Well W371 Replacement in Bishop Wellfield

Pre-Construction Evaluation Report

Eastern Sierra Environmental Group

Water Operations Division

Los Angeles Department of Water and Power

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1. PURPOSE

The City of Los Angeles, Department of Water and Power (LADWP) is planning to drill and construct a well to replace the existing Well W371 located in the Bishop Wellfield. The purpose of this report is to satisfy the requirements of Section IV.B of the Greenbook (the Technical Appendix to the Water Agreement), Guidelines for Drilling and Activating New Production Wells.

2. BACKGROUND

2.1 Introduction

LADWP plans to replace production well W371 in the Bishop Wellfield using the current industry standards for well construction and improve LADWP's operational flexibility in managing water resources in Owens Valley. The purpose of this report is to satisfy the requirements of Section IV.B. of the Greenbook, Guidelines for Drilling and Activating New Production Wells. According to Section VI of the Water Agreement, LADWP may replace existing wells and construct new wells in areas where hydrologic conditions are favorable.

Well W371 was constructed in 1980 using Cable Tool method to a depth of 252' below ground surface (bgs) to supply water for irrigation uses on City-owned lands on Bishop Cone. Well W371 casing is slotted from 80' to 146' bgs and 155' to 226' bgs. Originally operating with a production capacity of over 2.5 cubic feet per second (cfs), the production capacity has been declining over time to the current capacity of approximately 1.7 cfs despite multiple rehabilitation efforts, loosing approximately 30% of its pumping capacity. When operable, LADWP operates W371 year-round.

2.2 Hillside Decree

Section VII of the Water Agreement states: "*Any groundwater pumping by the Department on the "Bishop Cone" (Cone) shall be in strict adherence to the provisions of the Stipulation and Order filed on the 26th day of August, 1940, in Inyo County Superior Court in the case of Hillside Water Company, a corporation, et al. vs. The City of Los Angeles, a Municipal Corporation, et al., ("Hillside Decree")*".

"*The Department's annual groundwater extractions from the Cone shall be limited to an amount not greater than the total amount of water used on Los Angeles-owned lands on the Cone during that year. Annual groundwater extractions by the Department shall be the total of all groundwater pumped by the Department on the Cone, plus the amount of artesian water that flowed out of the casing of uncapped wells on the Cone during the year. Water used on Los Angeles-owned lands on the Cone, shall be the quantity of water supplied to such lands, including conveyance losses, less any return flow to the aqueduct system.*"

The Water Agreement requires that the Inyo County Water Department (ICWD) perform an annual audit of water used on City owned lands and groundwater extractions by LADWP on the Bishop Cone. As shown in Figure 1, LADWP has historically extracted less groundwater than allowed under the terms of the Hillside Decree. Replacement of W371 will provide additional groundwater supply for nearby uses and help balance groundwater extractions with water used on City-owned lands on Bishop Cone.

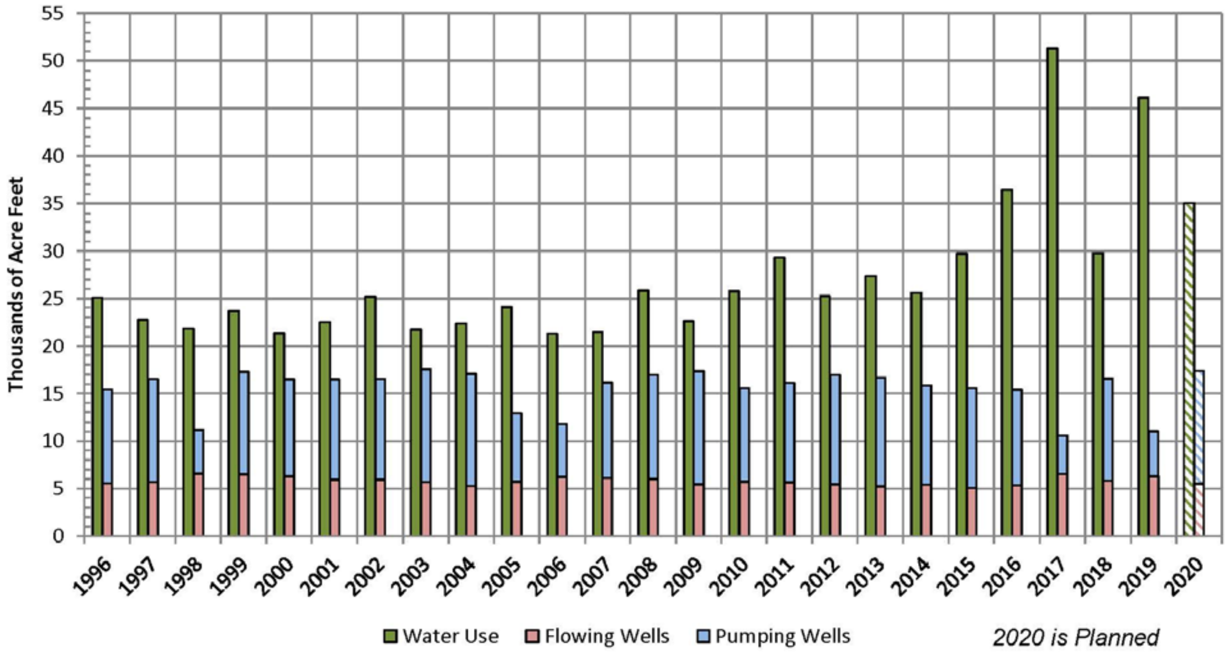

Figure 1 – Water used on City-owned lands and groundwater extraction by LADWP on the Bishop Cone

2.3 Location

The Bishop Wellfield is located in the northern Owens Valley and is south and west of Owens River, extending south to where Big Pine Canal crosses Highway 395. The main hydrologic features in the Bishop area are Bishop Creek and a large number of ditches that divert and distribute water from Bishop Creek throughout the wellfield for irrigation purposes. Figure 2 shows the location of the original W371 and the proposed location of W371R. Similar to the existing W371, the replacement well will discharge water to Bishop Creek Canal running south from the well site.

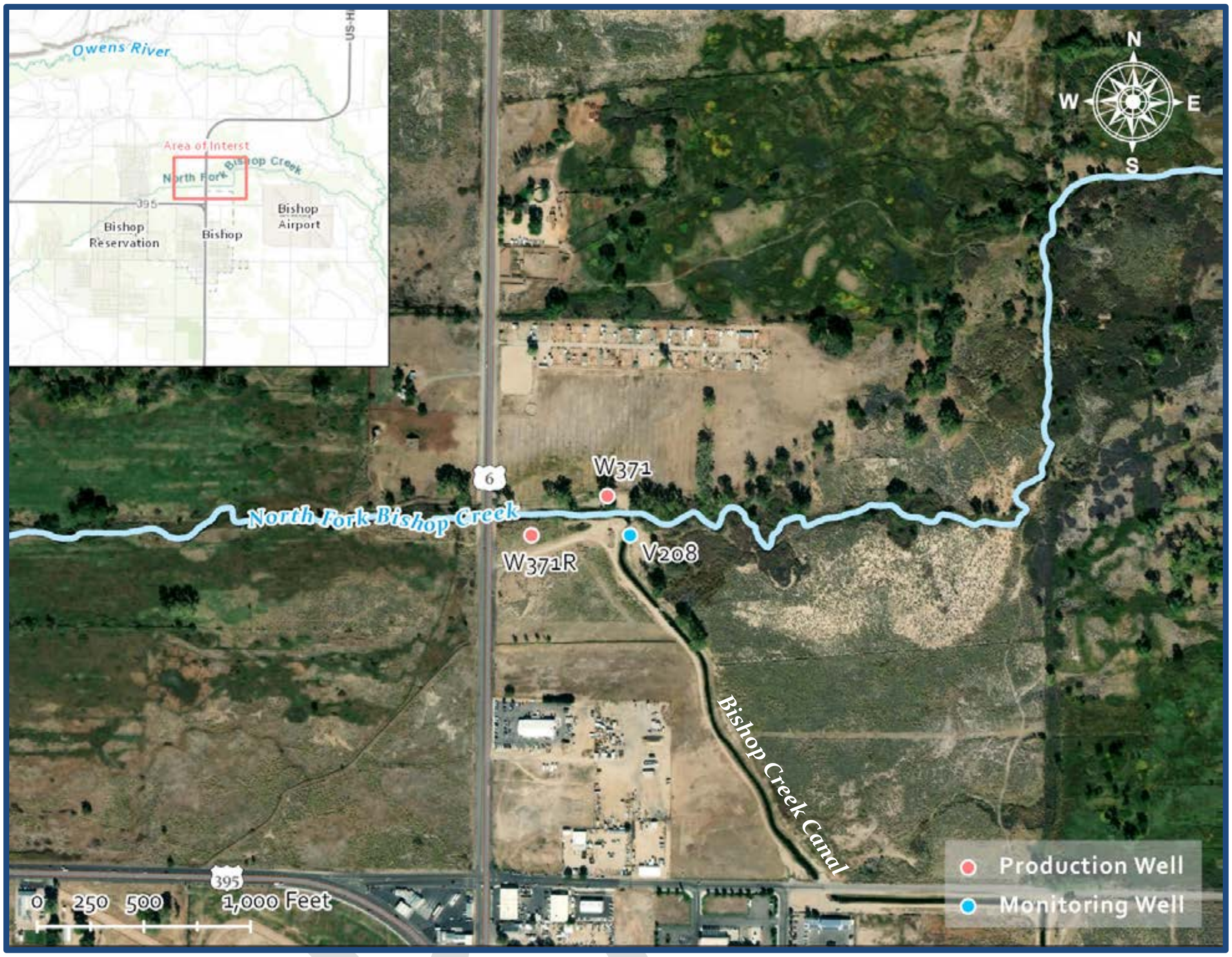

Figure 2 – Locations of existing well W371 and replacement W371R in Bishop Wellfield

3. HYDROGEOLOGIC CONDITIONS

3.1 Geology

The conceptual geological framework of the Owens Valley was presented in a U.S. Geological Survey (USGS) report in 1991 (Hollett, et. al., 1991). The Owens Valley was formed by a graben that was filled by debris eroded from the White/Inyo Mountains to the east and Sierra Nevada Mountain to the west. The Bishop Wellfield is located at the base of the Eastern Sierra Nevada Mountains, at the southern edge of the Volcanic Tablelands, and west and south of Laws Wellfield. The sediments underlying the Bishop Wellfield are a combination of alluvial deposits originating from the Eastern Sierra Nevada Mountains, periodic volcanic eruptions that resulted in Bishop Tuff formations north of the wellfield, and fluvial/lacustrine deposits stemming from the ancestral Owens River and the associated lake environment in the Bishop Basin.

3.2 Hydrology

3.2.1 Groundwater

Groundwater in Bishop Wellfield resides mainly in the alluvial and valley fill that consists of debris flows and fluvial material originating from mountain canyons. Groundwater in Bishop Wellfield flows generally in the southeasterly direction from the recharge areas west of the wellfield. Percolation from the Bishop Creek and all its diversion ditches are the main sources of recharge to the groundwater system in the Bishop Area.

A review of the driller's logs for the existing wells in Bishop Wellfield and previous studies indicate existence of shallow and deep aquifer zones separated by lower permeability materials. MWH (2005) summarized several stratigraphic trends as listed below:

- Volcanic tuff tends to thin toward the south and east.
- A relatively thick clay unit appears to underlie the central portion of Bishop Wellfield between approximately 3,200 and 3,600 feet above mean sea level (amsl)
- Above 3,600 feet amsl, sand and gravel deposits are predominant with interbeds of lenticular clay layers.
- Clay deposits tend to be thickest in the lowest lying areas. These low-lying areas may be related to the presence of alkaline lakes as hypothesized by Hollett and others (1991).
- The Volcanic Tablelands to the north of the Bishop Wellfield consist mainly of the welded tuff member of the Bishop Tuff. Gilbert (1938) describes the Bishop Tuff as pumice and welded ash that originated from the Long Valley Caldera Eruption.

The hydrologic characteristics of the aquifers were estimated in previous studies using data from pumping tests conducted on existing wells. The calculated transmissivites ranged from 1,200 to 120,000 ft^2/day. Lower transmissivites are found near the center of the valley in the lacustrine deposits (MWH, 2005). Hollett and others (1991) estimated vertical hydraulic conductivity of the confining clays in the valley ranges from 0.002 to 0.00083 ft/day. Storage coefficients (storativity) derived from Laws and Bishop Area aquifer pumping tests range from 2.6 x 10^{-12} (which is an outlier, the next highest value at a different well is 7.3 x 10^{-5}) to 0.24 [dimensionless].

Bishop Wellfield has historically been one of LADWP's larger wellfields in the Owens Valley. Currently, LADWP's eight production wells are operational in the Bishop Wellfield. Table 1 lists the total annual pumping from these wells and wells that have been replaced since the 1972 runoff year (ROY). As listed in the table, groundwater pumping in the Bishop Wellfield has been generally between 10 and 12 thousand acre-feet per year since the mid-1980s. The 10-year average listed in the bottom of table includes wet, dry, and normal runoff years. LADWP wells in the Bishop Area have a total combined pumping capacity of approximately 24 cubic feet per second and most of the wells are typically pumped during the irrigation season. In addition to LADWP wells, there are numerous relatively shallow private and community domestic supply wells in the Bishop Area. The City of Bishop also owns three production wells that provide water to its distribution system.

Table 1 – Groundwater pumping from LADWP wells in the Bishop Wellfield (AF/year)

Ruoff Yr.	W238	W410	W235	W406	W207	W411	W208	W371	W137	W407	W138	W408	W140	W141	W412	Total
1972-73	936		268		2,023		116		80		101		309	160		3,993
1973-74	1,763		857		1,002		871		392		968		399	866		7,118
1974-75	-		-		-		197		-		-		0	0		197
1975-76	1,022		688		-		376		63		595		178	532		3,454
1976-77	2,593		1,078		-		-		870		2,055		0	26		6,622
1977-78	2,022		740		2,378		553		739		1,734		1,497	1,385		11,048
1978-79	-		-		-		-		-		-		0	0		0
1979-80	2,074		621		1,512		158		361		1,093		1,441	511		7,771
1980-81	-		5		-				-		-		8	0		13
1981-82	2,343		803		2,134				574		1,378		1,276	1,179		9,687
1982-83	597		392		361				285		665		612	591		3,503
1983-84	1		-		8				1		-		0	1		11
1984-85	773		-		1,136				390		934		847	769		4,849
1985-86	2,488		885		1,244			777	666		1,587		1,476	1,362		10,485
1986-87	70		29		8			64	1		-		14	9		195
1987-88	2,135		1,713		1,308			897	671		1,357		1,544	1,353		10,978
1988-89	2,773		1,696		2,707			907	673		1,398		1,504	1,350		13,008
1989-90	1,723		756		2,405			932	705		1,393		1,522	1,264		10,700
1990-91	2,173		1,511		2,594			830	679		1,335		1,414	1,344		11,880
1991-92	2,468		772		2,516			874	491		1,414		1,562	1,526		11,623
1992-93	2,162		1,407		1,176			848	610		1,226		1,342	1,343		10,114
1993-94	1,996		1,266		95			946	598		1,221		1,383	1,196		8,701
1994-95	1,710		772		1,067			814	717		1,331		1,529	1,421		9,361
1995-96	731		283		508			371	347		584		759	698		4,281
1996-97	1,640		770		1,124			981	742		1,414		1,663	1,536		9,870
1997-98	2,066		1,008	30	1,950			1,232	665	32	1,159	26	1,394	1,259		10,821
1998-99	612		372	-	357			338		472	1,008	5	838	554		4,556
1999-00	2,394			1,169	1,515			715		1,035		1,575	1,264	1,097		10,764
2000-01	2,832			1,178	532			822		1,073		1,221	1,253	1,280		10,191
2001-02	2,176			1,594	1,122			1,070		1,056		1,195	1,200	1,210		10,623
2002-03	1,673	282		1,217	702	1,234		780		1,069		1,197	1,269	989	237	10,649
2003-04		2,896		1,515		1,686		1,452		842		1,176	1,247		1,434	12,248
2004-05		1,473		1,136		3,059		1,327		1,009		1,157	1,302		1,302	11,765
2005-06		2,124		559		600		969		453		1,160	1,318		0	7,183
2006-07		1,829		519		509		974		70		413	1,215		83	5,612
2007-08		2,592		1,115		1,505		1,323		995		1,122	988		378	10,018
2008-09		1,950		1,194		2,712		501		1,028		1,139	892		1,484	10,900
2009-10		2,837		1,270		1,617		1,273		1,012		1,047	1,292		1,489	11,837
2010-11		2,310		1,246		538		1,064		936		1,081	1,333		1,320	9,828
2011-12		2,548		1,020		1,298		1,113		876		1,107	1,317		1,196	10,475
2012-13		2,690		1,700		1,484		1,113		991		1,123	1,226		1,164	11,491
2013-14		2,633		1,222		1,618		996		1,295		1,156	1,312		1,198	11,430
2014-15		2,585		1,193		1,534		1,016		986		1,045	1,193		914	10,466
2015-16		2,513		1,166		1,329		936		990		1,176	1,253		1,141	10,504
2016-17		1,997		1,202		1,469		678		975		1,183	1,239		1,246	9,989
2017-18		92		411		0		216		1,014		1,163	1,165		0	4,061
2018-19		2,424		1,183		1,361		970		977		1,093	1,406		1,338	10,752
2019-20		769		180		84		227		892		1,002	1,294		214	4,662
Lates 10-Year Avg.	**n/a**	**2,056**	**n/a**	**1,052**	**n/a**	**1,072**	**n/a**	**833**	**n/a**	**993**	**n/a**	**1,113**	**1,274**	**n/a**	**973**	**9,366**

- Blank cells indicate year was before/after well commission.
- Dashed lines indicate that well was not in operation for given year.

3.2.2 Surface Water

The main water features in the Bishop Wellfield include the Owens River, Bishop Creek and its branches and diversions, which recharge the groundwater aquifer. The Owens River that runs from northwest of the wellfield to the east and then southward is considered the northern and the eastern boundary of the wellfield. The weather station at the Bishop Yard is the closest station to the Bishop Wellfield with a long-term average precipitation (from 1960 to 2019 ROYs) of 6.1 inches per year, higher than the average precipitation in the Owens Valley.

Table 2 lists the major flow gauges and their associated flows in Bishop Wellfield. The locations of the flow gauges are presented in Figure 3. As listed in this table, flows in streams diverting water from Bishop Creek are among some of the highest running into Owens Valley. In fact, the long-term average flow in Bishop Creek is highest of all creeks along the Eastern Sierra Mountains. In general, the Bishop Wellfield receives a high of volume in its creeks and ditches.

The Chandler Decree is a court decision in 1922 stipulating mandatory water delivery from Bishop Creek to the City of Bishop and land owners in the Bishop Area during irrigation season according to the class of their water rights. The City of Los Angeles has the right to use approximately 80% of water from Bishop Creek for use on its lands on Bishop Cone.

In 2005, MWH Americas, Inc., as part of Bishop Local Management Model development, conducted a general water balance estimation using the main inflow and outflow for the area (Bishop Creek and Bishop Creek Canal as inflows and north fork of Bishop Creek, A-Drain, Saunders Pond Return, and Rawson Pond Return as outflows). The approximate water balance that was conducted with flow data from the 1985 to 2003 ROYs showed that on average, half of the total inflow to the area or approximately 50,000 acre-feet per year is lost to a combination of evaporation, evapotranspiration, and infiltration (MWH, Americas, 2005).

Table 2 – Flow measurements in main Bishop area measuring stations

Station ID	Station Name	Volume [AF/year] 1991-2019 ROY Average
3324	Bishop Creek *Below Plant #6*	74,500
3186	Bishop Creek Canal *Below Intake*	23,500
3187	Indian Ditch *at L.A. Station*	20,200
3064	Matlick Ditch *at Intake #61*	3,600
3016	North Indian Ditch *Above Mumy Lane #58-E*	6,500
3194	South Fork Bishop Creek *below Bishop Creek Canal*	5,400
3191	A-drain *to Big Pine Canal*	19,400

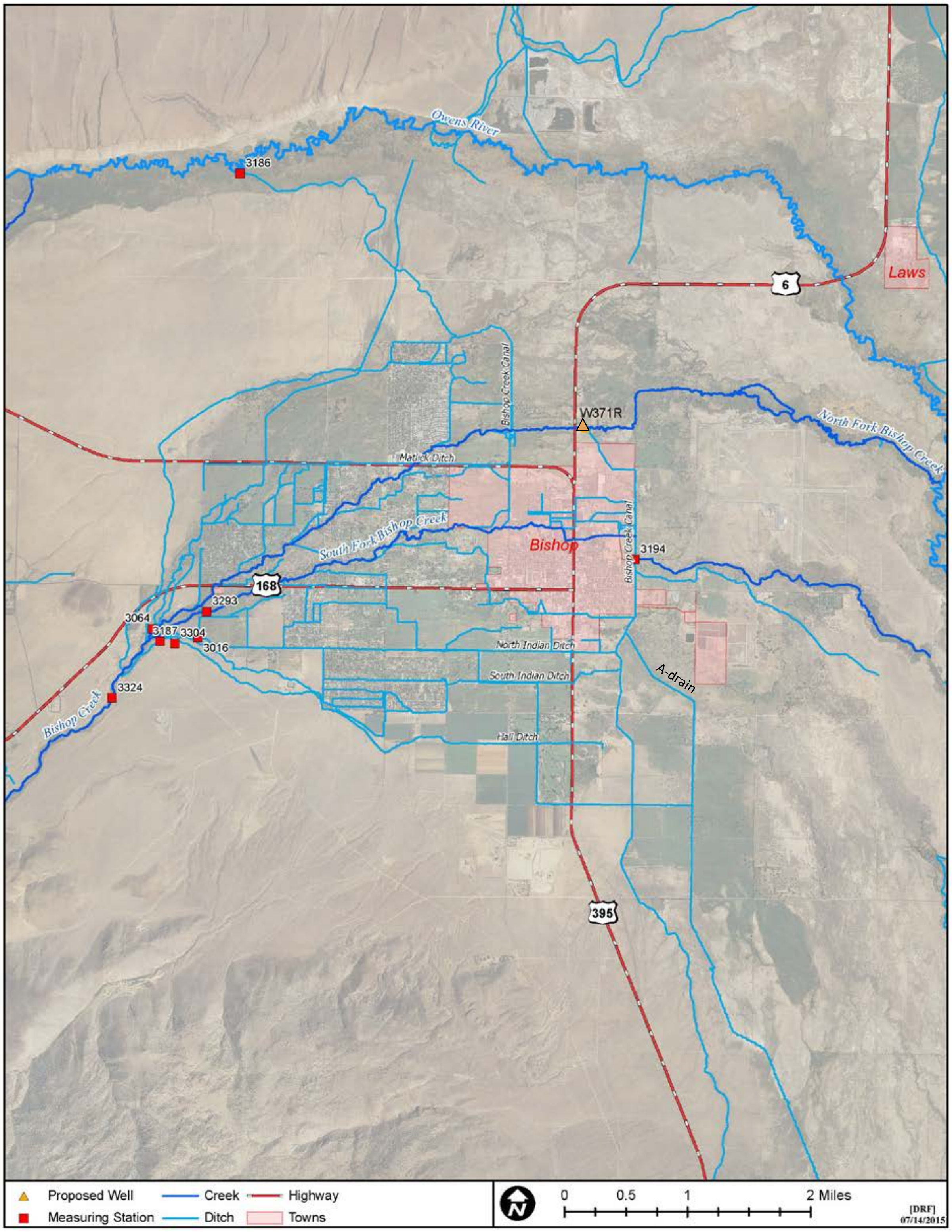

Figure 3 – Main surface water gauges in Bishop Wellfield

(Station 3191 is located southeast of the map range, measuring the flow from A-drain to Big Pine Canal)

4. ENVIRONMENTAL RESOURCES

4.1 Vegetation in the Vicinity of the Replacement Well

Vegetation parcels in the Bishop area were inventoried in 1987 and later classified according to the Water Agreement based on water use with designations of Type A to Type E. The vegetation parcels in the Bishop Area, their classifications and community designations are noted in Table 3. Vegetation parcels in the vicinity of W371 are presented in Figure 4. According to the Greenbook, Section II.A.2, “parcel boundary lines were transferred to orthophoto quadrangles at 1:24,000 scale. The final maps overlay the USGS 7.5-minute quads.” All vegetation types are described in the Greenbook, Section II.C.5 as follows:

- Type-A vegetation “consists of all parcels in communities with average ET less than or equal to 4.75 inches” and parcels with an “estimated annual evapotranspiration rate less than the quadrangle-average precipitation [rate].”
- Type-B vegetation consists of “scrub communities with an estimated average annual evapotranspiration greater than estimated average precipitation within the quadrangle” and “primarily includes Rabbitbrush Scrub and Nevada Saltbush Scrub communities.”
- Type-C vegetation consists of “all grass-dominated vegetation parcels with an estimated annual evapotranspiration greater than quadrangle-average precipitation.”
- Type-D vegetation consists of “all parcels dominated by riparian and marshland vegetation with an estimated annual average evapotranspiration greater than [quadrangle-average] precipitation.”
- Type-E vegetation consists of “all lands provided with surface water for irrigation, including enhancement/mitigation projects, recreation areas, wildlife habitats, stock water supplies, and water spread areas.”

Table 3 – Vegetation types and community types in the Bishop Cone based on Greenbook vegetation inventories

Vegetation Type	Parcels	Acres	Community Type	Acres
Type-A	81	10,953	Greate Basin Mixed Scrub	4,219
			Rabbitbrush Scrub	2,166
			Blackbrush Scrub	1,549
			Barren Lands ABAG	657
			Urban	581
			Big Sagebrush Scrub	566
			Shadscale Scrub	440
			Alkali Meadow	379
			Desert Saltbrush Scrub	291
			Nevada Saltbrush Scrub	105
Type-B	3	201	Rabbitbrush Scrub	201
Type-C	19	1,093	Alkali Meadow	885
			Rabbitbrush Meadow	208
Type-D	5	291	Modoc G.B. Cottw/Willow Riparian Forest	228
			Modoc Great Basin Riparian Scrub	63
Type-E	84	3,328	Irrigated Agriculture	2,486
			Rush/Sedge Meadow	688
			Non-Native Medow	133
			Intermittent Ponds	21
Total	192	15,866	17	15,866

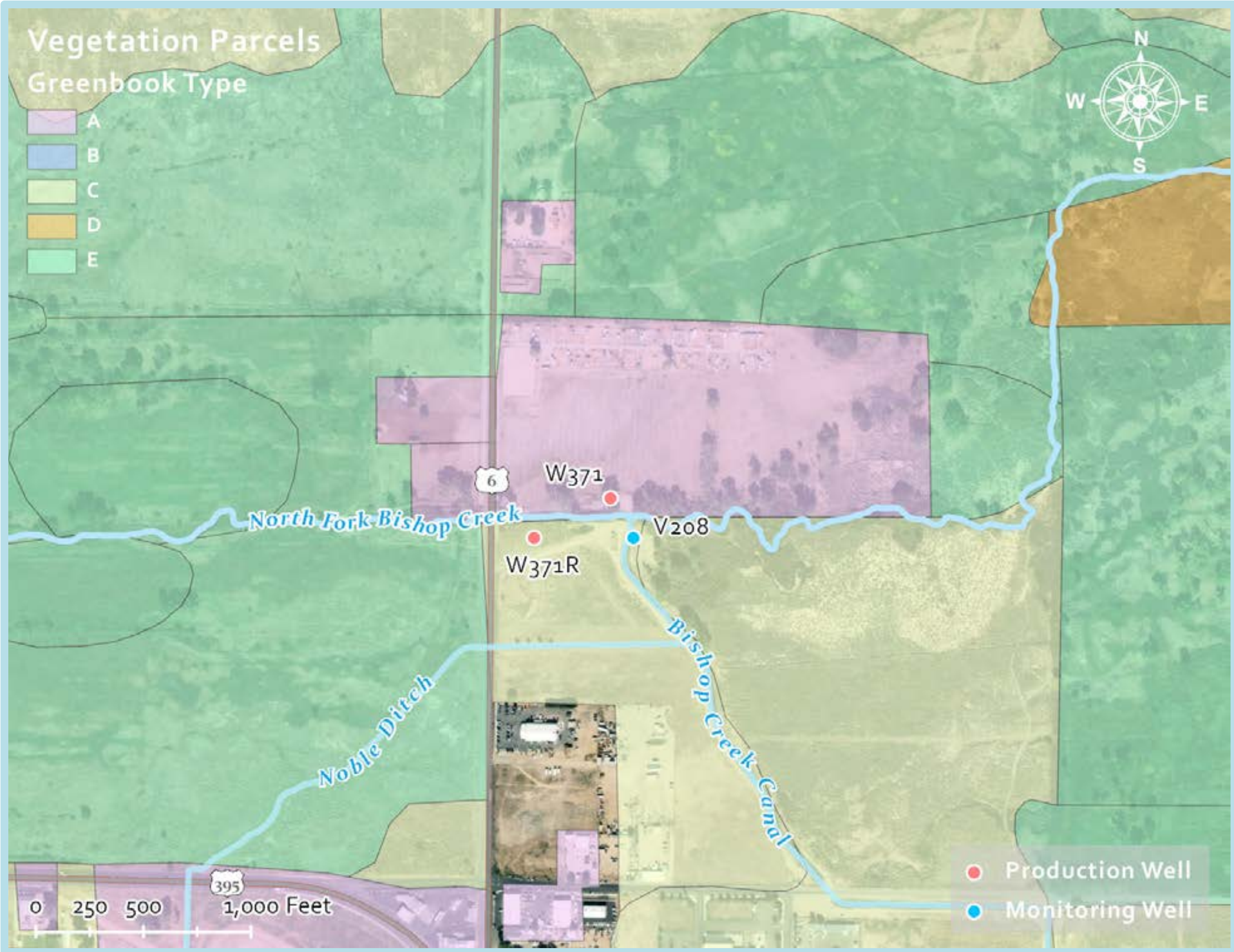

Figure 4 – Vegetation parcel in Bishop Wellfield in the vicinity of W371

4.2 Springs, Seeps, Flowing Wells

As a result of confining layers near the center of the valley, the deep confined aquifer in the Bishop Wellfield is under artesian head, which results in wells that are screened in the deep aquifer to flow to the Owens River. There are 15 flowing wells in the Bishop Wellfield, located adjacent to Owens River. The total flow from these wells discharging directly to Owens River after being measured using small weirs is presented in Figure 5. The 1971-2019 ROY average groundwater flowing volume from these wells is 5,580 acre-feet per year. The relatively small fluctuation in the flow rate appears to be a function of runoff induced recharge to the aquifer.

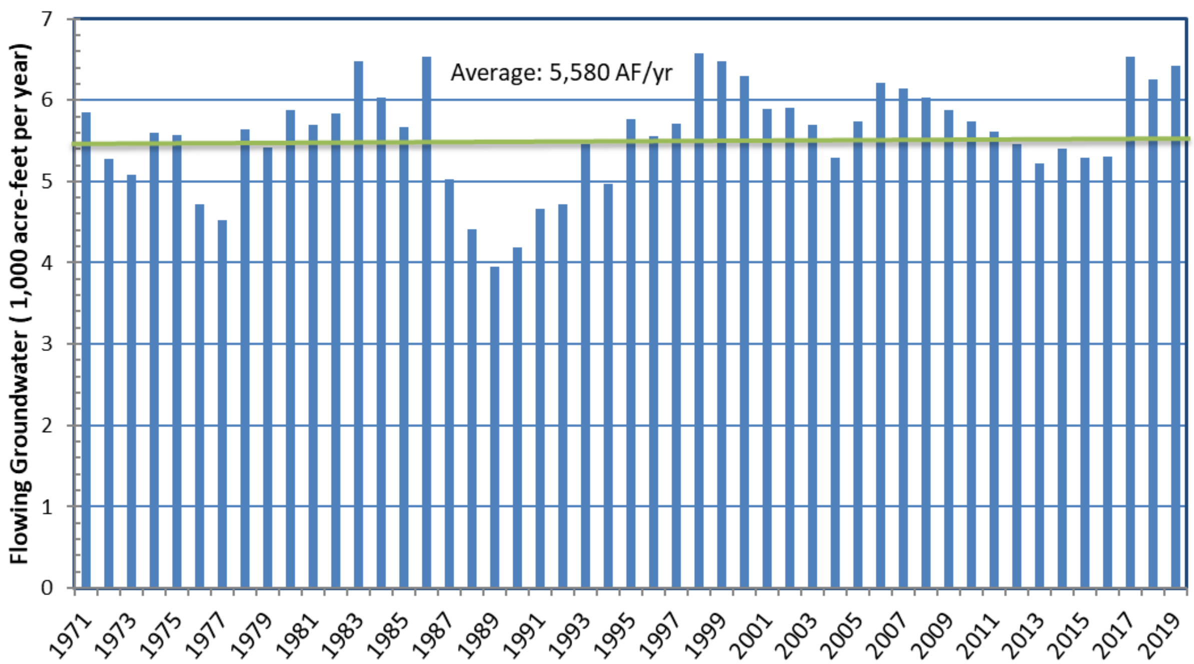

Figure 5 – Total annual groundwater extraction from flowing wells in the Bishop area

4.3 Private Wells

There are numerous private and community supply wells in the Bishop area that are used to provide water for domestic purposes. The private wells have typically small diameters and shallow depths, drawing water from the shallow aquifer and therefore susceptible to changes in groundwater levels in the shallow aquifer. Because the shallow aquifer is recharged mainly by the percolation of water from the numerous ditches running throughout Bishop area, changes in ditch operations could potentially affect groundwater levels in private and community supply wells. During the 2012-16 droughts and particularly in 2013, some ditches stopped operating or were operated at lower rates, reducing recharge to the shallow aquifer, lowering groundwater levels in private wells, and thus affecting the ability to pump water for domestic purposes. As a result, some domestic wells have been replaced with deeper wells. The locations of known private (non-DWP) wells in the vicinity of the Bishop area and W371 that LADWP requested and received for the California State Department of Water Resources (DWR) are presented in Figure 6.

There are no known private wells in the vicinity of well W371 or W371R. Replacing W371 with W371R should have a positive effect on groundwater levels in the shallow aquifer, especially during drought periods, because W371R is planned to pump water from the deep aquifer and supply water for irrigation on City-owned lands. As discussed in the next section, the difference in groundwater levels between pumping simulations of W371 and W371R supports this notion (see Figure 9).

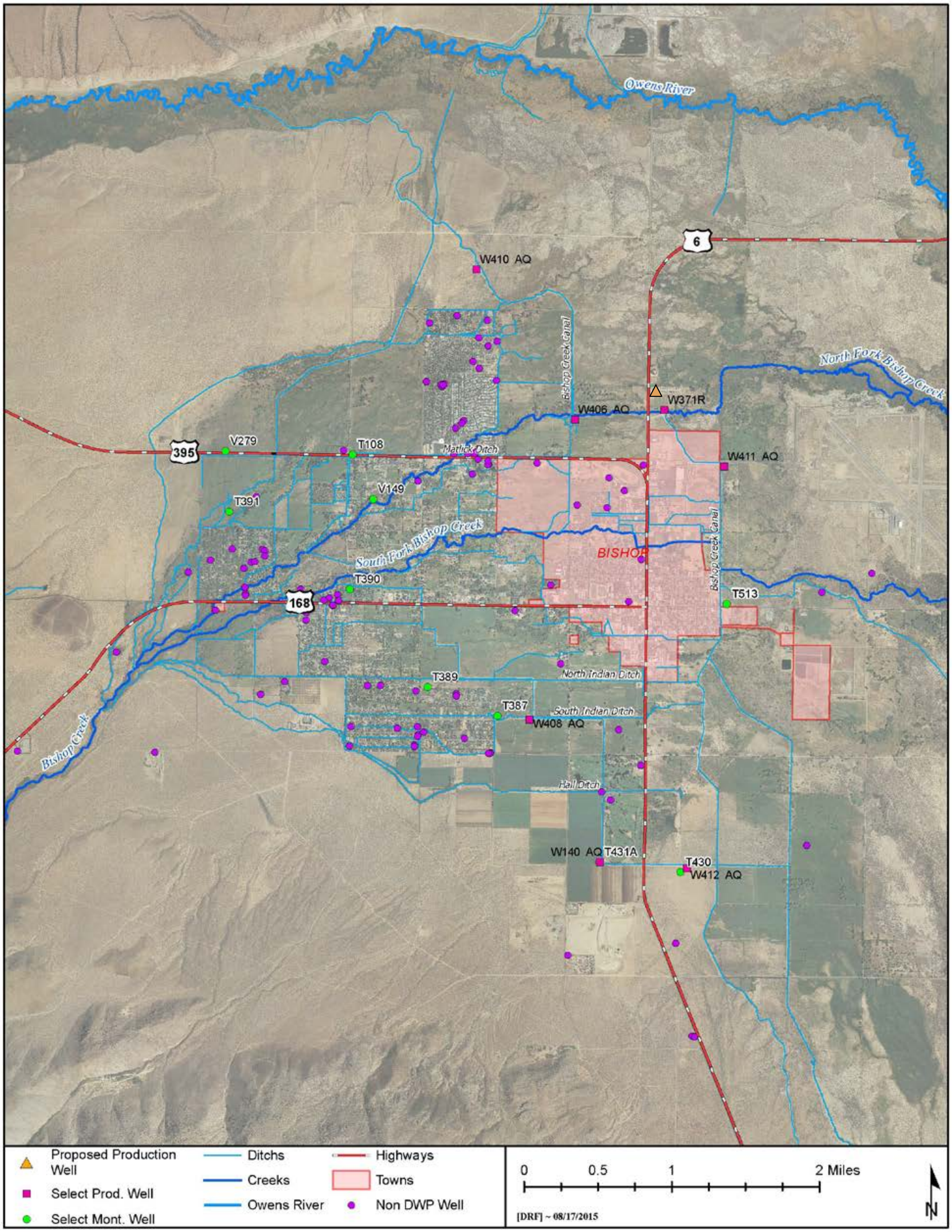

Figure 6 – Well locations LADWP received from DWR in the Bishop area (note that other wells may exist that are not documented by LADWP, ICWD, and DWR)

5. CONSTRUCTION AND TESTING

6.1 New Well Design

The exploratory borehole for W371R will be drilled to approximately 700 feet bgs. Based on the review of the lithologic and geophysical logs, the depth and screen length of the replacement wells will be determined. The preliminary design of W371R with a screen interval of 350 to 700 feet bgs is shown in Figure 7. This screen depth ensures that W371R will draw water mainly from the deep aquifer. The replacement well will be equipped with an 18-inch diameter casing and screen with High Strength-Low Alloy material.

Current industry standards for well drilling and design will be incorporated into plans for the installation of the well. These plans include using a mud rotary method for drilling and using a pre-fabricated casing and screen, along with placing a properly sized filter pack in the annular space between the screen and borehole wall. The appropriate screen slot size will be determined considering the soil samples from the zone where the well screen will be installed. The annular space between the casing and borehole, above the filter pack to the ground surface will be filled with cement seal to ensure that groundwater is protected from potential surface contamination.

The initial pumping capacity of W371R is expected to be approximately 3.5 cfs, based on the capacities of nearby pumping wells of similar design. Analysis of the data from the 24-hour pumping test is expected to determine the actual pumping capacity of this well. It is also understood that the pumping capacity of W371R will decrease over time.

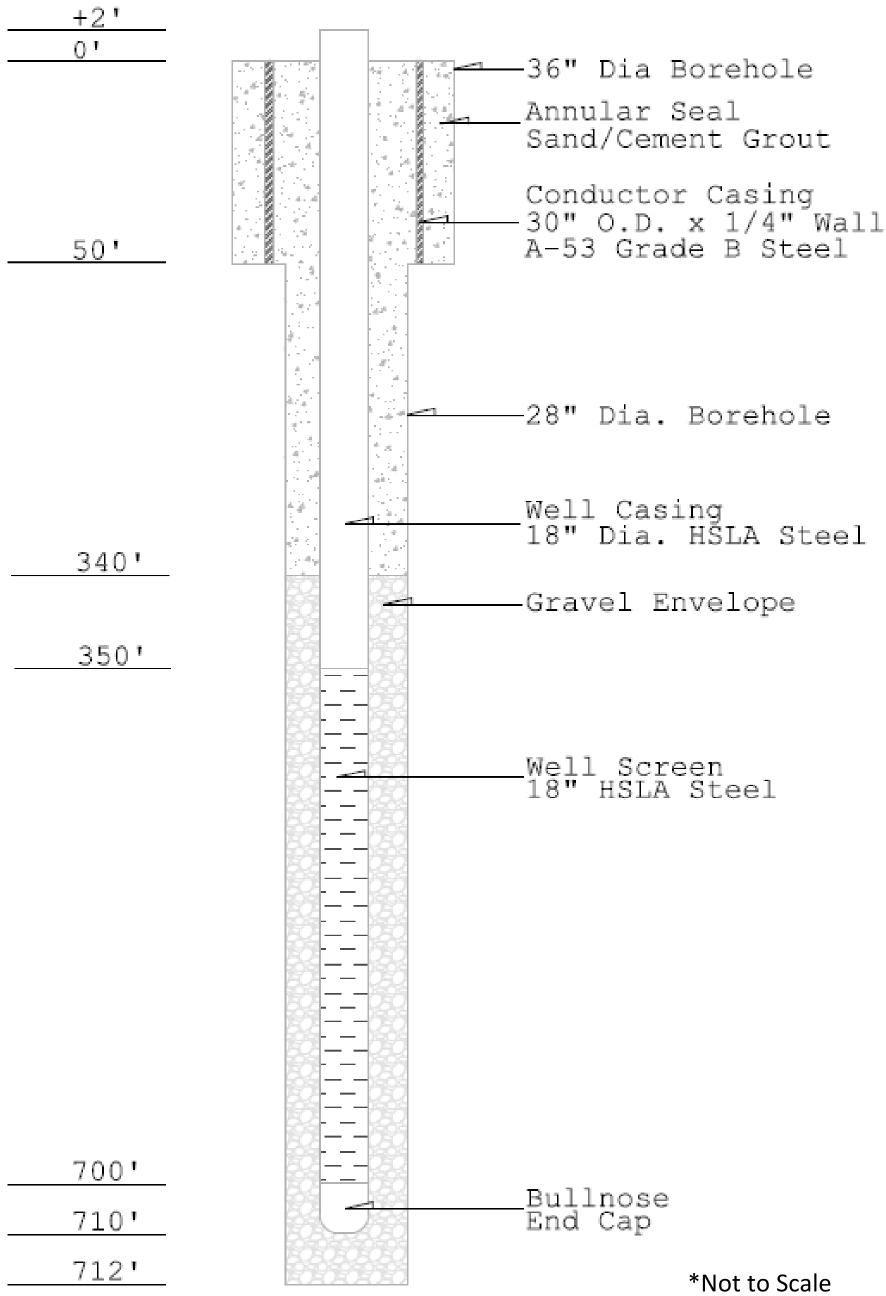

Figure 7 – Preliminary design for W371R in Bishop

6.2 Aquifer Test

Following the installation of W371R, the contractor will perform a step-drawdown test with up to four steps of increasing pumping rates and a 24-hour constant rate pumping test while collecting groundwater level data from nearby shallow and deep monitoring wells. Data from the pumping tests will be used to estimate aquifer characteristics in the vicinity of this location. Monitoring data will also be used to estimate the pumping capacity of the replacement well. However, similar to any other pumping wells, the pumping capacity of W371R is expected to reduce over time.

6. POTENTIAL IMPACTS ON GROUNDWATER-DEPENDENT RESOURCES

6.1 Well Operation Simulations

A groundwater flow model that was developed for the Bishop/Laws Wellfields by MWH Americas, Inc., was utilized to estimate the effect of operating the proposed replacement well W371R on the shallow aquifer groundwater levels. This model covers both Laws and Bishop wellfields. The MODFLOW based groundwater model includes three layers, simulating the shallow, intermediate, and deep aquifer with uniform cell size of 500 feet by 500 feet. The original well W371 is primarily slotted in the shallow and intermediate aquifer zones (layers 1 and 2). W371R is planned to be primarily screened in the deep aquifer zone (layer 3).

When operable, LADWP operates W371 year-round to supply water for uses on Bishop Cone. Therefore, the simulated drawdown resulting from pumping the existing W371 at an average rate of 2.5 cfs and the replacement well W371R at an average rate of 3.5 cfs were compared for one-year operation.

The resulting one-year pumping simulation drawdown contours of groundwater levels in the shallow aquifer are presented in Figures 8, 9, 10. Based on the contour maps, it is evident that pumping W371R results in significantly less drawdown in shallow aquifer groundwater levels than W371. The drawdown simulation for W371R resulted in 1 foot or less of drawdown, whereas the simulation for original W371 resulted in up to 10 feet in the shallow aquifer zone.

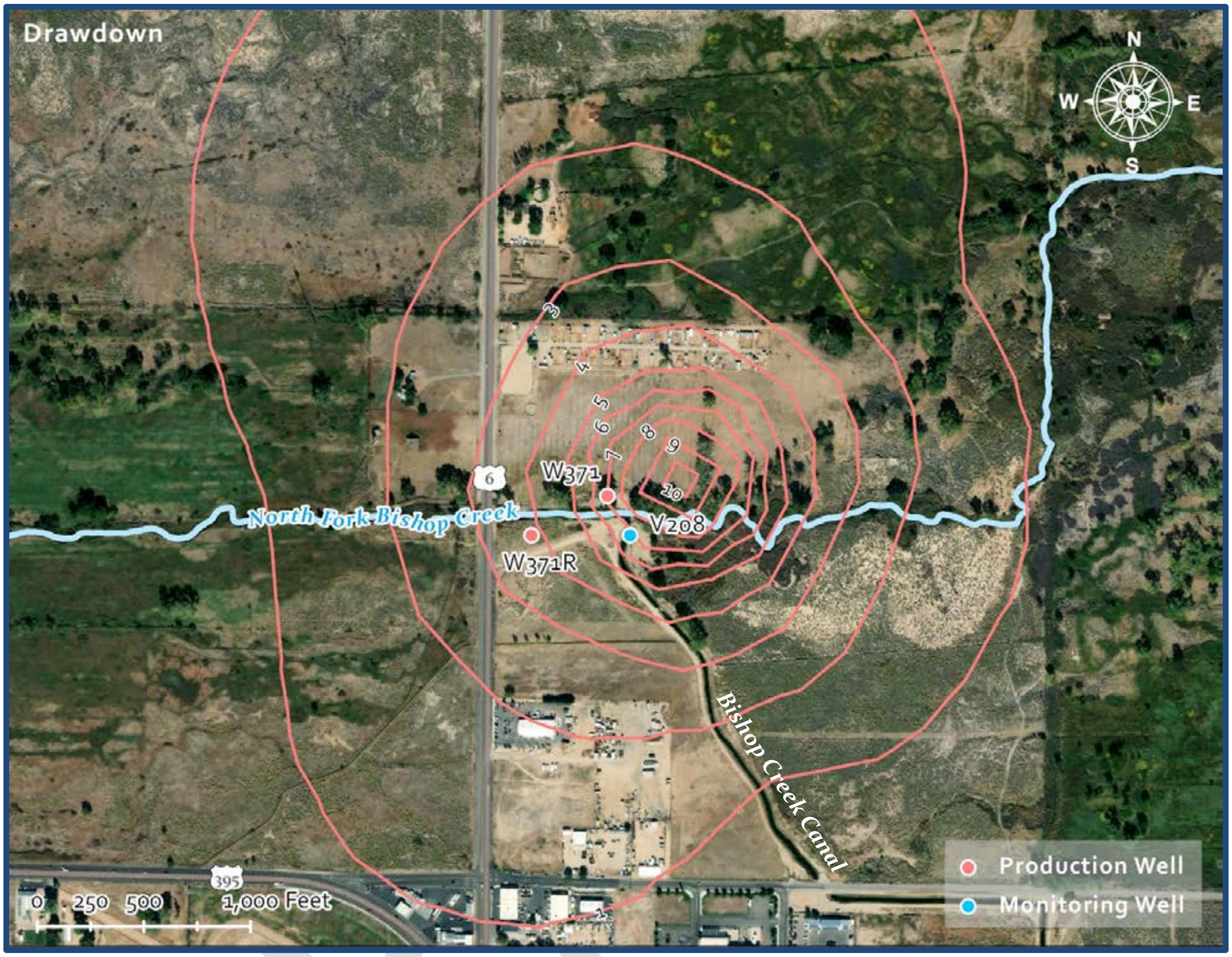

Figure 8 – Drawdown contours of groundwater levels in the shallow aquifer from pumping original **W371** at 2.5 cfs for one year

Figure 9 – Drawdown contours of groundwater levels in the shallow aquifer from pumping replacement well **W371R** at 3.5 cfs for one year

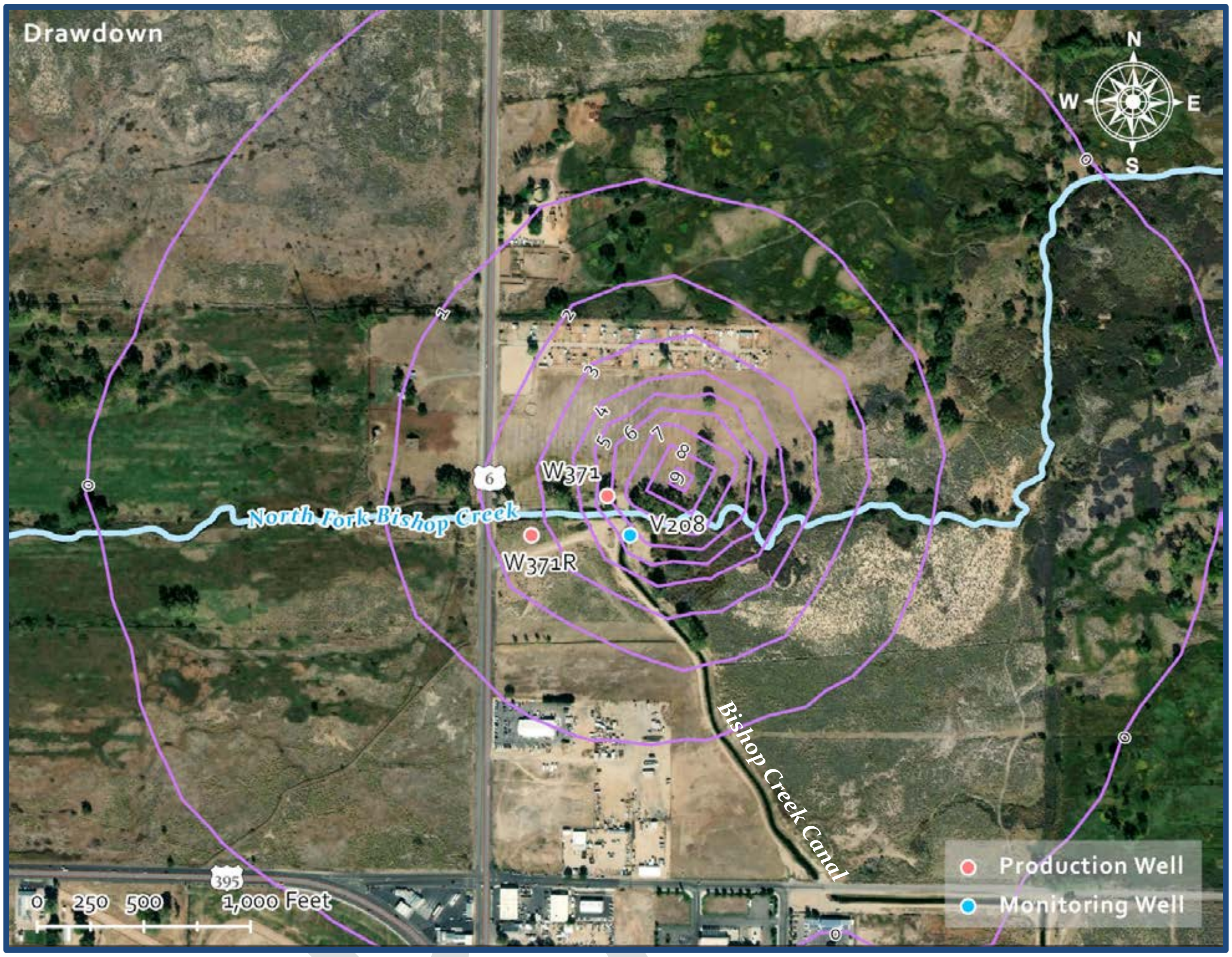

Figure 10 – Difference in shallow aquifer groundwater levels when operating W371 and W371R for one year, indicating less drawdown by W371R

Once W371R is drilled and data from 24-hour pumping test are analyzed, the calculated aquifer characteristics from the tests will be used to update and re-calibrate the model in the area near W371R. This updated model should yield an improved understanding of aquifer characteristics and produce a more realistic effect of pumping on groundwater levels in the shallow aquifer.

6.2 Potential Effects on Vegetation

The contours of drawdown were superimposed on the Bishop area vegetation parcel map, and are presented in Figures 11, 12, and 13 for the one-year pumping scenario.

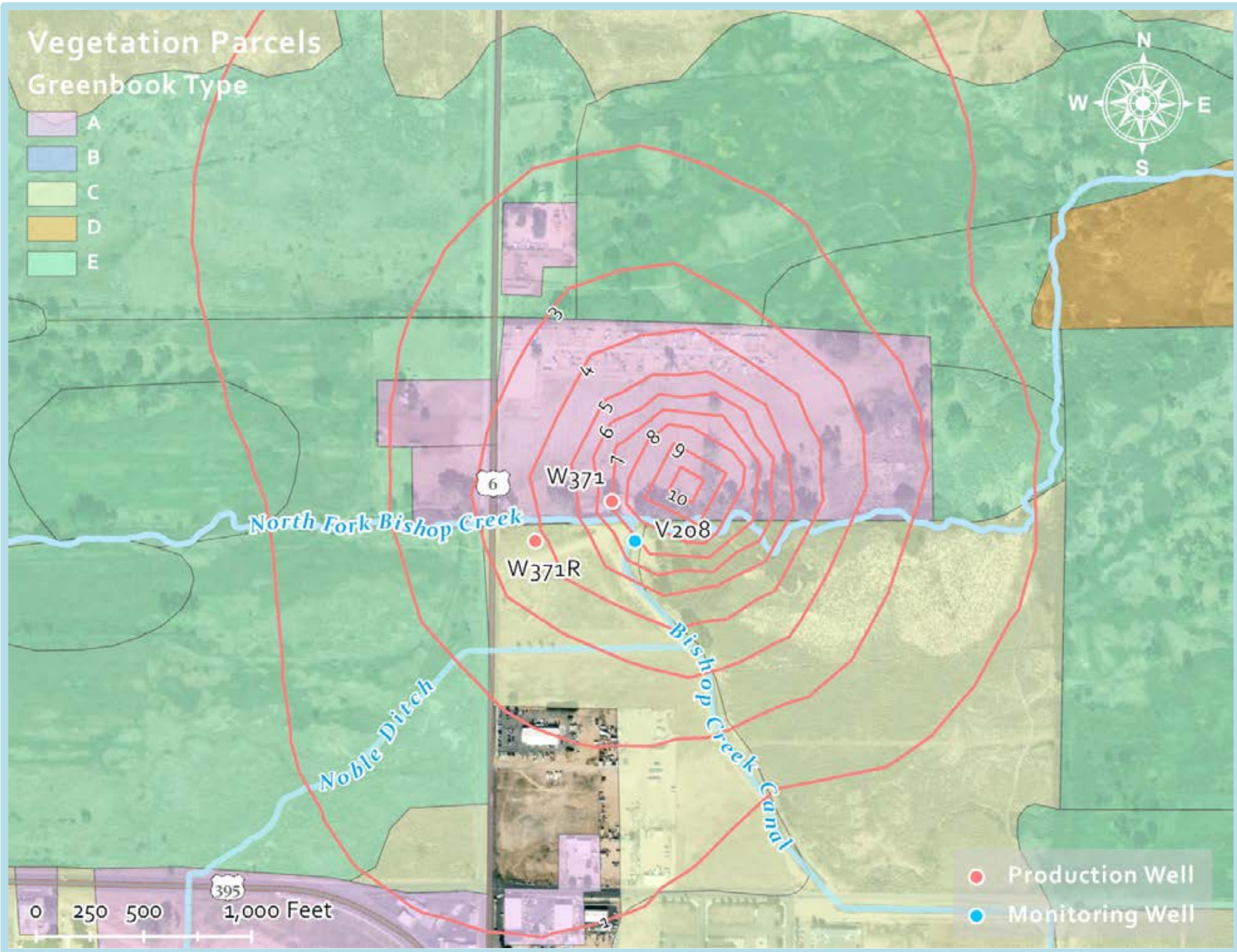

Figure 11 – Vegetation parcels and drawdown contours in the shallow aquifer from pumping original **W371** at 2.5 cfs for one year

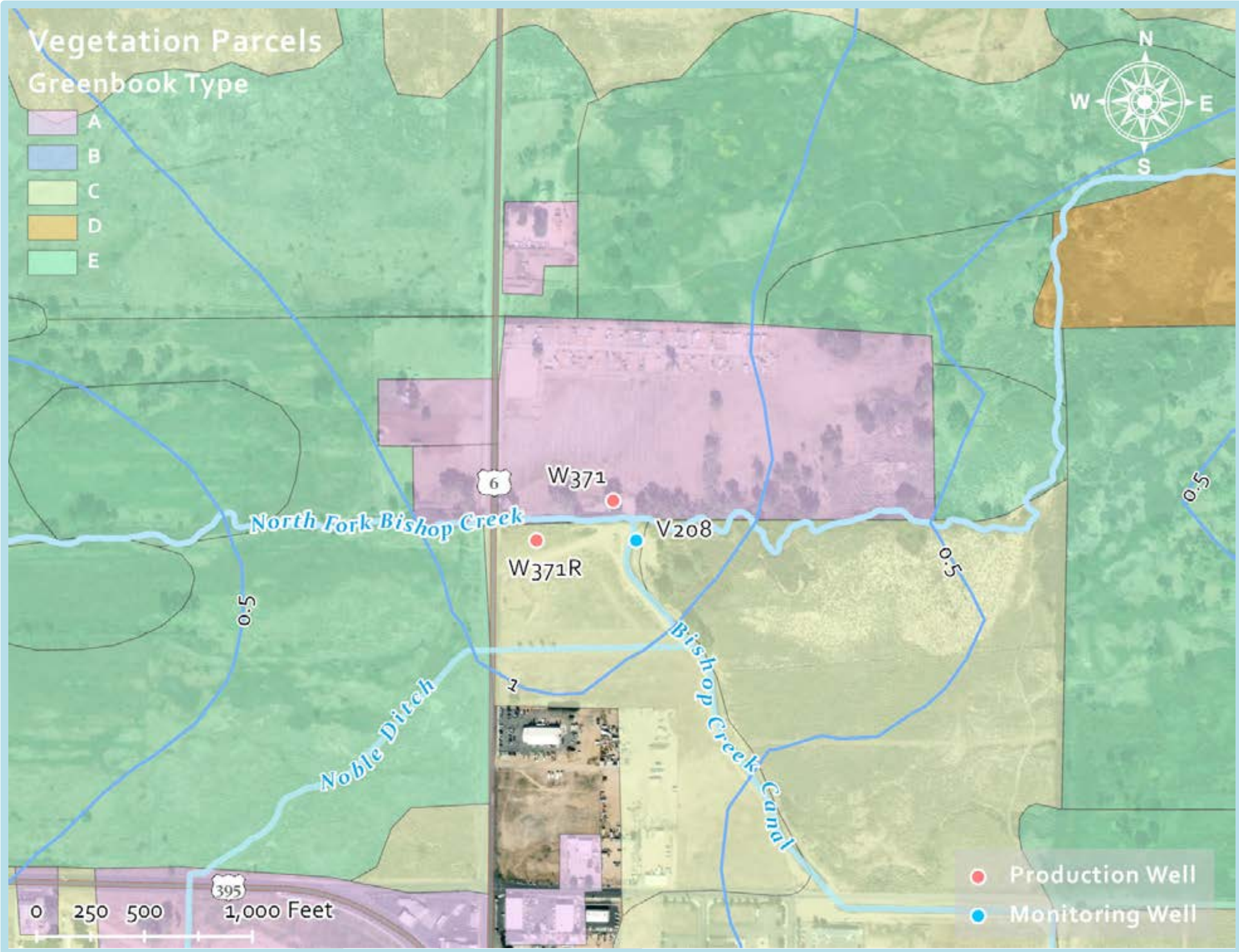

Figure 12 – Vegetation parcels and drawdown contours in the shallow aquifer from pumping **W371R** at 3.5 cfs for one year

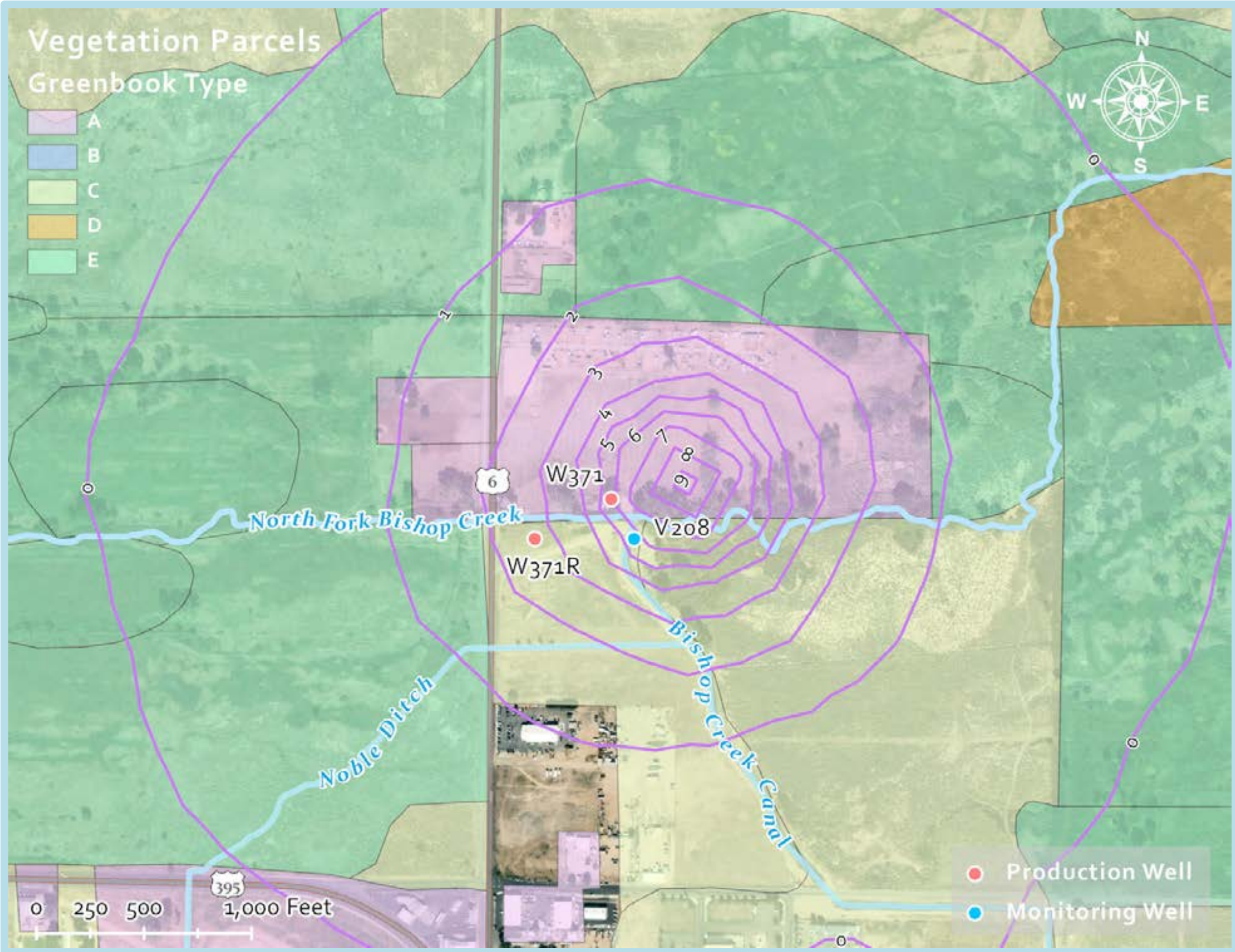

Figure 13 – Vegetation parcels and contours of the difference in shallow aquifer groundwater levels between the one-year pumping simulations of W371 and W371R, indicating less drawdown by W371R

7. OPERATION

Using the results of the analysis of the data collected during the pumping tests and the calculated pumping capacity, pump equipment will be designed and installed in the well. Operation of W371R is subject to the terms of Hillside Decree as described in Section 2.2 of this report. Water pumped from W371R will supply water for irrigating City-owned lands within Bishop Cone. According to the Water Agreement, the Technical Group is responsible for developing and implementing a monitoring plan during the initial operation. The monitoring plan will include both hydrologic and vegetation monitoring. The goal of the initial operation is to determine potential long-term impacts of operating the well.

After the completion of the initial operation phase of W371R, the regular operation of this well will be included in the LADWP's annual operation plan for Owens Valley.

8. ENVIRONMENTAL ASSESSMENT

Well W371R will be a replacement of an existing infrastructure and will be located adjacent to the existing well. The well will pump from the deeper aquifer and pumped water will be used for the same purposes as the well it is replacing. Computer simulations show that operation of the replacement well will have less effect than the existing well on the groundwater levels in the shallow aquifer. Therefore, no further impact to nearby vegetation is expected from the operation of the replacement well. Additional assessment will not be conducted for the replacement well W371R and LADWP plans to file a Notice of Exemption under the California Environmental Quality Act with Inyo County Recorder's Office.

9. REFERENCES

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