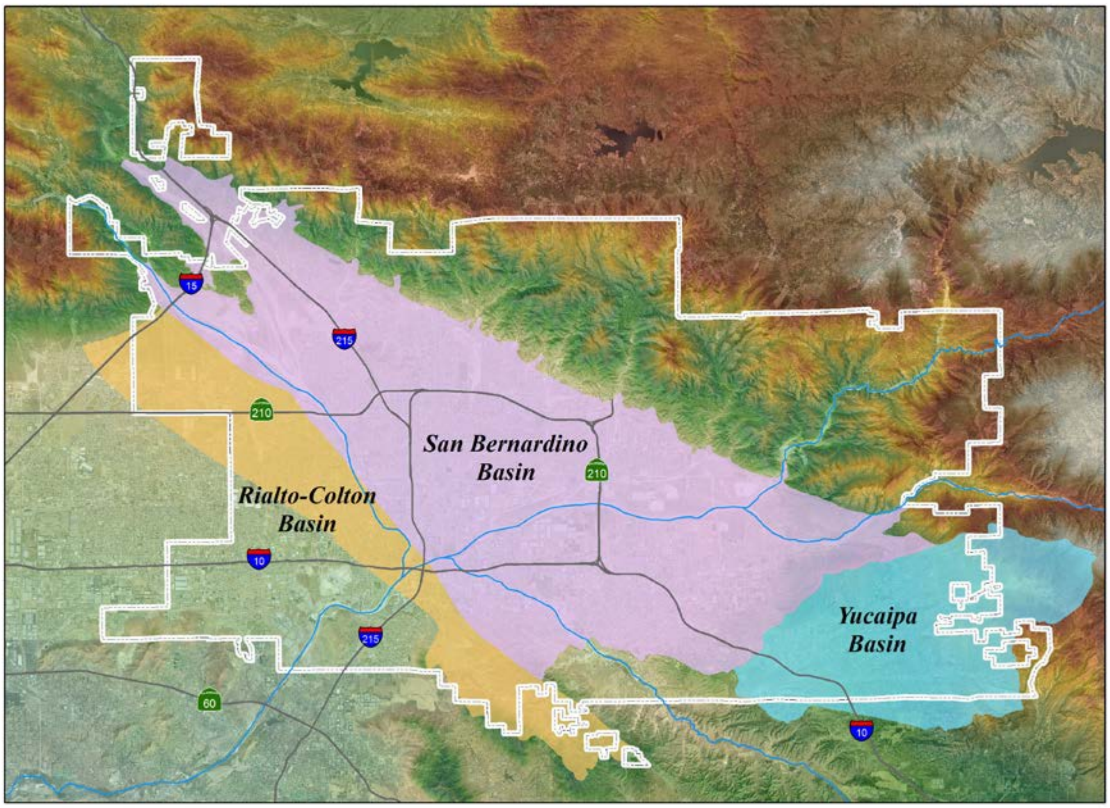
Change in Groundwater Storage for the San Bernardino Basin, Rialto-Colton And Yucaipa Basin Areas



July 2015

San Bernardino Valley Municipal Water District

Change in Groundwater Storage for the San Bernardino Basin Area And Yucaipa Basin Area

EXECUTIVE SUMMARY AND APPENDIX

July 2015

San Bernardino Valley Municipal Water District

Robert M. Tincher
Manager of Water Resources

Dan Borell
GIS Coordinator

ACKNOWLEDGMENT

Many public and private water agencies and various individuals have cooperated with the San Bernardino Valley Municipal Water District in furnishing the essential information upon which the Change in Storage Calculation is based.

Change in Groundwater Storage
For the San Bernardino Basin Area
And Yucaipa Basin Area
1934 – 2014

EXECUTIVE SUMMARY AND APPENDIX

Table of Contents

SUMMARY OF RESULTS

Background

The Change in Storage calculation provides an indicator, or "gauge", of current groundwater supplies and how they compare to past years. The San Bernardino Valley Municipal Water District (SBVMWD) has been calculating the change in groundwater storage for the San Bernardino Basin Area (SBBA) since 1970. The first calculation was completed for the years 1934 – 1960 by the State of California Department of Water Resources (DWR) and the results were summarized in Bulletin 104-5, Meeting Water Demands in the Bunker Hill-San Timoteo Area, Geology, Hydrology, and Operation-Economics Studies, Text and Plates (Olson, pp. 90 – 92). The DWR change in storage values were calculated using the Specific Yield Method (Olson, pp. 85 – 98) and a mathematical model developed by TRW, Incorporated, Redondo Beach, California (TRW). In 1980, SBVMWD updated the change in storage calculation to include the years 1961 – 1980 (Van Gelder). In the early 1990's, SBVMWD created a new change in storage model (SBVMWD Model) using software developed by Environmental Systems Research Institute (ESRI), Redlands, California. Like its predecessors, the SBVMWD Model calculates the change in groundwater storage (volume) using the Specific Yield Method which is based largely on the change in water level measurements and the soil porosity (for a detailed explanation of how the model works see **Appendix: SBVMWD Change in Storage Methodology**). In 2014, Valley District began calculating the change in storage for the Yucaipa Basin area for the Rialto-Colton basin beginning this year, 2015.

Calculation

SBVMWD calculates the cumulative change in groundwater storage (CCIS) by measuring the volume of water lost or gained as compared to the base year, 1934 which was selected to correspond with the first year of the DWR base period (Motokane, pp. 123 – 129). To provide consistency for the Rialto-Colton and Yucaipa areas, the same base year or its equivalent, 1993, was used. The annual change in storage (ACIS) is a measure of the volume of water lost or gained in the basin during the calendar year.

The wells used in the SBVMWD Model are shown on Figure 1 and the static water level data for these wells is illustrated on Figure 2. A comparison of current water levels to the first historic low water level/year is shown on Figure 3.

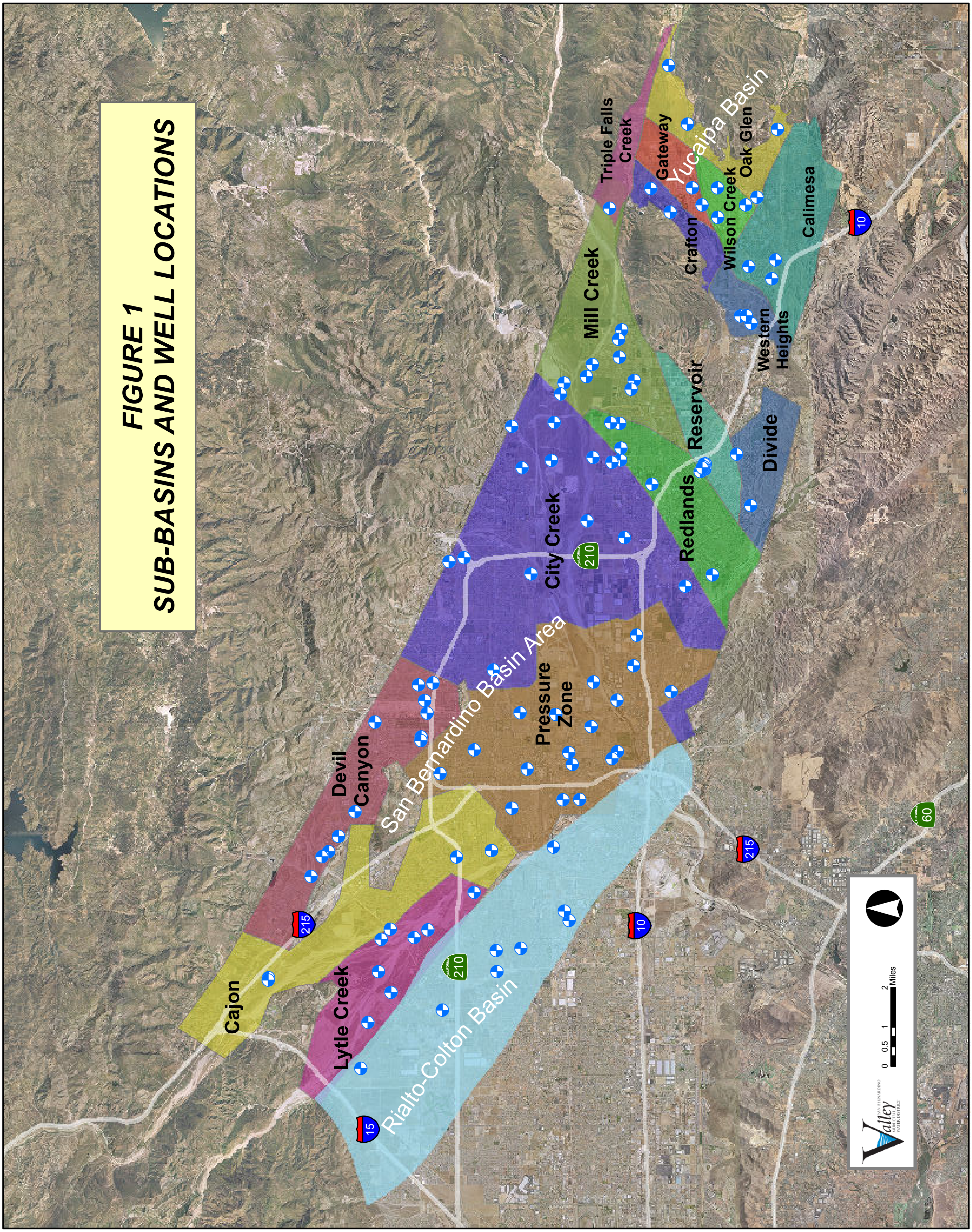


FIGURE 1
SUB-BASINS AND WELL LOCATIONS

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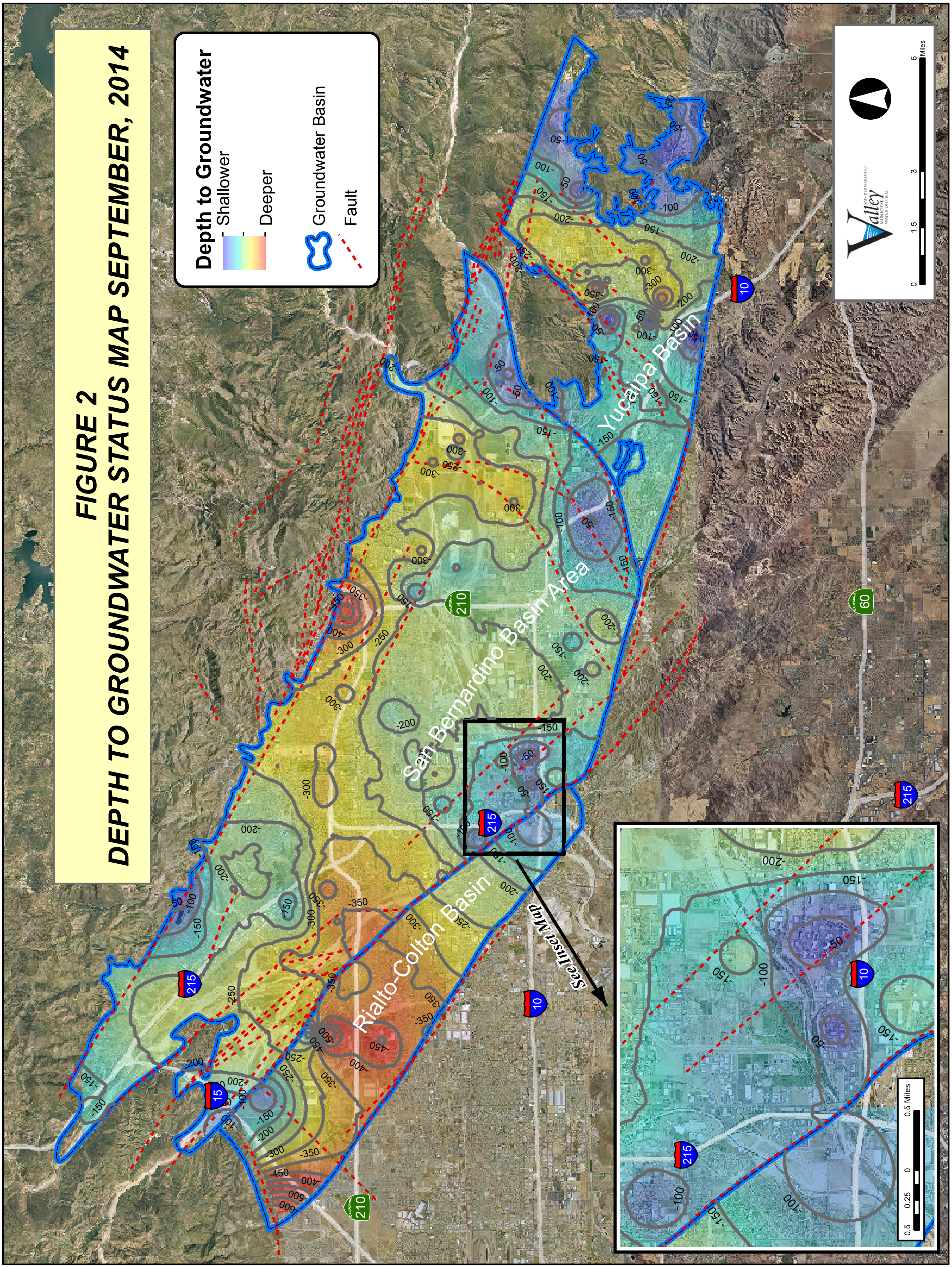

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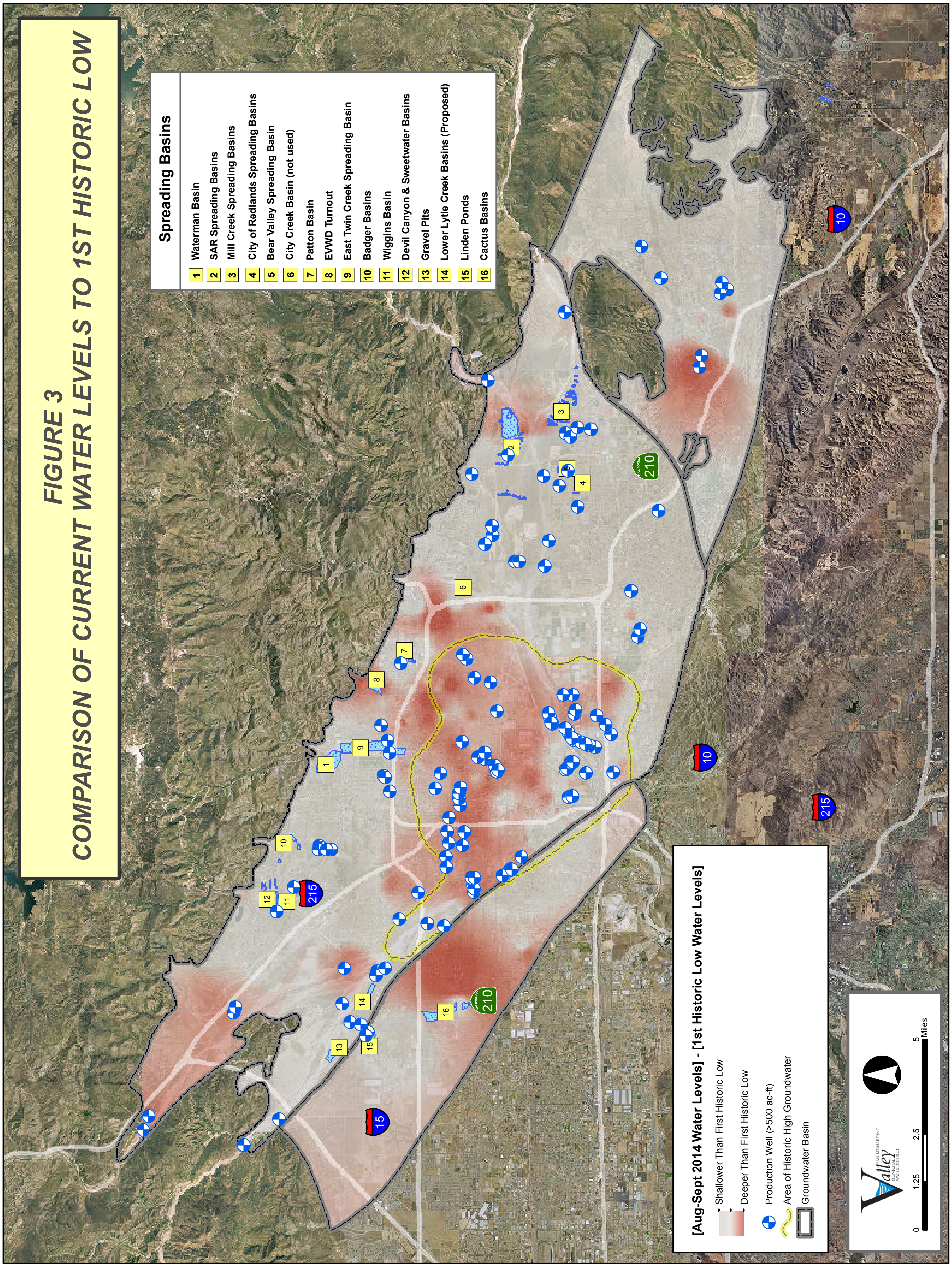


FIGURE 3
COMPARISON OF CURRENT WATER LEVELS TO 1ST HISTORIC LOW
Spreading Basins
1 Waterman Basin
2 SAR Spreading Basins
3 Mill Creek Spreading Basins
4 City of Redlands Spreading Basins
5 Bear Valley Spreading Basin
6 City Creek Basin (not used)
7 Patton Basin
8 EVWD Turnout
9 East Twin Creek Spreading Basin
10 Badger Basins
11 Wiggins Basin
12 Devil Canyon & Sweetwater Basins
13 Gravel Pits
14 Lower Lytle Creek Basins (Proposed)
15 Linden Ponds
16 Cactus Basins
[Aug-Sept 2014 Water Levels] - [1st Historic Low Water Levels]
Shallower Than First Historic Low
Deeper Than First Historic Low
Production Well (>500 ac-ft)
Area of Historic High Groundwater
Groundwater Basin
0 1.25 2.5 5 Miles
210
215
10
15
Document Path: Y:\1422ChangeInStorage\Figure3.mxd

In each basin area, the SBVMWD Model was calibrated using independent models. The below table summarizes the independent models used for calibration:

Table 1. Independent models used for calibration

Basin	Independent Models
Rialto Colton	USGS/Geoscience
San Bernardino	USGS/Geoscience, SBVWCD
Yucaipa	Geoscience

Although the independent models use slightly different data sets and, in some cases, use different methods, their results track well (Figures 4,5 and 6).

Figure 4. Comparison of SBVMWD and Geoscience Rialto-Colton Basin Cumulative Change In Storage Results

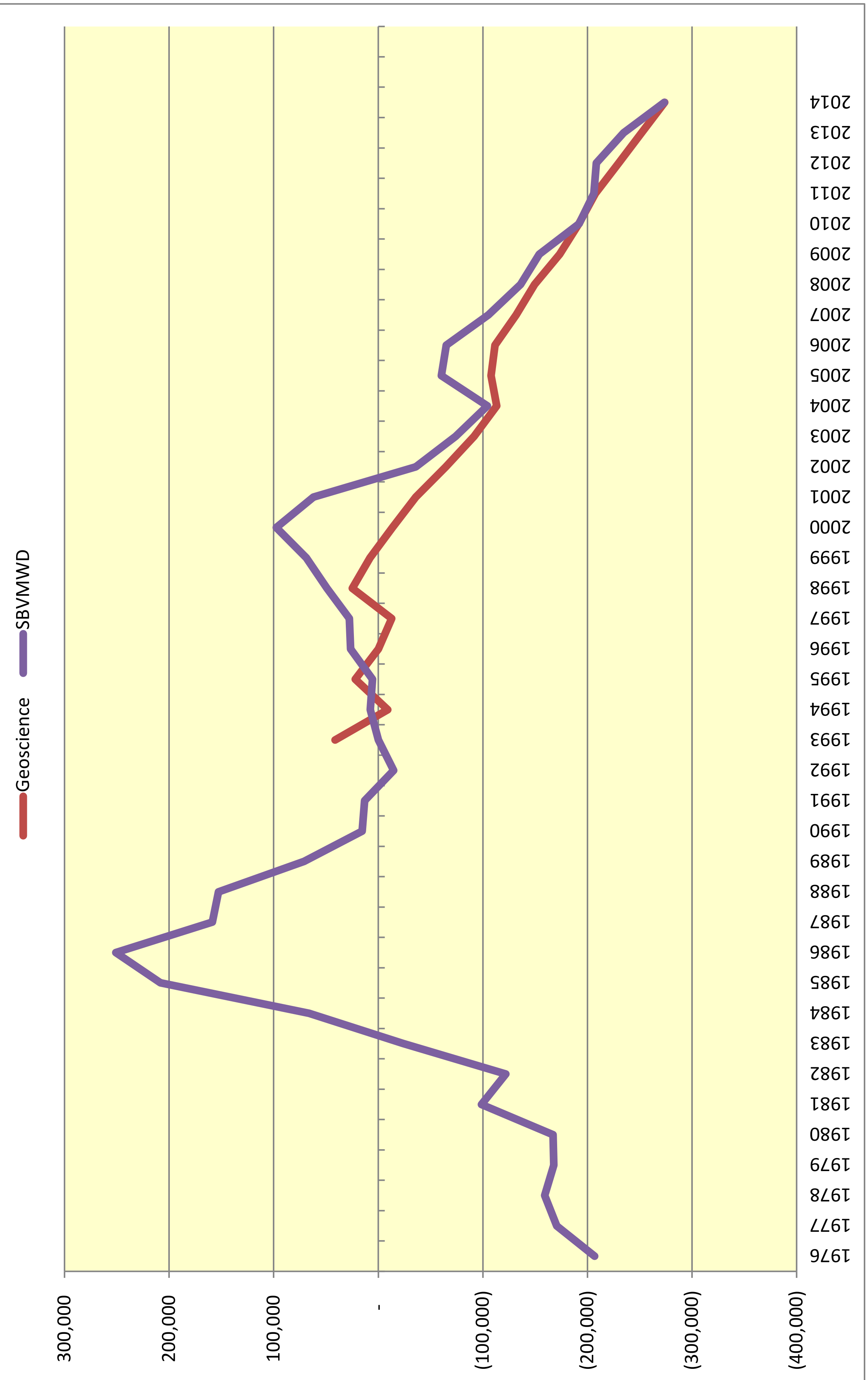


Figure 5 Comparison of DWR, SBVWCD, USGS and SBVMWD Cumulative Change in Storage Results

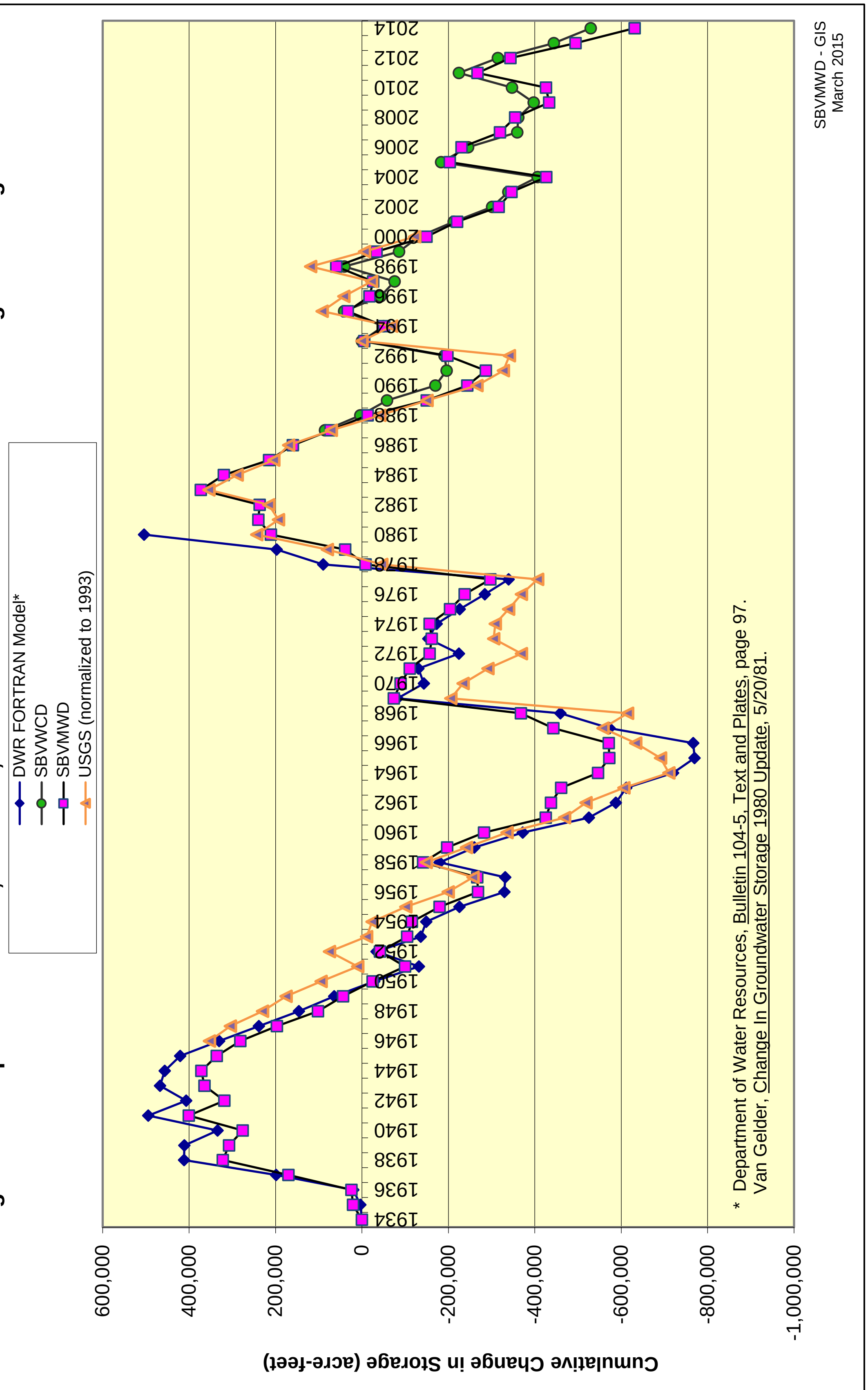
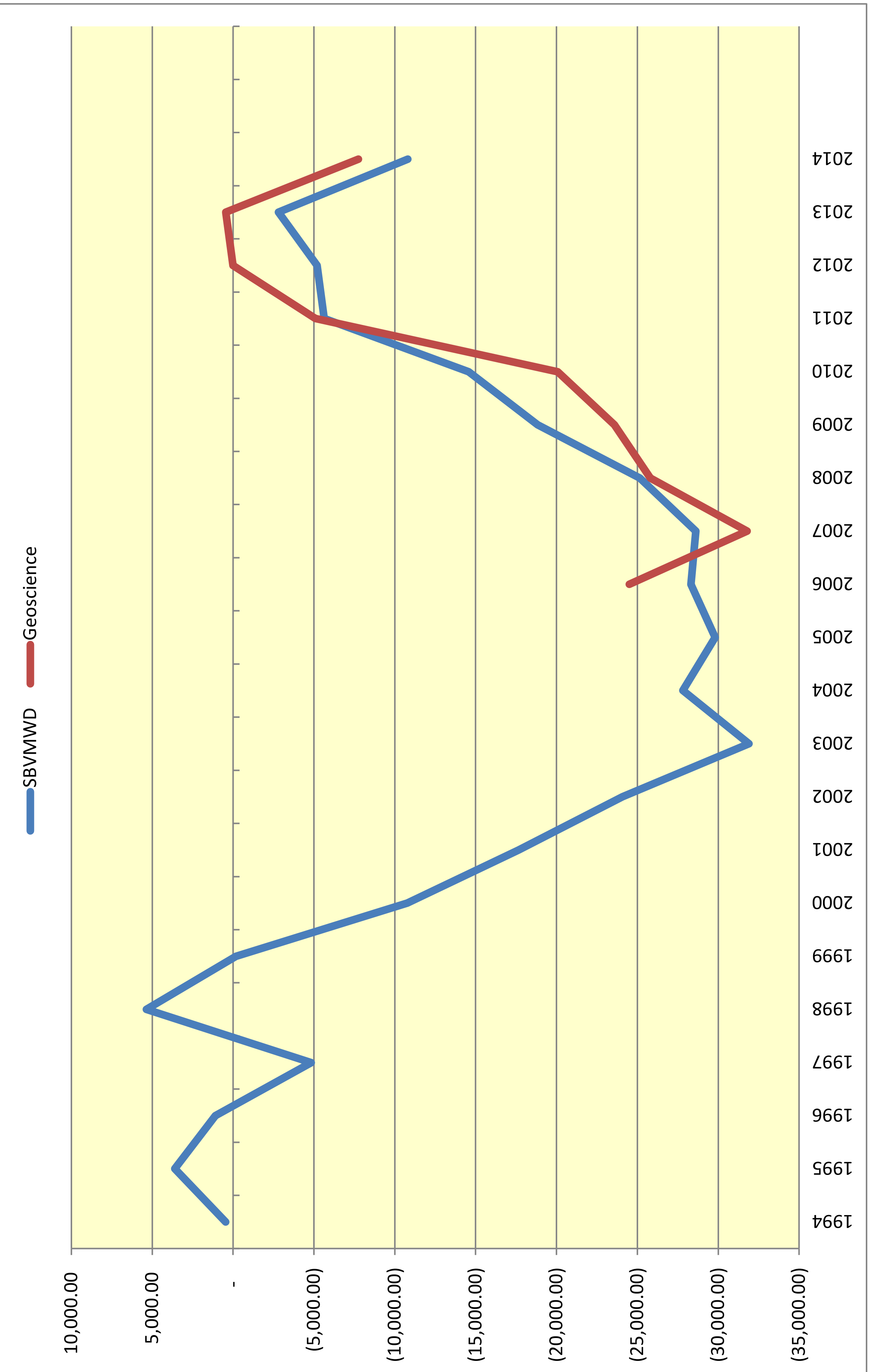


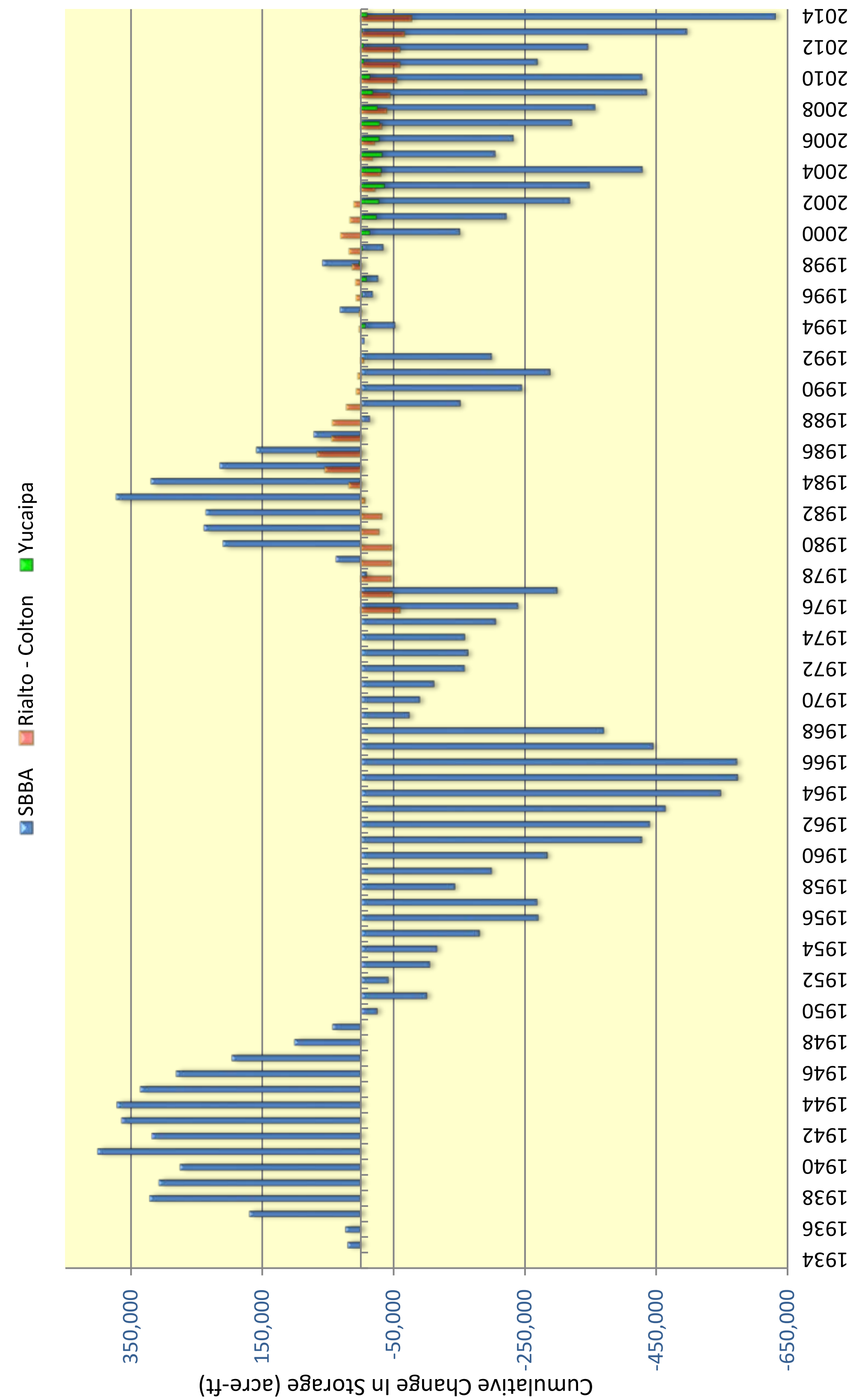
Figure 6. Comparison of SBVMWD and Geoscience Yucaipa Basin Cumulative Change In Storage Results



Summary of 2014 Results

The cumulative change in storage for both the Rialto-Colton Basin and the SBBA are at historic lows. These historic lows are largely due to the current drought conditions. The cumulative change in storage for the Yucaipa Basin is lower than last year but is still above the lowest value in the short period of record, starting in 1994. Yucaipa's storage levels are higher due to the in-lieu recharge associated with the large increase in imported water to the Yucaipa area beginning in 2005. The cumulative change in storage results for each basin are summarized on Figure 7.

Figure 7. Comparison of SBBA, Yucaipa and Rialto-Colton Basin Cumulative Change in Storage



The calculations in the SBBA and Yucaipa are performed for each individual sub-basin. The below pie charts illustrate the annual change in storage, by sub-basin.

Figure 8. Annual Change in Storage for the San Bernardino Basin Area, by sub-basin.

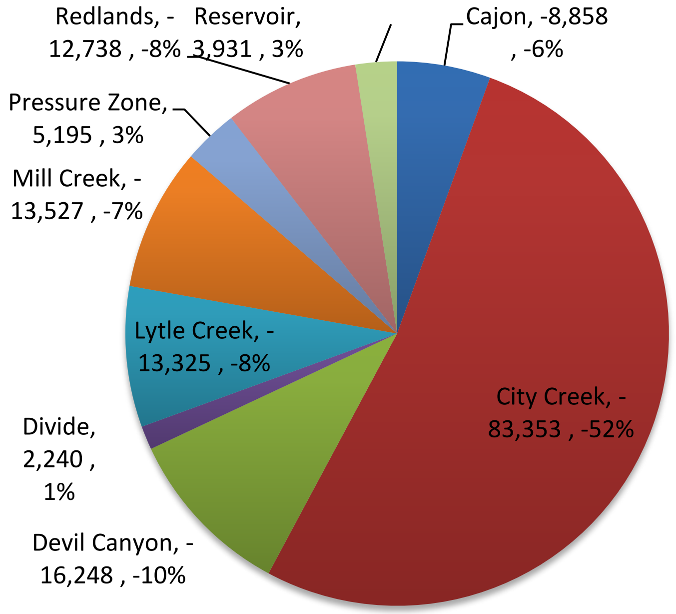
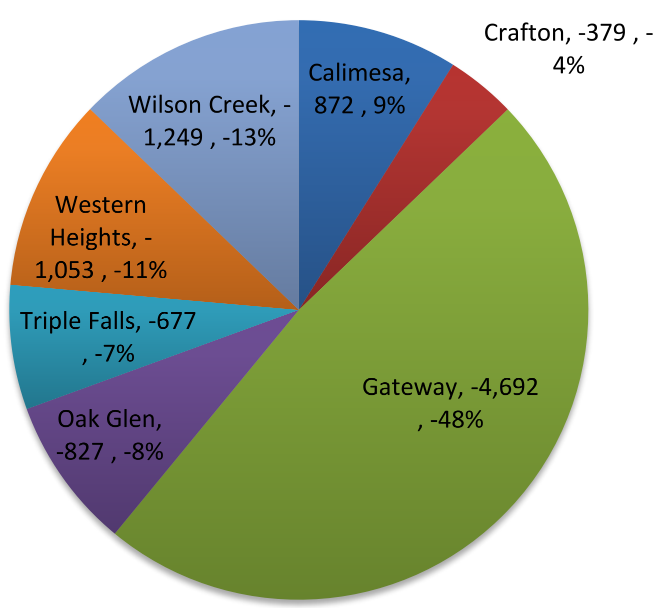


Figure 9. Annual Change in Storage for the Yucaipa Basin Area, by sub-basin.



2. Bibliography

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4) Motokane, Earl S., “Evaluation of the Base Period for the Bunker Hill-San Timoteo Area Investigation”. Meeting Water Demands in the Bunker Hill - San Timoteo Area, Geology, Hydrology, and Operation—Economics Studies, Text and Plates, February 1971, pp. 123 – 129.

5) Olson, L.J. and Stig J. Johanson, “Specific Yield and Storage Determination”. Meeting Water Demands in the Bunker Hill - San Timoteo Area, Geology, Hydrology, and Operation—Economics Studies, Text and Plates, February 1971.

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7) Southern California Earthquake Center (SCEC), University of Southern California. Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction Hazards in California, March 1999.

8) TRW, Incorporated. Simulation Program for Planned Utilization of the San Bernardino Valley and Riverside Ground Water Basins, Second Report, Report No. 07143-6001-R000, October 1967.

9) Utah Geological Survey web site (UGS):
http://geology.utah.gov/utahgeo/hazards/liquefy.htm

10) University of Washington (UW) web site:
http://www.ce.washington.edu/~liquefaction/html/what/what1.html

11) Van Gelder, Randy, Change in Groundwater Storage 1980 Update, May 20, 1981.

12) Western San Bernardino Watermaster (Watermaster), Annual Report of the Western-San Bernardino Watermaster for Calendar Year 1997, August 1, 2001.

APPENDIX

Change in Groundwater Storage for the San Bernardino Basin Area

Data Changes in the SBVMWD Change in Storage Model
Since April 2014 Report

Cajon Sub-Basin and Wells:
No Changes.

Devil Canyon Sub-Basin and Wells:
No Changes.

Lytle Creek Sub-Basin and Wells:
2014 data unavailable for 2 wells (FWC F34A, SBMWD Lytle Creek No.2)
Added WVWD Well 8A

Pressure Zone Sub-Basin and Wells:
2014 data unavailable for 1 well (USGS Backyard)

City Creek Sub-Basin and Wells:
2014 data unavailable for 2 wells (EVWD Plant 27, SBVWCD No. 1)
Added EVWD Plant 142

Redlands Sub-Basin and Wells:
No Changes

Mill Creek Sub-Basin and Wells:
No Changes.

Reservoir Sub-Basin and Wells:
No Changes.

Divide Sub-Basin and Wells:
No Changes.

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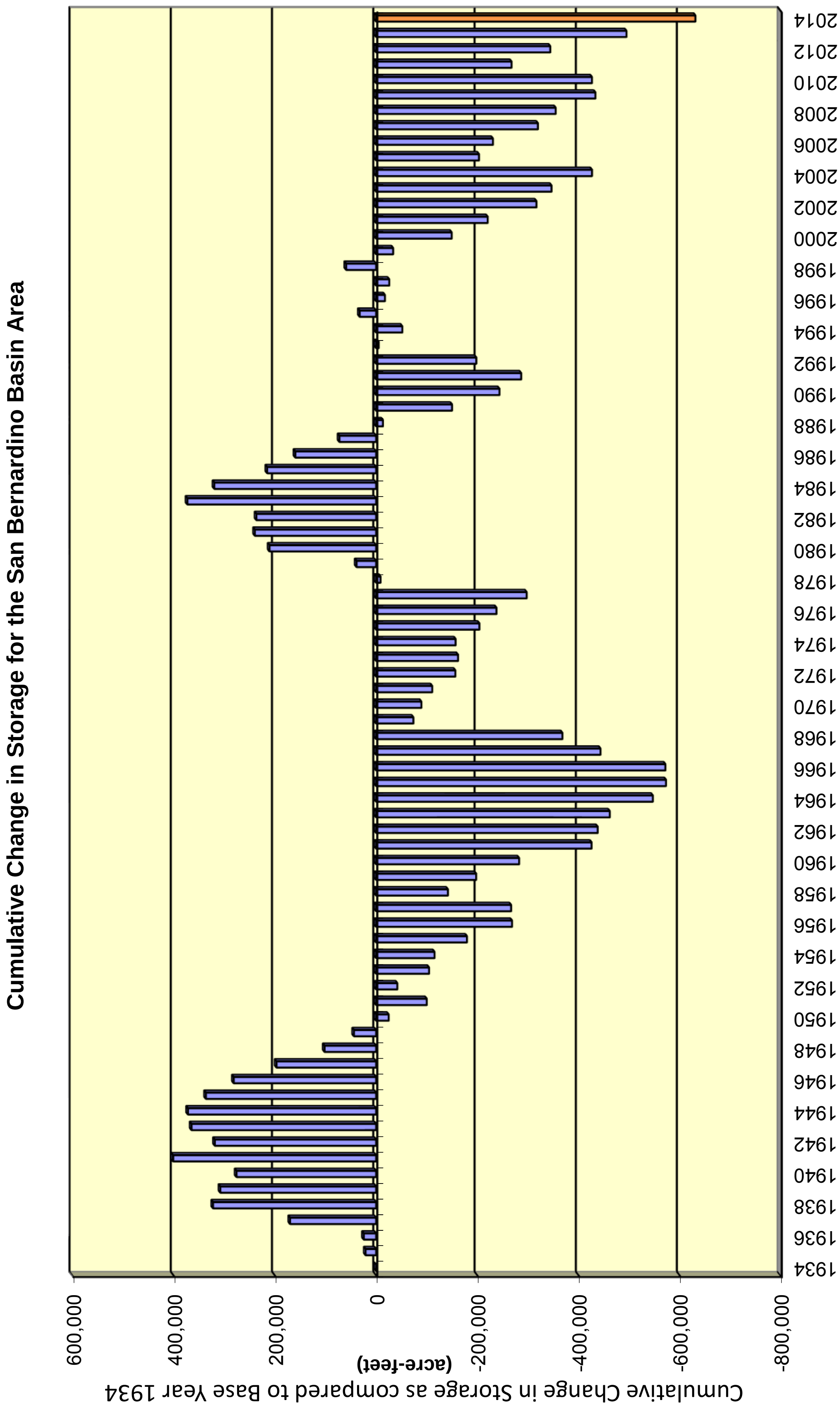
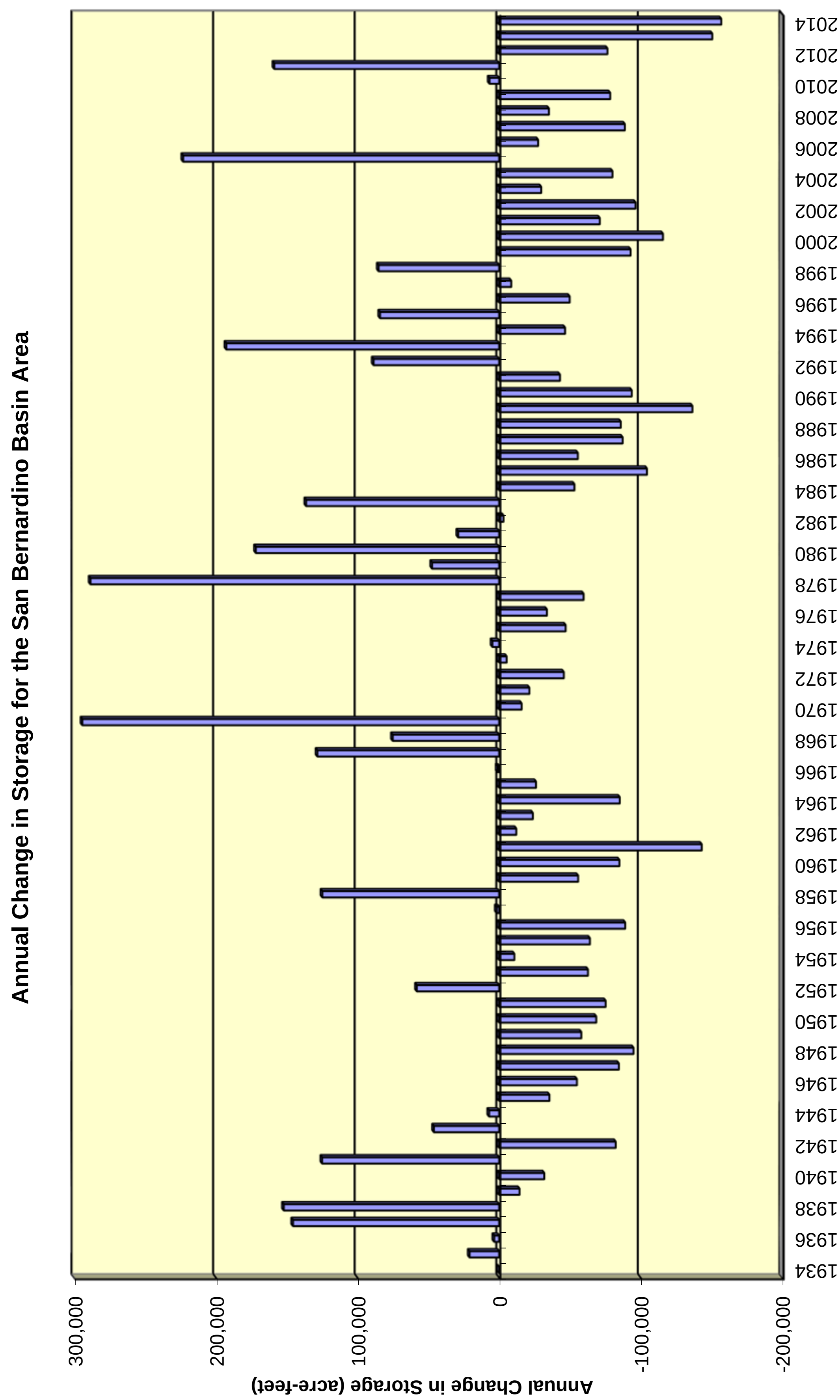

Cumulative Change in Storage for the San Bernardino Basin Area
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
600,000
400,000
200,000
0
-200,000
-400,000
-600,000
-800,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014



Annual Change in Storage for the San Bernardino Basin Area
Annual Change in Storage (acre-feet)
300,000
200,000
100,000
0
-100,000
-200,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

San Bernardino Valley Municipal Water District

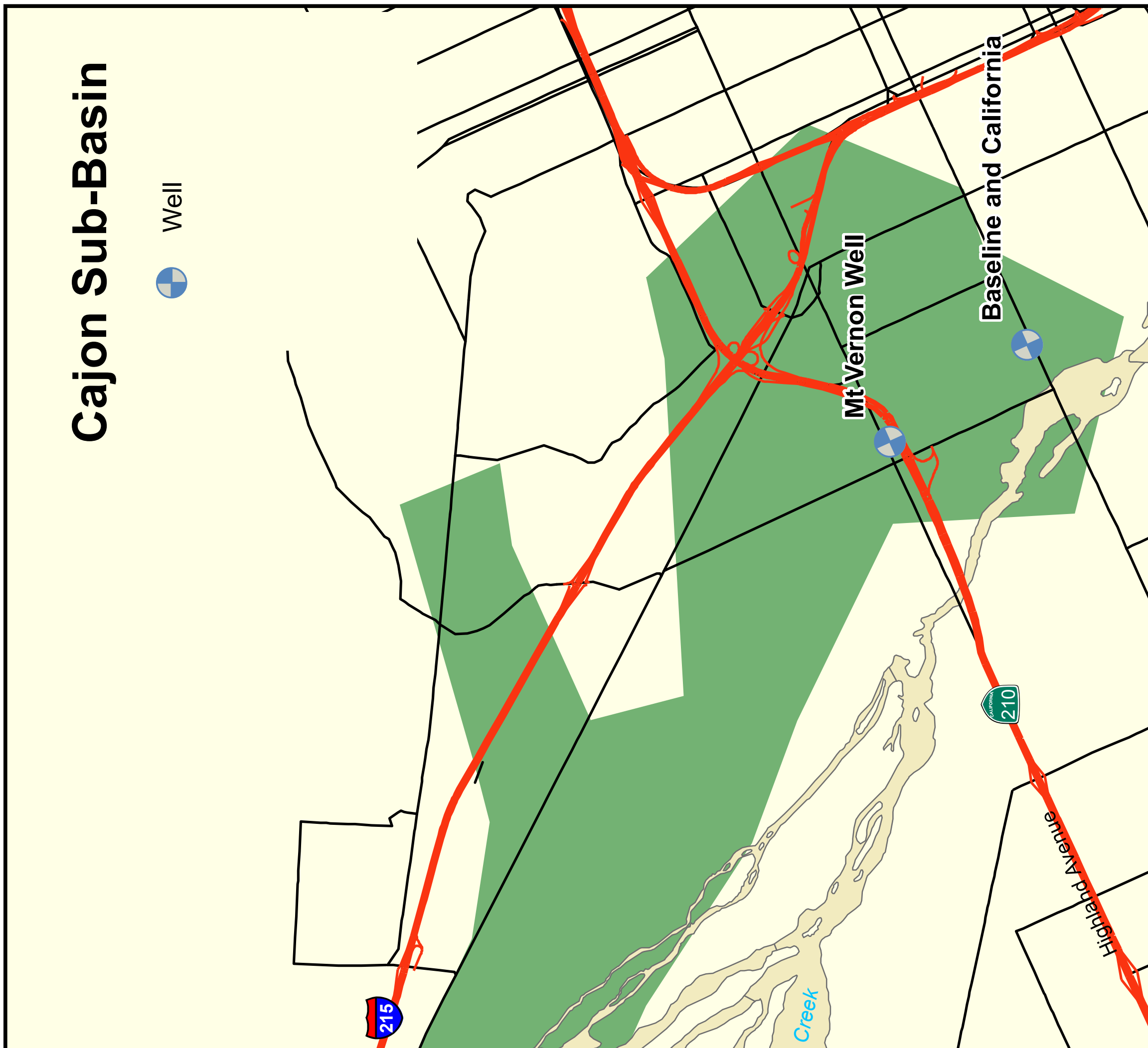
Change In Storage for the San Bernardino Basin Area 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	n/a	n/a	0
1935	6	20,870	20,870
1936	2	3,523	24,393
1937	23	145,589	169,982
1938	22	152,096	322,078
1939	3	-14,377	307,701
1940	-5	-31,859	275,842
1941	17	125,012	400,854
1942	-11	-82,317	318,537
1943	7	46,073	364,610
1944	0	7,091	371,701
1945	-5	-35,507	336,194
1946	-9	-54,920	281,274
1947	-12	-84,528	196,746
1948	-16	-94,909	101,837
1949	-9	-58,045	43,792
1950	-14	-68,538	-24,746
1951	-12	-75,214	-99,960
1952	11	58,167	-41,793
1953	-7	-62,735	-104,528
1954	1	-10,727	-115,255
1955	-11	-64,100	-179,355
1956	-14	-89,030	-268,385
1957	0	1,777	-266,608
1958	20	124,903	-141,705
1959	-8	-55,773	-197,478
1960	-13	-84,913	-282,391
1961	-18	-143,069	-425,460
1962	4	-12,103	-437,563
1963	-6	-23,803	-461,366
1964	-12	-85,205	-546,571
1965	0	-26,059	-572,630
1966	4	1,190	-571,440
1967	19	128,403	-443,037
1968	9	75,169	-367,868
1969	39	294,367	-73,501
1970	2	-15,864	-89,365
1971	-4	-21,340	-110,705
1972	-7	-45,689	-156,394
1973	1	-5,303	-161,697
1974	1	4,776	-156,921
1975	-5	-46,965	-203,886
1976	-6	-33,740	-237,626
1977	-9	-59,633	-297,259

San Bernardino Valley Municipal Water District

Change In Storage for the San Bernardino Basin Area 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1978	38	288,634	-8,625
1979	5	47,368	38,743
1980	21	171,822	210,565
1981	2	28,937	239,502
1982	1	-3,042	236,460
1983	16	136,343	372,803
1984	-7	-53,164	319,639
1985	-13	-104,413	215,226
1986	-8	-55,577	159,649
1987	-12	-87,184	72,465
1988	-12	-85,879	-13,414
1989	-16	-136,477	-149,891
1990	-13	-93,632	-243,523
1991	0	-42,951	-286,474
1992	11	88,692	-197,782
1993	30	192,725	-5,057
1994	-6	-46,564	-51,621
1995	13	84,107	32,486
1996	-3	-49,809	-17,323
1997	-1	-8,523	-25,846
1998	4	85,136	59,290
1999	-11	-92,827	-33,537
2000	-15	-115,680	-149,217
2001	-9	-71,069	-220,286
2002	-14	-96,300	-316,586
2003	-6	-29,706	-346,292
2004	-8	-80,017	-426,309
2005	33	223,178	-203,131
2006	-4	-27,539	-230,670
2007	-16	-88,767	-319,437
2008	-2	-35,158	-354,595
2009	-9	-78,417	-433,012
2010	4	6,803	-426,209
2011	17	158,805	-267,404
2012	-12	-76,469	-343,873
2013	-22	-150,503	-494,376
2014	-14	-136,683	-631,059



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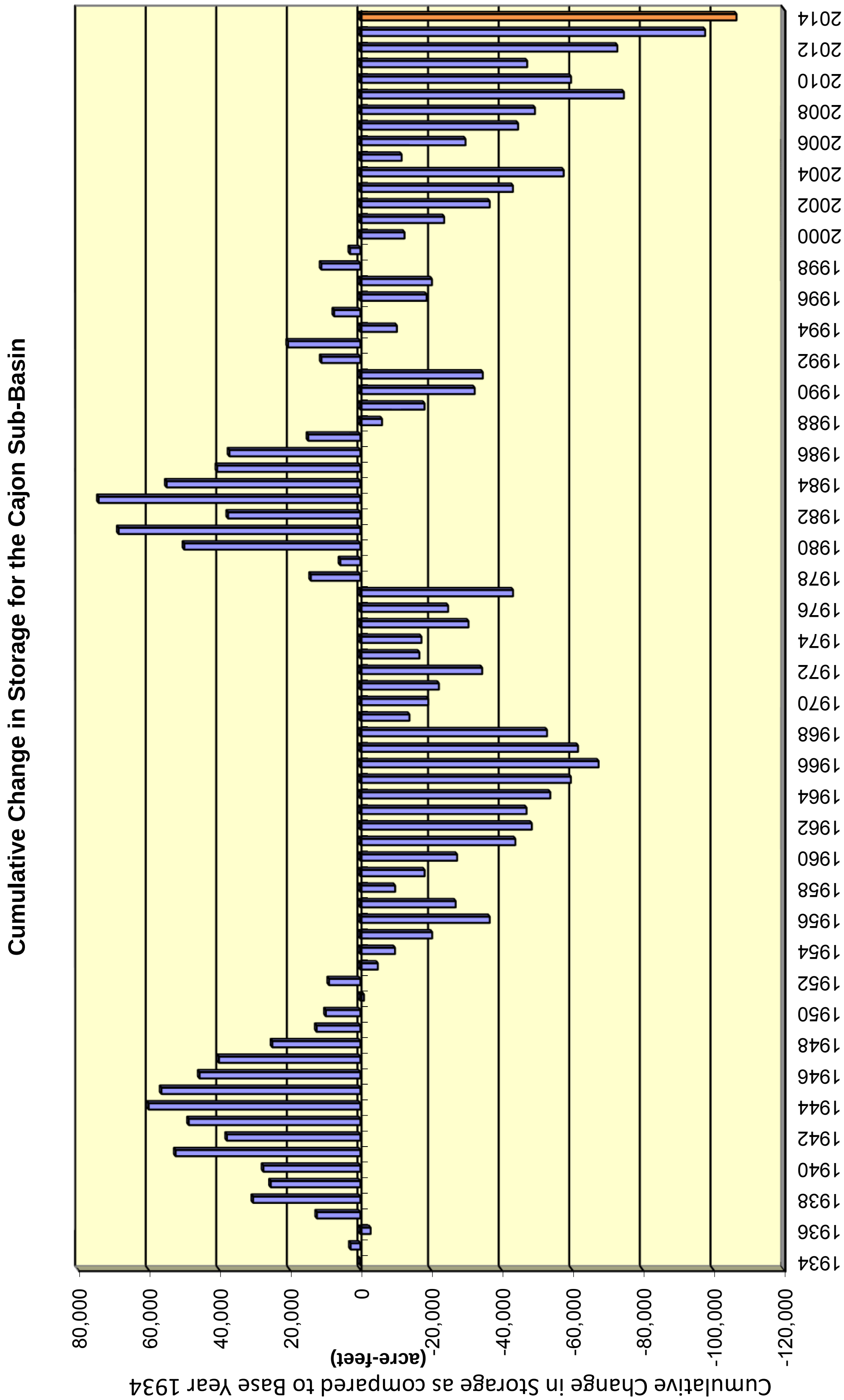
Cumulative Change in Storage for the Cajon Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
-100,000
-120,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
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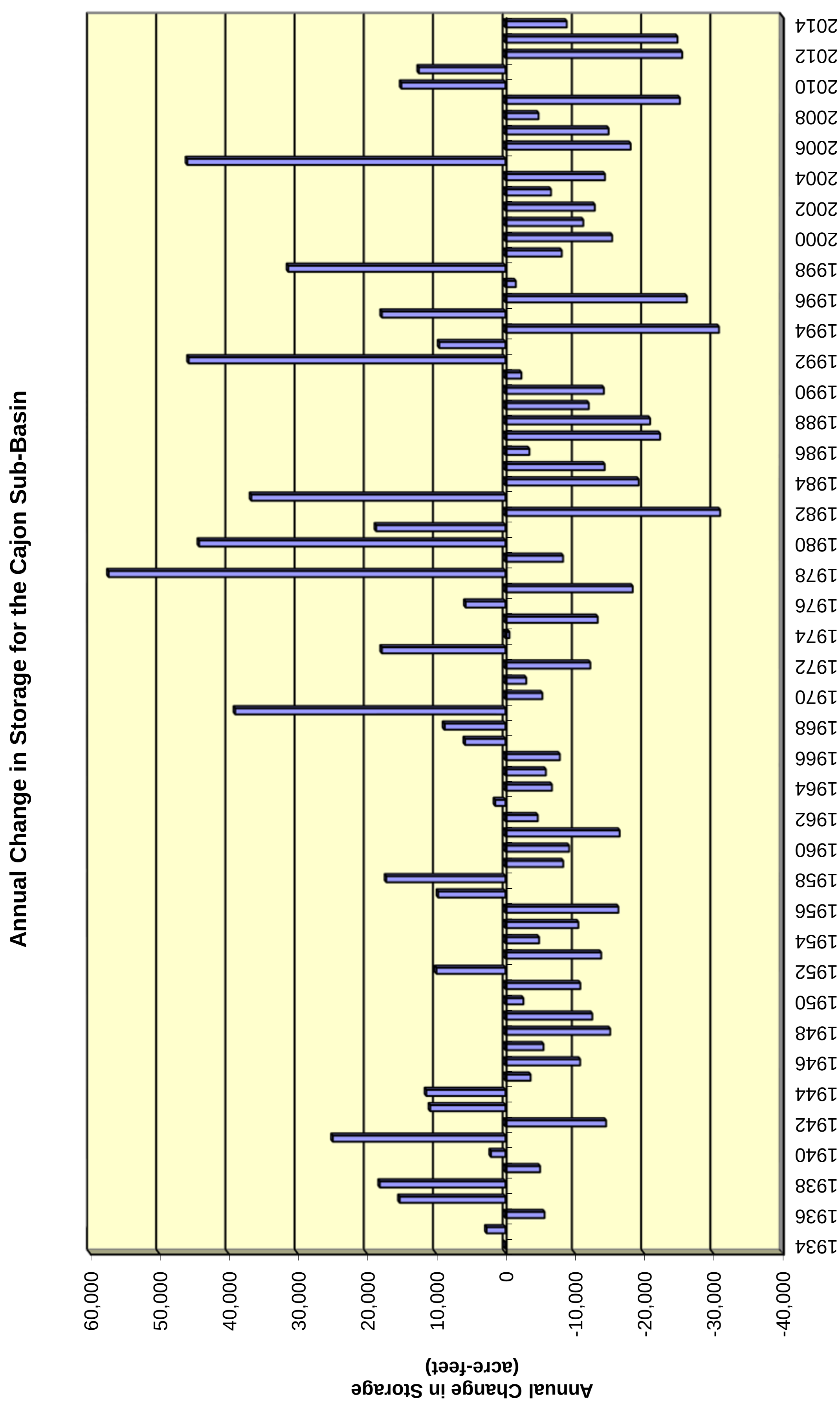
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Annual Change in Storage for the Cajon Sub-Basin
Annual Change in Storage
(acre-feet)
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

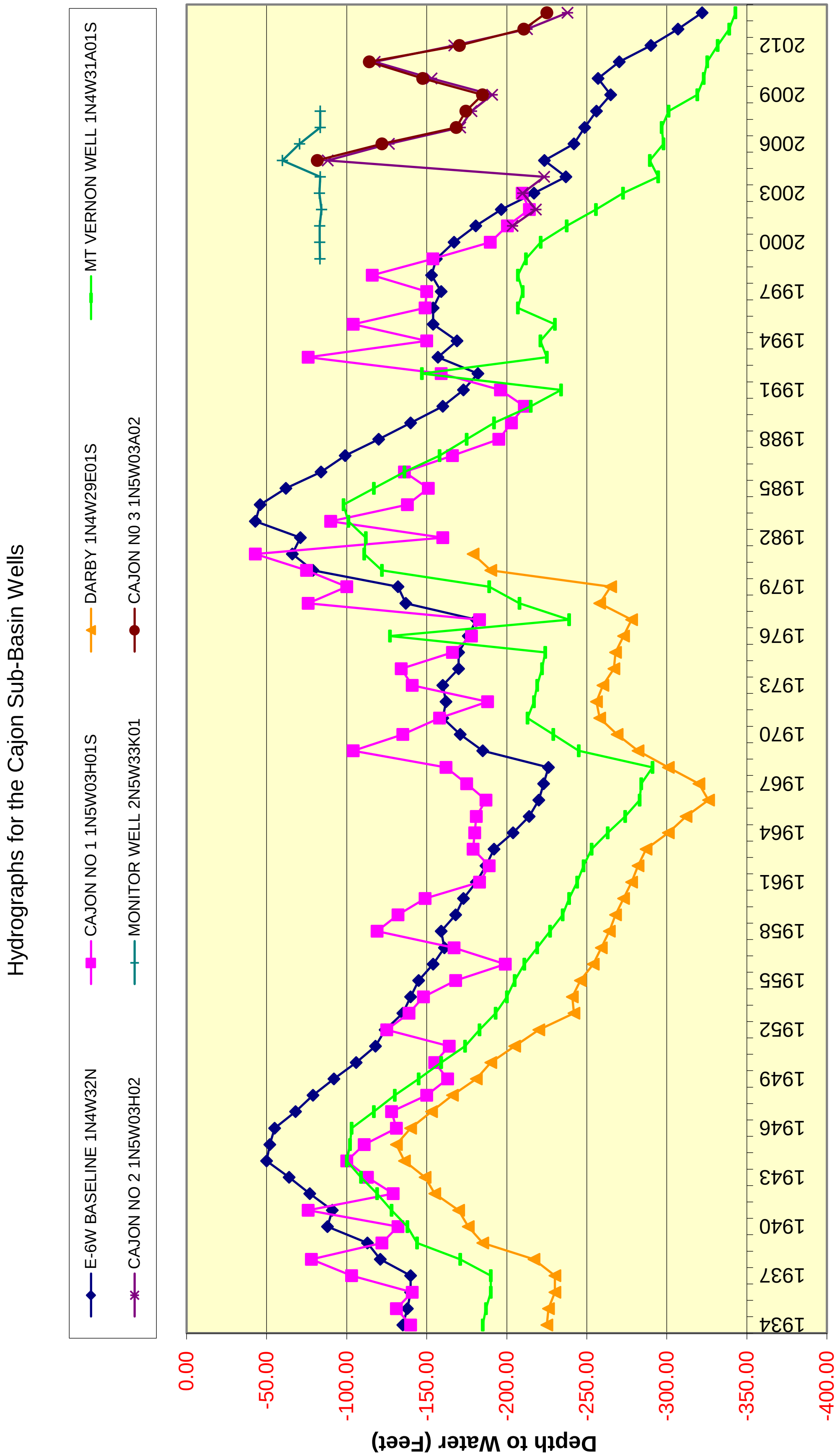
San Bernardino Valley Municipal Water District
Change In Storage for the Cajon Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	1	2,727	2,727
1936	-5	-5,653	-2,926
1937	10	15,215	12,289
1938	19	18,080	30,369
1939	6	-5,005	25,364
1940	8	2,091	27,455
1941	17	24,881	52,336
1942	-4	-14,541	37,795
1943	11	10,803	48,598
1944	12	11,376	59,974
1945	-3	-3,632	56,342
1946	-8	-10,790	45,552
1947	-9	-5,498	40,054
1948	-15	-15,133	24,921
1949	-14	-12,542	12,379
1950	-7	-2,595	9,784
1951	-13	-10,817	-1,033
1952	2	9,903	8,870
1953	-14	-13,833	-4,963
1954	-5	-4,860	-9,823
1955	-9	-10,534	-20,357
1956	-14	-16,316	-36,673
1957	3	9,655	-27,018
1958	9	17,153	-9,865
1959	-9	-8,349	-18,214
1960	-8	-9,204	-27,418
1961	-13	-16,502	-43,920
1962	-5	-4,666	-48,586
1963	-1	1,479	-47,107
1964	-9	-6,714	-53,821
1965	-8	-5,836	-59,657
1966	-9	-7,858	-67,515
1967	4	5,840	-61,675
1968	6	8,771	-52,904
1969	41	38,982	-13,922
1970	3	-5,336	-19,258
1971	4	-3,004	-22,262
1972	-9	-12,262	-34,524
1973	11	17,783	-16,741
1974	-3	-579	-17,320
1975	-9	-13,326	-30,646
1976	19	5,760	-24,886
1977	-32	-18,387	-43,273
1978	51	57,276	14,003

San Bernardino Valley Municipal Water District

Change In Storage for the Cajon Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	-2	-8,324	5,679
1980	55	44,197	49,876
1981	17	18,611	68,487
1982	-41	-31,017	37,470
1983	36	36,661	74,131
1984	-16	-19,249	54,882
1985	-16	-14,328	40,554
1986	-9	-3,458	37,096
1987	-22	-22,350	14,746
1988	-22	-20,895	-6,149
1989	-15	-12,038	-18,187
1990	-17	-14,210	-32,397
1991	-6	-2,305	-34,702
1992	38	45,699	10,997
1993	10	9,487	20,484
1994	-27	-30,849	-10,365
1995	17	17,786	7,421
1996	-7	-26,213	-18,792
1997	-3	-1,497	-20,289
1998	14	31,321	11,032
1999	-15	-8,134	2,898
2000	-14	-15,417	-12,519
2001	-10	-11,244	-23,763
2002	-13	-12,902	-36,665
2003	-5	-6,578	-43,243
2004	-14	-14,377	-57,620
2005	44	45,908	-11,712
2006	-23	-18,090	-29,802
2007	-22	-14,901	-44,703
2008	-5	-4,780	-49,483
2009	-13	-25,204	-74,687
2010	8	14,969	-59,718
2011	10	12,439	-47,279
2012	-33	-25,541	-72,820
2013	-27	-24,855	-97,675
2014	-15	-8,858	-106,533



Hydrographs for the Cajon Sub-Basin Wells
E-6W BASELINE 1N4W32N
CAJON NO 1 1N5W03H01S
DARBY 1N4W29E01S
MT VERNON WELL 1N4W31A01S
CAJON NO 2 1N5W03H02
MONITOR WELL 2N5W33K01
CAJON N0 3 1N5W03A02
Depth to Water (Feet)
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
-400.00
1934
1937
1940
1943
1946
1949
1952
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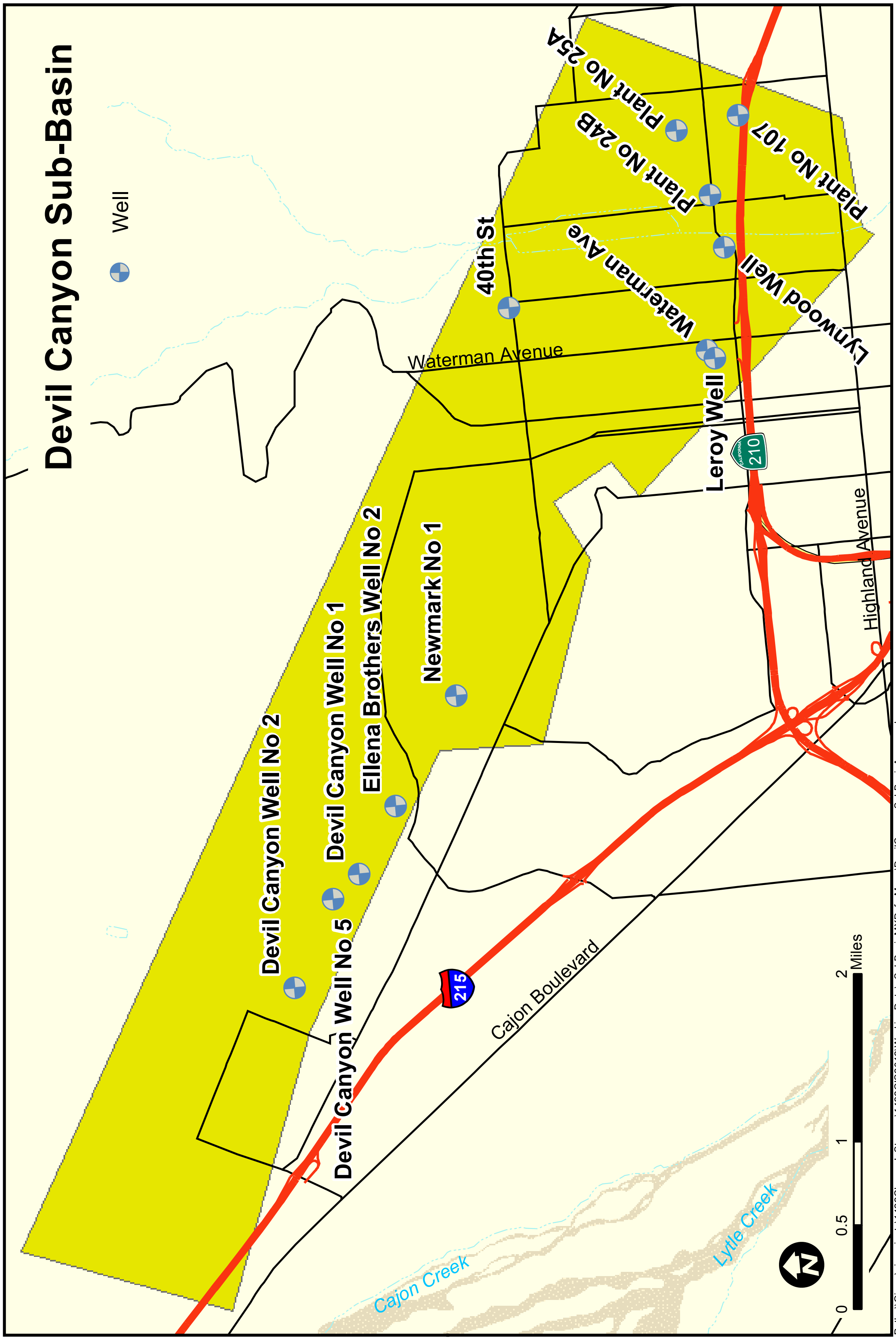
2000
2003
2006
2009
2012



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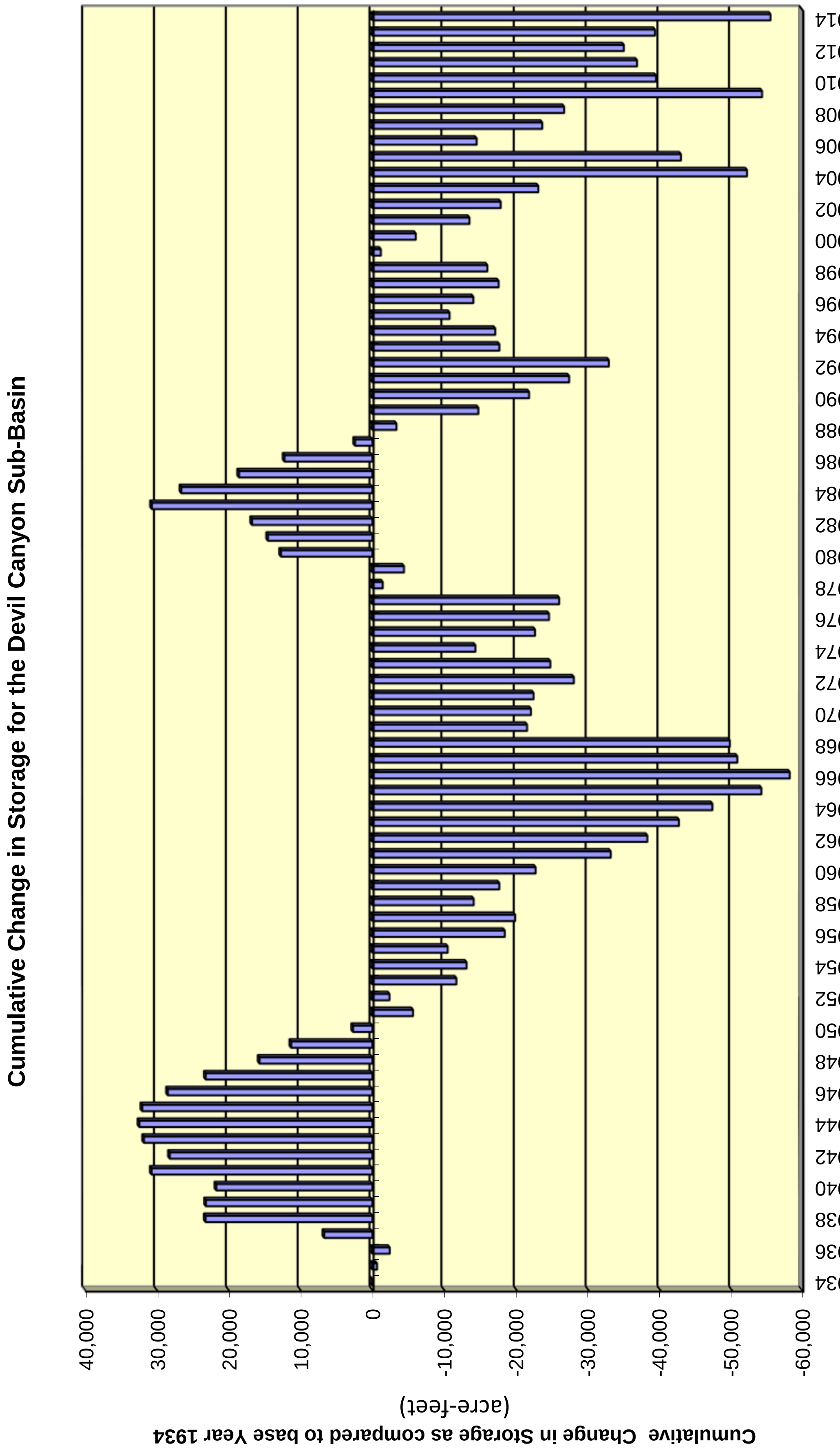
Cumulative Change in Storage for the Devil Canyon Sub-Basin
Cumulative Change in Storage as compared to base Year 1934
(acre-feet)
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
-60,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
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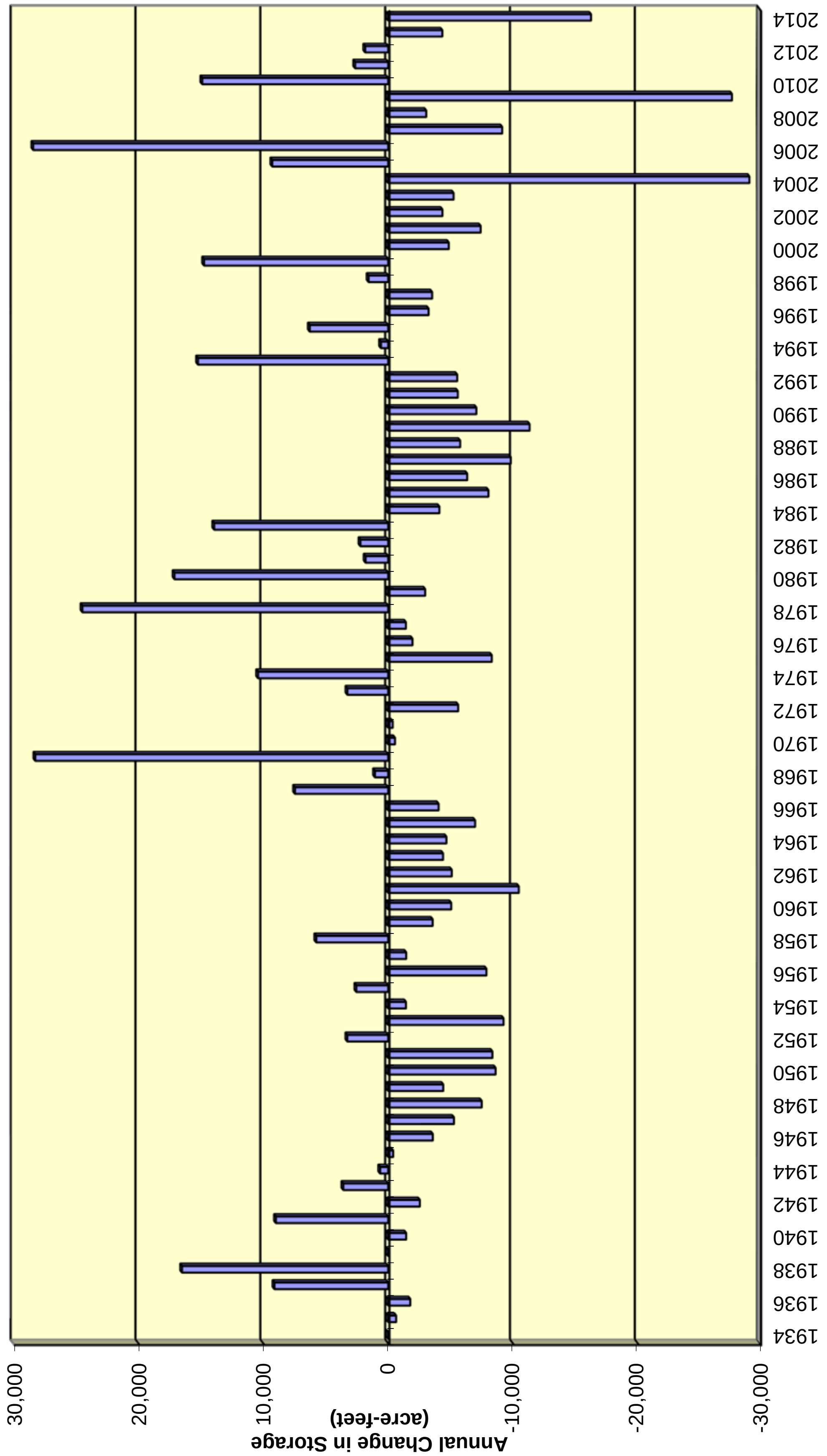
Annual Change in Storage for the Devil Canyon Sub-Basin



San Bernardino Valley Municipal Water District

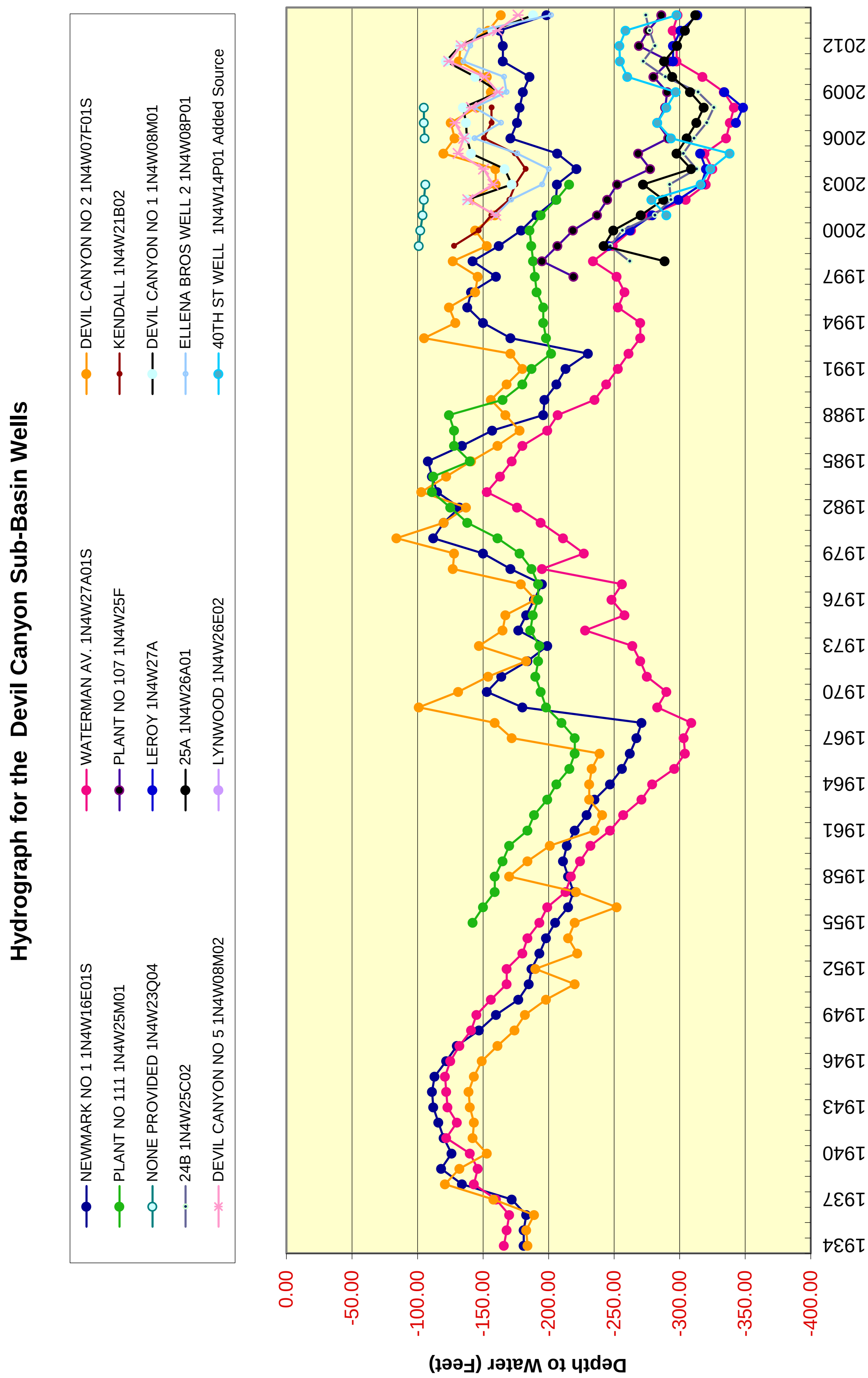
Change In Storage for the Devil Canyon Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	0	-635	-635
1936	-3	-1,769	-2,404
1937	17	9,114	6,710
1938	31	16,514	23,224
1939	1	-45	23,179
1940	-8	-1,440	21,739
1941	12	8,997	30,736
1942	-2	-2,536	28,200
1943	5	3,596	31,796
1944	1	646	32,442
1945	-2	-399	32,043
1946	-6	-3,572	28,471
1947	-9	-5,269	23,202
1948	-13	-7,490	15,712
1949	-8	-4,409	11,303
1950	-15	-8,602	2,701
1951	-14	-8,346	-5,645
1952	9	3,277	-2,368
1953	-17	-9,239	-11,607
1954	-1	-1,422	-13,029
1955	-7	2,555	-10,474
1956	-14	-7,872	-18,346
1957	1	-1,442	-19,788
1958	13	5,764	-14,024
1959	-6	-3,562	-17,586
1960	-8	-5,048	-22,634
1961	-17	-10,460	-33,094
1962	-8	-5,093	-38,187
1963	-5	-4,393	-42,580
1964	-7	-4,666	-47,246
1965	-10	-6,959	-54,205
1966	-6	-4,037	-58,242
1967	16	7,468	-50,774
1968	3	1,062	-49,712
1969	47	28,267	-21,445
1970	-2	-542	-21,987
1971	-4	-364	-22,351
1972	-12	-5,604	-27,955
1973	7	3,270	-24,685
1974	12	10,425	-14,260
1975	-10	-8,298	-22,558
1976	-6	-1,945	-24,503
1977	-1	-1,418	-25,921
1978	36	24,493	-1,428

San Bernardino Valley Municipal Water District

Change In Storage for the Devil Canyon Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	-1	-2,963	-4,391
1980	29	17,117	12,726
1981	-1	1,812	14,538
1982	1	2,224	16,762
1983	22	13,938	30,700
1984	-7	-4,102	26,598
1985	-13	-8,029	18,569
1986	-11	-6,328	12,241
1987	-15	-9,819	2,422
1988	-8	-5,764	-3,342
1989	-15	-11,326	-14,668
1990	-11	-7,063	-21,731
1991	-9	-5,576	-27,307
1992	-8	-5,528	-32,835
1993	30	15,236	-17,599
1994	0	579	-17,020
1995	9	6,283	-10,737
1996	-6	-3,236	-13,973
1997	-3	-3,519	-17,492
1998	16	1,572	-15,920
1999	-14	14,749	-1,171
2000	-9	-4,853	-6,024
2001	-14	-7,407	-13,431
2002	-7	-4,345	-17,776
2003	-13	-5,237	-23,013
2004	8	-29,138	-52,151
2005	13	9,289	-42,862
2006	13	28,432	-14,430
2007	-12	-9,131	-23,561
2008	-3	-3,047	-26,608
2009	-3	-27,693	-54,301
2010	21	14,894	-39,407
2011	10	2,648	-36,759
2012	-2	1,844	-34,915
2013	-9	-4,336	-39,251
2014	-20	-16,248	-55,499


Hydrograph for the Devil Canyon Sub-Basin Wells
NEWMARK NO 1 1N4W16E01S
PLANT NO 111 1N4W25M01
NONE PROVIDED 1N4W23Q04
24B 1N4W25C02
DEVIL CANYON NO 5 1N4W08M02
WATERMAN AV. 1N4W27A01S
PLANT NO 107 1N4W25F
LEROY 1N4W27A
25A 1N4W26A01
LYNWOOD 1N4W26E02
DEVIL CANYON NO 2 1N4W07F01S
KENDALL 1N4W21B02
DEVIL CANYON NO 1 1N4W08M01
ELLENA BROS WELL 2 1N4W08P01
40TH ST WELL 1N4W14P01 Added Source
Depth to Water (Feet)
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
-400.00
1934
1937
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1997
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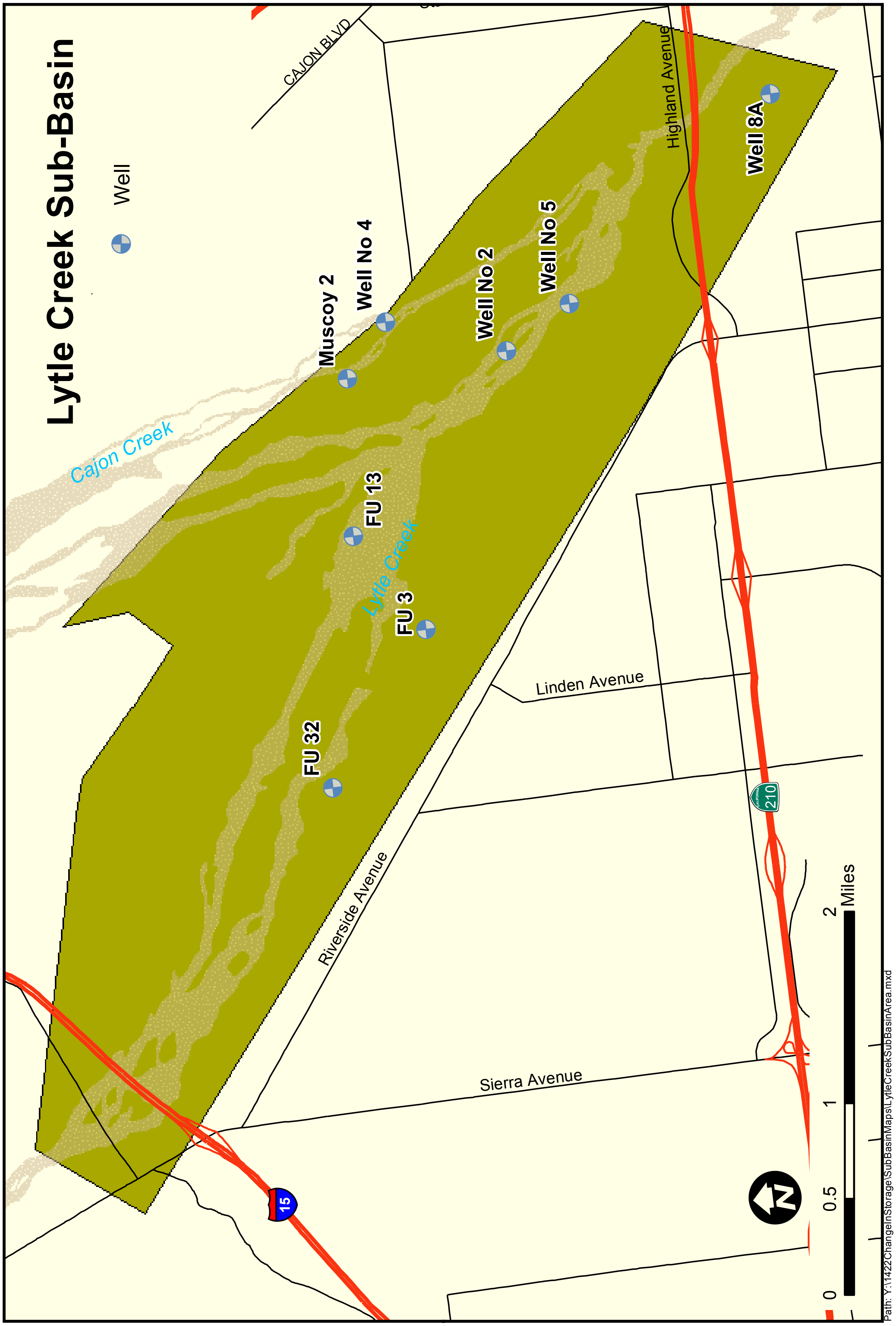
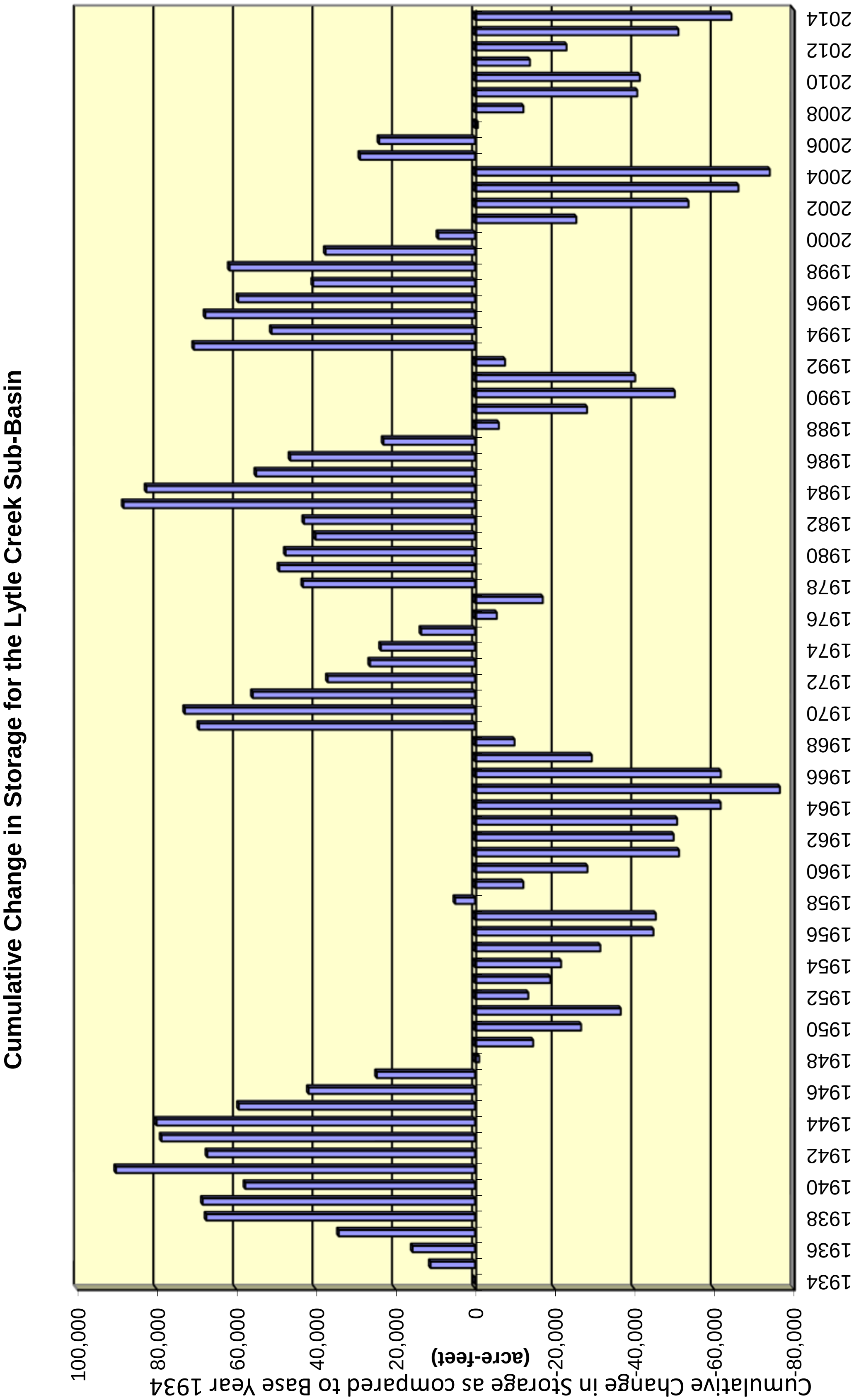
2003
2006
2009
2012



Lytle Creek Sub-Basin
Well
Cajon Creek
CAJON BLVD
Muscoy 2
Well No 4
Well No 2
Well No 5
Well 8A
Highland Avenue
FU 13
Lytle Creek
FU 3
FU 32
Linden Avenue
Riverside Avenue
Sierra Avenue
210
15
0
0.5
1
2
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\LytleCreekSubBasinArea.mxd



Cumulative Change in Storage for the Lytle Creek Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
100,000
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
1934
1936
1938
1940
1942
1944
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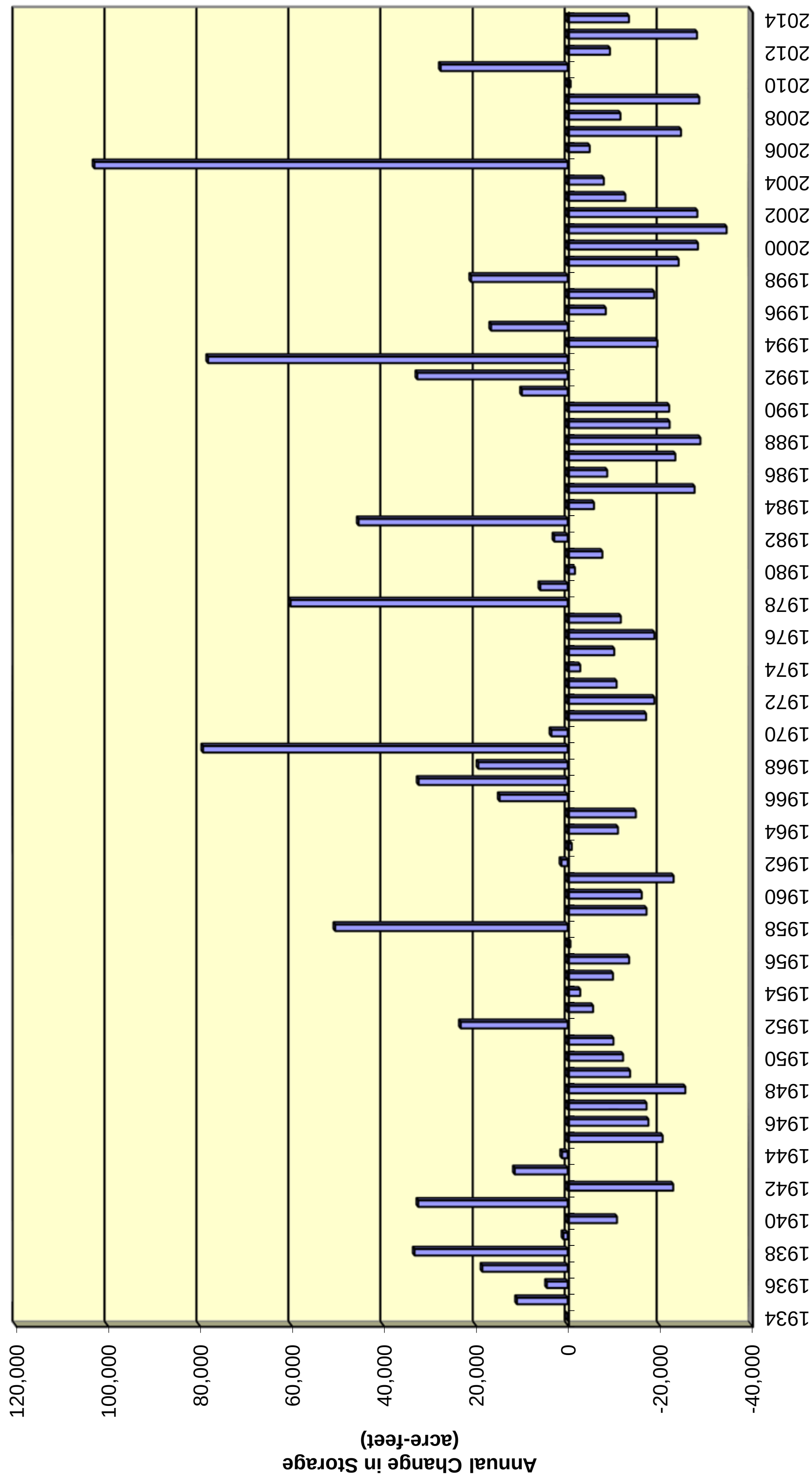
2014

Annual Change in Storage for the Lytle Creek Sub-Basin



San Bernardino Valley Municipal Water District
Change In Storage for the Lytle Creek Sub-basin 1934 - 2014

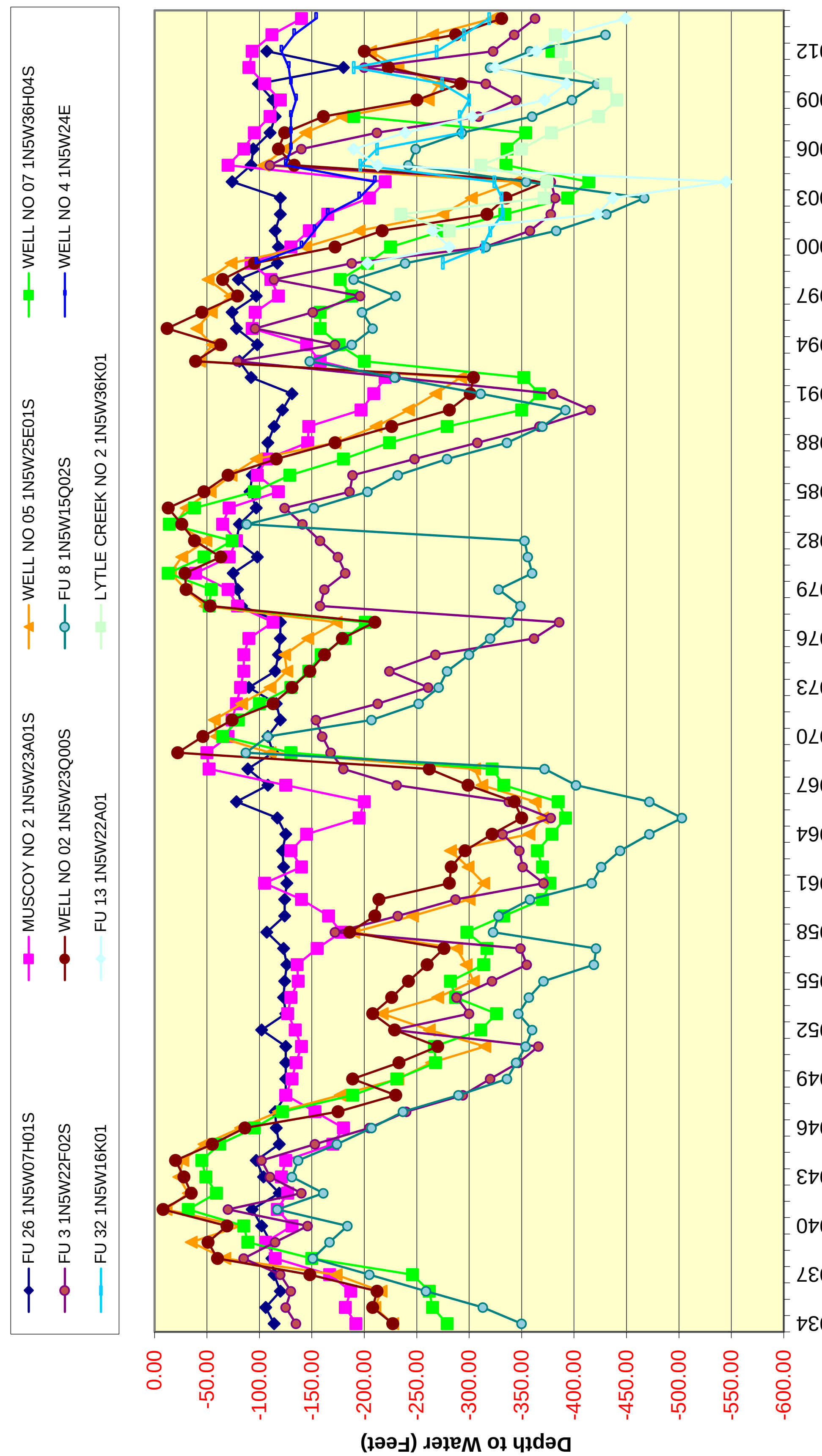
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	16	11,039	11,039
1936	3	4,524	15,563
1937	30	18,561	34,124
1938	62	33,297	67,421
1939	9	926	68,347
1940	-18	-10,717	57,630
1941	50	32,509	90,139
1942	-32	-22,956	67,183
1943	15	11,515	78,698
1944	2	1,224	79,922
1945	-32	-20,656	59,266
1946	-27	-17,567	41,699
1947	-27	-17,153	24,546
1948	-39	-25,594	-1,048
1949	-19	-13,579	-14,627
1950	-22	-12,057	-26,684
1951	-17	-9,964	-36,648
1952	30	23,256	-13,392
1953	-3	-5,523	-18,915
1954	-4	-2,738	-21,653
1955	-14	-9,853	-31,506
1956	-18	-13,361	-44,867
1957	-3	-596	-45,463
1958	68	50,451	4,988
1959	-26	-17,150	-12,162
1960	-22	-16,108	-28,270
1961	-28	-23,046	-51,316
1962	0	1,366	-49,950
1963	1	-885	-50,835
1964	-21	-10,938	-61,773
1965	-25	-14,831	-76,604
1966	18	14,805	-61,799
1967	53	32,429	-29,370
1968	33	19,431	-9,939
1969	129	79,194	69,255
1970	9	3,552	72,807
1971	-21	-17,053	55,754
1972	-27	-18,851	36,903
1973	-17	-10,643	26,260
1974	-7	-2,741	23,519
1975	-13	-10,131	13,388
1976	-26	-18,859	-5,471
1977	-20	-11,573	-17,044
1978	103	60,162	43,118

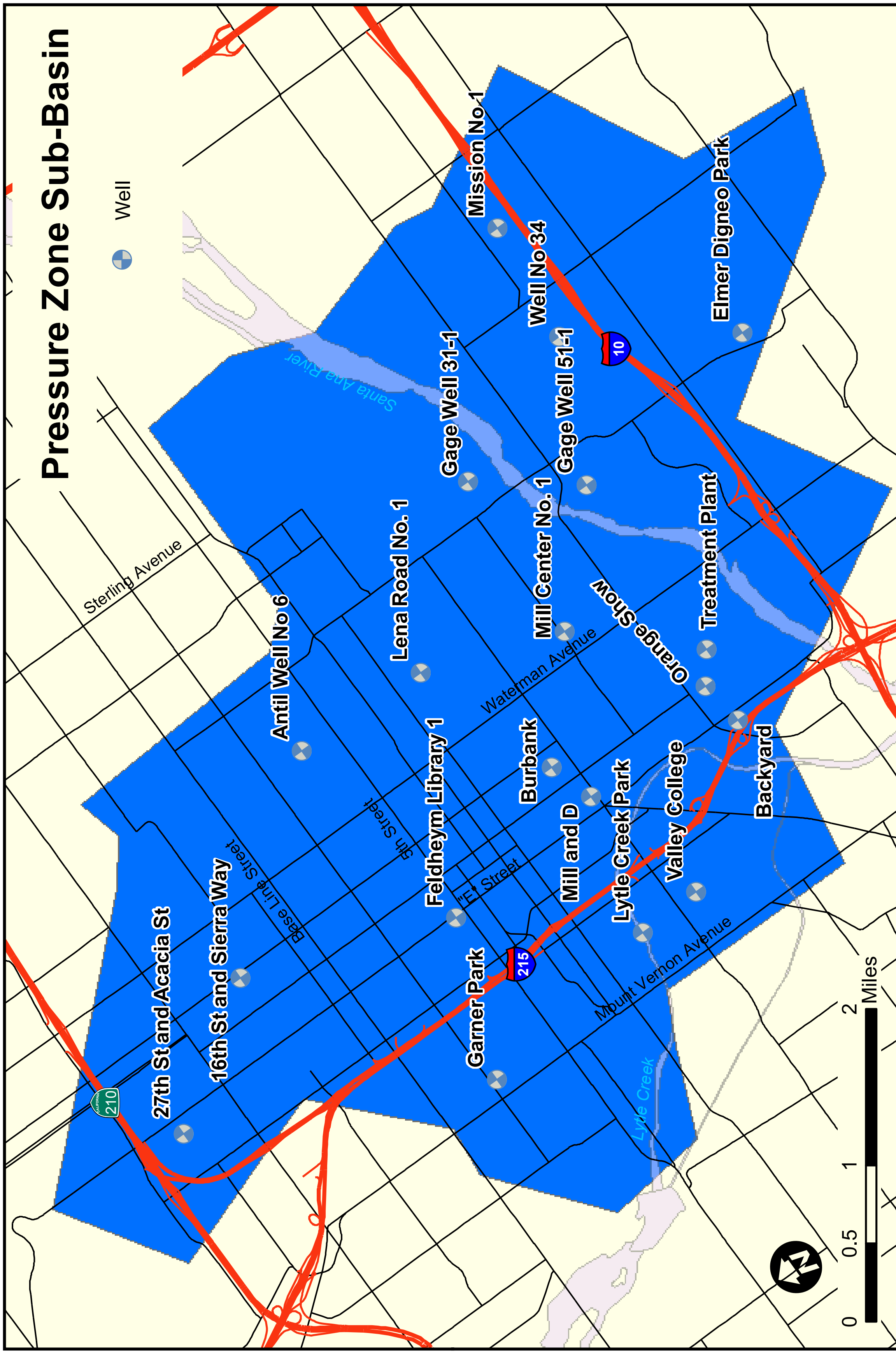
San Bernardino Valley Municipal Water District

Change In Storage for the Lytle Creek Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	10	5,964	49,082
1980	6	-1,588	47,494
1981	-18	-7,544	39,950
1982	1	2,912	42,862
1983	56	45,372	88,234
1984	-13	-5,730	82,504
1985	-38	-27,599	54,905
1986	-13	-8,602	46,303
1987	-36	-23,422	22,881
1988	-47	-28,867	-5,986
1989	-35	-22,178	-28,164
1990	-41	-22,083	-50,247
1991	5	9,959	-40,288
1992	35	32,721	-7,567
1993	139	78,106	70,539
1994	-21	-19,516	51,023
1995	30	16,655	67,678
1996	-13	-8,288	59,390
1997	-29	-18,815	40,575
1998	27	21,005	61,580
1999	-31	-24,144	37,436
2000	-57	-28,334	9,102
2001	-27	-34,576	-25,474
2002	-42	-28,205	-53,679
2003	-33	-12,542	-66,221
2004	-18	-7,866	-74,087
2005	153	102,835	28,748
2006	-9	-4,791	23,957
2007	-31	-24,651	-694
2008	-18	-11,482	-12,176
2009	-35	-28,620	-40,796
2010	26	-640	-41,436
2011	45	27,617	-13,819
2012	-48	-9,196	-23,015
2013	-35	-28,135	-51,150
2014	26	-13,325	-64,475

Hydrograph for the Lytle Creek Sub-Basin Wells




Pressure Zone Sub-Basin
Well
Mission No 1
Well No 34
Elmer Digneo Park
Gage Well 31-1
Gage Well 51-1
Santa Ana River
Lena Road No. 1
Mill Center No. 1
Treatment Plant
Orange Show
Sterling Avenue
Antil Well No 6
Waterman Avenue
Feldheym Library 1
Burbank
Mill and D
Lytle Creek Park
Valley College
Backyard
5th Street
"E" Street
Base Line Street
27th St and Acacia St
16th St and Sierra Way
Garner Park
Mount Vernon Avenue
Lytle Creek
210
215
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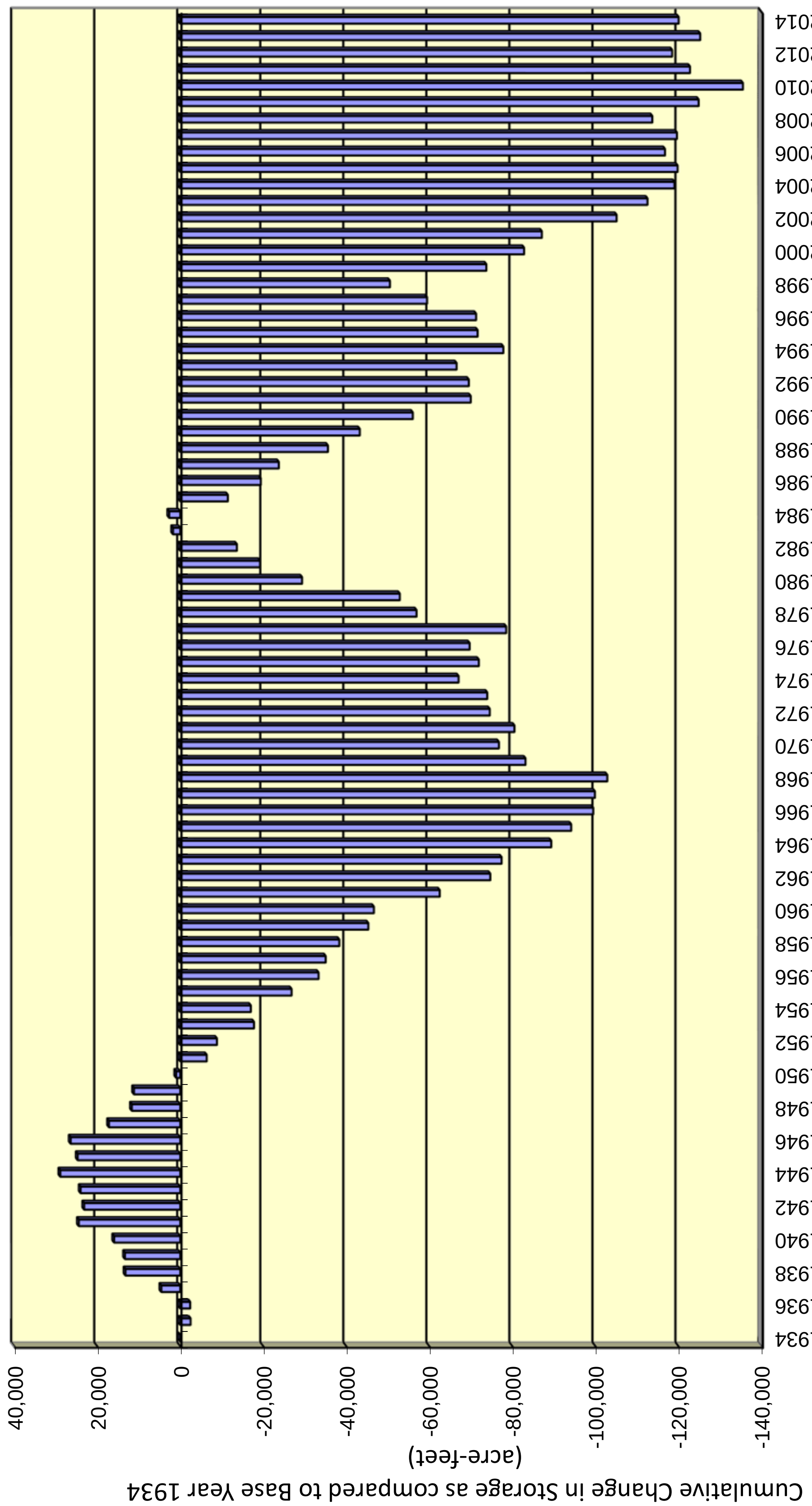
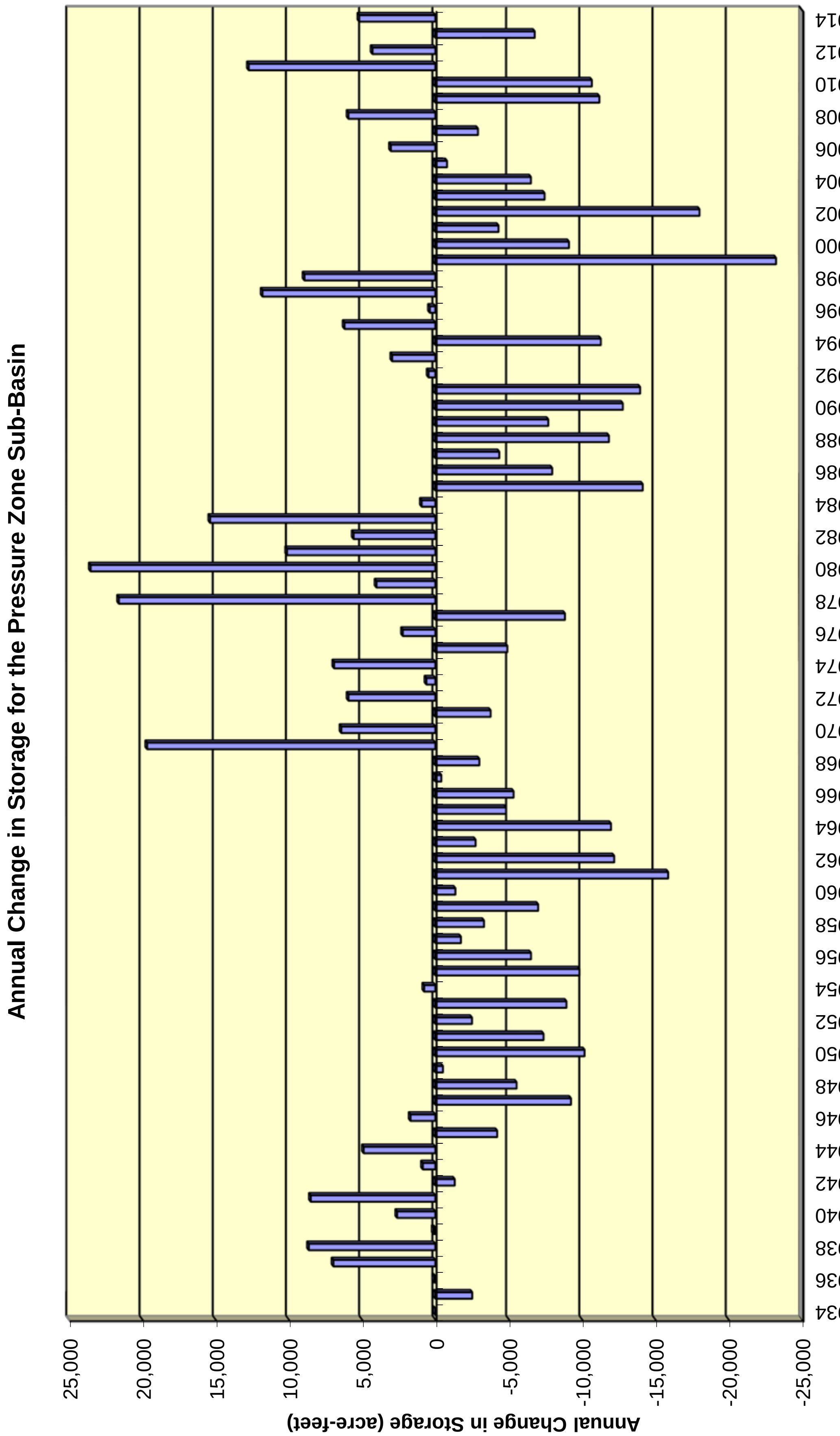
0 0.5 1 2
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\PressureZoneSubBasinArea.mxd

Cumulative Change in Storage for the Pressure Zone Sub-Basin





Annual Change in Storage for the Pressure Zone Sub-Basin
Annual Change in Storage (acre-feet)
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
1934
1936
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2014

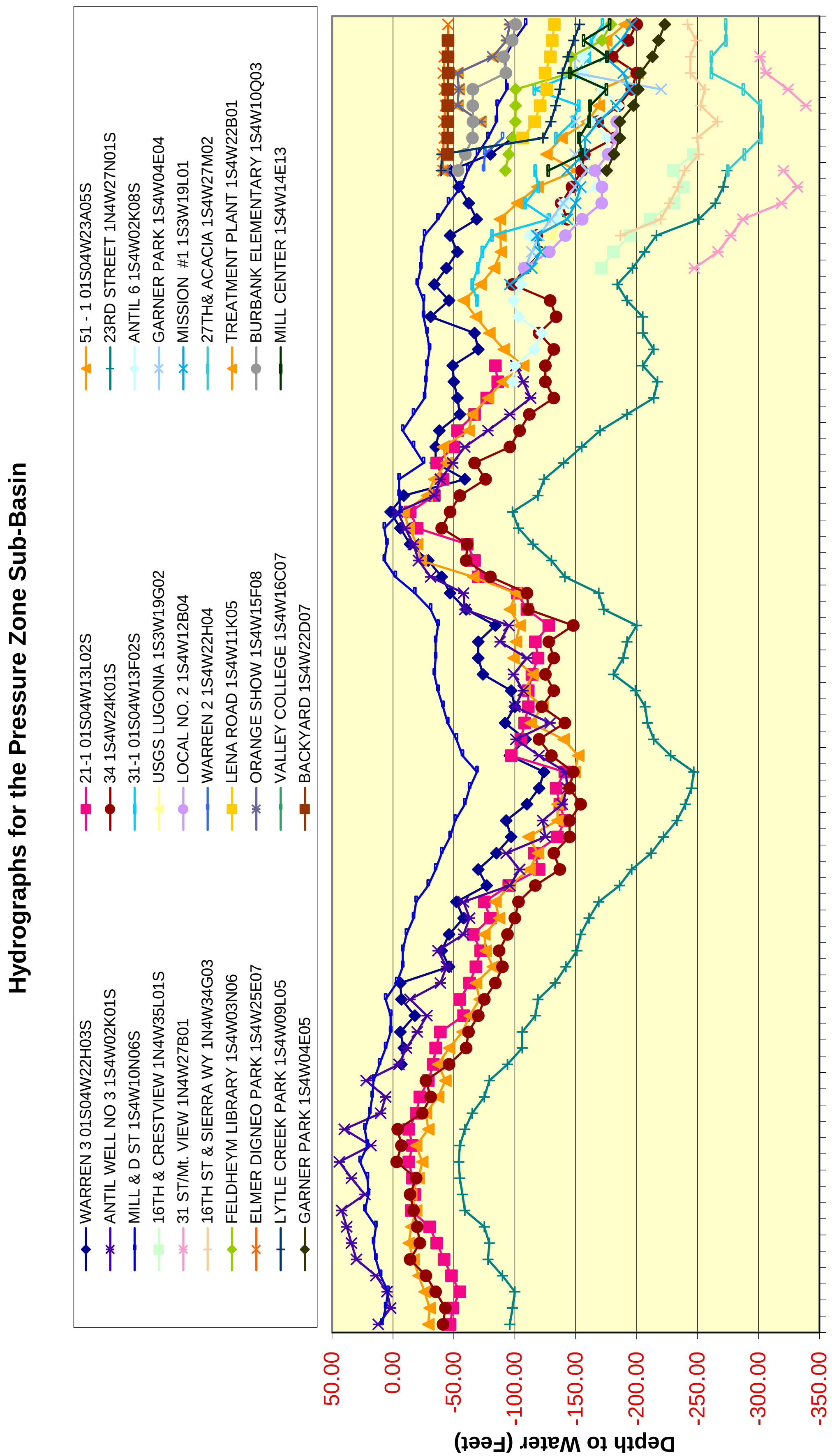
San Bernardino Valley Municipal Water District
Change In Storage for the Pressure Zone Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	-3	-2,484	-2,484
1936	1	89	-2,395
1937	8	6,961	4,566
1938	9	8,638	13,204
1939	1	121	13,325
1940	2	2,610	15,935
1941	7	8,507	24,442
1942	-3	-1,289	23,153
1943	1	853	24,006
1944	6	4,893	28,899
1945	-6	-4,190	24,709
1946	3	1,694	26,403
1947	-11	-9,229	17,174
1948	-6	-5,514	11,660
1949	0	-519	11,141
1950	-11	-10,156	985
1951	-7	-7,354	-6,369
1952	-4	-2,467	-8,836
1953	-9	-8,921	-17,757
1954	2	763	-16,994
1955	-9	-9,810	-26,804
1956	-12	-6,500	-33,304
1957	1	-1,713	-35,017
1958	-5	-3,289	-38,306
1959	-9	-6,988	-45,294
1960	1	-1,334	-46,628
1961	-19	-15,866	-62,494
1962	-11	-12,182	-74,676
1963	-3	-2,718	-77,394
1964	-12	-11,963	-89,357
1965	-6	-4,795	-94,152
1966	-8	-5,307	-99,459
1967	-3	-412	-99,871
1968	-4	-2,972	-102,843
1969	20	19,683	-83,160
1970	6	6,418	-76,742
1971	1	-3,741	-80,483
1972	5	5,932	-74,551
1973	2	612	-73,939
1974	7	6,910	-67,029
1975	-2	-4,883	-71,912
1976	3	2,218	-69,694
1977	-9	-8,818	-78,512
1978	22	21,610	-56,902

San Bernardino Valley Municipal Water District

Change In Storage for the Pressure Zone Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	5	4,020	-52,882
1980	25	23,540	-29,342
1981	15	10,127	-19,215
1982	6	5,581	-13,634
1983	14	15,379	1,745
1984	1	930	2,675
1985	-15	-14,130	-11,455
1986	-13	-7,945	-19,400
1987	-3	-4,335	-23,735
1988	-8	-11,820	-35,555
1989	-9	-7,680	-43,235
1990	-13	-12,770	-56,005
1991	-13	-13,955	-69,960
1992	-1	463	-69,497
1993	0	2,947	-66,550
1994	-7	-11,268	-77,818
1995	5	6,202	-71,616
1996	9	376	-71,240
1997	3	11,802	-59,438
1998	6	8,938	-50,500
1999	-8	-23,219	-73,719
2000	-10	-9,093	-82,812
2001	-5	-4,280	-87,092
2002	-19	-18,009	-105,101
2003	-8	-7,427	-112,528
2004	-9	-6,495	-119,023
2005	-1	-762	-119,785
2006	5	3,037	-116,748
2007	-6	-2,876	-119,624
2008	2	5,932	-113,692
2009	-7	-11,169	-124,861
2010	-4	-10,655	-135,516
2011	1	12,742	-122,774
2012	-2	4,292	-118,482
2013	-5	-6,753	-125,235
2014	-5	5,195	-120,040



Hydrographs for the Pressure Zone Sub-Basin
WARREN 3 01S04W22H03S
ANTIL WELL NO 3 1S4W02K01S
MILL & D ST 1S4W10N06S
16TH & CRESTVIEW 1N4W35L01S
31 ST/Mt. VIEW 1N4W27B01
16TH ST & SIERRA WY 1N4W34G03
FELDHEYM LIBRARY 1S4W03N06
ELMER DIGNEO PARK 1S4W25E07
LYTLE CREEK PARK 1S4W09L05
GARNER PARK 1S4W04E05
21-1 01S04W13L02S
34 1S4W24K01S
31-1 01S04W13F02S
USGS LUGONIA 1S3W19G02
LOCAL NO. 2 1S4W12B04
WARREN 2 1S4W22H04
LENA ROAD 1S4W11K05
ORANGE SHOW 1S4W15F08
VALLEY COLLEGE 1S4W16C07
BACKYARD 1S4W22D07
51 - 1 01S04W23A05S
23RD STREET 1N4W27N01S
ANTIL 6 1S4W02K08S
GARNER PARK 1S4W04E04
MISSION #1 1S3W19L01
27TH& ACACIA 1S4W27M02
TREATMENT PLANT 1S4W22B01
BURBANK ELEMENTARY 1S4W10Q03
MILL CENTER 1S4W14E13
Depth to Water (Feet)
50.00
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1934
1937
1940
1943
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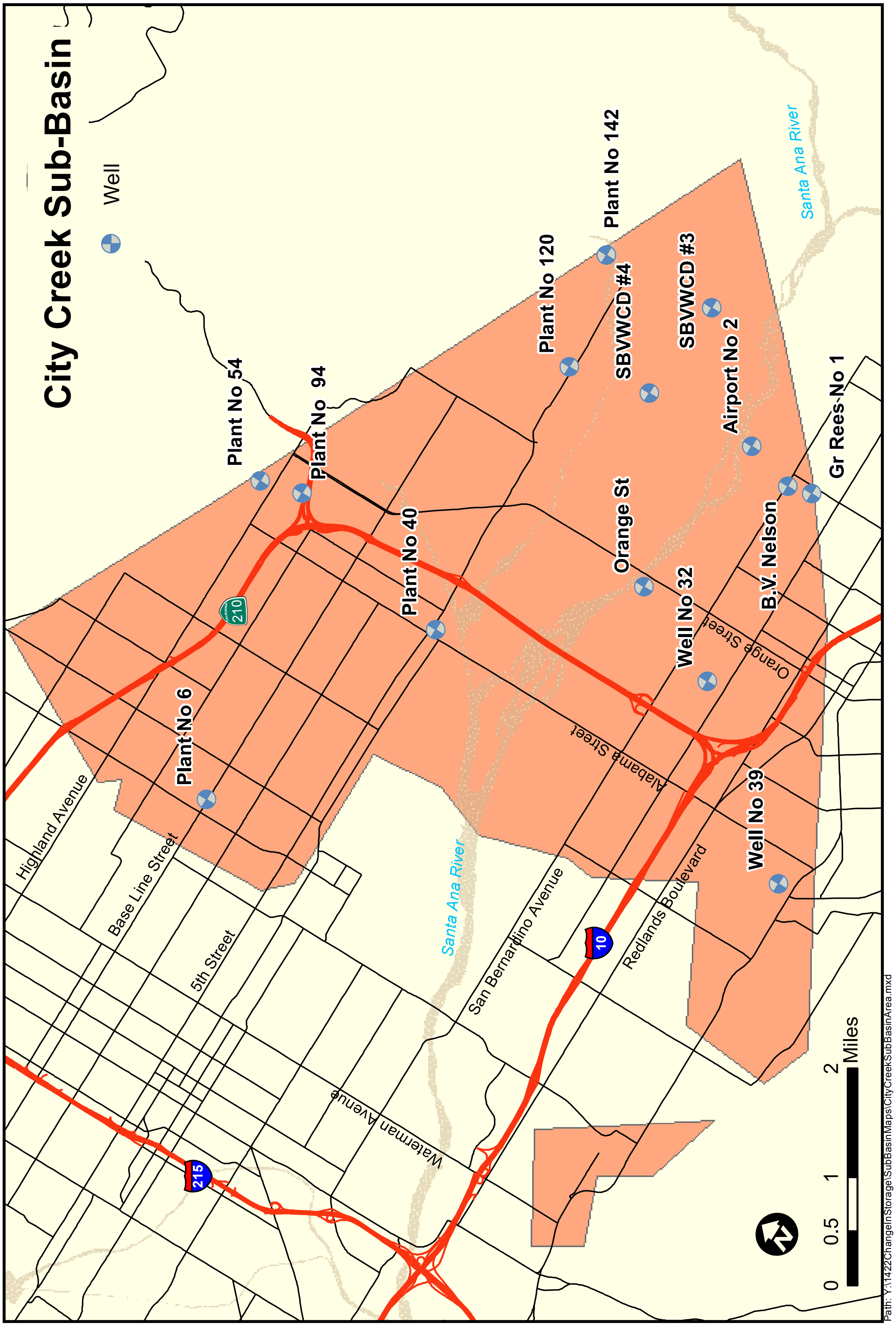
2006
2009
2012


City Creek Sub-Basin
Well
Plant No 54
Plant No 94
Plant No 40
Plant No 120
Plant No 142
Plant No 6
SBVWCD #4
SBVWCD #3
Airport No 2
Gr Rees No 1
Orange St
Well No 32
B.V. Nelson
Well No 39
Santa Ana River
Santa Ana River
Orange Street
Alabama Street
Highland Avenue
Base Line Street
5th Street
San Bernardino Avenue
Redlands Boulevard
Waterman Avenue
210
10
215
0
0.5
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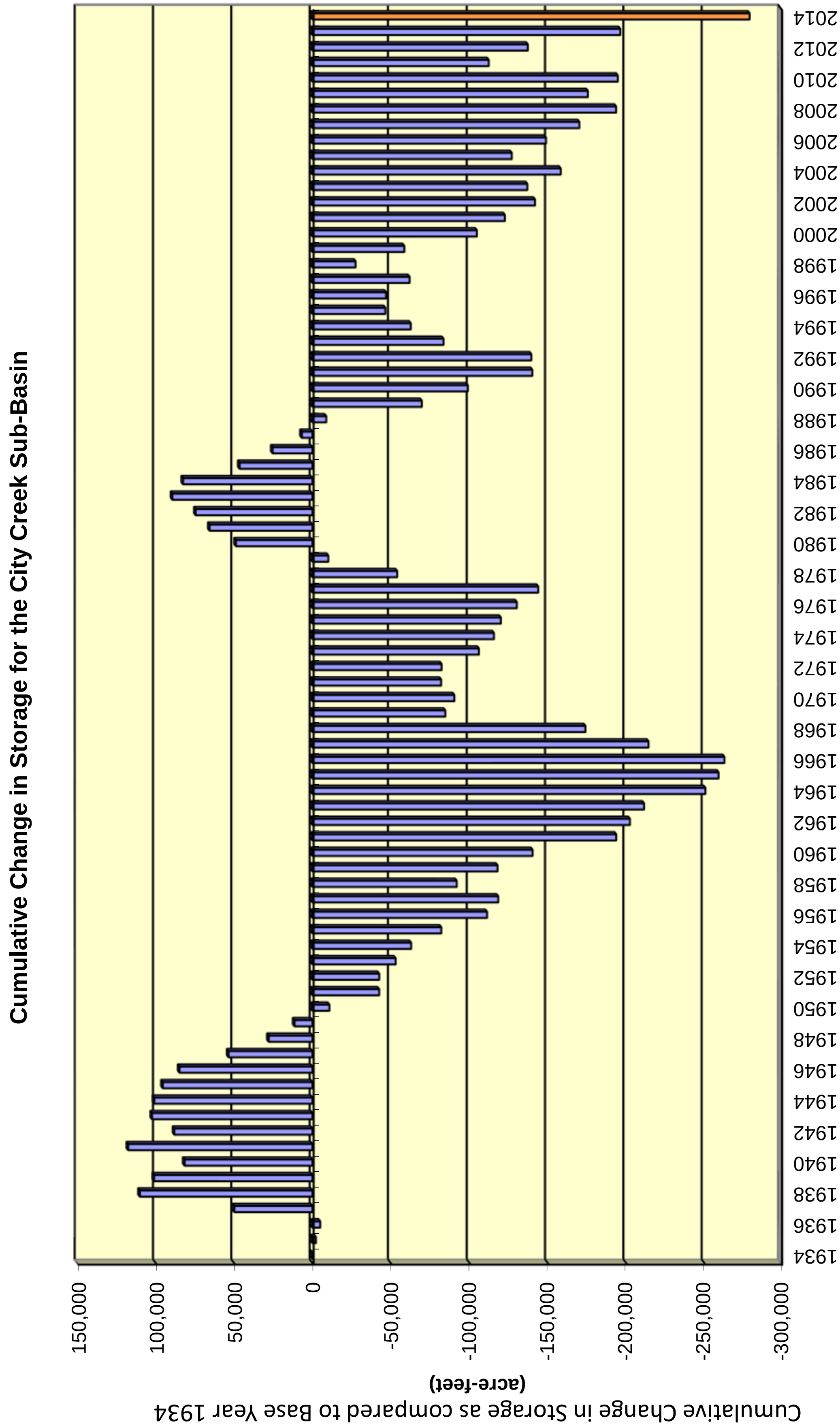
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\CityCreekSubBasinArea.mxd


Cumulative Change in Storage for the City Creek Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
150,000
100,000
50,000
0
-50,000
-100,000
-150,000
-200,000
-250,000
-300,000
1934
1936
1938
1940
1942
1944
1946
1948
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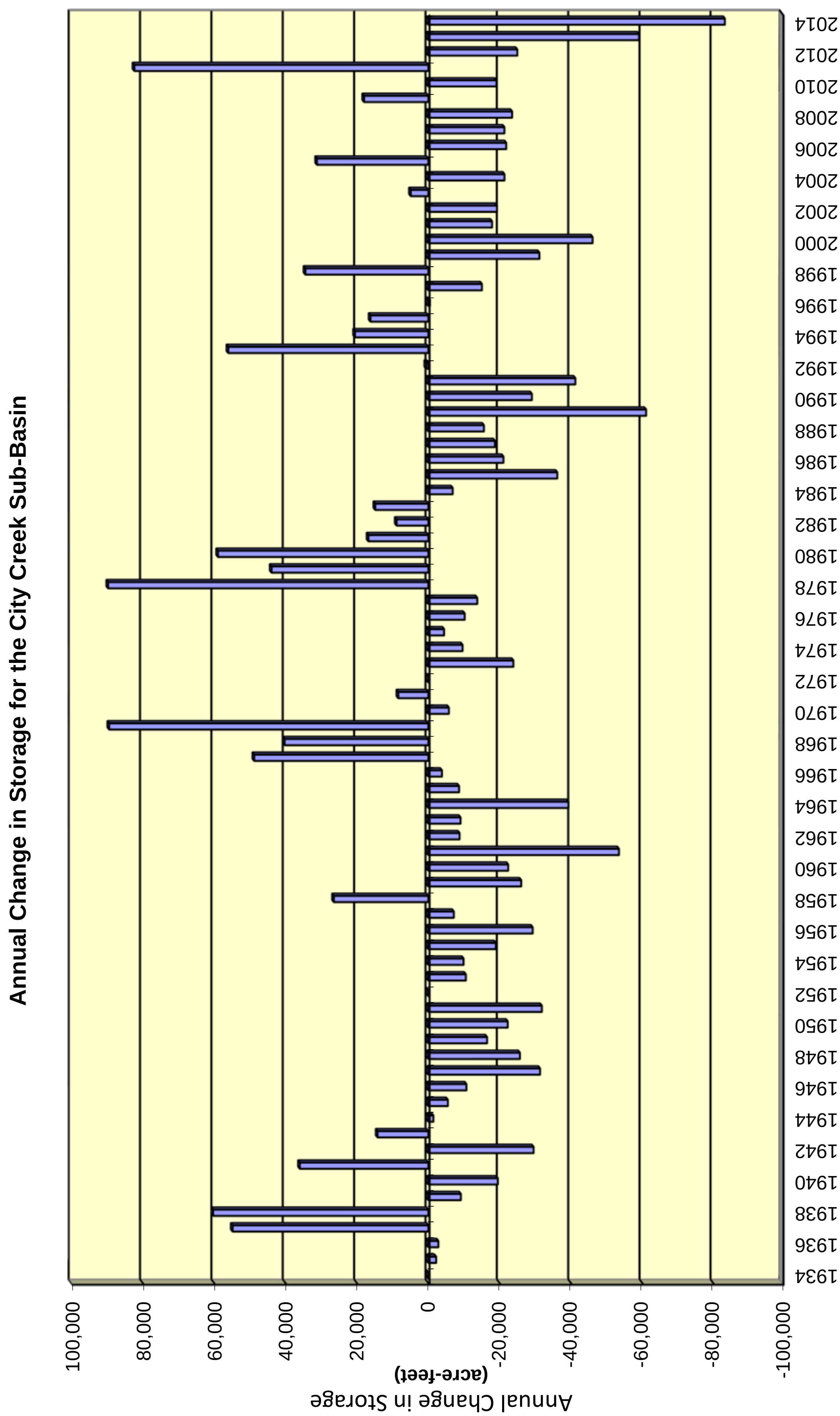
2014


Annual Change in Storage for the City Creek Sub-Basin
Annual Change in Storage
(acre-feet)
100,000
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
-100,000
1934
1936
1938
1940
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1944
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2012
2014

San Bernardino Valley Municipal Water District

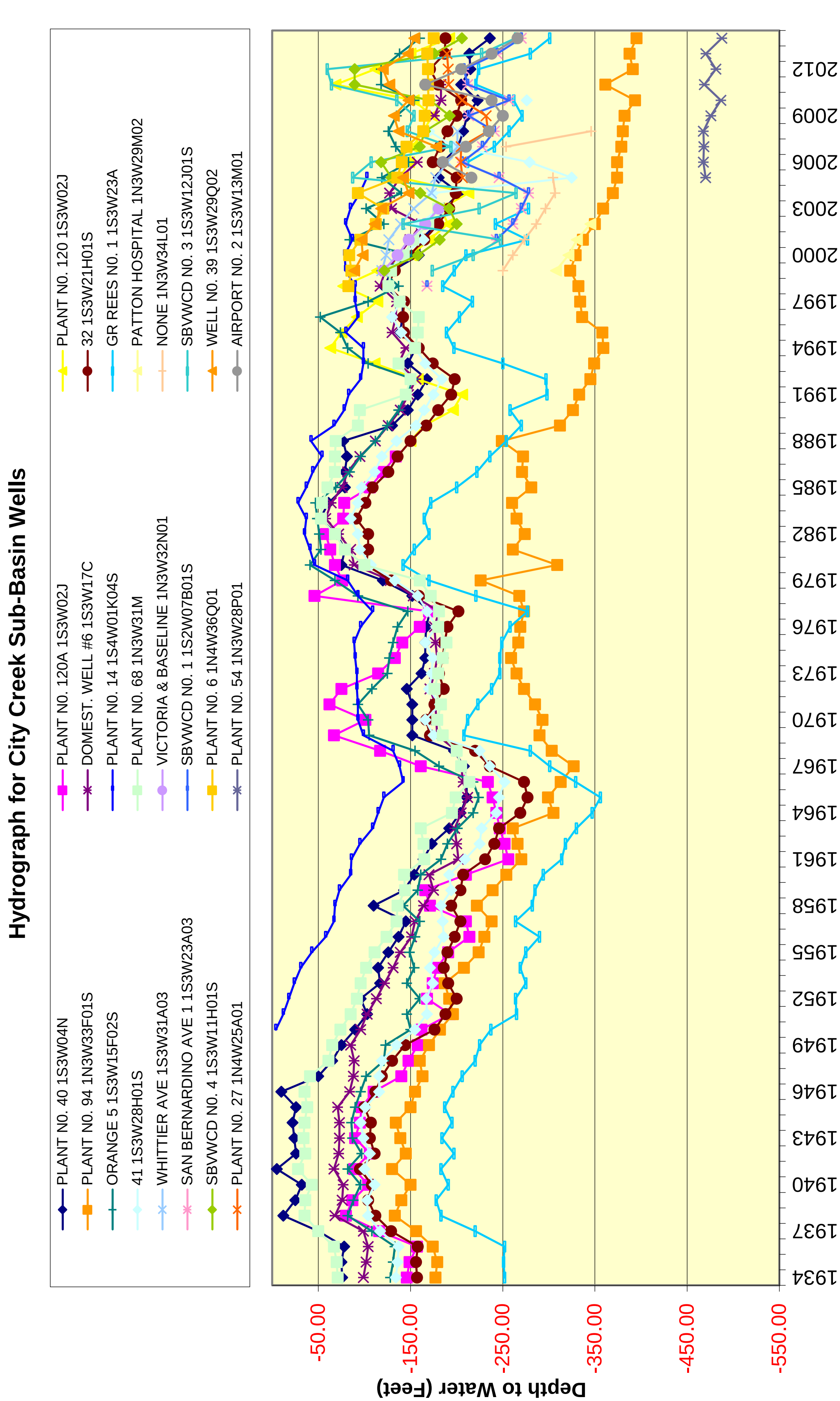
Change In Storage for the City Creek Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	-1	-2,179	-2,179
1936	-1	-2,802	-4,981
1937	24	54,853	49,872
1938	26	60,340	110,212
1939	-3	-9,101	101,111
1940	-8	-19,467	81,644
1941	15	36,016	117,660
1942	-13	-29,496	88,164
1943	7	14,244	102,408
1944	-1	-1,406	101,002
1945	-2	-5,458	95,544
1946	-6	-10,667	84,877
1947	-12	-31,299	53,578
1948	-10	-25,663	27,915
1949	-7	-16,455	11,460
1950	-16	-22,241	-10,781
1951	-13	-31,812	-42,593
1952	-1	-21	-42,614
1953	-4	-10,500	-53,114
1954	-4	-9,873	-62,987
1955	-8	-18,914	-81,901
1956	-12	-29,231	-111,132
1957	-2	-7,142	-118,274
1958	9	26,490	-91,784
1959	-11	-26,023	-117,807
1960	-9	-22,382	-140,189
1961	-21	-53,413	-193,602
1962	-4	-8,760	-202,362
1963	-5	-9,015	-211,377
1964	-17	-39,262	-250,639
1965	-4	-8,605	-259,244
1966	-1	-3,808	-263,052
1967	20	48,813	-214,239
1968	17	40,290	-173,949
1969	40	89,460	-84,489
1970	-1	-5,746	-90,235
1971	2	8,443	-81,792
1972	-1	-318	-82,110
1973	-8	-23,831	-105,941
1974	-3	-9,592	-115,533
1975	-2	-4,410	-119,943
1976	-5	-10,186	-130,129
1977	-7	-13,696	-143,825
1978	36	89,758	-54,067

San Bernardino Valley Municipal Water District

Change In Storage for the City Creek Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	22	43,951	-10,116
1980	21	58,966	48,850
1981	7	16,804	65,654
1982	2	8,897	74,551
1983	6	14,890	89,441
1984	-3	-6,823	82,618
1985	-16	-36,130	46,488
1986	-9	-21,038	25,450
1987	-8	-18,659	6,791
1988	-5	-15,578	-8,787
1989	-26	-61,028	-69,815
1990	-11	-29,017	-98,832
1991	-16	-41,190	-140,022
1992	-2	616	-139,406
1993	23	56,087	-83,319
1994	10	20,573	-62,746
1995	8	16,221	-46,525
1996	0	-453	-46,978
1997	-7	-15,021	-61,999
1998	12	34,478	-27,521
1999	-4	-31,118	-58,639
2000	-20	-46,018	-104,657
2001	-12	-17,857	-122,514
2002	1	-19,242	-141,756
2003	-14	4,923	-136,833
2004	-15	-21,327	-158,160
2005	18	31,225	-126,935
2006	16	-21,828	-148,763
2007	-25	-21,308	-170,071
2008	0	-23,474	-193,545
2009	-2	18,017	-175,528
2010	-17	-19,089	-194,617
2011	43	82,409	-112,208
2012	-7	-24,934	-137,142
2013	-37	-59,051	-196,193
2014	-19	-83,353	-279,546


Hydrograph for City Creek Sub-Basin Wells
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1934
1937
1940
1943
1946
1949
1952
1955
1958
1961
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1967
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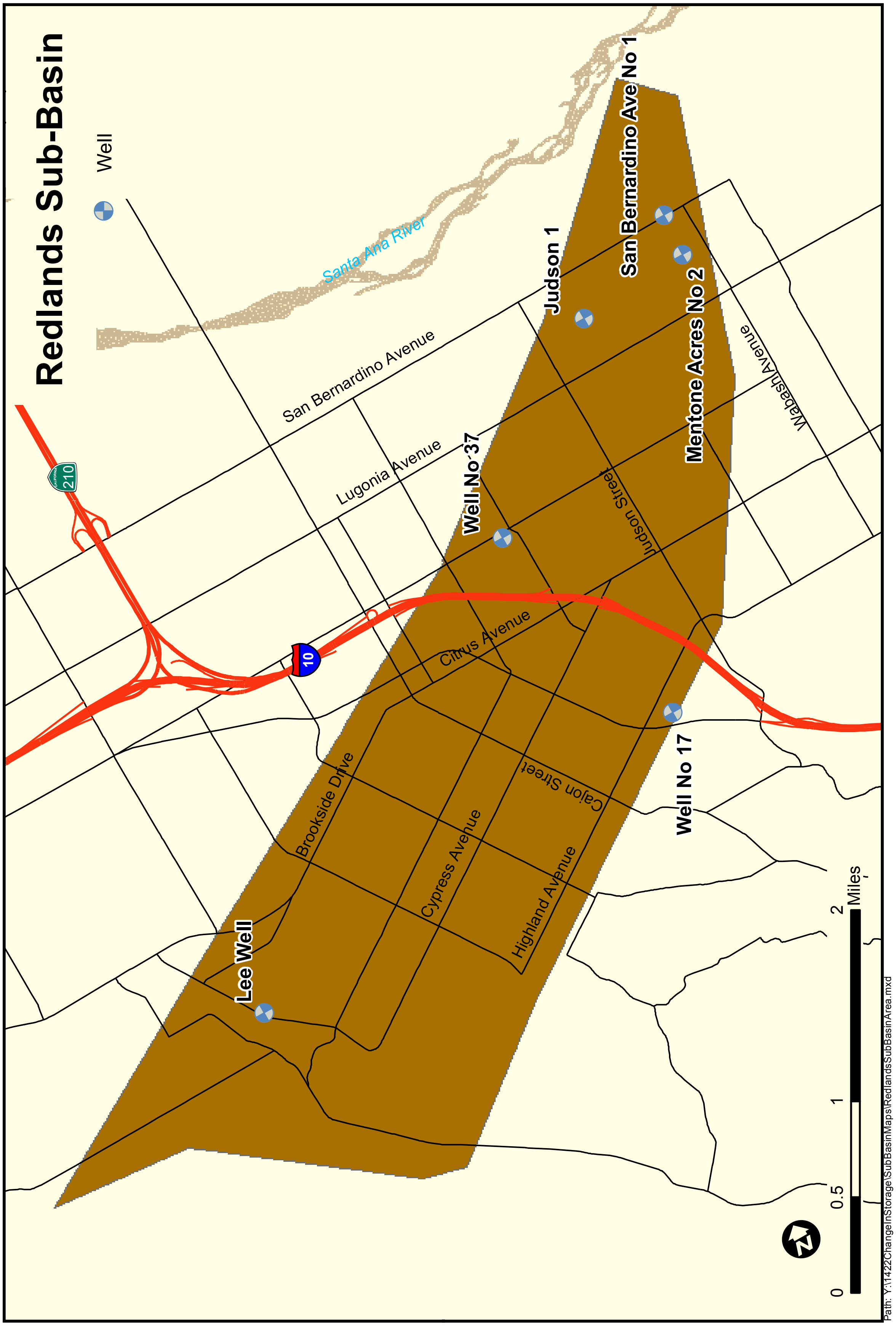
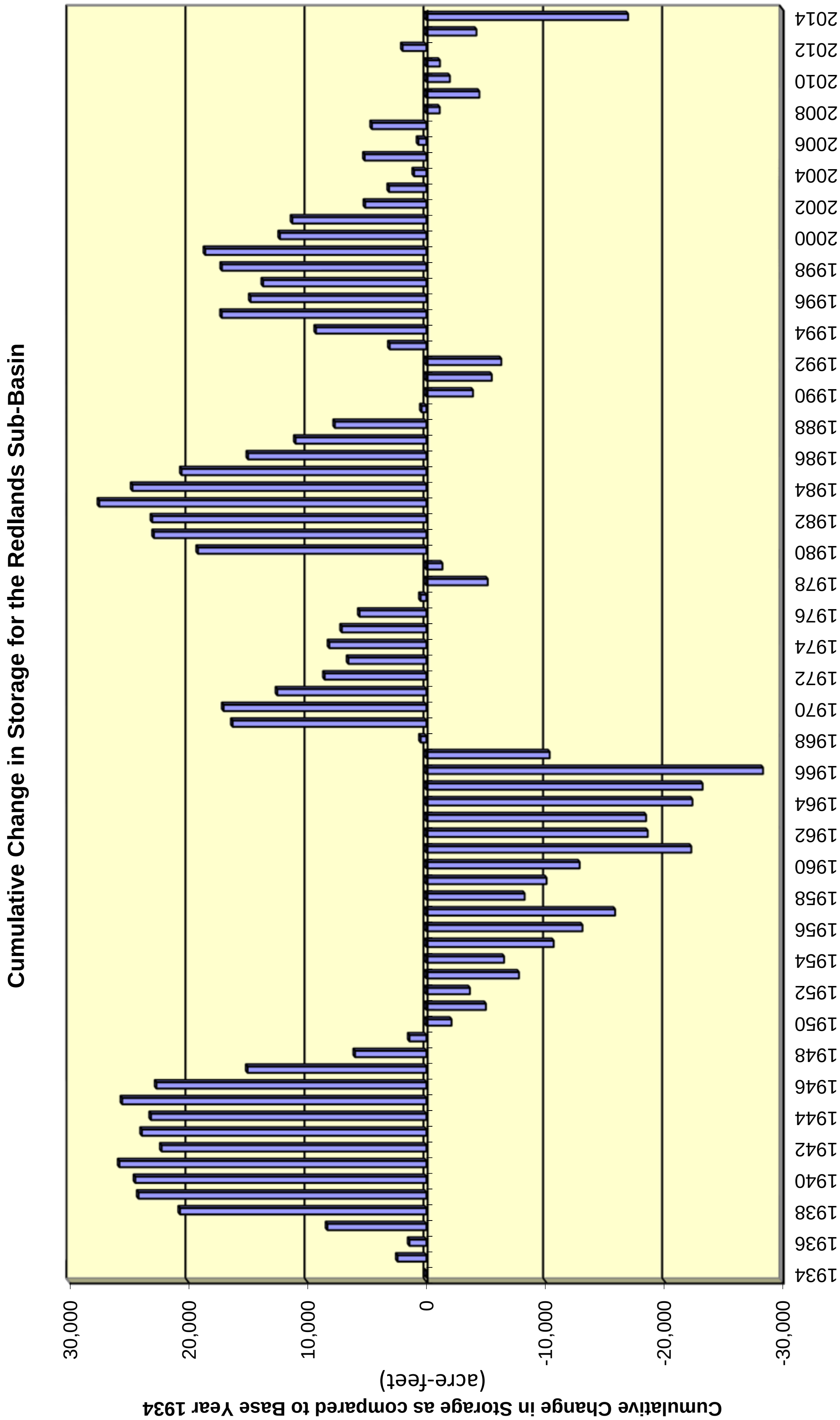
2009
2012
PLANT N0. 40 1S3W04N
PLANT N0. 94 1N3W33F01S
ORANGE 5 1S3W15F02S
41 1S3W28H01S
WHITTIER AVE 1S3W31A03
SAN BERNARDINO AVE 1 1S3W23A03
SBVWCD N0. 4 1S3W11H01S
PLANT N0. 27 1N4W25A01
PLANT N0. 120A 1S3W02J
DOMEST. WELL #6 1S3W17C
PLANT NO. 14 1S4W01K04S
PLANT N0. 68 1N3W31M
VICTORIA & BASELINE 1N3W32N01
SBVWCD N0. 1 1S2W07B01S
PLANT N0. 6 1N4W36Q01
PLANT N0. 54 1N3W28P01
PLANT N0. 120 1S3W02J
32 1S3W21H01S
GR REES NO. 1 1S3W23A
PATTON HOSPITAL 1N3W29M02
NONE 1N3W34L01
SBVWCD NO. 3 1S3W12J01S
WELL NO. 39 1S3W29Q02
AIRPORT N0. 2 1N3W13M01


Redlands Sub-Basin
Well
Santa Ana River
San Bernardino Avenue
Lugonia Avenue
Citrus Avenue
Judson Street
Wabash Avenue
Brookside Drive
Cypress Avenue
Highland Avenue
Cajon Street
Well No 37
Judson 1
San Bernardino Ave No 1
Mentone Acres No 2
Well No 17
Lee Well
210
10
0
0.5
1
2
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\RedlandsSubBasinArea.mxd


Cumulative Change in Storage for the Redlands Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
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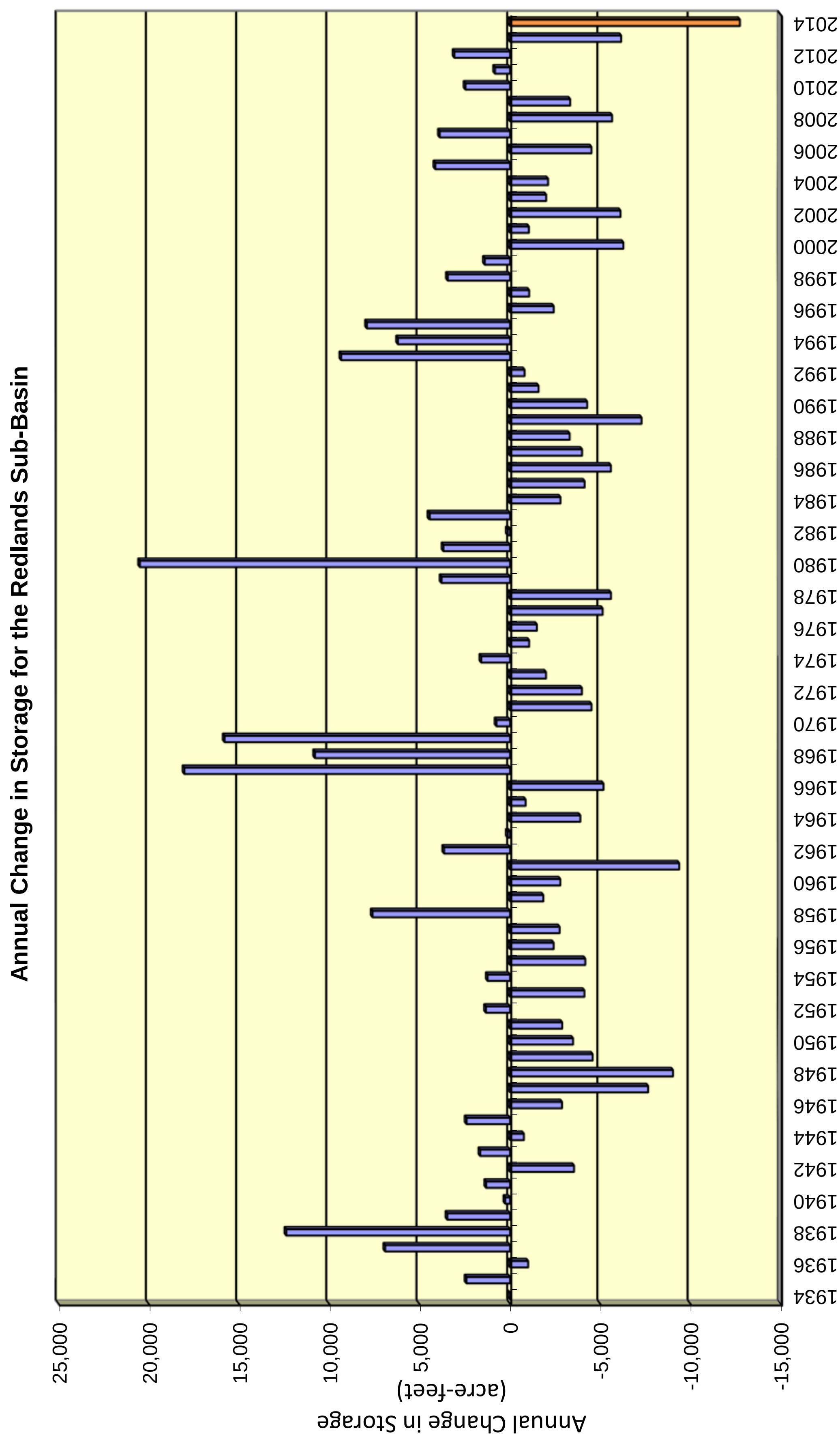
2006
2008
2010
2012
2014



Annual Change in Storage for the Redlands Sub-Basin
Annual Change in Storage
(acre-feet)
25,000
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
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2000
2002
2004
2006
2008
2010
2012
2014

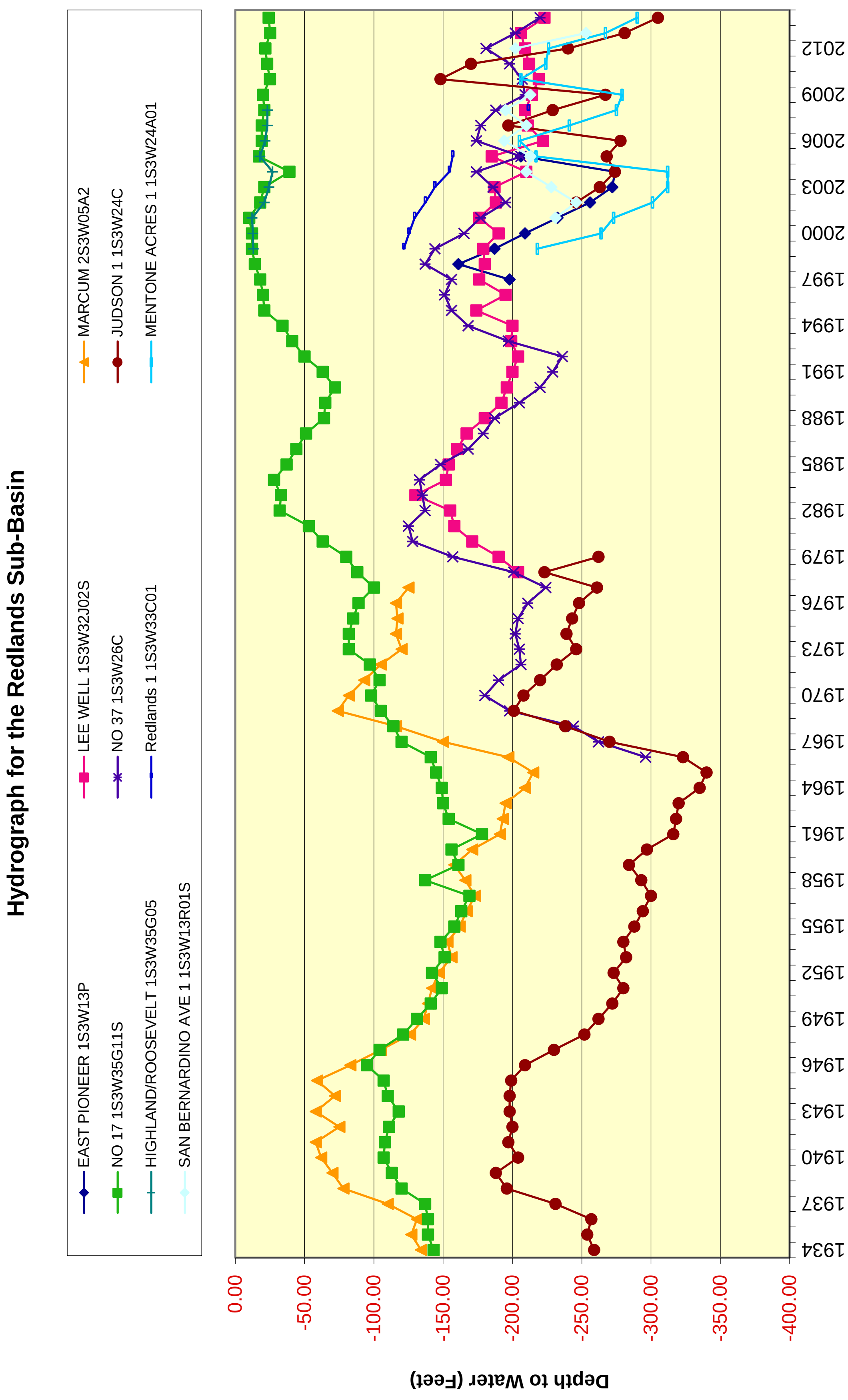
San Bernardino Valley Municipal Water District

Change In Storage for the Redlands Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	5	2,422	2,422
1936	-2	-1,000	1,422
1937	16	6,898	8,320
1938	28	12,380	20,700
1939	8	3,484	24,184
1940	-1	272	24,456
1941	3	1,330	25,786
1942	-8	-3,543	22,243
1943	4	1,658	23,901
1944	-2	-764	23,137
1945	5	2,417	25,554
1946	-7	-2,877	22,677
1947	-17	-7,651	15,026
1948	-20	-9,030	5,996
1949	-10	-4,575	1,421
1950	-8	-3,489	-2,068
1951	-6	-2,885	-4,953
1952	3	1,342	-3,611
1953	-9	-4,118	-7,729
1954	3	1,246	-6,483
1955	-9	-4,166	-10,649
1956	-5	-2,414	-13,063
1957	-6	-2,745	-15,808
1958	15	7,599	-8,209
1959	-2	-1,842	-10,051
1960	-7	-2,781	-12,832
1961	-20	-9,375	-22,207
1962	7	3,658	-18,549
1963	0	140	-18,409
1964	-9	-3,892	-22,301
1965	-2	-860	-23,161
1966	13	-5,177	-28,338
1967	39	18,026	-10,312
1968	23	10,790	478
1969	34	15,801	16,279
1970	3	759	17,038
1971	-10	-4,512	12,526
1972	-8	-3,981	8,545
1973	-3	-1,990	6,555
1974	4	1,601	8,156
1975	-3	-1,055	7,101
1976	-4	-1,485	5,616
1977	-12	-5,133	483
1978	24	-5,591	-5,108

San Bernardino Valley Municipal Water District
Change In Storage for the Redlands Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	7	3,805	-1,303
1980	22	20,494	19,191
1981	9	3,700	22,891
1982	4	140	23,031
1983	9	4,455	27,486
1984	-5	-2,791	24,695
1985	-9	-4,131	20,564
1986	-11	-5,586	14,978
1987	-8	-3,988	10,990
1988	-11	-3,303	7,687
1989	-10	-7,285	402
1990	-9	-4,273	-3,871
1991	-1	-1,576	-5,447
1992	1	-802	-6,249
1993	18	9,337	3,088
1994	12	6,189	9,277
1995	17	7,913	17,190
1996	-5	-2,416	14,774
1997	5	-1,057	13,717
1998	14	3,457	17,174
1999	-8	1,407	18,581
2000	-15	-6,279	12,302
2001	-5	-1,040	11,262
2002	-15	-6,120	5,142
2003	-6	-2,001	3,141
2004	-7	-2,104	1,037
2005	21	4,150	5,187
2006	1	-4,510	677
2007	5	3,900	4,577
2008	-9	-5,652	-1,075
2009	-14	-3,331	-4,406
2010	5	2,475	-1,931
2011	-3	840	-1,091
2012	19	3,089	1,998
2013	-26	-6,156	-4,159
2014	-35	-12,738	-16,897


Hydrograph for the Redlands Sub-Basin
EAST PIONEER 1S3W13P
NO 17 1S3W35G11S
HIGHLAND/ROOSEVELT 1S3W35G05
SAN BERNARDINO AVE 1 1S3W13R01S
LEE WELL 1S3W32J02S
NO 37 1S3W26C
Redlands 1 1S3W33C01
MARCUM 2S3W05A2
JUDSON 1 1S3W24C
MENTONE ACRES 1 1S3W24A01
Depth to Water (Feet)
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
-400.00
1934
1937
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1943
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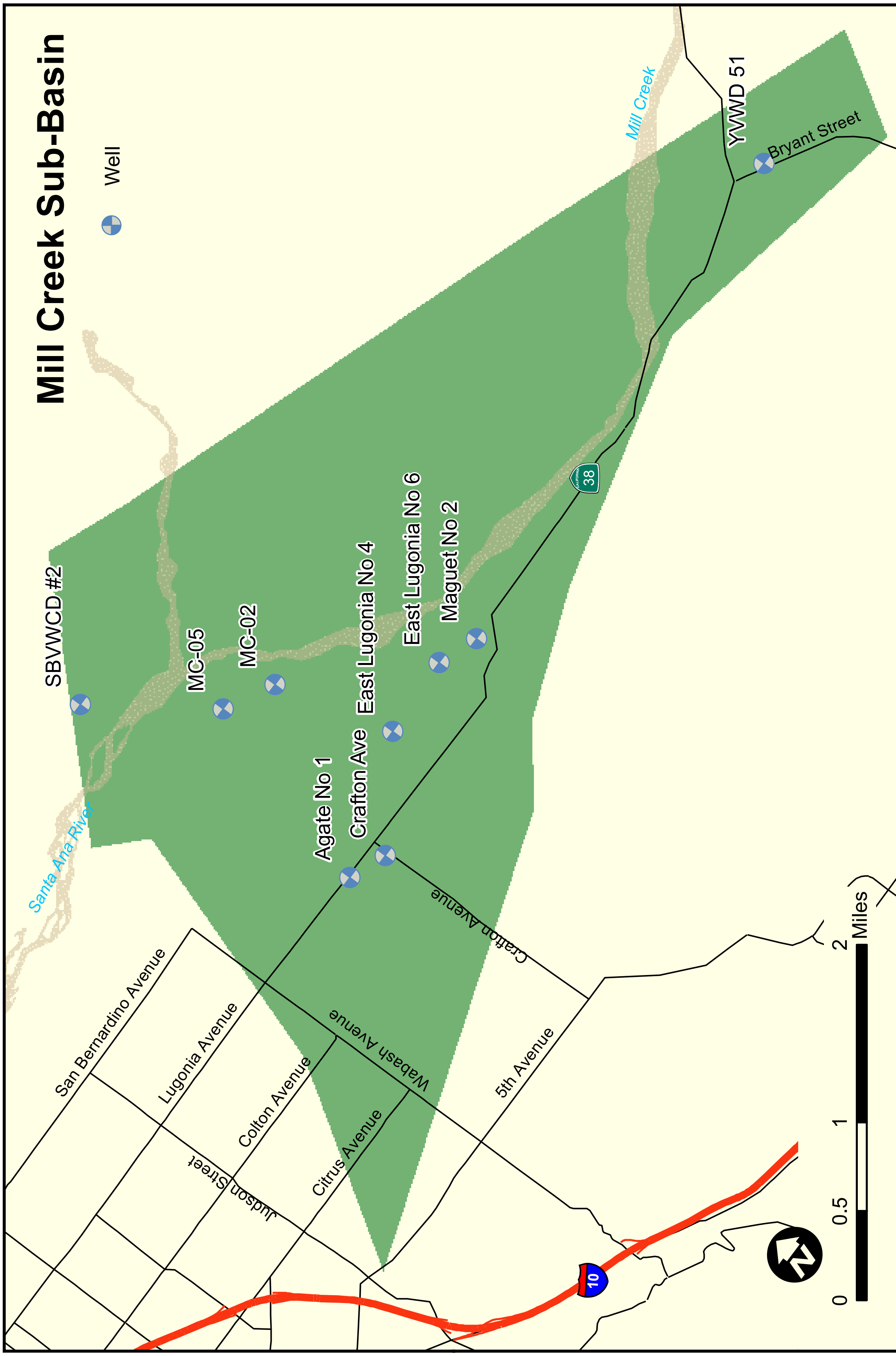
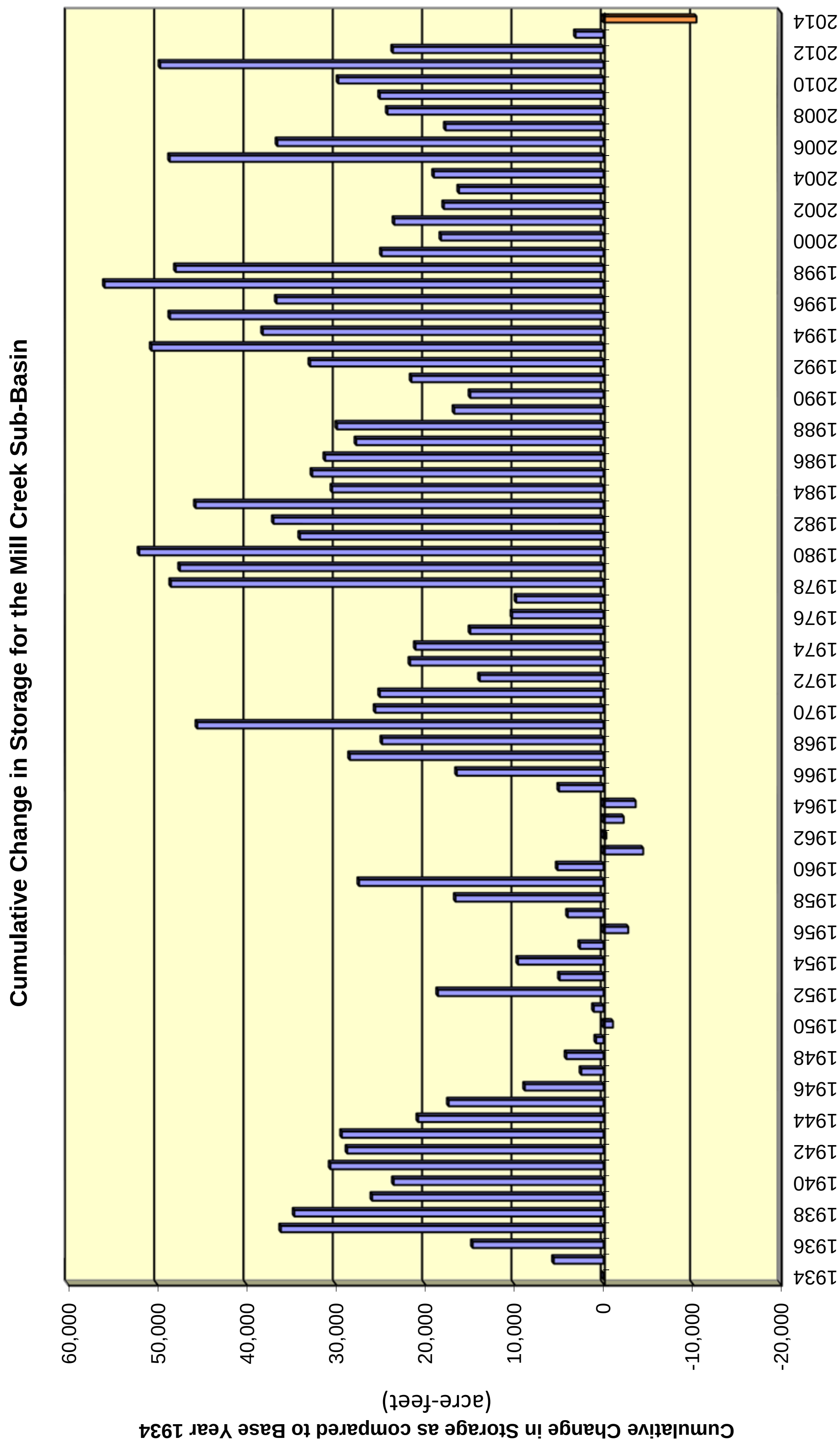
2012



Path: \\Gisws\gisprojects\1422ChangeInStorage\1422CIS2012\WorkingData\aSubBasinMXDsforMaps\MillCreekSubBasinArea.mxd


Cumulative Change in Storage for the Mill Creek Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
60,000
50,000
40,000
30,000
20,000
10,000
0
-10,000
-20,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
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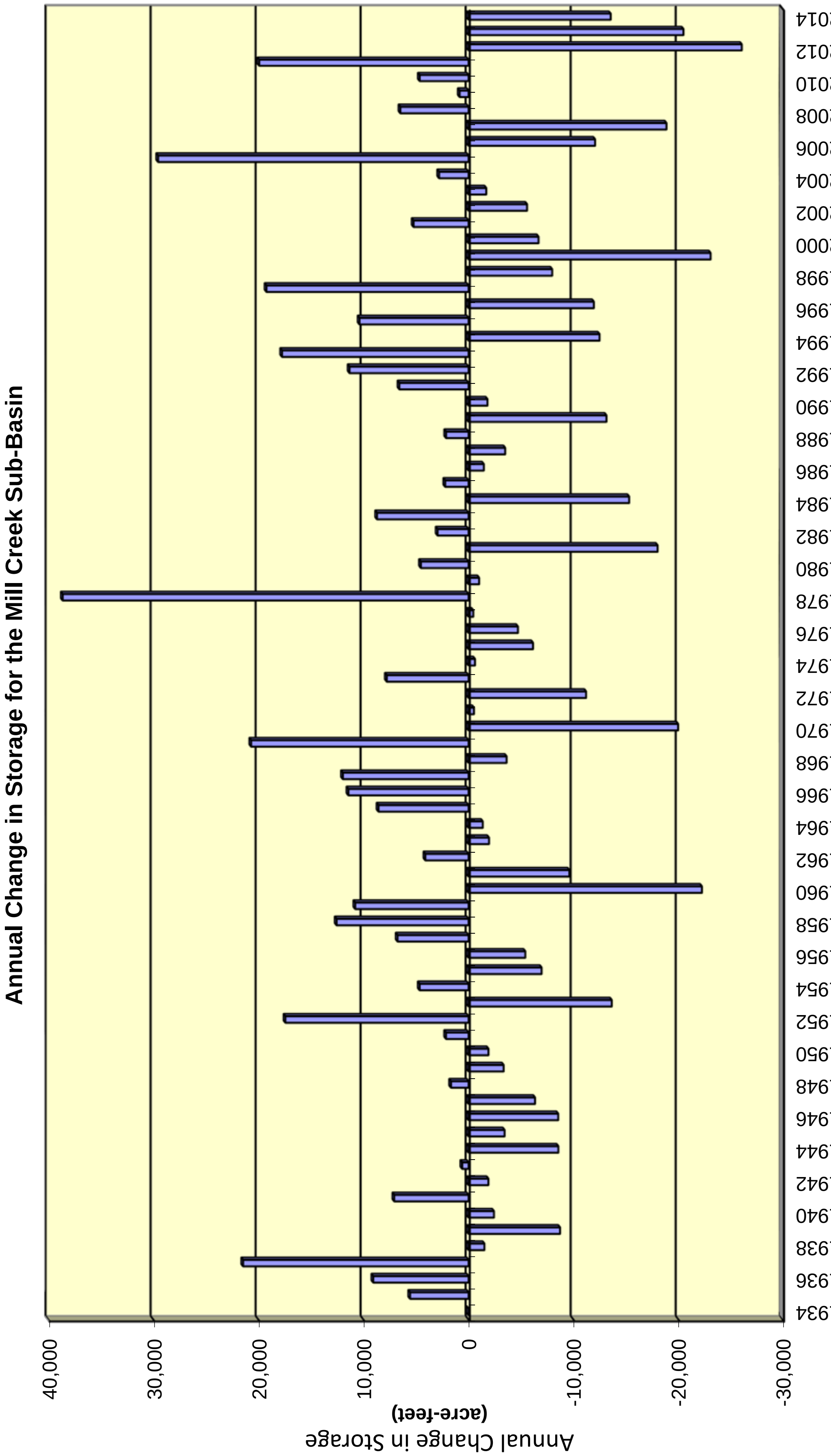
2014


Annual Change in Storage for the Mill Creek Sub-Basin
Annual Change in Storage
(acre-feet)
40,000
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
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2008
2010
2012
2014

San Bernardino Valley Municipal Water District

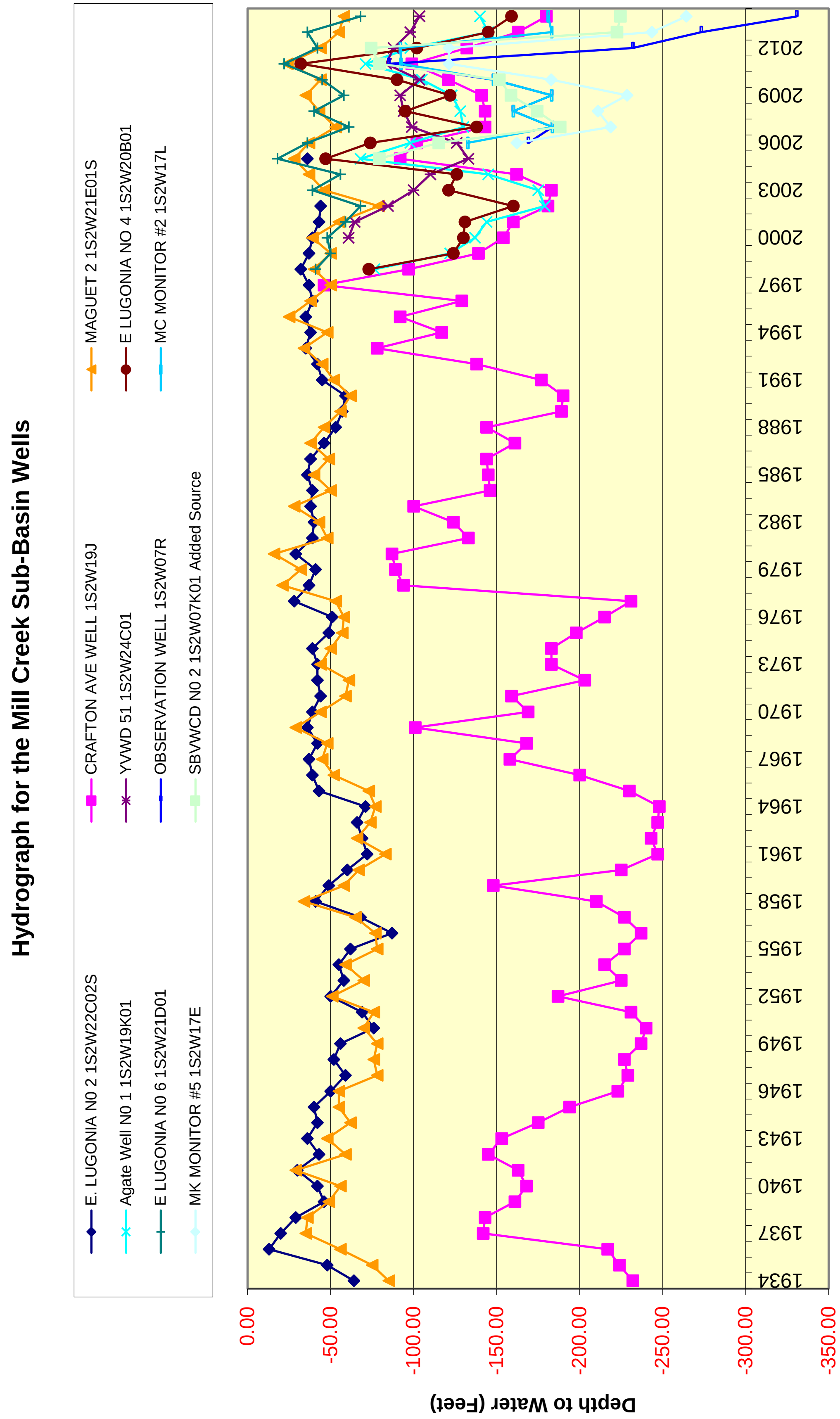
Change In Storage for the Mill Creek Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	11	5,575	5,575
1936	20	9,081	14,656
1937	30	21,472	36,128
1938	-4	-1,506	34,622
1939	-16	-8,705	25,917
1940	-3	-2,412	23,505
1941	15	7,081	30,586
1942	-8	-1,883	28,703
1943	3	608	29,311
1944	-14	-8,542	20,769
1945	-3	-3,421	17,348
1946	-13	-8,531	8,817
1947	-13	-6,322	2,495
1948	4	1,677	4,172
1949	-5	-3,332	840
1950	-5	-1,890	-1,050
1951	3	2,151	1,101
1952	29	17,447	18,548
1953	-22	-13,629	4,919
1954	8	4,664	9,583
1955	-13	-6,947	2,636
1956	-11	-5,394	-2,758
1957	14	6,767	4,009
1958	25	12,574	16,583
1959	10	10,797	27,380
1960	-32	-22,220	5,160
1961	-17	-9,592	-4,432
1962	8	4,121	-311
1963	-3	-1,939	-2,250
1964	-3	-1,344	-3,594
1965	17	8,585	4,991
1966	18	11,449	16,440
1967	17	11,973	28,413
1968	-6	-3,615	24,798
1969	31	20,705	45,503
1970	-29	-19,947	25,556
1971	-3	-507	25,049
1972	-15	-11,184	13,865
1973	12	7,794	21,659
1974	-1	-605	21,054
1975	-11	-6,130	14,924
1976	-7	-4,694	10,230
1977	4	-440	9,790
1978	53	38,652	48,442

San Bernardino Valley Municipal Water District

Change In Storage for the Mill Creek Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	-3	-1,001	47,441
1980	10	4,546	51,987
1981	-29	-17,993	33,994
1982	4	2,958	36,952
1983	14	8,723	45,675
1984	-23	-15,284	30,391
1985	5	2,232	32,623
1986	-3	-1,445	31,178
1987	-5	-3,482	27,696
1988	1	2,148	29,844
1989	-20	-13,125	16,719
1990	-3	-1,796	14,923
1991	12	6,593	21,516
1992	16	11,338	32,854
1993	26	17,767	50,621
1994	-19	-12,468	38,153
1995	17	10,390	48,543
1996	-18	-11,923	36,620
1997	24	19,248	55,868
1998	-30	-7,957	47,911
1999	-27	-23,059	24,852
2000	-12	-6,656	18,196
2001	-7	5,243	23,439
2002	-20	-5,565	17,874
2003	19	-1,681	16,193
2004	4	2,811	19,004
2005	41	29,567	48,571
2006	-18	-12,042	36,529
2007	-41	-18,835	17,694
2008	13	6,498	24,192
2009	-7	856	25,048
2010	17	4,657	29,705
2011	41	19,938	49,643
2012	-32	-26,058	23,585
2013	-54	-20,455	3,130
2014	-14	-13,527	-10,397


Hydrograph for the Mill Creek Sub-Basin Wells
E. LUGONIA N0 2 1S2W22C02S
Agate Well N0 1 1S2W19K01
E LUGONIA N0 6 1S2W21D01
MK MONITOR #5 1S2W17E
CRAFTON AVE WELL 1S2W19J
YVWD 51 1S2W24C01
OBSERVATION WELL 1S2W07R
SBVWCD N0 2 1S2W07K01 Added Source
MAGUET 2 1S2W21E01S
E LUGONIA NO 4 1S2W20B01
MC MONITOR #2 1S2W17L
Depth to Water (Feet)
0.00
-50.00
-100.00
-150.00
-200.00
-250.00
-300.00
-350.00
1934
1937
1940
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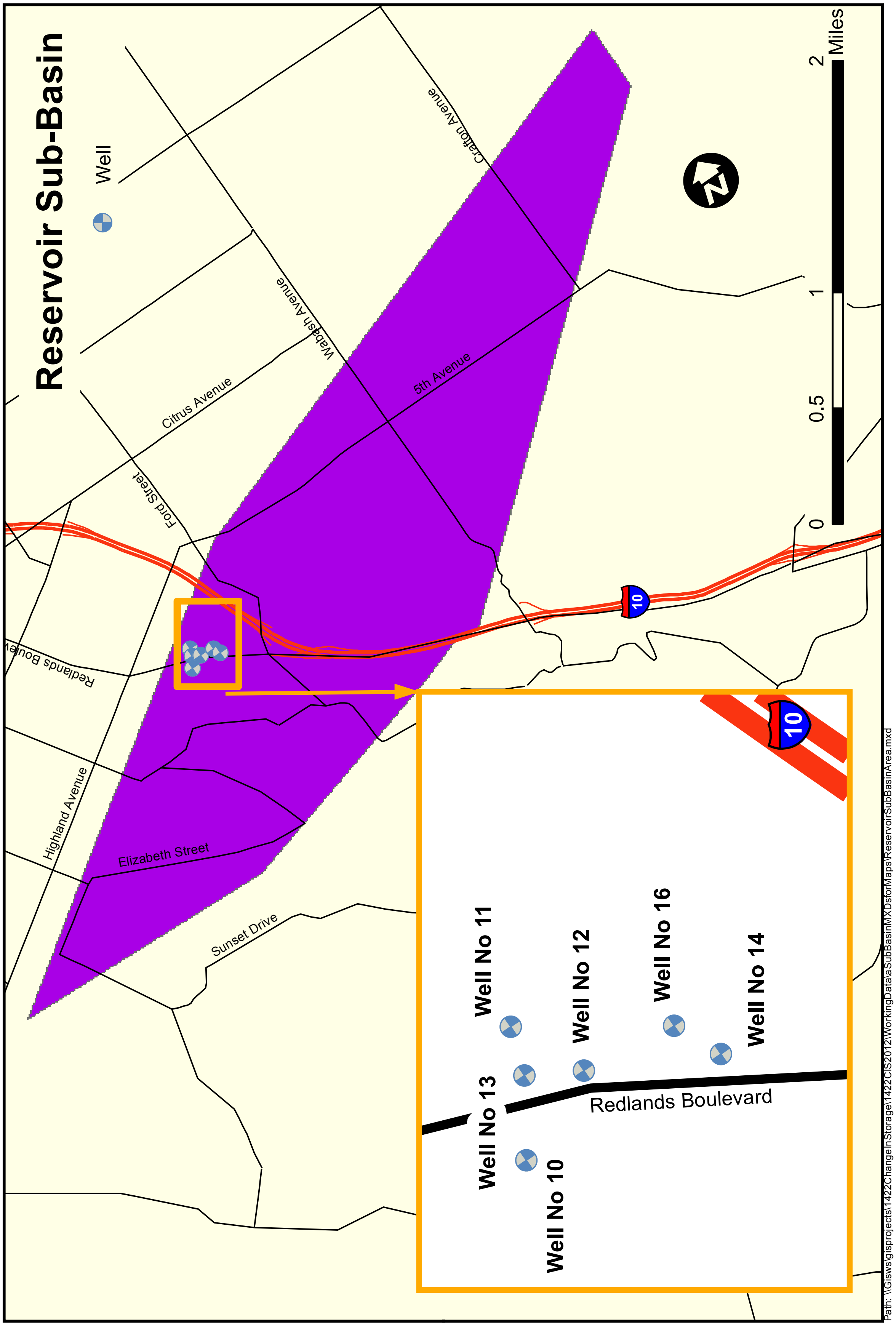
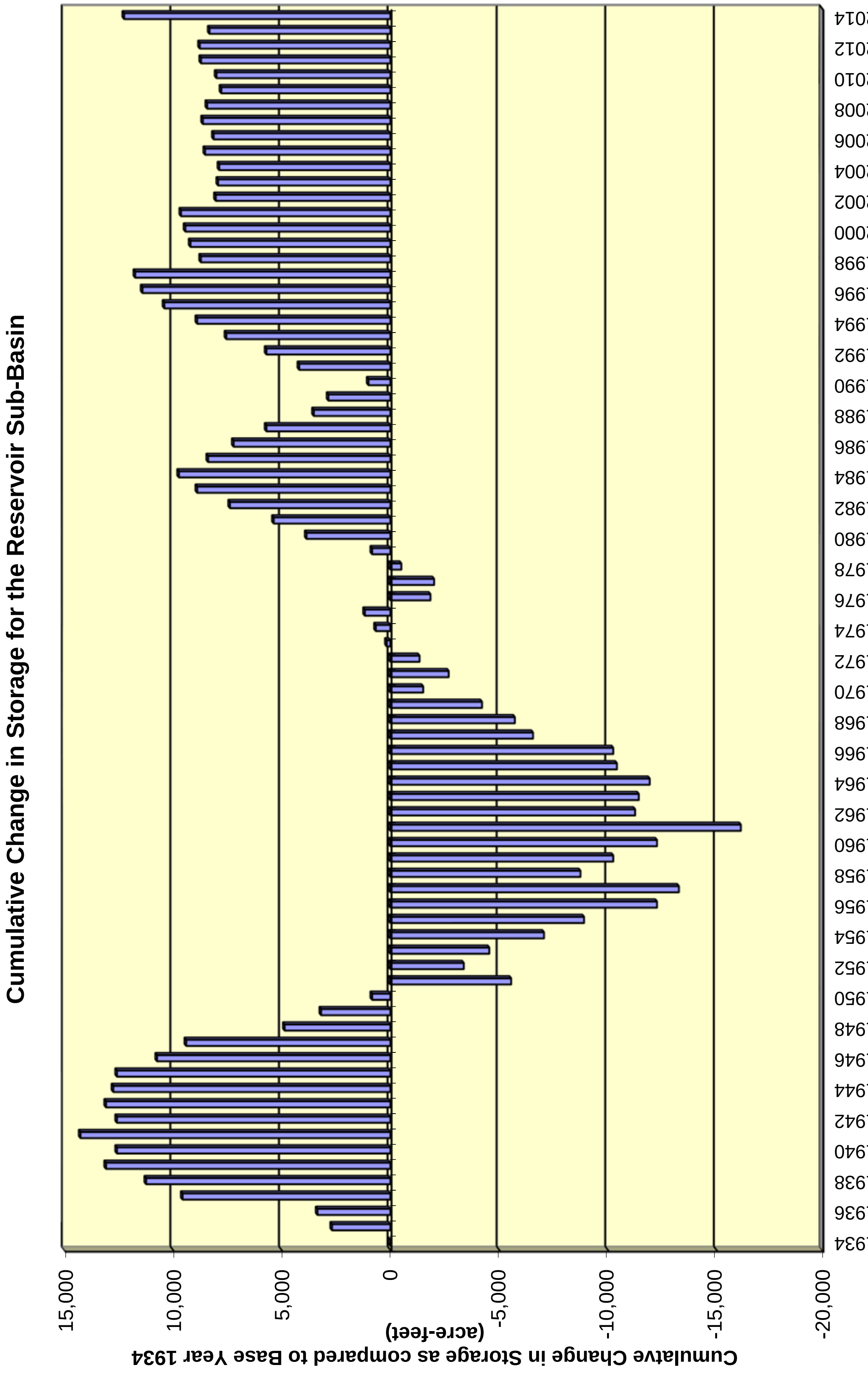
2003
2006
2009
2012



Reservoir Sub-Basin
Well
Crafton Avenue
Wabash Avenue
Citrus Avenue
5th Avenue
Ford Street
Redlands Boulev
Highland Avenue
Elizabeth Street
Sunset Drive
10
0
0.5
1
2
Miles
Well No 11
Well No 12
Well No 16
Well No 14
Well No 13
Well No 10
Redlands Boulevard
Path: \\Gisws\gisprojects\1422ChangeInStorage\1422CIS2012\WorkingData\aSubBasinMXDsforMaps\ReservoirSubBasinArea.mxd


Cumulative Change in Storage for the Reservoir Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
1934
1936
1938
1940
1942
1944
1946
1948
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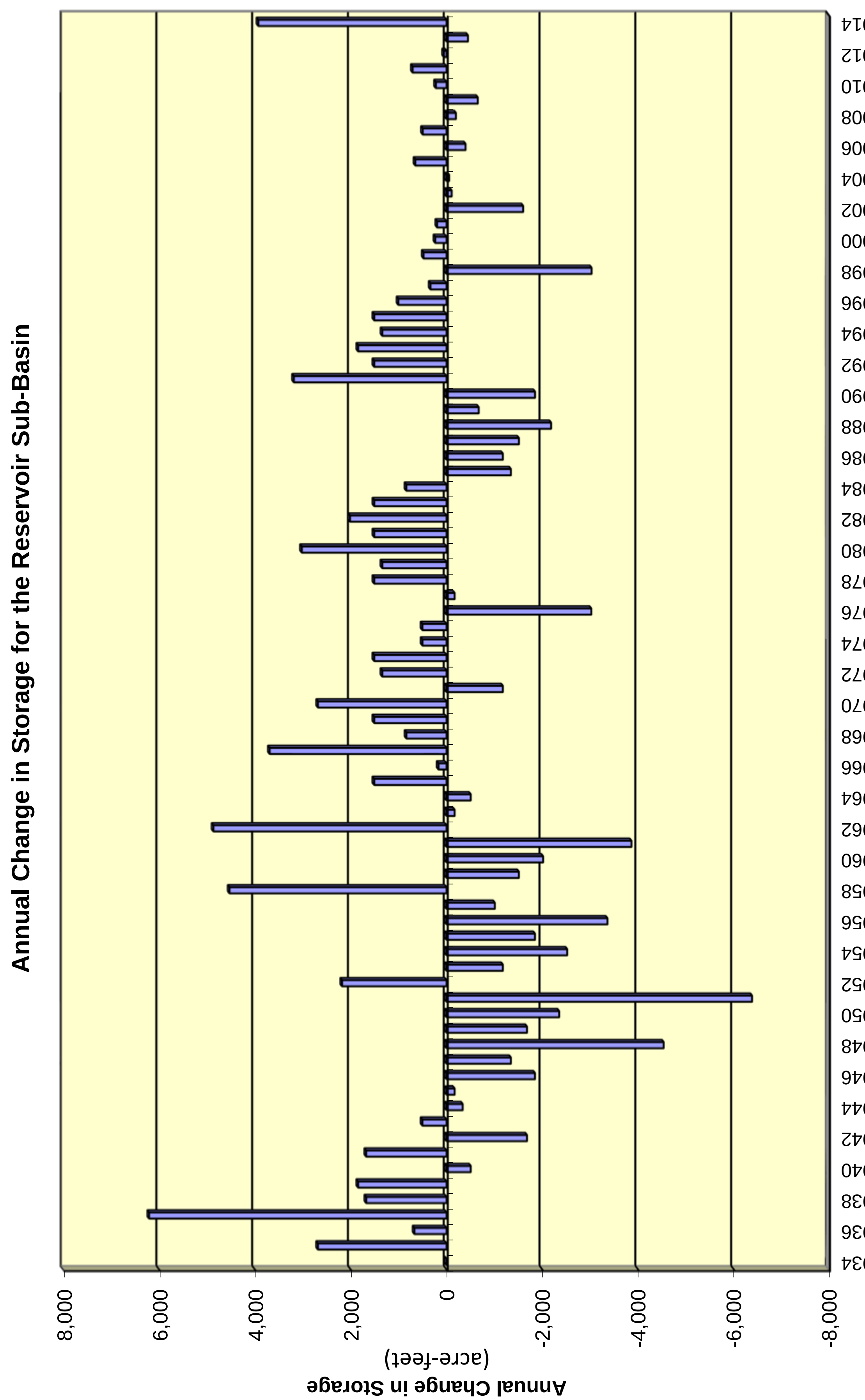

Annual Change in Storage for the Reservoir Sub-Basin
Annual Change in Storage
(acre-feet)
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
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2006
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2010
2012
2014

San Bernardino Valley Municipal Water District

Change In Storage for the Reservoir Sub-basin 1934 - 2014

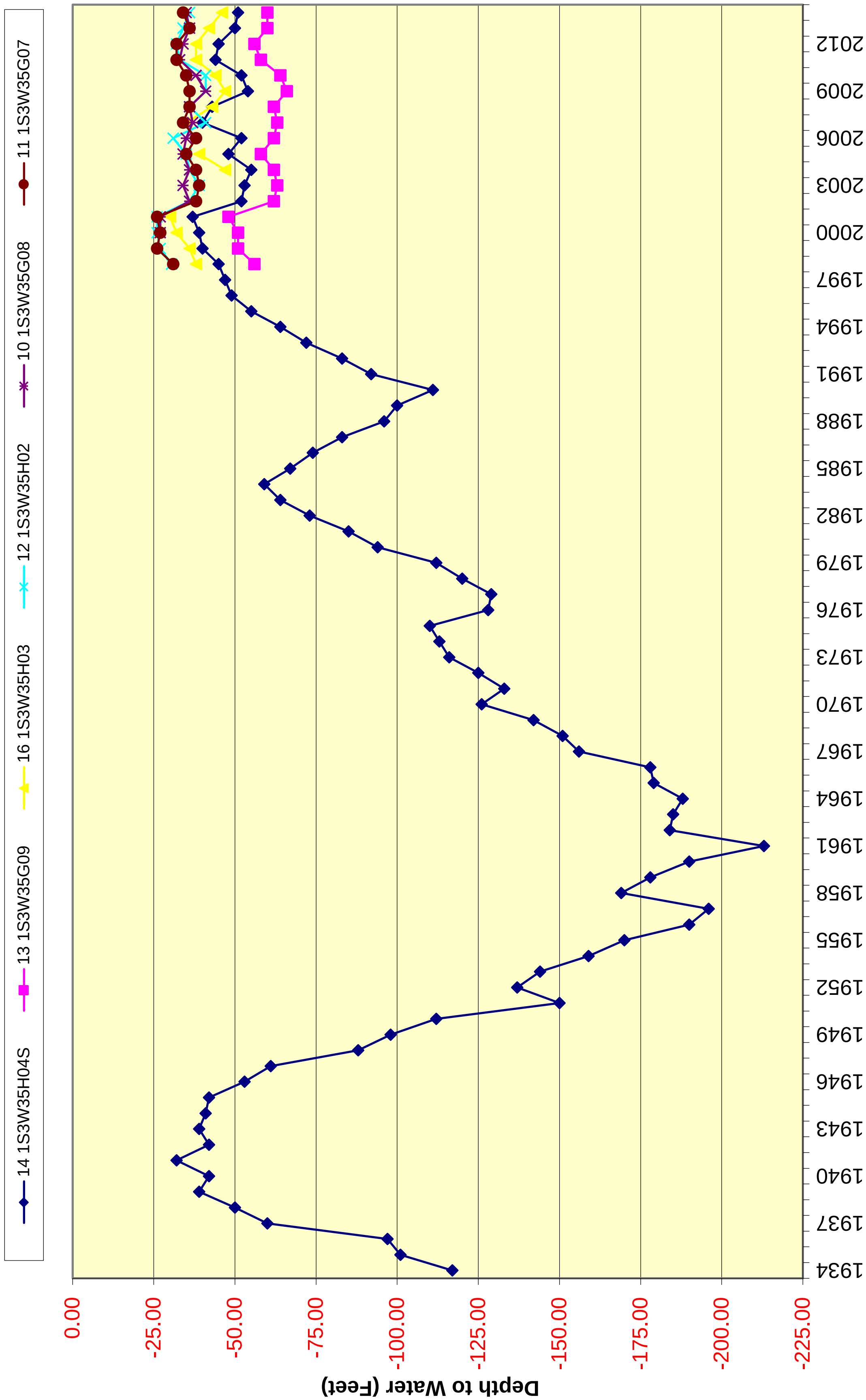
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	16	2,686	2,686
1936	4	671	3,357
1937	37	6,211	9,568
1938	10	1,678	11,246
1939	11	1,847	13,093
1940	-3	-504	12,589
1941	10	1,679	14,268
1942	-10	-1,679	12,589
1943	3	504	13,093
1944	-2	-336	12,757
1945	-1	-168	12,589
1946	-11	-1,846	10,743
1947	-8	-1,343	9,400
1948	-27	-4,532	4,868
1949	-10	-1,679	3,189
1950	-14	-2,350	839
1951	-38	-6,378	-5,539
1952	13	2,182	-3,357
1953	-7	-1,175	-4,532
1954	-15	-2,518	-7,050
1955	-11	-1,846	-8,896
1956	-20	-3,358	-12,254
1957	-6	-1,007	-13,261
1958	27	4,532	-8,729
1959	-9	-1,510	-10,239
1960	-12	-2,015	-12,254
1961	-23	-3,860	-16,114
1962	29	4,868	-11,246
1963	-1	-168	-11,414
1964	-3	-504	-11,918
1965	9	1,511	-10,407
1966	1	168	-10,239
1967	22	3,693	-6,546
1968	5	839	-5,707
1969	9	1,511	-4,196
1970	16	2,685	-1,511
1971	-7	-1,175	-2,686
1972	8	1,343	-1,343
1973	9	1,511	168
1974	3	503	671
1975	3	504	1,175
1976	-18	-3,021	-1,846
1977	-1	-168	-2,014
1978	9	1,510	-504

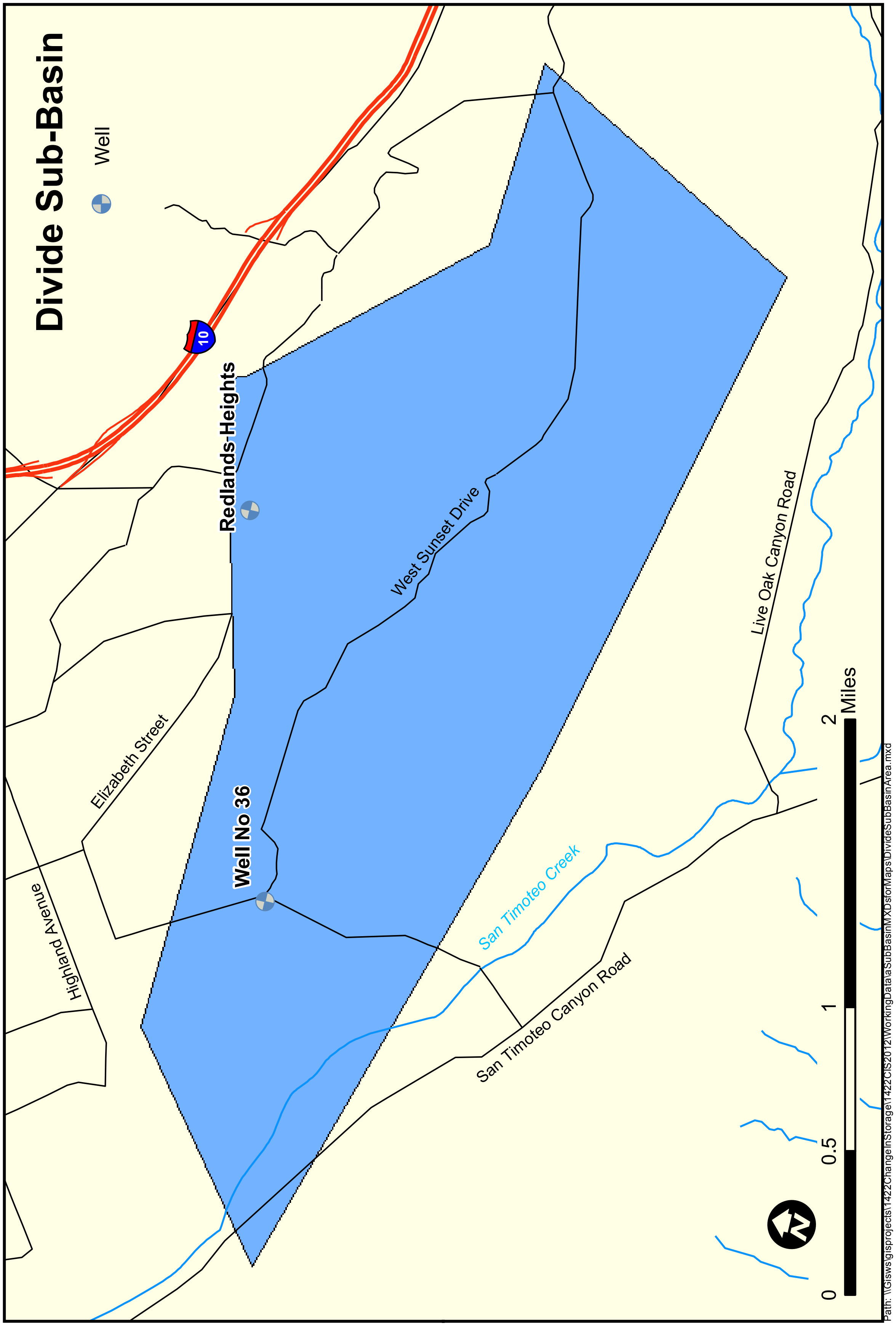
San Bernardino Valley Municipal Water District

Change In Storage for the Reservoir Sub-basin 1934 - 2014

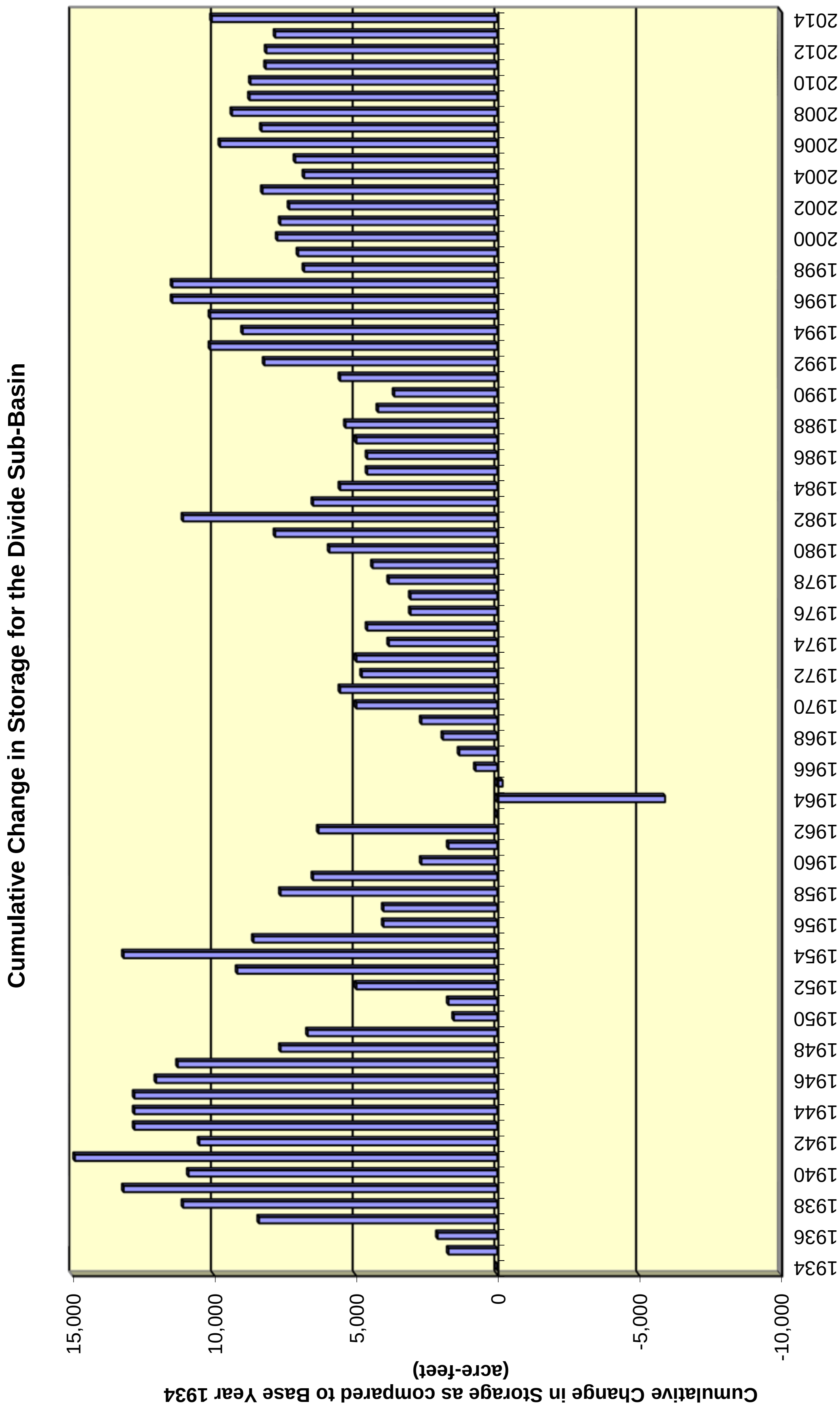
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	8	1,343	839
1980	18	3,022	3,861
1981	9	1,510	5,371
1982	12	2,015	7,386
1983	9	1,510	8,896
1984	5	840	9,736
1985	-8	-1,343	8,393
1986	-7	-1,175	7,218
1987	-9	-1,511	5,707
1988	-13	-2,182	3,525
1989	-4	-671	2,854
1990	-11	-1,847	1,007
1991	19	3,189	4,196
1992	9	1,511	5,707
1993	11	1,847	7,554
1994	8	1,342	8,896
1995	9	1,511	10,407
1996	6	1,007	11,414
1997	2	336	11,750
1998	-31	-3,027	8,723
1999	4	481	9,204
2000	-4	236	9,440
2001	1	197	9,637
2002	-5	-1,598	8,039
2003	-1	-106	7,933
2004	-8	-54	7,879
2005	4	652	8,531
2006	-2	-396	8,135
2007	1	497	8,632
2008	-1	-195	8,437
2009	-5	-652	7,785
2010	2	224	8,009
2011	6	708	8,717
2012	0	55	8,773
2013	-4	-446	8,327
2014	-1	3,931	12,258

Hydrograph for the Reservoir Sub-Basin Wells





Divide Sub-Basin
Well
10
Redlands-Heights
Well No 36
West Sunset Drive
Elizabeth Street
Highland Avenue
Live Oak Canyon Road
San Timoteo Creek
San Timoteo Canyon Road
0
0.5
1
2
Miles
Path: \\Gisws\gisprojects\1422ChangeinStorage\1422GIS2012\WorkingData\aSubBasin\MXDs\forMaps\DivideSubBasinArea.mxd


Cumulative Change in Storage for the Divide Sub-Basin
Cumulative Change in Storage as compared to Base Year 1934
(acre-feet)
15,000
10,000
5,000
0
-5,000
-10,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
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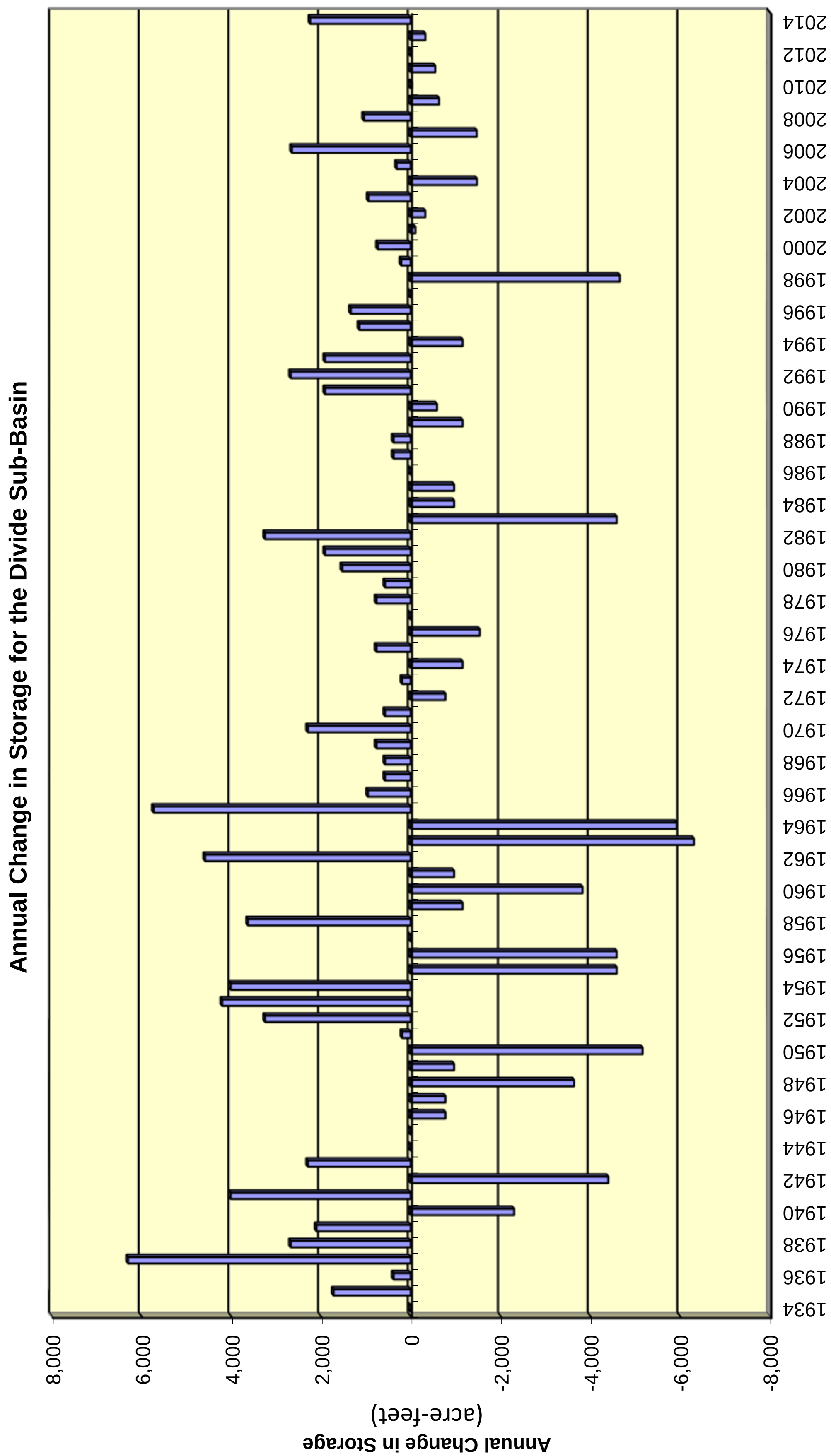
2002
2004
2006
2008
2010
2012
2014

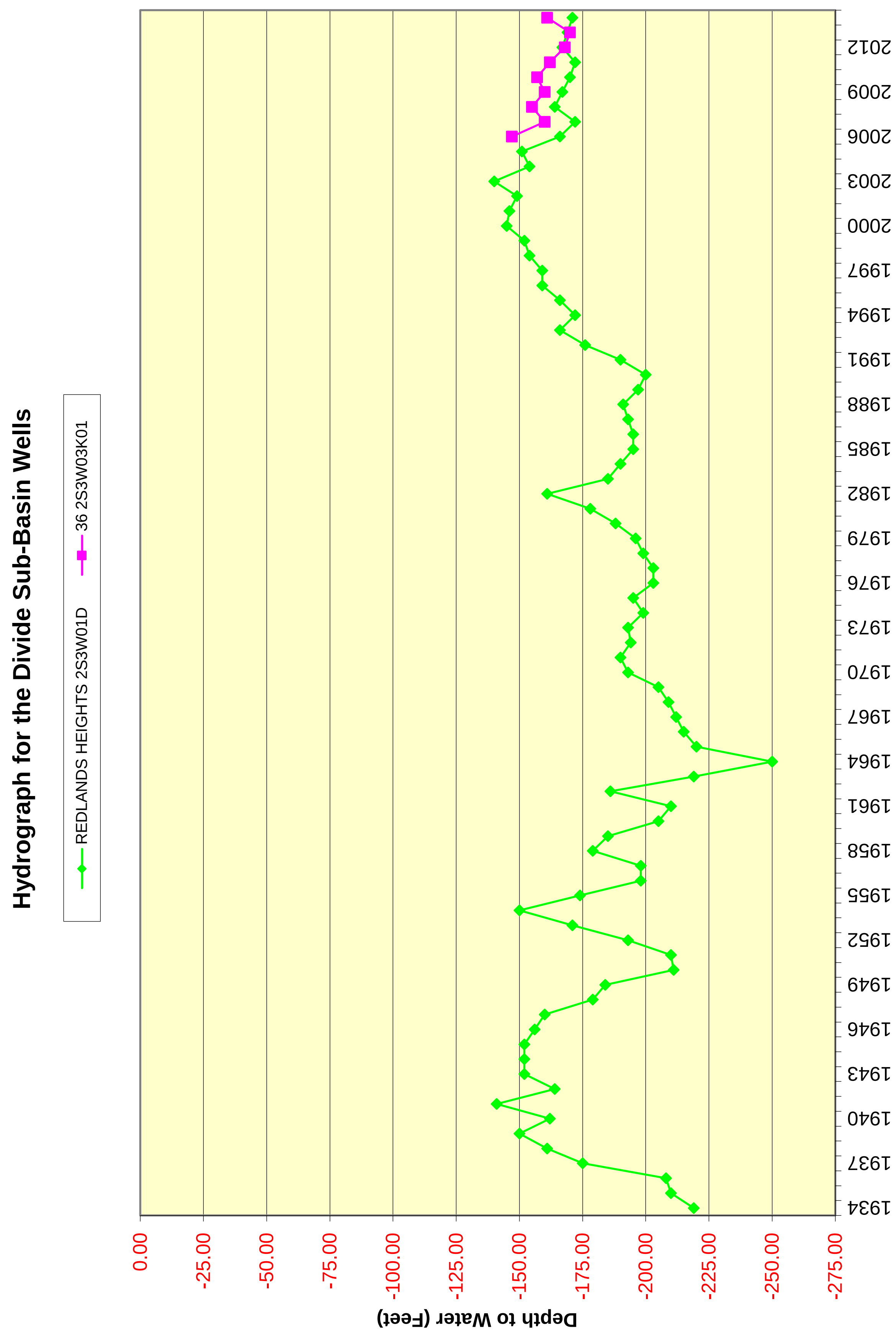

Annual Change in Storage for the Divide Sub-Basin
Annual Change in Storage
(acre-feet)
8,000
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
-8,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

San Bernardino Valley Municipal Water District
Change In Storage for the Divide Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1934	0	n/a	0
1935	9	1,719	1,719
1936	2	382	2,101
1937	33	6,304	8,405
1938	14	2,675	11,080
1939	11	2,101	13,181
1940	-12	-2,292	10,889
1941	21	4,012	14,901
1942	-23	-4,394	10,507
1943	12	2,292	12,799
1944	0	0	12,799
1945	0	0	12,799
1946	-4	-764	12,035
1947	-4	-764	11,271
1948	-19	-3,630	7,641
1949	-5	-955	6,686
1950	-27	-5,158	1,528
1951	1	191	1,719
1952	17	3,248	4,967
1953	22	4,203	9,170
1954	21	4,011	13,181
1955	-24	-4,585	8,596
1956	-24	-4,584	4,012
1957	0	0	4,012
1958	19	3,629	7,641
1959	-6	-1,146	6,495
1960	-20	-3,821	2,674
1961	-5	-955	1,719
1962	24	4,585	6,304
1963	-33	-6,304	0
1964	-31	-5,922	-5,922
1965	30	5,731	-191
1966	5	955	764
1967	3	573	1,337
1968	3	573	1,910
1969	4	764	2,674
1970	12	2,293	4,967
1971	3	573	5,540
1972	-4	-764	4,776
1973	1	191	4,967
1974	-6	-1,146	3,821
1975	4	764	4,585
1976	-8	-1,528	3,057
1977	0	0	3,057
1978	4	764	3,821

San Bernardino Valley Municipal Water District
Change In Storage for the Divide Sub-basin 1934 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1979	3	573	4,394
1980	8	1,528	5,922
1981	10	1,910	7,832
1982	17	3,248	11,080
1983	-24	-4,585	6,495
1984	-5	-955	5,540
1985	-5	-955	4,585
1986	0	0	4,585
1987	2	382	4,967
1988	2	382	5,349
1989	-6	-1,146	4,203
1990	-3	-573	3,630
1991	10	1,910	5,540
1992	14	2,674	8,214
1993	10	1,911	10,125
1994	-6	-1,146	8,979
1995	6	1,146	10,125
1996	7	1,337	11,462
1997	0	0	11,462
1998	5	-4,651	6,811
1999	2	210	7,021
2000	7	734	7,755
2001	-1	-105	7,650
2002	-3	-314	7,336
2003	9	943	8,279
2004	-14	-1,467	6,812
2005	3	314	7,126
2006	-15	2,649	9,775
2007	-10	-1,462	8,313
2008	7	1,042	9,355
2009	-4	-621	8,734
2010	0	-32	8,702
2011	-4	-537	8,165
2012	-1	-20	8,145
2013	-2	-315	7,830
2014	4	-17,938	-10,108


Hydrograph for the Divide Sub-Basin Wells
REDLANDS HEIGHTS 2S3W01D
36 2S3W03K01
Depth to Water (Feet)
0.00
-25.00
-50.00
-75.00
-100.00
-125.00
-150.00
-175.00
-200.00
-225.00
-250.00
-275.00
1934
1937
1940
1943
1946
1949
1952
1955
1958
1961
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1967
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1985
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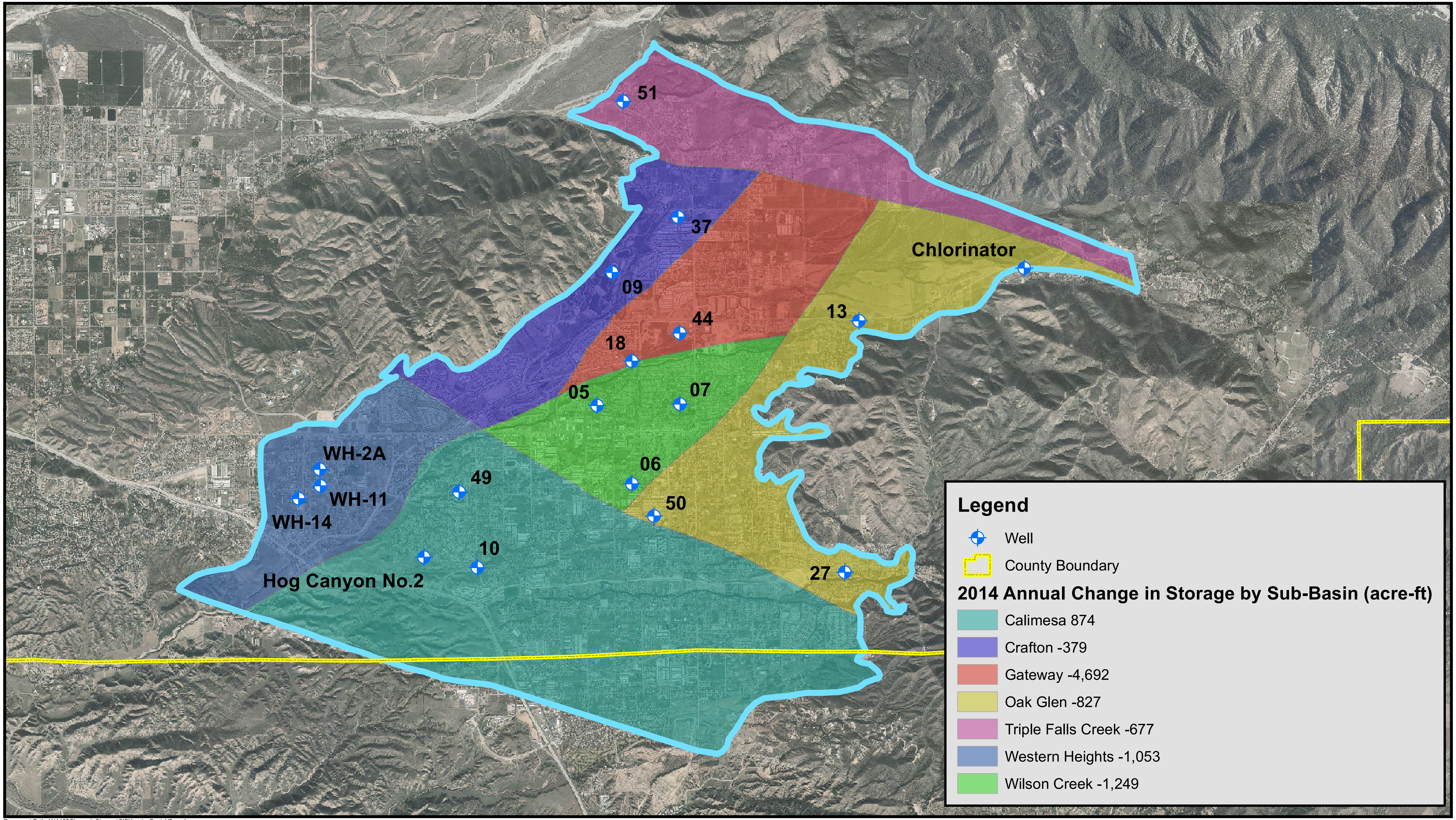
1991
1994
1997
2000
2003
2006
2009
2012



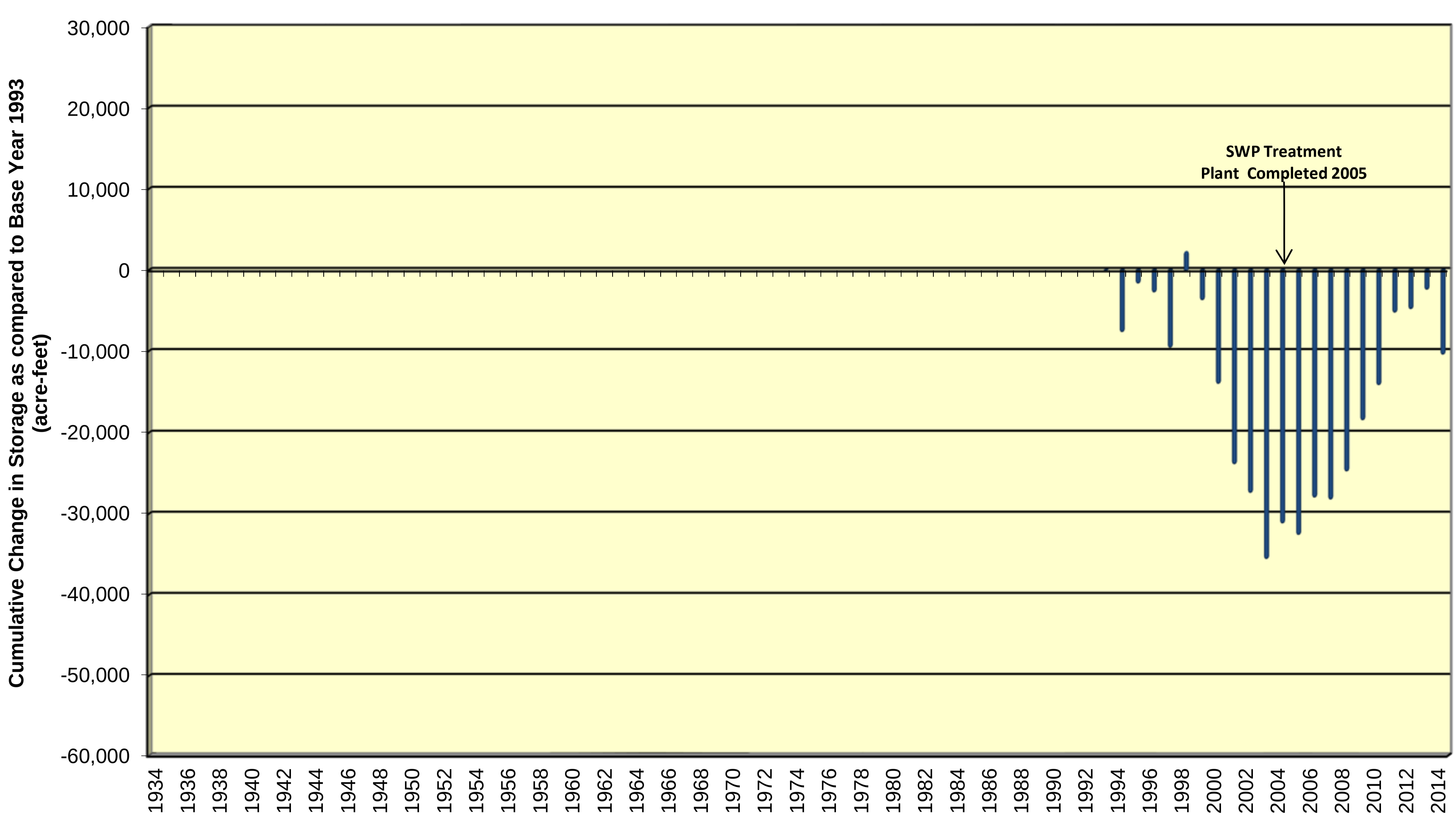
Change in Storage for Yucaipa Groundwater Basin

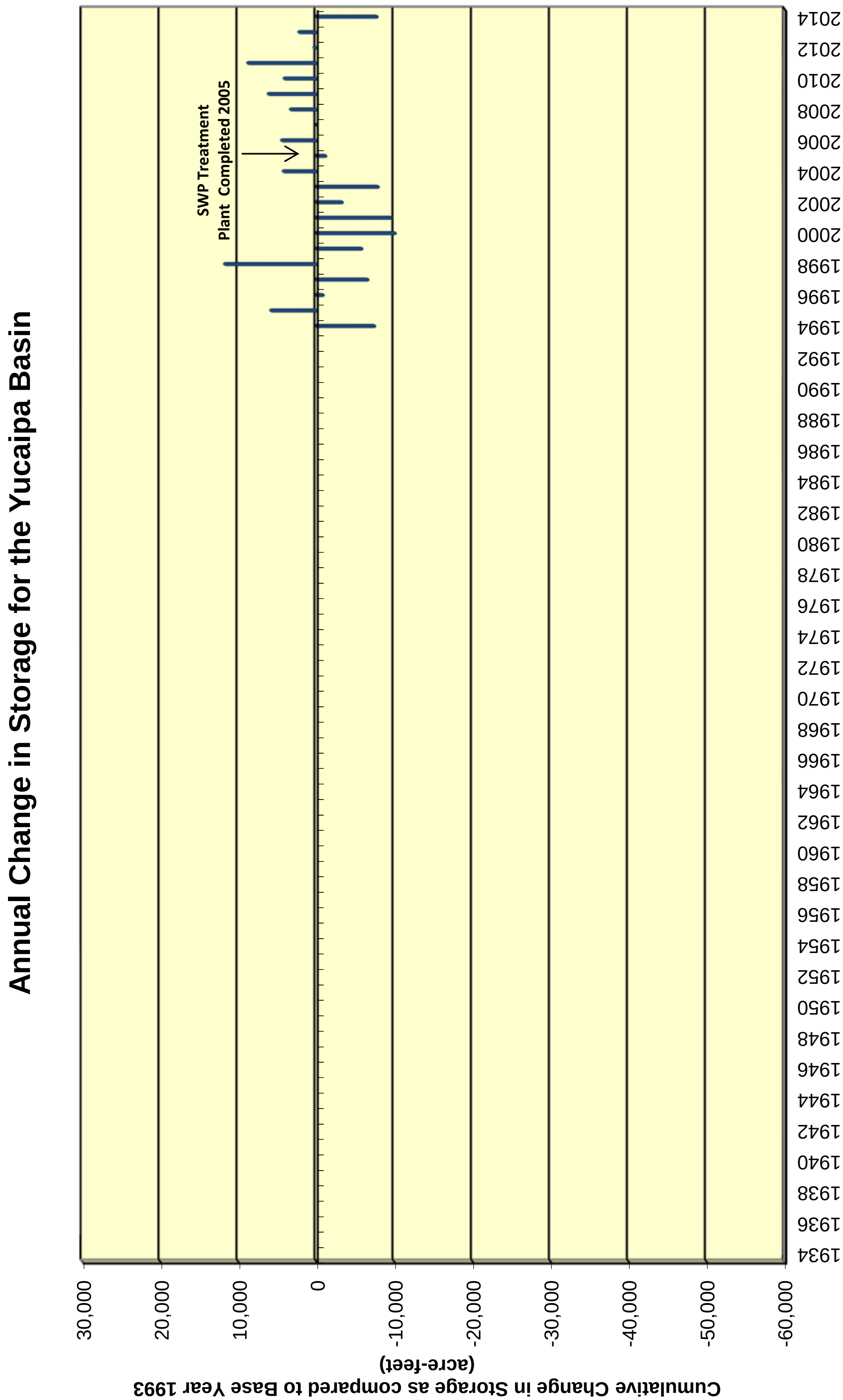
0 0.5 1 2 3 4 Miles

San Bernardino Valley Municipal Water District

Source: Geoscience Support Services, Inc. (Sub-Basin Boundaries)

Cumulative Change in Storage for the Yucaipa Basin




Annual Change in Storage for the Yucaipa Basin
SWP Treatment Plant Completed 2005
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
30,000
20,000
10,000
0
-10,000
-20,000
-30,000
-40,000
-50,000
-60,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
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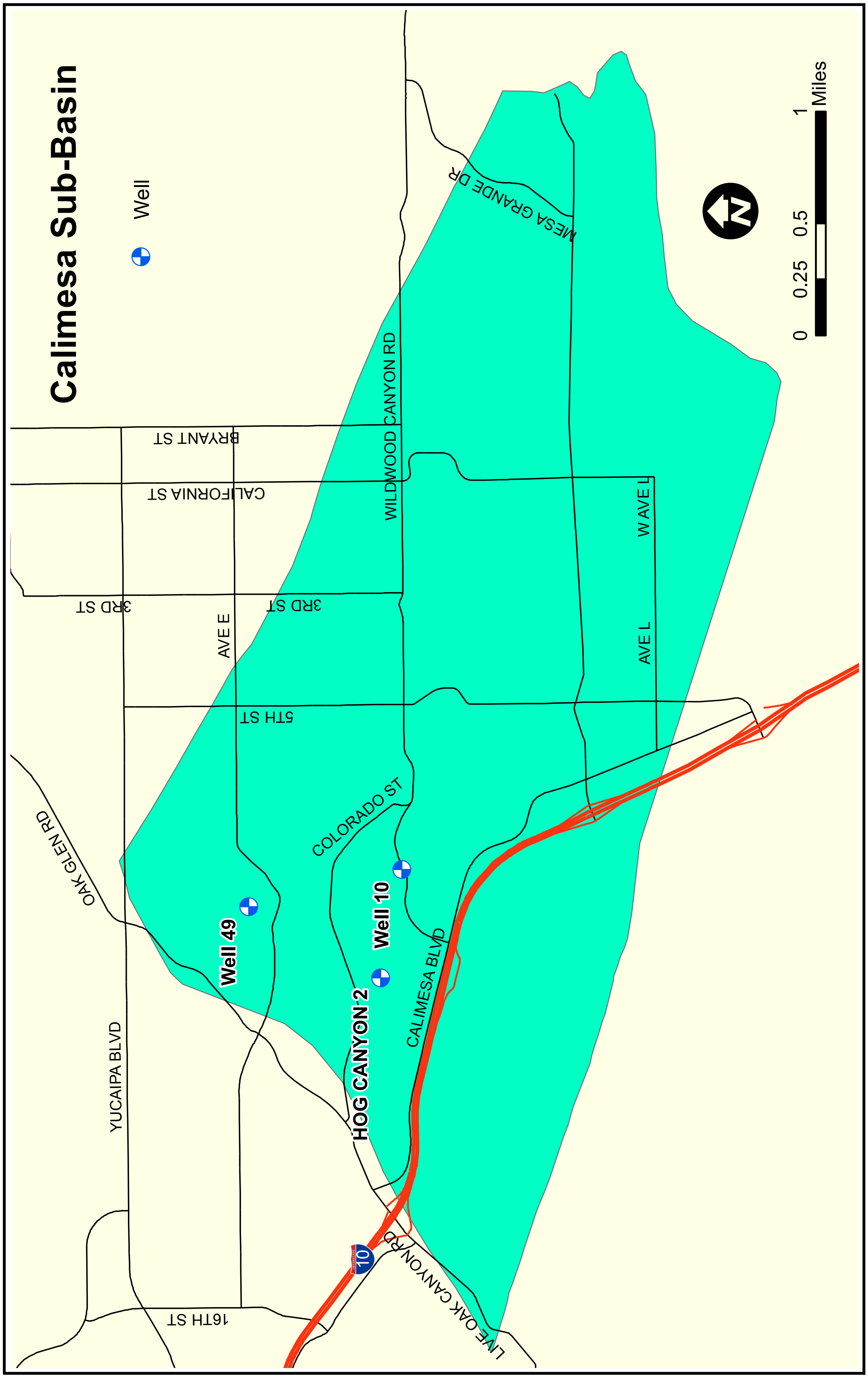
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

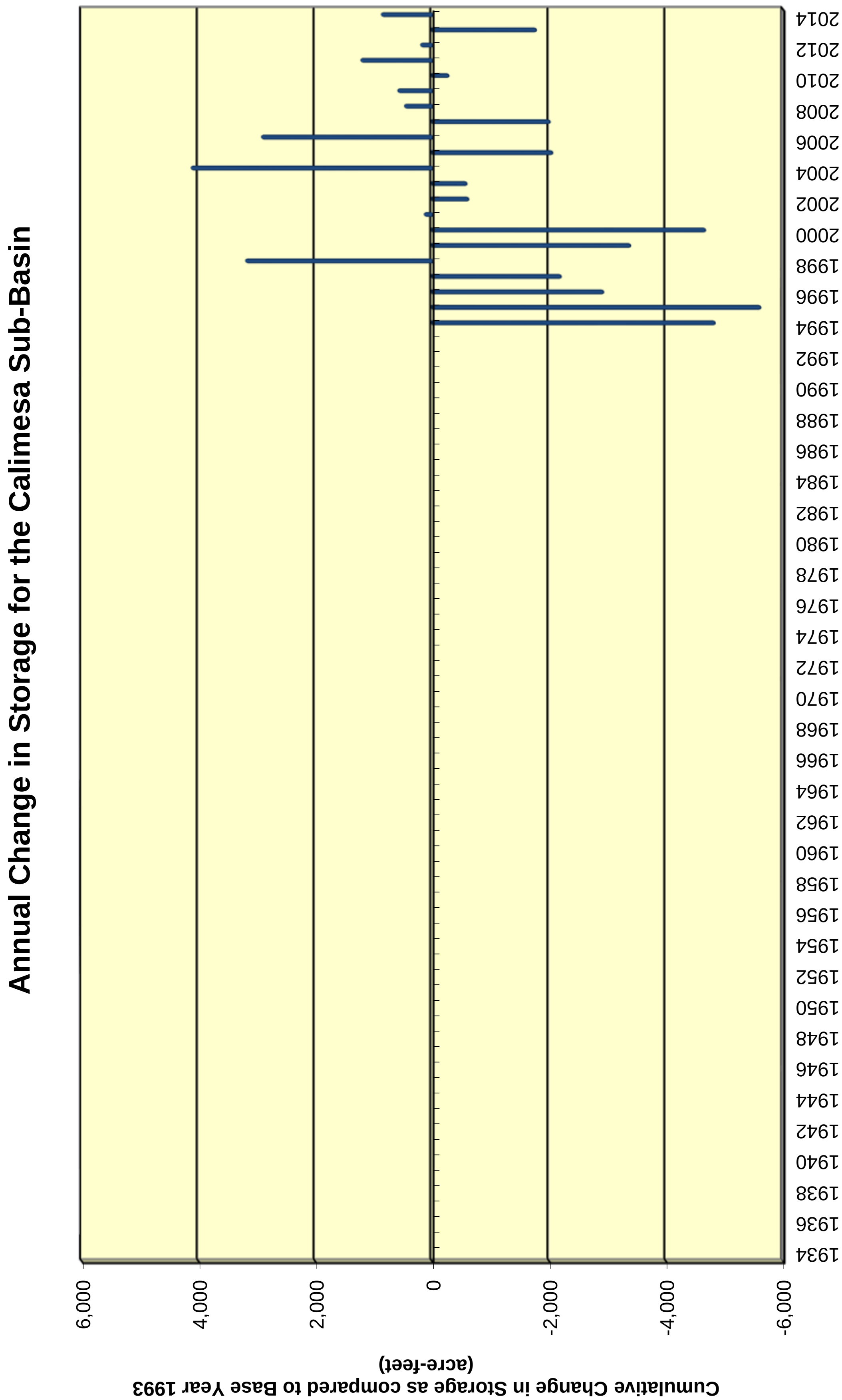
San Bernardino Valley Municipal Water District

Change In Storage for the Yucaipa Basin 1993 - 2014

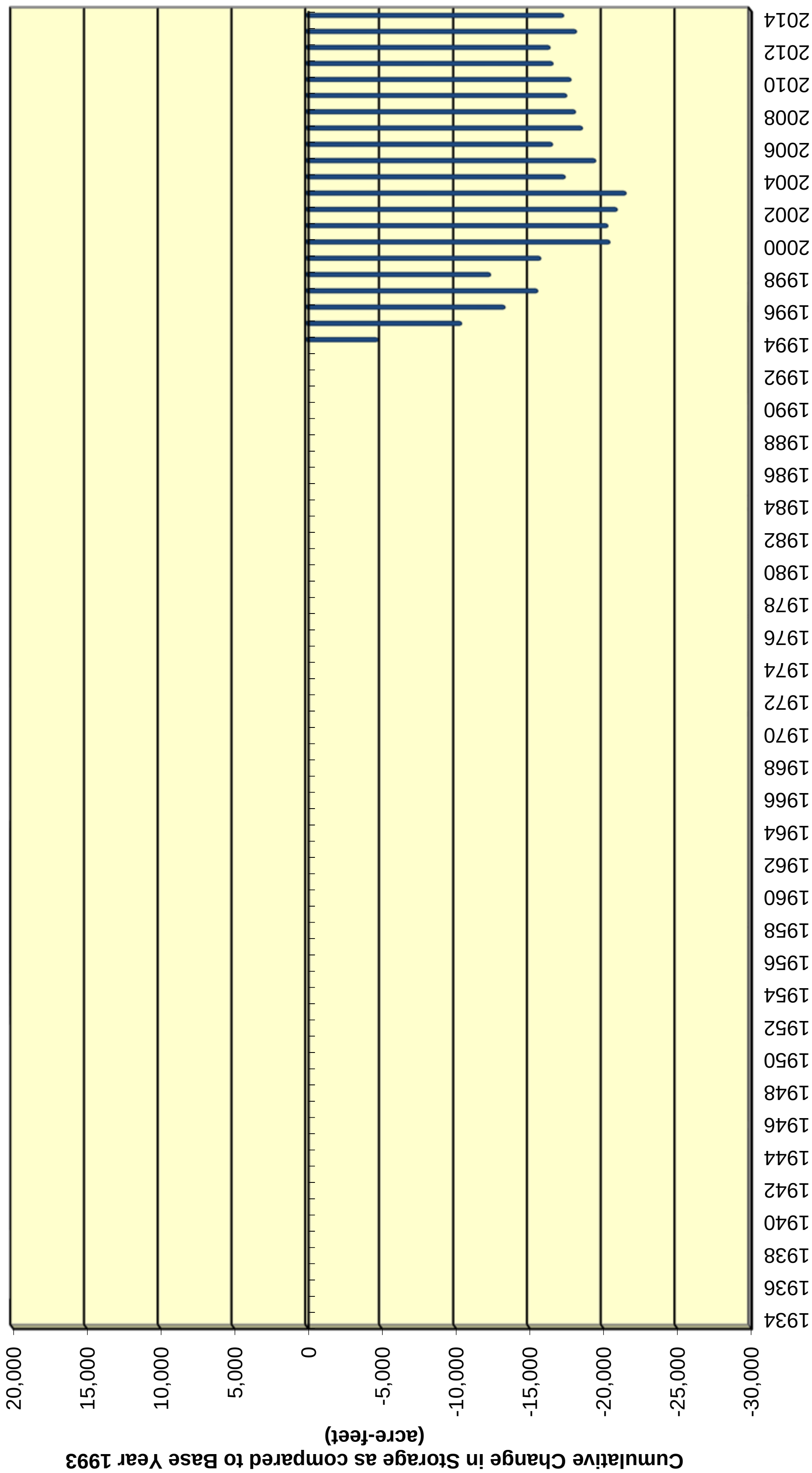
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0	0	0
1994	-4	-7,695	-7,695
1995	10	5,985	-1,710
1996	0	-1,088	-2,798
1997	-7	-6,827	-9,625
1998	13	11,912	2,287
1999	-7	-6,049	-3,762
2000	-10	-10,319	-14,081
2001	-14	-9,841	-23,922
2002	-2	-3,536	-27,458
2003	-10	-8,151	-35,609
2004	2	4,389	-31,220
2005	2	-1,418	-32,638
2006	4	4,602	-28,036
2007	1	-238	-28,274
2008	3	3,462	-24,812
2009	7	6,314	-18,498
2010	6	4,260	-14,238
2011	11	8,942	-5,296
2012	4	434	-4,862
2013	3	2,392	-2,470
2014	-11	-8,006	-10,476



Path: Y:\1422ChangeInStorage\SubBasinMaps\CalimesaSubBasin.mxd

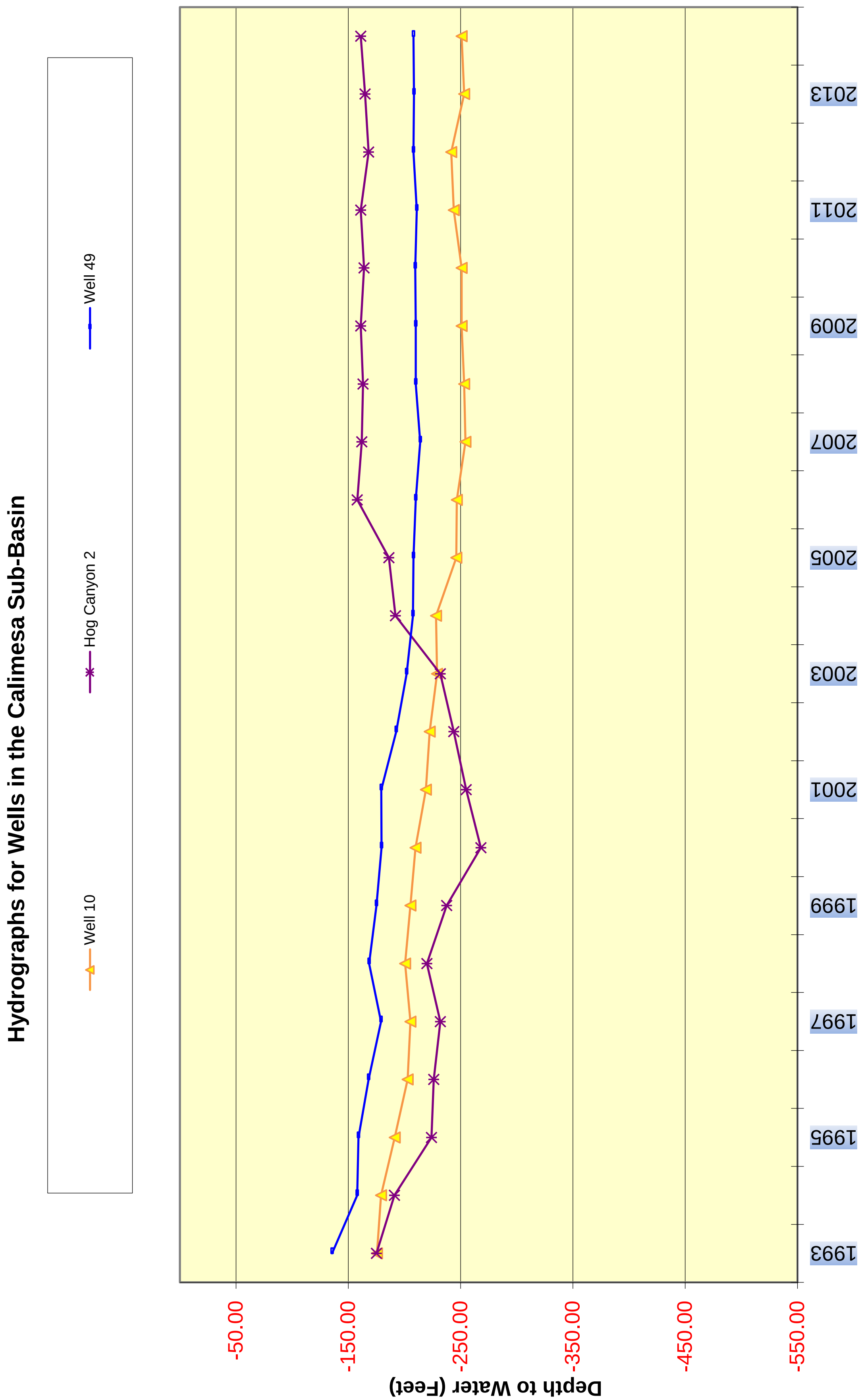

Annual Change in Storage for the Calimesa Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

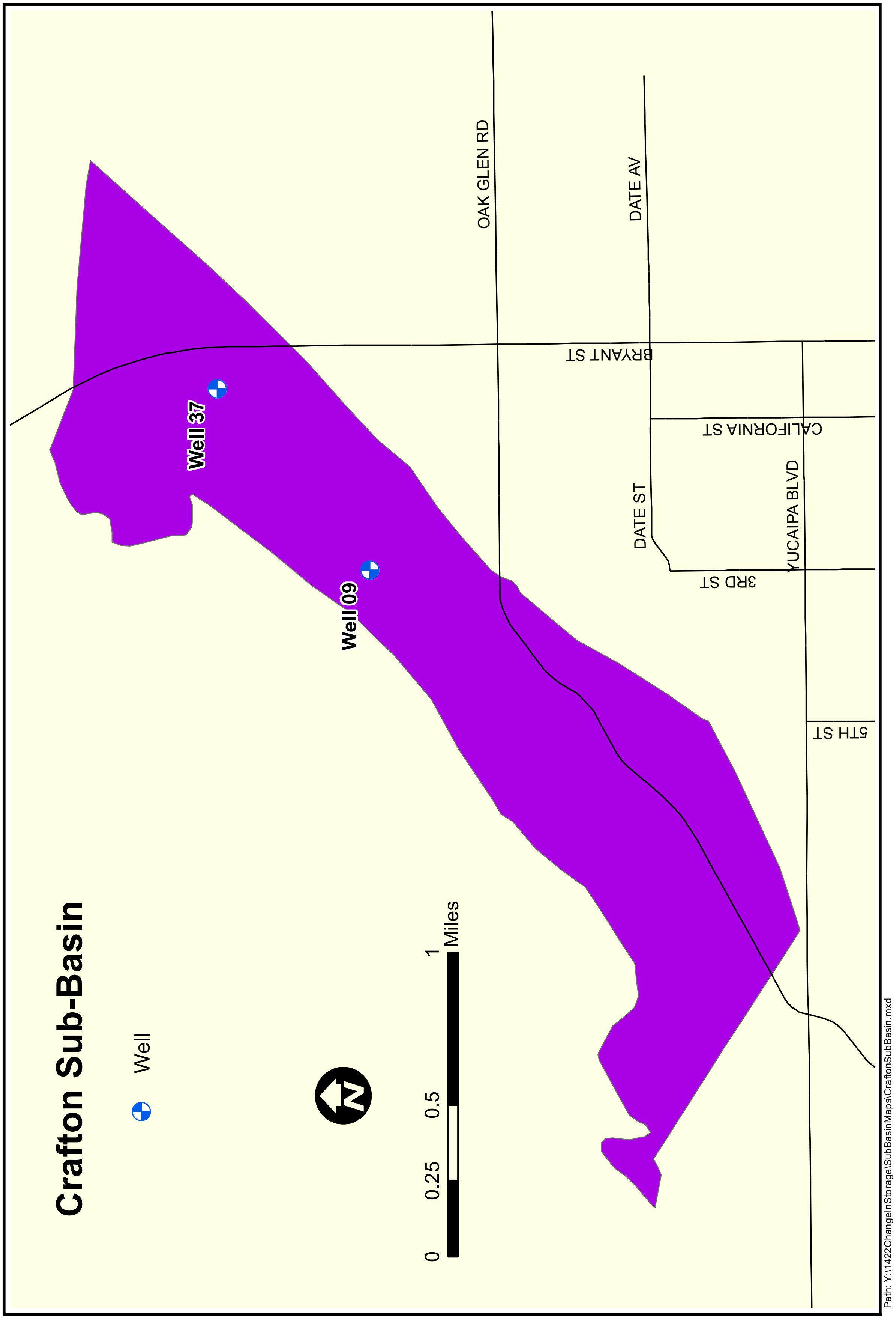
Cumulative Change in Storage for the Calimesa Sub-Basin



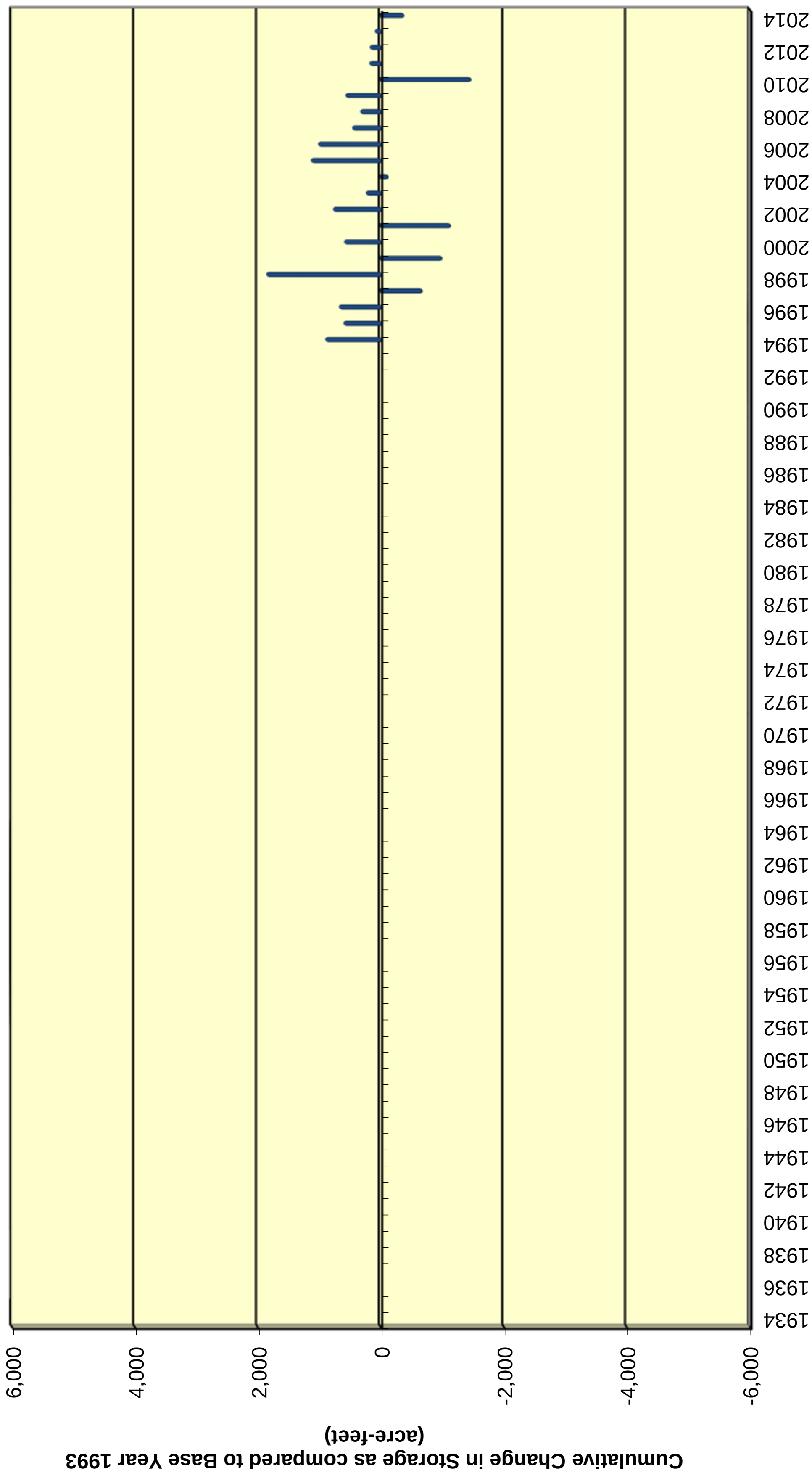
San Bernardino Valley Municipal Water District
Change In Storage for the Calimesa Sub-Basin

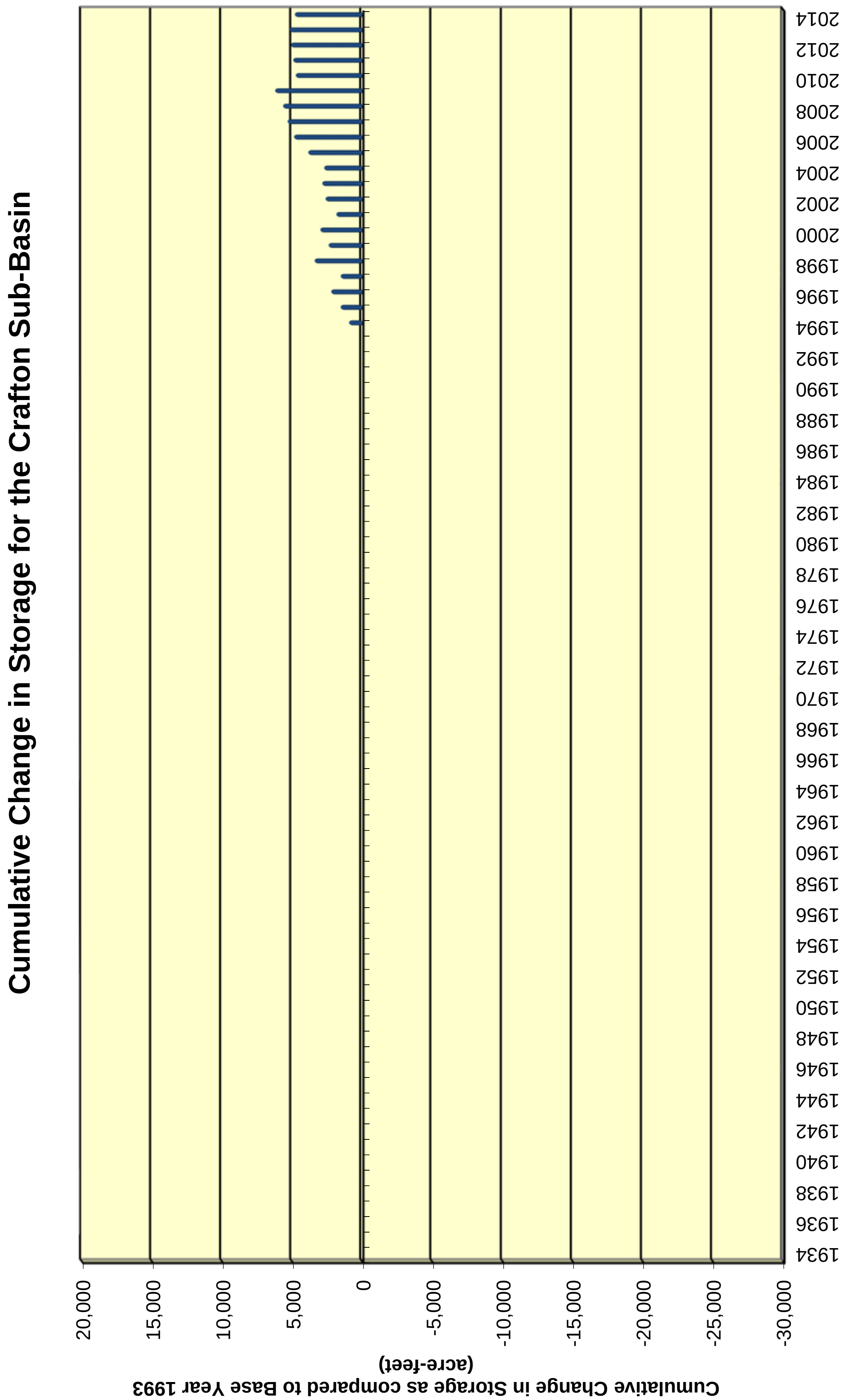
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	-14	-4,853	-4,853
1995	-15	-5,633	-10,486
1996	-8	-2,943	-13,429
1997	-6	-2,216	-15,645
1998	9	3,197	-12,448
1999	-10	-3,404	-15,852
2000	-13	-4,688	-20,540
2001	1	136	-20,404
2002	-2	-632	-21,036
2003	-1	-601	-21,637
2004	12	4,130	-17,507
2005	-4	-2,070	-19,577
2006	9	2,925	-16,652
2007	-5	-2,026	-18,678
2008	1	475	-18,203
2009	1	590	-17,613
2010	-1	-291	-17,904
2011	3	1,223	-16,681
2012	0	199	-16,482
2013	-4	-1,791	-18,273
2014	2	872	-17,401


Hydrographs for Wells in the Calimesa Sub-Basin
Well 10
Hog Canyon 2
Well 49
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013


Crafton Sub-Basin
Well
0
0.25
0.5
1
Miles
Well 37
Well 09
OAK GLEN RD
DATE AV
BRYANT ST
CALIFORNIA ST
DATE ST
YUCAIPA BLVD
3RD ST
5TH ST
Path: Y:\1422ChangeInStorage\SubBasinMaps\CraftonSubBasin.mxd

Annual Change in Storage for the Crafton Sub-Basin

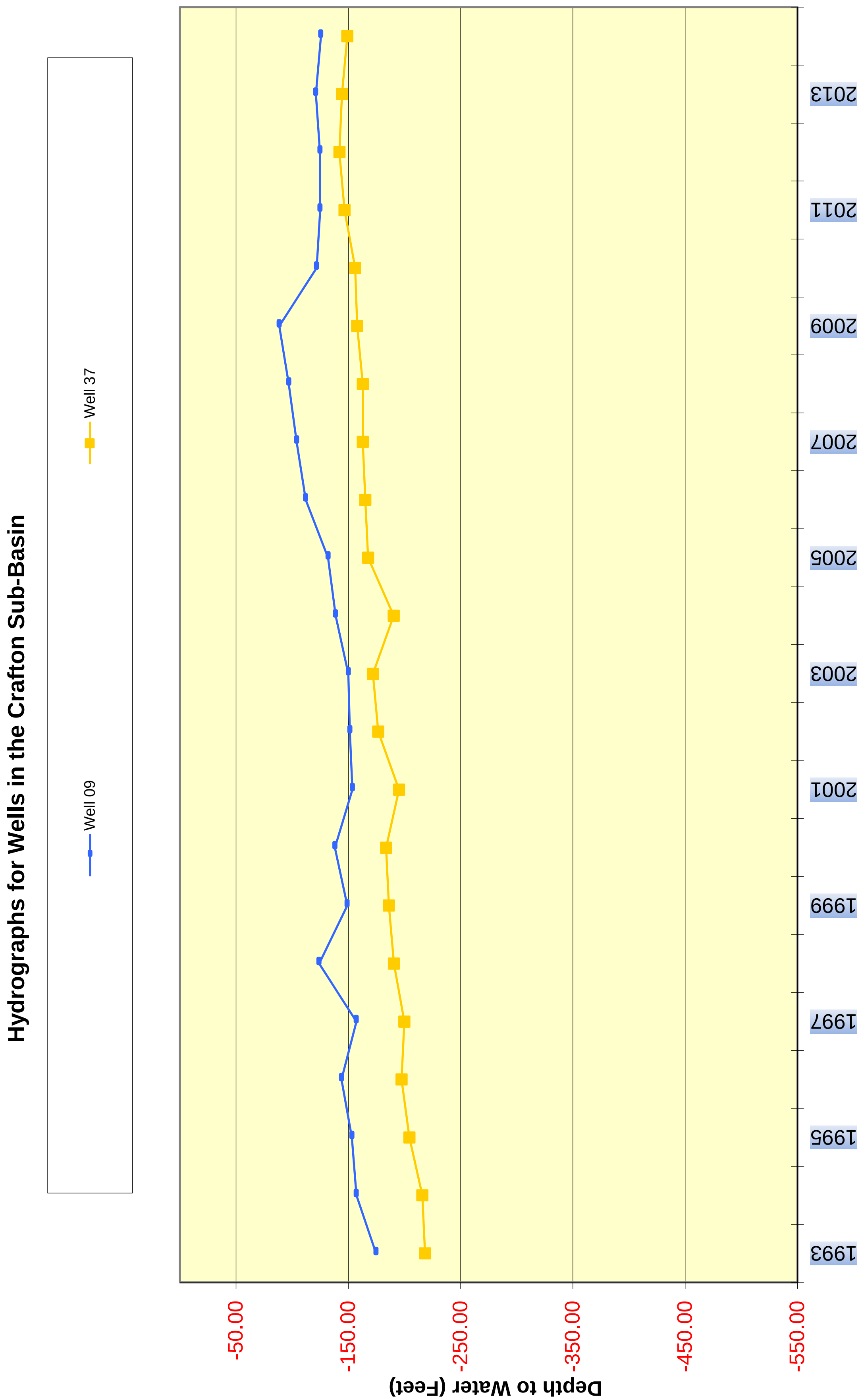



Cumulative Change in Storage for the Crafton Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

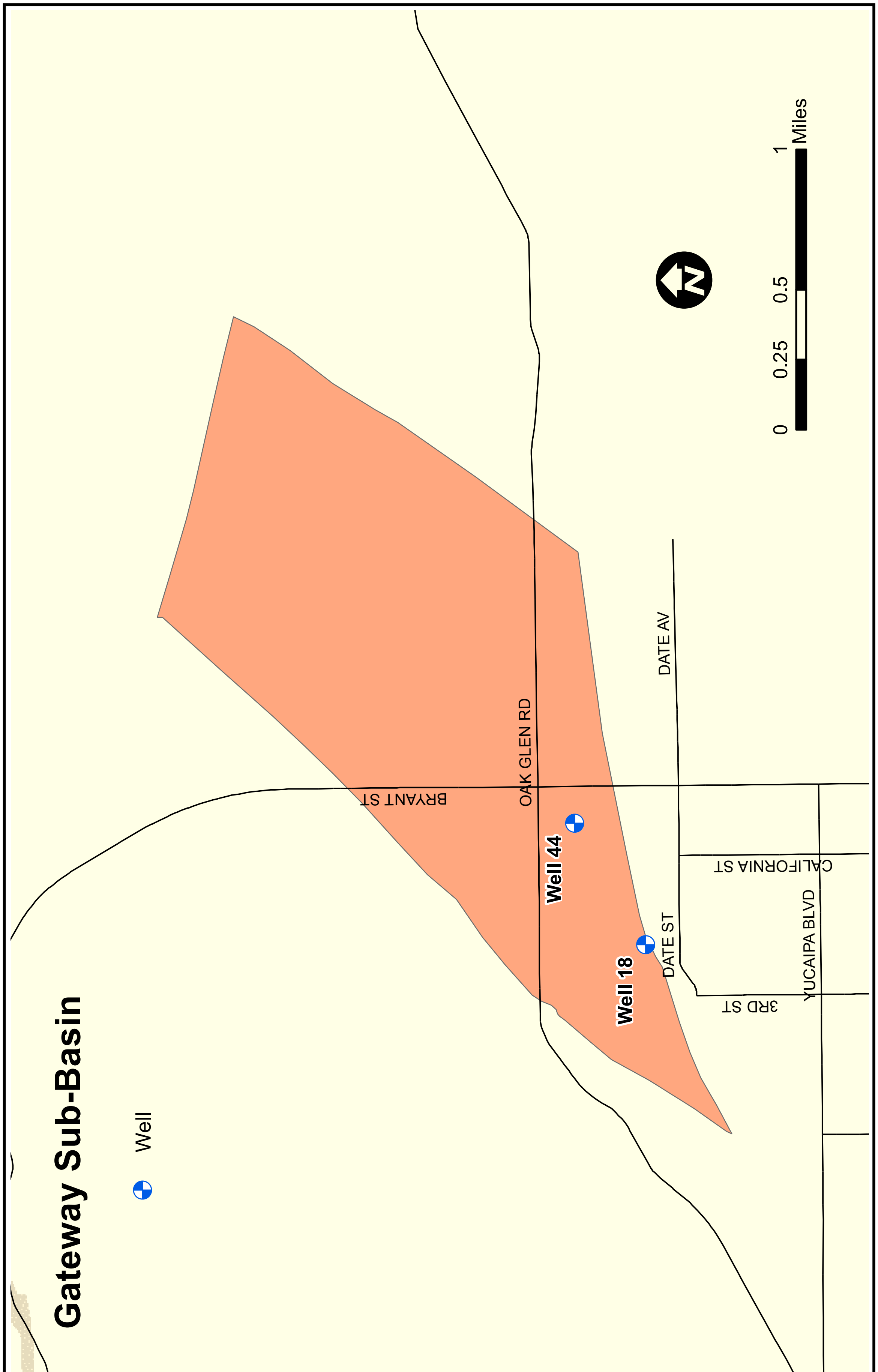
San Bernardino Valley Municipal Water District

Change In Storage for the Crafton Sub-Basin 1993 - 2014

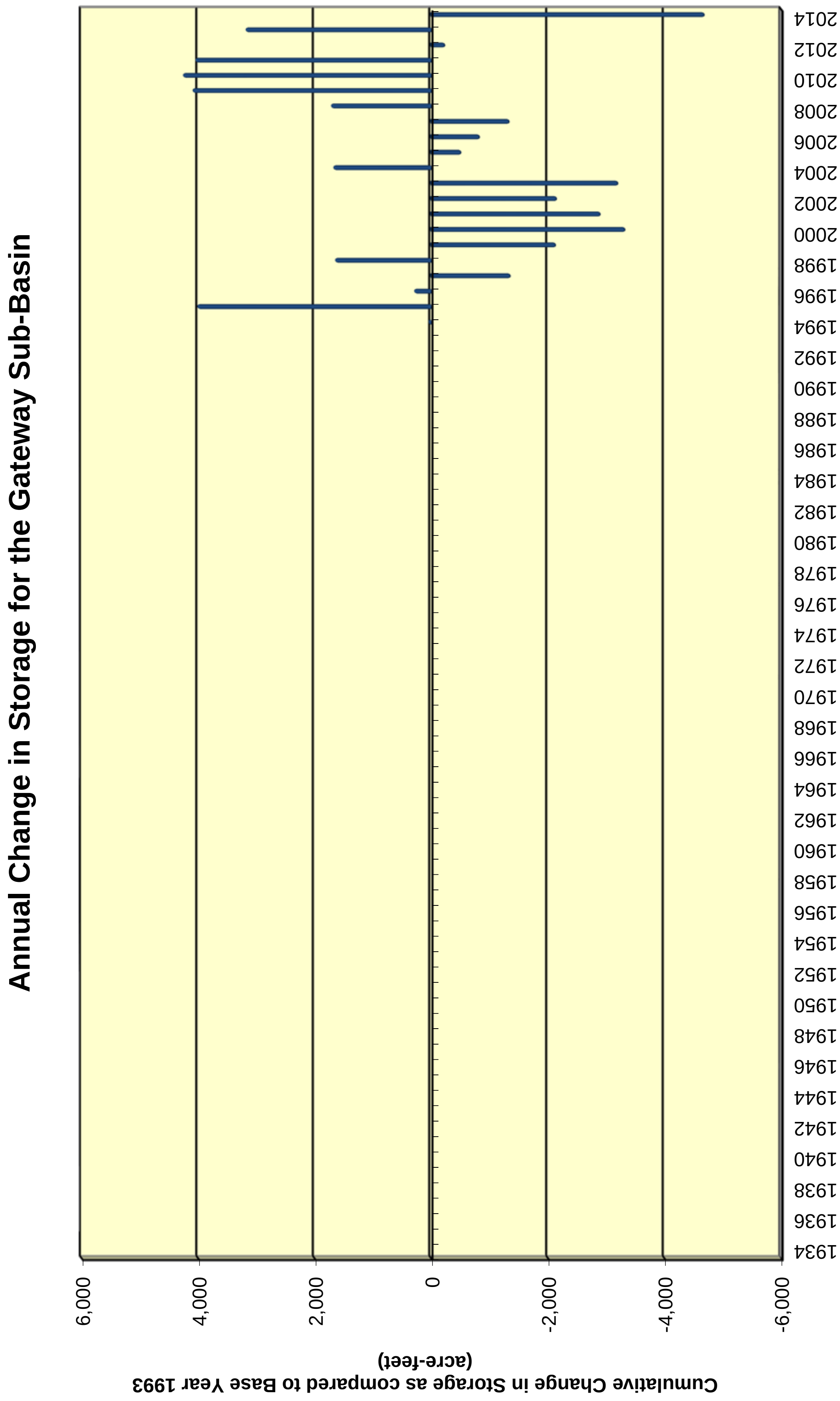
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	10	898	898
1995	8	602	1,500
1996	8	676	2,176
1997	-8	-678	1,498
1998	21	1,857	3,355
1999	-10	-1,000	2,355
2000	7	590	2,945
2001	-14	-1,139	1,806
2002	10	770	2,576
2003	3	234	2,810
2004	-4	-132	2,678
2005	15	1,132	3,810
2006	11	1,014	4,824
2007	5	459	5,283
2008	4	326	5,609
2009	7	568	6,177
2010	-16	-1,471	4,706
2011	3	180	4,886
2012	2	173	5,059
2013	1	91	5,150
2014	-5	-379	4,771



Hydrographs for Wells in the Crafton Sub-Basin
Well 09
Well 37
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
Depth to Water (Feet)
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013



Path: Y:\1422ChangeInStorage\SubBasinMaps\GatewaySubBasin.mxd



Annual Change in Storage for the Gateway Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
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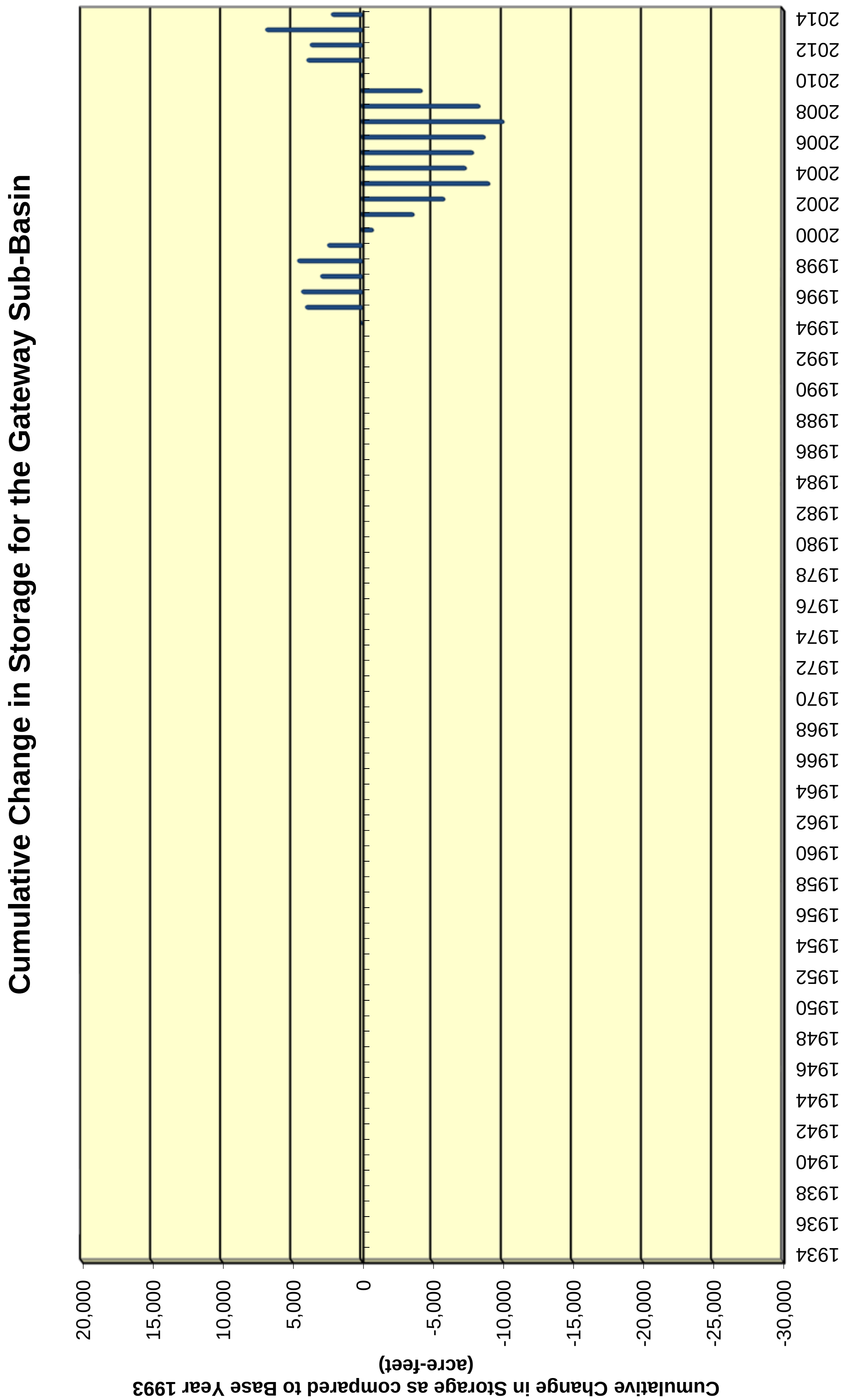
2004
2006
2008
2010
2012
2014

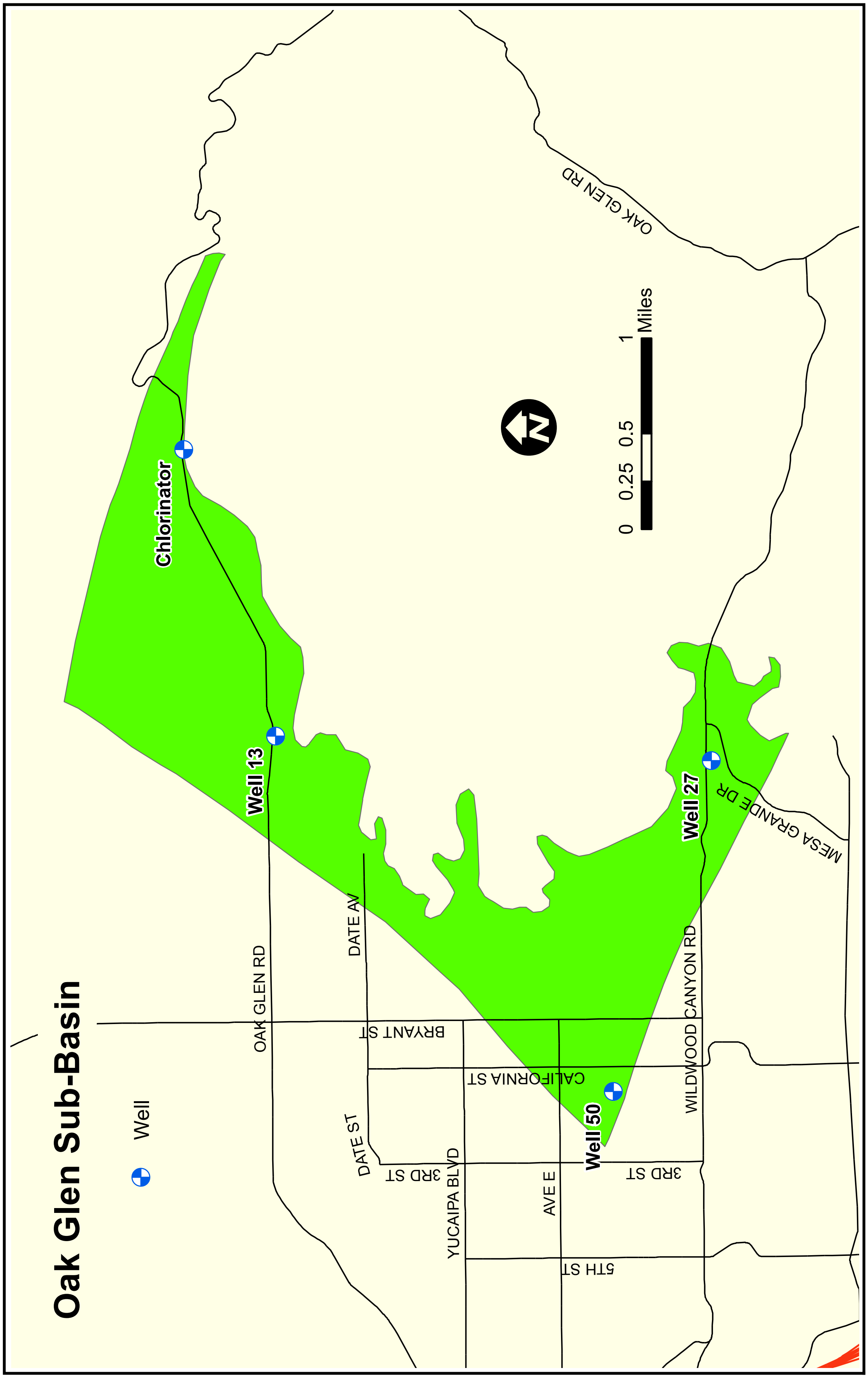

Cumulative Change in Storage for the Gateway Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

San Bernardino Valley Municipal Water District

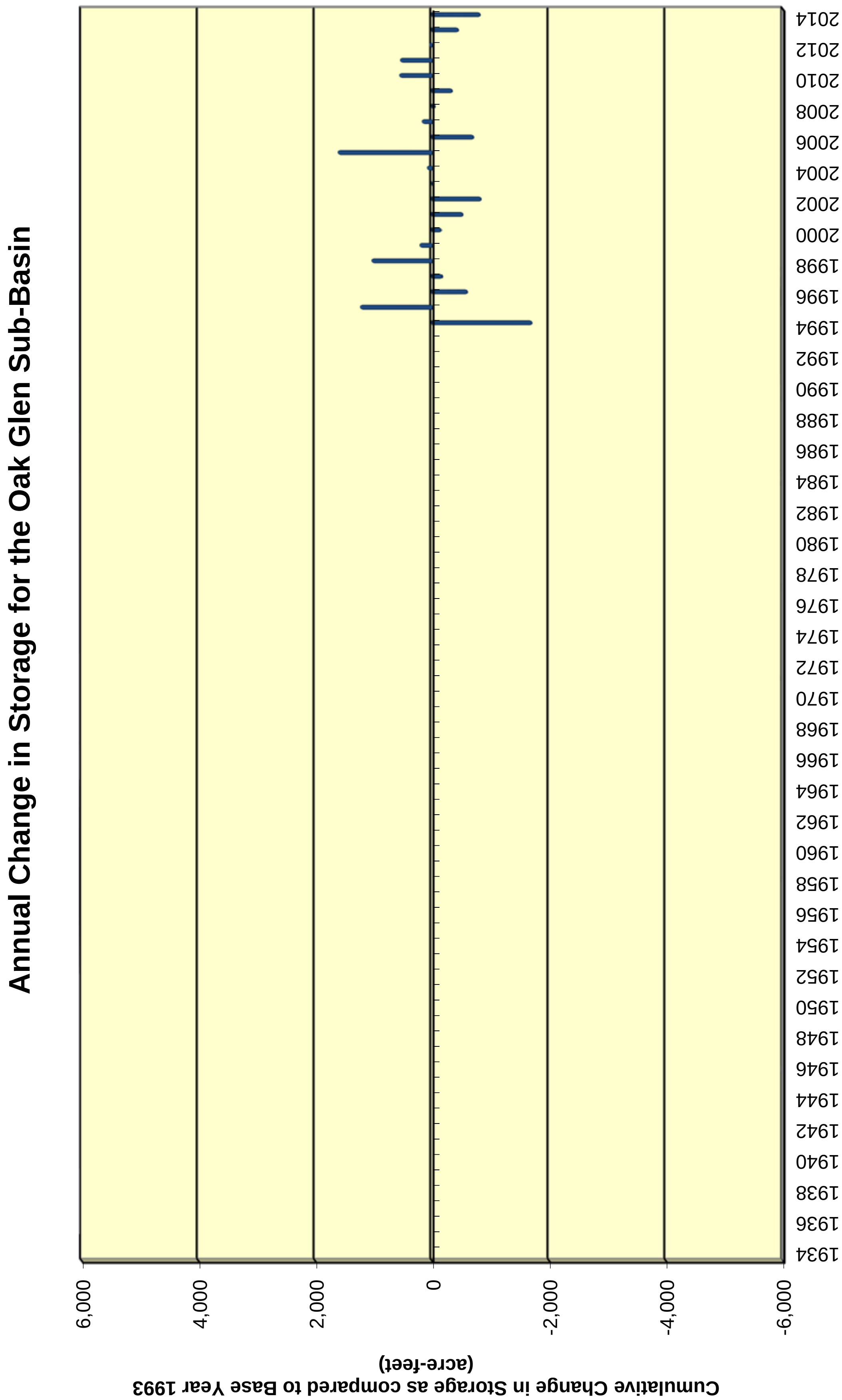
Change In Storage for the Gateway Sub-Basin 1993 - 2014

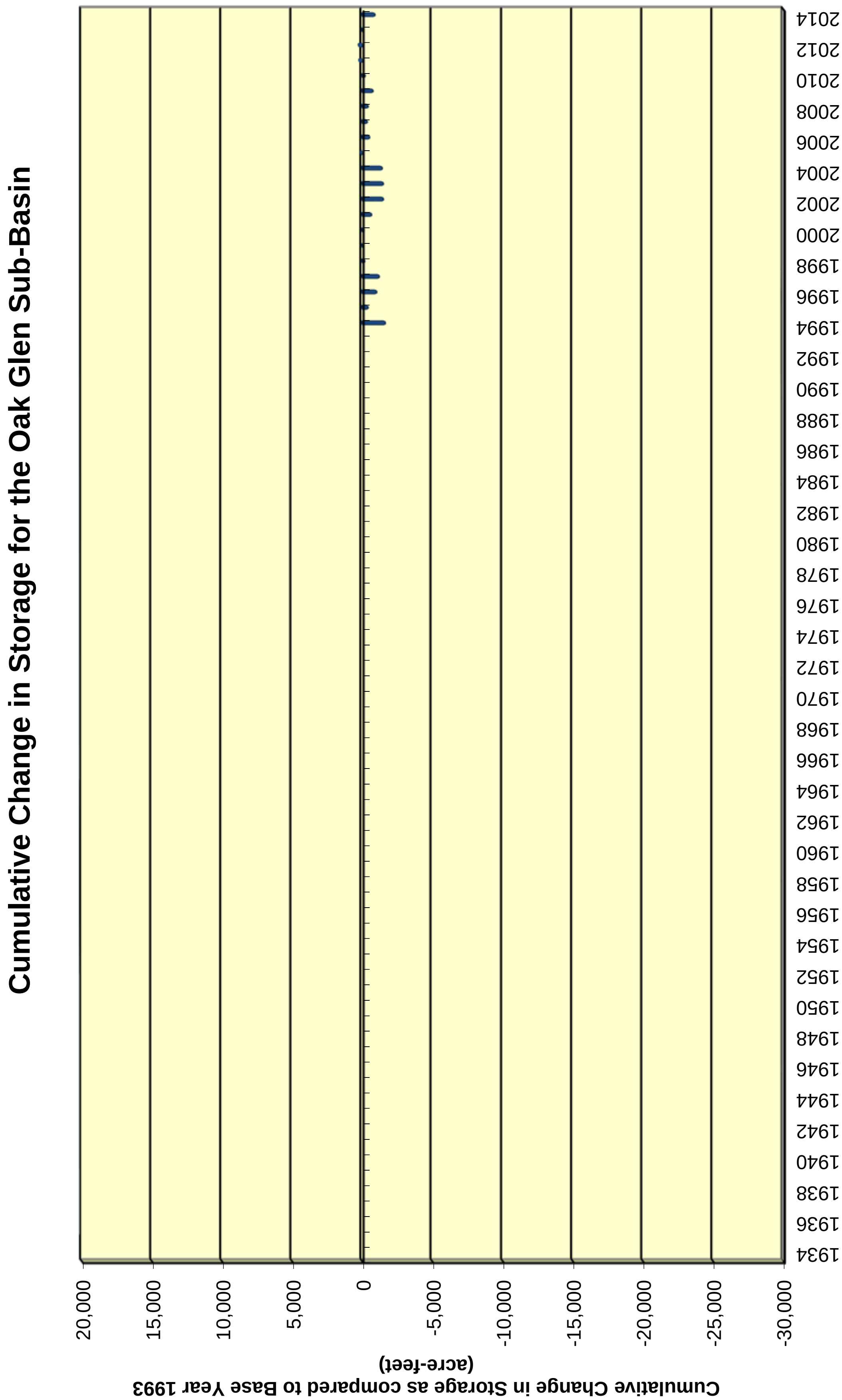
(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	24	36	36
1995	16	4,009	4,045
1996	2	284	4,329
1997	-12	-1,361	2,968
1998	16	1,642	4,610
1999	-22	-2,139	2,471
2000	-34	-3,331	-860
2001	-28	-2,906	-3,766
2002	-22	-2,156	-5,922
2003	-35	-3,209	-9,131
2004	14	1,673	-7,458
2005	-1	-514	-7,972
2006	-9	-833	-8,805
2007	-12	-1,342	-10,147
2008	16	1,712	-8,435
2009	37	4,089	-4,346
2010	42	4,254	-92
2011	44	4,041	3,949
2012	-4	-237	3,712
2013	34	3,179	6,891
2014	-47	-4,692	2,199


Hydrographs for Wells in the Gateway Sub-Basin
Well 18
Well 44
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013



Path: Y:\1422ChangeInStorage\SubBasinMaps\OakGlenSubBasin.mxd


Annual Change in Storage for the Oak Glen Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

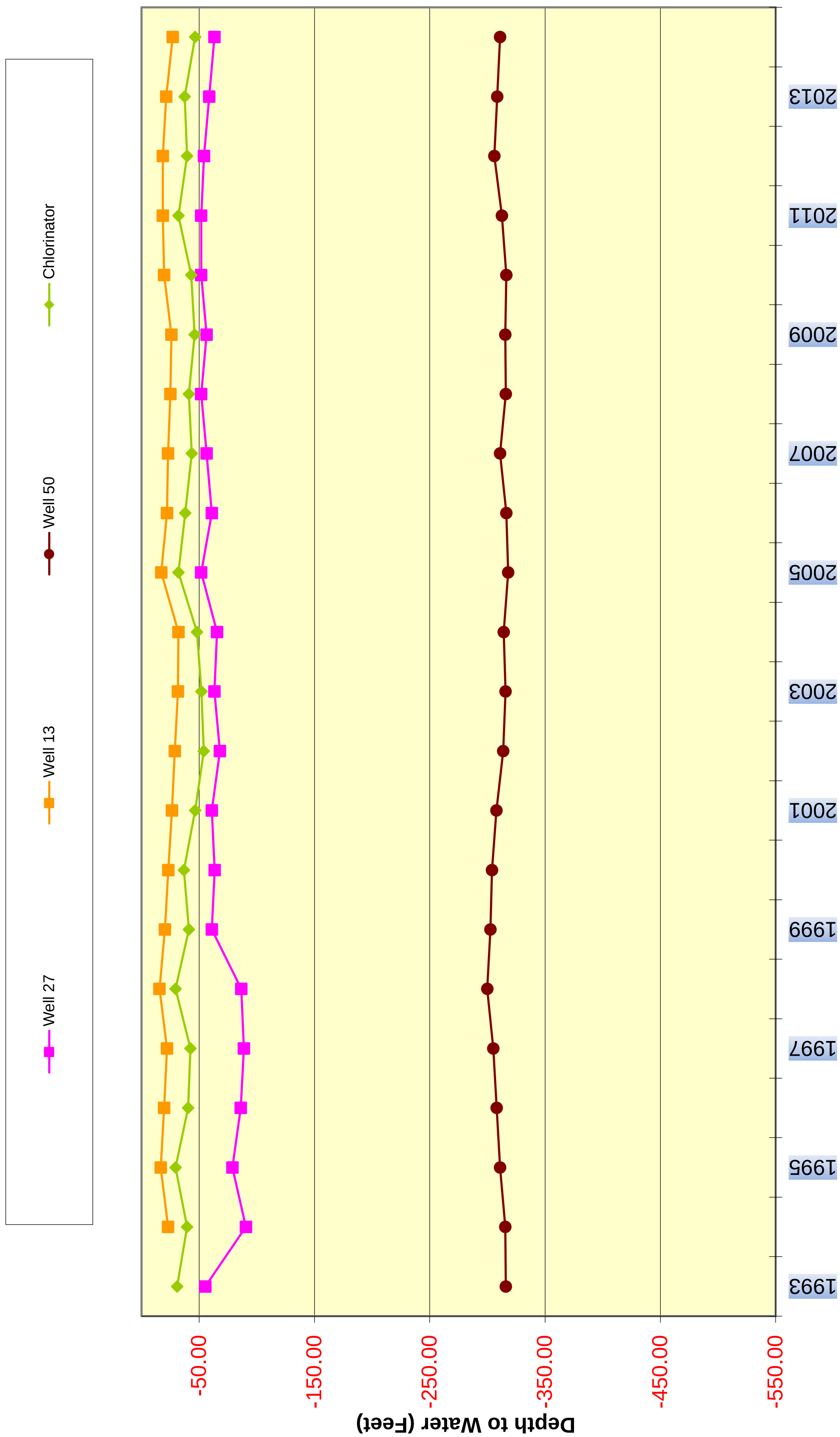

Cumulative Change in Storage for the Oak Glen Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

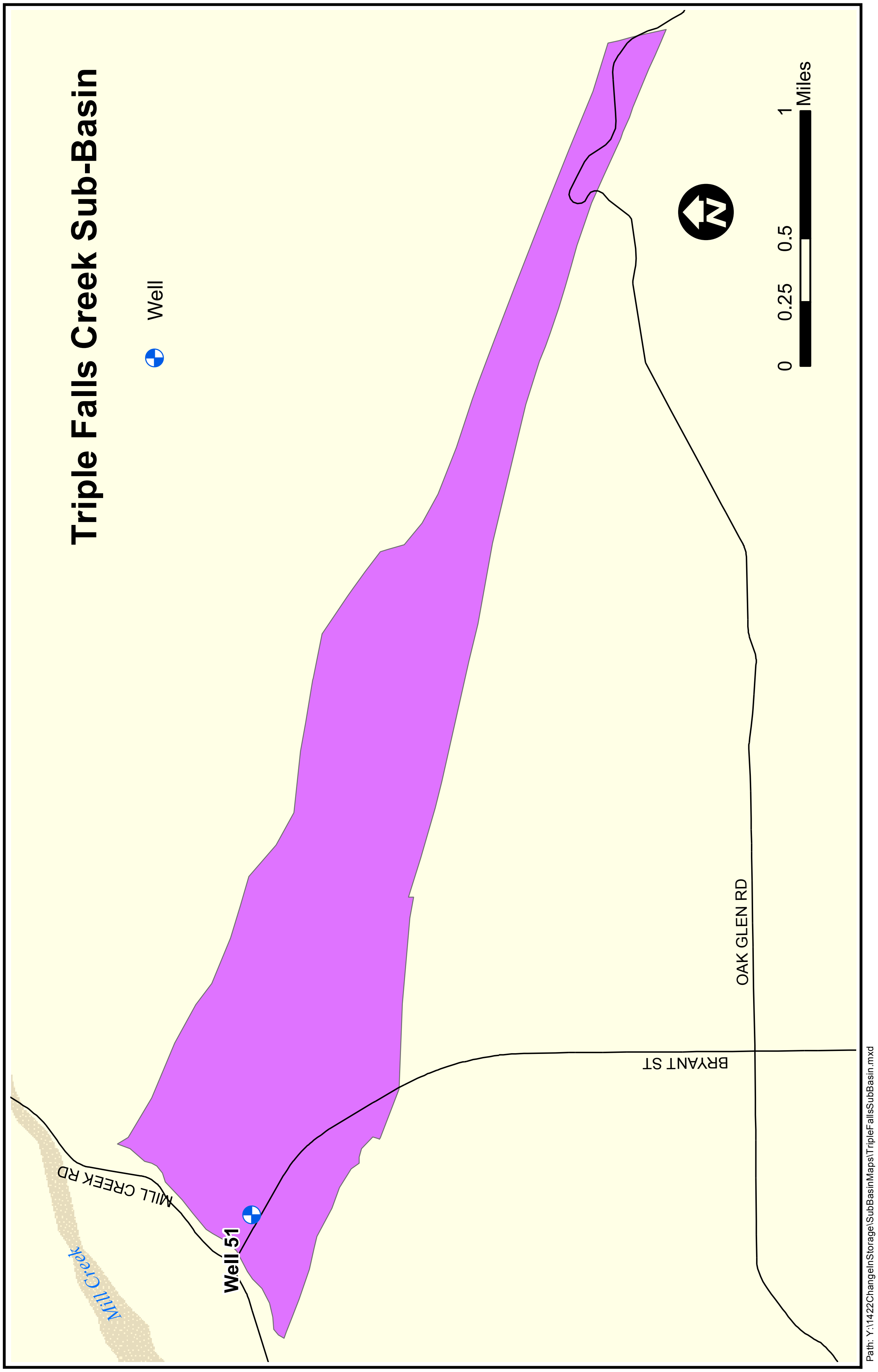
San Bernardino Valley Municipal Water District

Change In Storage for the Oak Glen Sub-Basin 1993 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	-17	-1,713	-1,713
1995	8	1,230	-483
1996	-4	-609	-1,092
1997	-1	-184	-1,276
1998	7	1,033	-243
1999	2	211	-32
2000	-1	-165	-197
2001	-4	-531	-728
2002	-6	-843	-1,571
2003	0	0	-1,571
2004	1	83	-1,488
2005	10	1,612	124
2006	-5	-715	-591
2007	1	171	-420
2008	0	-65	-485
2009	-3	-349	-834
2010	3	558	-276
2011	4	544	268
2012	-1	42	310
2013	-2	-454	-144
2014	-5	-827	-971

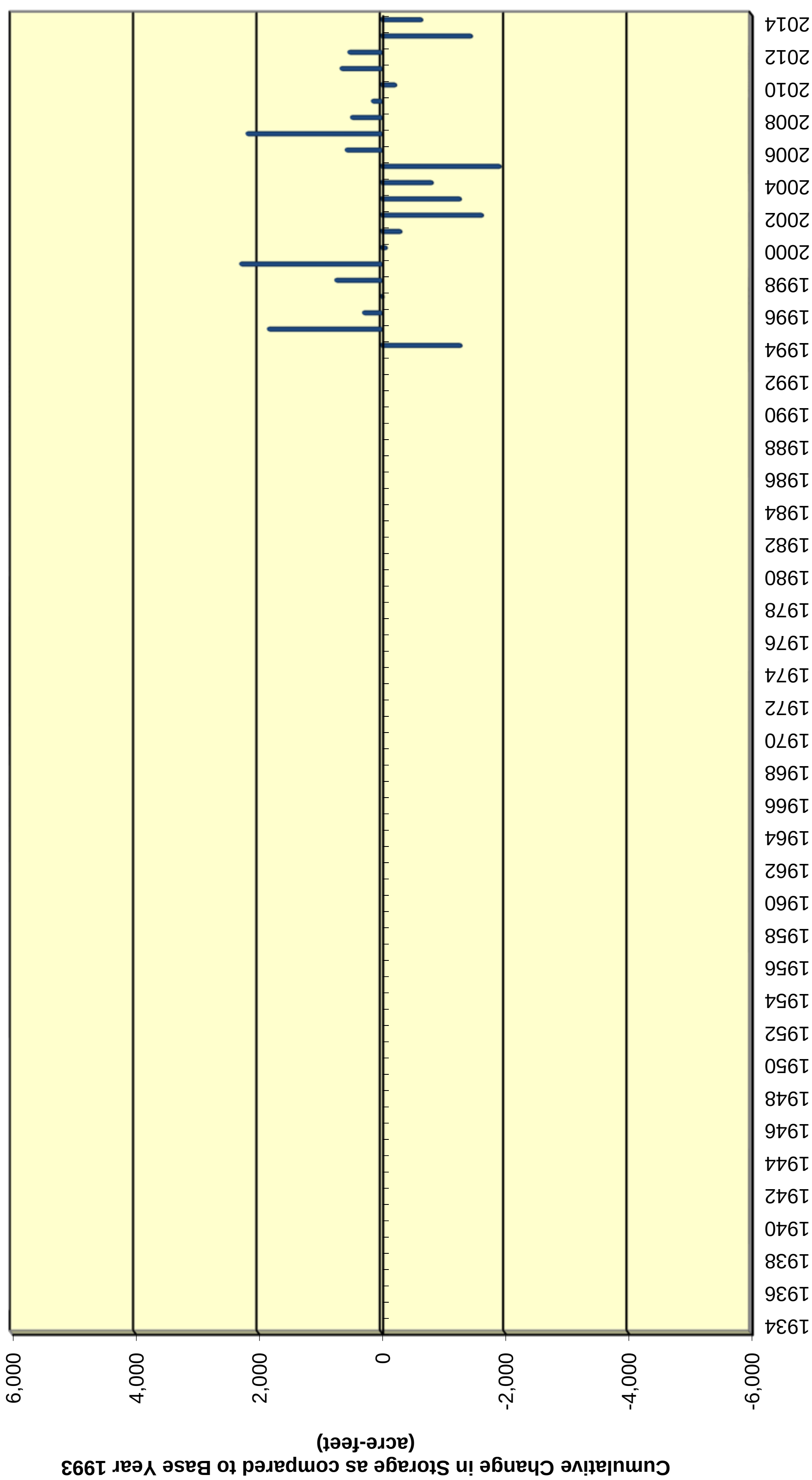
Hydrographs for Wells in the Oak Glen Sub-Basin



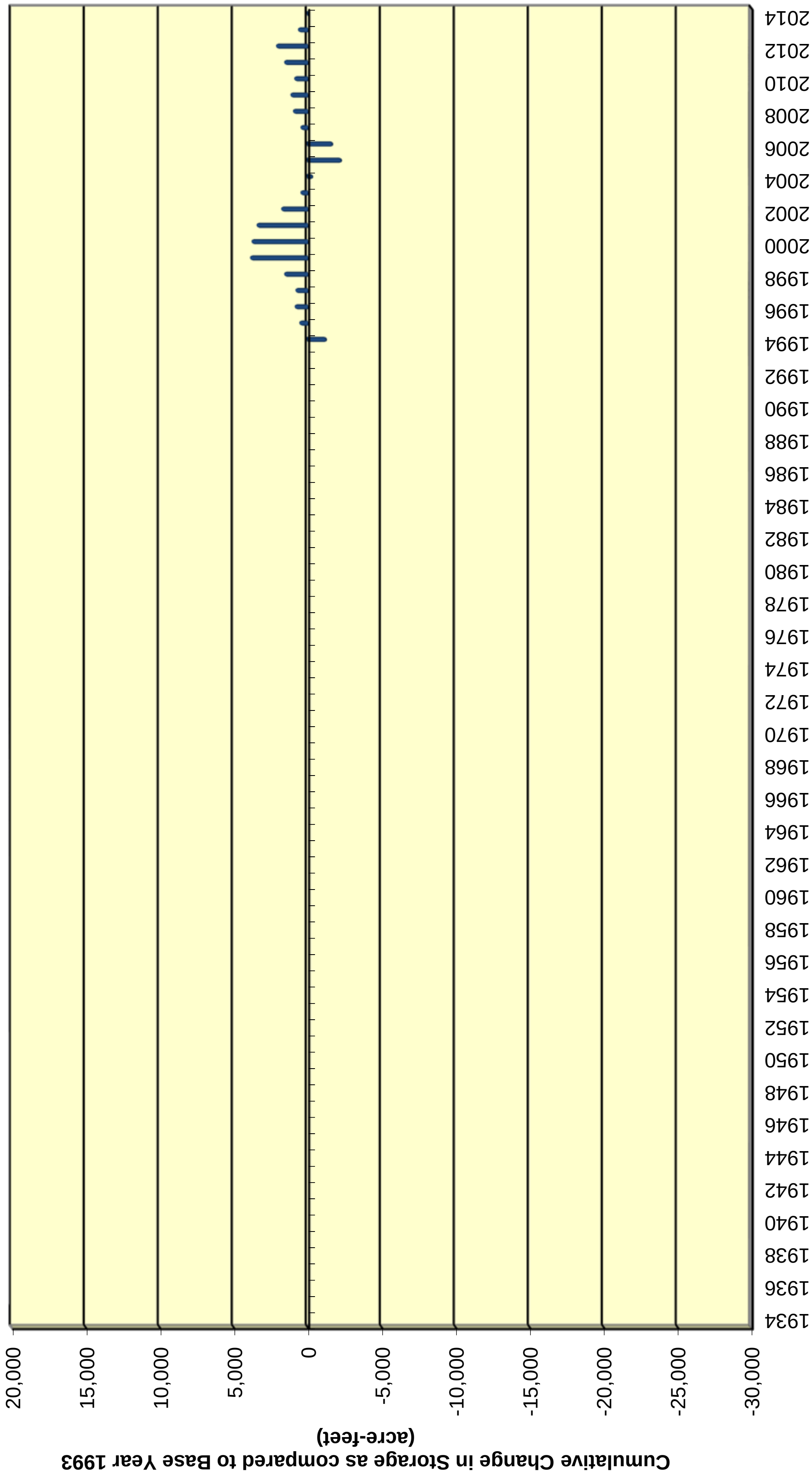


Triple Falls Creek Sub-Basin
Well
0
0.25
0.5
1
Miles
OAK GLEN RD
BRYANT ST
MILL CREEK RD
Mill Creek
Well 51
Path: Y:\1422ChangeInStorage\SubBasinMaps\TripleFallsSubBasin.mxd

Annual Change in Storage for the Triple Falls Sub-Basin



Cumulative Change in Storage for the Triple Falls Sub-Basin

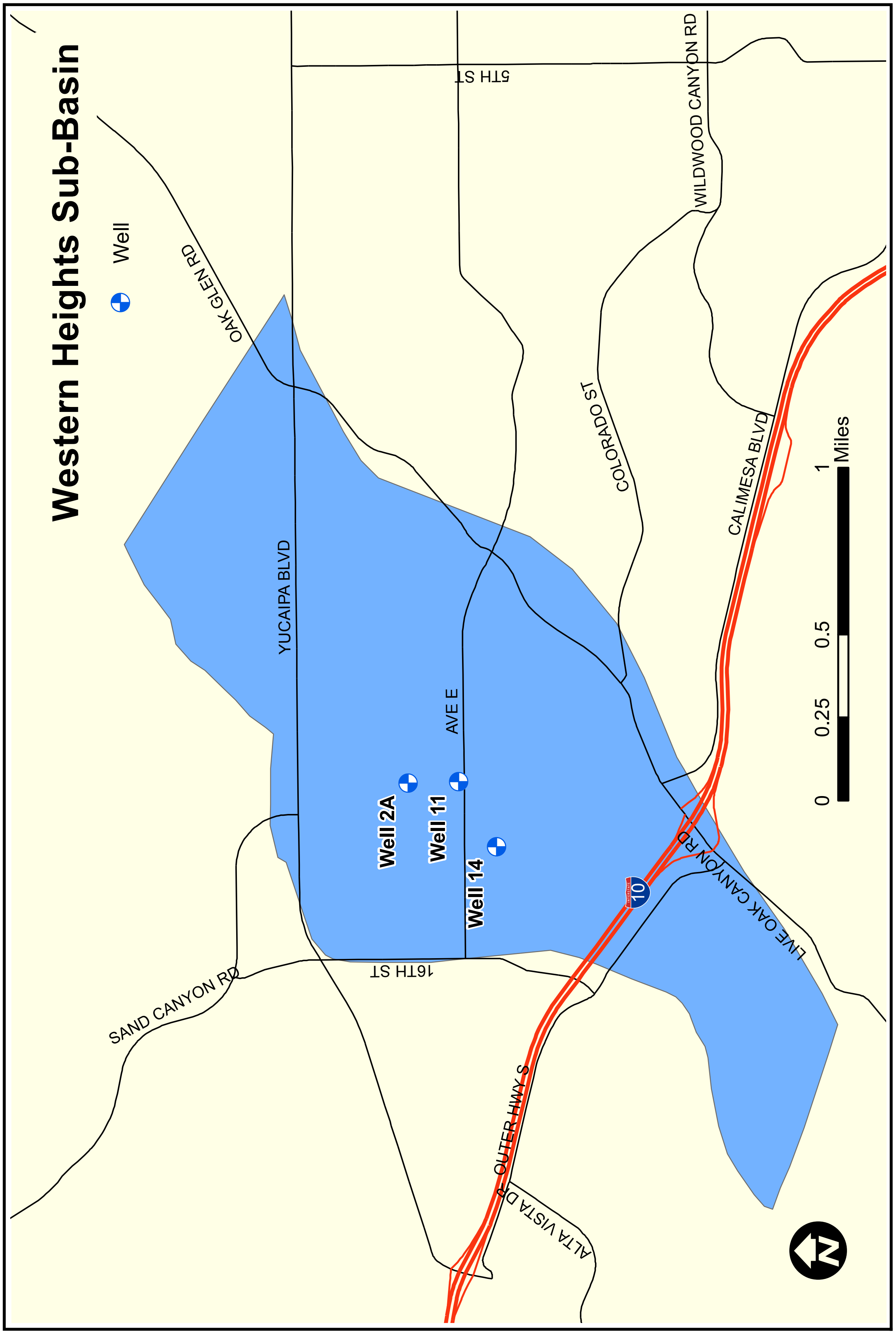


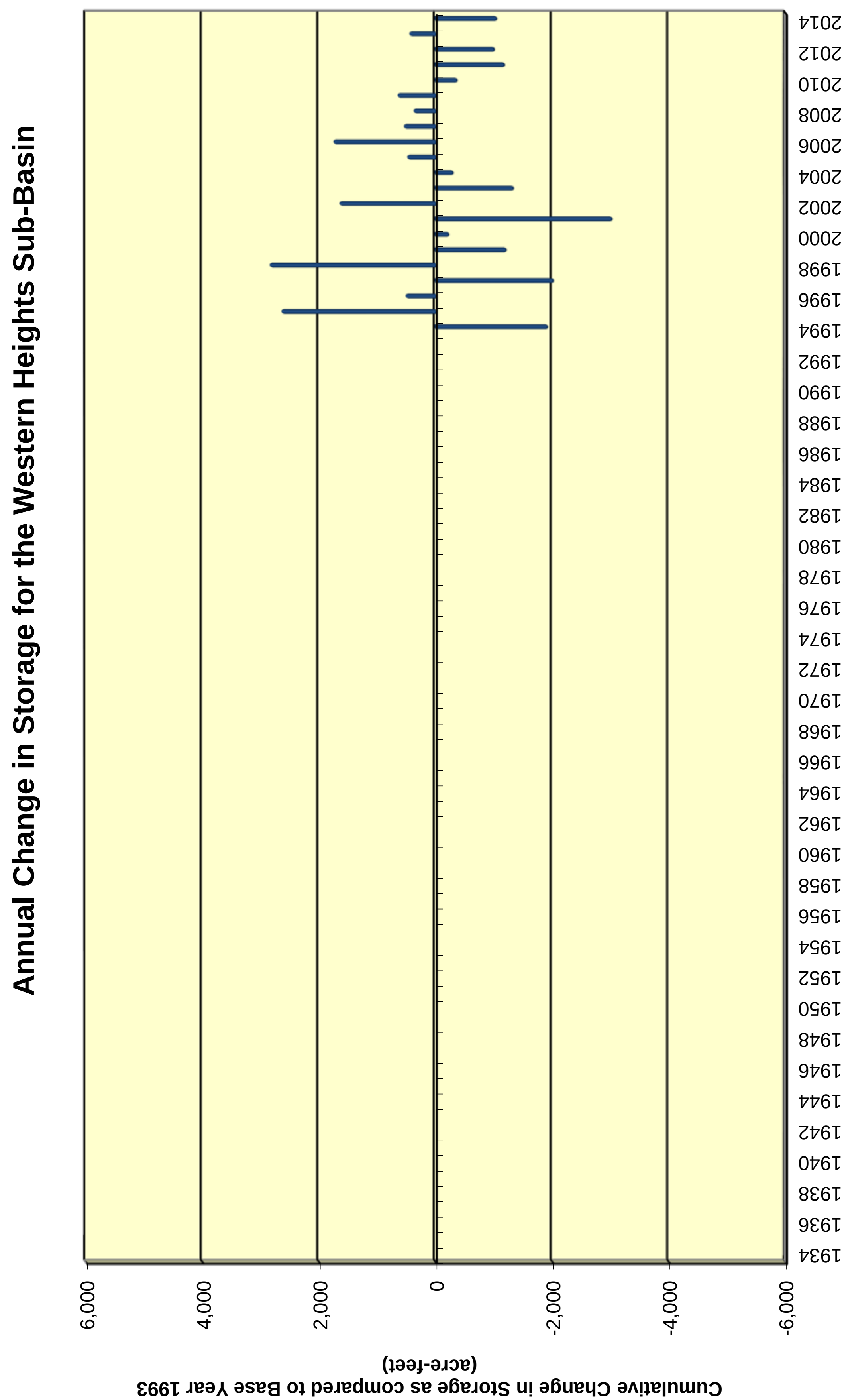
San Bernardino Valley Municipal Water District

Change In Storage for the Triple Falls Sub-Basin 1993 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	-16	-1,313	-1,313
1995	22	1,855	542
1996	4	313	855
1997	-1	-51	804
1998	9	763	1,567
1999	27	2,305	3,872
2000	-1	-102	3,770
2001	-4	-339	3,431
2002	-20	-1,661	1,770
2003	-15	-1,304	466
2004	-10	-847	-381
2005	-23	-1,949	-2,330
2006	7	594	-1,736
2007	26	2,202	466
2008	6	508	974
2009	2	169	1,143
2010	-3	-254	889
2011	8	678	1,567
2012	7	551	2,118
2013	-18	-1,483	635
2014	-8	-677	-42


Hydrographs for Wells in the Triple Falls Sub-Basin
Well 51
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013


Western Heights Sub-Basin
Well
OAK GLEN RD
5TH ST
WILDWOOD CANYON RD
COLORADO ST
CALIMESA BLVD
YUCAIPA BLVD
AVE E
Well 2A
Well 11
Well 14
10
LIVE OAK CANYON RD
16TH ST
SAND CANYON RD
OUTER HWY S
ALTA VISTA DR
0
0.25
0.5
1
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\WesternHeightsSubBasin.mxd


Annual Change in Storage for the Western Heights Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
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1984
1986
1988
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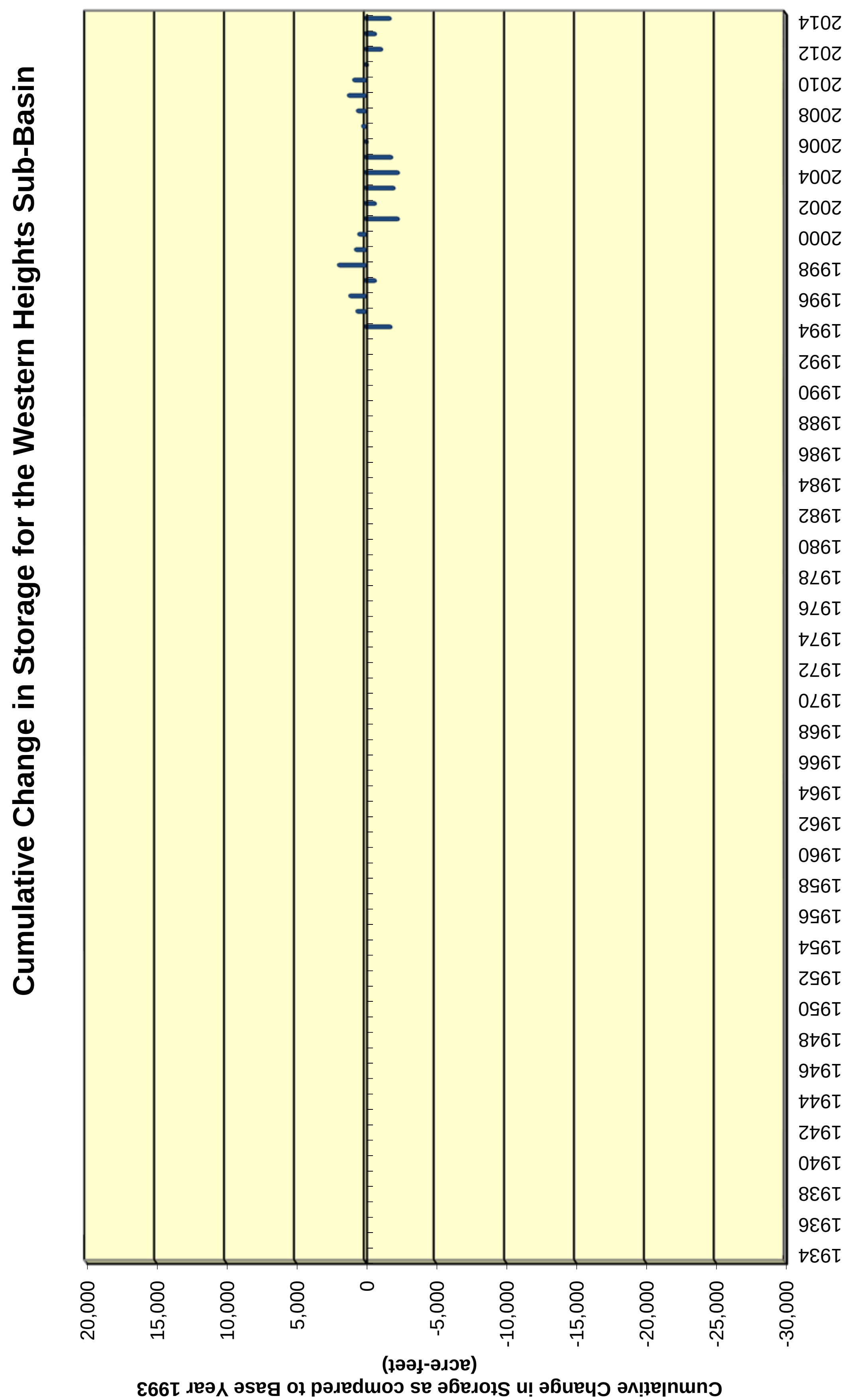
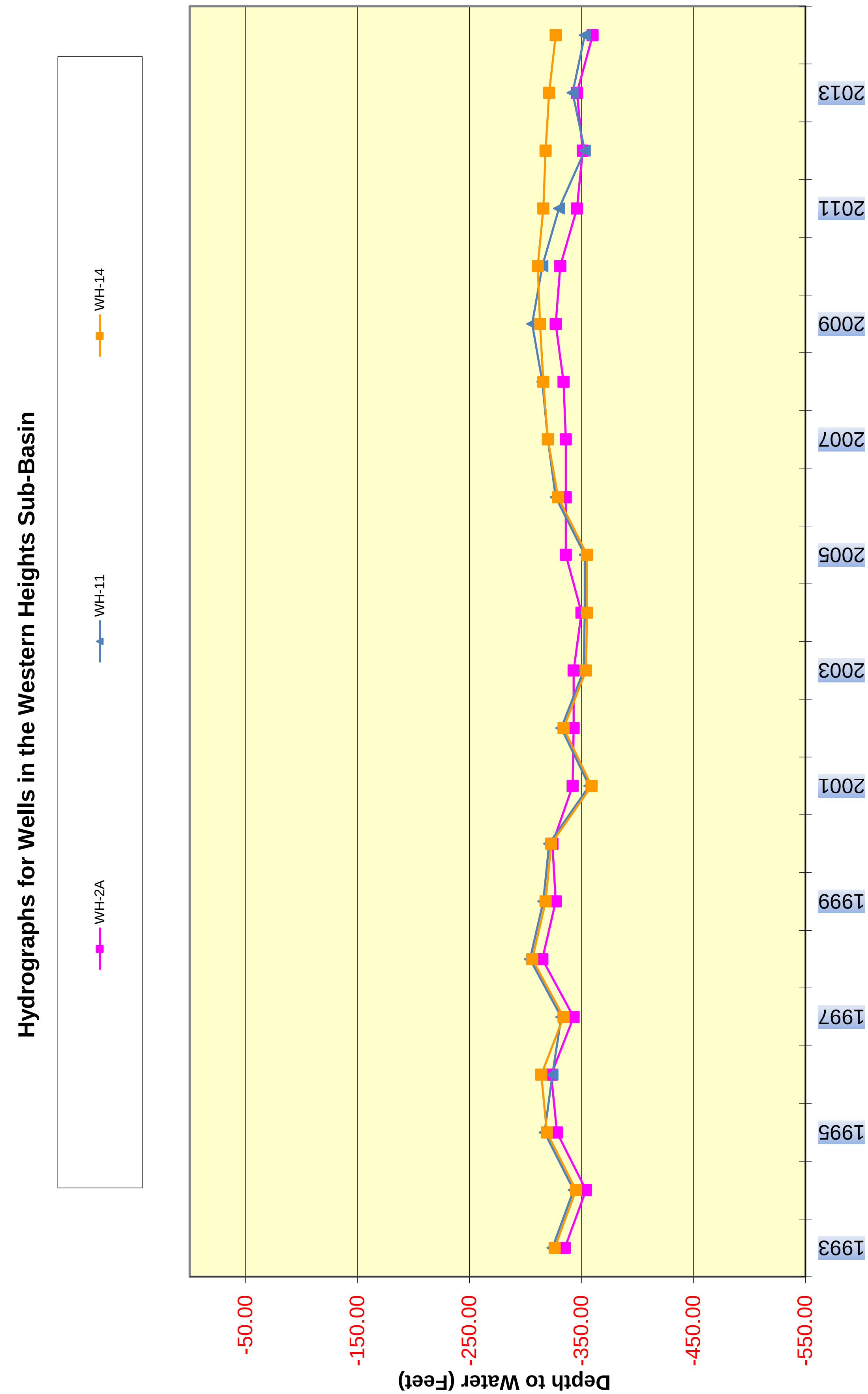
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014


Cumulative Change in Storage for the Western Heights Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

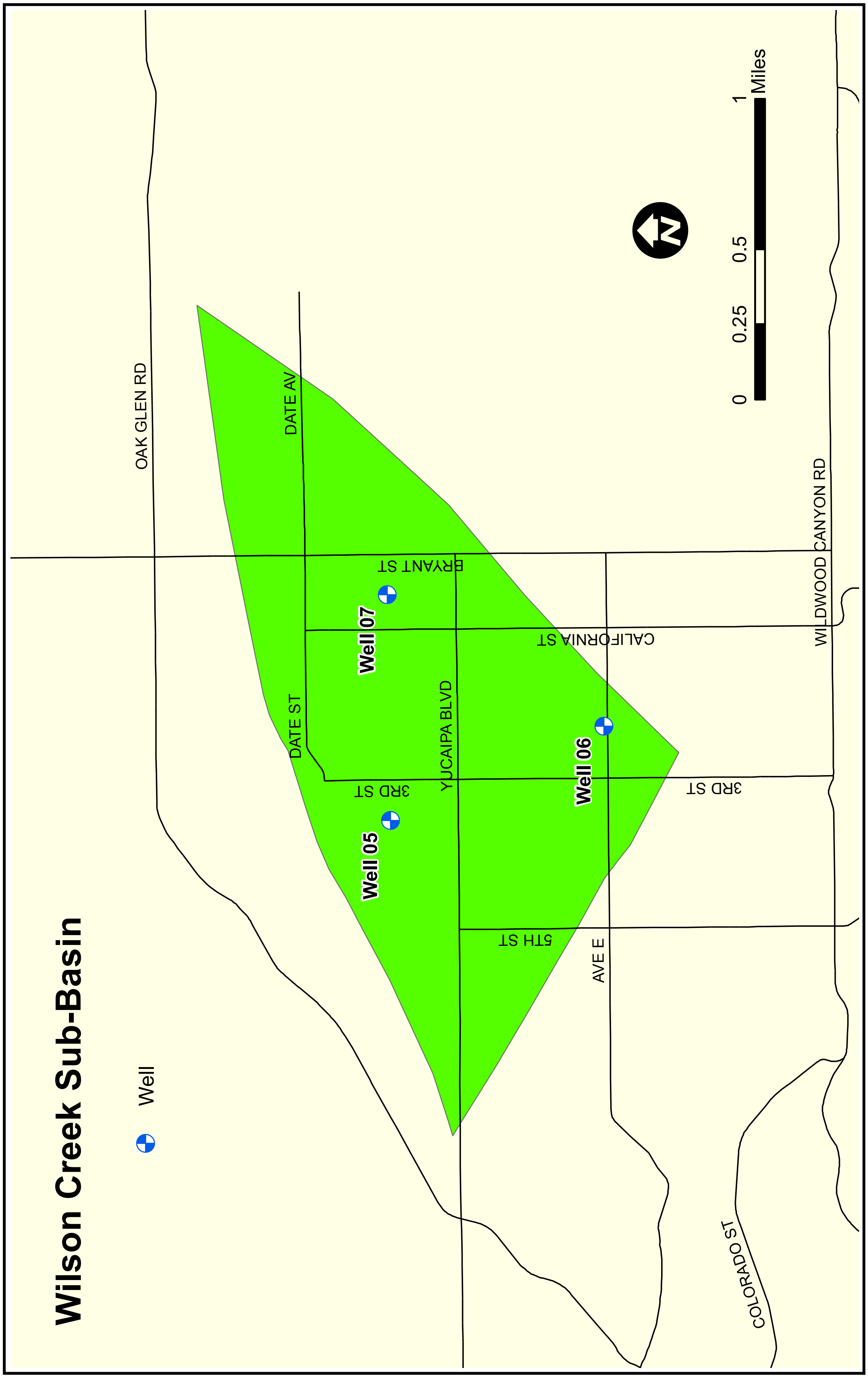
San Bernardino Valley Municipal Water District

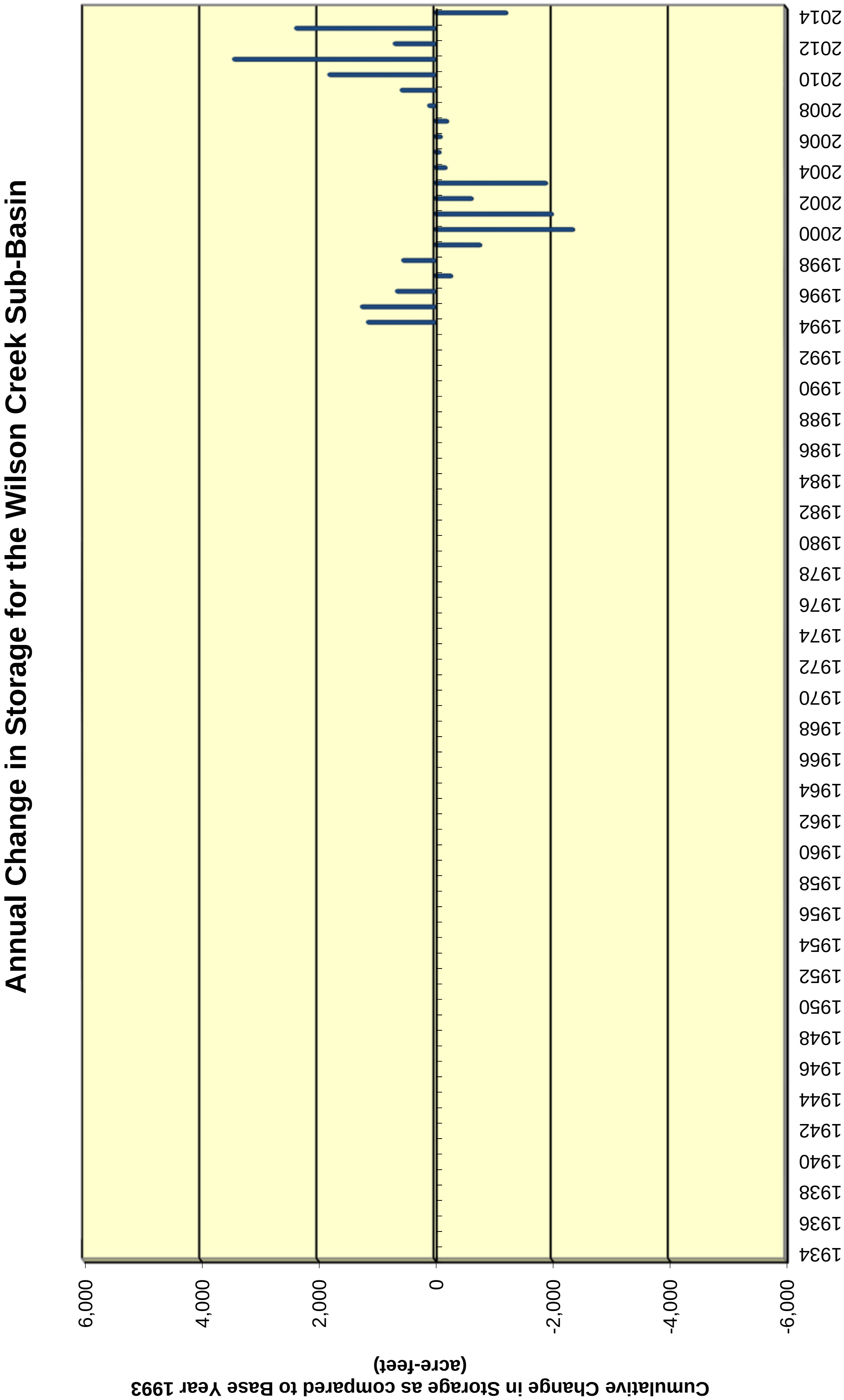
Change In Storage for the Western Heights Sub-Basin 1993 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	-19	-1,929	-1,929
1995	26	2,640	711
1996	5	507	1,218
1997	-20	-2,030	-812
1998	28	2,842	2,030
1999	-12	-1,218	812
2000	-2	-233	579
2001	-30	-3,035	-2,456
2002	16	1,644	-812
2003	-13	-1,343	-2,155
2004	-3	-307	-2,462
2005	5	480	-1,982
2006	17	1,746	-236
2007	5	537	301
2008	4	371	672
2009	6	644	1,316
2010	-4	-375	941
2011	-12	-1,189	-248
2012	-10	-1,016	-1,264
2013	4	444	-820
2014	-10	-1,054	-1,874



Hydrographs for Wells in the Western Heights Sub-Basin
WH-2A
WH-11
WH-14
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013


Wilson Creek Sub-Basin
Well
OAK GLEN RD
DATE AV
DATE ST
BRYANT ST
CALIFORNIA ST
YUCAIPA BLVD
3RD ST
3RD ST
5TH ST
AVE E
WILDWOOD CANYON RD
COLORADO ST
Well 05
Well 06
Well 07
0
0.25
0.5
1
Miles
Path: Y:\1422ChangeInStorage\SubBasinMaps\WilsonCrkSubBasin.mxd


Annual Change in Storage for the Wilson Creek Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
6,000
4,000
2,000
0
-2,000
-4,000
-6,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
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1972
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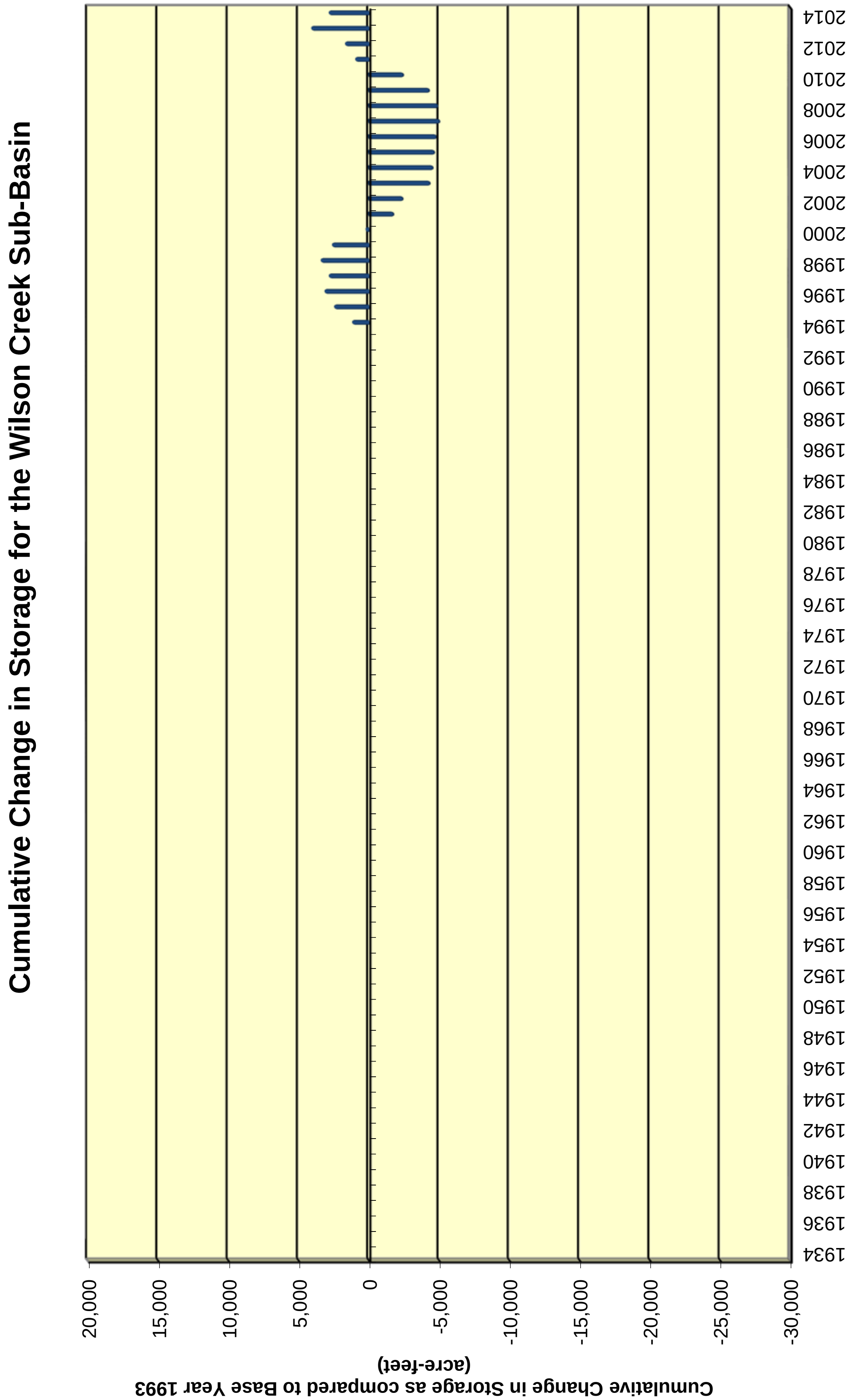
2004
2006
2008
2010
2012
2014


Cumulative Change in Storage for the Wilson Creek Sub-Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
20,000
15,000
10,000
5,000
0
-5,000
-10,000
-15,000
-20,000
-25,000
-30,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
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1962
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1970
1972
1974
1976
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1984
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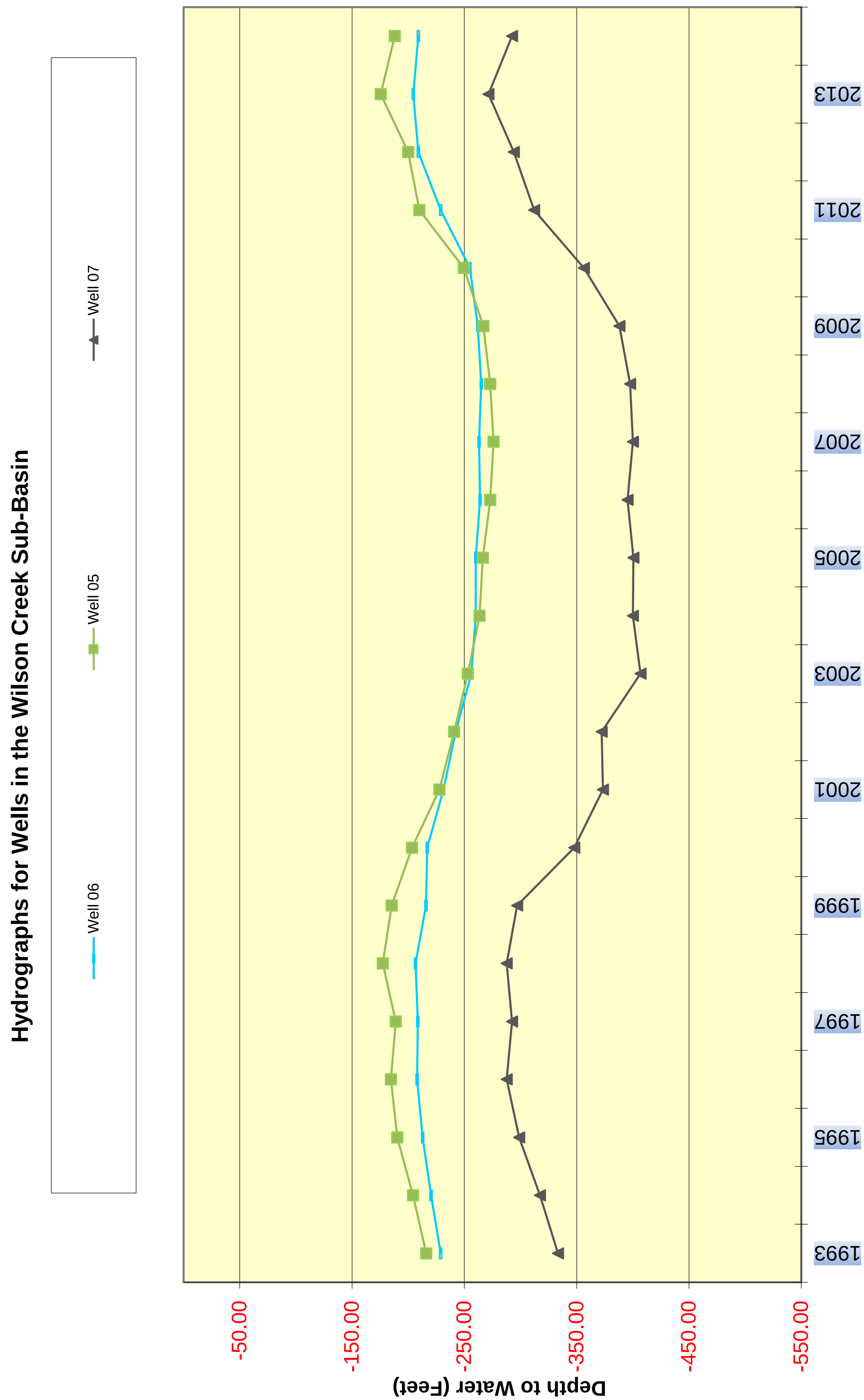
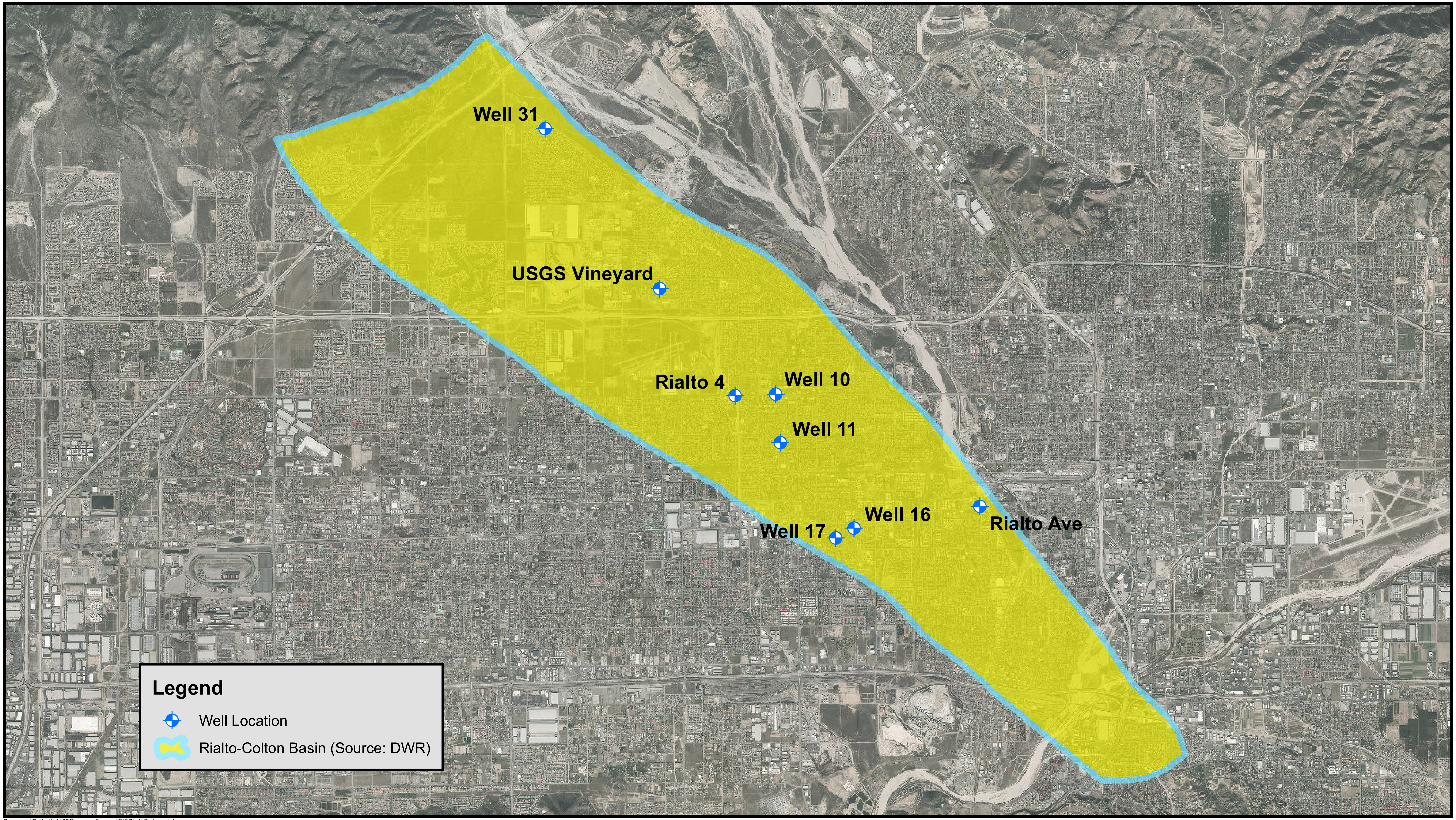
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

San Bernardino Valley Municipal Water District

Change In Storage for the Wilson Creek Sub-Basin 1993 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1993	0		
1994	12	1,179	1,179
1995	13	1,282	2,461
1996	7	684	3,145
1997	-3	-307	2,838
1998	6	578	3,416
1999	-9	-804	2,612
2000	-23	-2,390	222
2001	-21	-2,027	-1,805
2002	-8	-658	-2,463
2003	-20	-1,928	-4,391
2004	-3	-211	-4,602
2005	-1	-109	-4,711
2006	-2	-129	-4,840
2007	-2	-239	-5,079
2008	1	135	-4,944
2009	6	603	-4,341
2010	19	1,839	-2,502
2011	37	3,465	963
2012	16	722	1,685
2013	17	2,406	4,091
2014	-13	-1,249	2,842


Hydrographs for Wells in the Wilson Creek Sub-Basin
Well 06
Well 05
Well 07
Depth to Water (Feet)
-50.00
-150.00
-250.00
-350.00
-450.00
-550.00
1993
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013

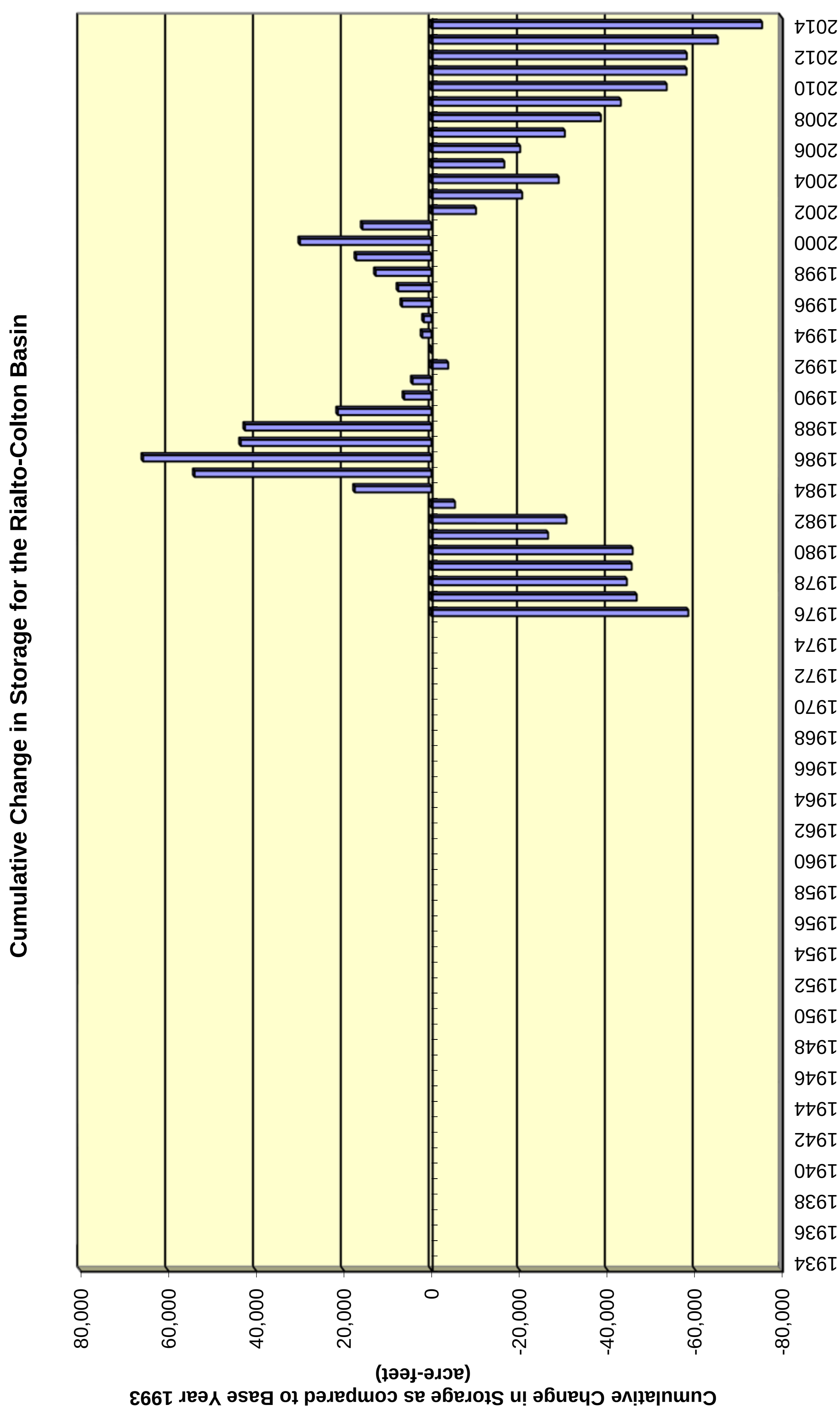


Document Path: Y:\1422ChangeInStorage\CISRialtoColton.mxd

SAN BERNARDINO Valley MUNICIPAL WATER DISTRICT

Change in Storage for Rialto-Colton Groundwater Basin

2013-2014 Change in Storage: -10,280 acre-ft


Cumulative Change in Storage for the Rialto-Colton Basin
Cumulative Change in Storage as compared to Base Year 1993
(acre-feet)
80,000
60,000
40,000
20,000
0
-20,000
-40,000
-60,000
-80,000
1934
1936
1938
1940
1942
1944
1946
1948
1950
1952
1954
1956
1958
1960
1962
1964
1966
1968
1970
1972
1974
1976
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1994
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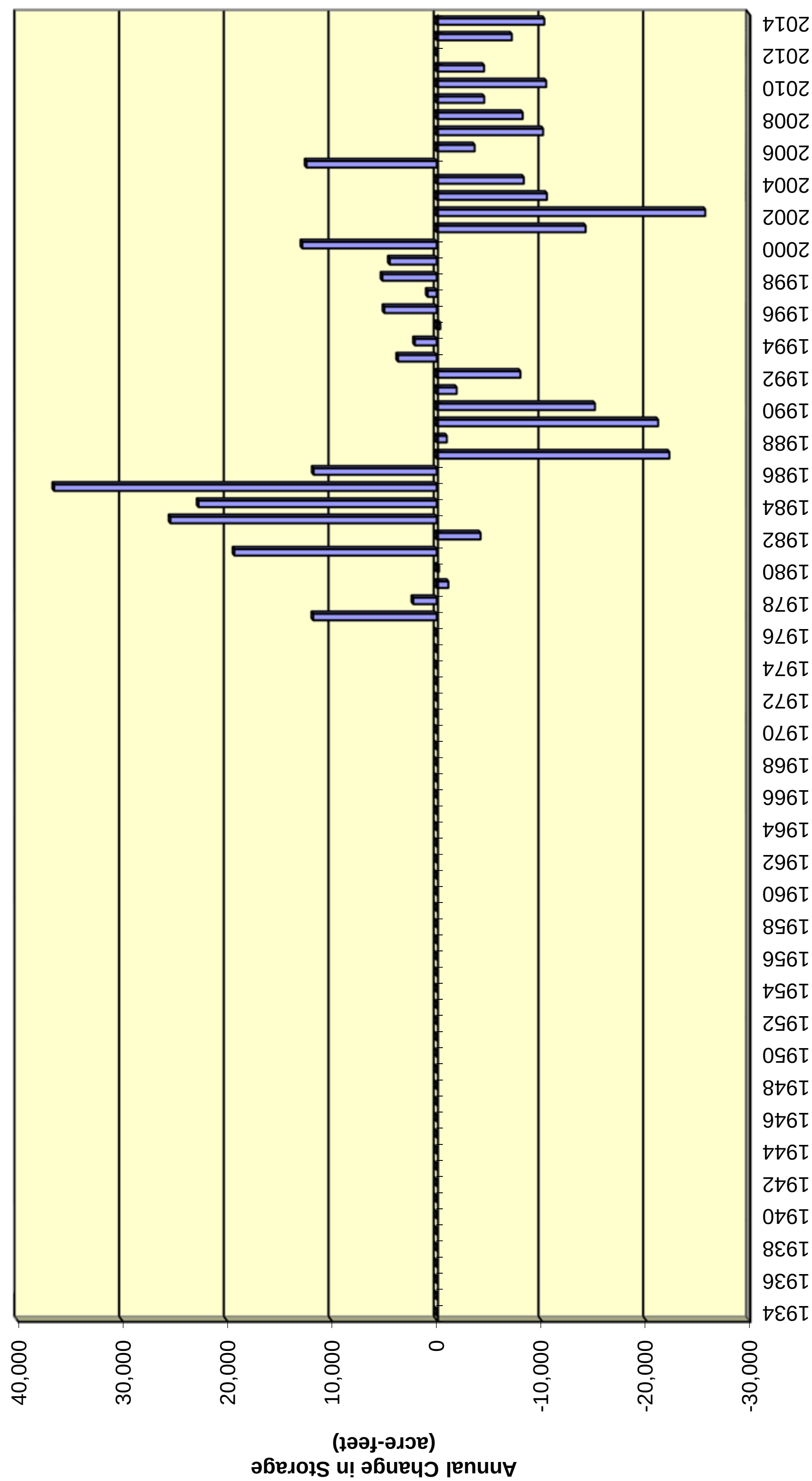
2002
2004
2006
2008
2010
2012
2014

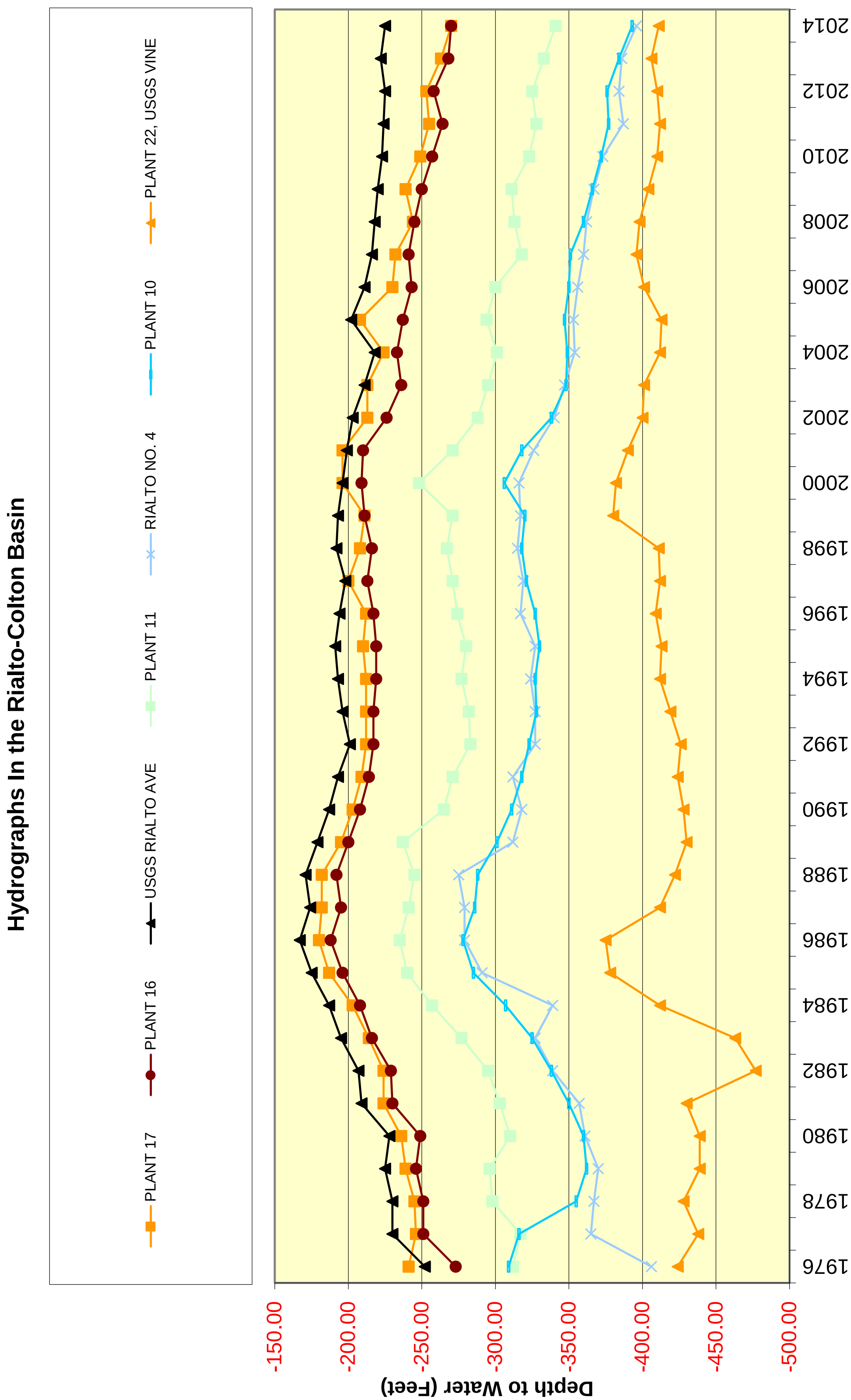
Annual Change in Storage for the Rialto-Colton Basin



San Bernardino Valley Municipal Water District

Change In Storage for the Rialto-Colton Basin 1976 - 2014

(1) Year	(2) Basin Index (ft.)	(3) Annual Change in Groundwater Storage (acre-feet)	(4) Cummulative Change in Groundwater Storage (acre-feet)
1976			-58,354
1977	7	11,742	-46,612
1978	0	2,239	-44,373
1979	0	-1,111	-45,484
1980	0	-218	-45,702
1981	10	19,268	-26,434
1982	0	-4,188	-30,622
1983	13	25,380	-5,242
1984	11	22,698	17,456
1985	20	36,486	53,942
1986	6	11,707	65,649
1987	-10	-22,232	43,417
1988	0	-962	42,455
1989	-11	-21,142	21,313
1990	-9	-15,111	6,202
1991	-2	-1,905	4,297
1992	-5	-7,992	-3,695
1993	1	3,695	0
1994	1	2,087	2,087
1995	-1	-339	1,748
1996	3	4,948	6,696
1997	1	868	7,564
1998	2	5,137	12,701
1999	2	4,439	17,140
2000	8	12,786	29,926
2001	-8	-14,217	15,709
2002	-14	-25,730	-10,021
2003	-5	-10,524	-20,545
2004	-5	-8,315	-28,860
2005	6	12,383	-16,477
2006	-3	-3,618	-20,095
2007	-5	-10,157	-30,252
2008	-4	-8,206	-38,458
2009	-2	-4,537	-42,995
2010	-6	-10,454	-53,449
2011	-3	-4,521	-57,970
2012	1	-48	-58,018
2013	-4	-7,173	-65,191
2014	-6	-10,274	-75,465



Hydrographs In the Rialto-Colton Basin
PLANT 17
PLANT 16
USGS RIALTO AVE
PLANT 11
RIALTO NO. 4
PLANT 10
PLANT 22, USGS VINE
Depth to Water (Feet)
-150.00
-200.00
-250.00
-300.00
-350.00
-400.00
-450.00
-500.00
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010
2012
2014

APPENDIX: SBVMWD CHANGE IN STORAGE METHODOLOGY

List of Figures

List of Tables

A. INTRODUCTION

The San Bernardino Valley Municipal Water District was incorporated on February 17, 1954. The District is one of 29 contractors of the California State Water Project (SWP) and has the fifth largest annual entitlement to SWP water at 102,600 acre-feet. The District takes delivery of SWP water through the Devil Canyon Powerhouse on the East Branch of the California State Aqueduct.

The District serves a population of about 600,000 people within a 328 square mile area in the east San Bernardino Valley. Currently, there are over 33 miles of 12-inch to 78-inch diameter pipelines in the District's delivery system. The system includes 28 service connections to deliver both native and SWP water for direct delivery or groundwater recharge within the District's boundary. Groundwater recharge is conducted to lessen the impact of increasing well production from the various groundwater basins within the District's boundary and to help the District meet certain legal obligations.

One of the legal obligations imposed on the District is the responsibility for maintaining the "safe yield" of the San Bernardino Basin Area. The safe yield is a theoretical maximum amount of water that may be removed from the basin on an annual basis without degrading the usable water supply. For the San Bernardino Basin Area, this amount has been set by the Western-San Bernardino Watermaster at 232,100 acre-feet/yr (Watermaster, pg. 24).

One method of accounting for groundwater that enters or leaves a basin area is to estimate the change in groundwater volume, or storage, using a network of observation wells. The change in groundwater elevation for these observation wells along with the given soil characteristics can be used to approximate the change in groundwater storage.

B. THE SBVMWD CHANGE IN STORAGE MODEL

B.1 Background

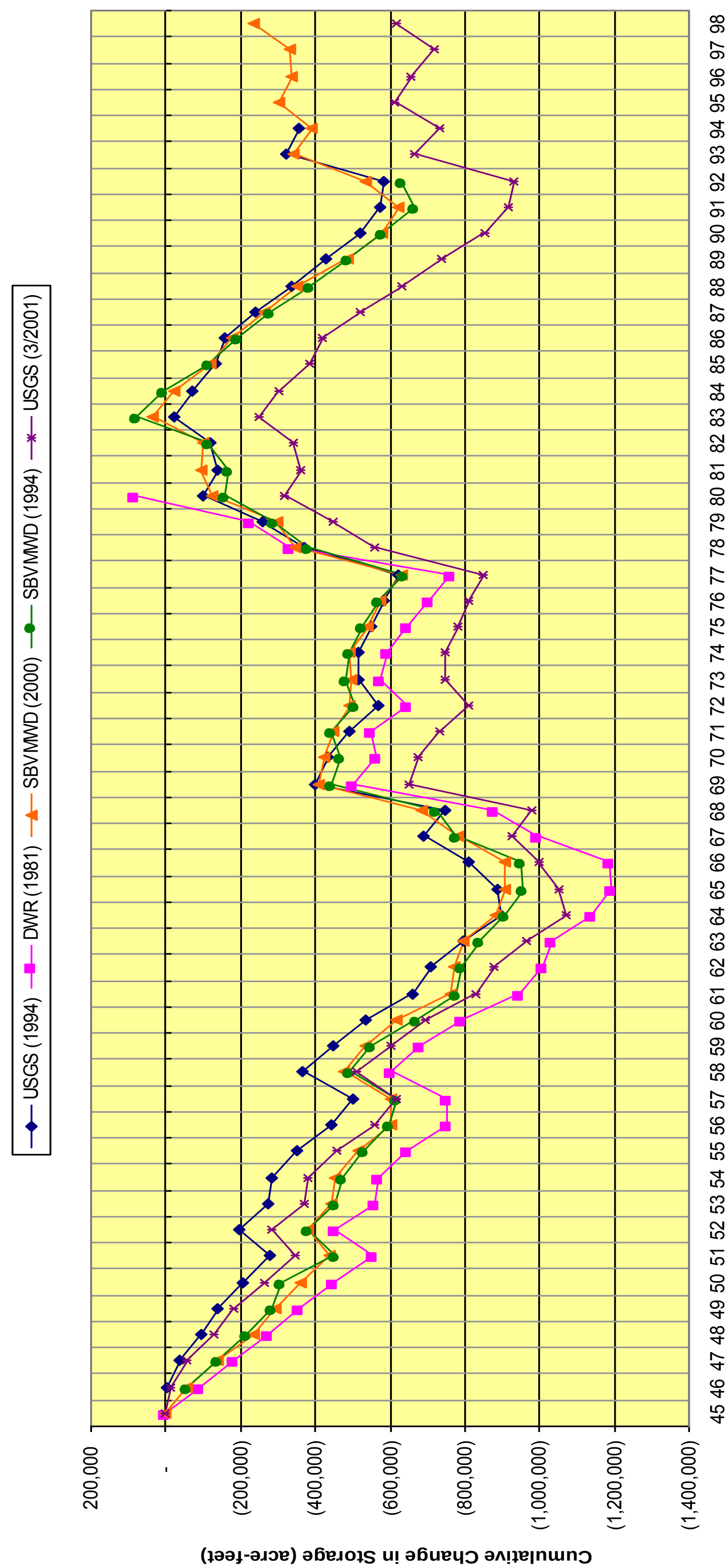
The San Bernardino Valley Municipal Water District (SBVMWD) has been calculating the change in groundwater storage for the San Bernardino Basin area since 1970. The first calculation was completed for the years 1934 – 1960 by the State of California Department of Water Resources (DWR) and the results were summarized in Bulletin 104-5, Meeting Water Demands in the Bunker Hill-San Timoteo Area, Geology, Hydrology, and Operation-Economics Studies, Text and Plates (Olson, pp. 90 – 92). The DWR change in storage values were calculated using the Specific Yield Method (Olson, pp. 85 – 98) and a mathematical model developed by TRW, Incorporated, Redondo Beach, California (TRW). In 1980, SBVMWD updated the change in storage calculation to include the years 1961 – 1980 (Van Gelder). In the early 1990’s, SBVMWD created a new change in storage model using GRID software developed by Environmental Systems Research Institute (ESRI), Redlands, California. GRID was selected because it allowed a finer model resolution and because it was able to interpolate surfaces or create contour maps from a spatial distribution of data points. The differences between the two models are summarized in Table B.1.1.

Table B.1.1. Differences between DWR model and SBVMWD Model.

Item	DWR Model	SBVMWD Model
Method of Analysis	Specific Yield Method	Specific Yield Method
Sub-basin boundaries	DWR Bulletin No. 104-5	DWR Bulletin No. 104-5
Wells (quantity)	75	See main report
Water Levels	Constant across “nodes”	Interpolated from given data
Specific Yield	DWR Bulletin No. 45	DWR Bulletin No. 45
Computer Software	FORTRAN IV	ESRI GRID® Software
Model resolution (cell size)	75 “nodes” (cells): Smallest cell= 589 acres Largest cell = 1,778 acres	335,758 cells: Uniform cell size: 100 ft. square (.23 acre)

Although the two models use different computer programs and a different quantity of wells (many of the wells used in the original study have since been abandoned) to calculate the change in groundwater storage, the results obtained from the two models are similar (see Figure B.1.1). The difference in the results can be mostly attributed to the improved capabilities of the SBVMWD model.

Figure B.1.1. Comparison of DWR FORTRAN Model, USGS MODFLOW Model and SBVMWD GRID Model Results



Geologists divided the DWR model for the San Bernardino Basin Area into 75 polygons (see Table B.1.2), or “nodes”, using the Theissen method of polygon construction. The nodes were drawn to surround an area where the soil characteristics, specific yield, and groundwater surface could be assumed constant. The change in storage was computed for each individual node using the Specific Yield Method. The sum of the change in storage for all of the nodes was the change in storage for the San Bernardino Basin area.

Table B.1.2. Quantity of Theissen Polygons (“Nodes”) for the Department of Water Resources Bulletin 104-5.

Area No.	Designation	No. of Nodes
1	Cajon	8
2	Devil Canyon	4
3	Lytle Creek	10
4	Pressure Zone	16
5	City Creek	19
6	Redlands	5
7	Mill Creek	8
8	Reservoir	3
9	Divide	2
	TOTALS	**75**

The surface area of the smallest node was 589 acres and the surface area of the largest node was 1,778 acres. The large node, or model cell size, provides one of the largest differences between the SBVMWD model and the DWR model. The SBVMWD model has been divided into a uniform, square cell size of 100 feet per side (0.23 acre). This smaller cell size of the SBVMWD model allows values to be more accurately assigned to each model cell based upon the given contour maps instead of assuming constant values across large areas like the DWR model. For example, each model uses storage coefficients from DWR’s Bulletin No. 45 (Eckis). The specific yield data from Bulletin No. 45 is presented on a contour map (Eckis, Plate E). The SBVMWD model is able to convert this contour map into a grid which contains a unique specific yield value for each of its 335,758 model cells. In contrast, the DWR model must assume a single, constant specific yield across each of its 75 larger nodes. The larger number of model cells in the SBVMWD model allows it to use a more accurate representation of the specific yield contour map in the change in groundwater storage calculation.

In addition to providing a more accurate representation of the specific yield contour map, the SBVMWD model also provides a more accurate representation of the water levels within each sub-basin. The DWR model assumes a constant water level across each of its 75 nodes. This constant groundwater surface across each node causes the DWR model to produce a groundwater surface with a “stair step” appearance. The finer resolution and ability of the SBVMWD model to interpolate a groundwater surface within each sub-basin from the given well data. This produces a water level surface that is more representative of the true surface than the “stair step” surface generated by the DWR model.

In conclusion, the DWR model and SBVMWD model produce similar results. The difference between the two models is most likely due to the finer model resolution and the interpolation capabilities of the newer SBVMWD model.

In the Yucaipa basin there was little water level data before 1993. To provide some consistency between the SBBA and Yucaipa calculations, a base year was chosen for the Yucaipa calculation that is equivalent to the SBBA base year. The change in storage results for the SBBA (figure 2) reveal that 1993 is essentially the same as 1934 the SBBA base year. Therefore, since data was not available in the Yucaipa basin back to 1934, the equivalent year 1993 was selected as the base year for the Yucaipa calculation. The results of the Yucaipa model are plotted on figures 6. Figure 6 provides the Yucaipa results on a different scale. The beginning trend of the Yucaipa basin CCIS results is similar to the SBBA which provides confidence in the results.

B.2 Method of Analysis

The San Bernardino Valley Municipal Water District (SBVMWD) Change in Storage (CIS) model calculates the cumulative change in storage (CCIS) using a spatial distribution of available wells and the Specific Yield Method, as put forth in the Department of Water Resources' Bulletin 104-5 (Olson, pg. 85). This method calculates the change in storage based upon an adaptation of the simple mathematical equation for calculating volume, (length * width * height).

$$\mathbf{CCIS = (h_{present\ year} - h_{base\ year})SA} \qquad \textbf{(Equation B.2.1)}$$

where,

CCIS = Cumulative change in storage, acre-feet

$(h_{present\ year} - h_{base\ year})$ = Change in saturated thickness, ft.

$h_{present\ year}$ = Depth to groundwater, present year

$h_{base\ year}$ = Depth to groundwater, base year (1934)

S = Specific Yield, dimensionless

A = Area, acres

In Equation B.2.1, “length * width” is given by the surface area, A, of the basin and “height” is given by, $(h_{present\ year} - h_{base\ year})$, the change in saturated thickness. The specific yield simply adjusts the volume calculation to account for the fact that only the pore space in the soil is available for water storage. Figure B.2.1 illustrates the Specific Yield Method.

Given the cumulative change in storage values for a series of years, these cumulative values can be used to calculate the annual change in groundwater storage. The annual change in groundwater storage is simply the difference between a year’s cumulative change in storage and the previous year’s cumulative change in storage (Equation B.2.2).

$$\mathbf{ACIS_{present\ year} = CCIS_{present\ year} - CCIS_{previous\ year}} \qquad \textbf{(Equation B.2.2)}$$

where,

ACIS = Annual Change in Storage for the present year, acre-feet

$CCIS_{present\ year}$ = Cumulative Change in Storage for the present year, acre-feet

$CCIS_{previous\ year}$ = Cumulative Change in Storage for the previous year, acre-feet

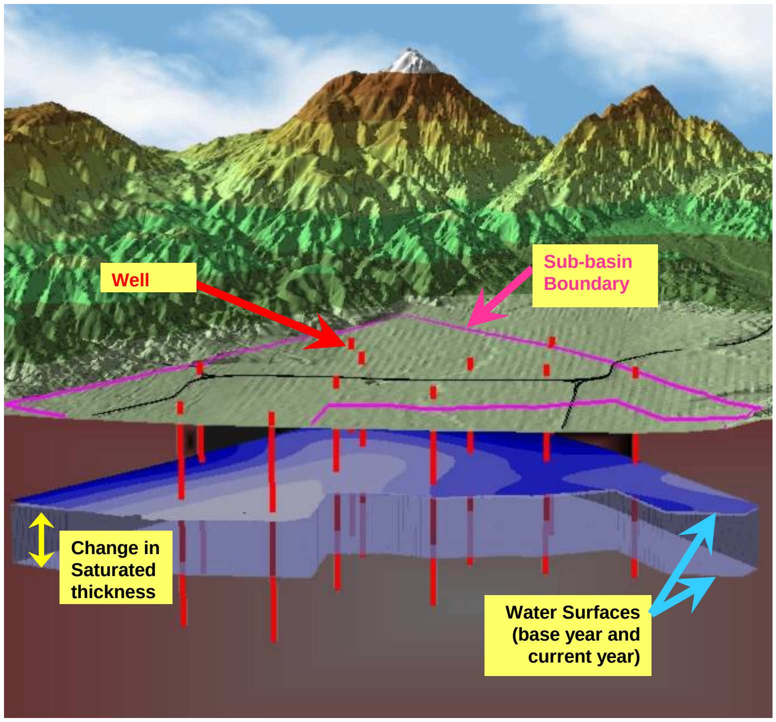


Figure B.2.1. Illustration of the Specific Yield Method for calculating the change in groundwater storage (Equation B.2.1).

B.3 Technical Approach

Each of the variables in the cumulative change in storage calculation (Equation B.2.1) varies depending upon the geographic position within the Basin Area and can be spatially represented by a contour map. The SBVMWD Change in Storage model was written in Environmental Systems Research Institute's (ESRI) GRID software because it allows contour maps to be converted into "grids" and used directly in the simple mathematical equation for the cumulative change in storage.

When a contour map is converted into a grid, the software essentially breaks the contour map down into smaller, user-defined pieces called cells. The GRID software stores a unique value within each grid cell depending upon its geographic location. For example, each cell in the depth to groundwater grid contains a unique value for the depth to groundwater based upon its geographic position in the grid. Figure B.3.1 illustrates the conversion of a contour map into a grid. The user has the flexibility to control the cell size. The smaller the cell size, the more representative of the actual contour map. However, there is a trade-off between cell size and processing speed. Since the software performs calculations on each individual grid cell, a finer grid requires more calculations and, therefore, takes longer to process. Thus, the challenge is to select the largest cell size possible without significantly impacting the results. The cell size for the SBVMWD CIS model is 100 feet square.

Once the contour maps have been converted to grids, these grids are used in Equation B.2.1. When the GRID software uses grids in any algebraic equation, the results are stored in a new grid. For example, when two grids are multiplied, the software essentially lays the two grids on top of one another and multiplies the values in each individual grid cell on a cell-by-cell basis. The results are stored in a new grid and are located in the same geographic cell location as the two values used in the calculation. The same logic applies to the cumulative change in storage calculation. The software generates the change in saturated thickness grid by subtracting one water level grid from the other. The change in saturated thickness grid (height) is then multiplied by the specific yield grid (unit less) and then multiplied by the cell size (area) which results in a grid containing the cumulative change in storage in each cell (see Figure B.3.2). The cumulative change in storage for the entire area is simply the summation of the individual cell values.

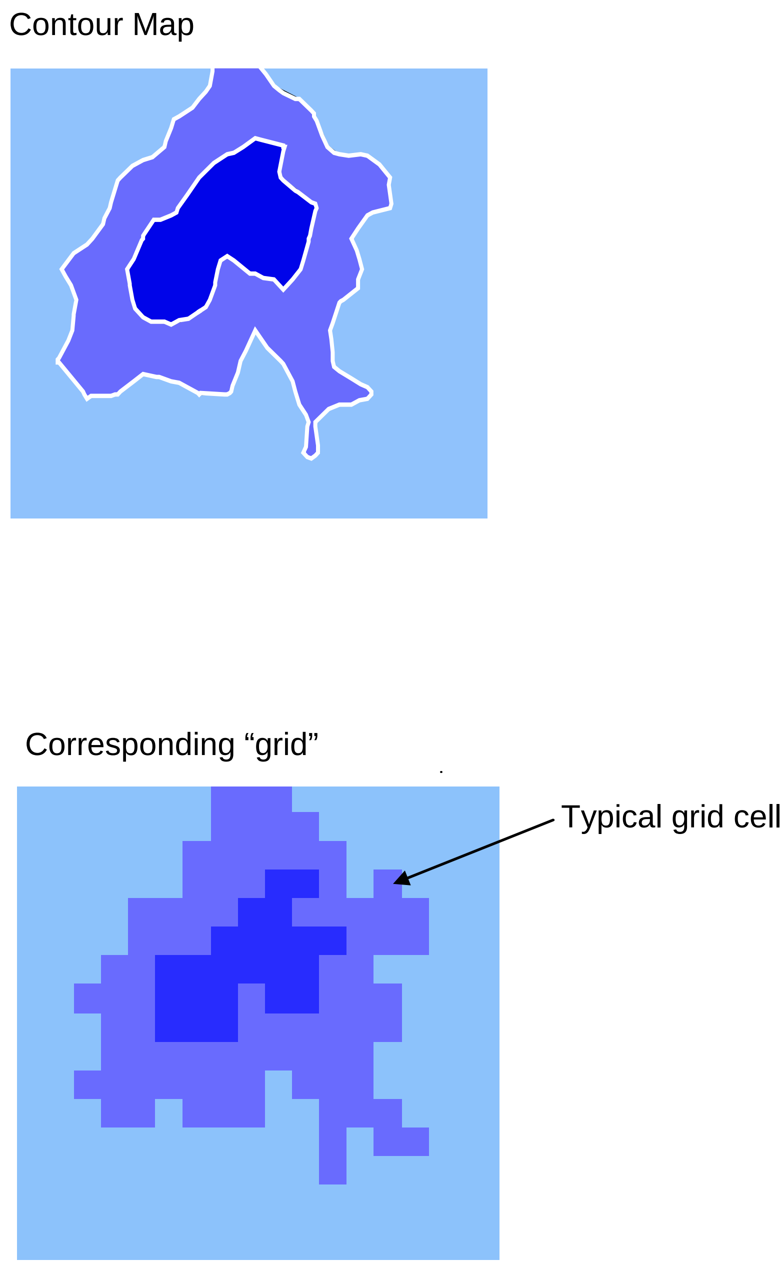


Figure B.3.1. Grid representation of a contour map.

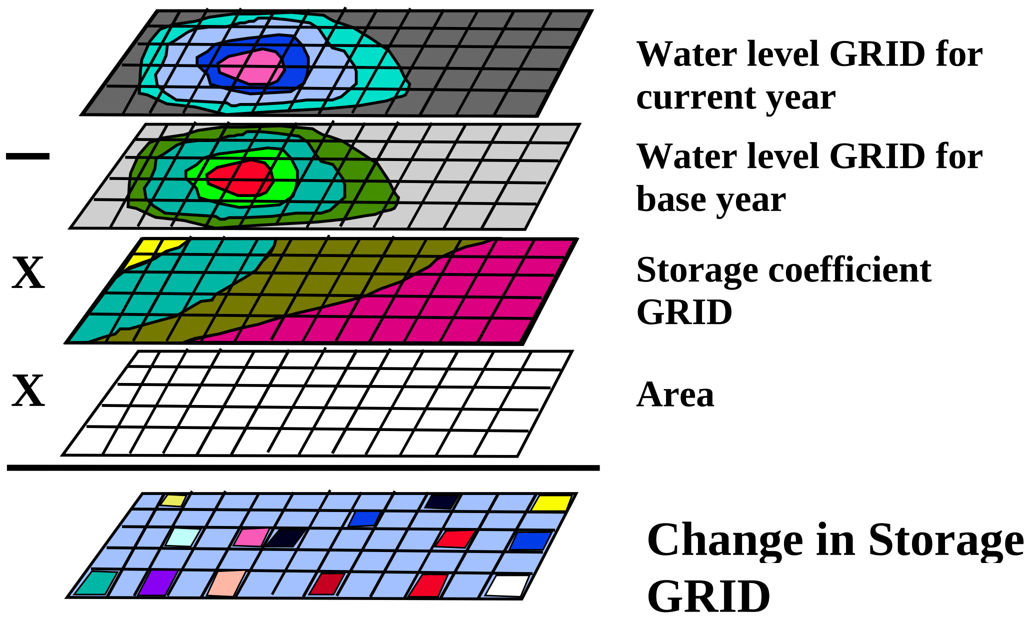


Figure B.3.2. Grid representation of Equation B.2.1.

The SBVMWD model uses the calendar year instead of the water year (October through September). Calendar years were chosen so that the SBVMWD model results would be coincident with the United States Geological Survey groundwater model results which are dependent upon local pumping records kept by calendar year.

B.4 Data

Sub-basin boundaries. For the San Bernardino Basin area, the SBVMWD Change in Storage model used the same sub-basins identified in the Department of Water Resources (DWR) Bulletin 104-5 (DWR, Plate 14) (Basin Groundwater Storage Data). DWR Geologists divided the San Bernardino Basin area into nine sub-basins based upon the known hydrologic barriers (faults) in the valley. In the Yucaipa Basin area, the CIS is calculated across the entire Basin Area. This may be later refined as more is learned about this Basin Area.

Well Locations. In the San Bernardino Basin area, wherever possible, the change in storage model used the same wells used in Bulletin 104-5. However, many of the original wells have since been abandoned and are no longer available for measurement. Whenever one of the original wells was unavailable, an attempt was made to find a "replacement well" in the same vicinity. If a replacement well was not available in the same vicinity, an effort was made to find an additional well within the sub-basin that would improve the spatial distribution of data points. In addition to geographic location, replacement wells were selected based upon the following criteria:

1. *Public ownership*. Because public water agencies tend to be more diligent at data collection, SBVMWD limited its selection of replacement wells to those owned by public water agencies.

2. *Similar hydrograph.* A hydrograph is a plot of the static water level over time. The hydrograph for each replacement well was compared to the hydrograph of the well it was replacing to ensure that the replacement well was measuring water levels from the same aquifer as the original well.

In the Yucaipa Basin area, wells were selected across the Basin Area.

Static depth to water. Like the DWR model, the SBVMWD Change in Storage model uses the highest, annual fall (September - December) static (pump OFF) depth-to-water measurement for each well. The fall season was selected because it follows the summer months during which basin water levels are drawn down to their lowest levels due to the high pumping demands. Fall is also chosen because the cooler fall weather causes pumping rates to dramatically decline and allows the water surface to recover to a level that is more representative of the static water surface.

Static water level data was obtained directly from the well owners and was verified to be static by reviewing the well's hydrograph. Large downward "spikes" in the data were investigated by comparing the depth of the spike to the estimated cone of depression. If the depth of the spike was similar to the cone of depression, that data point was assumed to be dynamic (pump ON) and the data point was eliminated from the analysis. When points were eliminated, or missing from the data, a straight-line interpolation was performed between the known points. Although there is some error associated with assigning points by straight-line interpolation, it was felt that omitting points from the overall interpolation of the water surface would cause a larger error in the analysis.

Before the depth to water data could be used in the Change in Storage model, it had to first be converted into a grid surface. The annual depth to water grids for each sub-basin were interpolated using the highest fall measurements and the Inverse Distance Weighted method of interpolation. Interpolation was intentionally performed separately within each sub-basin to eliminate the potential problem of interpolating across sub-basin boundaries, which are groundwater barriers.

Specific Yields. The specific yield is “the ratio of the volume of water that will drain under the influence of gravity to the volume of saturated rock” (Heath, pp. 28-29). The specific yield values used for the SBBA and Yucaipa Area were obtained from the Department of Water Resources report entitled South Coastal Basin Investigation Geology and Ground Water Storage Capacity of Valley Fill, Bulletin No. 45 (Eckis, Plate E) (see Figure B.4.1).

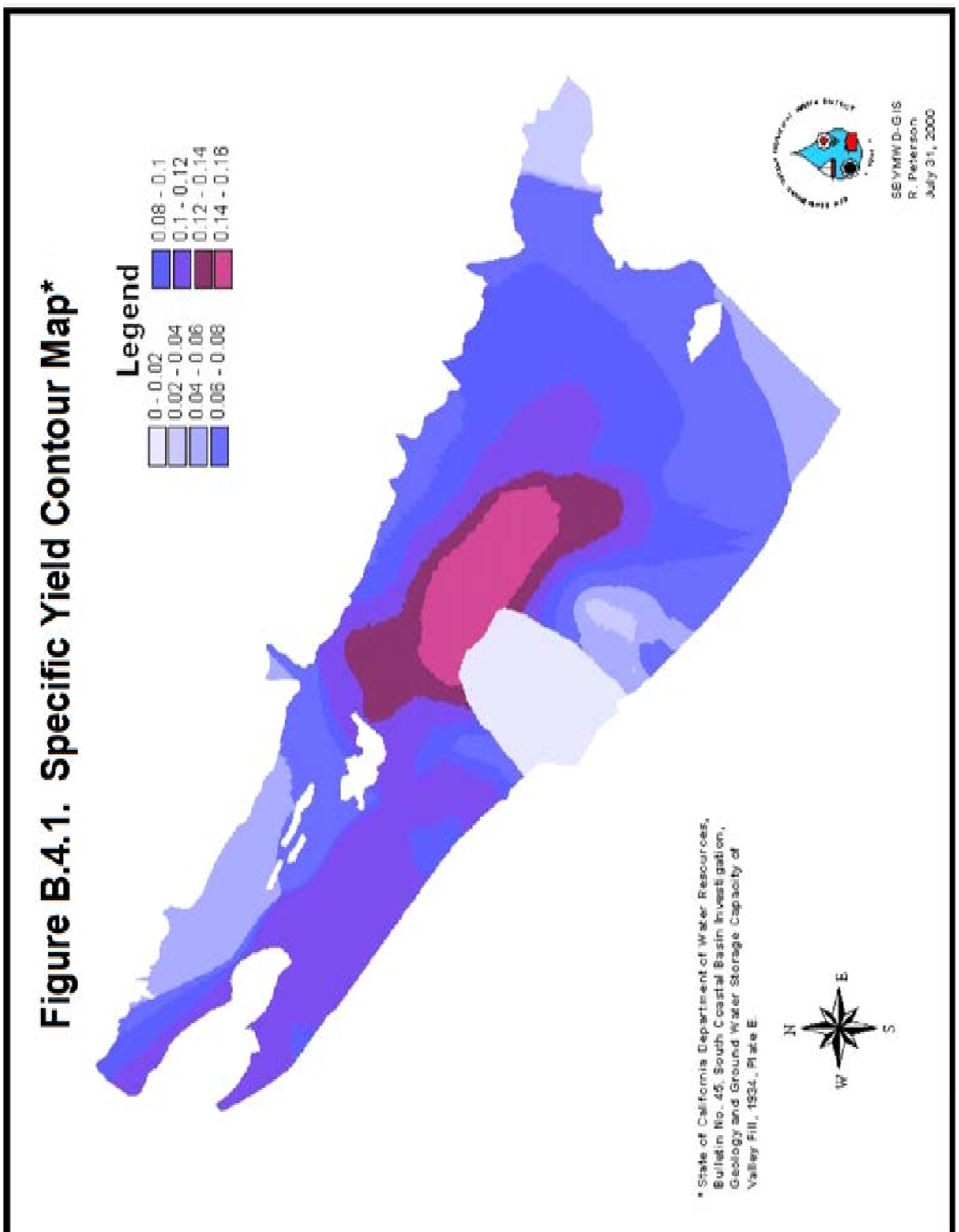


Figure B.4.1. Specific Yield Contour Map*

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