992
10/12/2010	124.85	119.23	-5.62	6E18L011993
4/9/2013	123.62	115.52	-8.10	6E18L011994
10/18/2013	123.38	115.88	-7.50	6E18L011995
3/28/2014	123.21	115.52	-7.69	6E18L011996
3/10/2015	122.82	115.36	-7.46	6E18L011997
4/20/2016	124.12	121.25	-2 87	6E18L011998
6/5/2000	125.44	127.90	2.46	6E20A011992
6/8/2001	127.88	125.89	-1 99	6E20A011993
7/29/2002	124.57	127.35	2.78	6E20A011994
7/31/2003	124.29	126.56	2.27	6E20A011995
2/12/2004	125.02	126.37	1.35	6E20A011996
2/10/2005	126.48	125.49	-0.99	6E20A011997
5/5/2005	125.78	124.91	-0.87	6E20A011998
5/13/2005	125.88	127.11	1.22	6E20A011999
2/17/2006	127.04	124.67	-2.37	6E20A012000
5/21/2006	126.45	126.86	0.41	6E20A012001
3/20/2008	123.99	122.66	-1.33	6E20A012002
3/12/2009	123.39	120.92	-2.47	6E20A012003
3/25/2010	122.95	121.66	-1.29	6E20A012004
10/12/2010	122.38	121.38	-1.00	6E20A012005
4/9/2013	125.49	120.89	-4.60	6E20A012006
10/18/2013	125.61	121.11	-4.50	6E20A012007
11/13/2013	125.63	120.64	-4 99	6E20A012008
3/28/2014	125.69	121.66	-4.03	6E20A012009
4/9/2014	125.70	120.95	-4.75	6E20A012010
4/15/2015	124.37	120.04	-4.33	6E20A012011

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/19/2015	124.58	120.08	-4.50	6E20A012012
4/13/2016	124.58	118.24	-6.34	6E20A012013
4/22/2016	125.00	118.40	-6.60	6E20A012014
1/1/1948	146.33	144.52	-1.81	6E22A012004
2/19/1953	145.30	146.72	1.42	6E22A012005
11/30/1953	145.00	146.78	1.77	6E22A012006
2/24/1954	144.97	145.55	0.58	6E22A012007
11/10/1954	144.67	145.75	1.08	6E22A012008
3/7/1955	144.65	145.93	1.28	6E22A012009
11/29/1955	144.38	144.76	0.38	6E22A012010
3/18/1956	144.33	145.78	1.44	6E22A012011
11/16/1956	144.03	145.58	1 55	6E22A012012
3/14/1957	144.00	145.78	1.78	6E22A012013
11/27/1957	143.69	145.60	1.92	6E22A012014
3/15/1958	143.65	145.65	2.00	6E22A012015
11/4/1958	143.38	144.90	1.53	6E22A012016
1/5/1959	143.36	144.98	1.62	6E22A012017
1/26/1959	143.35	144.98	1.63	6E22A012018
2/18/1959	143.33	145.01	1.68	6E22A012019
3/12/1959	143.32	145.16	1.84	6E22A012020
3/19/1959	143.31	145.04	1.73	6E22A012021
5/12/1959	143.24	144.98	1.74	6E22A012022
6/11/1959	143.19	144.98	1.79	6E22A012023
11/24/1959	142.98	144.86	1.88	6E22A012024
2/27/1960	142.98	144.97	1.99	6E22A012025
11/22/1960	142.64	144.66	2.02	6E22A012026
3/8/1961	142.59	144.74	2.15	6E22A012027
10/26/1961	142.27	144.28	2.01	6E22A012028
3/15/1962	142.19	144.31	2.12	6E22A012029
11/2/1962	141.88	143.88	2.01	6E22A012030
3/14/1963	141.81	143.85	2.04	6E22A012031
10/31/1963	141.73	143.81	2.08	6E22A012032
1/6/1964	141.72	143.57	1.85	6E22A012033
2/5/1964	141.72	143.44	1.72	6E22A012034
3/9/1964	141.71	143.50	1.79	6E22A012035
3/20/1964	141.70	143.85	2.14	6E22A012036
4/3/1964	141.69	143.42	1.73	6E22A012037
5/8/1964	141.65	143.31	1.66	6E22A012038
6/3/1964	141.61	143.14	1.52	6E22A012039
7/7/1964	141.56	143.15	1.59	6E22A012040
8/5/1964	141.51	143.04	1.53	6E22A012041
9/11/1964	141.46	142.87	1.41	6E22A012042
9/30/1964	141.44	142.85	1.41	6E22A012043
11/2/1964	141.40	142.90	1.50	6E22A012044
12/1/1964	141.38	142.99	1.61	6E22A012045
1/6/1965	141.37	143.07	1.70	6E22A012046
2/1/1965	141.36	143.08	1.72	6E22A012047
3/3/1965	141.34	143.09	1.75	6E22A012048
4/5/1965	141.32	143.09	1.77	6E22A012049

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
5/5/1965	141.28	142.94	1.66	6E22A012050
5/24/1965	141.25	142.91	1.66	6E22A012051
6/29/1965	141.19	142.67	1.48	6E22A012052
8/2/1965	141.14	142.76	1.63	6E22A012053
8/3/1965	141.14	142.71	1.58	6E22A012054
9/7/1965	141.09	142.71	1.62	6E22A012055
10/4/1965	141.05	142.69	1.63	6E22A012056
10/25/1965	141.03	142.71	1.69	6E22A012057
11/5/1965	141.02	142.69	1.67	6E22A012058
12/10/1965	141.05	142.83	1.78	6E22A012059
1/10/1966	141.07	142.94	1.88	6E22A012060
2/1/1966	141.07	142.85	1.78	6E22A012061
3/3/1966	141.06	143.04	1.98	6E22A012062
3/10/1966	141.06	142.81	1.75	6E22A012063
4/5/1966	141.05	142.77	1.72	6E22A012064
5/3/1966	141.01	142.66	1.64	6E22A012065
6/2/1966	140.97	142.61	1.63	6E22A012066
7/6/1966	140.92	142.73	1 81	6E22A012067
8/1/1966	140.88	142.68	1.80	6E22A012068
10/26/1966	140.77	142.64	1.87	6E22A012069
1/13/1967	140.74	142.69	1.95	6E22A012070
3/23/1967	140.71	142.71	2 00	6E22A012071
6/22/1967	140.58	142.53	1.95	6E22A012072
9/26/1967	140.44	142.09	1.65	6E22A012073
10/24/1967	140.41	142.11	1.70	6E22A012074
3/12/1968	140.36	142.34	1.98	6E22A012075
11/8/1968	140.06	142.08	2.02	6E22A012076
3/27/1969	140.03	140.34	0.31	6E22A012077
10/28/1969	139.75	142.00	2.25	6E22A012078
3/23/1970	139.69	141.64	1.95	6E22A012079
11/10/1970	139.42	141.23	1.82	6E22A012080
3/30/1971	139.39	141.33	1.93	6E22A012081
3/24/2009	130.06	136.05	5.99	6E22A012082
6/30/1980	136.98	111.39	-25.59	6E22A022083
6/30/1987	135.75	116.58	-19.18	6E22A022084
6/30/1991	134.97	125.72	-9.25	6E22A022085
6/30/1993	135.29	128.65	-6.65	6E22A022086
6/2/1998	135.18	135.53	0.36	6E22A022087
6/29/1999	134.83	136.54	1.71	6E22A022088
6/5/2000	134.46	136.84	2.38	6E22A022089
6/8/2001	133.99	136.66	2.67	6E22A022090
7/29/2002	133.37	135.38	2.02	6E22A022091
7/31/2003	132.81	135.50	2.69	6E22A022092
3/11/2009	130.30	139.12	8.82	6E22A022093
3/24/2009	130.28	137.29	7.01	6E22A022094
6/30/1987	136.89	121.76	-15.13	6E22B012095
6/30/1991	135.92	59.88	-76.04	6E22B012096
6/2/1998	135.61	134.87	-0.75	6E22B012097

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
2/12/2004	132.18	137.15	4.97	6E22B012098
2/10/2005	132.44	137.52	5.07	6E22B012099
2/17/2006	131.98	137.70	5.72	6E22B012100
2/22/2007	131.45	138.17	6.72	6E22B012101
2/21/2008	130.51	137.92	7.41	6E22B012102
12/1/2008	129.76	138.39	8.63	6E22B012103
3/25/2010	129.16	138.31	9.15	6E22B012104
11/18/2011	129.09	138.27	9.18	6E22B012105
4/17/2012	129.17	138.60	9.43	6E22B012106
12/21/2012	129.08	138.74	9.66	6E22B012107
4/9/2013	129.12	138.84	9.72	6E22B012108
5/3/2013	129.11	138.79	9.69	6E22B012109
11/25/2013	129.01	138.84	9.82	6E22B012110
2/5/2014	128.99	138.92	9.93	6E22B012111
4/9/2014	128.97	138.94	9.97	6E22B012112
6/3/2014	128.92	138.90	9.98	6E22B012113
12/9/2014	128.67	138.86	10.18	6E22B012114
3/30/2015	128.62	138.95	10.33	6E22B012115
4/15/2015	128.61	138.97	10.36	6E22B012116
11/18/2015	128.53	138.86	10.33	6E22B012117
4/13/2016	128.47	138.87	10.40	6E22B012118
6/30/1980	136.30	141.76	5.47	6E22D012103
6/30/1987	133.09	124.39	-8.70	6E22D012104
6/30/1991	132.60	114.94	-17.66	6E22D012105
6/30/1993	135.21	145.54	10.33	6E22D012106
6/30/1995	134.68	127.56	-7.12	6E22D012107
6/30/1997	132.90	126.46	-6 44	6E22D012108
6/2/1998	133.60	127.53	-6.07	6E22D012109
6/29/1999	132.36	126.77	-5.60	6E22D012110
6/5/2000	131.73	126.89	-4.84	6E22D012111
6/8/2001	129.18	126.86	-2.32	6E22D012112
2/12/2004	127.76	126.49	-1.27	6E22D012113
5/5/2005	125.99	110.00	-15.99	6E22D012114
5/13/2005	126.01	112.66	-13.36	6E22D012115
2/17/2006	126.45	114.64	-11.82	6E22D012116
5/21/2006	126.94	112.47	-14.47	6E22D012117
3/8/2007	126.03	114.88	-11.15	6E22D012118
12/1/2008	122.71	104.76	-17.95	6E22D012119
12/2/2008	122.72	105.11	-17.61	6E22D012120
3/25/2010	123.31	106.11	-17.20	6E22D012121
10/12/2010	123.51	108.49	-15.02	6E22D012122
4/9/2013	125.42	110.69	-14.73	6E22D012123
10/18/2013	125.49	109.65	-15.84	6E22D012124
3/28/2014	125.56	108.58	-16.98	6E22D012125
3/10/2015	125.11	108.67	-16.44	6E22D012126
10/12/2015	125.02	111.49	-13.53	6E22D012127
3/23/2016	124.98	112.92	-12.06	6E22D012128
6/30/1980	139.23	142.90	3.67	6E23E012121

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/30/1987	137.69	120.34	-17.35	6E23E012122
6/30/1991	136.83	126.13	-10.69	6E23E012123
6/30/1993	137.45	128.39	-9.06	6E23E012124
6/2/1998	137.54	136.16	-1.37	6E23E012125
6/29/1999	137.12	136.86	-0.26	6E23E012126
6/5/2000	136.76	137.14	0.38	6E23E012127
6/8/2001	136.41	137.99	1.58	6E23E012128
7/29/2002	135.81	137.23	1.42	6E23E012129
7/31/2003	135.42	138.66	3.24	6E23E012130
5/13/2005	135.53	139.24	3.71	6E23E012131
3/20/2008	134.01	139.36	5.36	6E23E012132
1/9/2009	133.80	139.23	5.43	6E23E012133
3/12/2009	133.67	139.75	6.07	6E23E012134
11/14/2012	133.13	123.23	-9.90	6E23E012135
6/30/1980	139.82	145.71	5.89	6E23J012135
6/30/1987	136.98	128.33	-8.65	6E23J012136
6/30/1991	136.21	112.79	-23.42	6E23J012137
6/30/1993	138.31	131.50	-6.81	6E23J012138
6/30/1995	138.95	133.91	-5 04	6E23J012139
6/30/1997	138.49	136.96	-1.54	6E23J012140
6/2/1998	139.33	138.30	-1.03	6E23J012141
6/29/1999	139.04	137.57	-1.47	6E23J012142
6/5/2000	138.83	139.88	1.05	6E23J012143
6/8/2001	138.67	139.82	1.15	6E23J012144
7/29/2002	138.19	140.55	2.36	6E23J012145
7/31/2003	138.15	140.83	2.68	6E23J012146
2/10/2004	138.26	139.58	1.32	6E23J012147
2/12/2005	138.93	142.11	3.17	6E23J012148
5/13/2005	138.56	142.41	3.85	6E23J012149
5/21/2006	138.20	140.43	2.23	6E23J012150
3/8/2007	137.32	138.39	1.07	6E23J012151
3/10/2008	136.72	137.51	0.78	6E23J012152
12/1/2008	136.30	139.40	3.10	6E23J012153
3/25/2010	136.75	141.39	4.64	6E23J012154
10/12/2010	136.52	140.39	3.87	6E23J012155
4/9/2013	136.14	140.60	4.46	6E23J012156
10/18/2013	136.38	142.85	6.47	6E23J012157
3/10/2015	135.63	143.46	7.83	6E23J012158
10/12/2015	135.38	142.92	7.54	6E23J012159
3/23/2016	135.43	143.31	7.88	6E23J012160
5/19/2004	137.73	140.41	2.68	6E23J022154
2/10/2005	138.33	143.27	4.94	6E23J022155
2/17/2006	137.83	141.44	3.61	6E23J022156
6/12/2006	137.59	141.26	3.66	6E23J022157
9/26/2008	135.72	139.79	4.07	6E23J022158
2/26/2009	136.19	140.44	4.25	6E23J022159
12/1/2009	136.01	141.35	5.34	6E23J022160
5/4/2010	136.17	141.53	5.36	6E23J022161

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/18/2010	135.70	141.26	5.56	6E23J022162
11/18/2011	136.46	142.54	6.08	6E23J022163
4/17/2012	136.20	143.85	7.65	6E23J022164
12/21/2012	133.58	144.05	10.46	6E23J022165
4/9/2013	135.55	143.65	8.10	6E23J022166
11/13/2013	135.80	143.01	7.21	6E23J022167
11/25/2013	135.79	144.26	8.46	6E23J022168
2/5/2014	135.77	143.07	7.30	6E23J022169
4/9/2014	135.69	144.48	8.79	6E23J022170
12/9/2014	135.16	144.53	9.37	6E23J022171
3/30/2015	135.07	143.18	8.11	6E23J022172
4/15/2015	135.04	143.12	8.08	6E23J022173
11/19/2015	134.91	141.75	6.84	6E23J022174
12/23/2015	135.01	141.90	6.89	6E23J022175
4/13/2016	134.74	140.04	5.30	6E23J022176
6/30/1980	141.97	138.48	-3.49	6E25A012158
6/30/1987	141.10	140.61	-0.49	6E25A012159
6/30/1991	139.81	136.04	-3.77	6E25A012160
6/30/1993	130.48	140.31	9.83	6E25A012161
6/30/1995	140.48	144.27	3.79	6E25A012162
6/30/1997	134.17	141.92	7.75	6E25A012163
6/2/1998	140.90	142.35	1.45	6E25A012164
6/29/1999	140.69	142.72	2.03	6E25A012165
6/5/2000	139.49	142.17	2.68	6E25A012166
6/8/2001	140.44	142.01	1.57	6E25A012167
7/29/2002	134.52	141.50	6 98	6E25A012168
7/31/2003	139.31	141.13	1.82	6E25A012169
2/12/2004	140.13	143.75	3.62	6E25A012170
5/21/2006	140.55	144.54	3.99	6E25A012171
6/12/2006	140.38	144.21	3.83	6E25A012172
2/22/2007	140.17	147.43	7.26	6E25A012173
3/8/2007	140.18	144.06	3.88	6E25A012174
1/20/2008	139.36	143.87	4 51	6E25A012175
9/26/2008	137.41	146.87	9.46	6E25A012176
12/1/2008	133.93	143.56	9.63	6E25A012177
2/26/2009	139.63	146.95	7.32	6E25A012178
11/18/2010	136.72	146.95	10.23	6E25A012179
4/17/2012	139.42	144.69	5.27	6E25A012180
11/14/2012	139.36	144.76	5.40	6E25A012181
4/9/2013	139.19	145.01	5 81	6E25A012182
11/25/2013	139.15	144.87	5.72	6E25A012183
2/5/2014	139.08	147.69	8 61	6E25A012184
4/9/2014	135.65	144.57	8 91	6E25A012185
11/20/2014	127.65	143.72	16.07	6E25A012186
6/30/1980	142.34	144.36	2.02	6E25C012176
6/30/1987	140.96	126.99	-13.97	6E25C012177
6/30/1991	139.83	127.60	-12.23	6E25C012178
6/30/1993	139.45	129.12	-10.33	6E25C012179

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
6/30/1995	140.73	138.21	-2.52	6E25C012180
6/30/1997	139.87	140.22	0.34	6E25C012181
6/2/1998	141.22	141.96	0.73	6E25C012182
6/29/1999	141.06	142.84	1.78	6E25C012183
6/5/2000	140.85	141.26	0.41	6E25C012184
6/8/2001	140.84	141.53	0.69	6E25C012185
7/29/2002	139.92	140.83	0.91	6E25C012186
7/31/2003	140.30	140.92	0.62	6E25C012187
2/12/2004	140.58	141.68	1.10	6E25C012188
2/17/2006	141.24	141.80	0.56	6E25C012189
6/12/2006	141.07	143.10	2.02	6E25C012190
2/22/2007	140.60	137.79	-2.81	6E25C012191
3/8/2007	140.58	142.05	1.46	6E25C012192
3/10/2008	140.15	142.44	2.29	6E25C012193
9/26/2008	139.35	135.00	-4.35	6E25C012194
12/1/2008	138.94	125.44	-13.50	6E25C012195
2/26/2009	140.01	136.55	-3.46	6E25C012196
3/25/2010	139.88	142.01	2.13	6E25C012197
11/18/2011	141.05	144.13	3.08	6E25C012198
4/17/2012	139.98	144.72	4.74	6E25C012199
11/14/2012	139.92	145.08	5.16	6E25C012200
4/9/2013	139.75	145.32	5.57	6E25C012201
11/13/2013	139.76	145.48	5.72	6E25C012202
11/25/2013	139.73	144.87	5.14	6E25C012203
2/5/2014	139.66	145.42	5.76	6E25C012204
4/9/2014	139.22	144.57	5.35	6E25C012205
11/20/2014	137.54	143.72	6.18	6E25C012206
2/5/2015	138.77	144.03	5.26	6E25C012207
11/9/2015	137.73	142.54	4.81	6E25C012208
4/28/2016	138.73	143.61	4.88	6E25C012209
1/1/1980	146.65	146.81	0.15	6E34A012194
5/5/2005	150.60	150.03	-0.57	6E34A012195
8/23/2005	150.47	150.34	-0.13	6E34A012196
10/12/2005	150.47	150.27	-0.19	6E34A012197
1/5/2006	150.71	150.47	-0.24	6E34A012198
2/22/2006	150.66	150.26	-0.40	6E34A012199
6/12/2006	150.48	150.35	-0.13	6E34A012200
2/22/2007	150.01	150.59	0.58	6E34A012201
2/13/2008	149.32	150.90	1.58	6E34A012202
12/1/2008	148.75	151.19	2.44	6E34A012203
3/25/2009	149.09	151.21	2.12	6E34A012204
11/13/2013	147.23	151.90	4.67	6E34A012205
11/20/1953	141.61	138.29	-3.32	7E07N012205
2/24/1954	141.57	138.44	-3.13	7E07N012206
11/8/1954	141.52	138.04	-3.48	7E07N012207
3/7/1955	141.52	138.21	-3.31	7E07N012208
11/29/1955	141.39	137.85	-3.54	7E07N012209
3/18/1956	141.12	137.96	-3.16	7E07N012210

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/16/1956	140.97	137.65	-3.32	7E07N012211
3/14/1957	140.87	137.47	-3.40	7E07N012212
11/27/1957	140.71	137.38	-3.32	7E07N012213
3/15/1958	140.57	137.52	-3.05	7E07N012214
11/4/1958	140.40	137.06	-3.34	7E07N012215
3/12/1959	140.22	137.27	-2.95	7E07N012216
11/24/1959	140.01	136.85	-3.16	7E07N012217
2/28/1960	140.01	136.98	-3.03	7E07N012218
11/22/1960	139.70	136.86	-2.84	7E07N012219
3/8/1961	139.53	136.95	-2.57	7E07N012220
10/26/1961	139.25	136.66	-2.60	7E07N012221
3/15/1962	139.14	136.75	-2.38	7E07N012222
11/2/1962	138.88	136.48	-2.41	7E07N012223
3/15/1963	138.74	136.56	-2.18	7E07N012224
3/20/1964	138.58	136.48	-2.10	7E07N012225
11/13/1964	138.36	135.38	-2.99	7E07N012226
3/19/1965	138.21	135.31	-2.91	7E07N012227
10/25/1965	138.00	136.09	-1.91	7E07N012228
10/3/2008	129.88	126.68	-3.20	7E07R012229
12/1/2008	129.81	127.17	-2.63	7E07R012230
12/4/2008	129.80	127.07	-2.73	7E07R012231
11/18/2010	128.69	126.26	-2.43	7E07R012232
11/14/2012	127.58	125.85	-1.73	7E07R012233
4/9/2013	127.34	125.84	-1.50	7E07R012234
11/13/2013	127.01	125.66	-1.35	7E07R012235
4/9/2014	126.76	125.62	-1.14	7E07R012236
4/15/2015	126.15	125.44	-0.71	7E07R012237
11/19/2015	125.81	125.25	-0.56	7E07R012238
3/23/2016	125.60	125.24	-0.36	7E07R012239
10/3/2008	129.88	126.68	-3.20	7E07R022231
12/1/2008	129.80	127.16	-2.65	7E07R022232
12/4/2008	129.80	127.06	-2.74	7E07R022233
1/12/2010	129.19	126.45	-2.74	7E07R022234
11/18/2010	128.69	126.26	-2.43	7E07R022235
11/14/2012	127.58	125.85	-1.73	7E07R022236
4/9/2013	127.34	125.84	-1.50	7E07R022237
11/13/2013	127.00	125.66	-1.34	7E07R022238
4/9/2014	126.76	125.62	-1.14	7E07R022239
4/15/2015	126.15	125.44	-0.71	7E07R022240
11/19/2015	125.81	125.26	-0.55	7E07R022241
3/23/2016	125.60	125.24	-0.36	7E07R022242
2/18/1953	147.06	151.91	4.85	7E20P012233
12/9/1953	146.91	149.80	2.90	7E20P012234
2/23/1954	146.84	151.61	4.77	7E20P012235
2/24/1954	146.84	151.68	4.84	7E20P012236
11/8/1954	146.75	148.99	2.24	7E20P012237
3/7/1955	146.66	149.58	2.92	7E20P012238

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
11/29/1955	146.55	148.69	2.14	7E20P012239
3/18/1956	146.44	151.08	4.63	7E20P012240
11/16/1956	146.35	151.39	5.04	7E20P012241
3/15/1957	146.26	151.72	5.46	7E20P012242
11/27/1957	146.17	152.00	5.83	7E20P012243
11/4/1958	146.00	152.00	6.00	7E20P012244
3/12/1959	145.88	152.13	6.25	7E20P012245
11/24/1959	145.79	152 26	6.47	7E20P012246
2/28/1960	145.73	152.31	6 58	7E20P012247
11/23/1960	145.61	152.34	6.73	7E20P012248
3/8/1961	145.51	152.37	6.87	7E20P012249
10/26/1961	145.42	152.42	7.00	7E20P012250
3/15/1962	145.31	152.44	7.13	7E20P012251
11/1/1962	145.22	152.43	7.21	7E20P012252
3/14/1963	145.11	152.46	7.35	7E20P012253
10/31/1963	145.08	152.47	7.39	7E20P012254
3/20/1964	144.95	152.54	7.59	7E20P012255
11/13/1964	144.90	152.35	7.45	7E20P012256
3/19/1965	144.79	152.25	7.46	7E20P012257
7/28/1965	144.76	152.33	7.58	7E20P012258
10/25/1965	144.73	152.32	7.59	7E20P012259
3/4/1966	144.67	152.04	7.36	7E20P012260
10/26/1966	144.61	152.23	7.62	7E20P012261
3/23/1967	144.50	152.20	7.70	7E20P012262
10/24/1967	144.45	152.13	7.68	7E20P012263
3/12/1968	144.35	152.13	7.78	7E20P012264
11/8/1968	144.28	152.11	7.83	7E20P012265
3/27/1969	144.18	152.04	7.86	7E20P012266
10/28/1969	144.11	151.97	7.86	7E20P012267
3/23/1970	144.01	149.94	5.93	7E20P012268
11/10/1970	143.93	151.88	7.95	7E20P012269
3/30/1971	143.82	151.85	8.03	7E20P012270
12/1/2008	139.98	151.95	11.97	7E20P012271
12/5/2008	139.99	152.09	12.10	7E20P012272
3/13/2009	139.99	151.95	11.96	7E20P012273
12/1/2008	141.32	147.40	6.08	7E30G042274
12/4/2008	141.33	147.73	6.40	7E30G042275
11/2/1952	152.60	152.37	-0.23	7E32Q012276
12/10/1953	152.48	154.51	2.03	7E32Q012277
11/10/1954	152.26	154.47	2.22	7E32Q012278
7/29/1965	150.46	153.22	2.76	7E32Q012279
2/20/1980	148.98	151.81	2.83	7E32Q012280
12/5/2008	149.28	153.28	4.00	7E32Q012281
3/12/2009	148.32	147.87	-0.46	7E03M022282
6/4/2007	127.99	199.11	71.13	6E31E030001
1/8/2008	126.78	197.63	70.85	6E31E030002

Attachment C. Residuals

Date	SIMULATED EQUIVALENT (meters)	OBSERVED VALUE (meters)	Residual (Observed - Simulated)	OBSERVATION NAME
5/8/2008	126.91	196.69	69.78	6E31E030003
8/11/2008	126.83	197.64	70.82	6E31E030004
8/12/2008	126.82	196.66	69.84	6E31E030005
12/5/2008	126.06	197.64	71.59	6E31E030006
5/13/2009	125.35	197.01	71.66	6E31E030007

APPENDIX D2

BWD Water Quality Review and Assessment

WATER QUALITY REVIEW AND ASSESSMENT: BORREGO WATER DISTRICT (BWD) WATER SUPPLY WELLS

OVERVIEW

The purpose of this Report is to review water quality data for active Borrego Water District (BWD) water supply production wells to

1) Provide an overview of water quality conditions among the wells and assess spatial variations;
2) Examine how water quality has changed over time due to overdraft;
3) Evaluate the potential relationships among multiple water quality parameters as a means to support trend analyses for the five primary chemicals of concern (COCs) that include arsenic, total dissolved solids (TDS), nitrate, sulfate, and fluoride (As, TDS, NO_3, SO_4, and F);
4) Determine how well water quality trends may (or may not) be able to be identified among BWD water supply wells; and,

The Borrego Springs Subbasin (Subbasin) of the Borrego Valley Groundwater Basin is in a state of critical overdraft and subject to the Sustainable Groundwater Management Act (SGMA). As defined under SGMA[1] "A basin is subject to critical overdraft when continuation of present water management practices would probably result in significant adverse overdraft-related environmental, social, or economic impacts."

Pursuant to SGMA a Groundwater Sustainability Plan (GSP) is currently under development for the Subbasin. This work updates and extends beyond prior work done by Dudek to assess water quality trends for BWD wells as described in the Draft Borrego Springs Subbasin Groundwater Quality Risk Assessment presented to the BWD Board on 6/28/2017.[2]

The analyses included herein will be used in subsequent ENSI reports to examine potential BWD water supply impacts and costs associated with current and future water quality conditions.

[1] See: https://water.ca.gov/Programs/Groundwater-Management/Bulletin-118/Critically-Overdrafted-Basins

[2] The data used in the Report were located and compiled by Dudek staff as part of the GSP preparation process. The analyses presented in this Report would not have been possible without their support.

Preparation of the GSP is underway and it is understood that the draft GSP will be available for public review by January 2019[3]. The GSP will include a range of potential options for Projects and Managements Actions (PMAs), including PMAs to address water quality and water quality optimization. Among the direct impacts of degraded groundwater quality to BWD include:

- Need for Water Treatment to achieve drinking water standards (on a per well basis)
- Impact of water quality on the choice and design of replacement wells at existing well locations
- Potential need for Intra-Subbasin Transfer of Potable water from new or existing wells due to degraded water quality due to natural or anthropogenic sources

Groundwater quality data also have a role in the assessment of potential water management options that include but are not limited to:

- Options for Enhanced Natural Recharge (understood to be limited)[4]
- Artificial Recharge using Treated Wastewater

Of primary concern to BWD is the ability of historical data combined with ongoing water quality monitoring program to assess water quality trends. The data are needed to support management of their water system, for example to assess the probability of MCL (maximum contaminant level) exceedances and to plan for water treatment, if needed.

[3] The GSP is being developed by the Groundwater Sustainability Agency (GSA) that consists of the County of San Diego and the Borrego Water District. See overview at: https://www.sandiegocounty.gov/pds/SGMA.html
[4] It is understood that that recharge basins within the floodplains where much of Borrego Springs' residential population is located are likely not permittable due to County Flood Control Management concerns. Similarly managed artificial recharge areas located along mountain fronts within or nearby to the Anza Borrego State Park are also not likely permittable given their potential impact on the State Park.

This report includes the following sections:

1.0 HYDROLOGIC CONDITIONS

A brief summary of the hydrologic conditions of the Subbasin is provided here to support review of the water chemistry data. Included is a description of groundwater recharge, pre- and post-development groundwater levels, and aquifer conditions. Many of the figures and much of the discussion included in this section was derived from the USGS Model Report prepared in 2015 entitled *Hydrogeology, hydrologic effects of development, and simulation of groundwater flow in the Borrego Valley, San Diego County, California*: U.S. Geological Survey Scientific Investigations Report 2015–5150[5]. For reference the *simulation of groundwater flow* refers to the use of a numerical model (in this case the USGS Modflow Model as described in the 2015 report) to examine the groundwater levels, recharge, and overall hydrologic conditions for the period of 1945 to 2010. The GSP contains additional detailed hydrologic information, and updates the USGS modeling work.

1.1 Basin Location and Setting: Contributory Watersheds

The Borrego Springs Subbasin (Subbasin) of the Borrego Valley Groundwater Basin is located at the western-most extent of the Sonoran Desert. The primary source of water to the Subbasin is surface water (storm water and ephemeral stream flow) that flows into the valley from adjacent mountain watersheds and infiltrates within the valley. The contributory watersheds are approximately 400 square miles (mi^2) and much larger in area than the approximately 98mi^2 Subbasin as illustrated in **Figure 1.**

Direct recharge by rainfall within the valley is very low compared to surface water inflows as the annual rainfall averages 5.8 inches per year (in/yr.) [USGS Model Report, page 43]. Stream and flood flows from the adjacent watersheds provide the bulk of the water that enters the Subbasin.

[5] Referenced herein as the "USGS Model Report": Faunt, C.C., Stamos, C.L., Flint, L.E., Wright, M.T., Burgess, M.K., Sneed, Michelle, Brandt, Justin, Martin, Peter, and Coes, A.L., 2015, Hydrogeology, hydrologic effects of development, and simulation of groundwater flow in the Borrego Valley, San Diego County, California: U.S. Geological Survey Scientific Investigations Report 2015–5150, 135 p.
See: http://dx.doi.org/10.3133/sir20155150

FIGURE 1 (from USGS Model Report)

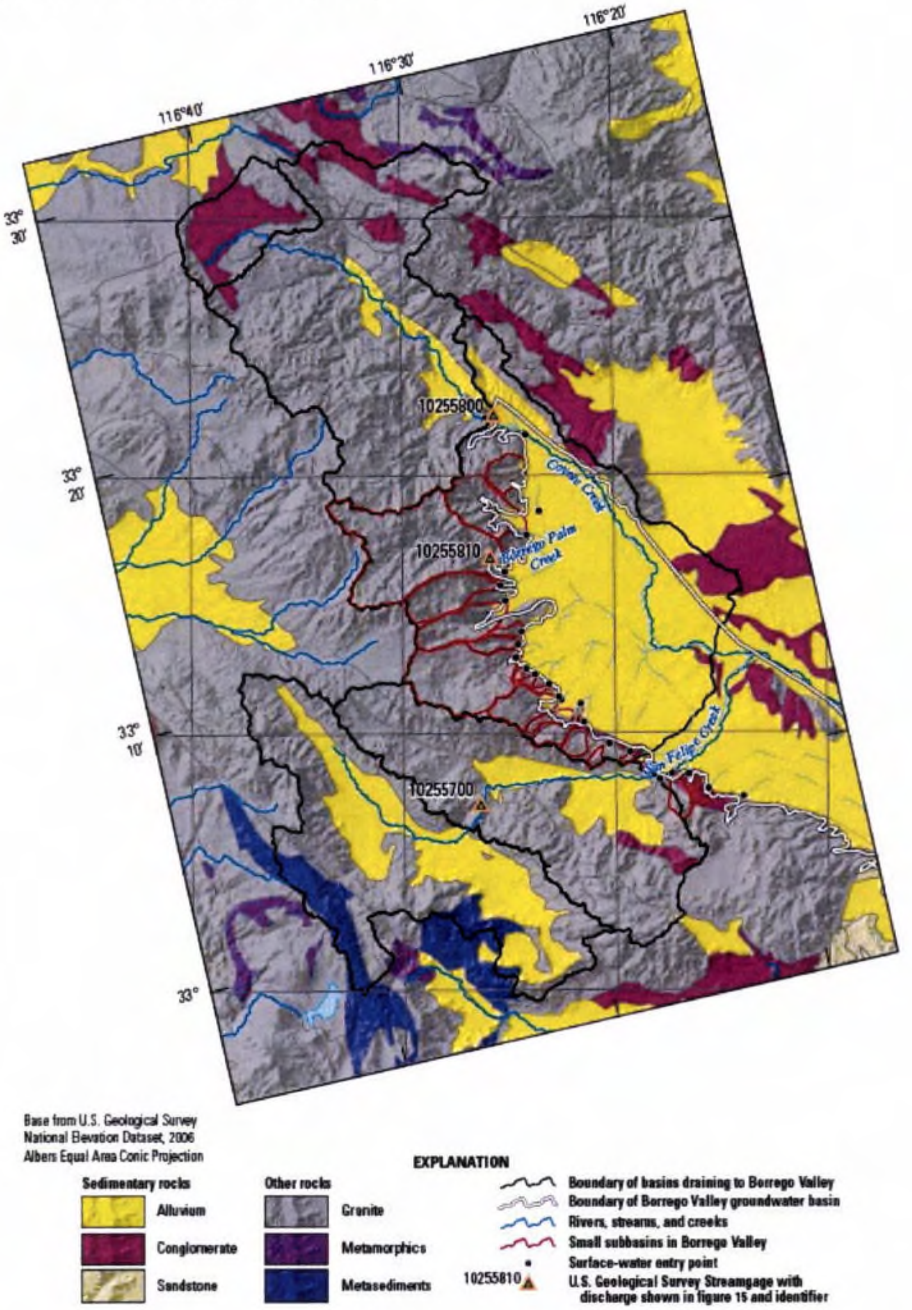


Figure 16. Drainage basin boundaries and geology used in the Basin Characterization Model to estimate climate-driven natural recharge in the Borrego Valley, California.

Note: The Subbasin lies within the area defined by alluvium. The tributary watersheds (e.g. that support Coyote Creek, Borrego Palm Creek, and San Felipe Creek) are outside of the Subbasin.

1.2 Historical Groundwater Conditions

The Subbasin receives recharge waters from the adjacent watersheds that include Coyote Creek, watersheds along the northwestern edge of the valley such as Borrego Palm Canyon, and San Felipe Creek that enters the south side of the valley (**Figure 1**).

Two water level maps from the USGS Model Report are included in **Figures 2A** and **2B** that depict pre- and post- development water levels (1945 and 2010). In both cases the Subbasin can be generally described as "closed" where surface water flows typically do not discharge from the valley but instead, if sufficient flows occur, terminate at the Borrego Sink.

Prior to development (**Figure 2A**) groundwater flow within the northern and central portions of the valley can generally be described as moving from northwest to southeast towards the Borrego Sink. Flow in the southern portion of the Subbasin is directed northeast towards the Borrego Sink. Pumping since 1945 has lowered groundwater levels and led the development of significant depressions of the water table associated with 'pumping centers' (see **Figure 2B**). From a groundwater perspective the overall flow patterns in the northern and central areas of the valley have changed from a roughly uniform flow (generally towards the Borrego Sink) to a condition where groundwater flow is reversed in some areas and now flows toward the pumping centers. The rate of pumping has greatly exceeded groundwater recharge rates and water levels have dropped well over 100 feet in some areas. Because the current rate of groundwater use continues to cause significant water level decline and loss of water from subsurface storage the Subbasin is now classified as being in critical overdraft.

Further description of historical and current groundwater conditions is included in the GSP.

FIGURE 2A (from USGS Model Report)

44 **Hydrogeology, Hydrologic Effects of Development, and Simulation of Groundwater Flow in the Borrego Valley**

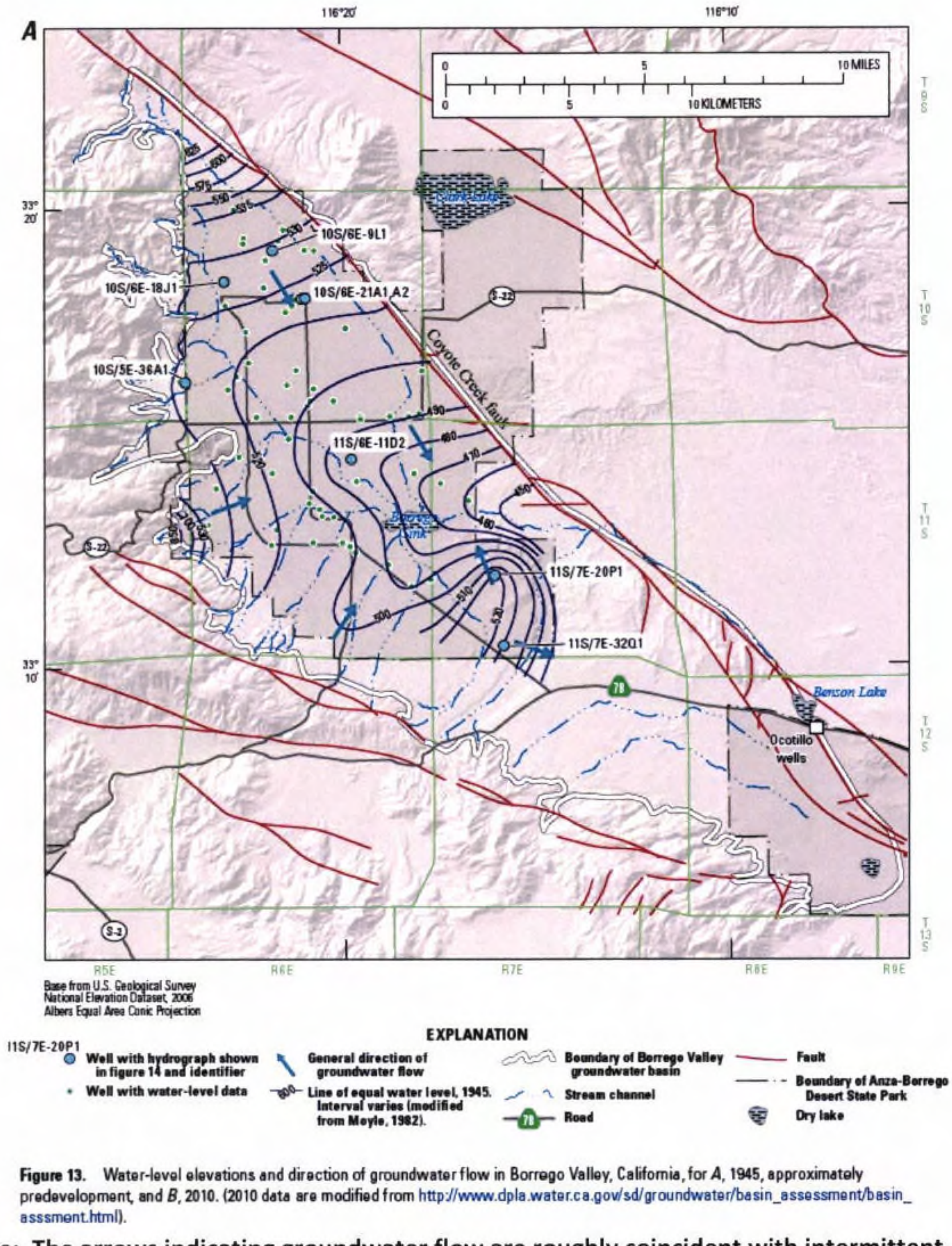


Figure 13. Water-level elevations and direction of groundwater flow in Borrego Valley, California, for *A*, 1945, approximately predevelopment, and *B*, 2010. (2010 data are modified from http://www.dpla.water.ca.gov/sd/groundwater/basin_assessment/basin_assment.html).

Note: The arrows indicating groundwater flow are roughly coincident with intermittent surface water channels (dashed blue lines) that enter from adjacent watersheds and flow towards the Borrego Sink.

FIGURE 2B (from USGS Model Report)

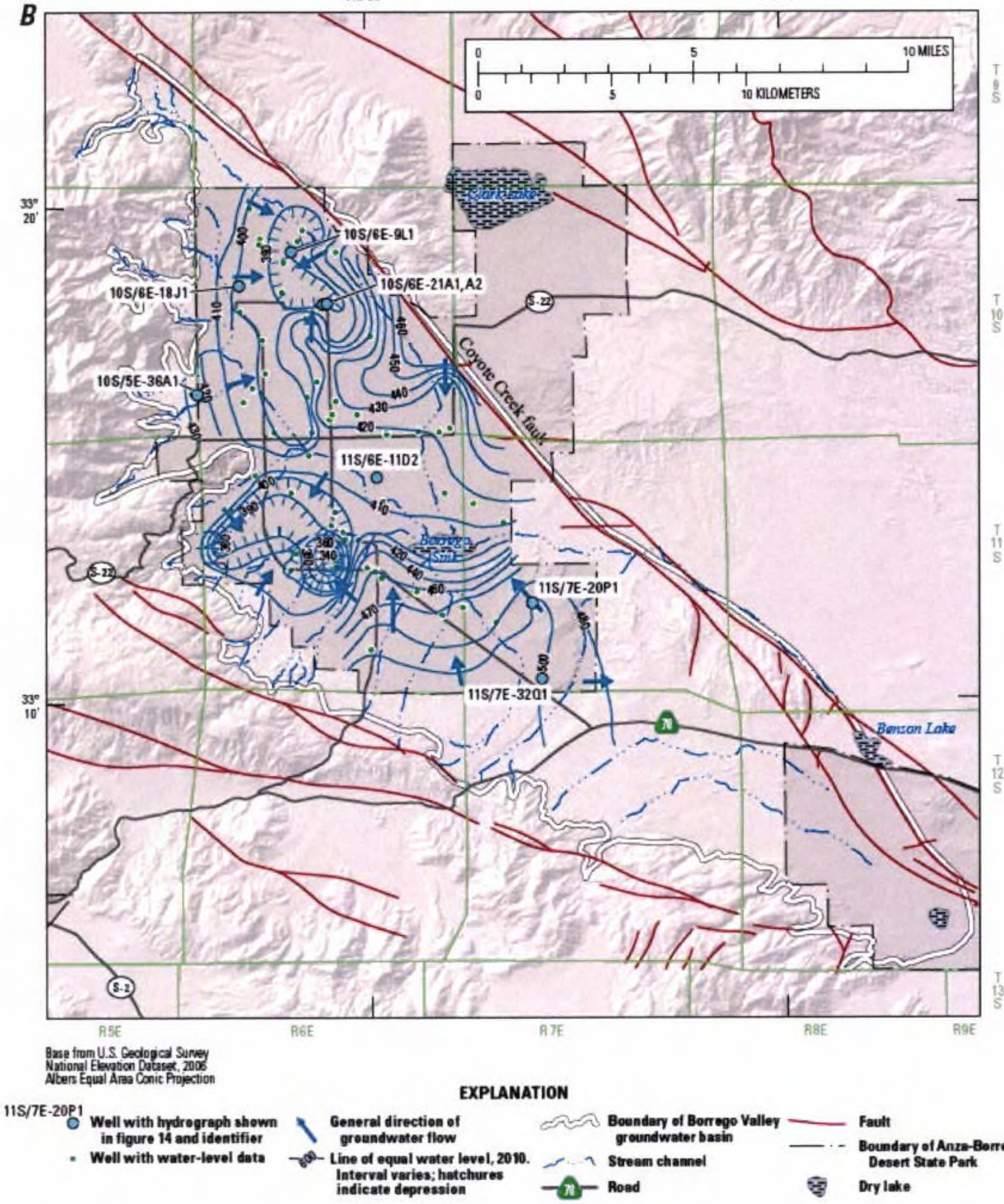


Figure 13. —Continued

NOTE: Hachured areas show the two major pumping centers in the Subbasin. The influence of northern pumping center has caused groundwater to reverse flow direction (see arrow at well 10S/6E-21A1). The central pumping center captures groundwater that was previously flowing south and southeastward towards the Borrego Sink.

1.3 Stratigraphy and Aquifer Conceptual Model

The current conceptual model for the aquifer system as incorporated in the USGS Model is that it consists of three unconfined aquifers named the upper, middle and lower aquifers. The upper and middle aquifers are the primary sources of water currently and are typically comprised of unconsolidated sediments. However, with time, the upper aquifer has become or is expected to become dewatered and the lower aquifer will become a more important source of water as overdraft continues.

The lower aquifer sediments become consolidated with depth and have been subject to folding and faulting. The lower aquifer provides water supply for some pumpers, especially in the southern area of the Subbasin. **Figure 3** (Figure 7 of the USGS Model Report) depicts the Borrego Valley Groundwater Basin as described by Moyle, 1982.[6] Additional work has been done by Mitten et al (1989),[7] and by Netto (2001).[8] Of these, Netto (2001) provides the most detailed analysis of basin stratigraphy based on well log review and interpretation. Review of their work supports that locally confined aquifer conditions are expected to occur.

In brief there are a number of geologic features relevant to groundwater conditions and water quality:

- The Subbasin, as exemplified by the flow of water and sediment toward the current-day Borrego Sink, has historically been the locus of sediment deposition. Sedimentation initially occurred in a marine environment (with sediment sources located to the east) and transitioned to terrestrial environments as seen today.[9]
- The Borrego Sink, similar to dry lake beds that occur in the desert, is a location where water evaporates and minerals will accumulate and can form evaporite deposits. Historically similar conditions occurred as sediments were deposited. Thus, the middle and upper aquifers have the potential to include evaporite deposits that can re-dissolve and lead to elevated concentrations of sulfates and carbonates that result in corresponding increase in TDS.

---

[6] Moyle, W. R., 1982, Water resources of Borrego Valley and vicinity, California; Phase 1, Definition of geologic and hydrologic characteristics of basin: U.S. Geological Survey Open-File Report 82–855, 39 p.
[7] Mitten, H.T., Lines, G.C., Berenbrock, Charles., and Durbin, T.J., 1988, Water resources of Borrego Valley and vicinity, California, San Diego County, California; Phase 2, Development of a groundwater flow model: U.S. Geological Survey Water-Resources Investigation Report 87–4199, 27 p.
[8] Netto, S.P., 2001, Water Resources of Borrego Valley San Diego County, California: Master's Thesis, San Diego State University, 143 p.
[9] See GSP. For general reference see: Dorsey, R.J., 2005. Stratigraphy, Tectonics, and Basin Evolution in the Anza-Borrego Desert Region. In "Fossil Treasures of the Anza-Borrego Desert", George T. Jefferson and Lowell Lindsay, editors, Sunbelt Publications, San Diego California, 2006
https://pages.uoregon.edu/rdorsey/Downloads/DorseyChaperNov05.pdf

- Structural features such as the Coyote Creek Fault, the Desert Lodge anticline, and the effect of basement uplift and exposure of lower aquifer sediments along the southeastern portion of the Subbasin (cross-section A-A' in **Figure 3**) limit groundwater flow within and out of the basin. The Coyote Creek Fault is assumed to be a 'no flow' boundary condition in the USGS Groundwater Model and as such serves to contain groundwater within the basin and direct flow to the southeast towards the Borrego Sink. The current-day topography combined with the geologic structure creates a 'closed' groundwater condition where ongoing evaporation of water will lead to the long-term accumulation of minerals (often referred to as 'salts') in soil and groundwater.
- While the lower aquifer is quite deep and contains a significant volume of groundwater, the sediments have less storage capacity than the upper and middle aquifers as quantified in the USGS Model by lower specific storage and specific yield. The lower aquifer is also expected to have poor water quality with depth.
- Waters that flow into the Subbasin from the adjacent watersheds will have varying chemistry depending on the geologic and hydrologic conditions encountered in the watersheds. For example, water that flows in Borrego Palm Creek from nearby crystalline rock of the San Ysidro Mountains (see **Figure 1**) will be different than the waters of San Felipe Creek that drain from an alluvial desert valley and more likely to accumulate dissolved minerals.

Please refer to the GSP for additional details.

FIGURE 3

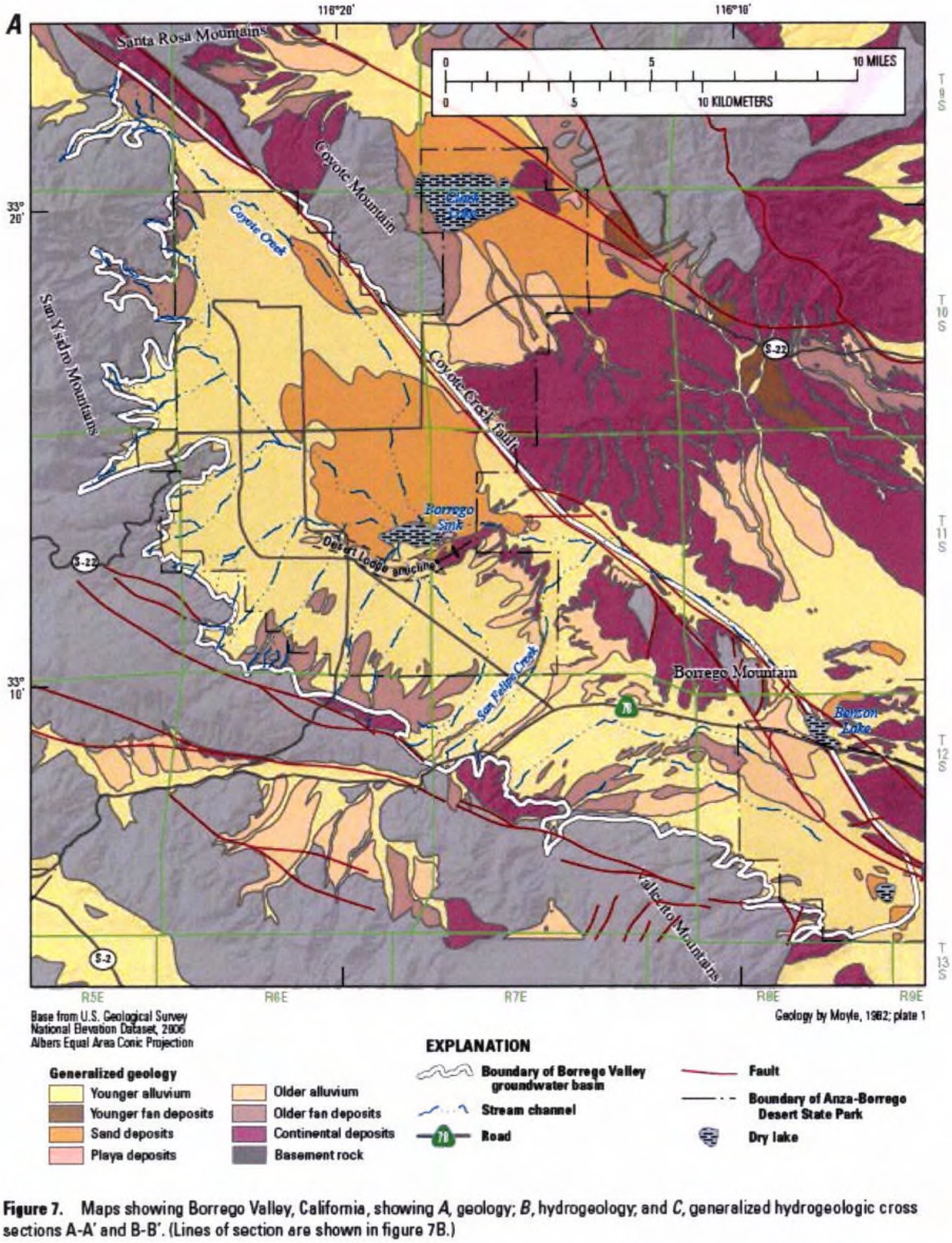


Figure 7. Maps showing Borrego Valley, California, showing *A*, geology; *B*, hydrogeology; and *C*, generalized hydrogeologic cross sections A-A' and B-B'. (Lines of section are shown in figure 7B.)

FIGURE 3, continued

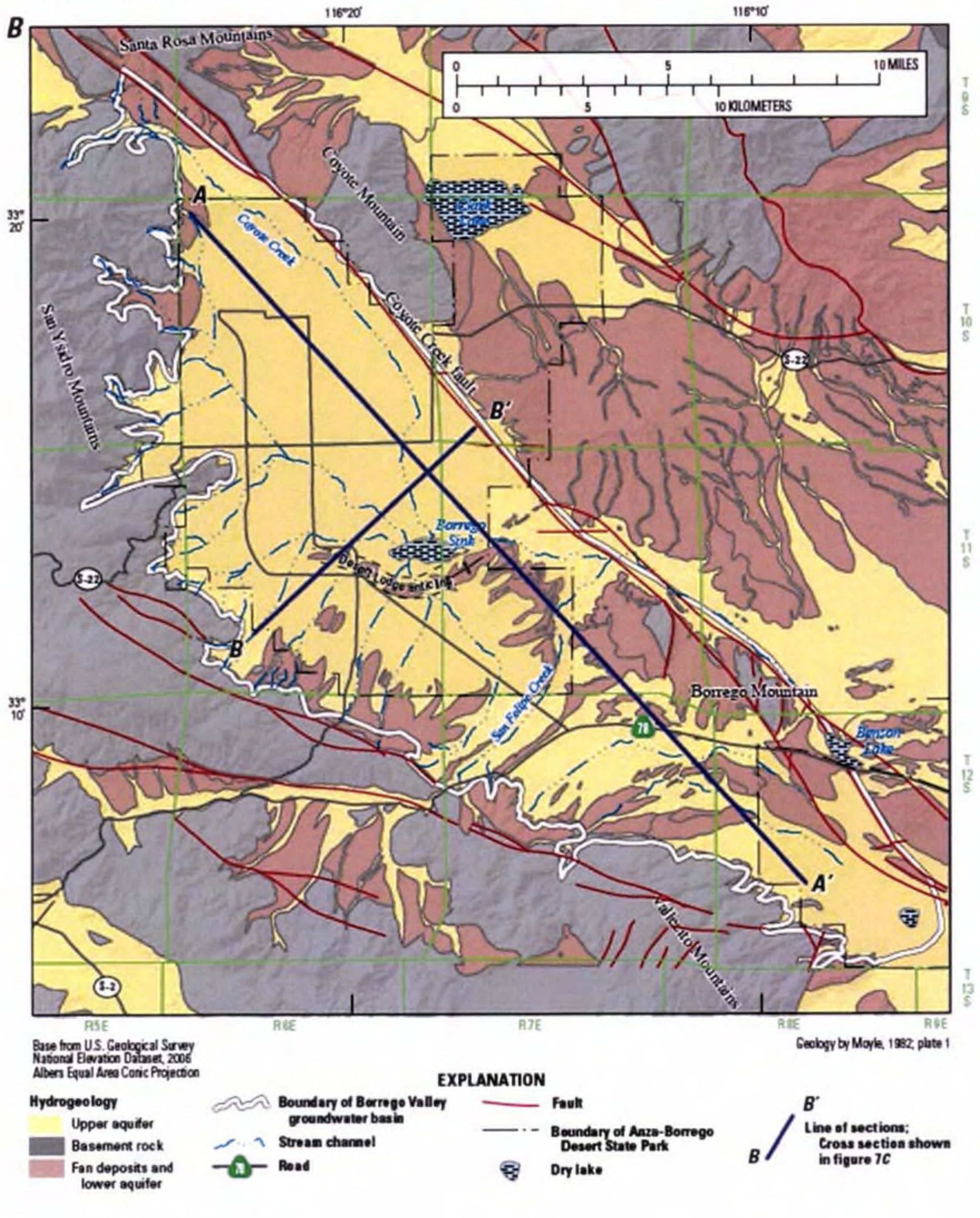
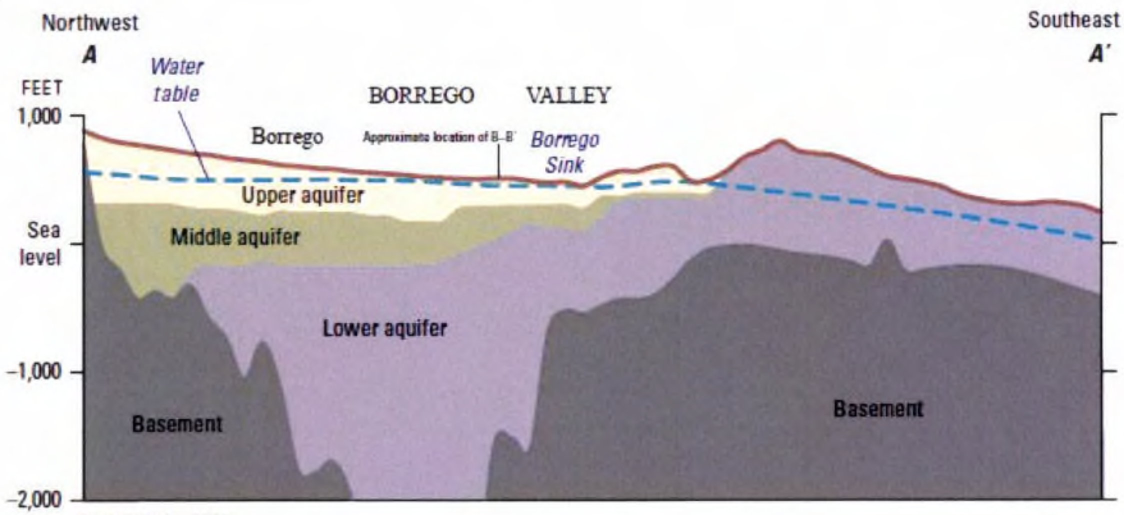


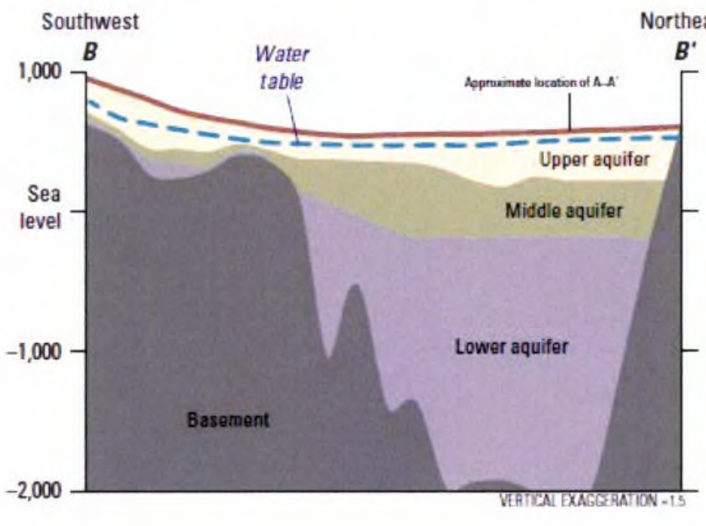
Figure 7. —Continued

FIGURE 3, continued

C



From Moyle, 1982



2.0 WELLS AND DATA USED IN THIS ANALYSIS

A total of 23 wells were included in this water quality analysis. Of these eight are active BWD supply wells and a ninth is used for emergency supply. The data for the wells were compiled and tabulated by Dudek staff as part of the GSP preparation process.

It is important to note that the wells were typically completed with long screened sections and can be open to flow from the upper, middle, and/or lower aquifers depending on the well construction, current groundwater levels, and well hydraulics. As a result, the data were not segregated by aquifer or depth.

Table 1A lists the active BWD wells and indicates the time periods when general minerals data were obtained. The wells have been segregated into three management areas (North, Central, and South) as established in prior work by Dudek.

TABLE 1A: BWD Water Supply Wells

Plot ID	Area	Well Name	GSA GWM Well	Year Inst.	gpm	Static Water Level (ft)	Draw Down (ft)	gpm/ft ***	Plant Eff.****	Well Depth (ft)	Sampling Period	
											start	end
4	North	ID4-4*	Yes	1979**	365	205.4	63.5	6	71	802	1954**	2017
5		ID4-11	Yes	1995	620	223.2	5.8	107	73	770	1995	2017
2		ID4-18*	Yes	1982	130	311.2	7.6	17	50	570	1984	2017
14	Central	ID1-10*	Yes	1972	317	213.9	11.5	28	54	392	1972	2017
9		ID1-12	No	1984	890	145.5	10.4	86	72	580	1988	2018
12		ID1-16	Yes	1989	848	230.9	24.3	35	71	550	1993	2016
8		ID5-5	Yes	2000	542	182.1	16.1	34	62	700	2004	2016
13		Wilcox	Yes	1981	205	305.2	5.8	35	NA	502	2000	2017
15	South	ID1-8	Yes	1972	448	71.2	47.7	9	51	830	1972	2018

Notes: Data from 2018 Pump Check Results (in Dudek New Wellsite Feasibility Report, in process)
*, wells being considered for replacement (3)
**, ID4-4 was redrilled in 1979.
***, gpm/ft calculated from Pump Check data
****, Plant Efficiency from Pump Check, in percent. Values less than 60% are viewed to be of concern.

The 'plot ID' listed in **Tables 1A and 1B** supports the map-based location of the wells and roughly proceeds from north to south.

TABLE 1B

Plot ID (Figure 7)	Management Area	In GWM program?	TDS (500/1000 mg/L)	F (2 mg/L)	NO3 (as N, 10 mg/L)	SO4 (250/500 mg/L)	As (10 ug/L)	Well Name		gpm	TD (msl)	Year Inst.	notes	anion/cation trend over time (see Piper Diagram)
		Water Quality: 2Q 2018 (MCL as indicated)												
3	North	.					<2	ID4-3	IA	no data			last tested 2007	Percent Sulfate Increased, may be stable; Calcium has been variable
4		yes	330	0 16	0.5	110	2.2	ID4-4	A*	365	-204	1979	(redrilled 1979)	Fairly stable (new well),
1		.					0	ID4-7/ Anza#4	IA	no data			last tested 1983	Percent Sulfate Increased (1973 to 1983)
5		yes	380	0 23	0 56	90	1.2J	ID4-11	A	620	-156	1995		Fairly stable
2		yes	630	0.87	0.54	270	<1.2	ID4-18	A*	130	-121	1982		Percent Sulfate Increasing
14	Central	yes	340	0.48	1.3	67	2.8	ID1-10	A*	317	-203	1972		Variable over time, no clear trend
9		yes	300	0.35	0 34	95	2.5	ID1-12	A	890	-48	1984		Fairly stable
12		yes	300	0.44	1	58	2.0	ID1-16	A	848	40	1989		Fairly stable
7A		.					<3	ID4-1	IA	no data			last tested 1980	Becoming more Calcium dominant (last gen min data 1980)
10		.					2.3	ID4-2	IA	no data			last tested 2010	Large change in 2010 (dec Sodium), no recent data to assess trend
7		.					2	ID4-5	IA	no data			last tested 1994	Limited data to assess trend
11		.					<2	ID4-10	IA	69?	200	1989	last tested 2012	Fairly stable
8		yes	330	0.8	0.39	100	2.1	ID5-5	A	542	-124	2000		Percent Sulfate Increased (2001 to 2013), may now be stable
6		.					6.4	Cocopah	A	1166	-393	2005	last tested 2013	Limited data to assess trend
13		yes	230	0.64	1.00	19	3.8	Wilcox	(A)	205	198	1981		Increasing bicarbonate, decreasing Calcium
20	South	yes	1600	0.18	0.76	700	<1.2	ID1-1	IA	200	-75	1972		Major changes 1972 to 2017: Increasing sulfate and Calcium; dec bicarbonate
21		yes	320	0.49	2.9	36	5.5	ID1-2	IA	200	-157	1972		Major changes 1972 to 2017: Increasing bicarbonate
15		yes	490	0.62	1.6	86	4	ID1-8	A	448	-335	1972		Increasing Sulfate and Chloride, Increasing Calcium
22		yes	830	0.56	0.5	350	15	Jack Crosby	(A)	10	194	2004		Limited data to assess trend
-		yes	640	0.37	20	100	2.5	WWTP	mw	mw	404	2009		Gen min data failed QA/ not assessed
16		yes	nm	nm	nm	nm	15	RH-3 (2017 data)	A	230	-323	2014		Limited data to assess trend
17		yes	400	1	0.49	110	6.3	RH-4	A	260	-147	2014		Limited data to assess trend
18		yes	480	1.3	3.6	100	15	RH-5	A	350	-169	2015		Increasing Bicarbonate
19		yes	330	1.2	3.3	31	13	RH-6	A	350	-312	2015		Limited data to assess trend
-		yes	450	0.51	1.2	76	2.8	MW-3	mw	mw	197	2005		Limited data to assess trend

xx exceeds the MCL

note: Secondary MCLs apply to TDS and Sulfate
Reccomended and maximum values
are listed for TDS and Sulfate

A* active BWD Production Well, * Indicates wells currently slate for replacement due to condition
A active non-BWD Production Well
IA Inactive BWD Well
mw Monitoring Well

Figure 4 shows the well locations and names used in this Report. Review of **Figure 4** shows that the well locations are spatially biased along the western portion of the valley and the Subbasin. This is because the BWD wells are located in populated areas within their historical service areas (or Improvement Districts [ID] as indicated by the well names).

The analytical data used in the Report were located and compiled by Dudek staff from multiple sources as part of the GSP preparation process. The data base used here is from July 2018- the GSP data base is updated and revised on an ongoing basis. This Report focuses on:

- Chemicals of Concern (COCs) that include arsenic, TDS, nitrate, sulfate, and fluoride (As, TDS, NO_3, SO_4, and F).
- General Minerals: comprised of four cations- calcium (Ca^{+2}), sodium (Na^{+}), magnesium (Mg^{+2}), and potassium (K^{+}); and four anions- sulfate (SO_4^{-2} [also a COC]), chloride (Cl^{-}), carbonate (CO_3^{-2}) and bicarbonate (HCO_3^{-}).
- Hardness and pH.

The overall intent of this Report is to assess the use of multiple water quality parameters to examine how the primary COCs at BWD wells vary over time and to examine the likelihood that drinking water quality criteria will be exceeded. Of primary concern are arsenic and nitrate. Sulfate is also of concern.

Other COCs not examined in this Report include pesticides, herbicides, naturally-occurring radionuclides, and unregulated contaminants for which monitoring is required. Per State Law the Borrego Water District tests their water supply wells in accordance with California Code of Regulations Title 22 for a wide variety of potential contaminants because they operate a publicly-regulated water system. For additional information refer to their Consumer Confidence Report (CCR, available at http://www.bvgsp.org/sgma-blank.html).

FIGURE 4


N
ID4-7
ID4-18
ID4-3
MW-1
DI GIORGIO ROAD
BORREGO SALTON SEAWAY
ID4-4
PEGLEG ROAD
COCOPAH
ID4-11
ID4-1
ID4-5
PALM CANYON DRIVE
MW-4
ID5-5
ID4-2
MW-5A/B
ID1-12
ID4-10
ID1-16
ID1-10
WILCOX
DEEP WELL TRAIL
WWTP
ID1-8
MW-3
JACK CROSBY WELL
RH-3
RH-4
ID1-1
RH-5
ID1-2
RH-6
PASS ROAD
BORREGO VALLEY
ENVIRONMENTAL NAVIGATION SERVICES, INC.
EXPLANATION BLOCK
ID4-4 Active BWD Groundwater Well
RH-4 Active Private Groundwater Well
ID4 Inactive BWD Groundwater Well
MW-1 Groundwater Monitoring Well
0 3,500 7,000
APPROXIMATE SCALE (FEET)
WELL LOCATION MAP
Borrego Valley Water District
Borrego Springs, California
JWJ
BWD
4
JWJ
CM
10/17/2018

3.0 SUBBASIN-WIDE WATER QUALITY: GENERAL MINERALS, ARSENIC, AND NITRATE

The term "general minerals" is a descriptor that includes the eight anions and cations that typically comprise most of the minerals, by mass, dissolved in groundwater. Anions are negatively charged and cations are positively charged. The eight dominant ions include four cations- calcium (Ca^{+2}), sodium (Na^{+}), magnesium (Mg^{+2}), and potassium (K^{+}); and four anions-sulfate ($SO4^{-2}$), chloride (Cl^{-}), carbonate ($CO3^{-2}$) and bicarbonate ($HCO3^{-}$). Of these, sulfate is a COC. TDS is also a COC and represents the sum all of the anions and cations in solution.

Table 2. Common Cations and Anions Analyzed in the Subbasin

Common Cations	Common Anions
calcium (Ca^{+2})	sulfate (SO_4^{-2})
sodium (Na^{+})	chloride (Cl^{-})
magnesium (Mg^{+2})	carbonate (CO_3^{-2})
potassium (K^{+})	bicarbonate (HCO_3^{-})

The dominant anions and cations can be used to examine how the chemistry of groundwater varies in time at a well, or spatially among wells. Because they occur as a result of rock and mineral dissolution, they can also be diagnostic of minerals such as sulfates and carbonates that occur in the subsurface, or that occur in water being recharged to the aquifer system.

Graphical methods used to depict multiple anions and cations include Stiff Diagrams and Trilinear or Piper Diagrams.[10] Both are used in this Report and will be explained in more detail in Sections 3.1 and 3.2, respectively.

3.1 Spatial Overview (DWR, 2014; Stiff Diagrams)

Stiff diagrams graphically depict the relative concentrations of three dominant anions (Cl, HCO3, and SO4) together with three dominant cations (Na, Ca, and Mg) determined from water samples.[11] A 2014 groundwater quality study was conducted by the California Department of Water Resources (DWR)[12] based on the compilation of DWR, BWD, and USGS water quality data generally obtained between 1950 and 2014. A map depicting Stiff Diagrams of water quality is depicted in **Figure 5**.

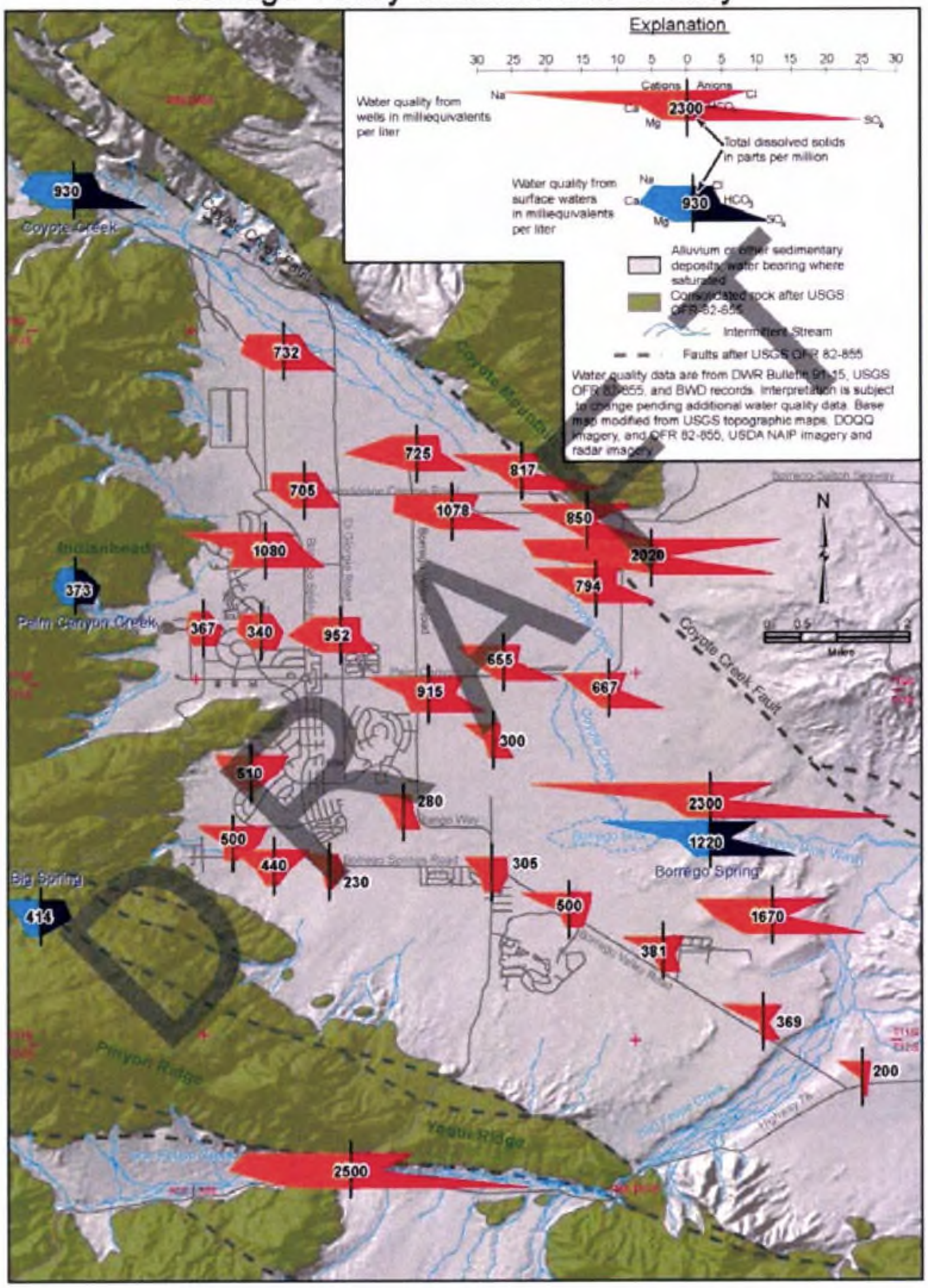
[10] An overview summary is provided by: Hem, J.D., 1989, Study and interpretation of the chemical characteristics of natural water: U.S.
Geological Survey Water-Supply Paper 2254, 3rd edition, Washington D.C., 263 p.

[11] Stiff, H.A., Jr., 1951, The interpretation of chemical water analysis by means of patterns: Journal of Petroleum Technology, v. 3, no. 10, p. 15-17.

[12] DWR, 2014. Powerpoint presentation by Dr. Tim Ross dated May 2014. A copy is included for reference in **Appendix A.**

FIGURE 5

Borrego Valley Groundwater Quality



An explanation of how the analytes are depicted using Stiff Diagrams is also included in **Figure 5.** The 'legs' and overall size of the diagrams increase as the analytes increase in concentration and allow visual comparison of each of the sample results. Also included in the diagrams is the TDS in milligrams per liter. For reference the TDS of drinking water should be no more than 1,000 mg/L and ideally less than 500 mg/L (the recommended and maximum secondary MCLs, respectively).

DWR noted based on comparison of surface water and groundwater chemistry that *"The high proportion of Sulfate in the surface water of Coyote Creek appears to dominate the character of groundwater in the northern and eastern parts of the basin. The more Bicarbonate waters of Borrego Palm Canyon and Big Spring influence the groundwater along the western and southern parts of the basin."* For reference, the surface water watersheds are shown in **Figure 1**.

Additional observations that can be made from the Stiff Diagrams include:

- Surface water inflows that enter the along the edges of the valley are the primary source of recharge. The highest quality groundwater (TDS < 500 mg/L) generally occurs near recharge areas.
- Groundwater quality tends to increase in TDS towards the Borrego Sink with distance from the recharge areas. Ongoing evaporation and accumulation of minerals is occurring within the Subbasin. The Subbasin is effectively a closed basin and has been a closed basin during much of the time that alluvial sediments have been deposited from current watersheds. (Please refer to the GSP for a detailed description of the Subbasin geology and sedimentology.)
- Elevated concentrations of sulfate in surface waters are of concern from a water quality standpoint. Groundwater within the San Felipe Creek watershed that potentially recharges the South Management Area contains relatively high concentrations of sulfate, calcium and sodium.
- The Stiff Diagrams highlight the dominance of sulfate in groundwater (lower right portion of the diagrams). Sodium and chloride (upper right and upper left 'legs') also occur at significant concentrations in many samples.

The DWR presentation also reviewed TDS trends with time and depth at selected wells. No consistent trends were identified. The data were not evaluated in terms of the upper, middle, or lower aquifer.

DWR also assessed nitrate. Review of their results is included in **Section 3.5**.

3.2 General Minerals: Spatial Variability Based on Piper Diagrams

The eight dominant anions and cations can also be analyzed using Piper trilinear diagrams (Piper, 1944).[13] In brief, the Piper plot is a visualization technique for groundwater chemistry data. It is based on a combination of ternary diagrams for the major anions and cations that are then projected onto a central diamond. The concentration data on (milligrams/liter) are converted to milliequivalent (meq/L), a measure of the number of electrochemically active ions in the solution.[14] The analytes are plotted as relative proportions in order to examine the relative percentages of each of the dissolved minerals, primarily to show clustering or patterns of samples. The diagrams also support interpretation of trends and potential mixing of waters that have different chemistry.

Figure 6A provides a brief explanation of the Piper diagram. The methodology is explained in more detail in **Appendix B**, together with the Piper trilinear diagrams for all of the wells as noted in **Table 1B.** Ternary diagrams present a combination of three values that add up to 100 percent. The three values are 'picked off of' the sides of triangle by projection along a triangular grid. Please refer to **Appendix B** as needed for additional explanation.

Recent general minerals data, dating from 2004 to present, were used to represent the water chemistry at each of the wells. Review of the data supported the use of two data subsets. The North and Central Management Area wells have been combined and the South Management Area wells are presented as a second set. **Figure 6** depicts the data. Each of the wells are numbered per **Figure 4** and **Table 1** to simplify the data presentation. The numbering generally follows from north to south along the axis of the valley.

3.2.1 Data Quality Review: General Minerals

The data presented in the Piper diagrams underwent a data quality review based on the ion chemistry. Groundwater under natural conditions should be at or near electrochemical equilibrium. Here the sum of the negatively charged anions (in meq/L) was checked versus the sum of the positively charged cations. The sums should be similar (within ~5%) for a solution that is in equilibrium. Not all of the data were used because in some cases not all of the eight general minerals data were analyzed and in other cases the anion/cation balance test failed. As explained above, the anion/cation balance test may fail as a result of less common anions or cations being present within the water quality sample that were not analyzed. Charge imbalance may also indicate laboratory error.

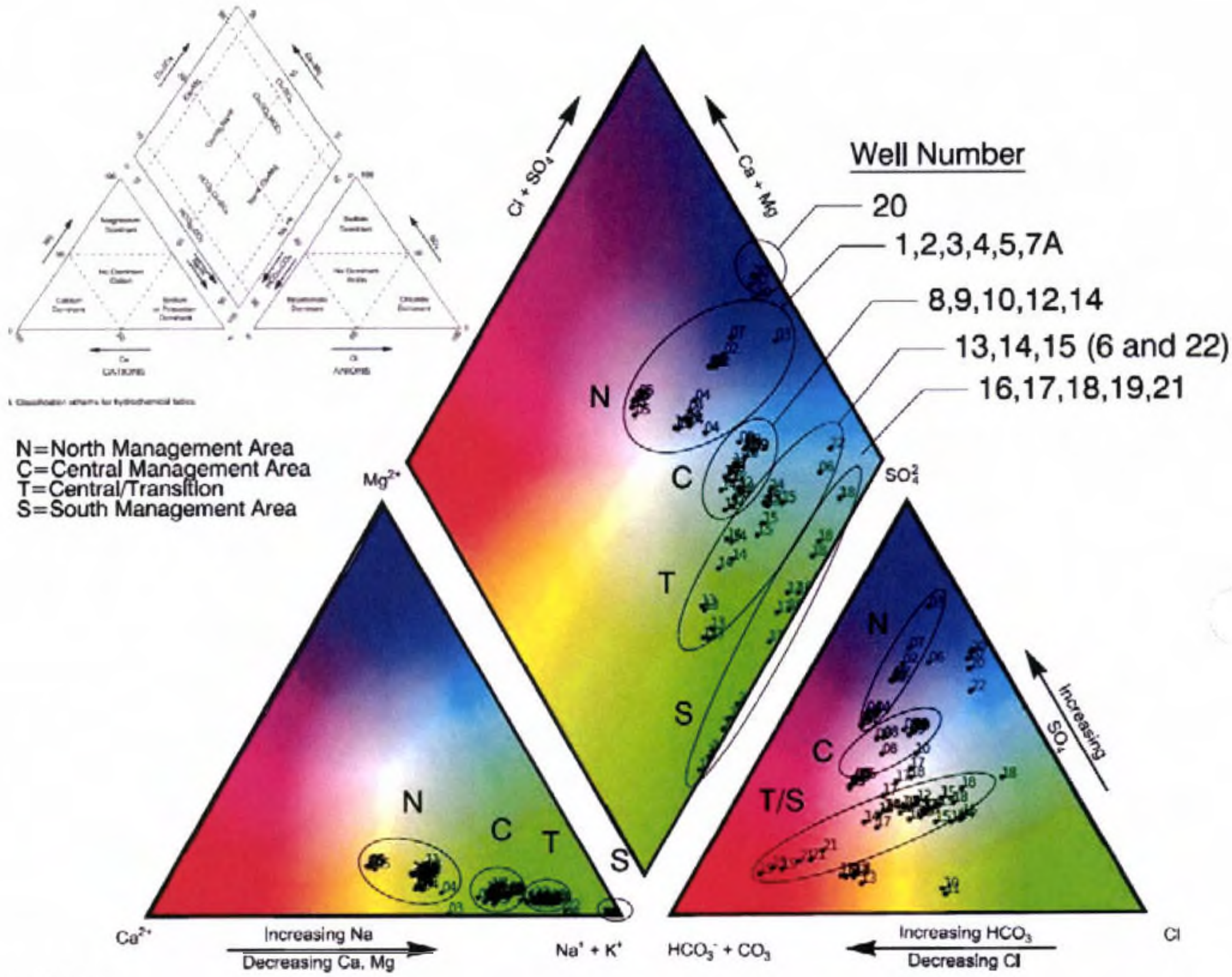
[13] Piper, A.M. 1944. A graphic procedure in the geochemical interpretation of water-analyses. Transactions-American Geophysical Union 25, no. 6: 914–923

[14] The number of ions in a solution is expressed in terms of moles, a unit widely used in chemistry as a convenient way to express amounts of reactants and products of chemical reactions. An equivalent is the number of moles of an ion in a solution, multiplied by the valence of that ion. For example, if 1 mole of NaCl and 1 mole of $CaCl_2$ are dissolved in a solution, there is 1 equivalent of Na, 2 equivalents of Ca, and 3 equivalents of Cl in that solution. The calculation is based on: mEq/L = (mg/L × valence) ÷ molecular weight.

The eight anions and cations generally comprise the bulk of the minerals that comprise TDS. Sodium and calcium are the dominant cations; bicarbonate, sulfate, and chloride are the dominant anions. The long-term average concentrations, in mg/L, for the nine BWD wells were TDS (378), calcium (39), sodium (82), magnesium (5.4), and potassium (5), sulfate (112), chloride (56), carbonate (0.6) and bicarbonate (124). Nitrate averaged 1.8 mg/L.

A calculation of TDS was made by summing the concentrations of the eight anions and cations and comparing it to the TDS for all samples that met a 5% or less charge imbalance criteria. On average the sum was less than the TDS by 40 mg/L, where the mass of cations exceeded the mass of anions. Other anionic COCs not included in the calculation include fluoride and nitrate, but when these were added into the calculations the mass of anions remained lower than the mass of cations. While the mass balances remained within tolerance, the results suggest that additional anions occur in groundwater that have not been tested. Phosphates are one type of anion that may occur but have not been included in the analytical program.

FIGURE 6: Piper Diagram, recent data for all wells (2004 to 2018)



Notes:

1. Numbers correspond to IDs shown in Figure 4. These generally increase from north to south.

2. The wells by management area include:

North Management Area: Wells # 1 to 5, #7, and #11

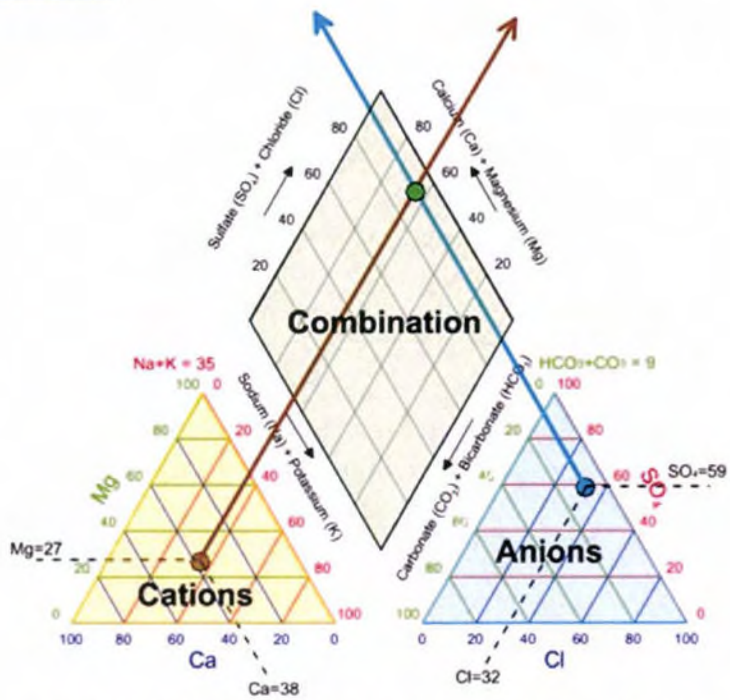
Central Management Area: Wells #8, #9, #10, and 12

"Transitional": Wells #6, #13, #15, #16, #22

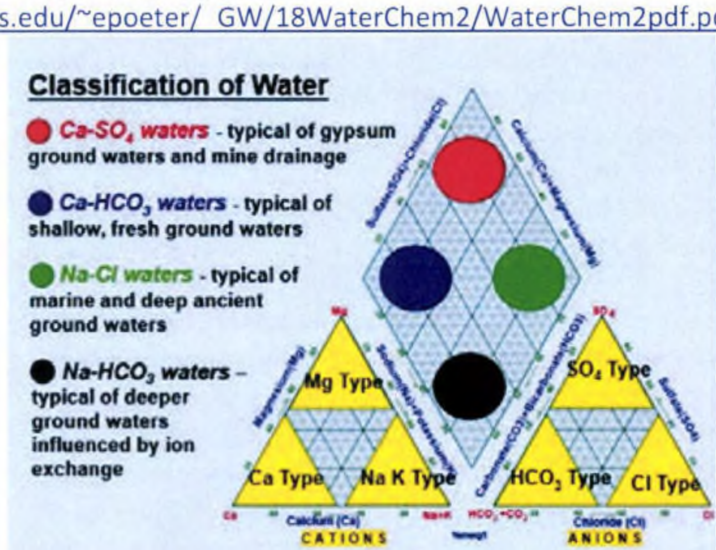
South Management Area: Wells #17 to 21, #23

FIGURE 6A

The Piper diagram is used to plot the 8 general minerals based on two ternary diagrams (triangles, at the base) that are projected onto a central diamond area. From (www.goldensoftware.com)



Where the subregions generally depict the chemical characteristics of the water (from http://inside.mines.edu/~epoeter/_GW/18WaterChem2/WaterChem2pdf.pdf)



Here colors are used to show subareas following a methodology presented by Peeters, 2014. (A Background Color Scheme for Piper Plots to Spatially Visualize Hydrochemical Patterns by Luk Peeters, Vol. 52, No. 1–Groundwater–January-February 2014). Also see **Appendix B**.

No distinction was made regarding well completion by aquifer because of a lack of water quality data as a function of depth. However, while the wells include a range of ell completions, the data do not indicate that any differentiation can be made among wells based on recent data (2004 to present). Review of the Piper Diagrams indicates that a systematic variation of water quality can be observed from north to south, and that the water quality in the South Management Area is sufficiently different to support segregation of the data into two data sets. Inorganic water quality depicted in the central Piper diagrams (**Figure 7**) indicates the data generally group by management area (MA): North MA (Wells # 1 to 7, and 11), Central MA (Wells #8, #9, #10, and 12), "Transitional" between the Central and South MAs (#13, #15, #16, #22), and South MA (#17 to 21, #23). Data from sets of wells align on the Piper diagram (**Figure 6**) indicative of waters that are mixing. Some general observations follow:

North and Central Management Areas

- A subset of the wells in the northern part of the basin (#1, #2, #3, and #4) occur along a line of anion data where high sulfate occurs.
- The North and Central Management Areas subdivide into two groups within the Piper diagram. With distance towards the south a general trend occurs where chloride decreases, bicarbonate increases, and sulfate decreases. Two mixing lines may occur where the waters go from sulfate dominant to a mixed condition (no dominant anion).

South Management Area

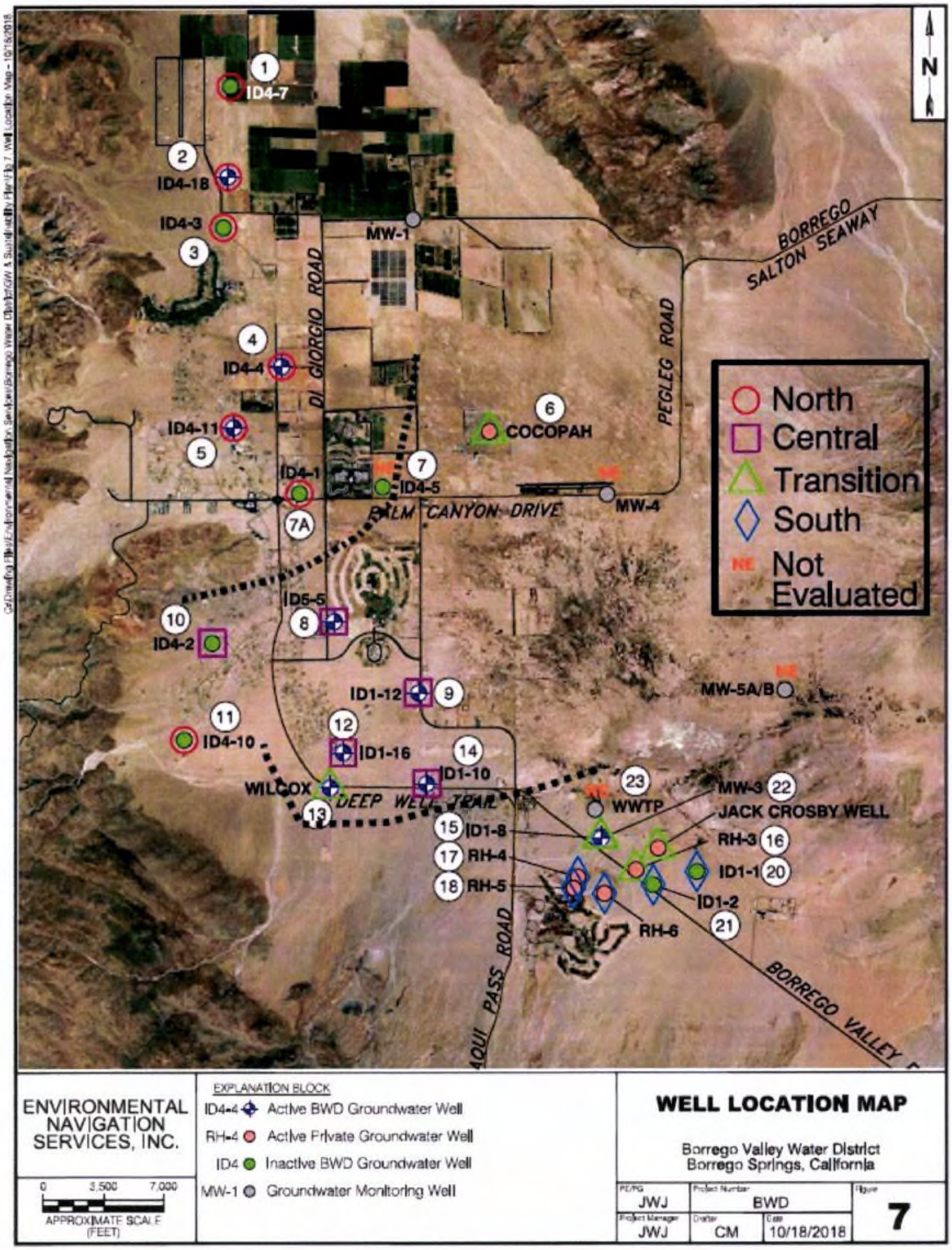
- A transitional zone occurs roughly coincident with the location of the Desert Lodge anticline (as depicted in **Figure 3**). The anticline is regarded as a structure that influences groundwater flow (refer to the GSP for further details).
- Mixing lines are observed for both cations and anions. For anions: as chloride decreases, bicarbonate increases, and sulfate decreases. For cations: as calcium decreases, sodium and magnesium increase.
- As also noted by the Stiff diagrams, the North Management Area has high sulfate as indicated by points that occur in the upper part of the cation ternary diagram. In contrast the South Management Area wells either have no dominant anion or become bicarbonate dominant (the lower left portion of the ternary diagram for anions).

Overall the Piper diagrams support that the inorganic water chemistry systematically varies across the Subbasin. The primary observations are summarized in **Figure 7**:

- Water quality gradually changes from north to south within the North and Central Management Areas, consistent with pre-development groundwater flow patterns.
- For both areas the cation relationships (calcium, magnesium, and sodium) are similar and are generally sodium dominant. In both cases the water quality is characterized by decreasing calcium and increasing percentages of sodium and magnesium.
- The South Management Area anionic water chemistry is different than the North and Central Management Areas, likely due to the difference in the San Felipe Creek recharge water and potential differences in aquifer mineralogy.

FIGURE 7

Shows water chemistry classified into the three Management Areas North, Central, and South. Also notes Transition (between central and south)



3.3 General Minerals: Variations Over Time at Wells, Piper Trilinear Diagrams

Of central concern to BWD and all other users of groundwater within the Subbasin is water quality degradation over time due to ongoing overdraft, irrigation and septic-related return flows, and loss of higher quality water due to dewatering of the upper aquifer. Piper trilinear diagrams were constructed for each of the wells using available historical data (compiled in **Appendix B**). Two examples are included as **Figures 8** and **9** where one well has had significant changes in water quality over time versus another that has been relatively stable.

The Piper diagrams depict relative ratios of the anions and cations, not the total concentrations. Also included in the figures are graphs of the anions and cations that present the measured concentrations (in mg/L).

<u>ID1-8 (South Management Area, Well#15 on **Figure 7**)</u>
Water chemistry has significantly changed over time at ID1-8. This well is in the South Management Area as depicted as Well #15 on **Figure 7**. It has been sampled since 1972. **Figure 8** includes a Piper Diagram and charts depicting TDS, cations, and anion concentrations over time.

Observed is historically decreasing bicarbonate, increasing chloride, and increasing calcium. Recent data indicates that water quality may be stabilizing.

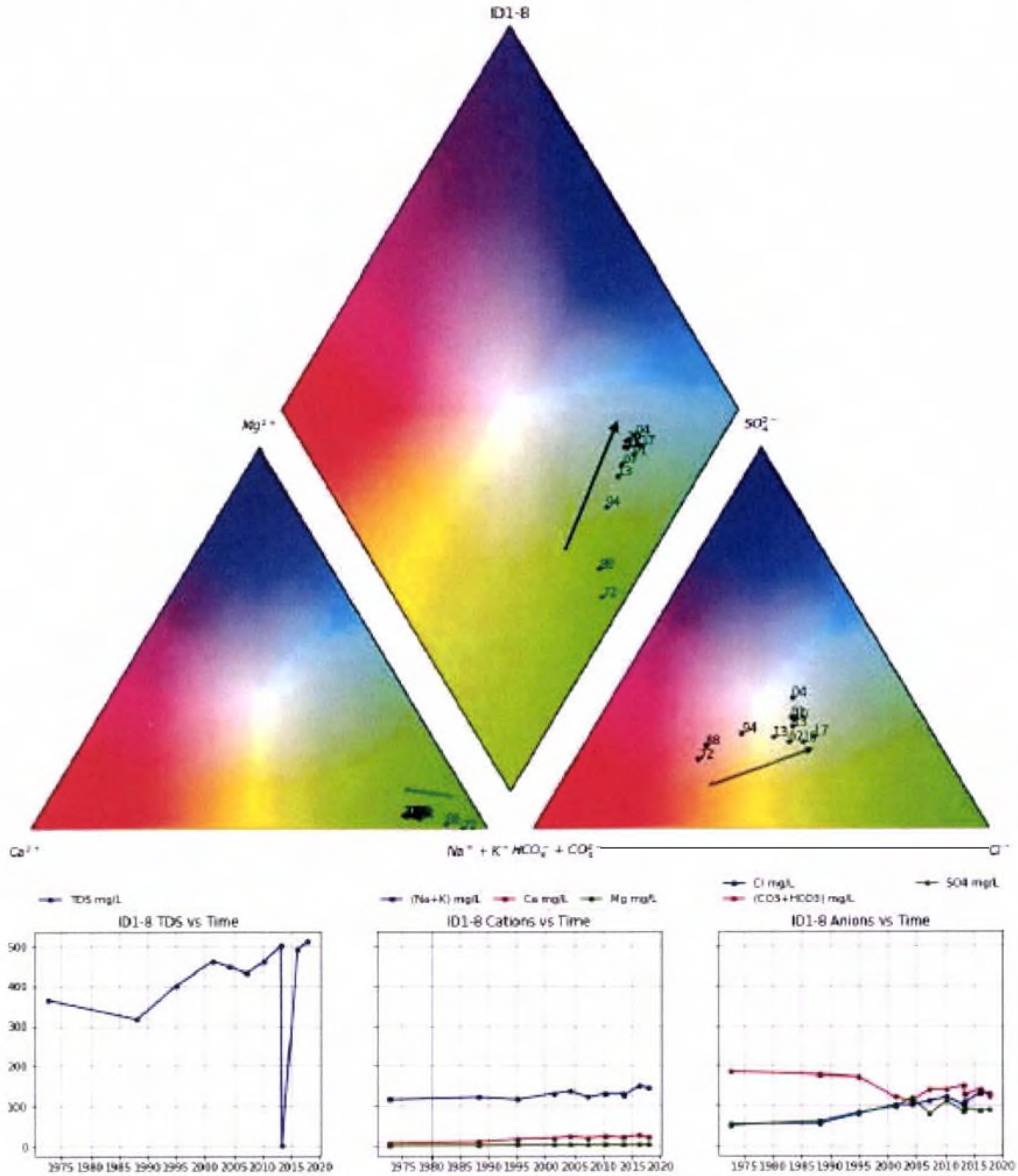
In terms of overall chemistry (see **Figure 6A**) the water in this well in now described as sodium chloride dominant, typical of marine and deep ancient groundwater.

<u>ID4-18 (North Management Area, Well #2 on **Figure 7**)</u>
This well is in the North Management Area as depicted as Well #2 on **Figure 7**. It also has been sampled since 1972. **Figure 9** includes a Piper Diagram and charts depicting TDS, cations, and anion concentrations over time.

There is much less overall change with time compared to ID1-8, but the sampling data do show sulfate is increasing. The change is subtle change but significant since concentrations are above the recommended secondary MCL of 250 mg/L, but do remain below the upper MCL of 500 mg/L. Sulfate is increasing as bicarbonate decreases over time. The points in the anion portion of the diagram (lower right triangle) occur along a line indicative of increasing sulfate.

In terms of anion chemistry (see Figure 6A) the water in this well in now described as sulfate dominant. Sulfate is a COC.

FIGURE 8: ID1-8 (see Figure 8A for explanation of the diagram and axes)

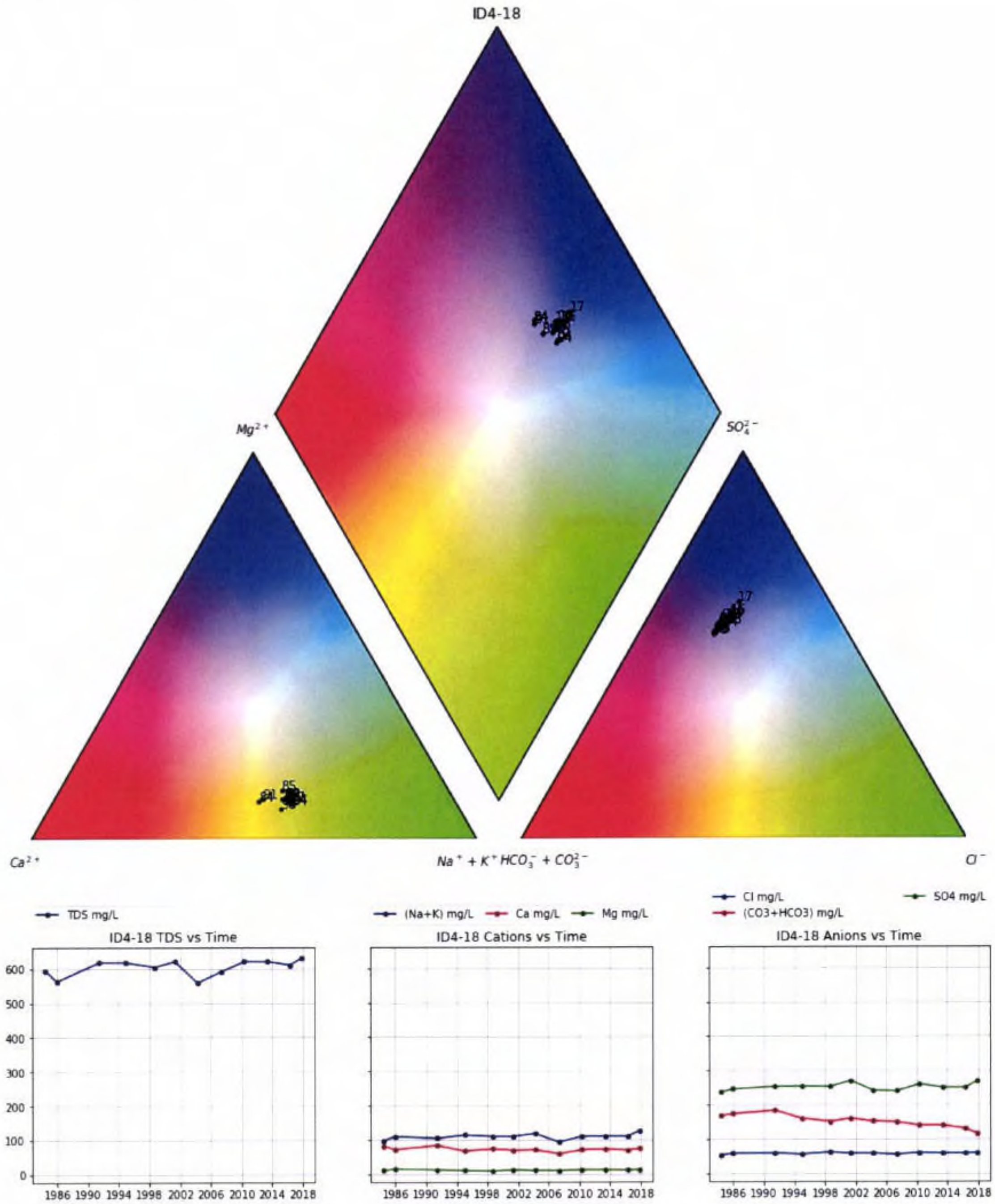


Notes:

1. The last two digits of the year the samples were taken are shown in the Piper diagram.

2. Chemistry has changed due to increases in sulfate, chloride, and sodium; and decreased bicarbonate. The change from 1970s to the 2000s is evident. TDS is also increasing.

FIGURE 9: ID4-18



Note:

1. The last two digits of the year the samples were taken are shown in the Piper diagram.

2. Water chemistry is fairly stable with a slow increase in sulfate and decrease in bicarbonate.

3.4 TDS with Depth

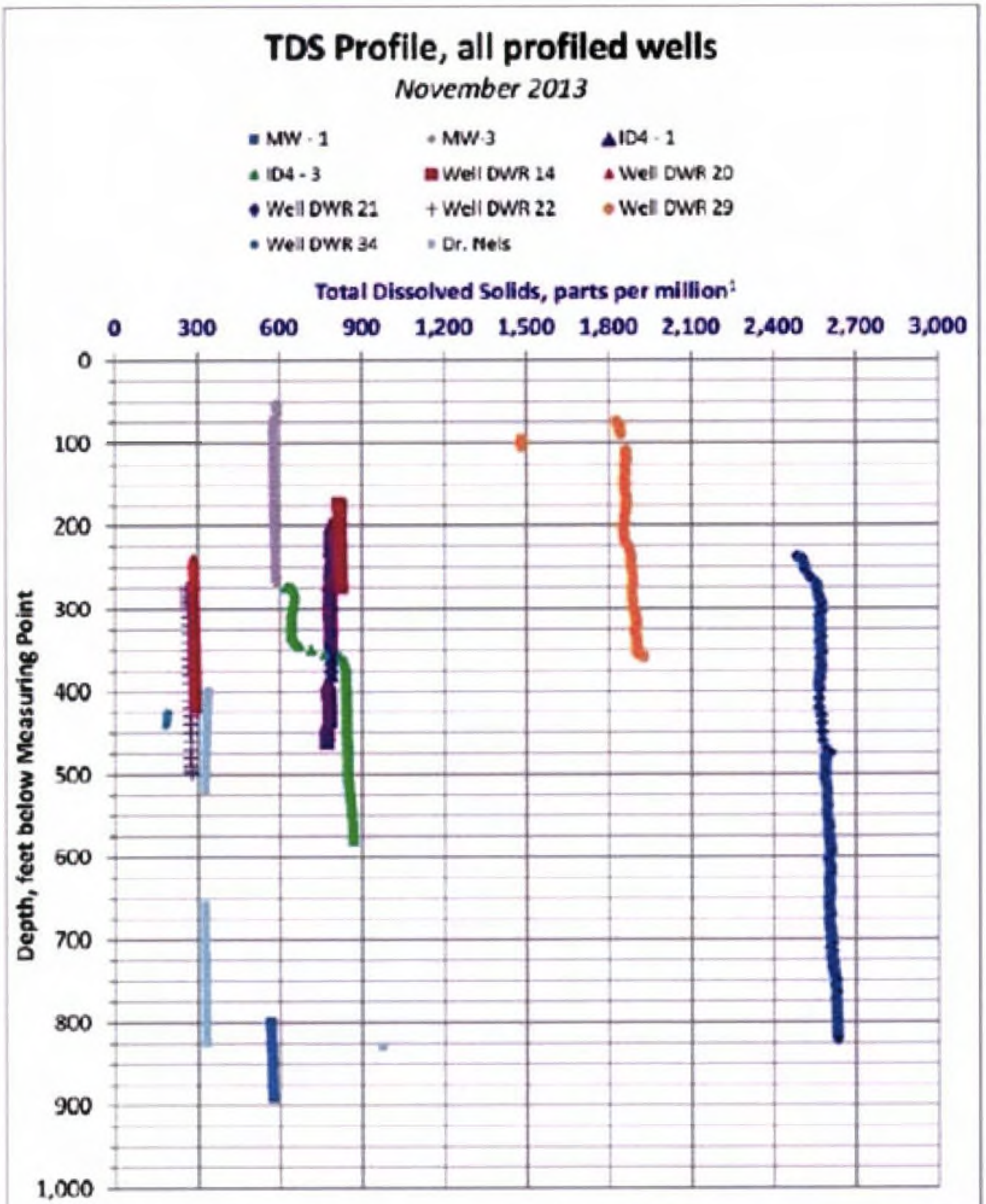
Well profiles based on TDS and temperature were presented by the DWR in a 2014 presentation (as referenced in footnote #11, a copy is included in **Appendix A**). **Figure 10** presents the profile data obtained from eleven wells that ranged in depth from 280 to 900 feet. For reference BWD water supply wells currently range in depth from 392 to 830 feet (Table 1).

Review of **Figure 10** supports the following:

- TDS varied by well, with linear increase with depth at each well. The exception is well ID4-3 where a step-wise increase in TDS was observed at a depth of approximately 350 feet.
- Groundwater temperature was relatively warm, ranging from approximately 80 to 90 °F. All wells exhibited increasing temperature with depth.

Geologic conditions and lithologies do change with depth, and it is generally expected that water quality change will decrease with depth. While quite important towards understanding the effect of overdraft on water quality, relatively few depth-specific groundwater chemistry data have been obtained in the Subbasin. The data presented in **Figure 10** are obtained by lowering measurement probes into the wells and are relatively inexpensive to collect provided there are no obstructions in the well. Additional discussion of well profiling methods is included in the report recommendations.

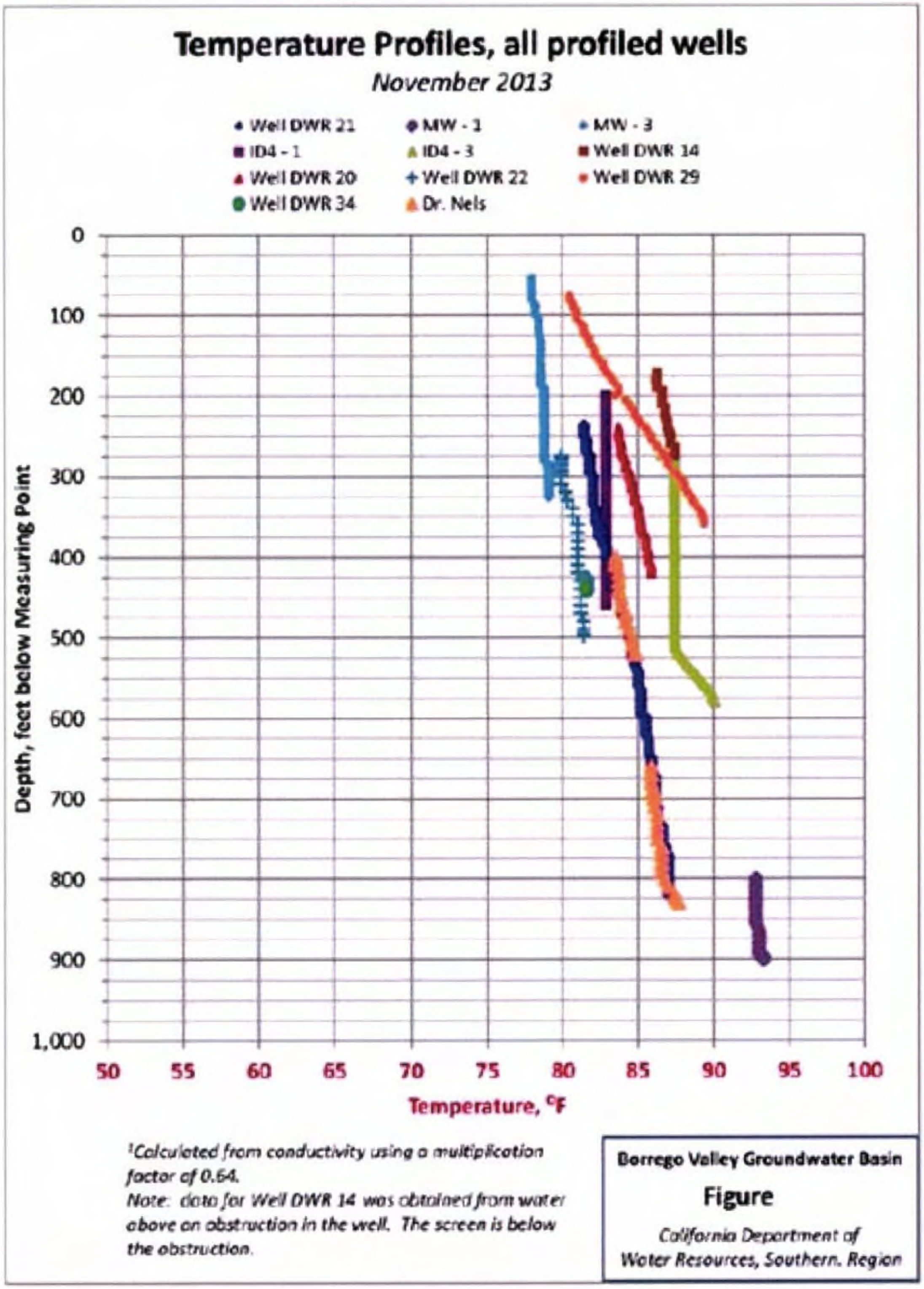
FIGURE 10



[1]Calculated from conductivity using a multiplication factor of 0.64.
Note: data for Well DWR 14 was obtained from water above an obstruction in the well. The screen is below the obstruction.

Borrego Valley Groundwater Basin
Figure
California Department of Water Resources, Southern Region

FIGURE 10, continued



3.5 Nitrate

Nitrate (NO_3) is a groundwater contaminant that is commonly detected in drinking water supplies obtained from alluvial basins throughout the southwestern US (see, for example, USGS NAWQA[15], CA SWRCB GAMA[16], and others). Nitrate in groundwater has many natural sources, but nitrate concentrations in groundwater underlying agricultural and urban areas are commonly higher than in other areas. The primary sources of nitrate in the Subbasin include fertilizers associated with agriculture and turf grasses (golf courses), and septic systems.

The relationship between groundwater quality and overlying land uses was examined by DWR (DWR, 2014; in **Appendix A**). **Figure 11** shows *"the distribution of nitrate analyses for the Borrego Basin. Maximum content is shown per section and sections are colored according to the number of analyses in the section. Sections where the maximum contaminant level (MCL) are exceeded are shown in hatched patterns."* The DWR analysis shows that nitrates occur above MCLs in multiple wells.

The USGS reviewed nitrate data and stated that *"TDS and nitrate concentrations were generally highest in the upper aquifer and in the northern part of the Borrego Valley where agricultural activities are primarily concentrated." (USGS Model Report, p.2) ... "Water-quality samples from wells distributed throughout the valley show that NO3-N concentrations ranged from less than 1 mg/L to almost 67 mg/L. NO3-N concentrations were highest in the shallow aquifer and exceeded the CA-MCL of 10 mg/L in some samples from the shallow and middle aquifers in the northwestern part of the basin (fig. 26). NO3-N concentrations in samples from the lower aquifer did not exceed 6.7 mg/L."* (USGS Model Report p.64)

Further spatial analysis of the occurrence of nitrate relative to land use is not included in this report. Additional review of nitrate data is included in **Section 3.7,** and in the GSP.

---

[15] Thiros, S.A., Paul, A.P., Bexfield, L.M., and Anning, D.W., 2014, The quality of our Nation's waters—Water quality in basin-fill aquifers of the southwestern United States: Arizona, California, Colorado, Nevada, New Mexico, and Utah, 1993–2009: U.S. Geological Survey Circular 1358, 113 p., http://dx doi.org/10.3133/cir1358. National Ambient Water Quality Assessment (NAWQA)

[16] Groundwater Ambient Monitoring and Assessment Program (GAMA See:)https://www.waterboards.ca.gov/gama/

3.5.1 Supporting Information Regarding Nitrate

Historical groundwater quality impairment for nitrates is noted in the GSP to predominantly occur in the upper aquifer of the North Management Area underlying the agricultural areas, and near areas with a high density of septic point sources. The primary source of nitrates is likely associated with either fertilizer applications.

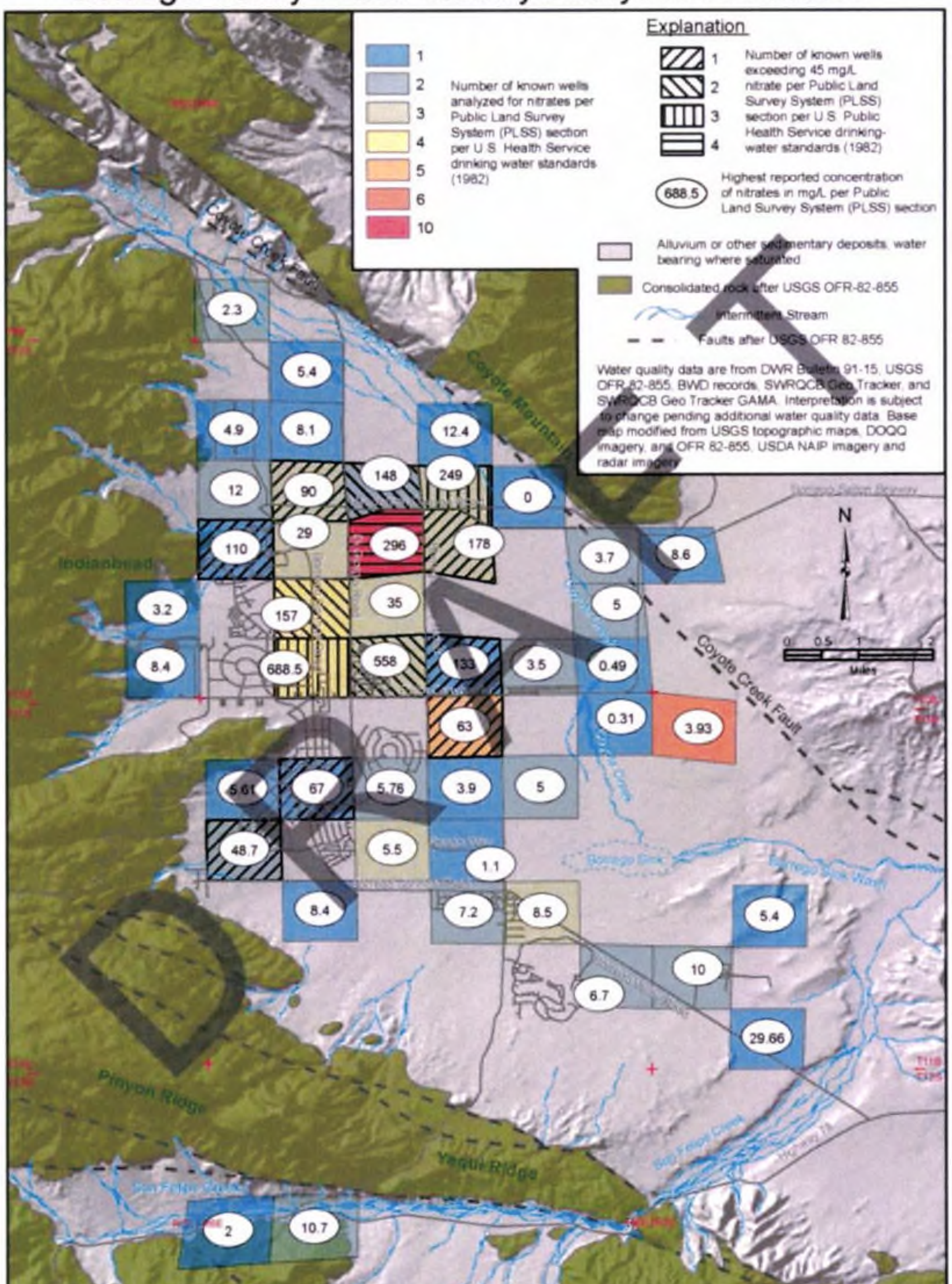
Information provided by Dudek in the GSP supports that nitrates have historically impacted multiple wells as follows. It is understood that the BWD Improvement District 4 (ID4) well 1 and 4, Borrego Springs Water Company Well No. 1 (located at the BWD office), the Roadrunner Mobile Home Park, and Santiago Estates wells were all taken out of potable service due to elevated nitrate. The latter two developments were connected to municipal wells operated by the BWD as an alternative source of supply. Well ID4-4 was re-drilled and screened deeper at the same location and successfully accessed good water quality not impacted by nitrates. The DiGiorgio wells 11, 14 and 15 located north of Henderson Road have historical detections of nitrate and TDS above drinking water standards. The existing groundwater network indicates elevated nitrate currently occurs at the Fortiner well No.1 in the North Management Area and at the BWD's WWTP monitoring well (see map, **Figure 4**).

Nitrate contamination enters the unconfined aquifer system via irrigation return flows and septic system discharge. An unconfined aquifer is directly open to the downward percolation of water. Thus, the uppermost portion of the aquifer is the most susceptible to nitrate impacts. However, as noted in **Table 1B**, nitrate impacts have been observed at low concentrations in all of the active BWD water supply wells.

There are two factors that can facilitate the downward migration of nitrates within the aquifer system- both caused by wells. The first is that ongoing pumping from deeper portions of the aquifer can actively draw shallow groundwater deeper into the aquifer system. The second is that inactive wells can act as conduits for groundwater flow and facilitate the drainage of water from the upper aquifer into deeper aquifers because of downward hydraulic gradients induced by ongoing pumping and overdraft (see Recommendations, Section 5.2, for additional discussion).

FIGURE 11

Borrego Valley Water Quality Analyses of Nitrates



3.6 Arsenic

Arsenic is the primary drinking water COC identified throughout alluvial basins across the desert southwest (see, for example, previously cited USGS NWQA Report, 2014). The fate and transport of arsenic highly depends on the hadrochemical environment. Chemical conditions control the chemical state (valence) of the ion in solution- here arsenic can occur as either arsenate (As^{+3}) or arsenate (As^{+5}). The chemical behavior of arsenic in groundwater depends on multiple factors including the pH and the relative state of oxidation (i.e., chemically oxidizing or reducing, or 'redox' state). Arsenate (As^{+5}) for example, tends to become more soluble as pH increases. Microbial processes are also known to be involved in the oxidation and mobility of arsenic.[17]

Arsenic concentrations above MCLs currently occur in groundwater in the South Management Area, primarily in wells installed for the Ram's Hill Golf Course. **Figure 12**, from BWD Board presentation by Dudek dated 1/25/2018, shows prior sampling results. Sampling results for the remainder of the Subbasin indicate arsenic to occur at less than half the MCL (5 micrograms per liter [µg/L]). The sampling results for active BWD wells are summarized in **Section 4**.

FIGURE 12

10

South Management Area: Arsenic

[17] Sun 2010. The Role of Denitrification on Arsenite Oxidation and Arsenic Mobility in An Anoxic Sediment Column Model with Activated Alumina. In Bioengineering and Biotechnology. https://onlinelibrary.wiley.com/doi/abs/10.1002/bit.22883 This work is cited because it supports that Nitrate, an alternative electron acceptor, can support oxidation of As^{+3} to As^{+5} (arsenate) by denitrifying bacteria in the absence of oxygen. Arsenate is generally considered to be mobile in groundwater at pH levels greater than 8.

3.6.1 Supporting Information Regarding Arsenic

To date all water quality testing has reported 'total arsenic'. While this is consistent with the reporting requirements for drinking water testing, the current monitoring program does not speciate arsenic by valence. The species that occur in groundwater can generally be inferred based on knowledge of water conditions- specifically the pH and Eh (or redox state).

A study of arsenic and nitrate in the Subbasin done in cooperation with the BWD was published by Rezaie-Boroon et al, in 2014.[18] The study was based on data from six BWD wells (ID4-18, ID4-11, ID1-12, ID4-10, ID1-10, and Wilcox) for the period of 2006 to 2014. Their trend analyses are not summarized here because four more years of data have since been collected and the trends have changed. Their work emphasized the following:

- The chemical environment as determined by pH and Eh is important. Both pH and Eh conditions control how dissolved arsenic occurs in aqueous environment (see reference).[19] Arsenic is more soluble in an alkaline (high pH) and anoxic environments. The relative mobility of arsenic depends on its valence, typically occurring as either arsenite (As^{+3}) or arsenate (As^{+5}). As^{+3} is typically more mobile than As^{+5} in anoxic groundwater.
- The presence of iron oxide coatings on soil and sediment particles supports arsenic adsorbtion and can cause the concentration of arsenic in solution to decrease. This will typically occur under oxidizing conditions where As^{+5} will generally occur versus As^{+3}, and where iron oxides will occur.
- *"The most common forms of arsenic in groundwater are their oxy-anions, arsenite (As+3) and arsenate (As^{+5}). Both cations are capable of adsorbing to various subsurface materials, such as iron oxides and clay particles. Iron oxides are particularly important to arsenate fate and transport"* because...*"arsenate [ed: As+5] strongly adsorbs to these surfaces in acidic to neutral waters."* Thus, increases in pH will support the desorption or release of arsenate into groundwater.

The interaction of arsenic with soil and aquifer material containing iron oxide is summarized in a 2015 report by the Water Research Foundation.[20] This study is potentially relevant to the use of arsenic-bearing irrigation water, because it shows that arsenic can be removed from water when passed through soil. The Water Research Foundation report concluded that "Results of this study provide an inexpensive arsenic treatment method for water utilities", while

[18] Rezaie-Boroon et al, 2014. The Source of Arsenic and Nitrate in Borrego Valley Groundwater Aquifer. Journal of Water Resource and Protection, 5, p1589-1602. https://www.scirp.org/journal/PaperInformation.aspx?PaperID=51944
[19] Stein, C.L., Brandon, W.C. and McTigue, D.F. (2005) Arsenic Behavior under Sulfate-Reducing Conditions: Beware of the "Danger Zone". EPA Science Forum 2005: Collaborative Science for Environmental Solutions, 16-18 May 2005, Washington DC.
[20] Water Research Foundation, 2015. In-situ Arsenic Removal During Groundwater Recharge Through Unsaturated Alluvium. Web Report #4299.

recognizing that the work was a pilot study and that a good understanding of site conditions is necessary to achieve similar results.

Arsenic may also be released from the dewatering or release of water in from clays. A recent study published in 2018 for the San Joaquin Valley of California examined the potential release of arsenic from the Corcoran Clay, a regionally extensive clay deposit that is being compressed as a result of land subsidence due to groundwater overdraft.[21] Their results "support the premise that arsenic can reside within pore water of clay strata within aquifers and is released due to overpumping".

Four factors were seen to contribute to the occurrence of arsenic in groundwater that included clay thickness, dissolved manganese (Mn) concentrations, elevation (depth), and recent subsidence. As stated in their report "We highlighted four of the most important variables describing arsenic concentration within the Tulare Basin in the recent model, shown in Fig. 2a-d [of their report]. Of these, the thickness of the Corcoran Clay (a confining unit that overlies a lower aquifer) shows a positive correlation with arsenic concentrations due to increased clay content. Elevation has a negative correlation, as lower areas are more likely to have been water-saturated and thus anaerobic. A positive correlation was found between $\log_{10}$(Mn) and arsenic concentrations, as the presence of manganese indicates an anoxic environment, in which arsenic tends to be more soluble. Significantly, recent subsidence from InSAR[22] [ed: land surface elevation data] showed a positive correlation, as over-pumping leads to increased pore water drainage from clays. The first three variables are well-known from the literature and not related to human activity. The quantitative link between pumping-induced subsidence and arsenic concentrations has not been shown before, and is directly related to human activity."

Their analysis supports that geochemical data that include measurements of oxidation-reduction potential (redox) and oxygen content, and testing for minerals that are indicative of geochemical conditions (such as ferrous and ferric iron, and manganese) can support assessment of the potential for arsenic to become mobile in the aquifer system. A recent USGS publication provides further explanation of the role of iron oxides under varying pH and redox conditions (USGS Scientific Investigations Report 2012–5065[23]). A key point made by the USGS is that arsenic becomes mobile at a pH greater than 8 under oxidizing and neutral/transitional

---

[21] Overpumping leads to California groundwater arsenic threat. By Ryan Smith, Rosemary Knight, and Scott Fendorf. June 2018. In Nature Communications (2018) 9:2089, DOI: 10.1038/s41467-018-04475, www.nature.com/naturecommunications. or at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5988660/pdf/41467_2018_Article_4475.pdf

[22] "InSAR (Interferometric Synthetic Aperture Radar) is a technique for mapping ground deformation using radar images of the Earth's surface that are collected from orbiting satellites". see https://volcanoes.usgs.gov/vhp/insar.html

[23] Predicted Nitrate and Arsenic Concentrations in Basin-Fill Aquifers of the Southwestern United States, by David W. Anning, Angela P. Paul, Tim S. McKinney, Jena M. Huntington, Laura M. Bexfield, and Susan A. Thiros; https://pubs.usgs.gov/sir/2012/5065/pdf/sir20125065.pdf

redox conditions, and is potentially mobile under strongly reducing conditions where both arsenite and iron can be in solution.

The USGS Model Report evaluated land subsidence in the Subbasin for the period of the 1960s to 2010 (page 70 of their report) and concluded that "...land subsidence attributed to aquifer-system compaction is not currently a problem in the Borrego Valley and is unlikely to be a significant problem in the future". However, this does not preclude the potential release or extraction of arsenic from clay-rich portions of the aquifer system that may occur under current or future pumping absent subsidence, or as a result of changes in geochemical conditions that could mobilize arsenic from clay-rich sediments that may contain arsenic.

Overall the occurrence, nature, and extent of arsenic in the Subbasin is not well understood. It is more prevalent in South Management Area wells. While currently water quality conditions are good relative to arsenic, it was observed to be at or near drinking water MCLs in multiple BWD water supply wells during the last decade and could affect BWD's water supply in the future.

3.7 Correlations Among Water Quality Parameters (Combined Data Assessment)

One of the goals of this Report is to evaluate whether multiple chemical parameters can be used to better define and predict COC trends at BWD water supply wells. Piper diagrams presented in **Section 3.2** were used to examine spatial trends and also illustrate that there are definable relationships among the general minerals seen in the trilinear diagrams. In this section the water chemistry data are combined for all wells to examine general relationships and correlations. The data set also includes pH, hardness. Other potentially important geochemical parameters such as iron and manganese were not included because they were not uniformly obtained for the water quality samples historically collected.

3.7.1 Water Quality Data Correlations

Water quality data obtained since 2004 were used to examine potential correlations and relationships. The recent data were selected to represent current conditions as water quality has changed over time in many wells. Among the parameters that were tested include anions (HCO_3, Cl, SO_4), cations (Ca, Mg, and Na [potassium was not included as less data were collected]), pH, TDS, Ca+ Na, Cl+HCO_3, As, F, and NO_3. Also included in the correlation analysis were two parameters named Midst and Low Sat that represented the percentage of well screen open to flow per aquifer unit as described in each of the wells (for example if a well is completed with the same amount of screen length per aquifer then both values would be 50 percent).

Correlations greater than 0.5 or less than -0.5 are highlighted in **Table 3**. Values between 0.5 and 0.7 are underlined, and values greater than 0.7 are in bold. The South Management Area data have been separated from the North and Central Management Areas.

Selected data are shown in graphical form in this section. The data set used in the correlations was limited to those samples where the general minerals charge balance was within 10 percent. The graphs further restrict the data to only include higher quality data with a +/- 5 % charge balance. Hem (1985) considers data with 5% charge balance to be of good quality[24].

[24] John Hem, 1985. Study and Interpretation of the Chemical Characteristics of Natural Water. USGS Water-Supply Paper 2254. From page 163: "Under optimum conditions, the analytical results for major constituents of water have an accuracy of +/-2 - +/- 10 percent. That is, the difference between the reported result and the actual concentration in the sample at the time of analysis should be between 2 and 10 percent of the actual value. Solutes present in concentrations above 100 mg/L generally can be determined with an accuracy of better than +/- 5 percent. Limits of precision (reproducibility) are similar."

Table 3

NORTH and CENTRAL	Bicarbonate	Chloride	Sulfate	Fluoride	Calcium	Magnesium	Sodium			cation	anion	pct middle	pct lower	Arsenic	Nitrate
	HCO3	Cl	SO4	F	Ca	Mg	Na	pH	TDS	Ca+Na	Cl+HCO3	MidSat	LowSat	As	NO3
HCO3	1.00	0.73	-0.38	-0.30	0.46	0.76	-0.10	-0.69	0.27	0.18	0.94	-0.48	0.30	-0.28	0.49
Cl		1.00	-0.26	-0.09	0.28	0.54	0.31	-0.53	0.43	0.36	0.92	-0.40	0.15	-0.13	0.72
SO4			1.00	0.26	0.46	0.07	0.67	0.16	0.70	0.70	-0.35	0.01	0.09	0.23	-0.43
F				1.00	-0.30	-0.23	0.54	0.48	0.15	0.21	-0.21	-0.43	0.47	0.66	-0.14
Ca					1.00	0.79	0.34	-0.60	0.72	0.77	0.40	-0.31	0.25	-0.32	0.14
Mg						1.00	0.23	-0.75	0.57	0.58	0.70	-0.48	0.40	-0.33	0.37
Na							1.00	0.03	0.83	0.86	0.10	-0.39	0.38	0.31	0.22
pH								1.00	-0.31	-0.30	-0.65	0.24	-0.12	0.68	-0.46
TDS									1.00	0.95	0.37	-0.41	0.33	0.04	0.21
Ca+Na										1.00	0.28	-0.43	0.39	0.04	0.23
Cl+HCO3											1.00	-0.47	0.24	-0.23	0.65
MidSat												1.00	-0.86	-0.30	-0.43
LowSat													1.00	0.30	0.22
As														1.00	-0.18
NO3															1.00

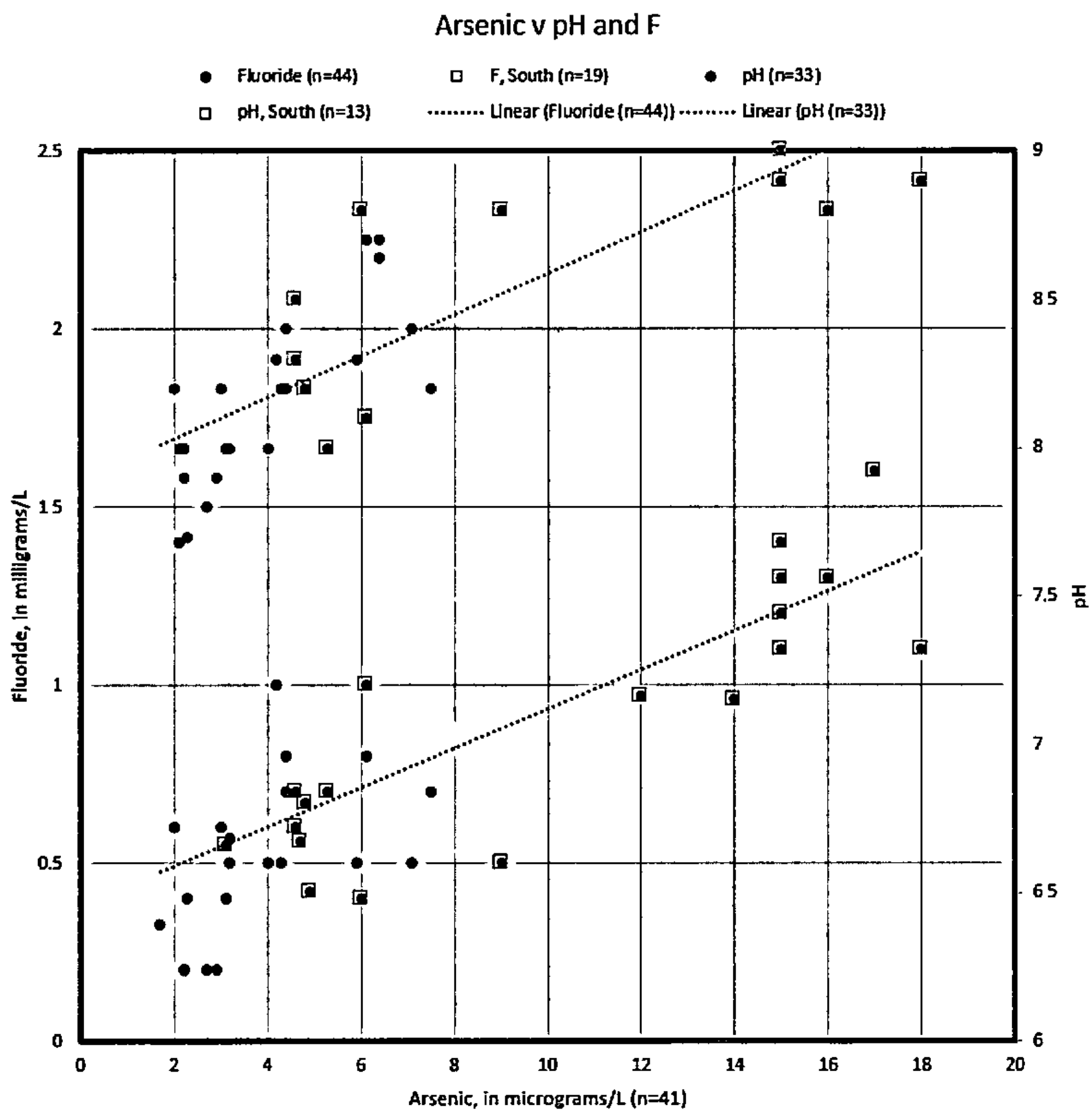
SOUTH	Bicarbonate	Chloride	Sulfate	Fluoride	Calcium	Magnesium	Sodium					pct middle	pct lower	Arsenic	Nitrate
	HCO3	Cl	SO4	F	Ca	Mg	Na	pH	TDS	Ca+Na	Cl+HCO3	MidSat	LowSat	As	NO3
HCO3	1.00	-0.45	-0.44	0.14	-0.37	-0.31	-0.16	0.27	-0.33	-0.25	0.14	0.31	-0.33	0.10	0.19
Cl		1.00	0.87	-0.31	0.80	0.36	0.83	-0.34	0.92	0.84	0.47	0.17	-0.19	-0.08	0.11
SO4			1.00	-0.37	0.95	0.46	0.73	-0.31	0.96	0.86	0.37	-0.03	0.04	-0.01	0.01
F				1.00	-0.48	-0.16	-0.14	0.56	-0.40	-0.41	-0.33	-0.23	0.23	0.73	-0.22
Ca					1.00	0.42	0.60	-0.46	0.92	0.78	0.29	0.05	-0.05	-0.13	0.08
Mg						1.00	-0.03	-0.13	0.42	0.16	0.07	-0.11	0.11	0.06	-0.05
Na							1.00	-0.10	0.81	0.86	0.49	0.24	-0.24	0.09	0.19
pH								1.00	-0.35	-0.25	-0.13	-0.18	0.19	0.55	-0.30
TDS									1.00	0.89	0.44	0.14	-0.14	-0.03	0.18
Ca+Na										1.00	0.70	0.18	-0.19	-0.06	0.15
Cl+HCO3											1.00	0.27	-0.30	-0.14	0.05
MidSat												1.00	-1.00	-0.15	0.46
LowSat													1.00	0.17	-0.45
As														1.00	-0.06
NO3															1.00

COC	North and Central	South
Arsenic	pH (.68), F (.66)	F (.73), pH (.55)
Nitrate	Cl (.72)	-none-
Sulfate	TDS (.70), Na (.67)	TDS (.96), Ca (.95), Cl (.87), Na (.73)
Fluoride	As (.66), Na (.54)	As (.73), pH (.56)
TDS	Na (.83), Ca (.72), SO_4 (.70), Mg (.57)	SO_4(.96), Cl (.92), Ca (.92), Na (.81)

Arsenic and Fluoride

Arsenic and fluoride concentrations are correlated and both increase with pH. **Figure 13** depicts arsenic versus fluoride and pH. (pH versus As is in the upper portion of the graph and the y-axis label is to the right; fluoride versus As is in the lower portion and the y-axis is to the left). In both cases the correlations are influenced by the higher arsenic concentrations observed in the South Management Area (as noted by squares drawn around the data points). Every occurrence of arsenic above the MCL of 10 µg/L is associated with pH values greater than 8.5 (upper portion of the graph).

FIGURE 13

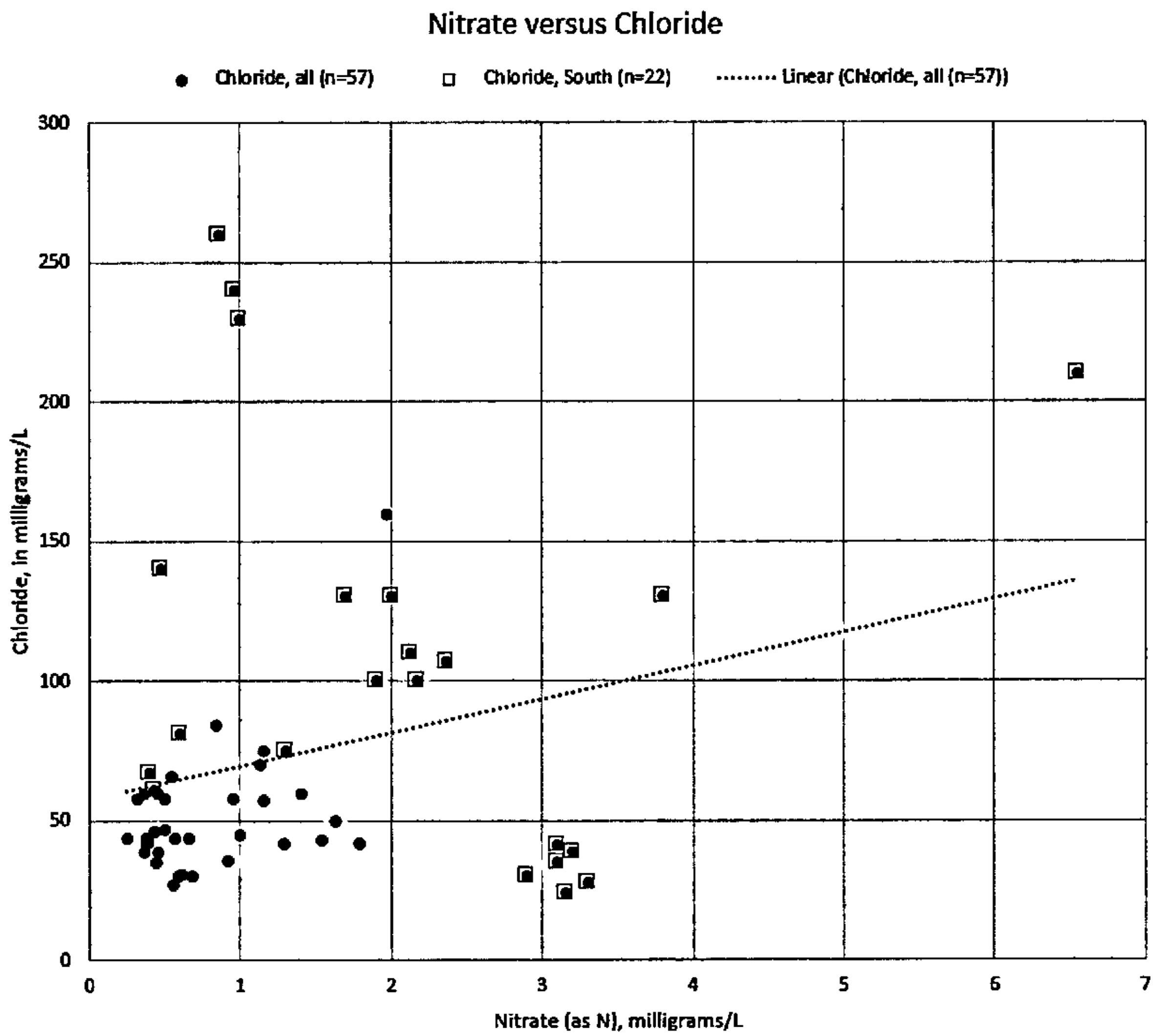


January 2020

Nitrate

Nitrate had few water quality parameter correlations. Nitrate versus chloride is depicted in **Figure 14**. While there was a statistically-indicated correlation in **Table 3** for the North and Central Management Areas, chloride does not appear to be a globally useful predictor of nitrate.

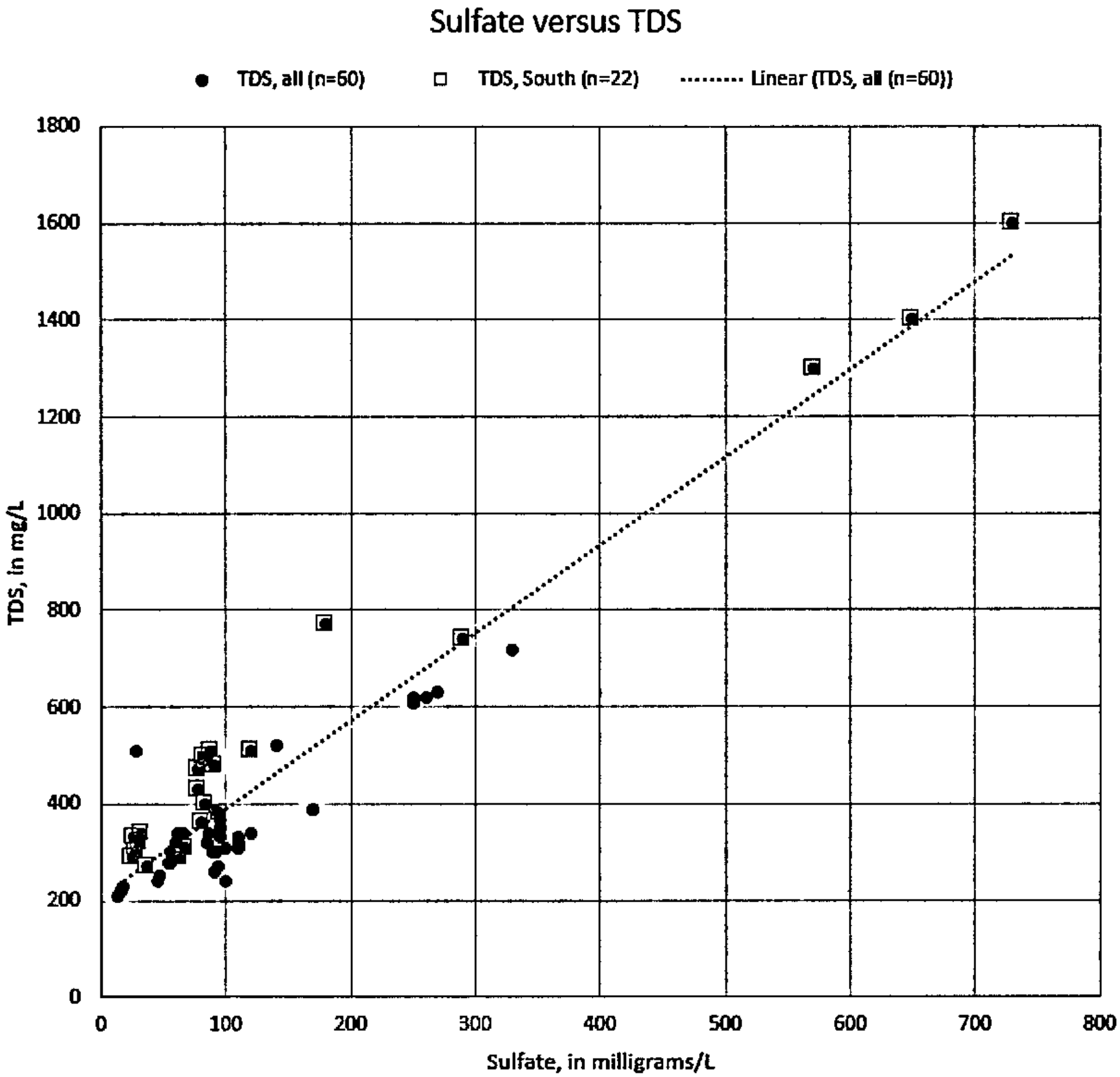
FIGURE 14



Sulfate

The correlation of sulfate with TDS is depicted in **Figure 15.** The three high sulfate values (> 500 mg/L) from the South Management Area strongly influence the correlation.

FIGURE 15

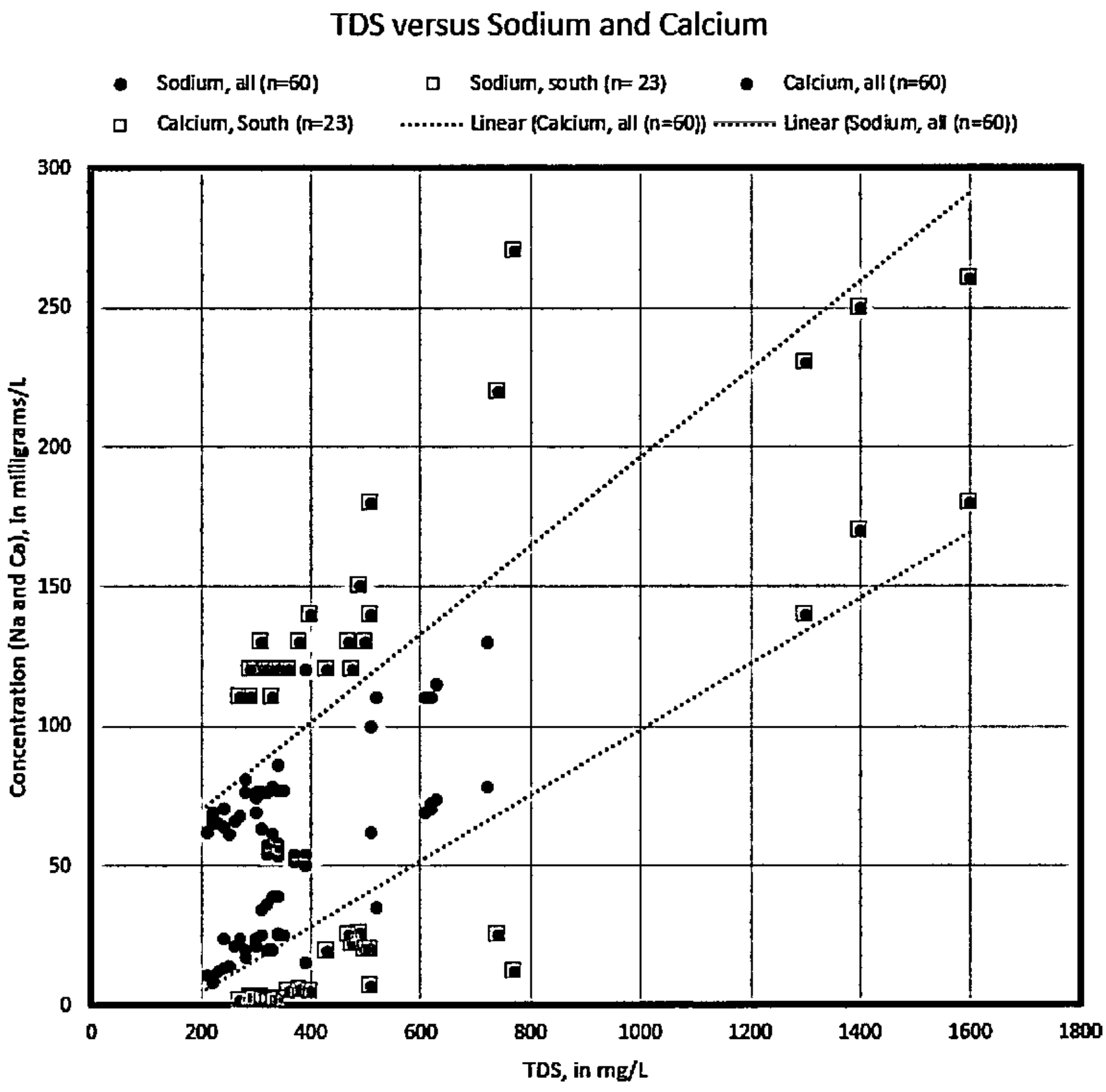


TDS

Multiple analytes correlated with TDS. Sulfate is shown in the previous figure. Sodium and calcium are shown versus TDS in **Figure 16**, and chloride versus TDS is shown in **Figure 17**. Both figures show that the South Management Area water chemistry is different than that observed to the north. The regression lines in **Figure 16** effectively split the two sets of data by management area.

While correlations exist for all three analytes, sodium and chloride represents a higher percentage of TDS and calcium represents a smaller percentage of TDS in the South Management Area.

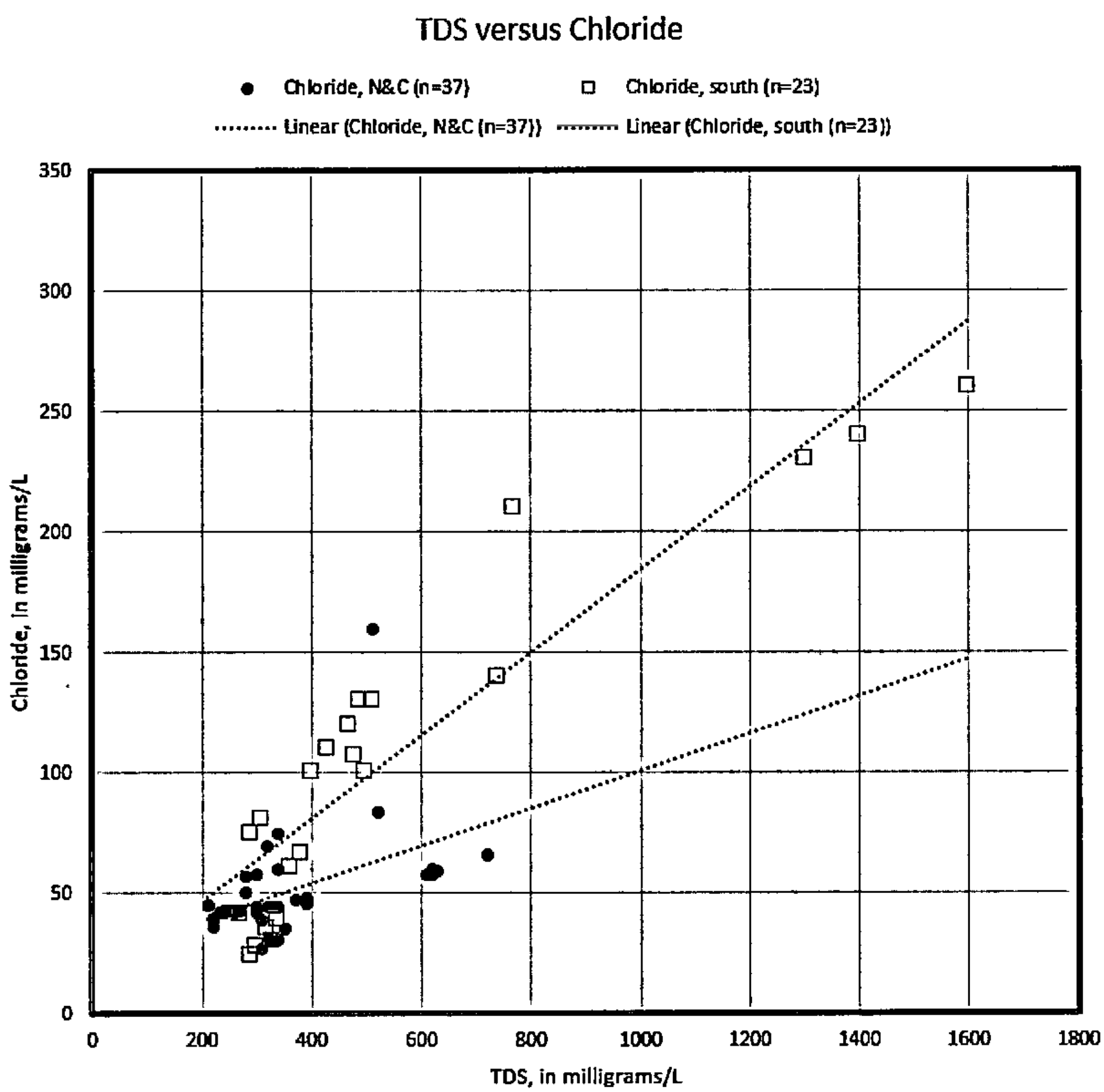
FIGURE 16



January 2020

Chloride data segregated by management area are depicted in **Figure 17**. The highest chloride concentrations typically occur in the South Management Area.

FIGURE 17



3.8 General Minerals: Summary of Observations

A summary of the Piper diagram analyses for the 23 wells used in this Report is included in **Table 1B**.

- Water quality has clearly changed over time. Of the 23 wells, six had insufficient general minerals data to assess trends. Of the 17 wells with sufficient temporal data, approximately 70 percent showed a change in natural water chemistry over time.
- Sulfate is the general mineral most commonly observed to be increasing in groundwater (as a relative percentage per the Piper diagrams).
- Groundwater quality systematically varies with distance along the valley, with water in the South Management Area being noticeably different. Here the well data were not differentiated by aquifer or relative depth

Five COCs are included in this Report. Nitrate and arsenic are currently the chemical of highest concern specific to BWD drinking water quality. Fluoride, sulfate, and TDS are other three COCs. The data were collected over varying time periods and not all sampling events included a complete set of the eight general minerals. A review of the COCs for all of the active BWD wells is provided in **Section 4**.

Limited depth-specific hydraulic and contaminant data are available to assess the nature and extent of COCs in groundwater. As a result, the analyses among wells is limited to spatial comparisons. The lack of depth-specific data is a data gap that affects the assessment of all water quality parameters. The primary impact of this data gap is that the depth-dependent data will provide a good indication of how water quality will change over time as water levels decline. If specific zones are contributing poor water quality, then the data can be used to selectively complete future water wells to reduce the impact of the inflow of poor water quality.

4.0 CHEMICALS OF CONCERN (COCs) AT BWD WATER SUPPLY WELLS

The five chemicals of concern (COCs) include arsenic, total dissolved solids, nitrate, sulfate, and fluoride (As, TDS, NO_3, SO_4, and F). There are nine BWD water supply wells reviewed here. The COC and Piper diagram data for these wells is depicted in the following Figures that follow this subsection:

Figure 18 ID4-4 (Well #4, as depicted in Figure 4)
Figure 19 ID4-11 (Well #5, as depicted in Figure 4)
Figure 20 ID4-18 (Well #2, as depicted in Figure 4)
Figure 21 ID1-10 (Well #14, as depicted in Figure 4)
Figure 22 ID1-12 (Well #9, as depicted in Figure 4)
Figure 23 ID1-16 (Well #12, as depicted in Figure 4)
Figure 24 ID5-5 (Well #8, as depicted in Figure 4)
Figure 25 Wilcox (Well #13, as depicted in Figure 4)
Figure 26 ID1-8 (Well #15, as depicted in Figure 4)

Of these, three wells are being considered for replacement- ID4-4, ID4-18, and ID1-10. **Table 4** summarizes the review of **Figures 18 through 26.**

Water quality trends, if identified, are based on visual description of the various data. The GSP describes the use of Mann-Kendall statistical trend analyses, a non-parametric way to detect a monotonic trend (up or down), to assess individual water quality parameters. The work here is focused on identifying correlations among parameters.

NOTE: Well ID4-4 was redrilled in 1979. Water chemistry changed.

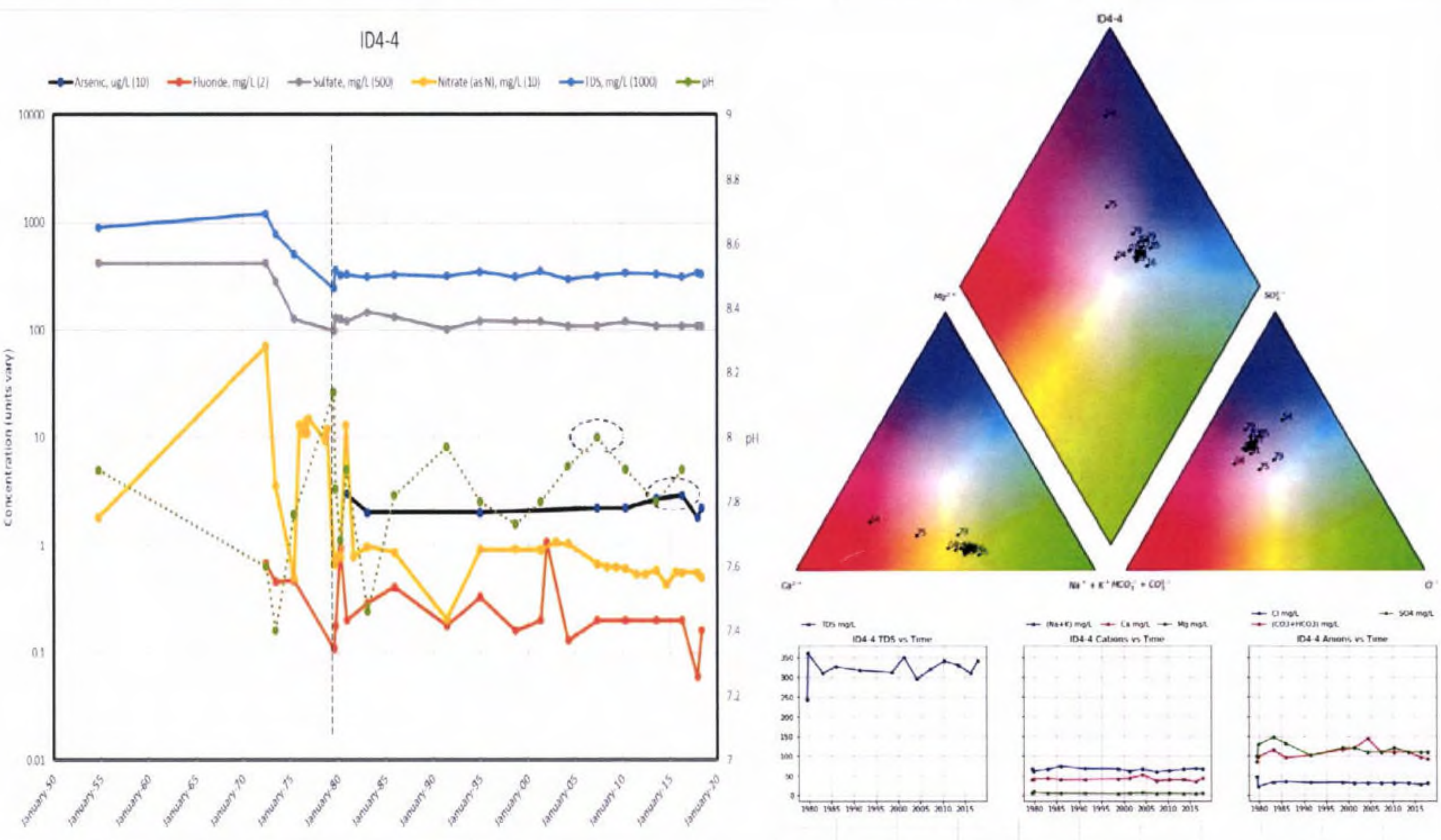


FIGURE 18. BWD Well ID4-4

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

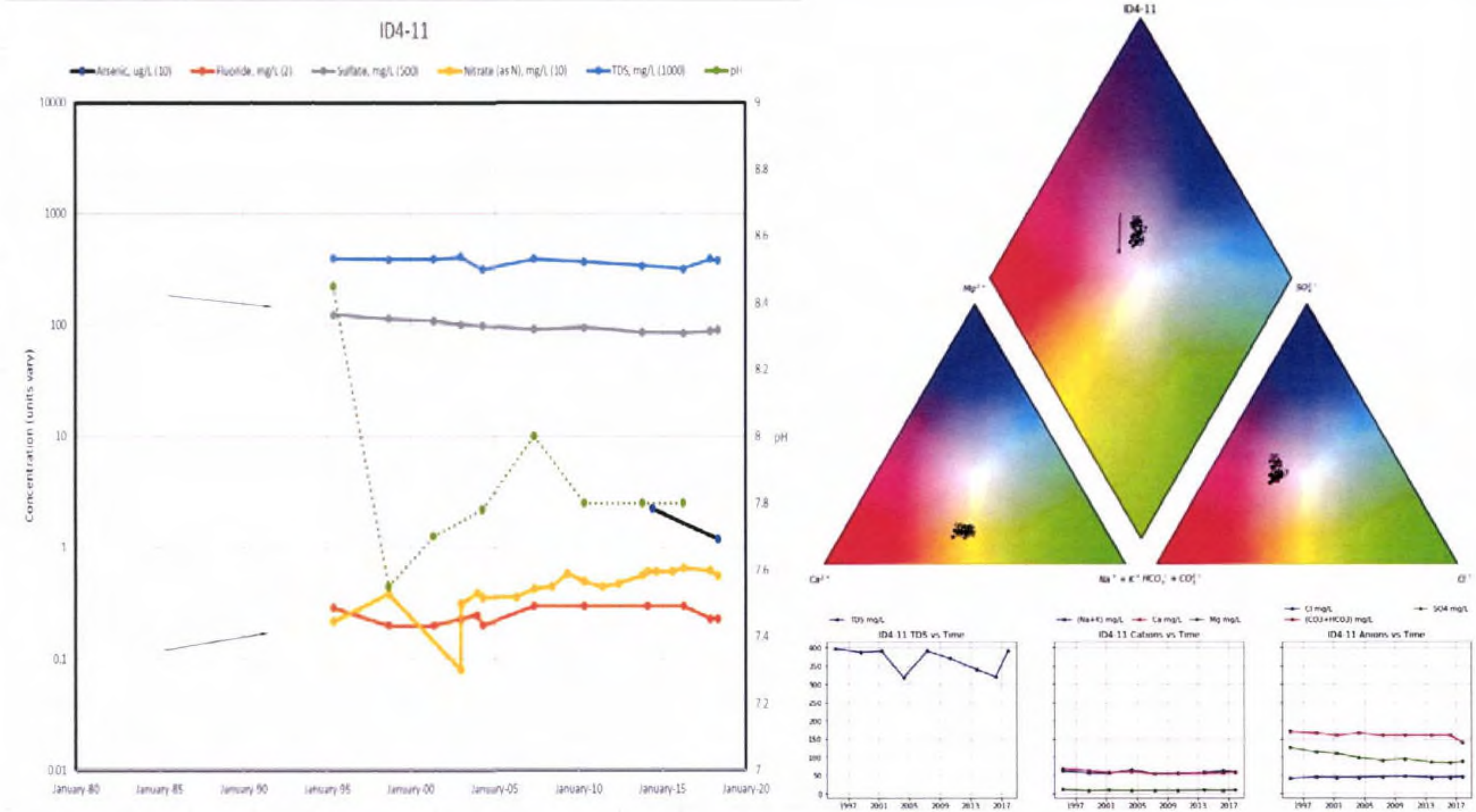


FIGURE 19. BWD Well ID4-11

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

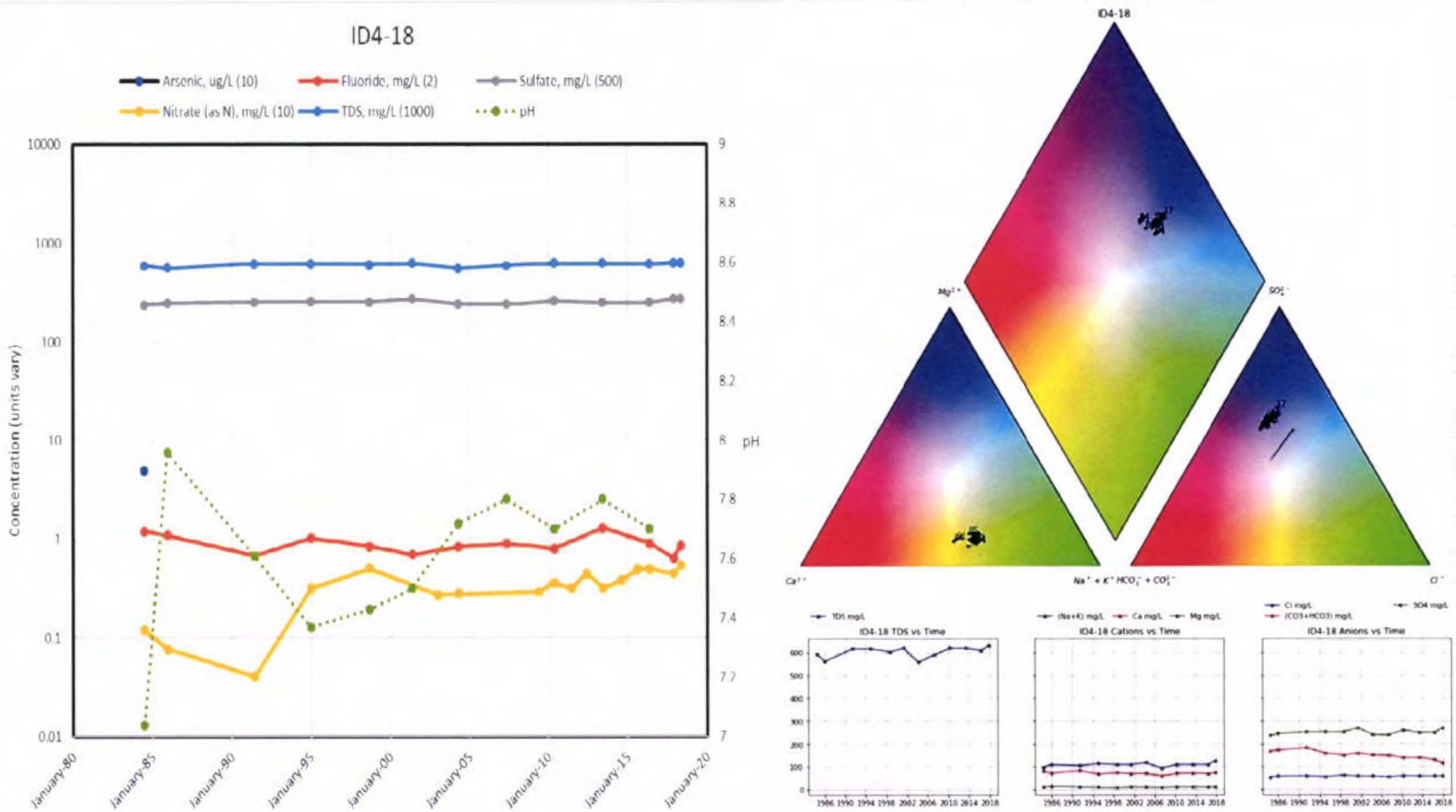


FIGURE 20. BWD Well ID4-18

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

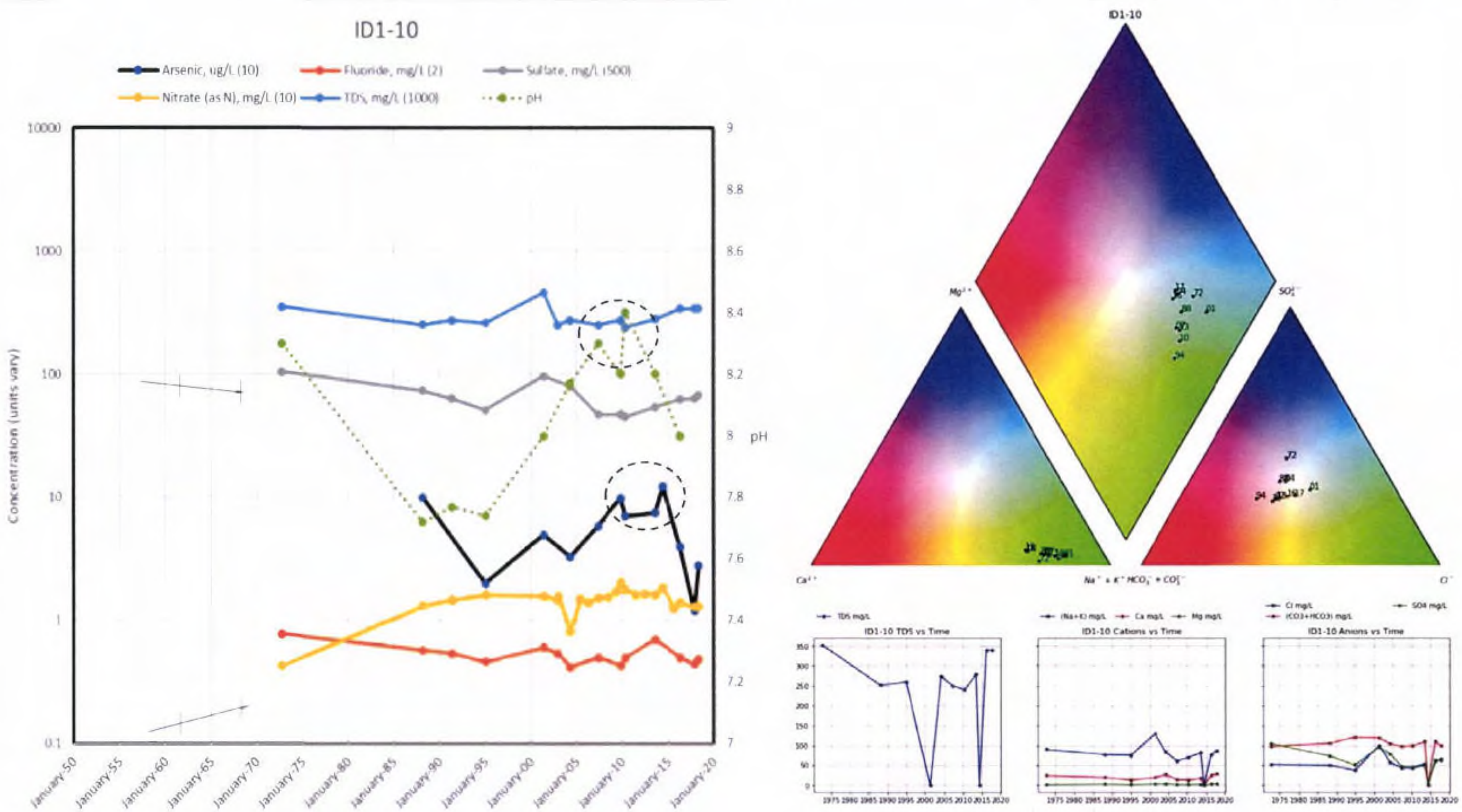


FIGURE 21. BWD Well ID1-10

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

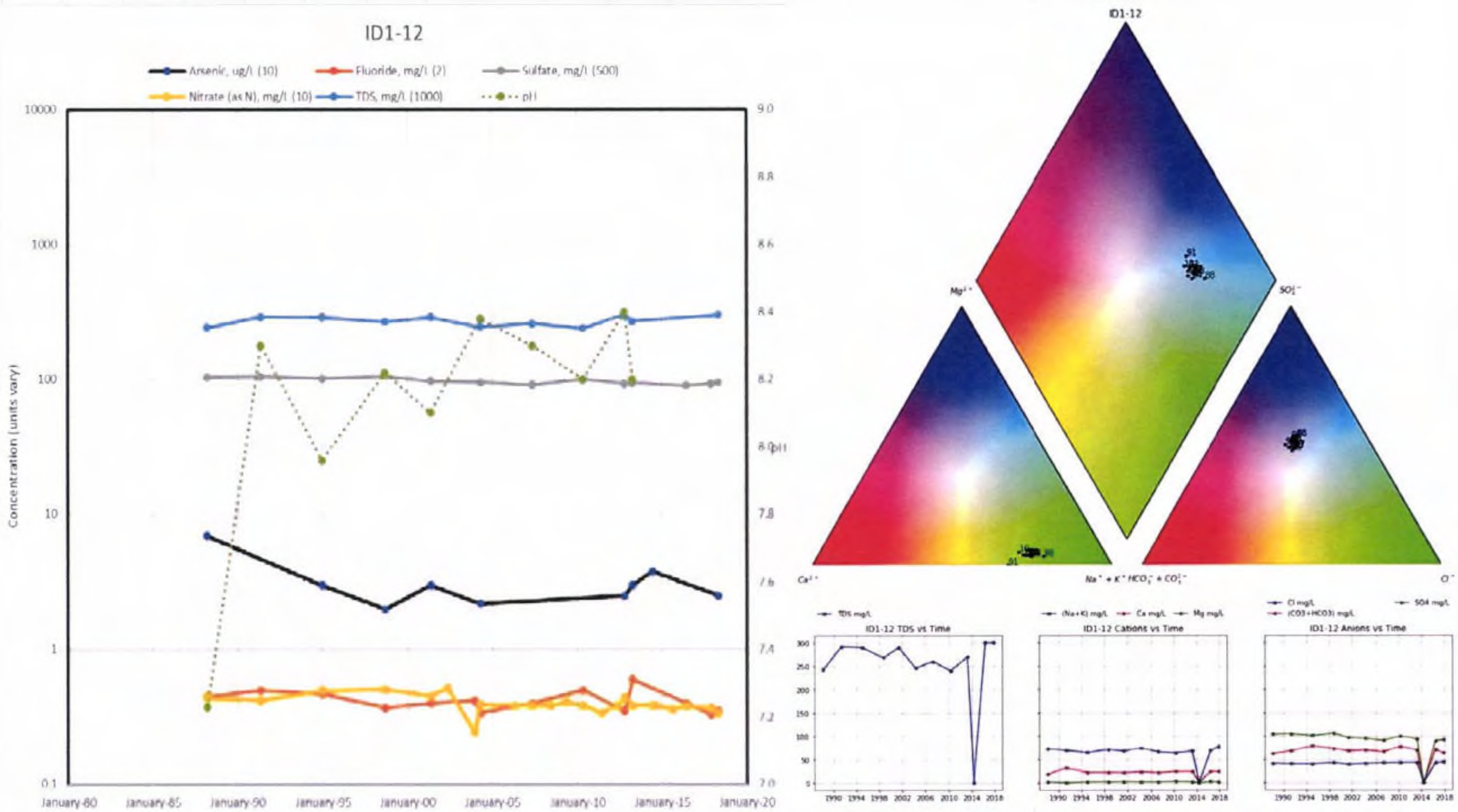


FIGURE 22. BWD Well ID1-12

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

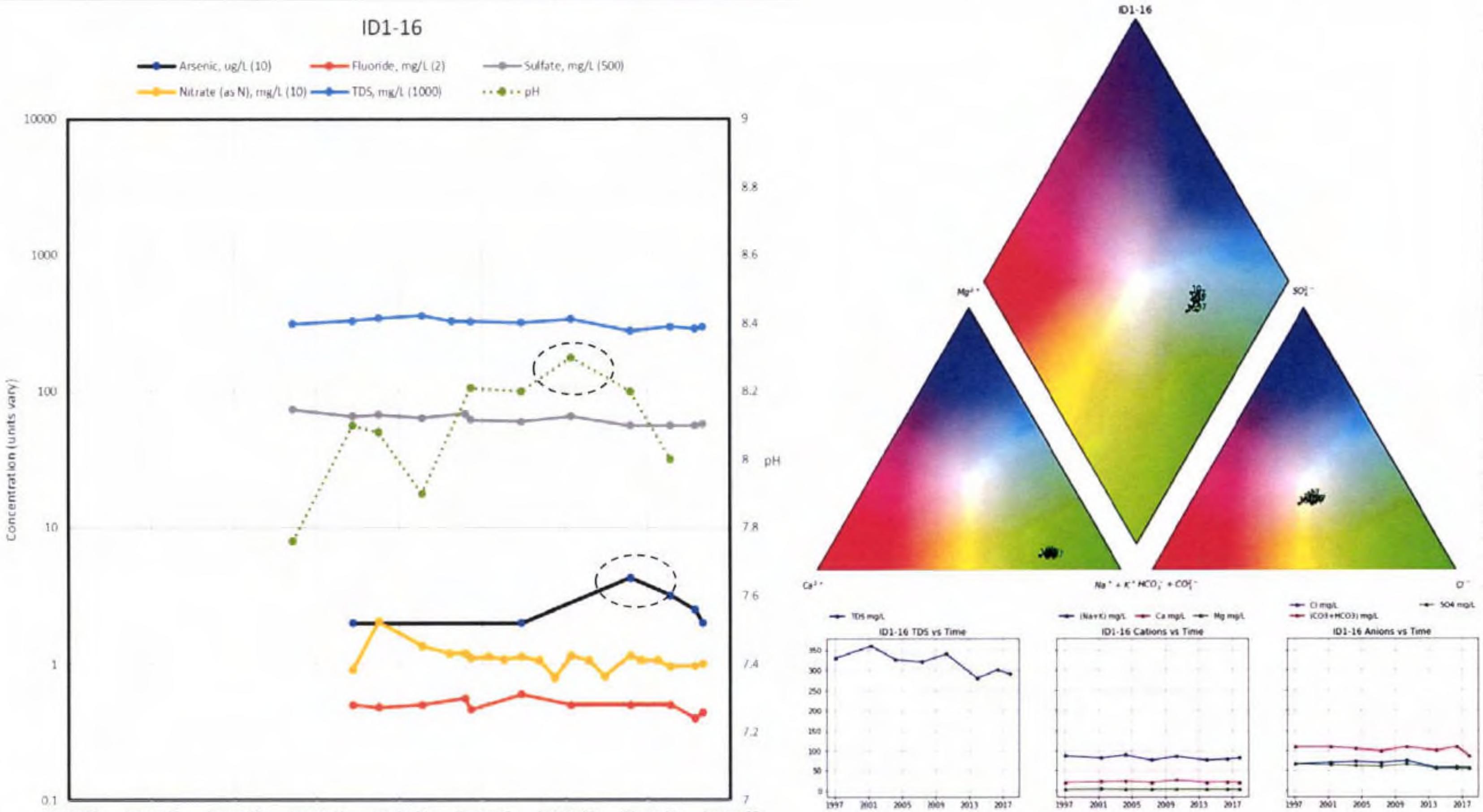


FIGURE 23. BWD Well ID1-16

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

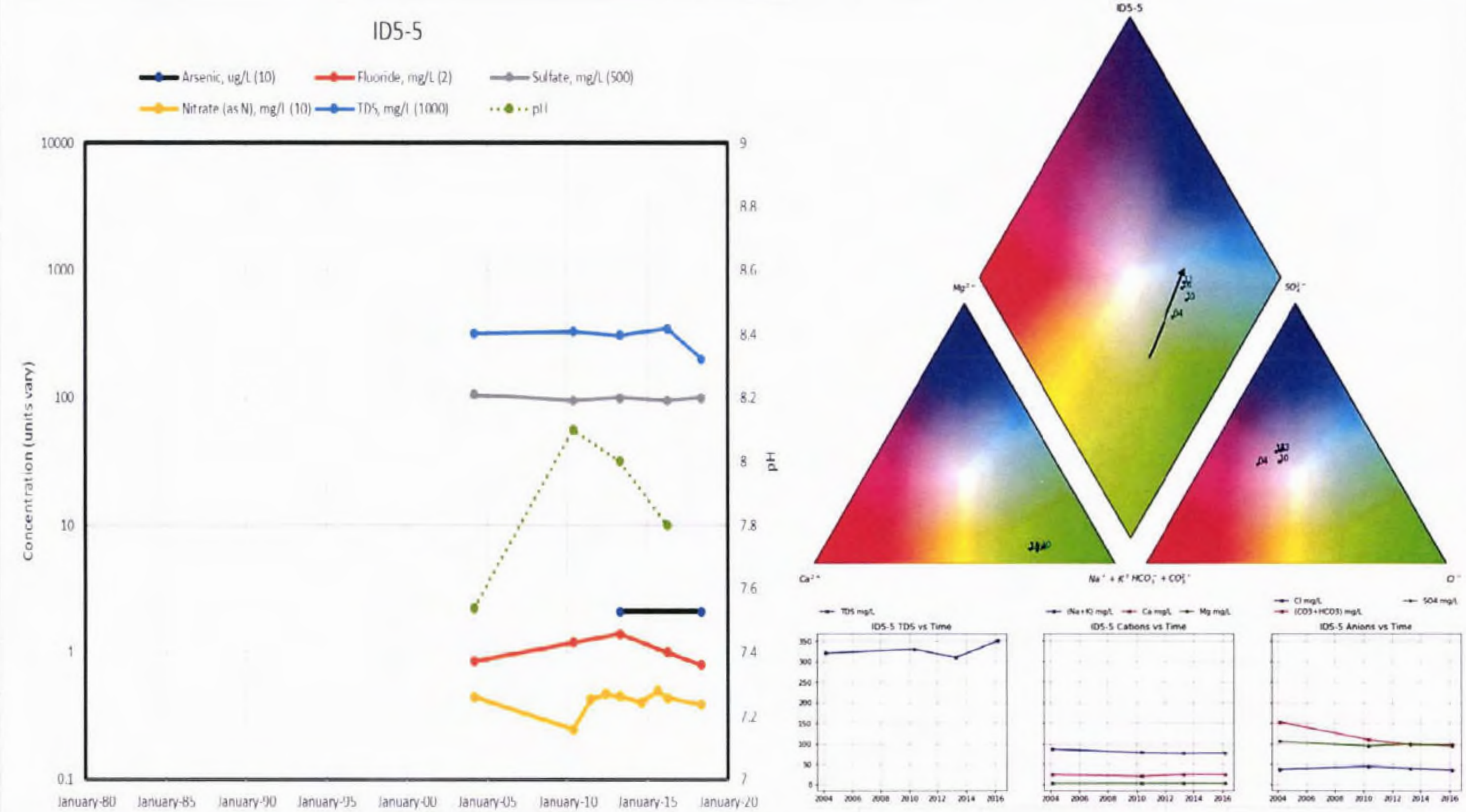


FIGURE 24. BWD Well ID5-5

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

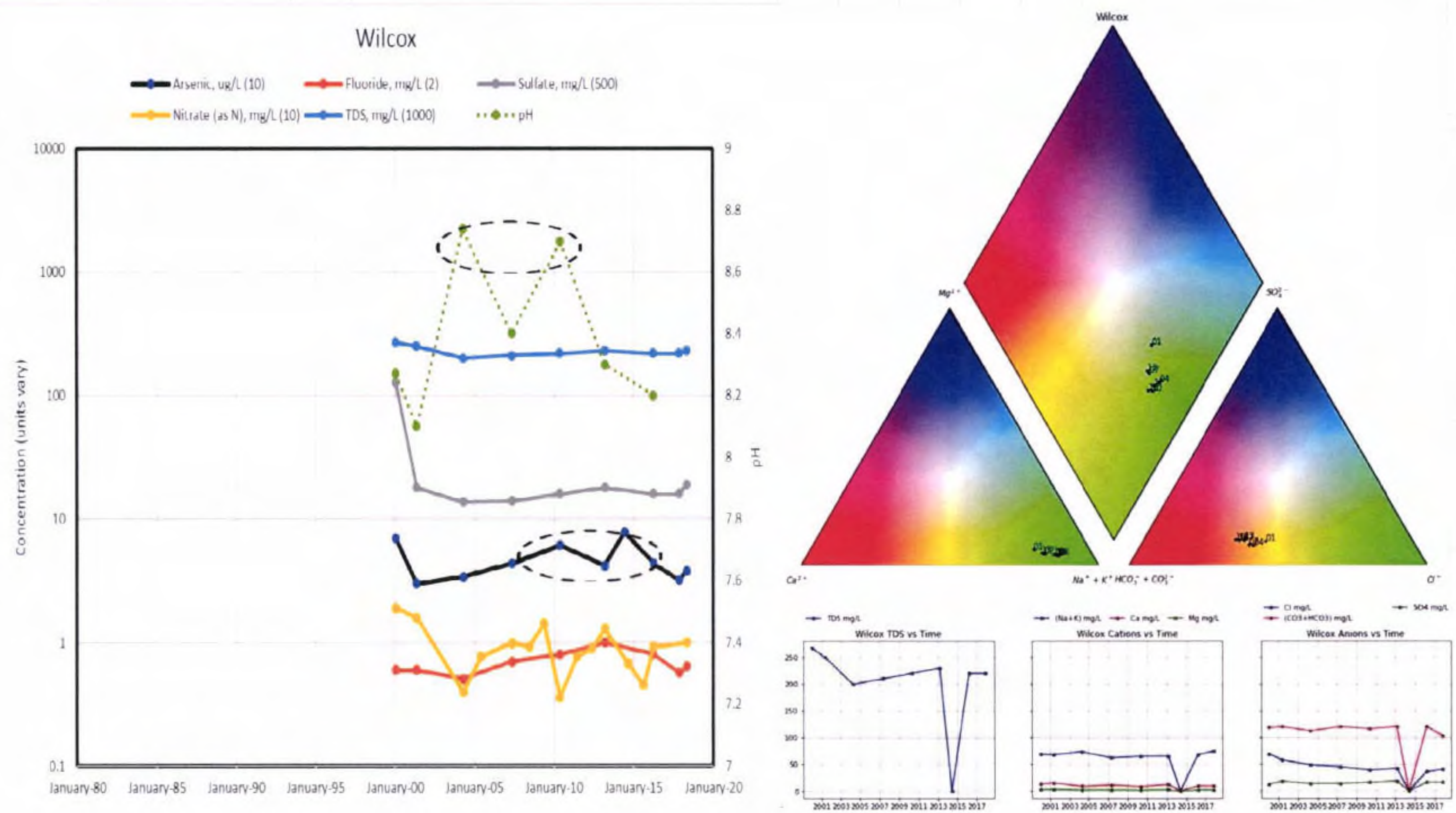


FIGURE 25. BWD Wilcox Well

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

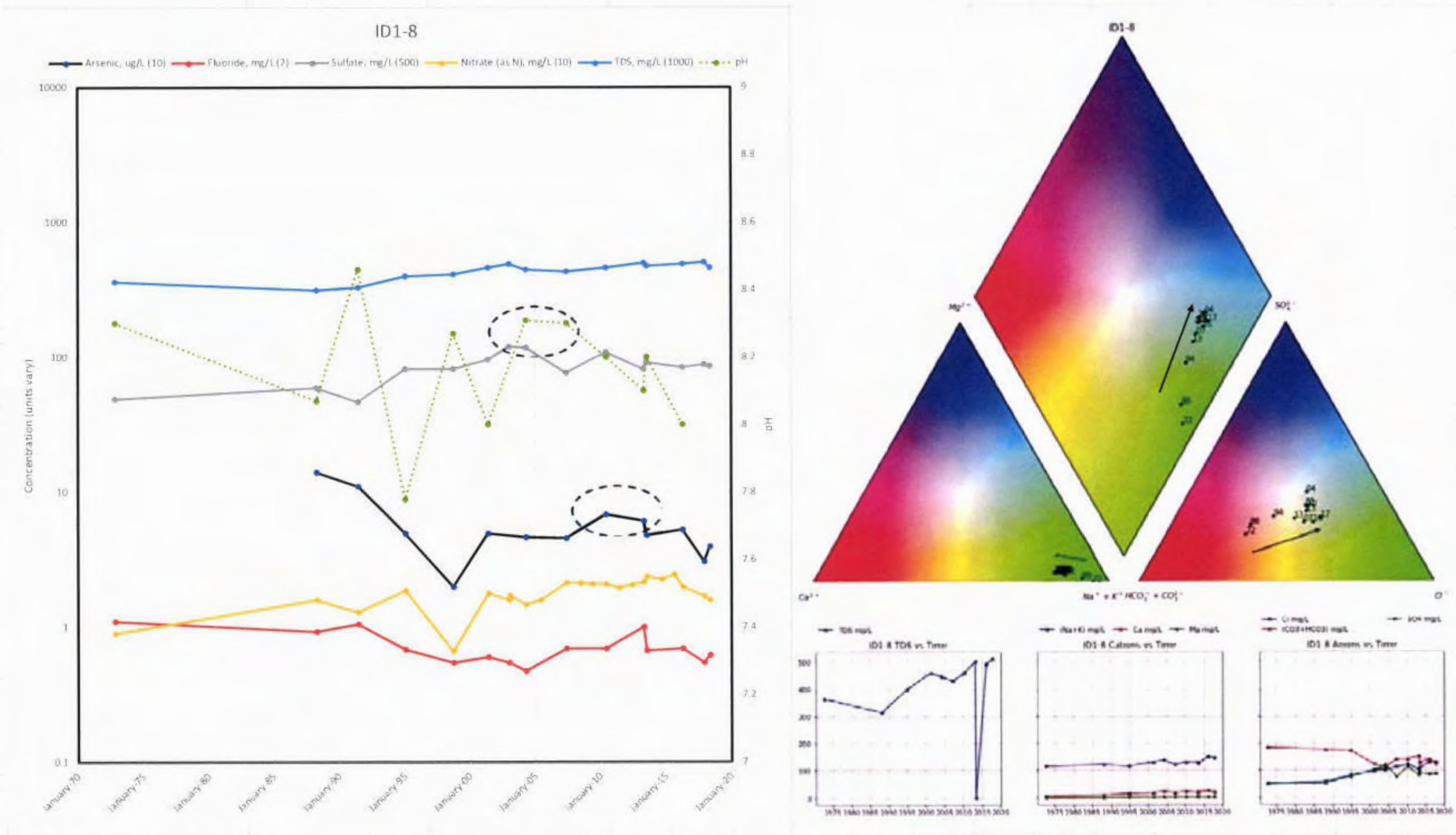


FIGURE 26. BWD Well ID1-8

Notes: pH and COC concentrations versus time shown left panel.
Piper trilinear diagram depicts change over time- the labels indicate the last two digits of the year when sampled (e.g. 72 = 1972)

January 2020

TABLE 4

WELL	TDS/ Gen Min (MCL: 500 recc/1000 max, mg/L)	Sulfate (MCL: 250 recc/500 max,mg/L)	Arsenic (MCL: 10 ug/L)	pH	Nitrate (MCL: 10 mg/L as N)	Fluoride (MCL: 2 mg/L)
ID4-4 (#4)**	Stable (330) TDS: 320 to 340 GenMins*: Vble, cation trend may develop	Stable (110) SO4: 110 to 120	In Range (2.2) As: 1 8 to 2.9	Stable Range pH*: 7.8 to 8	Decreasing (0.5) NO3: 1.0 to 0 43	In Range (0.16) 0.6 to 0.2
ID4-11 (#5)	Stable (380) TDS: 320 to 390 GenMins*: Vble, anion trend may develop	Stable SO4: 91 to 95 Was decreasing prior to 2005	Insuff. Data (2.1) As: 1.2 to 2.2 Two recent detects	Stable Range pH*: 7.8 to 8	Increasing (0.56) NO3: 0 36 to 0 66	In Range (0 23) 0.23 to 0.3
ID4-18 (#2)**	Possibly Increasing (630) TDS: 590 to 630 GenMins: inc SO4, dec HCO3	Increasing (270) SO4: 240 to 270 Slowly changing	Non-Detect	Stable Range pH*: 7.7 to 7.8	Increasing (0 54) NO3: 0.29 to 0.54	In Range (0 87) 0.54 to 1.3
ID1-10 (#14)**	Possibly Increasing (340) TDS: 250 to 340 GenMins: inc SO4, dec HCO3 (major changes since 1972)	Increasing (67) SO4: 45 to 67 Slowly changing	In Wide Range (2.8) As: 1.2 to 12.2 Maximum 6/2014	In Wide Range pH*: 8.0 to 8.4 Maximum 5/2010 (~2 *yr ahead of As*)	In Range (1.3) NO3: 1.27 to 2.02	In Range (0.48) 0.43 to 0.7
ID1-12 (#9)	Stable (300) TDS: 260 to 300 GenMins: Stable	Stable (95) SO4· 91 to 95	In Range (2.5) As: 2.5 to 3.79	In Range pH*: 8.2 to 8.4	In Range (0.34) NO3: 0.34 to 0.44	In Range (0 34) 0.38 to 0 6
ID1-16 (#12)	Possibly Decreasing (340) TDS: 280 to 340 GenMins: SO4 slowly decreasing	Decreasing (58) SO4: 56 to 66 Slowly changing	In Range (2.0) As: 2.0 to 4.3 Maximum 12/2013	In Range pH*: 8.0 to 8.3 Maximum 5/2010 (~3 *yr ahead of As*)	In Range (1.3) NO3: 1.27 to 2 02	In Range (0.48) 0 43 to 0.7
ID5-5 (#8)	Stable (350) TDS: 202 to 350 GenMins*: Vble, anion trend may develop (inc SO4)	Stable (100) SO4: 95 to 106	Insuff. Data (2.1) As: 2.1 (twice) Two recent detects	In Wide Range pH*: 7.54 to 8.1	In Range (0 39) NO3: 0.25 to 0.50	In Range (0.8) 0 85 to 1.4
Wilcox (#13)	Stable (230) TDS. 210 to 230 GenMins: SO4 slowly increasing	Increasing (19) SO4: 14 to 19 Slowly changing	In Range (3 8) As: 3.2 to 7.8 Maximum 6/2014	In Range pH*: 8 2 to 8.7 Maximum 5/2010 (~4 *yr ahead of As*)	In Range (1.0) NO3: 0.36 to 1.42	In Range (0.64) 0.57 to 0 87
ID1-8 (#15)	Possibly Increasing (460) TDS: 430 to 510 GenMins: long-term inc SO4 & Cl & Ca, dec HCO3 (major changes since 1972)	Stable (86) SO4: 82 to 110	In Range (4 0) As: 3.1 to 6 8 Maximum 5/2010	In Range pH*: 8.0 to 8.4 Maximum during 2004 to 2007 (*~3 to 6 yr ahead of As*)	In Range (1.6) NO3: 1.6 to 2.46 (long-term inc)	In Range (0.62) 0 55 to 1.0

Notes:
* Most recent general minerals and pH analyses done in 2016
** Wells expected to be replaced or re-drilled in short-term

Explanation:
Trends noted as Stable, Increasing, Decreasing, Possibly Increasing/Decreasing, or In a Range
Number after descriptor – e g. Stable (330), is the most recent sampling result from Spring 2018
Next line is the range of values observed since 2005
GenMins refers to the set of general minerals data- eight major anions and cations
xi, a value that is highlighted occurs at a concentration greater than 50% of the MCL
xi, a value that is highlighted and bold occurs at a concentration greater than the MCL

4.1 North Management Area (3 Wells: ID4-4, ID4-11, and ID4-18)

The North Management Area wells are generally located to the west and upgradient of the irrigated agricultural areas visible in **Figures 4 and 7**. COC-specific observations are included in **Table 4**.

ID4-4

ID4-4 was re-drilled in 1979 due to high nitrate concentrations related to the upper aquifer. Nitrate remains detectable but at low concentrations. Water quality is good and reasonably stable. The District is currently planning to re-drill this well at the same site as a result of poor well conditions that resulted in sanding and the installation if a well liner that limits the depth to which the pump can be installed in the well.

Additional information regarding the well replacement can be found in a 8/30/2018 Dudek presentation entitled "Water Vulnerability & New Extraction Well Site Feasibility Analysis" posted at the County SGMA website:
https://www.sandiegocounty.gov/content/dam/sdc/pds/SGMA/Prop-1-SDAC-Grant-Task-5-New-Extraction-Well-Site-Feasibility-Analysis.pdf

ID4-11

Water quality in ID4-11 is good and reasonably stable.

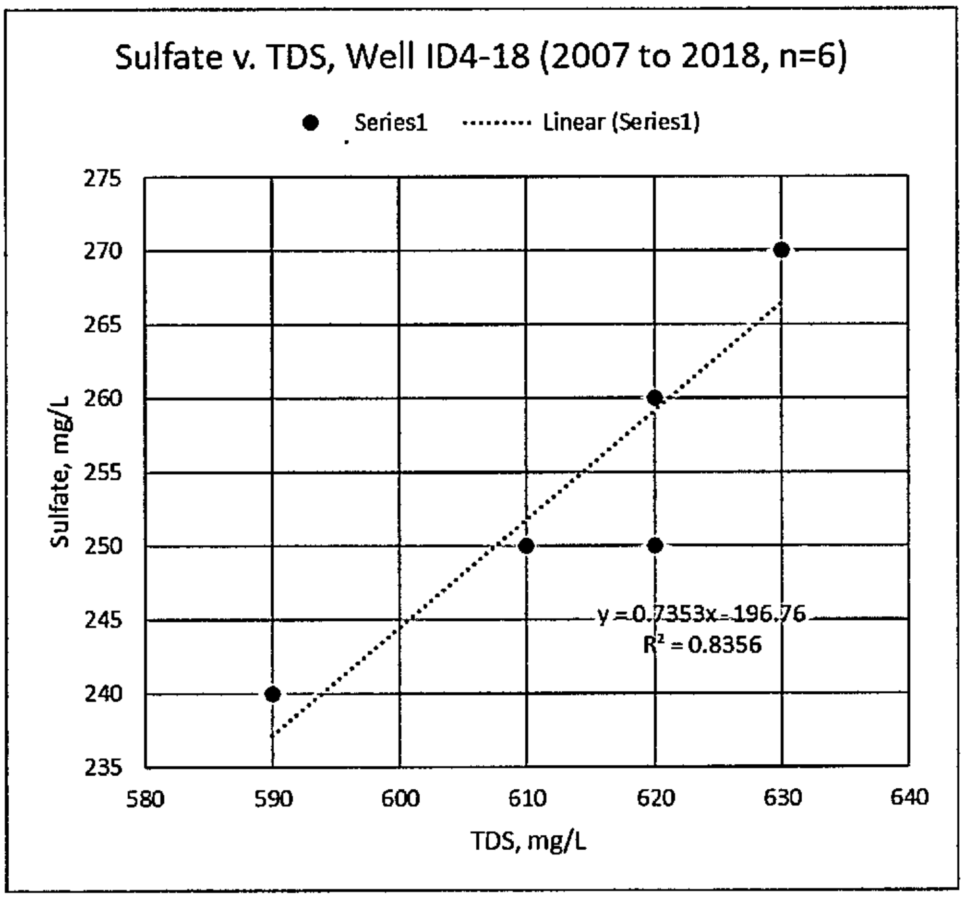
ID4-18

TDS is between the recommended and upper secondary MCL (currently at 630 mg/L). Sulfate is slowly increasing and is above the recommended secondary MCL of 250 mg/L. Arsenic has not been detected in this well (last reported as ND < 1.2 µg/L).

Figure 27 shows how TDS and sulfate are correlated and is presented as an example of how TDS measurements based on electrical conductivity testing may be able to be used to assess sulfate.

FIGURE 27

Date	TDS	Sulfate
5/8/2007	590	240
5/11/2010	620	260
6/10/2013	620	250
5/16/2016	610	250
11/17/2017	630	270
4/30/2018	630	270



4.2 Central Management Area (5: ID1-10, ID1-12, ID1-16, ID5-5, and Wilcox)

The Central Management Area is associated with both the "central" and "transitional" water quality type as indicated in **Figure 6** and COC-specific observations included in Table 4.

ID1-10

Water quality in ID1-10 is currently good and reasonably stable.

Elevated arsenic concentrations (a maximum of 12.2 μg/L that exceeded the MCL of 10 μg/L) were observed in 2014 that were preceded by elevated pHs of 8.2 to 8.4 (see **Figure 21**). Arsenic concentrations and elevated pH conditions have since declined.

ID1-12

Water quality in ID1-12 is currently good and reasonably stable.

ID1-16

Water quality in ID1-12 is currently good and reasonably stable.

Elevated arsenic concentrations (a maximum of 4.3 μg/L) were observed in 2014 that were preceded by and elevated pH of 8.3 (see **Figure 23**). Arsenic concentrations and elevated pH conditions have since declined.

ID5-5

Water quality in ID5-5 is currently good and reasonably stable.

Wilcox

Water quality in the Wilcox well is currently good and reasonably stable.

Elevated arsenic concentrations (a maximum of 7.8 μg/L) were observed in 2010 and 2014 that were preceded by elevated pH of greater than 8.6 (see **Figure 25**). Arsenic concentrations and elevated pH conditions have since declined.

4.3 South Management Area (1: ID1-8)

As previously discussed, the water chemistry observed in the South Management Area is distinctly different than that observed to the north. COC-specific observations are included in Table 4.

ID1-8

Water chemistry at ID1-8 has significantly changed over time, but now appears to be stabilizing. Water quality in ID1-8 is currently good.

Arsenic is of concern due to MCL exceedances consistently observed in nearby Ram's Hill wells.

Elevated arsenic concentrations (a maximum of 6.8 µg/L) were observed in 2010 that were preceded by an elevated pH of 8.3 (see **Figure 26**). Arsenic concentrations and elevated pH conditions have since declined.

5.0 SUMMARY

The multi-parameter assessment of water quality and COC trends provides additional insight compared to single parameter assessments.

Natural Water Chemistry (anions and cations)

- Natural water chemistry as determined by the eight dominant anions and cation systematically varies across the Subbasin (these include calcium [Ca], magnesium [Mg], sodium [Na], potassium [K], chloride [Cl], sulfate [SO4], bicarbonate [HCO3], and carbonate [CO3]).

  The observed variations generally correlate with the previously established management areas that are further discussed in the GSP. Overall trends generally correlate with the well location relative to the pre-development groundwater flow paths and distance from where recharge waters enter the Subbasin,

- Water samples from BWD water supply wells show that the dominant cations and anions are sodium and calcium; and bicarbonate, sulfate, and chloride, respectively.

- The water type transitions from a calcium sulfate to a sodium chloride in the Northern Management Area wells.

- Sodium bicarbonate type water generally occurs in the South Management Area as tested. The groundwater analysis further supports that the South Management Area has distinctly different water quality than observed in the north and central groundwater management areas.

- The primary causes for the difference in water quality within the Subbasin include variations in the water being recharged (e.g. Coyote Creek versus San Felipe Creek), proximity of irrigated lands (e.g. nitrate impacts due to fertilizer application), aquifer lithology (local deposits of evaporites and potential arsenic-bearing clays), aquifer depth (related to increase in TDS), and location within the Subbasin with respect to the Borrego Sink where enhanced evaporation of ephemeral surface water occurs.

- Due to the location of the BWD wells this analysis does not fully represent the water quality distribution in the Subbasin. Refer to **Figures 4 and 7** for the well locations. As result the spatial trends identified among the wells are limited to examining variations along the western side of the Subbasin.

- Water quality as a function of depth has not been assessed in the BWD water supply wells, for example by the use of depth-specific water sampling. Well profiling data obtained by the DWR (**Figure 10**, for example) indicate that TDS linearly increases with depth. Given the high correlation with sulfate, the increase in TDS implies that sulfate will also increase with depth.

- Multiple aquifers are represented in the water chemistry data because of the construction of the 23 wells used in this report. As a result, water quality could not be differentiated in terms of the three-layer aquifer system (upper/middle/lower) used by the USGS and others (for example in the USGS Model Report).

- Temporal trends are more readily identified when multiple general mineral analyses are considered for each of the wells. Here Piper trilinear diagrams were used to assess the eight dominant anions and cations.

- 17 of the 23 wells had sufficient anion and cation data for temporal analysis and in some cases, well over 40 years data are available. Of these approximately 70 percent have experienced changes in water chemistry over time. The changes are generally attributed to long-term overdraft.

Chemicals of Concern (COCs)

- Five COCs were examined: arsenic, nitrate, TDS, sulfate, and fluoride. The overall analyses are improved when all five parameters are considered together and geochemical factors such as pH are included. The five COCs are depicted together with pH for each of the nine active BWD water supply wells in **Section 4**.

- Single parameter trend assessments, for example using Mann-Kendall trend analyses included in previous studies, are not repeated here.

- The COC analysis is based on a comparison of concentrations with current MCLs. Down-revision of the criteria, especially for arsenic, could have a large impact on BWD operations should water treatment be required. The State of California MCL for arsenic was last revised (from 50 to 10 ug/L) on 1/28/2008[25]. As of February 2017, there is no indication that the State Water Resources Control Board is planning to revise the arsenic MCL[26].

- Overall the water quality is currently good and water can be delivered without the need for advanced treatment. However, short-term water quality trends have been of concern, especially for arsenic. The following summarizes the analysis per COC.

---

[25] See: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/Arsenic.html

[26] Per a state review from 2017: "We are not aware of changes in treatment that would permit materially greater protection of public health, nor of new scientific evidence of a materially different public health risk than was previously determined. Thus, we do not plan on further review of the arsenic MCL." See: https://www.waterboards.ca.gov/drinking_water/certlic/drinkingwater/documents/reviewofmaximumcontaminantlevels-2017.pdf

Arsenic and Fluoride

Arsenic concentrations were increasing in multiple BWD water supply wells until 2014 and have since decreased. The potential for MCLS to be exceeded is of high concern to BWD due to the potential cost of water treatment and/or well replacement. The MCL was temporarily exceeded in one well, ID1-10. Review of the data shows that there is a relationship between pH and arsenic where elevated arsenic concentrations occur under alkaline conditions with pH levels of approximately 8 and greater. Especially noteworthy is that peak arsenic concentrations can be observed to occur after the peak pH was observed in multiple wells (ID1-10, ID1-16, Wilcox, and ID1-8). The lag time is approximately 2 to 4 years. While additional data and observations are required to further assess the connection between arsenic and pH, this relationship could prove important toward the monitoring and management of BWD's water supply.

Fluoride is discussed with arsenic because it has been observed to correlate with arsenic. While fluoride occurs at detectable concentrations in all of the active BWD wells, it has not been of concern as concentrations have typically been well less than 1.0 mg/L, less than half the MCL. Given the correlation it may prove useful towards future trend analyses for arsenic.

TDS and Sulfate

TDS represents the sum of all anions and cations that occur in the water. Here a number of these anions and cations have been observed to correlate with TDS. **Figures 15 through 17** show the correlation with TDS for sulfate, sodium, calcium, and chloride. A specific example is shown for well ID4-18 in **Figure 27** where TDS and sulfate are well correlated.

The USGS Model Report (p. 2) identified TDS and sulfate as "the only constituents that show increasing concentrations with simultaneous declines in groundwater levels".

Electrical conductivity measurements are commonly used to assess TDS. In this case they can be used as a field-based monitoring tool for TDS, and in turn support tracking of sulfate. The TDS profiles presented by DWR (**Figure 10**) are examples of electrical conductivity measurements used to evaluate TDS.

Nitrate

Historically there have been significant nitrate-related water quality problems encountered in BWD wells that led to well reconstruction, abandonment, and replacement. These wells were typically producing water from the uppermost portion of the aquifer system. As noted in **Table 4**, nitrate occurs in all of the active BWD wells at varying concentrations well below the MCL. Nitrate predominantly occurs as a result of fertilizers contained in irrigation return flow, and from septic systems. Historically, because the upper portion of the aquifer system is unconfined, nitrate has primarily affected wells that were completed (open to flow) at the water table.

The USGS Model Report (p.2) noted that "TDS and nitrate concentrations were generally highest in the upper aquifer and in the northern part of the Borrego Valley where agricultural activities are primarily concentrated".

Nitrate concentrations are primarily related to land-based activities and do not correlate with inorganic water quality data. Overall determination of historical impacts and ongoing susceptibility of the aquifer to nitrate contamination will require review of prior, current, and future land use placed in a spatial context. Work done by DWR (for example as illustrated in **Figure 11**) is an example of how land use information can be used. Among the land use parameters that would go into a nitrate source analysis would the location and types of septic and sewer systems, current and historical agricultural activities, and current and historical irrigated turf/golf courses.

5.1 Other Potential COCs

This report focused on the dominant anions and cations, and the five primary COCs. Other potential COCs include naturally-occurring uranium and radionuclides. Anthropogenic COCs include herbicides, pesticides, and similar chemicals used for agriculture and turf management. Microbial contamination, typically associated with animal wastes and sewage/septic, is also of potential concern.

Groundwater quality provided by BWD water supply wells is currently good and meets California drinking water maximum contaminant levels (MCLs). To date the current wells are producing water without the need for treatment. The BWD public water supply monitoring program is conducted in compliance with the State of California's requirements as administered by the State Water Resources Control Board Division of Drinking Water (DDW) and includes a wide range of analytes.

BWD provides all sampling data to the DDW, and is listed as public water supply CA3710036. A summary of BWD's sampling program for other COCs can be reviewed in the annual consumer confidence report, available online at http://nebula.wsimg.com/c30a61991a5160ddf5e577fe9f7b3c01?AccessKeyId=D2148395D6E5BC38D600&disposition=0&alloworigin=1. The BWD is also sampling all of its water supply well semi-annually as part of the GSA monitoring network rather than the minimum 3-year timeframe currently required by DDW.

5.2 Recommendations

- The COC analysis supports expansion of groundwater monitoring and testing program to include field-based water quality measurements of water being produced by BWD. Monthly wellhead measurements are recommended for electrical conductivity (EC), pH, and oxidation-reduction (redox) potential. These could be conducted at the same time BWD personnel collect monthly bacteria samples. EC can be used to calculate TDS, and by correlation estimate sulfate in some wells. Redox and pH are key geochemical parameters that can readily be measured at the wellhead by BWD personnel.

- Conduct vertical profiling and depth-specific sampling of water supply wells when the wells become accessible, for example during pump removal for maintenance. The primary goals of the testing are to identify potential zones where water quality may be poor and to examine the relative rate of flow of water into the well with depth. Both types of information will support assessment of well performance as overdraft continues.

  Long-term the vertical profiling will provide data to better understand the water quality trends and support BWD water management planning. For example, the data will support assessment of sulfate trends by understanding how concentrations may or may not be increasing with depth and support projections of how water quality will change as overdraft while pumping reductions occur over the 20-year GSP planning period.

- Use the groundwater model to assess pre- and post-SGMA groundwater flow conditions and potential changes in water chemistry. Current pumping conditions have changed groundwater flow patterns within the North and Central Management Area due to the establishment of two pumping centers. Future pumping reductions will likely alter groundwater flow patterns. The model can be used to support calculations of groundwater flow rates and directions using 'particle tracking', a methodology that looks at how water flows over time. The modeling software (USGS Modflow model) includes Modpath, a post-processing software that works with the model output.

- Use the groundwater model water balance to develop a 'mixing cell' calculation of salt balance to assess the potential rate of accumulation of dissolved minerals associated with water use. The Subbasin is effectively a closed system where dissolved minerals and other solutes have will continue to accumulate over time. The primary purpose of the calculations is to assess long-term TDS changes that result from irrigation and septic return flows as overdraft continues. The calculations will also support examination of areas where BWD water production may need to be established using new or existing water wells.

- Investigate the potential causes of the temporary increases in arsenic concentrations and pH observed in BWD wells as a means of predicting future arsenic concentrations. A lag time of 2 to 4 years is observed in multiple BWD wells where elevated pH preceded the increase in arsenic concentrations that could prove to be important towards BWD's water supply and risk management.

- Expand on the analysis of nitrate in groundwater relative to land use as described by the DWR (e.g. **Figure 11**). Additional discussion of the occurrence of nitrate in groundwater is included in the GSP that describes land uses within the Subbasin.

- Expand the water chemistry and water quality evaluation to areas within and downgradient of the agricultural areas in the North and Central Management Areas.

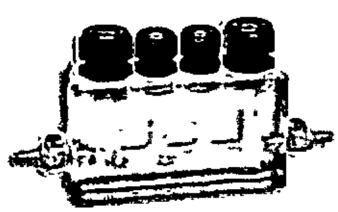
- Continue to collect the full suite of general minerals (8 anions and cations) together with pH and redox measurements. Water chemistry parameters should be collected using 'flow cells' where the chemistry of the water is tested before it is exposed to the atmosphere.[27]

- Conduct selective sampling for phosphate and review the overall electrochemical balance for all potential anions and cations to determine why the current data have excess cations relative anions (see **Section 3.2.1**).

- Further assess lithologic and geochemical conditions associated with the occurrence of arsenic. For example, work done in the San Joaquin valley (discussed in **Section 3.6.1**) linked the release of water from clay to increased arsenic concentrations in groundwater. Further review of Subbasin stratigraphy work done by Netto (2001) is warranted. Re-analysis of the geostatistical work done by the USGS to evaluate sediment lithologies may also prove useful towards understanding the nature and extent of sediments potentially associated with arsenic. Lithologic sampling and

---

[27] An example is shown below. Water flows directly from the well into a chamber where measurements are made. From: http://www.geotechenv.com/flowcell_sampling_systems.html. It is understood that Dudek staff are using flow cells during sampling of Rams Hill wells to measure pH, specific conductance, temperature, turbidity, dissolved oxygen, oxygen-reduction potential, and color. Their Sampling and Analysis Plan could be used for the remaining wells within the GSP monitoring program.



Geotech Flowblock
<40 mL cell volume for flow rates of
100 mL/min to 1 gpm (3.8 LPM)

geochemical testing for arsenic and related minerals is recommended during the installation of new wells.

- Investigate the potential interaction of microbially-mediated oxidation and reduction processes (e.g. denitrification and sulfate reduction) specific to arsenic mobility.

- Examine the potential application of recharge basins to facilitate arsenic removal as a result of geochemical processes in the vadose zone (see discussions in Section **3.6.1**).

- Develop an inventory of abandoned wells, including well completion information and potential condition. Abandoned wells have the potential to act as conduits for the downward flow of shallow groundwater contaminants such as surface applied fertilizers, agricultural chemicals, and turf management chemicals. Abandoned wells may need to be properly destroyed per California Well Standards (See information available from the County of San Diego https://www.sandiegocounty.gov/content/sdc/deh/lwqd/lu_water_wells.html)

- Continue to track changes in groundwater quality as a function of water level to assess trends relative to the potential for water quality degradation and the likelihood of the need for water treatment. Use the data to assess potential cost and water system reliability risks to BWD.

- Continue to track water treatment technologies and costs for arsenic as the potential for revision of the arsenic MCL is, in part, dependent on cost-benefit analyses for water treatment (see COC discussion in Section 5).

6.0 REFERENCES

All references are cited within the text using footnotes.

APPENDIX A

DWR, 2014

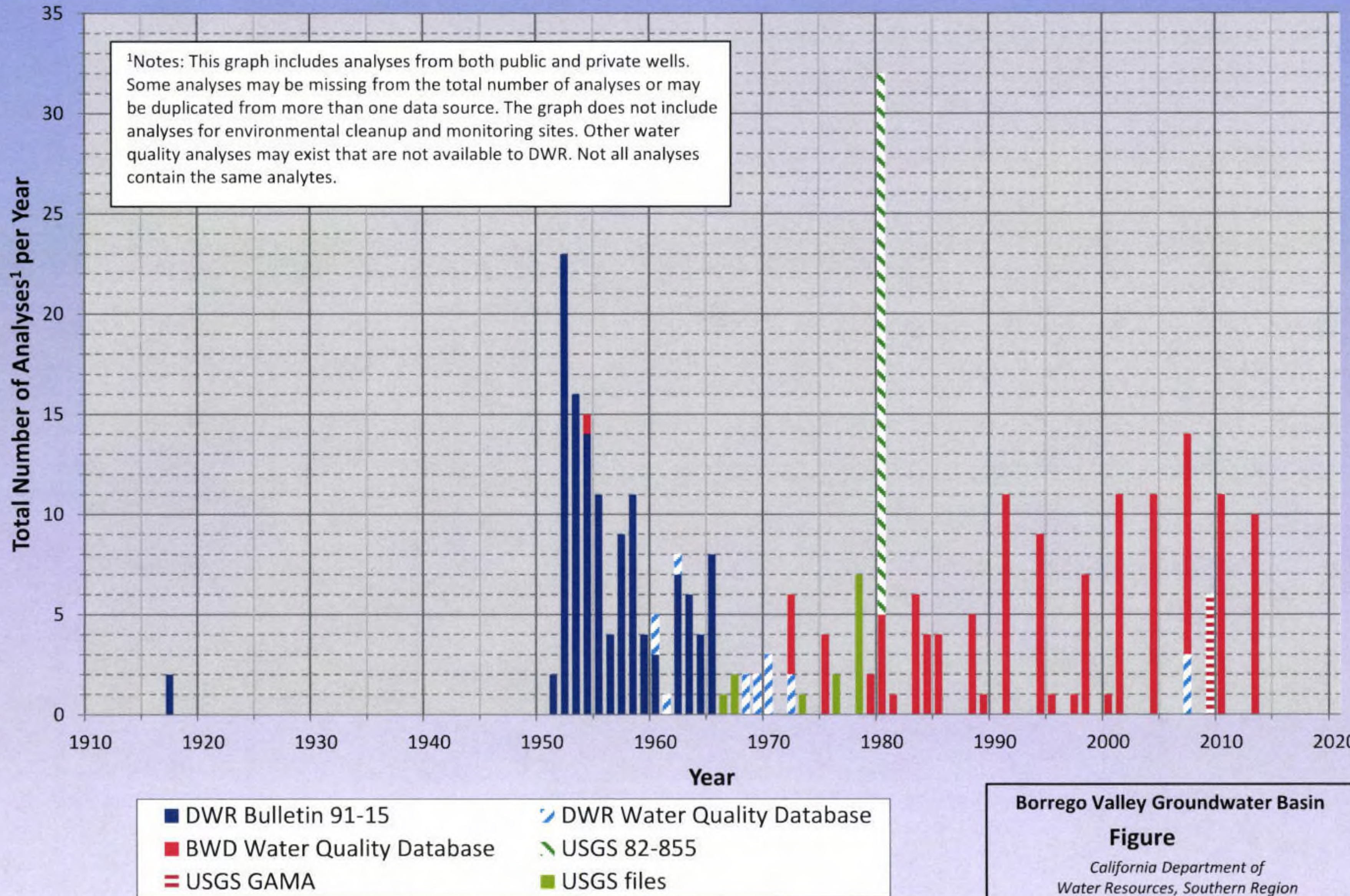
Groundwater Quality Information
for
Borrego Valley

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

Groundwater Quality Information for Borrego Valley

Southern Region May 2014

Water Quality Analyses by Year and Source



[1]Notes: This graph includes analyses from both public and private wells. Some analyses may be missing from the total number of analyses or may be duplicated from more than one data source. The graph does not include analyses for environmental cleanup and monitoring sites. Other water quality analyses may exist that are not available to DWR. Not all analyses contain the same analytes.

Borrego Valley Groundwater Basin

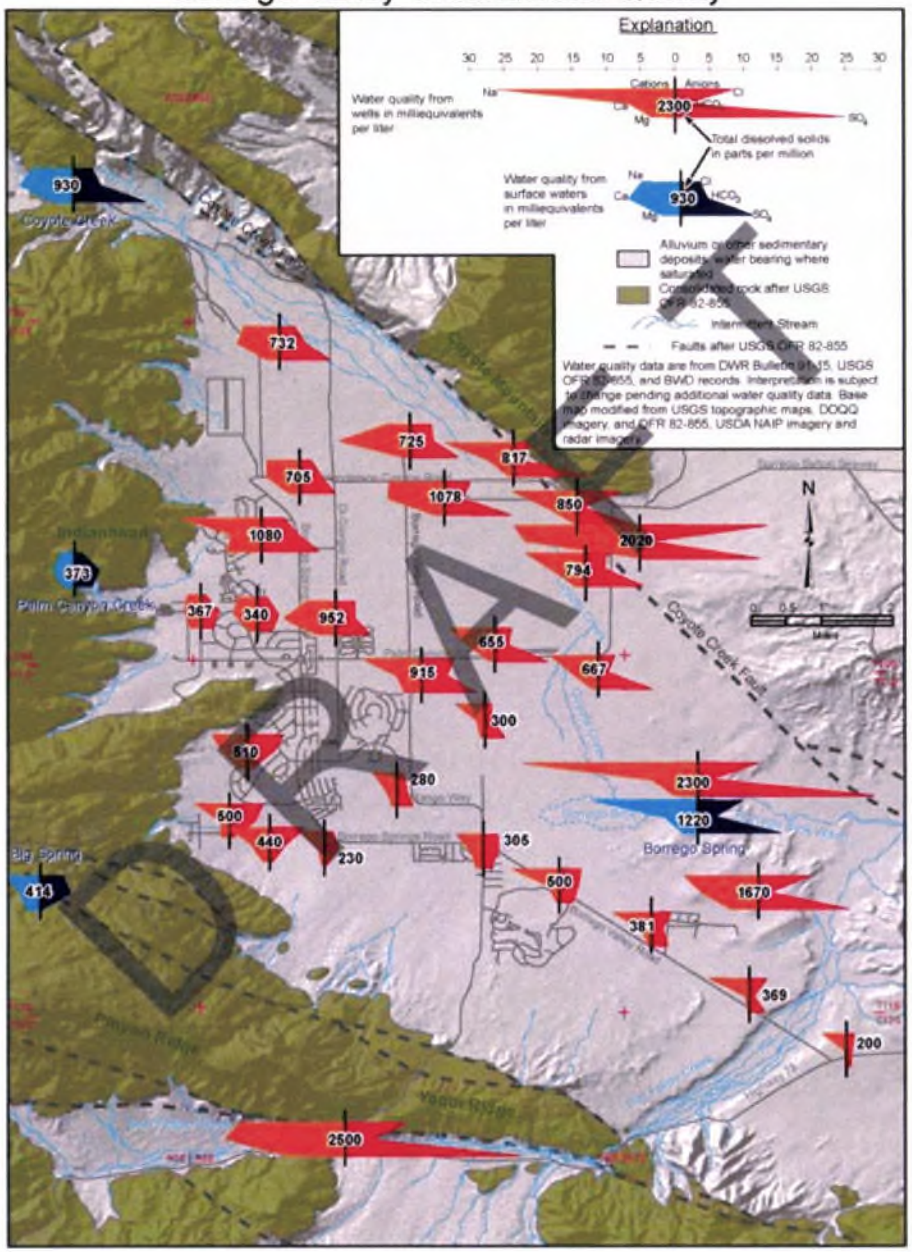
Figure

California Department of Water Resources, Southern Region

January 2020

More than 300 water quality analyses have been identified.

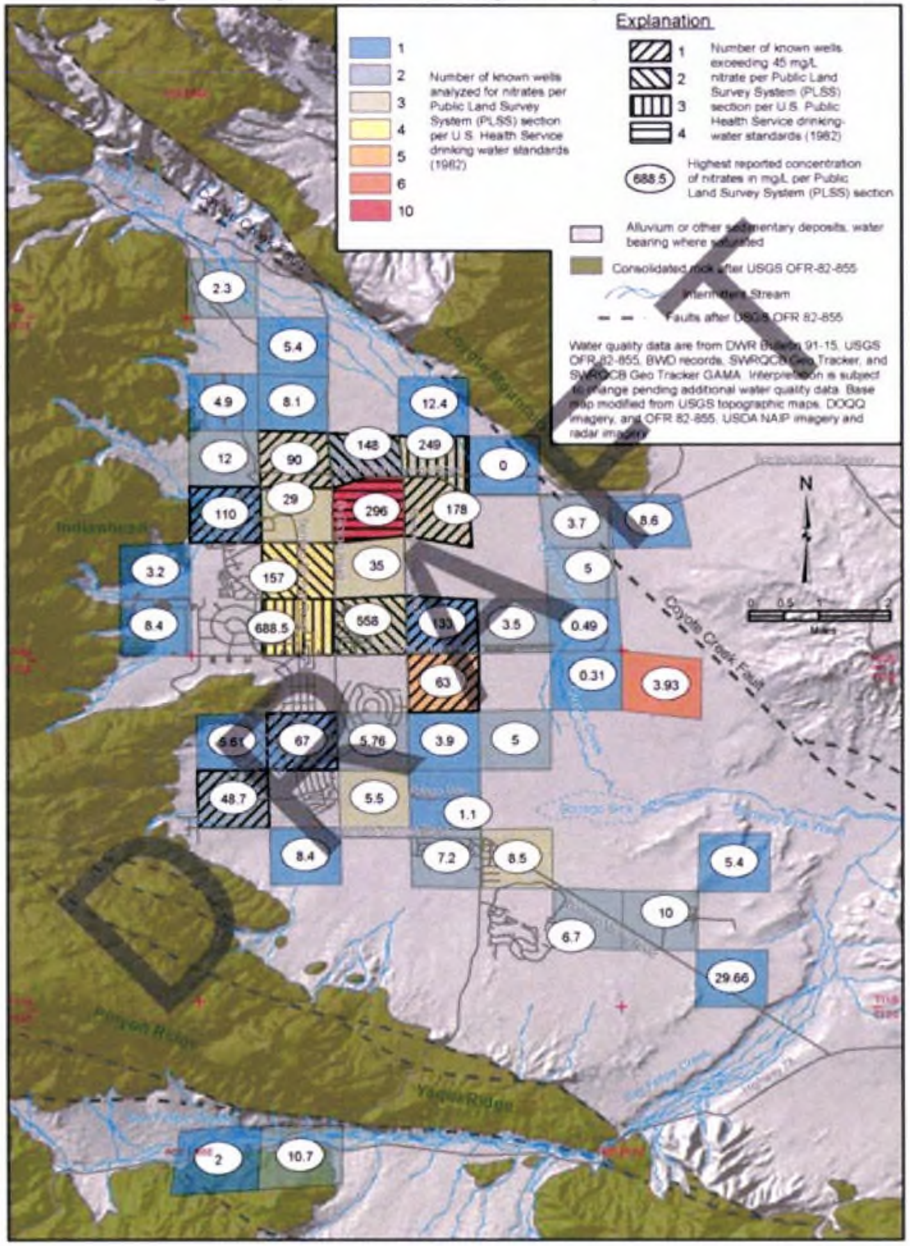
Borrego Valley Groundwater Quality



January 2020

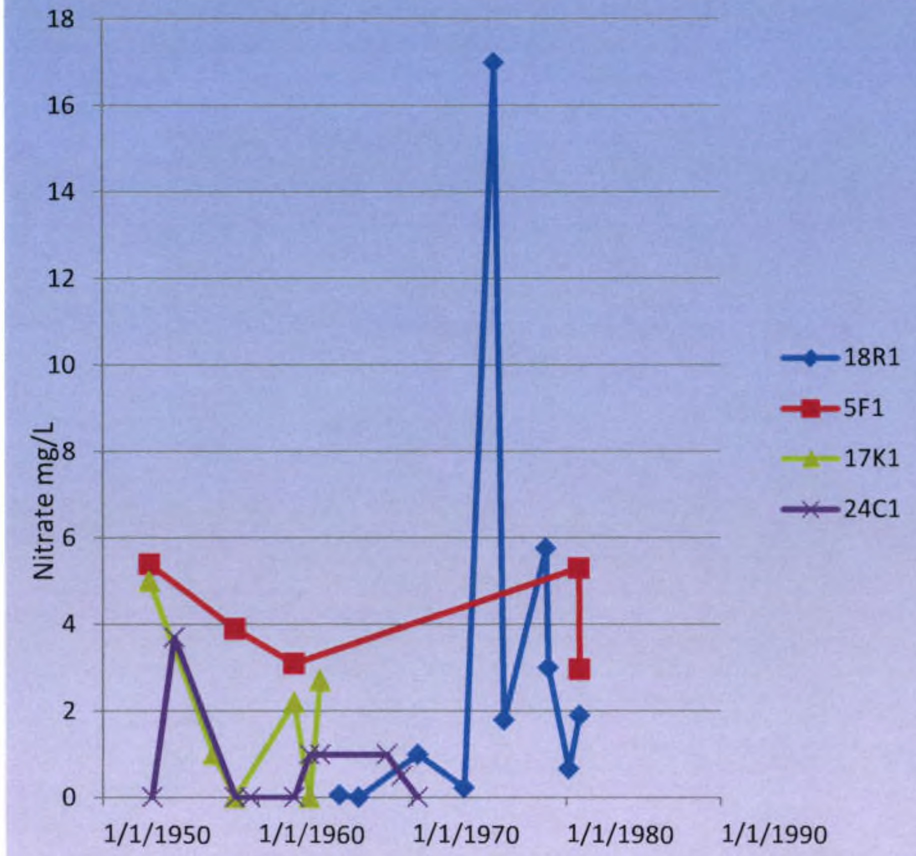
Figure showing major water quality constituents in groundwater and surface water in Borrego Valley. The high proportion of Sulfate in the surface water of Coyote Creek appears to dominate the character of groundwater in the northern and eastern parts of the basin. The more Bicarbonate waters of Borrego Palm Canyon and Big Spring influence the groundwater along the western and southern parts of the basin.

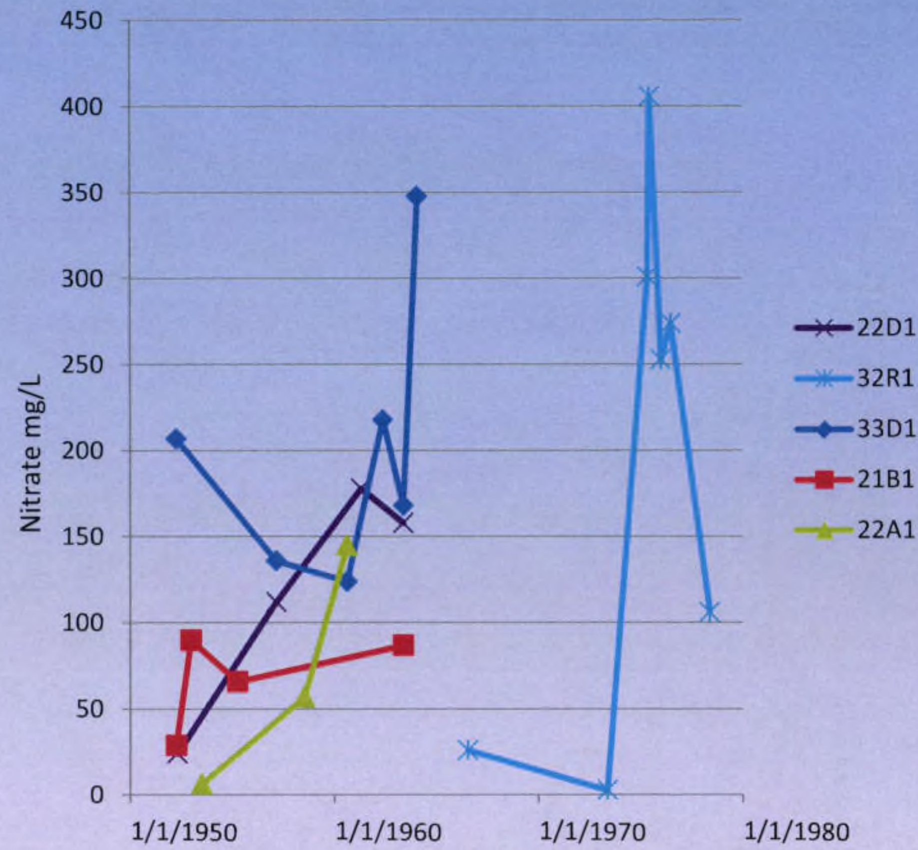
Borrego Valley Water Quality Analyses of Nitrates



January 2020

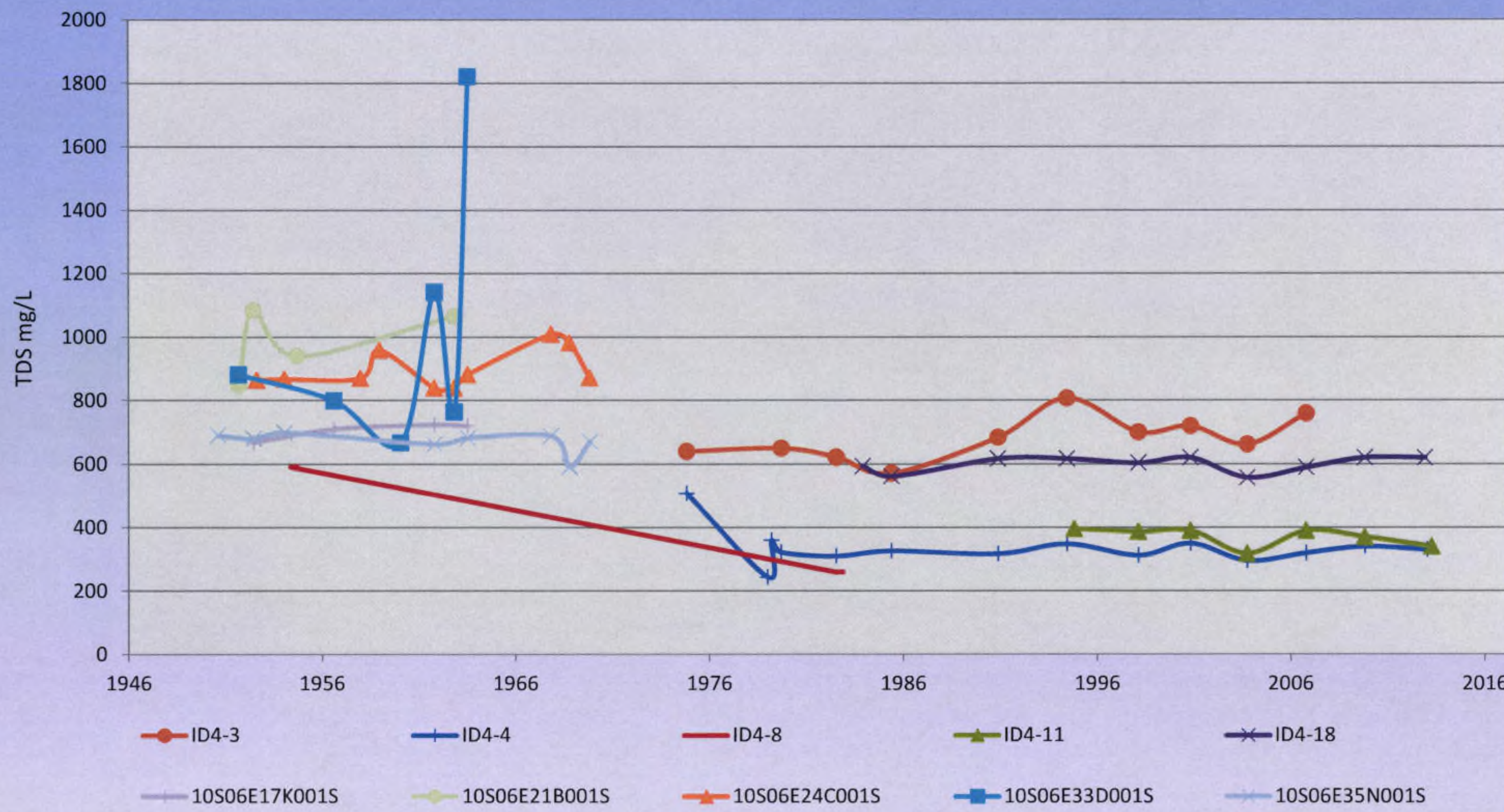
Figure showing the distribution of Nitrate analyses for the Borrego Basin. Maximum content is shown per section and sections are colored according to the number of analyses in the section. Sections where the maximum contaminant level (MCL) are exceeded are shown in hatched patterns.





Nitrate content is graphed through time for several wells in the Borrego Basin. No obvious trend is apparent. (MCL is 45 mg/L)

North Bo[illegible] Valley



Graph showing change in TDS content through time for several wells in the northern part of the basin. No clear increase in TDS is observed.

South Borrego Valley

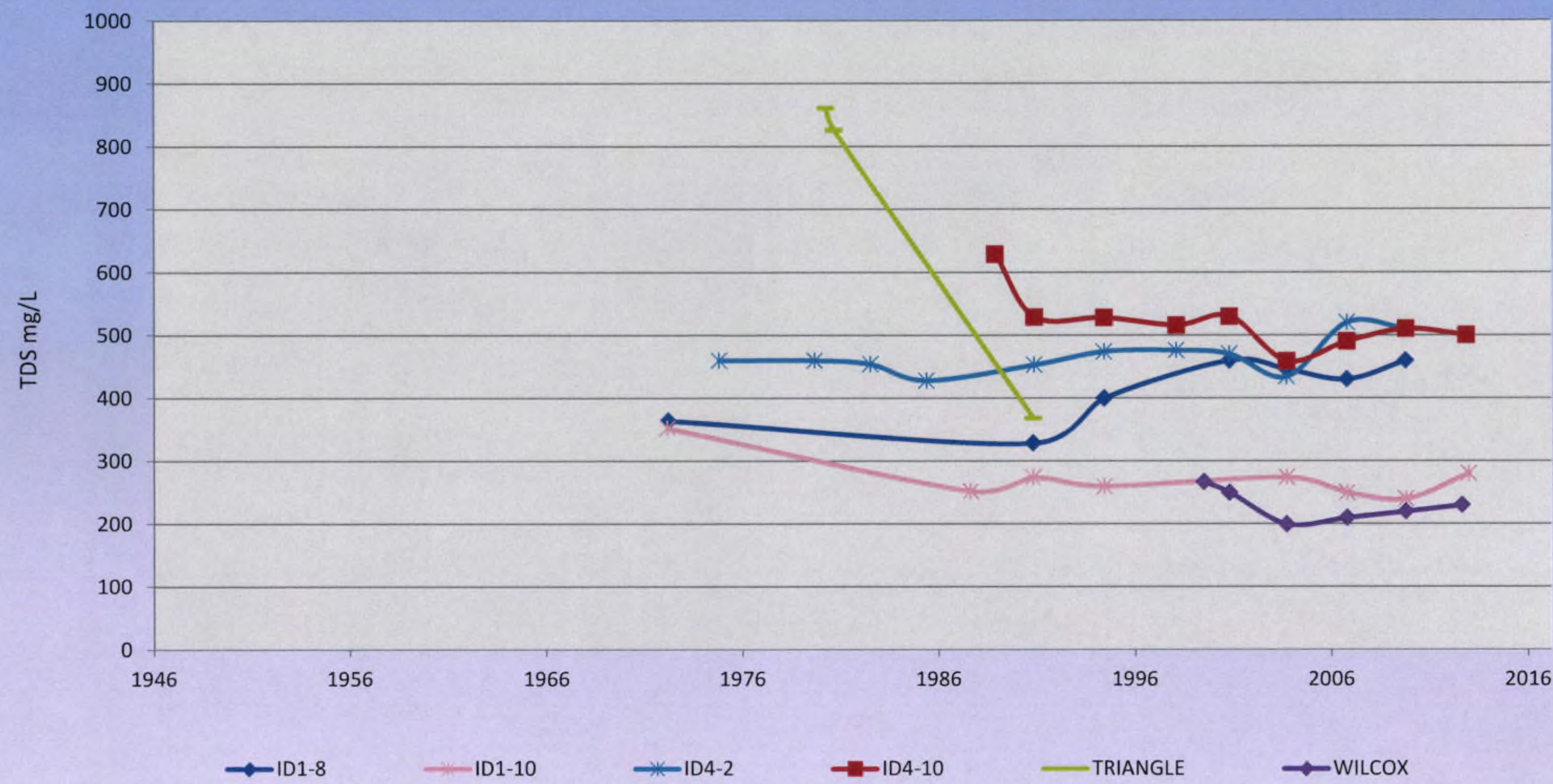
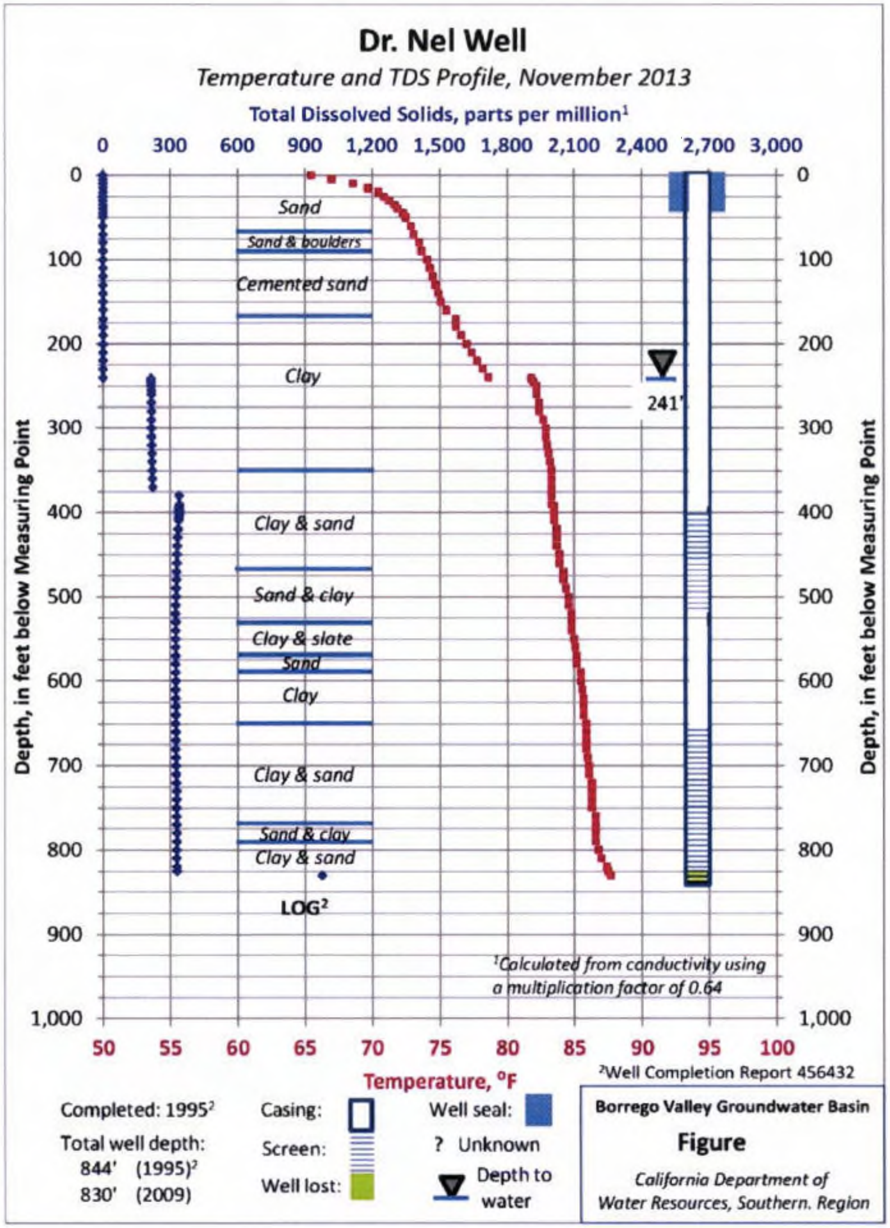
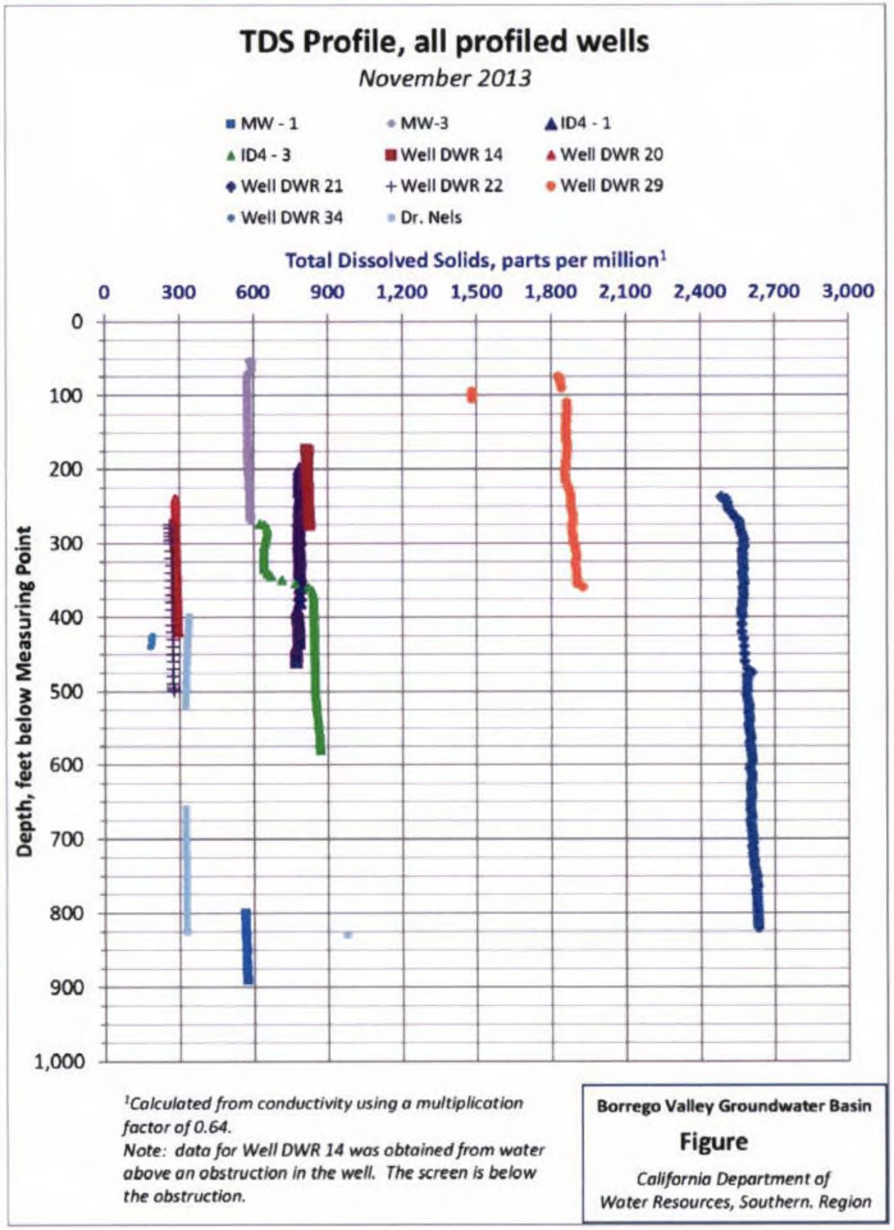


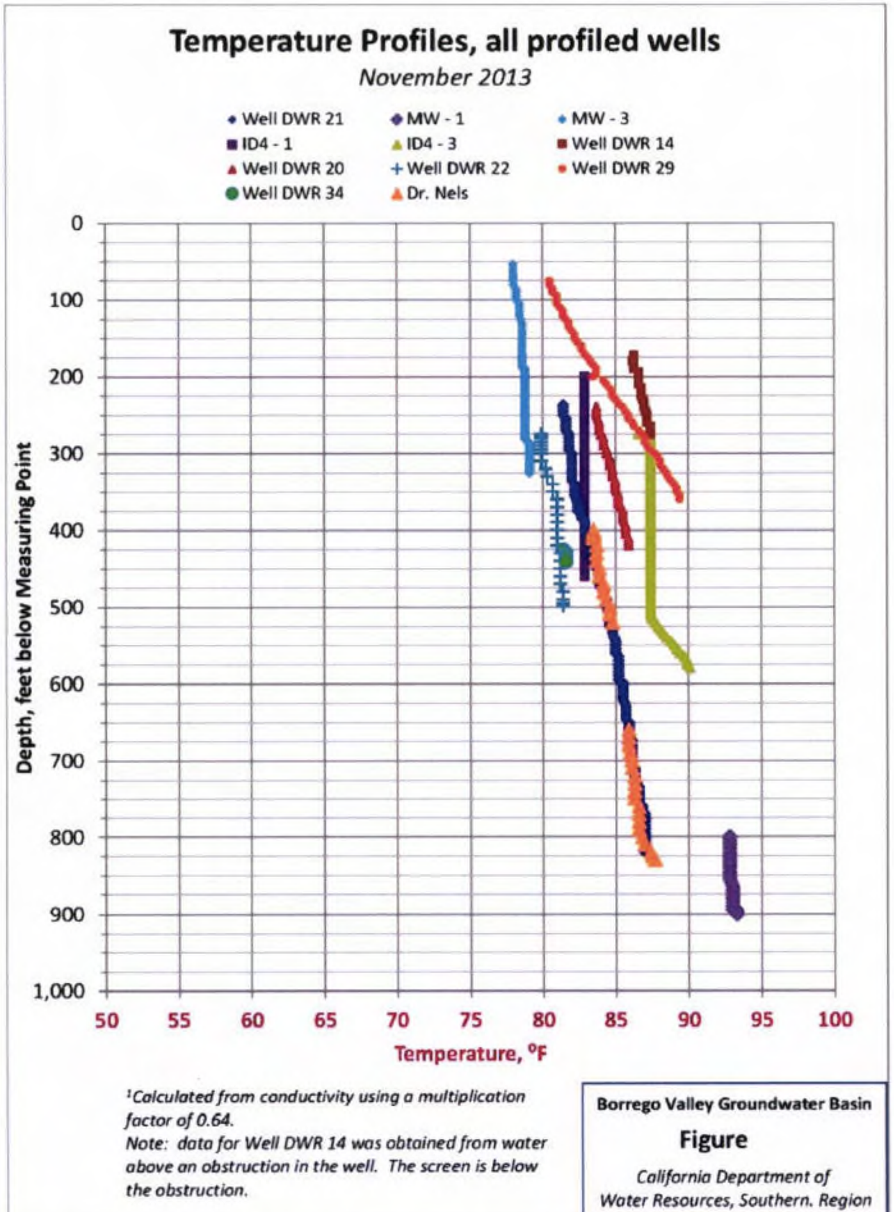
Figure showing TDS content through time for several wells in the southern portion of the basin. Most show decrease in TDS through time.



A profile of TDS content and temperature for Dr. Nel's Well. Changes in TDS appear to occur at the well screen. TDS does not change appreciably with depth through the screened interval. Temperature rises steadily with depth.



Profiles of TDS with respect to depth for wells in Borrego Valley. Most show slight increase in TDS with depth



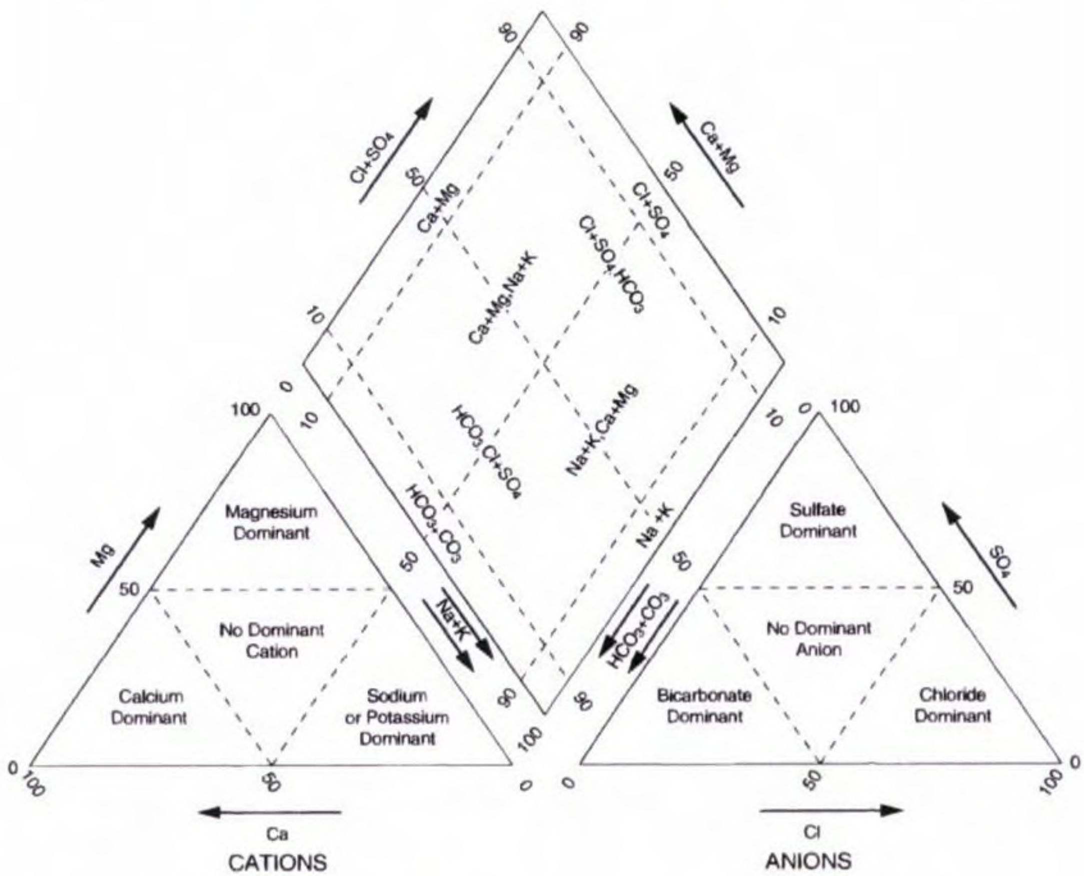
Profiles of Temperature with respect to depth. Most wells show increase in temperature with depth.

Summary

- More than 300 analyses identified
- Water character reflects recharge source
- More than 100 Nitrate analyses, widespread
- No apparent trend through time for Nitrate or TDS
- 11 Wells profiled for Temperature and TDS
- No consistent trend for TDS with depth in well.

APPENDIX B

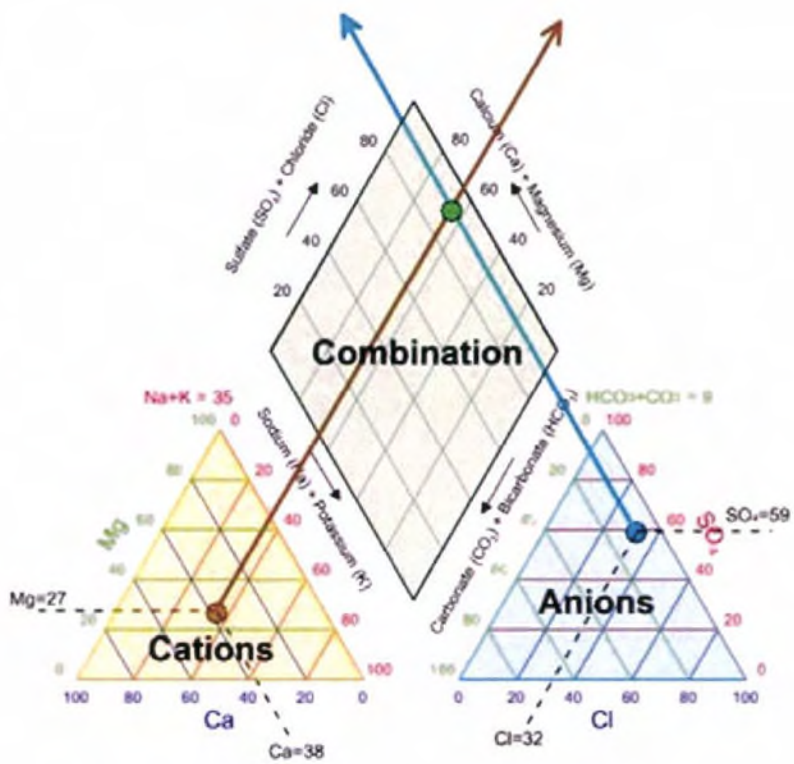
PIPER DIAGRAMS, ALL WELLS



A. Classification scheme for hydrochemical facies.

B.1 EXPLANATION OF PIPER DIAGRAMS

The eight dominant anions and cations that occur in groundwater can be used to describe of the type of water. A Piper trilinear diagram[1] combines sodium and potassium (cations), and carbonate and bicarbonate (anions) to reduce the total number of anions and cations from eight to six, with 3 values for each. This allows the anions and cations to be depicted using ternary diagrams. The values are then then projected onto a central diamond. An example of the projection follows:



From: https://support.goldensoftware.com/hc/en-us/articles/115003101648-What-is-a-piper-plot-trilinear-diagram-

The values used for the anions and cations are converted from mass/liter to milliequivalents/liter, a measure of the relative number of anions and cations in the solution. For example, if NaCl is dissolved into pure water there are an equal number of sodium cations (Na^+) and chloride anions (Cl^-). An analysis by weight will show that there is more chloride because chloride has a larger molecular weight (MW) - the MW of Na is 22.9 grams/mole versus Cl that has a MW of 35.45 grams/mole. 'Equivalents' are derived by dividing the reported mass by the MW so that the relative number of ions (in moles) is calculated.

[1] Piper, A.M. 1944. A graphic procedure in the geochemical interpretation of water-analyses. Transactions-American Geophysical Union 25, no. 6: 914–923

APPENDIX B: PIPER DIAGRAMS

The overall intent of the diagram is to support grouping and classification of water types, also termed hydrochemical facies. An example follows from https://www.hatarilabs.com/ih-en/what-is-a-piper-diagram-and-how-to-create-one

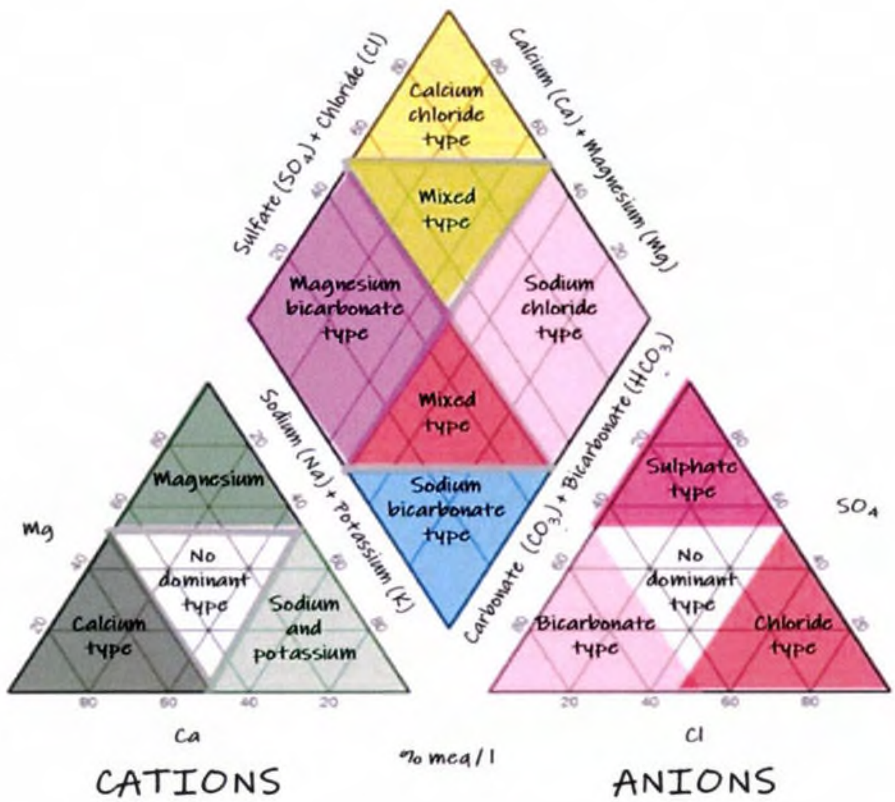


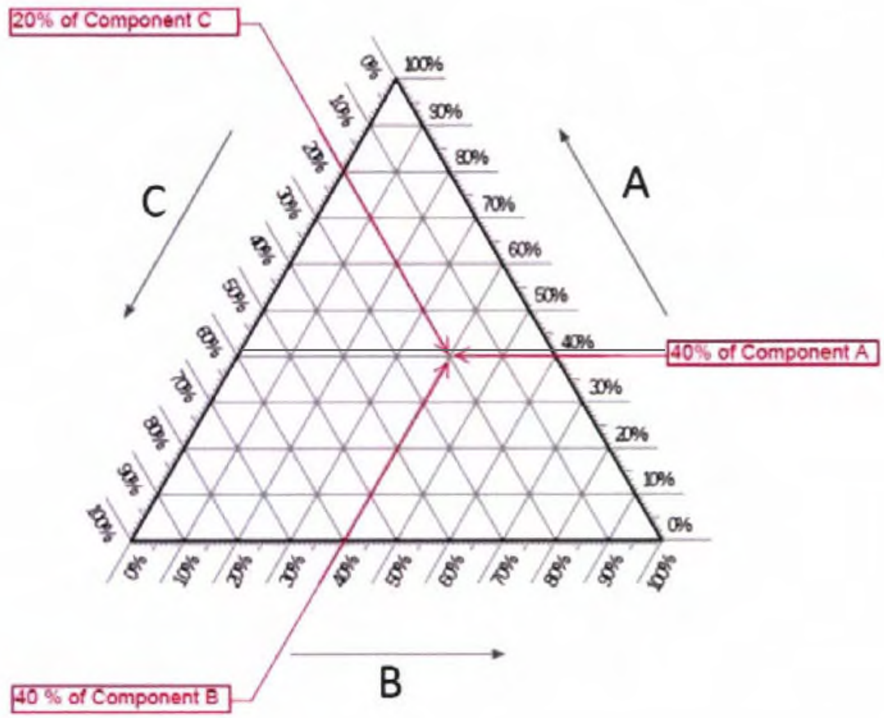
FIGURE 1A: HYDROCHEMICAL FACIES IN THE CATION AND ANION TRIANGLES AND IN THE DIAMOND.

The lower triangles are ternary diagrams that represent the relative proportion of anions or cations. The various types of water, or facies, are shown in the middle diamond.

Piper diagrams depicted in this report use a colored field scheme implemented in the Python programming language as published by Peeters, 2014[2]. Rather than drawing an underlying grid, the colored fields are used to help the visual interpretation of the data. The computations and graphics were developed using open source program code published by Peeters.

[2] Peeters, L., 2014. A Background Color Scheme for Piper Plots to Spatially Visualize Hydrochemical Patterns. Vol. 52, No. 1–Groundwater–January-February 2014

The following is an example of the ternary grid and how data are plotted:



All values equal 100% on the triangular grid. The highest percentage of each of the components occurs in the extreme corners of the triangle.

Values increase as indicated by the arrows.

Source:
https://upload.wikimedia.org/wikipedia/commons/thumb/a/ac/Blank_ternary_plot.svg/486px-Blank_ternary_plot.svg.png

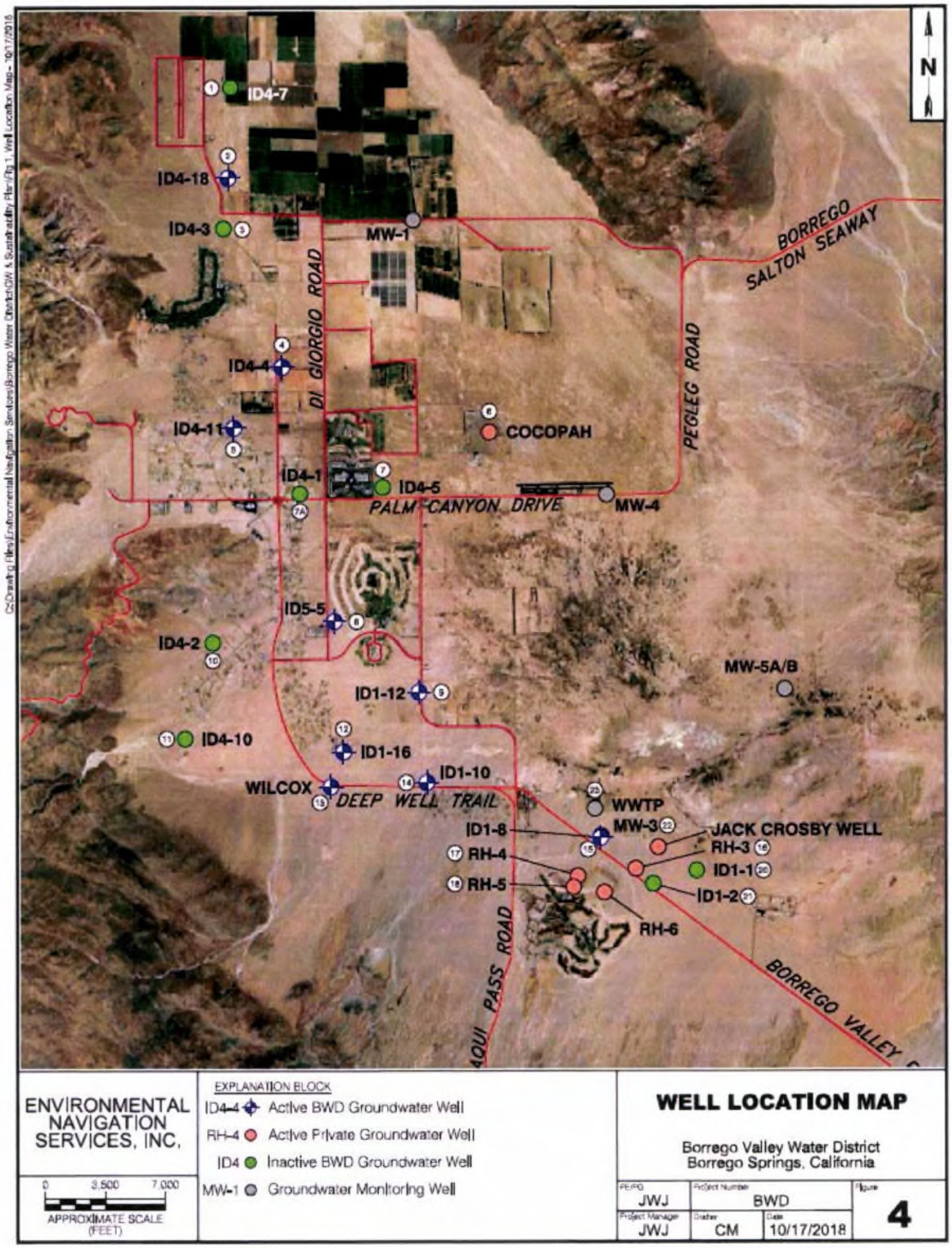
APPENDIX B.2 PIPER DIAGRAMS USED IN THE REPORT

The following diagram are presented in the following order:

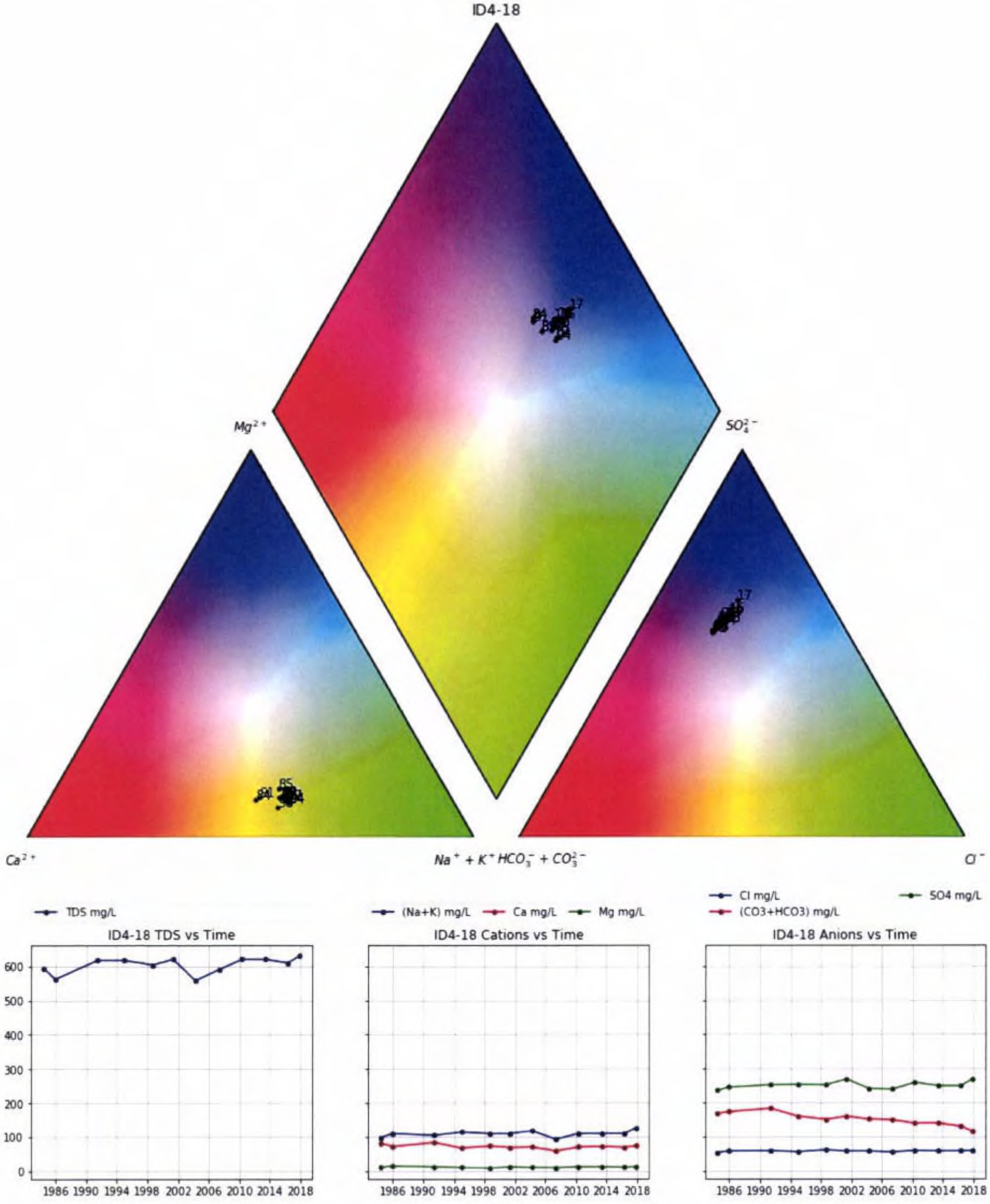
1: ID4-7 (not included due to insufficient data)
2: ID4-18
3: ID4-3
4: ID4-4
5: ID4-11
6: Cocopah
7: ID4-5
7A: ID4-1
8: ID5-5
9: ID1-12
10: ID4-2
11: ID4-10
12: ID1-16
13: Wilcox
14: ID1-10
15: ID1-8
16: RH-3
17: RH-4
18: RH-5
19: RH-6
20: ID1-1
21: ID1-2
22: Jack Crosby
23: WWTP (insufficient data)
24: MW-3 (insufficient data)

Recent Data: All (Piper only)
Recent Data: North and Central (Piper only)
Recent Data: South (Piper only)

A copy of the map follows (**Figure 4**, from main body of report)

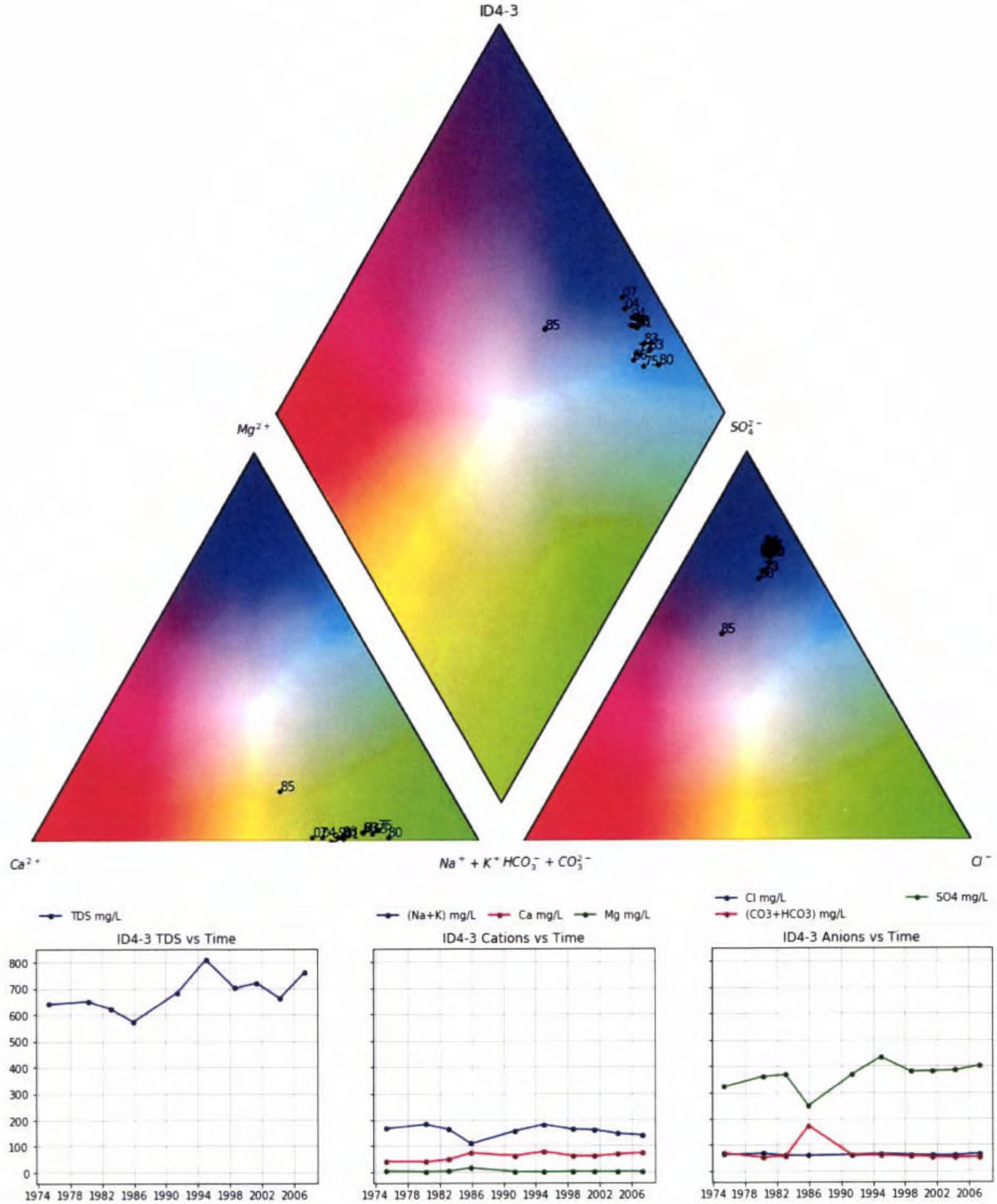

N
ID4-7
ID4-18
ID4-3
MW-1
BORREGO SALTON SEAWAY
DI GIORGIO ROAD
PEGLEG ROAD
ID4-4
ID4-11
COCOPAH
ID4-1
ID4-5
PALM CANYON DRIVE
MW-4
ID5-5
ID4-2
MW-5A/B
ID1-12
ID4-10
ID1-16
ID1-10
WILCOX
DEEP WELL TRAIL
WWTP
MW-3
ID1-8
JACK CROSBY WELL
RH-3
RH-4
ID1-1
RH-5
ID1-2
RH-6
AQUI PASS ROAD
BORREGO VALLEY
ENVIRONMENTAL NAVIGATION SERVICES, INC.
EXPLANATION BLOCK
ID4-4 Active BWD Groundwater Well
RH-4 Active Private Groundwater Well
ID4 Inactive BWD Groundwater Well
MW-1 Groundwater Monitoring Well
0 3,500 7,000
APPROXIMATE SCALE (FEET)
WELL LOCATION MAP
Borrego Valley Water District
Borrego Springs, California
JWJ
BWD
JWJ
CM
10/17/2018
4

2: ID4-18

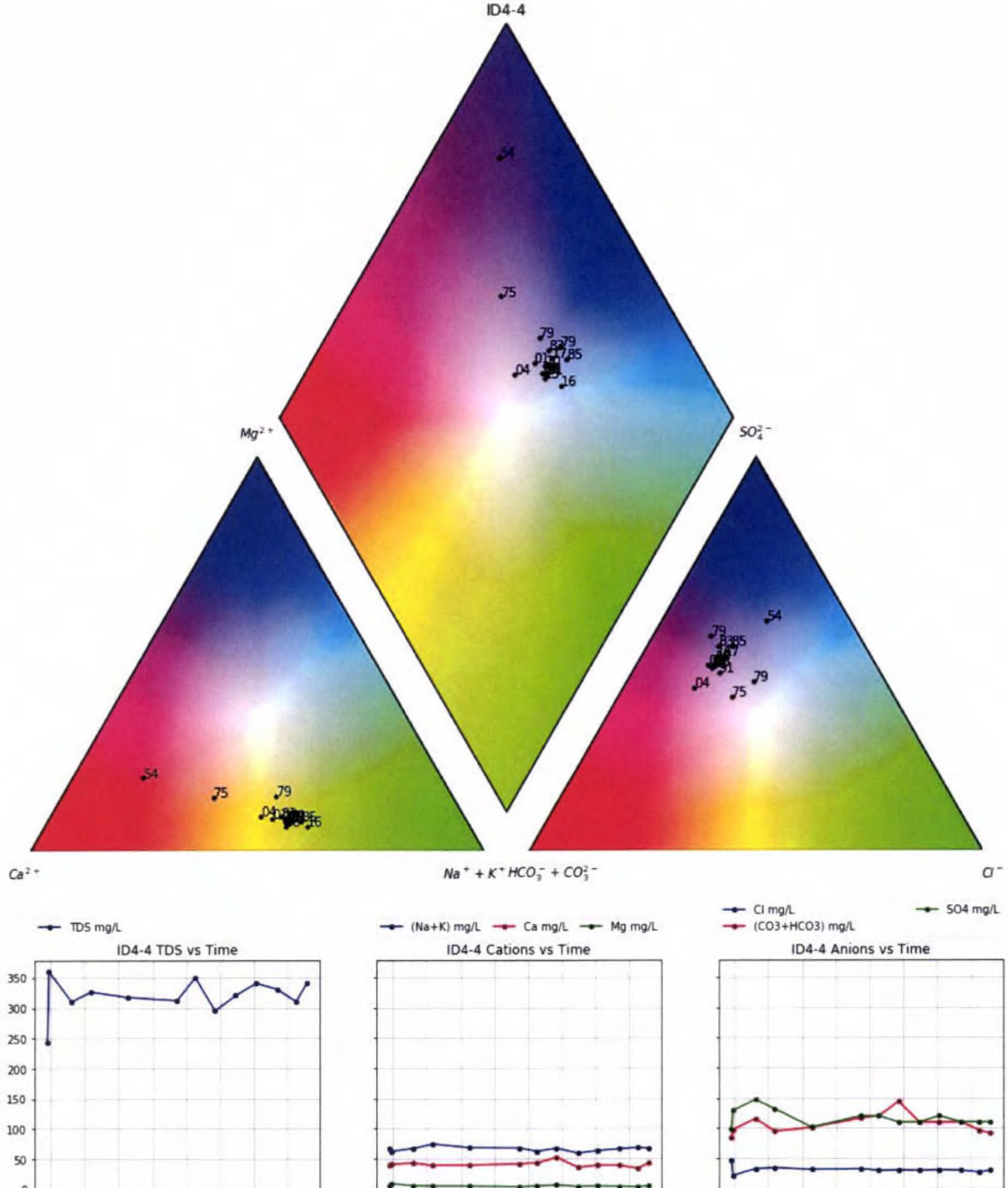

ID4-18
Mg²⁺
SO₄²⁻
Ca²⁺
Na⁺ + K⁺ HCO₃⁻ + CO₃²⁻
Cl⁻
TDS mg/L
ID4-18 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-18 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID4-18 Anions vs Time
0
100
200
300
400
500
600
1986 1990 1994 1998 2002 2006 2010 2014 2018

APPENDIX B: PIPER DIAGRAMS

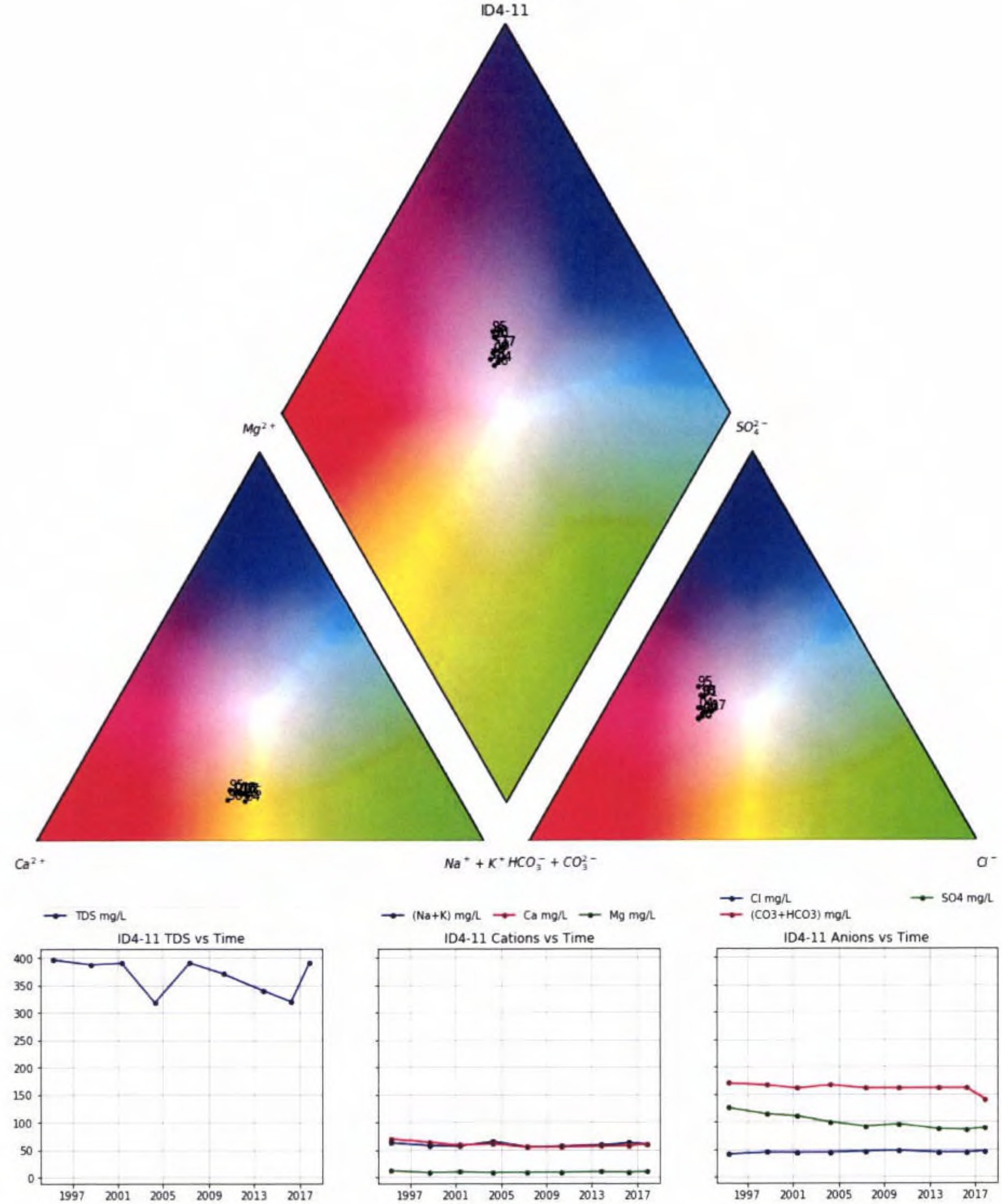
3: ID4-3



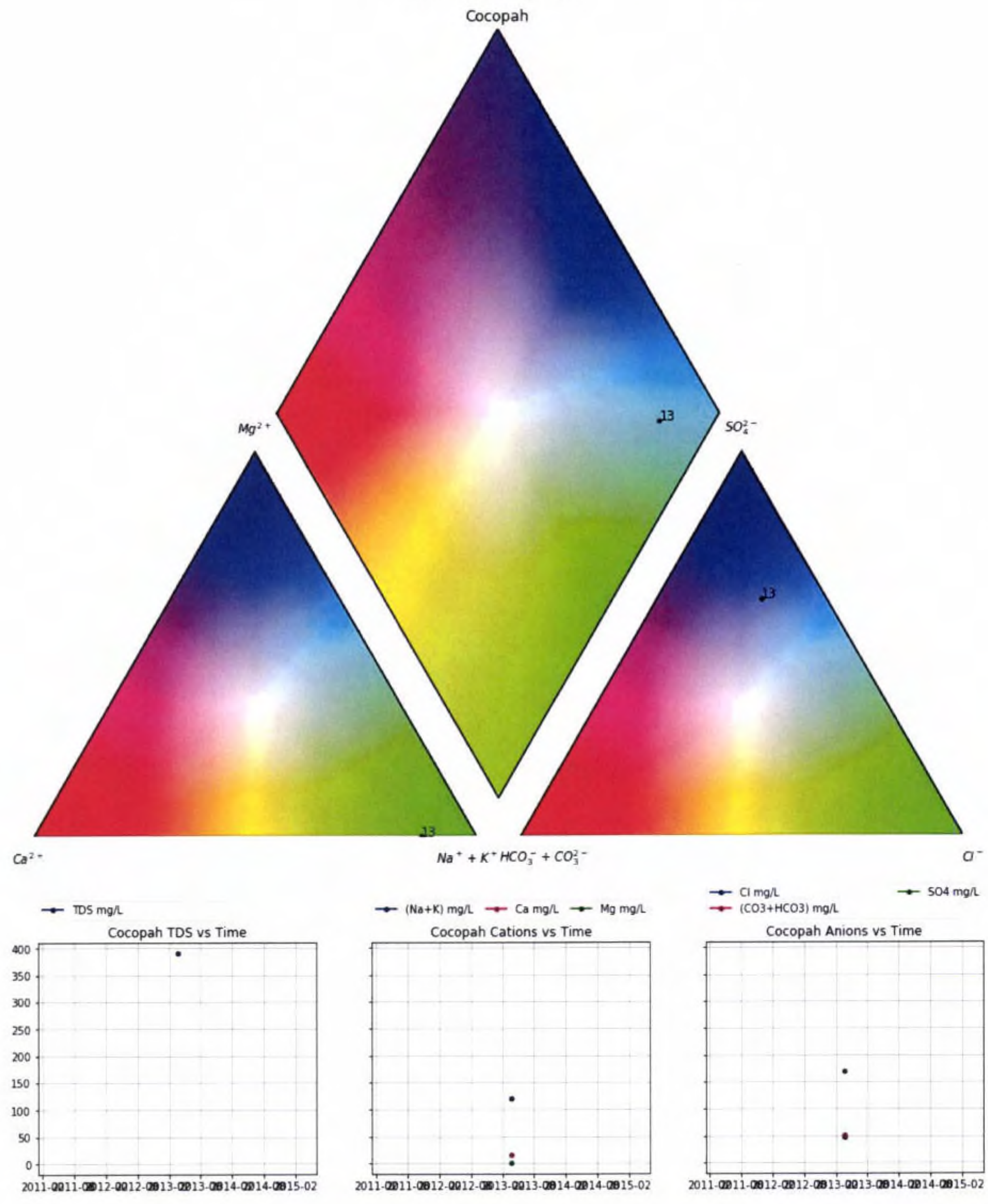
4: ID4-4


ID4-4
Mg2+
SO4 2-
Ca2+
Na+ + K+ HCO3- + CO3 2-
Cl-
TDS mg/L
ID4-4 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-4 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID4-4 Anions vs Time

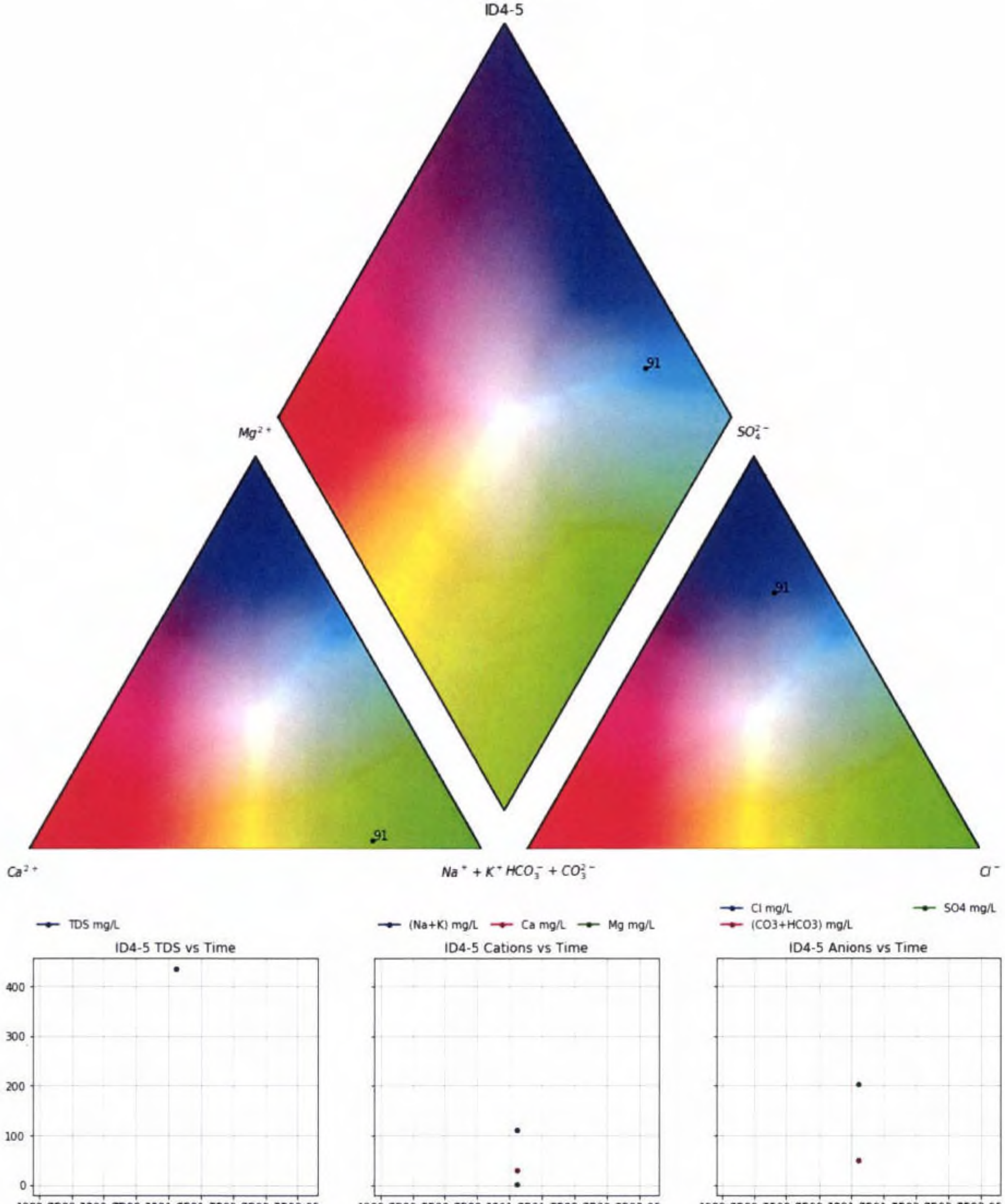
5: ID4-11


ID4-11
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+ HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID4-11 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-11 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID4-11 Anions vs Time
1997
2001
2005
2009
2013
2017

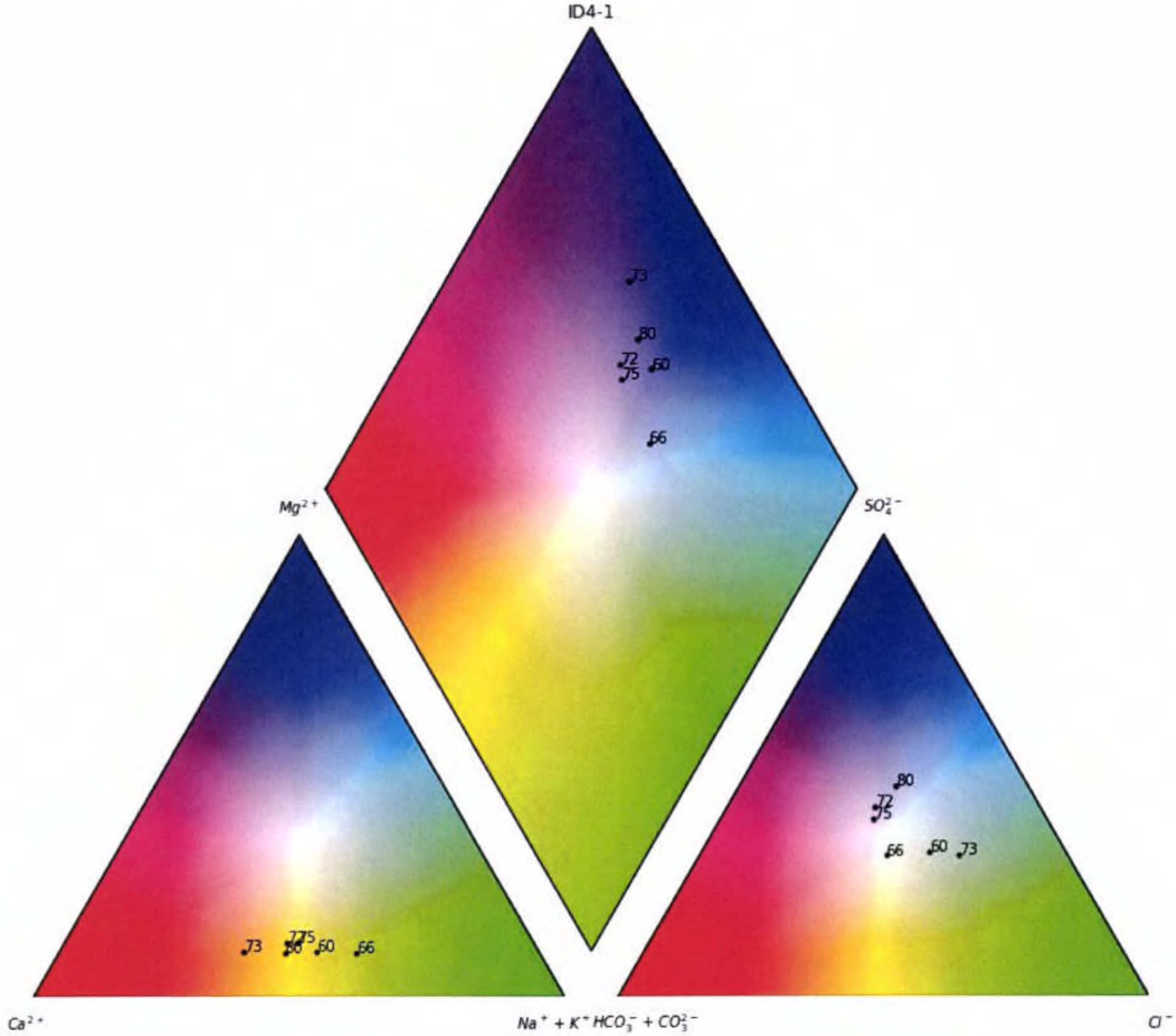
6: Cocopah


Cocopah
13
Mg^{2+}
SO_4^{2-}
13
13
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
Cocopah TDS vs Time
400
350
300
250
200
150
100
50
0
(Na+K) mg/L
Ca mg/L
Mg mg/L
Cocopah Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
Cocopah Anions vs Time

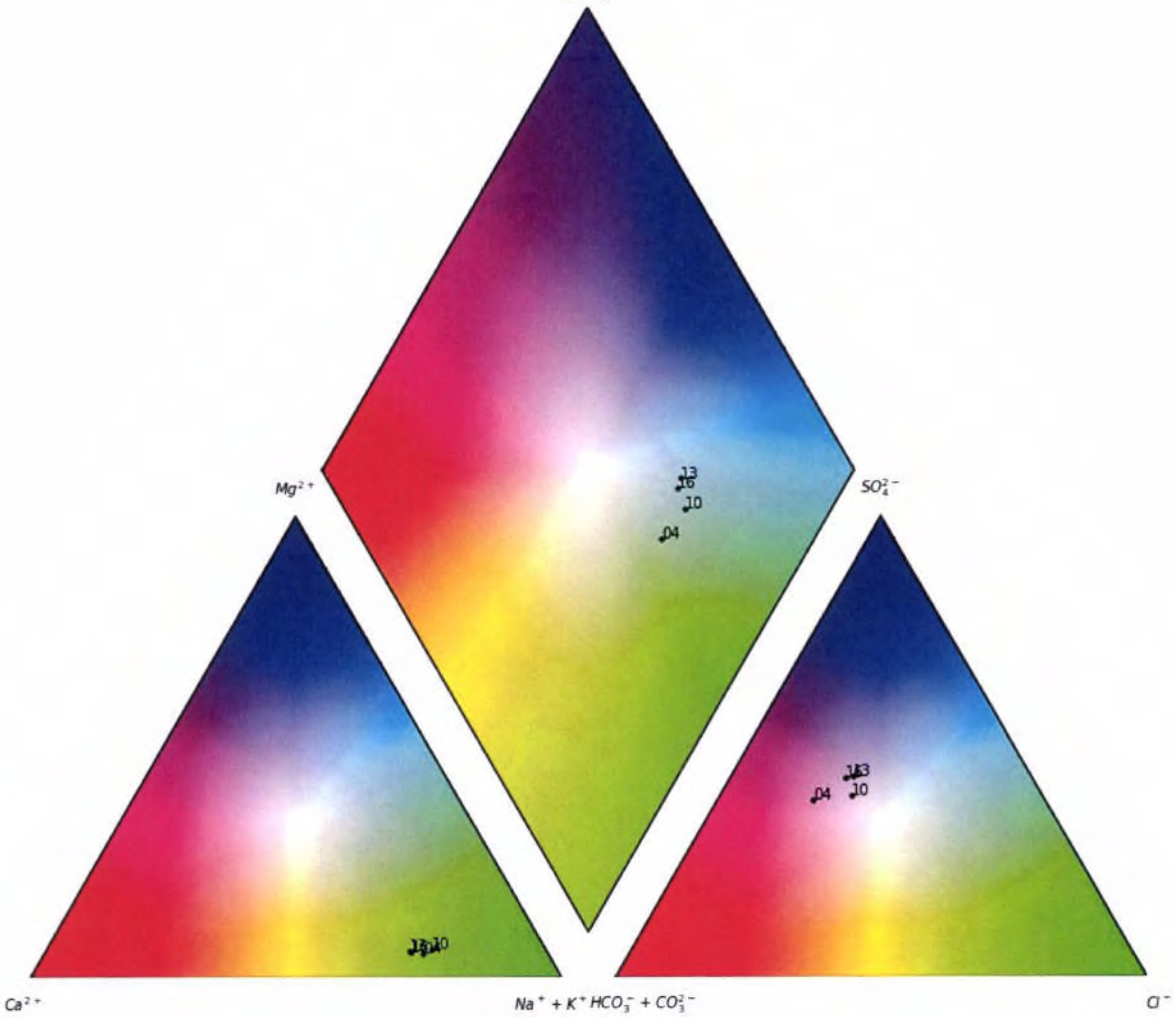
7: ID4-5

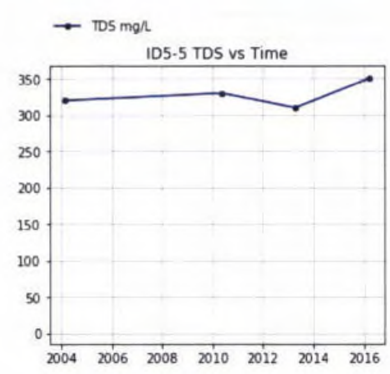

ID4-5
91
91
91
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID4-5 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-5 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID4-5 Anions vs Time
400
300
200
100
0

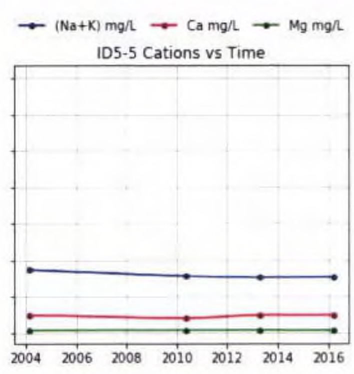
7A: ID4-1

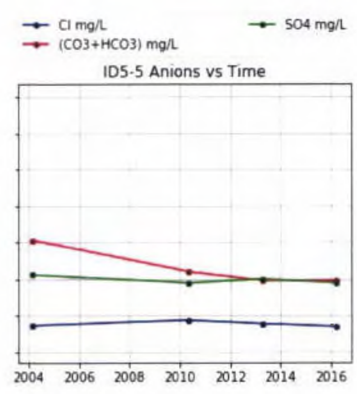

ID4-1
73
80
72
75
60
66
Mg2+
SO42-
73
80
72
75
60
66
Ca2+
Na+ + K+ HCO3- + CO32-
Cl-

8: ID5-5

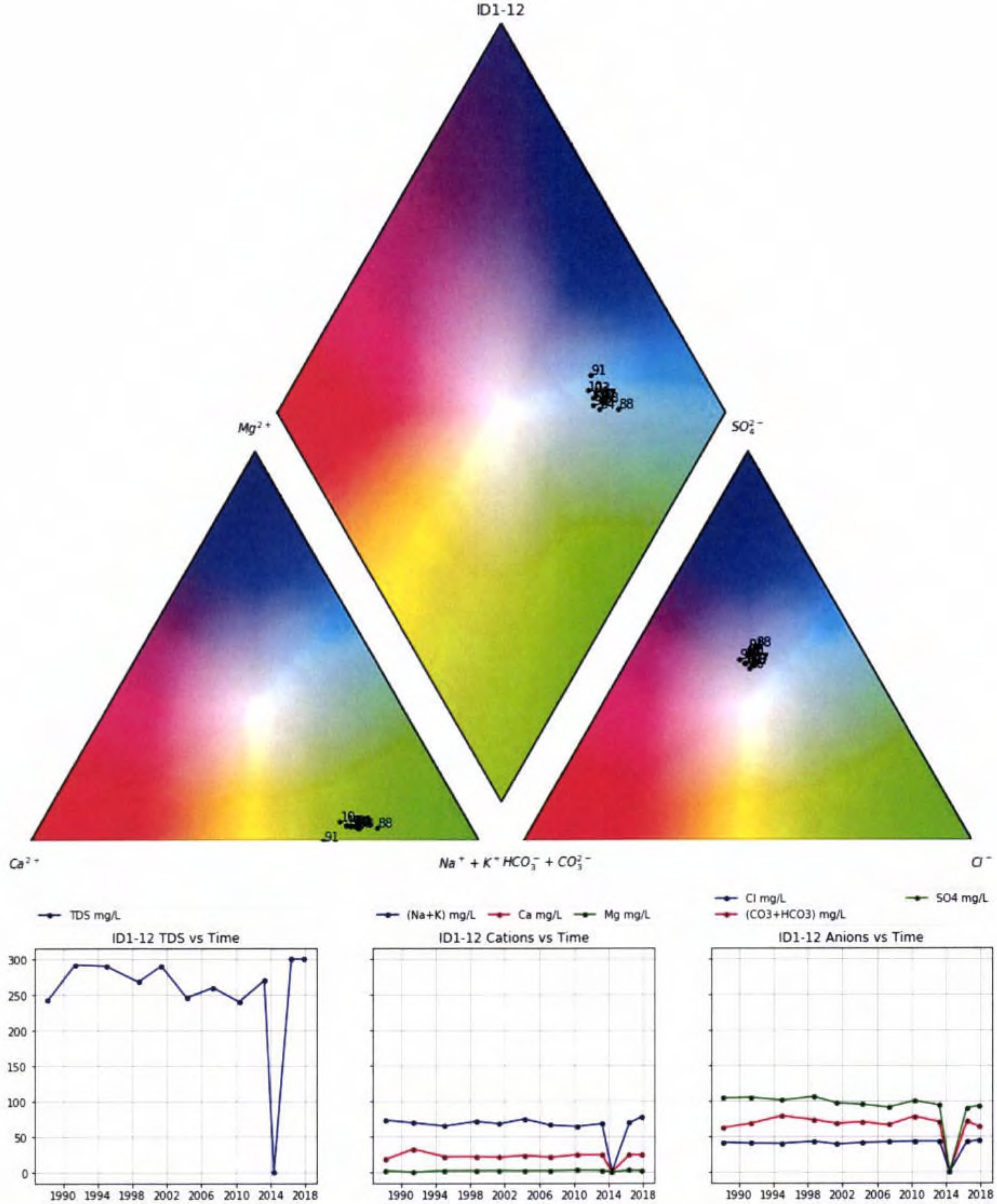

ID5-5
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
13
16
10
04


TDS mg/L
ID5-5 TDS vs Time
350
300
250
200
150
100
50
0
2004 2006 2008 2010 2012 2014 2016

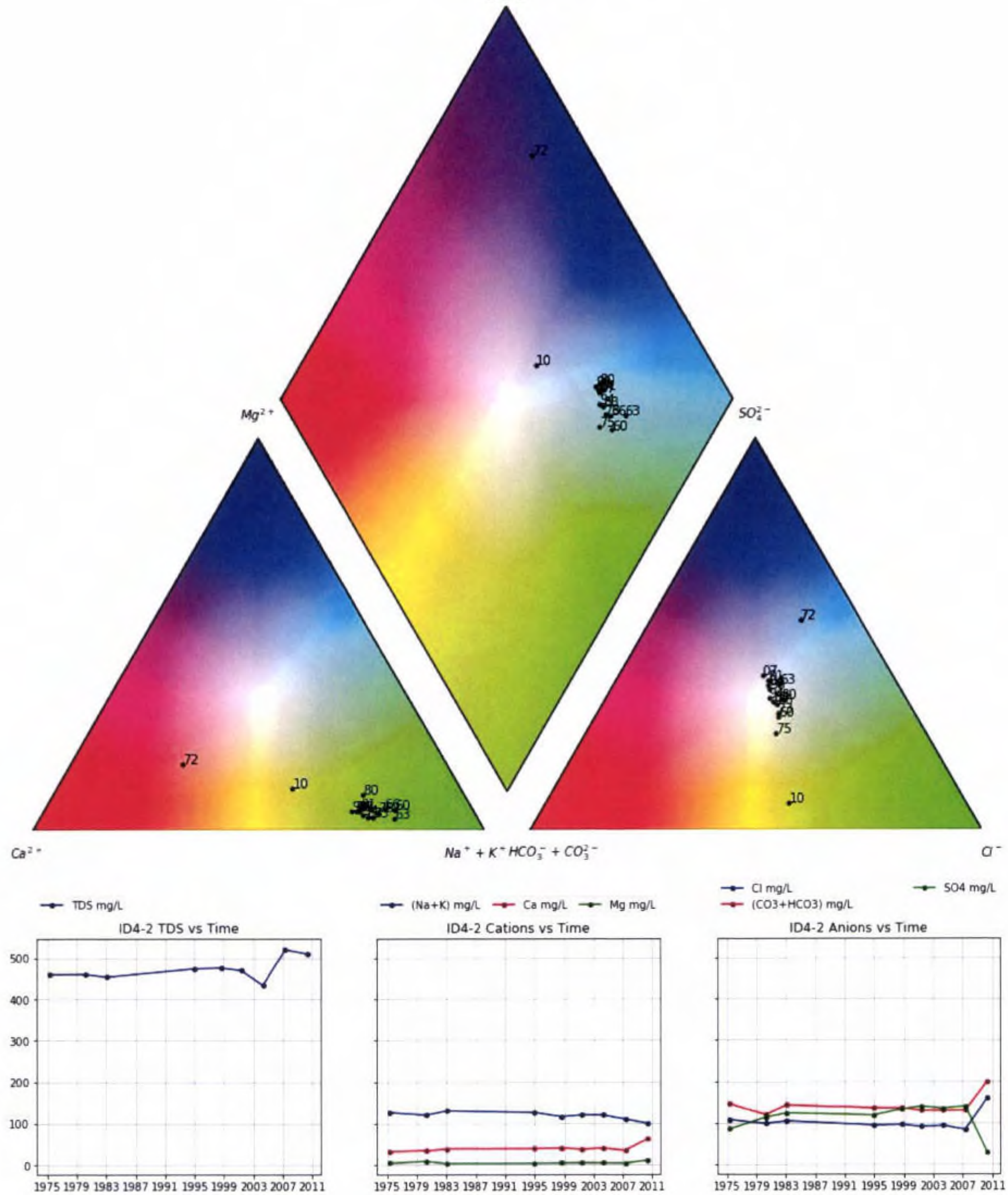

(Na+K) mg/L
Ca mg/L
Mg mg/L
ID5-5 Cations vs Time
2004 2006 2008 2010 2012 2014 2016


Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID5-5 Anions vs Time
2004 2006 2008 2010 2012 2014 2016

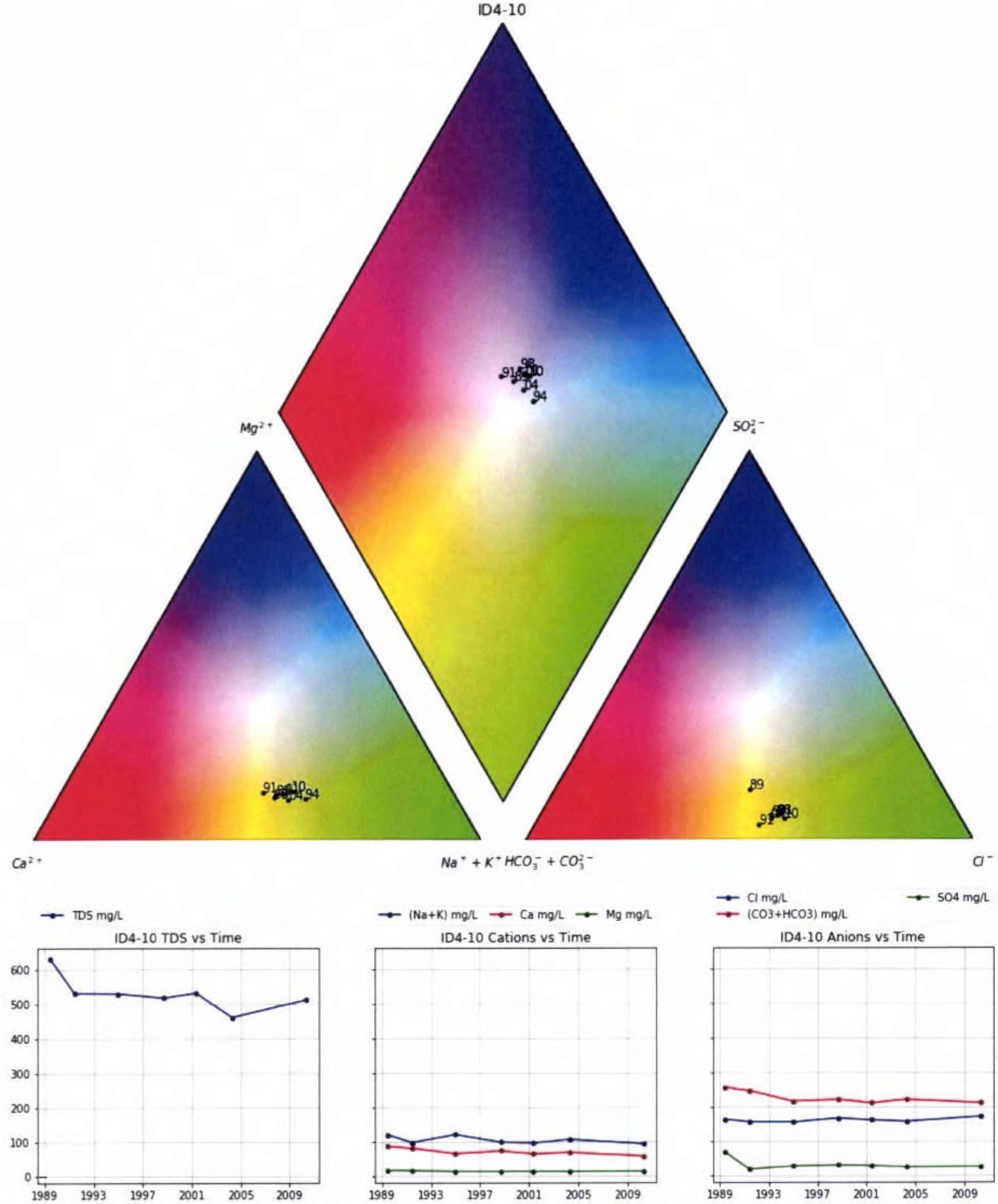
9: ID1-12


ID1-12
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID1-12 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-12 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID1-12 Anions vs Time

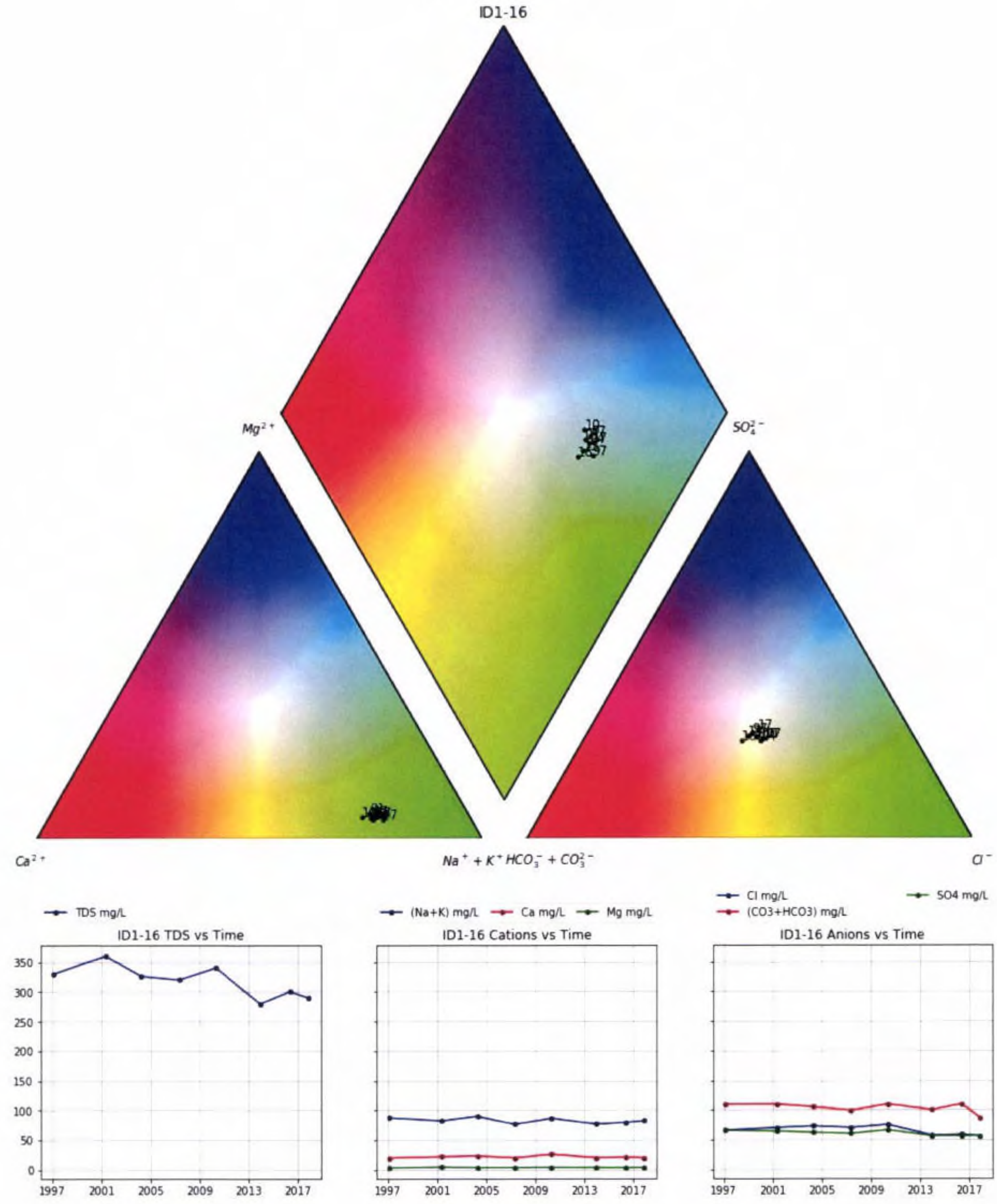
10: ID4-2

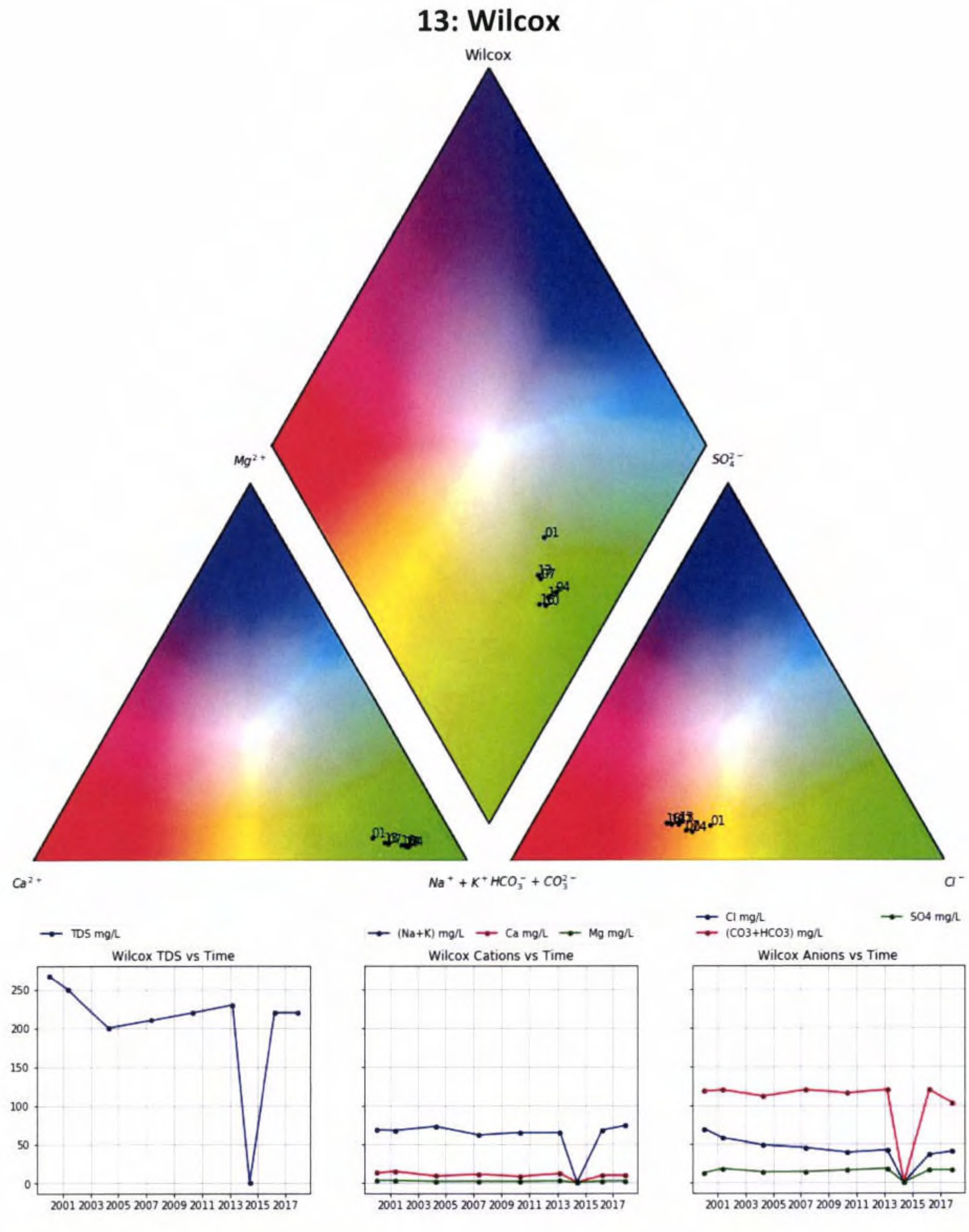

ID4-2
72
10
Mg2+
SO4 2-
Ca2+
Na+ + K+ HCO3- + CO3 2-
Cl-
TDS mg/L
ID4-2 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-2 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID4-2 Anions vs Time
500
400
300
200
100
0
1975 1979 1983 1987 1991 1995 1999 2003 2007 2011

11: ID4-10

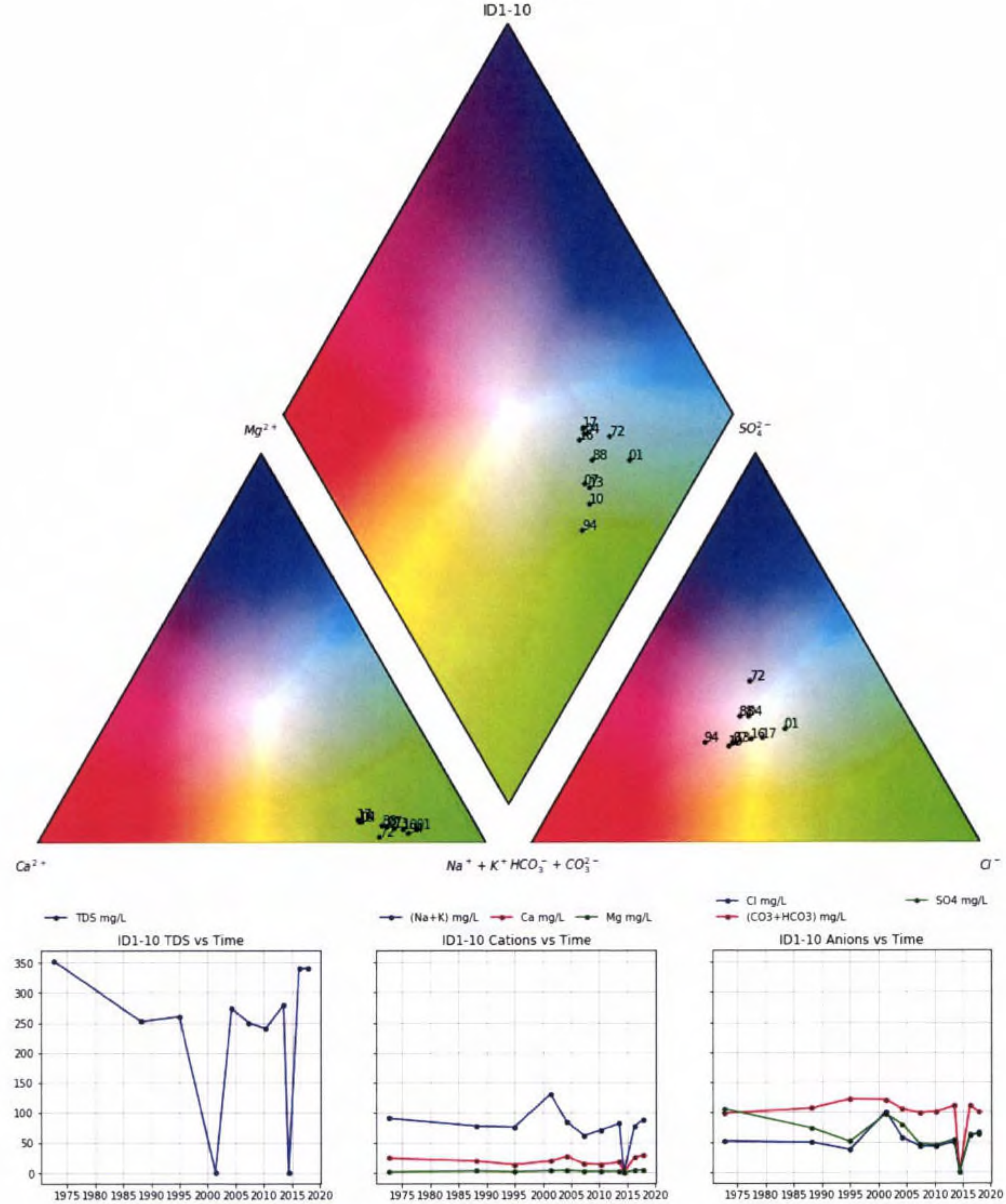

ID4-10
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID4-10 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID4-10 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID4-10 Anions vs Time

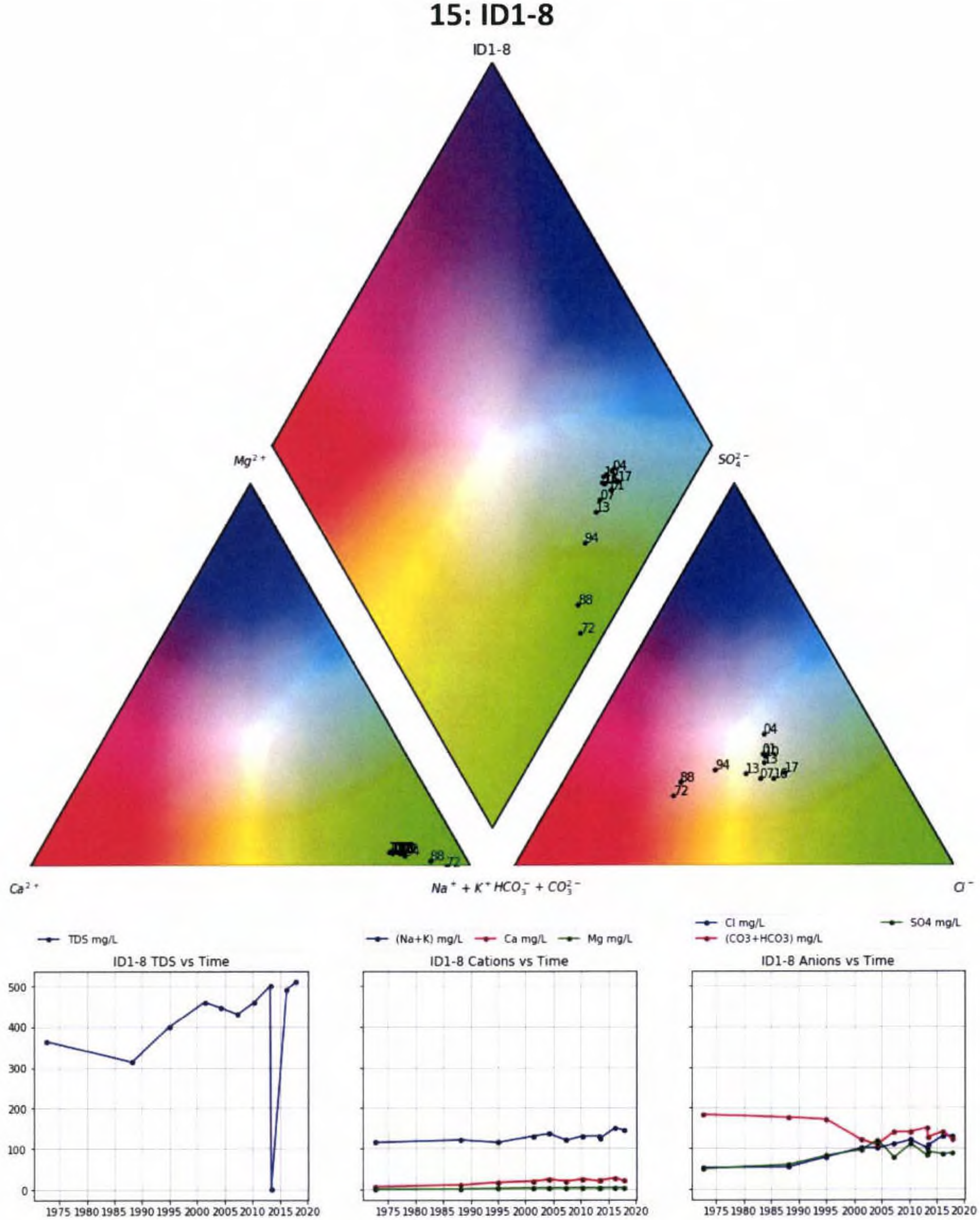
12: ID1-16


ID1-16
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+ HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID1-16 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-16 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID1-16 Anions vs Time
350
300
250
200
150
100
50
0
1997
2001
2005
2009
2013
2017

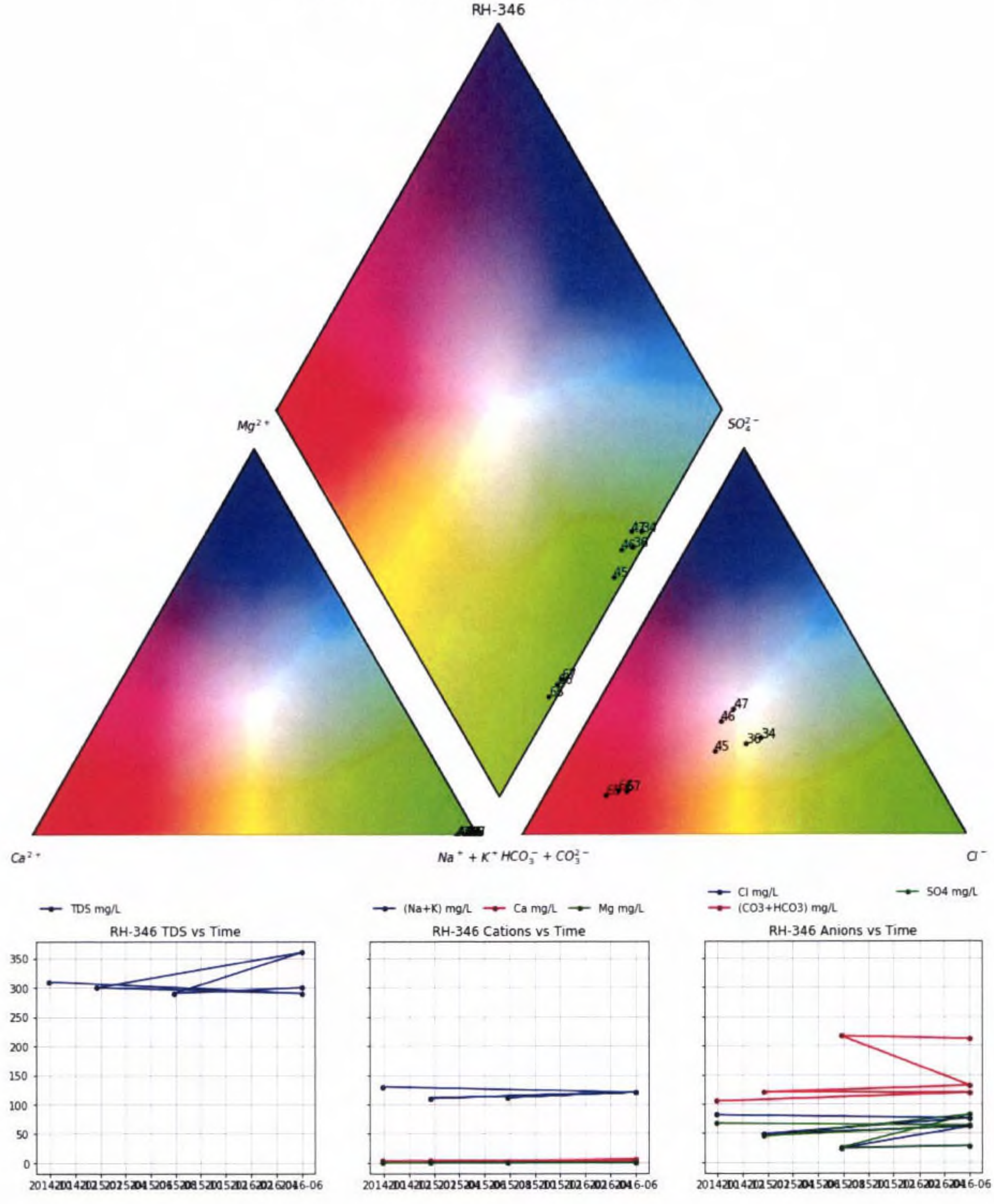

13: Wilcox
Wilcox
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
Wilcox TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
Wilcox Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
Wilcox Anions vs Time

14: ID1-10

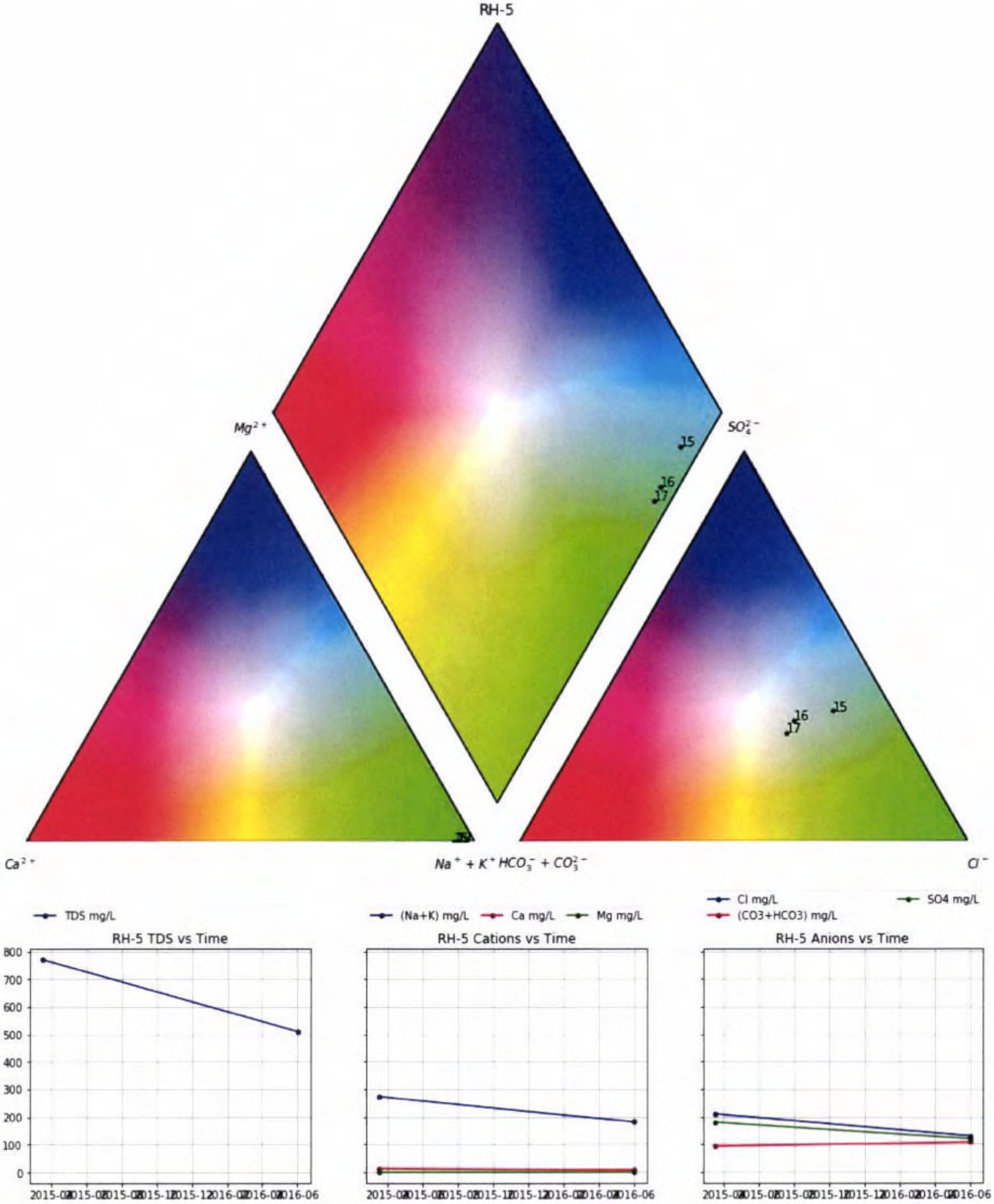

ID1-10
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID1-10 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-10 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID1-10 Anions vs Time


15: ID1-8
ID1-8
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
TDS mg/L
ID1-8 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-8 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID1-8 Anions vs Time
1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

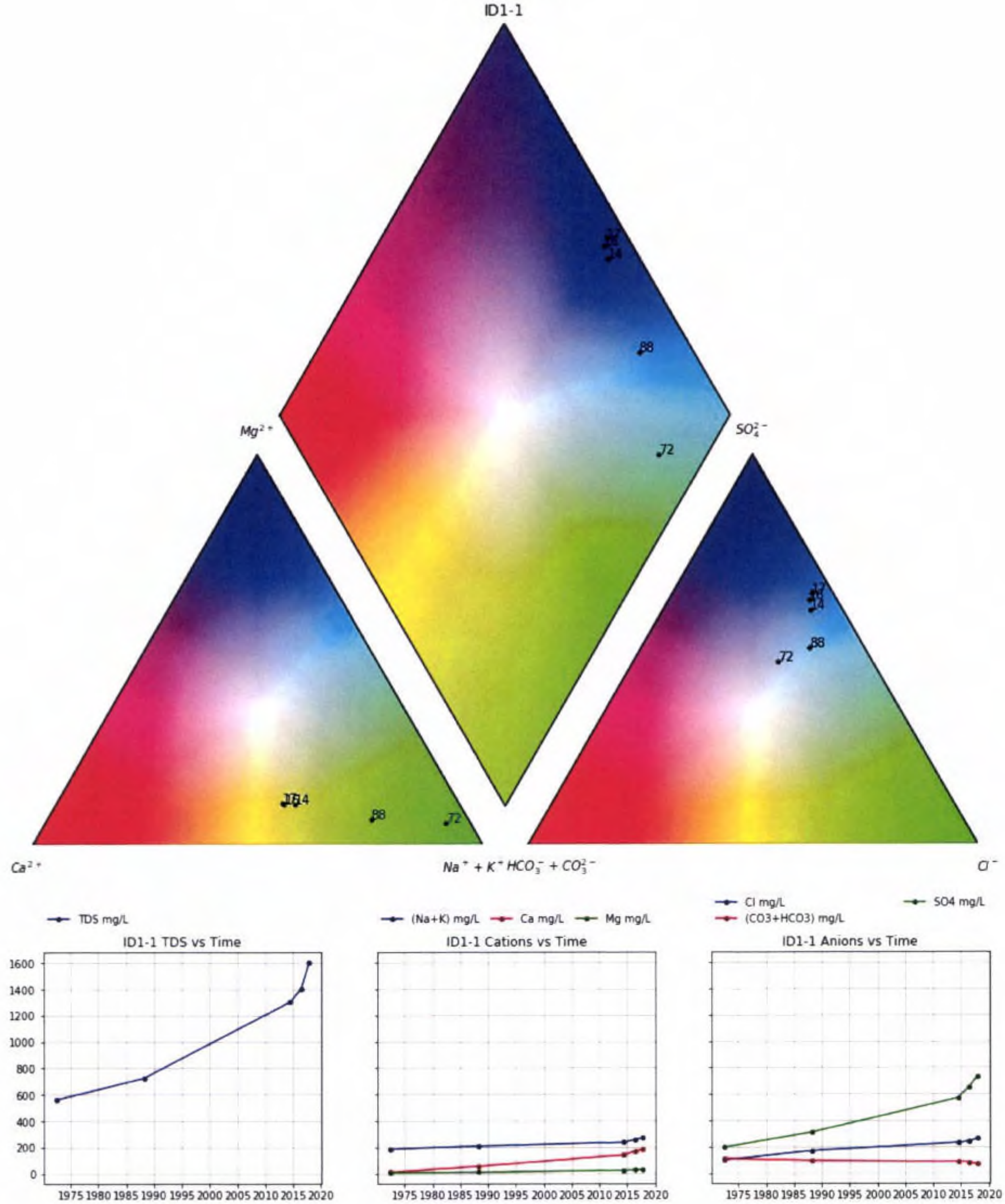
16: RH-3; 17: RH-4; 19: RH-6



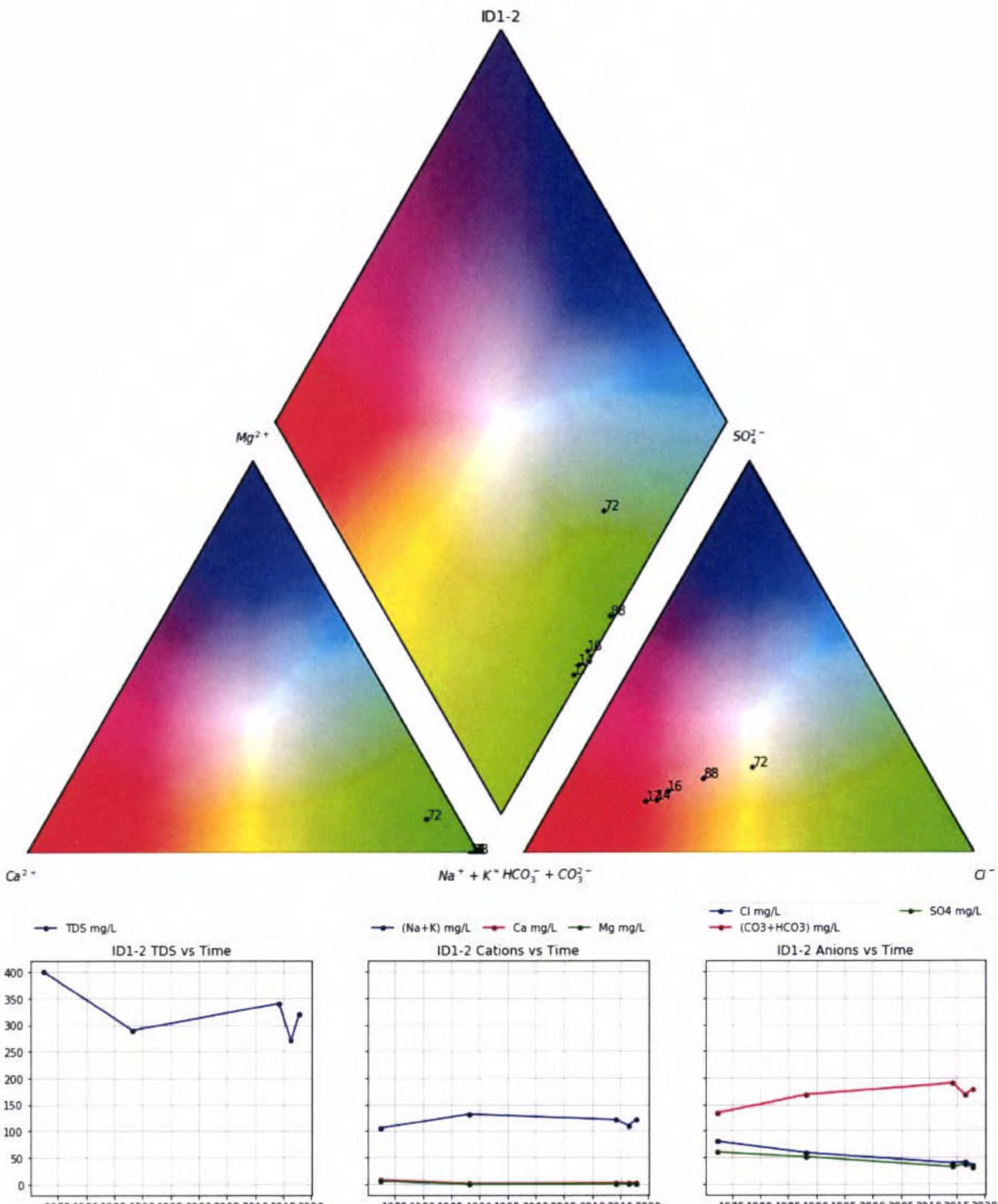
18: RH-5


RH-5
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+$ $HCO_3^- + CO_3^{2-}$
Cl^-
15
16
17
TDS mg/L
RH-5 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
RH-5 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
RH-5 Anions vs Time
800
700
600
500
400
300
200
100
0
2016-06

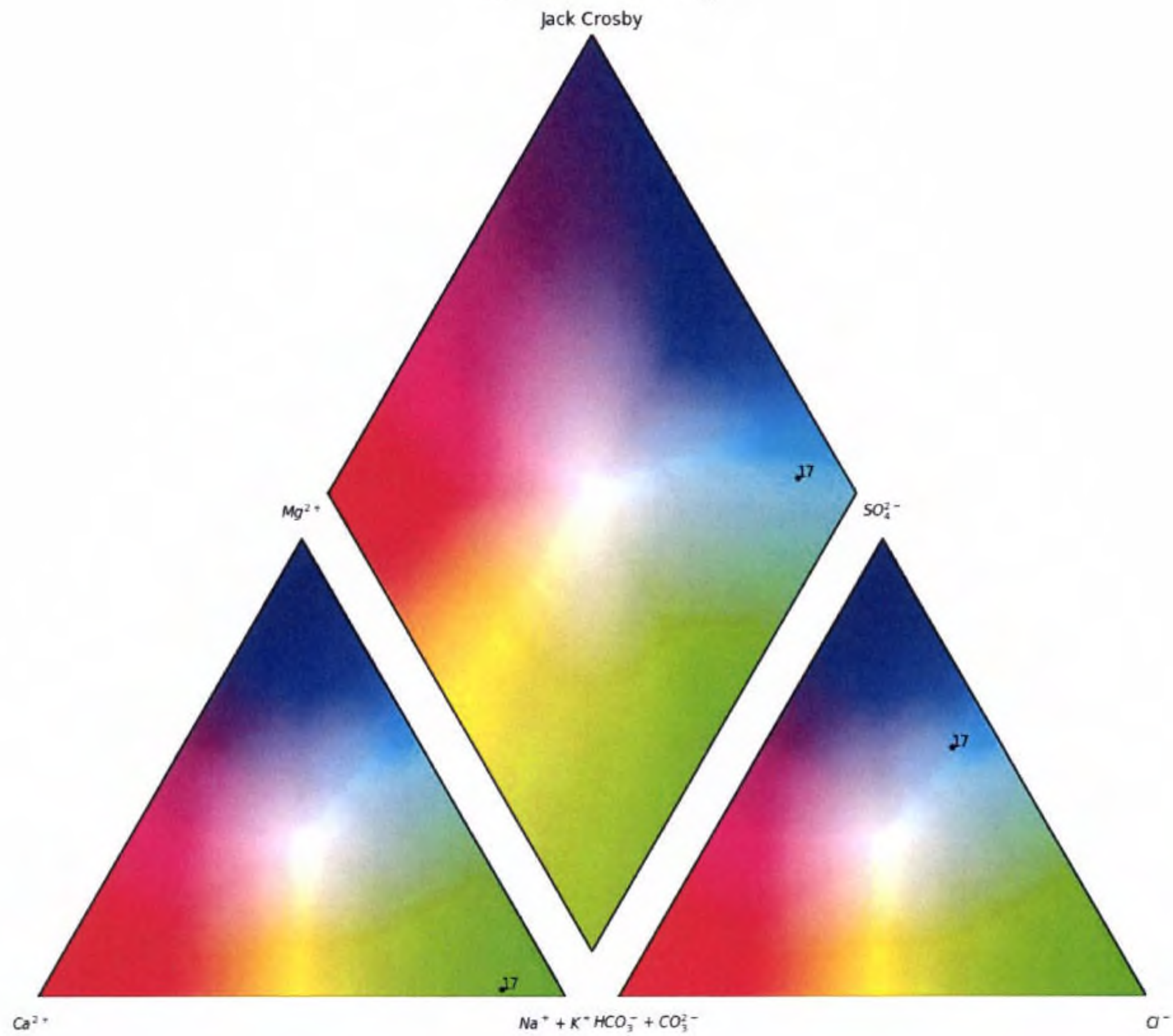
20: ID1-1


ID1-1
Mg^{2+}
SO_4^{2-}
Ca^{2+}
$Na^+ + K^+ HCO_3^- + CO_3^{2-}$
Cl^-
88
72
14
TDS mg/L
ID1-1 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-1 Cations vs Time
Cl mg/L
SO4 mg/L
(CO3+HCO3) mg/L
ID1-1 Anions vs Time
1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

21: ID1-2

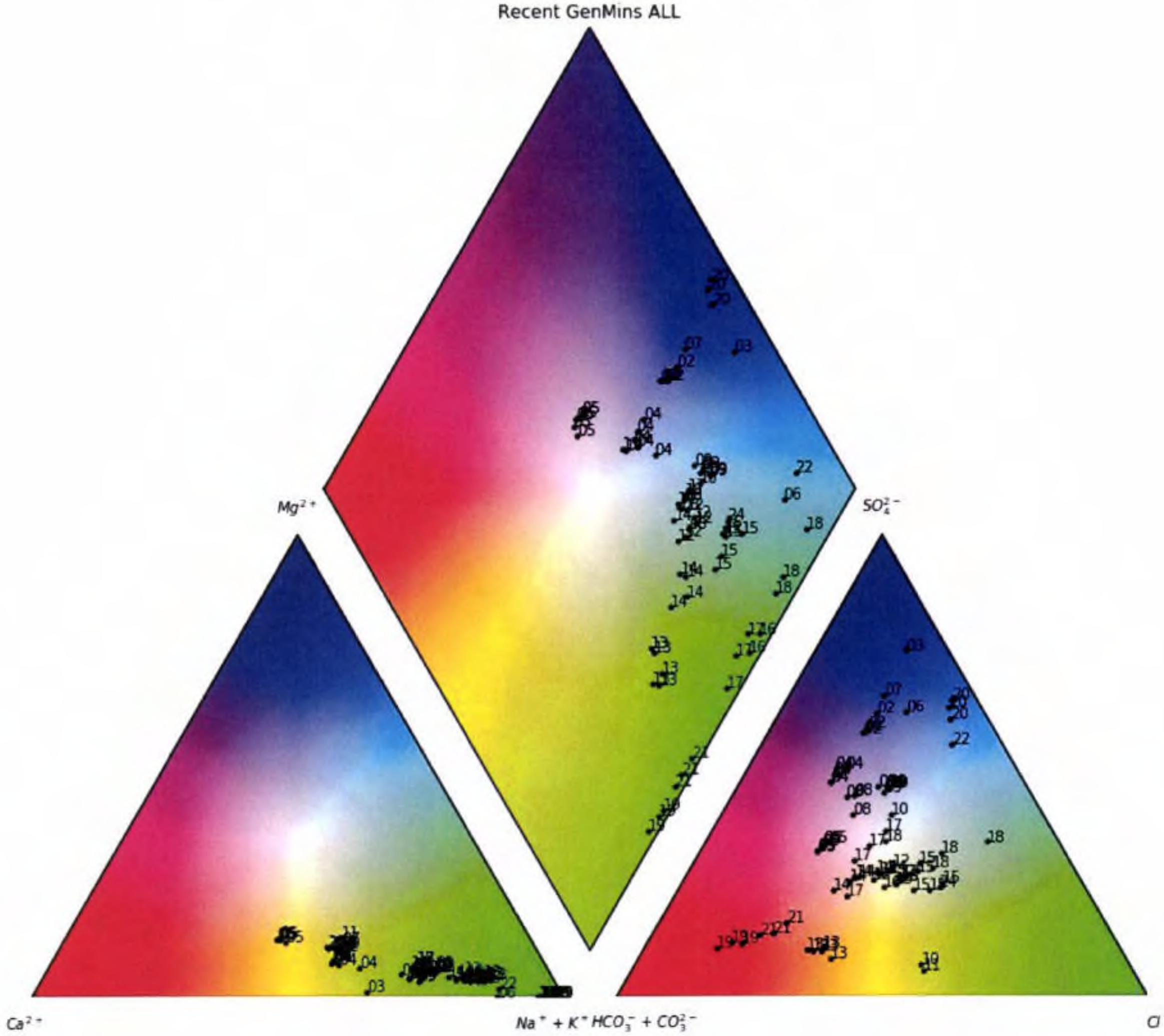

ID1-2
Mg2+
SO42-
Ca2+
Na+ + K+ HCO3- + CO32-
Cl-
TDS mg/L
ID1-2 TDS vs Time
(Na+K) mg/L
Ca mg/L
Mg mg/L
ID1-2 Cations vs Time
Cl mg/L
(CO3+HCO3) mg/L
SO4 mg/L
ID1-2 Anions vs Time
1975 1980 1985 1990 1995 2000 2005 2010 2015 2020

22: Jack Crosby



One data point so no plots generated.

Recent Data: All (Piper only)

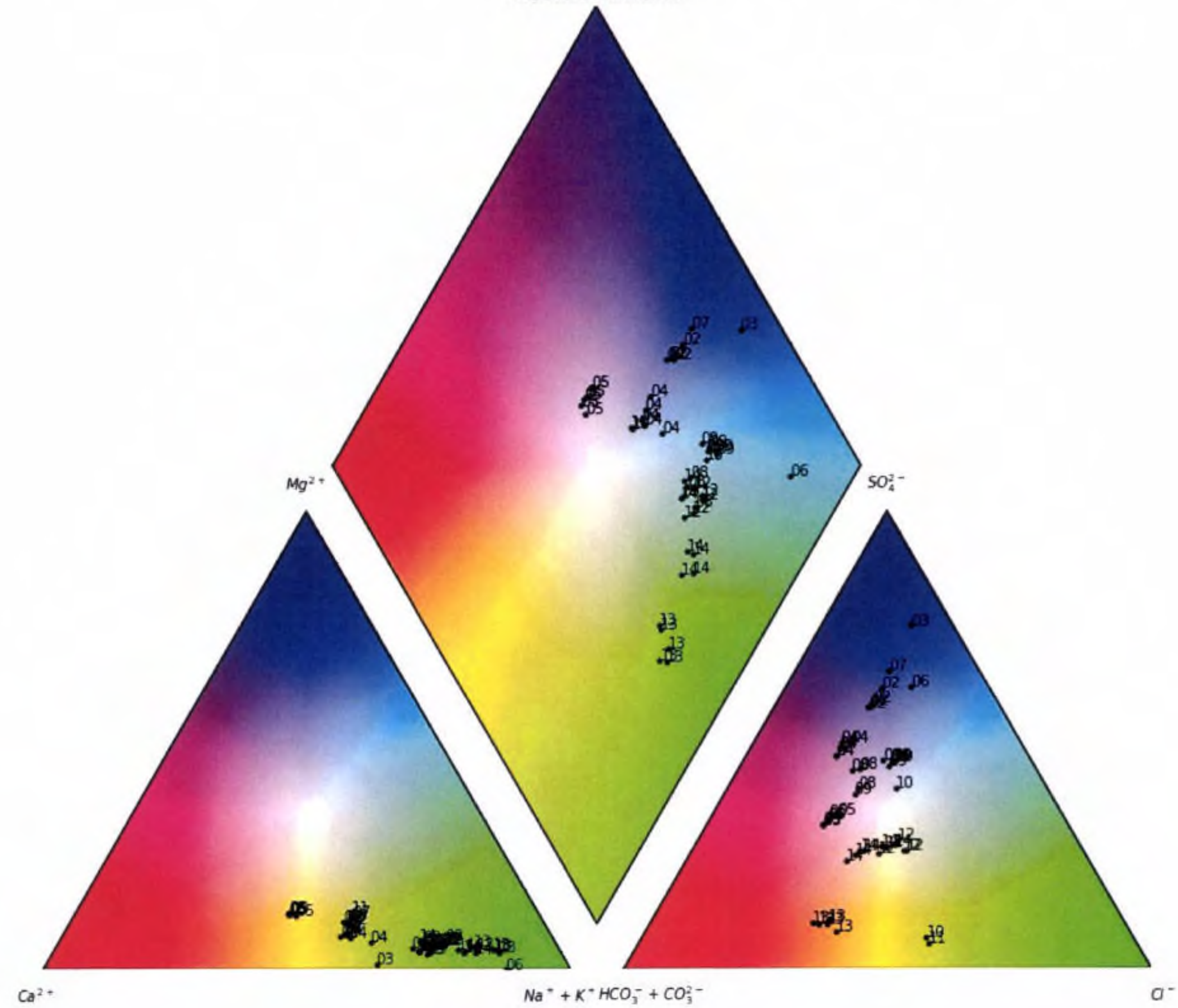


Notes:

The number on the diagrams correspond to sequential well numbers assigned to each of the wells as explained in the text. Data are for the period of 2005 to 2018.

This Piper diagram is further explained in **Figure 6**.

Recent Data: North and Central (Piper only)



Note: The number on the diagrams correspond to sequential well numbers assigned to each of the wells as explained in the text. Data are for the period of 2005 to 2018.