SECTION 3: PUMPING MANAGEMENT AND GROUNDWATER CONDITIONS

2020-21 PUMPING PLAN AND GROUNDWATER CONDITIONS

In accordance with the Water Agreement, Los Angeles Department of Water and Power (LADWP) prepares an Operations Plan (Plan) each April for the ensuing 12-month runoff year spanning April 1 to March 31. The 2020-2021 Plan included projected amounts for runoff, pumping, water used in the Owens Valley, water exported to Los Angeles, and an update of the groundwater mining calculations. The plan must also comply with the pumping well On/Off provisions of the Inyo/LA Long Term Water Agreement based on soil water and vegetation measurements. The Inyo County Water Department (ICWD) reviews LADWP's proposed operations plan, performing an analysis of the effects of LADWP operations on groundwater levels in the Owens Valley. Following a Technical Group meeting to resolve concerns raised by the County, LADWP finalizes the plan.

Predicted runoff from the Owens River watershed during the 2020-21 runoff-year is forecast to be 299,600 acre-feet (ac-ft) or 74% of the 50-year (1966-2015) average. The actual runoff value will be available in 2021 when all the surface water measurements that constitute the sum have been verified and tabulated. Figure 3.1 compares LADWP's forecasted runoff with the ensuing, actual runoff for each year.

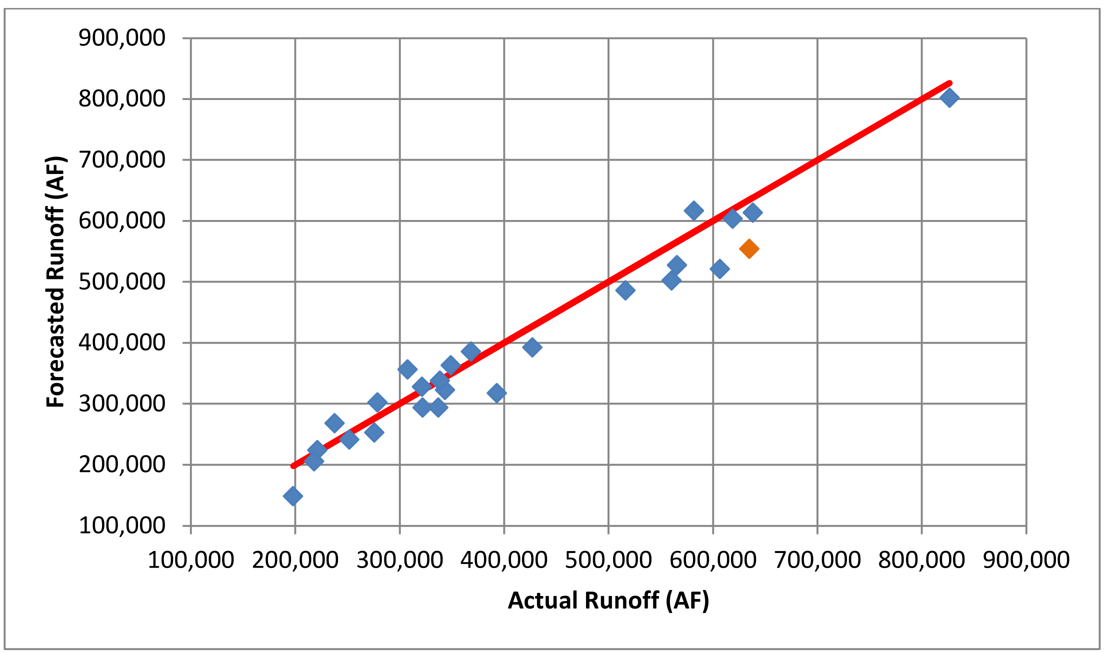

Figure 3.1. Comparison of actual and forecasted runoff 1994-2019 runoff years with 1:1 correspondence (100% accuracy between forecast and actual runoff) in red. Current year is orange diamond. The 2019 actual runoff was 635,000 ac-ft; forecasted runoff was 554,000 ac-ft.

Planned pumping for 2020-21 is in a range of 75,000-93,000 ac-ft. LADWP is predicting 93,780 ac-ft of water will be used in the Owens Valley, 49,600 ac-ft of which is planned for irrigation. The 2020-21 water exports from the Eastern Sierra (Inyo and Mono Counties) is planned to be 188,400 ac-ft (38% of

LADWP anticipated annual need). A more detailed discussion of the 2020-21 Operations Plan is presented in the "2020-21 Pumping" subsection that follows.

In 2019-20, the measured runoff was 635,000 ac-ft, approximately 155% of the 1966-2015 long-term average. Total pumping within the Owens Valley from Laws to Lone Pine for 2019-20 was 53,198 ac-ft, which was only 73% of LADWP's planned pumping amount of 73,712 ac-ft (Table 3.1). Owens Valley water uses for 2019-20 were 93,780 ac-ft, and Eastern Sierra water exports were approximately 332,000 ac-ft (67% of LADWP anticipated annual need).

Table 3.1. Planned and LADWP actual pumping by wellfield for the 2019-20 runoff-year. Estimated minimum pumping prepared by Inyo County for sole source uses is included for reference.

Wellfield	Estimated Minimum Pumping (ac-ft)	Planned Pumping (ac-ft)	Actual Pumping (ac-ft)	Percent Actual vs. Planned
Laws	6,300	8,220	5,878	72%
Bishop	10,400	11,280	4,762	42%
Big Pine	20,550	22,910	19,825	87%
Taboose-Aberdeen	300	8,820	6,653	75%
Thibaut-Sawmill	8,160	9,162	8,135	89%
Ind.-Oak	5,990	8,800	5,786	65%
Symmes-Shepherd	1,200	960	828	86%
Bairs-Georges	500	2,610	715	27%
Lone Pine	1,035	870	943	108%
Total	**54,195**	**73,712**	**53,525**	**73%**

ICWD uses groundwater levels from a suite of key monitoring wells (Indicator Wells) located throughout the Owens Valley near LADWP wellfields to both track and predict (using regression models) the effects of groundwater pumping on water tables. The effect of pumping and runoff in 2019-20 on water levels in the Indicator Wells is shown in Table 3.2.

Table 3.2. Depth to Water (DTW) at Indicator wells, April 2020. All data are in feet from reference point on the test well. Negative values denote a decline in water level. Baseline at monitoring sites is the April average of water levels from years 1985-87. Baseline was predicted from monitoring site/indicator wells regression models if the test well was not present from 1985-87.

Station ID, Monitoring site	DTW April 2020	Change from April 2019	Deviation from Baseline in 2020
Laws			
107T	23.50	4.65	0.77
434T	6.07	0.74	1.53
436T	5.98	1.53	2.12
438T	7.20	3.15	2.40
490T	8.87	1.93	4.20
492T	24.07	4.65	8.73
795T, LW1	8.15	1.41	5.14
V001G, LW2	13.94	4.98	5.68
574T, LW3†	10.73	1.27	2.35

Station ID, Monitoring site	DTW	Change from April 2019	Deviation from Baseline in 2020
Big Pine			
425T	13.90	3.37	1.00
426T	11.54	1.89	0.03
469T	21.19	0.87	0.48
572T	8.23	3.16	3.67
798T, BP1	11.70	2.94	4.35
799T, BP2	18.44	0.67	0.07
567T, BP3	12.32	3.78	1.64
800T, BP4	12.98	2.63	0.61
Taboose Aberdeen			
417T	23.46	2.42	3.51
418T	7.46	0.22	0.77
419T, TA1	4.11	0.76	2.52
421T	33.26	2.00	1.09
502T	9.05	0.98	-1.56
504T	8.23	0.79	2.54
505T	15.20	2.52	3.40
586T, TA4	6.4	0.22	1.92
801T, TA5	14.66	-0.41	-1.14
803T, TA6	4.99	2.41	3.71
Thibaut Sawmill			
415T	9.35	1.47	9.15
507T	3.87	-0.39	0.80
806T, TS2	9.52	-0.41	3.66
Independence Oak			
406T	3.56	1.93	-1.99
407T	11.69	0.89	-4.39
408T	4.00	1.47	-0.87
409T	6.55	3.88	-4.95
546T	4.75	0.50	-1.32
809T, IO1	9.35	2.86	-2.78
Symmes Shepherd			
402T	10.11	0.02	-2.08
403T	7.06	0.63	-1.73
404T	5.88	-0.10	-2.31
447T	35.34	3.92	-13.47

Station ID, Monitoring site	DTW	Change from April 2019	Deviation from Baseline in 2020
510T	7.08	-0.65	-2.08
511T	7.55	-0.44	-2.92
V009G, SS1	17.95	2.98	-11.12
Bairs George			
398T	3.96	0.86	2.39
400T	5.57	0.75	0.73
812T, BG2	12.72	1.95	0.74

Groundwater levels rose in 40 of the 46 non-dry monitoring wells (Figure 3.2); the average change in DTW in the 46 wells from 2019 to 2020 was a rise of 1.69 feet, with a median rise of 1.47 feet. Groundwater levels remain below levels of the mid-1980's vegetation baseline period in about one third of the indicator wells. A more detailed discussion of groundwater levels in Indicator wells and other monitoring wells at well-field locations across the Owens Valley is presented in the "Summary of Hydrologic Conditions" subsection that follows.

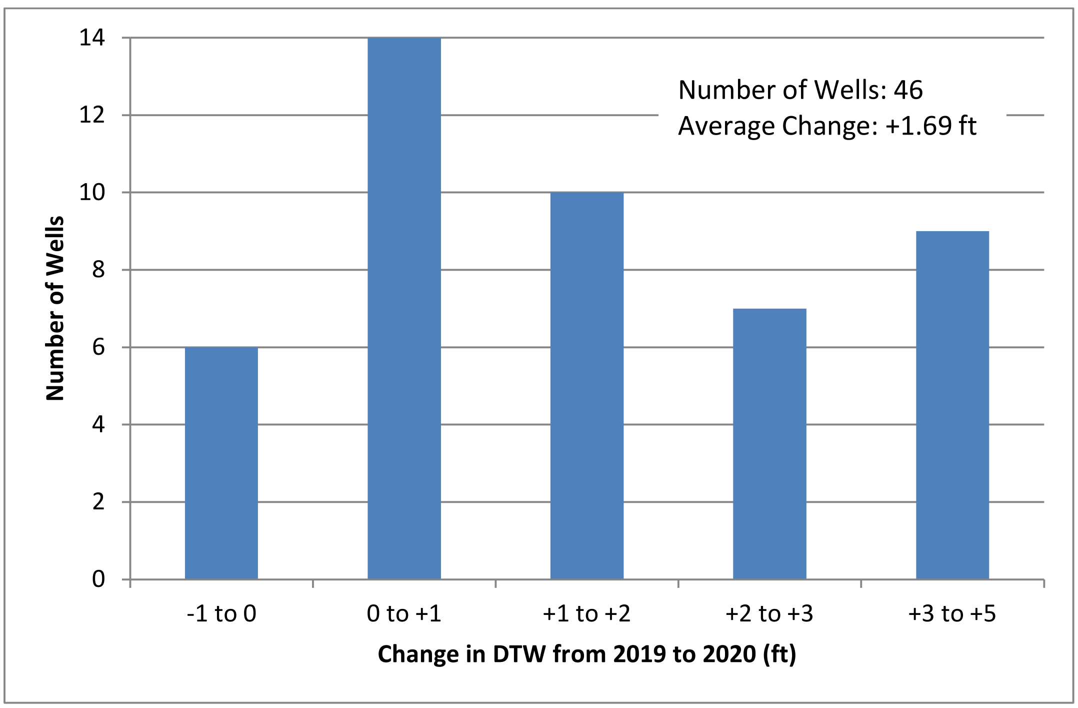

Figure 3.2. Histogram of change in DTW between April 2019 and April 2020 for 46 Indicator test wells. Positive changes indicate rising (shallowing) water tables.

The Water Agreement and Green Book include procedures to calculate a pumping limit to prevent groundwater mining to ensure that there is no long-term decline in aquifer storage; these calculations are summarized in Table 1.4 of LADWP's 2020-21 Operations Plan and are used to predict the pumping limit through September of 2020. Unlike the annual reporting periods which are based on runoff year (April to March), the annual period for the groundwater mining calculation is based on the water-year (October 1 through September 30). The mining calculation is a comparison of LADWP pumping and recharge for each wellfield on a water-year basis for the most recent 20-year period. The 2018-19 water-year groundwater recharge in the Owens Valley from the mining calculations was approximately 243,733 ac-ft compared to 62,208 ac-ft of pumping, and no wellfield was in violation of the groundwater mining provision in water-year 2018-19.

The 19.5-year total of pumping (pumping through April 2020) is subtracted from 20 years of recharge (recharge estimated through September 2020) to arrive at an April to September 2020 pumping limit for each wellfield and the Owens Valley as a whole. For the 20-year water mining calculation recharge is approximately 3.3 million ac-ft compared to 1.4 million ac-ft of pumping.

The 2019-20 water-year estimate of groundwater recharge in the Owens Valley from the mining calculations was approximately 160,419 ac-ft compared to 23,525 ac-ft of estimated pumping, and no wellfield is projected to be in violation of the groundwater mining provision in 2020.

The Big Pine wellfield is the only wellfield close to its mining provision limit with pumping at 84% of the total recharge thru water-year 2019-20 (20-yr total recharge of appx. 538,000 ac-ft compared to 454,000 ac-ft pumping) . Pumping exceeded recharge during the five-year period of the recent drought (2012-2016) and the ratio of pumping to recharge had risen to 91% (only a 43,687 c-ft surplus). This does not constitute a violation of the groundwater mining provision, but ICWD has suggested that pumping in this wellfield be curtailed to include only sole source, in-valley uses. A significant amount of water was spread into the Big Pine Wellfield in 2017 and 2019, this has decreased ratio of pumping to recharge in the Big Pine wellfield to approximately 84% (a surplus of 84,000 ac-ft.), but the relatively small difference between pumping and recharge is concerning and will continue to be monitored.

For the Owens Valley, the percentage of pumping to recharge through water-year 2019-20 is projected to be 15% due to the strong runoff and low pumping amount. Runoff (as an inflow) and pumping (as an outflow) are two of the components of the Owens Valley groundwater budget. It is important to note that evapotranspiration (evaporation and plant transpiration of groundwater primarily by native vegetation along the valley floor) is another primary component (as an outflow) of the groundwater budget; one that is implicitly protected by the Water Agreement. Therefore, looking at groundwater levels which track change in storage of the Owens Valley groundwater system and availability of groundwater to phreatophytic plants is of primary importance.

Summary of Hydrologic Conditions

The history of Owens Valley runoff and pumping since 1970 are presented in Figures 3.3 and 3.4. Since the Water Agreement was adopted and implemented (1992), annual pumping has averaged approximately 73,000 ac-ft and runoff 407,000 ac-ft.

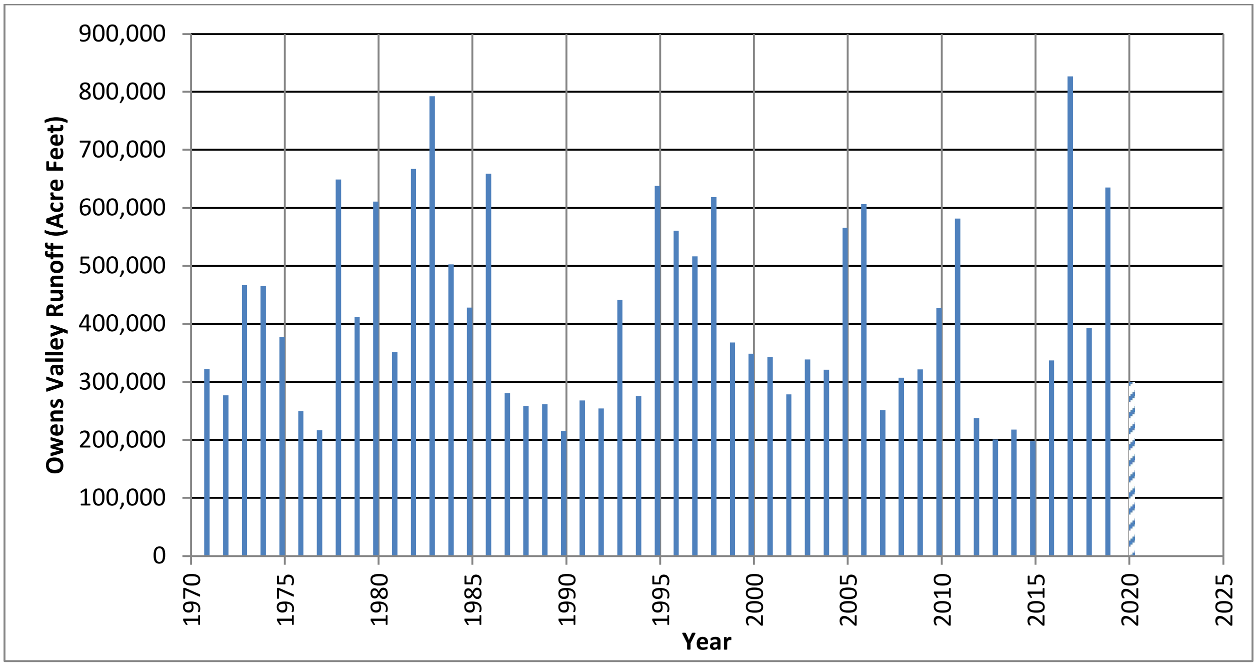

Figure 3.3. Measured Owens Valley runoff since 1970. Values are for the runoff year (e.g. runoff year 2019 includes April 1, 2019 through March 31, 2020). Dash line is current runoff year estimate.

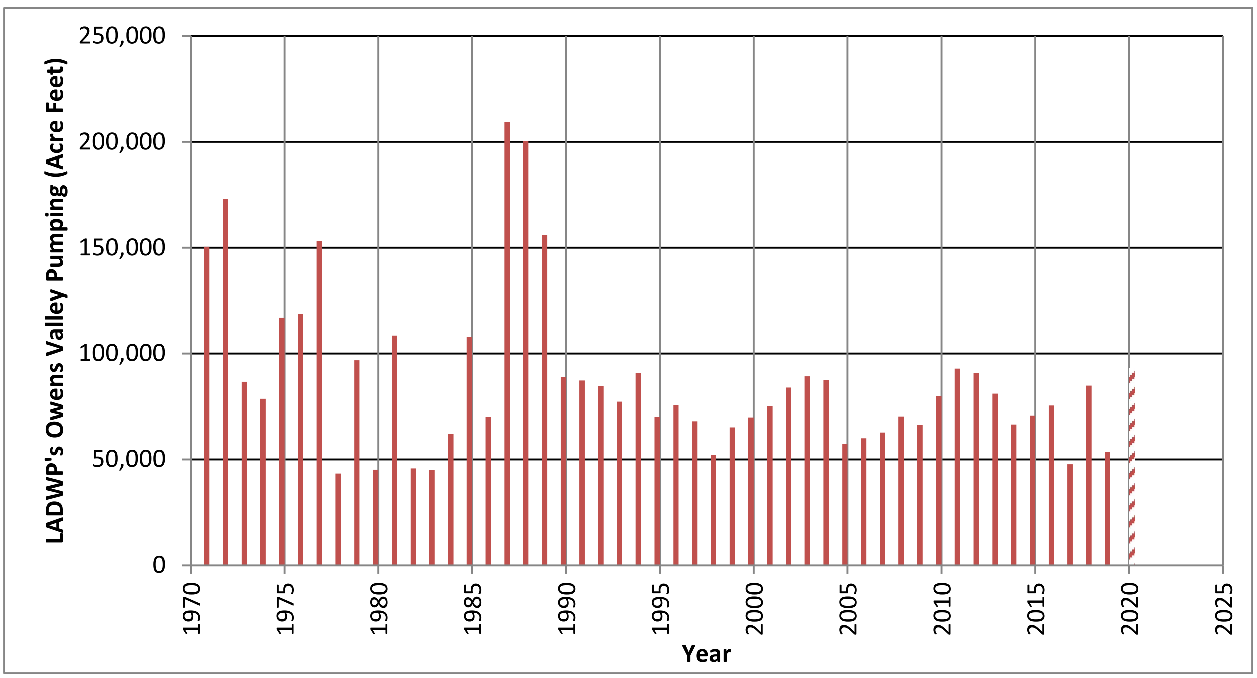

Figure 3.4. Total LADWP pumping in the Owens Valley since 1970 by runoff *year. Dash line is anticipated maximum pumping for current runoff year.*

Groundwater data is collected from several hundred monitoring wells located throughout the Owens Valley each spring and fall. Most wells are also visited on more frequent (weekly-monthly) schedules. Data presented in this section are depth-to-water (DTW) below ground surface (bgs) measured in feet.

Groundwater levels in all wellfields in the valley rose in 2019-20 (Figure 3.5) due to a combination of heavy runoff (155% of average) and low pumping (73% of 1992-2019 average). Average groundwater levels in Big Pine and Laws recovered between 2 to 3 feet (Table 3.2 and Figure 3.5). In Taboose-Aberdeen, Independence-Oak and Bairs-Georges groundwater rose between 1 to 2 feet. And water levels rose in Thibaut Sawmill and Symmes-Shepherd by less than 1 foot. Water levels in west Bishop were in the range of their historic norms. Between the years 2015-2017, west Bishop experienced extremely shallow or perched groundwater likely due to increased seepage from area ditches and ponds. This situation appears to be resolved and is discussed more fully in the Bishop Wellfield subsection that follows.

One method of analyzing hydrologic conditions in the Owens Valley is to compare recent groundwater levels with historic conditions. The LTWA uses the vegetation conditions documented from surveys conducted from 1984 to 1987 as its baseline for comparison of vegetation change. Therefore, ICWD uses the average April groundwater levels from 1985 to 1987 as a hydrologic "baseline." For more details and current vegetation status see ICWD Annual Report Section V "Vegetation Conditions" available at https://www.inyowater.org/documents/reports/inyo-county-water-dept-annual-report/. While this hydrologic baseline is not specifically prescribed in the Water Agreement, it is a comparison point between the hydrology and the vegetation conditions of the baseline period. Also, the April time-frame roughly coincides when DTW is typically shallowest each year. The hydrologic baseline DTW usually is an adequate indicator of groundwater and vadose zone moisture availability for phreatophytic vegetation, but should be considered a guide rather than a specific threshold that determines whether vegetation conditions are above or below baseline in the immediate vicinity of a monitoring well. Unlike the vegetation baseline, maintaining baseline DTW is not a requirement of the Water Agreement.

The record winter of 2017 and strong 2019 winter assisted in allowing water levels to recover from the recent 5-year drought. As of April 2020, DTWs in many wellfields were at or above baseline levels. However, certain wellfields were below baseline (Figure 3.6), including northern Taboose-Aberdeen, Independence-Oak, and Symmes-Shepherd. Hydrographs plotting DTW for selected wells are provided in the following discussions of conditions for each wellfield. The hydrographs presented below were selected to provide insight on water level changes over time.

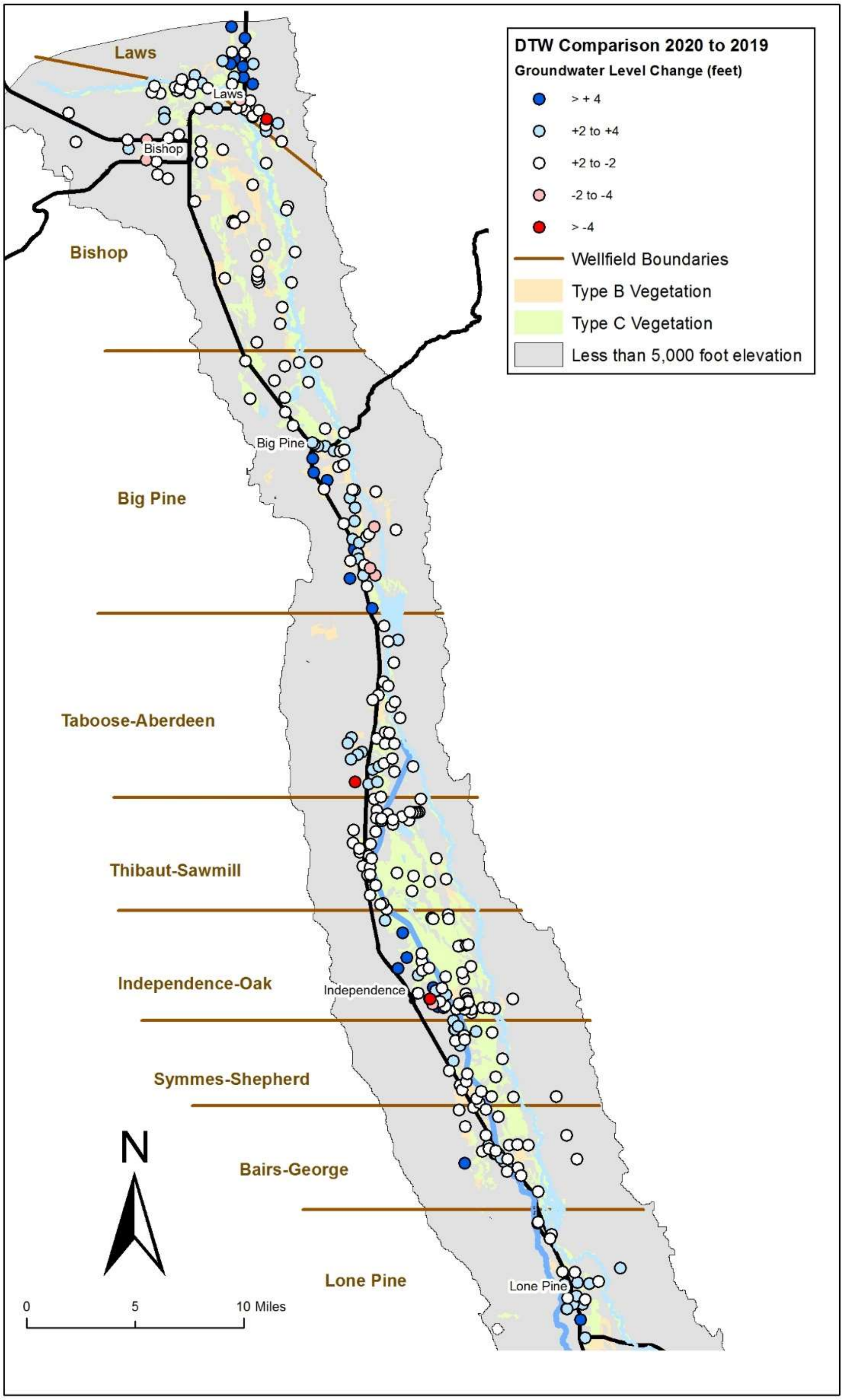

Figure 3.5. Change in water levels in Owens Valley monitoring wells from spring 2019 to 2020.

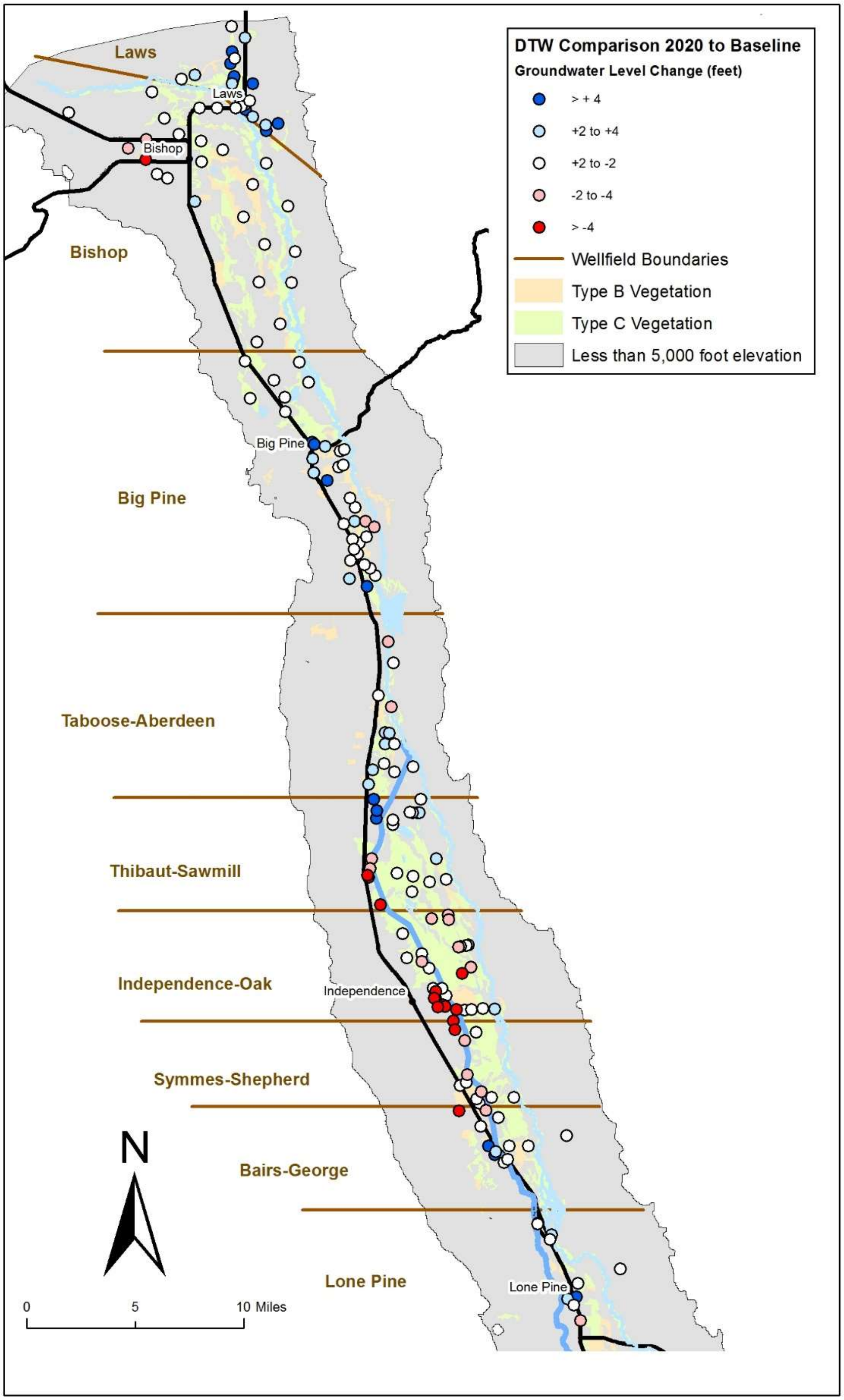

Figure 3.6. Spring 2020 groundwater levels wells compared with average water level in spring 1985-87.

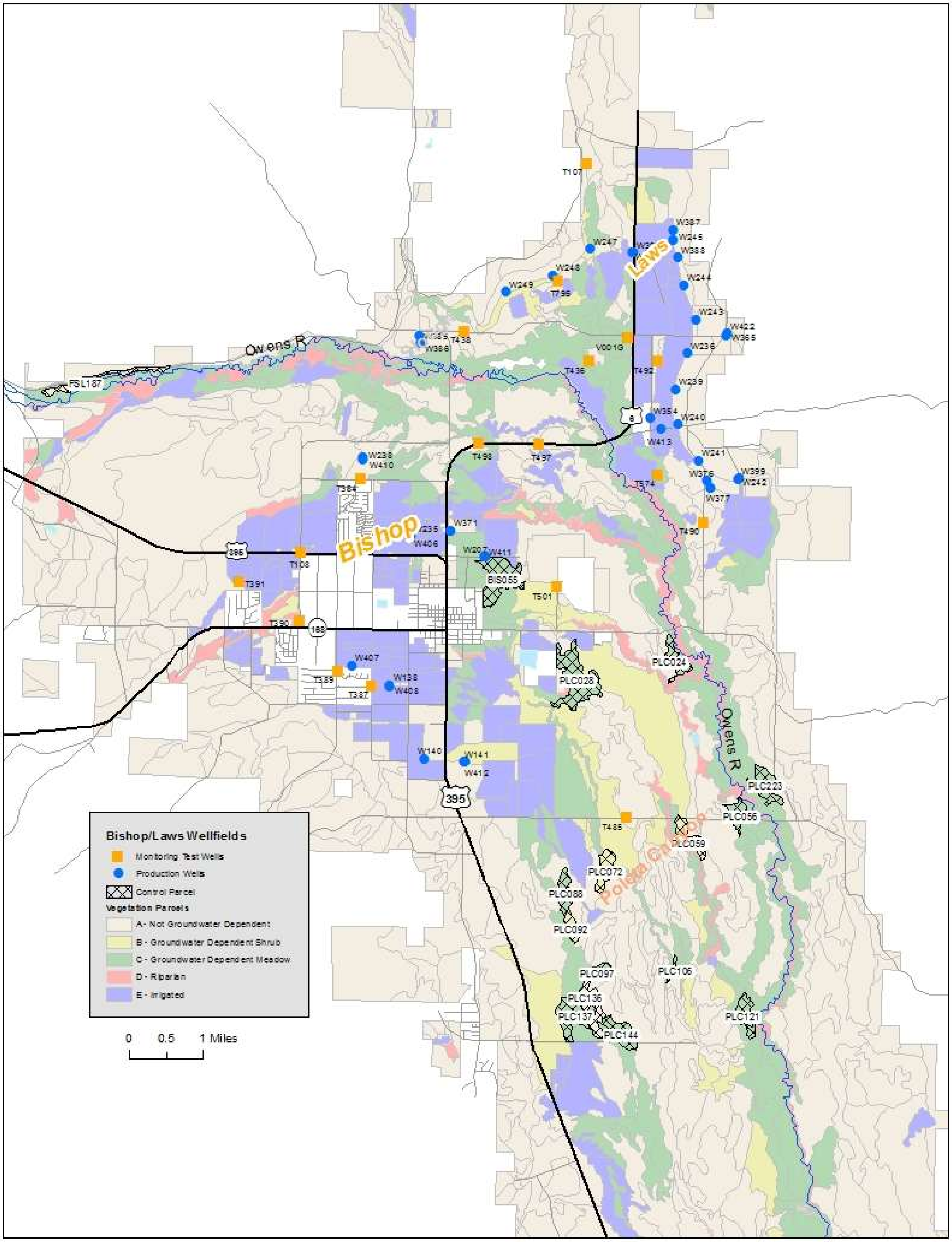

Figure 3.7. Map of monitoring wells and LADWP production wells in Laws and Bishop wellfields.

Laws Wellfield

In the 1970's and 80's, pumping along with irrigation and spreading from the Owens River via the McNally canals in Laws varied greatly from year-to-year causing large fluctuations in the water table (Figures 3.8 and 3.9).

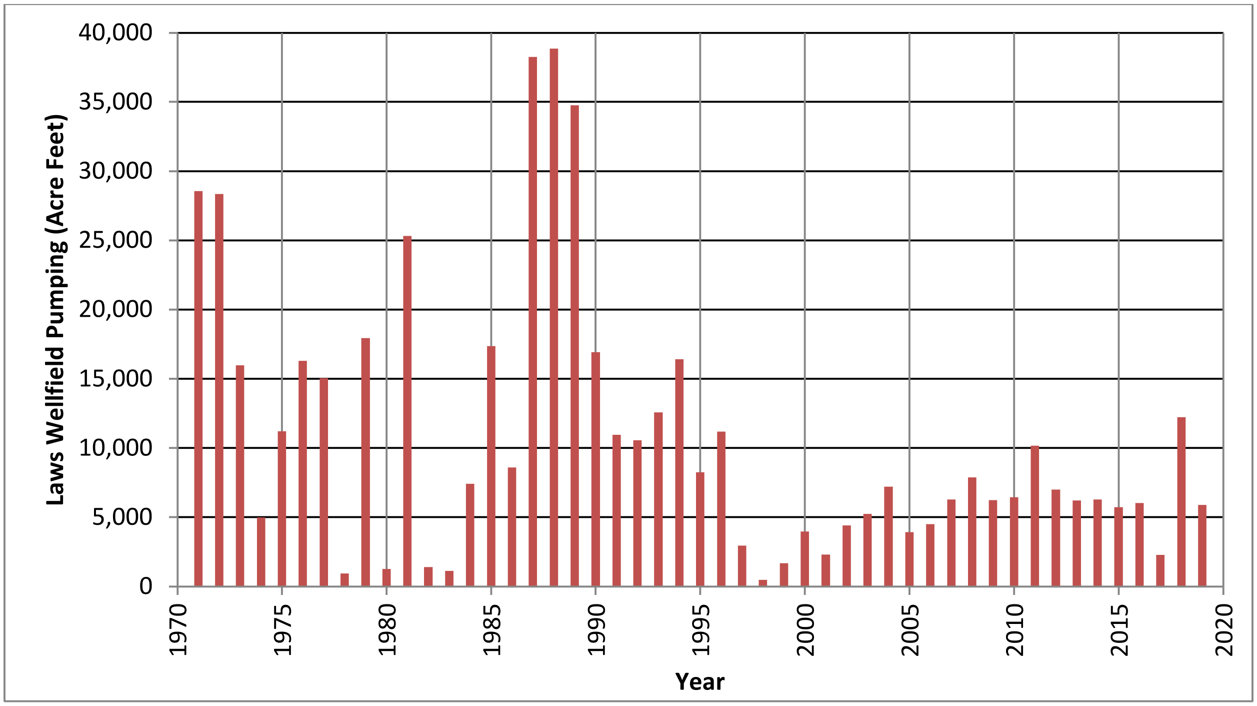

Figure 3.8. Pumping totals for the Laws wellfield.

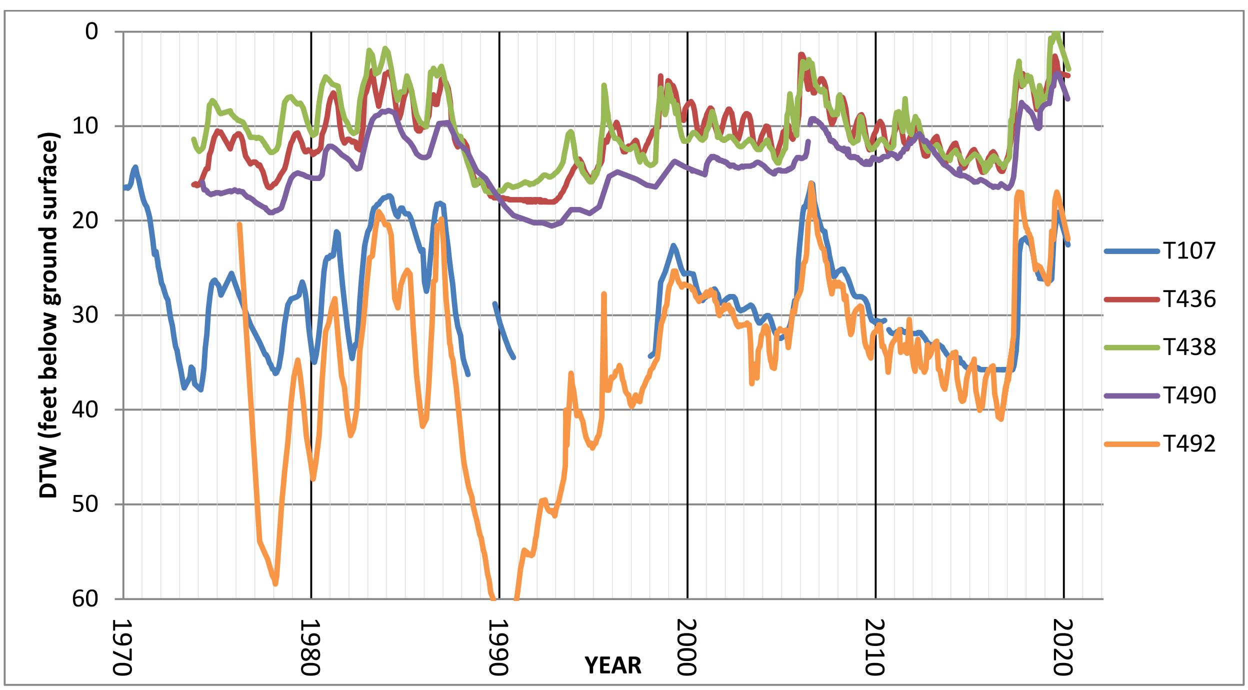

Figure 3.9. Hydrographs of indicator wells in the Laws wellfield. Well T492 is dry if DTW is below 60 ft, and well T107 is dry if DTW is below 37 feet.

This was especially true for T107 and T492 due to their proximity to the McNally canals and LADWP pumping wells. Heavy pumping and low recharge in the late 1980's caused severe groundwater level decline in Laws. Under the Water Agreement pumping has remained considerably below the maximum wellfield capacity. As a result, water levels rose, and beginning in 2000, water table fluctuations have been largely driven by pumping for local uses in the surrounding area and by water spreading following heavy snow winters (2005, 2006, 2011, 2017, 2019). In 2019-20, groundwater levels rose in all indicator test wells; and all nine indicator wells remained above baseline as of April 2020 (Table 3.2).

Bishop Wellfield

Groundwater pumping in the Bishop Wellfield is managed differently than other wellfields due to additional legal requirements governing LADWP operations. The environmental protections and goals of the Water Agreement still apply, however. The Water Agreement requires ICWD and Los Angeles to prepare an annual audit of pumping and uses on the Bishop Cone to demonstrate compliance with the Hillside Decree (the Decree itself does not contain audit procedures). The Hillside Decree is a 1940 Inyo County Superior Court stipulation and order under which LADWP groundwater extractions from both pumped and uncapped flowing wells cannot exceed the annual amount of water used on LADWP-owned land on the Bishop Cone.

It is important to understand that the Bishop Cone Audit is not an accounting of the water balance for the groundwater aquifer. Rather, it is an accounting based on the surface water applications (for irrigation and stockwater) to the Bishop Cone compared to groundwater pumping and flowing wells. Water supplied for irrigation in west Bishop upstream of LADWP pumping wells consists of surface water diverted primarily out of Bishop Creek and the Owens River. Pumped water from the center of the cone is also conveyed for irrigation using the same ditches and canals as the surface water, and most lands are supplied with a combination of pumped and surface water. Because it is impossible to separate surface and groundwater once they comingle in a canal or ditch, the most reliable method to assess compliance with the Hillside Decree is to compare the sum of pumping and flowing water against the sum of water uses applied to the cone.

Uses in the Bishop Cone Audit are calculated as the amount of water applied to a parcel minus the amount of water flowing off the parcel back into the canal or ditch system. In some cases several parcels are grouped into a single account and several monitoring stations are used to measure the water delivered to and exiting from the account. The accounts, as well as the individual deliveries/uses, are only included in the Bishop Cone Audit following a field inspection and Technical Group approval to ensure that appropriate monitoring is in place. Not all lands supplied with water or all water uses are included in the Audit.

The most recent Bishop Cone Audit examined conditions for the 2018-19 runoff year. Total groundwater extraction (pumping and flowing wells) on the Bishop Cone was 16,297 ac-ft compared with 26,992 ac-ft of recorded uses. Therefore, uses on the Bishop Cone exceeded extractions by approximately 10,695 ac-ft. If extractions had exceeded the amount of recorded uses, all groundwater could not have been used on the Bishop Cone and LADWP would be out of compliance with the Hillside Decree. That situation has not occurred since the audit procedures were implemented as part of the Water Agreement.

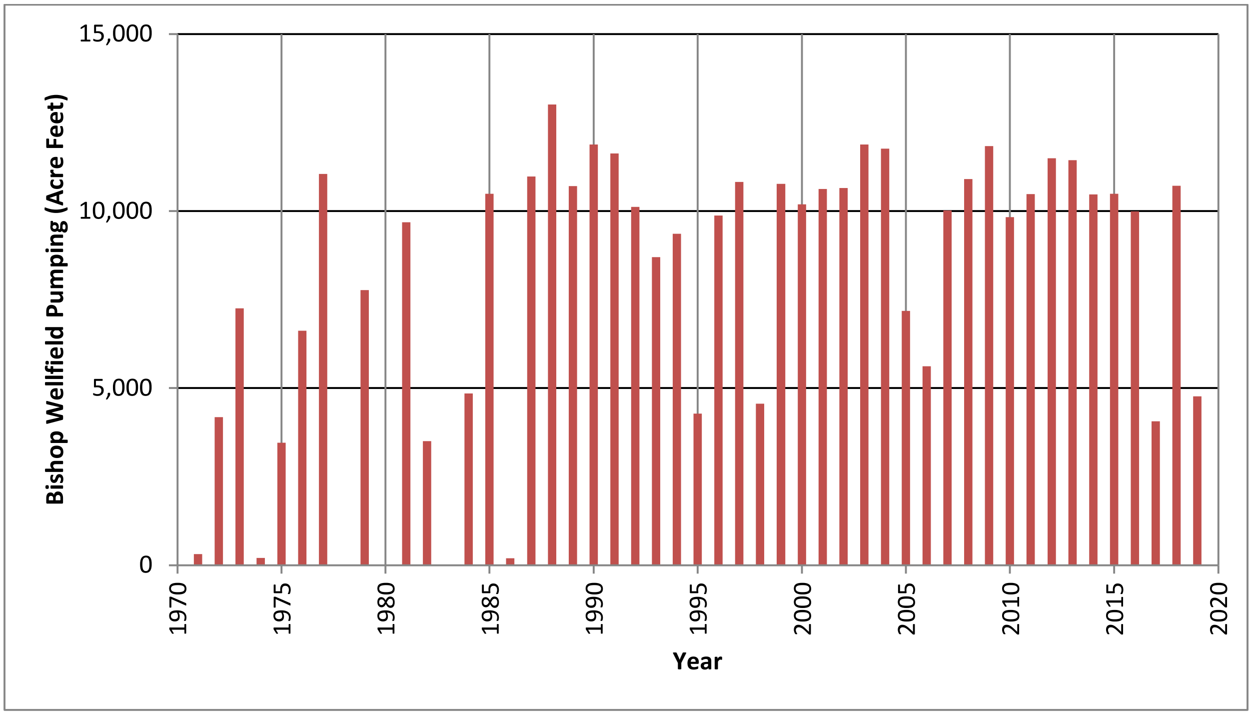

Figure 3.10. Pumping totals for the Bishop wellfield.

Pumping in the Bishop Wellfield has been relatively constant for the past 25 years except in above-normal runoff years when pumping decreased, for example 1998, 2006, 2017 and 2019 (Figure 3.10). Because of the Hillside Decree and relatively constant pumping, ICWD does not routinely use indicator wells to analyze LADWP's annual operations plan for this wellfield. Water levels in west Bishop typically peak after the summer irrigation season. Groundwater levels from 1980 to 2020 at several test wells located west, north, and east of the city of Bishop are presented in Figures 3.11.a -c. Constant pumping and consistent recharge from irrigation has historically resulted in relatively stable water levels in the Bishop Wellfield. However, the effects of the 2012 to 2016 drought can be seen in the recent water levels from Bishop Cone wells, especially wells in the western and northern portions of the wellfield.

It is likely that a combination of diminished surface water flows caused by the 2012-2016 drought and the change in timing of Bishop Creek surface flows negatively affected shallow groundwater levels in west Bishop from the fall of 2013 through the winter of 2014. Groundwater levels in this area dropped precipitously, in some cases to their lowest recorded levels. Several domestic wells went dry. Hydrographs of these groundwater declines can be seen in Figure 3.12. The declining groundwater levels prompted both ICWD and LADWP to increase the frequency of their monitoring on the western half of the Bishop Cone in order to more fully understand the changes in groundwater levels during the prolonged drought.

Groundwater levels recovered from the low water tables in fall and winter of 2013-14.. During this recovery, several residents of west Bishop noticed extremely shallow or perched water at their properties. It is theorized that once creek and ditch flows returned to the area in 2014, increased seepage of surface water led to the oversaturation of the near surface sediments. Additional investigations were conducted in 2016, including a report issued by the Department of Water Resources.

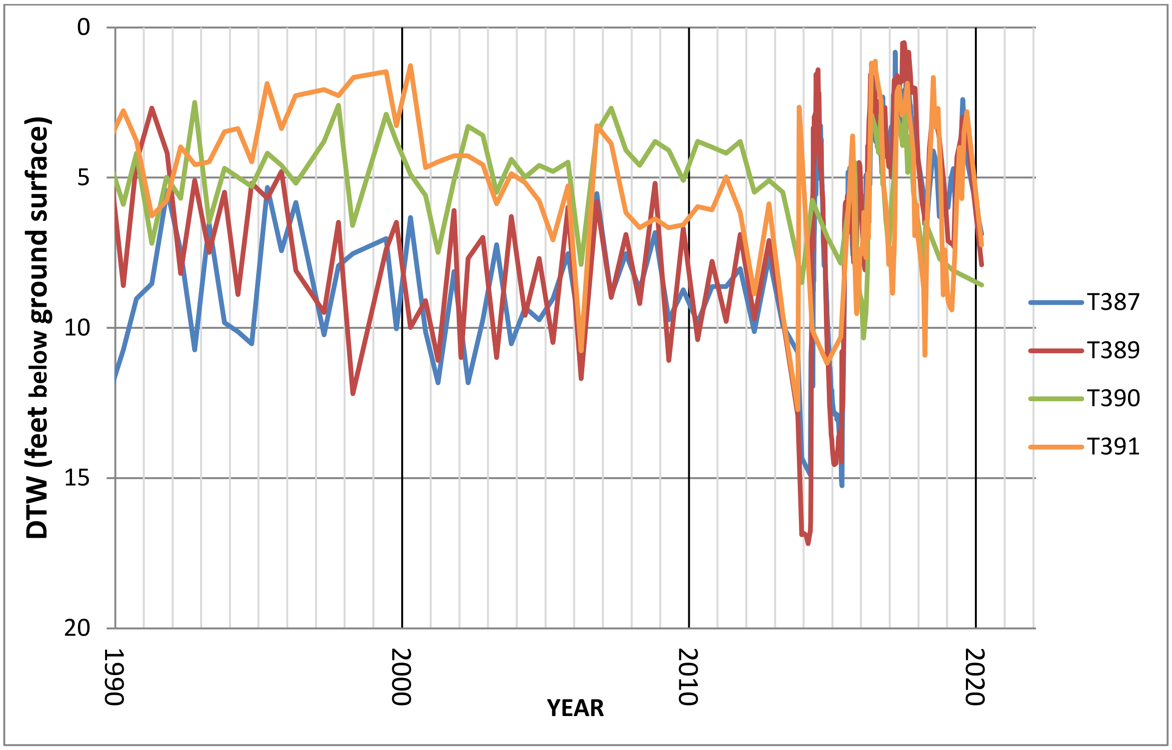

Figure 3.11.a. Hydrographs of selected monitoring wells in the western Bishop wellfield. Locations of the wells are shown in Figure 3.7.

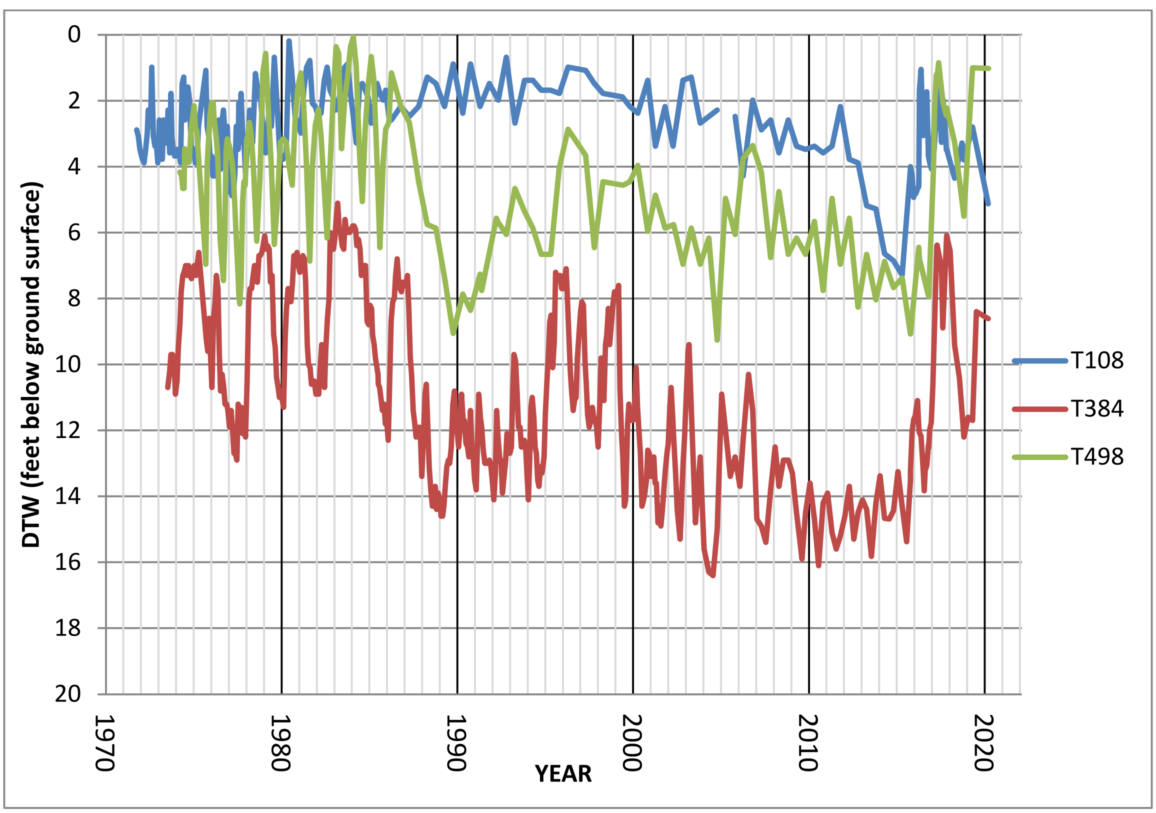

Figure 3.11.b. Hydrographs of selected monitoring wells in the northern Bishop wellfield. Locations of the wells are shown in Figure 3.7

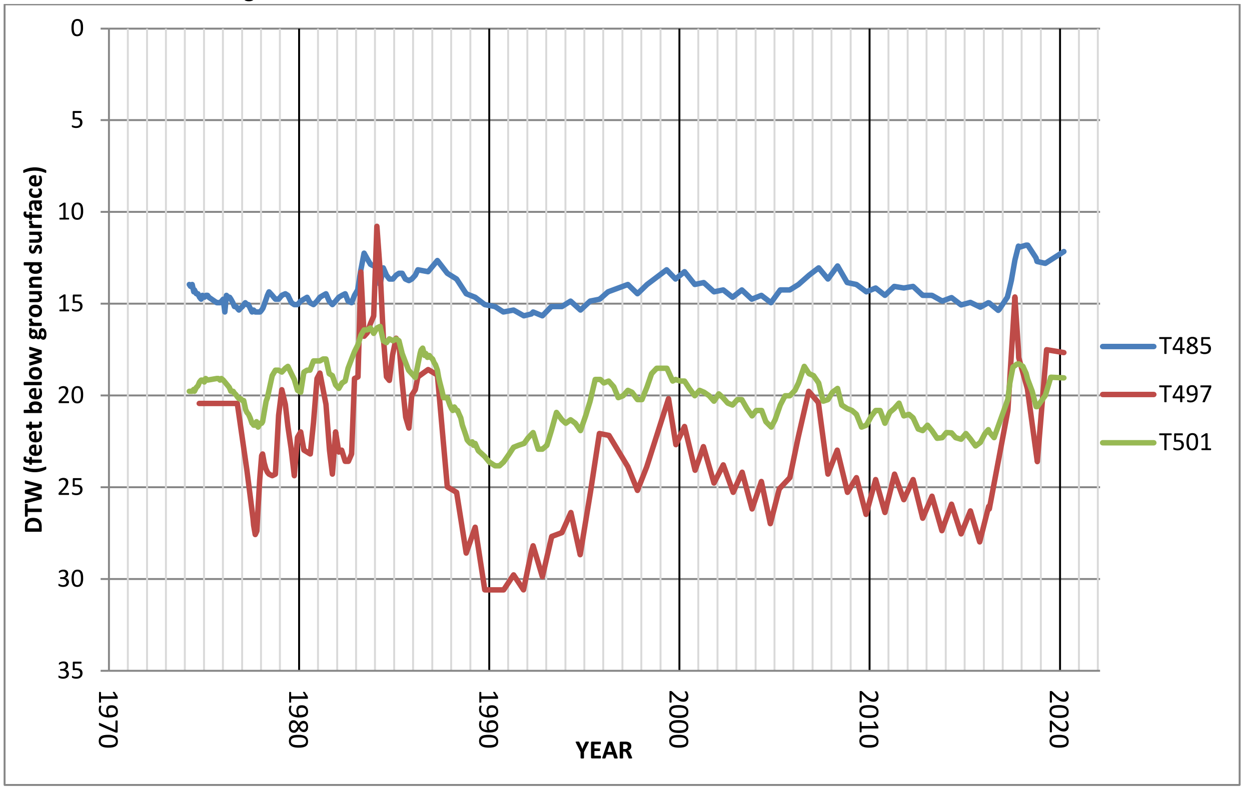

Figure 3.11.c. Hydrographs of selected monitoring wells in the eastern Bishop wellfield. Locations of the wells are shown in Figure 3.7

Subsequent to summer/fall of 2017, fewer problems with shallow groundwater have been reported and it is probable that the natural sealing caused by decaying biomass in ditches and ponds has led to a decrease in the 2014-15 seepage rates, lowering seepage back to their pre-2014 rates; and that the west Bishop hydrologic system is moving back towards it historic equilibrium.

Due to another significant winter, the 2019-20 forecasted flows in Bishop Creek exceeded the Chandler Decree minimums and also long-term averages, but no flooding problems were reported. For 2020-21, snowpack in the Bishop Creek drainage peaked at approximately 75% of average. Given the wet antecedent conditions and storage in the Bishop Creek reservoirs, creek flows are expected to meet or exceed Chandler flows for the 2020 season.

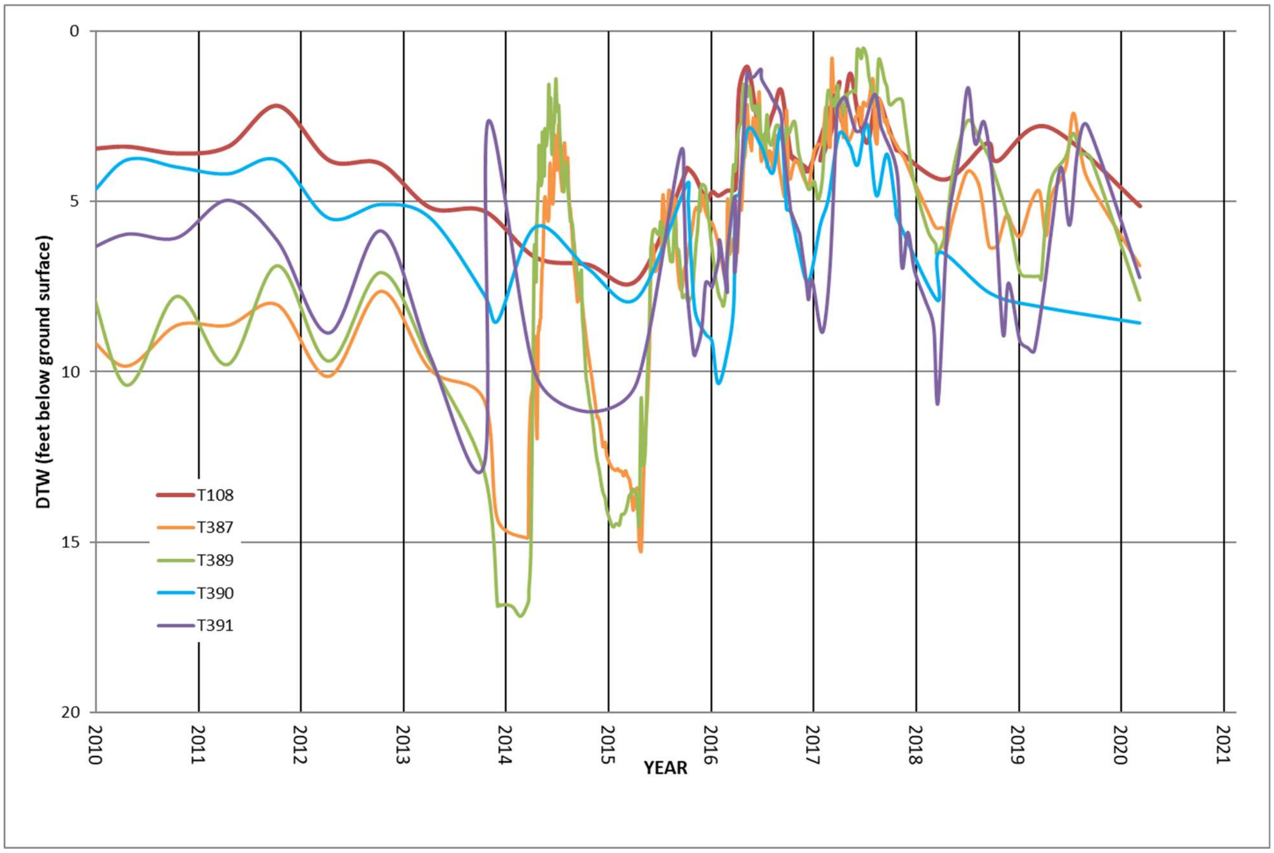

Figure 3.12. Recent hydrographs of selected monitoring wells in western Bishop wellfield. Locations of the wells are shown in Figure 3.7

Important takeaways from recently observed Bishop Cone conditions:

- Surface water flows play an integral role in recharging shallow groundwater levels in west Bishop; and the interaction between surface water and groundwater recharge is very sensitive to changes in equilibrium conditions
- Semiannual monitoring in spring and fall does not capture the full range of groundwater fluctuations in the Bishop area
- Thoughtful water management of Bishop Creek flows and the associated diversion and ditch flows should be used during drought and/or low runoff years to maintain some flow in area ditches
- In west Bishop there is a delicate balance between enough surface water seepage to recharge area groundwater and too much seepage to overwhelm infiltration rates, leading to undesirable, extremely shallow or perched water levels
- Many of the private wells in west Bishop are shallow and, therefore, more vulnerable to impacts associated with deepening groundwater levels
- Conservative pumping practices should be used on LADWP wells W407 and W408 during drought and/or low runoff years
- Information gathered in west Bishop during the past several years should be taken into consideration in regards to LADWP's potential new wells B2 and B5.

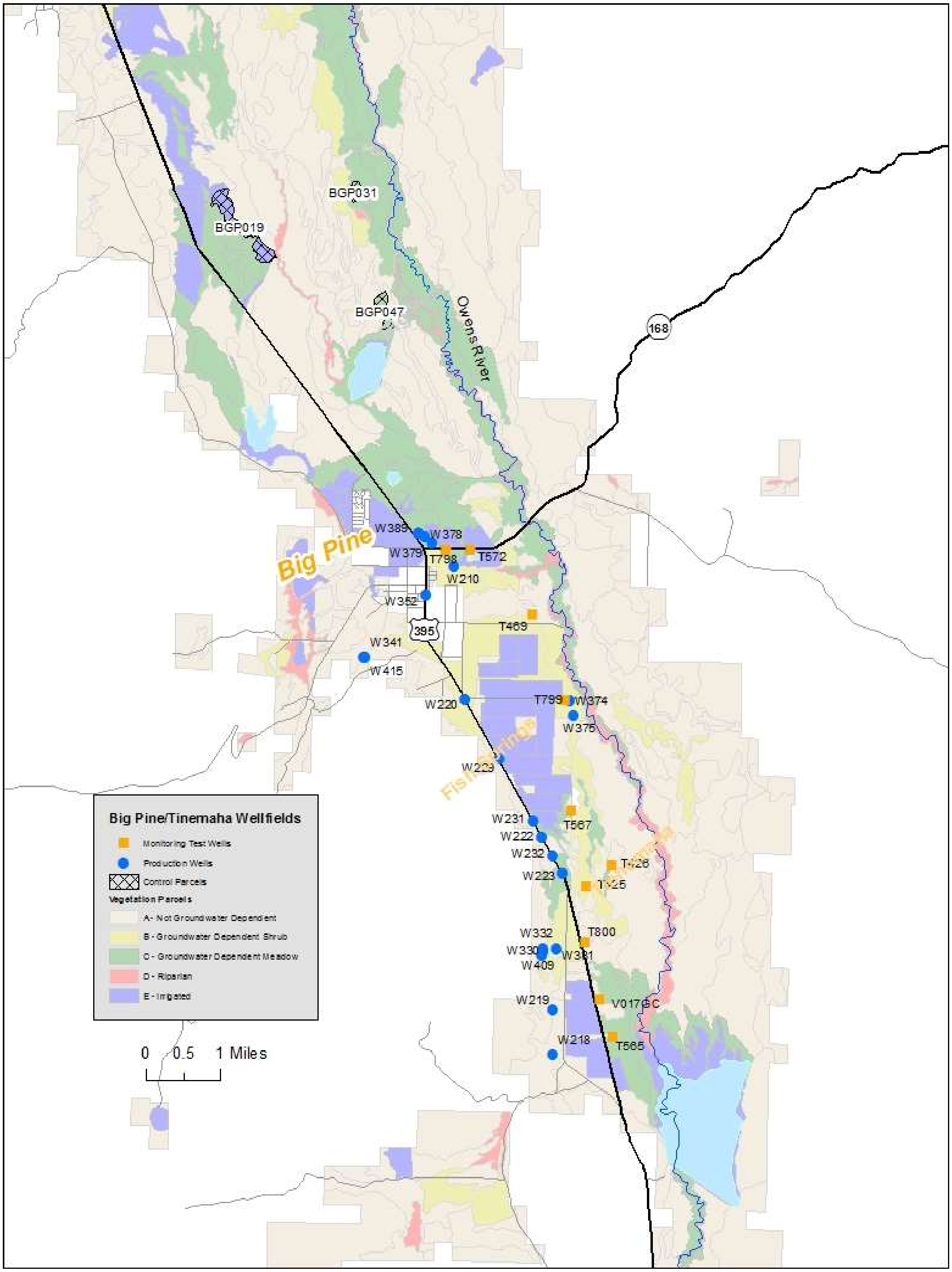

Figure 3.13. Map of monitoring wells and LADWP production wells in Big Pine wellfield.

Big Pine Wellfield

Since 1974, pumping in the Big Pine wellfield (Figure 3.14) has been consistently higher than other wellfields (Figure 3.13). Minimum pumping to supply uses in this wellfield include the Fish Springs Hatchery (approximately 19,500 ac-ft per year), Big Pine town supply (500 ac-ft per year), and the Big Pine northeast regreening Project (100-ac-ft per year). Pumping under the Water Agreement has largely been to supply these uses. It should be noted that most of the hatchery pumped water also reaches the aqueduct.

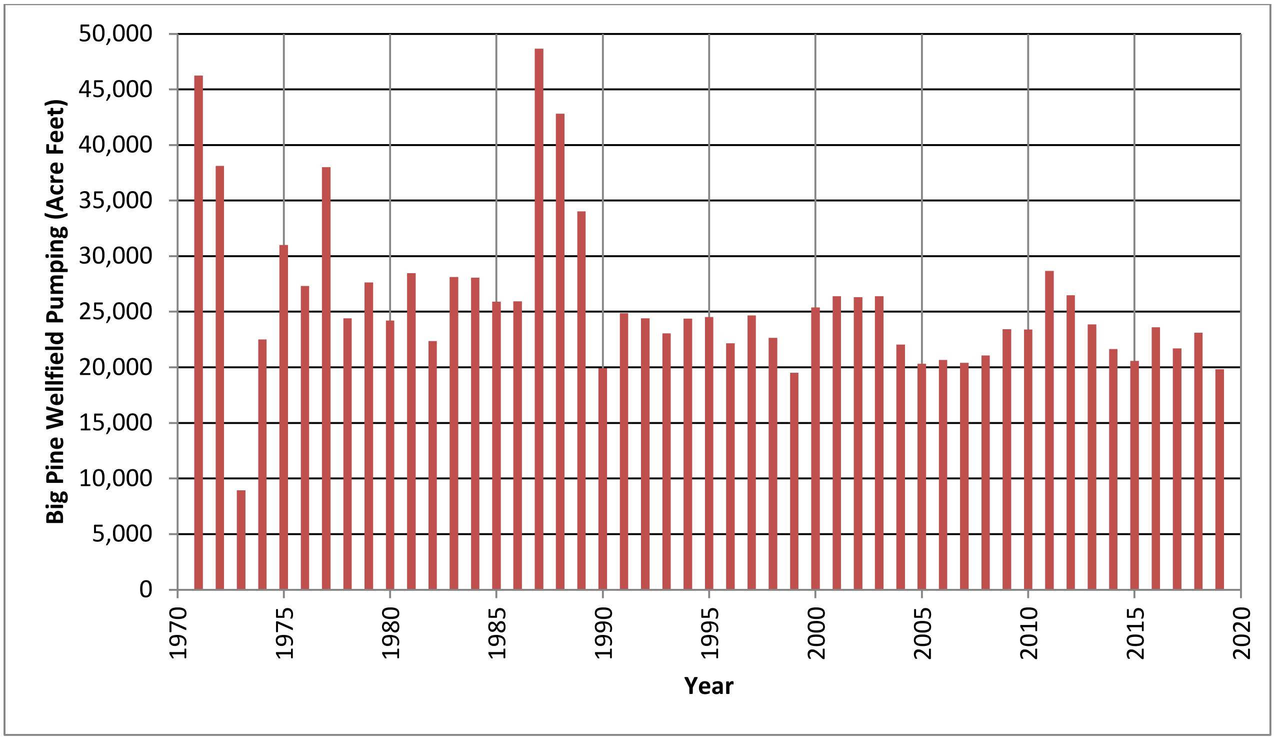

Figure 3.14. Pumping totals for the Big Pine wellfield

Groundwater rose in all eight Big Pine indicator and monitoring site wells in 2019-20 (Figure 3.15 and Table 3.2). All indicator wells were above baseline levels. ICWD also examined two test wells located just east of U.S. 395 near W218 and W219 to assess possible impacts from the additional export pumping during extended droughts (Figure 3.16). Both V017GC and T565 are located in or adjacent to groundwater dependent vegetation. Water levels declined in response to drought and pumping from 2012 to 2016. In 2017 and 2019, LADWP actively spread water into the Big Pine wellfield, notably south of town along the Red Mountain cinder cone. Both V017GC and T565 have recovered significantly since 2017 and remained above baseline levels as of April 2020.

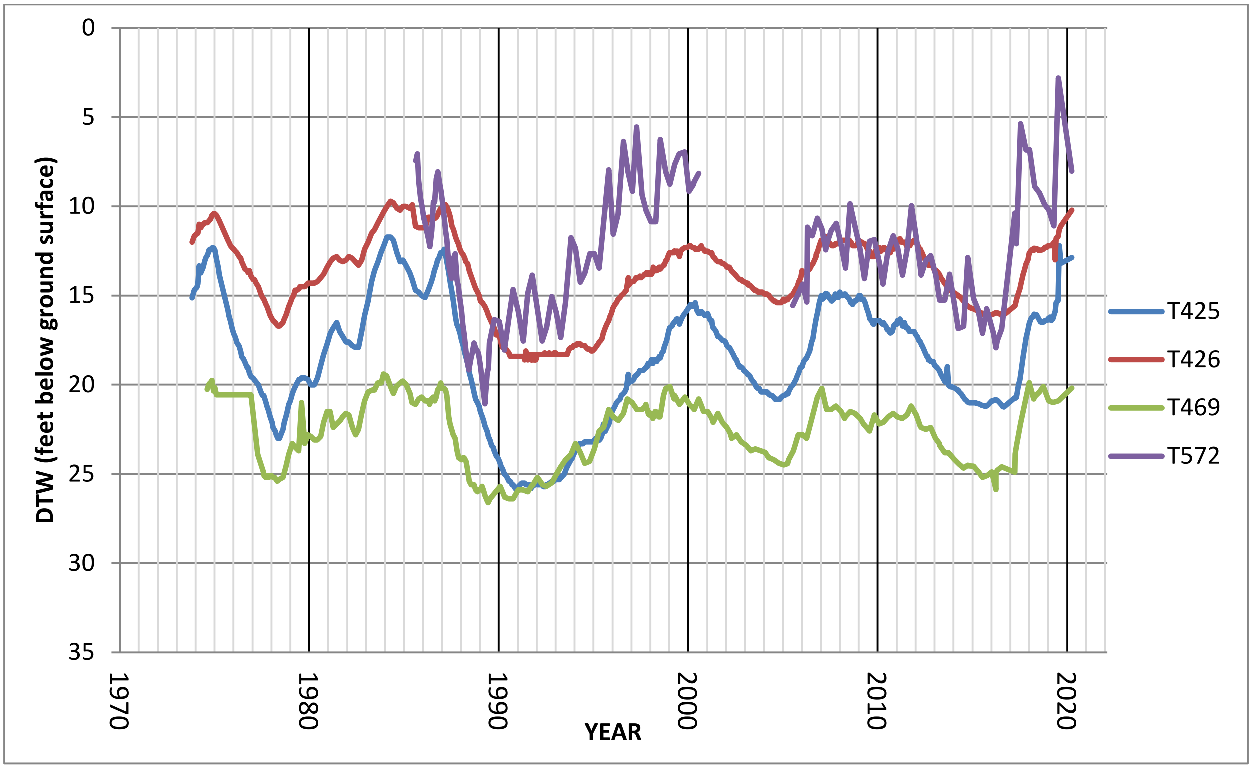

Figure 3.15. Hydrographs of indicator wells in the Big Pine wellfield. *Periods of missing data for T572 occurred when the well was plugged and in need of repair.*

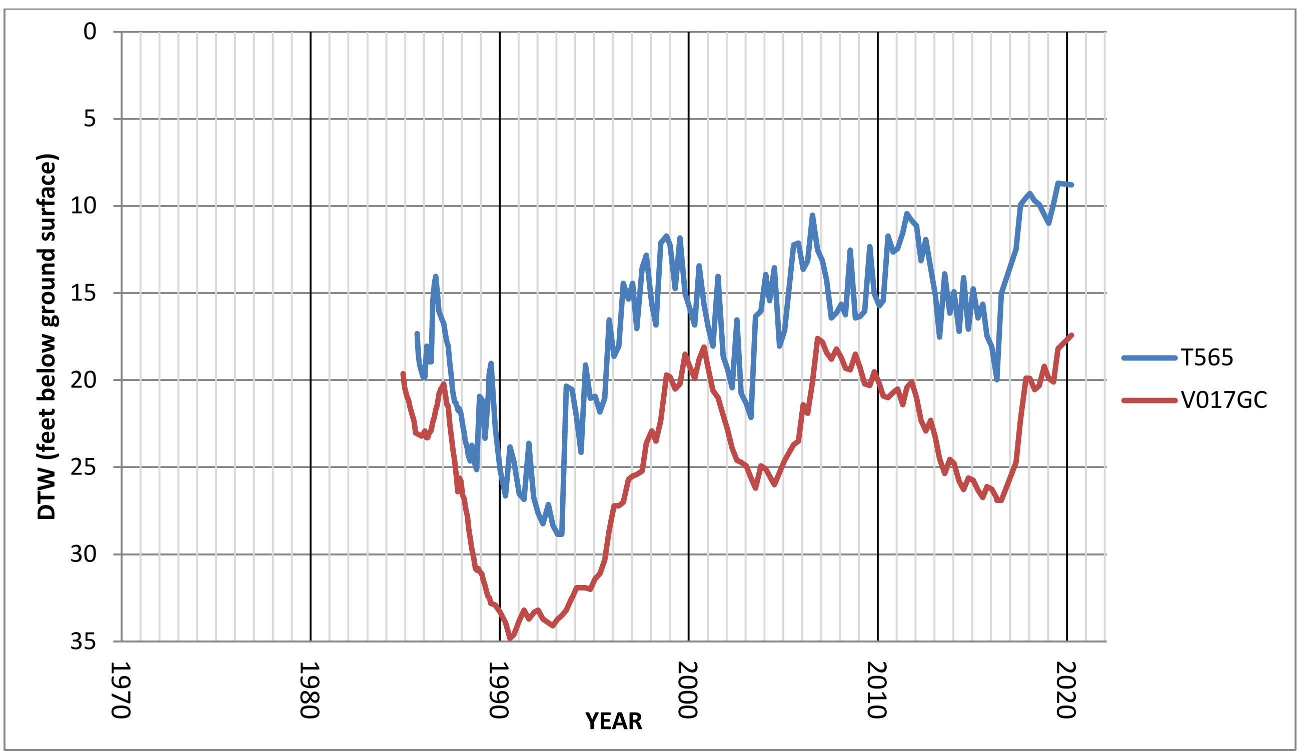

Figure 3.16. Hydrographs of monitoring wells in the southern Big Pine wellfield near pumping wells W218 and W219.

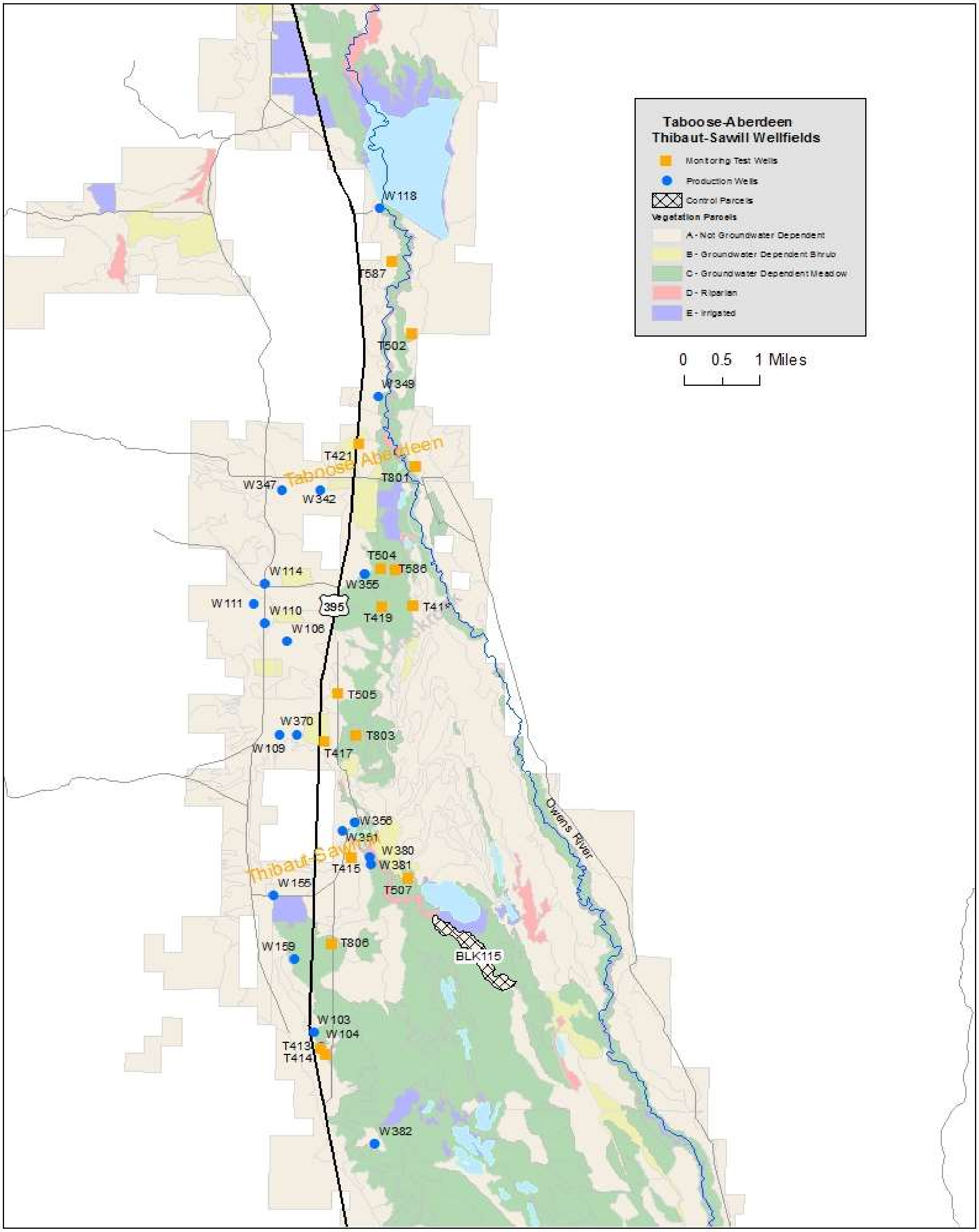

Figure 3.17. Map of monitoring and LADWP production wells in the Taboose-Aberdeen and Thibaut-Sawmill wellfields.

Taboose-Aberdeen Wellfield

Since 1990 under the Water Agreement, pumping in the Taboose-Aberdeen Wellfield (Figure 3.17) has remained much below the wellfield capacity (Figure 3.18). Minimum pumping for this wellfield is approximately 300 ac-ft to supply one mitigation project at Big Seeley Spring, and nearly all of the pumping since 2010 has been for aqueduct supply. LADWP pumped more than 14,000 ac-ft of water from the wellfield in 2018-19 (the most pumping since 1989), and groundwater levels declined. In 2019-20, due to heavy runoff and lower pumping stress, water levels rebounded in 9 of the 10 indicator/ monitoring site wells (Table 3.2). In April 2020, groundwater levels were above baseline levels in all but the two northern monitoring wells (T587 and T801). Depth to water in all wells varied between two feet below to four feet above baseline in April 2020 (Table 3.2).

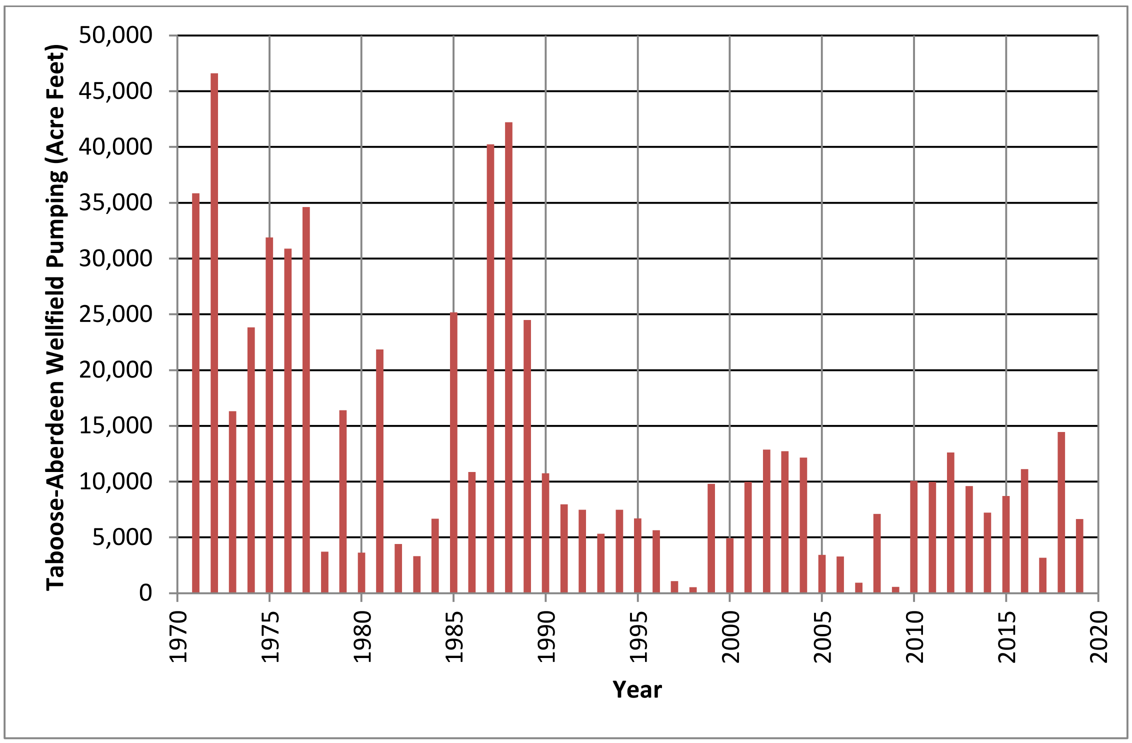

Figure 3.18 Pumping totals for the Taboose-Aberdeen wellfield.

Hydrographs for the indicator wells exhibit similar response to fluctuations in pumping and runoff (Figures 3.19 and 3.20). Most of the recent pumping has been from well W349 and W118 located in the northern portion of the wellfield. Well 118 has been operated consistently from 2011 to 2016, was off for the majority of the 2017-18 runoff year, but has been pumped consistently since 2018. Data from monitoring well T587 (a non-indicator well) is included because it is located adjacent to groundwater dependent vegetation near W118 and is used to assess the impacts of recent pumping.

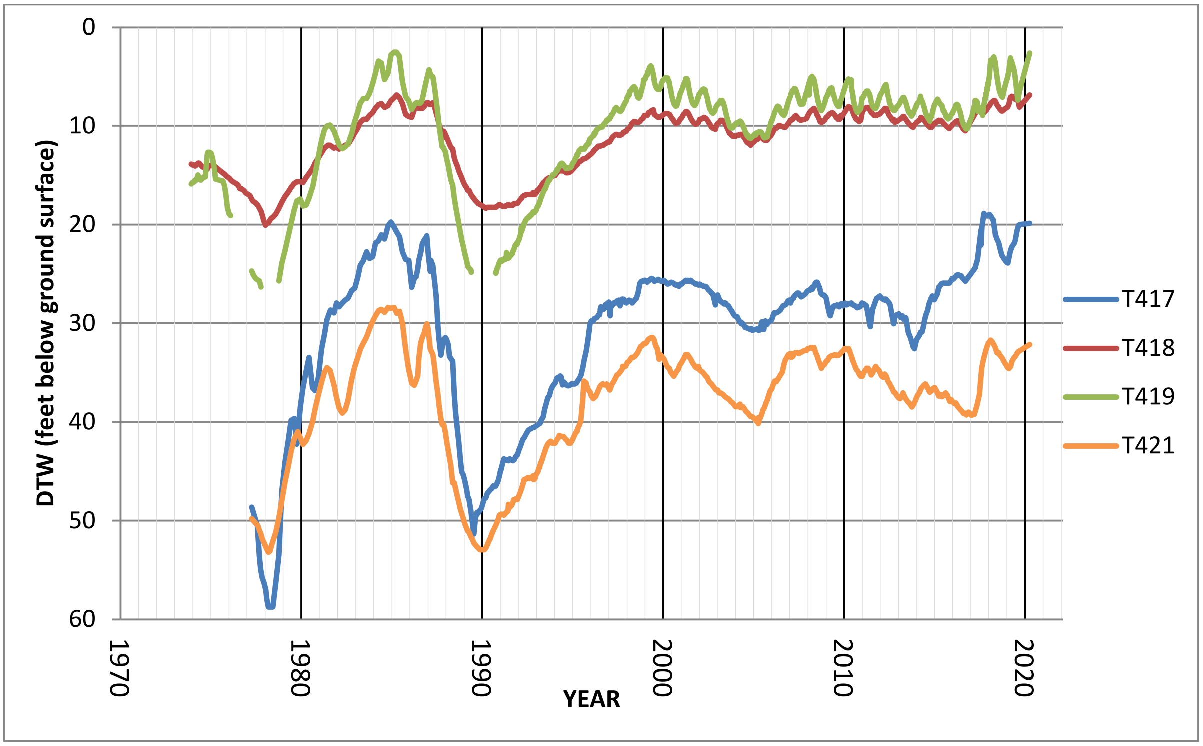

Figure 3.19. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

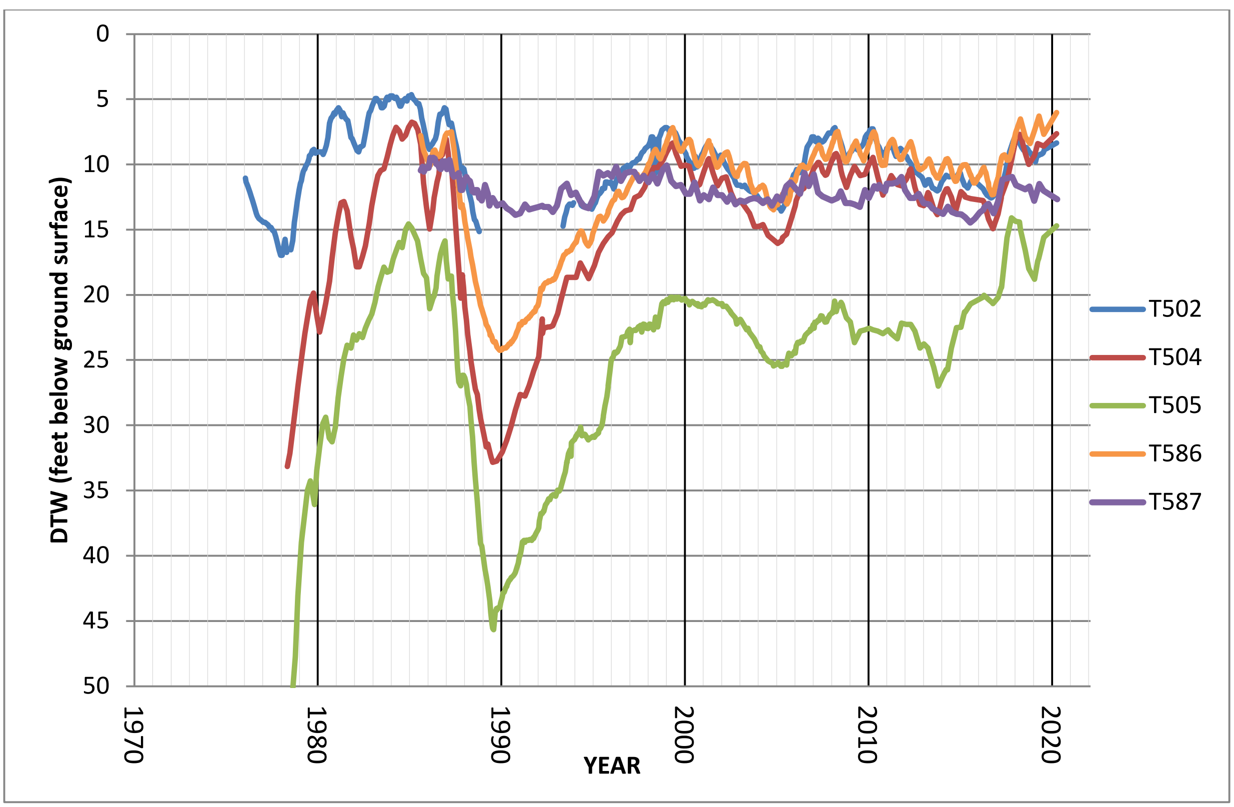

Figure 3.20. Hydrographs of indicator wells in the Taboose-Aberdeen wellfield. Periods of missing data denote when the test well was dry.

Thibaut-Sawmill Wellfield

Historically, most pumping in the Thibaut-Sawmill Wellfield has been to supply approximately 12,200 ac-ft annually to the Blackrock Fish Hatchery (Figure 3.21). In 2014, Inyo and Los Angeles agreed to reduce hatchery pumping to approximately 8,300 ac-ft as part of the settlement to the Black Rock dispute.

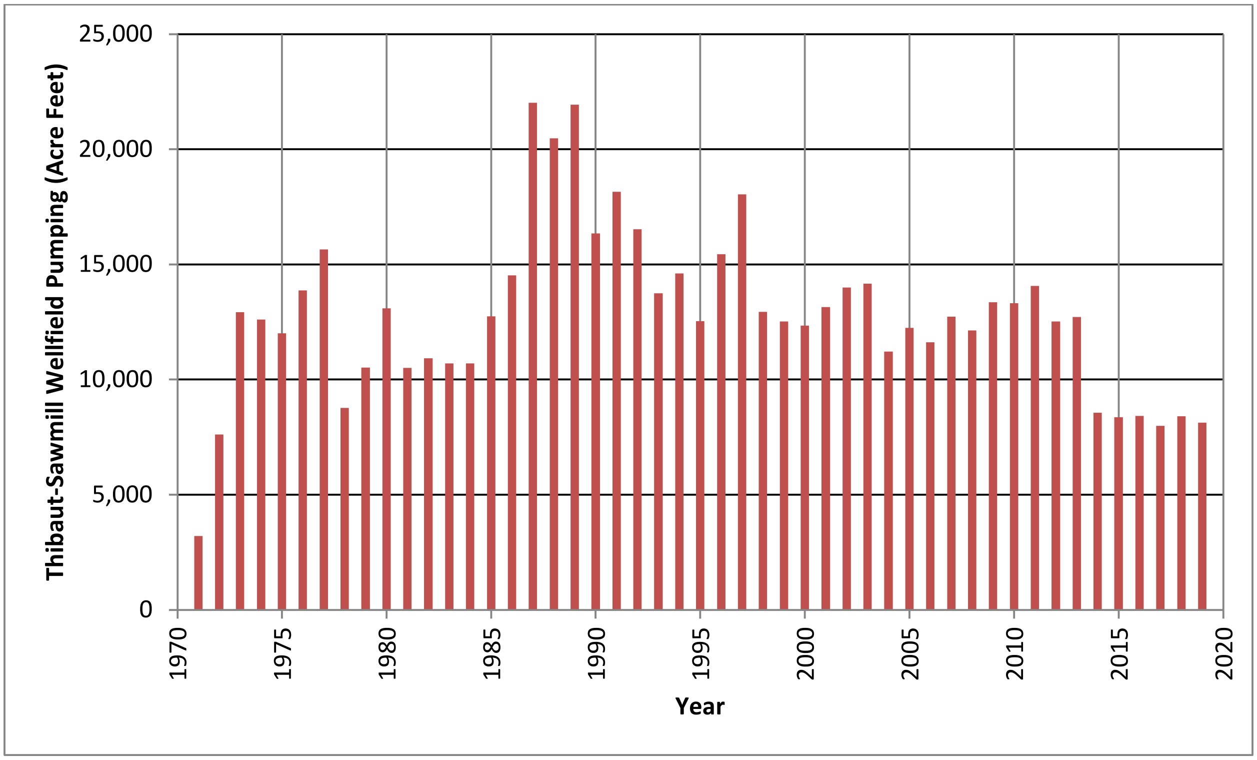

Figure 3.21. Pumping totals for the Thibaut-Sawmill wellfield.

Hydrographs of five test wells used to track water levels in Thibaut-Sawmill have exhibited different responses due to local water management within the wellfield (Figure 3.22). Wells T415 and T806, responding to reduced hatchery pumping, have exhibited a rising trend since 2014 and are both several feet above baseline levels. Wells T413, T414 and T507 located in the southern portion of the wellfield have recovered several feet since the end of the recent drought. However, the reduction in the hatchery pumping is not nearly as evident in these wells. Following nearly 10-years of stable water levels, in 2009 T507 began to respond to the establishment of wetlands in the Blackrock Waterfowl Management Area (BWMA). The rotational flooding of BWMA affects groundwater levels in this well.

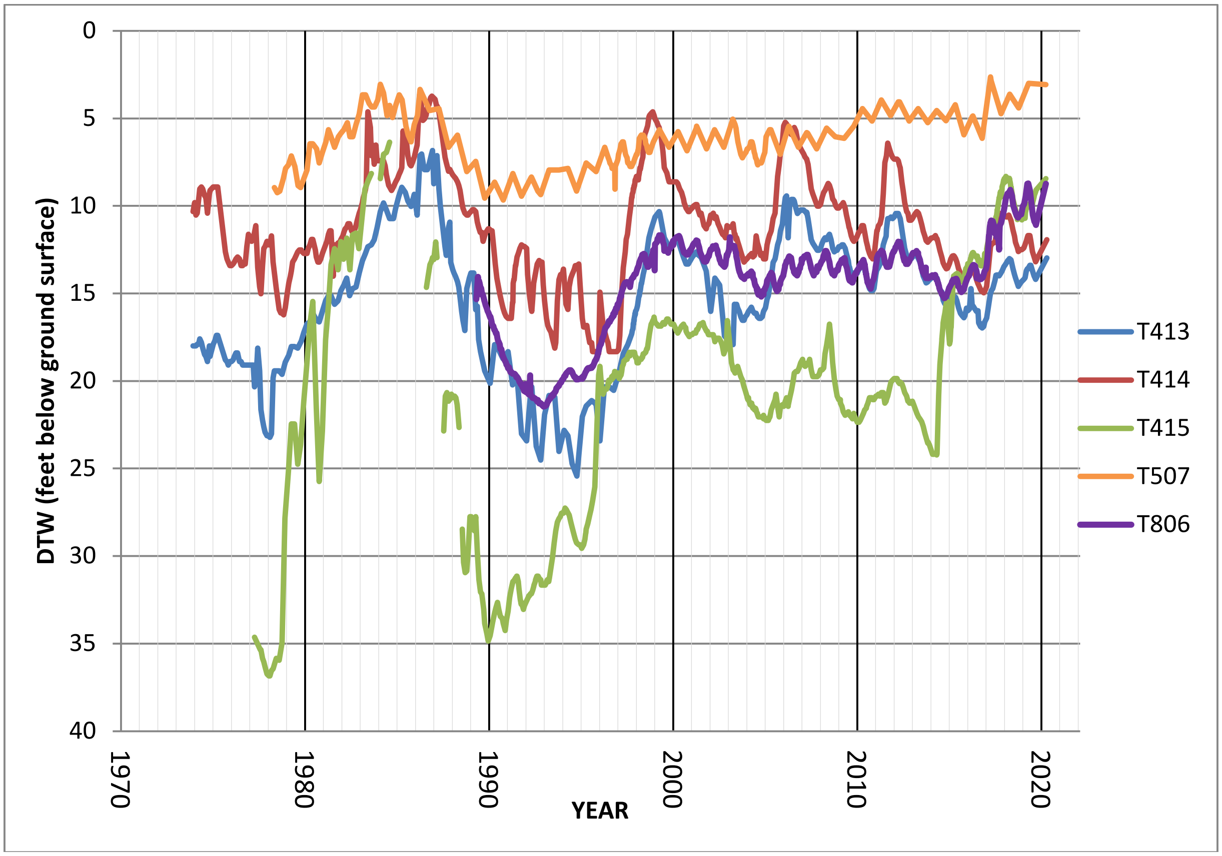

Figure 3.22. Hydrographs of selected test wells in the Thibaut-Sawmill wellfield.

In 2019-20, groundwater levels in the five Thibaut-Sawmill wells were stable (DTW change +/- 1.5 feet) from 2019 to 2020 (Table 3.2). All three indicator wells for Thibaut-Sawmill are at or above baseline level.

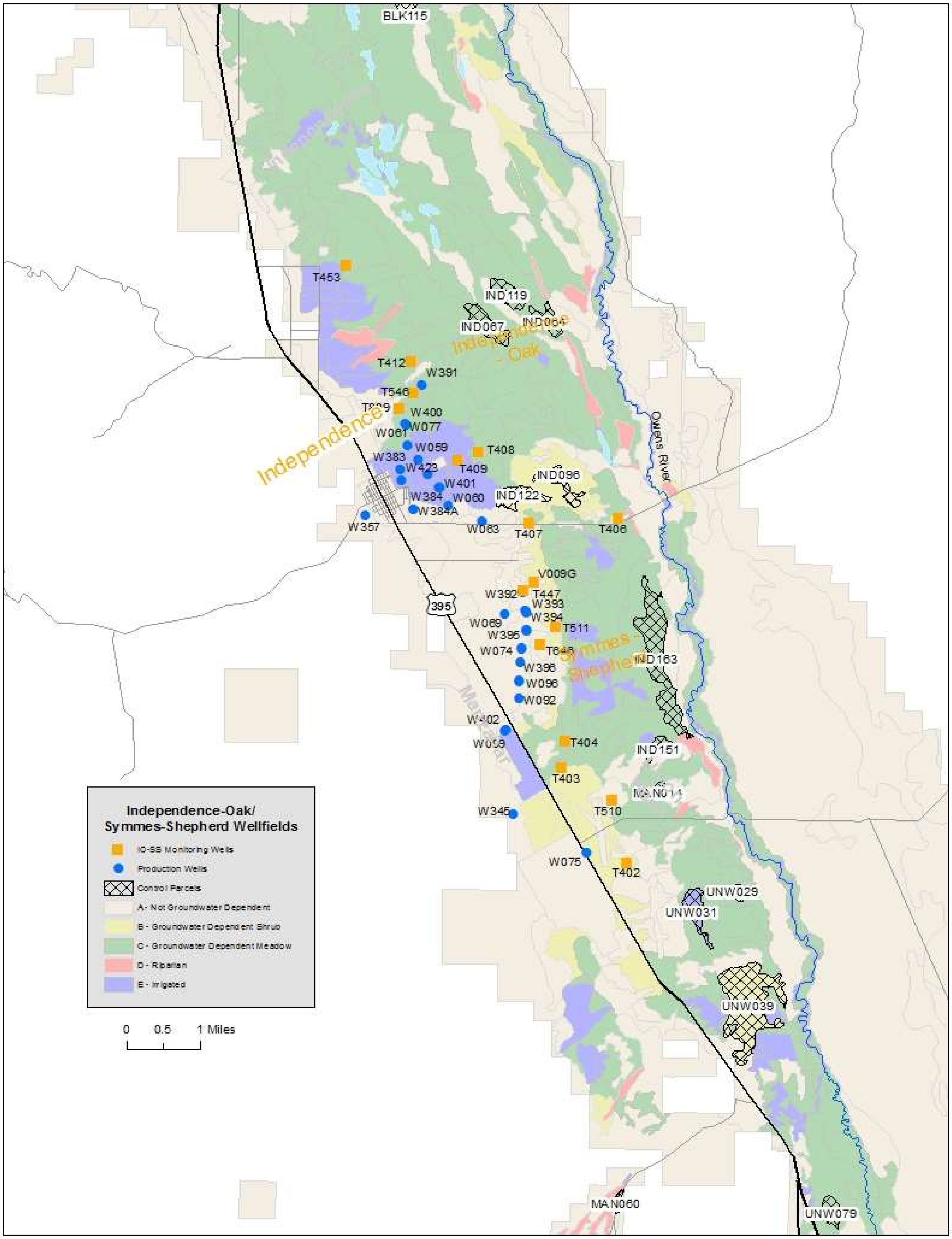

Figure 3.23. Map of monitoring and LADWP production wells in the Independence-Oak and Symmes-Shepherd wellfields.

Independence-Oak Wellfield

Pumping in this wellfield (Figure 3.23) is required to supply approximately 6,700 ac-ft annually for irrigation projects surrounding Independence and for town supply (Figure 3.24). LADWP pumped between 8,600-9,600 ac-ft from 2011 through 2016; however, with heavy 2017-18 runoff, this wellfield was only pumped for irrigation (approximately 6,000 ac-ft). In 2018-19 pumping for export resumed with the wellfield total at approximately 11,600 ac-ft. Due to above average 2019-20 runoff, pumping was reduced in Independence to less than 6,000 ac-ft for the past year.

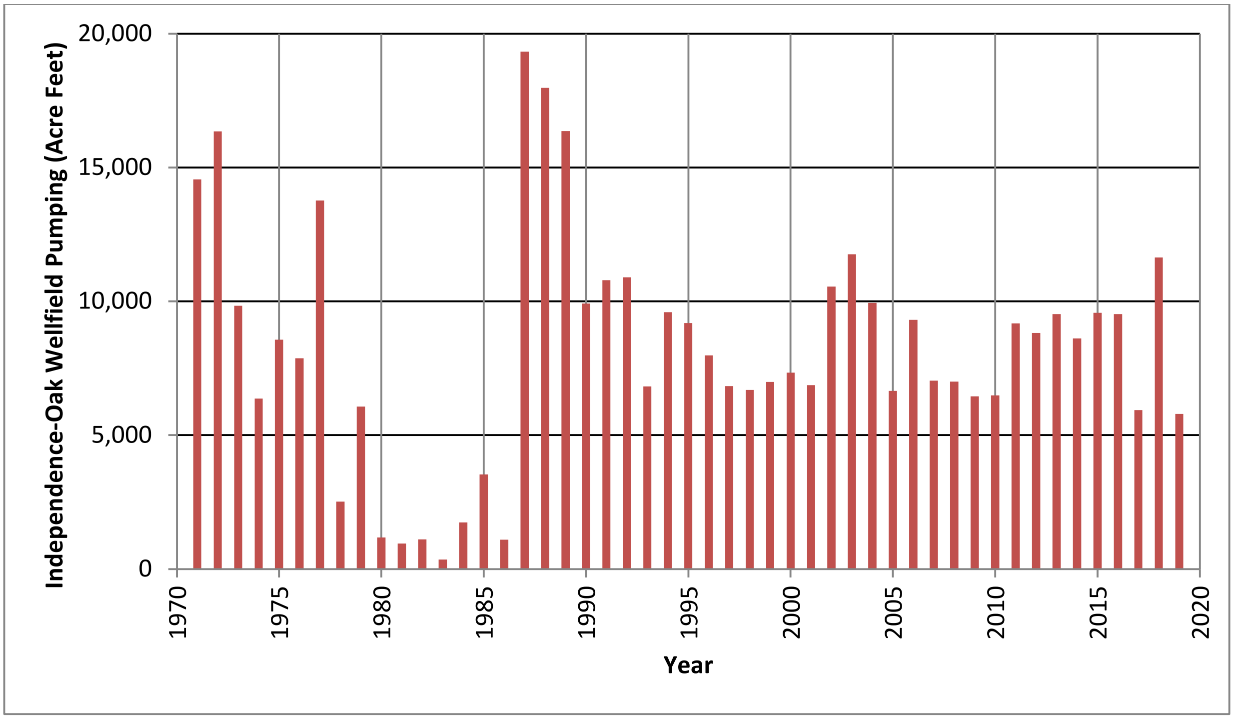

Figure 3.24. Pumping totals for the Independence-Oak wellfield.

Water levels had been stable through the first decade of 2000 in wells located in the center of the wellfield (T406, T407, T408, T409), but have declined in response to the increased pumping during the past decade. In 2017 and 2019, the combination of reduced pumping for export and increased recharge from heavy runoff allowed water levels to rebound somewhat. Groundwater levels in these wells recovered between 0.5 to four feet (Table 3.2 and Figures 3.25 and 3.26) as of April 2020.

All of the indicator wells in the Independence-Oak Wellfield were below the baseline in April 2020 by 0.8 to five feet (Table 3.2). Due to the declines in groundwater levels as compared to the baseline period in these wells ICWD staff has recommended to LADWP that pumping for export be minimized in this wellfield.

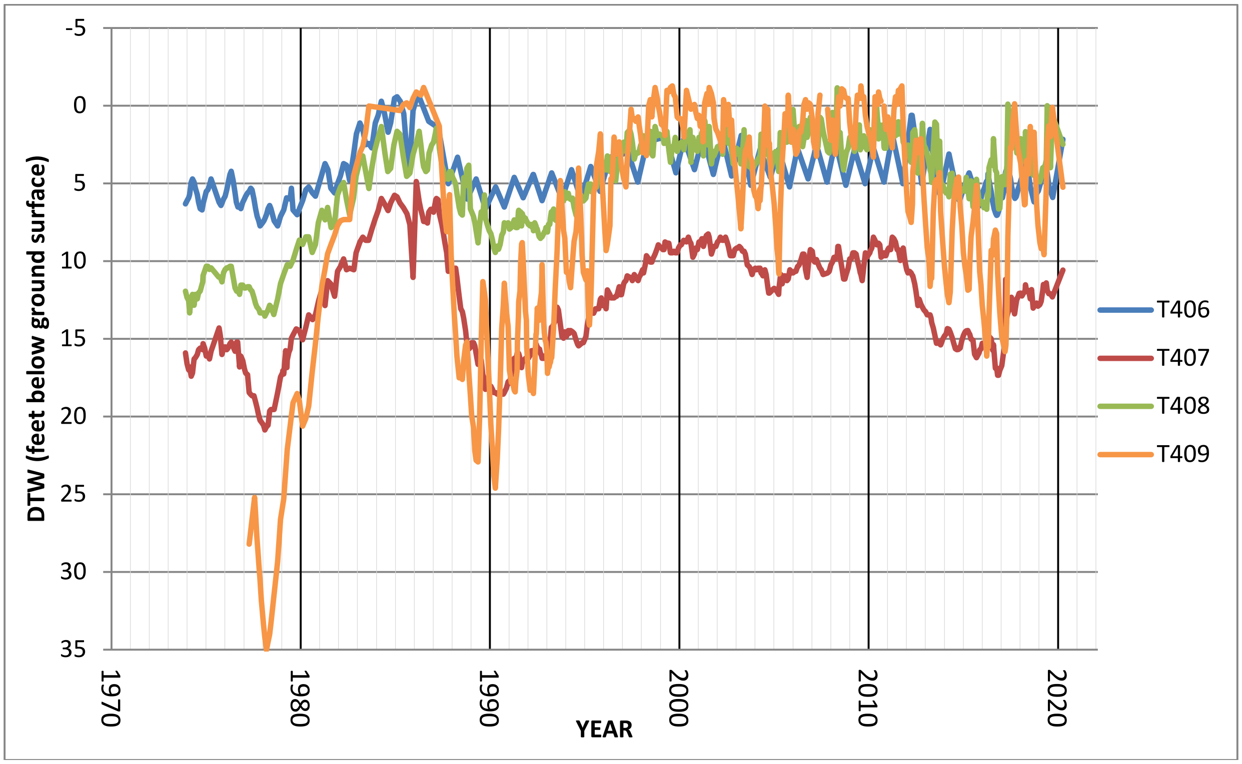

Figure 3.25. Hydrographs of selected test wells in the Independence-Oak wellfield

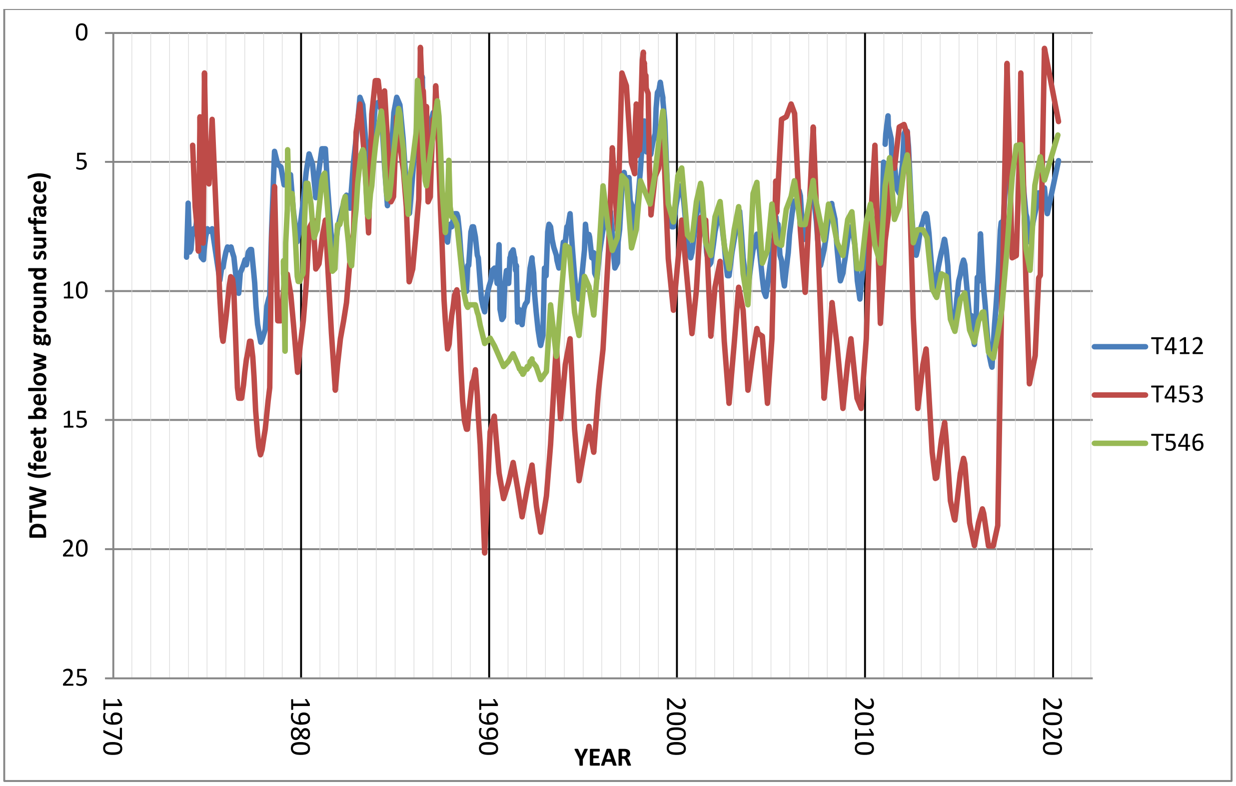

Figure 3.26. Hydrographs of selected test wells in the Independence-Oak wellfield

Symmes-Shepherd Wellfield

In the 1970's and 80's, pumping in the Symmes-Shepherd Wellfield varied considerably (Figure 3.27). Under the Water Agreement, pumping was reduced. Approximately 1,200 ac-ft of pumping is required to supply one mitigation project (irrigated agriculture from W402); however, pumping for aqueduct supply increased from 2010 to 2016, primarily in the northern part of the wellfield. All wells other than W402 have been off since 2017, and all four On/Off monitoring sites are in OFF status for 2020-21.

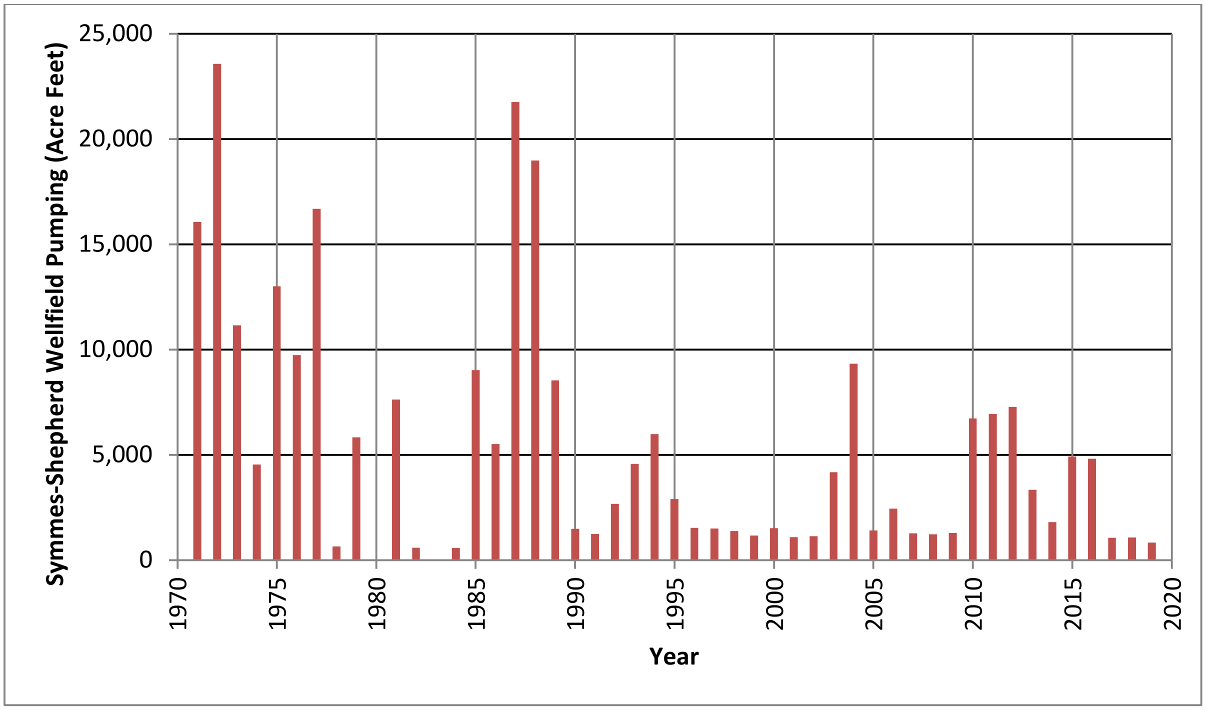

Figure 3.27. Pumping totals for the Symmes-Shepherd wellfield.

Groundwater levels were relatively stable from 2019-20, ranging from a decline of 0.5 feet to recovery of up to four feet (Table 3.2). Some test wells are buffered to a degree by their proximity to the Los Angeles Aqueduct (T402-404 and T510-511, see Figures 3.28 and 3.29). Test wells T447 and V009G are located near pumping wells in the northwestern portion of the wellfield and water levels responded by rising dramatically due to the reduction in pumping in 2017-18. Water levels rose an additional three to four feet during the past year. Although groundwater levels have recovered to some extent, water levels in all monitoring wells continue to be below baseline in 2020 (Table 3.2).

Due to the declines in groundwater caused by pumping and the recent drought, Inyo County-owned contaminant monitoring wells at the Independence landfill were dry or within a few feet of becoming dry in spring 2017. Cessation of pumping in 2017 combined with recharge has allowed water levels to recover between 15 and 25 feet in these four wells; however, ICWD continues to be concerned with water levels in Symmes-Shepherd that are between one to 14 feet below baseline levels as of 2020.

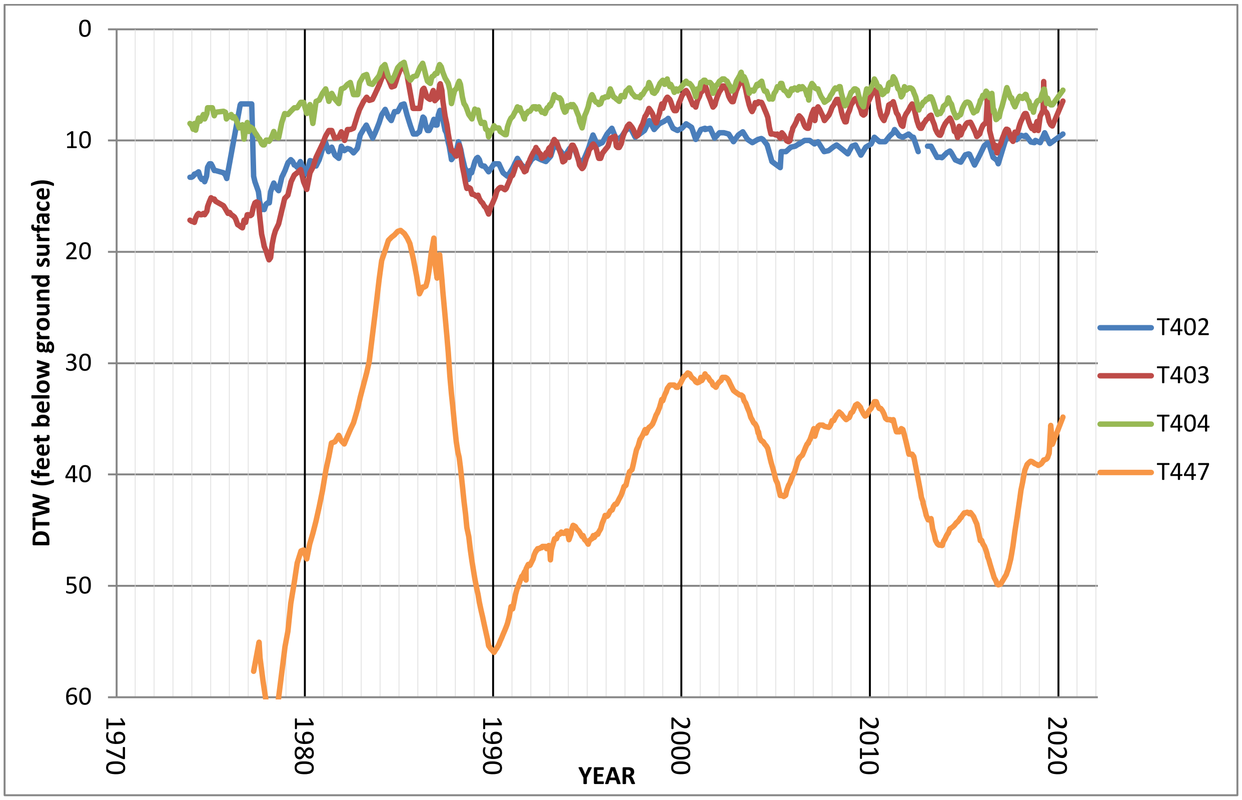

Figure 3.28 Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

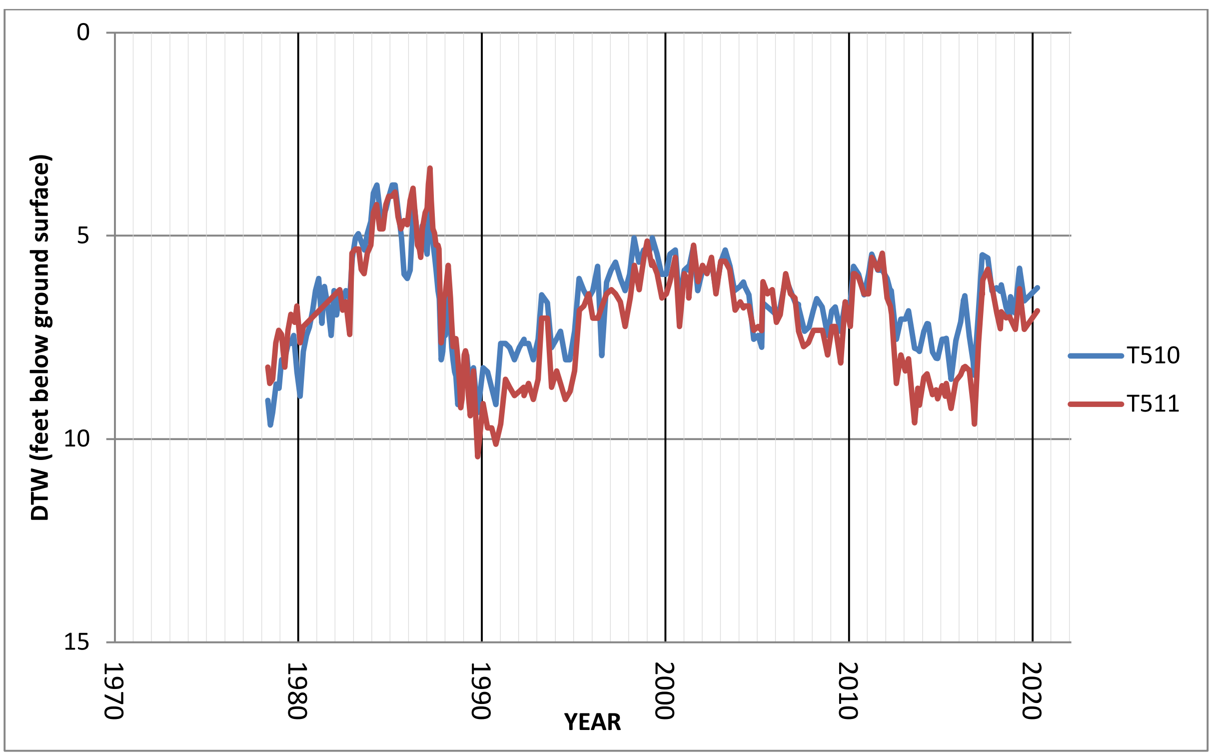

Figure 3.29 Hydrographs of indicator wells in the Symmes-Shepherd wellfield.

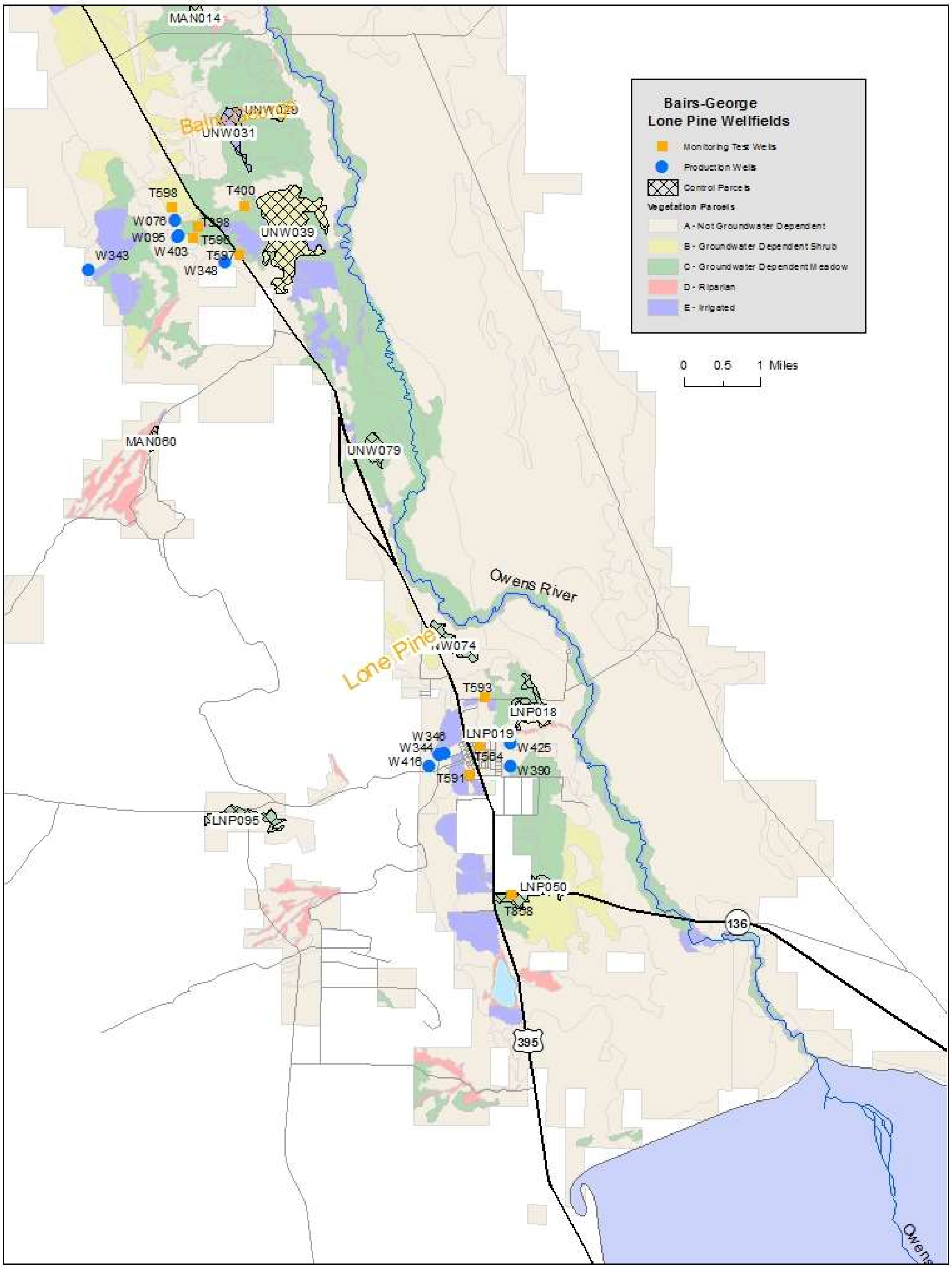

Figure 3.30. Map of monitoring and LADWP production wells in the Bairs-George and Lone Pine wellfields.

The Bairs-Georges Wellfield

In the 1970's and 80's, pumping and water levels in the Bairs-George wellfield (Figure 3.31) varied considerably, but under the Water Agreement, pumping has been reduced substantially. In dry years when surface flows decline, one well is exempt (W343) and can be operated to supply irrigated pastures. As in other wellfields, pumping for aqueduct supply increased in 2010-2016 compared with the lower amounts during the five preceding years.

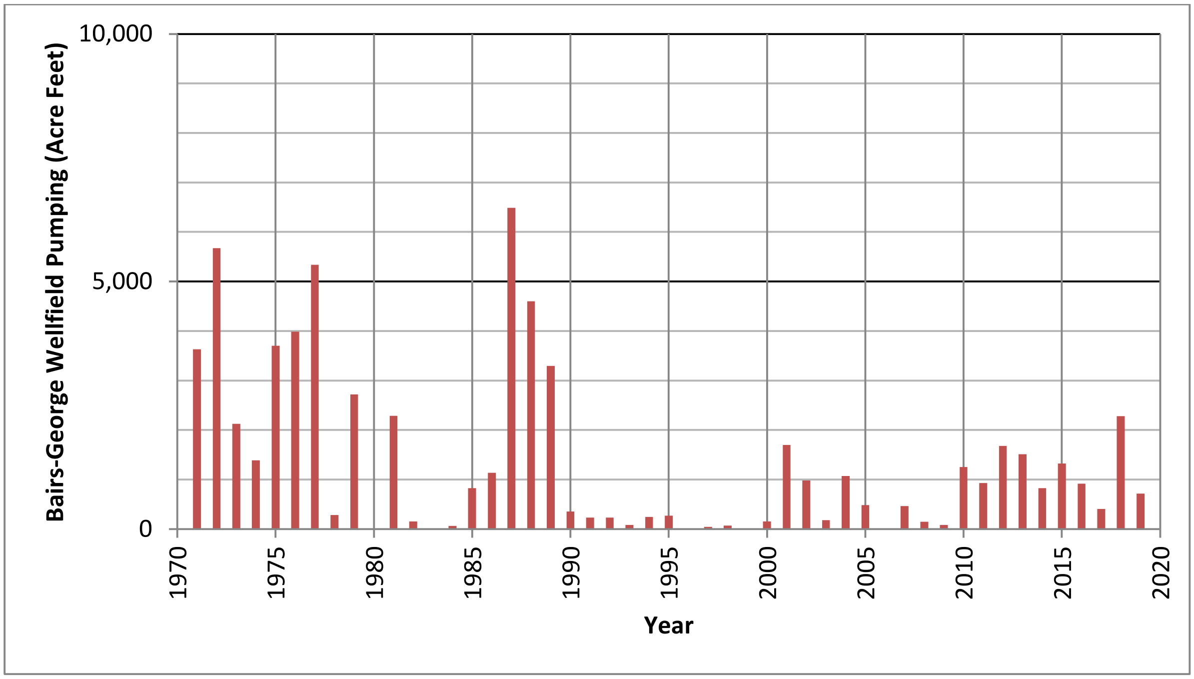

Figure 3.31. Pumping totals for the Bairs-Georges wellfield.

Since the mid 1990's groundwater levels in the three indicator wells have been relatively stable. However, in 2018-2019 LADWP pumped approximately 2,280 ac-ft from the wellfield; the most pumping since 1989. Water levels in 2018-2019 declined by one to four feet. However, pumping was reduced in 2019-20 to only 700 ac-ft and groundwater levels recovered between 0.75 and 2 feet this past year, and all three wells were above baseline in 2020 (Table 3.2).

The pumping wells are located west of the Los Angeles Aqueduct. Monitoring wells T597 and T398 (Figure 3.32) are in the immediate vicinity of the aqueduct and well T400 is east of the aqueduct. Water table fluctuations in these wells are buffered by the infiltration from the aqueduct, though the water table reduction as a result of the increase in pumping since 2010 coupled with the 2012-2016 drought is evident in T398 and T597. Pumping effects are less evident in T400. Monitoring wells T598 and T596 are located west of the aqueduct, and they exhibit larger fluctuations due to pumping (Figure 3.33).

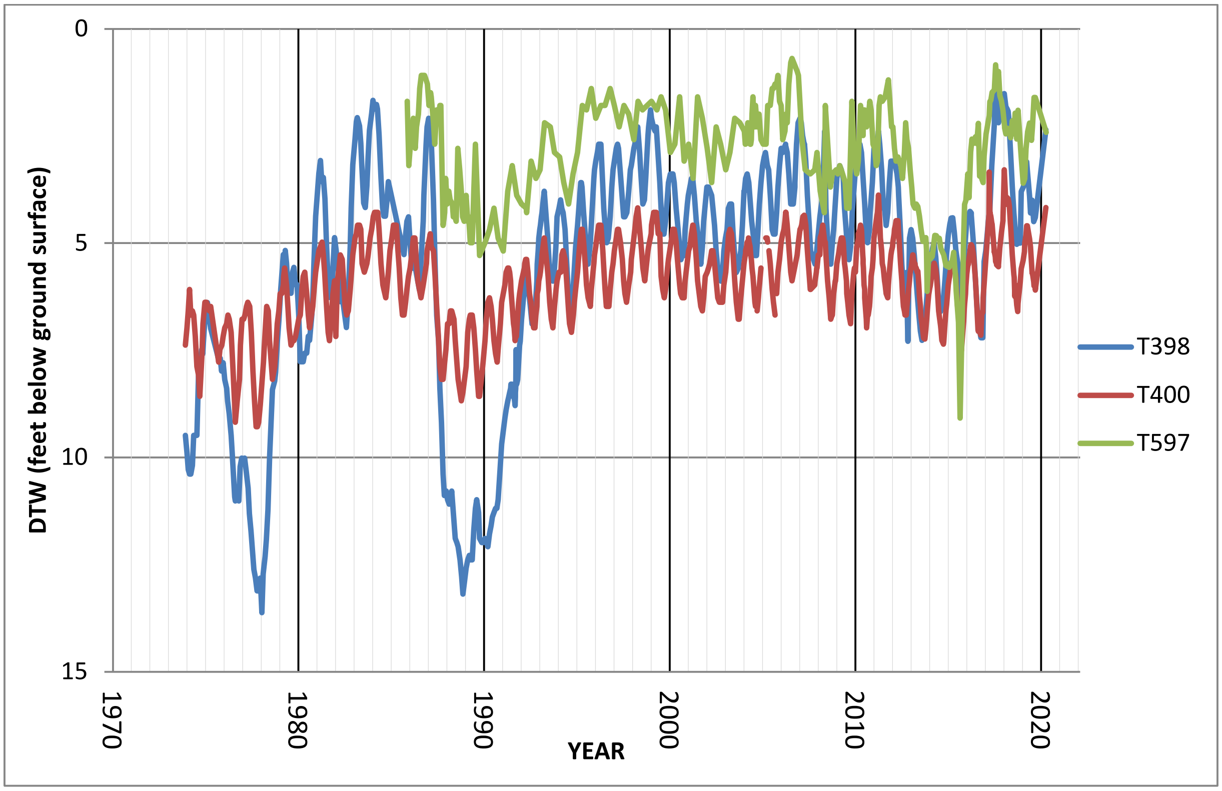

Figure 3.32. Hydrographs of indicator wells and 597T in the Bairs-Georges wellfield.

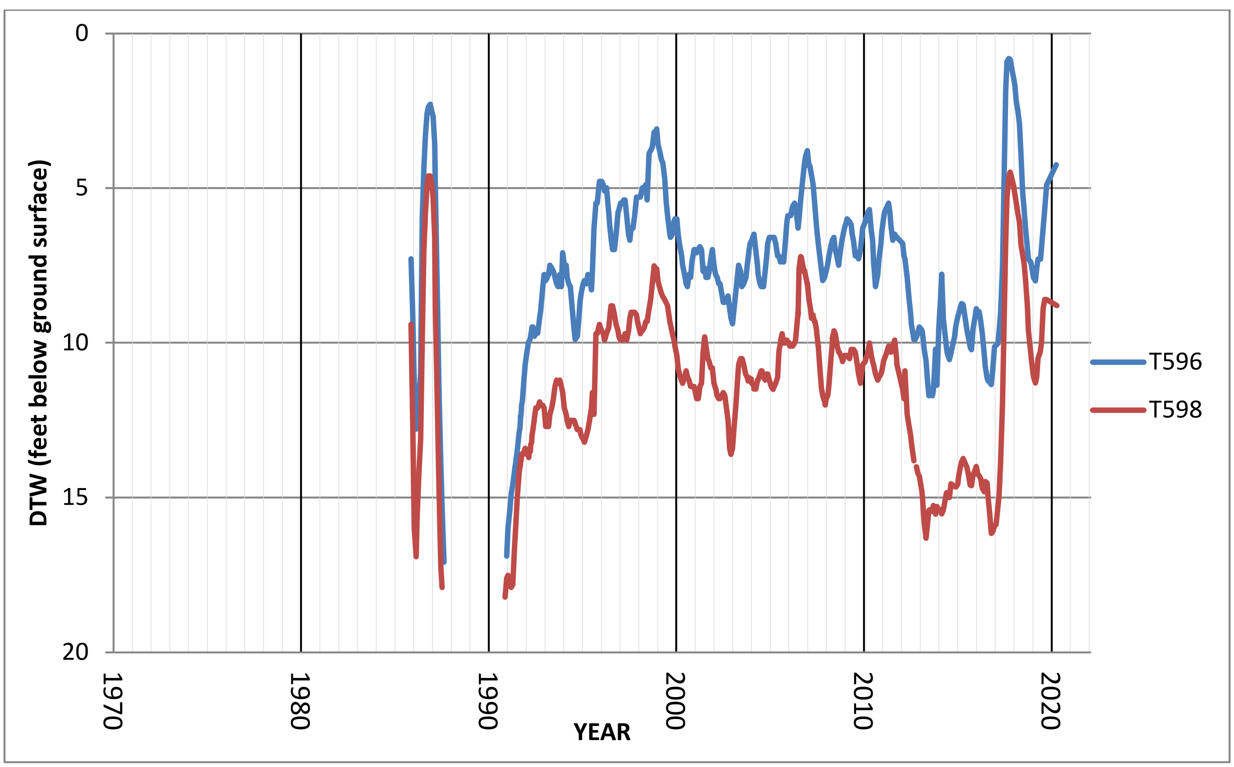

Figure 3.33. Hydrographs of selected wells in the Bairs-Georges wellfield.

The Lone Pine Wellfield

Most pumping in the Lone Pine Wellfield (Figure 3.30) has been to supply the town of Lone Pine and one mitigation project (approximately 1,300 ac-ft annually for irrigated agriculture). Pumping increased occasionally (e.g. in 2000) to offset aqueduct water previously supplied to Diaz Lake (Figure 3.34). In 2015, pumping also increased largely due to the operation of a new well (W425) to supply Van Norman field. The previous well (W390) degraded and production declined noticeably in 2008. The new well has capacity to fully supply the project. Because of the relatively constant pumping for sole-source uses, ICWD does not routinely use indicator wells to analyze the annual operations plan for this wellfield.

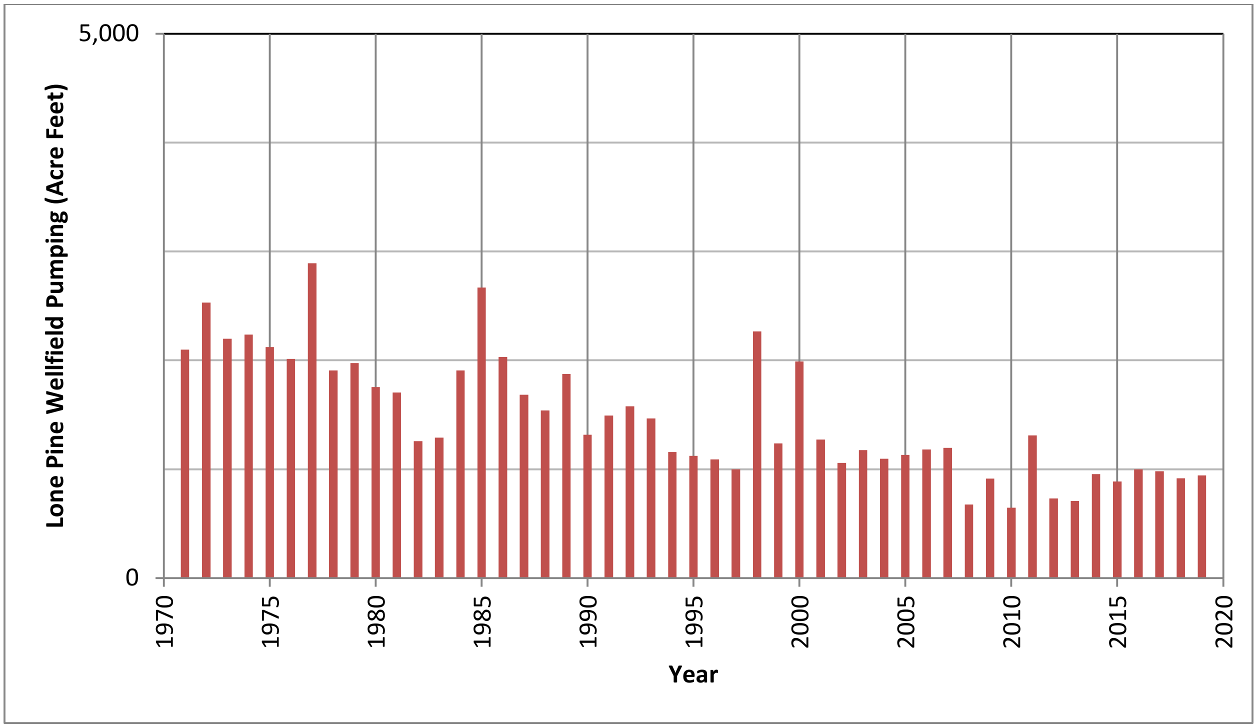

Figure 3.34. Pumping totals for the Lone Pine wellfield.

Hydrographs for test wells T564 and T591 are presented in Figure 3.35 to represent water levels near the town of Lone Pine where the LADWP pumping wells are located. Monitoring wells T593 and T858 are located in groundwater dependent vegetation north and south of Lone Pine, respectively. All wells exhibit seasonal fluctuations as well as water table response to decreased recharge due to drought. Pumping effects are not as evident. Water levels rose in 2017 and again in 2019 due to heavy runoff. Groundwater levels are similar to baseline levels.

In early 2010, LADWP tested a new production well, W416, installed to increase aqueduct supply. This new production well has been modified and initial tests to determine well capacity and performance have been completed. However, details of the operational monitoring have yet to be agreed upon by the Technical Group.

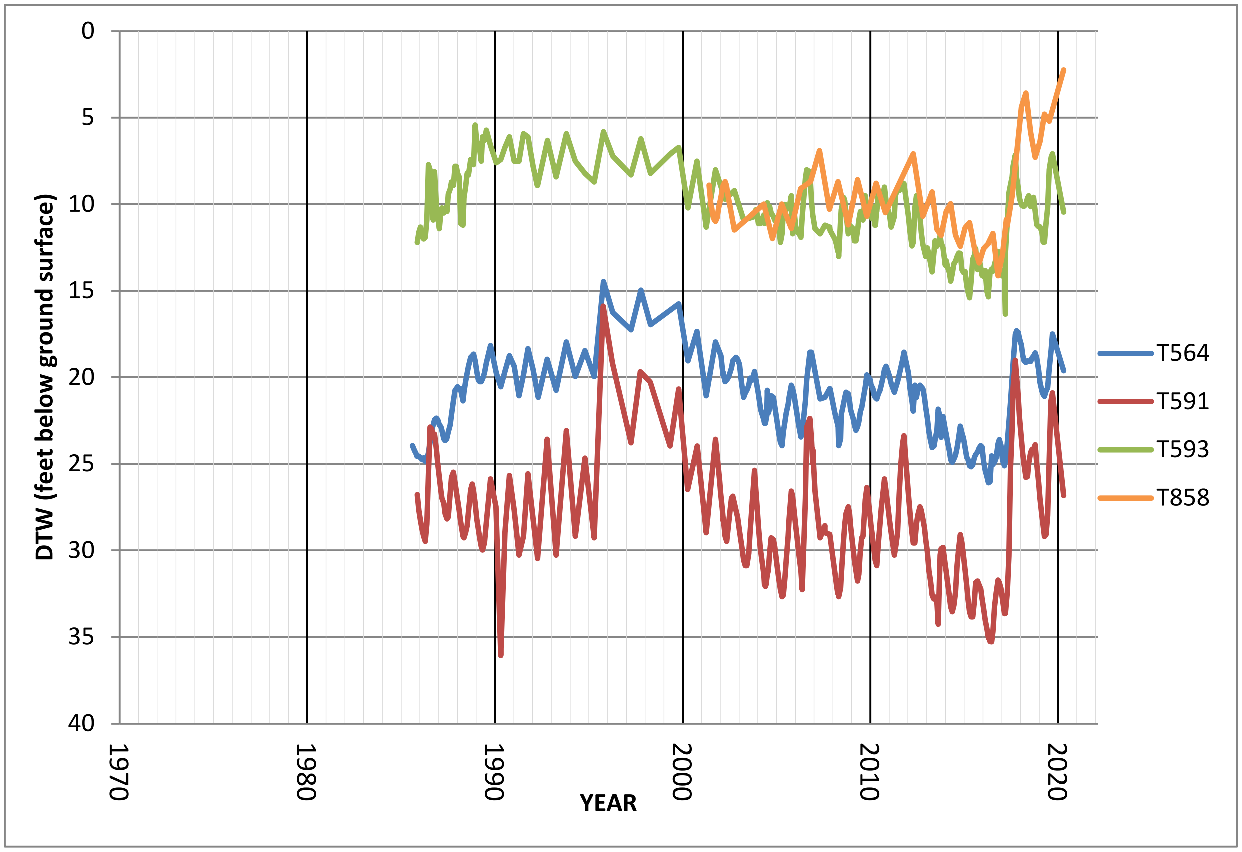

Figure 3.35. Hydrographs of selected test wells in the Lone Pine wellfield.

2020-21 Pumping Plan

LADWP issued its annual operations plan for the upcoming 2020-21 runoff year on April 20, 2020. The forecasted runoff for the Owens River watershed runoff is 299,600 ac-ft (74% of normal). LADWP provided a large range of planned pumping for the year between 75,000 and 93,000 ac-ft (Table 3.3). The pumping, at the low-end, is a mix of sole-source (in valley) and export; under LADWP's high pumping scenario a significant amount of pumping for export is planned (appx. 39,000 ac-ft).

Table 3.3. Planned LADWP pumping by wellfield for 2020-21 and ICWD proposed pumping.

Wellfield	LADWP MIN (75,000 AF)	LADWP MAX (93,000 AF)	In-Valley Min (54,300 AF)	Inyo Recommended (71,725 AF)
	Ac-ft/year	Ac-ft/year	Ac-ft/year	Ac-ft/year
Laws	7,580	10,460	6,000	7,580
Bishop	11,040	12,685	10,390	12,685
Big Pine	21,000	23,695	21,000	21,500
Taboose-Aberdeen	16,920	19,500	300	9,500
Thibaut-Sawmill	8,000	11,160	8,000	11,050
Independence-Oak	6,420	10,740	6,420	6,240
Symmes-Shepherd	960	960	960	960
Bairs-George	2,100	2,820	250	1,050
Lone Pine	980	980	980	980
Sum	75,000	93,000	54,300	71,545

The Water Department analyzed the effect of the operations plan on groundwater levels in the Owens Valley using regression models for several monitoring wells (Table 3.4). Most models rely on measured DTW in April 2020, planned wellfield pumping for the entire runoff year, and Owens Valley runoff to predict water levels next April. For several wells, Owens Valley runoff was not a statistically significant variable in the regression model. Water levels in those wells are correlated with pumping, and the models are still useful for evaluating the pumping plan. Also, models in Laws use the amount of water diverted from the Owens River into the McNally canals as the variable associated with recharge instead of runoff. Water spreading is not planned for Laws in 2020-21 (Table 2.5 of LADWP's Draft Plan), so the McNally Canals were assumed to have no flow for the Laws regression models.

The models used by the Water Department to analyze the annual operations plan predict water levels one year in the future (e.g. April 2020 to 2021) based on annual pumping for each wellfield. Four pumping scenarios are presented in Table 3.4: minimum pumping for In-Valley uses, the upper and lower pumping limits from LADWP's proposed Draft Plan, and ICWD's recommended pumping.

Table 3.4. Predicted water level changes at indicator wells and monitoring sites for: i) LADWP's proposed minimum pumping, ii) in-valley minimum pumping iii) LADWP's proposed maximum pumping and iv) ICWD's recommended pumping. Negative DTW values denote a decline. Predictions in this table are made to 0.1 ft. Extra digits are presented for rounding transparency.

Station ID, Monitoring site	LADWP MIN 75,000 ac-ft 2021 vs 2020	LADWP MIN 75,000 ac-ft 2021 vs Baseline	In-Valley MIN 54,300 ac-ft 2021 vs 2020	In-Valley MIN 54,300 ac-ft 2021 vs Baseline
	(DTW change ft)	(DTW change ft)	(DTW change ft)	(DTW change ft)
Laws				
107T	-4.92	-4.15	-4.39	-3.62
434T	-1.25	0.28	-1.02	0.51
436T	-3.02	-0.90	-2.79	-0.67
438T	-4.24	-1.84	-4.05	-1.65
490T	-2.45	1.75	-2.35	1.84
492T	-6.32	2.41	-5.47	3.26
795T	-11.05	-5.91	-10.30	-5.16
V001g	-6.18	-0.50	-5.75	-0.07
574T	-3.82	-1.46	-3.58	-1.23
Big Pine				
425T	-1.17	-0.17	-1.17	-0.17
426T	-0.72	-0.69	-0.72	-0.69
469T	-0.85	-0.38	-0.85	-0.38
572T	-2.79	0.88	-2.79	0.88
798T, BP1	-3.57	0.77	-3.57	0.77
799T, BP2	-0.43	-0.36	-0.43	-0.36
567T, BP3	-1.69	-0.05	-1.69	-0.04
800T, BP4	-0.79	-0.18	-0.79	-0.18
Taboose Aberdeen				
417T	-4.43	-0.92	-0.07	3.43
418T	-1.42	-0.64	0.46	1.24
419T, TA1	-3.97	-1.45	0.51	3.04
421T	-4.28	-3.19	0.26	1.35
502T	-2.00	-3.56	0.08	-1.48
504T	-4.87	-2.33	0.69	3.23
505T	-4.36	-0.96	0.08	3.48
586T, TA4	-2.95	-1.02	0.76	2.69
801T, TA5	-0.62	-1.75	0.41	-0.73
803T, TA6	-4.58	-0.87	-0.46	3.25
Thibaut Sawmill				
415T	0.10	9.25	0.10	9.25
507T	0.36	1.15	0.36	1.15
806T, TS2	0.12	3.78	0.12	3.78
Independence- Oak				
406T	-0.32	-2.31	-0.32	-2.31
407T	0.26	-4.13	0.26	-4.13
408T	0.05	-0.81	0.05	-0.81
409T	-0.54	-5.49	-0.54	-5.49
546T	-1.71	-3.03	-1.71	-3.03
809T, IO1	-0.92	-3.70	-0.92	-3.70
Symmes Shepherd				
402T	0.03	-2.05	0.03	-2.05
403T	0.52	-1.21	0.52	-1.21
404T	0.46	-1.86	0.46	-1.86
447T	0.64	-12.83	0.64	-12.83
510T	0.43	-1.65	0.43	-1.65
511T	0.42	-2.49	0.42	-2.49
V009G, SS1	0.71	-10.42	0.71	-10.42
Bairs George				
398T	-2.70	-0.31	-0.19	2.20
400T	-0.69	0.04	-0.22	0.51
812T	-3.56	-2.82	-1.37	-0.63

Station ID, Monitoring site	LADWP MAX 93,000 ac-ft 2021 vs 2020	LADWP MAX 95,000 ac-ft 2021 vs Baseline	ICWD Recommended 71,725 ac-ft 2021 vs 2020	ICWD Recommended 71,725 ac-ft 2021 vs Baseline
	(DTW change ft)	(DTW change ft)	(DTW change ft)	(DTW change ft)
Laws				
107T	-5.88	-5.11	-4.92	-4.15
434T	-1.65	-0.12	-1.25	0.28
436T	-3.44	-1.32	-3.02	-0.90
438T	-4.59	-2.19	-4.24	-1.84
490T	-2.63	1.57	-2.45	1.75
492T	-7.86	0.87	-6.32	2.41
795T	-12.42	-7.28	-11.05	-5.91
V001g	-6.98	-1.30	-6.18	-0.50
574T	-4.25	-1.90	-3.82	-1.46
Big Pine				
425T	-1.63	-0.63	-1.25	-0.25
426T	-0.98	-0.95	-0.77	-0.74
469T	-1.10	-0.62	-0.90	-0.42
572T	-3.29	0.38	-2.89	0.78
798T, BP1	-4.01	0.33	-3.66	0.69
799T, BP2	-0.67	-0.60	-0.47	-0.40
567T, BP3	-2.10	-0.46	-1.77	-0.12
800T, BP4	-1.35	-0.74	-0.90	-0.29
Taboose Aberdeen				
417T	-5.10	-1.60	-2.48	1.02
418T	-1.71	-0.94	-0.58	0.20
419T, TA1	-4.66	-2.14	-1.97	0.56
421T	-4.99	-3.89	-2.25	-1.16
502T	-2.32	-3.88	-1.07	-2.63
504T	-5.73	-3.19	-2.38	0.15
505T	-5.05	-1.65	-2.38	1.02
586T, TA4	-3.52	-1.60	-1.29	0.63
801T, TA5	-0.78	-1.91	-0.16	-1.30
803T, TA6	-5.22	-1.51	-2.74	0.97
Thibaut Sawmill				
415T	-2.34	6.81	-2.26	6.89
507T	-0.16	0.64	-0.14	0.65
806T, TS2	-0.50	3.16	-0.48	3.18
Independence- Oak				
406T	-0.62	-2.62	-0.32	-2.31
407T	-1.21	-5.60	0.26	-4.13
408T	-0.92	-1.79	0.05	-0.81
409T	-3.55	-8.50	-0.54	-5.49
546T	-2.35	-3.66	-1.71	-3.03
809T, IO1	-2.41	-5.20	-0.92	-3.70
Symmes Shepherd				
402T	0.03	-2.05	0.03	-2.05
403T	0.52	-1.21	0.52	-1.21
404T	0.46	-1.86	0.46	-1.86
447T	0.64	-12.83	0.64	-12.83
510T	0.43	-1.65	0.43	-1.65
511T	0.42	-2.49	0.42	-2.49
V009G, SS1	0.71	-10.42	0.71	-10.42
Bairs George				
398T	-3.68	-1.29	-1.28	1.11
400T	-0.87	-0.14	-0.42	0.31
812T	-4.41	-3.67	-2.32	-1.58

The analysis of water level changes if minimum pumping were conducted for specific uses in the Owens Valley is included as a basis for comparison with the higher levels of pumping in LADWP's proposed and Inyo County's recommended pumping amounts. Minimum pumping is not a constant and varies depending on runoff availability to supply irrigation or mitigation projects with surface water instead of groundwater where possible.

The upper limit of the pumping proposed in the Draft Plan is used to evaluate LADWP's proposed pumping because (1) it represents the maximum impact on the water table that the Draft Plan could have, and (2) except in high runoff conditions, LADWP has generally pumped near the upper end of the proposed range.

ICWD's analysis of the Draft Plan and recommendations for pumping are based on the goals and principles of the Water Agreement, the status of individual pumping wells according to Green Book soil water triggers, groundwater dependent vegetation conditions monitored by the Technical Group, water table conditions in each well field, and groundwater uses within each wellfield. ICWD recommends 71,545 ac-ft of pumping for 2020-21.

Average groundwater levels are expected to decline in all wellfields except Symmes-Shepherd under LADWP's 2020-21 maximum proposed pumping (Table 3.4). The average groundwater level change in the 46 indicator wells is predicted to be a decline of 2.7 ft under LADWP's maximum pumping scenario, a decline of 1.1 ft with in-valley minimum pumping, and a decline of 1.5 ft with the ICWD recommended pumping amount. By April 2021, under LADWP's maximum pumping scenario, average predicted water levels will be above (Thibaut-Sawmill) or approximately 2 feet below baseline in Laws, Big Pine, Taboose-Aberdeen and Bairs-George. However, groundwater levels will be more than 4 feet below baseline in Independence-Oak and Symmes Shepherd. Concerns and recommendations to LADWP's proposed 2020-21 pumping plan were described in the Inyo County Water Department's April 30, 2020 letter to LADWP. A summary of these comments are presented as follows:

The extraordinarily high amount of runoff in 2017-2018 promoted a substantial rise in the water table in most areas of the Owens Valley; however, some areas remain below water levels that prevailed during the mid-1980s when the baseline vegetation mapping occurred. ICWD's analysis and recommendations are based on water table conditions in each well field relative to baseline water levels, groundwater uses within each wellfield, and groundwater dependent vegetation conditions.

Although runoff has been well above average in two of the past three years, these good water years follow on the heels of an exceptional drought with runoff values below 60% for four consecutive years. The negative effects of this drought on vegetation were evident in depressed 2016 perennial cover values. Increased cover was noted in most parcels from 2017-2019; however, in 2019 perennial cover and grass cover remained below baseline in many vegetation parcels across the valley, notably in Laws. Maintaining a shallow water table in areas of groundwater-dependent vegetation in 2020 is necessary to encourage further recovery to baseline values, especially given the multi-year, feast-or-famine pattern of precipitation observed during the past 30 years. Shallow groundwater levels are particularly important to maintain perennial grasses which have seen more substantial declines than overall cover; this is especially relevant since preventing conversion of grass-dominated meadows to shrub communities is one of the components of the LTWA. It is, therefore, important to maintain shallow groundwater levels during multi-year periods of above-average runoff in anticipation of future drought periods.

In 2018, LADWP pumped approximately 85,000 ac-ft of groundwater and water levels across the valley fell by about 1 foot. The upper range of pumping for 2020-21, 93,500 ac-ft, in the Draft Plan (Table 3.3) would be the most pumping since the implementation of the LTWA and groundwater levels would fall valley-wide by a predicted average of 2.7 feet. In Laws, Taboose-Aberdeen, and Bairs Georges groundwater levels are predicted to fall five, four, and three feet, respectively.

ICWD's recommend pumping amount of 71,545 ac-ft is a more prudent recommendation which allows the multiple goals of the Water Agreement to be met with a more responsible and sustainable approach: a significant amount of groundwater would be pumped for use in Owens Valley and export to Los Angeles, while maintaining hydrologic conditions conducive to vegetation recovery and health.

ICWD has expressed concerns to LADWP about pumping and water level declines in three wellfields during the recent drought: southern Big Pine, Independence-Oak, and Symmes-Shepherd. Pumping for aqueduct supply has been concentrated from exempt and On-status wells located in these wellfields. Groundwater levels in several wells in Independence-Oak and Symmes-Shepherd wellfields are predicted to remain several feet below baseline. In addition, the groundwater mining limit calculation for the Big Pine wellfield shows a relatively small amount of recharge in excess of pumping over the past 20-year period. ICWD recommended that pumping in those wellfields be limited to sole source uses to allow for maximum water level recovery in this below-average runoff year.

The Water Department's comment letter with discussion on each wellfield and discussion regarding replacement wells and LADWP potential pumping tests can be found online at: https://www.inyowater.org/documents/pumping/dwp-annual-operations-plans/

Evaluation of 2019 DTW predictions

As noted in the previous sub-section, ICWD routinely uses linear regression models to predict the effects of pumping on DTW as part of its analysis of LADWP's annual operations plans. ICWD staff conducts an annual audit which examines the accuracy of these models by comparing the predictions with DTW measurements collected the following year on April 1. The regression models were constructed from historical data for wellfield pumping, Owens Valley runoff, and current water levels. The models in Laws rely on an estimate of the diversions into the McNally canals instead of Owens Valley runoff as the variable related to groundwater recharge. For four of the permanent monitoring sites, a second model was used that relies on predicted DTW in a nearby indicator well that responds similarly to pumping and runoff. The models were originally developed by Harrington (1998) and Steinwand and Harrington (2003). These reports are available on the Water Department website.

This analysis of the predictions includes uncertainty in the input variables (runoff forecast and planned pumping) as well as uncertainty in the empirical-based models. Model uncertainty includes all management actions and environmental conditions not captured in the regression model e.g. atypical recharge or pumping operations near one of the test wells. Predictions for 46 indicator wells made in April 2019 were compared to actual April 2020 DTWs for this report.

The 2019 predicted DTW values were based on the higher pumping amount planned by LADWP in their 2019-20 pumping plan (73,710 ac-ft). Actual pumping was approximately 72% (53,198 ac-ft) of the planned amount (Table 3.1). Wellfield pumping totals for the year differed by as much as 6,500 acre feet of the planned amounts in wellfields with indicator wells. The discrepancies in planned and actual pumping decrease the accuracy of predictions. The model predictions also rely on forecasted Owens Valley runoff and unavoidably include the uncertainty in that prediction.

The LADWP runoff forecast has tracked actual runoff with accuracy since 1994. However, in the past two runoff years, LADWP's forecast has under-predicted runoff by 75,000 and 81,000 ac-ft, respectively (second and third largest errors since 1994, Figure 3.1). These consecutive underpredictions are possibly due to continued water hold-over from the record 2017-18 winter and the large amounts of surface water spread in the valley. Shallow groundwater levels in the Owens Valley, not widely seen since the 1980s, may also be contributing to LADWPs underpredictions.

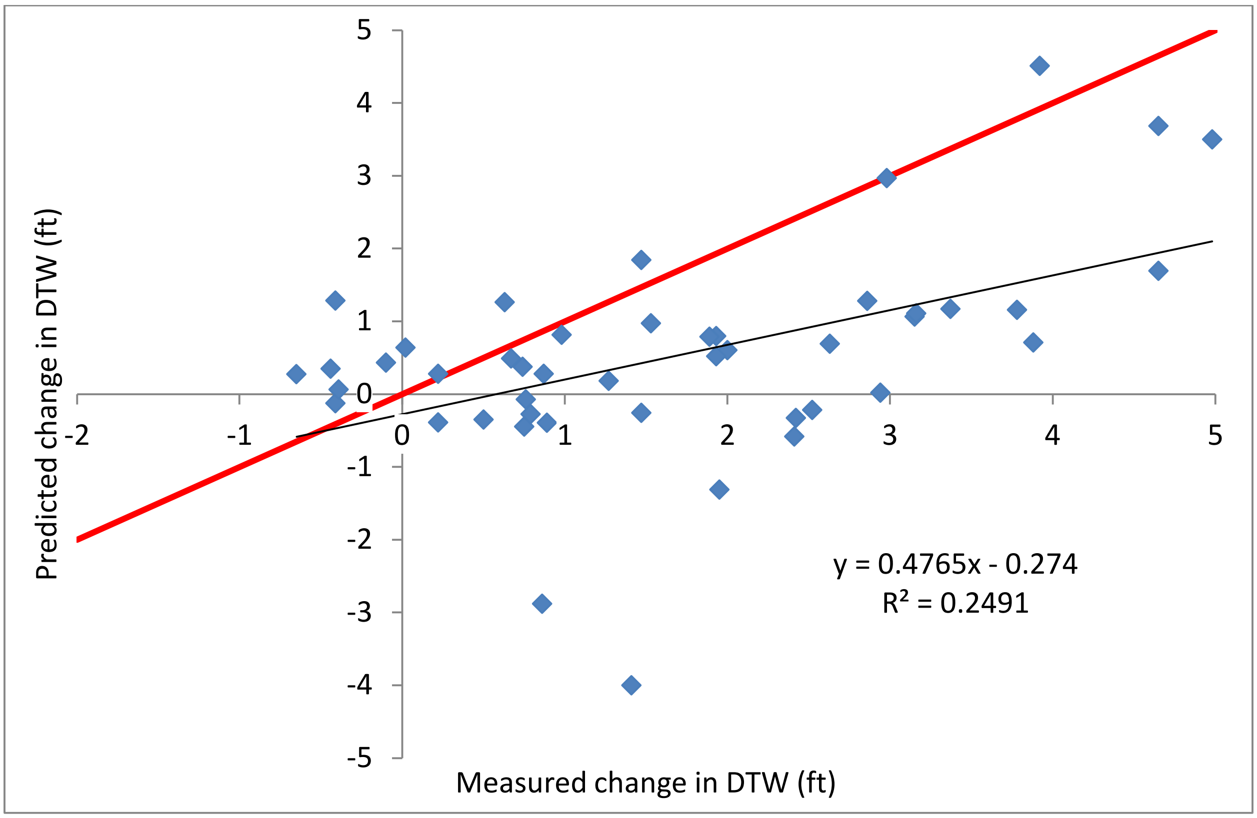

Figure 3.36. Measured and predicted change in DTW from April 2019 to April 2020 for 46 indicator wells. The solid red line is the 1:1 line. Negative values denote decline in water level. Data points right of the redline indicate actual groundwater level changes were more positive (shallower) than predicted.

The forecasted 2019-20 runoff was above average (137%) but well within the standard range of common runoff amounts. And, the 73,710 ac-ft of planned LADWP pumping was near the annual average of pumping for the past 25 years. Model performance in 2019-20, however, was less accurate than previous years due to a combination of erroneous inputs including: less pumping than planned, more surface water spreading in the McNally canals, and greater runoff than predicted. Measured versus predicted change in DTW are plotted in Figure 3.36. If the models were perfect predictors, the points would fall on the 1:1 line (slope of 1) between the lower left and upper right quadrants. The average absolute deviation between 2019 water level predictions and 2020 measured water levels was 1.6 ft. The indicator models underpredicted actual levels substantially. Only 29 of the 46 Indicator predictions were within 1.5 ft of the actual deviation. This measure of model performance is poorer than prior years

Although model predictions were less accurate than past years, the principal sources of error in 2019 predictions are a result of less actual pumping and higher runoff and surface water spreading but not the regression models themselves. For confirmation, the 2019 models were re-run with actual values: *i)* runoff, *ii)* McNally spreading, and *iii)* pumping (Figure 3.37). The subsequent model performance was more accurate, with the average difference between predicted and modeled DTWs approximately 0.8 feet. Model predictions were within 1.5 ft of actual in 38 of the 46 wells, and within 1 ft of actual in 32 of the 46 wells.

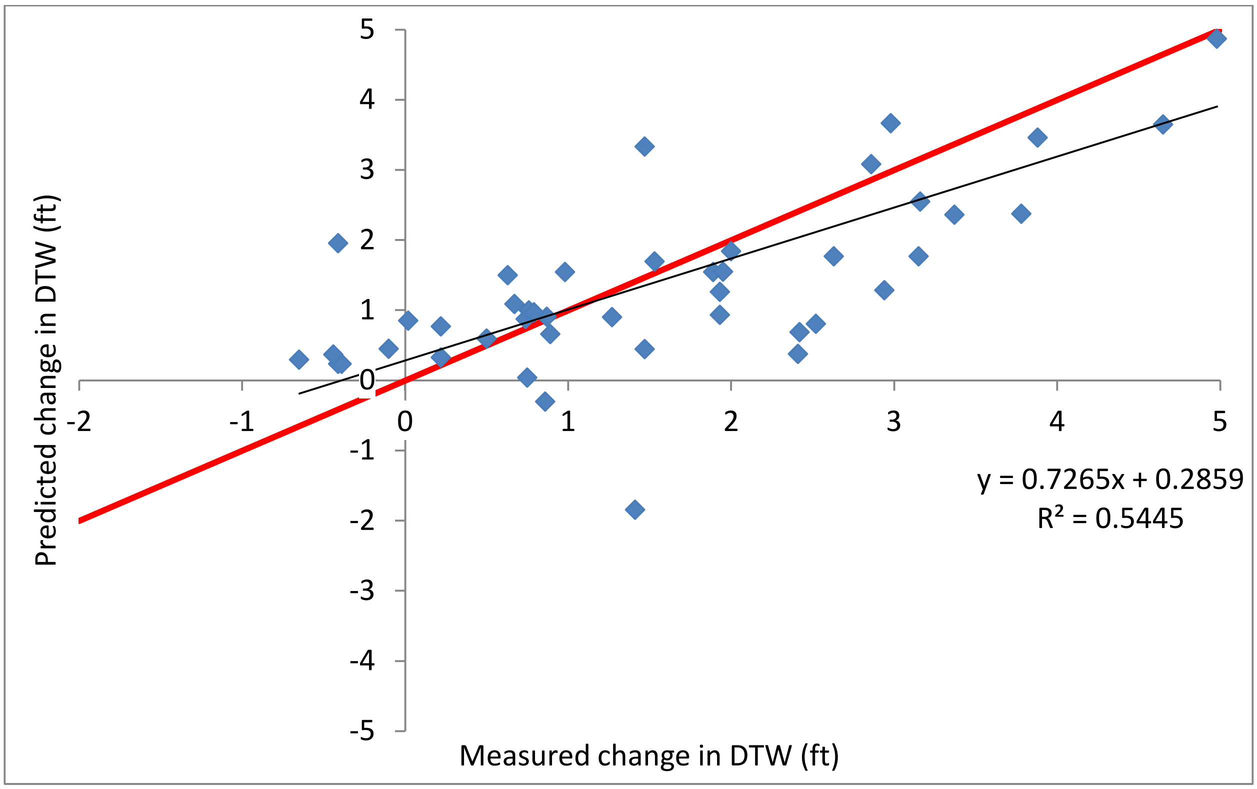

Figure 3.37. Measured and predicted change in DTW from April 2019 to April 2020 for 46 indicator wells. The solid red line is the 1:1 line. Negative values denote decline in water level. Data points right of the redline indicate actual groundwater level changes were more positive (shallower) than predicted.

References

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Steinwand, A.L, and R.F. Harrington. 2003. Simulation of water table fluctuations at permanent monitoring sites to evaluate groundwater pumping. Report to the Inyo/Los Angeles Technical Group, February 25, 2003.