Inyo County Response to LADWP Evaluation of Attributability and Significance of Vegetation Changes in Blackrock 94

Inyo County Water Department

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Executive Summary

The Arbitrators' Findings and Partial Award ordered that LADWP prepare and submit a written report with supporting evidence to the Technical Group and arbitration panel addressing whether LADWP's groundwater pumping and surface water management practices have had a significant impact on vegetation in vegetation parcel Blackrock 94. LADWP produced its report and provided it to the County on December 18, 2013. The Arbitrators' Findings and Partial Award also ordered Inyo County to file a response to the LADWP report with the Technical Group and the arbitrators. This is Inyo County's response to the LADWP report.

Concerning the cause of vegetation change in Blackrock 94, the parties appear to agree that Blackrock 94 has undergone a reduction in grass cover since the mid-1980's baseline monitoring period. The parties also agree that this change is attributable to reduced water availability, but disagree as to why the amount of water available to the vegetation has decreased. LADWP asserts that vegetation has changed as a result of naturally occurring wet dry cycles, while the County claims that vegetation changed as a result of water table declines due to groundwater pumping.

This report is introduced with a section identifying general areas of agreement and disagreement between the County and LADWP. The body of the report contains the County's examination of LADWP's evaluation of attributability and significance of the vegetation change. The County's examination of attributability is organized into sections on hydrology, soil water, and vegetation. While there are a number of data sets and analytical methods that Inyo and LADWP agree on, the County disagrees with LADWP's most important interpretations and conclusions concerning the causes of diminished water availability at Blackrock 94, the relation between hydrologic change and vegetation change, and LADWP's choice of control areas. The Significance section examines LADWP's discussion of the factors specified in the Green Book to evaluate significance of an impact.

The County disagrees with LADWP's conclusion that "*runoff-driven recharge of the aquifer is the main factor affecting water levels beneath Blackrock 94*." Both parties used groundwater models to investigate hypothetical groundwater pumping scenarios to determine how the water table would have behaved under different pumping conditions. Those model results show that water table fluctuations due to runoff and recharge alone are relatively small (a few feet) and that water table declines attributable to groundwater pumping have been about 10 to 15 feet or more. Those model results are consistent with other studies and water table observations in pumped and unpumped areas elsewhere in the Owens Valley. LADWP's analysis emphasized pumping at the Blackrock Hatchery and its relation to Blackrock 94. Since its initial report to the Technical Group in 2011, the County has maintained that both hatchery and non-hatchery pumping produced significant drawdown at Blackrock 94. The nearly constant hatchery pumping produces sustained drawdown, and the more variable pumping from other wells produces variable drawdown in addition to the hatchery effects. LADWP's modeling erroneously omitted an amount of pumping equivalent to the historic spring flow from Big Blackrock Springs, producing the paradoxical result that Blackrock Hatchery pumping has little effect on the water table despite being the largest amount of pumping in the region and relatively close to Blackrock 94.

LADWP's methods of soil water analysis produced an incomplete and incorrect assessment of soil water availability. The County's assessment corroborates the County's 2011 conclusions, and when combined with groundwater modeling results suggests that lowered water table due to pumping was the primary factor contributing to reduced soil water availability at monitoring sites TS1 and TS2 in Blackrock 94. Since the high water table period of the mid-1980's, soil water in Blackrock 94 has seldom reached the grass root zone at TS1 and TS2. This has resulted in persistent declines in vegetation cover and changes in community from grass-dominated to shrub-dominated. The vegetation at TS1 and TS2 change contrasts with nearby monitoring site TS3 which was less affected by pumping, the root zone has been replenished by groundwater, and the predominantly grass vegetation remained stable or increased.

LADWP developed a statistical relationship between vegetation cover, precipitation, and runoff for Blackrock 94. LADWP's model fits the measured vegetation cover at Blackrock 94 well, it cannot be used to examine how vegetation cover would have changed in Blackrock 94 if pumping had been different, because it ignores water table changes. The County developed a more suitable model to evaluate vegetation cover response to changes in water availability due to changes in precipitation and/or depth to water. Results of groundwater modeling and water table measurements were used to estimate the water table depth if pumping had not occurred. With no groundwater pumping, the County's models indicate that cover would have remained at or just below the cover in 1986. This is consistent with the vegetation conditions in vegetation parcel Blackrock 99, where the water availability had not been as severely reduced by pumping. Pumping, not fluctuations in runoff or precipitation, is the primary reason vegetation cover declined in Blackrock 94.

The control parcels selected by LADWP are not comparable to Blackrock 94 due to differences in initial baseline cover and composition, initial depth to water, precipitation, and differences in soils. Superficial similarities in the response to precipitation and/or runoff at LADWP's controls and Blackrock 94 provide no information on what would have happened to the vegetation at Blackrock 94 if pumping had not lowered the water table. LADWP's assertion that the vegetation changes identified in Blackrock 94 are natural, reversible, and driven by wet/dry cycles is not supported by its analysis of control parcels. Blackrock 99 is a much more appropriate control to compare with Blackrock 94, because soils, precipitation, baseline vegetation cover and composition, and initial depth to water are known to be similar. Parcel

Blackrock 99 has experienced the same wet and dry cycles since 1984-87, yet vegetation cover and composition have been maintained, even following wildfire.

In July 2007, wildfire burned through portions of Blackrock 94 and 99. The County and LADWP agree that although the fire affected Blackrock 94, it was not the cause of the decline in vegetation cover and loss of grasses. Following the fire, grass in parts of Blackrock 99 recovered quickly where the water table is sufficiently high, and recovery was slow or nonexistent in portions of Blackrock 94 where the water table is deep. The sharply different recovery rates after the fire are attributable to LADWP pumping that has created a sustained lowered water table under Blackrock 94 but not Blackrock 99.

In February 2011, the County presented its findings to the Technical Group concerning vegetation change in Blackrock 94 (ICWD report). The County concluded:

> *Available factual and scientific data indicate a measurable vegetation change since baseline has occurred in Blackrock 94, both in terms of vegetation cover and species composition. These changes occurred between baseline and 1991 and have persisted in time. Vegetation composition has changed toward increasing shrub proportion and a decrease in grass cover. While the proportion of shrubs in Blackrock 94 has not yet caused the parcel to change from Type C to Type B vegetation status, changes in species composition suggest a change in Type is occurring. Parcel Blackrock 94 is currently Type C, but is changing to Type B. Vegetation degradation is primarily attributable to changes in water availability resulting from groundwater pumping and reduced surface water diversions into the vicinity of Blackrock 94. The factors prescribed in the LTWA and Green Book for assessing the significance of an impact were evaluated and indicate that a significant change is occurring in Blackrock 94. The terms of the LTWA require that such impacts be avoided or mitigated.*

Based on our evaluation of the LADWP report, the County's conclusions have not changed. LADWP presents many analyses in its report that either are not relevant to addressing the requirements of LTWA section IV.B and Green Book section I.B, or are not executed and interpreted correctly.

A statistically significant decline in vegetation cover below baseline has persisted in Blackrock 94 for 17 of the 23 years since the County commenced the expanded monitoring in 1991. The vegetation in Blackrock 94 is converting from Type C meadow vegetation to Type B shrub vegetation. The County does not agree with LADWP's assessment that the change is not significant for several reasons.

The decline in cover and change in vegetation type in Blackrock 94 are attributable to LADWP's groundwater pumping. The changes occurring in the parcel are occurring in other wellfield locations and the vegetation changes in Blackrock 94 are considered significant impacts by the LTWA, the Green Book, and the 1991 Final EIR. The size of the area affected is similar to pumping impacts previously mitigated in the 1991 Final EIR. Mitigation measures in other areas of the Owens Valley do not mitigate the significant impacts at Blackrock 94 and there is no certainty that there will be recovery from these vegetation conditions when or if higher runoff and precipitation conditions occur.

The impact to Blackrock 94 is a new impact to vegetation, not previously identified or mitigated in the 1991 Final EIR. The Inyo/Los Angeles Long-Term Water Agreement was identified as a mitigation measure for new impacts occurring after the baseline vegetation conditions were established. As provided in the Inyo/Los Angeles Long-Term Water Agreement, the Technical Group should be ordered to develop a mitigation plan for the significant adverse vegetation decreases and changes in Blackrock 94.

Introduction

The Arbitrators' Findings and Partial Award ordered that LADWP prepare and submit a written report with supporting evidence to the Technical Group and arbitration panel addressing whether LADWP's groundwater pumping and surface water management practices have had a significant impact on vegetation in Blackrock 94. LADWP produced such a report (referred to herein as "LADWP report") and provided it to the County on December 18, 2013. The Arbitrators' Findings and Partial Award also ordered Inyo County to file a response to the LADWP report with the Technical Group and the arbitrators. This is Inyo County's response to the LADWP report. In this report, we refer to the material already submitted to the Technical Group and arbitration panel, including the County's report to the Technical Group concerning measurability, attributability, and significance of vegetation change in Blackrock 94, which is herein referred to as "ICWD report" and was included as Attachment 10 in the County's submittals to the arbitration panel (ICWD, 2011).

This response includes a short assessment of areas of agreement and disagreement between the County and LADWP, evaluation of LADWP's analyses of hydrology, soil water availability, vegetation conditions, and the significance of changes. The assessment of areas of agreement and disagreement is included for two reasons. First, the Inyo/Los Angeles Long Term Water Agreement's (LTWA) dispute resolution process (Sec. XXVI) requires that the Technical Group, "...*make a written report to the Standing committee explaining the areas of agreement, if any, the subject or subjects of disagreement, and each party's argument in favor of its position along with supporting data and background.*" Second, by identifying a number of data sets, analytical methods, and interpretations in common, we hope to focus the deliberation of the Technical Group and arbitrators to the issues that remain in disagreement.

The LADWP report is largely a scientific examination of the hydrology, hydrogeology, water management practices, land use, soils, and vegetation in Blackrock 94 and the vegetation parcels that LADWP identified as control parcels. The County's response is focused on analysis of data pertinent to the significance of changes in the parcel and what has caused those changes.

One procedural matter that we address here concerns the scope of the data that will be used in this response. LADWP states that "*LADWP expects that the County's response to this report will rely solely on data and analysis provided by the County to LADWP in the County's February 2, 2011 report and any data and analysis contained herein*" (LADWP report, p.1). Because LADWP introduced certain data and analyses that were not included in the County's February 2, 2011 report nor in the previous briefs, it is necessary in our response to we examine data related to LADWP's current analysis of soil water, vegetation/groundwater relationships, and LADWP's choice of control sites in order to fully address the arbitrators' order that "*Inyo County shall file a response to the City's report...*" Further, LADWP has omitted certain data that are relevant to assessing attributability and significance of change in Blackrock 94, such as satellite remote sensing of vegetation cover and vegetation as well as conditions in neighboring Blackrock 99. For the reasons just discussed, data and analysis in addition to that provided by the County to LADWP in the County's February 2, 2011 report should be considered.

Areas of Agreement and Disagreement

The Panel's Interim Order and Award remanded the matter to the Technical Group so that it may properly carry out its dispute resolution function. LADWP and the County have provided assessments of the attributability and significance of vegetation change in Blackrock 94 to the Technical Group and the arbitrators (LADWP report; ICWD report). The LTWA's dispute resolution procedures require that the Technical Group make a written report to the Standing Committee explaining areas of agreement and disagreement between the parties (LTWA Sec. XXVI.B.1). This section identifies the County's perspective on general areas of agreement and disagreement between the County and LADWP concerning attributability and significance of vegetation change in parcel Blackrock 94.

Areas of Agreement

Both parties agree that LTWA Sec. IV.B and Green Book Sec. I.C are the applicable sections for determining whether a significant effect has occurred in Blackrock 94. Concerning attributability, the parties agree that "*…it must be determined whether the impact is attributable to groundwater pumping or to changes in surface water management practices*" (Green Book, Sec. I.C.1.b; LTWA, Sec. VI.B). Section IV.B of the LTWA further provides a standard for the Technical Group to use in determining whether a change is attributable to LADWP's water gathering operations:

> *Decreases or changes in vegetation and other environmental effects shall be considered "attributable to groundwater pumping, or to a change in surface water management practices," if the decrease, change, or effect would not have occurred but for groundwater pumping and/or a change in past surface water management practices. This shall be determined by an analysis of all relevant factors…*

Both parties agree that water availability is the main driver of vegetation decrease and/or change in Blackrock 94. LADWP concludes that (LADWP report, p. 216):

> "*An analysis of variations in cover and composition within Blackrock 94 found these fluctuations to be primarily the result of fluctuations in grass cover within the parcel. Variations in grass cover within the parcel are predominantly the result of fluctuations in wet/dry climatic cycles. Factors including grazing, wildfire, and the expansion of Highway 395 have adversely affected vegetation cover within the parcel. However, the primary driver of decreases in vegetation cover are periods of decreased precipitation and runoff, which limit the amount of water available for grasses within the parcel.*"

LADWP further concluded that "*Grazing, fire, and the expansion of Highway 398* [sic] *had substantial and lasting impact on vegetation cover in Blackrock 94; however, LADWP believes* *grazing, fire, and Highway 395 are not the major factors attributable for vegetation cover changes in Blackrock 94.*"

In the ICWD report, the County concluded that "*Pumping induced declines in the water table 1987-1990 corresponded to decreases* [in] *vegetation cover and a change in species composition. In Blackrock 94, where pumping has withdrawn the water table from the grass root zone, grass cover has diminished*" (ICWD report, p. 56) and "*Vegetation degradation is primarily attributable to changes in water availability resulting from groundwater pumping and reduced surface water diversions in the vicinity of Blackrock 94*" (ICWD report, p. 66). The County, in its opening brief (p. 14), concluded:

> "*Although changes in surface water diversions by LADWP are a contributing factor, groundwater pumping by LADWP is the primary cause of the changes in vegetation. In particular, pumping induced declines in the water table during 1987-1990 were coincident with drier soil conditions and decreased vegetation cover. The water table decline and resulting vegetation disturbance initiated the conversion in species composition, and lack of water table recovery has promoted subsequent loss of grass cover.*"

It is apparent that both parties agree that the principal driver of change in Blackrock 94 is reduced water availability resulting in loss of grass. Thus, the principal task remaining for the Technical Group, the Standing Committee, and if necessary the arbitration panel is to identify the cause(s) of reduced water availability.

Both the County and LADWP rely heavily on data from line-point vegetation monitoring collected from 1991 onward. While both parties compare these data to the baseline data collected from 1984 – 1987, it is mutually recognized that it is difficult to make comparisons to the baseline data because of certain characteristics of the baseline data. The primary problem with the baseline information is that the locations of the original baseline vegetation transects were not documented by LADWP and thus are unknown. Despite these shortcomings, based on the reliance of both parties on the line-point monitoring, it appears there is recognition by both parties that these baseline data and subsequent monitoring by Inyo County are relevant to determination of attributability and significance.

Both parties have used similar analytical tools to evaluate attributability including univariate and multivariate statistical methods (correlation analysis, t-tests, ANOVA, Permanova, NMDS, and Permdisp), interpolation (kriging), groundwater models, and comparisons with control parcels unaffected or affected to a lesser degree by pumping. There appears to be general agreement that these techniques are applicable to analyzing conditions in Blackrock 94. The County does not always agree how these techniques were executed and interpreted in the LADWP report. These disagreements are explained in the subsequent sections of this response, and where necessary, alternate analyses are provided to evaluate LADWP's conclusions. No new data previously unavailable to either party are introduced, and the County's overall conclusion has not changed based on the analyses presented here.

The County and LADWP have used similar approaches to evaluating significance. Both parties used the lists of factors to be considered (LTWA, page 19; Green Book pp. 26-27) in their respective assessments of significance; however, the County and LADWP reached different conclusions as to significance.

Areas of Disagreement

Although LADWP and the County agree that water availability is the primary driver of vegetation decrease and change in Blackrock 94, there is disagreement on the relative importance of wet/dry cycles and pumping as causes of water table change at Blackrock 94, and on the relative importance of wet/dry cycles, precipitation, soil water availability, and groundwater on vegetation condition.

Concerning causes of water table change, the County disagrees with methods used and assumptions made by LADWP to model groundwater fluctuations in the Blackrock region. The County believes that LADWP's use of correlation analysis is inadequate to determine the relative effects of wet/dry cycles versus pumping-induced drawdown of the water table. LADWP's analysis of soil water data is similarly based on flawed methods, and its assessment is incomplete. We agree that evaluation of water availability as a function of depth within the soil profile is informative, but not as conducted by LADWP. The ICWD report concluded that sites in Blackrock 94 had little groundwater contribution to soil water in the grass root zone since monitoring began. This report shows that groundwater pumping was the main contributor to lack of available soil water at sites located in Blackrock 94, not variation in wet/dry cycles. Concerning vegetation change, the County believes that LADWP's correlation analysis is insufficient to support its conclusion that changes in runoff and precipitation drive vegetation change more than do changes in depth to water (DTW). Also, LADWP's conclusion that vegetation heterogeneity across the parcel caused false detection of change in plant composition is based on incorrect reasoning and inconsistent with its overall conclusion of the cause of decline in grass cover.

LADWP's radius of influence analysis of various pumping wells was conducted in a reasonable manner. However, the analysis looked at operation of individual wells for a period of one-year to determine the relative influence of each well for a particular set of controlled conditions. The relevance of that exercise in determining the effects of pumping as it actually occurred is unclear.

We disagree with LADWP's evaluation of the significance of decreases and changes in Blackrock 94.

We address these general disagreements in detail in the following sections responding to LADWP's analysis of attributability and significance of vegetation decreases and changes in vegetation. In addition to these disagreements over the material presented in LADWP's report, LADWP has omitted consideration of relevant data, including vegetation cover derived from satellite imagery, and data from a parcel neighboring Blackrock 94.

Attributability

LADWP's attributability discussion is organized into hydrology, soil water, and vegetation subsections. The County's response is similarly organized. The LADWP report contained various analyses related to causes of vegetation change. The Vegetation subsection below examines the relationships of hydrology and plant cover and composition presented by LADWP as well as its selections for control parcels and the comparison with Blackrock 94.

Hydrology

We disagree with LADWP's conclusion that:

> *Examination of hydrographs … shows clear response of groundwater levels to changes in runoff driven recharge. These observations plainly demonstrate that runoff –driven recharge of the aquifer is the main factor affecting water levels beneath Blackrock 94* (LADWP report, pp. 45-46).

Inspection of hydrographs from the Blackrock 94 permanent monitoring sites and control sites not affected by pumping refutes LADWP's stated conclusion (Inyo Attachment 22, Figure 10). It is not disputed that groundwater levels at Blackrock 94 vary due to a number of factors, including runoff-driven recharge; however, over the period 1970 to present, groundwater pumping has been the primary cause of changes in groundwater levels observed in Blackrock 94. This finding is supported by groundwater modeling performed by both LADWP and the County, as well as the USGS is a previous study (Danskin, 1998).

LADWP and ICWD both used groundwater models to evaluate the effect of different pumping scenarios on the water table at Blackrock 94. Both parties used models developed using the USGS Modflow groundwater modeling software (McDonald and Harbaugh, 1988). These tools are applicable and appropriate for determining the effect of various hydrological factors on the water table. Groundwater models simulate the physics of groundwater flow, thereby allowing us to assess the effects of varying recharge and pumping on the groundwater system. Groundwater model simulations are the best tool for assessing how the water table would have fluctuated had pumping been conducted differently. The ability of groundwater models to examine "what if" scenarios make them highly relevant to evaluating the central question of whether the "*decrease, change, or effect would not have occurred but for groundwater pumping…*" (LTWA, Sec. IV.B). The pumping scenarios modeled by LADWP and ICWD were similar:

1. <u>Actual pumping history.</u> This scenario simulates actual measured pumping and recharge to provide estimates of water table elevation produced by historical hydrological

inputs. This scenario provides a rendition of water table changes as they actually occurred for comparison with hypothetical scenarios. In this scenario, however, LADWP and ICWD analyzed different amounts for Blackrock hatchery pumping. LADWP used 'net hatchery pumping' (LADWP report, p.28), while ICWD used actual pumping from the hatchery wells. The effect of LADWP's decision to use net hatchery pumping is discussed below.

2. Hypothetical scenario: pumping for the Hatchery only. In this hypothetical scenario, only wells W351 and W356, the wells that supply the Blackrock Hatchery, are operated. This scenario simulates water table changes that would occur if only the Hatchery wells were operated, which provides an estimate of how much higher groundwater elevations would be if no hatchery pumping had occurred. Similar to the 'actual pumping', in this scenario, LADWP and ICWD's model inputs concerning the amount of the Blackrock hatchery pumping differed. LADWP used 'net hatchery pumping' (LADWP report, p.28), while ICWD used actual pumping from the hatchery wells. Also, in this scenario, LADWP eliminated pumping in the Thibaut-Sawmill wellfield and the south and central Taboose-Aberdeen well field, whereas ICWD's scenario eliminated all pumping except hatchery pumping.

3. Hypothetical scenario: pumping from all other wells except the Hatchery wells. This scenario simulates water table changes without the hatchery wells pumping, while other wells pump as they historically were operated. This scenario provides an estimate of how much higher groundwater elevations would be if only hatchery wells W351 and W356 had been operated.

4. Hypothetical scenario: no pumping. This scenario simulates water table changes that would occur with no pumping whatsoever. Water table fluctuations in this scenario are the result of variations in recharge. Recharge varies due to a host of variable surface water processes, both natural and managed. These include variations in precipitation, runoff, water spreading, irrigation return flows, and water provided to livestock. Comparison of this scenario with the other scenarios provides an estimate of how much higher groundwater elevations would be had no pumping occurred.

The results of ICWD's and LADWP's model runs are shown in Figures 1 and 2. Results are provided for monitoring sites TS1 and TS2, because these sites are representative of conditions within the parcel. Other locations in the parcel would show similar fluctuations as those present at TS1 and TS2, and similar relative differences between the various scenarios.

Certain differences exist between the groundwater models employed by LADWP and ICWD. ICWD used a model developed for the Owens Valley by the US Geological Survey as part of an Inyo County/LADWP cooperative study (Danskin, 1998) that was later updated as part of a subsequent study conducted by ICWD (Danskin, 2003). LADWP subsequently developed a

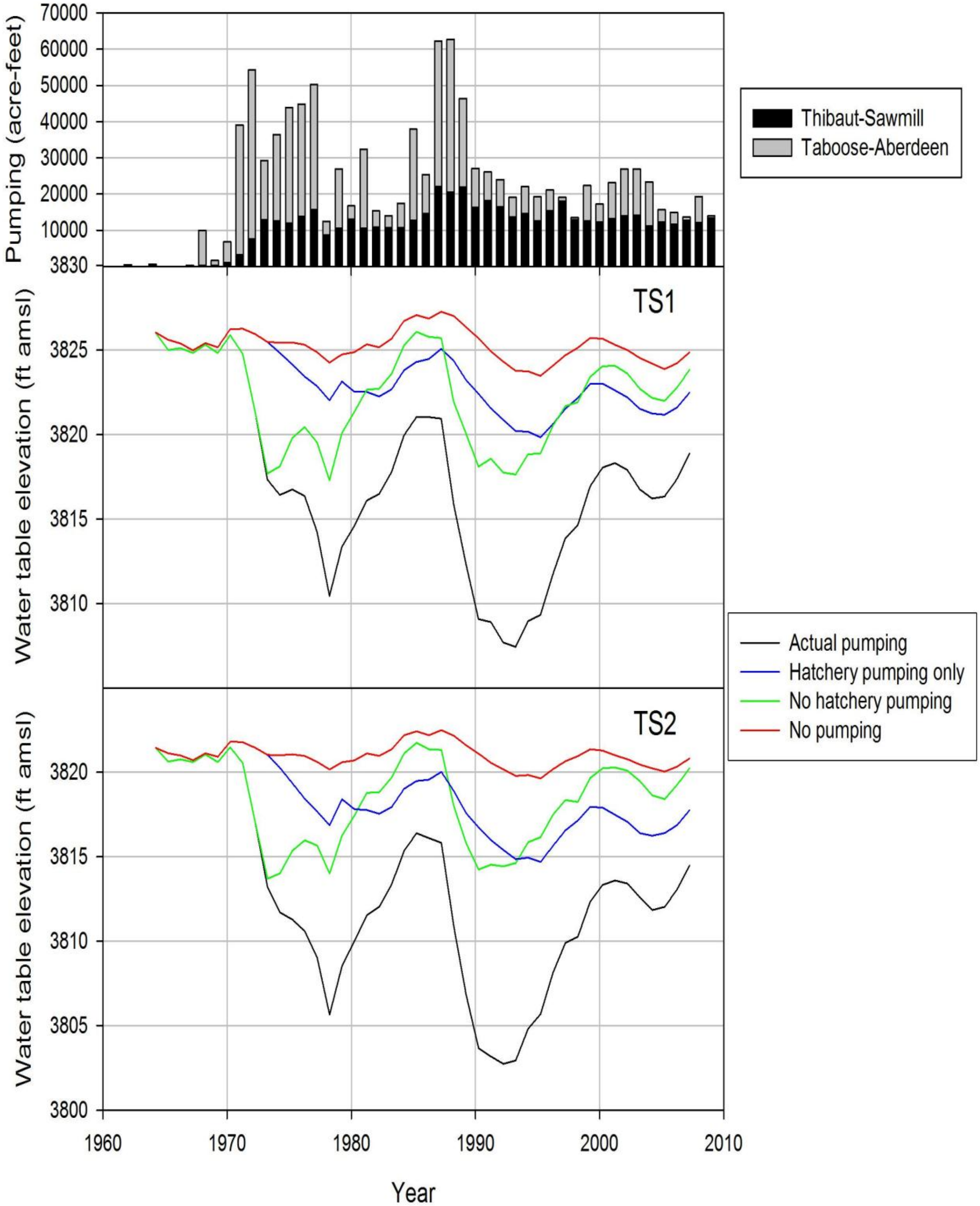

Figure 1. ICWD's groundwater modeling results (Figs. 18 and 19 from ICWD, 2011) and pumping amounts from the Thibaut-Sawmill and Taboose-Aberdeen well fields.

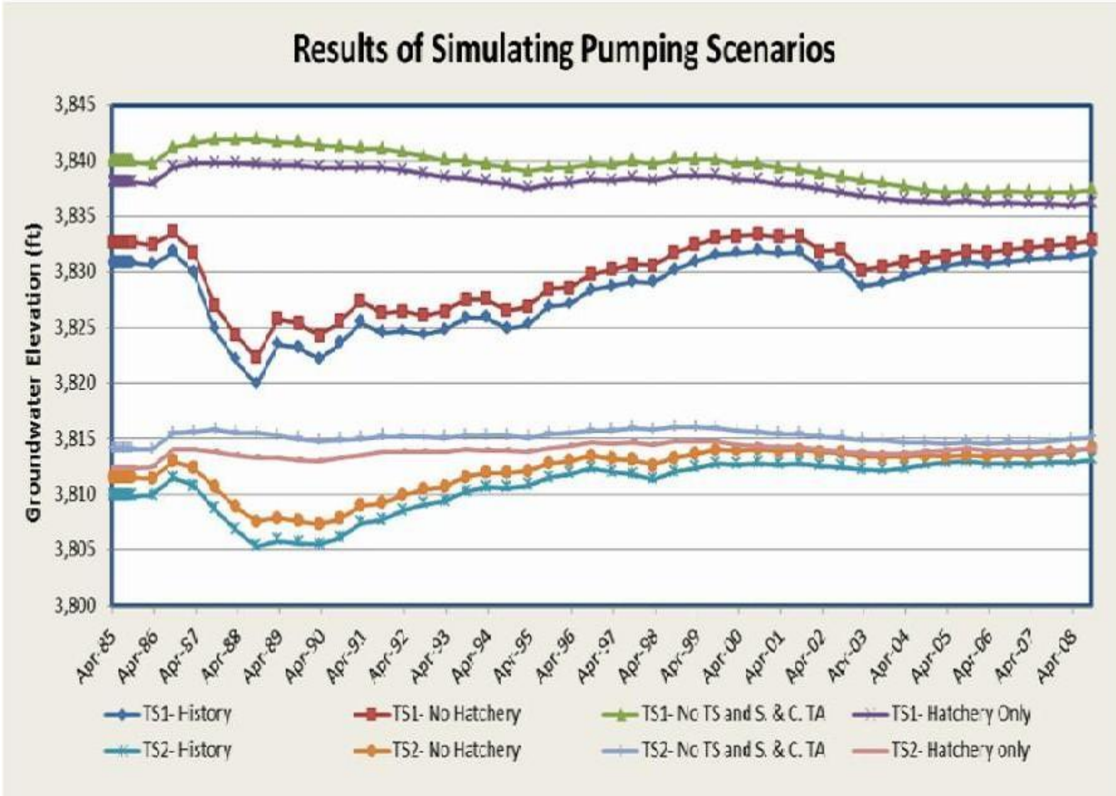

Figure 2. LADWP groundwater modeling results (LADWP report, Figure b.i.12, p. 43).

number of well-field-scale models based on a number of modifications to the USGS model framework, including segmentation of the USGS model into several well field models, smaller grid cells and time steps, and changes to the method used to calculate recharge. The USGS model is set up to simulate the period 1963 to present, whereas the LADWP model is set up to simulate the period from 1985 to present. To the best of our knowledge, the USGS model and the LADWP model(s) have not been systematically compared. The original model runs in the County's 2011 report end in 2008; no additional USGS model runs updating the predictions to the present have been conducted. Since the major hydrologic and vegetation changes were already apparent in 1991, the model results presented in the ICWD report are sufficient to complete the attributability analysis.

We agree with LADWP's comments regarding the limitations of either groundwater model to accurately simulate drawdown at Blackrock 94 (LADWP report, p. 41); therefore, we present a comparison between the model results and the actual observed conditions to assess the veracity of the models. Because ICWD and LADWP used different models to simulate the same hydrogeologic system and pumping scenarios, it is useful to compare the model results for the 'actual pumping history' scenario with the observed groundwater levels in order to evaluate the relative accuracy of the different models.

Table 1. Comparison of model results from the LADWP model and USGS model used by the County. Observed drawdown is from Table b.i.5 of the LADWP report (p. 36), using observations and estimated water table elevations. Model results for the LADWP model were estimated from Figure 2 (Figure i.b.12 of the LADWP report (p. 43)).

	Maximum drawdown mid-1980s to early-1990s		
Monitoring site	Observed (ft)	LADWP (ft)	USGS (ft)
TS1	22.3	~12	13.6
TS2	17.2	~7	13.7
	2007 water table elevation (feet above mean sea level)		
Monitoring site			
TS1	3824.4	~3831	3818.9
TS2	3813.8	~3809	3814.5

Table 1 compares results from the two models with observed water levels (or estimates derived from observations) in terms of drawdown during the period 1987-1992 and 2007 water table elevations at monitoring sites TS1 and TS2. Because the monitoring wells located at TS1 and TS2 were installed after the mid-1980s, we use LADWP's depth to water estimates for those sites to calculate drawdown (LADWP report, pp. 34–36). Also, T807, the well at TS1, was dry during the period when the minimum water level occurred, so LADWP's estimate was also used for the minimum 'observed' water level at that site.

The USGS model performs somewhat better than the LADWP model (Table 1). Both groundwater models underestimate drawdown from the mid-1980s water table peak to the minimum in the early-1990s. LADWP's model underestimates drawdown from the mid-1980s peak by 10.3 feet and 10.2 feet at TS1 and TS2 respectively; whereas, the USGS model underestimates drawdown at the sites by 8.7 and 3.5 feet. Water levels in 2007 are also simulated better by the USGS model than by the LADWP model. At TS1 and TS2, the LADWP model simulated 2007 water table elevation at 6.6 feet above and 4.8 feet below measured levels respectively. The USGS model was 0.7 feet above and 5.5 feet below the observed water table elevations.

Both LADWP and ICWD's actual pumping scenarios overestimate the amount of recovery that has taken place since the early-1990's. LADWP and ICWD both estimated average DTW beneath Blackrock 94 by interpolating DTW measurements from monitoring wells in the area (LADWP report, Figure b.i.9, p. 33; ICWD report, Figure 13, p. 38), both of which show the parcel being 10 to 12 feet below baseline levels in 2008.

Comparison of the various pumping scenarios with the ‘no pumping’ scenario shows that variations in pumping have a far greater influence on water table fluctuations than variations in recharge. ICWD and LADWP models both show this. Figure 1 presents the results from ICWD’s simulations (ICWD report, pp.52–53) along with pumping from the Taboose-Aberdeen and Thibaut-Sawmill wellfields, and Figure 2 shows the results of LADWP’s simulations (LADWP report, p. 43). Model results from LADWP and ICWD show that water table elevations in the ‘no-pumping’ scenario are higher than in the ‘actual-pumping’ scenario, which shows that pumping lowered the water table. As shown in Table 1, water table declines from the mid-1980s to early-1990s were actually somewhat greater than modeled by either LADWP or ICWD. Both LADWP and ICWD ‘no-pumping’ scenarios show only small water table fluctuations of a few feet in response to variability in recharge. This is similar to the range of water table fluctuations that are observed in areas of Owens Valley that are not affected by pumping (Inyo County Brief, Attachment 22, p. 33, Figure 10). ICWD’s results show greater water table variability associated with non-hatchery wells (the ‘no hatchery pumping’ scenario), consistent with the greater variability of non-hatchery pumping (Figure 1).

The models used by LADWP and the County both show that pumping has resulted in water tables significantly lower than would have occurred without pumping. LADWP’s results show that, without pumping, by 2008 the water table would have been approximately 6 and 2 feet higher at sites TS1 and TS2 respectively. During the period of maximum drawdown in the early 1990’s, LADWP’s results show that, in comparison with the water table elevations without pumping, pumping reduced water table elevations from their unpumped levels by approximately 23 and 10 feet at sites TS1 and TS2 respectively. The USGS model used by the County shows that 2008 water levels were 6.0 and 6.7 feet below their unpumped levels at TS1 and TS2 respectively, and were 15 and 17 feet below estimated unpumped levels during the maximum drawdown period of the mid-1990’s.

The results of both LADWP’s and the County’s groundwater modeling conflict with LADWP’s conclusion that wet/dry cycles and runoff fluctuations are the primary cause of water table fluctuations. On the contrary, the groundwater modeling results of both the County and LADWP show that pumping is the primary driver of changes in water table elevation at Blackrock 94. These results are consistent with the conclusion of the USGS concerning the relative effects of pumping and recharge in Owens Valley, where LADWP concluded “*…the ground-water model showed that pumpage is the dominant stress in the aquifer system both near well fields and in recharge areas.*” (Danskin, 1998, p. 138).

LADWP’s results erroneously indicate that the Blackrock Hatchery has little effect on the water table, because the model did not include the full amount of pumping at the Hatchery in the analysis. LADWP’s groundwater modeling results are shown in Figure 2 (copied from Figure b.i.12, p. 43, LADWP report). LADWP's results show that the water table in the 'hatchery only' scenario at both TS1 and TS2 is only 1 to 2 feet lower than in the 'no pumping' scenario. Similarly, LADWP's model results with no hatchery pumping show that eliminating hatchery pumping raises the water table only 1 to 2 feet above the 'actual pumping' scenario. Elsewhere, LADWP points out that Hatchery pumping is the majority of the pumping done in the area of Blackrock 94 (LADWP report, p. 24). These paradoxical results suggest that even though the Hatchery wells are the majority of pumping in the area and are relatively close to parcel Blackrock 94, they have only slight effect on the water table beneath the parcel, and more distant wells that pump less water have a greater effect. LADWP did not explain what hydrological conditions could produce that puzzling result.

The County suggests that LADWP's anomalous model results are due to incorrectly specified pumping at the Blackrock Hatchery. A key difference between LADWP's and the County's pumping scenarios is that LADWP used "net hatchery pumping" instead of actual hatchery pumping in scenarios where the hatchery wells were operating. LADWP defines net hatchery pumping as pumpage from wells W351 and W356 minus the average pre-pumping flow from Big Blackrock Spring minus infiltration losses from the hatchery pond and from the return ditch to the LA Aqueduct (LADWP report, pp. 25-28). LADWP's estimates of infiltration losses did not assess losses from evapotranspiration, which would reduce the amount of estimated infiltration; nonetheless, its method of calculating losses does not seem unreasonable and the Technical Group should consider this factor in any further work concerning groundwater use by the Hatchery.

LADWP's treatment of spring flow is incorrect. By neglecting to include the volume of water that previously flowed from the Big Blackrock Spring, LADWP's modeling treats this water as if it does not exist, when in fact it does. Excluding the natural discharge at the spring location incorrectly assumes that a large quantity of water (approximately 7000 ac-ft/year) remains in the aquifer forcing the model to predict a shallower water table in the surrounding area, including Blackrock 94. LADWP's unrealistic and inexplicable omission of this component of groundwater discharge explains both the tendency of its model to underestimate drawdown, and LADWP's paradoxical result that larger amounts of pumping closer to Blackrock 94 affect the parcel less than smaller more distant amounts of pumping.

In contrast to LADWP's results, the County's results show significant effects from both Hatchery and non-hatchery pumping. The County's results show that since 1971 when pumping in the region began in earnest, both hatchery and non-hatchery wells have caused significant drawdown at TS1 and TS2 (Figure 1).

Regarding correlation analysis, LADWP concludes that "…*DTW under TS1 and TS2 has a statistically significantly* [sic] *correlation with Owens Valley runoff and pumping from non-hatchery wells*" and "*DTW under TS1 and TS2 has no statistically significant correlation with Hatchery pumping*…" (LADWP report, p. 46). LADWP's correlation analysis is insufficient to determine whether pumping causes drawdown because it fails to distinguish fluctuations in DTW due to runoff and the sustained depression of DTW due to relatively constant pumping. LADWP's analysis detected the former and then they incorrectly concluded the latter did not affect water availability. Correlation analysis is an insufficient means to assess cause and effect relationships where drawdown persists after the beginning of pumping, or where a change in pumping occurred prior to the period of record used in the correlation analysis. If the effect persists after the pumping ceases, or the response to pumping continues to evolve after pumping has stabilized, then the statistical relationship may be absent while the causal relationship is real. LADWP's correlation results do not estimate the effect of hatchery pumping nor do the results estimate the relative contribution of runoff and pumping to changes in water levels with respect to the plant root zone or baseline water levels. For example, from Figure b.i.11 of the LADWP report (p. 35), LADWP concludes "*the hydrographs of monitoring wells T806 and T807 show DTW beneath Blackrock 94 is clearly more a function of Owens Valley runoff than groundwater pumping for Hatchery supply*" (LADWP report, p. 38). This conclusion is unsupported, because Hatchery pumping has been relatively constant since the early-1970's. The steep decline in the water table in the early-1970's is a result of this increase in pumping stress from the Hatchery wells and other wells. LADWP's presentation obscures this by omitting the period prior to 1972 when pumping was much less and the water table higher.

The groundwater modeling results discussed above (both LADWP's and ICWD's) are more relevant to assessing the effects of LADWP pumping than the correlation analyses LADWP presents in Table b.i.6 of the LADWP report. The groundwater modeling results of both parties show that pumping has produced the majority of water table change at Blackrock 94. LADWP's model results for the no pumping scenario respond negligibly due to fluctuations in runoff unlike the County's model results and the actual behavior of control areas. This apparent discrepancy between LADWP;s modeling and correlation analyses which concluded runoff is the primary control on water table fluctuations is a glaring contradiction.

LADWP's claims that pumping to supply the Black Rock Hatchery has been constant since 1972, and argue that water table changes due to pumping for the hatchery stabilized prior to 1986; therefore, hatchery pumping could not cause fluctuations in the water table in the late-1980's when vegetation declined. For example, LADWP argues that "*…Hatchery wells had been pumping continuously for 13 years prior to 1985 and the water table drawdown caused by the Hatchery wells had long since stabilized*" (LADWP report, p. 39). While we concur that Hatchery pumping has been a continual pumping stress in the region since 1972, it has varied to some extent, as shown in ICWD's report (Figure 10a on p. 34). Also, when assessing drawdown during the late-1980's and other drawdown events, variability of pumping from other wells in the Thibaut-Sawmill and Taboose Aberdeen well fields is an important consideration (Figure 1). Figure 1 shows that Hatchery pumping (wells W351 and W356) and pumping for the entire Thibaut-Sawmill wellfield peaked during the years 1987 – 1989, was less than the average pumping prior to that time, and was about average after that time. For the period 1972 -1986, pumping for Black Rock Hatchery was 91% of the 1972 – 2010 average; for the period 1987 –

1989, Hatchery pumping was 119% of average; and for 1990 – 2010, Hatchery pumping was 103% of average. Pumping from the entire well field has been more variable than that for the Hatchery alone. For the period 1972-1986, well field pumping was 86% of the well field 1972–2010 average; for the period 1987–1989, well field pumping was 157% of the well field average; and for 1990–2010, well field pumping was 101% of average. Pumping in the Thibaut-Sawmill well field and pumping for the Black Rock Hatchery both peak in the period during which the water table declined. Figures 12 and 13 in the ICWD report, and Figures b.i.6 in the LADWP report document that a sharp decline in the water table occurred during 1987–1989 when pumping peaked. The relative effects of hatchery and non-hatchery pumping are best approached through the groundwater modeling exercises presented above.

LADWP cites a Montgomery-Watson-Harza Americas, Inc. (MWH) report (LADWP report, p. 34) that purportedly evaluated recovery from drought conditions of 1987 to 1992. Recovery from the 1987-92 drought and period of high pumping is not the issue of this dispute or the purpose of this attributability analysis. The question at hand is whether the decline in vegetation would not have occurred but for LADWP pumping. The County's analysis suggested that the drawdown coincident with the initial change in vegetation between 1986 and 1991 was primarily due to pumping and that water levels after that time period would have been shallower but for LADWP pumping (Figure 1). LADWP's model results also suggest that in the absence of pumping, water levels would have changed little since 1985 (Figure 2).

Further, the MWH evaluation concluded that most monitoring wells in the Thibaut-Sawmill well field had recovered and that groundwater storage gains have more than replaced depletions. The standard for water table recovery in the MWH report was that water levels following the 1987-92 drought and period of high pumping rose to within 80% of the pre-drawdown level, an arbitrary threshold unrelated to vegetation conditions or LTWA goals and standards. LADWP's report Figure b.i.6 (p. 29) shows that many wells in the Thibaut-Sawmill wellfield remain below their levels of the mid-1980's, and Figure b.i.9 (p. 33) shows that by LADWP's own estimates the water table at Blackrock 94 remains approximately 8 to 10 feet deeper than during the mid-1980's. On this basis, MWH's conclusion that groundwater storage has recovered from depletions during the drought is clearly wrong, since reduced water table elevations in unconfined aquifers are by definition a reduction in groundwater storage.

Summary of Hydrological Analysis

Groundwater modeling is the most applicable tool available to determine how groundwater pumping has affected the water table. Both parties used groundwater models to evaluate hypothetical groundwater pumping scenarios to determine how the water table would have behaved under different pumping scenarios. LADWP's principal conclusion concerning the cause of water table change at Blackrock 94 was that "*runoff-driven recharge of the aquifer is the main factor affecting water levels beneath Blackrock 94*" (LADWP report, p. 46). That conclusion is contradicted by LADWP's own groundwater modeling, as well as the County's, which both show that water table fluctuations "*due to runoff-driven recharge*" are relatively small (a few feet) versus pumping driven water table declines, which are on the order of 10 to 15 feet. The USGS reached a similar general conclusion in its study of Owens Valley groundwater management (Danskin, 1998, page 138). Observations in areas of similar vegetation elsewhere in Owens Valley where the water table is unaffected by pumping confirm that water table fluctuations caused by varying recharge only vary by a few feet.

LADWP focuses almost exclusively on pumping at the Blackrock Hatchery and its effect on groundwater levels in Blackrock 94. The County's groundwater modeling shows that both hatchery and non-hatchery pumping produce significant drawdown at Blackrock 94. LADWP's modeling erroneously omitted an amount of pumping equivalent to the historic spring flow from Big Blackrock Springs, producing the erroneous result that Blackrock Hatchery pumping has little effect on the water table. The County believes its conclusion that pumping was the predominant factor reducing water availability that contributed to vegetation decline was correct, and that LADWP's various attempts to show otherwise are internally contradictory and incorrect.

Soil Water

The Green Book requires that soil water conditions be evaluated as part of an investigation of whether changes in vegetation are attributable to LADWP operations. In the ICWD report, the County summarized observations of available soil water data collected since 1988 at permanent monitoring sites TS1 and TS2 located in Blackrock 94 and TS3 located adjacent to Blackrock 99 (ICWD report, pp. 37-42). The County concluded that at TS1 and TS2 the soil above 2 m in the grass root zone was dry and little groundwater had contributed to soil water recharge at those sites since 1991. By contrast, the soil at TS3 has been much wetter than TS1 and TS2 and groundwater contributes to soil water. LADWP's analysis of attributability included an examination of soil water conditions in TS1 and TS2 but excluded TS3. This section briefly reviews LADWP's analysis and re-examines the history of soil water changes at monitoring sites in Blackrock 94 and the possible role of factors affecting water availability. LADWP chose three vegetation parcels as controls to compare with Blackrock 94, but it is important to note that there are no soil water data collected at those locations. The soil water data from TS3 are relevant to proper interpretation of soil water availability and vegetation changes at TS1 and TS2 and are evaluated here. Further, monitoring site TS3 has similar soils, precipitation, and baseline vegetation conditions as TS1 and TS2.

The County does not agree with the methodology used by LADWP or with all of its conclusions concerning soil water. LADWP restricted its evaluation to only include soil water data collected between 1996 and 2012. This period is several years after the decline of vegetation in Blackrock 94 was first measured by the County's vegetation monitoring program in

1991. Further, LADWP's analysis only included average soil water during the growing season thus ignoring soil water dynamics during winter when the majority of precipitation occurs and when seasonal contributions of groundwater to soil water are most observable. Soil water recharge from precipitation and groundwater during winter carries over into early summer and influences the average soil water content, but LADWP provides no reason to exclude data from the wettest portion of each year. LADWP's analysis examined total soil water content which includes water held in the soil that is not available to plants. LADWP's analysis relied on statistical correlation analyses to determine what factors affect water content, but LADWP's methodology provided an incomplete and sometimes incorrect assessment of soil water available for plant use. Finally, no comparison with soil water data collected at control sites or at the nearby monitoring site TS3 were included in LADWP's report. The numerous deficiencies in LADWP's approach necessitated the County to prepare a more appropriate examination of the soil water dataset to evaluate LADWP's conclusions. All data included in the County's analysis below had been provided previously to LADWP.

Background

Soil water content can be expressed several ways. Soil consists of solids (e.g. sand, silt, clay, organic materials) and pore spaces, some of which normally are filled with water and the rest with air. The soil is saturated below the water table where all pore spaces are filled with water. Soil water data collected by the County as part of the Technical Group monitoring programs are expressed in percent (%) of the volume of soil occupied by water (m^3 water/m^3 soil). It is useful to express water content in terms of the amount of water stored within a particular soil layer if the purpose is to track the amounts of water gained (e.g. rain) or lost (e.g. evaporation) from the soil over time. Stored soil water is expressed in units of depth similar to measurements of rainfall. To visualize this measurement, consider a 1 foot tall cylinder with three inches of water in the bottom. If that cylinder were then filled completely with dry soil and left to equilibrate, the 1 foot of soil in the cylinder would still contain three inches of water. The amount of stored soil water is calculated by multiplying the water content (volume basis) by the thickness of the soil layer. Values of stored water can be summed to determine the amount of water available for plant use for individual soil layers or for an entire monitoring profile. These are standard calculations included in the Green Book and employed by the Technical Group to determine whether certain LADWP pumping wells near each monitoring site can be operated (Steinwand, 1996).

A key property of soil is that even soil too dry to support living plants contains a small quantity of water strongly adsorbed to soil particles. This adsorbed water is referred to as the limiting water content and is not available to plants. Our primary monitoring instrument, the neutron probe, measures all the water in the soil including that not available to plants. The limiting water content depends on soil properties, and varies between approximately 2-14% for the soil properties observed at TS1, TS2, and TS3. Any evaluation of whether soil water contributed to a vegetation decline must account for this variation in water availability caused by differing soil properties. For example, the water content at one measurement depth may be 3% and 10% at another, but because the second soil has more silt or clay, the amount of water available for plant use may be near zero at both depths. Simply calculating average water content (%) of a soil layer contributes little information on the quantity of water available for use by plants. Comparing or averaging water content measurements at different locations as in LADWP's analysis without accounting for differing soil properties is also invalid. The difference between the total water content measured with the neutron probe and the limiting water content is called the available water content which also can be expressed as the amount of available water stored in a layer of soil (AWC) using the calculation described above. The analysis presented here relied on values of AWC.

Methods

The most extensive dataset of soil water data for the permanent monitoring sites was collected using the neutron probe. Other monitoring data collected using psychrometers are available, but the Technical Group discontinued that monitoring program in April 1996 in favor of the present program consisting of multiple monitoring points at each site monitored monthly using the neutron probe. Like LADWP's analysis, the information contained in this report use data collected using the neutron probe. Both agencies have the entire soil water dataset.

Neutron probe measurements at TS1, TS2, and TS3 began in 1987 at the direction of the Technical Group to check the accuracy of psychrometer measurements. In 1987-88, measurements only were collected four times at a single location at the depths psychrometer instruments were installed. Beginning in the fall of 1988, the entire soil profile near the same location was monitored at least three times a year as described in the Green Book (Sec. III. F.4.c, p. 77). The number of monitoring locations at each site increased and the monitoring profile deepened beginning in mid-1995 as improvements in the calibration and monitoring methods were implemented before final adoption by the Technical Group in April 1996. Each location consists of a single tube installed vertically in the soil through which the probe can be lowered to take measurements. Calculation of water content for the measurements before 1995 requires an assumption that could cause the water content at each depth to vary approximately $\pm$0.5%. The number of monitoring locations increased a second time in 2004 at TS1 and TS3. Even though the monitoring network was not as extensive during 1987-95 and requires additional assumptions to use, the soil water data are still informative and are especially relevant to the important period immediately following data collection for the LTWA baseline in 1986. The raw data and all calculations are included in Appendix B.

Calculation of available soil water content requires an estimate of the limiting water content. Limiting water content can be estimated indirectly using information on soil properties, or alternatively, at sites with stable water content and dry soils, it can be assumed the measured water content using the neutron probe approximates the limiting water content. The Technical Group adopted a combination of these methods to estimate limiting water content for pumping management (Steinwand, 1996). The estimate based on texture was considered approximate, and if actual measurements using the neutron probe were lower, that value was adopted as the limiting water content by the Technical Group.

Estimates of limiting water content had been determined previously for soil depths above than 2 m when the program was adopted by the Technical Group. Estimates below 2 m were not necessary to manage pumping and were not derived at that time. LADWP's analysis included data from below 2 m, but as described above, LADWP did not rely on estimates of available soil water to account for different soil properties at the monitoring locations. In order to evaluate LADWP's conclusions, an estimate of limiting water content was derived using methods similar to that adopted by the Technical Group in 1996. For sites TS1 and TS2, soil water content at lower depths experienced lengthy periods of nearly constant water contents less than 14% (e.g. Figure 1). Since the root zones at these sites were separated from the water table for extensive periods, it is safe to assume the soil water was not available to the plants. As a conservative estimate, the lowest water content ever measured was assigned as the limiting water content. This value is conservative in that any soil water measured above this value was counted as potentially available even if evidence of plant uptake during the growing season was lacking. The resulting estimates of limiting water content are consistent with field notes of soil texture collected during installation of the access tubes.

Monitoring site TS3 has not experienced lengthy periods of separation from the water table and relying on the lowest water content measured to estimate limiting water content for soil below 2 m would not be accurate or appropriate. Field notes and neutron probe calibration results (estimates of porosity) suggest the saturated soils at depth were predominantly sandy. The most common texture encountered during the 1995 neutron probe calibration samples was sandy loam (Steinwand, 1996). The estimate of limiting water content for sandy loam (6.6%, McCuen *et al.*, 1981) was used in this analysis unless a lower water content had been measured using the neutron probe. This means that for depths below 2 m at TS3, the estimates of available water content could be shifted slightly too low or high, all by the same amount, but the trends over time would be unchanged.

The effects of surface infiltration (rain or irrigation) and groundwater contributions to soil water recharge are evident from soil water changes within the soil profile. Figure 3 presents an example of soil water response to winter precipitation for a single monitoring location (in this example, it is valid to assess changes in water content (%) at each depth over time because the soil properties are constant). The October measurement represents the soil condition after an

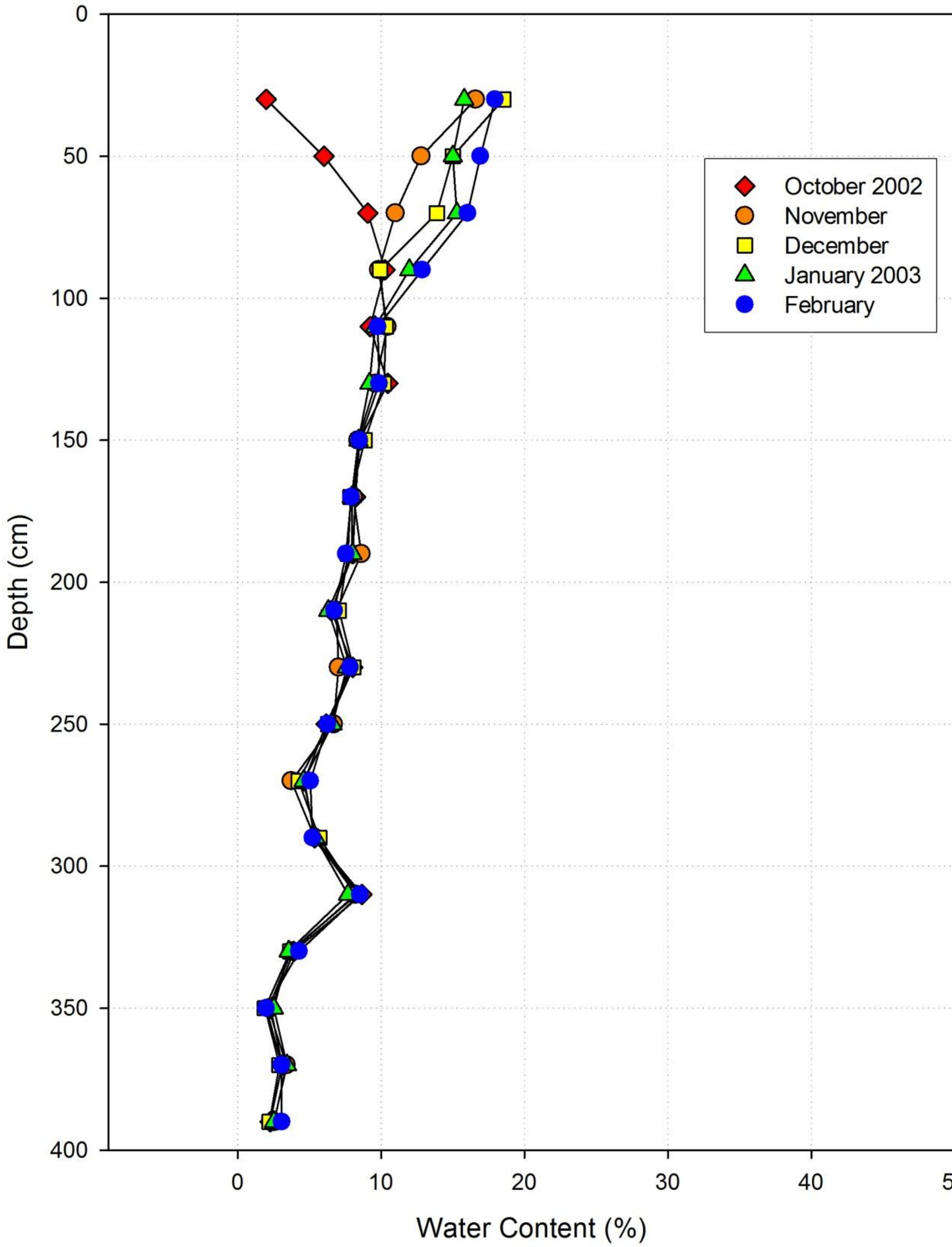

Figure 3. Example of precipitation infiltration during winter 2002-03. Soil depth affected by rain clearly distinguishable from lower depths with dry soil and constant soil water content.

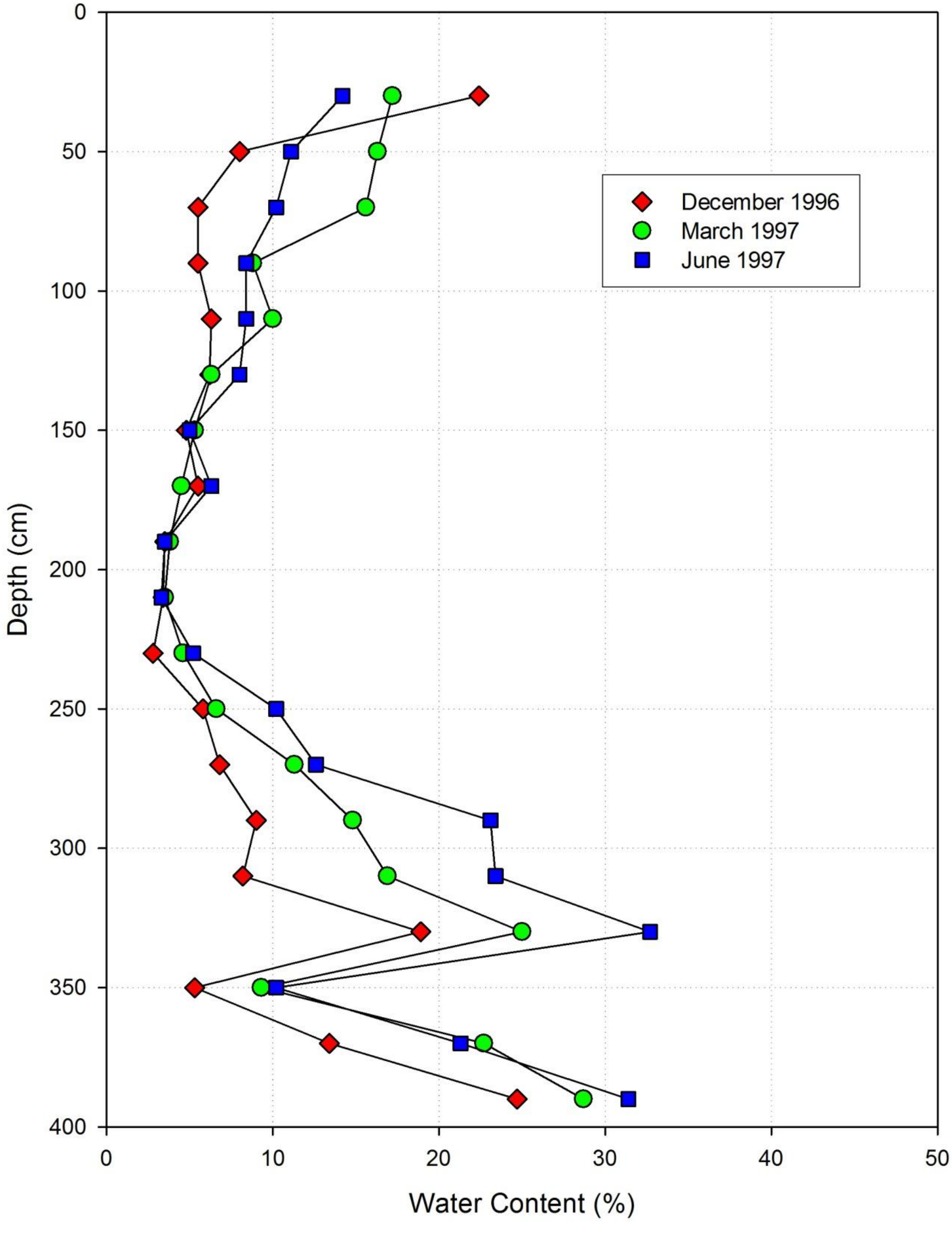

Figure 4. Example of lower soil depths progressively wetting from below as water rose during 1996-97.

extended period of little rain. Increasing soil water in response to rain in November, December, and February are plainly evident above 1 m. Lower depths were unaffected by infiltration and soil water content remained constant. The maximum infiltration depth depends on factors such as rainfall amount, soil properties, and how dry or wet the soil was when rain occurred, but typically precipitation affects depths shallower than 1.3 m at TS1 and TS3, and 1.5 m at TS2. Figure 4 shows an example where soil water deep in the profile responds to a rising water table. As the water table rises, the water content increases and the upper limit affected by capillarity rises in the profile. The soil above 1.3 m was affected by precipitation and evaporation/plant uptake during the growing season (e.g. compare March to June). Note that the water content increased at the bottom of the profile while simultaneously it decreased above 1.3 m. The middle portion of the profile (1.5-2.1 m) exhibits dry and relatively constant water content. Dividing the soil profile into layers is a useful and common method to summarize and track the various factors contributing to fluctuations in water availability. As shown in the examples in Figure 3 and 4, changes in water availability within the profile can be distinguished and interpreted physically (e.g. when it rains, the soil gets wet). LADWP assessed the factors affecting soil water changes over time using a linear statistical correlation analysis. Correlation can be insightful, but in this instance reliance exclusively on statistical correlation can lead to erroneous conclusions as shown below.

For this analysis, the soil was divided into layers to summarize changes in soil water similar to the approach adopted by LADWP. The surface layer increment was slightly deeper than that used by LADWP to include depths readily identifiable as affected by precipitation. The lower division boundaries were the same as used by LADWP (2, 3, and 4 m). For each layer, the AWC was calculated using the methods described above. Average AWC for each layer was calculated from individual locations at a site. The AWC for a particular layer and the site average were not calculated if there were missing data. Locations where monitoring did not extend completely through the bottom layer were not included in the site average for that layer. The number of monitoring locations has varied over time, and there are step changes in the AWC trends in 1995 and 2004 when the number of locations increased. The steps are small compared with changes due to groundwater recharge or precipitation. The locations used to calculate the average AWC for each month are described in Appendix B (TS1 2 3 Soil Water AWC data and graphs.xlsx).

Water table depth at the sites was measured in the associated monitoring well. When data from the associated well were not available, DTW was estimated based on the relationship with a nearby monitoring well with a longer period of record. Monitoring well 807T at TS1 and V156 located north of TS1 have parallel hydrographs. A regression relationship was developed constructed using paired measurements taken at each well less than 4 days apart (n=126, r^2=0.86, p<0.001). Monitoring well 806T and 582T are near TS2 and together constitute a single hydrograph for TS2 after correcting for differences in land surface elevation. The data and regression results are included in Appendix B. No estimates of DTW at TS3 were made; monitoring well 414T was plotted for comparison with well 851T located at the monitoring site.

Results

Soil water changes at sites TS1 and TS2 are discussed below followed by a comparison with TS3. Monitoring of the complete soil water profile began at all three sites in November 1988. Because of the limited data collected at site visits in 1987-88, it is not possible to calculate stored available soil water for layers for these early measurements. The discussion for each site begins with a comparison of water content in 1987-88 with subsequent measurements. In all cases the November 1988 measurement is the first measurement of AWC for a site.

Monitoring site TS1

The soil at TS1 was wetter in 1987-1988 than in the following years, particularly in the upper 1.5 m of the profile (Figure 5). For reference, the final measurement in Figure 5, November 1988, is the first measurement in Figure 6. This was likely due to precipitation and the shallower water table conditions in previous years. Precipitation amounts for the year before monitoring began and during October 1987 to April 1988 were below normal suggesting the higher water contents in 1987 and early 1988 included water retained in the soil following water table decline or possibly irrigation.

The upper layer (0-1.3 m) at TS1 was affected predominantly by infiltration from the surface (e.g. Figure 4). Except for two incidents of water spreading discussed below, precipitation was the only contributor to soil water above 1.3 m. The average AWC is near zero except following precipitation events. LADWP reached similar conclusion based on correlation analysis. It is not surprising that the soil at shallow depths is affected by precipitation.

Periods of water spreading are evident in the hydrograph for 807T in the summer of 1993, 1995, and 1996 consistent with spreading values presented by LADWP's report (Sec. 5.7, table b.vii.3). Spreading in 1993 did not affect soil water at TS1 above 4 m. Spreading operations affected available soil water directly by flowing across monitoring locations in 1995 and indirectly by raising the water table in 1996. The different mechanisms of soil water recharge are readily distinguished based on the timing and location of changes in the soil water profile (e.g. Figures 3 and 4). The effect of spreading in 1995 was variable across the site. Surface water flowed directly across one location (tube 2) and recharged depths below 1.3 m at another (tube 1). The third monitoring location appeared to be little affected by spreading (Appendix B). In 1996, all monitoring locations wet up from below in May and June in response to the sudden rise in the water table. Soil depths below 1.3 m (tube 1) to 2.1 m (tube 3) were affected.

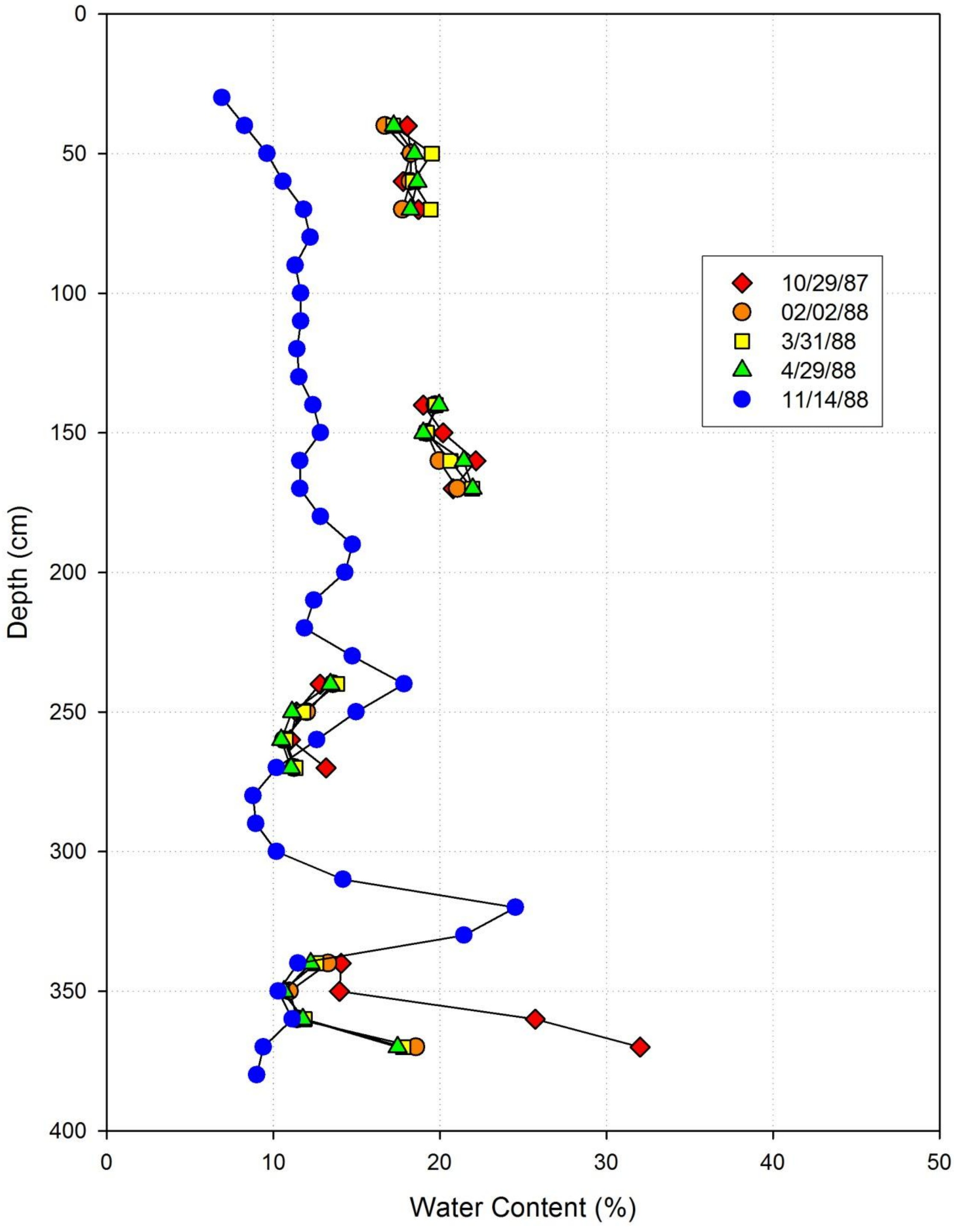

Figure 5. Soil water measurements at TS1 in the winter and spring 1987-88 and the first measurement of the entire profile in the fall of 1988 during a period of rapidly declining DTW.

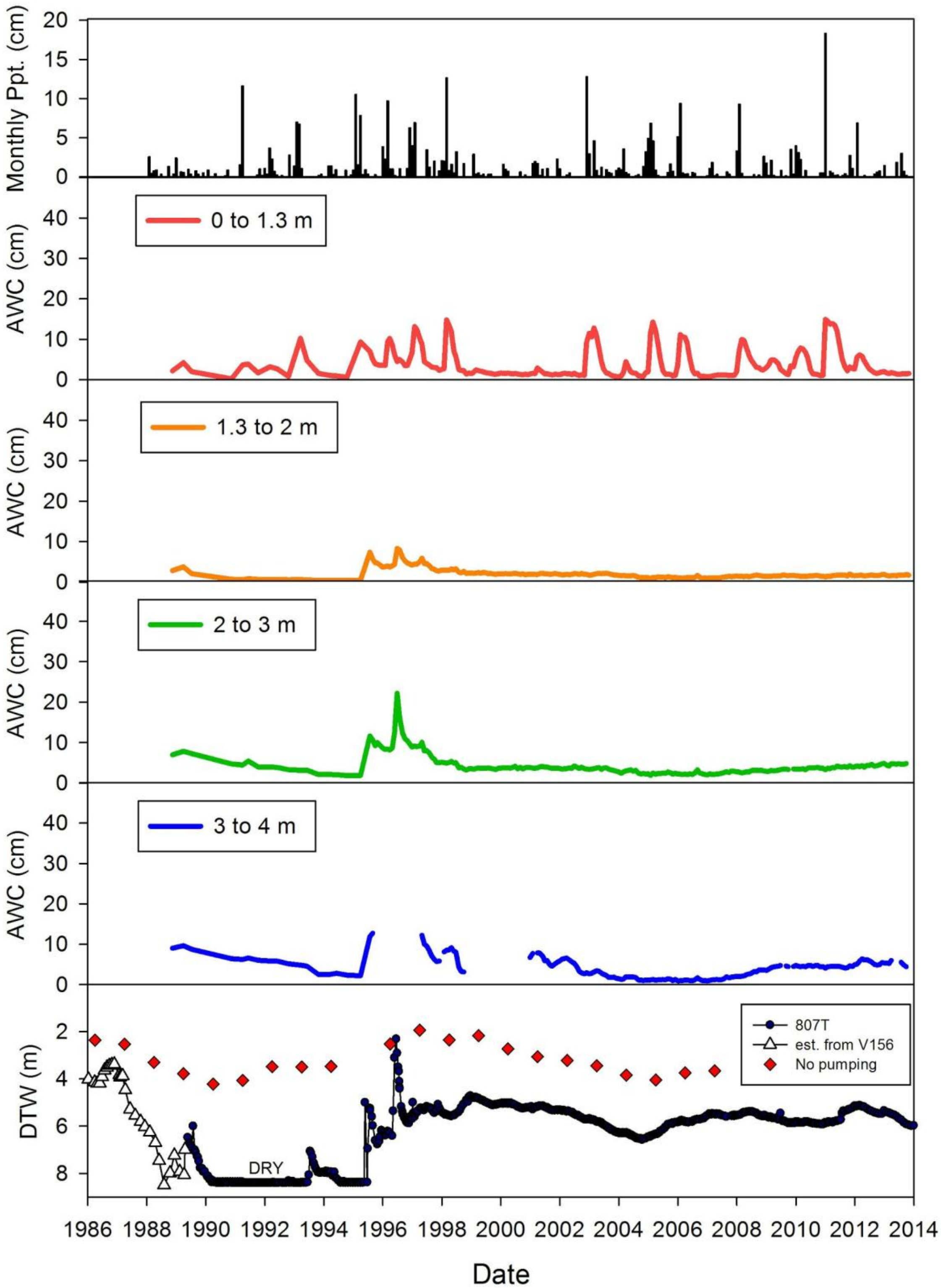

Figure 6. Average available soil water (AWC) stored in the soil profile and DTW at TS1. Top graph is monthly precipitation measurements at Independence measured by LADWP.

Following the spreading events in 1995 and 1996, AWC for layers below 1.3 m gradually declined until it was exhausted. Soil water in the middle layers was exhausted (1999) before the bottom layer (2005), consistent with the expected lower rooting density deeper in the soil profile and resultant slower rate of water extraction. AWC in the 1.3-2 m layer remains near zero to the present day. The slight rise in soil water in the 2-3 m and 3-4 m layers beginning in 2007 occurs during a period of relatively stable water levels and precedes the rising water table in 2011. It is most evident in tubes 2, 4 and 5 which are located adjacent to one another (Appendix B). The soil water recharge may be a consequence of the removal of vegetation by the Inyo Complex fire in July 2007.. After the fire, deep shrub roots were dead and no longer able to intercept capillarity from wetter layers near the water table at approximately 5 to 6 m.

Monitoring site TS2

The soil at TS2 was wetter in 1987-1988 than years immediately following, particularly in the upper 1.5 m of the profile (Figure 7). For reference, the final measurement in Figure 7, November 1988, is the first measurement in Figure 8. This is likely due to precipitation and the shallower water table conditions in previous years. Precipitation amounts for the year before monitoring began and during October 1987 to April 1988 were below normal suggesting the higher water contents in 1987 and early 1988 included soil water retained following water table decline.

The top layer (0-1.5 m) has been affected by precipitation only (Figure 8). No groundwater reaches above 1.5 m at this site. AWC appears to increase small amounts in a stepwise fashion following some years of high precipitation, in particular 1998, 2003, and 2005 (one tube only). The steps do not correspond with changes in depth to water or increases in AWC in the layer below. It appears that recharge from winter precipitation was not fully utilized during the following summer. Since this leftover precipitation was not used in subsequent years, it may not be available for plant uptake or may simply be bypassed in favor of uptake from wetter layers deeper in the profile by the shrub-dominated vegetation.

Plant uptake was evident in soil layers below 1.5 m between 1989 and 1994 at which time the available soil water was essentially exhausted (Figure 8). AWC remained near zero and relatively stable until late 1996 when AWC began to increase in response to a rising water table. As the profile wet from below, the lowest layer was affected first and then soil water increased in overlying layers. The amount of soil water added to the 1.5-2 m layer in 1998 was small (approximately 2 cm) and was not taken up by vegetation in subsequent years. LADWP did not detect significant relationships with water table depth at this site yet clearly, groundwater recharge has occurred below 2 m.

After 1998, the water table remained relatively stable between 3.6 and 4.4 m. Annual fluctuations due to plant uptake during summer and soil water recharge from groundwater each

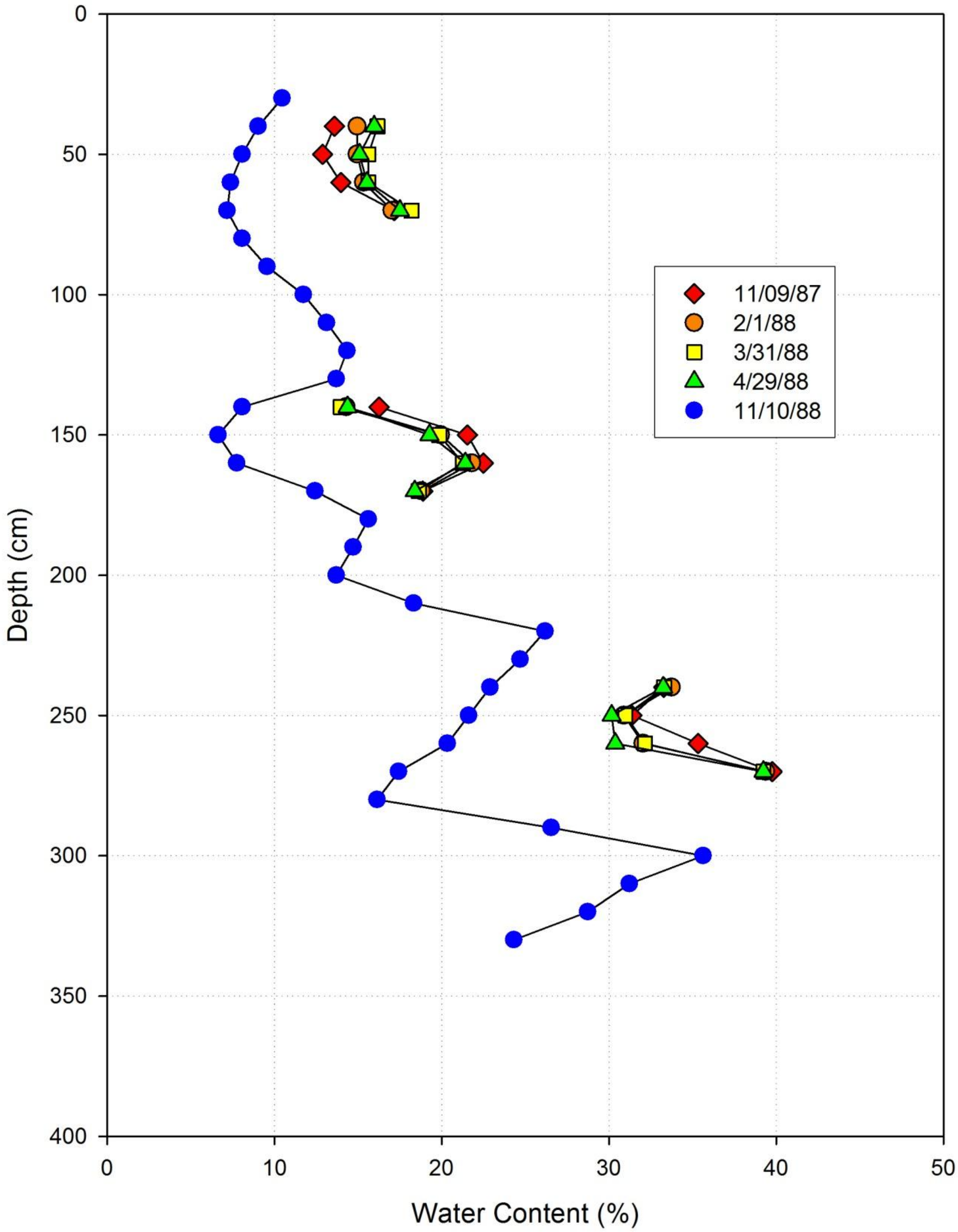

Figure 7. Soil water measurements at TS2 in the winter and spring 1987-88 and the first measurement of the entire profile in the fall of 1988 during a period of rapidly declining DTW.

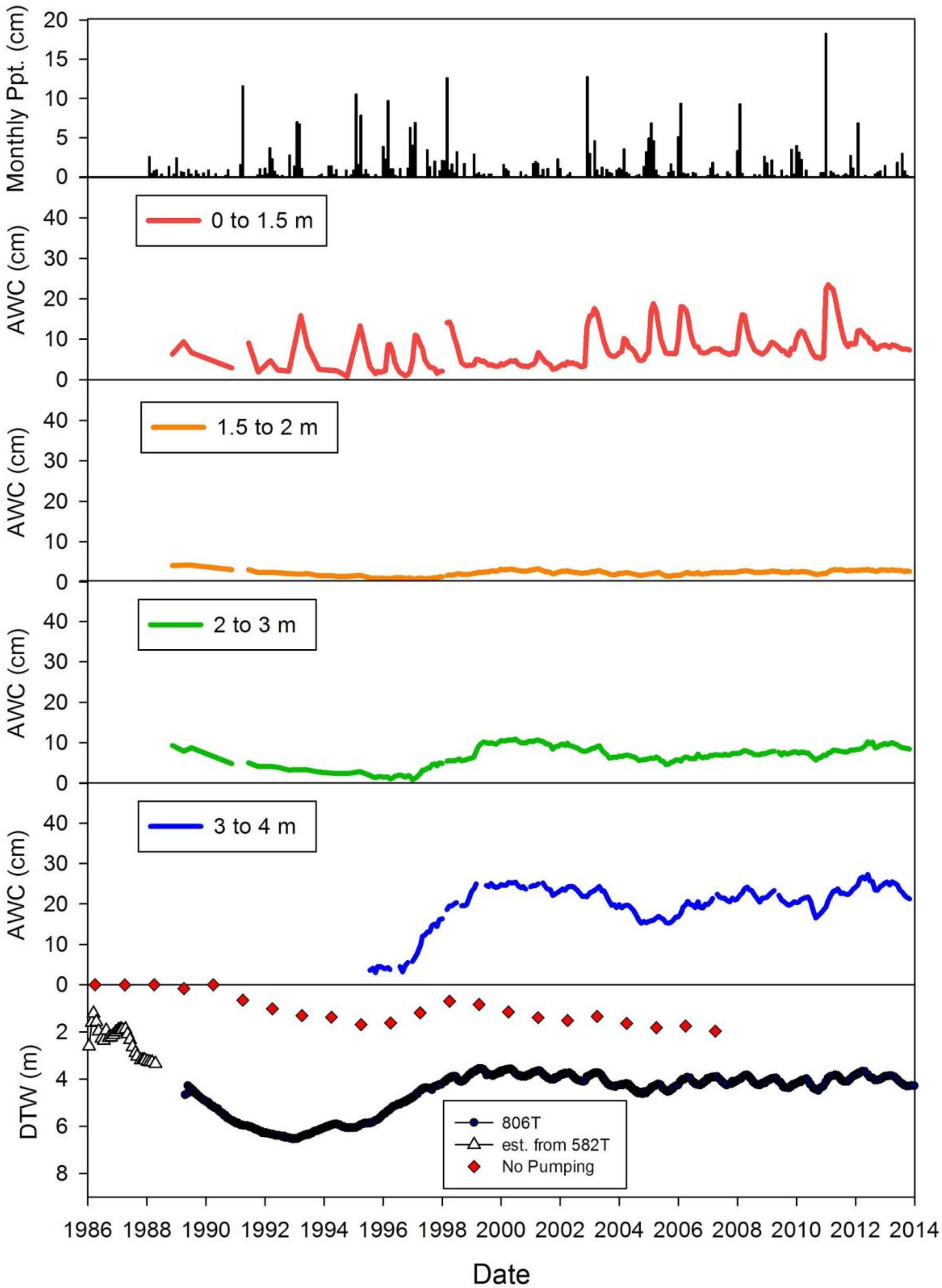

Figure 8. Average available soil water (AWC) stored in the soil profile and DTW at TS2. Top graph is monthly precipitation measurements at Independence measured by LADWP.

winter are evident below 2 m. Above 2 m in the grass root zone, the available soil water was stable and less than 2 cm of additional groundwater recharge occurred 1999 at any location within the site.

Monitoring site TS3

The soil was wetter in 1987-1988 than in November 1988, particularly in the upper 1.5 m of the profile (Figure 9). No data were collected between April 1989 and April 1994 restricting the analysis to a simple comparison that the soil in 1994 was drier than 1989 consistent with plant uptake and drainage occurring while the water table was declining.

Soil water in the top layer was near zero except for precipitation during the period 1994-97 (Figure 10). Soil water in the 1.3-2 m layer was also nearly exhausted by 1997. AWC in the deeper layers was low by 1997, but even at the lowest level, the sum of AWC below 2 m was approximately twice that available at TS1 and TS2. The water table at TS3 began to rise quickly in November 1997 and continued until it peaked in late 1998. AWC increased simultaneously in all layers and far exceeded that at TS1 or TS2. AWC in the top layer also responds to precipitation, but the groundwater contribution to the top layer was evident in 1999-2003 when annual increases in AWC occurred over winter despite the very low precipitation amounts. Groundwater continued to recharge AWC in all layers to the present.

Soil water trends in the lowest layer warrant additional discussion. AWC for the bottom layer is only calculated to a depth of 3.6 m rather than 4 m because high water tables hindered installation of monitoring tubes. As a result, the maximum AWC is less than is possible in a 1-m thick layer.   It was not possible to calculate an average AWC until 1996 when all depths at the four locations could be monitored. Note that the AWC rises sharply in 1998 and remains relatively constant except for decreases in 2003, 2004, 2009, and 2010 corresponding with declines in DTW. The constant AWC values represent saturated conditions below the water table. The maximum value of approximately 25 cm is consistent with the porosity of a sandy soil. Correlation analysis of data for this layer would suggest that DTW is not a significant influence on soil water. Clearly, such a conclusion would be untrue, highlighting the weakness in relying only on statistical methods.

Discussion

LADWP concluded that precipitation is the most important factor affecting soil water during the growing season at TS1 and TS2 and that soil water affects vegetation cover along the transect. The County agrees that precipitation is the predominant source of water present in the shallow layer above 1.3 or 1.5 m. The lack of a statistically significant relationship with DTW at TS1 is simply explained by the fact that groundwater has only affected AWC twice since 1991.

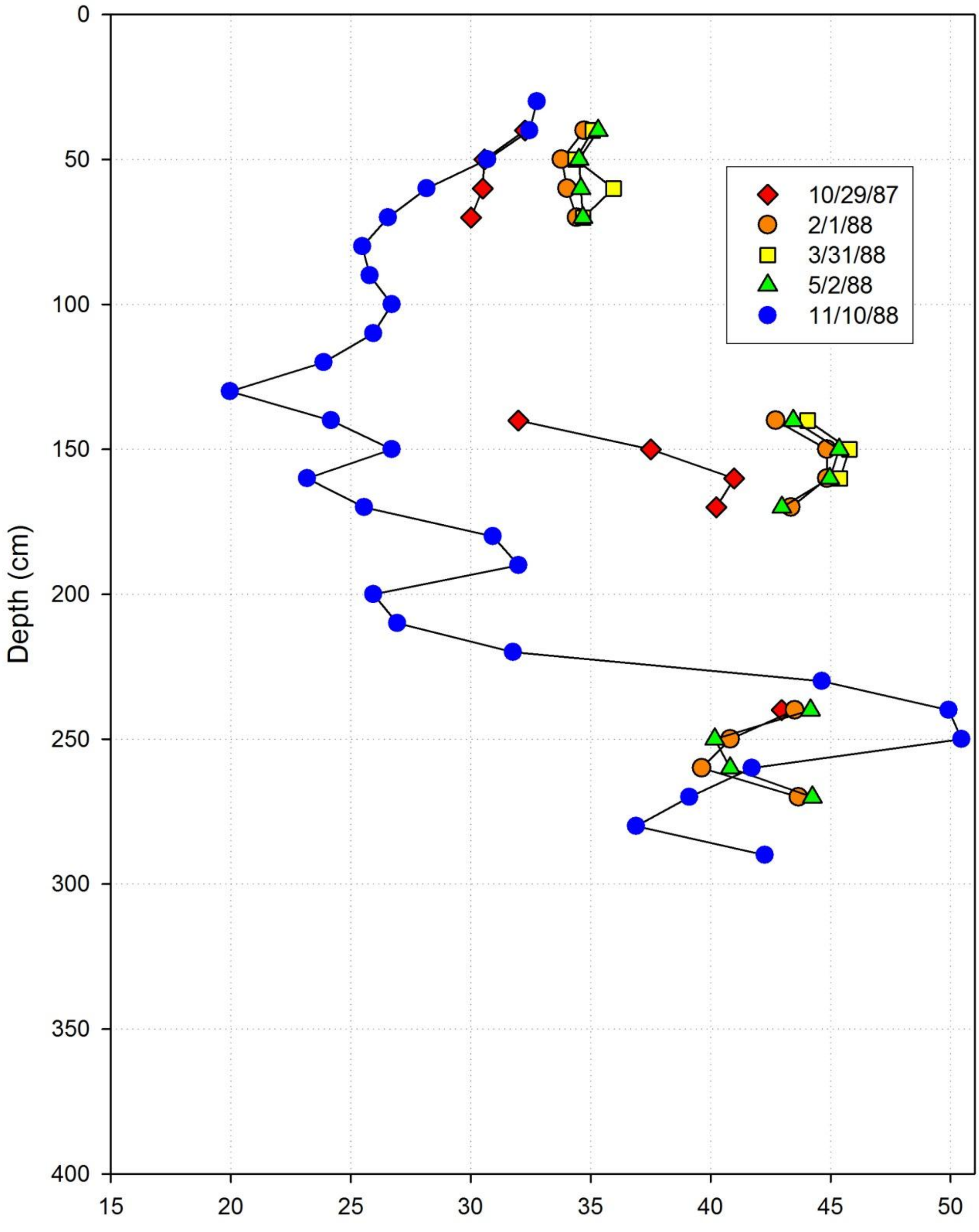

Figure 9. Soil water measurements at TS3 in the winter and spring 1987-88 and the first measurement of the entire profile in the fall of 1988.

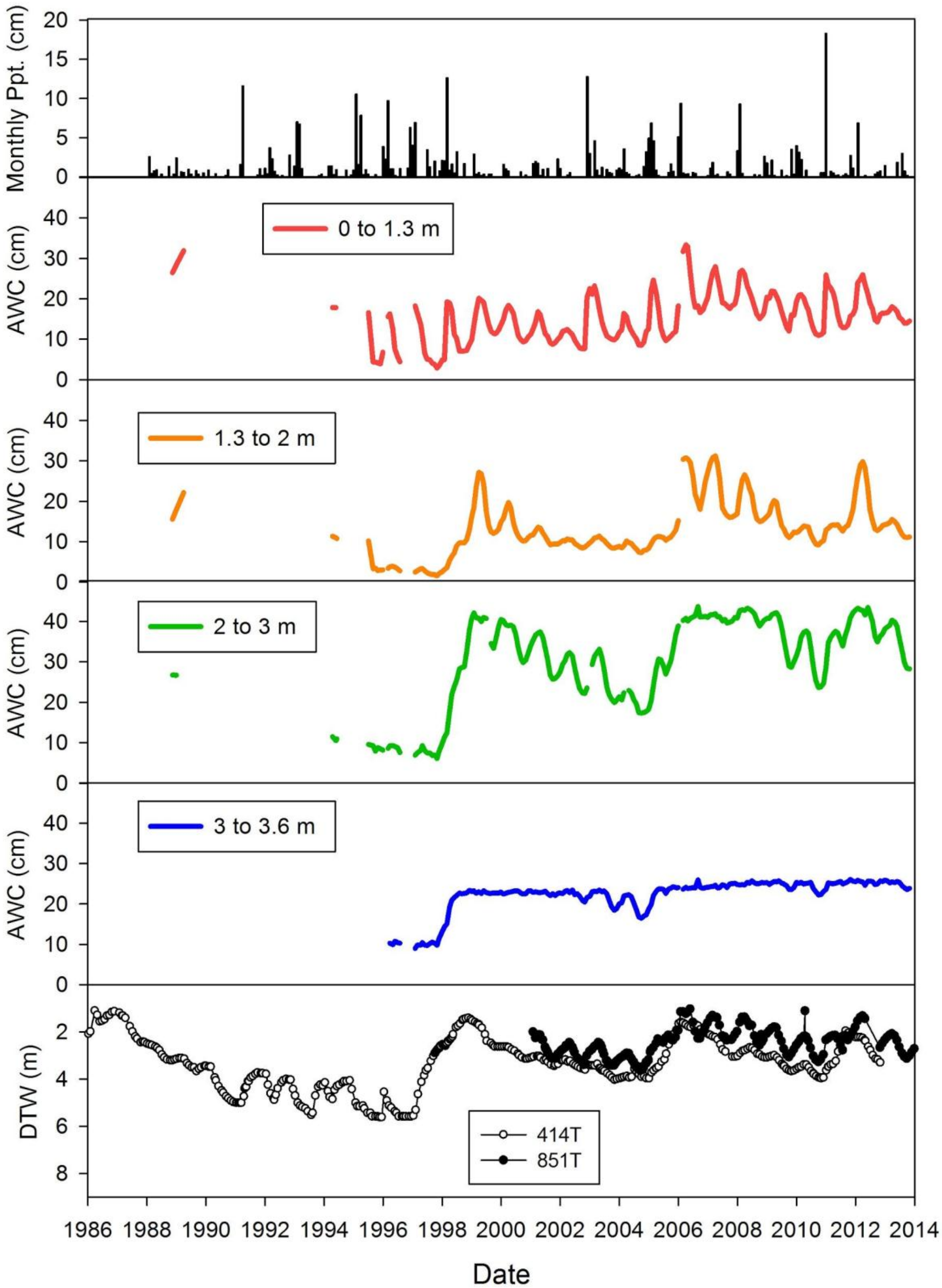

Figure 10. Average available soil water (AWC) stored in the soil profile and DTW at TS3. Top graph is monthly precipitation totals at Independence measured by LADWP.

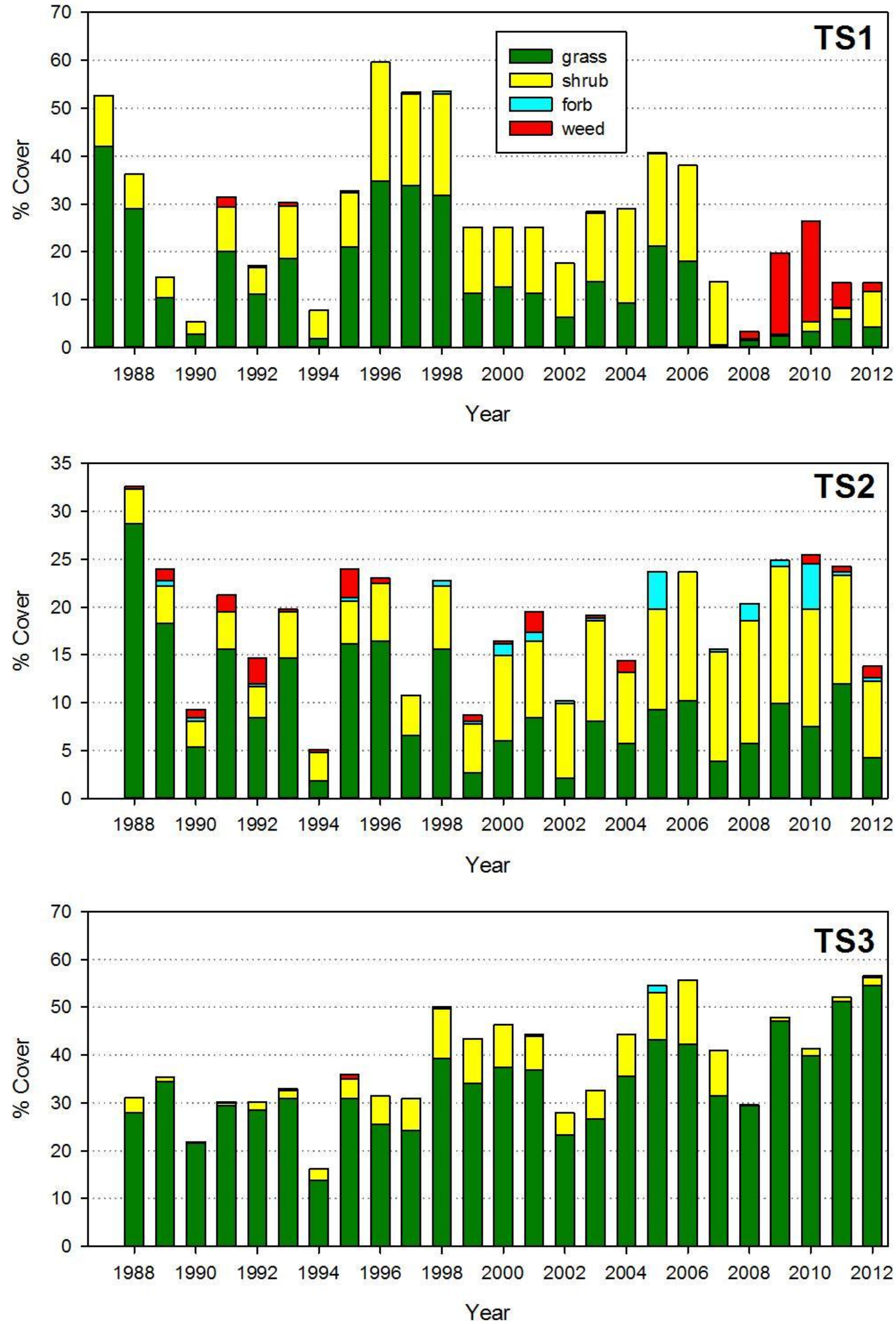

Figure 11. Vegetation cover by life form at TS1, TS2, and TS3 permanent monitoring sites. These are the same data in Figure 2 of ICWD (2011) updated through 2012.

However, the importance of even these isolated events of groundwater recharge to vegetation is apparent in the vegetation monitoring results. Vegetation cover was equal to or exceeded the initial measurement in 1987 only during 1996-98 corresponding with measurable available soil water derived from groundwater (Figure 11). The favorable vegetation cover during these three years cannot be simply due to the presence of precipitation in the upper layer as evidenced by the much lower vegetation cover in 2003, 2005, and 2006 that had similar AWC in the upper layer. The obvious conclusion is that the presence of groundwater promotes higher vegetation cover. Conversely, lack of groundwater recharge in the soil profile adversely affects vegetation at the site. In particular, grass cover at 1987 levels apparently cannot be sustained on precipitation alone. Neither of these conclusions should be startling given the widely accepted fact that phreatophytic plant communities are known to depend on shallow groundwater (Robinson, 1958; Nichols, 1994; Sorenson *et al*.,1991; Steinwand *et al*., 2006).

The situation at TS2 is similar to TS1 except in one important respect, the presence of groundwater below 2 m since 1997. Cover has remained below the initial measurement in 1988, and between 1988 and 1997 it fluctuated as soil water in the upper layer varied due to precipitation (Figure 11). Vegetation fluctuations were primarily due to changes in grass cover; shrub cover was relatively stable through this period. However, beginning in 1998 shortly after soil water below 2 m increased, the proportion of shrub cover increased greatly. Grass cover has remained much below levels measured in 1988. Restricting the groundwater contribution only to soil below 2 m favors deeper rooted shrubs at the expense of shallower rooted grass species. Precipitation alone cannot support the relatively high grass cover that existed in 1988.

Vegetation conditions at TS3 present a sharp contrast to TS1 and TS2. From 1987 to 1997, vegetation cover remained relatively stable as AWC declined. Total cover as well as grass cover increased dramatically in 1998 when the water table rose and wet the soil nearly to the surface. Grass cover and total cover actually exceeded the 1988 measurement within two years of the 2007 Inyo Complex fire in sharp contrast that recovery to the near complete failure of vegetation to recover at TS1 where AWC is much lower.

The Long Term Water Agreement standard to determine attributability is that;

> *“Decreases and changes in vegetation and other environmental effects shall be considered attributable to groundwater or to a change in surface water management practices, if the decrease, change, or effect would not have occurred but for groundwater pumping…”*

The County has shown using a groundwater model that LADWP pumping has lowered the water table at TS1 and TS2 in Blackrock 94 at least several feet compared to the no pumping scenario (Figure 1 and ICWD report). The groundwater model operates on an annual time step beginning April 1 each year. To assess whether DTW due to pumping contributed to the lack of AWC at TS1 and TS2, the groundwater model results were used to estimate DTW at the monitoring sites in the absence of pumping. The difference in water table elevation from the actual pumping and no pumping model scenarios was added to the DTW measurement collected on the date nearest to April 1 (Figures 6 and 8). In the absence of pumping, the water table at TS1 would have ranged between 1.9 and 4.2 m and would have fully recovered from drought to the 1986 depth (approximately 2.4 m) in 1997-1999. At TS2 the water table would have remained within the grass root zone between the soil surface and 2 m. Fluctuations due to varying runoff conditions and drought in the no pumping scenario are smaller than pumping and alone would not have lowered the water table sufficiently to eliminate soil water recharge from the water table at either site. Indeed the estimated water levels in the absence of pumping would have been similar to the actual water levels experienced at TS3, between 1 and approximately 4 m. It is apparent that pumping caused the lowered water table and lack of groundwater recharge to the root zone coincident with the vegetation decline that occurred at TS1 and TS2 in Blackrock 94.

Summary of Soil Water Analysis

LADWP employed faulty methods to assess the soil water conditions in Blackrock 94 and as a consequence presented an incomplete and incorrect assessment of the factors that affect soil water availability. To evaluate LADWP's conclusions, the County examined available soil water content for specific depth layers similar to LADWP. The assessment presented here corroborates conclusions presented in the County's 2011 report and suggests that groundwater pumping was the primary factor contributing to the lack of water availability measured at TS1 and TS2 in Blackrock 94.

Soil water present in the grass rooting zone (0-2 m) of the soil profile at TS1 and TS2 was due to precipitation except for brief periods in 1995 and 1996 at TS1 following water spreading. On this point the County and Los Angeles agree; however, we disagree on the implications of this observation. By comparison, soil water in the grass root zone at TS3 has been recharged by shallow groundwater during most of the monitoring period as well as by precipitation. Groundwater modeling results combined with measurements of DTW suggest that water table would have remained shallow enough at TS1 and TS2 to supply groundwater to the root zone in the absence of LADWP pumping. Site TS3 represents the expected condition of an alkali meadow with intact vegetation; sites TS1 and TS2 represent an impacted condition where the phreatophytic grasses have limited or no access to groundwater. It is reasonable to conclude that lack of available groundwater in the grass root zone due to LADWP pumping caused the decline in vegetation cover and in particular the decline in grass cover measured at the permanent monitoring sites TS1 and TS2 in Blackrock 94.

Vegetation

Background

The scientific discipline that investigates how hydrology affects ecosystems is referred to as ecohydrology. The types of scientific studies range from discovering basic hydrologic/vegetation relationships to detailed physiology studies of the movement of groundwater through soils and plants to the atmosphere. Plant physiology field studies have confirmed that soil and groundwater availability determines plant community leaf area and cover. Swings in vegetation cover in arid environments are controlled by the interaction of plant functional traits with fluctuations in the climatic water deficit (potential evapotranspiration PET - actual evapotranspiration AET). Actual evapotranspiration represents the simultaneous availability of biologically usable energy and water (Stephenson 1998). When the gap between potential and actual evapotranspiration widens owing to decreased water availability, plants respond by closing stomata, dropping leaves, partial xylem cavitation, or via other drought response traits; mortality occurs if the climatic water deficit is persistently incompatible with plant functional traits. The climatic water deficit, assuming that interannual variability in the potential evapotranspiration is stable, is affected by the seasonal distribution of infiltration from surface water and by water table elevation relative to the rooting distributions of the types of plants in the community. In shallow groundwater regimes, where the portion of the soil that is dry (at the limiting water content) is not deeper than plant roots, groundwater and the soil affected by capillarity above the water table provides the soil water necessary to meet the evaporative demand, plants can transpire freely and the climatic water deficit declines as transpiring plant surfaces increase. Thus soil water availability dictates the limits of vegetation cover in arid environments (unless limited by salinity or nutrient deficit). Precipitation, water spreading, irrigation and groundwater are the primary inputs that affect available water content of soil at Blackrock 94. Groundwater can add soil water if the water table rises into the root zone or through capillarity. Capillarity draws groundwater into a zone of unsaturated soil above the water table called the capillary fringe. Because rooting depth is limited, the effect that water table depth has on vegetation cover is strong until the capillary fringe falls beyond the maximum rooting depth. The response of vegetation to a varying water table is thus non-linear. When the capillary fringe declines beyond reach of the root zone, precipitation and surface water spreading then become the only hydrological inputs that affect vegetation; and when such transitions occur, cover decreases to equilibrate with diminished available soil water (Naumburg, *et al.*, 2005; Elmore *et al*., 2003; Elmore *et al*., 2006; Patten *et al*., 2008; Cooper *et al*., 2006).

The main disagreement between the County's explanation of the observed vegetation change in Blackrock 94 and LADWP's explanation is that the County believes the decline in vegetation cover is attributable to the decline in the groundwater elevation. LADWP believes that the decline in vegetation cover is not attributable to the decline in groundwater elevation.

Rather LADWP believes that the decline in cover is attributable to wet/dry climatic cycles represented by normal fluctuations of runoff and valley floor precipitation. The County recognizes that natural variation in runoff is a factor in the analysis; however, the evidence presented by the County has shown that pumping exerts a greater control on the groundwater system.

The purpose of the attributability analysis is to address the question:

Decreases or changes in vegetation and other environmental effects shall be considered "attributable to groundwater pumping...if the decrease, change, or effect would not have occurred but for groundwater pumping ***(***Water Agreement Section IV.B).

In answering the question, "would the vegetation change have occurred but for pumping?", an estimate of groundwater depth and vegetation cover at baseline was required to quantify the relationship between depth to water and vegetation cover for shallow groundwater hydrological regimes when the climatic water deficit approaches zero. Next, an estimate of the magnitude of drawdown attributable to pumping was required. Finally, the change in vegetation attributable to pumping was estimated based on a site-specific statistical relationship between depth to water, precipitation and vegetation cover. This was accomplished by adding the change in depth to water attributable to pumping to the observed depth to water to compute the predicted vegetation cover value under the hypothetical scenario of no pumping. The difference between observed vegetation cover and vegetation cover predicted under the no pumping scenario is the estimate of vegetation change attributable to pumping.

Vegetation Data

The ICWD line point data set provided an annual quantitative measure of the parcel average vegetation cover from 1991 to 2013. The challenge in using this dataset to address the question of whether vegetation change is attributable to pumping-induced drawdown, is that baseline measurements represent the only data point associated with depth to water levels within the grass root zone. The County has provided the arbitrators with extensive material concerning the strengths and weaknesses of the line point data sets (Inyo Attachments 10, 12, 18, and 22). One of the deficiencies of the line point data for statistical analysis is that the period 1987 to 1990, when the drawdown and grass decline occurred is not represented in the line point data. Spectral mixture analysis (SMA) of satellite imagery provided an annual cover estimate for the parcel from 1984 to 2011. This dataset was used to develop statistical models because average cover values are derived from the entire parcel, thus there is no sampling error associated with sample size and spatial dispersion of transects, and cover values were available for the period 1987 to 1990, a period unavailable in the line point data. Using SMA also addresses the problematic comparison between baseline data in which the transect locations

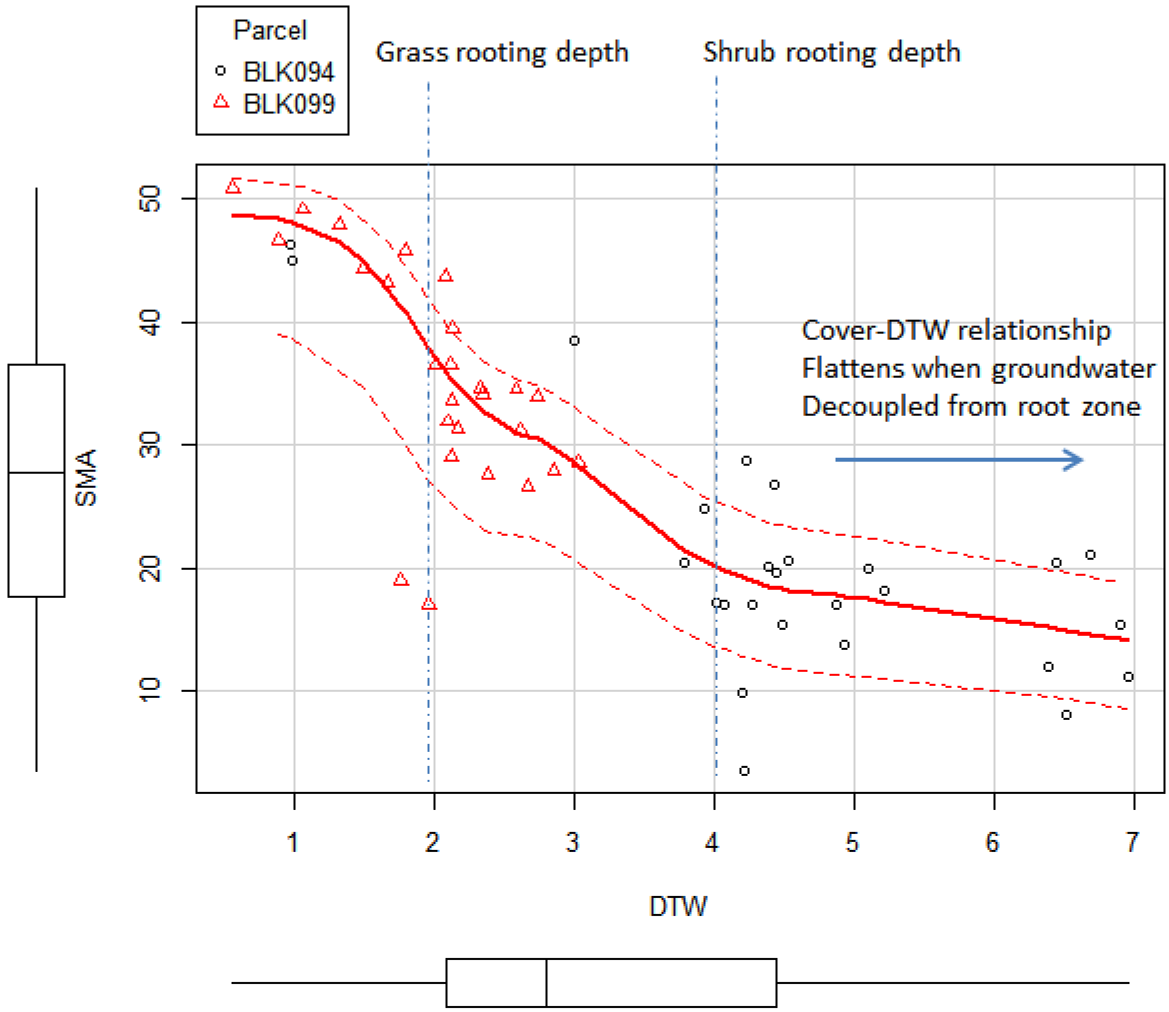

Figure 12. Fractional cover of green vegetation (derived by SMA) as a response to depth to water in both Blackrock 94 and 99. The trend line in vegetation cover is derived from locally weighted scatterplot smoothing (LOESS). The range encompassed by the dotted lines represents the 95% confidence interval. The four outliers below the confidence intervals are after 2007 fire.

are unknown and subsequent line-point data collected by ICWD and LADWP (LADWP report, pages 4-5). The SMA data were originally provided in the ICWD report (2011) and subsequent exchanges of data with LADWP.

Ecohydrology Conceptual Models: ICWD vs. LADWP

The County's line point data showed a parcel-average grass cover decrease from 29% in 1986 to 8.5% in 2012 (Inyo Attachment 25). Since 2000, grass cover has averaged 12% and varied between 7.5 and 19.4% suggesting the decline is persistent. This grass cover decline is the primary reason change has been detected in other metrics including: (a) decline in overall perennial cover, (b) decline in proportion of grass, (c) increase in proportion of shrub and (d) change in community composition. When groundwater levels declined beyond the level sufficient to wet the root zone in the late 1980s, grass dieback occurred as evident in the grass cover in the first measurement in 1991 (15.6%). Following the drawdown of the late 1980s, the remaining grass persisted solely on surface water (i.e., precipitation, spreading, irrigation tailwater). This effect is apparent when the relationship between cover and depth to water is plotted over the range of depth to water values observed in Blackrock 94 and its neighboring parcel to the south, Blackrock 99 (Figure 12).

After groundwater declined past 4 m depth, the influence of groundwater on cover diminished as plant roots could not reach the capillary fringe of the water table. Vegetation cover changed the fastest when certain depth to water thresholds were crossed. At 2 to 2.5 meters depth, water availability to grass roots diminishes (Elmore *et al.*, 2006) and this expected response is apparent in the data; and at 4 meters, shrubs begin to lose contact with groundwater and another inflection point in the data was evident at this depth (Figure 12).

LADWP proposed an alternative conceptual model. Using line point data (1991-2013), collected after the major drawdown in the late 1980's, LADWP found a relationship between vegetation cover, and the hydrological variables: runoff, depth to water, spreading, and precipitation. For the dataset used by LADWP that excludes 1987-1990, grass cover was more strongly correlated with water-year precipitation (r = 0.64) and runoff (r = 0.63) than with depth to water (r = -0.39). LADWP concluded that pumping-induced change in groundwater was not as important as precipitation and runoff in influencing grass cover:

> *It is apparent that with wet climatic conditions (period of wet years and high precipitation), vegetation cover increases. When dry climatic conditions (period of dry years and low precipitation) are prevalent, vegetation cover decreases, regardless of fluctuations in DTW and groundwater pumping* (LADWP report, p.85).

The statement that vegetation cover decreases, regardless of fluctuations in depth to water and groundwater pumping, is not generalizable to shallow groundwater conditions; and it is the shallow groundwater condition that is most relevant to the evaluation of vegetation change attributable to pumping. When groundwater is decoupled from the grass root zone, vegetation cover responds to precipitation to a greater extent since water availability is then controlled solely by precipitation (Elmore *et al*, 2006).

The first flaw in LADWP's interpretation of regression models is to assume relationships in its model are valid outside of the range of data that was considered. A response to precipitation when groundwater is absent does not logically lead to the conclusion that a shallower water table would have no effect on vegetation cover. The second flaw in

LADWP's interpretation is to assume that its model structure is an appropriate characterization of the ecohydrological system based solely on R^2 values and p-values. The omission in LADWP's "best model" is the shallow groundwater hydrological regime that would have been present in Blackrock 94 but for pumping. It is the shallow groundwater regime not included in LADWP's conceptual model that is of interest in answering the question of whether the vegetation change would have occurred but for pumping, and LADWP's failure to recognize this critical fact resulted in its evaluation of whether cover change was attributable to pumping being based on data too narrow in scope to adequately address the question.

Cause and effect inferences using correlation should be based on meaningful biological processes that have a direct mechanistic linkage to the response variable. If variables indirectly related to the hydrologic factors that affect plant cover are used, the interpretation of the correlation results to infer direct cause and effect mechanisms is obscured. LADWP included an indirect variable in its analyses, the annual value for Sawmill Creek runoff. Presumably this indirect variable was chosen because of strong univariate correlations with vegetation cover. However, runoff influences soil water through recharge of the aquifer or direct infiltration, and is thus highly correlated to depth to water (r = -0.85). Runoff is also positively correlated with surface water spreading; and at the valley-wide scale, runoff and precipitation are also highly correlated. It is not surprising that runoff is correlated to vegetation cover because the information contained in the runoff variable combines information contained in depth to water, surface water spreading, and precipitation variables which actually drive water availability and vegetation cover. LADWP includes all of these related variables in its full model, even though this guarantees multicollinearity and invalidates the meaning of the regression coefficients. Including both runoff and depth to water in the same multiple linear regression model, for instance, forces one of these variables to be redundant and obscures the physical mechanisms causing the regression results (i.e. depth to water in the model was positive rather than negative). LADWP interpreted the nonsensical signs of the regression coefficients to mean that the variable with the reversed sign should be excluded from further consideration. LADWP's final model, that was considered the best explanation for vegetation change, included the positive influence of precipitation and the positive influence of runoff. The model predicts that for every inch of precipitation there is a corresponding 1.8% increase in vegetation cover. For every 1000 acre feet of runoff, there is a corresponding 6% increase in cover.

$$\%\text{vegetation cover} = 1.8 \text{ x } (\text{precipitation inches}) + 6 \times \left(\frac{\text{runoff}}{1000 \text{ ac} - \text{ft}}\right) - 4.5 + \varepsilon$$

Since the data spanned 2376 to 5919 ac-ft of runoff, this represents a 6 x 2.3 = 13.8 % to 6 x 5.9 = 35.4% percent control over vegetation cover during the period represented by the data set (1986, and 1991-2013). Again, because runoff and depth to water are related, it cannot be stated with certainty, that runoff and not depth to water is actually controlling cover.

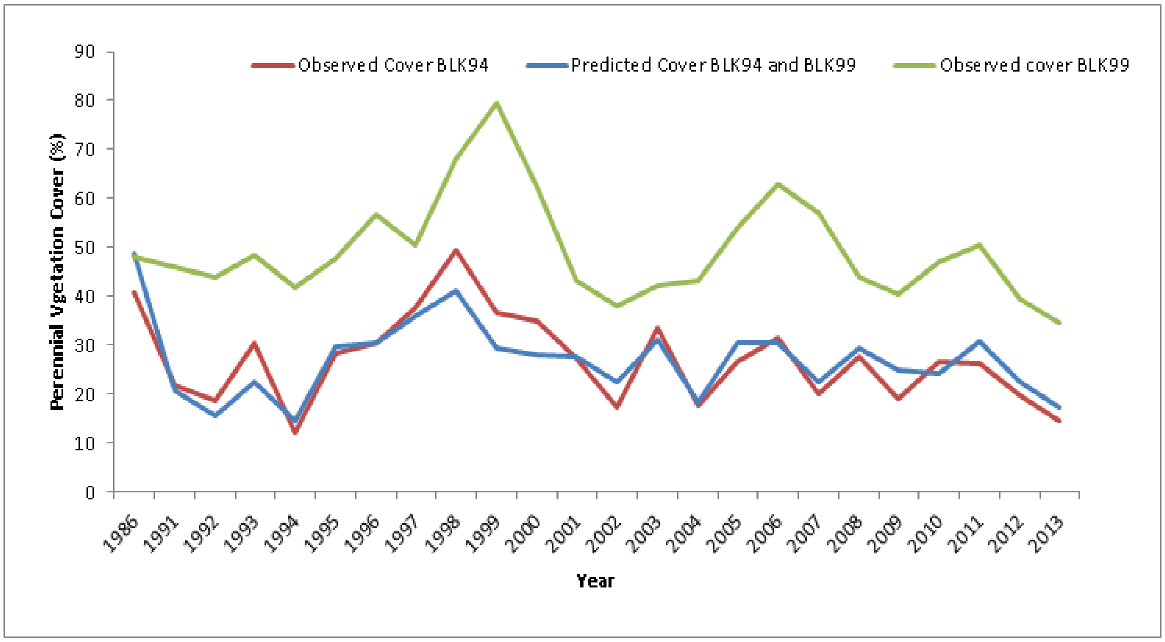

Figure 13. Observed vegetation cover (line point data) in Blackrock 94 and Blackrock 99 compared to predicted vegetation cover of both parcels using LADWP's model.

The LADWP model fits the measured cover values at Blackrock 94 well, (Figure 13), but the fundamental weakness of the model is that it cannot be used to examine the primary purpose of this analysis: would vegetation cover had changed in Blackrock 94 if pumping had been different? LADWP's model excludes depth to water as a variable, so response of cover to a different depth-to-water scenario or different meadow sites cannot be evaluated. For example, because differences in precipitation and runoff between Blackrock 99 and Blackrock 94 are negligible, this model would predict the same cover in both Blackrock 99 and Blackrock 94 despite similar initial vegetation. In this case, LA's model would underestimate cover in Blackrock 99 significantly (Figure 14).

LADWP misspecified its model of vegetation cover by only considering data collected after the most important depth to water threshold had been crossed. The County agrees that precipitation is a good explanatory variable for fluctuations in vegetation cover under conditions where groundwater is not accessible. That is not in dispute; however, that situation is indicative of an impacted condition caused by diminished water availability. If the water table or capillary fringe contacts the root zone, the level of cover that can be supported is much higher than cover supported solely by precipitation or infrequent spreading. While all these hydrological inputs influence soil moisture, the proper question in an attributability analysis is not whether or not there is a relationship between precipitation and cover over a narrow range of depressed depth-to-water values. The important questions are what are the relative magnitudes of the effects of

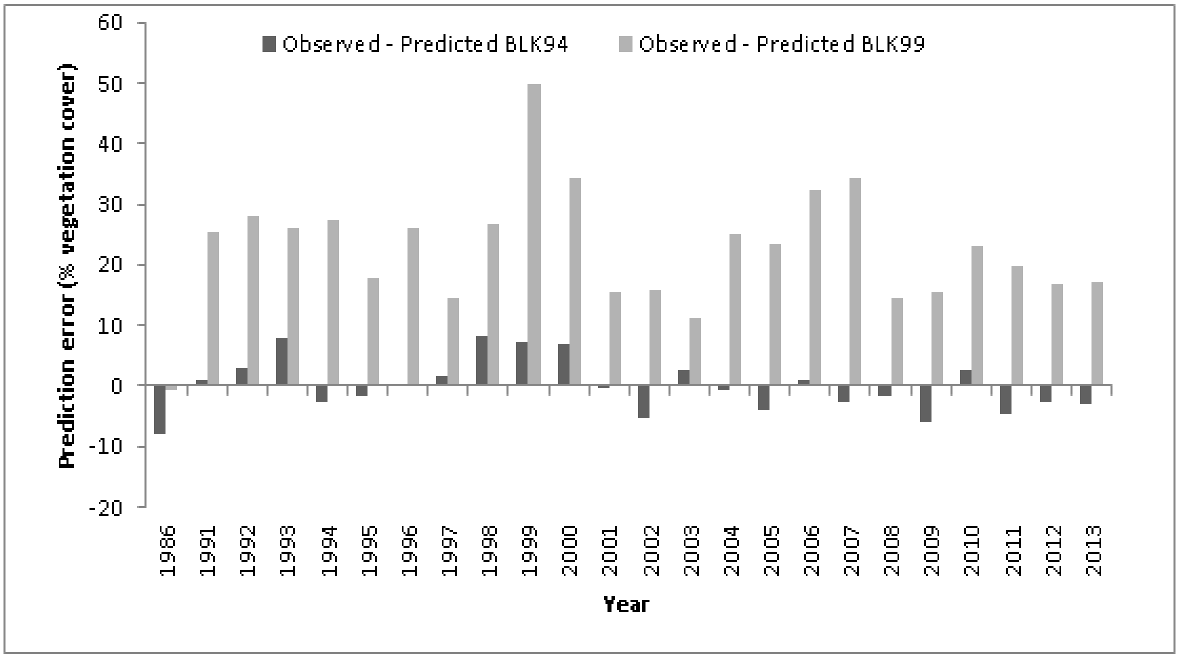

Figure 14. Prediction error when using LADWP's vegetation cover/precipitation/runoff relationship to predict cover in Blackrock 94 and Blackrock 99.

the different hydrological inputs (i.e. precipitation) on cover, and how do these effects change depending on other hydrological variables that influence soil water (i.e. depth to water). Because LADWP's model cannot be used to answer those questions, an alternative regression model was developed. Those results are discussed in the next section.

Cover, Precipitation and Water table Relationship

An appropriate model to assess whether changes in vegetation are attributable to LADWP operations relates cover to hydrological inputs that directly affect vegetation. Since pumping affects vegetation by altering depth to water, it is necessary to include depth to water in the model to link vegetation response to LADWP management actions. The task of the analyst is to find the relationship between cover and depth to water if it exists. Discovering the relationship may not be straightforward because it can be obscured by other factors that affect cover including precipitation or it may contain thresholds making some analyses using linear statistical methods unsuitable (including those in LADWP's report).

Vegetation cover responds to soil moisture from precipitation or groundwater. When the root zone is in contact with groundwater or the capillary fringe, cover will remain high regardless of the precipitation amount because water is in ample supply and doesn't limit growth. When groundwater is too deep to provide soil water to plants, the vegetation dies back

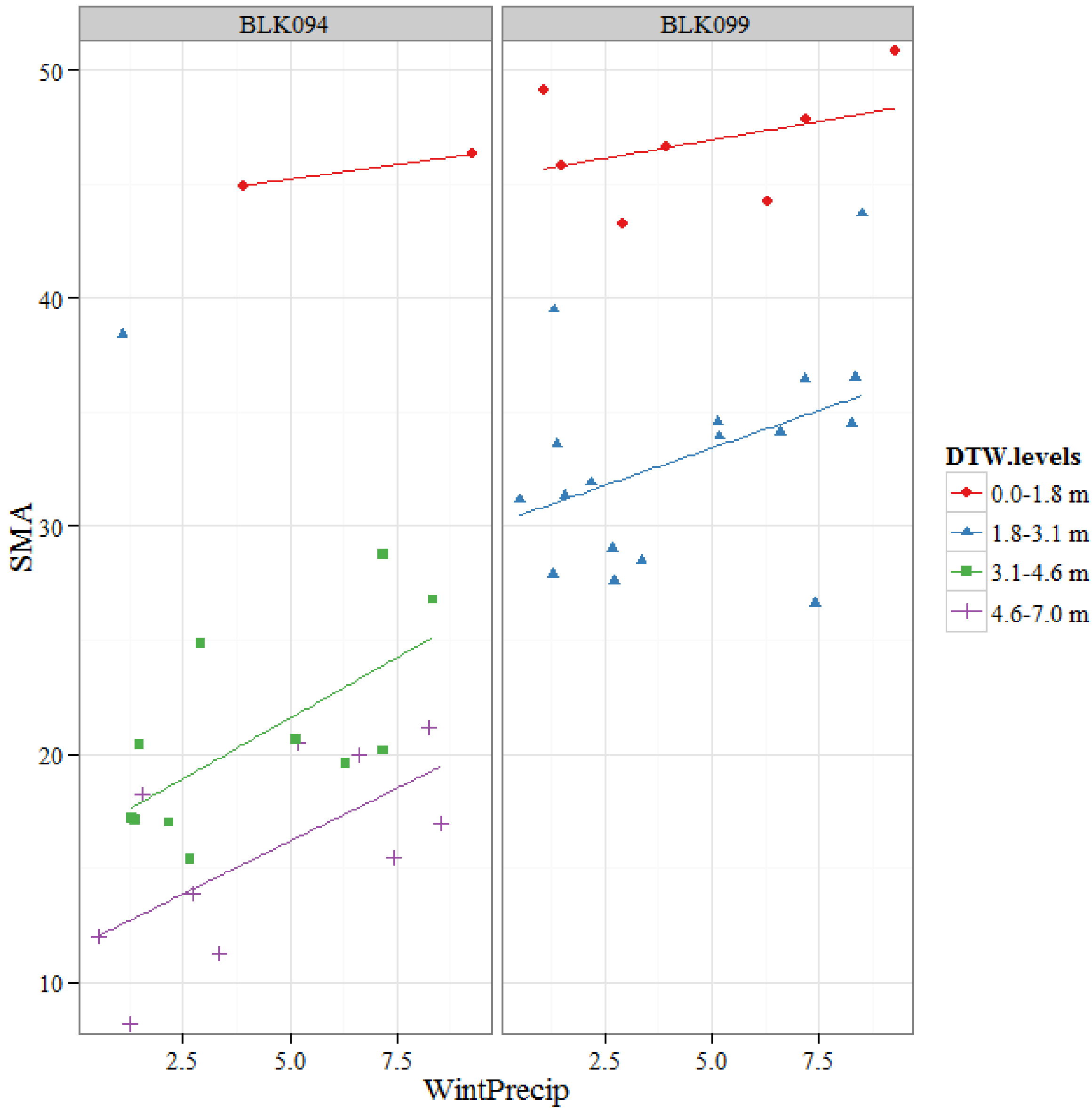

Figure 15. Vegetation cover derived by SMA of satellite imagery explained by depth to water and precipitation in Blackrock 94 and 99.

such that the transpiration demand of the remaining plants can be met by precipitation alone. Elmore et al, (2006) suggested alkali meadow cover responds to depth to water when it is shallower than 2.5 m consistent with the approximate 2 m root zone for the dominant grass species (Green Book, p. 82). The County hypothesized that the influence of precipitation should change as a function of depth to water and the relative effect of depth to water on vegetation cover should be greater than precipitation over the observed range depth to water (0.96 to 6.96 m) and winter precipitation (1.57 to 10.21 inches).

The hydrological and vegetation cover conditions in Blackrock 94 during baseline were similar to Blackrock 99. However, during the 1987-1990 period of increased pumping, the drawdown in Blackrock 99 was not as great as in Blackrock 94 (ICWD report, Figure 13, p. 38). Therefore, the relationship between cover, depth to water, and precipitation could be quantified over this critical range of depth to water values that would have occurred in Blackrock 94 but for pumping. Blackrock 94 only had depth-to-water values above 1.8 m in 1986 and 1987. By combining the data from the two parcels, vegetation response can be quantified over the entire range from shallow groundwater hydrologic regimes present in Blackrock 99 (and the no pumping scenario for Blackrock 94) as well as deep groundwater present in Blackrock 94 for most of the 1990's (Figure 15). Combining data for the two parcels for model development is also justified by the similar initial vegetation conditions, precipitation, and soils.

The SMA-derived vegetation cover data, depth to water values from the County's ordinary kriging (Inyo Attachment 24), and winter precipitation values measured at Independence by LADWP for both parcels every year from 1986 to 2010 (except 2007 and 2008 to remove the effect of a fire that burned through both Blackrock 94 and 99) were used to develop a multiple linear regression model that characterizes change in cover as a response to precipitation and depth to water. The structure of the model includes depth-to-water as a factor where different depth-to-water levels allow a unique response (i.e. different slopes) to precipitation (Figure 15). The depth-to-water levels were chosen based generally on rooting depths of grasses and shrubs and the specific numerical thresholds were chosen according to natural breaks in the dataset. The model suggests that at shallow groundwater regimes (0-1.8 m), for every inch of increase in precipitation, cover increases by 0.23%. The effect of precipitation on cover was similar for the 1.8 - 3.1 m depth-to-water range, but increased for deeper groundwater levels, ranging between a 0.7% and 0.8% increase in cover for every inch of added precipitation over the 3.1 to 7 m range. Between baseline and 2010, winter precipitation varied from 0.52 - 9.27 inches. The strongest precipitation effect occurred under deep groundwater hydrological regimes and under these conditions, 9.27 inches of winter precipitation could influence cover by at most 7.4%. At shallower groundwater levels, this precipitation effect could at most command a 2.1% control over vegetation cover. These responses to precipitation are small compared to the vegetation cover response to depth of groundwater evident from the large differences in the range of cover values that occurred at the different water-table depths (Figure 16).

The model predicts that declines in groundwater from the 0 - 1.8 m range to the 1.8 - 3.1 m range reduces cover by 12.7%. Within this range, grass roots likely receive some soil moisture from capillary rise of groundwater. Water table decline to the 3.7 to 4.6 m range is associated with a 25.3% decrease in cover. This is the range where depth to water has declined beyond the reach of grass roots but shrubs, having greater rooting depths, may still access soil water from groundwater. As groundwater declines to 4.8 - 7 m, cover decreases by 30.5%. In this range of groundwater depth, shrub roots can become decoupled from groundwater.

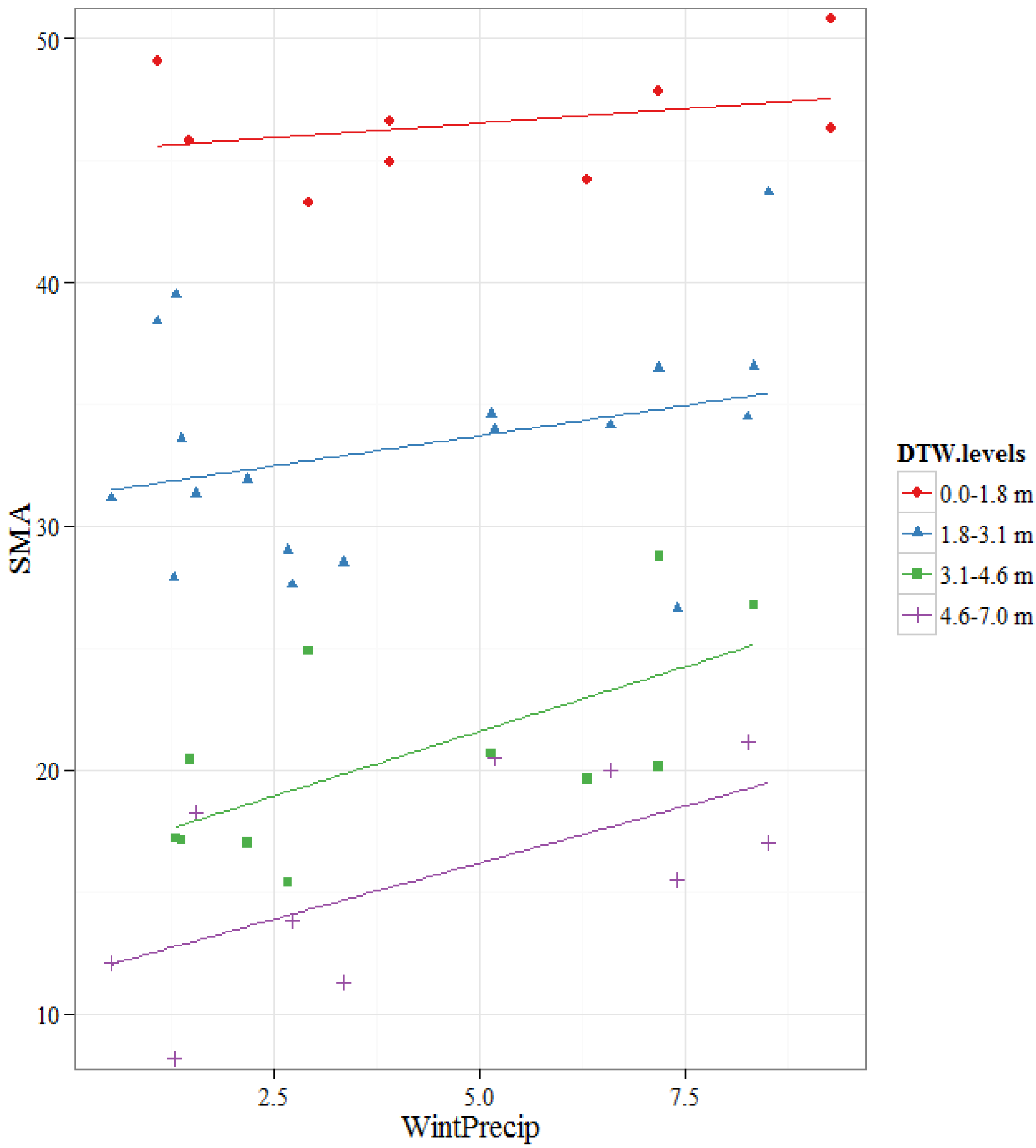

Figure 16. Graphical representation of the effect of both winter precipitation and depth to water on vegetation cover (derived by SMA of satellite data) for Blackrock 94 and Blackrock 99 combined datasets.

Table 2. Estimates of regression coefficients of ICWD's regression model explaining vegetation cover in terms of depth to water and winter precipitation. The estimates are interpreted as the effect size or relative influence each variable unit (i.e. meters or inches) has on percent vegetation cover. All regression coefficients are statistically significant (P-value <0.05).

Coefficients:	Estimate	Std. Error	t value	P-value
Intercept (i.e. DTW 0.0 -1.8 meters)	43.2873	1.5849	27.312	< 2e-16 ***
Winter Precip (inches)	0.6465	0.1934	3.343	0.00173 **
DTW 1.8 - 3.1 (meters)	-12.6800	1.5404	-8.231	2.23e-10 ***
DTW 3.1 - 4.6 (meters)	-25.2760	1.6933	-14.927	< 2e-16 ***
DTW 4.6 - 7.0 (meters)	-30.4537	1.7255	17.649	< 2e-16 ***

The depth to water thresholds, corresponding to rooting depths of grasses and shrubs, have an influence on vegetation cover four times greater than that of precipitation.

Between different depth to water levels, the relationship between precipitation and vegetation cover only varies by about 0.6% (i.e., 0.82% - 0.23%) vegetation cover for each inch of precipitation. This difference although real is small in magnitude compared to the depth-to-water effect, and the difference in slopes was not significant between the depth-to-water levels. Thus the model can be simplified to a parallel slopes model, using one precipitation response for all depth-to-water levels (0.6% cover increase for each inch of precipitation).

The simplified model with one precipitation effect for all depth to water ranges, explained 89% of the variance in vegetation cover over both Blackrock 94 and 99 (Adjusted R^2 = 0.89, $p < 0.0001$, Table 2). The general form of the model should be applicable to other areas but differences in soil properties and vegetation composition would necessitate site-specific parameterization.

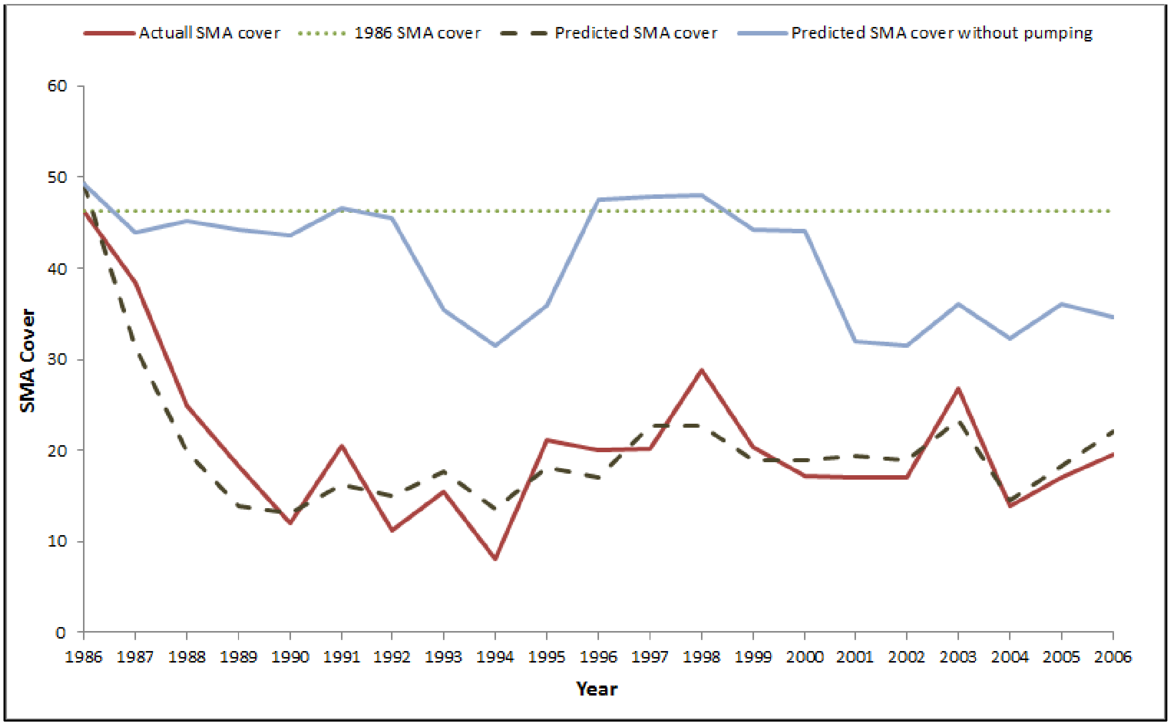

Figure 17. Actual cover in Blackrock 94 measured using SMA and predicted cover based on the no pumping groundwater model and ICWD's regression model. The 1986 SMA cover is shown as a reference to baseline cover.

Change in Vegetation Cover Attributable to Pumping

The magnitude of vegetation change attributable to pumping was estimated using ICWD's regression model in Table 2, precipitation measurements, parcel depth to water estimated from ordinary kriging (see Inyo Attachment 24), and the results from the groundwater flow model. Average depth to water for Blackrock 94 during baseline was about 3 feet according to ICWD's depth to water estimate (ICWD report, Figure 13, p.38). The USGS regional groundwater flow model for the Owens Valley (Danskin 1998), indicates that pumping caused the groundwater elevation to decline about 10 ft (3.1 m) in addition to the 3-4 ft declines associated with runoff variability.

The difference in water table elevation from the actual pumping and no pumping groundwater model scenarios was added to the parcel-averaged kriged depth to water to provide an estimate of depth to water in Blackrock 94 without pumping. Estimated depth to water for the no pumping scenario and precipitation measurements were used as input for ICWD's regression model (Table 2) to estimate the parcel-average vegetation cover values in Blackrock 94 if pumping had not occurred (Figure 17). Given the estimated depth to water in 1986 of 0.97 m, ICWD's regression model predicts 43% cover with no precipitation and 49%

cover with 10 inches of precipitation. Model-predicted cover using the kriged depth to water and measured precipitation replicated measured changes in SMA cover well (Figure 17). Using the estimated no pumping depth to water, the model predicts cover would not have declined dramatically and would have remained at or just below the cover in 1986. This is consistent with the expected vegetation response if the water availability had not been reduced by pumping, similar to conditions experienced in Blackrock 99 (Figure 13). Pumping, not fluctuations in runoff or precipitation, is the primary reason vegetation cover declined in Blackrock 94.

Composition change

Ordination of species cover using Non-Metric Multi-Dimensional Scaling (NMDS) reveals plant community composition differences between years, especially baseline composition compared to reinventory years. The County and LADWP agree that the primary source of variation in community composition over time is due to changes in grass cover. However, LADWP concluded that statistically significant changes in composition from baseline are not true changes in species relative cover, but rather the change is a false detection caused by differences in monitoring locations between the baseline inventory and later sampling. LADWP's conclusions only apply if the baseline data are an inflated estimate of the true 1986 average parcel cover and in particular grass cover. LADWP states:

> *The high heterogeneity within the parcel is the most important factor responsible for the measurable changes in species composition within Blackrock 94. However, if climatic conditions become similar to those runoff patterns prior to and during the initial inventory period or the wet period during the late 1990s, then the overall average community composition of Blackrock 94 will likely become similar to the initial inventory.* (LADWP report, page 85)

In the second sentence, LADWP contradicts its own conclusion by stating that composition will become similar to baseline if similar climatic conditions return, implying composition had actually changed. LADWP also concluded elsewhere that a decline in grass cover had occurred while shrub cover remained stable. The change in grass cover, that both LADWP and ICWD acknowledge as the primary vegetation change (see Agreements section above), is incompatible with LADWP's contrary conclusion that differences in composition are due to an inflated baseline cover estimate.

LADWP asserts that different sampling methods between baseline and later monitoring programs caused the false detection of vegetation change in the parcel. This hypothesis has been put forth previously to suggest the change was not measurable, but is presented in LADWP's report supported by new analyses to assert the change is not attributable to pumping. This hypothesis was addressed by the County previously (Inyo County Brief Attachments 12, 18, and 22) and shown to be incorrect, but here we explain why LADWP's hypothesis fails, and moreover, why its methodology is incapable of testing the hypothesis.

LADWP's primary mistake again is to evaluate spatial variability in sampling data collected 1991-present, after the impact alleged by the County occurred, to test whether the different sampling methods caused the measured change in vegetation since baseline. That reasoning and methodology is inherently circular. LADWP reasons that vegetation differences exist across the parcel after baseline and this is why the later samples are different than baseline. The analysis lacks the necessary information on variation in vegetation in 1986 that shows the baseline sampling overestimated total perennial cover and grass cover by insufficiently sampling low cover, non-meadow areas. In other words, to test LADWP's hypothesis one must show that the sampling locations during the baseline provided an inaccurate picture of the parcel in 1986, which cannot be inferred from LADWP's analysis of samples collected after 1991 during a period of drought and severe water table decline. Deficiencies of the baseline dataset and methods are well known and unfortunately the required information to assess whether baseline transects were biased to locations with higher-than-average cover was not recorded. New lines of reasoning in LADWP's report regarding the adequacy of baseline sampling are unconvincing. For example, LADWP made the observation that two of the nine baseline transects (22%) crossed sagebrush and then concluded that this was an under-representation of non-meadow vegetation at baseline because their analysis of conditions after 1991 shows a much larger portion of the parcel is not meadow. However, approximately 18% of the parcel is Cartago soil which should naturally support some sagebrush. The similar proportions (22% and 18%) are evidence that the Cartago soil may have been appropriately represented in the baseline dataset.

LADWP partitioned the northwest and southeast portions of Blackrock 94 based on the NMDS 3-axis solution, in particular axis 1, which is essentially a grass to shrub-dominated gradient across the parcel. LADWP divided the set of monitoring transects into two groups based on the distance from baseline along this grass to shrub gradient, and then mapped these transects groups to inform its delineation of the northwest and southeast portions of the parcel. Clearly, LADWP is comparing individual transects or portions of the parcel to the average conditions representing the whole parcel during baseline. This apples to oranges comparison invalidates LADWP's analysis of variation across the parcel to test whether the change from baseline is real. For example, a transect with grass cover in 1993 similar to the baseline average may actually reflect a change in vegetation if grass cover in 1986 at that location was greater than the baseline average. Unfortunately, the necessary information on variation in cover across the parcel during baseline to determine which possibility is more likely does not exist and has not been developed to support LADWP's conclusions.

LADWP, found that species composition in the non-meadow community (the northwest portion) has been measurably different from the initial inventory every year since 1991 (LADWP report p. 85). In other words, the northwest portion contained transects during the reinventory

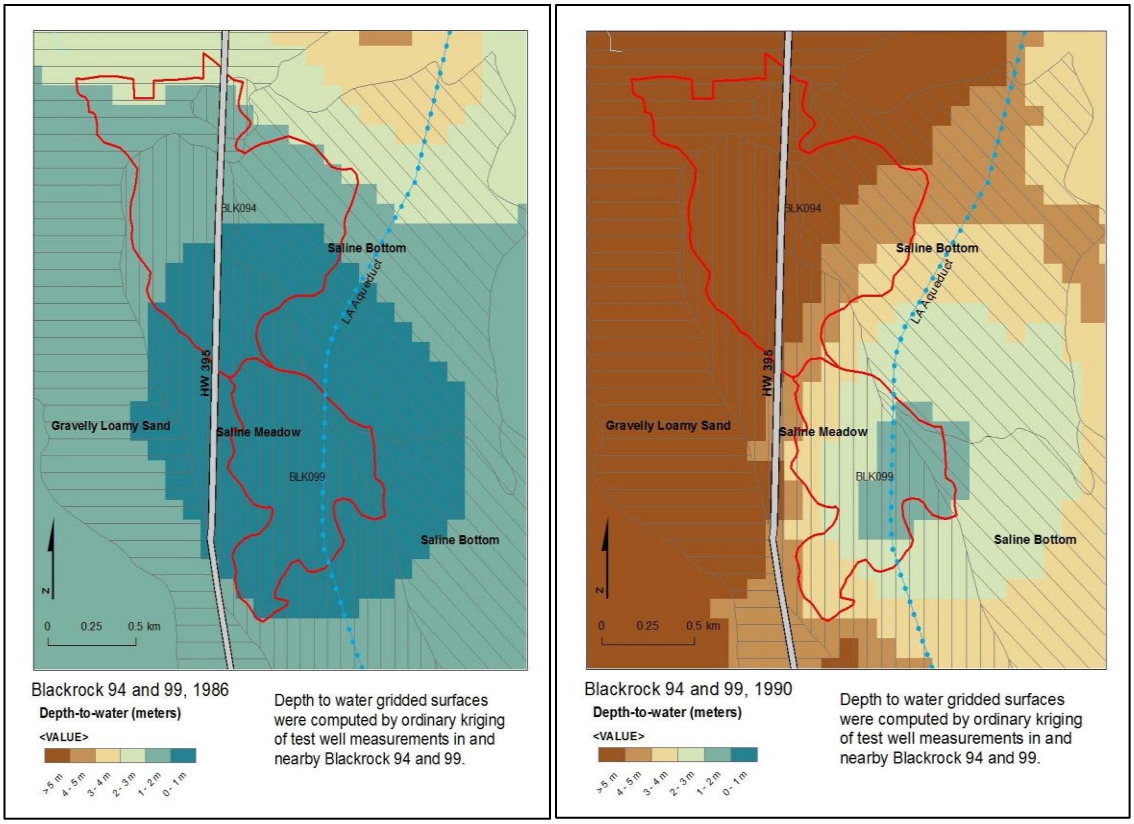

Figure 18. The water table has remained nearer the land surface in the southeast portion of Blackrock 94 which has supported higher vegetation cover since baseline than the northwest portion of the parcel. The depth to water gradient in 1986 (left) and 1990 (right) are shown.

period after 1991 that were more dissimilar from the average baseline condition compared to transects in the southeast portion which were more similar to baseline average composition. This finding led LADWP to conclude that the baseline grass cover values were inflated. But this finding does not support LADWP's hypothesis that baseline cover was spatially biased to high cover areas. Instead, this finding simply confirms what is already known, that perennial cover and grass cover is higher in areas of the parcel that experienced less severe drawdown and shallower water levels (Figure 18 and ICWD, 2011 Appendix A). The presence of a vegetation gradient is not evidence that baseline was biased high or that the differing sampling methods were responsible for the detection of vegetation impact.

There are more direct and valid methods to test whether vegetation change in Blackrock 94 has occurred, including comparing average composition representing the whole parcel at different times (ICWD, 2011), or examining each location within the parcel at different times using other data sources. Satellite data to conduct the latter analysis based on vegetation cover was included in the appendix of the County's 2011 report and is evaluated here to test LADWP's allegation that the observed change was an artifact of an inflated (biased) baseline combined

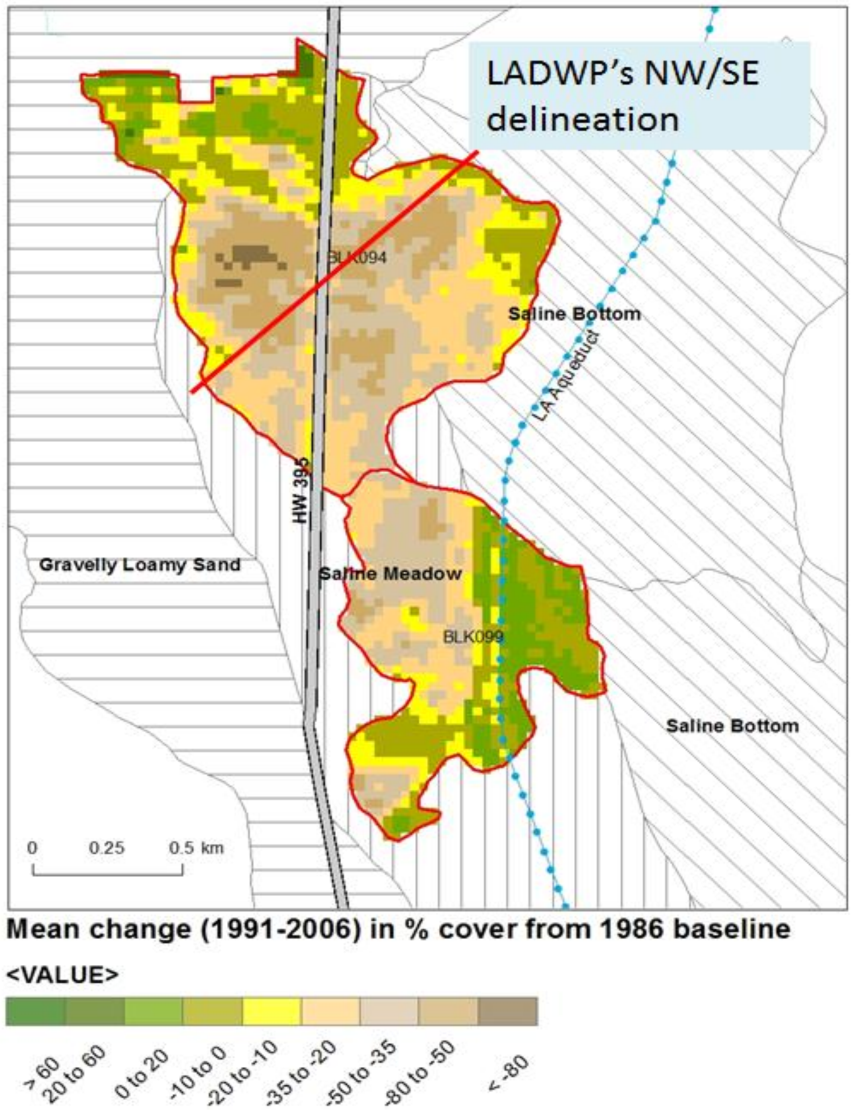

Figure 19. SMA vegetation cover change, relative to baseline, averaged over the period 1991 to 2006 (before the 2007 fire).

with an unbiased reinventory dataset. The SMA dataset can compare vegetation cover in 1986 and any later year at the same location and avoid making the mistake embedded in LADWP's analysis.

If LADWP's conclusions were true, the change from baseline in SMA cover should be stable in the southeast portion of the parcel and the change from baseline should be greater in the areas where spreading occurs, such as the northwest corner. LADWP states:

...the true alkali meadow in the community in the southeast has remained relatively stable in species composition compared to the initial vegetation inventory throughout the subsequent monitoring years. (LADWP report, p. 85)

SMA cannot measure composition directly but the following examination of changes in cover should test LADWP's conclusion because differences in community composition are mainly driven by grass cover in both LADWP's and the County's ordination analysis. Additionally, interannual change in the line point measurements are mostly due to grass cover change.

Further, the SMA average is not a sample but rather accounts for every 30 x 30 m pixel within the parcel and is thus free from sampling error associated with where transects are placed within the parcel. The results from computing the average change in each 30 x 30 m pixel for the period 1991-2006 relative to baseline show that most change has occurred in the Saline Meadow and Saline Bottom ecological sites (Figure 19).

The declines in vegetation cover in the central and southern portion of Blackrock 94 are contrary to LADWP's hypothesis that apparent vegetation change is attributable to a biased baseline. The Sandy ecological site (Cartago soil) in the northwest corner dominated by sagebrush shows the least change with respect to 1986 likely because water spreading although sporadic, does provide the soil water sufficient for spikes in growing season vegetation cover. Both the County and LADWP have documented spreading which also shows up in the SMA images. The largest declines in cover were located in the Saline Meadow and Saline Bottom ecological units encompassing the central and southern portion of Blackrock 94 and also the northern portion of Blackrock 99. The division of SE and NW portions of Blackrock 94 in LADWP's composition analysis doesn't correspond to the visible change in the SMA data (Figure 19). In summary, LADWP's analysis shows that the SE portion has higher cover than the NW portion, not that the baseline is biased, and the County's analysis of SMA data show that majority of Blackrock 94 has declined relative to 1986 baseline with the most significant declines occurring in areas where LADWP believes community composition has been stable.

Comparison with Control Parcels

One method to evaluate whether pumping caused the decline in vegetation in Blackrock 94 is to assume the cover response in two ecologically similar locations would have been the same but for their respective differences in pumping-induced drawdown. The pumping effect on vegetation according to the Water Agreement can be evaluated by:

...a comparison of the affected area with an area of similar vegetation, soils, rainfall, and other relevant conditions where such a decrease, change, or effect has not occurred, or has not occurred to the same degree. (LTWA, page 18-19, paragraph 4).

Comparison of Blackrock 94 and control parcels was performed by both the County and LADWP. If the control is appropriate, the initial vegetation conditions should be similar and environmental factors should have similar magnitudes and effects such that the different pumping regimes are the primary influence on vegetation cover. The County originally chose Blackrock 99 as the control to compare with Blackrock 94. Blackrock 99 did not experience as severe or persistent decline in water levels (ICWD report, Figure 13) in part because infiltration from the Los Angeles Aqueduct buffered the depth to water from pumping effects. Blackrock 99 is located directly south of Blackrock 94, and these two areas share the same soils, precipitation, initial vegetation conditions, and similar irrigation events leaving the difference in water levels as the primary hydrologic difference between Blackrock 94 and 99. Using vegetation cover data from Blackrock 99 and associated depth-to-water values, the County was able to provide a quantitative estimate of the vegetation decline that was due to pumping (Figure 17). Additional information on the similarities and differences in Blackrock 94 and Blackrock 99 are contained in the County's 2011 report.

LADWP selected three parcels located near Bishop and Lone Pine as controls for comparison with Blackrock 94. LADWP concluded in its report that:

> *Due to the strong relationships exhibited between the control parcels and Blackrock 94 in regard to changes in total perennial cover, changes in perennial grass cover, changes in shrub and grass proportions, and changes in species composition over time, and the fact that the control parcels are not affected by groundwater pumping, it can be easily inferred that these vegetative changes are driven by environmental factors other than groundwater pumping.* (LADWP report, page 128)

In this section we examine whether the initial vegetation conditions, soil characteristics, water table and vegetation cover over time are adequately controlled in LADWP's proposed control parcels to permit meaningful conclusions on the effect of DTW on vegetation in Blackrock 94. We also address the reasoning that LADWP used to arrive at its conclusion that vegetation decline in Blackrock 94 was solely driven by climatic factors, not pumping. We also demonstrate why the control parcels chosen by LADWP cannot control for the most critical environmental factors (initial vegetation cover/composition and depth to water) required by a control parcel analysis. However, first we explain why LADWP's analytical approach is illogical and cannot answer the question of whether pumping had an effect on vegetation in Blackrock 94.

There are chronic misapplications of correlation analysis in LADWP's evaluation of attributability, but perhaps the most severe problem is the lack of any linkage between what the analysis shows and what LADWP concluded from it. The purpose of a control was to determine how Blackrock 94 vegetation would have responded to natural climate variability without the added drawdown caused by pumping. The assumption is that the primary ecological difference between control(s) and Blackrock 94 is due to the effect of pumping. Given this assumption, the difference in vegetation between the control and the actual conditions at Blackrock 94 can be interpreted as the effect of pumping on vegetation cover. For this inference to be valid, the control parcel must satisfy several criteria. The control parcels selected by LADWP are not adequate to evaluate the effect of pumping on Blackrock 94 due to large differences in baseline cover and composition, initial depth to water, vegetation response over time, and differences in soil properties (detailed evaluations of these factors follow this section). Thus the critical assumption required in the control parcel analysis is shown to be invalid for LADWP's proposed control parcels.

LADWP's analytical approach is not designed to answer the primary question that the control parcel analysis was intended for. A valid analysis ideally should produce a quantitative estimate of the effect of pumping on Blackrock 94 (see Figure 17). LADWP performed several analyses that were unrelated to this question. LADWP concluded that an increase in vegetation cover from 1991 to 2000 and a decrease in cover following 2000 was a general trend shared by the control parcels and Blackrock 94. Based on that finding, LADWP inferred that Blackrock 94 vegetation was not influenced by pumping-induced drawdown. But this inference is not a logical conclusion given its results. The fact that vegetation cover in control parcels and Blackrock 94 is correlated to precipitation and runoff doesn't imply that depth to water is not important. This concept was quantitatively demonstrated above (cover, precipitation and water table section). LADWP ignored the magnitude of vegetation change in Blackrock 94 relative to baseline in favor of considering only the shapes of smoothed trend lines. But the purpose of the control parcel analysis is to estimate this magnitude of change due to pumping, not as LADWP has done which evaluates whether the control parcels and Blackrock 94 are correlated to precipitation and runoff. The fact that vegetation in Blackrock 94 and control parcels are correlated to precipitation and runoff does not provide any information about the magnitude of vegetation change in Blackrock 94 attributable to pumping.

Initial Vegetation Conditions

Control parcels and Blackrock 94 must have similar plant communities during the baseline because the species differ in their susceptibility to water table drawdown and response to other environmental factors. If the initial assemblages of species differ, the control parcels would be a poor approximation of how the vegetation in Blackrock 94 would have responded if pumping had not occurred. Blackrock 94 was classified as an alkali meadow based on baseline composition. Lone Pine 18 and Union Wash 29 were classified as alkali meadows with similar, but slightly lower proportion of grass species than Blackrock 94. Poleta Canyon 106, however, was dominated by rabbitbrush, a shrub, with a sparse understory of grass. Grass comprised only 32% of the vegetation community. In comparison, grass comprised over 70% of the vegetation in Blackrock 94. Based on this difference alone, Poleta Canyon 106 is not an adequate comparison for Blackrock 94. In addition, Poleta Canyon 106 baseline cover was measured along one transect that also intersected one and possibly two other parcels. Given LADWP's

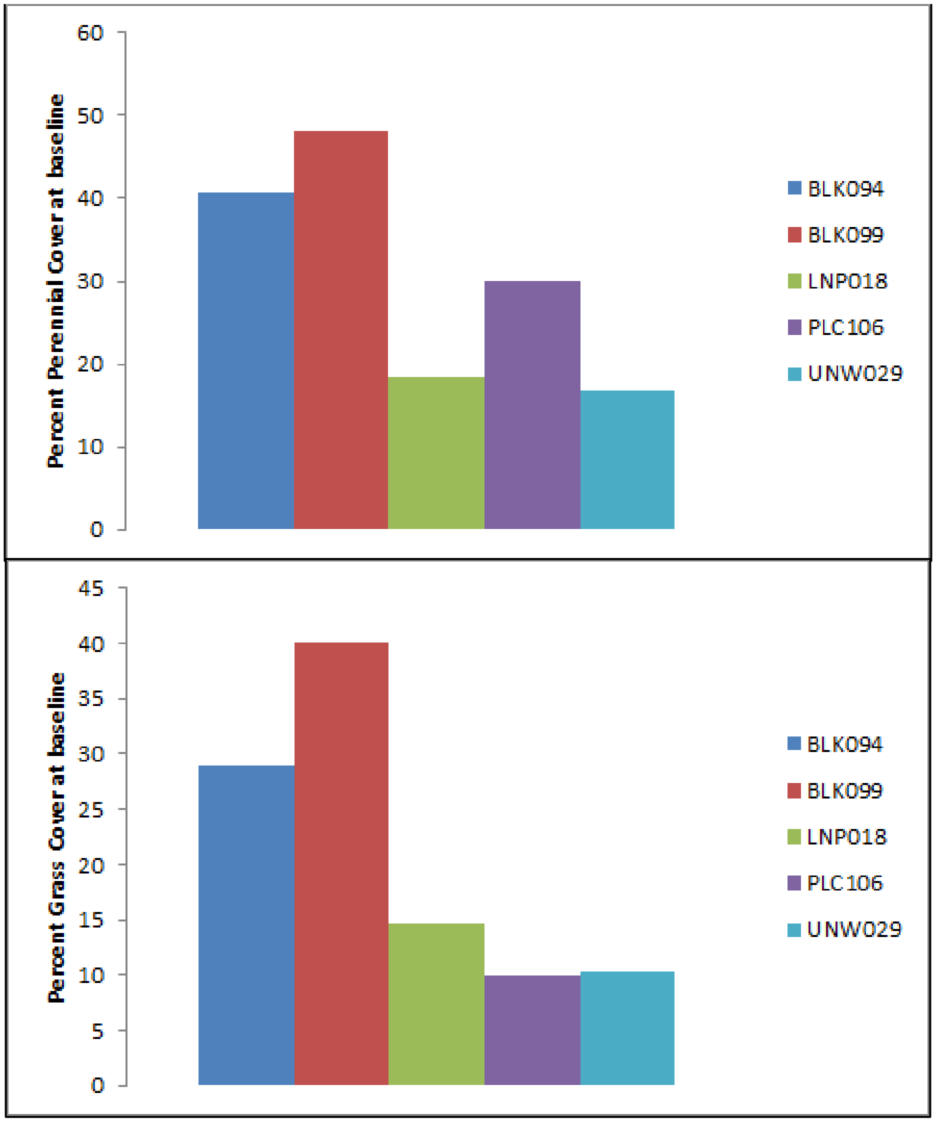

Figure 20. Perennial cover (top) and grass cover (bottom) during baseline line point inventory for Blackrock 94 and LADWP proposed control parcels.

concerns over the quality of the baseline data for Blackrock 94, it is perplexing why LADWP chose a control parcel with even more questionable baseline data.

Even if the species are similar, large differences in vegetation cover during baseline may reflect natural differences in productivity, water availability, or management history that invalidate the comparison with Blackrock 94. Vegetation cover at baseline for control parcels proposed by LADWP were all lower than Blackrock 94 (Figure 20). Perennial cover in Blackrock 94 during baseline was twice that of perennial cover in LADWP's proposed control parcels Lone Pine 18 and Union Wash 29. Grass cover in Blackrock 94 during baseline was twice that of grass cover for LADWP's control parcels. Initial vegetation conditions of LADWP's control parcels and their differences from Blackrock 94 are:

- Poleta Canyon 106 perennial cover was 30% (11% lower than Blackrock 94) and 10% grass cover (19% lower than Blackrock 94).
- Lone Pine 18 perennial cover was 18% (23% lower than Blackrock 94) and 15% grass cover (14% lower than Blackrock 94).
- Union Wash 29 perennial cover was 17% (24% lower than Blackrock 94) and 10% grass cover (19% lower than Blackrock 94).

The LADWP control parcels cannot provide any insight as to what vegetation conditions would have been in Blackrock 94 without pumping because even before the severe pumping of 1987-1990, the cover was substantially below that of Blackrock 94 presumably due to natural differences in other factors such as soils, precipitation, or DTW. It appears, based on fundamental differences in cover and composition that LADWP's control parcels are not comparable to Blackrock 94. The similarity of vegetation conditions in the 1986 baseline in Blackrock 94 and Blackrock 99 was documented in the ICWD report. Both parcels were classified as alkali meadows. According to line point data, Blackrock 94 had 41% perennial cover comprised mostly of grass (70%). Blackrock 99 had 48% perennial cover and 83% of that was grass. Clearly Blackrock 99 is more comparable to Blackrock 94 than any of the LADWP control parcels.

<u>Initial Depth to Water</u>

Blackrock 94 and 99 initially had similar depth to water (Figure 21). Over time, depth to water in Blackrock 99 varied within the approximate depth to water range in the grass root zone, and cover ranged from above 40% to 20%. Blackrock 94, having experienced the effects of pumping-induced drawdown to a greater degree, ranged from above 40% with a shallow water table to less than 5% cover after the water table declined. The difference in cover between Blackrock 94 and Blackrock 99 corresponds with differences in groundwater elevation differences caused by pumping. None of LADWP's proposed control parcels had baseline depth to water comparable to Blackrock 94; consequently these parcels cannot provide an adequate characterization of what vegetation conditions would have been in Blackrock 94 without pumping.

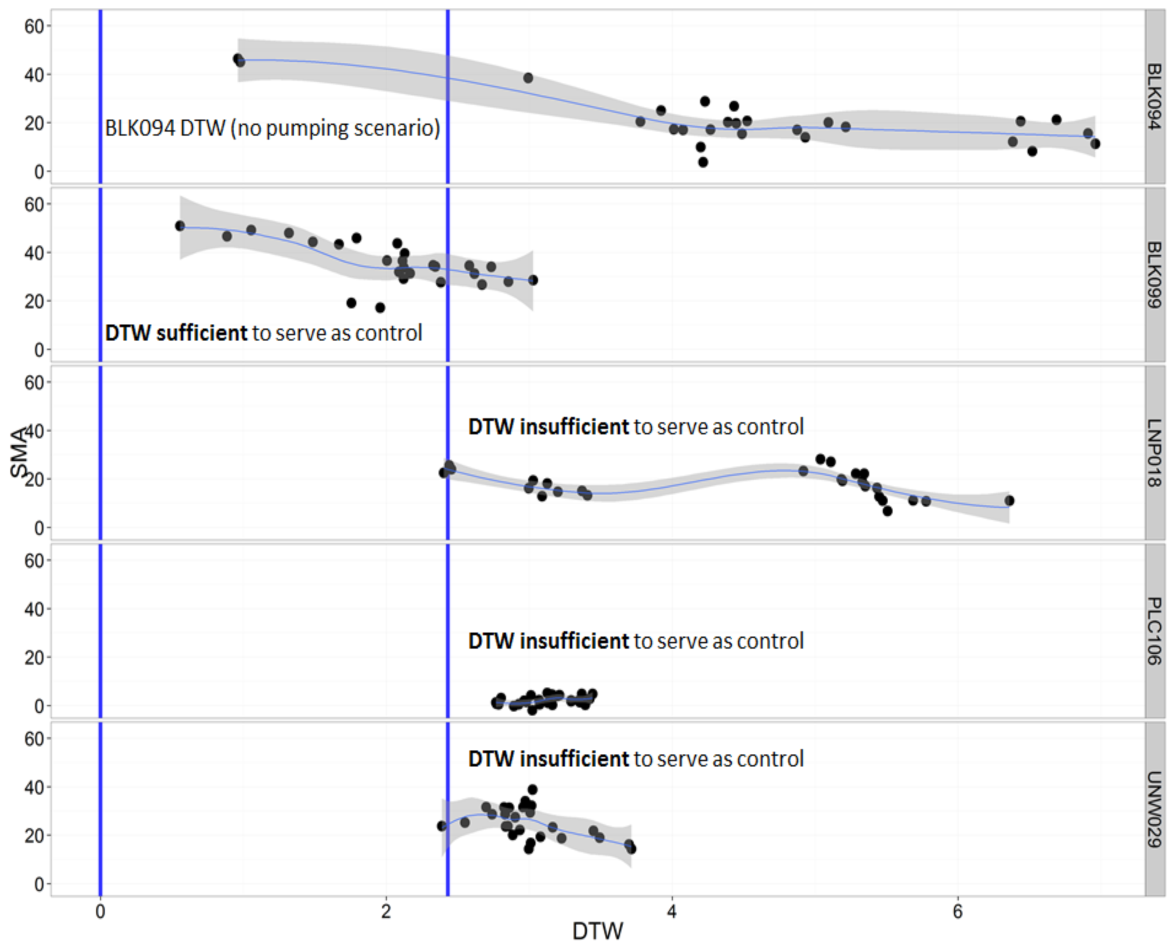

Figure 21. Vegetation cover (SMA % cover) as a function of depth to water (meters) at Blackrock 94, Blackrock 99, Lone Pine 18, Poleta Canyon 106, and Union Wash 29. Blue bars indicate the depth-to-water range (0 - 2.43 m) that is absent from LADWP's proposed control parcels and importantly, is similar to what would have been present in Blackrock 94 without pumping. Blackrock 99 includes this depth-to-water range and thus can be used as a control to assess the effects of pumping on Blackrock 94 vegetation. The line through the data was derived using LOESS and the gray region corresponds with the 95% confidence interval.

<u>Comparison of Precipitation at Control Parcels</u>

Precipitation in the Owens Valley alone is insufficient to fulfill the water needs of phreatophytic vegetation, but it does affect vegetation cover and soil water availability. Precipitation also promotes vegetation growth by increasing the availability of nutrients in the topsoil (Pataki, *et al.*, 2008). When groundwater is too deep for capillarity to reach the shallow soil, the effect of precipitation on water and nutrient availability and the resulting vegetation response is accentuated (Elmore *et al.*, 2006 and ICWD vegetation model above). Vegetation cover at sites with dissimilar precipitation, would be expected to differ.

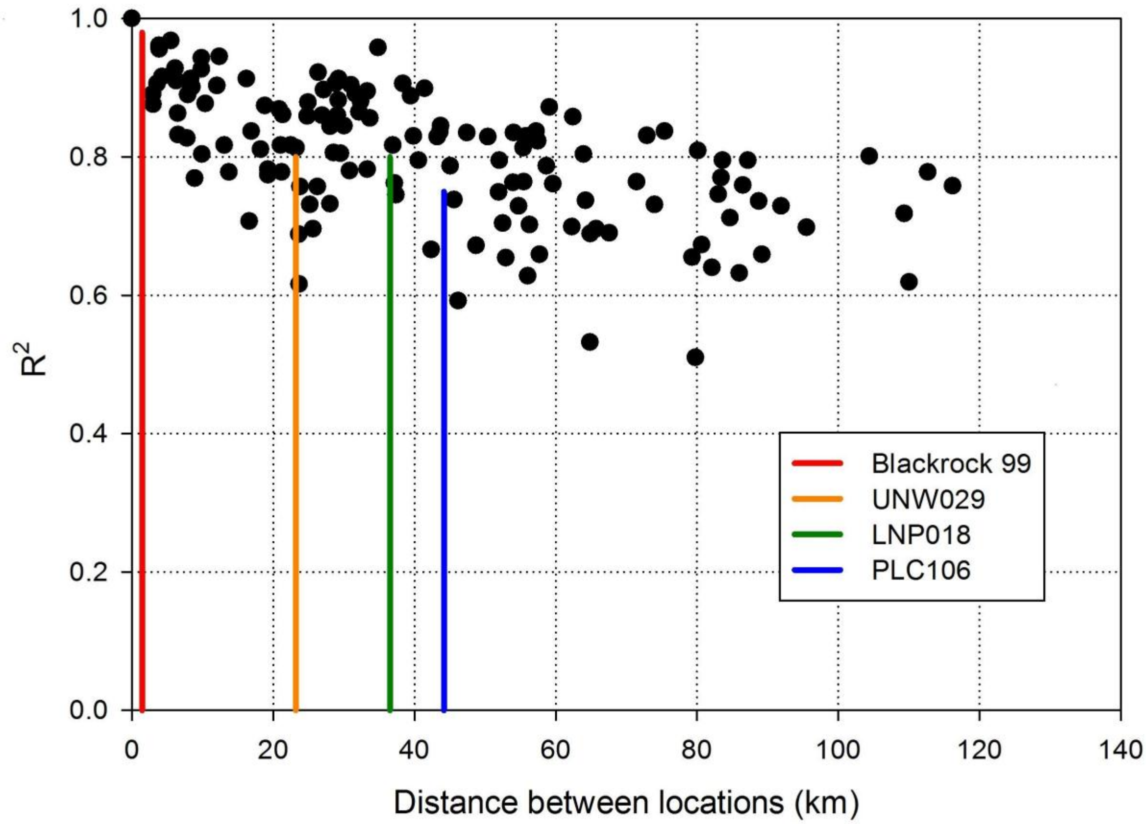

Figure 22. Correlation (R^2) of water year annual precipitation total as a function of distance between measurement gauges. Data are contained in Table 3 of Appendix A. The distance between Blackrock 94 and the four control parcels used by the County and LADWP are shown in the vertical bars. The vertical bars terminate at the approximate midpoint of the range of correlation values at each distance.

LADWP provided a brief description of their precipitation measurements, but did not examine if precipitation amounts were similar to the control parcels. No rain gauges are present in either the County's or LADWP control parcels preventing a direct comparison. Similarity of precipitation at the control parcels is assessed here using the analysis of rainfall variability in Owens Valley published in the ICWD Annual Report in 2010 (Appendix A).

LADWP noted that differences in average annual precipitation (water year: October through September) exist among the rain gauges nearest the sites. The range in average precipitation varied between 5.5 inches in the north to 3.7 inches in the south consistent with the general precipitation gradients in the valley. Precipitation at locations in the south and closer to the center of the valley is generally lower (Danskin, 1998, Figure 7). Data from the Lone Pine Yard and Alabama gates gauges near Union Wash 29 and Lone Pine 18 suggest the precipitation was usually lower at these sites than Blackrock 94. Correlation between measurement locations for water year precipitation is high, but the correlation decreases as distance between locations increased (Table 3 in Appendix A and Figure 22). If the known gradients in precipitation across the valley were taken into account as well as distance, the relationship probably would improve, however the result is intuitive. Sites closer to one another have more similar precipitation amounts than sites that are further apart. The distances of the LADWP control parcels and Blackrock 99 from Blackrock 94 are also shown on Figure 22. The LADWP control parcels are sufficiently distant from Blackrock 94 and closer towards the center of the valley to reasonably conclude that the amounts of precipitation at the LADWP control parcels is different than Blackrock 94 and almost certainly less comparable than Blackrock 99.

Comparison of Soils at Control Parcels

LADWP justified its selection of the parcels Poleta Canyon 106, Union Wash 29, and Lone Pine 18 on the basis that soils in these parcels were similar to Blackrock 94. If soils are similar at the control parcels and Blackrock 94, it is a reasonable assumption that the change in vegetation cover attributable to soil differences is negligible. An indication that soils may differ at the LADWP controls is the large differences in initial cover and composition which may reflect inherent differences in soil productivity. Key differences in the soil and landscape processes were not discussed by LADWP and the County does not agree that the soils suggest the parcels selected are more appropriate controls than Blackrock 99 originally selected by the County. Both the County and LADWP rely on information contained the USDA-NRCS soil survey and accompanying ecological site classes (Tallyn, 2002).

LADWP's analysis concluded soils at the sites are similar based on the overlapping range of selected soil properties (LADWP report, Sec 5.2 Table B.ii.13). Assessing similarity of soils is often not straightforward. There is considerable variation and overlap of the range of properties among soils and the analyst must decide which property is important for purposes of making the comparison. For example, the available water capacity (the amount of water between field capacity and limiting water content) of soils mapped in Blackrock 94 range from low to high. Most sites in the Owens Valley would have soils within that range, but not all would be good control sites. The primary reason for selecting controls in this attributability analysis is to determine whether differences in water availability were attributable to pumping. Comparing parcels with similar soils controls for one environmental factor influencing vegetation and thus improves the ability to detect pumping effects. LADWP overlooked key differences between the soils at Blackrock 94 and the control sites in their report.. These differences are reflected in the classification of the soils and in other soil properties, some of which were discussed in LADWP's report.

Table 3. Soils mapped in Blackrock 94. Three soil map units occur within Blackrock 94 and the portion of the parcel with each soil series is provided.

Soil map unit name	% of Blackrock 94	Classification†	Ecological Site
Shondow	50	fine-loamy Aquic Argixerolls	Saline meadow
Winterton	32	fine-loamy Argic Petrocalcid	Saline bottom
Cartago	18	sandy Xeric Torriorthent	Sandy

† All soil series are in the mixed and thermic families

Soils are mapped and classified to facilitate comparisons and interpretations of soil behavior and management of different locations (Soil Survey Staff, 1999). Soils are classified based on the arrangement layers ("horizons") exhibiting specific characteristics as well as soil properties that influence the potential uses of the soil (e.g. indicators of soil wetness). Soil horizons result from soil forming processes such as organic matter accumulation acting on the original sediment or rock over time. Soils with different classification denote areas of the landscape where different soil forming process and often ecological processes were dominant through time. The soil classification system is hierarchical: the highest category groups soils with similar soil forming processes as indicated by the presence or absence of diagnostic horizons. Lower categories progressively subdivide upper categories into smaller groups of soils with more similar properties and land use interpretations. The lowest category in the classification system is the soil series which is the name of units shown on the soil map. Sometimes a pair of soil series are mapped as a single unit or association because they occur in a recognizable pattern on the landscape.

In its comparison of soils at the control sites, LADWP did not present or discuss the classification of the soils and the information the classification conveys (Tables 3 and 4). At the highest level of classification, all of the soils in the control parcel selected by DWP are dry desert soils. None of the soils at LADWP control sites are equivalent to the Shondow soil that occupies half of Blackrock 94. The Shondow series is a soil with a thick, black topsoil due to accumulation of organic matter indicative of soil formation under grass vegetation. In the arid climate of the Owens Valley, the Shondow soil forms under meadow vegetation with a high water table. The Shondow soil has an aqua moisture regime which means the soil has features indicative of saturated conditions within 75 cm of the surface although these are probably relict features before pumping created a sustained lowered water table. Water table depth of the Shondow soil (unless artificially drained) is approximately 61-91 cm. No soil series at the control sites chosen by LADWP has soil properties that indicate the water table was that shallow. Based on soil interpretations, Poleta Canyon 106 and most of Lone Pine 18 have water tables deeper than 122 cm, and Union Wash 29 deeper than 102 cm. The Winnedumah series at Lone Pine 18 occupies a similar but slightly lower landscape position as the Shondow soil.

Table 4.. Soils mapped at LADWP control parcels.

Parcel	Soil map unit name (percent of parcel)	Classification†	Ecological Site
Union Wash 29	Reinhackle	coarse-loamy Xeric Natrargids	Saline bottom
Poleta Can. 106	Westgard-Reinhackle association	coarse-loamy Durinodic Haplargids & Xeric Natrargids	Saline bottom
Lone Pine 18	Winnedumah (49%) Mazourka-Eclipse (51%)	fine-loamy Xeric Haplargid course-loamy Typic Natrargids & sandy Typic Haplocambids	Sodic fan Sandy terrace

† All soil series are in the mixed and thermic families

Approximately 30% of Blackrock 94 was mapped as Winterton soil. This portion of the parcel more closely resembles soil at Poleta Canyon 106 and Union Wash 29 except for a finer texture and the presence of a hard subsoil horizon cemented by calcium carbonate. The Cartago soil in Blackrock 94 is similar to the Eclipse soil in Lone Pine 18 in that both are sandy with no cemented horizons or subsurface horizons with accumulated clay. However, the Cartago soil (gravelly loamy sand, 0-2% slope) occurs on the margins of alluvial fans adjacent to the Sierra Nevada, while the Eclipse soil formed in sandy alluvium on the valley floor. They have similar soil properties, but because they occur on different areas of the landscape, the natural vegetation is not similar except for one non-groundwater dependent grass species.

At lower categories, soils are placed into classes based on the weighted average particle size of the soil. It is a calculation that simplifies comparison of soils that have a range of soil textures. The portion of the soil included in the weighted average varies, but it is usually between the surface and the upper boundary of root limiting layers, the soil between 25-100 cm, or the portion of the subsoil with clay-enriched layers. Coarse loamy soils have clay content below 18% while fine-loamy categories have clay content above that value. Soils at Poleta Canyon 106 and Union Wash 29 are coarse-loamy and thus have less clay than almost all of Blackrock 94. The soil particle size classes of soils that occupy about half of Lone Pine 18 are comparable to Blackrock 94.

Ecological sites represent a portion of the landscape having a distinct combination of soil type, landform, potential plant community, ecological processes, hydrology, and climate (Soil Survey Staff, 1993; Tallyn, 2002). One or more soils that have similar plant communities and ecology are grouped together to define an ecological site (e.g. Saline Bottom). Each soil only occurs in one ecological site. No control parcel selected by LADWP contains the Saline Meadow class corresponding with the Shondow soil for half of Blackrock 94. Parcels Poleta

Canyon 106 and Union Wash 29 are Saline Bottom which comprises 30% of Blackrock 94. Parcel Lone Pine 18 has no ecological sites in common with Blackrock 94. In Lone Pine 18, the Sandy Terrace is dominated by shadscale and the Sodic Fan by saltbush and greasewood; all generally occur on soil with deeper water tables than alkali meadow vegetation typical of Blackrock 94 ecological sites.

In summary, more than half of Blackrock 94 occurs on soil and ecological sites dissimilar to any of the soils at LADWP's control sites. The classification of the Shondow soil at Blackrock 94 soil indicates soil formation influenced by shallower water table than the other parcels. Ecological site classes in Poleta Canyon 106 and Union Wash 29 are similar to 30% of Blackrock 94 but the soil textures are coarser. The Winnedumah soil that occupies half of Lone Pine 18 occupies a similar landscape position than the Shondow soil in Blackrock 94, but the two parcels have no ecological site classes in common suggesting the natural vegetation is not comparable. While there are some similarities of the soils at each of the LADWP control sites, key differences in major soil forming and ecological processes as well as soil properties exist.

Previously LADWP rejected the County's selection of Blackrock 99 as the most appropriate control claiming the soils are not comparable to Blackrock 94 (Inyo Brief, Attachment 22). Shondow and Winterton are the dominant soils in both parcels. Together these comprise 82% of the area of Blackrock 94 and 92% of the area of Blackrock 99. In fact, 55% of Blackrock 94 (including TS1) and 90% of Blackrock 99 (including TS3) occur within the same soil map delineation (a contiguous area with similar soil properties and classification). Further, different soils can support similar vegetation. When the Ecological Site descriptions for the soils underlying the parcels are compared, the similarity of the two parcels is more apparent. Saline Meadow and Saline Bottom should support a high cover meadow in the Owens Valley (Tallyn, 2002). The dominant vegetation for Saline Meadow (Shondow) is alkali sacaton (*Sporobolus airoides*), inland saltgrass (*Distichlis spicata*), saltbush (*Atriplex* sp.), and rabbitbrush (*Ericameria* sp.). Approximate vegetation cover for this Ecological site is 40 to 80 percent. The dominant vegetation for Saline Bottom (Winterton) is alkali sacaton, inland saltgrass, black greasewood (*Sarcobatus vermiculatus*), shadscale, and Parry saltbush (*Atriplex parryi*). Approximate vegetation cover for this Ecological Site is 20 to 40 percent. These two Ecological Site descriptions comprise 100% of Blackrock 99 and 82% of Blackrock 94.

Based on soils and the vegetation they naturally would support, Blackrock 99 is more similar than the parcels selected by LADWP and a more appropriate comparison for Blackrock 94. LADWP described how difficult it was to locate control sites in the same kinds of soil as Blackrock 94, but ignored the obvious solution to examine the adjacent parcel Blackrock 99. Blackrock 94 and 99 are occupied by 82% and 91% of the same soils (Shondow and Winterton). Indeed, nearly all of Blackrock 99 and the half of Blackrock occur in the same delineation of Shondow soil.

Temporal Dynamics of Vegetation Change in Blackrock 94 and Control Parcels

A suitable control to quantify the effect of DTW on vegetation at Blackrock 94 should have similar vegetation dynamics as Blackrock 94 except for the effect of pumping. Without pumping, given the assumption that initial vegetation conditions are similar and other environmental factors (i.e. precipitation and soil properties) influence the two areas similarly, the expectation is that the temporal trends in cover between the two areas should closely agree.

Temporal change in vegetation cover was similar in Blackrock 94 and Blackrock 99; the difference in vegetation cover between Blackrock 94 and 99 is due to the magnitude of drawdown from 1987 to 1990 across these parcels and the buffering effect of the Los Angeles Aqueduct on Blackrock 99 depth to water (Figure 23). The parcels proposed by LADWP to represent the vegetation conditions in Blackrock 94 under the no pumping scenario show responses to factors other than pumping over time (Figures 24-26). Here we highlight trends in vegetation cover for proposed control parcels in the context of the wet/dry climatic cycles that are both consistent and inconsistent with the notion that control parcels are responding to environmental variability in a similar manner as Blackrock 94. Because of the suspect origin of baseline for Poleta Canyon 106, and significant differences in community composition and soil properties compared to Blackrock 94 (described above), we limit this evaluation to LADWP's control parcels Union Wash 29 and Lone Pine 18. We first show the agreement of vegetation dynamics between Blackrock 99 and Blackrock 94 as an example of a suitable control.

Blackrock 99 compared to Blackrock 94

SMA cover in Blackrock 94 and Blackrock 99 was similar during baseline (see initial vegetation conditions section above). Over the period of increased pumping from 1987 to 1990, cover between these two parcels diverged. By 1990 SMA cover in Blackrock 94 had declined to 12% while SMA cover in Blackrock 99 only declined to 31%. Thus from 1986 to 1990 during the period of maximum pumping, Blackrock 94 and 99 diverged from 5% difference at baseline to a 19% difference coincident with pumping-induced drawdown.

The trends over time were essentially parallel (Figure 23) for the remainder of the time series with the divergence in cover originating from the pumping in the late 1980's remaining present. Both parcels showed an overall decline from 1990 to 1994 owing to below average runoff. From 1995 to 1998 cover increased in both parcels as increased runoff and reduced pumping allowed the water table to rise. However Blackrock 99 had cover of 48% and Blackrock 94 had cover of 29% during this wet period; a 19% difference that had persisted since 1990. The next period after the wet period of the late 1990s, LADWP describes as: "*characterized by a prolonged dry period with sporadic wet years (WY 2004-05, WY2005-06, and WY2010-11)"* (LADWP report, page 147). Another year with above average precipitation occurred in 2002-03. Both Blackrock 94 and 99 showed the same direction of response and magnitudes of cover

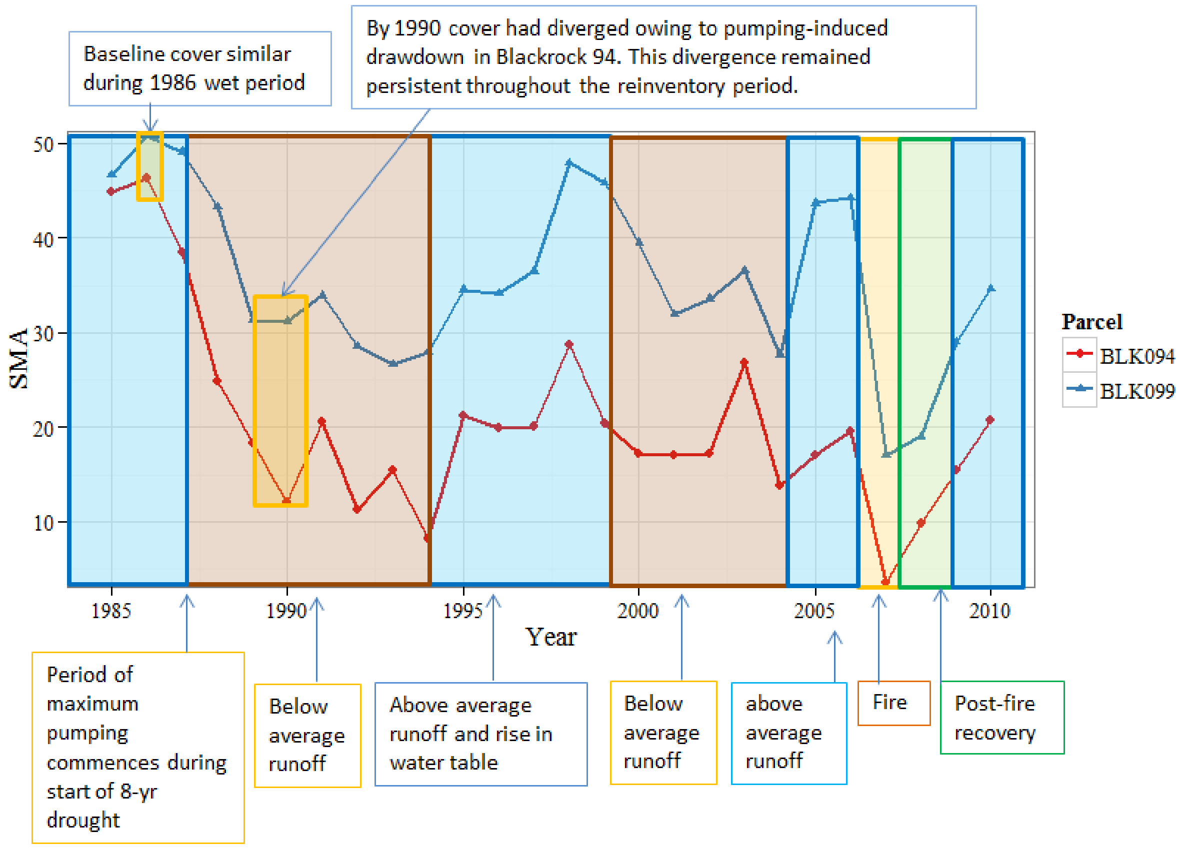

Figure 23. Blackrock 99 compared to Blackrock 94.

response over this period. Both parcels also show the same decline in cover in 2007 from the fire that burned through both parcels and suppressed cover in 2008 as it recovered from the fire. In summary, both parcels show the same effect from wet-dry climate cycles, precipitation and disturbances. This finding allows confidence in the use of Blackrock 99 as a control parcel to determine the influence of pumping on Blackrock 94 vegetation.

Lone Pine 18 compared to Blackrock 94

Cover in Lone Pine 18 was not similar to Blackrock 94 during the baseline, nor did trends in cover since baseline track similarly. In 1985 (baseline for Lone Pine 18), SMA cover in Blackrock 94 was 45% and 11% for Lone Pine 18 (Figure 24). In 1986 (baseline for Blackrock 94) SMA cover was 46% for Blackrock 94 and 7% for Lone Pine 18.

The period of increased pumping, 1987-1990, did not show divergence between these two parcel cover values; in fact, cover converged. By 1990 SMA cover in Blackrock 94 was 12% and SMA cover in Lone Pine was 13%. Thus from 1986 to 1990 during the period of maximum pumping, Blackrock 94 and Lone Pine 18 converged from a 34% difference to a 1% difference in

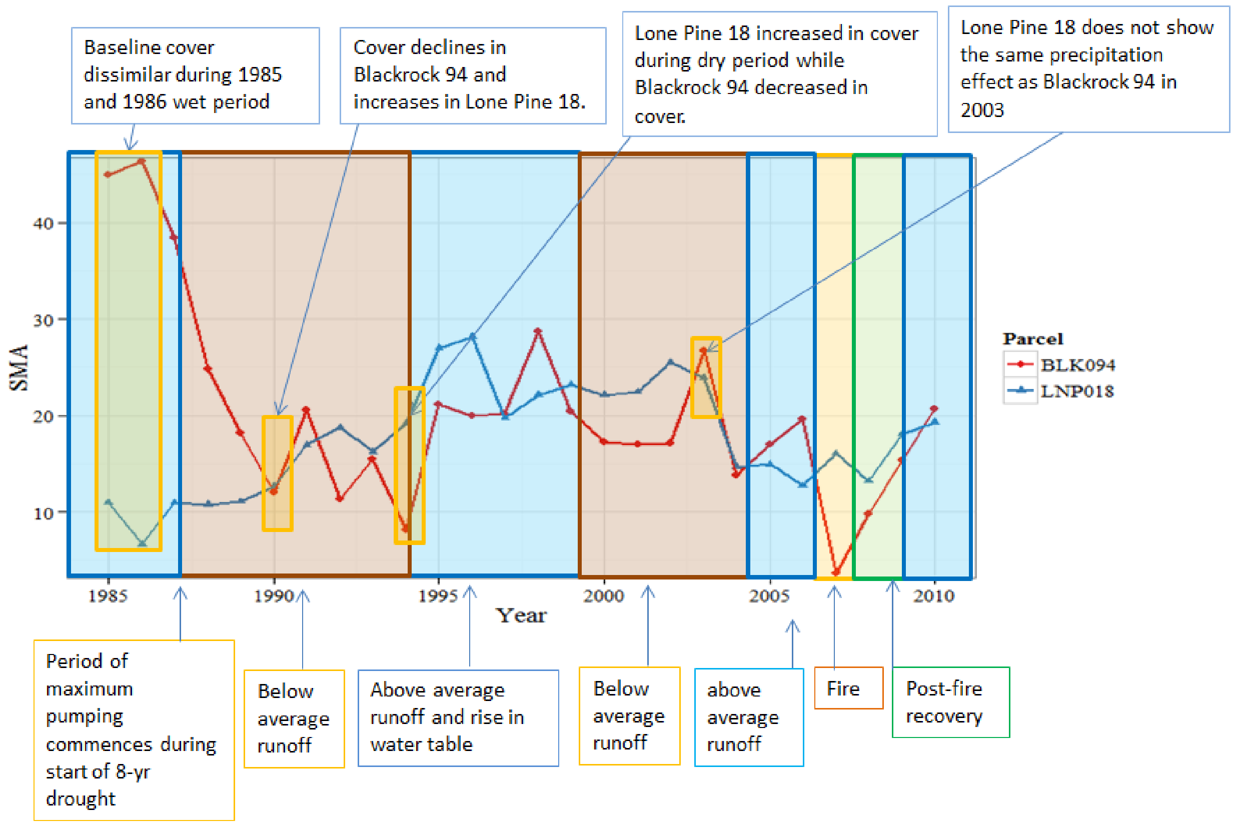

Figure 24. Lone Pine 18 compared to Blackrock 94.

SMA cover, largely due to a decline in cover at Blackrock 94. The fact that cover was different by 39% during baseline and then converged after the 1987-1990 increased pumping does not lend any confidence that this parcel can inform the evaluation of what vegetation conditions would have been realized in Blackrock 94 without pumping.

Blackrock 94 showed an overall decline from 1990 to 1994 owing to below average runoff (12% to 8%), yet Lone Pine 18 showed an overall increase (13% to 19%) during the period of below average runoff. This suggests a different environmental response that is not controlled for by using Lone Pine 18. This unexpected effect may be due that fact that Lone Pine 18 has different soil properties, precipitation or *received tail-water from irrigation directly west of the parcel* (LADWP report, page 117). From 1995 to 1998 cover increased in Blackrock 94 reaching its maximum cover during this period in 1998, however Lone Pine 18 reached its maximum cover in 1996. Lone Pine 18 did not have the same precipitation effect in 2003, when cover in Blackrock 94 increased and cover in Lone Pine 18 decreased, supporting the finding that differences in precipitation increase with distance (Figure 22, comparison of precipitation at control sites section).

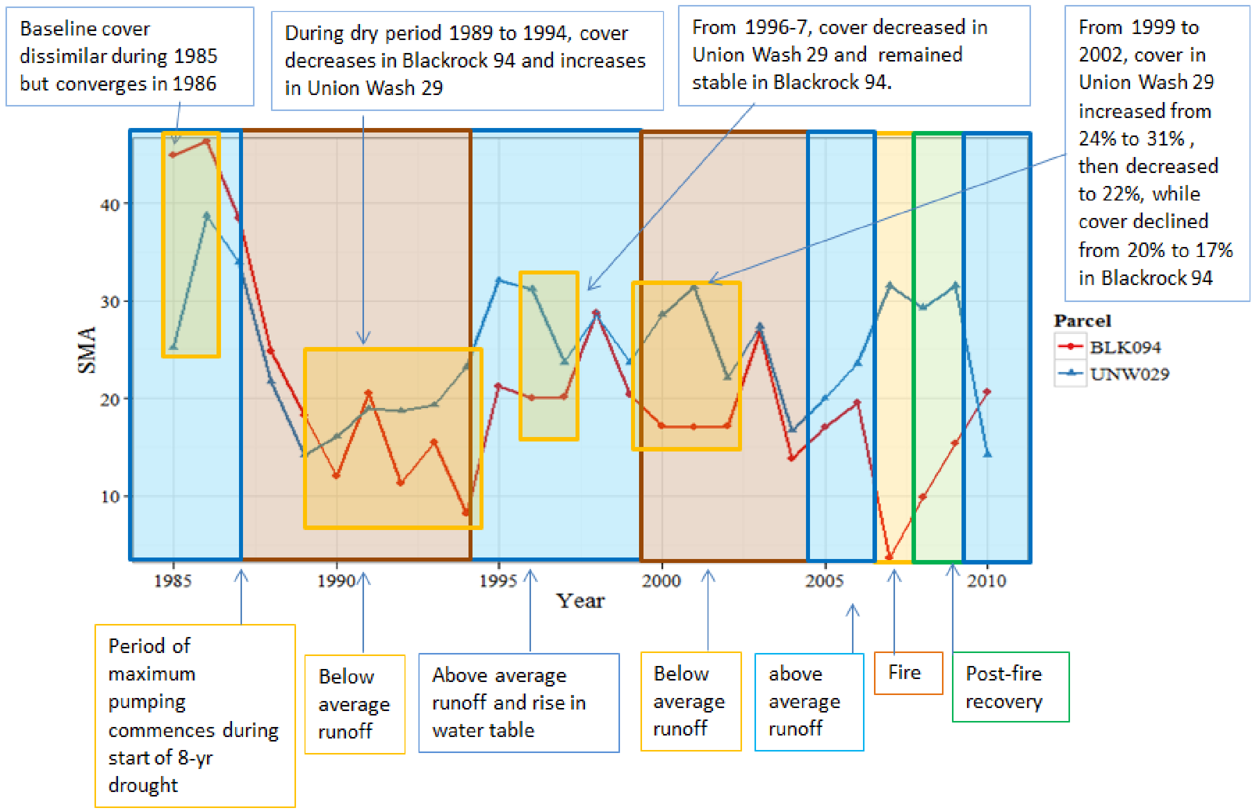

Figure 25. Union Wash 29 compared to Blackrock 94.

Union Wash 29 compared to Blackrock 94

SMA cover in Blackrock 94 was 45% and Union Wash 29 was 25% in 1985 (baseline for Union Wash 29) (Figure 25). In 1986 (baseline for Blackrock 94) SMA cover was 46 and 39% for Blackrock 94 and Union Wash 29, respectively. The period of increased pumping, 1987-1990, did not show a divergence between these two parcel cover values, rather cover values converged even closer after the period of maximum pumping.

In Union Wash 29, by 1989, cover had declined to a minimum and then over the dry period extending to 1994, cover increased from 14 to 23%. However, over this same period Blackrock 94 cover decreased from 18 to 8%, the opposite direction as Union Wash 29. These opposite trends suggest Union Wash 29 did not respond to this dry period in the same way as Blackrock 94.

Following the early 1990s dry period, cover increased in both parcels but differed in interannual directions. For instance, from 1996-97, cover in Union Wash 29 declined from 31 to 24% while in Blackrock 94, cover remained stable at 20%. From 1999 to 2001, cover in Union

Wash 29 increased from 24% to 31% while cover declined from 20% to 17% in Blackrock 94. Then from 2001 to 2002 cover in Union Wash 29 declined from 31% to 22% while Blackrock 94 remained at 17%. These differences suggest there are important environmental factors that are not controlled in Union Wash 29.

Summary of evaluation of LADWP control parcels

The control parcels selected by LADWP are not comparable to Blackrock 94 due to large differences in baseline cover and composition, initial depth to water, vegetation response over time, and differences in soil properties. Thus, LADWP's proposed control parcels cannot be used to make valid inferences about the expected response of vegetation in Blackrock 94 if LADWP pumping had not lowered the water table. Blackrock 99 is a much more appropriate control to compare with Blackrock 94. LADWP failed to provide a quantitative estimate of vegetation decline attributable to pumping in Blackrock 94. Rather, because, in one out of three of the control parcels, vegetation cover correlated with precipitation and runoff, LADWP concluded that the decline in vegetation in Blackrock 94 was due to climate variability and not pumping. That conclusion, however, does not follow from the results.

Fire

In July 2007, wildfire burned through portions of Blackrock 94 and 99. The County and LADWP agree that the fire affected Blackrock 94 but was not the cause of the decline in vegetation cover and loss of grasses in dispute. The County originally provided evidence of observable differences between areas of the two parcels that burned (ICWD report, pages 53-54). Within days following the fire, perennial native grasses sprouted and grew vigorously at TS3 (Figure 26). In contrast, no grass sprouted along the permanent transect at TS1, and no live hits were recorded along the transect during the remainder of the growing season (ICWD report, Figure 20). By the summer of 2009, TS3 was dominated by native grasses while TS1 was dominated by tumbleweed (Figure 9 and ICWD report, Figure 21). The sites have similar soils and differ primarily in DTW and vegetation composition before the fire (Figure 9 and 24).

The sharply different recovery rates after the fire are attributable to LADWP pumping that has created a sustained lowered water table under Blackrock 94 but not Blackrock 99. The negligible or delayed recovery from fire in Blackrock 94 compared to 99 is evidence that lack of water availability impedes recovery from natural disturbances. Where the water table is present near the grass root zone, events like the 2007 fire may support meadow persistence, i.e. promote grasses and remove shrubs, but fire may hasten the conversion to a shrub community where the water table is below the grass roots.

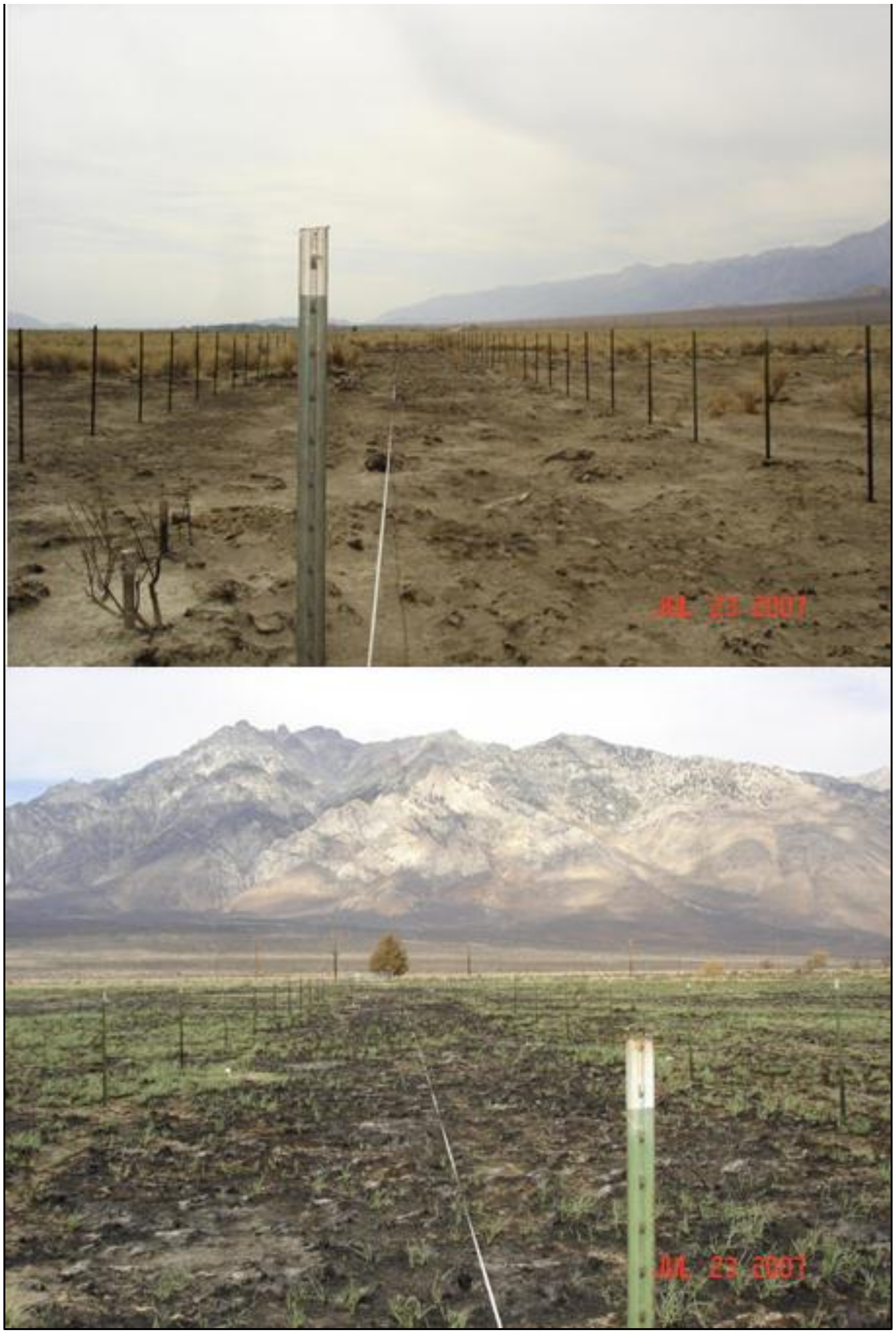

Figure 26. Photographs of permanent monitoring sites TS1 (top) and TS3 (bottom) sixteen days after the July 23, 2007 Inyo Complex fire. DTW at TS1 was 18.8 ft compared with 7.9 ft at TS3. Grass cover at TS3 had already begun to recover.

LADWP's assertion that the vegetation changes identified by the County in Blackrock 94 are natural, reversible, and driven by wet/dry cycles is conjecture. Neighboring parcel Blackrock 99 has experienced the same wet and dry cycles since 1984-87, yet vegetation cover and composition have been maintained, even following wildfire. This is not the case in Blackrock 94. LADWP's prediction of vegetation recovery when runoff and precipitation conditions are again similar to the baseline period is based largely on a general and unmeasured change in vegetation between the late 1970's EIR and baseline. Present conditions, however, are not comparable to the late 1970's. LADWP's conceptual model fails to consider the lack of resilience when another factor is imposed on phreatophytic vegetation. In the burned areas of Blackrock 94, vegetation recovery will require difficult re-establishment of grasses under conditions of negligible available soil water and soils exposed to erosion. Should climatic conditions improve, the vegetation in Blackrock 94 probably will not resemble the baseline conditions because the starting point for recovery does not resemble vegetation conditions in the late 1970's. The 1991 EIR discussed the danger in assuming vegetation changes are easily reversible:

> *Finally, it should be noted that centuries and perhaps millennia were required to produce the habitats, wildlife, and species diversity in Owens Valley that have been affected during the almost 90-year history of water export. For practical purposes such changes must be regarded as permanent. Even if water management were to revert to pre-project operations, the affected vegetation could require a time period of many decades to return to the pre-1970 conditions. (1991 FEIR 10-49).*

The County believes the extended period of degraded vegetation conditions in Blackrock 94 attributable to LADWP pumping constitutes a new impact that was not evaluated in the 1991 and that EIR that should be mitigated according to the LTWA.

Significance

As LADWP noted in its report, Water Agreement Section IV.B provides:

If the decrease, change, or effect is determined to be attributable to groundwater pumping or to changes in past surface water management practices, the Technical Group shall then determine whether the decrease, change, or effect is significant (Water Agreement, page 19, paragraph 2).

As required by Green Book section 1.C.1.c, the Technical Group is required to evaluate eight factors in determining the significance of an impact. LADWP evaluated the eight factors in its report and the County provides its responses to LADWP's evaluation in this section.

The size, location and use of the area that has been affected

LADWP first claims that the southeastern portion of Blackrock 94 has remained relatively unchanged as an alkali meadow and because of coarser soil types and higher elevation, the northwestern portion of the parcel has distinct plant communities from the alkali meadow. LADWP concluded that the southeast portion has remained stable (LADWP report, p. 81) and therefore that grass decline in the parcel overall occurred in the northwest portion of the parcel caused by the variation in spreading (correlated to runoff) and baseline precipitation.

The County acknowledges that grass cover is higher in the southeast portion compared to the northwest portion; however, this is expected because LADWP's groundwater pumping has not lowered the groundwater levels in the southeast portion of the parcel in comparison with groundwater levels in the northwest portion of the parcel (LADWP report, Sec. 5.2 Figure b.ii.9 and Figure 16).

With regard to the significance of variation between the southeast and northwest portions of the parcel, as noted on page 57 of the ICWD report, overall baseline perennial cover in Blackrock 94 measured 41%, while, on average, parcel cover from 1991-2009 was 27%. This represents a 1/3 decrease in cover on average. A 1/3 decrease in perennial cover is a significant decrease in cover. Thus, regardless of the claim that the vegetation in the southeast portion of Blackrock 94 has not changed as much as the vegetation in the northwest portion of the parcel, the overall change in perennial vegetation in the parcel is significant.

LADWP then claims that the size of the area of Blackrock 94 that has vegetation cover and composition less than baseline conditions is only 149 acres which constitutes a small portion of the Blackrock Vegetation and Wellfield Management Area which is 6,763 acres. As previously noted, the County disagrees that the vegetation changes and decreases in Blackrock

94 are limited to 149 acres; instead, the County has shown that the decreases and changes occur throughout the 334 acre parcel.

Concerning the use of the Blackrock Vegetation and Wellfield Management Area for determining whether a significant effect has occurred, this issue was addressed on page 13 of the October 21, 2013 arbitration decision. The decision found that:

> *The use of the Blackrock 94 parcel as an area of type C vegetation in the three step process was appropriate and in accordance with the LTWA and Green Book. There is nothing in either of these two documents which restricts the application of the three step process to only Vegetation and Wellfield Management Areas, inter alia.*

Regarding the size of the area adversely affected in Blackrock 94, the 1991 EIR identifies numerous significant impacts to vegetation due to groundwater pumping. Several of the specific impacts identified are similar in area to parcel Blackrock 94.
Impact 10-11 identified 655 acres of vegetation die-off and mitigated for this by irrigating the affected area. Impact 10-12 identified approximately 300 acres of impacted vegetation due to pumping wells W385 and W386, and mitigated for the impact by revegetation, water spreading, and cessation of pumping. Impact 10-13 identified that groundwater pumping affected approximately 60 acres in the Symmes-Shepherd wellfield, with mitigation comprising revegetation and water spreading as necessary. Impact 10-14 identified that groundwater affected spring flow and vegetation at spring vents in an area less than 100 acres, and various off-site mitigations were undertaken. Impact 10-18 identified vegetation decrease and change on approximately 640 acres in Laws, which was mitigated by 140 acres of revegetation and 541 acres of irrigation.

These impacts and mitigations documented in the 1991 EIR indicate that impacts to areas of vegetation of similar size to parcel Blackrock 94 were found to be significant by LADWP and the County in the 1991 EIR and a variety of strategies and actions were implemented to mitigate for the impacts.

Evaluation of the degree of the decrease, change, or effect within the affected area

LADWP contends that the observed decreases in vegetation cover in Blackrock 94 are not significant because:

1. These decreases were a result of drought or dry climatic cycles.

2. Vegetation cover has shown a very close relationship with the runoff patterns whereby vegetation cover decreases during drought and dry climatic cycles, and rebounds during wet periods.

3. The parcel contains at least two plant communities which are distinct from the alkali meadow. The upland northwestern portion of the parcel only resembles an alkali meadow during wet periods.

The underlying basis of LADWP's three contentions is that the decreases and changes in vegetation are not significant because they are not attributable to LADWP's groundwater pumping. In the preceding sections, this report has presented the reasons why the decreases and changes in vegetation are primarily attributable to LADWP's groundwater pumping and not primarily due to drought, dry climatic cycles and runoff.

Earlier in this report, Blackrock 94 and Blackrock 99, each with similar exposure to drought, wet/dry cycles, grazing, and soil type, but with different accessibility of plant roots to groundwater, are compared to show that the availability of groundwater is the primary cause of vegetation contrasts between the parcels. Blackrock 94 has chronically low cover and is transitioning from a grass-dominated community to a shrub-dominated community, while in Blackrock 99, vegetation cover has remained near baseline values and the parcel has a sustainable grass-dominated community given the shallower water table. LADWP's contention that the vegetation change identified by the County in Blackrock 94 is due to natural climatic variability is not defensible. The adjacent Blackrock 99 parcel has experienced the same wet and dry cycles since 1984-87, yet vegetation cover and composition have been maintained (even following wildfire). The primary difference between the parcels is the fluctuation in water table depth caused by LADWP's groundwater pumping which has caused greater drawdown in groundwater levels under Blackrock 94.

Concerning the degree of the decrease and change in vegetation, as stated at page 57 of the ICWD report, baseline perennial cover in Blackrock 94 measured 41%, while, on average, parcel cover from 1991-2012 was 27%. This represents a 1/3 decrease in cover on average, while in the same period, Blackrock 99 has maintained baseline cover values on average. The decrease in vegetation cover is persistent, occurring in 17 of 23 years since the Green Book monitoring program began in 1991 through 2013. Grass cover has decreased, while shrub cover changed little, resulting in an increasing proportion of shrubs. The changes in vegetation community composition suggest a transition from Type C to Type B vegetation is occurring in Blackrock 94. Such a decrease and change is contrary to the goals of the LTWA and is significant.

Regarding the significance of the change in vegetation in Blackrock 94, as stated on page 2-41 of the Final 1991 EIR:

…a change from a shrub meadow to a shrub cover (e.g., from rabbitbrush meadow to rabbitbrush scrub), would be a change not only of vegetation community but also of management type—from Type C to Type B. This would be recognized as a significant impact under the Agreement because the change would involve a loss of vegetation cover and an undesirable change in species composition. Such downward changes of management type are to be avoided under the Agreement.

Evaluation of the permanency of the decrease, change, or effect

LADWP contends that the vegetation decreases and changes in Blackrock 94 are not permanent and that vegetation cover is fully anticipated to meet or exceed baseline conditions following a period of higher precipitation and runoff. Once again, the primary basis of LADWP's contention is that the decreases and changes in vegetation are not significant because they are not attributable to LADWP's groundwater pumping. In the preceding sections, this report has presented the reasons why the decreases and changes in vegetation are attributable to LADWP's groundwater pumping and not primarily due to drought, dry climatic cycles and runoff.

As previously discussed, the decrease in vegetation cover is persistent, occurring in 17 of 23 years since the Green Book monitoring program began in 1991 through 2013. Such a lengthy period of vegetation decrease is inconsistent with the goal of the LTWA to avoid such decreases and to avoid changes from Type C to Type B vegetation. Maintaining the lowered water tables under Blackrock 94 as advocated by LADWP will not result in avoiding such significant impacts.

Concerning a possible vegetation recovery during a future period of higher precipitation and runoff, as discussed in the section of this report addressing the impacts of fire, in July 2007, wildfire burned through portions of Blackrock 94 and 99. The County originally provided evidence of observable differences between areas of the two parcels that burned (ICWD report, pp. 53-54). Within days following the fire, perennial native grasses sprouted and grew vigorously at TS3 (the monitoring site just outside of Blackrock 99), (Figure 27). In contrast, no grass sprouted along the permanent transect at TS1 (within Blackrock 94), and no live hits were recorded along the transect during the remainder of the growing season (ICWD report, Figure 20). By the summer of 2009, TS3 was dominated by native grasses while TS1 was dominated by tumbleweed (Figure 9 and ICWD report, Figure 21). The sites have similar soils and differ primarily in DTW and vegetation composition before the fire (Figure 9 and 24).

The sharply different post-fire vegetation responses after the fire are attributable to LADWP pumping that has resulted in a sustained lowered water table under Blackrock 94, but not Blackrock 99. The negligible or delayed grass recovery from fire in Blackrock 94 compared to Blackrock 99 is evidence that lack of water availability impedes vegetation recovery from natural disturbances. Where the water table is present near the grass root zone, events like the 2007 fire can enhance meadow communities, i.e. promote grasses and remove shrubs, but fire may hasten the conversion to a shrub community where the water table is below the rooting zone of the grasses.

LADWP's assertion that the vegetation changes identified by the County in Blackrock 94 are natural, reversible, and driven by wet/dry cycles is conjecture. The fact is that no significant vegetation recovery was observed in Blackrock 94 following the wet years of 2005, 2006, and 2011, when runoff in Owens Valley was respectively 136%, 146%, and 142% of normal. On the other hand, the neighboring parcel Blackrock 99 has experienced the same wet and dry cycles since 1984-87, yet vegetation cover and composition have been maintained, even following wildfire. LADWP's conjecture of vegetation recovery when runoff and precipitation conditions are again similar to the baseline period is based largely on a general and unmeasured change in vegetation between the late 1970's and the establishment of baseline vegetation conditions. Current conditions, however, are not comparable to the late 1970's. LADWP's prediction for vegetation recovery fails to consider the deleterious impacts of the vegetation's lack of resilience caused by the lowered groundwater levels in Blackrock 94 attributable to LADWP's groundwater pumping. The lack of resilience hinders the ability of the vegetation to recover from non-groundwater pumping stresses such as fire and, when fire occurs, it completes the conversion from meadow to shrub and weed dominated vegetation--a significant violation of the LTWA. Thus, there is no certainty that the meadow vegetation in Blackrock 94 will recover to baseline conditions even if precipitation and runoff are similar to the pre-baseline period.

Evaluation as to whether the decrease, change, or effect causes a violation of air quality standards

The County concurs with LADWP that there are no data available that suggests air quality has been negatively impacted at Blackrock 94.

Evaluation of the cumulative effect of the impact when judged in relation to all such areas on the Owens Valley

LADWP first contends that there are no possible cumulative effects of the decreases and changes in vegetation in Blackrock 94 when judged in relation to other areas in the Owens Valley because no significant impacts to vegetation in the Owens Valley attributable to LADWP's groundwater pumping or to LADWP's surface water management practices have been determined by the Technical Group since the 1991 EIR was certified. LADWP then contends that there are no cumulative effects of the decreases and changes in vegetation in Blackrock 94 when judged in relation to other areas in the Owens Valley because, as it contends with several of its other significance factor evaluations, the decreases and changes at Blackrock 94 are due to wet/dry climatic cycles and are not attributable to LADWP's groundwater pumping. LADWP finally contends that changes in vegetation at other parcels in the Owens Valley are solely due to the same wet/dry climatic cycles that drive the vegetation decreases and changes in Blackrock 94.

In the preceding sections, this report has presented the reasons why the decreases and changes in vegetation at Blackrock 94 are attributable to LADWP's groundwater pumping and not primarily due to drought, dry climatic cycles and runoff. Concerning the observation that the Technical Group has not found significant impacts due to LADWP's groundwater pumping or surface water management practices and with regard to LADWP's contention that changes in vegetation in other parcels in the Owens Valley are solely due to wet/dry climatic cycles, it should be pointed out that the 1991 EIR clearly recognized that LADWP's groundwater pumping could cause valley-wide decreases and changes in vegetation during a severe drought and provided a mitigation measure for such impacts.

Although the Technical Group has not determined that LADWP's groundwater pumping has caused a significant impact on vegetation since 1991, the draft 1991 EIR on page 10-70, discusses the role of a "Drought Recovery Policy" as a mitigation measure for the valley-wide impacts of groundwater pumping. Moreover, in response to comment PD-17, on page 2-28 and 2-29, the Final 1991 EIR provides a further discussion of the Drought Recovery Policy:

> *Recognizing the experimental nature of the management and mitigation techniques, and under the severe conditions of the current drought, it has been agreed by LADWP and Inyo County to conservatively manage groundwater pumping during this drought and during a period of recovery following the drought, LADWP and Inyo County have agreed that the following policy will govern future groundwater pumping:*
>
> *Recognizing the current extended drought, the Standing Committee establishes a policy for annual management of groundwater pumping during this drought. The goal of this policy is that soil water within the rooting zone recover to a degree sufficient so that the vegetation protection goals of the Agreement are achieved. To this end, groundwater pumping during this drought, as well as the period of recovery, will be conducted in an environmentally conservative manner, taking into consideration soil water, water table, and vegetation conditions. It is recognized that soil water in the rooting zone is naturally replenished by precipitation and from the water table. Further, soil water, water tables, and vegetation conditions will be monitored by the Technical Group to ensure that the goal of this policy is being achieved and for purposes of evaluating the effectiveness of the existing well turn-off /turn-on provisions.*
>
> *This policy is to provide guidance to the Standing Committee for establishing annual pumping programs during the current drought as well as during a period of recovery. It is intended that groundwater pumping will continue to be conducted in an environmentally conservative manner as was done during the 1990-91 and 1991-92 runoff years until*

there has been a substantial recovery in soil moisture and water table conditions in areas of Types B, C, and D vegetation that have been affected by groundwater pumping. The Standing Committee will establish annual pumping programs based on an evaluation of current conditions, including soil moisture level, water table depth, degree of water table recovery, soil type, vegetation conditions, the results of studies pertaining to vegetation recovery, and compliance with the goals of the Agreement. It is probable that this policy will result in reduced annual pumping programs as compared to annual pumping programs based solely on soil moisture conditions.

As can be seen from the foregoing, the Standing Committee has recognized the need to manage groundwater pumping so that there is water table recovery to cause an increase in soil water to promote vegetation recovery. LADWP's plan to maintain lowered groundwater levels in Blackrock 94 while waiting for precipitation and runoff to cause a vegetation recovery is clearly inconsistent with the goal of the Standing Committee stated in the Drought Recovery Policy.

Finally, LADWP's contention that changes in vegetation at other parcels in the Owens Valley are solely due to the same wet/dry climatic cycles that drive the vegetation decreases and changes in Blackrock 94 is without merit. The County has shown that groundwater pumping adversely affects vegetation in well field parcels throughout the valley and that the decreases and changes in vegetation at Blackrock 94 are not occurring in isolation. The effects of groundwater pumping on vegetation throughout the valley were discussed in the County's Initial Brief. On pages 15 and 16, the County's Initial Brief states:

The LTWA provides that vegetation cover in parcels potentially affected by pumping (wellfield parcels) is to be compared to parcels unaffected by pumping (control parcels). The results of such an evaluation show that throughout the Owens Valley, vegetation in wellfield parcels is generally below baseline measurements while cover in control parcels is generally above baseline cover. Wellfield parcel cover is negatively correlated with changes in depth to groundwater caused by groundwater pumping while control parcel cover is unaffected; this indicates that groundwater pumping adversely affected wellfield parcels throughout the Owens Valley. Although the analysis did not exhaustively examine cumulative impacts, the results of the comparison between wellfield parcels and control parcels throughout the valley indicate that the decreases and changes documented at Blackrock 94 are not occurring in isolation.

Evaluation of the value of existing enhancement and mitigation projects addressing the environmental consequences of similar impacts

LADWP identifies and discusses 8 enhancement or mitigation projects in vicinity of Blackrock 94 including the Lower Owens River Project (LORP) and the Blackrock Fish Hatchery. It is important to note that none of the identified projects provide mitigation for the impacts to vegetation at Blackrock 94.

Although the LORP is a valuable mitigation project it does not provide mitigation for the impacts at Blackrock 94. As noted on pages 33 and 34 of the County's Response brief, the LORP:

> …only provides compensatory mitigation for "*the area of riparian and meadow vegetation that has been lost and will not be restored because of the elimination of spring flow due to groundwater pumping…"*

Thus, the Lower Owens River Project is not intended to mitigate the impacts of groundwater pumping on groundwater dependent vegetation (such as at Blackrock 94) that was not caused by the "*elimination of spring flow due to groundwater pumping*." Additional support of this fact is that loss of riparian and meadow vegetation mitigated by the Lower Owens River Project which was caused by the elimination of spring flow is estimated to be less than 100 acres while the impacts at Blackrock 94 are in excess of 300 acres.

Concerning the Blackrock Fish Hatchery, on pages 32 and 33 of the County's Response Brief, the scope of the mitigation provided by the Blackrock Fish Hatchery is discussed. The Response Brief states that the Blackrock Fish Hatchery provides:

> *…mitigation for elimination on spring flow at Blackrock Spring and for impacts to vegetation dependent on the springflow; however, it does not address impacts at Blackrock 94 or provide mitigation for the impacts to groundwater dependent vegetation at Blackrock 94. This can be seen from Table VE-2 on page 2-43 of Volume 1 of the Final 1991 EIR which shows that the area mitigated by Mitigation Measure 10-14 is only 6 acres. 6 acres is significantly less than the more than 300 acres impacted at Blackrock 94. The impacts at Blackrock 94, shrub encroachment and loss of cover in an alkali meadow, differ distinctly from the loss of riparian, marsh, and pond habitat mitigated by Mitigation Measure 10-14. Moreover, the impacted vegetation identified in Mitigation Measure 10-14 is located adjacent to Big Blackrock Spring while the impacted groundwater dependent meadows at Blackrock 94 are located from 1.3 to 2.3 miles from Big Blackrock Spring. Finally, the fish hatchery, the pond and the fish rearing facilities are not located on Blackrock 94. The foregoing clearly demonstrates that the first part of Mitigation Measure 10-14 is not mitigation for the vegetation impacts at Blackrock 94.*

Concerning the other enhancement and mitigation projects identified by LADWP, including the development and implementation of the Owens Valley Land Management Plan, in each instance, the projects are mitigation for specific adverse impacts that were caused by LADWP's groundwater pumping from 1970 to 1990 or, in the case of the land management plan, for the potential cumulative impacts of LADWP water gathering operations and Owens Valley land use practices; therefore, none of the projects identified by LADWP serve as mitigation for the significant decreases and changes in vegetation at Blackrock 94. (See 1991 FEIR Chapter 10 (Vegetation) Impact 10-14 (pages 10-59 to 10-62).)

As noted in the ICWD Report on pages 64 and 65, the LTWA serves as the mitigation measure to mitigate any impacts of LADWP's groundwater pumping that occur after the 1970-1990 period. Thus, mitigation for the vegetation impacts at Blackrock 94 should be implemented consistent with the LTWA because such impacts are not offset by other valuable mitigation measures and projects that do not mitigate the vegetation decreases and changes in Blackrock 94.

Evaluation as to the impact, if any, on rare or endangered species and on other vegetation of concern

In its evaluation or the impact of its groundwater pumping on rare and endangered species and other species of concern, LADWP concludes that "*…groundwater pumping, changes in DTW, or surface water spreading are not the primary influences affecting this population."* In the ICWD report (p. 58) the County concluded, *"…the rare plant data are insufficient to document any trend or impact related to LADWP surface water or groundwater management."* There is no disagreement on this point.

Evaluation as to whether the decrease, change, or effect affects human health

In its report, LADWP concluded that there are no data available that suggests human health has been affected by vegetation changes at Blackrock 94. In the ICWD report (p. 59) the County concurred with LADWP's findings by concluding that there "…*is no indication that the condition of the parcel is affecting human health.*"

Summary of Significance Analysis

The vegetation cover in Blackrock 94 has been below baseline vegetation cover for 17 of the 23 years since the Technical Group commenced expanded vegetation monitoring in 1991. The vegetation in Blackrock 94 is converting from Type C meadow vegetation to Type B shrub vegetation. These changes are attributable to LADWP's groundwater pumping operations. Such changes are defined as significant impacts by the LTWA, the Green Book and the 1991 Final EIR. Mitigation measures in other areas of the Owens Valley do not mitigate the significant impacts at Blackrock 94.

There is no certainty that there will be recovery from these vegetation conditions in the event of a return of persistent higher runoff and precipitation conditions. Further, there is no certainty as to when such improved runoff and precipitation conditions will occur. In lieu of passively waiting for runoff and precipitation improvement, the Standing Committee has recognized in its Drought Recovery Policy that in persistent drought conditions, such as are currently prevailing, there is a need to conservatively manage groundwater pumping to cause groundwater levels to recover to increase soil water available to the vegetation in order to achieve the vegetation management goals of the LTWA.

As provided in the LTWA, the Technical Group should be ordered to develop a mitigation plan for the significant adverse vegetation decreases and changes in Blackrock 94.

Summary and Conclusions

LADWP and the County agree that water availability is the primary driver of vegetation change in Blackrock 94. While there are a number of data sets and analytical methods that Inyo and LADWP agree on, the County disagrees with LADWP's most important interpretations and conclusions concerning causes of diminished water availability at Blackrock 94, the relation between hydrologic change and vegetation change, LADWP's choice of control areas, and the significance of the impact.

The County disagrees with LADWP's conclusion that "*runoff-driven recharge of the aquifer is the main factor affecting water levels beneath Blackrock 94*." Groundwater modeling is the most applicable tool available to determine how groundwater pumping has affected the water table. Both parties used groundwater models to investigate hypothetical groundwater pumping scenarios to determine how the water table would have behaved under different pumping conditions. Groundwater model results show that water table fluctuations due to recharge alone are relatively small (a few feet) and water table declines attributable to groundwater pumping have been about 10 to 15 feet or more. The USGS reached a similar general conclusion in its study of Owens Valley groundwater management. Observations in areas of similar vegetation elsewhere in Owens Valley where the water table is unaffected by pumping corroborate these results.

LADWP's analysis emphasized pumping at the Blackrock Hatchery and its relation to Blackrock 94, and concluded that because hatchery pumping is relatively constant, drawdown due to hatchery pumping stabilized prior to the mid-1980's. The County's groundwater modeling showed that both hatchery and non-hatchery pumping produce significant drawdown at Blackrock 94. The nearly constant hatchery pumping produces sustained drawdown, and the more variable pumping from other wells produces variable drawdown in addition to the hatchery effects. LADWP's modeling erroneously omitted an amount of pumping equivalent to the historic spring flow from Big Blackrock Springs, producing the paradoxical result that Blackrock Hatchery pumping has little effect on the water table, despite being the largest amount of pumping in the region and relatively close to Blackrock 94.

LADWP employed faulty methods to interpret soil water conditions in Blackrock 94 and as a consequence presented an incomplete and incorrect assessment of the factors that affect soil water availability. The County's assessment corroborates conclusions presented in the County's 2011 report and shows that water table withdrawal was the primary factor contributing to the lack of water availability measured at TS1 and TS2 in Blackrock 94. Since the high water table period of the mid-1980's, soil water in Blackrock 94 has seldom reached the grass root zone at TS1 and TS2. This has resulted in persistent declines in vegetation cover and changes in community from grass-dominated to shrub-dominated. Site TS3 that was less affected by pumping has had groundwater in the root zone in most years since 1987 and vegetation cover remained stable or increased.

LADWP developed a statistical relationship between vegetation cover, precipitation, and runoff for Blackrock 94. LADWP's model excludes depth to water as a variable, so response of groundwater dependent vegetation cannot be evaluated. For example, because differences in precipitation and runoff between Blackrock 99 and Blackrock 94 are negligible, this model would predict the same cover in both Blackrock 99 and Blackrock 94, which would significantly underestimate cover in Blackrock 99. The LADWP model fits the measured vegetation cover at Blackrock 94 well, but cannot be used to examine how vegetation cover would have changed in Blackrock 94 if pumping had been different, because it ignores water table changes. The County developed a more suitable model capable of evaluating cover response to changes in water availability due to changes in precipitation and/or depth to water.

The magnitude of vegetation change attributable to pumping was estimated using the model developed by the County. The amount of drawdown attributable to pumping was estimated using the difference between the 'no pumping' and 'actual pumping' groundwater model scenarios. The model-predicted water table declines indicate that cover would have remained at or just below the cover in 1986. This is consistent with the expected vegetation response if the water availability had not been reduced by pumping similar to conditions experienced in Blackrock 99. Pumping, not fluctuations in runoff or precipitation, is the primary reason vegetation cover declined in Blackrock 94.

The control parcels selected by LADWP are not comparable to Blackrock 94 due to large differences in initial baseline cover and composition, initial depth to water, precipitation, and differences in soils. LADWP's choice of control parcels is insufficient to meet the Green Book requirement that soil water at the affected site be compared to control sites, because soil water measurements do not exist for LADWP's control parcels LADWP's assertion that the vegetation changes identified by the County in Blackrock 94 are natural, reversible, and driven by wet/dry cycles is not supported by its analysis of control parcels. Neighboring parcel Blackrock 99 has experienced the same wet and dry cycles since 1984-87, yet vegetation cover and composition have been maintained, even following wildfire. Blackrock 99 is a much more appropriate control to compare with Blackrock 94, because soils, precipitation, baseline vegetation cover and composition, and initial depth to water are known to be similar. The efficacy of Blackrock 99 as a control site derives largely from its proximity to Blackrock 99. For these reasons, the County believes that the Technical Group should use Blackrock 99 as a site-specific control for Blackrock 94.

In July 2007, wildfire burned through portions of Blackrock 94 and 99. The County and LADWP agree that although the fire affected Blackrock 94, it was not the cause of the decline in vegetation cover and loss of grasses. Contrasting response to the 2007 fire shows that grass recovers quickly where the water table is sufficiently high, and recovery is slow or nonexistent where the water table is deep. The negligible or delayed recovery from fire in Blackrock 94 compared to 99 is evidence that lack of water availability impedes recovery from natural disturbances. One simply cannot assume vegetation will revert back to baseline conditions during the next wet cycle. The sharply different recovery rates after the fire are attributable to LADWP pumping that has created a sustained lowered water table under Blackrock 94 but not Blackrock 99.

In February 2011, the County presented its findings to the Technical Group concerning vegetation change in Blackrock 94 (ICWD report). The County concluded:

> *Available factual and scientific data indicate a measurable vegetation change since baseline has occurred in Blackrock 94, both in terms of vegetation cover and species composition. These changes occurred between baseline and 1991 and have persisted in time. Vegetation composition has changed toward increasing shrub proportion and a decrease in grass cover. While the proportion of shrubs in Blackrock 94 has not yet caused the parcel to change from Type C to Type B vegetation status, changes in species composition suggest a change in Type is occurring. Parcel Blackrock 94 is currently Type C, but is changing to Type B. Vegetation degradation is primarily attributable to changes in water availability resulting from groundwater pumping and reduced surface water diversions into the vicinity of Blackrock 94. The factors prescribed in the LTWA and Green Book for assessing the significance of an impact were evaluated and indicate that a significant change is occurring in Blackrock 94. The terms of the LTWA require that such impacts be avoided or mitigated.*

Based on our evaluation of the LADWP report, our conclusions have not changed. LADWP presents many analyses in its report that either are not relevant to addressing the requirements of LTWA section IV.B and Green Book section I.B, or not executed and interpreted correctly. In this response, we have shown that measurable changes in vegetation in Blackrock 94 would not have occurred but for LADWP groundwater pumping and are significant.

For all reasons presented by the County in these proceedings, its pleadings and herein, the arbitration panel is asked to:

1. Determine that a measureable and significant change and decrease in vegetation has occurred or is occurring at Blackrock 94 that is attributable to LADWP's groundwater pumping and to its changes in surface water management practices; and

2. To direct the Technical Group to develop and commence implementation of a mitigation plan within one year for the impacts at Blackrock 94 in compliance with L TWA Section IV .B and Green Book Section I. C.

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Appendices

Appendix A. Excerpt from the 2010 ICWD Annual Report, Precipitation Section

Introduction

Precipitation in the Owens Valley is monitored at nine stations by Los Angeles Department of Water and Power (LADWP), one station by the National Oceanic and Atmospheric Administration (NOAA), and at seven stations by Inyo County Water Department (ICWD, Table 1). The ICWD program began in December 1991 to support an analysis of the vegetation database and maps suggested in the Green Book (Section V.A.1.b). This article summarizes results from all stations for the period that the Inyo program was in place.

Table 1. List of rain gauge abbreviations used in this article as well as location name and gauge operators.

Abbreviation	Name/Location	Operator
RG1	Laws 1 monitoring site	Inyo
RG2	Laws museum	Inyo
RG3	BC2 monitoring site	Inyo
RG4	BP2 monitoring site	Inyo
RG5	Goose Lake	Inyo
RG6	TS2 monitoring site	Inyo
RG7	Union Wash, NE of Lone Pine	Inyo
NOAA	Bishop airport	NOAA
BISYD	Bishop maintenance yard	DWP
BPPH	Big Pine Powerhouse	DWP
BPYD	Big Pine maintenance yard	DWP
TIN	Tinemaha Reservoir	DWP
LAAIT	Los Angeles aqueduct intake	DWP
INDYD	Independence maintenance yard	DWP
ALGT	Alabama gates	DWP
LPYD	Lone Pine maintenance yard	DWP
CWGT	Cottonwood gates	DWP

Methods

Monitoring was completed by manual reads collected daily for the LADWP/NOAA gauges. Inyo gauges were visited after known or suspected rain events and individual measurements constitute storm totals. Previously, ICWD constructed a precipitation database based on data for LADWP gauges provided in the LADWP daily aqueduct report. Those reports are produced before internal quality control procedures are completed, and the data they contain are subject to change. When discrepancies were noted in the daily report (e.g. the daily measurement and running total disagree), an estimated value was entered into the database.

Data from LADWP gauges discussed in this article were provided after the quality control procedures were completed, and the earlier corrections estimated by ICWD were discarded.

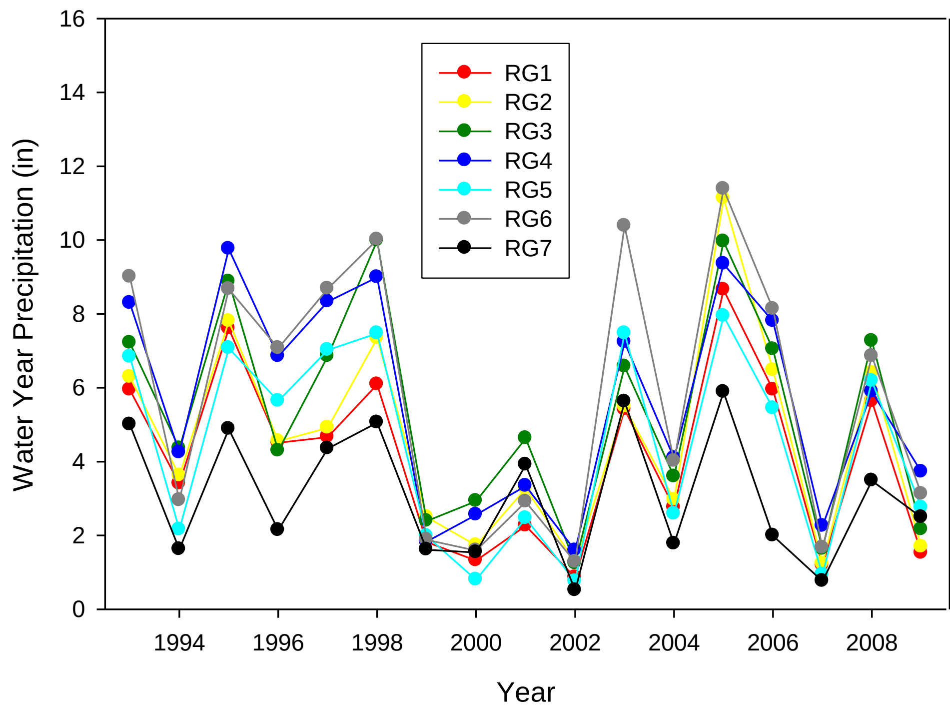

Figure 1. Water year precipitation totals for the seven Inyo County gauges for the period of record.

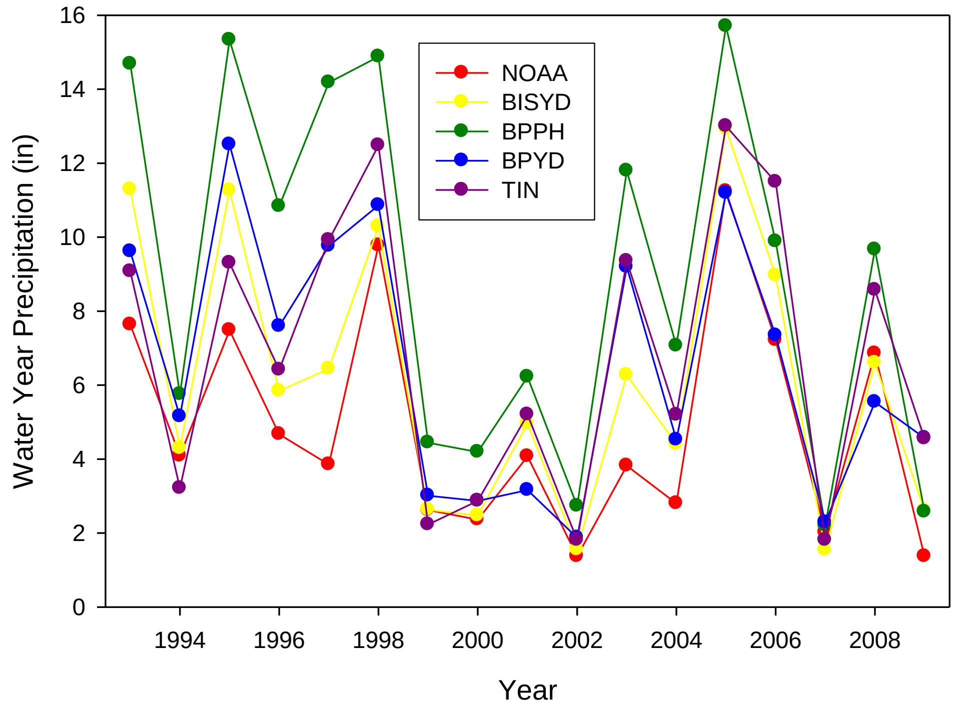

Figure 2. Water year precipitation totals for the LADWP gauges in the northern Owens Valley and the NOAA gauge at the Bishop Airport.

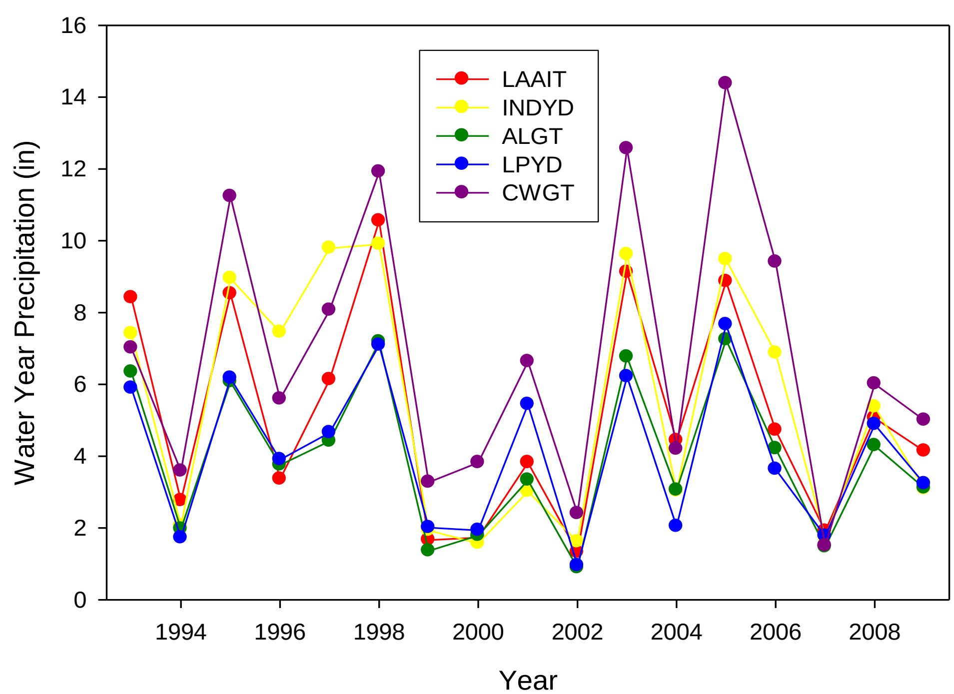

Figure 3. Water year precipitation totals for the LADWP gauges in the southern Owens Valley.

Precipitation measurements can be summarized several ways depending on the purpose of the analysis. Two frequently used quantities are water year and winter precipitation total. Water year is defined as the period from October 1 to September 30 and is referred to by the ending date. For example, water year 1993 encompasses the period October 1, 1992 to September 30, 1993. The Owens Valley climate is characterized by moist winters and dry summers. Approximately 80% of the annual precipitation occurs from October to April. Because the evapotranspiration demand is low during winter, much of the precipitation is stored in the soil where it is a reservoir for plant use during the growing season. For the analysis presented here, winter is defined as October 1 through March 31. Other time periods or definitions could be used to represent winter, but for the purpose of examining trends or comparing locations, the Oct.1-Mar. 31 definition is sufficient.

Discussion

Water year (October 1-September 30) totals and average for the period of record are presented in Table 2. In general, the totals for the Inyo gauges is less than that measured in nearby LADWP gauges. Most Inyo gauges were located closer to the center of the valley, and the lower values reflect the general precipitation gradients in the valley (Danskin, 1998). Simple inspection of the inter-annual trends, however, suggests that

Table 2. Water year totals and averages for Inyo and LADWP rain gauges during the period of operation of the Inyo gauges. Measurements are in inches.

Water Year	RG1	RG2	NOAA	BISYD	RG3	BPPH	BPYD	RG4	TIN	LAAIT	RG5	RG6	INDYD	RG7	ALGT	LPYD	CWGT
1993	5.94	6.29	7.63	11.29	7.21	14.68	9.61	8.29	9.07	8.41	6.83	9.00	7.41	5.00	6.34	5.89	7.01
1994	3.40	3.62	4.09	4.29	4.354	5.75	5.15	4.24	3.21	2.76	2.155	2.95	2.06	1.62	1.97	1.72	3.58
1995	7.60	7.80	7.48	11.26	8.87	15.33	12.5	9.76	9.30	8.52	7.07	8.67	8.95	4.88	6.07	6.17	11.23
1996	4.51	4.55	4.67	5.84	4.29	10.83	7.59	6.85	6.41	3.36	5.64	7.07	7.45	2.14	3.75	3.9	5.59
1997	4.66	4.91	3.85	6.44	6.85	14.18	9.76	8.33	9.92	6.13	7.02	8.68	9.79	4.35	4.42	4.65	8.06
1998	6.09	7.34	9.77	10.29	9.98	14.88	10.86	8.99	12.48	10.55	7.47	10.01	9.9	5.055	7.18	7.09	11.91
1999	1.82	2.5	2.62	2.63	2.39	4.44	3.01	1.83	2.23	1.66	1.98	1.88	1.93	1.61	1.36	2.01	3.27
2000	1.32	1.73	2.36	2.47	2.93	4.19	2.87	2.56	2.87	1.73	0.8	1.59	1.57	1.54	1.79	1.93	3.82
2001	2.26	3.27	4.07	4.96	4.63	6.22	3.16	3.34	5.20	3.82	2.46	2.91	3.02	3.91	3.33	5.44	6.63
2002	0.86	1.28	1.37	1.55	1.24	2.73	1.87	1.59	1.81	1.32	0.75	1.28	1.61	0.51	0.89	0.95	2.4
2003	5.41	5.49	3.82	6.27	6.57	11.79	9.19	7.23	9.35	9.12	7.47	10.38	9.61	5.62	6.76	6.21	12.56
2004	2.75	2.96	2.8	4.4	3.59	7.06	4.52	4.09	5.19	4.43	2.58	4.01	3.03	1.77	3.05	2.04	4.19
2005	8.65	11.13	11.24	12.94	9.96	15.7	11.19	9.35	13.00	8.86	7.94	11.38	9.47	5.88	7.24	7.66	14.37
2006	5.94	6.47	7.21	8.96	7.04	9.88	7.34	7.8	11.49	4.72	5.44	8.13	6.87	1.99	4.21	3.63	9.4
2007	1.19	1.23	2.02	1.54	1.63	2.2	2.29	2.25	1.81	1.91	0.93	1.66	1.73	0.76	1.47	1.77	1.5
2008	5.63	6.4	6.85	6.6	7.26	9.66	5.54	5.89	8.57	5.06	6.18	6.85	5.37	3.48	4.29	4.88	6.01
2009	1.52	1.69	1.37	2.6	2.16	2.57	4.57	3.72	4.55	4.14	2.75	3.12	3.09	2.49	3.11	3.23	5
Average	4.09	4.63	4.90	6.14	5.35	8.95	6.53	5.65	6.85	5.09	4.44	5.86	5.46	3.09	3.95	4.07	6.85

Table 4. Regression equations and summary statistics for estimating water year precipitation at Inyo gauge locations from LADWP gauges.

Inyo gauge	DWP gauge	regression equation	r^2
RG1	BISYD	0.63*BISYD + 0.23	0.91
RG2	BISYD	0.72*BISYD + 0.24	0.91
RG3	TIN	0.71*TIN + 0.52	0.89
RG4	BPYD⊥	0.80*BPYD + 0.40	0.96
RG5	INDYD	0.78*INDYD + 0.16	0.94
RG6	INDYD	1.03*INDYD + 0.21	0.95
RG7	LPYD	0.81*LPYD - 0.19	0.93

⊥: Correlation with INDYD was slightly better than BPYD. Either model would provide acceptable results.

precipitation totals among gauge locations is correlated (Figures 1-3). Results of a correlation analysis comparing each gauge to all others is presented in Table 3. Correlation for water year precipitation was high, and generally weakened slightly as distance between gauges increased. The high correlation between the gauges suggest that it may be possible to develop statistical models of the spatial pattern of precipitation. in the valley That analysis is beyond the scope of this work, but may be completed in the future if needed.

One important advantage of the LADWP dataset is the much longer period of record than the Inyo monitoring program. The longer record is necessary for analyses that extend to the 1984-87 period when the vegetation baseline for the Water Agreement was established. For all Inyo gauges, at least one LADWP gauge could be identified as a surrogate based on an acceptable linear regression model relating precipitation measured at the two locations (Table 4).

Examination of winter precipitation produced results similar to those from the analysis of water year totals (Figures 4-6, and Tables 5-6). The Inyo and LADWP measurements are well correlated. In fact, the correlation between gauges for winter precipitation is higher than for water year totals for most pairs. That may reflect different precipitation patterns between winter and summer storms. Winter storms tend to be frontal systems that affect a large portion of the valley. Summer showers are more isolated, weakening the correlation between pairs of stations for the water year totals. The differences in correlation are so small, however, that this interpretation is speculative.

The original goal for the expanded the rain gauge network was to improve the understanding of the precipitation patterns in the valley. That goal for Inyo County's monitoring program has been met, and the field measurements were discontinued in 2009.

Table 3. Coefficient of determination (r^2) matrix of water year precipitation totals. The gauges are arranged north to south.

r^2	*RG1*	*RG2*	*NOAA*	*BISYD*	*RG3*	*BPPH*	*BPYD*	*RG4*	*TIN*	*LAAIT*	*RG6*	*RG5*	*INDYD*	*RG7*	*ALGT*	*LPYD*	*CWGT*
RG1	1																
RG2	0.961	1															
NOAA	0.832	0.906	1														
BISYD	0.913	0.910	0.891	1													
RG3	0.903	0.907	0.863	0.890	1												
BPPH	0.865	0.806	0.696	0.859	0.869	1											
BPYD	0.845	0.757	0.616	0.813	0.811	0.916	1										
RG4	0.895	0.805	0.688	0.860	0.861	0.928	0.956	1									
TIN	0.836	0.830	0.745	0.817	0.891	0.817	0.778	0.877	1								
LAAIT	0.704	0.672	0.592	0.738	0.795	0.778	0.817	0.774	0.769	1							
RG6	0.872	0.813	0.659	0.795	0.835	0.897	0.882	0.922	0.913	0.827	1						
RG5	0.858	0.787	0.628	0.764	0.829	0.904	0.880	0.913	0.874	0.804	0.968	1					
INDYD	0.764	0.690	0.532	0.689	0.761	0.888	0.899	0.906	0.844	0.782	0.945	0.943	1				
RG7	0.632	0.640	0.510	0.655	0.731	0.729	0.702	0.654	0.666	0.856	0.732	0.757	0.707	1			
ALGT	0.795	0.770	0.673	0.809	0.837	0.830	0.837	0.835	0.845	0.958	0.906	0.879	0.837	0.876	1		
LPYD	0.698	0.729	0.659	0.736	0.795	0.737	0.696	0.699	0.749	0.829	0.762	0.782	0.731	0.927	0.901	1	
CWGT	0.758	0.778	0.619	0.718	0.801	0.712	0.759	0.746	0.831	0.804	0.823	0.763	0.787	0.780	0.860	0.817	1

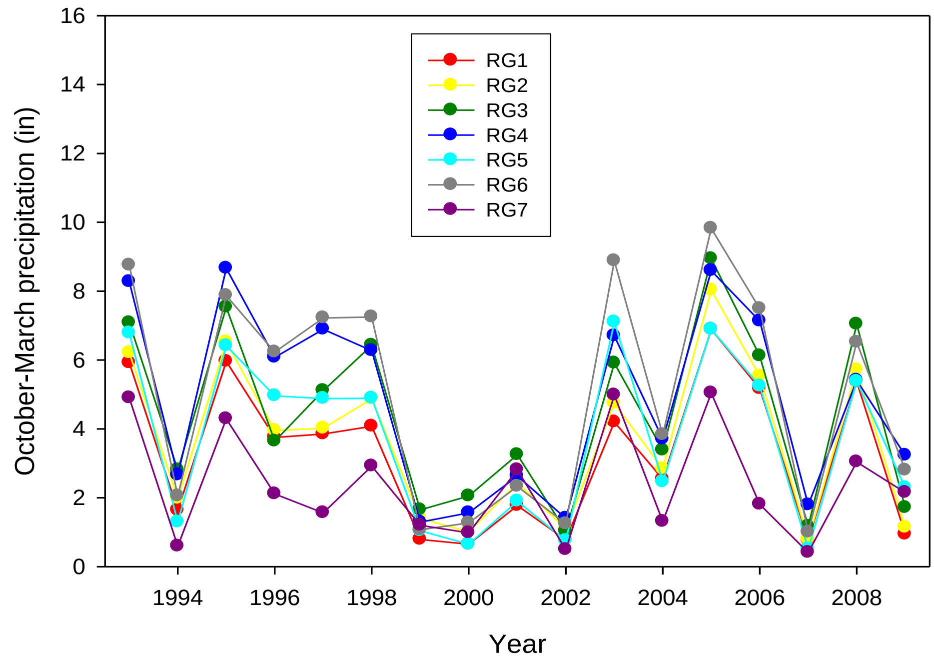

Figure 4. Winter precipitation totals for the seven Inyo County gauges for the period of record.

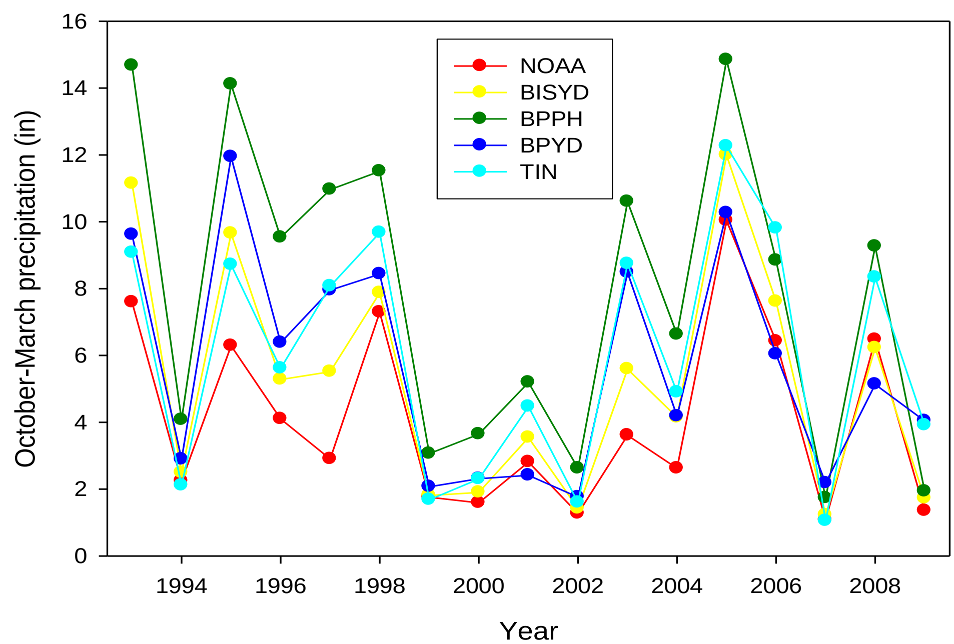

Figure 5. Winter precipitation totals for the LADWP gauges in the northern Owens Valley and the NOAA gauge at the Bishop Airport.

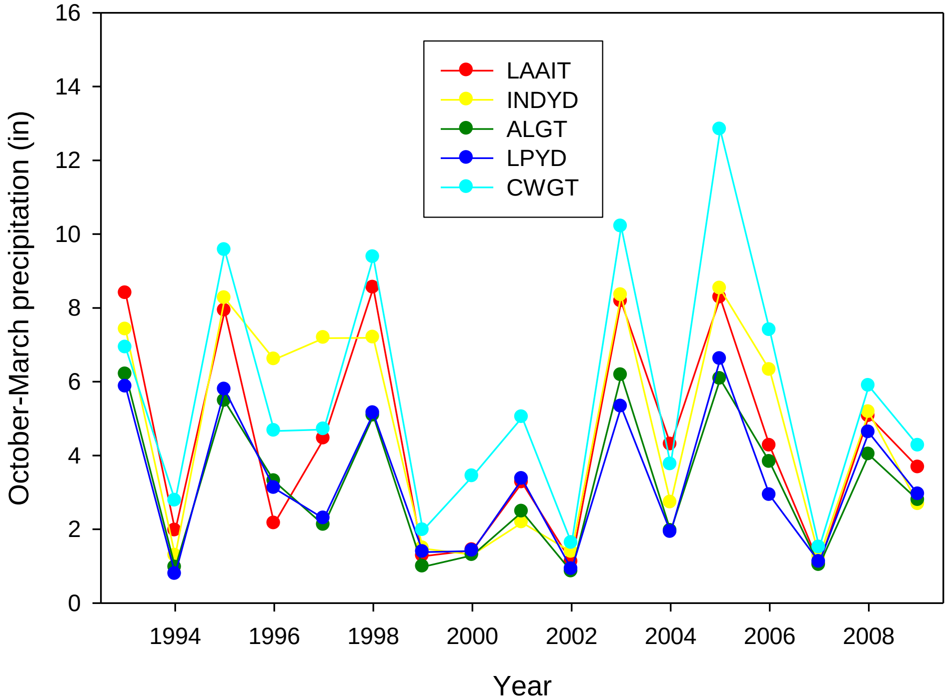

Figure 6. Winter precipitation totals for the LADWP gauges in the southern Owens Valley.

Table 5. Winter (October 1-March 31) totals and averages for Inyo and LADWP rain gauges during the period of operation of the Inyo gauges. Measurements are in inches.

Water Year	RG1	RG2	NOAA	BISYD	RG3	BPPH	BPYD	RG4	TIN	LAAIT	RG5	RG6	INDYD	RG7	ALGT	LPYD	CWGT
1993	5.92	6.21	7.59	11.14	7.08	14.67	9.61	8.27	9.07	8.39	6.78	8.75	7.41	4.9	6.19	5.86	6.92
1994	1.64	1.98	2.24	2.49	2.81	4.07	2.89	2.66	2.11	1.96	1.29	2.05	1.28	0.59	0.96	0.78	2.77
1995	5.96	6.52	6.29	9.65	7.53	14.11	11.94	8.66	8.71	7.92	6.41	7.87	8.26	4.29	5.47	5.78	9.56
1996	3.75	3.95	4.1	5.28	3.64	9.53	6.38	6.08	5.61	2.15	4.96	6.23	6.6	2.11	3.3	3.11	4.66
1997	3.85	4.02	2.9	5.51	5.11	10.96	7.95	6.89	8.07	4.45	4.88	7.22	7.18	1.56	2.11	2.29	4.7
1998	4.075	4.87	7.29	7.87	6.425	11.51	8.43	6.27	9.67	8.54	4.89	7.25	7.19	2.92	5.07	5.14	9.37
1999	0.79	1.4	1.76	1.81	1.65	3.06	2.07	1.29	1.68	1.27	1.04	1.07	1.48	1.2	0.98	1.38	1.97
2000	0.65	1.01	1.59	1.9	2.05	3.64	2.31	1.56	2.3	1.43	0.65	1.27	1.31	0.98	1.29	1.41	3.43
2001	1.77	2.43	2.81	3.54	3.25	5.19	2.41	2.63	4.47	3.26	1.9	2.33	2.18	2.81	2.47	3.36	5.03
2002	0.78	1.1	1.27	1.42	1.03	2.62	1.76	1.4	1.6	1.11	0.75	1.24	1.38	0.49	0.85	0.91	1.62
2003	4.2	4.74	3.61	5.59	5.91	10.6	8.48	6.7	8.74	8.17	7.1	8.88	8.34	4.98	6.17	5.32	10.2
2004	2.54	2.84	2.62	4.15	3.38	6.62	4.18	3.7	4.9	4.29	2.46	3.83	2.72	1.31	1.95	1.92	3.75
2005	6.89	8.03	10.03	11.99	8.94	14.84	10.26	8.59	12.26	8.27	6.89	9.82	8.52	5.04	6.07	6.61	12.83
2006	5.17	5.53	6.42	7.61	6.12	8.84	6.03	7.13	9.8	4.26	5.24	7.49	6.31	1.81	3.82	2.92	7.39
2007	0.77	0.79	1.07	1.22	1.17	1.73	2.18	1.79	1.05	1.06	0.51	1	1.25	0.41	1.02	1.11	1.5
2008	5.37	5.71	6.47	6.22	7.04	9.26	5.13	5.41	8.33	5.06	5.38	6.51	5.17	3.04	4.02	4.62	5.88
2009	0.94	1.14	1.35	1.72	1.71	1.93	4.04	3.23	3.91	3.67	2.29	2.8	2.67	2.15	2.78	2.94	4.26
average	3.24	3.66	4.08	5.24	4.40	7.83	5.65	4.84	6.02	4.43	3.73	5.04	4.66	2.39	3.21	3.26	5.64

Table 6. Coefficient of determination (r^2) matrix of winter precipitation totals. The gauges are arranged north to south.

r^2	*RG1*	*RG2*	*NOAA*	*BISYD*	*RG3*	*BPPH*	*BPYD*	*RG4*	*TIN*	*LAAIT*	*RG6*	*RG5*	*INDYD*	*RG7*	*ALGT*	*LPYD*	*CWGT*
RG1	1																
RG2	0.988	1															
NOAA	0.860	0.898	1														
BISYD	0.921	0.937	0.912	1													
RG3	0.952	0.970	0.880	0.907	1												
BPPH	0.903	0.905	0.770	0.919	0.890	1											
BPYD	0.793	0.790	0.629	0.817	0.784	0.899	1										
RG4	0.915	0.889	0.715	0.872	0.855	0.916	0.922	1									
TIN	0.890	0.906	0.816	0.850	0.921	0.842	0.773	0.881	1								
LAAIT	0.684	0.714	0.648	0.748	0.783	0.761	0.802	0.722	0.781	1							
RG6	0.904	0.892	0.722	0.833	0.875	0.902	0.866	0.954	0.932	0.771	1						
RG5	0.895	0.877	0.683	0.798	0.854	0.879	0.856	0.933	0.880	0.761	0.976	1					
INDYD	0.828	0.818	0.636	0.770	0.795	0.888	0.910	0.939	0.864	0.730	0.960	0.949	1				
RG7	0.634	0.671	0.576	0.673	0.685	0.672	0.674	0.626	0.644	0.801	0.679	0.748	0.653	1			
ALGT	0.760	0.779	0.711	0.780	0.788	0.765	0.786	0.777	0.793	0.881	0.831	0.868	0.800	0.908	1		
LPYD	0.735	0.774	0.737	0.775	0.795	0.748	0.746	0.707	0.761	0.860	0.745	0.789	0.725	0.935	0.945	1	
CWGT	0.709	0.772	0.718	0.737	0.806	0.711	0.742	0.716	0.834	0.820	0.775	0.752	0.754	0.773	0.853	0.840	1

Appendix B. CD of data and analyses used in this report.