Recruitment Report and Analysis

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1.0 Review of Methods Used by the Water Department to Measure Recruitment

1.1 Green Book Guidance

On October 18, 1991, the Inyo County Water Department (Water Department) and the Los Angeles Department of Water and Power (LADWP) finalized the Long Term Water Agreement (LTWA). The Water Department and LADWP developed groundwater management procedures for the Owens Valley and Inyo County, called the "Green Book" which is the technical appendix to the LTWA. Management according to the LTWA and the Green Book was the preferred alternative in the 1991 EIR evaluating water supply for LADWP's second aqueduct. The Green Book provides the management and monitoring goals for pumping well management areas within the Owens Valley. According to the Green Book, the primary goals of the LTWA are "to manage groundwater pumping and surface water management practices as follows: 1) to avoid causing significant decreases in live vegetation cover; 2) to avoid changing a significant amount of vegetation from one classification to a lower (alphabetically) classification; 3) to avoid causing other significant effects on the environment; 4) to manage rare plants in a manner consistent with State and Federal laws pertaining to rare and endangered species; and 5) to evaluate whether changes in vegetation result in a significant impact on rare or endangered species and on other vegetation of concern. If any of these goals are not achieved, feasible mitigation of the affected area will be implemented (Inyo County and City of Los Angeles, 1990)."

Section III.C.5 of the Green Book describes the requirement to conduct recruitment monitoring at permanent monitoring sites. The Green Book states that the intent of this monitoring is "to determine community processes in relation to hydrologic management and ambient conditions, and to determine long-term trends in vegetation dynamics". In addition, the Green Book defines recruitment as "the process of replacement of aging and declining members of a plant community" (Green Book, Page 57).

Excerpts from the Green Book follow:

Page 48:
Quantitative yearly recruitment inventories at all monitoring sites will include woody and herbaceous perennial species, and weedy and nonweedy annual species. The intent of the recruitment studies is to determine community processes in relation to hydrologic management and ambient conditions, and to determine long-term trends of vegetation dynamics.

Page 52-53:
Permanent belt transects will be used to evaluate the recruitment of herbaceous and woody perennial species.
a. Ten belt transects, 1 m wide and each 10 m long, will be located on the left-hand side of the transect as viewed facing along the transect from the zero end.
b. Evaluation of belt transects will be performed during three periods:

i. Herbaceous species will be evaluated within one week of the April point-frame measurements.

ii. Herbaceous species will again be evaluated within one week of the peak season (late June) point-frame measurements.

iii. Both herbaceous and woody perennial species will be evaluated within one week of the August point-frame measurements.

c. Data collection for nonwoody species within the belt transects will be standardized to enable easy data analysis.

i. All species will be identified by their standardized abbreviations.

ii. All individuals of herbaceous perennials and annual species will be recorded.

d. Data collection for woody perennials that are recognizably younger than surrounding vegetation will be recorded into three age classes:

i. Plants germinated during the current year

ii. Plants germinated the previous year

iii. Plants germinated two or more years previously but still having recognizable juvenile characteristics, such as:

- *Comparatively small stature*
- *Relatively thin stem-base cross section*
- *Lack of flowering/seed set*

Appendix A provides a table taken from Manning (2006) that lists the permanent transect, whether there is an exclosure present, and if the transect is a control or a wellfield.

1.2 Changes to Green Book Monitoring Methods

For undocumented reasons the original monitoring methods described in the Green Book were changed prior to or during the 1991 monitoring season. The most significant change to the monitoring program was the decision to focus only on shrub recruitment. Recruitment data for herbaceous annuals and perennials were not included in the 1991-1993 Report on Shrub Recruitment (Manning 1994). It is possible that the methods as envisioned by the Green Book were simply too time-consuming to carry out, or the objectives of the monitoring program were revised. According to Water Department staff, shrubs were selected for monitoring because only shrubs were recruiting within the monitoring sites (Steinwand 2010). Manning (1994) states that monitoring detectable changes (i.e., recruitment and tracking cohorts) may help to determine the health of the vegetation. None of the Water Department reports fully document the reasons for the changes. Shrubs that were encountered at the permanent monitoring sites are listed in Table 1.

1.3 Current Monitoring Methods

The Water Department has described the recruitment monitoring program as of 2006 as follows (Manning, 2006):

A survey to locate and record information on new shrub seedlings associated with each

permanent transect has been carried out annually beginning in 1991. A belt, 1m in width and 100m long, extending the full length of the transect along the left side of each permanent transect line, is 5 monitored for new shrub recruits. During 1991 and 1992, recruitment data were collected at the times that point frame data were collected, and little if any data were collected on the sizes of new recruits. An analysis of recruitment results in those two years suggested that the observers varied in detection and assessment of new recruits; for example, questions arose whether a small plant in the belt was a new seedling, one that was missed the previous year, or simply an older individual of small stature. The confusion was expected in this newly-implemented monitoring procedure. In 1993, recruitment data collection was reduced to once per year (late summer or early fall), and the field protocol was rewritten to ensure more accurate data collection. For each newly encountered shrub, the location, species, and dimensions are recorded. Dimensions, in cm, are the longest diameter (length), the diameter perpendicular to the length (width), and the seedling height. Seedlings with dimensions smaller than 1cm are encountered, but they are recorded as 1cm. In instances where many new recruits are clustered, location and species are noted, the total number of individuals is counted or estimated, and a size range is recorded for seedlings in the cluster. Typically, mortality is high in such clusters; therefore, in subsequent years, individual shrubs are easier to count and measure. Since 1991, each new recruit has been monitored until it dies or disappears (presumed dead but no remnant). That is, seedlings that became established in 1991, for example, are re-located, and if alive, the current year's dimensions are recorded. In this way, recruits are monitored for growth and survival in subsequent years, and by monitoring these individuals, it is easier to identify plants that are new to the site.

More recently, Manning (2008) provided additional details of the monitoring program.

From 1994 onward, I collected the shrub recruitment data in late summer. As a result, all of the shrub germination that would have occurred that year is not captured. What is captured is (hopefully) the members of the given years' cohort that survived the summer.

To collect the data, the 100-m tape is anchored to the end posts. Shrub recruits occurring within a 1-m wide belt to the left side of the transect are recorded with regard to location along the tape, identified to cohort (year germinated) and species, and measured. Notes may be recorded to help find the recruit in subsequent years. Care needs to be taken to insure the identity of the recruit; that is, for example, is a newly-observed small shrub an individual that germinated in spring of this year? Or is it an older recruit that was overlooked the previous year? If you cannot make a very accurate determination (based on the size and appearance of other members of the cohort and/or factors that may have accounted for not noticing the shrub in a previous year), don't place it in any group, but it may be useful to note it so you don't run into the same dilemma next year.

Survival and growth of all previous years' recruits are monitored. Previous year's data are needed in the field to find these. Size is the length, width, then height of the shrub to the nearest centimeter. Length is the longest diameter, width is the diameter

perpendicular to length; height is average tallest height. Reproductive features are noted if present. Photos are taken at some sites most years. Earlier photos are slide film, later are digital, and they should appear in the directory labeled as photos. We note on the data sheets if photos were taken, and each photo is labeled with date and site.

In addition, the Water Department has developed a written field protocol for conducting the recruitment monitoring (ICWD, N.D.). This document, entitled "Shrub Recruitment", is provided as Appendix B.

1.3.1 Placement of Permanent Monitoring Sites

The permanent monitoring sites were not randomly selected. Wellfield sites generally occur in the phyreatophytic plant community closest to the pumping wells linked to the site. The Control sites were believed to be unaffected by pumping and an attempt was to place one or more control sites near each wellfield. If biased selection rules were employed in the placement of permanent monitoring sites, caution should be exercised when making general conclusions regarding responses of the species in question on a larger scale.

1.3.2 Data Management

According to Manning (2008), data from the 2006 field season were entered into spreadsheets. Previous and subsequent seasons have either not been entered or have not yet been reviewed.

2.0 Evaluation of Existing Recruitment Data for Temporal Trends or Changes Associated with Water Management or Other Causes

The 2006 Water Department analysis of recruitment monitoring from 1995-2005 provides an accurate summary of the recruitment monitoring program, and the remaining sections summarize the conclusions from the 2006 report. Manning (2006) sums up the results of ten years of data collection on the 1995 cohort as follows: *The recruitment data were further analyzed to see what information they may provide in an analysis of changes in number of shrubs at the sites over time. Results of this preliminary analysis showed that insight into trends in shrub encroachment occurring valley-wide may be limited when using the permanent monitoring site data because, unlike the valley as a whole, livestock grazing has been excluded from many of the sites. In general, large numbers of shrub recruits occur at a few wellfield sites, but negligible differences were found in survival rate of the 1995 shrub cohort between wellfield and control sites.*

This analysis would be more complete if documentation of the rationale for changing the Green Book monitoring protocol could be located. The Green Book focuses on the function of plant recruitment as it relates to maintenance of plant community structure. The methods used, however, focus on a subset of the plant community - the shrub layer. Invasion of shrubs could indicate changes in vegetation community structure not allowed under the Water Agreement. However, recruitment monitoring alone does not provide

cover data and does not document vegetative increases in cover (such as increasing cover of a rhizomatous grass).

2.1 Shrubs and Their Relevance

Many shrub species in the Owens Valley are adapted to survive on precipitation alone, and these do not require groundwater near the surface. Herbaceous plants, especially perennial grasses and other monocots, often contribute substantial cover within plant communities that are groundwater dependent, and are therefore sensitive to changes in water management. Table 1 provides a list of the shrub species monitored under this program, along with their wetland indicator status, and whether the species occurs in a groundwater-dependent (Type B, C, or D) community. It is interesting to note that the majority of the shrubs monitored under this program are often observed encroaching into sites impacted by groundwater withdrawal.

Table 1. Shrub Species Encountered in Permanent Monitoring Sites 1991-2009

Shrub	USFWS Wetland Classification	Types B, C, D Vegetation (per Green Book)	Recruits Counted?*
Atriplex torreyi (ATTO)	FAC	Dominant	Yes
Chrysothamnus nauseosus (CHNA)[1]	Upland/not listed	Dominant	Yes
Sarcobatus vermiculatus (SAVE)	FACU	Dominant	Yes (sometimes)
Artemisia tridentata (ARTR)	Upland/not listed	NO, Type A	Yes
Atriplex confertifolia (ATCO)	UPL	Subdominant to uncommon	Yes
Atriplex parryi (ATPA)	FACW	Subdominant	Yes
Atriplex polycarpa (ATPO	FACU	NO, Type A	Yes
Psorothamnus arborescens var. *minutifolius* (PSARM)	FACU	NO, Type A	No
Suaeda moquinii (SUMO)	FAC	Subdominant	No
Allenrolfea occidentalis (ALOC)	FACW	Subdominant	No
Atriplex canescens (ATCA)	FACU	NO, Type A	No
Tetradymia axillaris (TEAX)	Upland/not listed	NO, Type A	No
Asclepias fascicularis (ASFA)	FAC	Subdominant	No
Apocynum cannabinum (APCA)	FAC	Subdominant	No

*See Manning (2006) for more details

Table 1 illustrates a principal reason that the shrub recruitment data would be difficult to apply to the original Green Book goal of determining community processes in relation to

[1] It is unclear which subspecies of Chrysothamnus is referred to in Table 1. Different subspecies are more mesic while others are more xeric.

hydrologic management and ambient conditions, and determining long-term trends in vegetation dynamics. Strictly speaking, the species chosen for recruitment monitoring may better document shrub invasions, unless the study sites were dominated by shrubs at the beginning of the study.

2.2 Shrub Recruitment as a Monitoring Trigger

The Shrub Recruitment Report for 1991-1993 (Manning, 1994) discusses how shrub recruitment may relate to community response to mortality and stressors: *"By understanding the natural patterns of species turnover and succession (if any) in a community, one is able to recognize aberrations in the patterns that may be caused by an acute perturbation or a chronic stress. Distinguishing stresses from which a community can recover on its own from those which may so alter the system so as to require human intervention to correct is critical to the adequate management of vegetation."* The report also infers that the goal of the recruitment monitoring is to detect "*other changes at a site that could be monitored to determine the health of the vegetation."*

Manning (2008), looking back at this monitoring effort, provides some background information that may help clarify the goals of the shrub recruitment monitoring. She states, "*In sum, by the time the recruitment data will show dramatic effects of long-term water table management, it will be too late. Shrub recruitment is not a good "trigger" type of indicator to monitor".* It is possible that the original goals of the recruitment monitoring program were changed to better understand and track shrub encroachment as another tool, perhaps an "early warning system" that could be used to assess long term trends and determine the effects of pumping. Manning's conclusion above regarding shrub recruitment as a monitoring trigger has merit, and should be considered when planning for future monitoring efforts.

In addition, few of the shrub species currently being monitored provide definitive evidence of a type change resulting from groundwater pumping. For example, *Chrysothamnus nauseosus* recruitment and establishment may provide little information without observing simultaneous responses of more desirable species, along with knowledge and full consideration of land management activities. For example, *Chrysothamnus* cover may increase in the presence of disturbances, including grazing, vehicular disturbance, or fire, irrespective of water management changes.

2.3 Shrub Cohort Survival

The recruitment data yielded some interesting information such as rates of shrub survival. In her 2006 report, Manning calculated survival between 1995 and 2005. Patterns and trends at sites within similar plant communities and sites subjected to different groundwater and grazing management were examined. The 2006 report provides differences in numbers of survivors and survival rates between meadow and scrub, fenced and unfenced, and control and wellfield conditions.

2.4 Shrub Establishment Mechanism

Shrubs do not exhibit substantial recruitment events in most years. The data (Manning 1994, 1995, and 2006) show a strong association with major rainfall events and recruitment. For example, 1991, 1995, 2003, and 2005 had at least one major storm triggering major recruitment events.

2.5 Long-Term Shrub Survival Considerations

Data for the 1995 shrub recruitment cohort for each permanent monitoring site are presented by Manning (2006). For each monitoring site, Manning presented information on habitat type (meadow or scrub), livestock grazing, and the location of the site relative to pumping. In general, Manning found that survival is very low in the first few years following the 1995 recruitment, but rates of survival increased radically as the shrubs attained larger stature.

2.6 Water Management

Recruitment survey monitoring reports focus much more on precipitation than water management. DTW is discussed in the 1991-1993 monitoring report (Manning 1994). The report concludes that sites with lowered water tables due to pumping did not appear to affect recruitment differently from control sites. However, two sites (BP1 and TS1) that previously experienced perennial dieback due to pumping had initial high survival of *Atriplex torreyi* (ATTO) recruits (Manning 1994). In the 1994 recruitment report, Manning (1995) reports that the greatest numbers of ATTO were located at sites that had experienced a lowering of the water table (TS1, TA3, BP1, and TA3).

Later Water Department results (Manning, 2006) also indicate that grazing exclosures may influence survival more than either vegetation/habitat type or groundwater management. Given the poor experimental design of the permanent monitoring sites and recruitment monitoring program it is not possible to make any generalizations about pumped versus un-pumped sites due to the major influence of the grazing exclosures.

2.7 Grazing

For one cohort monitored for ten years, the average percent survival was higher and overall average time to attain a higher survival rate was lower at sites where livestock have been excluded (Manning 2006). Manning (2006) also reports that only four sites: BP3, TA1, TS1, and TS2 exhibited an overall survival rate greater than 10 percent. All of these sites are dominated by meadow and protected by grazing exclosures. In addition:

Overall, survival averaged 8% for recruits within exclosures, but only 3% for those not protected from livestock grazing. On average, within exclosures, the average time for survival rate to achieve >= 90% was 4.9 years, compared with 5.9 years for recruits not in exclosures. And, once >= 90% survival was reached within exclosures, average

overall survival from that point through 2005 averaged higher within exclosures (93% v. 89%). Survival of 1995 recruits in meadow sites appeared to exceed survival in scrub sites, with an average of 6% survival and 5.2 yrs to 90% in meadows, compared with 2% survival and 6.6 yrs to 90% in scrub sites. Differences between meadow and scrub sites were greater when sites were exclosed. The ten exclosed meadow sites averaged 9% survival of 1995 shrubs and 4.4 yrs to achieve 90% survival, but the one exclosed scrub site averaged <1% survival and 9 yrs to achieve 90% survival (Manning, 2006)
Overall, the highest average 1995 survival (9%) and the shortest average time to achieve >= 90% survival (4.4 yrs) were seen in the nine exclosed wellfield sites (all nine were meadows and results were the same for the ten exclosed meadow sites, which includes one control site). By comparison, wellfield meadow sites without exclosures averaged 3% survival for 1995 recruits in 2005 and averaged 5.4 yrs to achieve 90% survival (Manning 2006).

Because livestock are generally free to graze most parts of the Owens Valley, these results may not be representative of vegetation community changes that would occur in the presence of grazing.

2.8 Cohort Contribution to Shrub Cover

Manning's (2006) examination of the recruitment data conclude that although new shrubs have persisted within monitoring locations, their contribution to cover is relatively minor, and cannot account for the overall shrub cover increase observed from 1990 -2005. Therefore, at least some of the cover increase should be attributed to shrubs present before 1990, which exhibited an increase in live cover.

3.0 Recommended Changes to the Recruitment Monitoring Program

The primary design flaws are the lack of replication, small sample size, and lack of experimental design to account for known variables that confound the detection of the main treatment effect. For example several types of plant communities are sampled on several soil/landscape units at either fenced or unfenced single transects. Based on my review of the monitoring program and dataset, along with discussions with Water Department staff regarding the level of effort involved with conducting the monitoring, I recommend that the recruitment monitoring program be discontinued. The monitoring effort is very high and unfortunately the data do not appear to be useful for describing community process, nor do the data provide meaningful information for groundwater management. Manning (2008) sums it up as follows and I concur:

This is a lot of hard work that, to date, has not provided any really relevant information to managing pumping.

I recommend refocusing the funding currently expended on recruitment into other priority Water Department programs. The ongoing Green Book revision should eliminate the recruitment monitoring requirement. One new area where monitoring resources could be redirected, is a collaborative targeted studies program designed to answer Water

Department and LADWP critical management questions. Targeted studies increase the effectiveness of monitoring and management by improving knowledge about the ecological system and effectiveness of management techniques. Targeted studies may be implemented as short-term pilot studies at small spatial scales rather than as long-term monitoring.

4.0 Testable Hypotheses Relative to the Intent Stated in the Green Book

The Green Book States: "*The intent of the recruitment studies is to determine community processes in relation to hydrologic management and ambient conditions, and to determine long-term trends of vegetation dynamics."* As stated earlier, the placement of the sites may have been biased, which limits the ability to use the data to generalize about community or Owens Valley-wide processes. However there are a number of possible investigations that could be examined in the future:

- Other factors (besides precipitation) that affect shrub survival. These may include competition, seed or seedling predation, vegetative cover, organic litter or mulch, soil stability and fertility, seed/seedbank longevity.

- Effects of grazing management on shrub seedling recruitment. Water Department data appear to show an inverse correlation of shrub survival to grazing, as some of the sites with the highest rates of survival are within exclosures.

- Recruitment data could be used to further understanding of the autecology of the focal species: growth rates, time to flowering and seeding, or sexual expression in the genus *Atriplex*.

The benefit of targeted studies is that they help to resolve uncertainties while providing knowledge that can improve land management. Under a targeted studies program, experimental treatments to manage shrub encroachment could replace the recruitment studies. Two possible subjects for targeted studies are provided here.

- Timing, duration, and intensity of grazing could be investigated relative to survival, or to investigate if at times grazing could be used as a tool to help control shrubs where they are encroaching into other habitat types. This type of information is necessary to discriminate pumping effects from other land management practices.

- Plant succession, vegetation recovery, and weed dynamics in response to fire could be undertaken in a series of controlled burns. Areas with differing existing vegetation communities, a range of DTW, and differing disturbance histories could be compared to discover how fire can be used as a management tool to improve vegetation conditions. The interaction of pumping, grazing, and fire management should be better understood to develop more integrated strategies for land management.

5.0 References

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