Inyo County Water Department Site Assessment of Five Bridges Impact Area

March 2018

Executive summary

The Five Bridges Impact Area is a 300 acre site that was impacted by groundwater pumping conducted by LADWP in 1987 through 1989. The impact was identified in the environmental impact report *Water from the Owens Valley to Supply the Second Los Angeles Aqueduct, 1970 to 1990, 1990 Onward, Pursuant to a Long Term Groundwater Management Plan* (1991 EIR). Impact 10-12 identifies that,

> *Vegetation in an area of approximately 300 acres near Five Bridges Road north of Bishop was significantly adversely affected during 1988 because of the operation of two wells, to supply water to enhancement/mitigation projects.*

The 1991 EIR noted that,

> *Water has been spread over the affected area since 1988. By the summer of 1990, revegetation of native species had begun on approximately 80 percent of the affected area. LADWP and Inyo County are developing a plan to revegetate the entire affected area with riparian and meadow vegetation. This plan will be implemented when it has been completed*.

The *Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management* (1999 Plan) was finalized by the Inyo/Los Angeles Technical Group in 1999.

This document examines the status of the Five Bridges Impact Area with respect to the goals set in the 1999 Plan. The site-specific goals from the 1999 Plan are to:

> *Restore the area to a complex of vegetation communities with similar species composition and cover as exists at local similar sites. The goal will be attained when the desired vegetation conditions are achieved and are sustainable.*

Quantitative Cover Goals are:

For Alkali Meadows, live cover goals are 60% composed of four different perennial species. Riparian scrub live cover goals are 90% composed of four different perennial species.

The 1999 Plan also provides that the site would be:

...considered rehabilitated when cover was 90% and composition 75% of the site specific goal with an 80% confidence limit.

In this report, when the cover reaches 90% of its cover goal, Inyo County Water Department (ICWD) staff conclude that it has reached its "Mitigation Goal." The 1999 Plan, recognizing that 80% of the original impact area had recovered, indicated that the size of the remaining area to be mitigated was approximately 60 acres encompassing five parcels listed in the Plan.

To assess the status of the Five Bridges Impact Area relative to the mitigation goals stated above, ICWD analyzed vegetation data from two permanent vegetation transects that were established in 1989, 22 additional transects that were established in 2004 and 2006, and satellite imagery that extends back to 1984. Additionally, ICWD analyzed surface water and groundwater data from LADWP surface water gaging stations and monitoring wells. To determine whether vegetation trends in the impact area could be explained by natural variability independent of pumping or whether the effect of pumping on vegetation conditions persists, we compared vegetation trends in the Five Bridges Impact Area using line point data and satellite data to nearby areas of similar vegetation that were unaffected by pumping.

<u>Wellfield Monitoring Site transects L4a and L4b.</u> These two transects were used to evaluate whether the mitigation measures have reached their goals because they are specifically referred to in the 1999 Plan: "*Monitoring will consist of annual photopoints and annual reading of the two previously established vegetation transects.*" Additionally, they have a longer period of record than the line point transects discussed below. Transect L4a has achieved its Mitigation Goal of 54% cover in three of 29 years monitored. Transect L4b has achieved its Mitigation Goal of 54% cover for meadow sites in 18 of 27 years monitored. Transect L4b has fluctuated above and below its mitigation goal, and arguably has met the goal. Transect L4a has very rarely met its goal. Based on the two permanent transects, it cannot be concluded that the Five Bridges Impact Area has been fully mitigated.

<u>Line Point transects.</u> Based on line point transects, ICWD determined that areas originally mapped as riparian vegetation did not meet the Mitigation Goal of 81% in any year that they were monitored and alkali meadow areas achieved the Mitigation Goal of 54% once in the last six years and 8 of 14 years overall. Based on the combination of riparian and alkali meadow cover, it cannot be concluded that the Five Bridges Impact Area has been fully mitigated.

Remote Sensing. The NDVI record shows pre-impact (1987) values were achieved only five times in 30 years since the impact.

Control Parcels. Mean perennial cover from line-point transects and mean growing season NDVI were similar in the impact area and the control area prior to the pumping impact. In the year following impact, the impact area dropped significantly below the control area in both data sets. Neither line point nor the NDVI record from the impact area converged consistently back to values comparable to the control area, suggesting depressed vegetation conditions in the impact area are not due to environmental variability alone. From the longer NDVI record (1984-2017), both control and impact groups responded similarly to drought and wetter conditions, but the mean NDVI of the impacted parcels remained persistently below the mean of the control parcels since the impact occurred.

Change in vegetation type from riparian to meadow. Based on either the Green Book (baseline) or LADWP remapped acreages from 1981 aerial imagery, there has been a significant loss of either 43 or 40 acres, respectively, of riparian vegetation as of 2017. A significant amount of Type D riparian vegetation converting into either Type C meadow or Type B scrub would violate the vegetation management goals and principles described in Section IV.A of the Water Agreement. The riparian vegetation in the Five Bridges Impact Area does not resemble pre-impact conditions, and the original impact has not been successfully mitigated.

Invasive species. As described in the 1999 plan, the unrecovered portion of the Impact Area was infested with pernicious non-native weeds. Although the infestation is less severe in areas following extensive treatment by LADWP, the weed infestation is a continued obstacle to successfully mitigating the site. Weed control treatment appears necessary for the foreseeable future.

Conclusion. The goals for the Five Bridges Mitigation Project are given in the 1991 "*Final Environmental Impact Report - Water from the Owens Valley to Supply the Second Los Angeles Aqueduct, 1970 to 1990, 1990 Onward, Pursuant to a Long Term Groundwater Management Plan*" and the 1999 "*Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management.*" This report examined multiple lines of evidence to assess whether the Five Bridges Impact Area has achieved its goals. This evidence shows that the Impact Area has not met its goals.

Introduction

In March 1987, the Los Angeles Department of Water and Power (LADWP) drilled wells W385 and W386 in the Five Bridges area of the Laws wellfield. The wells were operated from October 1987 to spring of 1989, extracting 8,801 acre-feet of groundwater. The groundwater pumping from the two wells resulted in significant adverse impacts to approximately 300 acres of riparian vegetation in the vicinity of the wells (Figure 1).

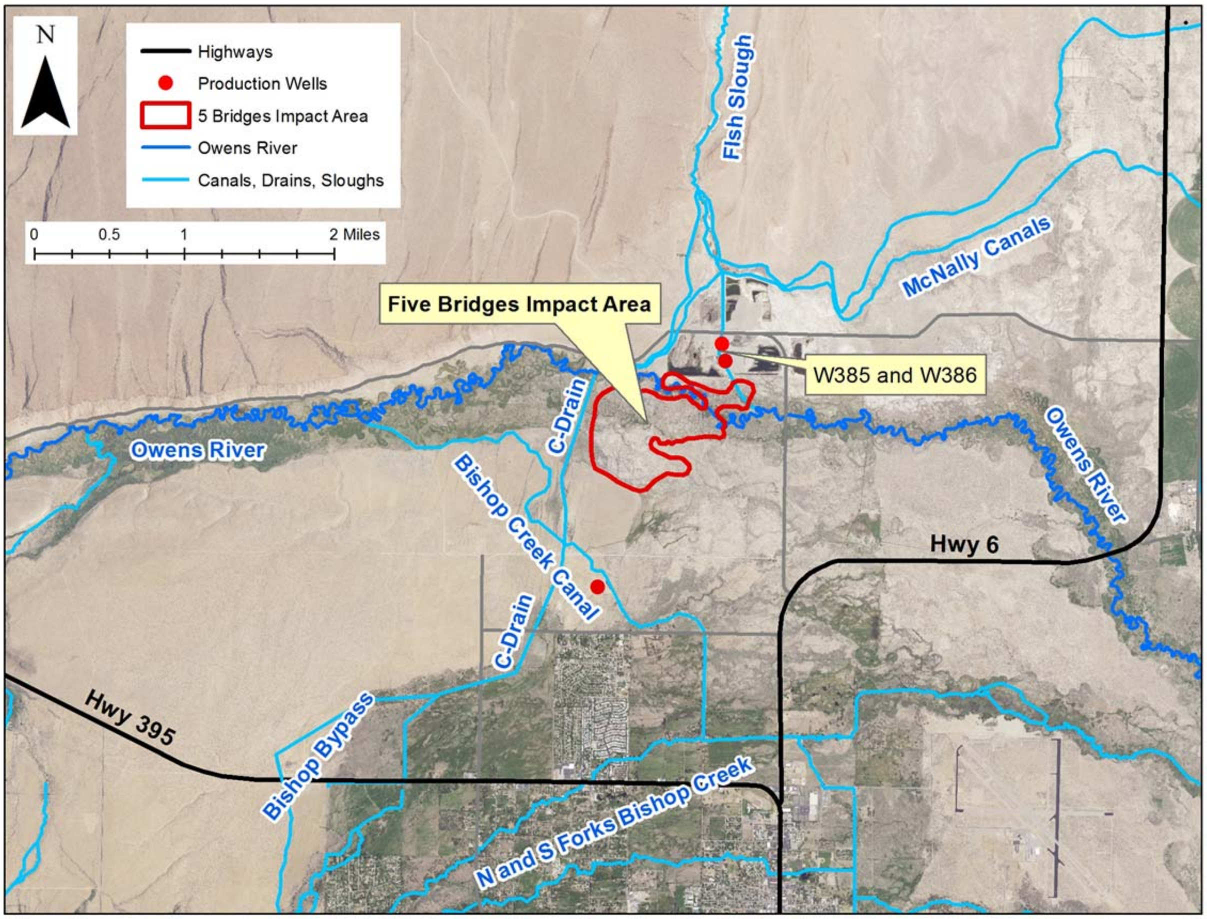


Figure 1. Location of the Five Bridges Impact Area.

That impact was evaluated in the 1991 EIR for the Inyo/Los Angeles Water Agreement (Water Agreement) as impact 10-12. The Five Bridges Impact Area was also included in the 1999 Revegetation Plan (1999 Plan). The 1999 Plan was prepared in accordance with the Green Book to comply with the 1997 Memorandum of Understanding adopted to settle litigation over the adequacy of the 1991 EIR (MOU, 1997). Numerous activities have been implemented by LADWP over the past three decades to mitigate the original impact attempting to recover the site to conditions resembling pre-impact conditions. This report evaluates vegetation conditions through 2017 to assess whether the mitigation efforts have accomplished goals stated in the 1999 Plan and whether shallow groundwater levels have recovered from drawdown caused by pumping W385 and W386. Vegetation cover and composition data from field measurements, satellite imagery time series, and photo points were used to assess the condition of the site relative to mitigation goals.

The 1991 EIR indicated that "*revegetation of native species had begun on approximately 80 percent of the affected area,*" and the 1999 Plan noted that that "*remedial measures have mitigated approximately 80% of the area*," leaving approximately 60 acres of impacted vegetation. In 2017, despite exceptional runoff and precipitation conditions, it was still possible to identify a similar amount of impacted acreage that is not meeting mitigation goals, due to a combination of barren or low cover, weed infestation, and areas where riparian vegetation has been lost. This area includes the pasture called the multiple completion meadow in the central portion of the impact area, south of the Owens River in the vicinity of parcels FSL 126, 125, and the western half of 124. In February 2018, the Five Bridges Impact Area and the Owens River floodplain to the east and west burned.

Mitigation Goals

1991 EIR and Long Term Water Agreement

The 1991 Draft EIR included mitigation measure 10-12 which identified the Five Bridges Impact Area and provided that *"Water has been spread over the affected area since 1988. By the summer of 1990, revegetation of native species had begun on approximately 80 percent of the affected area. LADWP and Inyo County are developing a plan to revegetate the entire affected area with riparian and meadow vegetation. This plan will be implemented when it has been completed.*"

Mitigation measure 10-12 was clarified in the Final EIR. On page 3-16 of Volume I of the Final 1991 EIR, titled "Revisions to the Agreement and Draft EIR," it is acknowledged that "*Approximately 300 acres in the Five Bridges area are being mitigated through a combination of alternatives one and two; that is, pumping has been discontinued in the area, surface water has been supplied to stimulate natural revegetation and active revegetation has occurred in a portion of the area.*"

A mitigation action plan and schedule for Five Bridges was included as Appendix B-5 of the Final EIR. That plan elaborated on mitigation activities, both ongoing and planned, and set out a goal for mitigating the site: "*The overall goal for mitigation of the Five Bridges impact area is to return the area to a complex of vegetation communities with similar species composition and cover as exists at local sites with similar environmental parameters*."

Two permanent vegetation monitoring transects were established in 1989 within the impact area as noted in the Green Book (technical appendix to the Water Agreement). These permanent transects are referred to as L4a and L4b.

1999 Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management

In 1997, a memorandum of understanding was finalized to resolve legal challenges to the adequacy of the 1991 EIR (MOU, 1997). In accordance with Section III.F of the MOU, the Technical Group in 1999 completed a revegetation plan for a number of sites with impacted vegetation, including the Five Bridges Impact Area (1999 Plan). The 1999 Plan included actions to be taken at each site and included site specific project goals, methods, implementation schedules, and success criteria. A memorandum from the Technical Group was presented to the Standing Committee at its October 1, 1999 meeting indicating that the Technical Group had finalized the 1999 Revegetation Plan and presented it to the public. The process to finalize the 1999 Plan was consistent with the Green Book procedure to produce mitigation plans (Section I.C.2).

The 1999 Plan established several project goals that would indicate mitigation success. The overall goal for all sites was to *"...restore vegetation type that previously existed, to establish* *perennial vegetation comparable to nearby areas or to revegetate with other native Owens Valley species."* Specific goals for each site were also included in the Plan. Each site was to be *"considered rehabilitated when cover is 90% and composition 75% of the site specific stated goal with an 80% confidence limit. At least 25% of vegetation cover must include recruits at least three years old that appear to have germinated without human intervention. This would give assurance that the site has become self-sustaining. For example, if the site goal is 15% live cover composed of 13 species, then the goal will be met when live cover reaches 13.5%, consists of at least 10 species, and 3.5% of the plants are approximately 3 years old.*"

For the Five Bridges Impact Area, the specific quantitative goals for mitigation were: "*Goal: Restore the area to a complex of vegetation communities with similar species composition and cover as exists at local similar sites. The goal will be attained when the desired vegetation conditions are achieved and are sustainable. Live cover and composition numbers are from on-site mapping during the 1984-87 vegetation inventory. For Alkali Meadows, live cover goals are 60% composed of four different perennial species. Riparian scrub live cover goals are 90% composed of four different perennial species. Composition numbers are 75% of the previously mapped number of species*."

Several of the activities in the 1999 Plan were based on recommendations of LADWP's consultant Dr. William S. Platts (Platts, 1996). Consistent with the recommendations of Dr. Platts and consistent with Mitigation Measure 10-12, the key components of the 1999 Revegetation Plan call for:

- Map the site to delineate areas that still require mitigation.
- Eliminate artificial irrigation of the site and instead conduct three pulse flows of the Owens River, in order to flood the mitigation area for 24-hours, three times each summer (May/June, July, August)
- Allow the water table to remain at its natural level by a "permanent shutdown" of pumping wells W385 and W386.
- Prepare and plant portions of the site with native species
- Develop and implement a 10-year grazing plan.

Since implementation of the 1999 Plan, LADWP requested use of C-Drain through a diversion on the Bishop Creek Canal for irrigation due to difficulty in successfully irrigating the site by pulsing the Owens River. LADWP has conducted numerous additional activities not specified (nor prohibited) by the 1999 Plan to mitigate the site. Attempts in 2003 by the Technical Group to revise the 1999 Plan to reflect the change in irrigation method were unsuccessful.

The 1999 Revegetation Plan recognized that 80% of the 300-acre Five Bridges impact area had been mitigated and that "*The area still requiring mitigation is predominately mapped as Alkali Meadow and encompasses vegetation parcel nos. 53, 123 [sic], 124, 125, and one narrow strip of Riparian Scrub along the river and meanders, parcel no. 54.*" Inyo County Water Department staff believes that "123" is an error, because parcel FSL123 is located at the far eastern edge of the impact area, and that instead parcel FSL 126, located adjacent to parcels FSL 54 and FSL 125, was intended.

The Mitigation Goals for the Five Bridges site would be met if:

1. Alkali meadow parcels FSL053, FSL124, FSL125, and FSL126 sustain a 54% cover Mitigation Goal (equal to 90% of their assigned cover goal of 60%) with an 80% confidence interval and comprised of at least 3 perennial species characteristic of nearby alkali meadow parcels (equal to 75% of their assigned species composition requirement of 4), and

2. Riparian parcel FSL054 sustains an 81% cover Mitigation Goal (equal to 90% of its assigned cover goal of 90%) with an 80% confidence interval comprised of at least three perennial species characteristic of nearby riparian parcels (equal to 75% of their assigned species composition requirement of 4).

As of 2016, LADWP had reported in its annual report that the mitigation project was fully implemented but not meeting goals (LADWP, 2017). In January 2018, LADWP provided a report and presentation to the Technical Group (LADWP, 2018) analyzing conditions at the Five Bridges Impact Area and concluded the site had met the goals in 2017 but did not indicate whether or not it believes the vegetation conditions are sustainable.

Background and Setting

The Five Bridges Impact Area is located in the northern portion of the Owens Valley in the immediate vicinity of the confluence of the Owens River and Fish Slough at the base of the Volcanic Tablelands. The impacted vegetation is on the floodplain of the Owens River and consists primarily of riparian stands and alkali meadows.

Wells W385 and W386 were drilled by LADWP in March 1987 and screened to draw groundwater from approximately 50 to 550 feet. Their purpose was to supply or provide make-up water for enhancement/mitigation projects in Owens Valley and to dewater nearby gravel deposits to facilitate gravel mining. As originally designed, these wells were screened in both shallow and deep aquifers. Pumping of W385 and W386 began in October 1987. When 8,801 acre-feet of groundwater was pumped from the wells between 1987 and 1989, groundwater levels in the surrounding shallow aquifer dropped, and as a result, approximately 300 acres of groundwater dependent vegetation along the Owens River, known as the Five Bridges Impact Area was degraded. The area of impacted vegetation spans the north and south sides of the Owens River (Figure 1). LADWP stopped pumping these wells in 1989 and implemented a series of activities for the purpose of restoring the site as described in the 1991 EIR.

Wells 385 and 386 remained off until 1993 when LADWP and ICWD conducted a two-month pumping test with intensive groundwater monitoring from November 1993 to January 1994 for the purpose of quantitatively determining the attributability of pumping from these wells with groundwater declines in the impact area. Both wells were pumped simultaneously with a combined pumping rate of 16.5 cfs over 60 days extracting a total of 2,098 acre-feet of groundwater. Water table declines north and south of the Owens River and in the impact area were recorded almost immediately upon commencing pumping. The two wells have remained off (except for a 24 hour pump test on each well following modification) with groundwater data collection continuing at monitoring wells to the present.

Ecological Overview

A primary goal of the Water Agreement *"is to avoid certain described decreases and changes in vegetation."* The basis for evaluating vegetation impacts is a vegetation map compiled in 1984-87 by LADWP and subsequently adopted as the baseline for the Water Agreement. Vegetation in the Five Bridges area was mapped from July-September 1987 (Green Book, p.35) before the pumping impact occurred. The map delineated areas of similar vegetation composition referred to as parcels. Each parcel was given a unique identifier number and USGS quadrangle name. The parcels were further grouped into management Types based on the expected water use of the vegetation in the parcels and dominant species present. Vegetation water use was based on calculated evapotranspiration derived from vegetation cover and composition and estimated transpiration rates for individual species (Green Book, Chapter II). The management Types for native vegetation generally correspond to non-phreatophytic communities (Type A), phreatophytic scrub (Type B), phreatophytic meadow (Type C), and riparian communities (Type D). For Types B, C, and D the Water Agreement goals are to avoid causing significant decreases in vegetation cover and to avoid causing significant areas of vegetation to change to a Type preceding it alphabetically (e.g. D to C). Specific goals for each Type are provided in the Agreement (Section IV) and Green Book (Section I.A). Both goals were violated in the Five Bridges Impact Area and evaluated in the 1991 EIR.

The original Five Bridges Impact Area included portions of vegetation parcels Fish Slough 42, 44, 53, 54, 120, 121,122, 124, 125, 126, 128, 129, and 130. Each parcel was sampled during the baseline vegetation inventory with line point intercept transects (line point) or was assigned a surrogate dataset from a nearby parcel of similar ecological characteristics. Parcels FSL124, FSL125, and FSL126 were assigned the same baseline value as FSL053. Parcel FSL054 was largely riparian vegetation comprised of willows and rose. This parcel was assigned an “ocular” cover estimate of 90% probably due to the difficulty in completing line point transects in vegetation of that stature and density.

Perennial pepperweed (*Lepidium latifolium*) is a state-listed, noxious weed in California. This species was established in the Five Bridges Impact Area since monitoring began at the site shortly after the impact. *L. latifolium* is an aggressive invader of disturbed and seasonally wet sites. It forms dense stands that compete with and exclude native species. *L. latifolium* spreads by seed and root fragments that can be accelerated with flooding. For this report, we exclude *L. latifolium* cover from data used to evaluate cover goals since it is highly undesirable.

Table 1. Parcel name, number of line point transects within Five Bridges Impact Area, Baseline cover, 2017 perennial cover not including *L. latifolium*, Green Book Vegetation Management Type and Holland Vegetation Classification.

Parcel	No. line point transects in Five Bridges Impact Area	Parcel Baseline Cover %	Parcel 2017 Cover %	Green Book Vegetation Type and Holland Vegetation Class
FSL042	0	13	NA	Type A - Desert Sink Scrub
FSL044	1	70	44	Type C - Alkali Meadow
FSL053	4	60	46	Type C - Alkali Meadow
FSL054	8	90	47	Type D- Riparian
FSL120	0	54	NA	Type C - Alkali Meadow
FSL121	0	12	NA	Type A - Great Basin Mixed Scrub
FSL122	0	11	NA	Type B - Rabbitbrush Scrub
FSL124	5	60	65	Type C - Alkali Meadow
FSL125	3	60	57	Type C - Alkali Meadow
FSL126	2	60	52	Type C - Alkali Meadow
FSL129	5	49	40	Type C - Alkali Meadow
FSL130	9	24	33	Type C - Alkali Meadow

Soils and Subsurface Materials Overview

Soils at the site have been mapped by the NRCS and, in general, consist of finer grained soils along the former Owens River floodplain and coarser grained soils on the terrace area immediately above the floodplain. The floodplain soils are primarily Torrifluvent-Fluvaquentic Endoaquolls consisting of sandy-silty clays which are somewhat poorly drained. The terrace soils are sandy-loams and are moderately to excessively drained. Both these soil types vary in thickness across the mitigation area. A prominent gravel-cobble layer has been noted beneath the finer soil horizons at several locations across the site (Figure 2).

The shallow subsurface aquifer in the vicinity of the mitigation area (based on well logs) consists of coarser grained alluvial and fluvial sand, gravel and cobble deposits related to the Owens River flood plain. The upper aquifer layer is poorly to moderately consolidated. Deeper subsurface layers include the buried Bishop Tuff overlaying older sands, silts and clays related to previous fluvial and lacustrine environments. The Bishop tuff and/or clay layers at depth can create confining or semi-confining layers which separate the recent alluvial and fluvial deposits ("shallow aquifer") from the older buried sediments ("deep aquifer"). It should be noted that due to the construction and operation of reservoirs on the Owens River and Bishop Creek, the former floodplain is largely inactive.

Figure 2. Exposure of finer textured soils over gravel-cobble layer in down-cut irrigation ditch in the Five Bridges Impact Area. The red line denotes the approximate boundary between the different parent materials. The extent of capillarity where fine-grained surface material intersects the shallow water table is apparent as the darker soil color on the right side of the photo.

Hydrologic Overview

In general, surface water and groundwater, originating from the Sierra, enters the project area from the west along the Owens River. Additional ground and surface water flows northeast from the Bishop Creek alluvial fan towards the southern boundary of the impact area. The Volcanic Tablelands and Fish Slough are located north of Five Bridges Impact Area and provide surface flow, and potentially groundwater flow, to the northern boundary of the mitigation area. There are a series of north-south striking faults running north from Bishop through the project area into the Volcanic Tablelands, which may affect groundwater flow.

Flows in the Owens River are related to seasonal runoff from the Sierra and also LADWP reservoir management. Surface and groundwater exit the project area to the east or southeast. Additional surface flows include water diverted from the Owens River into the Bishop Creek Canal (west and south of the project) for irrigation into the mitigation area and the McNally Canals (north and east of the project) for water spreading in the Laws area. Other hydrologic factors which affect the site include evapotranspiration which peaks spring through summer, precipitation which occurs primarily late-fall through spring, and pumping in Laws or the Bishop Cone (notably pumping from LADWP production wells W385, W386 and W410), and/or water diversions in the Bishop Creek alluvial fan and surface flows from the C-Drain located south of the impact area. Groundwater levels in the vicinity of the project are generally shallow (less than 15 feet below ground surface).

Hydroecology

In arid and semi-arid regions like the Owens Valley, shallow groundwater supports riparian, meadow, and phreatophytic shrub-dominated plant communities. A critical source of water for these phreatophytes is either direct uptake of water from roots intercepting the shallow water table and/or uptake of moisture from soils in the unsaturated zone which is recharged by capillarity from groundwater and precipitation. This relationship between phreatophytic vegetation and shallow groundwater levels at or near the plant root zones has been researched extensively (Amlin and Rood 2002, Cooper et al 2005, Duell 1990, Elmore et al 2006, Stromberg et al 1993).

Methods

A variety of relevant datasets with differing monitoring scales and attributes have been collected at Five Bridges Impact Area by Inyo County and/or LADWP. Most of the data are current through 2017 runoff year. A description of the data and methods used in this analysis follows.

Wellfield Monitoring Site Transects

Vegetation cover has been measured since 1989 at two permanent vegetation transects, L4a and L4b. Measurements at the 100-meter transects were collected using methods similar to the line point program described below. During the development of the 1999 Plan, these two transects had a continuous period of monitoring and were included to assess the cover and composition mitigation goals. The criteria for considering the site rehabilitated as defined at these two permanent transects (L4a and L4b) is vegetation cover reaching or exceeding the 1999 Plan's 54% cover Mitigation Goal for alkali meadow composed of three perennial species (see explanations 1 and 2 in Mitigation Goals section above). For this analysis, perennial pepperweed (*Lepidium latifolium)* did not contribute to meeting the cover and composition goals.

Line-Point Transects

Vegetation cover and composition are monitored annually using the line-point-intercept method (line point transects or transects). This technique is described in detail in the Green Book, Section I.C Box I.C.1.a.ii, and the 1999 Plan states "*Line-point transects will be used to determine whether the site has met the goals stated above.*" Line point transects have been used to monitor vegetation trends in all Type C alkali meadow parcels within the mitigation area since 2004. Subsequent transect locations were established within the remaining mitigation area in 2006 in FSL054, mapped as Type D, Riparian. These transects have been monitored through 2017.

The Mitigation Goals are 54% perennial cover for alkali meadow and 81% perennial cover for riparian parcels (see explanations 1 and 2 in Mitigation Goals section above). Each year's data was compared to the Mitigation Goals using a one-sample t-test at the 80% confidence level. The one sample *t*-test is used here to determine whether the line point transect sample for each year could have been generated from a population with a mean equal to the Mitigation Goal. Transects in alkali meadow parcels FSL53, 124,125,126 identified in 1999 Plan as still requiring mitigation were aggregated into one group representing the impacted alkali meadow area and transects within FSL54 were compared separately to the riparian Mitigation Goal. Cover of *Lepidium latifolium* was removed from the data set before statistical analysis. Parcels FSL129 and FSL 130 were not considered in need of further mitigation at the time the 1999 Plan was finalized by the Technical Group; therefore, they are not included in the alkali meadow group in these comparisons. From 2004 to 2017, FSL130 has been at its baseline cover values each year except the drought years of 2013 through 2015. FSL129 has been at its baseline cover value in each year except 2004, 2008, and 2014 through 2016 (all drought years).

Remote sensing

Although not specifically prescribed in either the 1991 EIR or the 1999 Plan, remote sensing techniques using LandSat data (available from 1984 through 2017) can be used to monitor changes in vegetation conditions over time and allow additional comparisons to be made between pre- and post-impact vegetation changes. Live green plants contain chlorophyll which absorbs visible light from 0.4 to 0.7 um. The cell structure of leaves also reflects near-infrared light from 0.7 to 1.1 um. The normalized difference vegetation index (NDVI) is the ratio of the reflected radiation in the near-infrared to the reflected radiation in the red wavelength. NDVI has been used to estimate Leaf Area Index, biomass, chlorophyll concentration in leaves, plant productivity, and fractional vegetation cover and is used for mapping groundwater-dependent vegetation in arid lands (see review in Pettorelli *et al* 2005). To assess changes over time in vegetation cover, LandSat Thematic Mapper imagery was used to calculate the NDVI from available growing season images.

NDVI was the index most strongly correlated with cover values measured in the field by the Inyo/Los Angeles line point vegetation monitoring program (see below). The Enhanced Vegetation Index (EVI) correlation with ground measured cover was approximately the same as NDVI, but at high cover, the EVI values were persistently below measured values. NDVI is known to be related to leaf area index (Vina, 2011), but the relationship levels off above LAI of approximately 3. It is possible that reliance on NDVI will limit the ability to detect small changes at very high cover, but NDVI can be used to determine whether cover in a given year is similar to baseline years or whether two separate areas have qualitatively different vegetation vigor. However, NDVI cannot differentiate the specific composition of the green vegetation present and, therefore, cannot distinguish between desirable species and undesirable weeds.

The NDVI time series for April 1 through October 31 (growing season) (1984-2017) was zonally averaged to the Five Bridges Impact Area polygon, and also subareas corresponding to vegetation parcels that were clipped from the Impact Area. The time series of the mitigation area is plotted and compared to the 1987 NDVI growing season (Apr 1 - Oct 31) average. The change in NDVI from 1987 to 2017 was mapped across the mitigation area to isolate spatially where, in 2017, vegetation cover was comparable to 1987 conditions. Individual mitigation area parcel time series were examined and compared to nearby control parcels to determine to what extent the continuous record of interannual growing season vegetation vigor from 1984 through 2017 was comparable between parcels in the mitigation area and a set of parcels west of the mitigation area of the same vegetation type.

Comparison to Control parcels

Impacted parcels included FSL53, FSL54, FSL124, FSL125, FSL126. Control parcels were selected for comparison to parcels in the mitigation area to provide context for natural ranges of variability in vegetation cover that respond to climatic and environmental factors unrelated to the initial pumping impact. Vegetation parcels FSL128, FSL138, and FSL166, mapped as alkali meadow and rush/sedge meadow, west of the impact area on the south side of Owens River, were selected as control parcels because they have been monitored with line point transects since 2004 and had similar perennial cover prior to the impact (Figure 3). Both line point time series (2004-2017) and the NDVI time series (1984-2017) are compared between control and impact parcel groups.

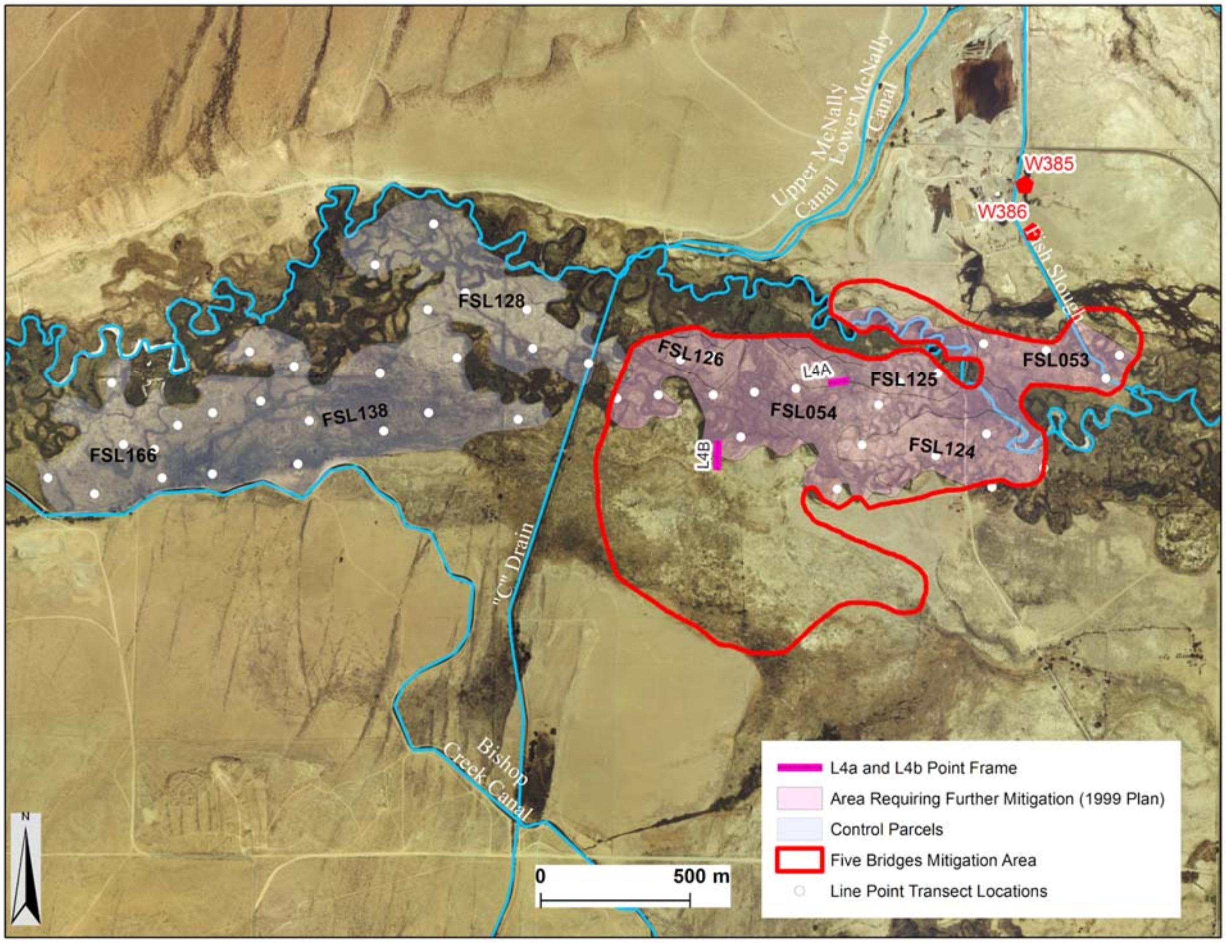


Figure 3. Location of the portions of vegetation parcels within the Five Bridges Impact Area requiring further mitigation in the 1999 Plan, control parcels west of C-drain and locations of line point transects used to evaluate Mitigation Goals and to provide quantitative comparisons between the impact area and a control area.

Hydrologic data

Groundwater levels are collected in monitoring wells across the Five Bridges Impact Area using electric tape manual reads. Most of these monitoring wells are shallow piezometers used to monitor the unconfined aquifer which is indicative of whether groundwater is accessible to vegetation. Monitoring also occurs in several wells screened in deeper subsurface layers. Flow monitoring of the major rivers, canals and diversions occurs at flumes or weirs using data-logging devices corrected to manual measurements. Pumping amounts are collected at well-outflow totalizing gauges. Hydrologic data sources used for this report include the Test Well and

Totals and Means databases provided by LADWP along with a limited number of ICWD hydrologic reads from October to December 2017.

Lepidium latifolium

Perennial Pepperweed (*Lepidium latifolium*) is an invasive noxious weed, rated as having a high negative ecological impact by the California Invasive Plant Council. *Lepidium latifolium* presence is shown at line-point transect locations where it was detected in 2017 to visually evaluate the distribution of the infestation and to help determine the remaining areas of concern. Photopoints are examined at transect locations hosting *L. latifolium* and from supplementary photo points in areas poorly represented by line-point transects (Appendix B).

Sustainability

Criteria for evaluating the sustainability of the vegetation recovery in the mitigation area, or the likelihood that meadow and riparian vegetation can be maintained under natural groundwater levels and natural disturbances are not provided in either the 1991 EIR or the 1999 Plan. For revegetation projects, the 1999 plan suggests differentiating and quantifying newly recruited individuals (revegetation occurring in the three most recent years) relative to the total cover measured. A proportion of newly established to already established perennial cover of 25% was suggested as a value that would inform whether or not natural regeneration could occur in the absence of irrigation and/or planting used in initial mitigation efforts. Recruitment has not been monitored within the Five Bridges Impact area. Rhizomatous, groundwater-dependent vegetation, as exists at the site, largely expands in cover vegetatively and was likely impractical to differentiate vegetative regeneration from seedling establishment. Therefore, additional metrics were considered to quantify whether the site has met the sustainability goal stated in the 1999 Plan.

The frequency with which cover and composition goals are met over time is a simple approach to assessing the sustainability of the vegetation recovery and is, therefore, the method used in this assessment. However, LADWP’s proposed change to eliminate all surface water irrigation (2018) from Bishop Creek canal represents a change in hydrologic conditions at the site, and it is unclear how to evaluate sustainability under a future hydrologic regime that departs significantly from conditions under which the vegetation monitoring data described above were collected.

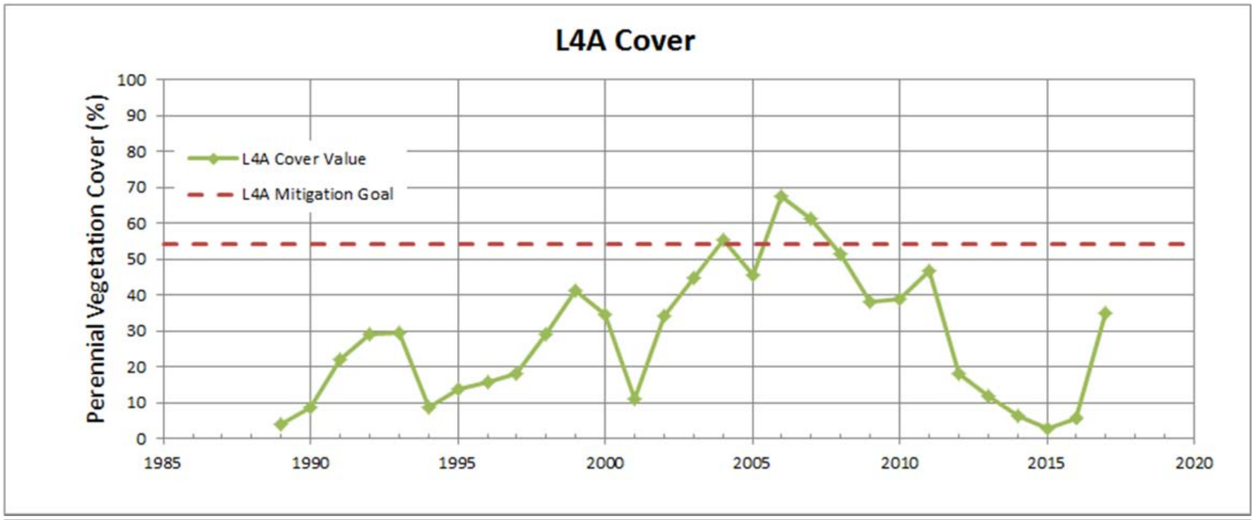
Type Change

A vegetation type change from Type D riparian to Type C alkali meadow which has occurred in FSL054 is discussed in the context of Greenbook vegetation management goals. Remapping of the vegetation communities based on 1981 and 2017 aerial imagery was conducted by LADWP staff and provides an approximation of the acreage and spatial extent of this undesirable and prohibited Type change.

Results and Discussion

Wellfield Monitoring Site Transects L4a and L4b

Transect L4a has achieved its 54% Mitigation Goal 3 of 29 years monitored (10%). Transect L4b Transect has achieved its 54% Mitigation Goal in 18 of 27 years monitored (66%) (Figures 4 and 5). While L4a is representative of the heavily disturbed areas within the mitigation area, L4b is representative of the areas that have recovered since the initial pumping impact in 1987. The observation that L4a achieved its 1999 Plan Mitigation Goals in only 10% of years monitored shows that the Five Bridges Impact has not been successfully mitigated.



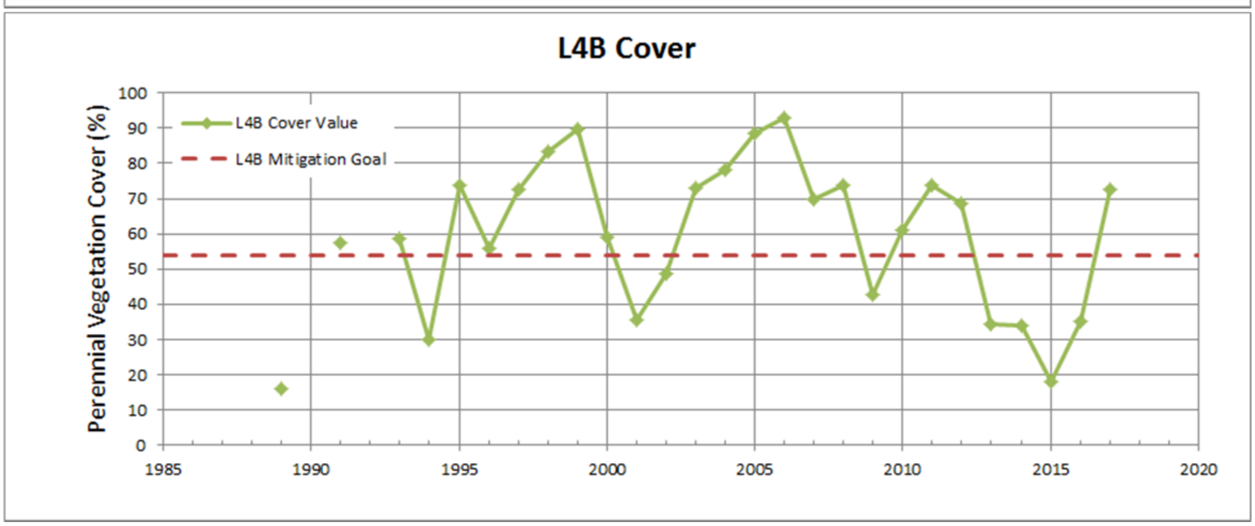
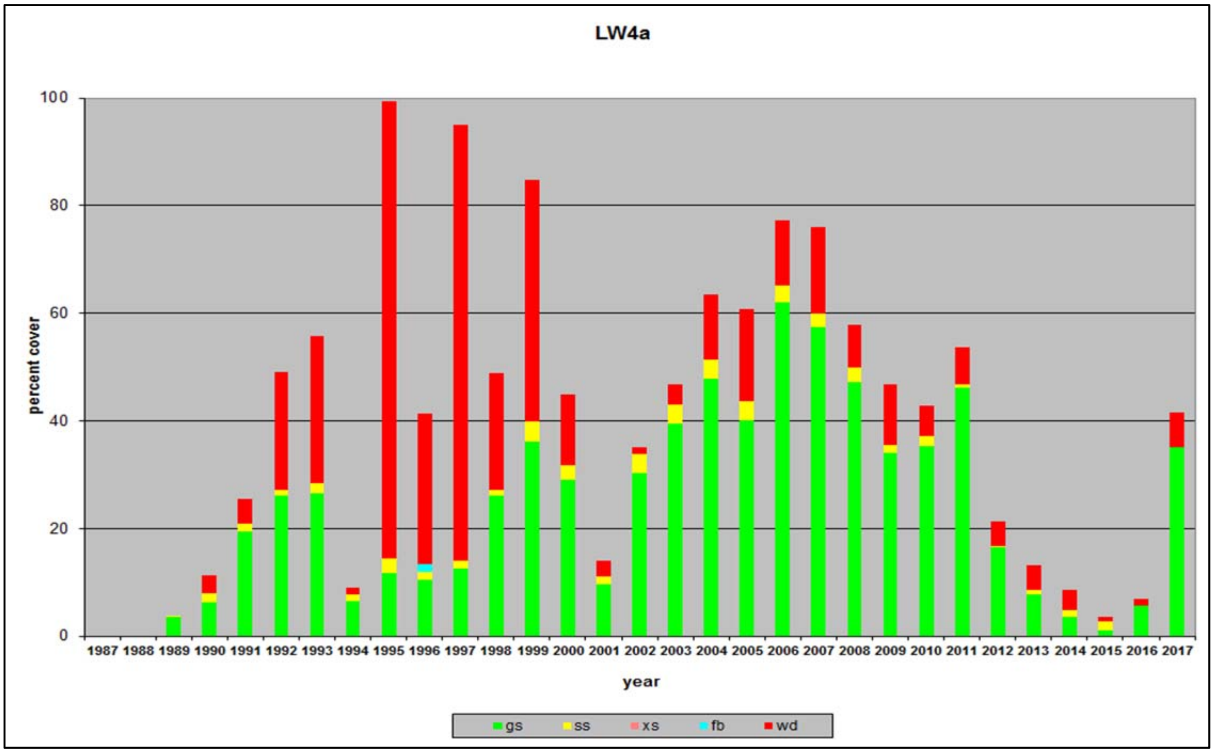


Figure 4. Perennial vegetation cover values at wellfield monitoring transects L4a and L4b with their associated 54% Mitigation Goal. Cover values at L4B for 1990 and 1993 are not available.



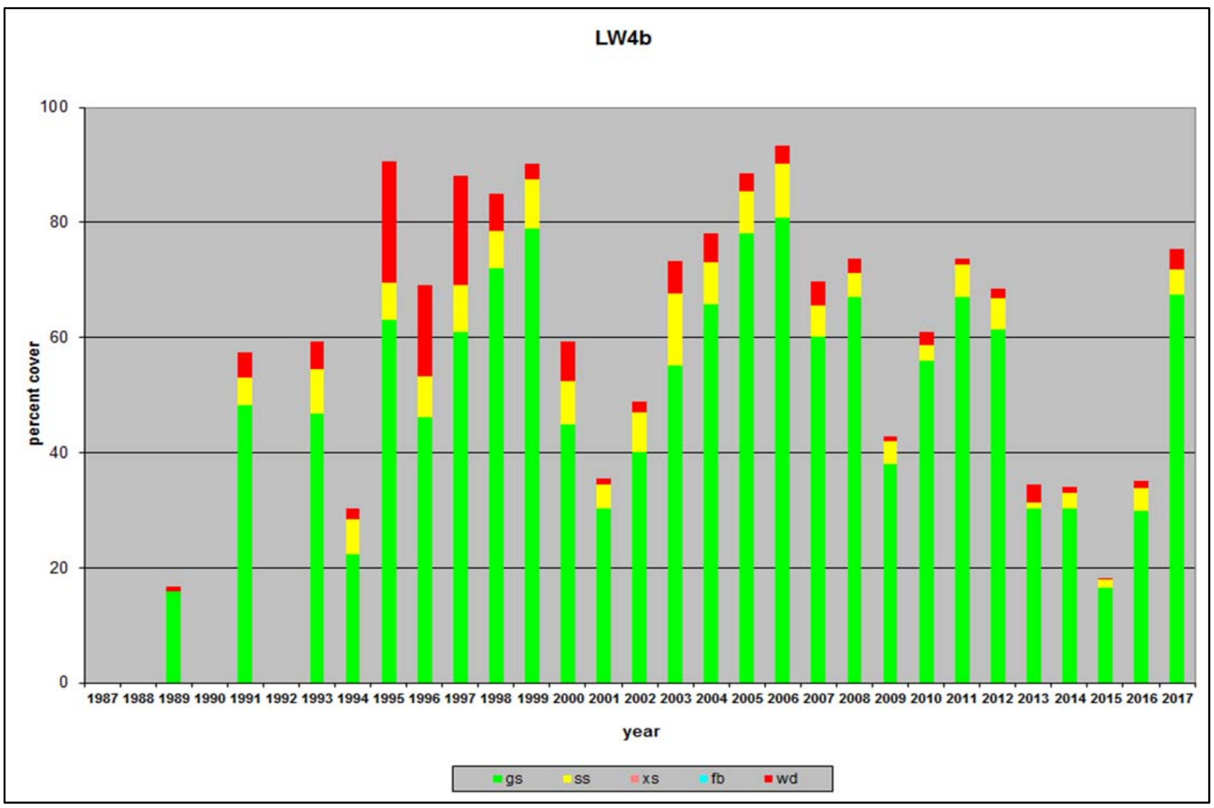


Figure 5. Total live cover measured at transects L4a (top) and L4b (bottom). Species were aggregated into grass (gs), groundwater-dependent shrub species (ss), upland shrub species (xs), forbs (fb), and weeds (wd). The Mitigation goal for these sites is 54% (top of yellow and green bars).

Line-Point cover and composition

Mean perennial cover averaged over line-point transects from FSL53, 124,125, and 126 within the mitigation area did not meet the Mitigation Goal in 6 of the 14 years (2005, and 2012-2016)(Figure 6). Species richness (number of species detected), however, did meet the Mitigation Goals for composition of three perennial species (See Appendix A for species list).

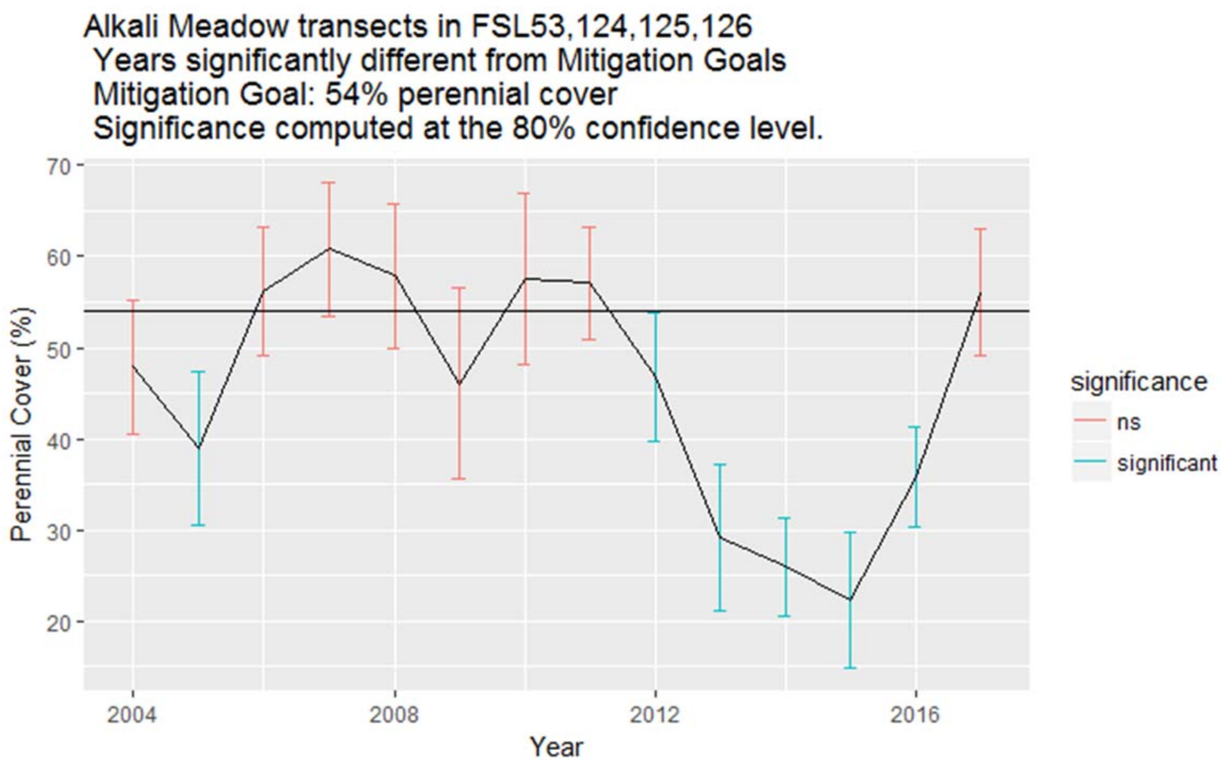


Figure 6. Perennial cover averaged over transects in parcels FSL53, 124, 125, 126 that are within the Five Bridges Mitigation Area. The Mitigation Goal for meadow perennial cover is 54%.

Mean perennial cover averaged over riparian transects from FSL54 within the mitigation area did not achieve its Mitigation Goal in any of the 12 years it has been monitored (2006-2017) (Figure 7). Species richness (number of species detected) met the Mitigation Goal for composition of three perennial species (See Appendix for species list). Willow present within the Five Bridges Impact Area prior to the pumping impact has not re-established.

The dominant species in FSL54 in 2017 were grasses (*Elymus triticoides*, *Distichlis spicata*) and shrubs (*Ericameria nauseosus*) with minor amounts of riparian species (*Salix*, spp. and *Rosa woodsii*). In the baseline mapping, riparian species were predominant. See below for additional discussion of the change in vegetation Type within the Impact Area.

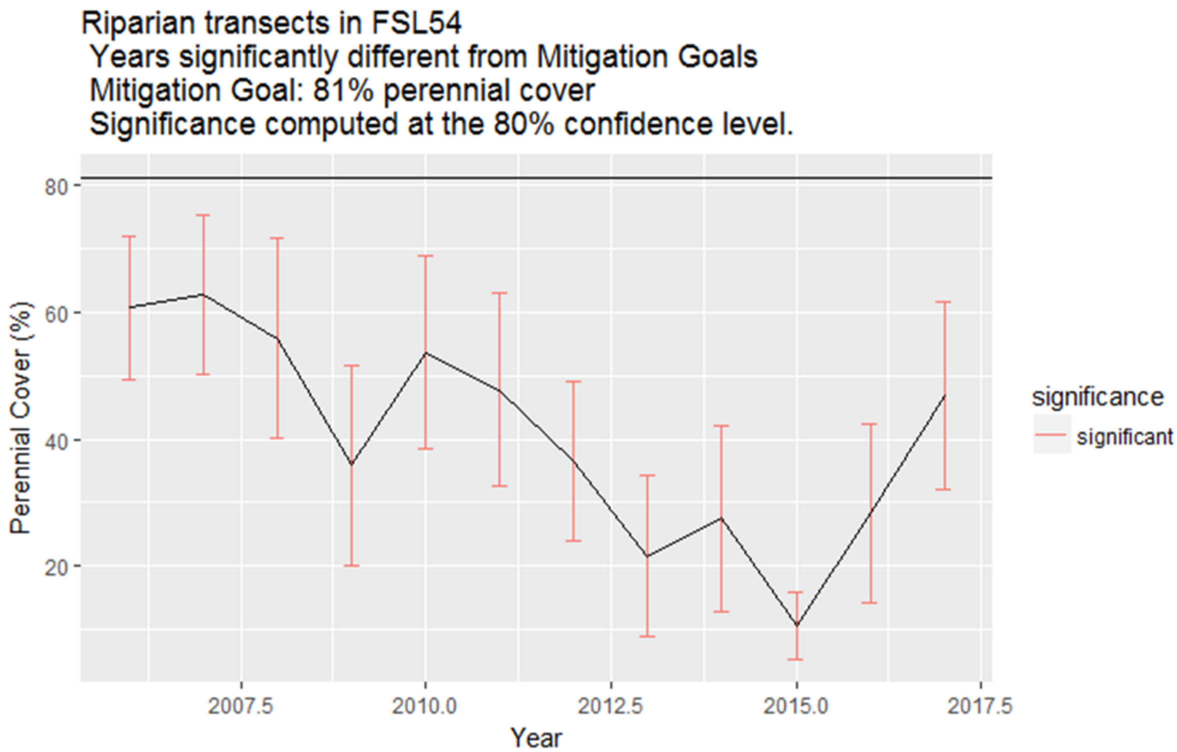


Figure 7. Perennial cover averaged over transects in riparian parcel FSL54 that are within the Five Bridges Mitigation Area. Mitigation Goal for riparian perennial cover is 81%.

Taken together, in 2017, out of 22 line point transects located in parcels described by the 1999 Plan as needing further recovery, only 8 transects (36%) achieved cover values compatible with Mitigation Goals (54% for meadow transects and 81% for riparian transects) (Figure 8).

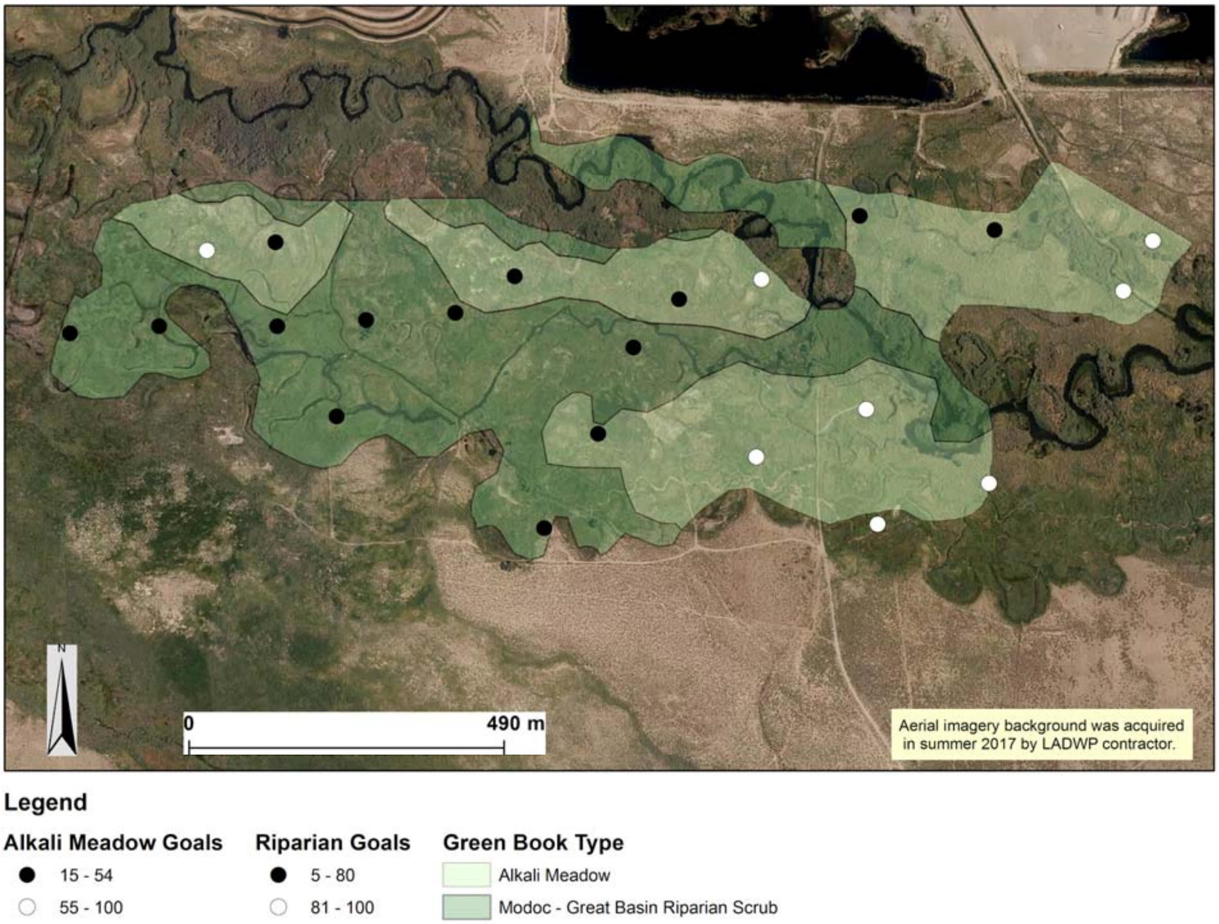


Figure 8. Line point transects within alkali meadow and riparian parcels identified in the 1999 Plan as requiring further mitigation. Transect locations are color-coded according to whether or not perennial cover in 2017 was above or below 1999 Plan Mitigation Goals: below Mitigation Goals (black); above or at Mitigation Goals (white).

Areas in FSL 54, FSL 124, and FSL125 have areas that are persistently barren and host *L. latifolium* (e.g. Figure 9 and additional photopoints in Appendix B). These areas of significant *L. latifolium* infestation have implications for the remote sensing results and the discussion that follows.

Figure 9. FSL54 line-point transect #4 mapped as riparian has extensive bare areas denuded of desirable perennial species in 2016 (left) and with high cover of invasive perennial pepperweed, *L. latifolium,* in 2017 (right).

Remote Sensing

Mean growing season NDVI derived from Landsat 5/7/8 was regressed against mean parcel total vegetation cover (including annuals) from line point transects for 12 parcels (FSL51, 53, 54, 123, 124, 125, 126, 128, 129, 130,138, 166) within the vicinity of Five Bridges Impact Area including years 2004-2017 for which line point cover estimates were available ($p < 0.05$, $R^2 = 0.58$) (Figure 10). Where line point transects provide a sample mean estimate for annual cover based on a single mid-summer measurement per transect, NDVI values were averaged over the entire growing season (April 1-October 31) for every 30-m pixel within each parcel. The correspondence between the two vegetation metrics is strong given the difference in spatial resolution, spatial coverage and time period over which values were computed. Three useful pieces of information are contained in the satellite imagery record: (1) it provides continuous measurements (2-week intervals) compared to a single measurement in summer with line point, (2) the record spans 20-years further back in time than the line point record and (3) it provides continuous spatial coverage at 30-m resolution compared to approximately one 50-m transect per acre using line point transects. However, because NDVI is related to the density of chlorophyll in plant canopies, it cannot distinguish between undesirable invasive weeds and desirable native vegetation (Figure 9).

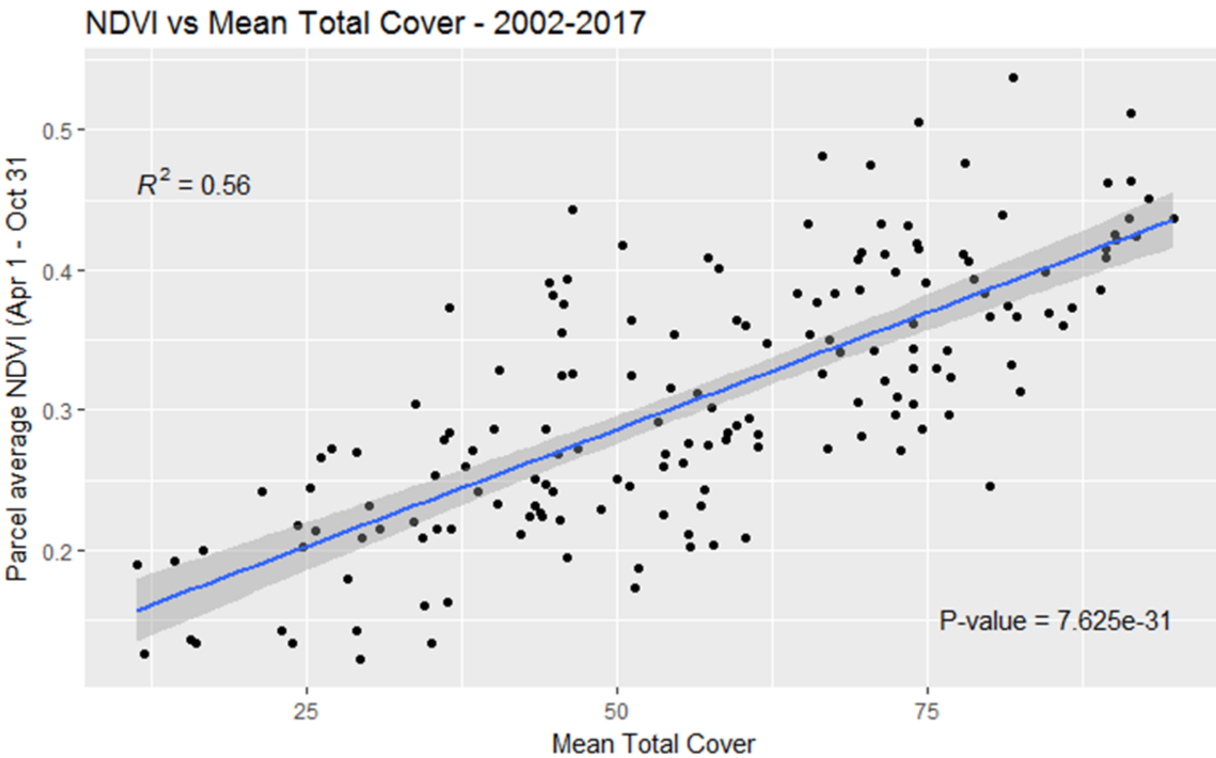


Figure 10. Relationship between mean total cover vs mean growing season NDVI for all parcels within and adjacent to the mitigation area.

The NDVI growing season average for 1987 (pre-impact) was compared to (a) 1988 (post-impact) (b) 1999 when the mitigation plan was approved and (c) 2017. These maps illustrate where vegetation cover during the growing season was lower than 1987 conditions (Figures 11, 12, 13). The 1987 to 1988 comparison shows the portion of the Five Bridges Impact Area that declined in total vegetation cover after pumping commenced (Figure 11). The 1999 Plan described remaining unmitigated areas including portions of meadow parcels FSL53, 124, 125, and 126 and riparian parcel FSL54. The 1987 to 1999 comparison shows these parcels having lower growing season NDVI than 1987 (Figure 12). The 1987 to 2017 comparison show comparable mean growing season NDVI in the Five Bridges Impact Area except for portions in FSL54 and 125 (Figure 13). However, in 2017, both of these parcels had high cover of undesirable weedy species that contribute to the NDVI magnitude observed in 2017 (Figure 9).

The raw NDVI values for each Landsat scene available were extracted for the entire Five Bridges Impact Area and plotted from 1984-2017 to compare interannual trends (n = 1,742 scenes). The 1987 growing season average (Apr 1 - Oct 31) NDVI roughly coinciding with the baseline vegetation mapping is highlighted and compared to the ensuing time series 1988 to 2017 to enumerate the frequency that NDVI met or exceeded pre-impact 1987 NDVI. From 1988 to 2017, the 1987 growing season average NDVI was exceeded in 5 years out of 30 (1995, 1996, 1997, 2006, 2017) (Figure 14).

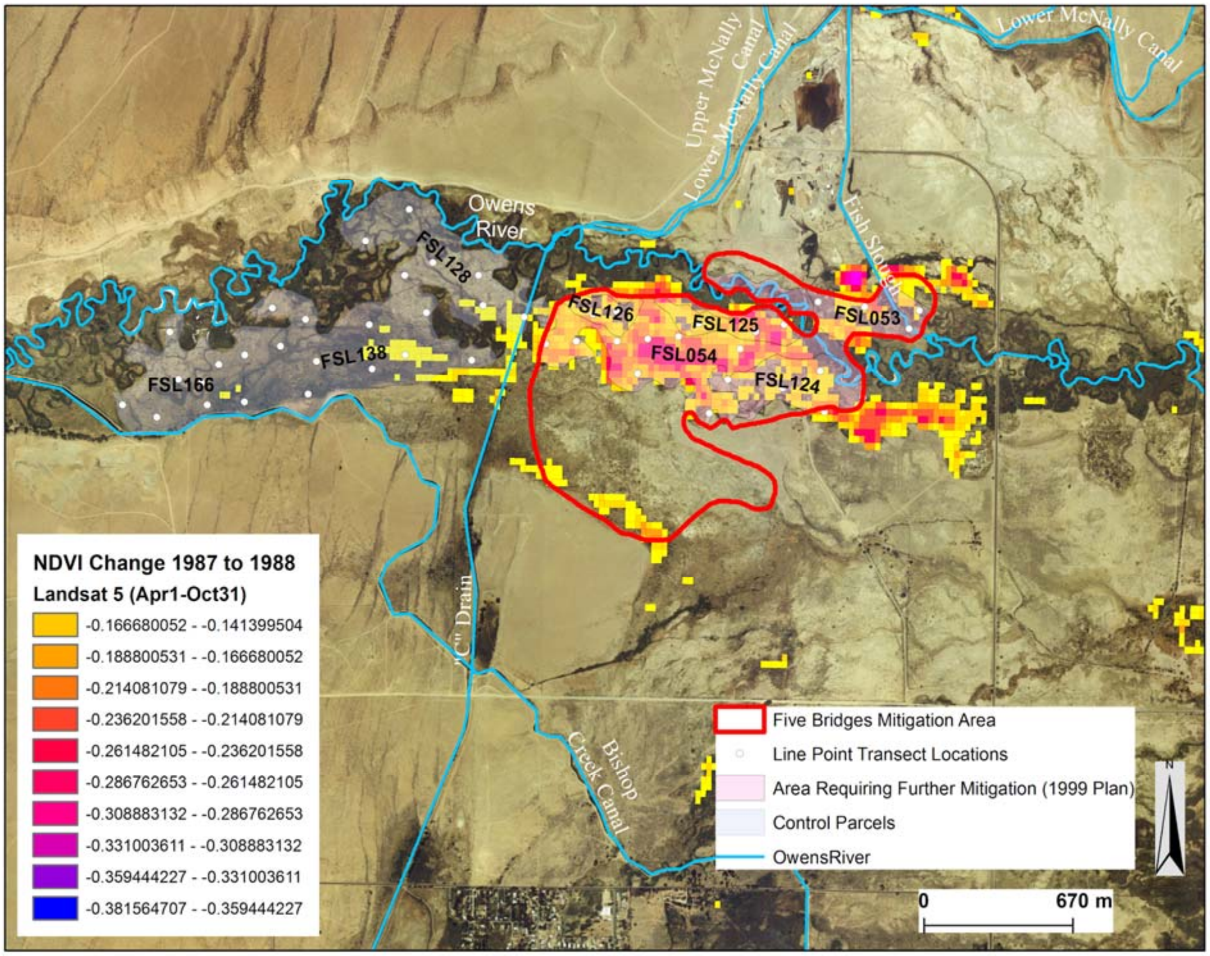


Figure 11. Change in growing season NDVI from 1987 to 1988. Color scale indicates increasing declines and correspond to die off of riparian and meadow vegetation within the Five Bridges Impact Area from pumping W385/386. Areas where surface water has collected, that produce more negative NDVI values (blue colors), such as in gravel ponds on the north side of Owens River, should be interpreted as surface water change and not vegetation change.

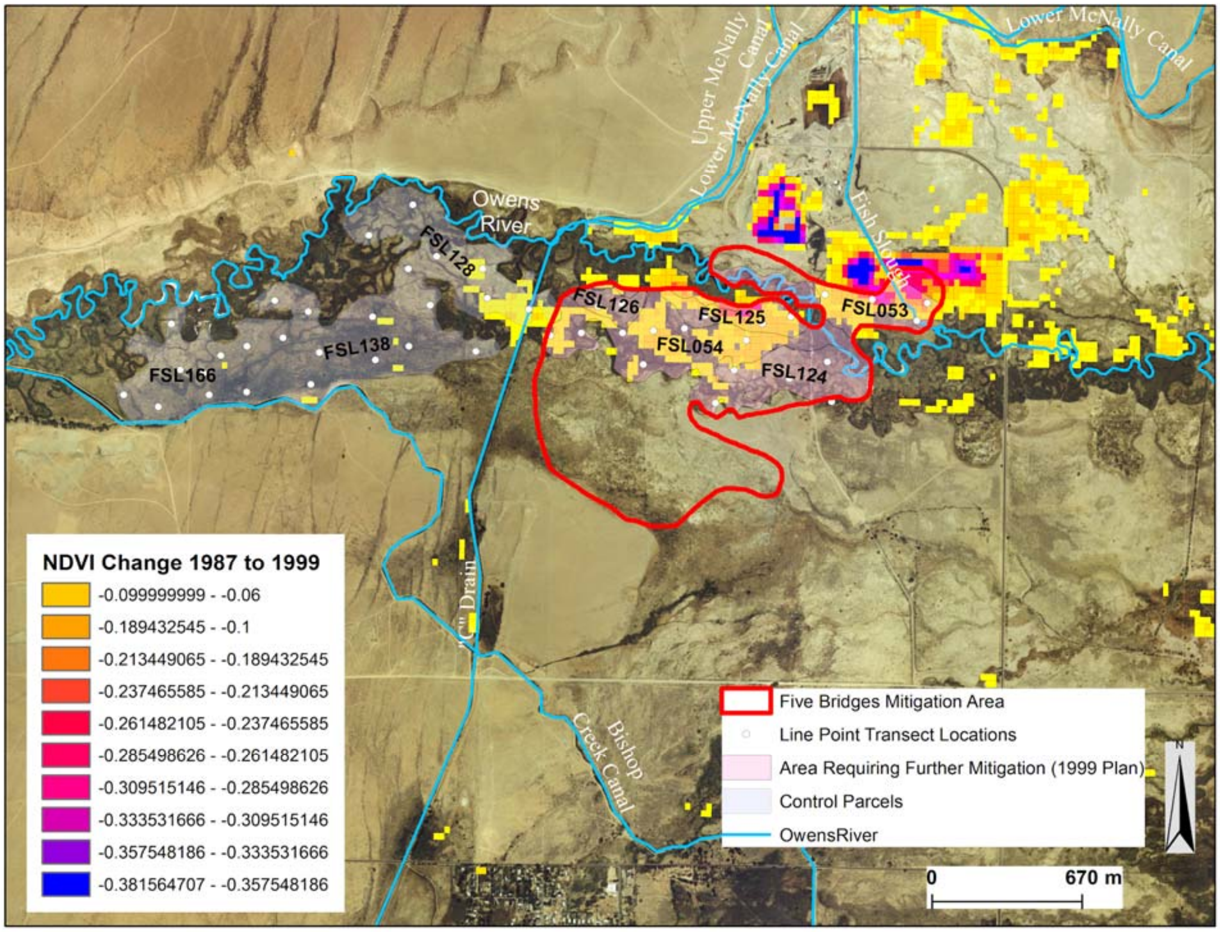


Figure 12. Change in growing season NDVI from 1987 to 1999, during approval of the Five Bridges 1999 Mitigation Plan. According to the 1999 Plan, parcels needing further recovery included FSL53, 54, 124, 125, and 126. Areas where surface water has collected, that produce more negative NDVI values (blue colors), such as in gravel ponds on the north side of Owens River, should be interpreted as surface water change and not vegetation change.

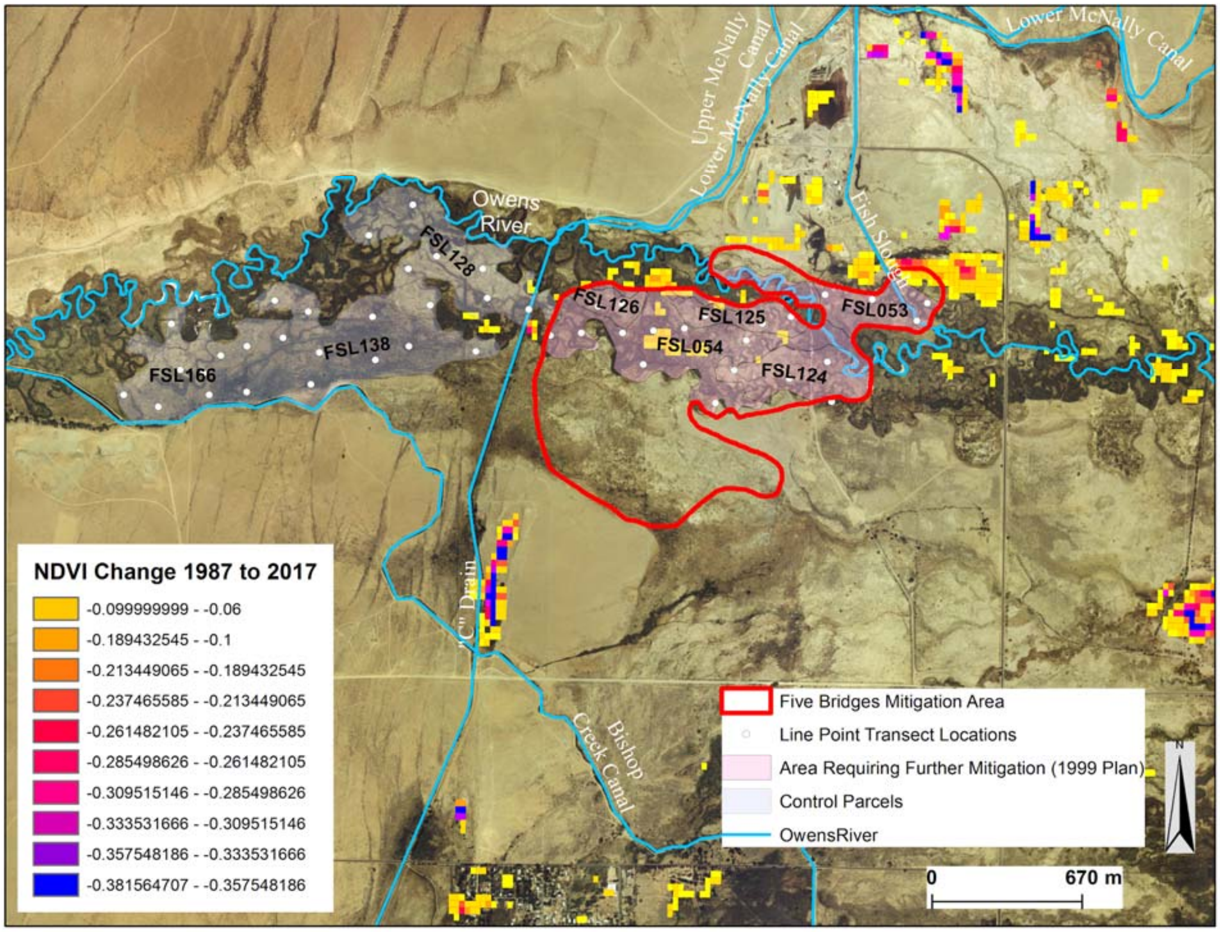


Figure 13. Change in growing season NDVI from 1987 to 2017. Growing season NDVI reached record high levels in 2017 across the Five Bridges Mitigation Area. Part of this signal in 2017 was boosted by vegetation cover of undesirable weeds. Areas where surface water has collected, that produce more negative NDVI values (blue colors), such as in gravel ponds on the north side of Owens River and the east side of the C-Drain, should be interpreted as surface water change and not vegetation change.

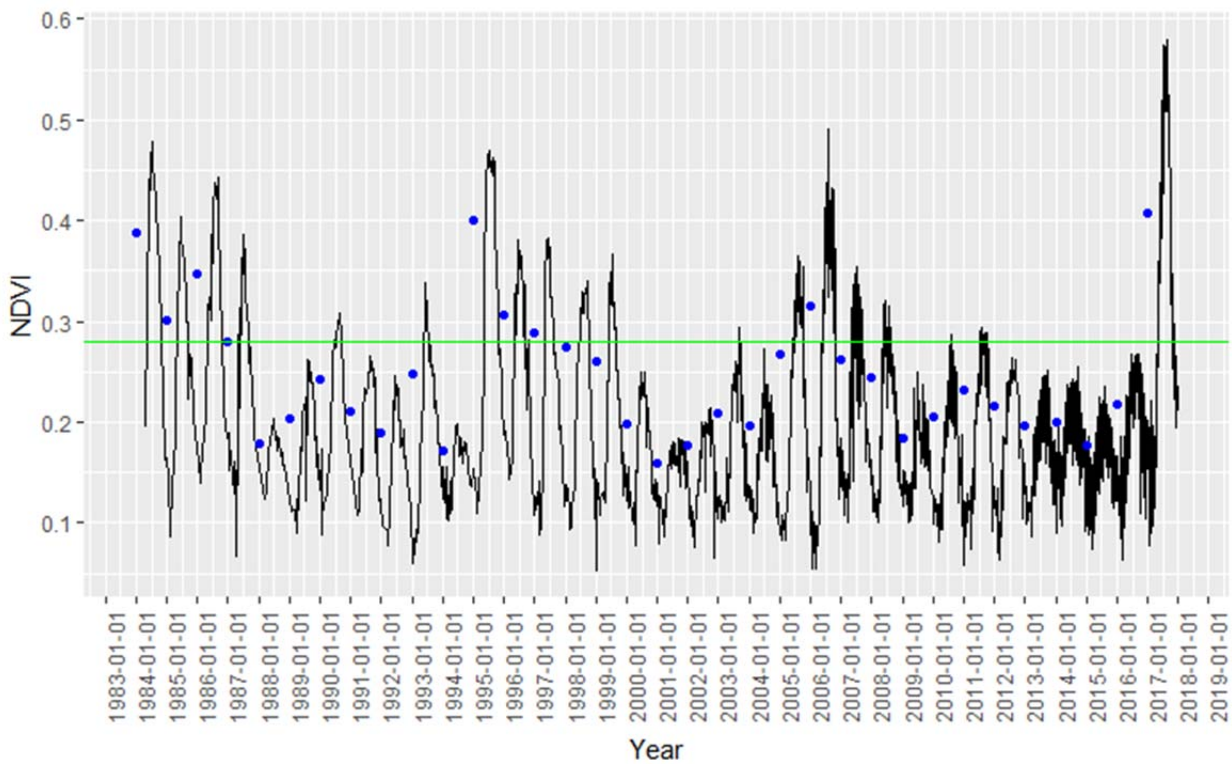


Figure 14. NDVI 1984-2017 from Landsat 5/7/8 (*n* = 1,742 scenes). Green horizontal line denotes NDVI growing season average (Apr 1 - Oct 1) for 1987 and Blue points denote growing season average for each year. Pumping commenced in October of 1987.

Comparison with Control Parcels

In both the remote sensing and line point datasets, vegetation declines are evident during periods of drought and low runoff (e.g. 2012-2016). To evaluate whether the trends in vegetation cover in the Five Bridges Impact Area could be explained by natural environmental variability independent of the 1988 pumping impact (pumping of W385 and W386 began in October 1987) the line-point transect record (1987, 2004-2017) and NDVI record (1984-2017), for the portion of the Impact Area identified in the 1999 Plan as needing further recovery, was compared with control parcels that were relatively unaffected by the pumping impact.

Perennial cover averaged over control-parcel (FSL128,138,166) transects (*n* = 25) was plotted against mean perennial cover averaged over impact-parcel (FSL53,124,125,126) transects (*n* = 22). In 1987 mean perennial cover for the control and impact groups were similar and not statistically different (Figure 15). In 2004, five years after the 1999 Plan was approved and the first year of line point monitoring, the area that the 1999 Plan indicated needed further recovery was significantly below the control-parcel average ($p < 0.01$). This trend has continued through 2017. Control area mean perennial cover has remained at or above 1987 values while impact area mean perennial cover has remained significantly below the control mean. The natural environmental signal of drought and wetter periods is evident in both groups including the recent drought which depressed perennial cover valley-wide. During this recent drought, the control group dropped to levels comparable to the highest cover obtained by the impact group while the impact group dropped to record lows for the line-point record as recently as 2015. Lack of convergence of the impacted group back to control parcel levels, suggests the area needing further recovery in 1999 still requires further recovery, and the extremely low cover observed during the most recent drought is not a consequence of natural climatic fluctuations alone, but rather a legacy effect from the compounded influence of pumping, subsequent disturbance, and various unsuccessful management practices to recover the site.

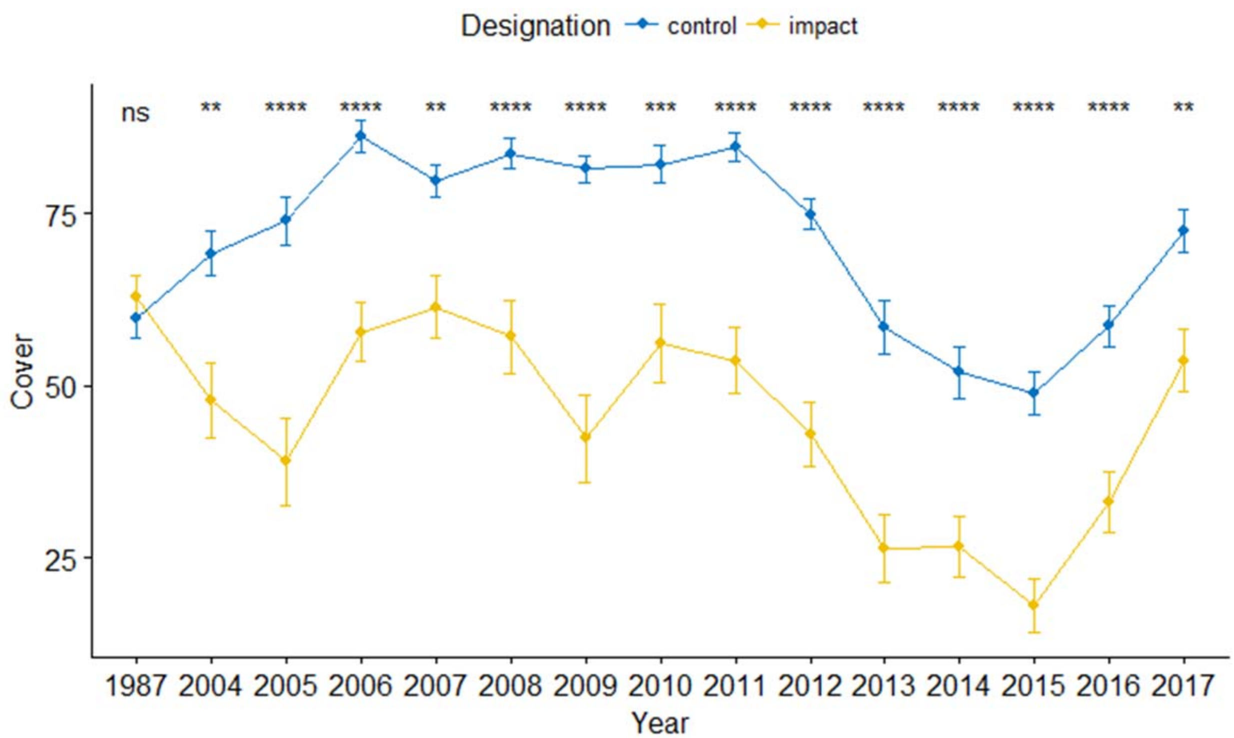


Figure 15 Perennial cover derived from line point transects averaged over control parcels FSL128,138,166 (control) and Five Bridges Impact Area parcels FSL53, 54, 124,125,126 (impact). Mean transect perennial cover is compared between control (*n* = 25) and impact groups (*n* = 22) at the 95% level using a two sample t-test. Significant differences in group means is denoted by ns: p > 0.05, *: p <= 0.05, **: p <= 0.01, ***: p <= 0.001. Error bars represent 1 standard error.

Similar to the approach taken above for the line-point record, the growing season NDVI time series (1984-2017) was extracted for control and impacted parcels (Figure 16). These parcel-scale NDVI time series were then averaged to the either the control or impact group set and these means were compared to quantify the frequency with which impact parcel vegetation cover was comparable to the control parcels. Mean NDVI for control parcels was not statistically different from impact parcels during the pre-impact baseline years 1984-1987, corroborating the similarity in control and impact groups prior to pumping impact as observed in the line-point record. In 1988, the growing season NDVI in impacted parcels diverged from the control parcel group mean coincident with the pumping-induced loss of riparian and meadow vegetation within the Five Bridges Impact Area. This divergence has been persistent over the 30-year time series with the exception of 1995 and 2006 (Figure 16).

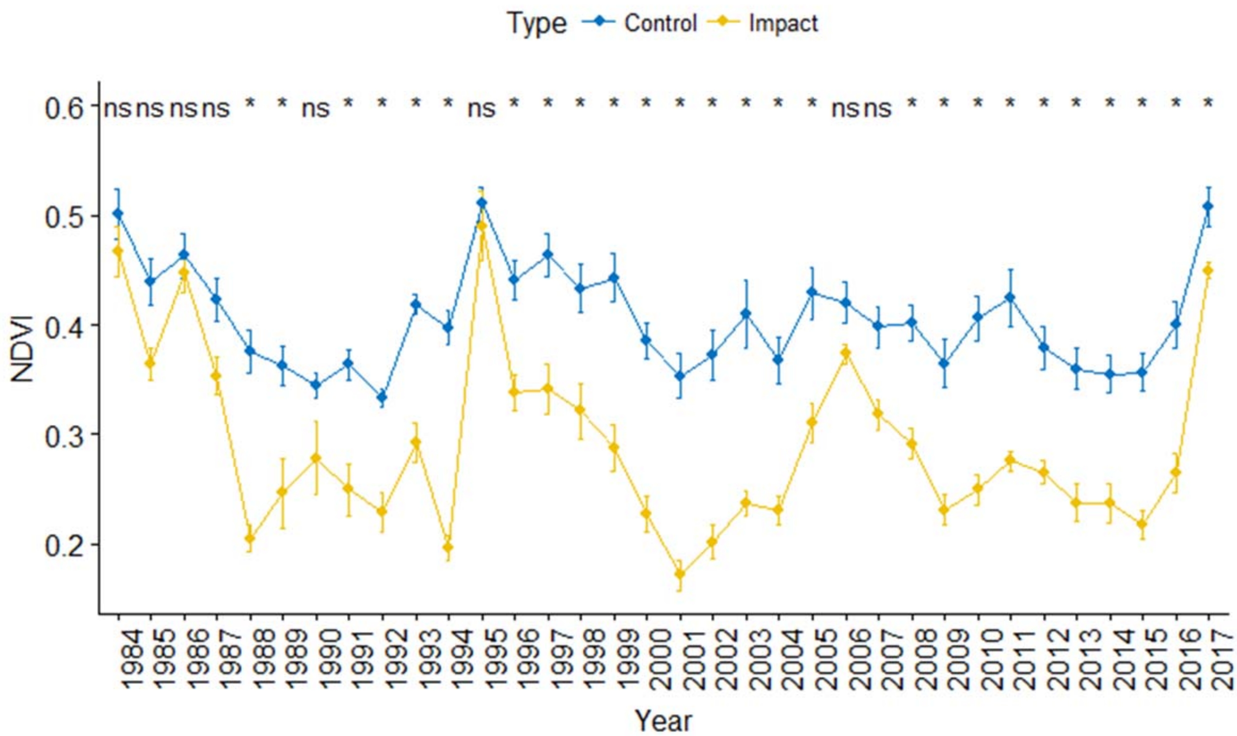


Figure 16. Comparison of growing season mean NDVI (Apr1-Oct1 mean) averaged across impact parcels (*n* = 5; FSL53, 54, 124, 125, 126) that were clipped to the Five Bridges Impact Area and control parcels (*n* = 3; FSL128, 138, 166) (ns or not significant: $p > 0.05$, *: $p <= 0.05$; error bars represent 1 standard error).

The persistent difference in vegetation cover in line point and remote sensing data between impacted parcels and nearby control parcels consisting of similar vegetation communities suggests that the 1991 EIR overall goal *"... to return the area to a complex of vegetation communities with similar species composition and cover as exists at local sites with similar environmental parameters" and the 1999 Plan goal "to establish perennial vegetation comparable to nearby areas..."* have not been met.

Hydrologic Discussion

The primary hydrologic question related to the mitigation area is: have groundwater levels recovered to "natural levels" as specified in the 1999 Plan. ICWD staff interprets "natural levels" in this context to mean groundwater levels have recovered from pumping induced drawdown.

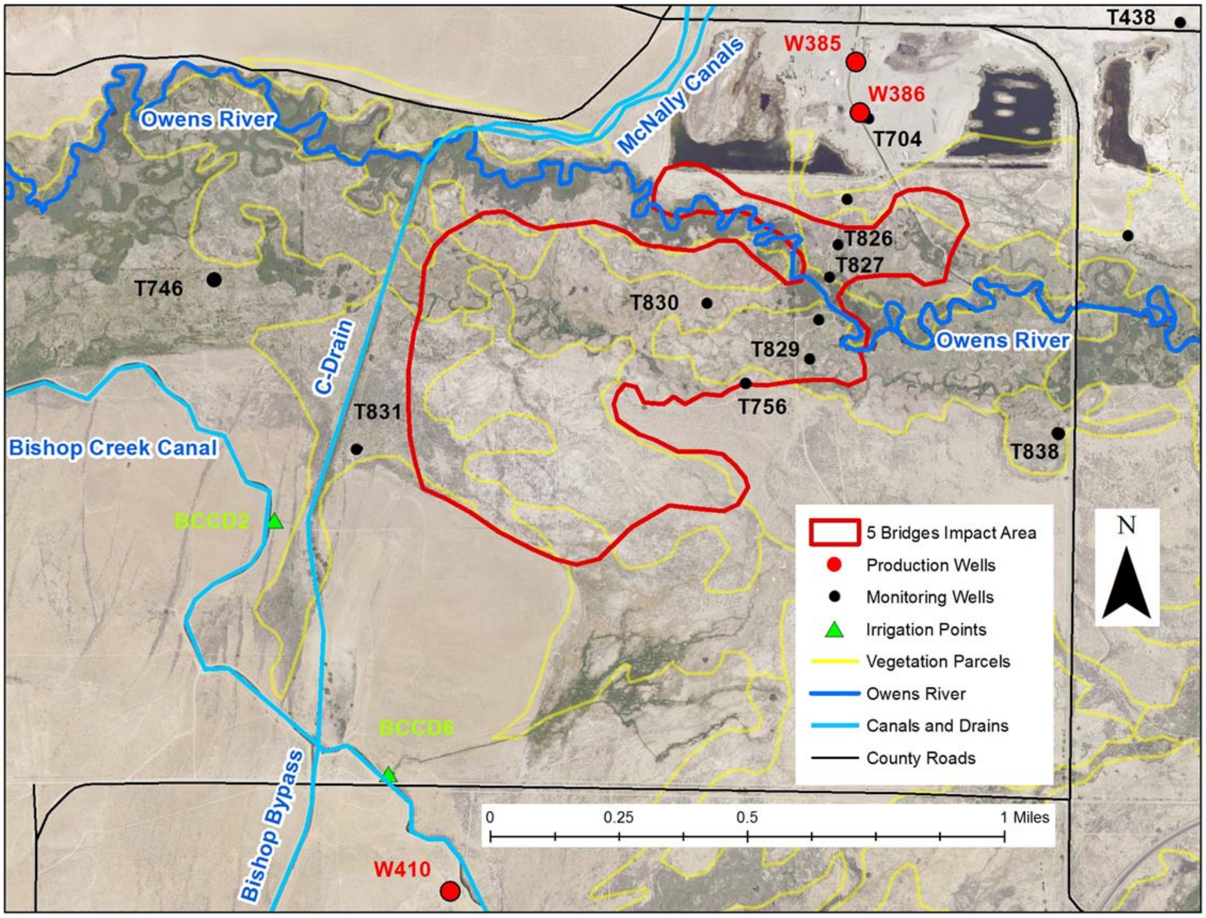


Figure 17. Map of significant hydrologic features including production wells (groundwater extraction), monitoring wells, irrigation flow monitoring points and surface water features.

Surface Water

There are several surface water features that influence the hydrology of the Five Bridges Impact Area (Figure 17). The Owens River and its McNally Canal diversions, the Bishop Creek Canal (BCC) and its Diversion #6, and irrigation from the C-Drain into the impact area with input flows from BCC Diversion #2 and the Bishop Creek Bypass. For the purpose of determining whether groundwater levels have recovered from pumping impacts in the mitigation area, the surface water features can be simplified into two primary drivers: the Owens River and BCC Diversion#2. A more thorough analysis and discussion of the associated hydrologic factors and their relationship to vegetation conditions is possible but beyond the current scope of this site assessment. However, such analysis would be appropriate if considering future actions and/or potential Technical Group modifications of the 1999 Plan, especially in light of the 2018 Pleasant Valley Fire, which burned large portions of the Owens River floodplain including the Five Bridges Impact Area.

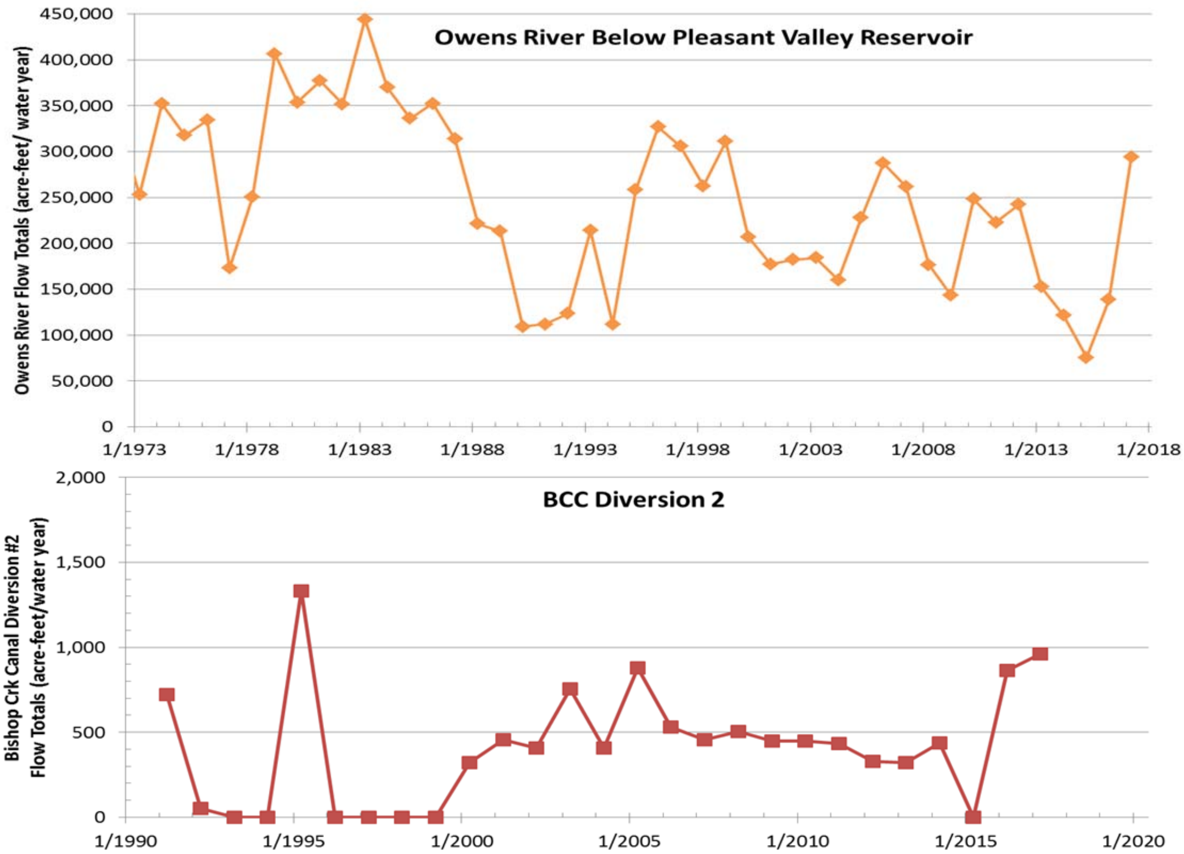


Figure 18. Annual surface water flows (acre-feet per water year) in the Owens River and BCC Diversion #2.

Seepage from the Owens River has a substantial hydrologic influence on nearby groundwater levels. During periods when flows in the Owens River are high, the stage (river level) rises and leading to more seepage and shallower groundwater levels. High water levels in the Owens River can also flood abandoned meanders also contributing to increased seepage. Conversely, during periods of low flow, river stage and seepage rates decline. Flows in the Owens River are driven by a combination of climatic factors (runoff in the upper Owens River watershed and Mono Basin) and LADWP management of the Long Valley and Pleasant Valley reservoirs. Sierra runoff determines the amount of water available over a multi-year time frame, whereas the storage capacity of Long Valley reservoir allows LADWP to actively manage yearly runoff, typically having lower river flows in the fall through winter and higher flow rates from spring through summer to supply aqueduct flows in-sync with Los Angeles-area water demand.

Monthly flows in the Owens River range from approximately 5,000 to 45,000 acre feet per month (af/mo); winter flows have averaged around 6,000-12,000 af/mo during the past 15 years while summer flows average about 21,000-24,000 af/mo. Historically, flows in the Owens River were tens of thousands of acre-feet greater in 1970s and 1980s owing to larger water exports from the Mono Basin. These exports have decreased significantly since the 1990s with the 1994 State Water Resources Control Board Decision D-1631 limiting LADWP exports from Mono Basin.

The 1999 Plan called for high volume pulse flows in the Owens River three times a year for the purpose of temporarily flooding the impact area. Owens River pulse flows in the early 2000s failed to adequately flood the site. LADWP requested that flows from the Bishop Creek Canal be used for the purpose of meeting the 1999 Plan's goal of irrigating the site three times a summer. Irrigation from the Bishop Creek Canal's Diversion #2 flows east into the C-Drain and then north to a turnout point. From the turnout point, BCCD2 irrigation flows east into the mitigation area along an existing ditch/former meander system across the southern floodplain portion of the mitigation area.

A portion of BCCD2 flows can return to the Owens River in the vicinity of T828; however, most flow continues east past T829 towards T838 and Five Bridges Road. The general practice since 2002 has been to supply water from BCCD2 to the impact area several times during the growing season (April-October). During the past 15 years, winter diversions have averaged 15-30 af/mo, with summer flows averaging 50-100 af/mo. Summer flows typically occur from May to September. The average amount of irrigation water delivered to the site through Bishop Creek Diversion #2 from 2002-2016 is approximately 470 acre-feet/year.

Based on the hydrogeologic characteristics of the impact area, positive correlations between surface water flows in the vicinity of the BCCD2 flow path and nearby groundwater levels are expected. The shallow aquifer in the Five Bridges Impact Area has high hydraulic conductivity. When surface water is applied or flow in conveyances increase near the site, seepage and infiltration occurs and groundwater levels are expected to rise.

Groundwater

Hydrographs comparing the depth-to-water (DTW) over time have been analyzed to determine whether groundwater levels have returned to pre-impact levels. Records of groundwater levels have been measured by LADWP staff from 1973 to-date in one well (T438), at several wells from the late 1980s to date (700 series), and at several shallow wells from 1993 to-date (800 series). Depth-to-water collection intervals for these test wells vary from semi-annually to weekly over their periods of record.

Figure 19 compares three area test wells with longer periods of data. Monitoring well T438 is east and downgradient of production wells W385 and W386; T704 is in the immediate vicinity of W385 and W386 and on the north side of the Owens River, and T756 is south of the Owens River within the area of pumping impact. Drawdown related to the pumping of W385 and W385 from October 1987 to April 1989 (8,801 total acre-feet) can clearly be seen in T438 and T704 with the steep declines in water table. The initial data point for T756 was February 1989, reflecting the depressed water table due to groundwater pumping. Partial recovery of the water table can be seen in these three test wells following cessation of pumping in April 1989.

Drawdown and recovery, related to the two-month pumping test of W385 and W386 in 1993-94 (2,098 total acre-feet) can also be seen in T438, T704, and T756. Since 1993-94, pumping has been halted at W385 and W386 (except for a 24-hour pump test following well modification) and pumping in neighboring Bishop Cone wells has been relatively constant (ICWD, 2017)

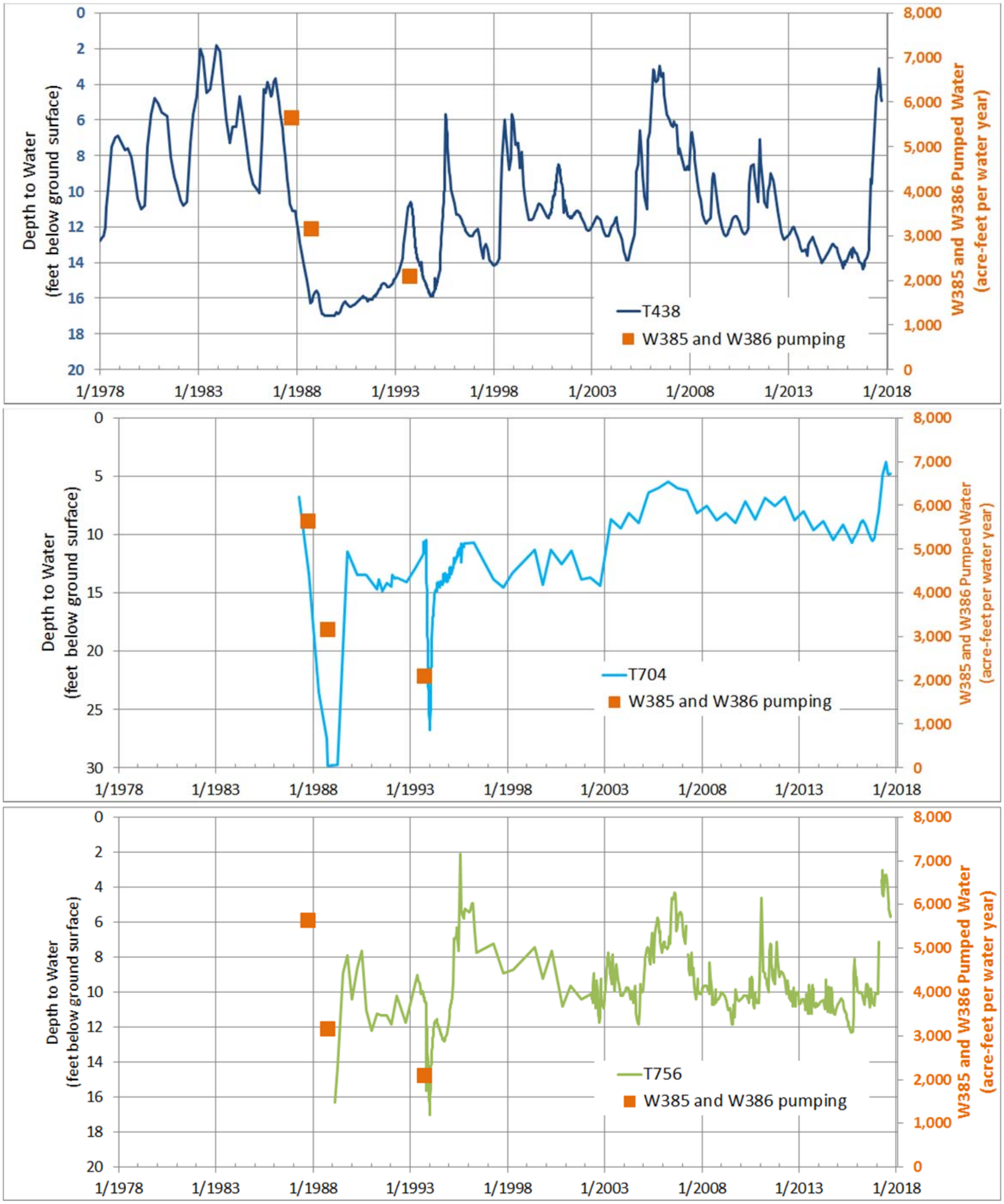
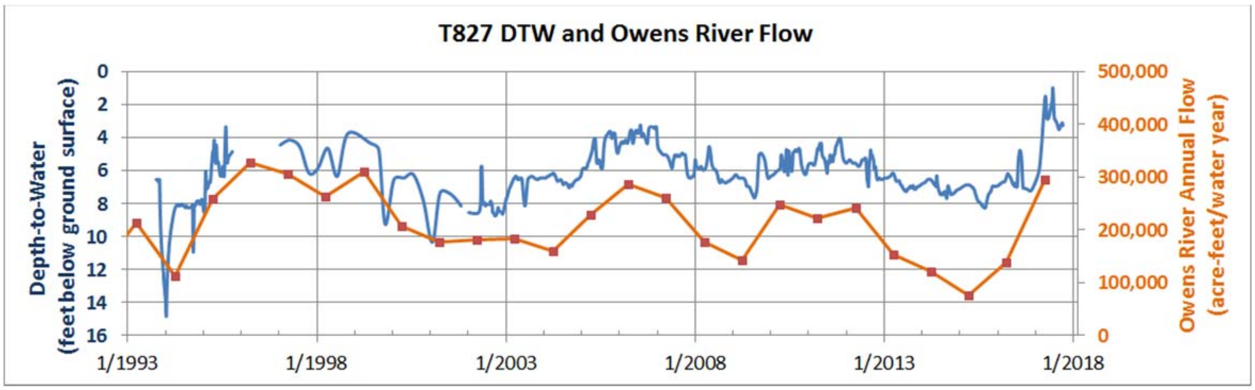
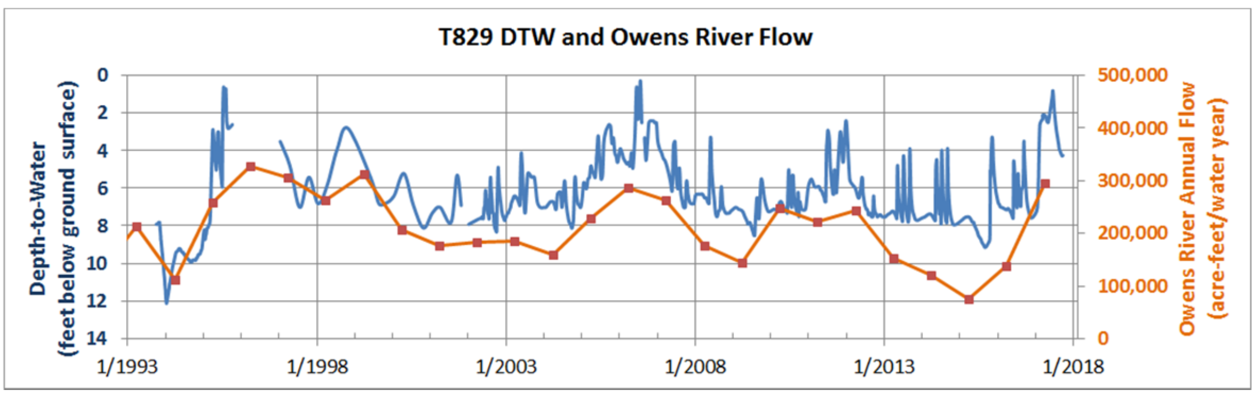


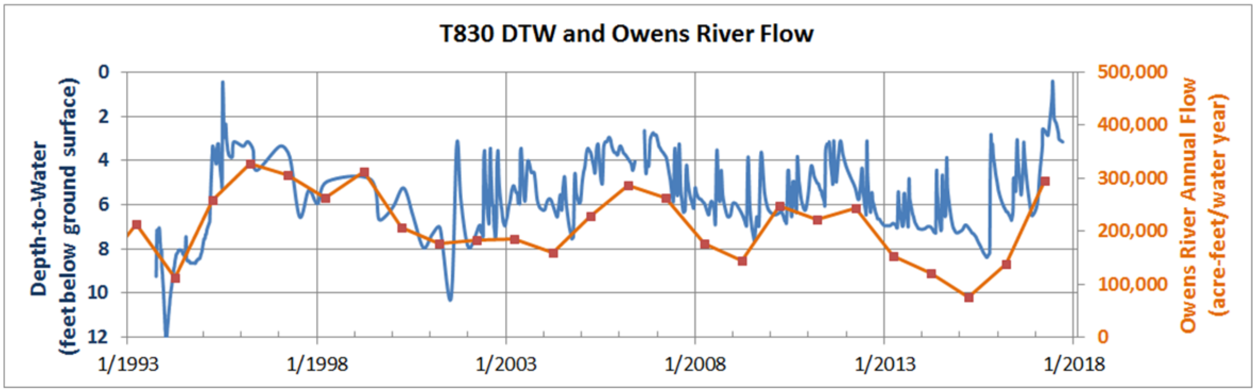
Figure 19. Hydrograph of groundwater levels (feet below the ground surface) at monitoring wells T438, T704 and T756 and total annual pumping (acre feet) at W385 and W386. Note the steep declines in groundwater level attributable to pumping W385 and W386 from 1987-89 and also 1993-94.

The influences of drought, above average runoff, and surface water management are apparent in the monitoring well datasets (Figure 19). Groundwater levels at T438 have recovered several times (late 1990s, mid 2000s, 2017 to-date) to pre-pumping levels. Although there is only one, pre-pumping DTW for T704 and no pre-pumping data for T756, the fact that all three wells respond in concert to the same hydrologic influences allows the inference to be made that groundwater levels across the mitigation site have recovered from the 1987-89 pumping and the more limited pumping in 1993-94. In 2017, groundwater levels at all three wells were at or near all-time highs.

Examining DTW in the extensive network of shallow monitoring wells installed in 1993 and comparing those water levels to surface flow and groundwater pumping allows additional insight into groundwater level recovery.







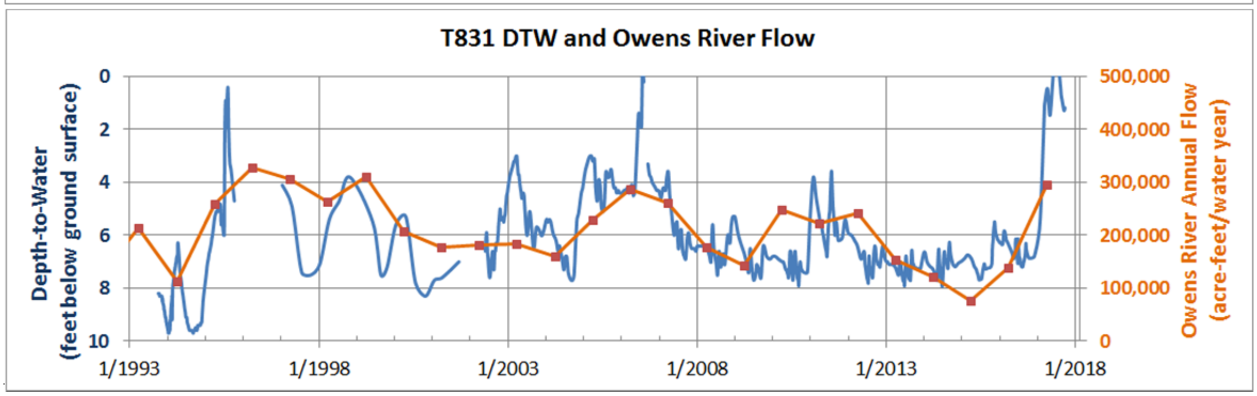


Figure 20. Depth-to-water (in feet below ground surface) at four of the monitoring wells installed in 1993 compared to annual flow totals (acre-feet per water year) in the Owens River below Pleasant Valley Dam.

All four monitoring wells from Figure 20 are in the impact area; T827 is located immediately north of the Owens River, T829 and T830 are located south of the river in the central portion of the impact area, and T831 is south of the river in the southwest corner of the impact area. The steep drawdown-and-recovery spikes associated with the 2-month pumping test of W385 and W386 in 1993/1994 are evident in all three graphs, as are Owens River flow fluctuations driven by runoff variation and river management. Depth-to-water in all four monitoring wells in 2017 were at or near all-time highs (shallowest) and within 2 feet of ground surface.

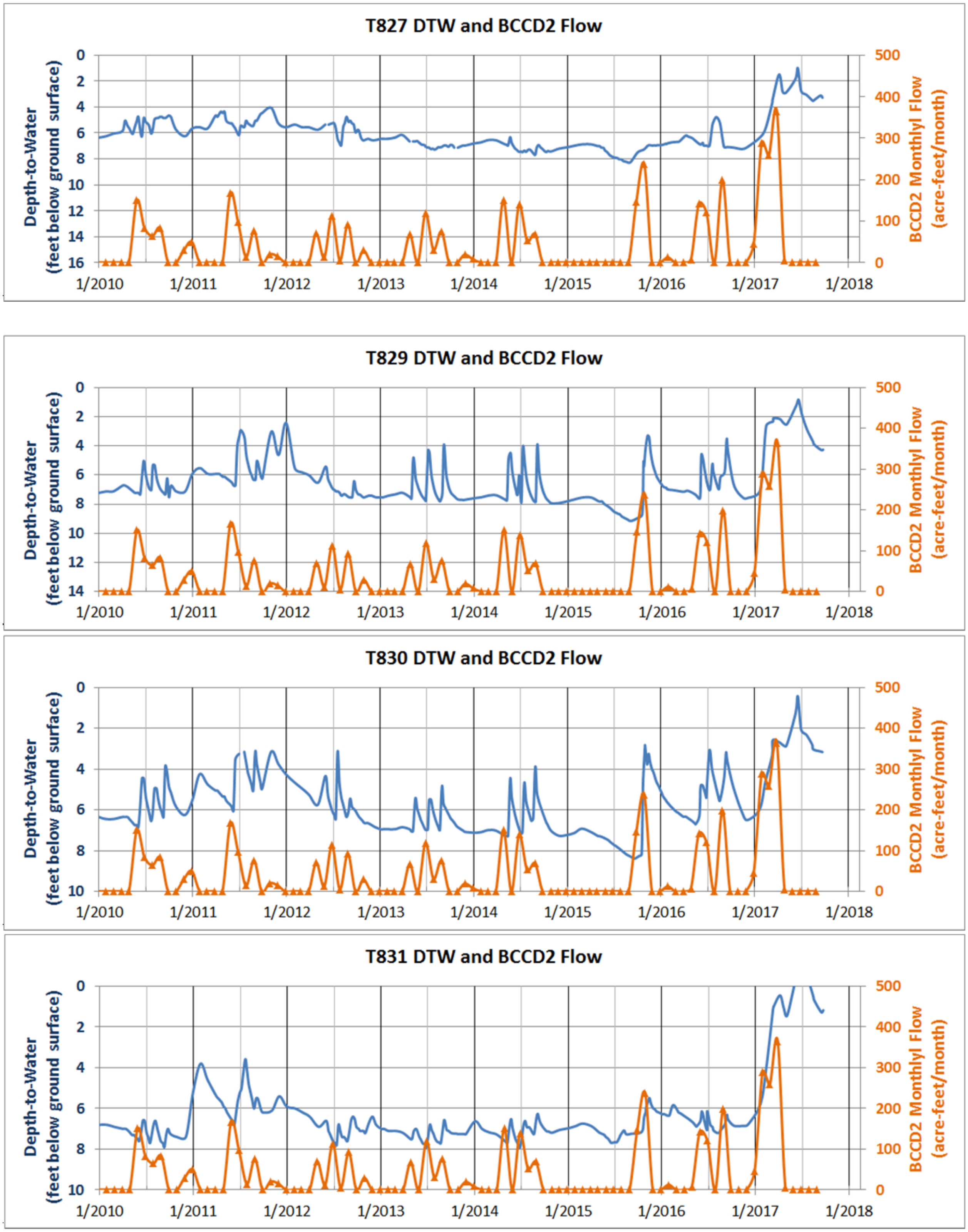


Figure 21. Depth-to-water (in feet below ground surface) at four of the monitoring wells installed in 1993 compared to monthly flow totals (acre-feet) in the Bishop Creek Canal Diversion #2 (BCCD2).

Figure 21 presents DTW from the same four wells as Figure 20 but from 2010-2017 to examine the relationship between surface flows and groundwater levels in greater detail. Notably, in Figure 21 DTW is compared with monthly flows from the BCCD2 instead of the annual flows of the Owens River presented in Figure 20. The summer DTW spikes (shallow groundwater) in wells T829, T830 and T831 correlate with BCCD2 flows. There is a weak correspondence between DTW in T827 and BCCD2 flow, which is expected because T827 is on the north side of the Owens River and BCCD2 flows are only on the south side. As surface flows from BCCD2 are routed in the near vicinity of wells T829-831, the subsurface sands and gravels allow seepage and infiltration to mound groundwater adjacent to the ditches and monitoring wells.

The magnitude of the summer DTW spikes caused by BCCD2 flows vary in relation to the amount of water released but in general range from approximately 1 foot in T831; 1-2 feet in T830 and T756; and 2-4 feet in T829. As can be seen in Figure 21, it appears that irrigation through BCCD2 has the intended effect of raising water levels in the impact area that was originally to be accomplished, according to the 1999 Plan, by pulsing the Owens River three times each summer. Although the shallow groundwater spikes due to irrigation are temporary in nature, bringing the water table up through the coarser gravels into the overlying finer-grained soils can wet shallower levels in the soil profile due to the greater capillarity of the finer-grained material. This moisture is then available for vegetative transpiration.

An exceptional amount of precipitation occurred during winter of 2016-17, and the ensuing 2017 runoff was projected to be approximately double the long-term average, comparable in the past 50 years only to 1969 and 1983. At the Five Bridges Impact Area, the exceptional 2017 runoff resulted in high flow volumes in the Owens River and BCCD2 (Figure 18), in significant flow diversions from the Owens River in the northern part of the impact area in the McNally Canals, and significant flow diversions from the Bishop Creek Bypass through the C-Drain in the southern part of the impact area. During summer 2017 widespread surface flows were observed across both the northern and southern portions of the Five Bridges Impact Area. Groundwater levels in area monitoring wells all rose in response to these hydrologic influences (Figures 18-20). It is unlikely, however, that the amount of runoff, with its accompanying high volume flows and surface water diversions, is sustainable or would be repeated regularly.

Based on the groundwater and surface water review, ICWD concludes that cessation of pumping from W385 and W386 along with surface water management has allowed groundwater levels to recover from pumping induced drawdown.

Lepidium latifolium

L. latifolium has been detected in every parcel that comprises the mitigation area. The most densely concentrated infestations are located in FSL054, FSL125, FSL124, and FSL129. One transect in FSL130 within the mitigation area hosted *L. latifolium (*Figure 22*)*.

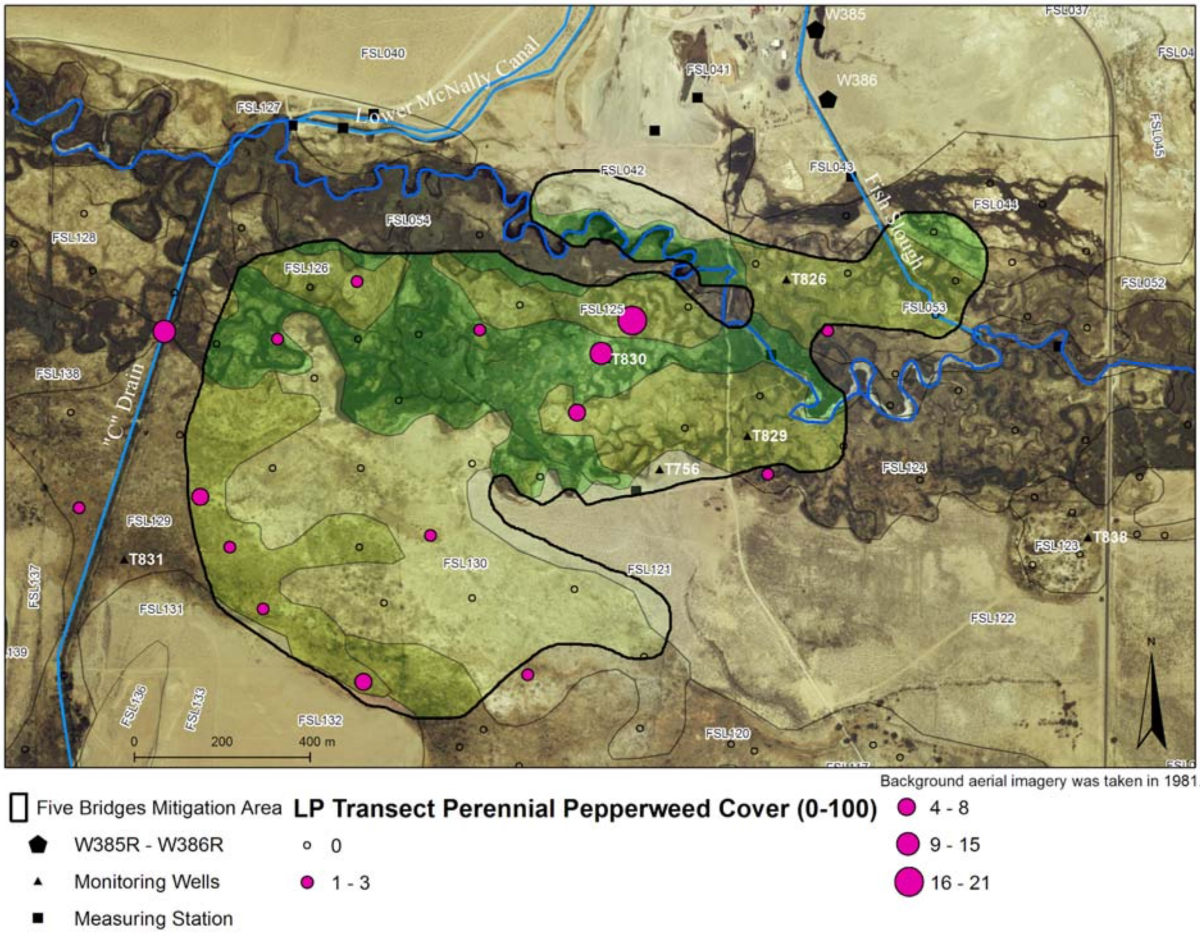


Figure 22. *L. latifolium* cover percentage recorded on line-point transects in 2017. The infestation is widespread across the site with the highest cover in FSL054 (previously mapped as riparian) and FSL124, FSL125, FSL126 and FSL129 (previously mapped as alkali meadow).

The C-drain, irrigation ditches and disturbed unrecovered areas continue to host noxious weeds, most notably *L. latifolium*. The main infestations are clustered in and around what was previously riparian scrub (e.g. near FSL054). Inyo and LADWP staffs appear to be in agreement that weed eradication and/or control efforts will be necessary at the Five Bridges Impact Area into the foreseeable future.

Sustainability

In LADWP's 2017 Annual Report, LADWP concluded the Five Bridges Impact Area was not meeting goals as of summer 2016 (LADWP 2017). LADWP's conclusion in 2018 (as presented to the Technical Group in January) was that the Five Bridges Impact Area had met its goals in 2017. In this report, based on line point transects, ICWD determined that areas mapped as riparian did not meet Mitigation Goals in any year that they were monitored and alkali meadow areas achieved the 54% goal once in the last six years (Table 2). While transect L4b achieved the Mitigation Goal in 66% of years it was measured, L4a achieved the Mitigation Goal in only

10% of the years measured. The NDVI record shows pre-impact (1987) growing season mean (Apr1 - Oct 31) NDVI was reached five times in 30 years since the impact (31%). Neither line point nor the NDVI record from the impact area converged with the control parcel mean consistently after the impact suggesting depressed vegetation conditions are not due to environmental variability alone as both control and impact groups responded similarly to drought and high runoff/precipitation conditions.

The anomalously high runoff year of 2017 allowed LADWP to spread significantly more surface water throughout the Five Bridges Impact Area than has been done in the past or that is expected on average into the future. Coincident with this large amount of irrigation, grass cover increased throughout the mitigation area except for portions of the Five Bridges Impact Area that remain barren or are infested with *L. latifolium*.

For meadow vegetation to meet Mitigation Goals, periodic access to soil and groundwater is required. It is unknown whether LADWP's 2018 proposed pulse flow regimes (abandoning irrigation from BCCD2 through the C-Drain in favor of high volume pulse flows from the Owens River) associated with its Owens River Gorge Restoration Project, will allow Owens River stage to reach levels sufficient to sub-irrigate floodplain vegetation for a duration that is compatible with maintaining Mitigation Goals. Testing whether water table and vegetation cover can be sustained without upgradient irrigation to the site from BCCD2 would seem logical before declaring the vegetation conditions observed in 2017 as sustainable.

Now that the site has burned, the level of vegetative recovery after fire could inform whether or not desirable vegetation conditions in the Five Bridges Impact Area is sustainable As compared to non-impacted parcels.

Year	L4a meets Mitigation Goal	L4b meets Mitigation Goal	Meadow LP Transects meet Mitigation Goal	Riparian LP Transects meet Mitigation Goal	NDVI at 1987 value	Impacted transects at Control mean	Impacted NDVI at Control mean
1984	*NA*	*NA*	*NA*	*NA*	YES	*NA*	YES
1985	*NA*	*NA*	*NA*	*NA*	YES	*NA*	YES
1986	*NA*	*NA*	*NA*	*NA*	YES	*NA*	YES
1987	*NA*	*NA*	*NA*	*NA*	YES	YES	YES
	W385 and W386 Pumping Impact						
1988	*NA*	*NA*	*NA*	*NA*	NO	*NA*	NO
1989	NO	NO	*NA*	*NA*	NO	*NA*	NO
1990	NO	*NA*	*NA*	*NA*	NO	*NA*	YES
1991	NO	YES	*NA*	*NA*	NO	*NA*	NO
1992	NO	*NA*	*NA*	*NA*	NO	*NA*	NO
1993	NO	YES	*NA*	*NA*	NO	*NA*	NO
1994	NO	YES	*NA*	*NA*	NO	*NA*	NO
1995	NO	YES	*NA*	*NA*	YES	*NA*	YES
1996	NO	YES	*NA*	*NA*	YES	*NA*	NO
1997	NO	YES	*NA*	*NA*	YES	*NA*	NO
1998	NO	YES	*NA*	*NA*	NO	*NA*	NO
1999	NO	YES	*NA*	*NA*	NO	*NA*	NO
2000	NO	YES	*NA*	*NA*	NO	*NA*	NO
2001	NO	NO	*NA*	*NA*	NO	*NA*	NO
2002	NO	NO	*NA*	*NA*	NO	*NA*	NO
2003	NO	YES	*NA*	*NA*	NO	*NA*	NO
2004	YES	YES	YES	*NA*	NO	NO	NO
2005	NO	YES	NO	*NA*	NO	NO	NO
2006	YES	YES	YES	NO	YES	NO	YES
2007	YES	YES	YES	NO	NO	NO	YES
2008	NO	YES	YES	NO	NO	NO	NO
2009	NO	NO	YES	NO	NO	NO	NO
2010	NO	YES	YES	NO	NO	NO	NO
2011	NO	YES	YES	NO	NO	NO	NO
2012	NO	YES	NO	NO	NO	NO	NO
2013	NO	NO	NO	NO	NO	NO	NO
2014	NO	NO	NO	NO	NO	NO	NO
2015	NO	NO	NO	NO	NO	NO	NO
2016	NO	NO	NO	NO	NO	NO	NO
2017	NO	YES	YES	NO	YES	NO	NO

Table 2. Years in which L4a and L4b transects met Mitigation Goal (L4a/b at Mitigation Goal), years in which meadow line point transects met Mitigation Goal (Meadow LP transects at Mitigation Goal), years in which riparian line point transects met mitigation Goal (Riparian LP transects at Mitigation Goal), years in which growing season (Apr 1 - Oct 31) NDVI reached pre-impact growing season NDVI (1987), years in which line point transect cover in impact area reached control mean (LP Transects at Control Mean), and years in which mean NDVI of impacted parcels reached mean NDVI of control parcels (NDVI at control mean).

Type Change D to C

As noted in the Ecologic Overview Section, the vegetation map (breaking parcels into vegetation communities) that was compiled from 1984-87 was adopted as the baseline conditions in the Water Agreement. This map is referred to as the baseline or Green Book map. Both field mapping and interpretation of 1981 aerial images were used to create the Green Book map. For its 2018 assessment, LADWP staff compared vegetation community acreage in the Five Bridges Impact Area for three categories: acreage from the legally agree-upon Green Book map, acreage from a reinterpretation of the 1981 aerial imagery using “heads up digitization”, and acreage from 2017 using digital interpretation of the 2017 aerial imagery. Figure 23 and

Table 3 presents the results of LADWP's three mapping categories. As can be seen, the primary difference between baseline values and LADWP's 1981 reinterpretation is that the baseline map had 36 more acres of alkali meadow and 38 acres less of scrub; riparian acreage is similar in both. In Table 3, ICWD staff compared the acreages of vegetation communities mapped by LADWP in 2017 to both the baseline map and LADWP's remapping of 1981 conditions. Using either the baseline map or LADWP's 1981 map, there has been a significant loss of 43 or 40 acres, respectively, of riparian vegetation as of 2017. The change in dominant species in FSL54 in the line point dataset is presented in Table 4.

The demonstrated loss of riparian vegetation is contrary to the 1991 EIR Mitigation Measure 10-12 goal *"...to revegetate the entire affected area with riparian and meadow vegetation"* and the 1999 Plan's goal *"... restore vegetation type that previously existed, to establish perennial vegetation comparable to nearby areas or to revegetate with other native Owens Valley species."* Furthermore, this vegetation type change, converting Type D riparian acreage into either Type C meadow or Type B scrub, is specifically prohibited in Section IV.A of the Water Agreement. Therefore, this impact to riparian vegetation at the Five Bridges Impact Area has not been successfully mitigated and does not resemble pre-impact conditions.

It may be ineffective to restore the riparian vegetation in an area coincident with intensive weed control activities. However, the failure of the riparian areas to recover from the initial pumping impact despite periodic irrigation and cessation of pumping for more than 25 years suggests that on-site mitigation measures have been ineffective, not that the impact has been fully mitigated. The Technical Group has not revised the 1999 Plan to include alternative mitigation measures and the portion of the riparian vegetation in the Impact Area (FSL 54) now supports different vegetation cover and composition.

Vegetation Complex	Greenbook Vegetation Type		Remapped 1981 Type		Mapped 2017 Type		2017 Acreage Change	
	(ac)	(%)	(ac)	(%)	(ac)	(%)	ΔBL	Δremap
Barren	1	0	2	1	4	1	3	2
Meadow	206	67	170	55	208	68	2	38
Riparian	81	26	78	25	38	12	-43	-40
Scrub	20	7	58	19	58	19	38	0
Total	**308**	**100**	**308**	**100**	**308**	**100**		

Table 3. Acreages of vegetation complexes shown on the Water Agreement baseline map (Greenbook) and two maps prepared by LADWP based on 1981 imagery and 2017 imagery.

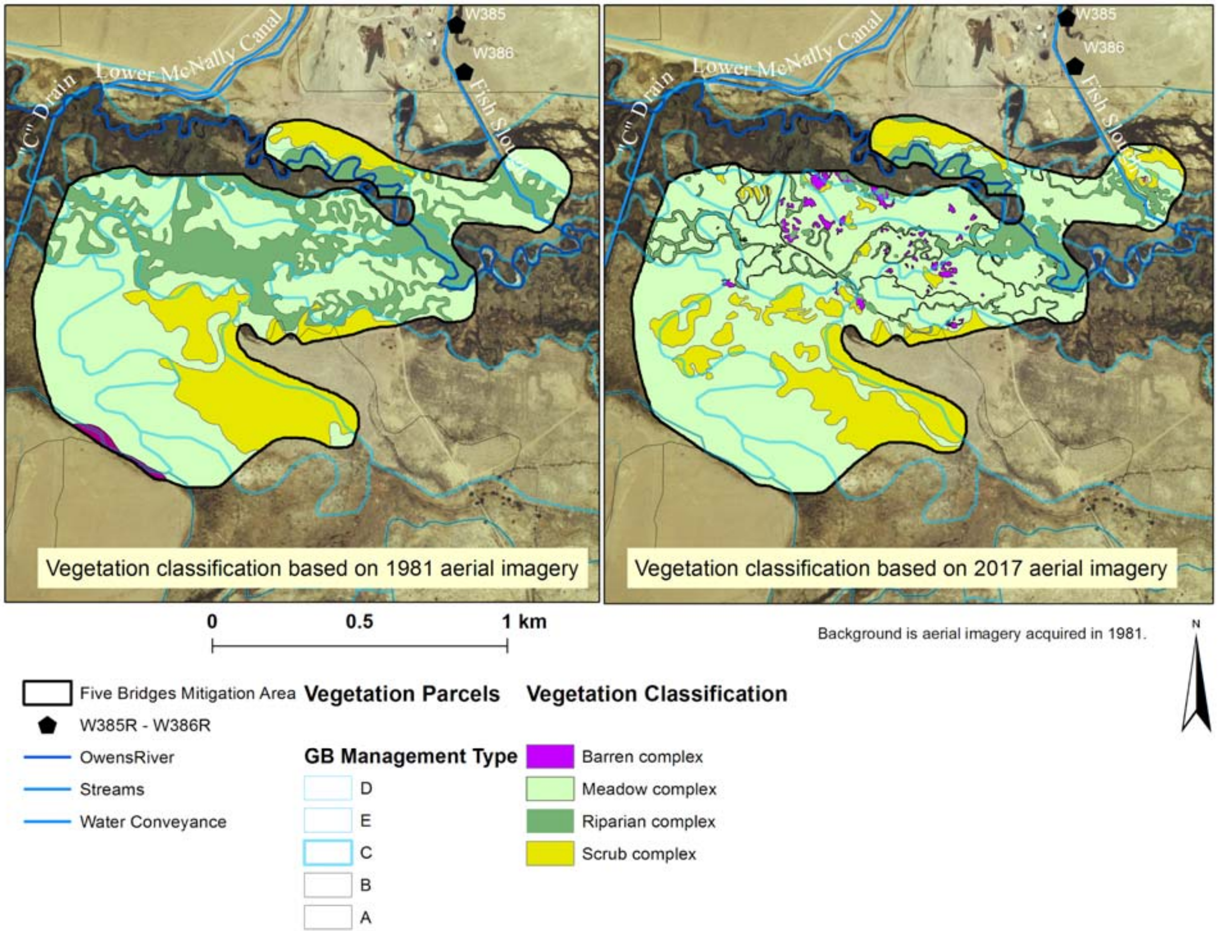


Figure 23. Vegetation communities in the Five Bridges Impact Area based on reinterpretation of 1981 aerial imagery and newly acquired 2017 aerial imagery (interpreted and delineated by LADWP staff). Note the loss of riparian (dark green) vegetation from 1981 to 2017 and also the increase in barren (purple) areas.

Table 4. Species composition compared between 1987 and 2017 in riparian parcel FSL54. Primary changes include a loss of willow and rose cover (80% in 1987 to 8% 2017) and an increase in grass cover (4% in 1987 to 58% in 2017).

FSL54	Specis	Common Name	1987	2017
Species 1	*Salix spp*	Willow	68	2
Species 2	*Rosa woodsii*	Wild Rose	12	6
Species 3	*Scirpus acutus*	Tule Bulrush	5	1
Species 4	*Phragmite australis*	Common Reed	2	2
Species 5	*Chrysothamnus nauseosus*	Rubber Rabbitbrush	2	10
Species 6	*Leymus triticoides*	Beardless Wild Rye	2	46
Species 7	*Distichlis spicata*	Saltgrass	2	12

Conclusion

The goals for the Five Bridges Mitigation Project are given in the 1991 "*Final Environmental Impact Report - Water from the Owens Valley to Supply the Second Los Angeles Aqueduct, 1970 to 1990, 1990 Onward, Pursuant to a Long Term Groundwater Management Plan*" and the 1999 "*Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management.*" Multiple lines of evidence show that the Five Bridges Impact Area has not achieved its goals. This evidence includes vegetation cover and species composition measurements along field transects, satellite remote sensing of vegetation indices, vegetation community mapping from aerial photography, and comparison of conditions within the Impact Area to nearby areas of similar vegetation.

References

Amlinn, N. and S. Rood. 2002. Comparative Tolerance of Riparian Willows and Cottonwoods to Water-Table Decline. *Wetlands, Vol. 22, No. 2, June 2002, pp. 338-346.*

City of Los Angeles Department of Water and Power and County of Inyo. 1991. Water from the Owens Valley to Supply the Second Los Angeles Aqueduct, 1970 to 1990, 1990 Onward, Pursuant to a Long Term Groundwater Management Plan, Vols I-III.

Cooper, D., J. Sanderson, D. Stannard, D. Groeneveld. 2005. Effects of long-term water table drawdown on evapotranspiration and vegetation in an arid region phreatophyte community. *Journal of Hydrology 325 (2006) 21-34*.

Duell Jr., Lowell. 1990. Estimates of Evapotranspiration in Alkaline Scrub and Meadow Communities of Owens Valley, California, Using the Bowen-Ratio, Eddy-Correlation, and Penman-Combination Methods. *United States Geological Survey Water-Supply Paper 2370-E.*

Elmore, A., S. Manning, J. Mustard and J. Crane. 2006. Decline in alkali meadow vegetation cover in California: the effects of groundwater extraction and drought. *Journal of Applied Ecology, 2006, **43**, 770-779.*

Inyo/Los Angeles Technical Group. 1999. Revegetation Plan for Impacts Identified in the LADWP, Inyo County EIR for Groundwater Management.

Inyo County Water Department. 2017. Annual Report 2016-2017.

Los Angeles Department of Water and Power. 2017. 2017 Annual Owens Valley Report.

Los Angeles Department of Water and Power. 2018. Assessment of Vegetation Conditions of the Five Bridges Mitigation Area and Future Five Bridges Efforts.

Pettorelli, N., Vik, J. O., Mysterud, A., Gaillard, J. M., Tucker, C. J., & Stenseth, N. C. (2005). Using the satellite-derived NDVI to assess ecological responses to environmental change. *Trends in ecology & evolution, 20(9), 503-510*.

Platts, William. 1996. Final recommendations based on the goal to re-establish native grasses and willow. Five Bridges Mitigation Project. Letter to Lloyd Anderson, LADWP. December 8, 1996.

Stromberg, J. and R. Tiller. 1996. Effects of Groundwater Decline on Riparian Vegetation of Semiarid Regions: The Sand Pedro, Arizona. *Ecological Application 6(1), 1996, pp. 113-131.*

Vina, A., et al. 2011. Comparison of different vegetation indices for the remote assessment of green leaf area index of crops. *Remote Sensing of Environment (2011), doi 10.1016/j.rse.2011.08.010.*

Appendix A. Parcel, species name, common name, life cycle and type (grass, shrub, forb, weed) detected on line-point transects in 2017, within Five Bridges Impact Area.

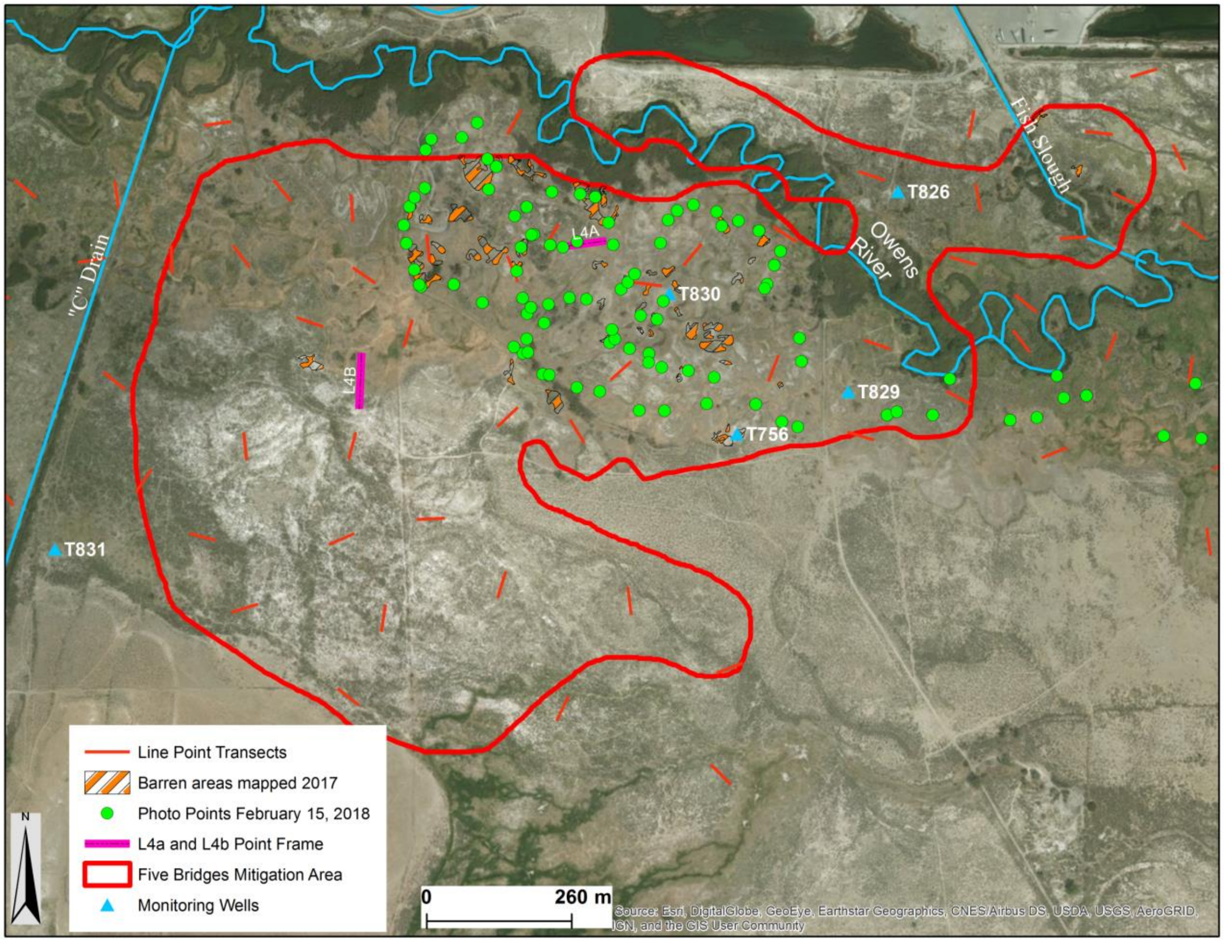
Parcel	Species Name	Common Name	Lifecycle	Type
FSL053	Atriplex truncata	Wedgescale	Annual	forb
FSL053	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL053	Cordylanthus maritimus ssp. canescens	bird's-beak, Alkali	Annual	forb
FSL053	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL053	Distichlis spicata	Saltgrass	Perennial	grass
FSL053	Juncus balticus	rush, Baltic	Perennial	grass
FSL053	Juncus mexicanus	rush, Mexican	Perennial	grass
FSL053	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL053	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL053	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL053	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL053	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL053	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL053	Rosa woodsii var. ultramontana	rose, Intermountain	Perennial	shrub
FSL053	Salix exigua	willow, Coyote/Narrow-leaf	Perennial	shrub
FSL053	Suaeda moquinii	inkweed, Bush	Perennial	shrub
FSL053	Salix laevigata	willow, Red	Perennial	shrub
FSL054	Polypogon monspeliensis	grass, Annual rabbitsfoot	Annual	weed
FSL054	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL054	Cordylanthus maritimus ssp. canescens	bird's-beak, Alkali	Annual	forb
FSL054	Helianthus annuus	sunflower, Annual	Annual	weed
FSL054	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL054	Eriogonum sp.	Buckwheat	Annual/Perennial	shrub
FSL054	Carex sp.	Sedge/Carex	Perennial	grass
FSL054	Distichlis spicata	Saltgrass	Perennial	grass
FSL054	Juncus balticus	rush, Baltic	Perennial	grass
FSL054	Leymus cinereus	wildrye, Great Basin	Perennial	grass
FSL054	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL054	Phragmites australis	reed, Common	Perennial	grass
FSL054	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL054	Typha sp.	Cattail	Perennial	grass
FSL054	Anemopsis californica	Yerba mansa	Perennial	forb
FSL054	Apocynum cannabinum	dogbane, Hemp	Perennial	forb
FSL054	Asclepias fascicularis	milkweed, Narrow-leaf	Perennial	forb
FSL054	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL054	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL054	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL054	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL054	Rosa woodsii var. ultramontana	rose, Intermountain	Perennial	shrub

FSL054	Salix exigua	willow, Coyote/Narrow-leaf	Perennial	shrub
FSL124	Polypogon monspeliensis	grass, Annual rabbitsfoot	Annual	weed
FSL124	Atriplex truncata	Wedgescale	Annual	forb
Parcel	**Species Name**	**Common Name**	**Lifecycle**	**Type**
FSL124	Cordylanthus maritimus ssp. canescens	bird's-beak, Alkali	Annual	forb
FSL124	Helianthus annuus	sunflower, Annual	Annual	weed
FSL124	Laennecia coulteri	horseweed, Coulter's	Annual	forb
FSL124	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL124	Distichlis spicata	Saltgrass	Perennial	grass
FSL124	Eleocharis sp.	Spikerush	Perennial	grass
FSL124	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL124	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL124	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL124	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL124	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL124	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL124	Rosa woodsii var. ultramontana	rose, Intermountain	Perennial	shrub
FSL125	Atriplex truncata	Wedgescale	Annual	forb
FSL125	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL125	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL125	Distichlis spicata	Saltgrass	Perennial	grass
FSL125	Leymus cinereus	wildrye, Great Basin	Perennial	grass
FSL125	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL125	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL125	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL125	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL125	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL125	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL126	Atriplex phyllostegia	Arrowscale	Annual	forb
FSL126	Atriplex truncata	Wedgescale	Annual	forb
FSL126	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL126	Helianthus annuus	sunflower, Annual	Annual	weed
FSL126	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL126	Distichlis spicata	Saltgrass	Perennial	grass
FSL126	Leymus cinereus	wildrye, Great Basin	Perennial	grass
FSL126	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL126	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL126	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL126	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL126	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL126	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL128	Helianthus annuus	sunflower, Annual	Annual	weed
FSL128	Distichlis spicata	Saltgrass	Perennial	grass

FSL128	Juncus balticus	rush, Baltic	Perennial	grass
FSL128	Leymus cinereus	wildrye, Great Basin	Perennial	grass
FSL128	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
Parcel	**Species Name**	**Common Name**	**Lifecycle**	**Type**
FSL128	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL128	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL128	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL128	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL128	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL128	Salix exigua	willow, Coyote/Narrow-leaf	Perennial	shrub
FSL129	Atriplex truncata	Wedgescale	Annual	forb
FSL129	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL129	Chenopodium berlandieri	goosefoot, Pitseed	Annual	weed
FSL129	Cordylanthus maritimus ssp. canescens	bird's-beak, Alkali	Annual	forb
FSL129	Helianthus annuus	sunflower, Annual	Annual	weed
FSL129	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL129	Distichlis spicata	Saltgrass	Perennial	grass
FSL129	Juncus balticus	rush, Baltic	Perennial	grass
FSL129	Juncus mexicanus	rush, Mexican	Perennial	grass
FSL129	Leymus cinereus	wildrye, Great Basin	Perennial	grass
FSL129	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL129	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL129	Glycyrrhiza lepidota	licorice, American	Perennial	weed
FSL129	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL129	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL129	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL129	Rosa woodsii var. ultramontana	rose, Intermountain	Perennial	shrub
FSL129	Salix exigua	willow, Coyote/Narrow-leaf	Perennial	shrub
FSL129	Populus fremontii	cottonwood, Fremont's /Alamo	Perennial	shrub
FSL130	Amaranthus sp.	Pigweed /Amaranth	Annual	weed
FSL130	Atriplex phyllostegia	Arrowscale	Annual	forb
FSL130	Atriplex serenana	Bractscale	Annual	weed
FSL130	Atriplex truncata	Wedgescale	Annual	forb
FSL130	Bassia hyssopifolia	bassia, Fivehook	Annual	weed
FSL130	Chorizanthe brevicornu	spineflower, Brittle	Annual	forb
FSL130	Cordylanthus maritimus ssp. canescens	bird's-beak, Alkali	Annual	forb
FSL130	Eriogonum deflexum	buckwheat, Skeleton	Annual	forb
FSL130	Eriogonum maculatum	buckwheat, Spotted	Annual	forb
FSL130	Salsola tragus	Tumbleweed /thistle, Russian	Annual	weed
FSL130	Astragalus sp.	Milkvetch	Annual/Perennial	forb
FSL130	Distichlis spicata	Saltgrass	Perennial	grass
FSL130	Juncus balticus	rush, Baltic	Perennial	grass
FSL130	Leymus cinereus	wildrye, Great Basin	Perennial	grass

FSL130	Leymus triticoides	wildrye, Beardless/Creeping	Perennial	grass
FSL130	Sporobolus airoides	sacaton, Alkali	Perennial	grass
FSL130	Astragalus lentiginosus	milkvetch, Specklepod	Perennial	forb
Parcel	**Species Name**	**Common Name**	**Lifecycle**	**Type**
FSL130	Lepidium latifolium	pepperweed, Perennial	Perennial	weed
FSL130	Atriplex confertifolia	Shadscale	Perennial	shrub
FSL130	Atriplex torreyi	saltbush, Nevada/Torrey's	Perennial	shrub
FSL130	Ericameria nauseosa	rabbitbrush, Common	Perennial	shrub
FSL130	Sarcobatus vermiculatus	Greasewood	Perennial	shrub

Appendix B. Photo points



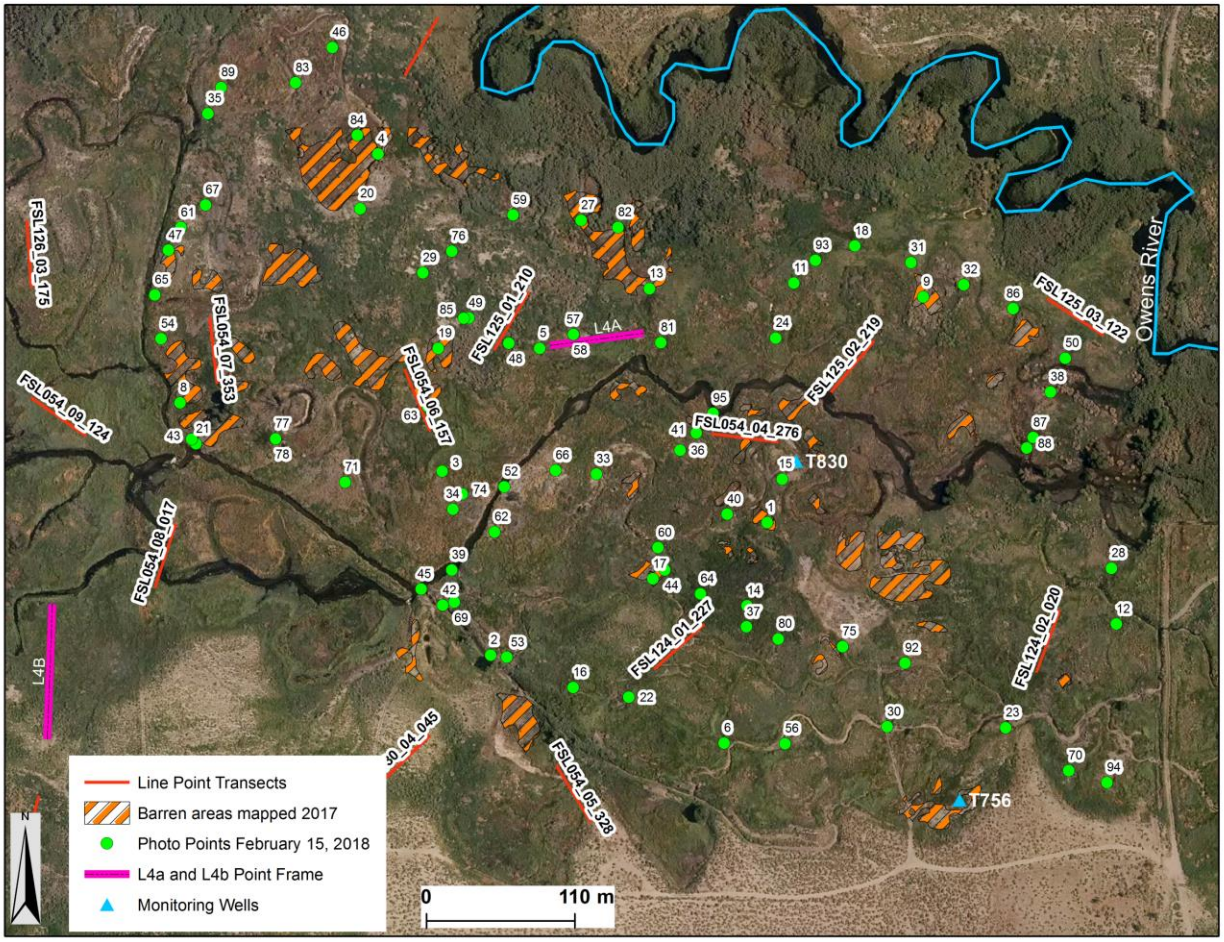


Fig 1. Locations of photo points acquired 15 February 2018 in reference to the Five Bridges Impact Area (top). The area known as the Multiple Completion Meadow, that has been slow to recover from pumping, encompasses portions of riparian parcel FSL 54, and meadow parcels, FSL 124 and 125 (bottom). Photos are numbered on this map to cross-reference spatial location of photos below. Bare areas were mapped by LADWP staff. Most photo points have *L. latifolium* present. Line point transects, permanent monitoring transects L4A and L4B, and monitoring wells are shown for reference. The photo points cover the area highlighted as needing further recovery in the 1999 Revegetation Plan.

Fig 2. Photo Point # 73 - Northwest portion of Multiple Completion Meadow. Extensive bare areas exist *with L. latifolium* established. Furrows are residual from drill-seeding activities by LADWP.

Fig 3. Photo Point # 42 - Northwest portion of the Multiple Completion Meadow. Extensive bare areas exist with L. latifolium established. Furrows are residual from drill-seeding activities by LADWP.

Fig 4. Photo Point # 76 - Northwest portion of the Multiple Completion Meadow. Extensive bare areas exist with *L. latifolium* established. Furrows are residual from drill-seeding activities by LADWP.

Fig 5. Photo Point # 43 - Northwest portion of the Multiple Completion Meadow. Patchy bare area, native grass and *L. latifolium* established.

Fig 6. Photo Point # 50 – Western portion of the Multiple Completion Meadow. *L. latifolium* established and leafing out on Feb 15, 2018.

Fig 7. Photo Point # 8 - Western portion of the Multiple Completion Meadow. *L. latifolium* established.

Fig 8. Photo Point # 65 - Western portion of the Multiple Completion Meadow. *L. latifolium* established in foreground.

Fig 9. Photo Point # 65 - Western portion of the Multiple Completion Meadow. *L. latifolium* is established in bare areas with native grass in the background.

Fig 10. Photo Point # 59 - Central portion of the Multiple Completion Meadow. Native grass, bare areas and *L. latifolium* established.

Fig 11. Photo Point # 17 - Central portion of the Multiple Completion Meadow. Native grass, bare areas, and *L. latifolium* established.

Fig 12. Photo Point # 11 - Northern portion of the Multiple Completion Meadow. Native grass, bare areas, and *L. latifolium* established.

Fig 13. Photo Point # 53 - North-Central portion of the Multiple Completion Meadow. Bare areas, *L. latifolium*, and native grass in background.

Fig 14. Photo Point # 70 - North-Central portion of the Multiple Completion Meadow. Bare areas, *L. latifolium*, and native grass.

Fig 15. Photo Point # 10 - North-Eastern portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 16. Photo Point # 9 - North-Eastern portion of the Multiple Completion Meadow. Bare area and *L. latifolium* in foreground.

Fig 17. Photo Point # 34 - Eastern portion of the Multiple Completion Meadow. Bare areas and *L. latifolium* in foreground.

Fig 18. Photo Point # 34 - Eastern portion of the Multiple Completion Meadow. Native grass, bare areas and *L. latifolium* in foreground.

Fig 19. Photo Point # 20 - Southern portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 20. Photo Point # 49 - Southern portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 21. Photo Point # 49 - Central portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 22. Photo Point # 62 - Central portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 23. Photo Point # 32 - Central portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 24. Photo Point # 36 - Central portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 25. Photo Point # 56 - Central portion of the Multiple Completion Meadow. *L. latifolium* in foreground.

Fig 26. Photo Point # 56 - Central portion of the Multiple Completion Meadow. *Salsola tragus* (tumbleweed) patch in foreground.