DRAFT WORKPRODUCT

Borrego Valley Groundwater Basin
Borrego Springs Subbasin
Groundwater Overview

Borrego Valley Groundwater Basin Sustainability Plan

Advisory Committee Meeting

May 15, 2017

Geosyntec consultants

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Presentation Topics

1. Water Budget
2. Water Credits
3. Water Quality
4. Projects and Management Actions

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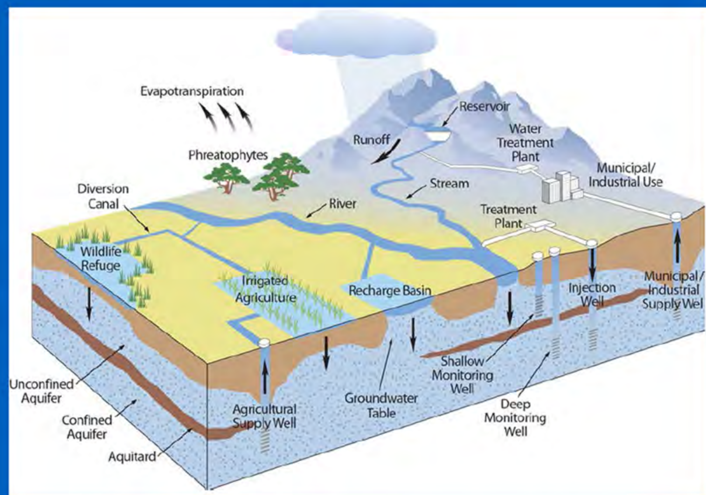
Water Budget Fundamentals



Source: DWR 2015

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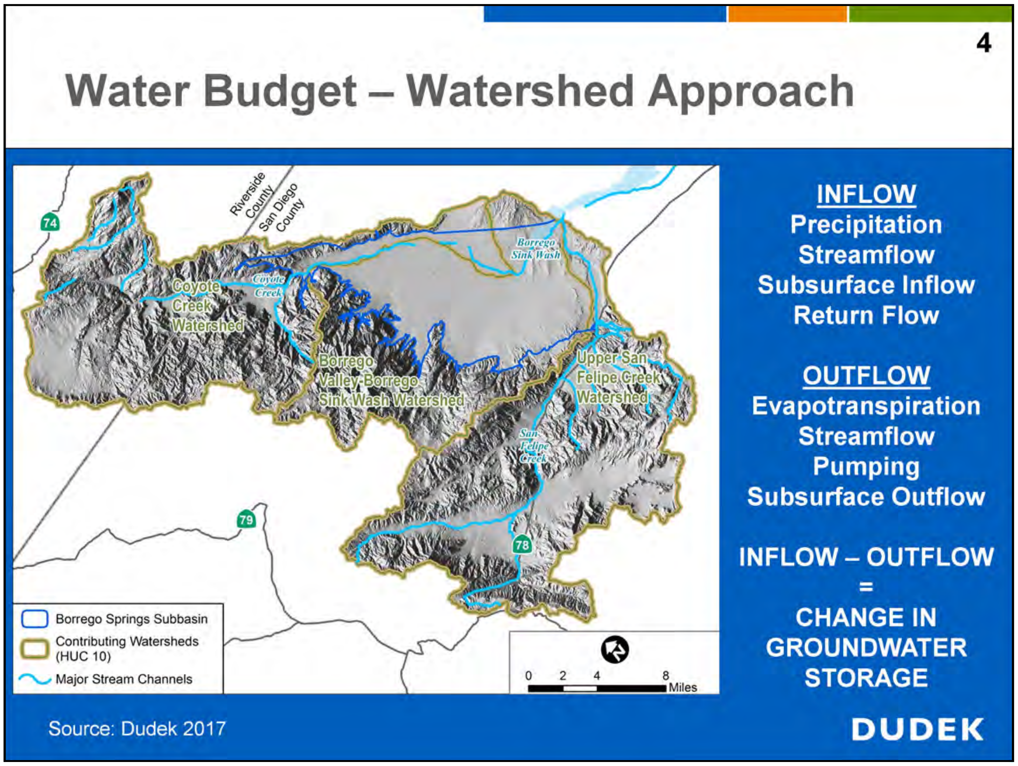
“The water budget takes into account the storage and movement of water between the three components of the hydrologic cycle, the atmosphere, the land surface, and the subsurface. A water budget is a foundational tool used to compile or estimate water inflows (supplies) and outflows (demands) into an accounting of the total groundwater and surface water entering and leaving a basin, and to calculate the difference between inflows and outflows as a change in the amount of water stored” (DWR 2016).



The Borrego Springs Subbasin is approximately 98 square miles or 62,776 acres

The contributing watersheds to the subbasin include the Coyote Creek watershed at about 179 square miles or 114,615 acres and the Upper San Felipe Creek water shed at 194 square miles or 124,124 acres.

A majority of the recharge to the subbasin is sourced from areas outside of the subbasin due to greater precipitation that occurs in the contributing watersheds.

Most of the recharge to the subbasin is sourced from the Coyote Creek watershed and recharges the subbasin as infiltration of streamflow through shallow alluvial sediments.

Mountain front recharge that occurs at the interface between surrounding bedrock and unconsolidated sediments is also an important source of recharge predominantly along the smaller tributaries that enter the subbasin.

“In principle, a water budget is a simple concept that measures, evaluates, and takes into consideration water inflow and outflow from all parts of the atmosphere, land surface and subsurface components of a basin. In reality, it can be difficult to accurately measure and account for all components of the water budget for a given area” (DWR 2016).

(e.g. Identified Data Gap: Agricultural Groundwater Production)

Water Budget – Watershed Analysis

- **What is the water budget and how does it relate to sustainable yield?**

It is traditional to equate the sustainable yield, or safe yield, to long-term average recharge to the basin.

"Over the 66-year study period, on average, the natural recharge that reaches to the saturated groundwater system is approximately 5,700 acre-feet per year, but natural recharge fluctuates in the arid climate from less than 1,000 to more than 25,000 acre-feet per year" (Faunt 2015).

For initial planning purposes, **5,700 acre-feet per year** is considered the long-term average recharge or "sustainable yield" of the basin until additional analysis is performed.

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Water Budget - Model

- **Why not just use the already prepared USGS estimate?** The USGS estimate focuses on the historical period form 1945–2010. SGMA requires the water budget to include **historical**, **current** and **projected** water budget conditions (§354.18(a)).
- **Does the USGS estimate include return flows from irrigation?** Yes, "Recharge from irrigation return flows was estimated to be about 20–30% of agricultural and recreational pumpages" (Faunt 2015).
- **Will the updated water budget estimate be substantially different from the already prepared USGS estimate (i.e. will substantially more or less water be available to water users in the Borrego Springs Subbasin)?**

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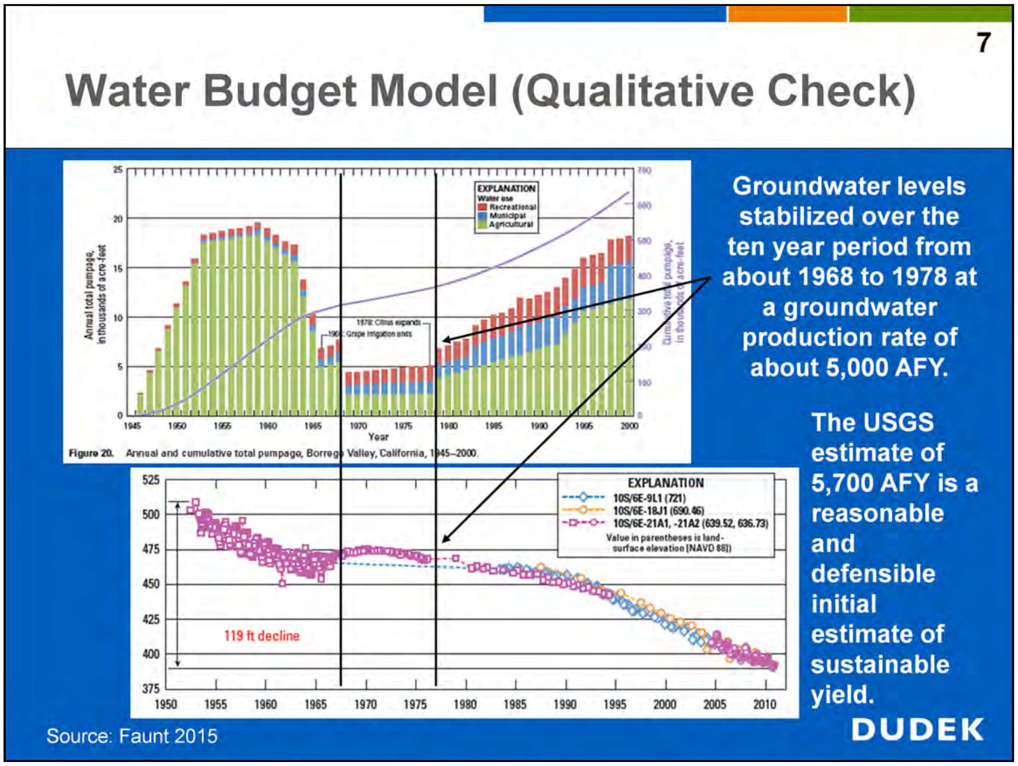
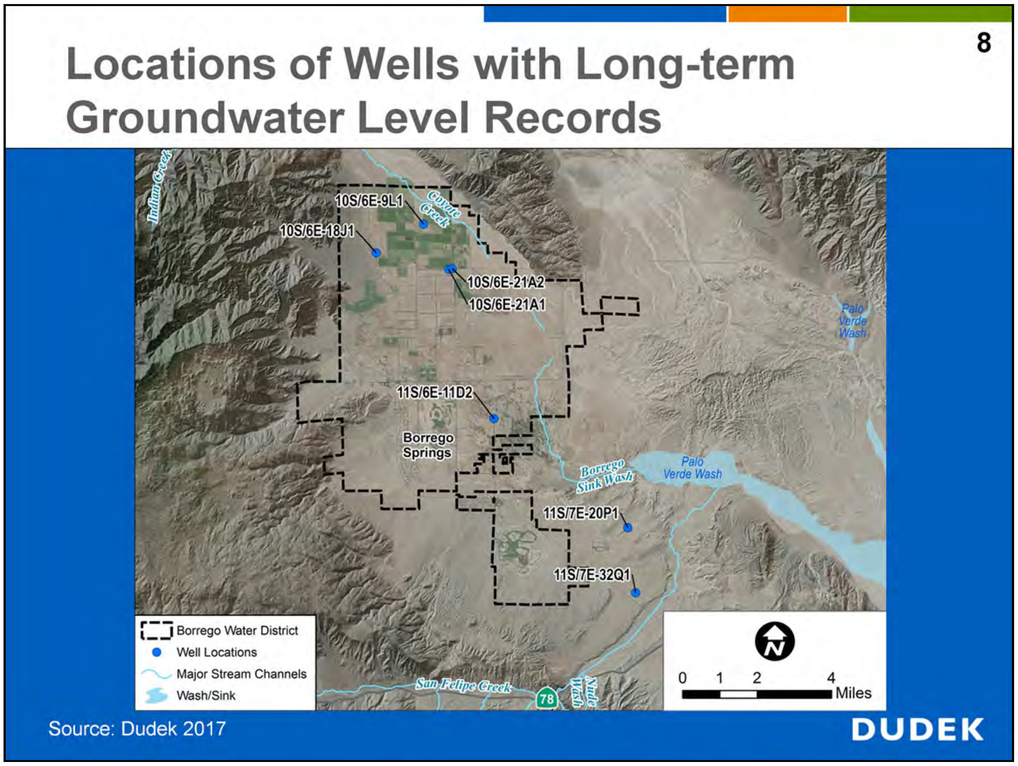


The estimate of 5,700 AFY of recharge can be qualitatively checked by reviewing charts of historical data in the USGS report. The upper figure presents annual pumping in the Borrego Valley. It shows that for the for the period **1968 to 1978** pumping was approximately **5,000 AFY**. It also shows that agricultural pumping was only 50% of total pumping (as opposed to 2010 when it was 72%), thus the uncertainty about total pumping is somewhat less than during other periods of higher agricultural pumping. The lower figure presents historical groundwater levels. Review of this figure indicates that groundwater levels were relatively stable for the period **1968 to 1978** at pumping rates of approximately **5,000 AFY.**

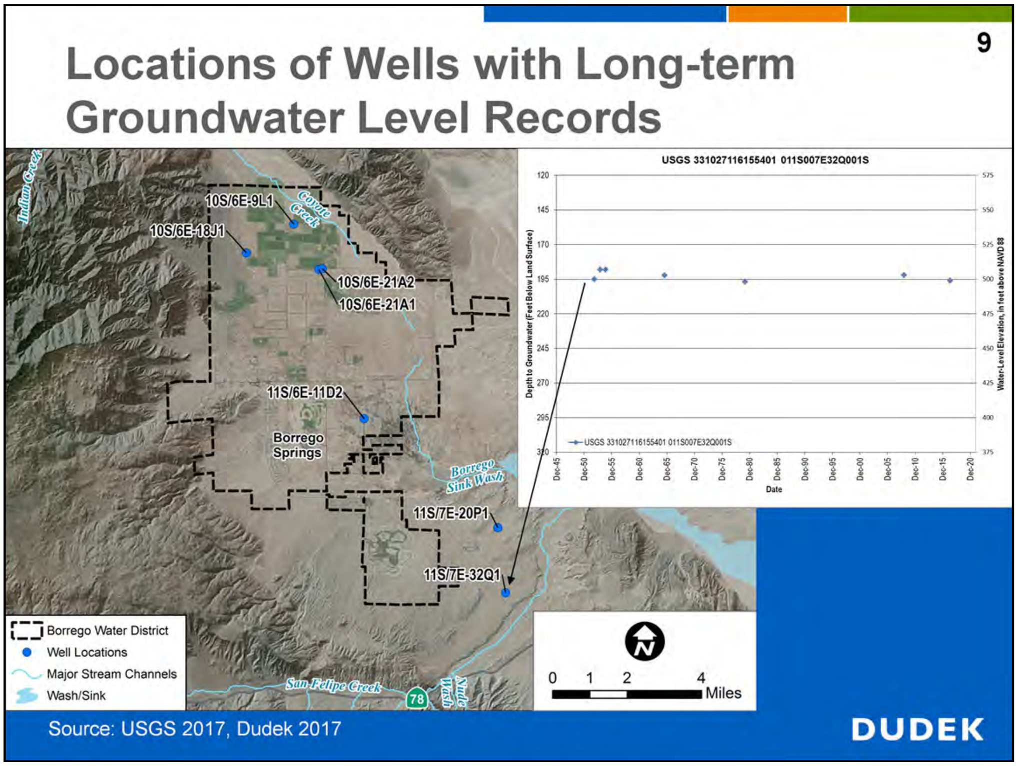
In contrast, total pumping ranged from approximately **7,000 to 13,000 AFY** between **1980 and 1993** and groundwater levels declined even though the previous cumulative rainfall deficit was erased during this period.

It is clear that current groundwater production rates are unsustainable. The USGS estimate of 5,700 AFY is a reasonable and defensible initial estimate of sustainable yield. The uncertainty associated with that estimate can and should be addressed over the next 5 to 10 years.

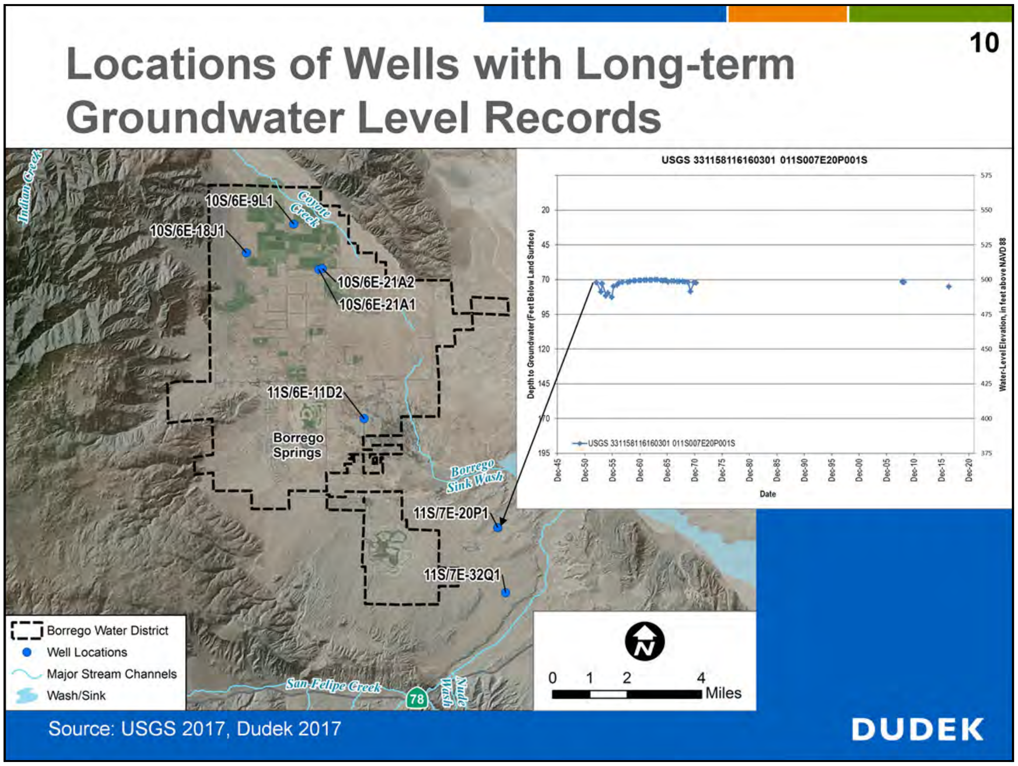
Even if the sustainable yield ultimately proves to be slightly greater than 5,700 AFY, there is no reason to continue pumping at rates of 10,000 to 19,000 AFY that are obviously unsustainable.



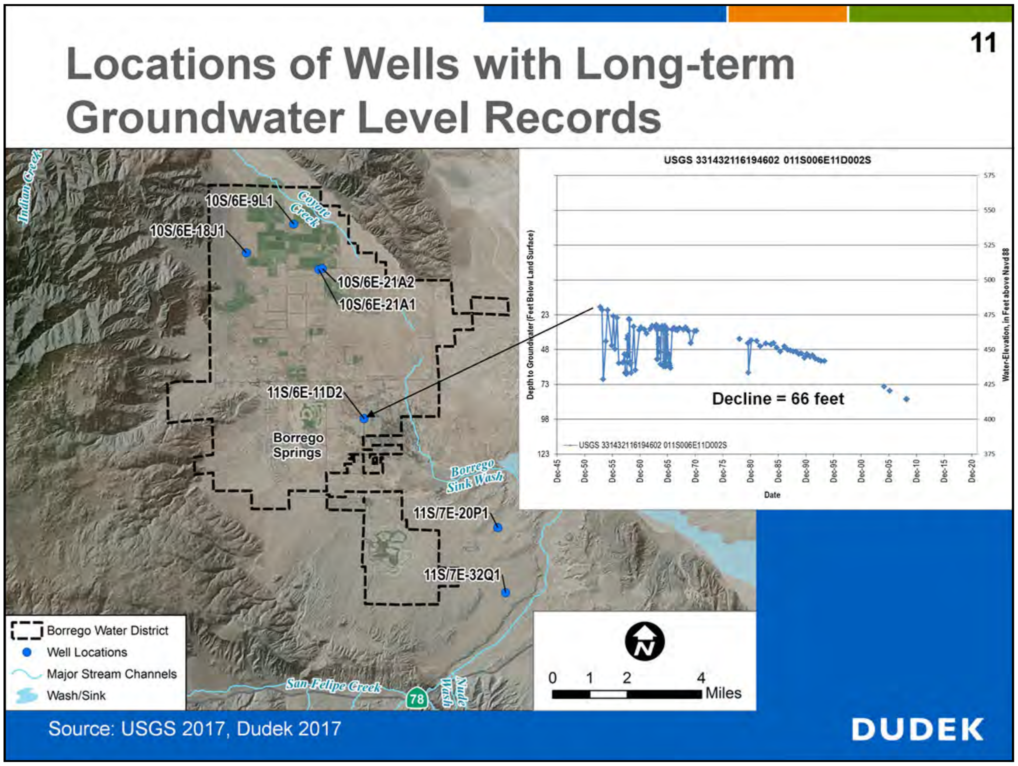
Because of the complexities involved with accurately measuring and accounting for all components of the water budget, the best way to determine if **inflows = outflows** over a period of time is to review groundwater level records and estimate the overall change in groundwater storage. This figure displays the location of water well in the Borrego Springs Subbasin with long-term groundwater level records.



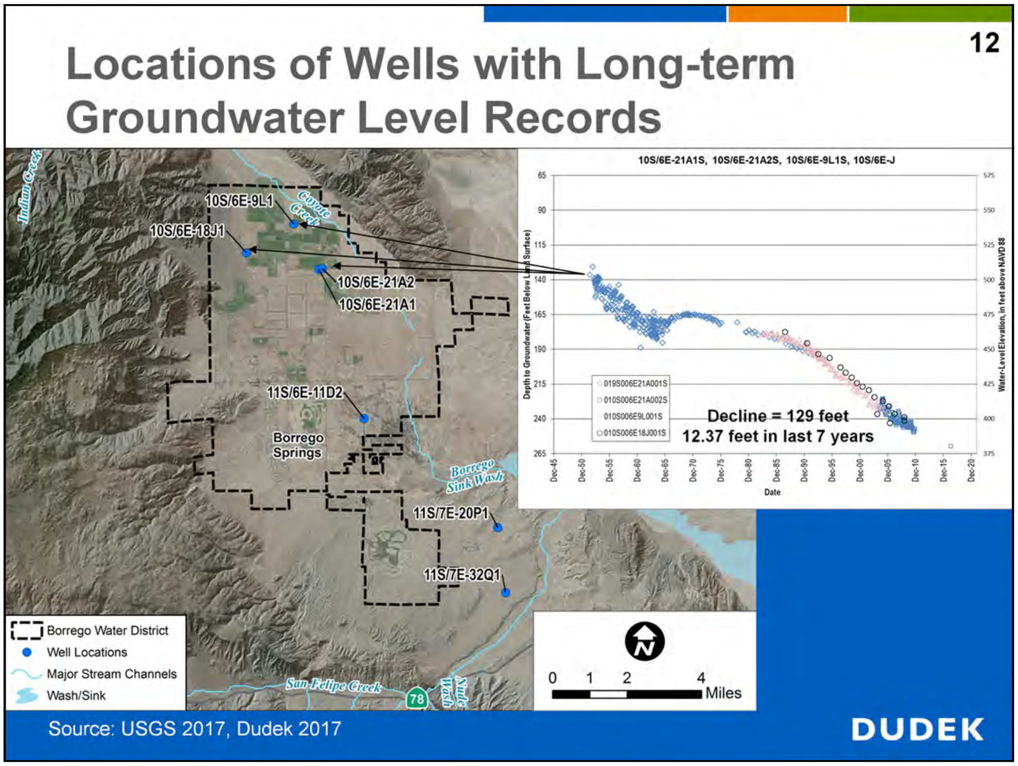
State Well ID: 11S/7E-32Q1 indicates groundwater elevations are stable at about 500 feet above NAVD 88 near San Felipe Creek over the period from 1950 until 2017.



State Well ID: 11S/7E-20P1 indicates groundwater elevations are also stable at about 500 feet above NAVD 88 near "Sleepy Hollow" area by the Borrego Air Ranch over the period from 1950 to 2017.

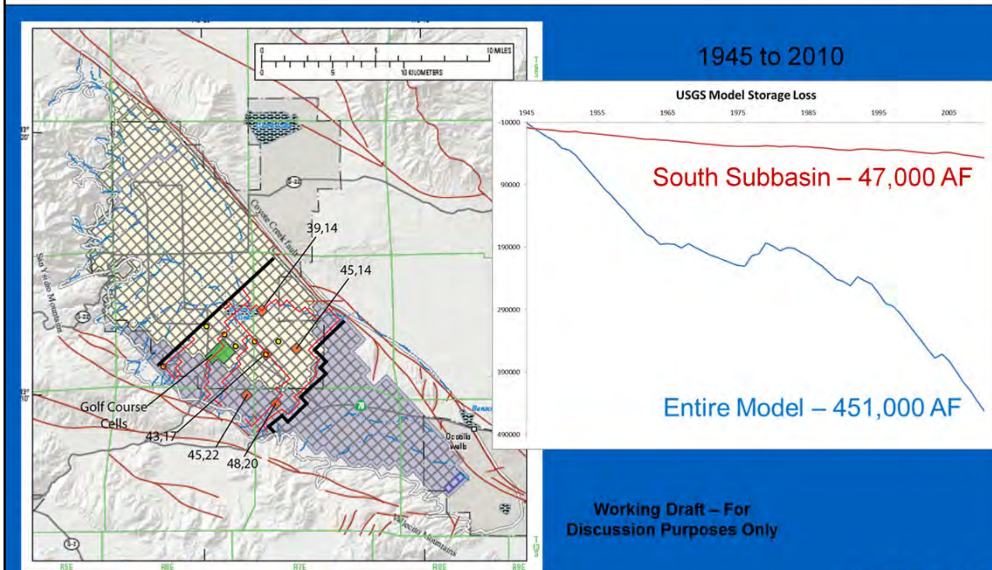


State Well ID: 11S/6E-11D2 indicates groundwater elevations have declined 66 feet over the period from 1950 to 2010 in the area northwest of the Borrego Sink.

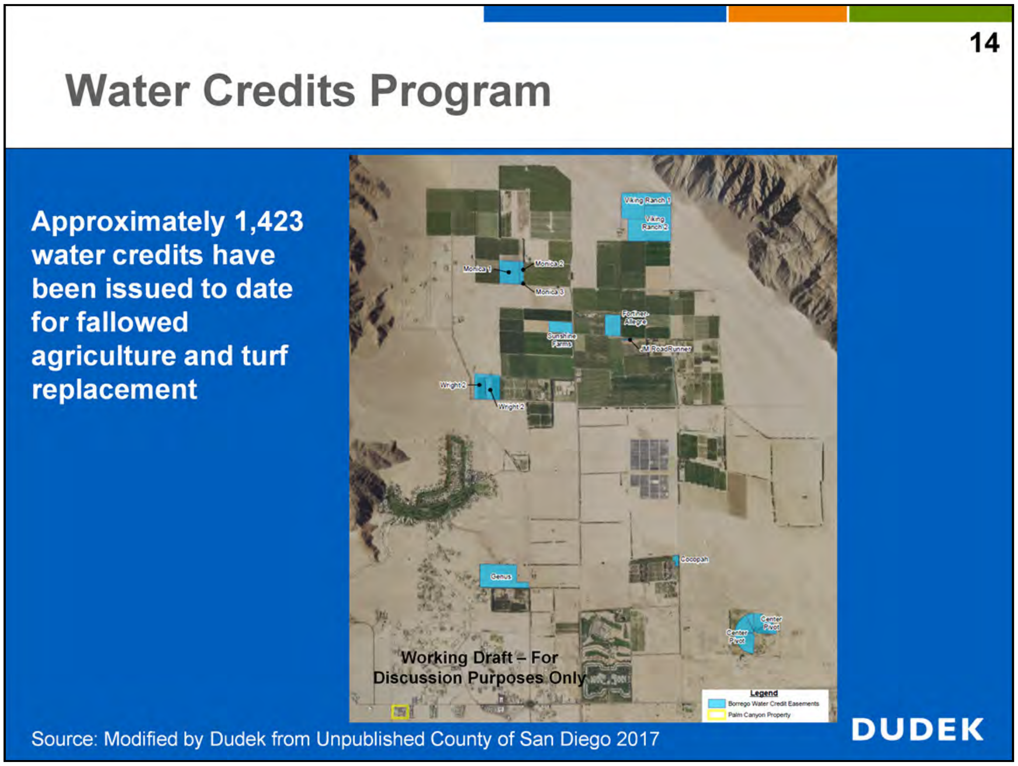


Wells 10S/6E-21A1 and 21A2, 10S/6E-9L1 and 10S/6E-18J1 indicate groundwater levels have declined 129 feet over the period from 1950 until 2017 in the northern portion of the Borrego Springs Subbasin where agricultural pumping is greatest. Over the last 7 years (2010 to 2017) the groundwater level in well 10S/6E-21A2 has declined 12.37 feet.

Groundwater Levels/Groundwater Storage



Based on the observed change in groundwater levels over time multiplied by the aquifer storage coefficients (volume of water released form storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer) an estimate of change in groundwater storage can be made. Based on these estimates, almost 500,000 acre-feet of water was removed from groundwater storage in the Borrego Springs Subbasin over the period from 1945 to 2010. Almost 90% of the groundwater storage loss has occurred in the North and Central portions of the Subbasin with about 10% of the groundwater storage loss occurring south of the Desert Lodge anticline.



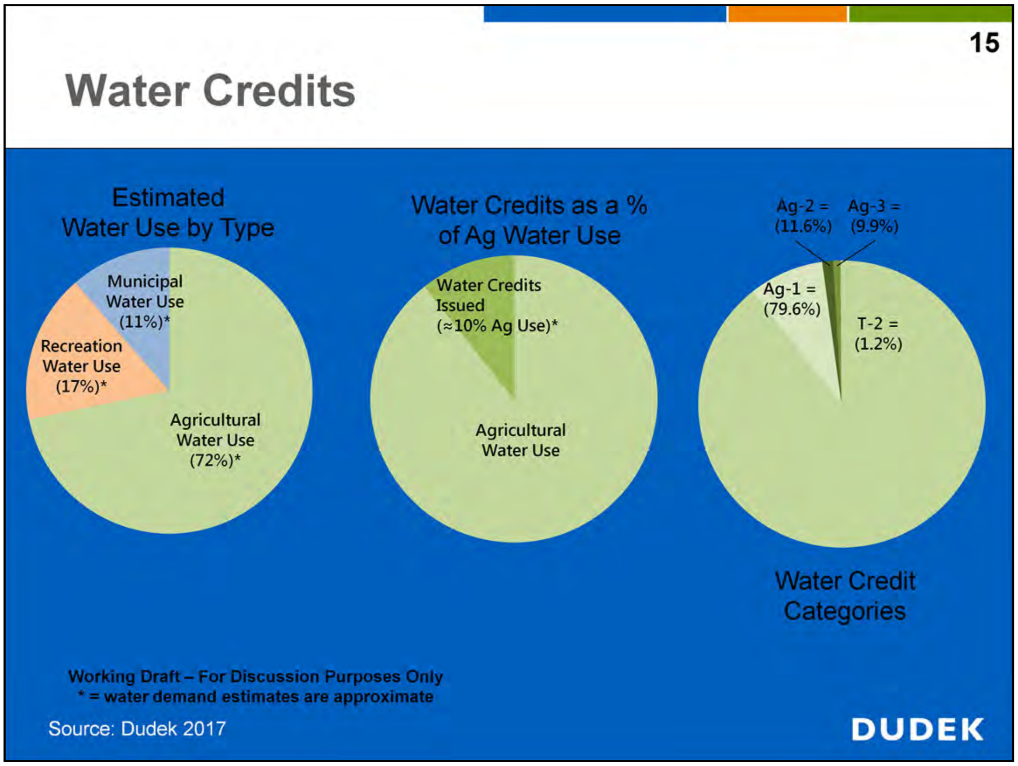
In order to address the overdraft condition of the Borrego Springs Subbasin, the Borrego Water District (BWD, District), in cooperation with the County of San Diego (County), developed and implemented a Demand Offset Mitigation Water Credit Policy (WCP).

The policies establish credit procedures for fallowing of agricultural land based on crop type and a defined watering intensity.

The current WCP for new development consists of two policies: one to satisfy the County New Subdivision Policy and one to satisfy the District WCP.

One water credit is defined as a one acre-foot per year and converts to the approximate water demand of a single equivalent dwelling unit (EDU) or single family residence.

For water credits that represent actual reductions in water use, should water credits be counted as part of the baseline water use under SGMA and production rights assigned to the water credits based on the required reduction requirements?



Water credits issued to date represent about 10% of current estimated agriculture water demand.

Credits were issued for different categories including:

Ag-1 – Land must have been actively farmed from January 1, 2008 to the present. Complete removal of crops. Easement must be approved by the County and the County must be included as a third party beneficiary (County credits).

Ag-2 – Land must have been actively farmed form January 1, 2008 to the present; includes complete removal of crops (BWD credits).

Ag-3 – Previously irrigated land that has been restricted to "Desert Landscape". Annual water usage reporting required.

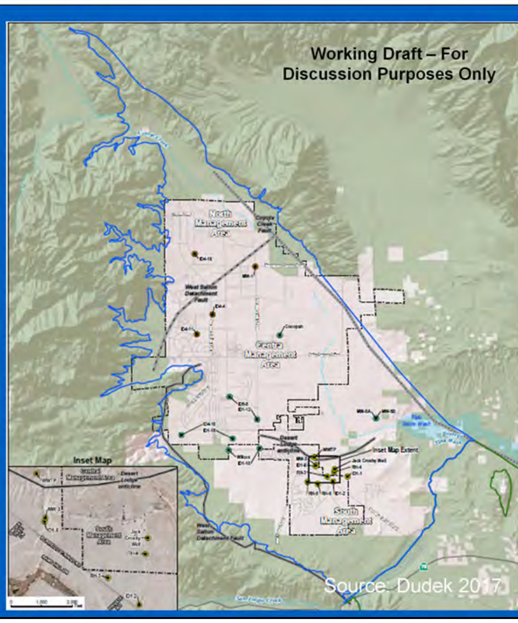
T-1 – Restrict current live turf irrigation; restricts all forms of irrigation.

T-2 – Restricts current live turf irrigation to "Desert Landscaping". Required to submit water usage reports based on flow meter records.

T-3 – Restricts live turf irrigation to a lower "quantifiable and verifiable lower water use landscape". Annual reporting of water usage required.

TK – The removal of tamarisk or other high water use windbreaks that are larger than one foot in diameter

Borrego Springs Subbasin



- Management Areas based on conceptual model of subbasin structure and upper, middle and lower aquifer units.
- BWD Indicator Wells
  - North Management Area
  - Central Management Area
  - South Management Area

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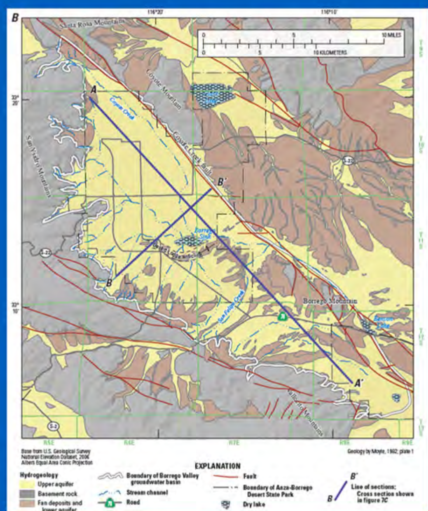
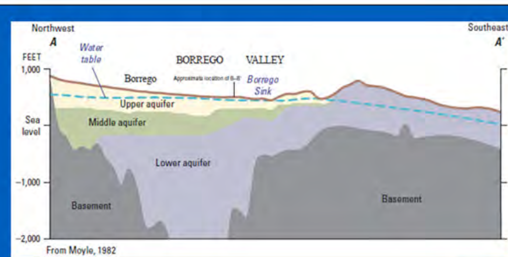
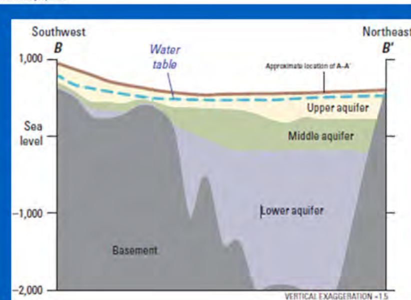
One approach to basin management is to subdivide the Borrego Springs Subbasin into three management areas based on structural features in the basin, the Desert Lodge anticline, and the West Salton Detachment Fault, which may partially compartmentalize a North Management Area, Central Management Area, and South Management Area.

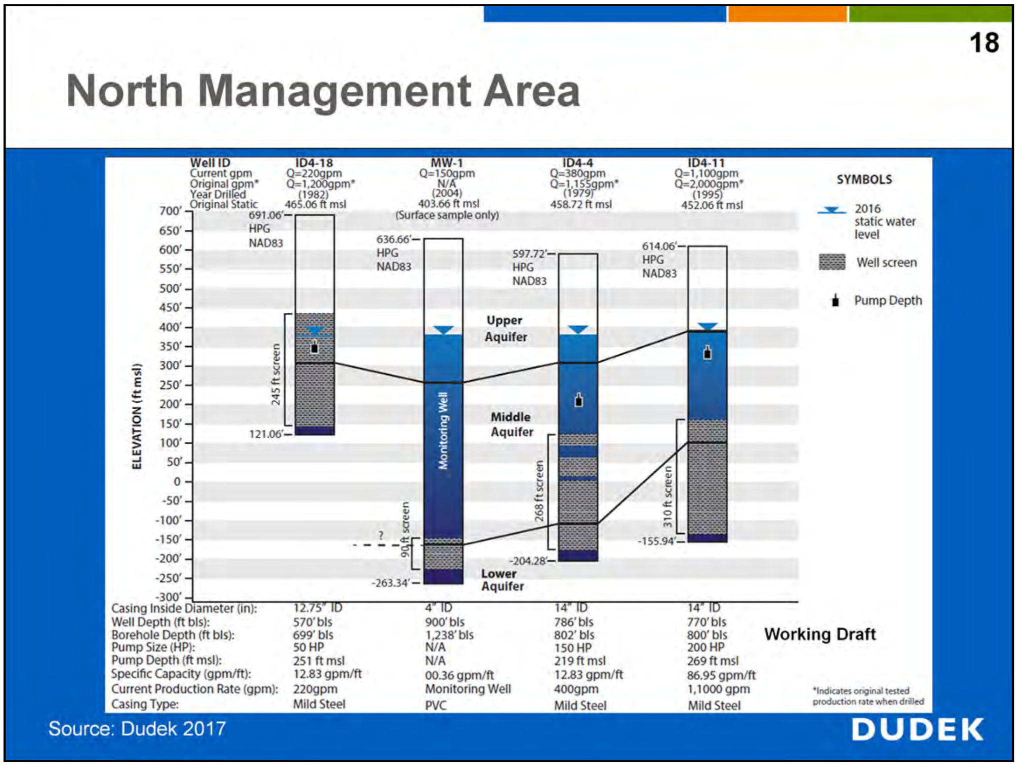
Basin Geometry





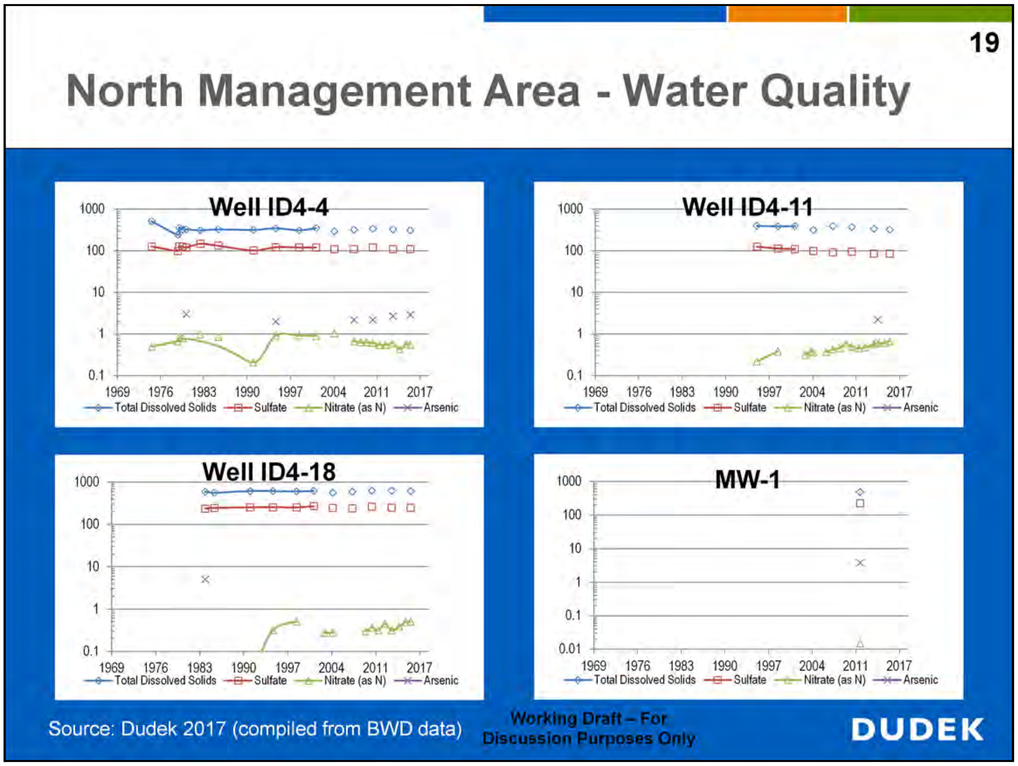


Source: Faunt 2015



For each management area, the District' s wells was have been catalogued. The USGS' interpretation of the upper, middle and lower aquifers from the numeric model have been plotted to show which aquifers each District well is screened. This allows for interpretation of wellhead groundwater quality results by aquifer.

North Management Area wells are predominantly screened in the middle aquifer but portions of wells ID4-4 and ID4-11 are screened in the lower aquifer and a portion of Well ID4-18 is screened in the upper aquifer. Better lateral and vertical coverage is required to monitor the North Management Area.

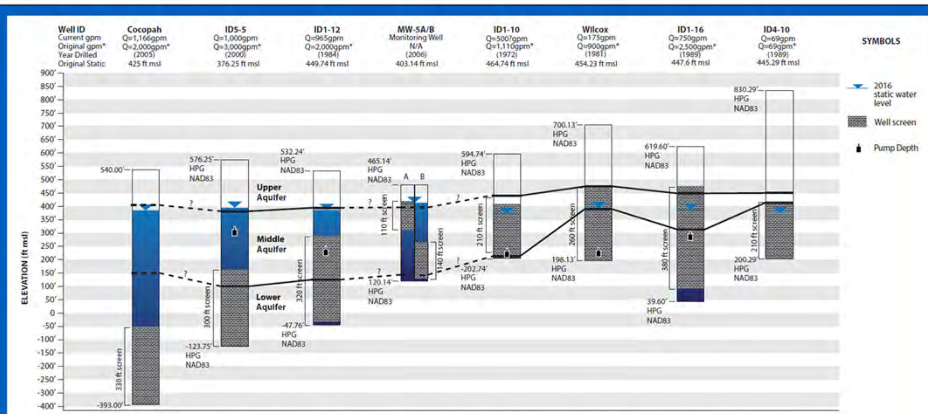


Arsenic concentrations for wells located in the North Management Area are predominantly less than half the MCL (< 5 µg/L) in both the middle and lower aquifers. No recent wellhead sample is available for the upper aquifer overlying the North Management Area. USGS identified five wells in the vicinity of Henderson Canyon Road adjacent to areas of agricultural use with three of the five wells were screened in the upper aquifer that exceed nitrate MCL.

All concentrations of the BWD wells are below one-half the California drinking water MCL for nitrate.

Additional indicator wells are needed in the North Management Area to better monitor water quality both laterally and vertically.

Central Management Area



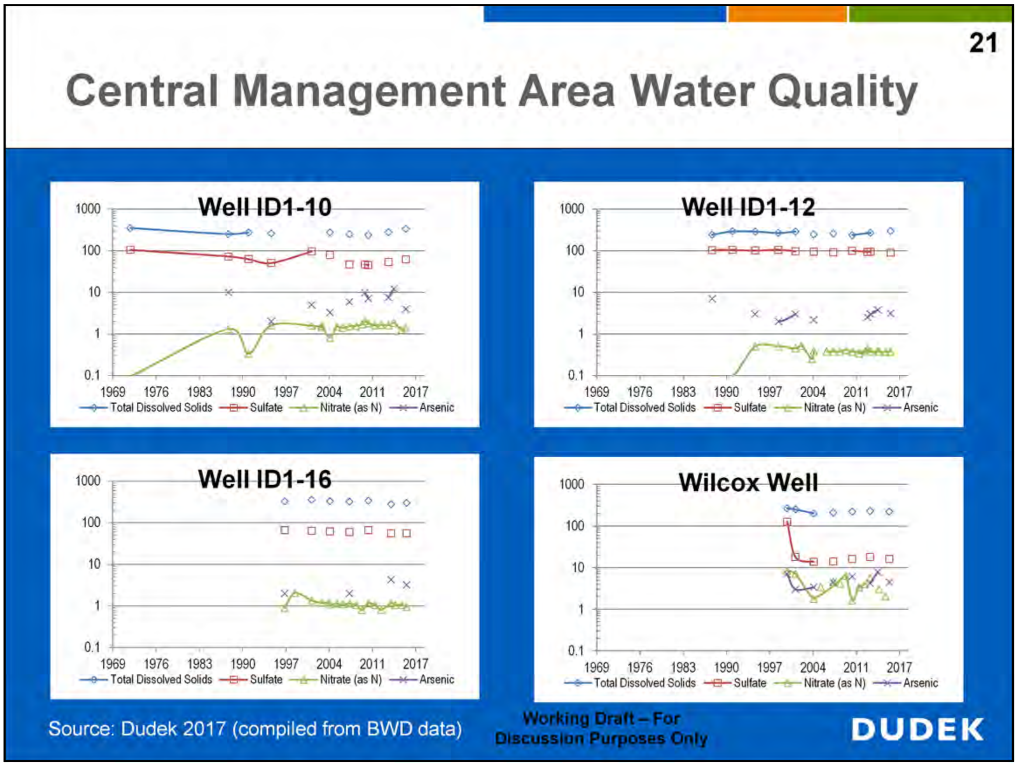
	Cocopah	ID5-5	ID1-12	MW-5A/B	ID1-10	Wilcox	ID1-16	ID4-10
Casing Inside Diameter (in):	14" ID	16" ID	14.75" ID	4" ID	12.75" ID	12.75" ID	16" ID	8" ID
Well Depth (ft bls):	570' bls	700' bls	580' bls	900' bls	392' bls	502' bls	550' bls	630' bls
Borehole Depth (ft bls):	699' bls	708' bls	726' bls (2004)	1,238' bls (2004)	816' bls	502' bls	705' bls	630' bls
Pump Size (HP):	160 HP	200 HP	200 HP	N/A	150 HP	80 HP	200 HP	N/A
Pump Depth (ft msl):	N/A	316 ft msl	242 ft msl	N/A	204 ft msl	225 ft msl	219 ft msl	N/A
Specific Capacity (gpm/ft):	N/A	N/A	75.4 gpm/ft	N/A	20.3 gpm/ft	26.4 gpm/ft	31.0 gpm/ft	20 gpm/ft
Current Production Rate (gpm):	1,166 gpm	1,000 gpm	965 gpm	Monitoring Well	500? gpm	350? gpm	723 gpm	N/A
Casing Type:	Mild Steel	Mild Steel	Mild Steel	Mild Steel	Mild Steel	Mild Steel	Mild Steel	Mild Steel
Drop Pipe:	N/A	10"	8"	N/A	8"	6"	8"	N/A

*Indicates original tested production rate when drilled.

Working Draft

Source: Dudek 2017

Central Management Area wells are predominantly cross-screened in the middle and lower aquifers. Well ID1-10 is screened solely in the middle aquifer. Cocopah Well and ID4-10 are solely screened in the lower aquifer.



Arsenic concentrations from 2016 for wells located in the Central Management Area were less than half the MCL (< 5 µg/L) for wells predominantly screened in the middle aquifer and less than the MCL (<10 µg/L) for wells predominantly screened in the lower aquifer. No recent wellhead sample is available for the upper aquifer overlying the Central Management Area.

Exceedance for arsenic noted in Well ID1-10 was a non-compliance sample collected for an academic study. Subsequent sampling indicated the wellhead concentration is 4 µg/L or less than half the MCL.

Concentrations in all wells are below one-half the California drinking water MCL (10 and N, 45 as NO3) for nitrate.

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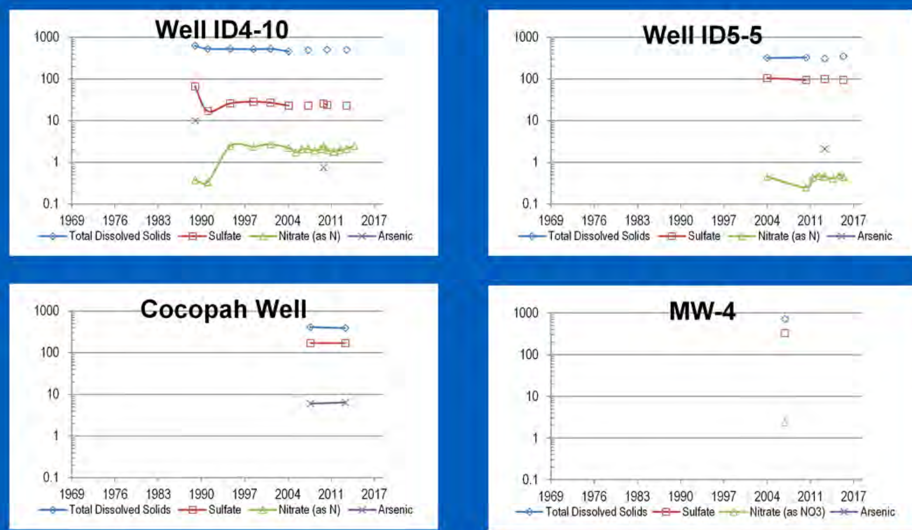
Central Management Area Water Quality



Source: Dudek 2017 (compiled from BWD data)

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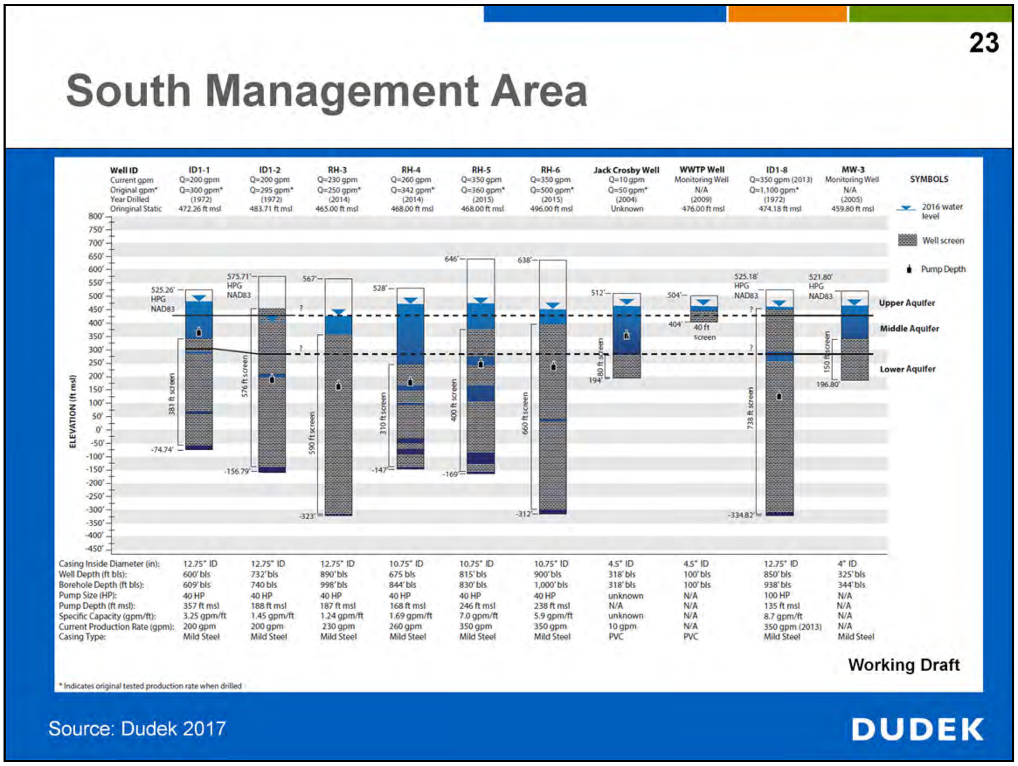
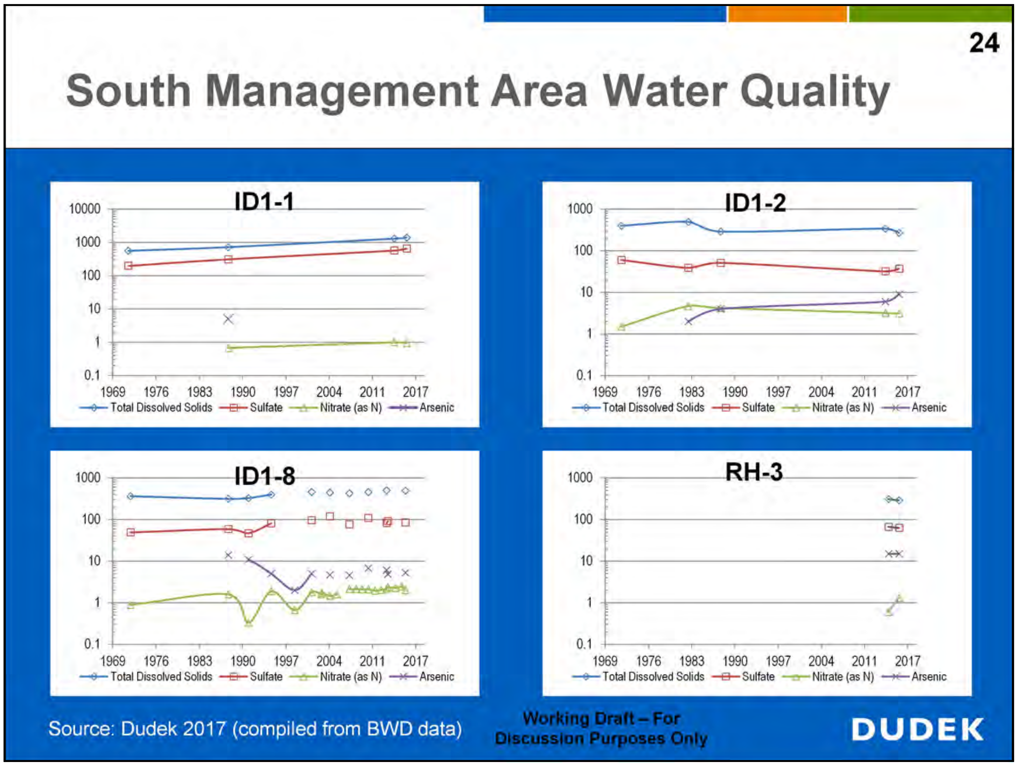
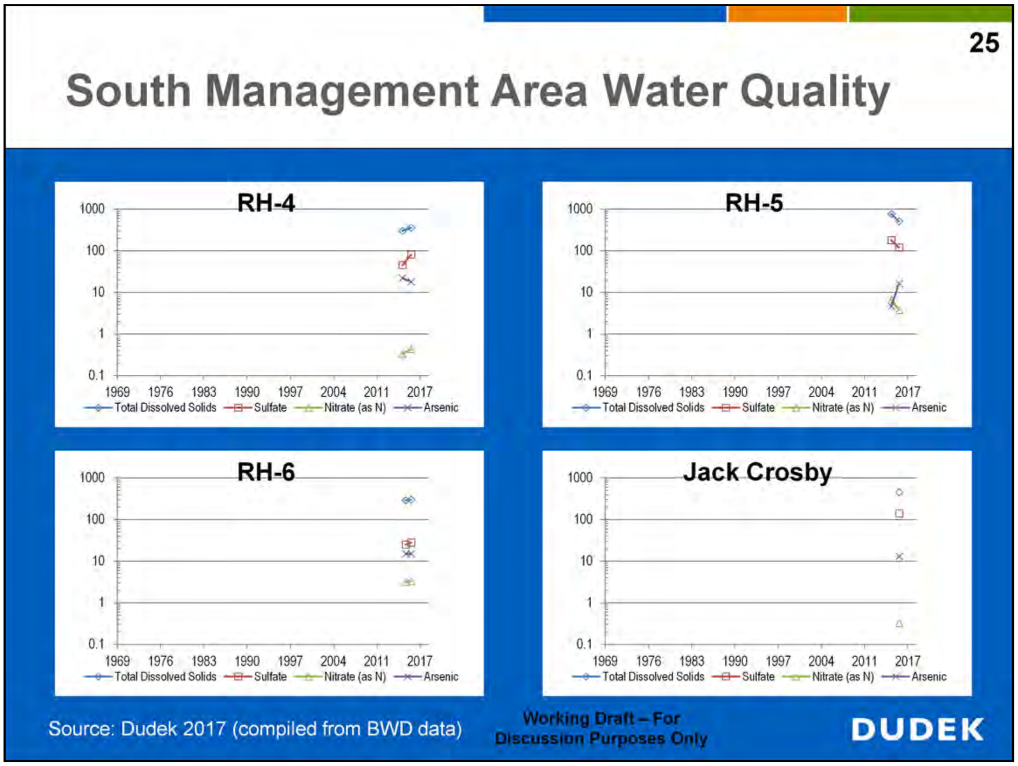
Cocopah Well and Well ID4-10 are screened solely in the lower aquifer. The arsenic concentration is Cocopah Well is about 6 µg/L. Arsenic is not detected in ID4-10 above the reporting limit.



Southern Management Area Wells are predominantly screened in the lower aquifer with cross-screening in the middle aquifer. Based on borehole geophysical logs the middle and lower aquifers are not well distinguished in the Southern Management Area. (The layering from the USGS numeric groundwater model was used to distinguish the middle form the lower aquifer for this analysis). The only well solely completed in the middle aquifer is WWTP Well, with no arsenic data available.



Most wells exceed the arsenic drinking water standard of 10 µg/L in the Southern Management Area. Exceptions are Wells ID1-1, ID1-2 and ID1-8.



Rams Hill Wells RH-3, RH-4, RH-5, RH-6 and Jack Crosby Well exceed the arsenic drinking water MCL of 10 µg/L. All new Rams Hill wells exceed the MCL when initially installed except RH-5, which increased in concentration form 4.6 µg/L to 16 µg/L over the first year of groundwater production.

Mann Kendal Trend Analysis

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Mann-Kendall Trend Analysis Results

Well ID	TDS	Sulfate	Arsenic	Nitrate	pH
North Management Area Wells					
ID4-4	No trend	Decreasing	No trend	No trend	No trend
ID4-11	No trend	Decreasing	Insufficient data	No trend	No trend
ID4-18	No trend	No trend	Insufficient data	No trend	No trend
MW-1	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Central Management Area Wells					
ID4-10	Decreasing	No trend	Insufficient data	No trend	No trend
Wilcox	No trend	No trend	No trend	Decreasing	No trend
ID1-10	No trend	No trend	No trend	No trend	No trend
ID1-12	No trend	Decreasing	No trend	No trend	No trend
ID1-16	No trend	Decreasing	No trend	No trend	No trend
ID5-5	No trend	No trend	Insufficient data	No trend	No trend
Cocopah	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
MW-4	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
South Management Area Wells					
ID1-1	**Increasing**	**Increasing**	Insufficient Data	Insufficient Data	Decreasing
ID1-2	No trend	No trend	**Increasing**	No trend	No trend
ID1-8	**Increasing**	**Increasing**	No trend	No trend[1]	No trend
RH-3	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
RH-4	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
RH-5	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
RH-6	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
Jack Crosby	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data
WWTP-1	Insufficient data	Insufficient data	Insufficient data	Insufficient data	Insufficient data

Notes: A minimum of 4 data points are required to calculate trend (non-detects were not used as data points in this analysis to calculate trend).
[1] An increasing nitrate trend is observed in Well ID1-8 if the 2016 water quality result is ignored.

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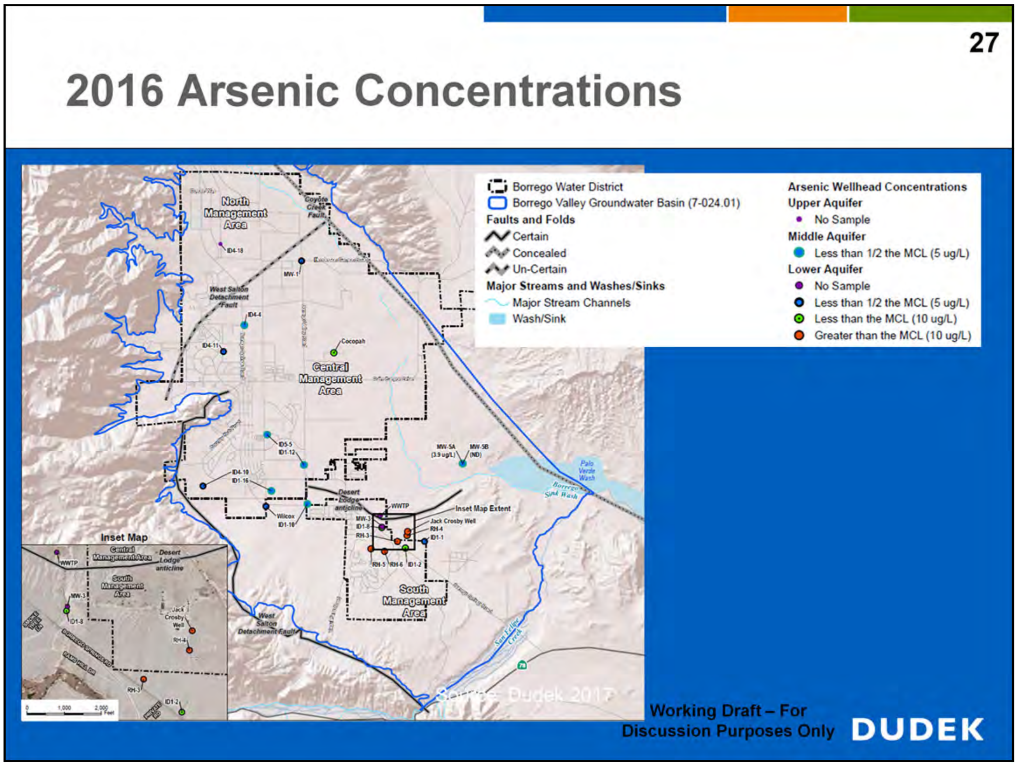
The Mann-Kendall test was applied to assess trends in groundwater quality. The Mann-Kendall test does not require regularly spaced sample intervals, is unaffected by missing time periods, and does not assume a pre-determined data distribution. The Mann-Kendall test assesses whether or not a dataset exhibits a trend within a selected significance level.

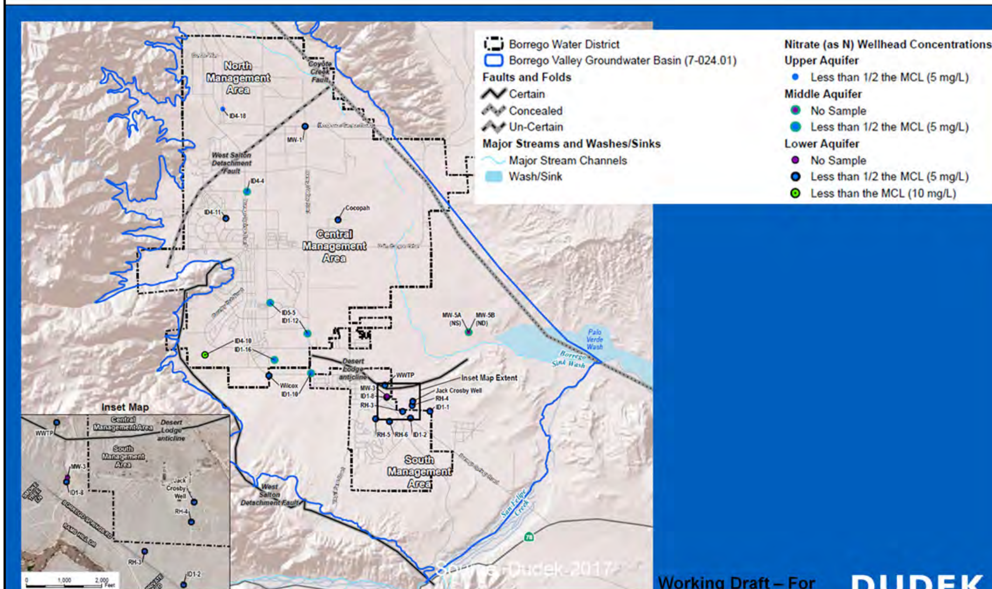
Increasing groundwater concentration trends were exhibited for TDS in wells ID1-1 and ID1-8, sulfate in wells ID1-1 and ID1-8, arsenic in well ID1-2, and nitrate in well ID1-8, if the latest water quality result is ignored in that well.

Insufficient data is noted for several wells and constituents.



Arsenic drinking water exceedance above the MCL of 10 micro-grams per liter noted for most wells located in the Southern Management Area.

2016 Nitrate Concentrations



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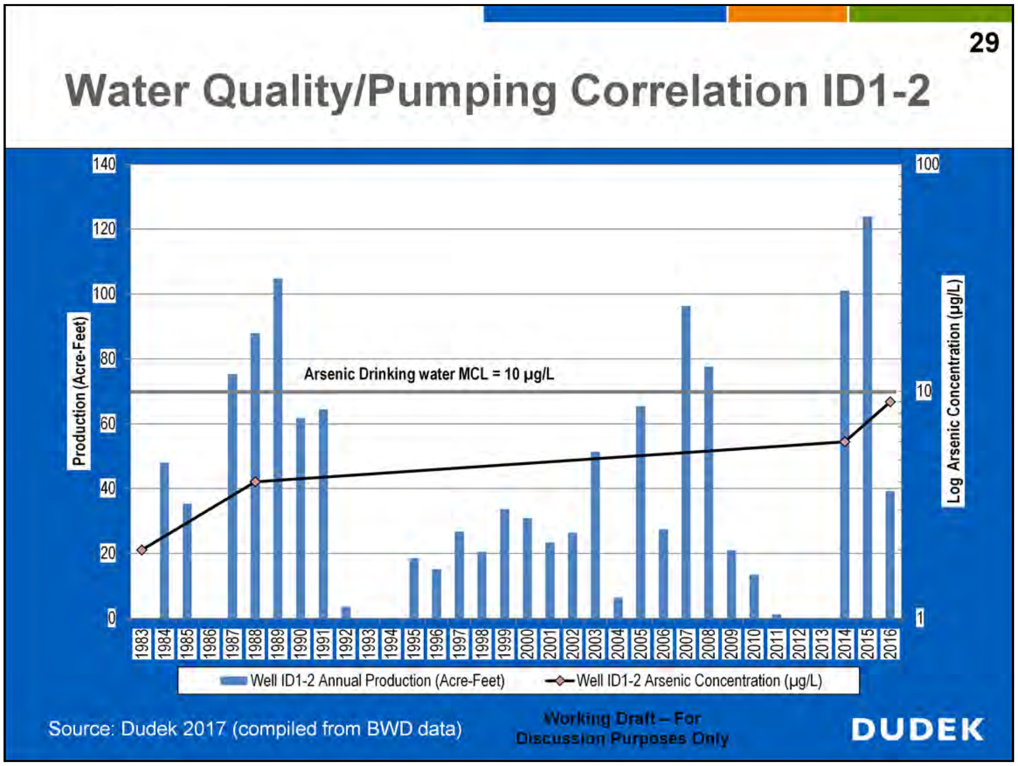
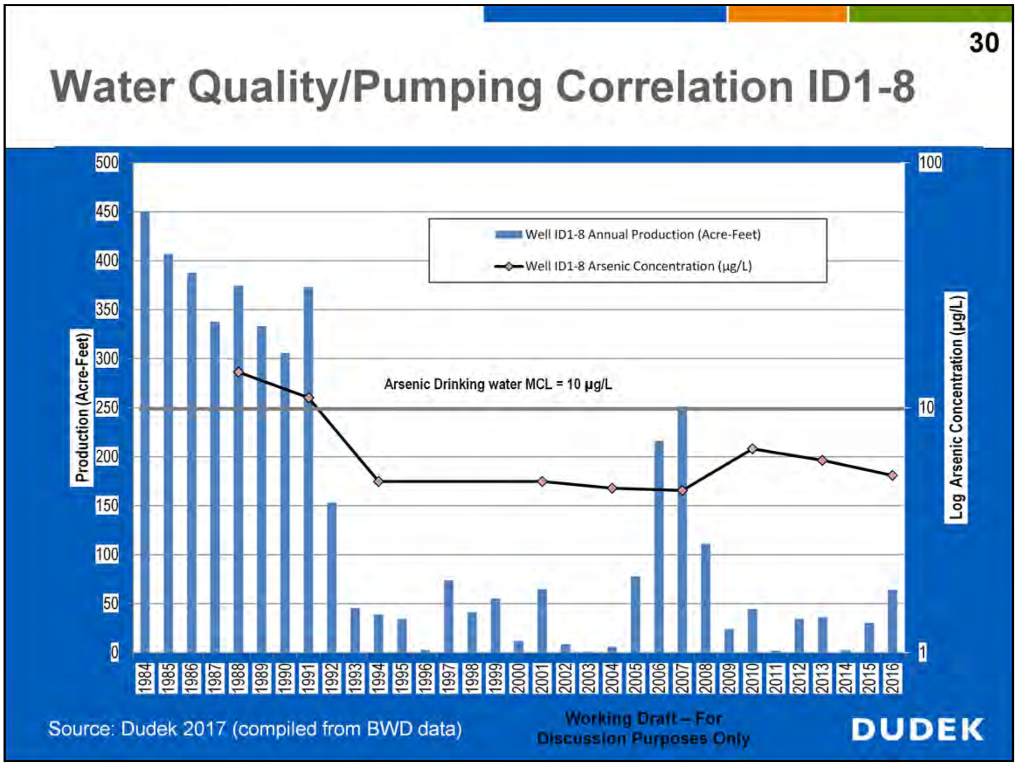
Nitrate is below the drinking water standard of 10 mg/L as nitrogen in all District wells and typically less than ½ the MCL.



As indicated by the Mann-Kendall trend analysis, arsenic concentrations in Well ID1-2 has an increasing trend. Annual groundwater production at Well ID1-2 was compared with available arsenic concentration data.

A linear regression analysis of the dependent variable, arsenic concentration, was plotted versus the independent variable, annual groundwater production, for Well ID1-2. The fit for the Well ID1-2 linear regression was poor (R square value = 0.03). Sufficient groundwater level data is not available over the period of record to determine if there is a correlation between arsenic concentration and groundwater levels. Additional arsenic concentration, production and groundwater level data is required to make any further correlation of the data for Well ID1-2.



Annual groundwater production at Well ID1-8 was compared with available arsenic concentration data. Historical data indicates exceedance of the ***current*** arsenic drinking water MCL of 10 µg/L during a period of greater groundwater production in the 1980's and early 1990's. Based on the resumption of increased pumping in 2007, there appears to be about a 2-year lag of pumping versus observed increased arsenic concentrations. It should be emphasized that this analysis is performed using the limited available water quality data.

As there appears to be about a 2-year lag in increased arsenic concentration versus pumping, a linear regression was performed by forcing the data with a 2-year correction. A linear regression analysis of the dependent variable, arsenic concentration was plotted versus the independent variable, annual groundwater production with a 2-year lag applied for Well ID1-8 (Figure above). The fit for the Well ID1-8 linear regression 2-year lag was best (R square value = 0.83).

That is 83% of the arsenic variation is explained by independent variable annual groundwater production and there is only a .03% chance result occurred as result of chance.

Projects and Management Actions

Cost Rank	Action Description	Net AFY Overdraft Reduction	Million $ cost	$/AF (20 years)	$/AFY
1	Manage tamarisk	350	$0.56	$116.26	$1,600.00
2	Retire old citrus, 50% of citrus acres, $10k per acre	5,183	$13.13	$184.07	$2,533.28
3	Replace 85 acres golf irrigated turf with native landscaping	478	$1.53	$232.58	$3,200.84
4	Retire mid-aged citrus, 25 % of citrus acres, $14k per acre	2,591	$8.91	$249.87	$3,438.83
5	Retire 70% of all citrus acres (GSP)	7,670	$27.61	$261.58	$3,600.00
6	Replace 90 acres golf irrigated non-turf area with native landscaping	386	$1.62	$304.95	$4,196.89
7	Retire 75% of palm acreage, $15k per acre	2,147	$10.36	$350.61	$4,825.34
8	Reduce municipal irrigated landscape area	317	$2.70	$618.88	$8,517.35
9	Reduce HOA landscaping	66	$0.56	$616.51	$8,484.85
10	Maximize citrus irrigation efficiency	264	$2.52	$693.58	$9,545.45
11	Stop golf winter over-seeding on 300 acres	154	$1.54	$726.61	$10,000.00

Source: Mann 2014, Dudek 2016

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In 2014, Dr. Roger Mann established the costs of water sustainability alternatives in BVGB. These include improving irrigation efficiency, converting landscaping to native coverage, storm water management, and fallowing of citrus acreage.

The projects are ranked based on lowest water savings cost per acre-foot per year in column 1.

The estimated maximum net amount of water savings for each action item is listed in column 3.

The total project cost for the maximum water savings is listed in column 4.

The present value of water per acre-foot is calculated in column 5 using a discount rate of 4.34% over 20 years.

The cost per acre-foot reduction is listed in column 6.

Projects and Management Actions

Cost Rank	Action Description	Net AFY Overdraft Reduction	Million $ cost	$/AF (20 years)	$/AFY
12	Percolation ponds and wastewater recovery wells below sewer evaporation ponds	50	$0.60	$871.93	$12,000.00
13	Golf irrigation system management (physical and operational)	41	$0.51	$903.83	$12,439.02
14	Irrigation efficiency on remaining palm, potato and nursery	101	$1.40	$1,007.18	$13,861.39
15	De Anza Country Club storm water project, 24 acres	154	$2.21	$1,042.73	$14,350.65
16	Rehabilitate golf irrigation systems on remaining acres	304	$5.76	$1,376.73	$18,947.37
17	Retire 75% of potato acreage, $15k per acre	512	$10.54	$1,495.79	$20,585.94
18	Improve HOA irrigation efficiency	26	$0.78	$2,179.82	$30,000.00
19	Municipal landscape audits	127	$3.80	$2,174.10	$29,921.26
20	Viking Ranch storm water project, 150 acres	300	$10.32	$2,499.53	$34,400.00

Source: Mann 2014, Dudek 2016

Working Draft – For Discussion Purposes Only

DUDEK